Forest Service
U.S. DEPARTMENT OF AGRICULTURE

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A HISTORY OF THE USDA FOREST SERVICE AVIATION PROGRAM

Loading fire equipment (knapsack containing fire hose) into a Forest Service Stinson SR-6A monoplane piloted by Merle Moltrup in Ely, MN.

A History of the USDA Forest Service Aviation Program

Firefighting Missions

Cover: Dramatically staged photo showing an array of equipment used in controlling wildfires—including a helicopter performing a hose lay and a smokejumper's parachute. Shasta-Trinity National Forest, August 1955. Forest History Society photo.

Back cover: Cargo is packed and ready to be loaded at the Aerial Fire Depot in Missoula, MT, 1961. USDA Forest Service photo by W.E. Steuerwald. Credits and captions for other images on these opening pages appear later in the book.

Title page photos: Please see later chapters for photo credits; all of these photos appear later in the book.

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USDA Forest Service Points-of-Contact and/or Collectors of Historical Information:

- Paul Linse, Assistant Director, Aviation, Washington Office
- Aaron Schoolcraft, Branch Chief, Aviation Strategic Planner, Washington Office
- Kelly Hedgepeth, Assistant Aviation Strategic Planner, Washington Office
- John Nelson, Airworthiness Branch Chief, Washington Office

USDA Forest Service Subject Matter Superstars

Nathan Alexander, Jami Anzalone, Shane Bak, Amy Baumer, Mark Belitz, Walter Bunt, Leslie Casavan, Lori Clark, Beau Dobberstein, Simon Driskell, Joseph Fansler, Scott Fry, Sue Gethen, J.T. Gilman, David Gomez, Eric Graff, Keith Hackbarth, Clark Hammond, John Harris, Nate Hesse, Everett Hinckley, George Hough, Michael Huneke, Dan Johnson, Joel "Henny" Jungemann, Philip Ketel, Pete Lannan, Cindy Matthews, Tom Mellin, Hans Ohme, Ezequiel "Rock" Parrilla, Robert Roth, Yolanda Saldana, Nikki Sandhoff, Heath Schaaf, Kris Schmidt, Eric Shilling, and Shawn Steber.

Former Practitioners and Program Leaders

Lanny Allmaras, Fred Cooper, Rick Dunlap, Brad Gibbs, Barry Hicks, Terry "Tar" Lesmeister, Bill Meadows, Jeff Meyerholz, Bill Moody, Ken Ross, Roger Savage, Chuck Sheley, David M. Stack, Ron Vail, and Rusty Warbis.

Associations, Collections, Libraries, Museums, and Historical Societies

- American Aviation Historical Society, Riverside, CA
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PREFACE

It has been our honor to spend the last year researching and documenting a history of firefighting aircraft in the U.S. Department of Agriculture (USDA), Forest Service. This opportunity was made possible through award of a contract "to develop a history of the use of aircraft used for aerial firefighting focusing on Forest Service missions, aircraft, and contracts." The idea for this contract was conceived by Assistant Director (Aviation) Paul Linse who realized that such a record would be invaluable for agency aviation leaders and practitioners. An understanding of the history and development of Forest Service aviation programs can help inform future management decisions.

The main challenge we encountered in writing this book was to remain focused on the Forest Service "missions, aircraft, and contracts" specified in the contract without wandering into the incredible number of related topics and tangents. In keeping with the statement of work, this project is intentionally focused on smokejumping and smokejumper aircraft, airtankers, aerial supervision, helicopters, and aerial infrared mapping. Hopefully, additional topics can be incorporated in the future—there is definitely more to tell.

This book focuses on the Forest Service. Many organizations—from other Federal agencies to private companies—played major roles in the development of aerial firefighting methods. Rather than a complete origin story of each method (which could easily be a book on its own), our primary focus is on implementation by the Forest Service. This is not intended to discount the significant role Forest Service partners have had in the development of aerial firefighting techniques.

Aircraft contribute to the mission of fire suppression and do not, by themselves, suppress fires. Aircraft are a valuable tool for inserting and extracting firefighters, equipment, and supplies; applying water, fire suppressants, and retardants; and serving as platforms for aerial reconnaissance, aerial supervision, and aerial mapping. They are also used to accomplish aerial ignition in support of both wildland and prescribed fires. Aircraft are machines used to achieve fire management objectives—ultimately it is the people who develop, utilize, maintain, manage, and fly these machines who make all the difference and are the true heroes.

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Short Brothers C-23A Sherpa smokejumper aircraft.
USDA Forest Service photo.

CHAPTER 1

Introduction

INTRODUCTION

1.1. About This Book

This book tells the story of the use of firefighting aircraft by the U.S. Department of Agriculture (USDA), Forest Service. Chapters focus on the following topics: early history, major programmatic events, smokejumping, airtankers, aerial supervision, helicopters, and infrared mapping.

This book is designed as a resource for agency aviation managers to better understand the origins of firefighting aircraft and the development of aerial firefighting missions in the Forest Service. Organized thematically around type of aircraft, mission, or both, it presents a history of firefighting aircraft use from the early 1900s through the early 2020s. It is meant as a starting point and could be updated or expanded on in the future as sources and time allow.

Each chapter in this book includes significant events, background information, early program testing and implementation, program development, lists of historical aircraft makes and models, and information on aircraft contracts as available. The hope is that having a historical context will help inform future management decisions.

The Forest Service has used aircraft in its wildland firefighting mission for over a century. Data has been collected on numerous topics and in various formats to create a historical record of aircraft use on fires. The intent of this book is to compile some of this data together and help create a more comprehensive understanding of the origins and development of aerial firefighting programs in the Forest Service.

1.2. About Sources

Although every attempt has been made to accurately reflect the facts, this book does not address the accuracy of any of the source material. The information presented is also only as complete as the availability of source materials allowed. A discussion of source materials is included in the endnotes, and any missing or conflicting information is noted.

1.3. About Titles, Spelling, and Gendered Language

Organizational titles have evolved over the last century. For example, predecessor organizations for today's Air Force changed six times from 1907 to 1947: Aeronautical Division, Signal Corps; Aviation Section, Signal Corps; Division of Military Aeronautics; U.S. Army Air Service; U.S. Army Air Corps; and U.S. Army Air Forces. Numerous other titles relevant to this book have changed over the years, including job titles and regions of the Forest Service. The spelling of certain aviation terms has also changed. To avoid confusion, this book uses standard, simplified titles and spellings that modern readers will recognize. Organizational standards such as resource typing are also expressed in current terms as of 2022.

In the early days of aerial firefighting, it was common to use masculine nouns and pronouns when referring to firefighters and other personnel. Gendered language is viewed as exclusionary today; modern readers may no longer understand the word "man" to be synonymous with "person." This book uses gender-neutral language throughout, except in a few cases to avoid changing direct quotes.

With regards to fire and aviation management within the Forest Service, what started as merely a function within the Branch of Operation in 1909 has since become Fire and Aviation Management within the State and Private Forestry Deputy Area by 2022. This book uses the designations at the time of reference, and an overview of the evolution from 1909 to 2022 is below.

1909 – Fire control function in Branch of Operation

1935 – Division of Fire Control and Improvements established

1937 – Redesignated as Division of Fire Control

1959 – Division of Fire Control transferred to newly established National Forest Protection and Development Divisions

1965 – Division of Fire Control becomes a component of newly established National Forest System

1974 – Redesignated as Fire Management Staff

1976 – Redesignated as Aviation and Fire Management Staff

1986 – Redesignated as Fire and Aviation Management Staff and transferred to State and Private Forestry

Another important Forest Service program that has supported Fire and Aviation Management since the 1940s—but gone through significant name changes—is the National Technology and Development Program (NTDP). References to the Missoula Aerial Equipment Development Center (later Missoula Technology and Development Center), the Arcadia Fire Equipment Development Center (later dropping "Fire" from its name), or the San Dimas Technology and Development Center all refer today to the larger NTDP group.

1.4. Significant Events by Decade

1900-1910s

1903—Wright Brothers make first powered aircraft flight
1905—First practical airplane developed
1905—Establishment of the Forest Service
1905—"Use of the National Forest Reserves" issued
1910—"Big Blowup" wildfires occur in Idaho and Montana
1910—Forest Service Bulletin No. 82: "Protection of Forest from Fire"
1919—U.S. Army aircraft and personnel requested for patrols
1919—Air patrols begin with Army assistance

1920s

1920—One-way air-to-ground communications possible
1926—First cargo airdropped on a wildfire
1927—End of Army assistance on air patrols
1928—Forest Service begins its own aviation program
1928—Aerial scouting highly successful on Ridge Route Fire
1928—Regions start developing airfields
1929—Development of two-way radiotelephone
1929—First use of airplanes by Forest Service in the Lake States

1930s

1930—12+ airplanes used and over 500 hours flown
1930—Required airplane features established for fire work
1931—"Aerial firebombing" presentation at fire meeting
1931—First use of an autogyro on a forestry mission
1931—Initial testing of parachute drops and live jumps
1932—First autogyro contracted for fire protection
1934—Parachute Jumping Experiment proposed
1935—Aerial Fire Control Project launched
1937—Cargo dropping with burlap parachute standardized
1938—Aerial photographs taken and dropped to fire boss
1938—Forest Service acquires its first airplane
1938—Seaplane program begins in the Eastern Region
1939—Parachute Jumping Experiment begins
1939—Sikorsky designs and pilots first practical helicopter

1940s

1940—First smokejumper fire jumps occur
1940—80 airfields available Forest Service-wide
1940—Parachute Jumping Experiment evolves to program
1943—Civilian Public Service Program begins
1944—Experimental phase of smokejumping ends
1945—Smokejumper training, techniques, gear standardized
1945—Project Fire Fly and the Triple Nickles take flight
1945—Forest Service and Army begin testing helicopters in mountains
1945—Bell Helicopters begins developing Bell G47B (47-B)
1946—Civilian Public Service Program ends
1946—Bell 47-B used for recon on a wildfire in Canada
1946—Sikorsky R-5As used in limited capacities on fires
1947—First extended helicopter use on a wildfire
1949—First helicopter training film for firefighters

1950s

1951—First turbine-engine helicopter manufactured
1953—Successful 1,300-gallon free-fall of water with DC-7
1954—Operation FIRESTOP tests water/retardant drops
1954—Operation FIRESTOP develops "best practices"
1954—Missoula Aerial Fire Depot dedicated
1955—First water "air drop" made on the Mendenhall Fire
1956—First airtanker squadron (seven airtankers)
1956—Forest Service acquires 8 TBM-3Us from U.S. Navy
1956—First airtanker contracted

1.4. Significant Events by Decade

1950s cont.

1957—Helicopter use moves beyond experimental phase
1957—First fully operational helitack crew hired
1957—Los Angeles County Fire Department uses helicopters on fire
1957—Allouette II helicopter introduced
1957—26 airtankers operating in California
1957—First airtanker numbering system
1958—Helicopters lay 10,000-ft hose on Morris Fire
1958—Standardized lesson plans for helicopter safety
1958—300 California firefighters trained in helicopter use
1959—10 helicopters used on Woodwardia Fire
1959—First helitack training film
1959—F7F, B-25, PB4Y-2 airtankers introduced

1960s

1960—Largest airtanker has 2,000-gallon capacity
1960—AJ-1, B-26, PV-2, and SBD/A-24 as airtankers
1961—TBMs tested at Edwards Air Force Base
1961—Drop tank, hover-fill, and bucket operations begin
1961—Bell 47G-3B and Hiller 12E helicopters introduced
1962—Multi-engine airtankers required in Pacific Southwest Region
1964—Extensive use of helicopters (19) on the Coyote Fire
1964—First use of medium-sized turbine-engine Bell 204-B
1964—Smokejumpers experiment with rappelling
1965—Federal Aviation Administration Grant of Exemption No. 392 and No. 392A
1965—First comprehensive "Helitack Training Guide"
1968—Smokejumper fitness standards adopted
1969—50 helicopters used on Swanson River Fire in Alaska

1970s

1972—National Fire Plan results in aviation budget increases
1972—Smokejumpers experiment with rappelling
1972—Airtanker Screening and Evaluation Board created.
1973—National Coordination Center established at Boise Interagency Fire Center
1973—Office of Aircraft (Aviation) Services created within the Dept. of the Interior
1973—First rappel bases established at Chelan and Santiam
1973—First operational fire rappel by Forest Service
1973—Air operations administration audit by Office of Inspector General
1974—National Aviation Plan developed to address inspector general audit
1974—National Helicopter Operations Study
1974—S-2 airtankers enter service
1974—First year of national airtanker contract
1974—First female leadplane pilot
1975—Washington Office Aviation Service Group established at Boise Interagency Fire Center
1975—Bell 212 helicopters used for rappel
1976—Rappel formally authorized by National Office
1976—National Wildfire Coordinating Group established
1977—First female rappellers
1978—Grant of Exemption 392 revision
1978—1984—Purchase of 20 Beechcraft Baron 58P airplanes
1979—First use of Simplex Helitorch
1979—National Smokejumper Base Study

1980s

1981—First female smokejumper pilot
1981—First female smokejumper
1983—Operational Retardant Evaluation study begins
1983—Rappel terminated due to reduced budgets
1985—Incident Command System implemented
1986—Type 3 helicopter rappelling initiated
1986—Premo Mark III aerial ignition device approved
1987—C-119 airtankers grounded
1987—Historical Aircraft Exchange Program (HAEP) begins
1989—Geographic Area Coordination Center System
1989—C-23A Sherpas acquired for smokejumper aircraft

1.4. Significant Events by Decade

1990s—Rapid expansion of the rappel program
1990—Office of General Counsel determines Forest Service lacks authority for HAEP
1990—First airtankers from HAEP on contract
1991—Final HAEP exchanges completed
1991—C-23A Sherpa airplanes incorporated into fleet
1991—Ram-air parachute program halted after a fatality
1991—Analysis process for national shared resources
1993—National Fire Aviation Council established
1993—BIFC renamed to National Interagency Fire Center
1994—South Canyon Fire fatalities in Colorado
1994—In-flight structural failure of Airtanker 82, C-130A
1994—Interagency Helicopter Operations Guide
1995—National Airtanker Study (NATS) begins
1998—Tactical Aircraft Resource Management Study

2010—Safety Management Systems formalized in policy
2010—Rappel Program suspended pending risk assessment
2010—Partial reactivation of rappel in the Pacific Northwest Region
2011—Reactivation of rappel across the agency
2011—First national rappel training
2011—First risk management workbook developed
2012—Aerial Firefighting Use & Effectiveness Study begins
2012—First National Rappel Academy in Salmon, ID
2012—First female smokejumper base manager
2012—Awarded Gold Standard Safety Certification by General Services Administration (GSA)
2013—Safety impact analysis of smokejumping and smokejumper aircraft
2014—SD3-60 Sherpa airplanes acquired via National Defense Authorization Act (NDAA)
2014—Triple Nickles Room dedicated at National Office
2015—Smokejumpers begin national transition to ram-air
2015—Short-haul implemented at two helicopter bases
2017—National Night Air Operations Plan approved
2019—Gold Standard Safety recertification by GSA

1990s **2000s** **2010s** **2020s**

2001—Development of Fire Traffic Area (FTA) concept
2002—In-flight structural failure of Airtanker 123, PB4Y
2002—In-flight structural failure of Airtanker 130, C-130A
2002—Blue Ribbon Panel Report
2002—Type 1 helicopter contracted for personnel transport
2002—FireWatch Program begins.
2003—Aerial supervision module (ASM) program initial trial
2004—Approval and expansion of ASM program
2004—NTSB safety recommendations on airtanker accidents
2006—Aviation doctrine developed
2007—Airworthiness Directive grounds fleet of Barons
2007—Regions directed to establish regional rappel training
2008—Iron 44 S-61 helicopter accident
2008—Missoula smokejumpers begin using ram-air parachute
2008—Dutch Creek Medical Extraction Protocols
2009—Rappel training fatality, Willow Creek, CA
2009—Station Fire in California influences aviation programs

2020—Aerial Firefighting Use & Effectiveness final report
2021—FireWatch Program ends
2021—10 SD3-60 Sherpas acquired via NDAA are operational


DOUGLAS C1
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De Havilland DH-4 biplanes flying close together on an aerial fire patrol over Olympic National Forest in Washington State, 1921. USDA Forest Service photo by William J. Paeth.

Opposite page: A Dougals C-1 biplane in flight in April 1926. U.S. Air Force photo.

CHAPTER 2

EARLY HISTORY THROUGH 1930s

2.1. Significant Events

1903—Wright Brothers make first powered aircraft flight.

1905—First practical airplane developed.

1905—Establishment of the Forest Service.

1905—"Use of the National Forest Reserves" manual issued by the Secretary of Agriculture.

1910—"Big Blowup" wildfires occur in northern Idaho and western Montana.

1910—Forest Service Bulletin No. 82 titled "Protection of Forest from Fire."

1919—Chief Graves requests U.S. Army equipment and personnel for patrol.

1919–27—Army-assisted air patrols in Northern, Pacific Northwest, and Pacific Southwest Regions.

1920—One-way air-to-ground communications possible.

1920—First fatal aviation accident in the history of Forest Service aviation.

1926—First documented instance of cargo being airdropped on a wildfire.

1928—Forest Service begins its own aviation program.

1928—Aerial scouting on the Ridge Route Fire contributes to rapid suppression.

1928–35—Regions develop airfields.

1929—Development of two-way radiotelephone.

1929—First use of airplanes by Forest Service in the Lake States.

1930—More than a dozen airplanes in use and over 500 hours flown.

1930—Required airplane features established for work on forest fires.

1931—"Aerial firebombing" presentation at the national fire control meeting.

1932—Autogyro contracted in Pacific Northwest Region.

1935—Aerial Fire Control Project launched to test fire-retarding applications.

1937—Standard method of cargo dropping established with burlap parachutes.

1938—Aerial photographs taken and dropped to fire boss on Angeles National Forest.

1938—Forest Service acquires its first airplane, a Stinson Reliant SR-10, tail number N2166, purchased for $15,000 (equivalent to $291,000 in 2022).[1]

1938—Seaplane program with Forest Service-owned aircraft begins in the Eastern Region.

1939—Parachute Jumping Experiment begins in Pacific Northwest Region.

1940—Eighty airfields available Forest Service-wide.

2.2. The New Forest Service and Powered Flight

In 1905 the Forest Service was established in the U.S. Department of Agriculture to manage 85.6 million acres of forest reserves transferred from the Department of the Interior's General Land Office.[2]

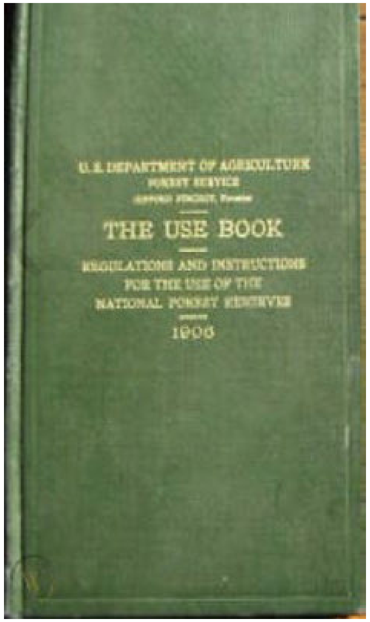
Orville and Wilbur Wright made the first powered aircraft flight in 1903. Their 12-second flight on December 17th of that year led to the development of the first practical airplane in 1905 and launched worldwide efforts to build better flying machines.[3]

Coincidentally, the establishment of the Forest Service and development of the first practical airplane both occurred in 1905. In the more than 100 years since, aircraft have developed from an innovative concept to an incredibly versatile and important tool in both wildland fire management and other natural resource efforts.

The "Use of the National Forest Reserves: Regulations and Instructions" was issued by the Secretary of Agriculture in 1905. Commonly known as the "Use Book," it became the initial manual that directed Forest Service actions. Regarding fire, it stated: "Officers of the Forest Service, especially forest rangers, have no duty more important than protecting the reserves from forest fires. During dry and dangerous periods all other work should be subordinate. Most careful attention should be given to the prevention of fires. Methods and equipment for fighting them should be brought to the highest efficiency. No opportunity should be lost to impress the fact that care with small fires is the best way to prevent large ones." [4]

Implementing the idea that "care with small fires is the best way to prevent large ones" was an even greater challenge in the early days of the Forest Service than it is today. The forest reserves were huge and full of rugged terrain. Information on the outbreak of fires was difficult to communicate and accurate mapping of fires was almost impossible. Roads were being built for motorized vehicles, but the primary method of accessing the forest reserves was still by horseback, by foot, or both.

Few events in the Forest Service's history were as impactful as the 1910 wildfires in northern Idaho and western Montana. "Official reports . . . estimated that 1,736 total fires burned more than 3 million acres of private and federal land and consumed an estimated 7.5 billion board feet of timber. At least 85 people were killed. Several small towns were completely destroyed, and one-third of Wallace [Idaho] was burned."[5]



The "Use Book" (142 p.) issued in 1905 was sized to easily fit into a ranger's packet while patrolling on horseback. This little book was a precursor to the modern-day Forest Service Manual and Handbook. USDA Forest service photo.

Forest Service Bulletin No. 82

If the new Forest Service were to succeed, it needed to improve its ability to suppress forest fires. To accomplish this goal, Henry S. Graves, Chief of the Forest Service from 1910 to 1920, issued Forest Service Bulletin No. 82 in 1910. Titled "Protection of Forest from Fire," the bulletin emphasized the following five points:[6]

- Quick arrival at the fire
- A thorough organization of the fighting crew
- Skill in attacking and fighting fires
- Proper equipment
- An adequate force

Chief Graves' five points are as valid today as they were in 1910. As aircraft technology evolved, innovative Forest Service leaders and aviators collaborated to take advantage of aircraft to support wildfire suppression missions.

The de Havilland DH-4 was used for early air patrols over Forest Service land. A 1968 newspaper clipping states: "A chance meeting in San Francisco between U.S. Army Air Corps Major Henry 'Hap' Arnold and Coert du Bois, California regional forester of the U.S. Forest Service, resulted in the first aerial fire patrol." It operated under Arnold out of March Field, patrolling the San Bernardino Mountains in 1919. San Diego Air and Space Museum photo.

2.3. Air Patrol with the Army 1919–1927

2.3.1. Initial Experiment (1919)

In January 1919 Chief Graves attended an annual forestry conference in Montreal, Canada, where a full discussion was held "by experts of the use of flying boats or aeroplanes [sic] in forest fire patrol and forest mapping and reconnaissance." After the conference, Chief Graves requested that Secretary of War Newton D. Baker issue an order for the U.S. Army to provide equipment and personnel for experimental patrols in cooperation with the Forest Service.[7]

What followed were 9 years of learning and development by trial, error, and innovation. In the beginning, there were few airfields, no air-to-ground radios, and no "ground receiving stations." Because there was no rapid method of getting information from a pilot or observer to Forest Service personnel on the ground, initial patrols frequently didn't result in the first reported detection of a new fire.

The Army and Forest Service began the patrols in California, with the first flight out of March Field in Riverside County, CA, on June 1, 1919. According to a history of early aviation in the U.S. Army, "Two flights per day were flown over parts of the Cleveland and Angeles National Forests. In addition, a Balloon School at Ross Field in Arcadia, California kept a balloon aloft at 3,000 feet each day to provide lookout service for part of the Angeles National Forest."[8]

The benefits of the patrols were immediately apparent, with other regions soon requesting service. In Oregon, at the request of forestry officials and the Governor, bases were established in the cities of Salem and Roseburg. In August 1919, Colonel H.H. ("Hap") Arnold took command of the patrols. His assertive leadership led to numerous improvements, including selection of base airports with better facilities (for example, Red Bluff instead of Redding, CA).[9]

The first "experimental" season ended in October 1919 with over 2,800 flight hours. According to a history of early aviation in the U.S. Army, "they reported 570 fires, 27 of these were first reported by plane." Eight major accidents occurred, with one fatality on the first day of operations.[10]

2.3.2. Forest Service Starts to Assume Control of Air Patrol Mission (1920)

Based on the success of the patrols in 1919, Colonel Arnold and the Forest Service planned for a much-expanded program the following year—92 aircraft with flight crews and support personnel to cover the States of California, Oregon, Washington, Idaho, Montana, and Wyoming. However, after Congress appropriated $50,000 for the aerial patrols, initial plans were scaled back to only California. The postwar demand for gasoline to fuel newly manufactured automobiles was huge, resulting in a scarcity that proved to be a major limitation for the air patrol program.[11]

Air patrol had been an experiment in 1919 led by the Army. Initially, the Army provided the aircraft, pilots, and mechanics, with the mechanics often serving as aerial observers. From the Army's point of view, the patrols "declined" after 1919.[12] The Forest Service assumed control of the mission in 1920, with the Army lending its pilots and planes while Forest Service employees filled the role of aerial observers.

Air patrol bases were established at Red Bluff, Fresno, and Mather Field in California. An extensive "planning and instructional conference" was held at March Field in Riverside County, CA. Topics included "flying, meteorology, map reading, first aid, radio, fire protection, fire suppression, and safeguarding timber areas outside national forests."[13]

As the fire hazard in Oregon became more serious during the summer of 1920, patrols were also flown from Medford and Eugene. Firefighters were even transported by airplane to wildfires on the Lassen National Forest in northeastern California. Summary reports from 1920 indicate that the air patrols flew nearly 4,000 hours and had first reports of 818 fires.[14]

Further Plans for Air Patrol: Camp Lewis is First of Three Main Bases Selected; Will Report Fires by Radio Telephone; to Carry Bombs

According to plans for forest air patrol completed by the war department, three main bases for airplanes will be established this winter for the states of Montana, Wyoming, Idaho, Washington, Oregon, and California. Only one has been definitely selected, that being Camp Lewis, which will serve as a base for the states of Washington and Oregon. Major A.D. Smith will recommend the establishment of a base at Missoula for the states of Idaho, Montana, and Wyoming, while another base will be established in California.

There will be two main sub-bases for each main base, with a total of...15 to 20 sub-bases used entirely for assembling supplies. The War Department will transfer 54 airplanes for air patrol in these six states, with aviation army officers as pilots, the Forest Service furnishing an observer for each plane who is familiar with the topography of the forests on the routes to be covered.

Photographs will be taken in preliminary trips before the first season of each forest and photographic maps made. Each machine will carry radio telephone apparatus, with which to communicate to the ranger stations and lookouts regarding any fires that may be discovered, it being expected that connection by this means may be secured in less than 15 minutes. Chemical percussion bombs weighing 50 pounds each will be carried by the planes and dropped on the flames whenever possible.

—Excerpt from an article in the Missoula Sentinel, October 13, 1919

Aircraft provided by the Army were initially Curtiss JN-4D "Jennys," later replaced by the de Havilland DH-4. Both of these aircraft were open cockpit, two-seat biplanes. By 1925 the Army provided the de Havilland DH-4 aircraft, with the Forest Service hiring the pilots, mechanics, and observers.[15]

Left: Curtiss JN-4D "Jenny" (1918). The early 1920s were known as the "Jenny Era." Charles Lindbergh said that the Jenny was underpowered, "somewhat tricky," and "splintered badly when they crashed," but that once someone learned to fly one, "they were just about capable of flying anything on wings with a reasonable degree of safety."[16] Photo courtesy of Glenn H. Curtiss Museum. Right: De Havilland DH-4 in flight on patrol in southern California in 1921. Forest History Society photo.

> *"Airplanes will become a permanent feature of the ceaseless battle against fires in the national forests."*
>
> –Forest Service news release in 1919

2.3.3. First Fatal Accident in Forest Service Aviation (1920)

Emergency landings were not uncommon during the air patrols, with at least a few reported each year. A fatal accident occurred on July 10, 1920, when an airplane scouting a fire near Alturas, CA, "went out of control and fell in a spin into the fire."[17] This should be considered the first fatal accident in the history of Forest Service aviation.

According to a history of the Modoc National Forest written by William S. Brown, Sr., "The landing field at Alturas [California] was much too small and during the [1920] season, six ships crashed in that vicinity. On July 10, 1920, a plane crashed and burned near Alturas, killing the three occupants: Sergeant Wayman Haney (pilot), Corporal Antonio Salcido, and Forest Observer Benjamin H. Robie."[18] Robie, a Forest Service employee, was stationed at Red Bluff, CA.[19]

First Fatality in Forest Service Aviation (July 10, 1920)

The September 1920 issue of *American Forestry* included an article titled "Forest Guard Killed While Fighting Fire." The National Museum of Forest Service History online archives include a copy of this article. As late as 1940, an article in *Fire Control Notes* erroneously claimed that no Forest Service employee had ever been injured in an airplane. Complete text of the *American Forestry* article is as follows:

"While directing from the air the work of 100 or more fire fighters [sic], battling blazes raging in the Lassen National Forests at Alturas, California, three men, two non-commissioned army officers and a government forester, fell over 1,000 feet to their death on July 10, when their airplane went into a tail spin and plunged to the ground. News of the fate of the trio was received by officers of Mather Field, a government flying field in California. The victims were: Sergeant Wayman T. Haney, Corporal — Salcida, Forest Guard Benjamin H. Robie.

"Since July 4 flames have been sweeping the Lassen timber district. Aviators and foresters of the United States forest patrol service have been directing the work of volunteer fire fighters, circling over the blazing area in planes. When the fire appeared to be fairly under control, flames burst out anew in several places and late on the night of the 10th, the volunteers busily attempting to stem the fire's progress, were startled to see the plane suddenly go into a tail spin and shoot downward.

"The machine landed at a spot where the flames were burning fiercely and if the occupants were not killed outright, they undoubtedly were burned to death."

2.3.4. Air Patrol Lays the Groundwork for Aviation Program Development (1921–1927)

Plans for air patrol in 1921 were similar to the previous year, with the addition of a patrol in Washington State over the Olympic Peninsula. The partnership continued, with the Army providing "the pilots, mechanics, and plans" and covering "the normal expenses of air operation" while the Forest Service "furnished observers and paid the expenses of the patrol bases and the cost of telephone and telegraph."[20] Occasional gasoline shortages continued. Patrol results were good in 1921, although there were fewer flights and less area covered. Reports mention for the first time the value of "aerial scouting," keeping track of fires from the air.[21]

In 1922, without an appropriation to pay for flights, the Forest Service requested aerial patrols through the War Department when the fire season heated up, resulting in limited air patrols that year in California, Oregon, and Washington.[22]

The fire season was exceptionally mild in 1923. The Army made "just 75 flights totaling just over 200 flight hours."[23] The next year in 1924, despite a higher fire danger, the Army used only two planes for air patrols in Oregon.[24]

After 3 years without a special appropriation for air patrol, the Forest Service received $50,000 in 1925. The Army agreed to loan the Forest Service some airplanes to set up its own air patrol. The Forest Service received 10 de Havilland DH-4B airplanes from the Army and, according to a history of early aviation in the U.S. Army, after hiring "reserve officers, pilots, and ex-enlisted men with Air Service training as mechanics, the Forest Service flew its own patrols in 1925. After 2 more years of operations, however, the Forest Service gave the work to civilian contractors."[25]

Army patrols began in the Northern Region in 1925 from a base in Spokane, WA. The region experimented with aerial mapping and organized aerial fire patrols with pilots and aircraft provided by Mamer Flying Service and Wallace Aerial Surveys, both of Spokane.[26]

The Army patrols continued through 1927, with patrols conducted in the Northern, Pacific Northwest, and Pacific Southwest Regions. Many improvements made the patrols more and more valuable. Particularly important was the development of air-to-ground communication. Without effective, two-way air-to-ground communication, pilots had to land, signal from the air, drop messages, and/or release carrier pigeons to get a fire report to a ground station—all of which delayed reporting the fire. By the end of 1920, one-way air-to-ground communication was possible, which decreased reporting time. Some two-way air-to-ground radios were in use by 1929.[27]

R.B. Adams demonstrating the first wireless radiotelephone to be used by the Forest Service. Helena, Montana, 1919. USDA Forest Service photo.

Left: De Havilland DH-4 biplane used for forest air patrol at Mather Field, California (no date). Forest History Society photo. Right: Douglas C-1 biplane in flight in April 1926. U.S. Air Force photo.

The Forest Service learned a great deal from the Army patrols. In addition to the numerous fires detected and reported, some intangible benefits of the patrols included the following:

- Airplanes were demonstrated to have a definite usefulness in forest fire control and value in scouting ongoing fires.
- Airplanes were proven as a cost-effective tool for reducing initial attack response time.[28]

By 1927 the organizational and physical infrastructure was developing to manage fledgling aviation operations in the Forest Service. Contracts had been awarded for aviation services, pilots and mechanics had been hired, and communications had been established. The operational considerations of mission planning and operating ground radio receiving stations had been developed.

Aviation operations were becoming progressively more complex, beginning with aerial fire detection patrols, then leading to smokejumping and airtanker operations. The promise of the benefits of the use of aircraft in fire suppression was recognized by regional and national fire program leadership, and the job of independently operating the aerial fire detection mission was underway.

2.4. The Changing Role of Aircraft in Forest Fire Control

As the Forest Service began flying on its own in the year 1928, it led to an era of innovation and development in aviation. Air patrol evolved to fire scouting, transportation of people and cargo, and cargo dropping. Landing fields were developed. The Forest Service took advantage of and experimented with technologies including the autogyro, two-way air-to-ground radios, and aerial photography. Many lessons were learned during the early stages of the aviation program.

2.4.1. Evolution of Air Patrol

In addition to supplying the aircraft, the Army carried the majority of the cost of the fire patrols. When Army assistance was phased out, the Forest Service was faced with the logistical challenges of obtaining and funding aircraft. The Forest Service had to fund continued air patrols from a $50,000 appropriation for aviation activities in fire control. While the Army-era patrol routes were designed to cover large areas, emphasis was placed on areas where air patrol was significantly superior to existing methods.[29]

Using commercial contract air services, air patrols resumed in the Pacific Southwest Region on July 1, 1928. Pacific Coast Air Service (Oakland, CA) was contracted to cover northern California. They provided the aircraft and pilots while the Forest Service provided observers and cargo handlers. Western Air Service (Los Angeles, CA) was contracted to provide services for southern California using a Douglas biplane. In addition to air patrol, contracted aircraft were used for emergency transportation of firefighters, supplies, and equipment.[30]

Patrols continued in the Northern Region with two aircraft reporting good success in locating small, lightning-caused fires in areas not adequately covered by lookouts. Fire scouting was done as well as freight and passenger hauling. Having only six available landing fields was a limiting factor.[31]

A major breakthrough in communications occurred in 1929 with the development of a 60-pound, two-way radiotelephone, which could be set up on a fire for continuous contact with scouting aircraft. This development was invaluable to the effectiveness of communication between spotters in the air and firefighters on the ground.[32]

In 1930—only the third year of the Forest Service operating its own aviation program—aircraft use was growing at an incredible rate. Airplanes were being used in the Southwestern, Pacific Southwest, Pacific Northwest, Northern, Intermountain, Rocky Mountain, and Eastern Regions, with more than a dozen airplanes and more than 500 hours flown.[33]

The Pacific Northwest Region contracted Portland Airways, Northwest Air Service, and Mamer Air Transport Company for aircraft and pilots, with good success in both detection and scouting. The first Forest Service use of airplanes in the Lake States occurred in 1929 with three aircraft on the Superior and Chippewa National Forests in Minnesota.[34]

Early Airplane Requirements for Forest Fire Work[35]

- Good payload of 500 to 1,000 lbs
- Good field of vision for the pilot and observer
- Stability at low speeds and in rough air conditions
- A good-sized door removable for dropping freight, with no obstructions
- Room for installation of a two-way radio
- Cabin space to accommodate a variety of firefighting equipment and supplies
- Good instrumentation

2.4.2. Scouting Fires from the Air

One of the hoped-for benefits when the Army patrols began in 1919 was getting an overall view of an emerging fire—with the ability to communicate the situation. Some scouting did occur during the Army era, but with the development of portable two-way air-to-ground radios in 1929, it took on new importance.

A notable instance of large fire scouting occurred in California on the Ridge Route Fire on the Angeles National Forest on September 14, 1928. The observer's information contributed to the location of hot spots and rapid suppression of the fire.[36]

In 1936, the Northern Region specified that airplanes should be used for "making first examination on large fires whose boundaries are not accurately known and for first examination after subsequent extended runs into drainages not readily reached by ground scouts."[37] By 1937, the Pacific Southwest Region handbook stated that contracted airplanes would be made available and when appropriate should be used for "scouting specific areas following electrical storms" and "making reconnaissance of large fires whose boundaries are not accurately known."[38]

HOW IS THIS FOR MOVING?

LOS ANGELES, Sept. 21 (AP) Traveling at an average speed of 144 miles an hour for 656 miles, a Western Air Express Fokker cabin liner is believed to have set a new world's speed record for commercial airplanes, according to Major C. C. Moseley, vice president of the company and one of the pilots on the trip. The plane flew from here to Salt Lake in four hours and five minutes, as against the scheduled time of six hours. It carried, besides 992 pounds of mail, eight passengers, the total load being 2889 pounds.

4 MORE PLANES RACE EASTWARD

Missing Pilot Wins Out Over Fierce Gale, Resumes Race

MINES FIELD, Los Angeles, Sept. 21 (AP)—The second of three aerial races from here to Cincinnati, was started off at 10

WORST FIRE OF YEAR SWEEPING ON UNCHECKED

30,000 Acres Blackened By Blaze; Watershed Threatened

NEWHALL, Cal., Sept. 21 (AP). Five motorists, trapped in a raging brush fire along the Bakersfield-Los Angeles Ridge route highway today, were seriously burned. Four, two women and two men, were removed to the hospital here, while the fifth, a man, was taken to the San Fernando health center for treatment.

In the hospital here are Mrs. Belle Wile of Pasadena and her son; R. M. Montgomery, also of Pasadena, and Mrs. Julia Koyle of Los Angeles. At San Fernando, G. A. Elmer, about 51, a laborer of Oroville, Cal., was treated for serious burns.

The fire swept out of control before noon today, according to reports to the Los Angeles county sheriff's sub-station here. The blaze is believed to have started when an automobile truck caught fire on the winding mountain highway.

Newspaper article about the Ridge Route Fire in the San Pedro News Pilot on September 21, 1928.[40] Interestingly, adjacent articles are about cross-country aerial races and a new speed record for commercial airplanes.

Aerial photographs were taken on the Angeles National Forest in 1938, developed in a portable darkroom on the aircraft, and dropped to the fire boss. By 1939, the Northern Region had trained six firefighters to take and drop aerial photographs directly to the fire boss.[39]

2.4.3. The Autogyro Experiment

First developed in the early 1920s, the autogyro was a rotary-wing aircraft pre-dating the modern helicopter. An unpowered rotor moved in free autorotation to develop lift with a separate, engine-driven propeller providing forward thrust. An autogyro was contracted for forest fire control work in 1932. It was based in Seattle and Wenatchee, Washington. One documented successful mission was the freefall of light packages of food, equipment, and supplies to fires on the Siskiyou National Forest. The contract was not renewed because the cost-benefit was unsatisfactory due to performance limitations.[41]

Autogyro at Summit Meadows, Mt. Hood National Forest, 1932. USDA Forest Service photo by Ron Headley.

2.4.4. Landing Fields as a Limitation and a Challenge

One of the biggest challenges in using aircraft for more than patrol and scouting missions was the lack of well-located landing fields. The delivery of firefighters, overhead personnel, equipment, and supplies depended on the development of these facilities.

Regions began to actively pursue development of landing fields in or near national forests. The most active was the one with the most inaccessible terrain—the Northern Region. With help from the Civilian Conservation Corps, the Northern Region began developing airfields in 1933 and by 1937 had approximately 20 airfields.[42] The Pacific Southwest Region surveyed and improved 35 emergency landing fields in 1928 to improve safety,[43] and by 1935 landing fields were available at forest supervisor headquarters on the seven national forests with the most wildfire activity in the Intermountain Region.[44] All of these improvements resulted in 80 landing fields servicewide by 1940.[45] Some of these initial landing fields are now the backcountry airstrips that recreationists use today.

2.4.5. Cargo Dropping

With millions of acres of remote terrain—often only accessible via pack string—the Forest Service soon realized that airplanes could be used to airdrop cargo to firefighters. The first documented instance of cargo being dropped on a wildfire occurred in Washington State in 1926 on the Chelan National Forest (now the Okanogan-Wenatchee National Forest) during the Army air patrol era.[46] Firefighters on the Mount Constance Fire on the Olympic National Forest in 1929 were resupplied almost entirely by airplane, ensuring that fire suppression activities could continue uninterrupted despite a 3-day walk to the nearest resupply point.[47]

The Forest Service experimented to ensure efficient and repeatable cargo delivery methods. Experiments in the Northern Region began in about 1928, with gasoline and pumps included in the cargo.[48] Although it proved unsuccessful as a cost-effective tool, the autogyro used on the Siskiyou National Forest in 1932 did successfully deliver (free fall) light packages of food, equipment, and supplies on wildfires.[49]

Early dropping systems were simple, often consisting of small bags stuffed within larger bags with some straw in the bottom. These "loose" bags were then dropped to the ground in a free fall. Steady advances were made in dropping techniques between

Top: Examining eggs after landing during air supply drop training at Pearson Field in Vancouver, WA in 1937. USDA Forest Service photo by E. Lindsay. Above: Packing an aerial delivery in Montana in 1936. USDA Forest Service photo by K.D. Swan.

1925 and 1937, including a "tight package" method[50] and the use of parachutes to reduce breakage. By 1937 a standard method had been developed that involved inexpensive burlap parachutes. The Pacific Northwest Region institutionalized this method in cargo dropping workshops held in Pendleton, OR and Vancouver, WA. Load limits had increased and even radios were being dropped successfully.[51]

The burlap parachute method was successfully used to deliver cargo during fires on the Siskiyou National Forest in 1938. During a "fire bust" with 4,500 firefighters in 50 camps, many in remote locations, 5 airplanes made 282 trips and delivered 112 tons of cargo. Six of the camps were supplied solely by air.[52]

The Northern Region modified former military parachutes and used them with excellent success, providing needed equipment and supplies to remote areas in a timely manner while also reducing costs. The cost per pound of 17 tons of cargo delivered to the Deer Creek Fire on the Idaho National Forest in 1940 was cheaper than using pack strings.[53]

The Forest Service realized that an organization was needed to manage and execute large-scale aerial cargo dropping activities. Key personnel were identified, including dispatchers, packers, parachute riggers, checkers, drivers, and paracargo droppers.[54]

By 1946, aerial cargo dropping was seen as a viable, timely, and cost-efficient way of resupplying firefighters. The following considerations were evaluated when deciding whether or not to use aerial cargo delivery to supply firefighters:

- Number of firefighters to be supplied
- Need for speed in deliveries
- Availability of airplanes of suitable payload and design
- Availability and condition of access roads and trails
- Need for establishing camps on the fireline
- Need for pack stock to transport water on the fireline
- Proximity of the warehouse, airfield, and fire
- Smoke, fog, or turbulent air that could limit the use of airplanes
- Availability of an adequate crew for packing, loading, and dropping cargo[55]

Cargo dropping on a national forest in Montana in May 1947. Forest History Society photo.

> *By 1937, the Pacific Southwest Region handbook stated that contracted airplanes would be made available and when appropriate should be used for "scouting specific areas following electrical storms" and "making reconnaissance of large fires whose boundaries are not accurately known."*

Stearman biplane used on aerial fire patrol in southern California, 1932. USDA Forest Service photo by W. I. Hutchinson

2.4.6. Transporting Personnel and Cargo

Extremely interested in transporting personnel and cargo, the Northern Region made this requirement a key feature of their 1931 contract for air services. In July 1931, using a Zenith biplane and a Travel Air 6000, they delivered over 100,000 pounds of cargo to Big Prairie, MT. The savings to the Forest Service in time and money was significant. By 1934, the Northern Region had seven backcountry landing fields, and aerial transportation of cargo was routine and had been conducted without safety issues.[56] Regional policy in 1936 included the use of aircraft "to transport smokechasers and fire suppression overhead," as well as "fire tools, equipment, and firefighters to landing fields in inaccessible areas under certain conditions."[57]

By the start of World War II, the Pacific Southwest, Pacific Northwest, Northern, Intermountain, and Southwestern Regions preidentified and mapped locations where it was beneficial to transport personnel and equipment by air. Each region had developed methods that suited their needs.

2.4.7. Multi-Mission Use of Aircraft

Airplanes were fast becoming multi-mission tools in firefighting, with proven functionality in missions ranging from patrol to dropping cargo to transporting people, equipment, and supplies. One well-documented example of this occurred during an extended "fire bust" in Montana and Idaho in 1931. An average of "21 fires per day for 72 days in mostly remote country" resulted in airplanes being "assembled from all over the northwest" and pilots flying "day after day" on diverse missions, including scouting, mapping, plotting routes for firefighters, and transporting personnel and supplies.[58]

Top: Loading supplies for dropping by airplane. Big Creek Fire, Los Padres National Forest, August 1941. Forest History Society photo. Above: Travel Air 6000 at Big Prairie, MT. Photo courtesy of Hank Galpin.

2.4.8. Eastern Region De Havilland Beaver Program

One of the earliest and most versatile multi-mission aviation programs in the Forest Service is the Eastern Region's De Havilland Beaver Program. First established in 1938, this unique program based at the Superior National Forest's Ely Seaplane Base in northern Minnesota is still in operation today.[59] With wide-ranging missions, including fire management operations, emergency response, and natural resource projects, there is much to tell about this program that goes beyond the scope of this book.

Over 3 million acres in size, the Superior National Forest includes over a million acres of the Boundary Waters Canoe Area Wilderness (BWCA). In 1926 much of the land within the BCWA was set aside to preserve its primitive character and it was designated as a wilderness area in 1964.[60] The role of aircraft was closely considered when the BCWA was established, and over-flight altitude restrictions for aircraft have been in place there since 1949.[61] Forest Service Beaver pilots have been granted permission to enter the prohibited area by the forest supervisor when warranted.[62]

Recreationists in canoes alongside a Forest Service Stinson seaplane at Kekekabic Lake in Minnesota circa 1938.

Left: Forest Service Seabee seaplane at Thomas Lake on the Superior National Forest in 1948. Right: Transferring fire equipment from a pickup truck to a Forest Service Stinson seaplane at the Ely Seaplane Base in 1940. USDA Forest Service photos by Leland J. Prater.

Aircraft have been used for administrative purposes on the Superior National Forest since 1929, with the Forest Service seaplane program officially taking flight in 1938 with a 1934 Stinson seaplane (variously reported as a model SR-5A or SR-6A).

Other aircraft flown by Forest Service pilots from the Ely Seaplane Base over the years include a Piper J-4 Cub Coupe, Noorduyn Norseman, Seabee, Stinson 108-3 and 108-2, and Cessna 180 and 185. Three de Havilland DHC-2 Beavers that have been with the program since 1956, 1959, and 1967, respectively, are still in service.[63]

The Eastern Region De Havilland Beaver Program is highly flexible with their ability to configure the aircraft to land on wheels, floats, or skis as needed. Fire management operations include aerial detection, aerial scouting of wildfires, scooping and dropping water on fires, transportation of wildfire personnel and equipment, and monitoring prescribed burns and smoke dispersal. Former missions that were undertaken in earlier years of the program included smokejumping and paracargo dropping.

The program also performs search and rescue and medical evacuations. Natural resource missions include aerial surveys for timber management, land use/exchanges, and weather damage; wildlife surveys and telemetry; fish surveys and stocking; aerial seeding; and forest health monitoring. Training missions include pilot flight checks, individual pilot developmental training, and unique opportunities to support organizations such as the Federal Bureau of Investigation and the U.S. Navy's test pilot school. The program also plays an important public relations role, with attendance at various aviation-related events.

The program has a rich history (examined here only briefly) as well as some exciting opportunities for the future, including further cooperation with local natural resource agencies and Voyager and Isle Royale National Parks. The Beavers may also soon be considered as a platform for aerial ignition in support of prescribed burning.

Left: One of the de Havilland DHC-2 Beavers on skis. USDA Forest Service photo by Joel "Henny" Jungemann. Right: The three de Havilland DHC-2 Beaver airplanes that have been with the Eastern Region's Beaver Program since the 1950s and 1960s and are still in service in 2022. USDA Forest Service photo by Joseph Schoolcraft.

2.4.9. Early Lessons Learned

The early years of the Forest Service's aviation program saw many developments and lessons learned. Airplanes better suited for transport and light airplanes ideal for scouting missions had come into use. The number of Forest Service landing fields had gradually increased, as well as the number of airplanes owned by the Forest Service. Two-way radio communication had been developed and was proving extremely beneficial for patrol and scouting flights. Aerial photography for fire mapping was coming into use. Transport of personnel and equipment was becoming a major role for aircraft in fire control. Effective free fall and parachute methods of supply delivery to the fireline had been developed—a parachute method of delivering firefighters was even being considered.[64] Airplanes had become an indispensable, innovative, multi-use tool in wildland fire suppression.

2.4.10. Aerial Fire Control Project—A Vision for the Future

By the mid-1930s, aerial patrols, transportation of personnel and cargo, and parachuting cargo to firefighters were common in all western regions. Ideas on how to best do the job circulated in the literature of the day, particularly in the Forest Service publication *Fire Control Notes*, which began in 1936.

While regions were developing and implementing various aviation missions as their needs, budgets, and opportunities allowed, the National Office was wrestling with how to capture the promise of the gasoline engine and mechanization.

The "origin stories" of the airtanker, aerial supervision, and smokejumper programs include the same two meetings: the 1931 and 1936 national fire control meetings in Spokane, WA. The 1931 meeting included a powerful presentation on the idea of "aerial firebombing." The 1936 meeting launched the Aerial Fire Control Project under the leadership of David P. Godwin, assistant director of Fire Control (precursor to the modern Fire and Aviation Management) from the National Office.[65] This project was tasked with investigating the use of aerial fire-retarding applications—including chemicals, water, and even explosives.[66]

Assigned to the Pacific Southwest Region, the Aerial Fire Control Project conducted firebombing experiments with aircraft, including the newly acquired Stinson Reliant SR-10, tail number N2166, piloted by Harold King. The results were disappointing, and the chemical retardant tested was seen as having little more effect than water. During the summer of 1939, the decision was made to abandon the project and devote the remaining funds and remainder of the fire season to the experimental delivery of "smokechasers" via airplane and parachute in the Pacific Northwest Region.[67]

David P. Godwin

David P. Godwin, circa 1940. Assistant director and later director of Fire Control, Godwin was a strong early supporter of aerial fire control and played a major role in the Parachute Jumping Experiment of 1939. He died in an airline crash on June 13, 1947. Courtesy of the National Museum of Forest Service History, Fred Cooper Collection.

2.5. Aircraft Makes and Models, 1920–1939

Table 2.1 lists some of the aircraft makes and models used by the Forest Service in the 1920s and 1930s. All the aircraft listed below were provided by civil aviation operators; military aircraft are not included as they are discussed throughout chapter 2. Unless otherwise noted, the information below was sourced from Malcolm Edward Hardy's "The Use of Aircraft in Forest Fire Control" (1946).[68]

Table 2.1. Aircraft makes and models in the Forest Service, 1920–1939

Make/Model	Function	Comments
Alexander Eaglerock[69]	Air patrol	Unknown owner
Autogyro	Cargo dropping	Unknown owner
Douglas M2	Air patrol	Owner: Western Air Express
Fairchild monoplane	Air patrol	Owner: Pacific Coast Air Service
Fokker Universal	Cargo dropping	Owner: Bigelow Aviation
Ford Tri-Motor	Cargo dropping, personnel and cargo transport	Owner: Mamer Flying Service[70]
Lockheed and Ryan airplanes	Air patrol	Owner: Northwest Air Service
Lycoming Stinson Junior	Air patrol	Owner: Portland Airways
Ryan 2-place monoplane	Air patrol	Owner: Pacific Coast Air Service
Stearman biplane	Air patrol, cargo dropping, cargo transport	Owner: Mamer Air Transport
Stinson monoplane	Air patrol, cargo dropping, cargo transport	
Stinson Tri-Motor	Air patrol, cargo dropping, cargo transport	
Travel Air	Air patrol, cargo dropping, cargo transport	Owner: Johnson Flying Service[71]
Waterhouse-Romair	Air patrol	Owner: Pacific Coast Air Service
Zenith biplane	Personnel and cargo transport	Owner: Bennett[72]

Forestry professionals in northern Idaho demonstrate an electric megaphone that was to be used in the summer of 1948 to direct ground crews from an airplane. The 22-pound megaphone could broadcast over a distance of 2 miles. Forest History Society photo.

CHAPTER 3

MAJOR PROGRAMMATIC EVENTS

This chapter summarizes major programmatic events and trends that had an overarching impact on the Forest Service's aviation program. They apply to multiple mission areas and aircraft types (fixed- and rotor-wing) and are explained here to avoid duplication in later chapters. They are presented in chronological order.

3.1. The 1940s–1970s

3.1.1. Air Operations Handbook (1940s)

Many of the developing missions in the Forest Service aviation program were unique to forestry and fire control (e.g., cargo dropping and smokejumping). Others such as reconnaissance were similar to missions already being performed by the U.S. Army. To communicate best practices, organizational expectations, and to provide some uniformity, the Air Operations Handbook was developed. As the 1905 "Use Book" evolved into the Forest Service Manual System of today, the Air Operations Handbook established the system of manuals, handbooks, and guides that direct today's Forest Service aviation management program.

Publication of the Forest Service Air Operations Handbook began in the 1940s. One early handbook, circa 1947, included a 58-page chapter/pamphlet on cargo dropping prepared by the Division of Fire Control in the Pacific Northwest Region.[1] The earliest Air Operations Handbook currently available was published in 1952 and consisted of four parts, as follows:

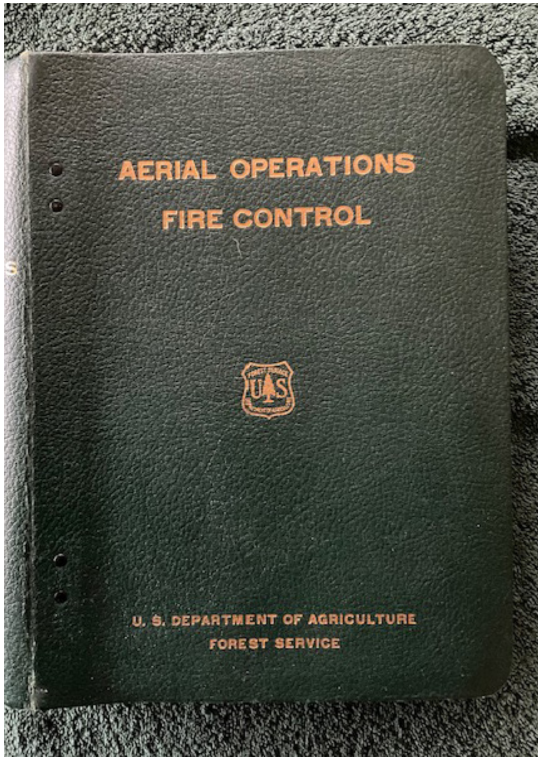
1. **General.**
   This section applied to all aviation activities. It included instructions on how to (a) prepare specifications and templates for contracting; (b) perform fixed-wing and helicopter emergency charters (equivalent to today's call-when-needed agreements); (c) contract for air operation services, including smokejumping (equivalent to today's exclusive-use contracting); and (d) conduct aerial spraying.

   Interestingly, pilot qualifications for contractors and Forest Service pilots were not the same—1,000 hours were required for a fixed-wing contract pilot-in-command, 250 hours for a helicopter pilot-in-command, and 3,000 hours for a Forest Service GS-11 fixed-wing pilot-in-command.[2]

2. **Smokejumping.**
   This section included highly detailed descriptions and direction regarding equipment, aircraft configurations, and procedures for smokejumping.

3. **Air Cargo.**
   This section included procedures for packaging, loading, and transporting cargo including delivery by parachute.

4. **Aerial Reconnaissance.**
   This section provided guidance on the planning and operation of aerial reconnaissance patrols.



Cover of the 1952 Air Operations Handbook.

3.1.2. Trends in Early Aircraft Use (1949–1973)

Aircraft use reports (1949, 1950, and 1973) and annual fire reports (1964–1968) help show the type and volume of aviation activities in the Forest Service, which rose steadily over time to more than 114,000 flight hours in 1973.

According to an aircraft use report for 1949, aircraft made 7,957 flights for a total of 10,548 hours of flying in connection with fire control work by the Forest Service. They transported 8,770 firefighters and 1,318,000 pounds of cargo.[3] In 1950, 5,636 flights were made by fixed-wing aircraft for a total of 8,248 hours. The 16 airplanes owned by the Forest Service made 41 percent of the flights that year. Contract operators accounted for 58 percent and military aircraft for 1 percent. Helicopters were used for 1,381 total flight hours, with 1,255 of these hours occurring in California. Aircraft transported 10,244 passengers and 377 tons of supplies, of which about 174 tons were dropped by parachute. The Pacific Southwest Region made the greatest use of aircraft while the Northern Region ranked second.[4]

Annual fire reports were published by the Forest Service in the 1960s to summarize fire control activity. The 1964 report indicates that aircraft were flown for 35,276 hours that year on fire control activities (average yearly hours were 42,293 for the previous 5-year period, 1959–1963). Airtankers dropped 5,368,423 gallons of retardant on 1,505 fires in 1964 (yearly average was 4,758,000 gallons on 1,308 fires for the previous 5-year period, 1959–1963).[5]

The report for 1966 indicates that fixed-wing aircraft flew 42,894 hours and helicopters 13,459 hours. The total of 56,353 hours that year was an increase of 43 percent over the previous 5-year average. Airtankers dropped 5.9 million gallons of retardant on 1,746 fires in 1966, smokejumpers were used in controlling 614 fires, and helicopters transported initial attack crews to more than 1,400 fires.[6]

The 1967 annual fire report indicates that the Forest Service set a new record for aircraft use: 74,598 flight hours. Smokejumpers were dropped on 1,247 fires. More than 1.7 million pounds of equipment and supplies were airdropped to ground crews. Helicopter and fixed-wing airtankers delivered a record 7.7 million gallons of retardant to more than 2,000 fires. Helicopter use increased significantly this year and proved to be an exceptionally valuable part of the modern fire control force.[7]

The 1968 annual fire report shows that airtankers and helitankers were used on a greater proportion of fires than ever before—nearly 21 percent. Helicopters now accounted for nearly 25 percent of total aircraft flight hours for fire control activities.[8]

In a 1973 aircraft use report, 81,916 hours of fixed-wing and 32,197 of helicopter flight time were reported for a total of 114,113 hours flown that year. Nearly 16 million gallons of retardant were dropped.[9]

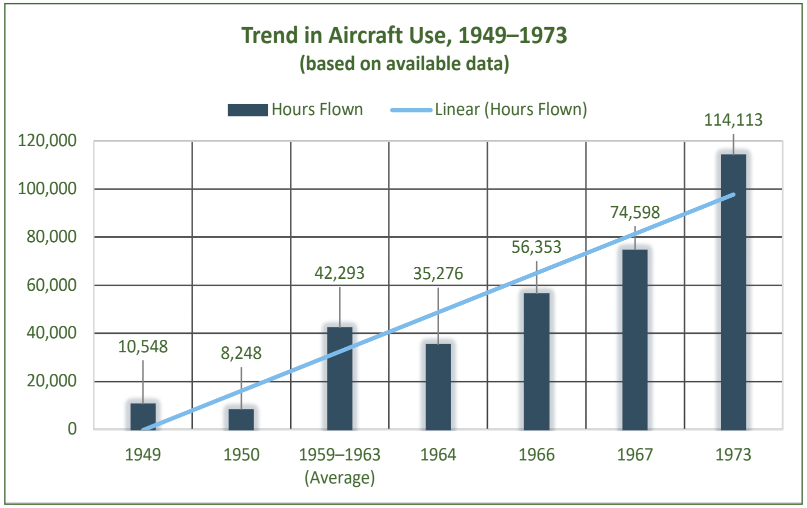


Figure 3.1. The implementation of aircraft standards and procedures in the 1940s and 1950s laid the foundation for the aviation program to grow rapidly through the 1960s and 1970s.

3.1.3. Federal Excess Personal Property Program (1956)

The Federal Excess Personal Property Program (FEPP) refers to aircraft excessed by the Department of Defense and acquired by the Forest Service on behalf of State foresters for the purpose of wildland and rural firefighting. Excess military aircraft are not certificated by the Federal Aviation Administration (FAA) (i.e., they are not approved to transport passengers in a civil setting). Many States were interested in obtaining excess military aircraft for wildland firefighting.

The FEPP program and procedures were established under the authority of the Federal Property and Administrative Services Act of 1949, Public Law 94–519. Under the law the Forest Service retains ownership of the aircraft, but loans them to State cooperators for firefighting. The program allows for aircraft to be used in any needed mission profile in support of wildland firefighting, including personnel transport and training missions. State foresters and the Forest Service have been using this process since 1956.[10]

In 2022, 11 states had FEPP aircraft, either fixed-wing, rotor-wing, or a combination of both: Alaska, Arkansas, California, Florida, Maine, Montana, North Carolina, New Jersey, Nevada, South Carolina, and Washington.

3.1.4. FAA Grant of Exemption Nos. 392 and 392a (1965)

A Federal Aviation Administration (FAA) Grant of Exemption excuses compliance with certain regulation(s), often under certain conditions and/or with limitations. In 1965, the FAA granted Exemptions No. 392 and 392a to permit the Forest Service to deviate from certain provisions of the Code of Federal Regulations (CFR) for "the expeditious conduct of operations," to the extent deemed necessary by the Chief and subject to limitations. Under Exemption No. 392, air operations in the Forest Service were allowed to deviate from certain regulations, as long as the operations were related to wildfire, another emergency, or training for these emergencies. An amendment, No. 392a, followed soon after to extend the exemption to apply to nonemergency events as well.[11]

Exemption No. 392, signed by G.S. Moore, director of the FAA's Flight Standards Service, became effective April 1, 1965. Under this exemption, the Chief of the Forest Service authorized deviations from Federal Aviation Regulations related to:

1. Operation of fixed-wing aircraft below 500 feet
2. Nonuse of seat belts
3. Removal of aircraft door
4. Use of unequipped airfields

The first deviation related to operations below 500 feet was allowed (with limitations) for reconnaissance, aerial surveys, cargo dropping, and aerial application of fire retardants. The second and third deviations related to seat belts and the aircraft door applied to smokejumper and cargo-dropping operations.

In a letter dated May 5, 1965, the Chief requested authority to deviate in nonemergency situations as well. The resulting Grant of Exemption No. 392a was issued to "supplement" Exemption No. 392. Signed by Edward C. Hodson, acting director of the Flight Standards Service, it went into effect on August 12, 1965.

More information on these exemptions—including the specific limitations attached—can be found in Forest Service Handbook (FSH) 5709.16, chapter 30, "Aviation Operations."

3.1.5. Presuppression Budget Funding Increase (1972)

The 1972 National Fire Plan was based on containing fires at 10 acres and controlling them by 10 a.m. on the day after discovery. The resources needed to meet these objectives resulted in a fourfold increase in presuppression budgets (for preparedness activities such as staffing, training, and contracting for aircraft) in the mid-1970s. As it turned out, this increase in budgets did not result in a significant increase in suppression effectiveness.

Most of the budget increases were for airtankers, helicopters, and helitack crews, with only a modest increase for smokejumpers. By the late 1970s, an emphasis on aligning protection with resource values and anticipated fire effects—rather than providing a set protection standard for all lands—resulted in significant scaling back of these increased budgets.[12]

3.1.6. Boise Interagency Fire Center (1973)

The Boise Interagency Fire Center (BIFC) became the Forest Service's national coordination center in 1973. The Forest Service adopted the doctrine of total mobility and reorganized its role at BIFC, which became the focal point for the interregional exchange of firefighting resources.[13] Total mobility involved tracking the current status of all resources nationally and dispatching the closest resource to the incident regardless of agency. BIFC was renamed as the National Interagency Fire Center (NIFC) in 1993.

3.1.7. National Interagency Coordination Center (1973)

Dedicated in 1970, a primary function of the National (Boise) Interagency Fire Center was to host, staff, and manage the National Interagency Coordination Center (NICC) for four Department of the Interior agencies with wildfire management responsibilities—the Bureau of Land Management, National Park Service, Bureau of Indian Affairs, and U.S. Fish and Wildlife Service. In 1973 the Forest Service also assigned its national coordination center to NICC.[14]

NICC maintains a near real-time status (at least daily) of critical wildfire suppression resources. When resources are in short supply, the coordinator on duty confers with NIFC directors to establish priorities and communicate these priorities to the field. By the late 1970s the National Association of State Foresters and the Department of Defense each had an onsite representative to interact with NIFC directors during higher preparedness levels (a measure of demand for critical resources rated 1 to 5, with preparedness level (PL) 5 being the highest and most severe).[15]

In the 1980s a strong bond was developed between NIFC and the Federal Emergency Management Agency (FEMA). Only 13 months after the creation of FEMA, much of the on-the-ground response to the eruption of Mount St. Helens was managed by the Forest Service under a "Principal Federal Agency" delegation of authority from FEMA. This resulted in a FEMA representative being present at NIFC during high preparedness levels and particularly when NIFC was operating in support of declared disasters and emergencies. FEMA representation continued until 2003 when representation changed to the Department of Homeland Security.[16]

The Boise Interagency Fire Center (BIFC) dedication on July 25, 1970. In 1973, BIFC became the Forest Service's National Coordination Center and, 2 years after that, home of the Washington Office Aviation Service Group. National Interagency Fire Center photo.

The National Interagency Coordination Center (NICC) at the National Interagency Fire Center in Boise, ID, August 2011. USDA Forest Service photo.

3.1.8. DOI Office of Aircraft Services (1973)

In July 1973, the Secretary of the Interior created the Office of Aircraft Services (OAS) to provide aviation oversight and support for the nine Bureaus within the Department of the Interior (DOI).

OAS responsibilities included contracting for aircraft on behalf of the DOI Bureaus and providing pilot and aircraft approval services (carding). This resulted in OAS and the Forest Service standardizing many of their contracting specifications and requirements and led to shared contracts with bid items from multiple agencies with standardized requirements. The result was a standardized approach to both contracts and operations while respecting the prerogatives of both DOI and the Forest Service.

Two points of friction arose between OAS and the Forest Service. First was the value received from the administrative fee that OAS added to the cost of each contract to cover costs that the Forest Service had already funded "off the top;" second was the fact that although OAS had control of aircraft and pilot approvals, aviation accidents were accountable to the operating agency, not to OAS.

In the mid-2000s DOI reorganized and moved OAS under their National Business Center and its name was changed to the Aviation Management Directorate. In August 2012, another realignment changed the organization's name to Office of Aviation Services (OAS).[17]

3.1.9. Washington Office Aviation Service Group (1975)

An audit report in 1973 by the USDA Office of Inspector General (OIG) on "Forest Service Air Operations Administration" outlined a number of deficiencies, inefficiencies, and safety issues in the agency's completely decentralized aviation management program. A National Aviation Plan was developed in response to the OIG report, communicating direction by the Chief to resolve the organizational issues identified in the report. This led to the establishment of the Washington Office Aviation Service Group at BIFC in 1975.[18] Its role in developing national standards was defined. The audit report package also acknowledged that some of the group's duties had been handled informally by Forest Service aviators stationed in Boise since at least 1972, namely those leading the national infrared program.[19]

3.1.10. National Multi-Agency Coordinating Group (Mid-1970s)

Although NICC filled resource orders in the order they were received while honoring overall priorities, there were times when agency executive-level priorities needed to be set. By the mid-1970s the authority to set and implement priorities for scarce suppression resources for large fires was delegated to each agency's onsite director. Working collaboratively to set priorities, these agency directors were to become what is now the National Multi-Agency Coordinating Group (NMAC).

One function of NMAC is to track the status of critical suppression resources, referred to as "national shared resources." Included in the listing of national shared resources are smokejumpers and smokejumper aircraft, large and very large airtankers, type 3 multi-engine water scoopers, national aerial supervision modules and leadplanes, exclusive-use air tactical aircraft and personnel, modular airborne firefighting systems, national contract type 1 and type 2 helicopters and associated contract personnel, rappellers, and national (agency and contract) infrared aircraft.[20]

Other ongoing tasks for NMAC are to work with Geographic Area Coordination Groups (formed in the early to mid-1980s) to determine their suppression resource needs, prioritize these needs, and communicate with agency executives, as well as State and foreign governments to optimize the use of resources and collaboratively resolve interagency issues as they arise.

3.1.11. National Wildfire Coordinating Group (1976)

The National Wildfire Coordinating Group (NWCG) was chartered in 1976. The intent was to "coordinate the programs of the participating agencies so as to avoid wasteful duplication and to provide means of working together constructively." The group was to serve as a "formalized system to agree upon standards of training, equipment, aircraft, suppression priorities, and other operational areas." Initially, NWCG standards included training and experience requirements for firefighting positions. Administrative standards and titles—for helicopter managers, for example—were initially left to the agencies.[21]

NWCG now includes members from all five wildland firefighting agencies represented at NIFC, as well as from the International Association of Fire Chiefs, Intertribal Timber Council, National Association of State Foresters, and the United States Fire Administration (Federal Emergency Management Agency). There are also associate members from the National Weather Service and DOI's Office of Wildland Fire.[22]

3.2. The 1980s–1990s

3.2.1. Geographic Area Coordination Groups (Early to Mid-1980s)

Geographic Area Coordination Groups (GACGs) were formed in the early to mid-1980s. The five federal wildland fire partners were involved in these groups, as well as State forestry agencies and other partners. An initial task of the groups was to develop plans and training to transition their geographic area from a large fire organization (LFO) approach to wildfires to the new incident command system (ICS). This resulted in reformation of many incident management teams on an interagency basis. In some cases, these teams later incorporated State forestry and local fire agency personnel.[23]

In 1973, Robert L. Bjornsen became the first Forest Service director at the Boise Interagency Fire Center (BIFC). Working with Jack Wilson of the Bureau of Land Management, the two had the vision and authority to begin making BIFC a true interagency fire center. Bjornsen (back row, third from the right) is shown here at the national fire directors meeting in 1978. Photo courtesy the National Museum of Forest Service History (Edward G. Heilman Collection).

3.2.2. Incident Command System (1985)

The incident command system (ICS)—an element of the National Interagency Incident Management System—was fully implemented in all Federal agencies and many States in 1985. This provided additional opportunities for aviation standardization.[24] ICS replaced the large fire organization structure for incident management. NWCG adopted ICS with the intent of establishing common terminology and organization on all incidents. This facilitated aviation operations across agency boundaries using the same communications, terminology, and operational expectations.

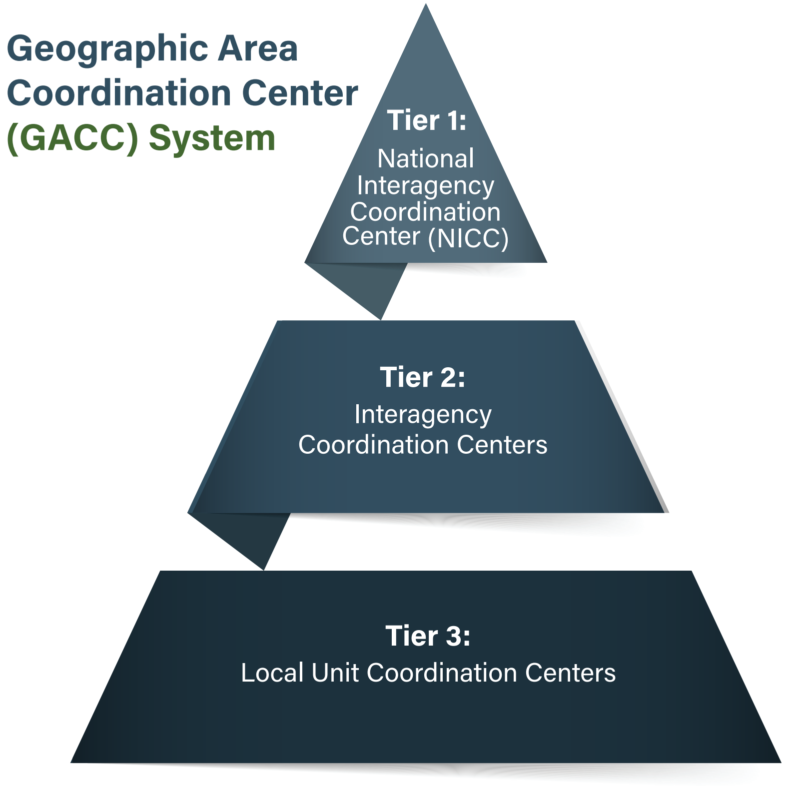
3.2.3. Geographic Area Coordination Center System (1989)

Directed by the National Wildfire Coordinating Group (NWCG) and facilitated by the Geographic Area Coordination Groups (GACGs), the Geographic Area Coordination Center (GACC) system was established in 1989. This system established 11 tier 2 interagency coordination centers, which were the organizational bridge between tier 3 local unit coordinator centers and the tier 1 National Interagency Coordination Center (NICC).[25]

This replaced the previous system in which each Federal agency had its own tier 2 coordination center either at the regional, State, or area office organizational level (depending on the agency). These tier 2 coordination centers were independent entities and coordination between adjacent agencies was inconsistent.[26]

Interagency cooperation became an everyday activity. In many locations, local units merged their tier 3 coordination/dispatch centers and in some cases their entire wildfire management organizations.[27]

Reorganization of the coordination system had profound effects on aviation management. Interagency helitack crews were established. Daily status reports were updated as fire activity occurred and aircraft availability changed, resulting in a near real-time understanding of resource availability. Aviation resources were dispatched to fires on a “closest force” basis, regardless of which agency funded the resource or which agency was receiving the service. Interagency operations became a day-to-day expectation, dramatically transforming Forest Service aviation operations and creating a truly cooperative effort in wildland firefighting. [28]



3.2.4. Public Aircraft Tensions (Early to Mid-1990s)

All Federal Excess Personal Property aircraft (see chapter 3.1.3) operate as public aircraft under the Public Aircraft Statue.[29] In the early 1990s the Forest Service and the State forestry agencies that used public aircraft for firefighting were under pressure from a powerful trade association and a U.S. Senator from South Dakota regarding the legal basis for the operation of those aircraft.

The trade association wanted to maximize the use of contract helicopters by limiting or prohibiting the use of FEPP helicopters owned by the Forest Service and operated by State foresters. The greatest pressure for this was in Washington State.[30]

Following the death of his State's Governor in a State-owned public aircraft accident due to a maintenance failure, the U.S Senator introduced legislation that would eliminate authority for Federal and State agencies to set their own aviation standards, requiring that aircraft operated as "public" aircraft be subject to the same airworthiness, supplemental type certificates, and technical standard orders as "civil" aircraft.[31]

The above issues resulted in legislation, Public Law 103–411, which specified a $10,000 fine for a pilot who flew a State government aircraft on a fire when an equivalent contractor aircraft was available and not used. This caused tremendous concern, particularly among State helicopter pilots.

The FAA developed Advisory Circular 00-1.1A with input from Forest Service aviation staff. The circular allowed States to use FEPP aircraft for initial attack purposes but required that the FEPP aircraft be replaced on Federal fires as soon as "civil" aircraft could be obtained. This deprived some FEPP programs of significant reimbursable flight time.

While the law technically applied to the California Department of Forestry and Fire Prevention FEPP airtankers as well, the airtanker industry informally agreed not to raise the issue.[32]

Several complaints were made about State firefighting helicopters being assigned when contract helicopters were available. The FAA decided all complaints in favor of the States because in each instance when State helicopters were used, replacement contract helicopters had been ordered as resources. The letter of the law was followed and no pilots ended up being fined. Tensions caused by this issue were eventually eased with the end of term of the board chair of Helicopter Association International.[33]

The commercial helicopter industry lobbied for limitations in other locations. For example, the State of Oregon passed a State Senate resolution in 1997 that prohibited the State from pursuing a Federal excess helicopter program.[34]

3.2.5. National Shared Forces Task Force Report (1991)

The National Shared Forces Task Force Report—known as the "Mann Report" after Chairman Jim Mann, the director for Fire and Aviation Management in the Northern Region at the time—was adopted in 1991 as the budget and programmatic justification process for national shared resources. It provided the structure and methodology for four major interagency studies related to aviation:[35]

1. National Study of Type 1 and 2 Helicopters to Support Large Fire Suppression[36]
2. Aerial-Delivered Firefighter Study
3. National Airtanker Study Phase I and II
4. Tactical Aerial Resource Management Study

These studies are discussed in more detail in other chapters of this book.

3.2.6. National Fire Aviation Coordination Group (1993)

The National Fire Aviation Coordination Group (NFACG) was established in 1993 to coordinate interagency aviation support for Federal fire management activities. It was the first chartered national interagency group emphasizing aviation in fire management as its mission. NFACG consisted of the director of DOI's Office of Aircraft Services, the assistant director of the Forest Service's aviation program, and BLM's aviation program manager. Issues addressed included standardization of policies and procedures, aircraft and pilot specifications and approval standards, and aviation business management.[37] The group was replaced by the Aviation Management Council (AMC) in 1998.

3.2.7. North American Free Trade Agreement (1994)

A multilateral agreement between the United States, Canada, and Mexico, the North American Free Trade Agreement (NAFTA) took effect on January 1, 1994. NAFTA specified that “each signatory country will authorize (subject to applicable safety rules) the operation of a range of ‘specialty air services’ by operators of the other signatory countries.” Specialty air services included wildland firefighting. Implementation of NAFTA resulted in a number of primarily Canadian companies entering the U.S. aviation market or aligning with a U.S. company to provide aerial firefighting services.[38]

3.2.8. Interagency Helicopter Operations Guide (1994)

The Interagency Helicopter Operations Guide (IHOG) was completed and adopted by the Forest Service in 1994. It was developed over 6 years with more than 100 participating subject matter experts.

The National Fire Aviation Coordination Group (NFACG), which was formed during development of the IHOG, assumed oversight and sponsorship of the guide. Implementation of the IHOG resulted in standards, best practices, and an interagency approach to resolving agency differences in helicopter operations.

Although its focus was on helicopter operations, the IHOG had significance for the entire aviation program—it was the first interagency aviation guide and became the model for many others. For more detailed information about the history of the IHOG, see chapter 7.5.3.

3.2.9. Aerial-Delivered Firefighter Study (1995–1999)

In the late 1990s an effort was undertaken by the Forest Service to scientifically model the optimal mix of aerially delivered firefighters. The study was called the “Aerial Delivered Firefighter Study” (ADFF Study). It started as an interagency effort, but the BLM withdrew from the study in March 1999, citing that the simulation parameters of the model could not accurately take into account their concept of total mobility in smokejumper deployment.[39]

Objectives of the study included examining:

- Centralized versus decentralized smokejumper bases
- Tradeoffs of helicopter versus smokejumper operations
- Base-level (current) funding plus/minus 20 and 40 percent
- Road closures
- Federal wildland fire policy

As with any computer simulation model, the ADFF Study simulation had limitations that translated to concerns about the results. One of the biggest limitations had to do with how the simulation modeled the dispatching of assets. Because the model used historical data when dispatching, it had the advantage of taking all uncertainty out of the process. In the real world, dispatchers have less-than-perfect information. Because the model had certainty about a fire’s behavior, it was more efficient in responding to a fire, never underestimating or overestimating needed resources.

There were many other limitations that created concern among stakeholders from the helicopter and smokejumper programs. Both program areas were concerned that the model had no way to account for the value of any mission outside of initial or extended attack of wildfires. Missions such as cargo transport, reconnaissance, firefighter retrieval and supply, employee medical extraction, and aerial ignition were not considered by the model as having any value.

The final ADFF Study was issued on October 20, 1999. The study offered no recommendations but did offer a series of findings. Although it is difficult to cite any direct and tangible changes that occurred from the study, perhaps its greatest contribution was that it reaffirmed the value and need for both helicopter and smokejumper operations.

3.2.10. Upgraded Standards for Aerial-Delivered Firefighters (1995–2010)

On July 6, 1994, 14 firefighters—including 3 smokejumpers and 2 helitack crewmembers—perished when they became entrapped during a blowup on the South Canyon Fire on Storm King Mountain in Colorado. Major factors that contributed to the tragedy were the presence of fire in the bottom of a steep, narrow canyon; strong upcanyon winds; and underburned fuels not providing an adequate safety zone.[40]

An investigation of the fatalities and contributing factors was completed in August 1994. An interagency team was then formed to study the findings and conclusions of the “South Canyon Fire Investigation Report” and propose a course of corrective action. In October 1994, the team recommended that minimum fire management qualifications be established and that personnel acting in fire management positions be qualified for the “level of complexity involved.”[41]

In December 1995, the Secretaries of Agriculture and the Interior directed Federal wildland fire agencies to "establish fire management qualification standards to improve firefighter safety and increase professionalism in fire management programs." An interagency task group was formed to create "minimum qualification standards for key fire management positions." Their work resulted in the "Interagency Fire Program Management Qualification Standards and Guide" (IFPM Standard), which was approved in January 2000. Implementation of the improved standards proved to be a multi-year endeavor from 2004 to 2010.[42]

Significant changes were made in the standards for Federal wildland firefighters, including aerially delivered firefighters. Improvements included an emphasis on significantly increased training, experience, and specific qualifications for many positions. The upgraded standards applied to many aviation-related positions, including type 1 and 2 helibase managers. A Forest Service addendum to the IFPM Standard was issued in October 2019.[43]

3.2.11. Aviation Management Council (1998)

The Aviation Management Council (AMC) was chartered in 1998 to replace the National Fire Aviation Coordination Group. This was done at the request of the Federal Fire Aviation and Fire Leadership Council to broaden the organization to address both fire and nonfire aviation issues.[44] Working groups met in fall 1998 to reach agreement on a program of work, including the Smokejumper Aircraft Screening and Evaluation Board; Interagency Airtanker Board; Single-Engine Airtanker Board; Interagency Helicopter Operations Group; Aviation Training and Qualifications Team; Interagency Leadplane Operations Group; and Information, Business Management, and Acquisitions groups.[45]

3.3. The 2000s–2021

3.3.1. Presuppression Budget Funding Increase (2001)

After a record-breaking fire season in 2000, the National Fire Plan once again included a significant increase in funding for presuppression programs. The Forest Service preparedness budget increased by 49 percent between fiscal years 2000 and 2001.[46]

3.3.2. Interagency Standardization (2002)

In 2002 the Forest Service dramatically increased its participation in the annual publication of "Interagency Standards for Fire and Fire Aviation." The 8 agency references in 2001 increased to 120 references in 2002.[47] This was one way to quickly establish and communicate agency direction following the Thirty-Mile Fire tragedy in 2001 in which four wildland firefighters died while trying to escape a rapidly spreading fire on the Okanogan-Wenatchee National Forest. A number of issues were raised following the fire. While many were related to fire operations—including checklists and briefings—one issue raised was how to rapidly authorize airdrops of suppressants when a body of water possibly contained threatened or endangered fish.

Since the Forest Service directives system often took years to implement new agency direction, use of the "Interagency Standards for Fire and Fire Aviation" to communicate direction provided a definite publication schedule with an annual opportunity for updates. It rapidly became the repository of much of the program management guidance on fire and fire aviation operations, resulting in further standardization of aviation programs.[48]

3.3.3. Blue Ribbon Panel (2002)

Following two airtanker crashes in the summer of 2002—both involving wing failures in former military aircraft—the Chief of the Forest Service and Director of the BLM assembled a "Blue Ribbon Panel" to assess the safety and effectiveness of Federal aerial firefighting operations. Completing their "Blue Ribbon Panel Report" in December 2002, the panel determined that the largest challenge to aerial firefighting in the United States was "the need to collaborate to raise standards."[49]

Based on the Blue Ribbon Panel's report, the Forest Service and BLM opted to:

- Not renew contracts for nine retired military C-130 and PB4Y2 airplanes.
- Retire 11 of the Beechcraft Baron 58P leadplanes that exceeded the 6,000-hour safe life limit.
- Begin an indepth safety and airtanker suitability evaluation (through Sandia Laboratories in New Mexico) of the Lockheed P-3 Orion; Lockheed P2V Neptune; and Douglas series, including the DC-4, DC-6, and DC-7.[50]

3.3.4. Aviation Doctrine (2006)

Doctrine consists of fundamental principles that help guide employee actions in support of agency objectives. These principles are authoritative and inform policy, but they leave room for applying judgment in application. Doctrine can include broad principles for numerous aspects of a program, including accountability, communication, guides, handbooks, leadership, learning, manuals, mission statements, operations, qualifications, relationships, roles, safety management systems, standardization, standards, technology, and training.

Foundational aviation doctrine for the Forest Service as outlined in Forest Service Manual 5702.1 was developed at the Fire and Aviation Management "Rotor & Wing" Conference in January 2006.[51]

Fire and Aviation Management staff at the Forest Service's "Rotor & Wing" Conference in 2006. USDA Forest Service photo.

3.3.5. Fire Program Analysis System (2007)

Not having a standard method to perform cost-benefit analyses of wildland fire suppression resources made long-term budget and resource planning difficult.[52] The National Fire Management Analysis System (NFMAS), coupled with the 1991 National Shared Forces Task Force Report, established a predictable method of objectively analyzing the costs and benefits of wildfire suppression resources. In 2007 NFMAS was discontinued and replaced by the Fire Program Analysis system.[53]

When the Fire Program Analysis system was implemented to replace NFMAS, it did not include a standardized mechanism for analyzing national shared resources. The impact of this on the aviation program was significant, with justification for most wildland fire aviation resources depending on their service to multiple national forests.

3.3.6. Commercial Sourcing Studies (2008)

In the mid-2000s the Office of Management and Budget (OMB) issued quotas to Federal agencies to complete a certain number of A-76 competitive sourcing studies.[54] The purpose of the studies was to find opportunities to implement program improvements and reduce operating costs. In response, the Forest Service commissioned a study of its aviation program to explore opportunities for efficiency. At the time it was referred to as the "Competitive Sourcing Study," and one of the components was to compare contracted versus owned aircraft and contracted versus agency pilots.

The results of the study were published in July 2008. The official name of the document was the "Management Efficiency Assessment of Aviation Activities in the USDA Forest Service." A vendor was hired to help with the report, and they assessed the Forest Service's aviation program by dividing it into six distinct business areas:

- Aerial Delivery of Firefighters and Support
- Aerial Detection and Command and Control
- Aerial Fire Suppression – Airtanker and Large Helicopter
- Aerial Resource Support (Natural Resources and Fuel Management Missions)
- Aviation Contract Management and Quality Assurance
- Aviation Program Management

The study generated 33 recommendations, many of which overlapped with other efforts and have been implemented. Some of the recommendations were very broad and could be described more appropriately as organizational goals.[55]

3.3.7. Station Fire (2009) Influences Aviation Programs

On August 26, 2009, the Station Fire ignited on the Angeles National Forest in southern California. Growing to over 160,000 acres, it was the largest wildfire in California in 2009. On the third day of the fire, tragedy struck when two Los Angeles County firefighters were killed in a vehicle accident while fighting the fire.

Subsequent investigations criticized the Forest Service for failing to use aggressive tactics on the fire—no aircraft were used the first night of the fire and not until the late morning of the second day. Similarly, no attempt was made to activate Los Angeles County night-flying helicopters.

Actions taken as a result of the Station Fire tragedy influenced a variety of aviation-related programs, including aerial supervision capability and technology employed for wildland firefighting. The Station Fire was also the reason the night helicopter operations program was started on the Angeles National Forest.

3.3.8. Safety Management Systems (2010)

On June 22, 2006, the FAA issued Circular 120.92, titled "Introduction to Safety Management Systems for Air Operators." It was developed as an example of how to optionally implement a Safety Management Systems (SMS) program. SMS consists of four components for comprehensively managing aviation safety: safety policy, risk management, assurance, and promotion.[56]

Using the FAA circular as a way to introduce the concept of SMS, the Forest Service formally incorporated SMS as agency direction in 2010. Forest Service Manual 5702 establishes the agency's direction for the implementation of SMS.[57]

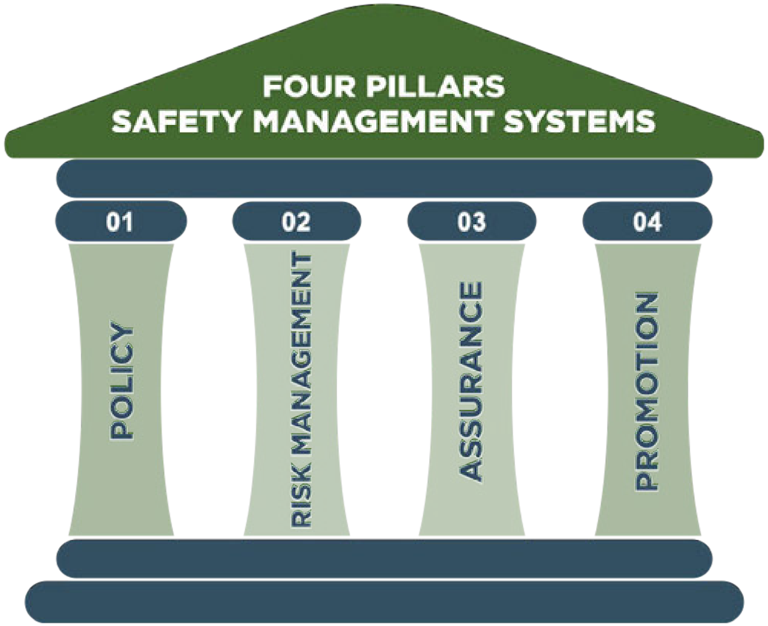
The Interagency Committee on Aviation Policy (ICAP), formed by the General Services Administration (GSA), included an objective for all Federal agencies that operate aircraft programs to implement SMS by 2016. The Forest Service was credited as having met this goal.[58]

Implementation of SMS resulted in major changes in the Forest Service aviation program and a spectacular decrease in aviation accidents and fatalities.[59]

Figure 3.2 is adapted from the "USDA Forest Service Aviation Safety Summary FY 2017" and summarizes the number of accidents, fatalities, and flight hours in Forest Service aviation for 30 years from 1988 to 2017.

The report explains that the graph "suggests a downward shift in the trend with regard to flight hours (exposure to risk) and the number of aircraft accidents experienced beginning in 2011. Prior to 2011, the number of flight hours generally correlated to the number of accidents."[60] In the 2 years prior to 2011, additional staffing was added to the Airworthiness Branch (inspectors and an aerospace engineer), SMS was adopted as policy and incorporated into contractor requirements, and the first risk management workbook was developed. The numbers suggest that with these actions, the Forest Service made "significant strides" in aviation safety.[61]

Numerous risk assessments following the SMS model have been completed for Forest Service aviation programs. Programmatic assessments completed to date include those for transportation of personnel in type 1 helicopters, helicopter rappelling, short-haul and hoist for law enforcement, aerial ignition, night helicopter operations, large airtankers, airtanker bases, aerial supervision, water scoopers, smokejumping and smokejumper aircraft, static and drop testing, and unmanned aircraft systems (UAS). Many of these programmatic risk assessments also included a section on safety assurance.



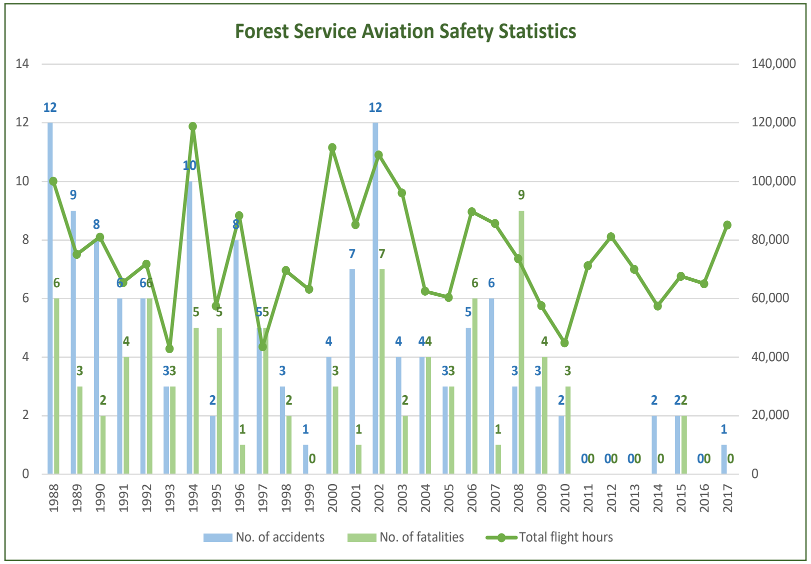


Figure 3.2. Aircraft accidents and fatalities were drastically reduced with the implementation of Safety Management Systems (SMS) practices in 2010.

3.3.9. Aerial Firefighting Use and Effectiveness Report (2012–2020)

The "Aerial Firefighting Use and Effectiveness (AFUE) Report" was the largest and longest systematic documentation of aerial firefighting in Forest Service history. As the project was being organized, the Government Accountability Office report GAO-13-684 (August 2013) on Federal fire aviation program success was published, which further emphasized the need to collect information on aircraft performance and effectiveness.

With the need for information clearly identified, the mission of AFUE was to examine how airtankers and helitankers were being used and how well they were meeting suppression objectives.

From 2015 to 2018, data-gathering teams documented aerial firefighting operations on 272 incidents in 18 States—including 18,929 helicopter drops, 3,303 water scooper drops, and 5,379 airtanker retardant drops. Each drop was analyzed based on its success and categorized by meteorological and fuel conditions and drop characteristics.

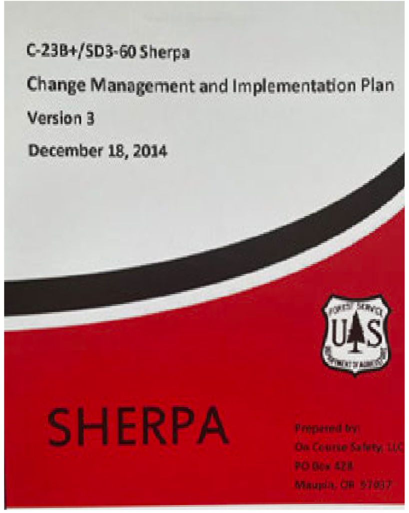
The data gathered led to two new performance metrics: (1) an interaction percentage—the proportion of drops that physically interact with the fire—and (2) a probability of success—the number of effective drops divided by total number of drops.

A discussion of the methodology and key findings is documented in the "Aerial Firefighting Use and Effectiveness (AFUE) Report," dated March 2020. One of the more interesting findings is that for drops from all aircraft, the probability of success is 82 percent.

The enormous amount of data gathered during the study is likely to inform future analyses and some of the lessons learned may be forthcoming.[62]

3.3.10. National Defense Authorization Act (2014)

To aid the Forest Service in its fire suppression mission, the National Defense Authorization Act (NDAA) of 2014 authorized a transfer of aircraft from the military. The authorization included 7 Lockheed C-130H airplanes from the U.S. Coast Guard for use as airtankers and 15 Short Brothers C-23B+ Sherpas from the Army National Guard for use as smokejumper aircraft.



Cover of the C-23B+/SD3-60 Sherpa Change Management and Implementation Plan (CMIP), December 2014. In 2011 the Forest Service aviation program adopted a formal process for managing and implementing significant changes within the organization. This process is outlined in the Change Management and Implementation Guide, which was initially developed in December 2011 and updated in 2016. The change management process provides guidance for successfully implementing a major transition, including identifying risks and developing a communications plan.

The NDAA directed a complex process to make the 30-year-old C-130Hs ready for service as airtankers, including "center and outer wing-box replacements, programmed depot-level maintenance, and modifications necessary to procure and integrate a gravity-drop aerial dispersal system." Accomplishing these tasks required a sequence of expensive and time-consuming actions by the Coast Guard, Air Force, and Forest Service. In February 2018, the Forest Service announced their intention to abandon the program. The 2019 NDAA redirected the transfer of the seven C-130Hs to the California Department of Forestry and Fire Prevention.

The C-23B+ Sherpas arrived at just the right time. Two DC-3s were being retired and the four C-23A Sherpas owned and operated by the Forest Service were getting more expensive to operate. The upgraded model offered improved performance and the opportunity for conversion to fully certificated SD3-60 Sherpas. Following extensive maintenance, upgrades, and installation of smokejumper equipment, the Forest Service put 10 of the "new" Sherpas into service as smokejumper aircraft.[63]

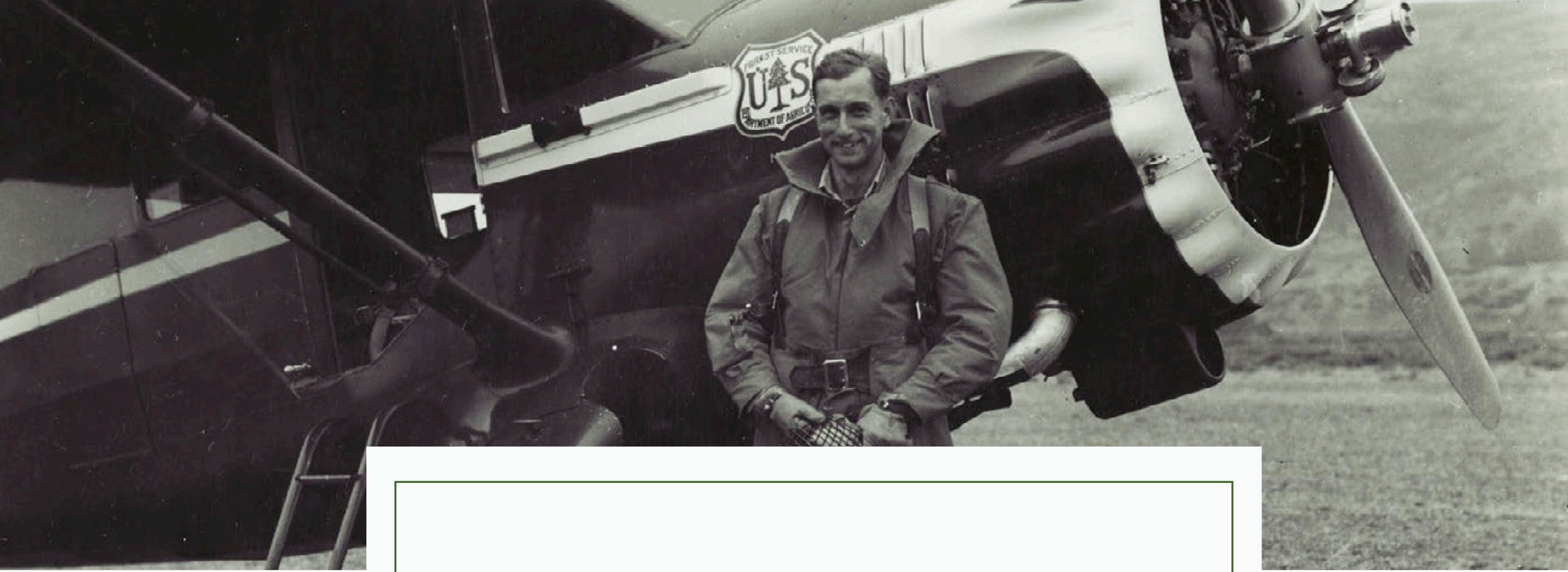
The Story of the Forest Service Aviation Paint Job

The first airplane owned by the Forest Service was painted a dark color (see chapter 5.3.1). Because dark colors absorb sunlight, tend to fade, and can make it more difficult to spot damage, aircraft color schemes over the years evolved toward white. By 1960, the Forest Service had established a distinctive, high-visibility white paint theme with red and black accents, proportions, and color arrangements following established Federal specifications of the time, and often included the Forest Service shield.

A new paint job is often the last step in the process when the Forest Service obtains a "new to them" airplane. In contrast to the drab grays and greens that camouflage military aircraft, the emphasis is on high visibility. In the top photo at right, a C-23A Sherpa is shown blending in on the tarmac after delivery from the military in 1991. The same airplane , with Forest Service livery and tail number N179Z, stands out at the historic Moose Creek backcountry airstrip in Idaho during a smokejumper mission in 2010.

The paint design, logos, and other aspects of "branding" an aircraft are known as an aircraft's "livery," a term for an identifying design, symbol, or uniform designating ownership or affiliation.

Top: Photo courtesy of Gordon Harris. Bottom: USDA Forest Service photo by Shane Bak.



Francis Lufkin prior to his first jump during the 1939 Parachute Jumping Experiment. One of the pioneers of smokejumping, Lufkin managed the North Cascades Smokejumper Base from 1940 until his retirement in 1972. He is standing in front of the first airplane owned by the Forest Service, a Stinson Reliant SR-10. USDA Forest Service photo.

CHAPTER 4

SMOKEJUMPING

4.1. Significant Events

1931—Parachute drop tests of weighted "dummies" and two "live" jumps.
1939—Aerial Fire Control Project funding transferred to Parachute Jumping Experiment.
1939—Parachute Jumping Experiment conducted October through November.
1940—The term "smokejumper" is coined.
1940—Parachute Jumping Experiment evolves into the smokejumper program.
1940—Development of operation plans and purchasing of equipment.
1940—Smokejumpers trained at Winthrop, WA, and Seeley Lake, MT.
1940—First fire jumps occur in the Northern and Pacific Northwest Regions, including the first fire jump on the Nez Perce National Forest.
1940—North Cascades (Washington) Smokejumper Base established (1940 to present).
1941—Missoula (Montana) Smokejumper Base established (1941 to present).
1943—McCall (Idaho) Smokejumper Base established (1943 to present).
1943—Cave Junction (Oregon) Smokejumper Base established (1943 to 1981).
1943—Civilian Public Service Program begins.
1944—Experimental phase of smokejumping ends.
1944—Smokejumpers used in Pacific Southwest Region for the first time.
1945—Smokejumper qualifications, training, jumping techniques, and gear standardized.
1945—Quick release harnesses tested.
1945—Project Fire Fly and the 555th Parachute Infantry Battalion (Triple Nickles).
1945—First smokejumper fatality, PFC Malvin L. Brown (Triple Nickles).
1945—"Continental Unit" managed as first designated "Air Control Area."
1945—First fire jump into Canada.
1946—Civilian Public Service program ends.
1948—Quick release harnesses established as standard.
1949—Smokejumpers perform demonstration jump on the National Mall, Washington, DC.
1949—Twelve current and one former smokejumper perish in the Mann Gulch tragedy.
1950—"Red Skies of Montana" filmed at the Missoula Smokejumper Base.
1951—Smokejumper subbase established at Grangeville, ID.
1951—West Yellowstone (Montana) National Park Service Smokejumper Base established.
1954—Idaho City (Idaho) Smokejumper Base established (1954 to 1969).
1957—Redding (California) Smokejumper Base established (1957 to present).
1959—Fairbanks (Alaska) BLM Smokejumper Base established (1959 to present).
1964—Redmond (Oregon) Smokejumper Base established (1964 to present).
1965—West Yellowstone (Montana) Smokejumper Base begins to be managed by Forest Service.
1969–1970—Idaho City (Idaho) Smokejumper Base closed and moved to Boise, ID.
1972—West Yellowstone (Montana) Smokejumper Base established as independent base (1972 to present).
1972—Grangeville (Idaho) Smokejumper Base established as independent base (1972 to present).
1973—La Grande (Oregon) Smokejumper Base established (1973 to 1982).
1976—Smokejumper Aircraft Screening and Evaluation Board/Subcommittee established (originally SASEB, later changed to SASES).
1979—National Smokejumper Base Study.
1979—BLM begins a study of ram-air parachutes leading to a successful field evaluation.
1980—Alaska BLM Great Basin Project begins with detailed smokejumpers in Grand Junction, CO.
1980—Boise (Idaho) Smokejumper Base (Forest Service) closed.
1981—Cave Junction (Oregon) Smokejumper Base closed.
1981—First female smokejumper.
1981—First female smokejumper pilot.
1982—La Grande (Oregon) Smokejumper Base closed.
1982—BLM smokejumpers make first fire jumps with ram-air parachutes in Alaska.
1982—La Grande (Oregon) Smokejumper Base closed.
1983—BLM smokejumpers make first fire jumps with ram-air parachutes in the Great Basin.
1984—The 100,000th fire jump occurs on the Clearwater National Forest.
1984—Smokejumpers have been aerially delivered to over 25,000 fires since 1940.
1985—Redding (California) BLM Smokejumper Base established
1986—Two ram-air canopies evaluated by Forest Service at Redmond Smokejumper Base.
1986—Redding (California) BLM Smokejumper Base discontinued.
1986—Boise (Idaho) BLM Smokejumper Base established (1986 to present).
1991—Forest Service smokejumpers discontinue use of ram-air parachutes after a fatality.
1991—C-23A Sherpa airplanes incorporated into the smokejumper aircraft fleet.
1993—Smokejumper restraint systems installed in all smokejumper aircraft.
2008—Northern Region smokejumpers begin a transition to ram-air parachutes.
2012—First female smokejumper base manager (Grangeville, ID).
2013—Smokejumping and Smokejumping Aircraft Safety Impact Analysis is completed.
2014—SD3-60 Sherpa airplanes acquired via National Defense Authorization Act (NDAA).
2014—Triple Nickles Multipurpose Room dedicated at National Headquarters.
2015—Forest Service approves a transition from round to square (ram-air) canopies.
2015—Project leader and team identified for Ram-Air Parachute System Implementation Project.
2016–2022—Ram-Air Parachute System Transition Operations Plan (RAOP) developed, approved, and implemented annually.
2021—Ten SD3-60 Sherpas acquired via NDAA are operational.

4.2. Background—Why Smokejumping?

The Forest Service was continually innovating to address the five essential components of effective fire suppression as outlined in the bulletin released by Chief Graves in 1910 (see chapter 2.2), especially the need for a rapid response by a skilled and organized workforce. If firefighters could be delivered aerially, this could greatly reduce response time.

As early as 1931, parachute drop tests of weighted "dummies"—as well as two "live" parachute jumps—were conducted in the Intermountain Region by Thomas (T.V.) Pearson. These tests were considered successful; however, the request for a formal evaluation of the use of parachutes to deliver "smokechasers" was not supported by the other three regions with major wildfire activity (the Pacific Southwest, Pacific Northwest, and Northern Regions).[1]

The Northern Region communicated its reluctance in a letter to the Washington Office from Regional Forester Evan Kelley on July 19, 1935. Kelley wrote, "The best information I can get from experienced fliers is that all parachute jumpers are more or less crazy—just a little bit unbalanced, otherwise they wouldn't be engaged in such a hazardous undertaking." (See appendix D for the full text of this letter.)

While Regional Forester Kelley did not believe parachuting firefighters was a wise idea, others did. Strong supporters of the Parachute Jumping Experiment included Director Ray Headley and Assistant Director David Godwin of Fire Control at the Washington Office and the following staff from the Pacific Northwest Region: Regional Forester C.J. Buck, Fire Control member Otto Lindh, Assistant Regional Forester M.C. Merritt, Captain Harold King (chief pilot), and Fire Control Director Jack Campbell. These influential supporters were committed to seeing the Parachute Jumping Experiment have its day.[2]

A smokejumper's view before exiting the aircraft. USDA Forest Service photo.

4.3. Parachute Jumping Experiment (1939)

Launched in 1936 in the Pacific Southwest Region, the Aerial Fire Control Project (see chapter 2.4.9) focused on aerial "firebombing" experiments. The study concluded that chemical retardants were no more effective than water, so the project was abandoned in 1939. Remaining funds and the newly acquired Stinson Reliant airplane were transferred to the Pacific Northwest Region to experiment with the delivery of firefighters via parachute. Assistant Director Godwin advocated for this outcome and the Fire Control director and staff in the Pacific Northwest Region were fully in support.[3]

From October 5 to November 15, 1939, the experimental parachute project was conducted in accordance with the following objectives:[4]

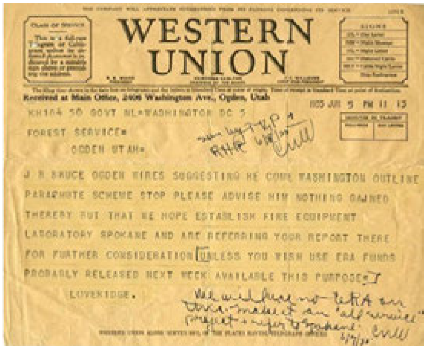
- To determine the feasibility of delivering firefighters by parachute in rough terrain, high altitudes, and timbered areas.
- To develop and test protective clothing to ensure safe landings in timber, rocky areas, steep slopes, and other potentially hazardous jump sites.
- To develop procedures and equipment for reaching the ground after landing in trees, and for retrieving parachutes, personnel, and equipment.

The Winthrop Ranger District on the Chelan National Forest was selected to host the experimental parachute project. This location was selected for several reasons: (1) Forest leadership was considered to be aerially minded, having used aircraft for aerial patrol for a number of years, (2) the airport was owned by the Forest Service (which gave it full control of the airfield and facilities), and (3) the proximity of steep, rugged, and heavily timbered terrain. (Russians were parachuting to fires by this time, but only in flat and open areas.)

The overall design of the project was to use a mix of Forest Service employees and contractors from the Eagle Parachute Company (Lancaster, PA). Forest Service personnel involved were Assistant Director Godwin, Pilot Captain Harold King, Fire Guard Francis Lufkin, and others. The parachute company provided equipment for the project as well as experienced parachutists.

After performing "dummy" drops (weighted loads without a person under the parachute) in various terrain types, 58 "live" jumps were made by 11 individual jumpers, including professional contract jumpers, Forest Service administration and support personnel, and Fire Guard Lufkin. Significant equipment redesign was done on the harness, protective suit, and let-down devices for tree landings. The 30-foot parachute was also modified slightly so that it would open differently and "give the jumper a less severe yank."[5] Only two minor injuries occurred: a leg ligament strain during a landing in timbered terrain and a facial laceration during the opening of a parachute.[6]

Fire Control Chief Walt Anderson of the Chelan National Forest was credited for naming the parachuting firefighters, saying, "Of all the ways to get to a fire in a hurry, smokejumping tops them all—you better call that hardy firefighter SMOKEJUMPER." He extolled how they could get into the air quickly, see the smoke, know which way the wind was blowing, and go directly to the fire without having to hunt through inhospitable terrain.[7]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LOVERIDGE.

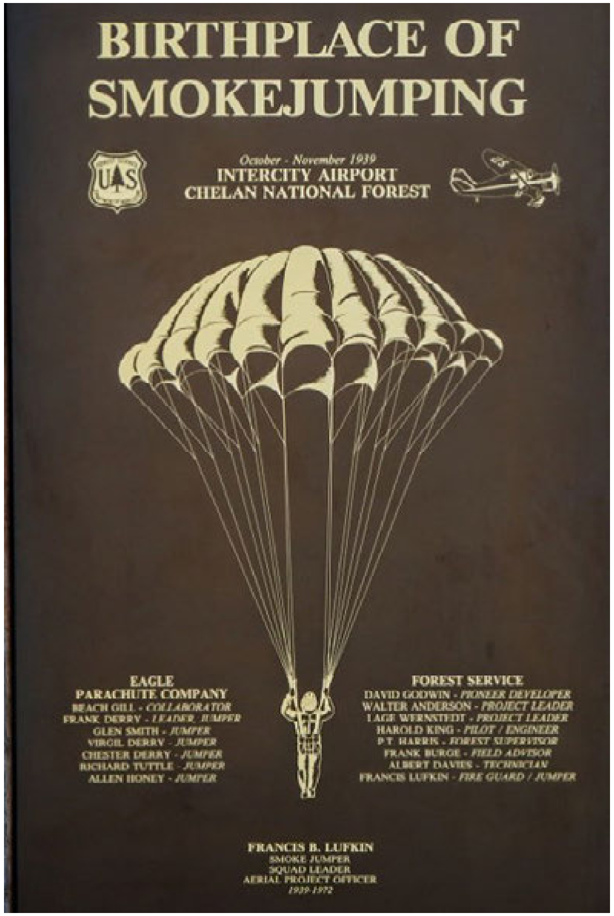
Top: A telegram on June 5, 1935, from Earl Loveridge, assistant chief of the Division of Operations, about funding for the "Parachute Scheme." Although the word "scheme" has negative connotations today, in 1935 it was most likely just synonymous with "plan." Top right: An exit demonstration from the Stinson Reliant on the ground during the 1939 Parachute Experiment in Winthrop, WA. Photo by Harold C. King, sourced from Eastern Washington University Digital Commons, Winthrop Collection. Bottom right: Jumpsuit and letdown rope, taken during the 1939 Parachute Jumping Experiment. USDA Forest Service photo by David P. Godwin.

The following conclusions were drawn from the experiment:[8]

- Smokejumpers could land safely in a wide range of green timber types (except tall Douglas-fir and redwood types) as long as the terrain was satisfactory.
- Elevations under 7,000 feet offered no obstacles, and successful landings could be expected on mountain meadows, open ridges, and even steep open slopes (if boulders were not too close together).
- Areas with snags, downed timber, dead lodgepole, extremely steep slopes, deep canyons, and rock cliffs or ledges should be avoided.
- Jumpers experienced less fatigue in jumping than that which would result from a short hike up a steep hill.
- The denser the timber, the easier the landings and the less landing impact experienced by the jumpers. (Landings in thickets of young trees were termed "feather bed" landings because of how the vertical descent of the jumper was checked.)
- Retrieving a parachute canopy from the crown of a tree could be a problem.
- The ability to steer the parachute contributed greatly to an accurate landing on the ground target. Wind conditions needed to be taken into consideration to minimize unexpected drift.
- There was no evidence of fear or panicky state of mind even in first-time jumpers.

The conclusion that firefighter delivery via parachute could be done safely led to the next phase of the smokejumping program in 1940: the development of operation plans, including cost estimates, equipment and personnel specifications, and purchasing of equipment and supplies.[9]

Reflecting back on the experimental parachute project, Assistant Director Godwin wrote, "If we can intelligently adapt transportation by air to our ends, it may open up an era of time-cutting which our present forest fire organization plans have hardly glimpsed."[10]



Commemorative plaque at the North Cascades Smokejumper Base in Winthrop, WA, showing the original 1939 Eagle BT-30 parachute used during the 1939 Parchute Jumping Experiment. Additional interpretive text below the plaque reads: "A 'hare-brained and risky scheme' became the profession of smokejumping here in the fall of 1939. Forest Service firefighters and employees of the Eagle Parachute Company made 58 jumps into clearings and timber, testing whether men could safely parachute to remote wildfires. They flew up in a single-engine Stinson and rode silk Eagle parachutes down. Their injury-free experiment proved that parachuting firefighters could 'land safely in all kinds of green timber common to the Chelan National Forest,' and smokejumping was born. Francis Lufkin and Glen[n] Smith made the first fire jumps in the Pacific Northwest Region just west of here on August 10, 1940."

4.4. Early Smokejumper Program Development (1940s)

4.4.1. First Fire Jumps and Expansion into the Northern Region

The Northern and Pacific Northwest Regions each organized a small squad of smokejumpers for the 1940 fire season. New recruits were selected from the most experienced firefighters.[11] Recruits had to be 21–35 years of age, weigh 190 pounds or less, pass a Civil Aeronautics Authority (predecessor of the FAA) physical examination for pilots, and be free from airsickness, hernia and heart conditions, and excessive nervous reaction before or after jumping.[12]

During the 1940 training season, the Eagle Parachute Company assisted both regions. The Pacific Northwest Region trained a crew of seven at Winthrop, WA. The Northern Region project leader, Merle Lundrigan, received his orientation there as well, subsequently returning to Seeley Lake, MT, to supervise the training of his crew, which was then stationed at the Moose Creek Ranger Station on the Bitterroot National Forest. The two units shared a Travel Air 6000 airplane contracted from Johnson Flying Service (Missoula, MT).[13]

A visit by four U.S. Army staff officers to the smokejumper training camp (Montana) in June 1940 left a lasting impact on future military operations. Major William Cory Lee later employed Forest Service techniques and ideas in organizing the first paratroop training at Fort Benning, GA. This led to the development of the U.S. Army Airborne Divisions that were so essential to the Allied victory in World War II.[14]

The Pacific Northwest Region jumped two fires that first season, while the Northern Region jumped nine fires. The first fire jump in the history of smokejumping was made by Rufus Robinson on July 12, 1940, on the Marten Creek Fire, Nez Perce National Forest. Earl Cooley is credited with making the second fire jump on the same fire. Both occurred from the Travel Air 6000 piloted by Dick Johnson.[15] The first jumps in the Pacific Northwest Region followed soon after on August 10, 1940. These jumps were made by Francis Lufkin and Glenn Smith on the Little Bridge Creek Fire, Twisp Ranger District, also from the Travel Air 6000.[16]

First smokejumper squad at Seeley Lake, MT, June 1940. Pictured left to right (back row): Glenn Smith, Earl Cooley, Merle Lundrigan (project leader), Jim Alexander, Chet Derry; (front row) Rufus Robinson, Jim Waite, Frank Derry (project manager), George Case, Dick Lynch, and Bill Bolen. Courtesy of the National Museum of Forest Service History.

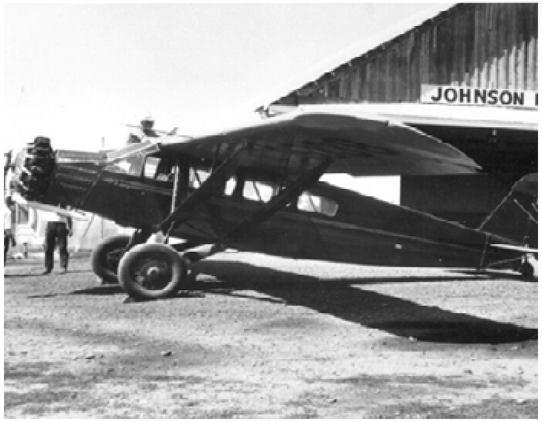
Left: Smokejumper Rufus Robinson shown here standing in front of a Ford Tri-Motor. Right: Travel Air shown with smokejumper ready to exit. USDA Forest Service photos.

Smokejumping had played a successful role in fire suppression during the 1940 season, with "no incapacitating injuries," and the recommendation was made to continue operations in 1941 with a new parachute developed by Chet Derry in December 1940 that opened using a static line.[17]

The second year of the program in 1941 was a year of limited funding, with only enough money to fund a single smokejumper location. Training and staffing that year were centered in Missoula, MT. The Northern Region was chosen due to its 8 million acres of roadless area and because Johnson Flying Service could provide airplanes, pilots, and mechanical services. Jumpers in the Northern Region were to be "on call" for other regions.[18] Five airplanes were on call, including three Curtiss Travel Air 6-place cabin airplanes (6 passenger seating capacity) and two Ford Tri-Motor 12-place airplanes (12 passenger seating capacity).[19]

Centralizing the project in the Northern Region allowed expansion to a three-squad contingent of 26 smokejumpers. The squads were located at Moose Creek on the Bitterroot National Forest, Big Prairie on the Flathead National Forest, and Nine-Mile Camp west of Missoula.[20] After training in Montana, Francis Lufkin staffed the Winthrop Base to ensure it was ready to host Northern Region smokejumpers and aircraft when they were needed in the Pacific Northwest.[21]

Incorporating the newly developed static line was a significant improvement over the manually controlled ripcord. Jumpers initial-attacked or reinforced nine fires this second season, some of them in the Pacific Northwest. The Ford Tri-Motor and Curtiss Travel Air both proved well suited to smokejumper operations.[22]



Left: Ford Tri-Motor under contract from Johnson Flying Service about to take off with a squad of smokejumpers in August 1941. Lolo National Forest, MT. Forest History Society photo. Right: Johnson Flying Service Travel Air 6000.[23]

Smokejumper hooked up to the static line. Montana, August 1945. Forest History Society photo.

4.4.2. World War II Era and the Civilian Public Service

World War II greatly limited the number of personnel available to staff the smokejumper program for the 1942 fire season. The four-squad approach in the Northern Region continued, but training for the season began with only 5 experienced jumpers, and fire suppression training was emphasized since only a few of the 33 new recruits had previous fire experience.[24]

The parachute equipment situation was almost as bad. The only parachutes available were ones rejected by the military that required experimentation and modification to be made usable. One innovation was the development of the Derry slotted parachute, which offered maneuverability, easy opening, a slow rate of descent, and relatively little oscillation.

Smokejumpers were credited with controlling 31 fires in the 1942 fire season. Four additional fires were controlled along with the aid of ground forces. A savings of $66,000 was credited to the smokejumper program.[25] Accidents were few and not considered an impediment to the future of the program.[26]

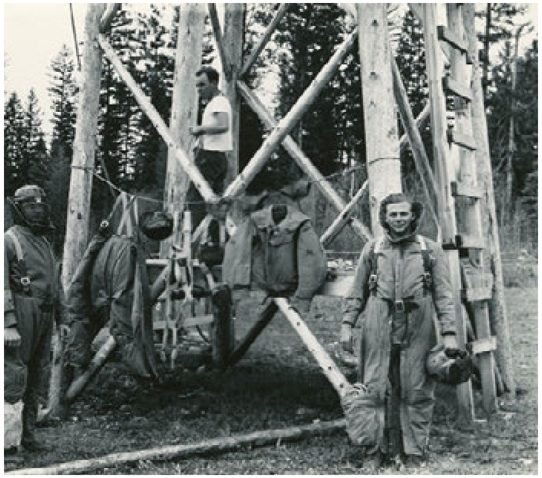
Johnson Flying Service provided smokejumper aircraft and other aircraft used for the transportation of firefighters, equipment, and supplies. An example of the contract specifications for six aircraft in two capability classes is provided in appendix C.

Personnel shortages reached a critical stage in 1943, with only five experienced jumpers returning. Inquiries were received from 4-E draftees (conscientious objectors) in Civilian Public Service (CPS) camps who wished to secure noncombat work. Sixty candidates were selected, a majority of whom were from the "Peace Churches" (Mennonite, Brethren, and Friends).[27]

The CPS consisted of 12,000 draftees who joined to perform nonmilitary service. Enrollees volunteering to become smokejumpers were assigned to CPS "Camp 103" based at Nine-Mile Camp, west of Missoula, MT. Approximately 250 CPS volunteers were trained as smokejumpers through 1946.[28] Several of the CPS volunteer smokejumpers later joined the Forest Service, including one who became a parachute loft supervisor.

The Pacific Northwest and Intermountain Regions participated in 1943, each sending personnel to Missoula to be trained as squad leaders, riggers, and overhead for CPS squads. Training was conducted for approximately 70 new smokejumpers at Seeley Lake, MT. Parachute rescue units (mainly flight surgeons) from other agencies, including the Coast Guard, Air Force, and Canadian Air Observer School also participated in the training. Again, the season was considered a success, although a few minor injuries occurred during training that were serious enough to prevent the personnel involved from jumping during the fire season.[29]

Nearly 60 percent of the CPS enrollees returned for the following season in 1944, continuing to form the majority of the smokejumping force. Approximately 120 smokejumpers went through the training held in the Northern Region. A standby unit was located in Missoula, with 40–50 smokejumpers working on projects at nearby bases who could be called on as needed.[30]



Civilian Public Service smokejumpers. Top: Lolo National Forest, MT, 1943. Bottom: By jump training tower. Seely Lake, MT, 1943. Courtesy of the National Museum of Forest Service History, Roy E. Wenger Collection.

Previously, the smokejumper program had been considered a special unit financed from experimental funds. In 1944, the Northern Region included smokejumpers in their regular organization, an indication of the effectiveness of the program. Some national forests reduced their firefighting staff, becoming wholly dependent on smokejumpers for initial attack.[31]

About 100 fires were handled by smokejumpers in 1944. Jumpers were used on larger fires and in larger groups. Smokejumpers were used in the Pacific Southwest Region for the first time on the Happy Camp District of the Klamath National Forest. Smokejumping transitioned from an experiment to a regular operational component of fire control.[32] Training and safety measures were considered a success in keeping the accident rate low, and it was determined that the program could be further expanded.

Aircraft delivering smokejumpers and paracargo continued to diversify. In cooperation with the Marine Corps, Navy DC-3 aircraft were used on fires in southern Oregon.[33] The Ford Tri-Motor and Curtiss Travel Air continued to be the mainstay for smokejumping operations in the Northern and Intermountain Regions.[34]

4.4.3. Project Fire Fly and the 555th Parachute Infantry Battalion

In the final year of World War II, the Japanese military launched free-sailing, unmanned, paper balloons carrying incendiary material. The balloons conveyed canisters filled with thermite and a bomb containing shrapnel or "fire pots" designed to ignite fires upon impact with trees or other vegetation. Launched in Japan, they drifted across the Pacific in 80 to 100 hours. Most of those recovered landed on the west coast including Alaska, Canada, and Mexico—a few went as far east as Michigan.

On May 5, 1945, the only World War II fatalities from enemy action on mainland North America occurred when a picnicking family encountered one of the explosive bombs from a balloon near Bly, OR. The resulting explosion killed six people.[35]

The Forest Service and other agencies were gravely concerned about these balloons with the upcoming fire season. Never in the history of the Forest Service were there fewer physically qualified firefighters. The National Office requested military assistance. The Army designed a plan to provide assistance to civil agencies to combat any forest fires started by balloons or other causes. The Forest Service represented all fire protection agencies in the formulation of plans and operation of the project, which was called Project Fire Fly.

Project Fire Fly provided troops trained to fight fires, including 2,700 ground troops and 300 paratroopers. Aircraft included 32 Stinson L-5 and Noorduyn C-64 reconnaissance planes with personnel to detect fires, and 7 Douglas C-47 transport planes to carry paratroops and ground troops to remote, inaccessible fires and to move ground troops, supplies, and overhead.[36]

Army paratroopers called into action as smokejumpers were the 555th Parachute Infantry Battalion of 300 soldiers. The 555th—also known as the Triple Nickles—was an all-Black unit stationed at Camp Mackall, NC. On May 6, 1945—the day after the civilian fatalities in Oregon— they boarded a troop train and departed for Pendleton, OR.[37]

Members of the Triple Nickles, the 555th Parachute Infantry Battalion, at Pendleton Army Airfield during a briefing in 1945. National Archives photo.

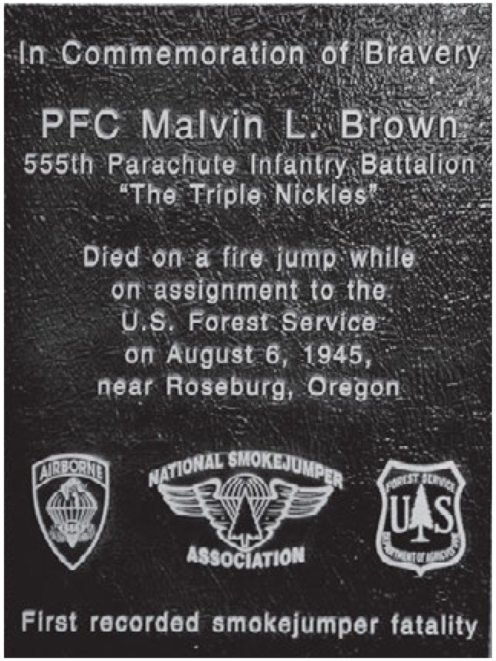
The troops were already familiar with Army parachutes, maps, and operations, but at Pendleton they faced new challenges and were trained in timber jumping, letdowns, and firefighting. They were issued smokejumper football helmets with face masks but wore fleece-lined flying jackets and trousers rather than canvas jumpsuits. After three training jumps, the battalion was declared ready; 200 stayed in Pendleton while 100 went to Chico, CA.

From mid-July to early October 1945, the 555th paratroopers participated in 36 missions and amassed more than 1,200 jumps.[38] Some of these fires involved 555th paratroopers working alongside Forest Service smokejumpers. In one instance, 100 paratroopers were dropped to support 10 smokejumpers on a 300-acre fire on the Chelan National Forest, making control of a large fire in an inaccessible location possible for the first time. Another mass jump by 50 paratroopers was made near Mt. Baker, WA.[39]

Tragedy struck the 555th on August 6, 1945, when Private First Class Malvin L. Brown died after falling to the ground and landing on rocks while executing a letdown from a 150-foot tree on the Umpqua National Forest.[40] On the 70th anniversary of his death, Brown was recognized with a memorial plaque installed in Mt. Calvary Cemetery in Baltimore, MD. The plaque honors his bravery and notes that PFC Brown's death is the first recorded smokejumper fatality.[41]

The 555th Parachute Infantry Battalion was recognized for its contributions at a ceremony on the National Mall during the 50th birthday celebration of Smokey Bear in 1994.[42] On February 27, 2014, Associate Chief Mary Wagner dedicated the Triple Nickles Multipurpose Room at the National Headquarters in Washington, DC, citing the contributions of the 555th Parachute Infantry Battalion to the Forest Service.[43]

Above: 555th Parachute Infantry Battalion parachuting into a forest in Oregon to fight a wildfire caused by a Japanese incendiary balloon in 1945. Smoke from the fire can be seen in the lower right.[44] USDA Forest Service photo. Right: Plaque erected in 2015 at the Mt. Calvary Cemetery recognizing Malvin L. Brown's bravery and sacrifice.



4.4.4. Expansion of the Program

As World War II came to an end, the 1945 fire season proved more severe than any since 1940.[45] Continued expansion of the CPS program and the return of some war veterans increased the total number of smokejumpers in the 3 regions to about 220, of which 100 were experienced. Training of the new candidates and most of the refresher training was conducted under the direction of the Northern Region at Nine-Mile Camp. Bases were staffed at Missoula, MT (153 smokejumpers); McCall, ID (36 smokejumpers); Winthrop, WA (15 smokejumpers); and Cave Junction, OR (15 smokejumpers).[46]

Smokejumpers were used on 265 fires that season with 1,236 individual jumps on 23 national forests, and 2 national parks, as well as U.S. Indian Service and private timber association lands.[47] The first fire jump into Canada was also made.[48]

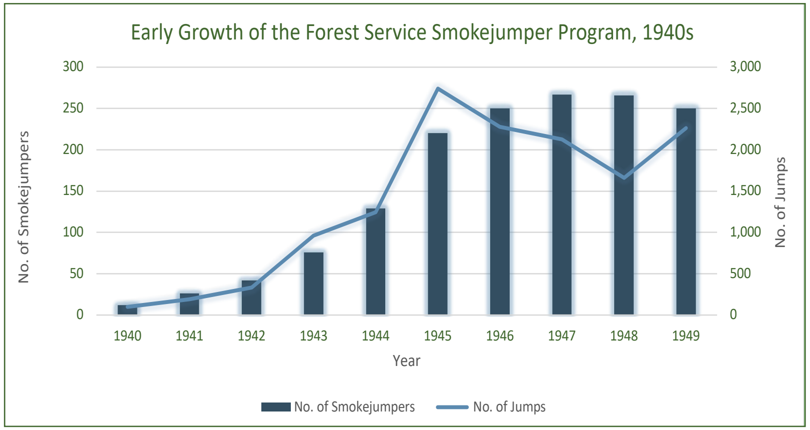


Figure 4.1. Official jumps (training, fire, rescue) by Forest Service smokejumpers in the 1940s throughout the United States.[49]

An experimental "Air Control Area" known as the "Continental Unit" was designed with over 2 million acres of roadless areas, including remote and inaccessible parts of the Flathead, Lewis and Clark, Lolo, and Helena National Forests. Within this unit, smokejumpers and air patrol handled fire activity to the exclusion of most ground forces. The vast majority of the 52 fire lookouts in the area were discontinued. The outcome was considered a success. Of the 29 fires detected, 16 were initial-attacked by smokejumpers. In addition, smokejumpers discovered 11 fires flying to and from the unit.

Other significant events of 1945 included the following:[50]

- Two UC-64 Noorduyn Norseman airplanes were loaned by the Army to the Pacific Northwest Region.
- Smokejumper qualifications, training and jumping techniques, and jumping gear (including parachutes, jumpsuits, and rigging) were standardized.
- Air transportation was demonstrated as a quick and effective means of initial attack and also for placing additional crews on fires escaping initial attack.
- Quick release harnesses were tested (and adopted as standard by the program in 1948).

With the end of the war, the CPS program was terminated in 1946. The three regions engaged in smokejumping needed to develop a new organization around the small group of trained and experienced staff that remained. Training was increased and the program remained roughly the same size: 164 smokejumpers in the Northern Region, 43 in the Intermountain Region (McCall, ID), and 53 in the Pacific Northwest Region.[51]

In 1947, about 50 percent of the previous year's jumpers returned, making the task of training easier. For the first time, the Intermountain and Pacific Northwest Regions conducted their own training. A detail was initiated on the Gila National Forest in the Southwestern Region for the period May 25 through June 25. This operation was supplied with a Noorduyn Norseman airplane, a pilot from the Pacific Northwest Region, and a supervisor and eight smokejumpers from the Northern Region.[52] The addition of the C-47/DC-3 to the Johnson Flying Service fleet made it possible to transport larger crews.[53]

In 1948, the number of smokejumpers increased from 225 to 244 mainly because more jumpers were employed in Cave Junction, Winthrop, and McCall. A new unit was established at Idaho City, ID.[55]

Conditions were exceptionally dry the following year in 1949, which proved to be a busy and tragic year for the new smokejumper program. Nationally, 354 fires were jumped, with 1,335 individual jumps—this was the greatest number of fires and jumps since the start of the program in 1940. On August 5, 1949, 12 smokejumpers and a former smokejumper died in the Mann Gulch Fire on the Helena National Forest, with only 3 smokejumpers escaping the fire.[56]

Smokejumpers were beginning to be recognized for their skill and expertise in firefighting, usefulness as overhead on large fires, and potential role in public relations. That same year, four Missoula smokejumpers jumped from a Ford Tri-Motor piloted by Bob Johnson, landing in the park (the "Ellipse") between the Washington Monument and the White House. The jump was part of an effort to promote fire prevention with hundreds of business executives and newspaper reporters in attendance.[57]

Smokejumpers in Washington, DC, in 1949. Left to right: Bill Hellman, Skip Stratton, Bill Dratz, and Ed Eggen. Smokejumpers continue to play an important public relations role today, with thousands of visitors to smokejumper bases each year, significant media interest, and frequent participation in local community events. Forest History Society photo.

The Forest Service used the Noorduyn Norseman for various tasks, including hauling dynamite and dropping meals to firefighters.[54] San Diego Air and Space Museum Archives photo.

4.5. Program Development and Implementation (1950–2021)

4.5.1. The 1950s

Entering its second decade in the 1950s, the smokejumping program had experienced tragedy, received national recognition, and was a primary resource for rapid and mobile initial attack, particularly on remote fires. During the 1950s there were between 250 and 339 Forest Service smokejumpers annually, with an average of 295. The majority of smokejumpers in the 1950s were college students.[58]

Specific contracting information and/or annual aircraft lineups for the Northern Region during the 1950s could not be sourced, but during this decade contract aircraft provided by Johnson Flying Service included Ford Tri-Motors, a Curtiss Travel Air, Douglas DC-2 and DC-3s, a twin-engine Beechcraft (model unknown), and as of 1954, a Curtiss C-46.[59]

Many of the Johnson Flying Service aircraft also served the McCall and Idaho City Smokejumper Bases. In addition to the makes and models listed above, Idaho City also used a Cunningham-Hall aircraft in 1956 and 1957.[60]

In the Pacific Northwest Region, they used a Noorduyn Norseman at Cave Junction, OR, from 1950[61] to 1955 and a twin-engine Beechcraft from 1956 to 1958, both owned and piloted by the Forest Service.[62] The Winthrop, WA, base used the Noorduyn Norseman through 1957 and the twin-engine Beechcraft C-45 after that.[63]

Aircraft cited as being occasionally used during the 1950s in the Pacific Northwest include Forest Service DC-3s and Twin Beechcraft, and contract Fokker, Lodestar, and Fairchild 71s.[64] Another aircraft not cited above, which the Air Operations Handbook (1952) describes as suitable for smokejumping, was the Fairchild C-82 Packet.[65]

Fire activity fluctuated annually and between the regions with smokejumper bases. The number of smokejumpers was on a gradual rise, and in times of need smokejumpers were moved between regions as conditions dictated.[66]

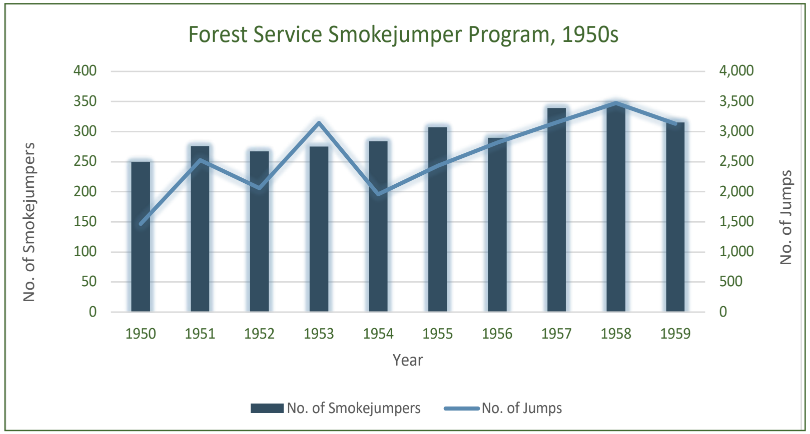


Figure 4.2. Official jumps (training, fire, rescue) by Forest Service smokejumpers in the 1950s throughout the United States.[67]

In 1950 the Missoula smokejumpers participated in the development of the Hollywood movie "Red Skies over Montana," which was released in 1951. In a cooperative effort in 1951, the Northern Region selected and trained a five-smokejumper crew for use by Yellowstone National Park, based at West Yellowstone, MT. Also in 1951, a subbase of the Missoula Base was developed and staffed at Grangeville, ID.[68]

One of the busiest years to date occurred in 1953, with the three regions operating smokejumper bases being extremely active. Missoula smokejumpers dropped more than 200 tons of fire supplies via paracargo, not including smokejumper cargo.[69]

On September 22, 1954, President Dwight D. Eisenhower dedicated the Missoula Aerial Fire Depot (AFD), which included the Missoula Smokejumper Base, located at the Missoula airport.[70]

In 1957 the Pacific Southwest Region established the Redding Smokejumper Base with 26 smokejumpers and the Intermountain Region expanded their 2 bases. Forest Service smokejumpers in all regions completed 3,153 jumps that year, a new all-time high.[71]

Since 1947 the Southwestern Region had used a detailed (nonpermanent) smokejumper crew. In 1958 they employed a smokejumper supervisor year-round and increased their crew size to 24 smokejumpers.[72]

In 1958 the Forest Service's Twin Beechcraft, N164Z, crashed while dropping cargo on the Eight Mile Fire on the Okanogan National Forest, resulting in the death of the pilot and three smokejumpers. This was the first aircraft accident during an active smokejumper mission.[73]

In 1959 the Winthrop Base began an annual detail of smokejumpers to La Grande, OR.[74] This eventually led to the establishment of La Grande as a full-time smokejumper base in 1973.[75]

Smokejumpers had been making rescue jumps for years. In 1959, a unique rescue jump occurred following "the most powerful earthquake in Montana's history," which measured 7.8 on the Richter scale and "triggered the largest landslide ever recorded in North America. An estimated 80 million tons of earth and rock fell from the side of a mountain into the Madison River, forming a dam and creating what is now known as 'Quake Lake.'" It was estimated that 28 people were killed as water surged through 3 campgrounds. Eight Missoula smokejumpers dropped into the canyon the next morning to aid the injured and evacuate survivors to higher ground.[76]

Top: Twin Beechcraft N164Z in 1958, either on the day of the crash or a few days before. Photo taken by Jack McKay (from 35MM film) and provided by William Moody. Bottom: Crowd attending the dedication of the Aerial Fire Depot and Missoula Smokejumper Base in Missoula, MT, on September 22, 1954. Forest History Society photo.

The Bureau of Land Management (BLM) activated a 17-person smokejumper unit at Fairbanks, AK, in 1959. These were experienced smokejumpers recruited from Forest Service bases and given refresher training at Missoula. This began an era of cooperation between the Forest Service and BLM, vital to the future success of the smokejumper program. An extremely busy year followed in 1960. Frequent exchanges of smokejumpers were made between regions. Forest Service smokejumpers were detailed to Alaska for the first time in support of the BLM base in Fairbanks. Twenty Northern Region smokejumpers participated in this assignment.[77]

Twin Beechcraft dropping smokejumpers near Silver Star Mountain, Okanogan National Forest, 1966. USDA Forest Service photo from Moody's "History of the North Cascades Smokejumper Base."

4.5.2. The 1960s

By the third decade of the smokejumper program in the 1960s, the program was well established with permanent bases in the Northern, Intermountain, Pacific Southwest, and Pacific Northwest Regions and a seasonal base in Silver City, NM. The average annual number of smokejumpers during this decade was 378, a 28-percent increase from the previous decade. The smallest number was 321 in 1960 and the largest was 427 in 1968.[78]

Smokejumper aircraft used during the 1960s were initially the Ford Tri-Motor, Curtiss Travel Air, DC-3/C-47, and Twin Beechcraft (multiple models). (The Noorduyn Norseman had been phased out in the late 1950s.) By the end of the decade, other aircraft had come into use, including the de Havilland Twin Otter, Pilatus Turbo Porter, Cessna 206, Aero Commander, and de Havilland DHC-4 Caribou. The Northern Region relied on contract aircraft and pilots, the Intermountain Region had a mix of contract and Forest Service aircraft and pilots, and the Pacific Northwest Region had a fleet of Forest Service aircraft and pilots.[79]

The year 1969 marked the 30th anniversary of the smokejumper program. The Forest Service transitioned away from the Ford Tri-Motor and Travel Air that had been the core of the Johnson Flying Service fleet in favor of the DC-3, Twin Otter, and Twin Beechcraft E-18.[80]

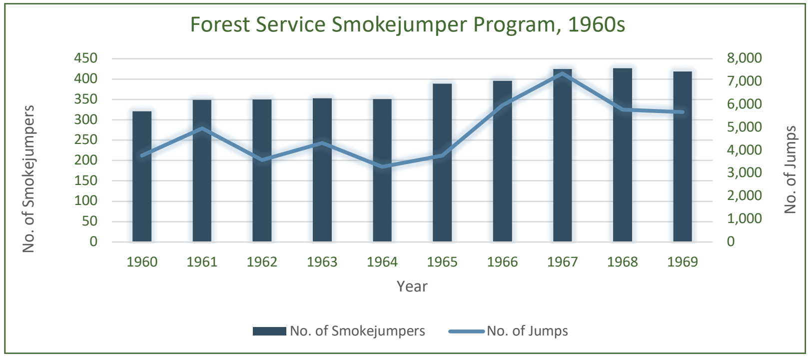


Figure 4.3. Official jumps (training, fire, rescue) by Forest Service smokejumpers in the 1960s throughout the United States.[87]

Original leaders were still actively involved, including Base Manager Francis Lufkin at Winthrop and Base Manager Earl Cooley at Missoula. Many others from the early days were still in supporting or leadership roles, including William (Bill) Wood and David ("Skinny") Beals. A long-time smokejumper base supervisor (Missoula) and equipment specialist, Wood was now the Pacific Northwest Region's fire equipment specialist. Beals was a Civilian Public Service smokejumper who became a squad leader at Winthrop, WA, and later the loft supervisor at Redmond, OR.

Many others, however, had moved on to other jobs—particularly jobs that didn't involve being an active smokejumper as the policy of the times indicated that if a smokejumper "made a jump before age 29 they are allowed to continue jumping until age 40." This age limit served to move experienced smokejumpers into ranger district fire organizations and to some degree perpetuated the model of smokejumping as primarily a summer job for college students.[81]

The degree to which the smokejumper program was dependent on college students was demonstrated in 1960 with the development of a program to provide formerly qualified smokejumpers a refresher training while they were working on forestry-related assignments on ranger districts. They could then be recalled for assignments as smokejumpers when needed.[82]

The Redmond Air Center (RAC) was established in 1964 in Redmond, OR, as a regional center for aerial firefighting. The center included the Redmond Smokejumper Base, with experienced overhead and smokejumpers from other bases providing expertise and leadership.[83]

In 1965 the Northern Region assumed management of the interagency smokejumper base at West Yellowstone, MT, previously managed by the National Park Service. A cooperative funding arrangement was made between the Northern Region, Rocky Mountain Region, Intermountain Region, Yellowstone National Park, Grand Teton National Park, BLM, and Bureau of Sport Fisheries (a bureau within the U.S. Fish and Wildlife Service) to construct facilities. The base was initially operated as a satellite base for the Missoula smokejumpers.[84]

A fatal accident occurred in 1965 when a Johnson Flying Service Twin Beechcraft crashed on the Norton Creek Fire about 50 miles east of McCall, killing the pilot and spotter. The crash occurred between the first and second cargo drops on a windy and turbulent day.[85]

During 1967, all smokejumper bases sent booster crews to the Northern Region.[86] The next year (1968), the fire season was relatively mild in the Pacific Northwest, but record-setting smokejumping activity occurred at the Silver City and BLM-Fairbanks Smokejumper Bases, with assistance from an all-time high number of Forest Service detailers.[87] Smokejumper base managers met in 1968 and took a step closer to program standardization by adopting a common physical fitness standard.[88]

4.5.3. The 1970s

The 1970s averaged 423 smokejumpers per year, with the high being 446 in 1970 and 1971 and the low being 380 in 1979. This represented a 12-percent increase in average smokejumper staffing over the 1960s.[89] Aircraft in use during the 1970s were the Twin Otter, Twin Beechcraft, Beechcraft 99, Beechcraft King Air, Douglas DC-3/C-47, de Havilland Caribou, and Aero Commander.[90]

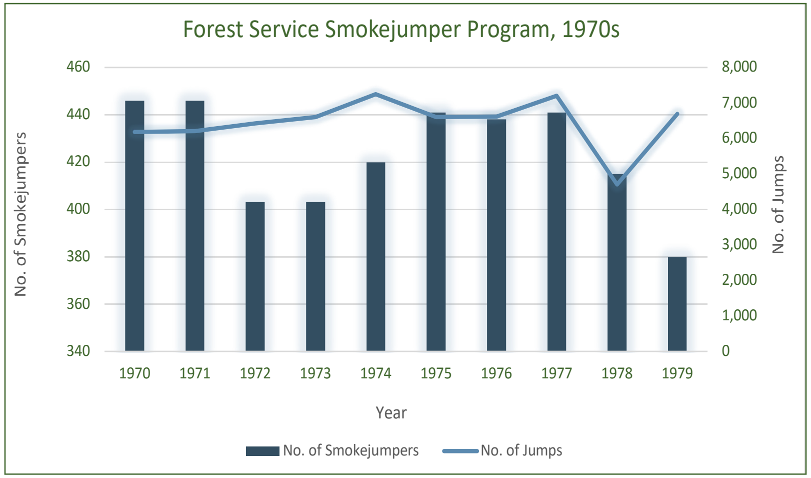


Figure 4.4. Official jumps (training, fire, rescue) by Forest Service smokejumpers in the 1970s throughout the United States.[91]

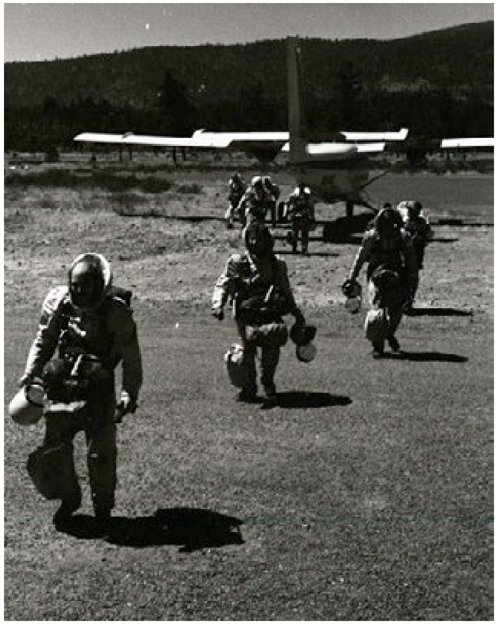
Several administrative changes in the early 1970s were to have a major impact on the smokejumper program. The first change involved the overtime pay rate. Since 1952, overtime had been paid at the regular time rate. In 1970 it became one and one-half times the hourly rate. The second change was that the upper age limit for a smokejumper position was increased from 40 to 65. With the passage of Federal legislation for firefighters in 1972, depending on their career history, smokejumpers became eligible for retirement at age 50 with 20 years of service, with a mandatory retirement age of 55 (changed to 57 in 2001). Those who wanted to make a career of smokejumping were now able to stay in the program as long as they met the physical fitness standards.[92]

Another record-setting wildfire year occurred in 1970. This time the epicenter was the Pacific Northwest—particularly the Okanogan and Wenatchee National Forests—the "backyard" of the North Cascades Smokejumper Base. The smokejumper program demonstrated its mobility between regions, with over 100 smokejumpers from other regions assisting in the Pacific Northwest.[93] Tragically, in June 1970, a Redding smokejumper was fatality injured during a fire jump on the Shasta-Trinity National Forest when his static line became wrapped around his neck while exiting a DC-3.[94]

In 1971, Earl Cooley, one of the pioneers of the smokejumper program, left his position as superintendent of the Missoula Base, becoming a fire equipment specialist for the Northern Region. The following year, Francis Lufkin retired—Lufkin had participated in the original Parachute Jumping Experiment and then served as the North Cascades Smokejumper Base Manager for many years.[95] West Yellowstone, MT, and Grangeville, ID, became independent bases in 1972. At least part of the motivation for this change was an effort at decentralization to lessen the size of the Northern Regional Office.[96] A busy year for the program occurred in 1973, with an extended and intense fire season throughout the West. Interregional movement of smokejumpers was common to increase staffing ahead of lightning busts.[97]

Johnson Flying Service was underbid for the Missoula smokejumper aircraft contract in 1975 by the Christler Flying Service. For the first time in smokejumper program history, Johnson Flying Service was not a smokejumper aircraft contractor. By the end of 1975, Johnson Flying Service was sold to Evergreen Airlines—an era had passed.[98]

Other smokejumper aircraft contractors in the 1970s (and in some cases in the succeeding decades) included Abe Bowler Air Service, Orofino, ID; Hillcrest Aviation, Lewiston, ID; Elgin Flying Service, Cody, WY; Avery Aviation, Cody, WY; Aero-Dyne Aviation, Renton, WA; Intermountain Aviation, Marana, AZ; Evergreen Helicopters/Aviation/Airlines, Marana, AZ, and McMinnville, OR; Methow Aviation, Winthrop, WA; Kenn Borek Air, LTD, Calgary, Alberta; ERA Helicopters, Juneau, AK; Leading Edge Aviation Services, Missoula, MT; and Bighorn Airways, Sheridan, WY.



Top: DC-3 aircraft. USDA Forest Service photo from Moody's "History of the North Cascades Smokejumping Base." Right: Smokejumpers in jump gear walking from a Twin Otter airplane after a dry run, circa 1975. Photo by Dougals C. Beck, courtesy of Eastern Washington University Digital Commons.

In 1976 North Cascades Smokejumper Base Manager Bill Moody and former McCall Smokejumper Doug Bird made a trip to the Union of Soviet Socialist Republics (USSR), now Russia, to assess Russian aerial firefighting equipment, procedures, and training. This resulted in an evaluation of the Russian "Forester" parachute, which offered performance improvements over the Forest Service FS-10 parachute. Aspects of the Forester parachute were used as the basis for design of the FS-12 parachute, which was implemented by 1980 in the Forest Service.[99]

After several moderate years, 1977 was marked by a severe drought throughout the West. Extensive fire activity occurred in Oregon and northern California, and smokejumpers were moved around as needed.[100] After another moderate season in 1978, the 1979 fire season was again more active with the Grangeville Smokejumper Base having its busiest season to date.

The decade ended with the National Smokejumper Base Study in 1979. This study was to have far-reaching effects, resulting in the closure of the Forest Service smokejumper base in Boise, the recommended closure of the Cave Junction and La Grande bases, and proposed centralization of Pacific Northwest Region smokejumper training and parachute loft activities in Redmond. Also recommended for closure was the Grangeville Smokejumper Base.[101]

4.5.4. The 1980s

The 1980s averaged 324 smokejumpers per year, with a high of 363 in 1980 and a low of 288 in 1989. This represented a 24-percent decrease in average staffing over the 1970s.

Aircraft in use during the 1980s included the Twin Otter, Volpar, Beechcraft 99, Beechcraft King Air 90, Beechcraft King Air 200, Banderanti, Casa 212, Douglas DC-3/C-47, Basler Turbo BT-67 (turbine engine DC-3), Cessna 206, and Caribou.[102]

Implementation of the 1979 National Smokejumper Base Study continued with the Forest Service Boise Smokejumper Base being closed in 1980. The Boise BLM Smokejumper Base opened several years later in 1986. In 1981, the Cave Junction Smokejumper Base was closed after 38 years with 5,390 jumps on 1,445 fires. The North Cascades Smokejumper Base was reduced in size and became a satellite base of Redmond. In 1982, the La Grande Smokejumper Base was closed after 9 years with 1,610 jumps on 449 fires. Grangeville—originally slated for closure—was retained as a smokejumper base.

Bill Moody in the door of an aircraft, 1963. Photo by Jerry Gildemeister, courtesy of Eastern Washington University Digital Commons.

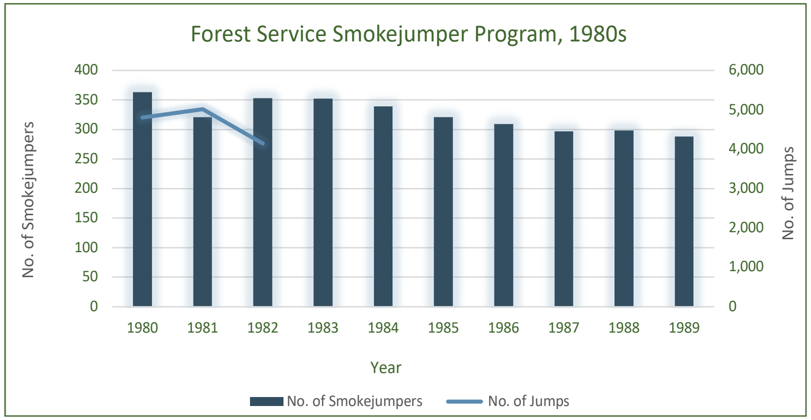


Figure 4.5. Official jumps (training, fire, rescue) by Forest Service smokejumpers in the 1980s throughout the United States. National summary figures not found for total jumps during 1983–1989.[103]

Following a Regional Smokejumper Base Study in 1984, the North Cascades Smokejumper Base was returned to full smokejumper base status with an established staffing of 20 smokejumpers and 1 smokejumper aircraft.[104]

Two historic firsts occurred in 1981. Deanne Schulman completed “rookie” training to become the first female Forest Service smokejumper. Charlotte Larson was hired and qualified as the first female smokejumper pilot the same year. Both were based at the McCall Smokejumper Base.[105]

A tragic accident occurred at the Redding Smokejumper Base on May 11, 1981, when a Forest Service Beechcraft Baron 58P crashed into the paracargo building killing four Forest Service employees on board. The resulting fire burned their equipment, loft, and facilities. Temporary equipment was borrowed from other bases and the Redding Smokejumper Base was back in operation by June 10, 1981. The base operated from temporary facilities until new ones were ready in the spring of 1984.[106]

Ram-air (square) parachutes were studied and evaluated by BLM-Alaska smokejumpers beginning in 1979. One immediate conclusion was that they offered the opportunity to jump safely in significantly higher winds. Sport models were improved to ensure that the jumper was in a stable position relative to the parachute upon deployment. Small drogue parachutes—an idea borrowed from the Russian gear that the FS-12 Forest Service parachute was modeled on—were incorporated and solved the problem of unstable exits.[107]

Ram-air parachutes were used on fires in Alaska in 1982 and were first used in the Great Basin by BLM smokejumpers in 1983. The BLM then began a gradual transition to the ram-air parachute.[108]

Between 1982 and 1990, Forest Service smokejumpers and the smokejumper equipment specialist at the Missoula Technology Development Center (MTDC) were highly interested in the BLM’s developing ram-air program. They observed demonstration drops and some participated in rookie and refresher training.[109] From 1986 through 1989, some Redmond smokejumpers were trained on ram-air parachutes by BLM-Alaska trainers.[110]

Mixed-Load Procedures

One of the foundations of the smokejumper program has been the interoperability of smokejumpers between bases and agencies based on common training and standards. As the BLM began operationally implementing ram-air parachutes in 1983, mixed-load procedures were developed. These procedures enabled smokejumpers equipped with significantly different parachute systems—ram-air and round parachutes—to safely jump in the same planeload.

First Women in Smokejumping

Charlotte Larson and Deanne Shulman became the first female smokejumper pilot and first female smokejumper in 1981, 37 years after the adoption of smokejumping in the Forest Service. Their accomplishments are commemorated in the Smithsonian Air and Space Museum in Washington, DC.

Other significant firsts for women in smokejumping were achieved by Robin Embry and Sarah Doehring. Embry, who started smokejumping in Grangeville, ID, in 1985, became the first woman to retire as a career smokejumper in the fall of 2012, with 27 years in the profession. Doehring, who started smokejumping in Missoula, MT, in 1991, became the first female smokejumper base manager in 2012 at the Grangeville Smokejumper Base.

While procedural details for mixed loads have changed over the years , the topics they address are comprehensive, including spotter training, prejump spotter checks, the number of jumpers per stick, exit techniques, "slap" (signal to jump) procedures, ram-air rigging, dual agency spotting of mixed loads, aircraft considerations, dropping procedures, drop altitudes, exit points, jump list management, and equipment required.

The first use of mixed loads from a Forest Service smokejumper base occurred in 1989 during evaluations at Redmond and La Grande, OR. Procedures have evolved over the decades since they were first used—including some years when the two agencies could not come to an agreement and the use of mixed loads was suspended, limiting smokejumper operations to a single parachute system per aircraft. As of July 2022, mixed loads were still being used by the Forest Service as the remaining round parachute smokejumpers are transitioning to ram-air parachutes.[111]

From 1990 to 1993, BLM smokejumper spotters were required to refresh on round parachutes. In 1993, this requirement was replaced with participation in a round spotter training session conducted by a Forest Service lead smokejumper spotter.[112]

4.5.5. The 1990s

The 1990s averaged 285 smokejumpers per year, with a high of 330 in 1992 and a low of 259 in 1997. This represented a 13-percent decrease in average annual smokejumper staffing over the 1980s.[113]

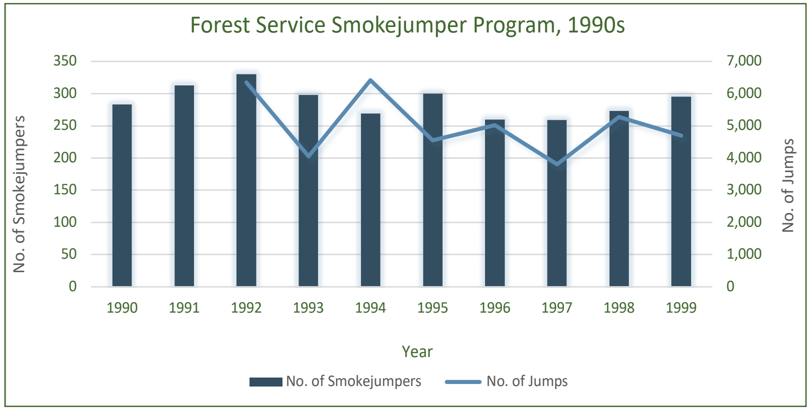


Figure 4.6. Official jumps by Forest Service smokejumpers in the 1990s throughout the United States. Complete summary data not found for 1990 and 1991.[114]

Aircraft in use during the 1990s included the Twin Otter, Volpar, Beechcraft 99, Beechcraft King Air 90, Beechcraft King Air 200, Banderanti, Casa 212, Douglas DC-3/C-47, Basler Turbo BT-67 (turbine engine DC-3), and Short Brothers C-23A Sherpa.[115]

Ram-Air Parachute Training Fatality (1991)

The BLM's experience with ram-air parachutes from 1979 to 1990 had convinced a number of smokejumpers that ram-air canopies offered significant performance improvements over the FS-12, the Forest Service's main parachute canopy then in use. Specifically appealing was the potential for softer impact landings and the ability to jump safely in higher winds, both due to the parachute's unique flight characteristics.

Forest Service smokejumpers detailed to Alaska as early as 1983 often participated in mixed loads with Alaska smokejumpers and had the opportunity to personally see the benefits and complexities of this system. In 1985 a number of Forest Service smokejumper base managers and the Forest Service parachute systems equipment specialist were trained on the ram-air system in Alaska.

Some smokejumpers from the Redmond Smokejumper Base were trained on ram-air parachutes by BLM smokejumpers beginning in 1986, reporting favorable results. With this information, the Northern Region offered ram-air parachute training to some of their experienced smokejumpers in June 1991. The training was conducted by trainers from the BLM and Redmond Smokejumper Base.[116]

During the training, a Forest Service smokejumper squad leader died while making a training jump on a ram-air parachute. The jumper, who had 234 previous static line jumps on round parachutes, was unable to pull the handle to release his main parachute. He deployed his reserve just before impact, but was unable to slow his descent enough to survive the fall. The ram-air parachute evaluation and training work that the Forest Service had been conducting was immediately halted, not to be reengaged until 2008.

The interagency (Forest Service and BLM) accident investigation concluded that for some unknown reason the smokejumper erred in not pulling the handle that would have released his main parachute. The November 1991 Occupational Safety and Health Administration (OSHA) investigation commented that "the head of the agency did not furnish employment which was free from recognized hazards that were likely to cause death or serious harm from the possibility of impact with the ground during evaluation parachute jumps."[117] OSHA formally cited the Forest Service with two willful and five serious violations for an unsafe and unhealthy working environment.

The five "serious" violations were that (1) altimeters were not provided or utilized; (2) the training manual did not cover potential ram-air parachute malfunctions, emergency procedures if a jumper is unable to find or pull the drogue release handle, or proper procedures for a canopy controllability check; (3) parachute equipment safety checks were inadequate; (4) ram-air parachute equipment was not properly set or inadequate, including grommets on the right main riser, 3-ring release riser cable housing assemblies, drogue 3-ring release assembly, plastic snaps on the main and reserve containers, and reserve riser toggles; and (5) properly fitting helmets were not provided (visibility could be obstructed due to movement of the helmet during canopy deployment).[118]

The two "willful" violations were that an automatic activation device was not provided and that "adequate altitude" was not provided during the evaluation jump (they had deviated from the designated altitude of 4,000 feet above ground level (AGL)).[119]

Smokejumper CYPRES 2 automatic activation device (ADD) control unit. Mounted on the reserve canopy, the AAD automatically deploys the reserve if the smokejumper has a vertical speed exceeding 78 mph within an "activation window," which would be 1,200 to 400 feet above ground level for a normal operational jump at 3,000 feet above ground level.[120]

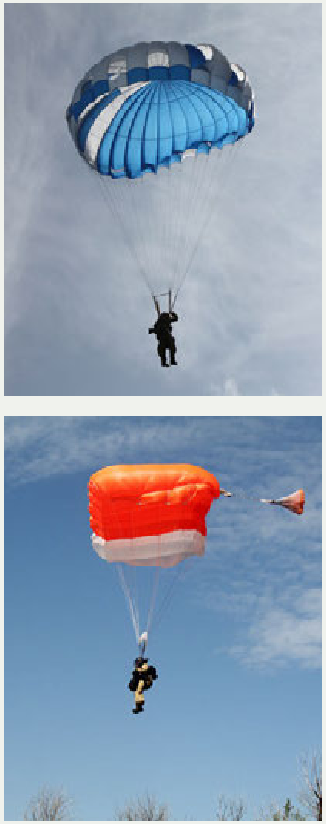
Round or Square—What's the Difference?

There are advantages and disadvantages to both round and square (e.g., ram-air) parachutes.

Round canopies are incredibly reliable and are deployed via a static line, meaning that a rip cord does not have to be pulled by the smokejumper. The static line attaches to an overhead cable, and as the jumper departs the aircraft, the parachute is automatically deployed. According to the Interagency Smokejumpers Operations Guide (2017), the minimum jump altitude for a round parachute is 1,500 feet above ground level.

Since the advent of anti-inversion netting in 1977, the Forest Service has never had a main canopy failure with a round parachute. However, when compared with ram-air parachutes, round canopies have limited steering ability, do not perform as well in high winds, and as a general statement, result in "harder" landings. Round canopies do afford a steeper rate of descent—potentially advantageous in heavy timber with limited open terrain.

Ram-air canopies are rectangular and are actually a parafoil (wing), which means that a smokejumper "flies" the canopy. While it takes more skill to manipulate a ram-air parachute, if properly executed, a softer landing can be the result. Ram-air parachutes require smokejumpers to pull a rip cord upon exiting the aircraft, and as a general statement require more skill to use. Ram-air parachutes also do not require a packing table to be repacked after use and can be repacked in almost any setting. According to the Interagency Smokejumper Operations Guide (2017), the minimum jump altitude for a ram-air parachute is 3,000 feet above ground level.



Historically, round parachutes (top) have been used by Forest Service smokejumpers. The agency began an official transition to ram-air parachutes (bottom) in the 2000s. USDA Forest Service photos.

The Forest Service disagreed with and appealed some of the OSHA findings, but the disagreement soon became moot as the Forest Service proceeded to shut down the evaluation and training with ram-air parachutes. Subsequently, the Forest Service and BLM incorporated most of OSHA's findings into their smokejumper programs—including automatic activation devices (AADs) and better training on possible malfunctions—or the findings were determined to be inappropriate.

Conversion of C-47s and Introduction of C-23 Sherpas (1991)

Having an adequate number of smokejumper aircraft was a challenge in the early 1990s. Aircraft owned by the Forest Service comprised a small part of the overall fleet. Several C-47s were still in the fleet along with a few Twin Otters that the Forest Service owned.

The agency-owned smokejumper aircraft fleet took a dramatic turn for the better in 1991. The newly acquired C-23A Sherpas were deployed, and N142Z, a C-47 known as "Jump 42," returned to service following its conversion to turbine engines.

Since the 1940s, the DC-3 and C-47 had played a huge role in expanding the ability to deliver more smokejumpers in a single flight—in some cases, up to 16 smokejumpers. Originally built in the 1940s, they were unfortunately becoming more difficult to maintain. Stan McGrew—an exceptionally thoughtful and persistent smokejumper pilot in McCall—had an idea.

Basler Aircraft Company of Oshkosh, WI, was converting DC-3s and C-47s to turbine engines and remanufacturing the aircraft to modernize many of its features, offering increased speed, payload, and reliability. With persistence and Washington Office support, McGrew convinced agency leadership that the conversion was worthwhile.

In all, two Forest Service C-47s were converted—N142Z ("Jump 42") based in McCall, ID, and N115Z ("Jump 15") based in Missoula, MT. The turbine-converted C-47s were designated as BT-67s and proved to be superb performers, serving for almost 20 additional years.[121]

While working with the Department of Defense on the Historical Aircraft Exchange Program (see chapter 5.6.2 and 5.6.3), the Forest Service became aware of the Air Force's intent to retire C-23A Sherpas. The Sherpas were built by Short Brothers Aviation in Northern Ireland and were uniquely designed to haul cargo and operate successfully from shorter, nonpaved airfields. Their boxy design provided good internal room for managing cargo.

Built in 1943 as a C-47A, this DC-3/BT-67 (N100Z/N142Z) served the Forest Service from 1970 to 2012 (42 years) primarily as a smokejumping and paracargo platform. In April 1991, it became the first DC-3 in the Forest Service fleet to be converted from piston to turbine engines.[122]

The Forest Service acquired seven Sherpas that were converted to smokejumper aircraft, four for the Forest Service and three for the BLM. The conversion process involved refurbishing the aircraft by installing windows, avionics packages, and equipment to specifically support smokejumper missions, and painting the aircraft in Forest Service livery. The Forest Service initially deployed three Sherpas in 1991, one each to the Redmond, Redding, and Missoula Smokejumper Bases. The fourth Forest Service Sherpa entered service the following year in 1992 at the Redmond base.

The C-23A was designed and built for the military. Attempting to certificate them to civil aviation requirements was costly and would have resulted in a decreased payload, detracting from their primary mission as smokejumper aircraft. Decreasing the payload of the aircraft meant not as many smokejumpers or cargo could be transported during missions.

Left: Short Brothers C-23A Sherpa airplane designated as a smokejumper aircraft, 1991. Photo courtesy of Gordon Harris. Right: Sherpa pilots Shane Bak and Eldon Hatch in August 2015. Photo courtesy of Shane Bak.

The BLM decided to dispose of their three Sherpas, with transfer of the last aircraft occurring in the winter of 1999–2000.[123] The Forest Service continued using theirs through 2019. The Forest Service decided to fly the Sherpas using a public-use designation under Federal Aviation Administration Regulation 91 (FAR 91) for smokejumping and firefighting missions. By keeping the aircraft uncertificated, the non-fire-suppression personnel transport missions that were envisioned when the aircraft were first acquired were not possible. Despite this more limited mission profile, the C-23A Sherpas proved to be an excellent and versatile smokejumper aircraft.[124]

National Smokejumper Association (1992)

In 1992 the National Smokejumper Association (NSA) was established as a nonprofit organization in Missoula, MT, to preserve the history of smokejumping and to provide a voice for its members on issues of interest. Their magazine—initially called *The Static Line* and later changed to *Smokejumper*—is published quarterly and an excellent source of smokejumper history. The materials that the association develops are archived by Eastern Washington University

Smokejumper Seat and Restraint System (1993)

Smokejumpers had been sitting on cargo boxes or on the aircraft floor unrestrained during most smokejumping missions. The combination of a bulky jumpsuit, a main parachute on their back, and a reserve parachute in front made sitting in forward-facing seats either difficult or impossible depending on the aircraft. MTDC smokejumper equipment specialists worked with private industry to obtain smokejumper seats and restraint systems that were eventually adopted by both the Forest Service and BLM for all smokejumper aircraft. This served to reduce the risk of injury to smokejumpers in case of severe turbulence or a crash.[125]

Development of the FS-14 Parachute (1997)

In 1992, after the Forest Service evolution toward ram-air parachutes had been discontinued, the Washington Office issued direction to support the development of "an improved smokejumper delivery system based on state-of-the-art technology." Managers developed dual objectives of achieving a common system between the Forest Service and BLM and identifying specific performance characteristics that were required.[126]

Work from this effort resulted in the adoption of the FS-14 as the primary main canopy parachute for the Forest Service in 1997. The FS-14 replaced the FS-12, which had been used since 1980. It came in three sizes depending on the weight of the jumper: 28, 30, or 32 feet in diameter. The FS-14 was highly stable, allowing quicker flat turns with a forward speed of 10 mph.[127] The FS-14 was perhaps the best-performing round canopy in the world and was adopted by military special forces for use in some of their missions.

4.5.6. The 2000s

The 2000s averaged 299 smokejumpers per year, with a high of 313 in 2008 and a low of 288 in 2006. This represented a 6-percent increase in average annual smokejumper staffing over the 1990s.

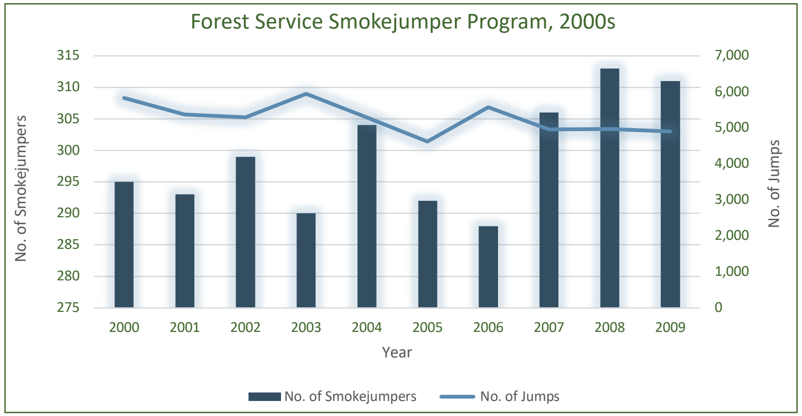


Figure 4.7. Official jumps by Forest Service smokejumpers in the 2000s throughout the United States.[128]

Northern Region Begins Transition to Ram-Air Parachutes (2008)

In 2008, a group of Northern Region Forest Service smokejumper technical experts and MTDC equipment specialists identified objectives for future parachute needs. These objectives included increasing "operational capability" to reduce fire suppression costs. If smokejumpers could staff fires "during more severe environmental conditions," such as in higher winds or turbulence, costs could be reduced by suppressing high-potential fires at the earliest opportunity rather than waiting for more favorable parachuting conditions. Most importantly, their objective was to accomplish this "without increasing and with the goal of reducing the likelihood of serious or minor injuries attributed to parachute landings."[129]

A memorandum of understanding (MOU) was approved between the BLM and the Northern Region "to provide the Northern Region with the necessary expertise to operate ram-air smokejumper equipment safely and efficiently and to establish clear lines of authority and procedures for the Northern Region utilization of the BLM parachute system."[130]

The MOU established a multi-year progression plan with emphasis on development of a self-sufficient ram-air program in the Northern Region. Benchmarks included (1) the ability to approve field rigging supervisors, (2) self-sufficient loft manufacturing and participation in "first article" inspections, (3) initial and refresher training conducted by the Northern Region training cadre, (4) establishing a "ram-air focal point" for the Northern Region, and (5) adequate system equipment inventory, personnel, and oversight to operate independently.[131]

Ten Forest Service smokejumpers were trained in Alaska on the BLM ram-air parachute system in 2008. Their first operational jumps also occurred in Alaska. After additional training in Missoula, they were integrated with BLM smokejumpers in the Great Basin for the rest of the fire season. In 2009, the Missoula and West Yellowstone smokejumper bases sent 12 additional experienced smokejumpers to Alaska for ram-air "rookie" training. BLM smokejumper bases manufactured harnesses and reserve containers for the Northern Region. The BLM also hosted initial parachute rigger instruction with final rigger instruction at the end of ram-air rookie training. The BLM provided ram-air advisors in the form of a spotter and field rigging supervisor to Missoula.[132]

4.5.7. The 2010s to 2021

The 2010s averaged 301 smokejumpers per year, with a high of 328 in 2010 and a low of 287 in 2019, with no significant change in average annual smokejumper staffing over the decade. (The total number per year tends to fluctuate based on the percentage of new hires who are successful during initial training and other administrative factors.)

Aircraft in use during the 2010s included the Basler Turbo BT-67 (turbine engine DC-3), Casa 212, de Havilland DHC-6 Twin Otter, Dornier 228, and Short Brothers C-23A and SD3-60 Sherpas.[133] Tragically, in June 2021, a West Yellowstone smokejumper died after suffering landing injuries while parachuting to a fire in New Mexico.

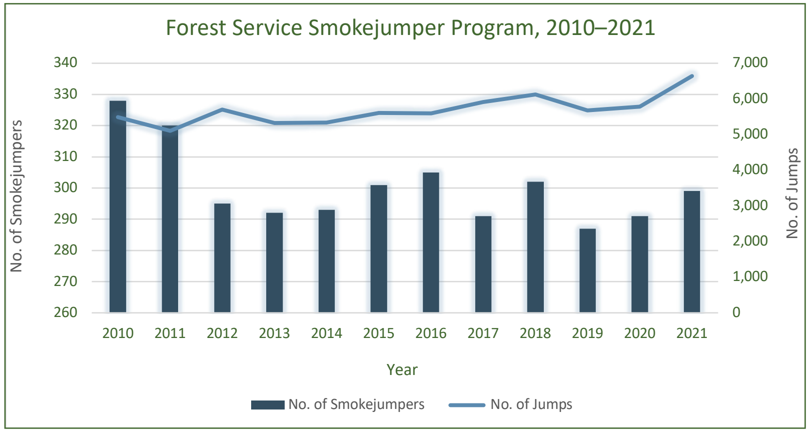


Figure 4.8. Official jumps by Forest Service smokejumpers from 2010 to 2021 throughout the United States.[134]

Aircraft used in the 2010s by the Forest Service for smokejumping include (clockwise from top left) the Casa 212 (photo by Greg Goebel), the Dornier 228 (photo by Gerard van der Schaaf), and the de Havilland DHC-6 Twin Otter (USDA Forest Service photo).

Ram-Air Parachute Risk Assessments (2010)

In 2010, National Aviation Safety Manager Ron Hanks and Northern Region Aviation Safety Manager Gary Boyd led an effort to understand ram-air parachute system implementation from a risk management perspective.[143] They used a Safety Management Systems (SMS) approach to complete two interrelated risk assessments, with Northern Region and BLM smokejumpers as the subject matter experts.

One of these assessments focused on the BLM parachute system in Forest Service operations while the other focused on Forest Service operations in the two systems. Hazards, mitigation measures, and residual risk were identified. The finding was that ram-air parachutes could be safely used in Forest Service operations and that operations using a mix of ram-air and round parachute systems in the same aircraft could be safely accomplished with mitigation measures. This was one of the first uses of the SMS approach to risk management in the Forest Service.

Northern Region Continues Transition to Ram-Air Parachutes (2010–2015)

The Northern Region continued its deliberate move toward canopy transition. The annual transition plan was broken into the following areas: management, training, loft, operations, and integration of Northern Region ram-air smokejumpers into BLM operations. The Northern Region made steady progress qualifying smokejumpers on the ram-air parachute and become more and more self-sufficient each year.

With BLM support, Northern Region ram-air trainers were developed and assisted the BLM in parachute refreshers. Ram-air training for Northern Region smokejumpers was conducted in Missoula. By 2011, Northern Region trainers were able to assume a leading role in ram-air training and the annual detail in Silver City, NM, included ram-air smokejumpers from the BLM. The region had become self-sufficient in BLM system parachute rigging and conducted their own rigger training for Forest Service smokejumpers.

By the end of 2015, 71 Northern Region smokejumpers were using ram-air parachutes. Self-sufficiency had been achieved.[135]

Smokejumper and Smokejumper Aircraft Safety Impact Analysis (2013)

In 2013, the smokejumping community conducted a national safety impact analysis (risk assessment and quality control evaluation) for smokejumper and smokejumper aircraft operations. Chartered by the national aviation safety manager and national smokejumper program manager, the assessment team identified 99 hazards and 158 mitigation measures that when implemented would lower the overall risk level associated with the program. The mitigation measures were prioritized and implemented. The smokejumper community continues to review hazards and mitigation measures often to ensure that mitigation measures are being implemented and to identify and mitigate new hazards as they are discovered.[136]

Smokejumper Base Managers Council (2015)

The Forest Service Smokejumper Base Managers Council was formally chartered in March 2015. The council was created to focus on programwide standardization and ensure mutual support for all smokejumper bases. It also provided a forum for equipment development, interagency cooperation, strategic communication, and leadership for the implementation of SMS.

National Decision to Transition to Ram-Air Parachutes (2015)

The Northern Region had been successfully using ram-air parachutes since 2008, with 71 smokejumpers qualified on the parachute by the end of 2015. Looking to the future, the Forest Service began to consider what the parachute system for the agency should be. Deputy Chief Jim Hubbard issued annual letters authorizing the use of ram-air parachutes by qualified smokejumpers in all regions.

A Forest Service smokejumper training on a ram-air parachute. USDA Forest Service photo by Sam Duffey.

Forest Service smokejumpers, regional foresters, and fire and aviation leaders, along with the National Federation of Federal Employees (NFFE), BLM, National Smokejumper Association, and many other individuals and organizations communicated during preparation for the transition. The overarching principle was to use both the required aviation program analysis and SMS approach to managing a complex organizational change. Major steps in the process included:

- Development of an Aviation Business Case for a parachute systems analysis by the Washington Office Aviation Management Group (2012) and development of multiple briefing papers (2013). The Aviation Business Case developed programmatic alternatives, concluded that the transition to the ram-air parachute was beneficial, and recommended that it be accomplished over a 10-year period.[137]
- A survey sponsored by the NFFE was sent to all smokejumpers (2013) and the results were summarized (2014). Sixty-three percent of the active Forest Service smokejumpers responded—48 percent supported the transition, 14 percent were neutral, and 38 percent were opposed. The results were categorized by base and by years of smokejumping experience.[138]
- Discussions with the BLM to determine their ability and willingness to provide in-person support during the initial phases of the transition (2013). The BLM was enthusiastically willing to help support the transition with the understanding that a point would come when the Forest Service needed to be capable and ready to manage its own ram-air system.
- The Programmatic Risk Assessment and Safety Assurance report for Smokejumper Operations and Smokejumper Aircraft Operations (2013) was reviewed and submitted to the Washington Office for the approval of an implementation plan. The Washington Office elected not to sign the implementation plan but supported implementation of many of the mitigation measures contained in the risk assessment.
- Updating two risk assessments developed in 2010 for the Northern Region ram-air project (2014). These updated risk assessments incorporated the years of experience that the Northern Region had gained since 2008. Four additional hazards were identified in each risk assessment. Mitigation measures were updated and modified as needed.
- Developing a change management and implementation plan (CMIP) (2014–2015). The CMIP documented the transition implementation process. It was never formally signed as the assistant director of aviation at the time was reluctant to pursue increasing personnel ceilings to fully staff the project. This was eventually overcome by using not-to-exceed (NTE) positions and unfilled positions on existing organization charts in the Northern Region. Although the CMIP was not signed, the decision memo of July 1, 2015, said, "A change management and implementation plan will be developed to start transition at the beginning of fiscal year 2016." Annual operating plans were developed each year of the transition beginning in 2016. Key components of the CMIP have been incorporated into these operating plans.

The years of planning, preparation, and communication came to fruition when on July 1, 2015, the decision memo committing the Forest Service to a measured transition to ram-air parachutes was formally signed by Fire and Aviation Management Director Tom Harbour—7 years after the Northern Region had begun training on the square parachutes (see appendix D). The smokejumper program was ready to begin the transition starting in October 2015.

National Transition to Ram-Air Parachute (2015–2022)

Major change is always difficult. The smokejumper program faced numerous challenges as the national transition to ram-air parachutes began. How does a smokejumper successfully switch from a parachute system they have used for years or even decades to a "new" system? And how do they make this change with safety and confidence? How does the program move ahead while continuing to maintain expertise in the previous system and bolster the confidence of round parachute smokejumpers who haven't transitioned to the new system? How do you ensure all smokejumpers are valued regardless of the parachute system they use?

To address these concerns, the smokejumper program used the CMIP process. This process incorporated the knowledge of BLM ram-air practitioners, the experience of the Northern Region's early ram-air adopters, and the concerns and ideas of the rest of the Forest Service smokejumper community. The 4-year result was the "Ram-Air Parachute System Implementation Project Change Management and Implementation Plan." Leader's intent for the project included an emphasis on excellent safety outcomes, maintenance of smokejumper program capability, honoring individual choices of employees to the maximum extent possible, and the importance of monitoring and management support at all levels.[139]

Ram-air parachute systems were seen as a better way to meet the objectives first outlined in 2008:

1. To increase operational capabilities so that fires may be staffed during more severe environmental conditions (winds, turbulence, etc.) thereby reducing fire suppression costs by catching potentially high-severity fires at the earliest opportunity, instead of waiting for more favorable parachuting conditions.
2. To accomplish the first objective without increasing, and with the goal of reducing, the likelihood of serious and minor injuries attributed to parachute landings.[140]

During the 4 years that the smokejumper community had been working on the possibility of a transition to ram-air parachutes, they learned to embrace and understand the processes associated with transition and change management. These processes included assessing readiness for and planning for change, the inevitable phases involved, the need for monitoring, and the role of leaders.

Elements of the national strategy for the transition included:[141]

- Accomplishing the servicewide transition within 10 years.
- Maintaining a predictable, multi-year stream of funding to support the implementation and transition.
- Continuing the use of mixed loads of FS-14 round parachutes and ram-air parachutes until completion of the implementation.
- Qualifying a smokejumper on only one parachute system at a time.
- Ensuring that the national smokejumper operational capability is not diminished during the transition.
- Training experienced smokejumpers on a ram-air parachute system during a 5-week time period.
- Sharing expertise of smokejumpers in the Northern Region with those in other regions.
- Having dedicated transition personnel, including a ram-air parachute system project leader, a project training lead, a Safety Management System (SMS) specialist (safety, quality and safety assurance, data management), and a ram-air parachute system specialist.
- Establishing a Forest Service ram-air parachute systems equipment position at the Missoula office of the National Technology and Development Program (NTDP).
- Developing a national interagency memorandum of understanding (MOU) with the BLM, with annual evaluations.

There are many ways to frame a transition—the one that the smokejumper community adopted is “the transition period begins when people are starting to recognize a change may be coming and ends when the change has been made and everyone is working comfortably again in their positions. It is the time and process by which smokejumper personnel get through the change.” A comment heard at the start of the transition was “Nobody’s transitioned until we’re all transitioned—we’re all in this together.”[142]

The Northern Region’s ram-air project, which began in 2008, was guided by an MOU with the BLM whose employees provided significant guidance and technical assistance. With the decision memorandum of July 1, 2015, responsibility and accountability for the oversight and management of the Forest Service ram-air parachute system was transferred from the BLM to the Forest Service. The Forest Service began developing and documenting direction for their own ram-air system.[143]

With the decision to transition made, leader’s intent established, programmatic objectives defined, and elements of a national strategy developed, the transition was underway. It was guided by an annual "Ram-Air Parachute System Transition Operations Plan" (RAOP), produced by the smokejumper community, and included an after-action review (AAR) of the current year’s efforts and a detailed plan for the upcoming year’s activities. The plan indicated that the BLM and Forest Service smokejumper programs would continue as a partnership with interoperability as a core value, but that each agency would be responsible for its own parachute system. The BLM was willing to assist during the transition, but there were limits to the extent of assistance they would be able to provide.

Acknowledged in the plan was the importance of codifying policy and standard operating procedures, performing an annual AAR, and having adequate funding to support the transition. It was understood there would be an increase in workload and responsibilities at each base during the transition phase.[144]

Oversight for the transition was provided by a Ram-Air Implementation Steering Committee (RAISC) made up of the project leader, two smokejumper base managers, the national smokejumper program manager, an NTDP equipment specialist, a regional aviation officer, and the branch chief of aviation operations. Others served in advisory capacities, including a regional aviation safety manager, an NFFE union representative, and a line officer.

The role of the RAISC was to provide "guidance and oversight for the transition." Another working group was established by the RAISC, the Ram-Air Parachute System Change Management Action Team (RACMAT); however, this group was discontinued at the end of 2018 as its work was duplicative of the RAISC.[145]

New positions were needed to help guide the transition, including a project leader, training lead, and SMS specialist.[146] There was a delay filling all these positions due to the challenges involved in adding positions to the Washington Office organization chart, but with the support of the Fire and Aviation Management director of the Northern Region and a series of temporary assignments and details, the positions were eventually filled. In addition, NTDP was asked to create a new ram-air parachute systems specialist position, which was filled without difficulty.[147]

Based on the findings of the previous year's AAR and the objectives established for the upcoming year to move the program toward a full transition by 2026, each year the RAOP outlined the activities that needed to occur for the transition to succeed. It included a calendar of events and action plan.[148] Base managers and training, parachute loft, operations, and safety representatives from each base participated in development of the yearly plan, proposing and evaluating alternatives with much "give and take."

A constant concern was the pace of the transition—was it too slow, too fast, or on target? Before each yearly plan was finalized, all had to agree that it was achievable and supportable, even though sometimes the options selected weren't everyone's preference.[149] The smokejumper program made great gains as a national program during this period, with individual bases frequently compromising for the common good of the program.

By 2016, objectives and training were designed around two categories of smokejumpers: "rookies" who were new to smokejumping and experienced smokejumpers who were ram-air transition trainees (affectionately known as RATTs). The 2016 RAOP focused on continued training of the 36 ram-air jumpers in the Northern Region and training the first 8 RATTs in the Pacific Southwest Region.[150] So there wouldn't be a degradation of capability, 44 rookies were trained on round parachutes in 2016. This allowed the total number of smokejumpers to stay consistent as ram-air parachute equipment, training, and loft capabilities were developed.[151]

A major effort was made to build ram-air skills in overhead positions—this capacity building paid off in the following years. All agreed that the 2016 year had been highly successful, and a number of lessons were learned that were incorporated into the plan for the following year.[152]

Ram-Air Training Lead Mark Belitz gives instructions to smokejumper rookie candidates with a Short Brothers SD3-60 Sherpa aircraft (N142Z) in background. USDA Forest Service photo.

In 2017, the total number of new ram-air smokejumpers qualified was 62, with 34 of these from the Redding, McCall, North Cascades, or Redmond bases. All bases now had smokejumpers being trained on the ram-air parachute. Trainers from one base trained smokejumpers from other bases, exchanges that led to improvements in standardization. While the number of smokejumpers using ram-air parachutes was increasing as planned, the overall level of complexity was also increasing. All seven smokejumper bases now had jumpers qualified on two different parachute systems.[153]

Ram-air transition trainees (RATTs) getting instruction at McCall, ID, in 2017. USDA Forest Service photo.

During 2018, the BLM's Boise Smokejumper Base trained rookies from the Forest Service's Redding base and shared ram-air gear—this proved very successful and was much appreciated by the Forest Service. No rookies were trained on round parachutes in 2018 and 2019. The SMS specialist and training lead positions were finally filled on a long-term basis, but Project Leader Mike Fritsen retired. An operational pause occurred after an incident.[154]

A governmentwide furlough in 2019 caused delays that resulted in significantly fewer new ram-air trainees than original projections. The Redding and McCall bases both hosted their first ram-air rookie training. Every smokejumper base was able to host their own ram-air refresher training. The strong partnership with the BLM's smokejumper program continued as a BLM smokejumper filled the project leader position on a 120-day detail and the BLM trained two RATTs and assisted in rookie training at McCall and Redding. The project leader position went unfilled, with employees covering the work in an “acting” capacity. At the end of 2019, Smokejumper Program Manager Roger Staats retired after leading the program for 4 years.[155]

The transition progressed throughout 2020 in spite of challenges associated with the coronavirus (COVID-19) pandemic. Travel and intermingling of trainees from multiple bases was rapidly changed to help limit exposure. The Redmond base divided larger training groups into semi-isolated pods and McCall conducted some training modules virtually. Much of the learning and informal quality control that had occurred through in-person interactions and observations was reduced due to reliance on electronic communications. Three rookie smokejumpers at the North Cascades base were trained on round instead of ram-air parachutes to minimize travel and exposure risk.

Staffing the project leader position with 120-day detailers was not optimal and was having adverse effects on employee workloads. These continual transitions and vacancies led to both the project leader and national smokejumper program manager positions being vacant in October 2020. Combining training for rookies and RATTs produced mixed results.[156]

While the pandemic continued to present challenges during 2021, bases were creative in applying the lessons learned in 2020 to accomplish training while limiting interaction and travel for training. A total of 34 RATTs and 35 rookies successfully completed ram-air training.[157] Operationally boosting smokejumpers from one base to another was more limited than usual in 2021. Instead, long-distance dispatches delivering smokejumpers into the working circle of another smokejumper base occurred more frequently. This method minimized the risk of COVID-19 exposure from jumpers stopping at another base. The Redding Smokejumper Base reported seven instances of long-distance initial attacks launched from smokejumper bases outside of California.[158]

Approximately 93 percent of Forest Service smokejumpers were qualified on ram-air parachutes by 2022. In the 7 years since the ram-air transition was formally approved, the smokejumper program had changed significantly. The ram-air transition—combined with an emphasis on SMS and a passion for excellence—resulted in a higher level of technical commonality in the program than ever before.

Personnel transitions are common in the Forest Service, and the smokejumper program is no exception; in the first 7 years since the ram-air transition was approved, there were 3 program managers, 13 individuals occupying 7 smokejumper base manager positions, and 3 individuals serving as the ram-air training lead. The community knows how to adapt.[159]

Figure 4.9 and table 4.1, adapted from the 2022 "Ram-Air Parachute System Transition Operations Plan," show the progression of the ram-air parachute transition.

Smokejumper Fatality on the Ericks Fire (2021)

In May 2021, fire activity throughout the State of New Mexico was already above average. High temperatures and low moisture levels were prompting red flag warnings and the southern half of the State already had three active fires. On May 24, smoke was reported in the bootheel area of southwestern New Mexico. State officials requested smokejumper support from the Gila National Forest.

During the jump, Smokejumper Tim Hart was injured while landing in a sloped, rocky area. Medical response was immediate, with the aircraft dropping trauma gear and his fellow jumpers (including four emergency medical technicians) providing initial care. During the medical cargo drop, aircraft personnel noted the extreme change in wind conditions between the initial flyovers and the cargo drop. Hart was evacuated by helicopter just over an hour later and transported to a hospital. Despite the medical treatment, he succumbed to his injuries and passed away on June 2.

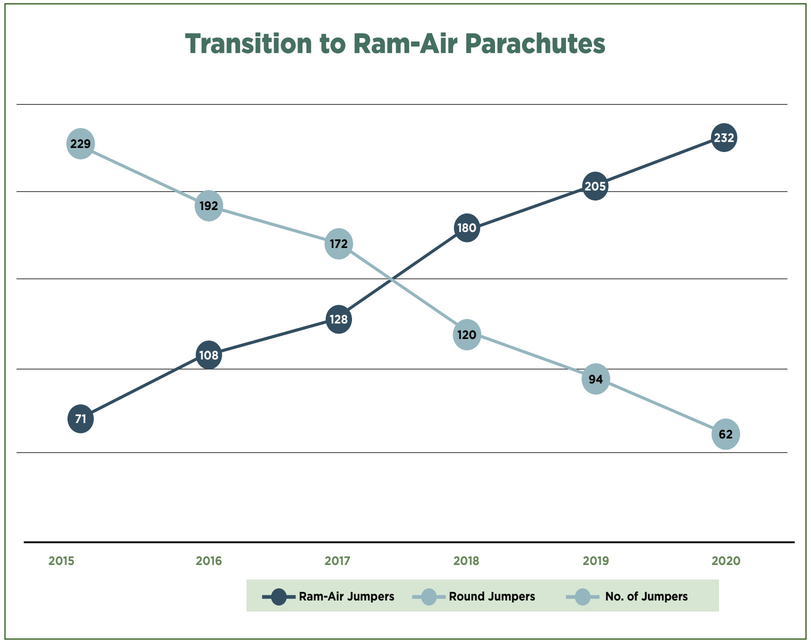


Figure 4.9. From 2015 to 2020, the number of smokejumpers using ram-air parachutes steadily increased as the use of round parachutes decreased.

Table 4.1. Statistics for transitioning from round to ram-air parachutes in 2022, by location

Base	Total Jumpers	Ram-Air	Round	Percent transitioned
Missoula (MSO)	77	75	2	97%
West Yellowstone (WYS)	30	30	0	100%
Grangeville (GAC)	28	28	0	100%
McCall (MYL)	65	60	5	92%
Redding (RDD)	35	35	0	100%
Redmond (RAC)	43	33	10	77%
North Cascades (NC58)	24	19	5	79%
Washington Office	5	5	0	100%
Total	**307**	**285**	**22**	**93%**

4.6. Smokejumper Missions

Smokejumpers excel in all phases of fire suppression. Their unique combination of skills, experience, qualifications, fitness, and "esprit de corps" puts them among the most versatile firefighters in the Forest Service.[160]

The first smokejumpers were experienced "fire guards" who were expected to independently suppress most fires by themselves. Their fire training was standardized in the "Fire Guard Training Handbook" of 1937. With 3 days of formal training and a lot of on-the-job experience, they were ready to take on fires.[161]

As of 1984, Forest Service smokejumpers had executed 100,000 fire jumps. Many of these were traditional two-person jumps to suppress small, lightning-caused fires in remote locations. Some involved many smokejumpers, including a 300-acre fire on the Chelan National Forest in 1945 that had 10 smokejumpers and 100 paratroopers from the 555th Parachute Infantry Battalion. Smokejumpers have been delivered to provide specific skills, including advanced timber felling, wilderness fire monitoring, emergency medical response, and to fill overhead positions.[162]

4.6.1. Firefighting

The day-to-day preparedness for smokejumping is to be ready for an initial attack dispatch with a rapid departure of less than 15 minutes. A typical initial attack involves receiving and confirming the fire location and determining if any special equipment or qualifications are needed.

Once over the fire, the spotter and smokejumper-in-charge select the jump spot. Wind indicators (colored streamers) are released from the planned jump altitude to determine wind direction and speed. The pilot determines the route of flight based on guidance from the spotter, including alignment of the approach to the drop site.

From this point, procedures will vary depending on the aircraft and number of smokejumpers. Typically, the first "stick" of two jumpers will move to the door. When the first smokejumper is in position and the spotter determines that the aircraft is in position and properly aligned with the intended flight line, a sharp slap on the shoulder or leg is the signal to the smokejumper to depart the aircraft. The second smokejumper will receive the signal to jump with at least a 3-second delay behind the first jumper.

After landing, smokejumpers retrieve their equipment and proceed to the fire. If a smokejumper is suspended in a tree, he/she will use their letdown equipment and training to lower themselves to the ground. After dealing with the fire, parachutes are retrieved from trees using tree climbing equipment if necessary.

Once at the fire, a smokejumper's responsibilities are the same as any other firefighter. Demobilization from a fire can be accomplished in a number of ways, including by:

- Pack-out—Smokejumpers carry their gear (100+ lbs.) to the nearest pickup point.
- Longline—A helicopter longline transports most of the smokejumpers' gear to a pickup point; the smokejumpers then hike to the pickup point.
- Pack string—A pack string of horses or mules transports most of the smokejumpers' gear; the smokejumpers then hike to a pickup point.
- Helicopter—A helicopter retrieves the smokejumpers and their gear.
- Vehicle—If a road is present nearby, a vehicle transports the smokejumpers and their gear to their base.

4.6.2. Paracargo

An initial paracargo delivery of equipment and supplies to support smokejumpers usually occurs immediately after they have landed and are ready to receive the cargo. Paracargo is usually dropped from an altitude of several hundred feet. The initial delivery provides enough food, water, and fuel for 48 to 72 hours in most conditions. Most fire cache items can be delivered via paracargo, including water, food, hand tools, chainsaws, crosscut saws, pumps, fire hose, and gas. Paracargo can be used to deliver equipment and supplies to a wildfire regardless of whether it was initial attacked by smokejumpers.

Joint Precision Airdrop System (JPADS)

The Joint Precision Airdrop System (JPADS) allows equipment and supplies to be delivered aerially with a ram-air parachute to ground personnel via an autonomous guidance unit (AGU). JPADS is a relatively new technology to the smokejumper program that helps reduce risk exposure by eliminating the need for low-level flight during cargo dropping. This smart technology can allow up to 1,300 pounds of cargo to be dropped from 3,500 to 24,500 feet AGL with similar accuracy regardless of visibility. The hope is that JPADS can play an important role in delivering medical supplies, resupplying remote spike camps, and saving helicopter flight time. It offers the potential to deliver critical supplies to meet fire and land management objectives when no other means may be feasible due to inadequate visibility.[163]

The Forest Service acquired its first JPADS unit in 2007. The first operational drop was in 2015 on the Bear Lake Fire on the Beaverhead-Deerlodge National Forest in Montana. As of July 2022, all 7 of the Forest Service smokejumper bases have JPADS capability, with a total of 45 units.[164]

Joint Precision Airdrop System (JPADS) landing with 500-lb payload. USDA Forest Service photo by JT Gilman.

4.6.3. Other Missions

Tree climbing skills were an important part of the work of early forest guards who often installed and repaired telephone lines that were the backbone of the communications system before radios were common or portable.

In addition to retrieving parachutes and paracargo hung up in trees, smokejumpers have put their tree climbing skills to other uses, including forest health and wildlife habitat projects.

In the early days, smokejumpers were often the "best hope" that a downed flyer or injured hunter had for being rescued. Medical rescue capability was emphasized at some bases; in some cases they even designated a rescue supervisor position. Equipment to support the mission was developed, including a Stokes litter mounted on a low-pressure airplane tail wheel. In addition, some bases provided parachute training to medical doctors and military air rescue specialists.[165]

Every smokejumper base has smokejumpers with certified skills as timber fallers and buckers, both with chainsaws and crosscut saws. Several of the bases have instructors on their staff.[166] These skills have often been put to unique uses. For example, following Hurricane Hugo in 1989, smokejumper fallers were mobilized to the Francis Marion National Forest near Charleston, SC, to deal with storm-damaged trees.[167]

Prior to helicopters, rescue operations were a significant aspect of the smokejumper program. Rescue stretchers, like the one seen hear near Missoula, MT, circa 1955, consisted of a Stokes litter (a wire basket, conforming to the shape of a human body, into which an injured person could be strapped) mounted on an airplane tailwheel. Courtesy of the National Museum of Forest Service History.

4.7. Partnerships

An incredible number of partnerships and relationships have developed in the over 80 years of smokejumping. Discussions of these are scattered throughout this chapter, located where they fit into the overall story, including Project Fire Fly and the 555th Parachute Infantry Battalion, and the role that Forest Service smokejumpers played in the development of the U.S. Army's Airborne Division.

Other relationships are well-told in *Smokejumper* magazine articles and other media, including the story of Forest Service smokejumpers and their roles in the Central Intelligence Agency and its subsidiaries. This section highlights a few of the notable partnerships.

4.7.1. National Technology and Development Program

Smokejumper equipment specialists at the Missoula Technology and Development Center—now a part of the National Technology and Development Program (NTDP)—have played key roles in the evolution of the smokejumper program. The national smokejumper equipment project leader position began in the 1940s as an additional duty at the Missoula Smokejumper Base and then migrated to the Missoula Aerial Equipment Development Center when it was established in 1953.[168] Later, national smokejumper equipment specialist positions were established to help with the workload.[169]

Ongoing technical support of the smokejumper program is provided through the Smokejumper Technical Services Project at NTDP. Equipment specialists have a wide range of duties, including smokejumper aircraft evaluations, aircraft accessory development, research and development of smokejumper equipment and parachutes, technical drawings of smokejumper equipment, parachute rigging manuals, first-article equipment inspections, and collaboration with the U.S. military and parachute industry. They also maintain databases of malfunction abnormalities, injuries, and proposed projects, and serve on a wide range of subcommittees and councils as both advisory and primary members.[170]

To ensure personnel safety and the interchangeability of smokejumpers between bases and agencies, smokejumper and paracargo equipment and delivery procedures must be standardized and "functional, technically sound, and essential to the task."[171] A formal process for equipment development starts with the Smokejumper Base Managers Council. Serving as an equipment development committee, the council provides input and requests to the smokejumper equipment project leader at NTDP, with the national smokejumper program manager providing direction and serving as a point of contact. Development of equipment that requires significant funding follows a formal equipment development process.[172]

4.7.2. Bureau of Land Management Smokejumper Program

The Forest Service and Bureau of Land Management (BLM) smokejumper programs have been in a partnership since the establishment of the BLM's smokejumper program in 1959. They have operated with the intent of mutual interoperability and with a high level of trust in each other's skills and abilities. While this story is told from a Forest Service perspective, the BLM smokejumper program appears in a number of places as a key contributor and partner with the Forest Service.

4.7.3. National Park Service Smokejumper Program

In 1946 the National Park Service provided funds for a small group of smokejumpers from the Missoula Smokejumper Base to be available for fires in Glacier and Yellowstone National Parks. In 1951 a crew of five National Park Service smokejumpers, selected and trained by the Northern Region, was based at West Yellowstone, MT. In 1965 the Northern Region operated the West Yellowstone Base as an interagency effort, with eight smokejumpers. Cooperator funding for the base came from the National Park Service, BLM, Bureau of Indian Affairs, and Bureau of Sport Fisheries. In 1966 eight smokejumpers were stationed at the West Yellowstone interagency base. The interagency base continued as a partnership with some funding from the National Park Service through at least 1987.[173]

Smokejumper Liaison

Mark Belitz, who served as the national smokejumper program manager for the Forest Service in the early 2020s, recalls his time as a "smokejumper liaison" with the National Park Service: "I was the only NPS-funded smokejumper from 2001 to 2008. I was hired and paid by Yellowstone National Park from 2002 to 2008 (2001 was my 'detailed' rookie year). My title was 'smokejumper liaison.' In the spring of 2008, I was hired by the Forest Service as part of the West Yellowstone smokejumper crew. Brian Hatfield served as the smokejumper liaison after me, but only for one summer; that position has been vacant since."

4.7.4. Canadian Smokejumper Programs

During World War II, Northern Region smokejumpers trained Canadian air observers and air transport command aviators in parachuting. The first Canadian parachute-delivered firefighting force was established in the Province of Saskatchewan in 1947, with support and advice from Northern Region smokejumpers.[174]

In the 1970s an innovative and entrepreneurial company—International Forest Fire Systems, Ltd.—offered both contract smokejumpers and smokejumper aircraft as well as contract rappellers and rappel helicopters to several Provinces. Other contractors continued these services through the mid-1990s.[175]

The British Columbia Forest Service parattack program has been in operation since 1998. The parattack program has interacted with the USDA Forest Service smokejumper program on equipment, training, and other topics.[176]

4.7.5. U.S. Military Branches

The U.S. military branches have been a source of smokejumper aircraft since 1944 when the U.S. Marine Corps loaned a DC-3 to the Forest Service for smokejumper use.[177]

Many other smokejumper aircraft originated with the U.S. military, including many of the Twin Beechcraft aircraft and both versions of the Short Brothers Sherpas. Some of these aircraft were obtained via excess property as authorized by Congress.

There are numerous occasions when the U.S. military has received rough-terrain parachute training from Forest Service smokejumper units. U.S. military units have also used Forest Service smokejumper aircraft as jump platforms to obtain familiarity with other aircraft types.[178]

4.8. Smokejumper Aircraft Makes and Models

Table 4.2 lists aircraft used for smokejumper missions. Not included are aircraft that were tested but never used operationally. Aircraft with the same capacity and appearance may be grouped. Some of the dates (as well as contracted vs. owned) are approximate and/or a best professional estimate.

Major sources include:

- U.S. Forest Service National Smokejumper Training Guide, 2016.
- *The Static Line.* National Smokejumper Association. October 1994, January 1995, April 1995, August 1995, January 1996, April 1996, January 1997, October 1996, and October 1997.
- Personal communication with Bill Meadows, Bill Cramer, and Bill Moody.

Table 4.2. Smokejumper aircraft makes and models

First use	Last use	Make	Model(s)	Owned	Contracted	Engine type	Notes
1939	1941	Stinson	Reliant SR-10	✓		Single	First aircraft ever purchased by the Forest Service; first Lufkin jump; five-place, high-winged, single-engine; used at Winthrop, WA, during the Parachute Jumping Experiment
1939	1969	Ford	Tri-Motor		✓	Multi	Large, slow-flying, high-winged, three-engine (one on each wing and one on the nose), carried 8 smokejumpers and their cargo
1940	1969	Travel Air (later Curtiss-Wright)	6000 6B		✓	Single	The first fire jump was made from a Travel Air[179]
1940s	Early 1970s	Beechcraft	Includes C-45 Expeditor, AT-11 Navigator and E-18[180]	✓	✓	Multi	Low-winged, two-engine, carried 4 smokejumpers and cargo; commonly known as a "Twin Beech," also referred to as a "Twin Beechcraft"
1944	1990	Douglas	DC-3/C-47 Dakota	✓	✓	Multi	Large, low-winged, two-engine, capable of carrying up to 16 smokejumpers
1945	Early 1950s	Noorduyn	UC-64 Norseman	✓	✓	Single	High-winged, single-engine, carried 4 smokejumpers and their cargo
Early 1950s	Late 1950s	Fokker	Super Universal		✓	Single	Used at West Yellowstone, MT
1950s	1960s	Douglas	DC-2		✓	Multi	Similar to DC-3 but slightly smaller, carried 12 smokejumpers and their cargo
1954	1958	Lockheed	Model 18 Lodestar		✓	Multi	High-winged, twin-engine, carried 4 smokejumpers and their cargo
1959	1975	Aero Commander	500B[181]	✓		Multi	High-winged, twin turbine engine,[182] carried 2 smokejumpers
1960	1970	Curtiss	C-46[183] Commando	✓		Multi[184]	Capable of carrying 32 smokejumpers

Table 4.2. Smokejumper aircraft makes and models (continued)

First use	Last use	Make	Model(s)	Owned	Contracted	Engine type	Notes
1960	Early 1970s	Grumman	G-21, Goose		✓	Multi	High-winged, twin-engine, could land on ground or water, carried 4 smokejumpers, used only in Alaska
1960s	1960s	de Havilland	DHC-2, Beaver	✓		Single	High-winged, single-engine, carried 4 smokejumpers; only 1 jump in the Northern Region
Late 1960s	1980s	Cessna	206, Stationair	?	✓	Single	High-winged, single-engine, carried 2 smokejumpers and their cargo
1960s	Unknown	Pilatus	PC-6, Turbo Porter		✓	Single	
1968	Still in use	de Havilland	DHC-6, Twin Otter	✓	✓	Multi	High-winged, twin turbine engines, carries 8 to 10 smoke-jumpers, excellent short takeoff and landing (STOL) aircraft for backcountry airstrips
1972	Early 1980s	de Havilland	DHC-4, Caribou		✓	Multi	High-winged, twin reciprocating engine, rear door exit, capable of carrying 20 smokejumpers, used primarily in Northern Region
1974	Late 1980s	Beechcraft	Super 18, Volpar		✓	Multi	Extended Twin Beechcraft, turbine engines, carried 8 smokejumpers and their cargo
1974	Early 1990s	Beechcraft	99	✓		Multi	Low-winged, twin turbine, fast, carried 6–8 smokejumpers
1974	Early 1990s	Beechcraft	King Air 200	?	?	Multi	Twin turbine, fast, similar to Beechcraft 99 but with a high “T” tail, carried 6–8 smokejumpers and their cargo
1976	1976	Short Brothers	SC-7, Sky Van		✓	Multi	High-winged, twin turbine, large rear exit door
1978	Early 1990s	Beechcraft	90	✓		Multi	Also called King Air 90; low-winged, small twin engine, carried 4 smokejumpers
1981	Still in use	Construcciones Aeronauticas S.A. (Casa)	C-212		✓	Multi	Spanish-built, high-winged, twin turbine engines, large rear opening door (but exits are performed from a side door), carries 8 smokejumpers and their cargo

Table 4.2. Smokejumper aircraft makes and models (continued)

First use	Last use	Make	Model(s)	Owned	Contracted	Engine type	Notes
1983	Late 1990s	Embraer	Banderanti 110		✓	Multi	Brazilian made, similar to Beechcraft 200, twin engines, carried 8 smokejumpers and their cargo
1991	2015	Basler	BT-67	✓	✓	Multi	Turbine engine DC-3. Two agency-owned C-47 air-planes converted to twin turbines; carried 20 smokejumpers at over 200 knots
1990s	Unknown	Cessna	208, Grand Caravan		✓	Single	High-winged, single turbine, tested in 1970s but not completely evaluated until 1999 in Grangeville, carried 6 smokejumpers and their cargo
1990s	Still in use	Dornier	Do 228		✓	Multi	Twin turbine, fast, in-flight door allows speed in excess of 200 knots until time to go into jump configuration, carries 10 smokejumpers
1991	2019	Short Brothers	Sherpa C-23A/330	✓		Multi	"Short Brothers" sometimes shortened to "Shorts;" short-winged, twin-tailed, twin turbine engine, boxy design, side-door exit, carries 12 smokejumpers and their cargo; 30% of lift capacity comes from fuselage; last operational season for the "A" model Sherpas was 2019; sold via auction in 2020; replaced by the "B" model Sherpa SD3-60s acquired via NDAA
2014	Still in use	Short Brothers	Sherpa C-23B+ /SD3-60	✓		Multi	Acquired via NDAA; replaced the Sherpa C-23As
2021	Still in use	de Havilland	DHC-8		✓	Multi	Contracted by OAS for the Alaska smokejumpers
Unknown	Unknown	Stearman	Model 75, Kaydet		✓	Single	Low-winged, twin turbine, fast, carried 6–8 smokejumpers

NDAA = National Defense Authorization Act; OAS = Office of Aircraft Services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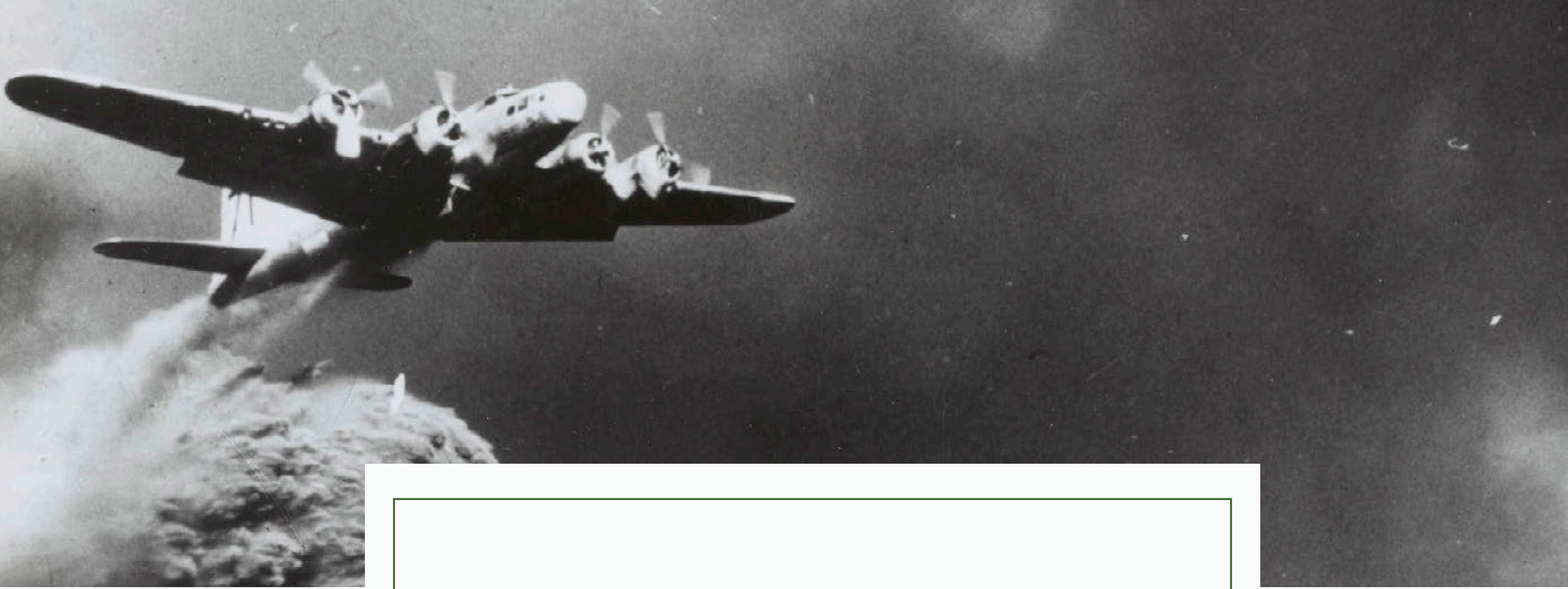


Above: A B-17 drops retardant on the Tool Box Fire on the Silver Lake District, Fremont National Forest, OR, in 1966. USDA Forest Service photo.

Opposite page: A very large airtanker drops retardant on the Cedar Fire on the Sequoia National Forest, CA, in 2016. USDA photo by Lance Cheung.

CHAPTER 5

AIRTANKERS

5.1. Significant Events

1953—Douglas DC-7 demonstrates successful 1,300-gallon free-fall of water.

1954—Operation FIRESTOP evaluates aerial attack systems including water and retardant.

1955—First water drops on a fire by Pilot Vance Nolta, flying a Boeing Stearman 75 (Mendenhall Fire).

1956—First airtanker squadron (seven airtankers) centered in Willows, CA.

1956—First airtanker contracted, a Naval Aircraft Factory N3N-3, tail number N45084, from Jensen Flying Service, Sacramento, CA (now in the Pima Air and Space Museum in Tucson, AZ).[1]

1957—Twenty-six airtankers operating in California.

1957–59—More aircraft models are converted to airtankers.

1960—The largest airtanker is now 2,000 gallons.

1958–60—At least 11 airtankers crashed resulting in the death of at least 17 pilots.

1963—At least 96 aircraft configured as airtankers.[2]

1964—Regional airtanker program era begins with all regions in the lower 48 States having contracts for airtankers.

1968—Forest Service study establishes intent for all airtankers to be multi-engine.

1968—Study of the first 12 years of airtanker use determines 79 percent of all drops to be probably or definitely effective.

1971—First use of Modular Airborne Firefighting Systems (MAFFS) on Romero Fire, Los Padres National Forest in California.

1972—Airtanker Screening and Evaluation Board created.

1974—National airtanker program era begins with the first national contract.

1974—Forest Service Chief approves the National Aviation Plan, establishing the "Washington Office Aviation Service Center" at BIFC (renamed to NIFC in 1993).

1978—Grant of Exemption 392 revision addresses procedures for dropping retardant in FAA-designated congested areas at less than 500 feet elevation.

1983—Operational retardant evaluation (ORE) study begins.

1987—C-119s grounded.

1987—Historical Aircraft Exchange Program (HAEP) begins with the acquisition of 28 C-130As and P-3As for airtanker contractors.

1988—ORE study concludes.

1990—Office of General Counsel determines Forest Service lacks authority for HAEP.

1990—First airtankers from HAEP on contract.

1991—Last HAEP exchanges completed.

1994—C-130A crash due to an in-flight structural failure en route to a CAL FIRE incident.

1995—National Airtanker Study (NATS) begins and Phase 1 is completed.

1996—NATS airtanker schedule of items implemented in contract.

1996—NATS Phase 2 completed.

1996—Participants in HAEP indicted.

1997—Participants in HAEP convicted.

1999—Interagency implementation plan for NATS 2 approved.

2000—HAEP convictions overturned because of errors in instructions to trial jury.

2002—Forty-four bid items on national airtanker contract, two are exclusively BLM and six are paired with BLM.

2002—A C-130A and PB4Y2 and their crews are lost in accidents due to aircraft structural failures.

2002—Blue-Ribbon Panel reviews Forest Service aviation program and issues findings.

2003—C-130A, PB4Y2, DC-6, and DC-7 are decertified as federal airtankers.

2003—Forest Service sued regarding the environmental impact of aerially applied retardant.

2006—First very large airtanker (VLAT) utilized, T-910, a DC-10 from 10 Tanker.

2009—National Interagency Aviation Strategy (updated) is approved.

2011—First "next generation" airtanker on contract, Tanker 40, a BAe 146 from Neptune Aviation.

2011—Forest Service completes action directed by the U.S. District Court regarding the environmental impacts of aerial-applied retardant.

2011—Last of the exchanged turboprop airtankers retired.

2011—Termination of Aero Union's contracts due to not meeting |airworthiness requirements.

2011—Programmatic risk assessment completed for large airtankers and airtanker bases.

2012—Programmatic risk assessment completed for water scooper operations.

2012—Forest Service Large Airtanker Modernization Strategy finalized.

2014—Seven C-130Hs are "bailed" to the Forest Service from the Coast Guard.

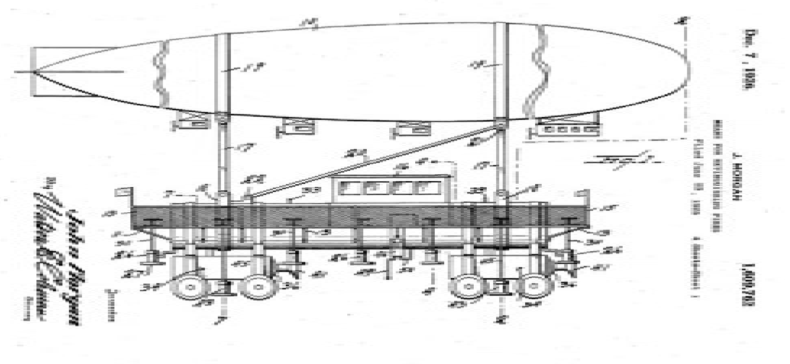
2018—Conversion of seven transferred C-130s is discontinued; aircraft are "bailed" to CAL FIRE.

2018—Aviation Strategy Implementation 2018-2022 projects continued development of "next generation" airtankers.

5.2. Background—Why Airtankers?

Suppressing wildfires by direct attack from the air was an idea that had fascinated both forester and layperson alike since the early days of flight. But numerous difficulties had to be overcome before the idea could become a reality: finding aircraft with adequate capacity; developing effective suppressants to drop; developing effective tanking and gating systems; recruiting pilots who could accurately perform the drops; and, most importantly, determining how to make these drops with a high level of safety.

Early proposals were made for a variety of approaches that sound strange today, including sending an airplane up with a load of common salt to be sprinkled on clouds in the fire area with the hope of producing rain. In 1911, the Forest Service tested carbon tetrachloride as a suppressant, deciding it had no superiority over water in forest fire control. (Formerly used in fire extinguishers and as a precursor to refrigerants, this colorless liquid has since been phased out because of environmental, health, and safety concerns.) The Forest Service rejected a 1919 proposal that recommended dropping gas bombs on fires.[3] At least three patents were awarded to inventors in the 1920s for aerial suppression systems—one was called a “fire prevention and extinguishing composition” and used a telescope as an aiming device for the pilot. The other two were balloons that either dropped or pumped water, one from a fire engine suspended beneath the balloon.[4]



Drawing from United States Patent Office, No. 1,609,762. “Means for Extinguishing Fires” patented by John Morgan of Scranton, PA, on December 7, 1926. Application filed June 23, 1925. Serial No. 39,118. Sheet 1.[5]

5.3. Initial Testing

Some highly experienced leaders in the Division of Fire Control—who had their own visions for how aircraft could contribute to direct attack on wildfires—tested their own best ideas.

In 1930, at Felts Field in Spokane, WA, Fire Control Director Howard Flint (Northern Region) dropped beer kegs filled with water from a Ford Tri-Motor flown by Nick Mamer. They also extended a hose from the aircraft to see if water could be applied to the fire that way. Neither idea was successful—the beer kegs shattered and the hose dissipated water into the air with very little reaching the ground.[6]

In February 1937, the Physics Department at the University of California conducted a theoretical study to determine the efficacy of free-flowing water drops. Their study concluded that “the slip steam effect of a moving airplane would so break up a falling column of water so that none could effectively reach the ground.” This conclusion put a damper on the development of direct aerial attack systems for a number of years as field tests had not yet been able to disprove the research conclusions.[7]

5.3.1. Aerial Fire Control Project (1935–1939)

At the 1936 Spokane Fire Control meeting, a decision was made to conduct experiments in the feasibility of dropping "fire retarders" from aircraft on small fires. Individual projects were assigned to the organization thought best able to handle them. The investigation of foams was assigned to the Division of Fire Control, and that of chemicals to the Forest Products Laboratory in Madison, WI.[8]

The direct attack phase of the Aerial Fire Control Project occurred from December 1936 to June 1939. Its purpose was to develop techniques for dropping fire suppressants with accuracy and in sufficient concentration to hold small forest fires to the smallest possible size, pending arrival of ground crews.

Tests were conducted in the area of Oakland, CA.[9] A Travel Air airplane leased from Duck Air Services in Oakland was used in the initial tests.[10] A wide variety of chemicals and foams were tested, and the conclusion was that "most of these chemicals have corrosive action and handling them around aircraft presented problems. In general, then, water was found to be as effective for practical reasons as any of the retardants tested."[11]

Loading two 10-gallon "can bombs" filled with foam chemicals on the bomb rack of a Travel Air 5-6000-B, California, 1937. USDA Forest Service photo by W.I. Hutchinson.

The conclusion was that new chemicals should be researched, more efficient equipment devised, and new tactical methods for direct aerial firefighting developed.[12] The first aircraft owned by the Forest Service, a Stinson Reliant SR-10, was acquired in August 1938 and flew some of the tests. The direct attack program was determined to be unsuccessful in the summer of 1939 and the Stinson Reliant was transferred to the Pacific Northwest Region for the Parachute Jumping Experiment.[13] No further activity on dropping suppressants from aircraft took place in the United States until after World War II.[14]

Purchased in 1938, the first Forest Service airplane was a Stinson Reliant SR-10. It was eventually traded to the Civil Aeronautics Administration in 1941 for four Piper Cubs. Photos taken in California in 1938. Forest History Society photos.

5.3.2. Post-World War II (1947–1953)

The conclusion of World War II resulted in the availability of faster and larger capacity aircraft, facilitating continued exploration of this technology. Major testing of "aerial bombing" (dropping bomb containers of water) on forest fires was conducted in 1947. By this time, David P. Godwin was the Director of Fire Control and had been personally involved in the successful Parachute Jumping Experiment, which had led to the smokejumper program. Surely the first effective airtankers couldn't be too far behind?[15]

Using a cooperative agreement between the U.S. Army Air Forces and Forest Service, experimentation began in June 1947 with a variety of aircraft and bomb types at Eglin Field in Fort Walton Beach, FL. The experiments were then moved to Great Falls (MT) Air Force Base (renamed to Malmstrom Airforce Base in 1955) where they tested dropping fused bombs designed to burst in the air and disperse chemicals, water, or both onto fires. The final phase of testing occurred on three national forests in western Montana. Initial results indicated that better ordinance design was necessary for the B-29s (the bomb container used didn't work well for fire suppression) and that the P-47 was effective. Plans for a major test expansion in 1948 were then cancelled due to lack of funding.[16]

In late 1953, during a test flight of the prototype Douglas DC-7, the crew jettisoned 1,300 gallons of ballast water from an elevation of approximately 500 feet. The water was spread over "about 1 mile in length and over 200 feet in width." The water remained on the ground for 10 minutes despite a temperature of 106 degrees Fahrenheit and relative humidity of four percent. The Douglas Aircraft Company realized the firefighting potential and offered up the aircraft for testing. The subsequent "Aerial Delivery of Water Experiment" conducted by the Los Angeles County Fire Department, California Department of Forestry, USDA Forest Service, and Douglas Aircraft Company took place on December 2, 1953.

Drops were made from a DC-7 carrying six 400-gallon ballast tanks, with three 6-inch diameter dump valves. Four courses were laid out with fuel moisture content measuring devices, hydro-thermographs, and test fires. Dropping 400 gallons at a time from varying altitudes from between 150 and 600 feet, the drops showed no appreciable effect on the test fires and no great concentrations of water on the ground. However, for the first time, it was concluded that "free-falling water dropped from a low flying aircraft will reach the ground."[17]

Now the idea of a workable airtanker seemed within reach. Water could be dropped from a fixed-wing aircraft with enough quantity to wet fuels. Now was the time for a thorough test of the newfound possibilities.

Example of a Douglas DC-7, American Airlines, year unknown. Built from 1953 to 1958, the DC-7 was the last major piston-engine airplane made by the Douglas Aircraft Company. American Airlines ordered 25 airplanes at a price of $40 million, which covered development costs. American Airlines received its first DC-7 in November 1953, inaugurating the first nonstop coast-to-coast service in the country (taking 8 hours).[18]

5.3.3. Operation FIRESTOP (1954)

Operation FIRESTOP—in all capital letters in the literature of the day—was a cooperative effort to make exploratory studies in two research areas: (1) civil defense against fire and (2) reduction of loss from large wildland fires through the development of new or unconventional fire control measures. It was designed as a 1-year operational study with a 3-month field test program ending July 1, 1955. This chapter focuses on the portions of the project related to "fire retardant studies" and "application technique studies."[19]

Cooperators for Operation FIRESTOP included a myriad of partners providing either labor, equipment, and/or facilities for the project. Cooperators included the Forest Service (including the California Forest and Range Experiment Station and Arcadia Equipment Development Center), California Department of Forestry, Los Angeles County and City Fire Departments, and Pacific Intermountain Association of Fire Chiefs.[20]

The fire retardant studies in Operation FIRESTOP resulted in significant conclusions. It was found that readily available chemicals could be applied in a water solution on forest fuels to make limited quantities of water go farther and to extend the amount of time that prewetting vegetation was effective. The flanks and rear of a fire, and sometimes even the head, could be stopped by a chemical fireline. A hot fire in heavy brush would often drop out of the crowns when it hit chemically treated fuels, plus its rate of spread could be reduced by as much as 50 percent. It was determined that chemical firelines could be put in by aerial application, but that they had to be applied at rates varying from 4 to 10 pounds per 100 square feet of treated fuel and would still require conventional mop-up and patrol work.[21]

The application technique studies in Operation FIRESTOP were largely concerned with aerial delivery of water and other retardants. A TBM-1C Torpedo Bomber, N9394H, operated by Paul Mantz Air Services dropped 600 gallons of water during the testing process.[22] The result was described as a "heavy drench," 50 by 270 feet in size.[23] The same airplane made two drops on the Jamison Fire on September 1, 1954, with no results recorded.[24] Also tested were drops by Sikorsky S-55, Hiller 12B, and Bell 47 helicopters using a small "hook-on" helitanker unit.[25]

Operation FIRESTOP demonstrated that under certain conditions suppressants could be beneficial to fire control efforts and that fixed- and rotary-wing platforms could deliver them. Determining this under research conditions was a huge hurdle, but the challenge of developing an actual airtanker program was just beginning.

5.4. Program Implementation—The Early Years (1955–1963)

The first chemical used in air attack work was sodium calcium borate, developed and marketed by the U.S. Borax Company in 1954 as "Firebrake." Four to five pounds of borate mixed with one gallon of water produced "a heavy, white, sticky, fire-resistant liquid" which was claimed to "pre-treat brush and wood for 8 to 10 hours."[26]

Creating a workable airtanker with skilled pilots who could accurately drop retardant was a collaboration between Fire Control Officer Joe Ely from the Mendocino National Forest and Floyd and Vance Nolta, operators of Willows Flying Service in Willows, CA. Ely was motivated to find better methods of fire suppression following the 1953 Rattlesnake Fire where 15 firefighters were killed.[27] Ely was impressed with the precision of agricultural aerial applicators. Preliminary trials were made at Willows Airport in August 1955 with drops of 125 gallons of water or 100 gallons of borate. The tests were conducted at 80 mph and at 30 feet of altitude. The result was a coverage area of 20 by 600 feet.[28]

Left: Joe Ely (left), Floyd Nolta (center), and Forest Supervisor Bob Dasman (right) pose for a photo in front of Nolta's Boeing Stearman that was converted to drop water on fires. Mendocino National Forest, CA, 1956. Right: Stearman airtanker dropping 100 gallons of borate on the Inaja Fire on the Cleveland National Forest, CA, 1956. Forest History Society photos.

The first operational airtanker was a Stearman 75, PT-17 Kaydet (N75081) flown by Vance Nolta. It is credited with the first airtanker drop on a wildfire on August 12, 1955. It dropped six loads of water on the Mendenhall Fire on the Mendocino National Forest in California, significantly contributing to suppression of the fire.[29]

Another first in 1955 was the work of Fire Staff Officer Bob Beeman on the Wenatchee National Forest and the Wenatchee Air Service that resulted in the testing of a Piper Super Cub with a 100-gallon tank and wing-mounted spray bar. On July 23, 1955, the Super Cub was used on a cheatgrass and sagebrush fire, slowing it enough for ground crews to control it at 55 acres."[30]

The Forest Service and California Department of Forestry worked together throughout the early days of the airtanker program, collaborating on aircraft design, development, and operation.[31]

The first airtanker "squadron" was formed in August 1956—it was comprised of four Stearman PT-17s and three Naval Aircraft Factory N3Ns from local agricultural aerial applicators in the Willows-Red Bluff area. N75081 was designated as "Airtanker 1." The cost for the squadron to be available for fire duty (standby) in 1956 was $4,000 (or slightly over $40,000 in 2022 dollars).[32] The squadron worked on 25 fires, dropping water on 21 and borate on 14, with loads ranging from 100 to 150 gallons. Air attack was credited as a deciding factor on 20 of the 25 fires. Based in northern California, the squadron was dispatched south to fight the Inaja Fire on the Cleveland National Forest in November. In its first use outside of northern California, the squadron made over 1,000 drops, resulting in the most publicity the fledgling airtankers had yet received—Los Angeles newspapers called them the "borate bombers."[33]

Plaque at the airport in Willows, CA, honoring the early history of the airtanker program.

After making 1,350 drops totaling 83,120 gallons of water and 65,990 gallons of fire retardant, many conclusions were drawn from the airtanker squadron activities in 1956. It was determined that airtankers could:

- Hold a small fire until initial attack forces arrive.
- Cool hotspots so firefighters can enter the area and work safely.
- Knock down spot fires.
- Build a fire-retardant line with borate in advance of a fire or where firefighters cannot work.
- Reduce the probability of crowning.
- Strengthen existing firelines.
- Directly support ground forces actively engaged in line construction.
- Fire-proof areas where spot fires are probable, such as exposed slopes in steep canyons.

And that airtankers could not:

- Knock down hot, rolling brush or timber fires.
- Safely make drops in high winds over 30 mph.
- Make drops in the bottoms of steep canyons or other inaccessible places.
- Cool down hot fires in heavy fuels under timber stands.
- Work at night.

Pilot specifications were established as: (1) at least 1,000 hours of flying time, including either 500 hours of agricultural flying or 200 hours of spraying, cargo dropping, seeding, baiting, fish planting, or similar low-level mountain flying experience; (2) completion of a performance test with a series of water drops in various maneuvers—at least five drops before a pilot is allowed on a fire; and (3) a 1-day pilot training program each spring or early summer to familiarize new pilots with operational procedures and firefighting tactics.

Procedures for pilots were established as: (1) checking the air hazard map, (2) making a dry run, (3) watching visibility, and (4) using visual signals (when radio communications fail).[34]

The lessons learned became the initial standards for the development of the fledgling airtanker program. The Forest Service and California Department of Forestry were proceeding in alignment on implementing this new firefighting resource that offered so much promise. For his ideas that led to the development of the first operational airtankers, Ely received a cash award of $100 (which equates to about $1,020 in 2022 dollars)—rumor has it he "spent the money at a tavern buying drinks for the pilots." [35]

In late 1956, the Forest Service acquired eight TBM-3Us from the U.S. Navy, which became N102Z through N109Z. After testing a series of tanks in TBM-3Us and a Consolidated PBY-6A Catalina, a design was developed and shared with operators for a 600-gallon tank in the TBM-3U and a 750-gallon tank in the PBY-6A. These Forest Service designs were appreciated by the contractor community and gave them a clear idea of what the Forest Service wanted in tanking systems.[36]

Navy TBM-3U aircraft freshly overhauled and delivered to the Forest Service for evaluation as a firefighting airtanker. Photo was taken prior to testing at Concord, CA, in December 1956. Photo by Bill Larkins.

An era of development and improvement was underway. Operators were eager to provide airtankers. Two of the original squadron operators converted Beechcraft AT-11 twin-engine aircraft for retardant operations, creating the first "heavy" (large) airtanker.[37]

As the number of airtankers grew, the Arcadia Fire Equipment Development Center was engaged in multiple projects supporting the development of retardants, delivery systems, and airtanker bases.[38]

From 1956 to 1957, the total number of airtankers used in California increased from 8 to 26, necessitating an urgent need for a system of aircraft identification. A system was formulated in March 1957 for the first time by the Pacific Southwest Region as follows: "Numbers will be assigned by the Forest Service (1–50 for northern California and 51–99 for central and southern California)." [39] This was the first of many initiatives that led to national standards for airtanker numbering, crucial for facilitating movement between Forest Service regions. Each region was assigning their own numbers and duplications began to appear, making it necessary in 1962 to add an identifying letter to designate the region in which the aircraft was under contract. Letter designations were "A" through "F" for the Northern, Rocky Mountain, Southwestern, Intermountain, Pacific Southwest, and Pacific Northwest Regions, respectively.[40]

In 1957 Ford Tri-Motors were used to drop borate in the Northern and Intermountain Regions with loads of about 500 gallons with excellent success.[41] Modeled after successful efforts in Canada, experiments were carried out by the Forest Service with several float-based aircraft, including the Noorduyn Norseman and de Havilland Beaver at Ely, MN, in 1957, 1958, and 1961.[42] By 1961 de Havilland Beavers were considered effective as water droppers on the lake country of the Superior National Forest. In comparative tests with a Stearman, water drops from a Beaver covered five times the area.[43] Experimentation with a Grumman F7F Tigercat was conducted in Salem, OR, in 1958, leading to successful development of a tank holding 500 gallons that was a precursor of the modern belly tank.[44]

TBM airtanker flying over a dozer on the Cleveland National Forest in the late 1950s. Courtesy of the National Museum of Forest Service History, Harvey Mack Collection.

A year of rapid operational development occurred in 1959. A trend toward former military aircraft began with the introduction of the F7F (750 gallons), B-25 (1,000 gallons), and PB4Y-2 (2,000 gallons). The large capacity of the PB4Y-2 offered a new and exciting opportunity in aerial firefighting.

Four Forest Service TBMs (600 gallons) were used "to set standards, develop techniques, and provide leadership"—the start of the Forest Service airtanker testing and approval process that is the industrywide standard today. Private operators became interested in switching from lighter aircraft to TBMs. With its capacity and durability, the TBM became the aircraft most used for firefighting and the primary airtanker used in the United States for the next 10 years.[45]

In 1959 bentonite was introduced as a retardant—it was considerably less expensive than borate, but only effective for 2 to 3 hours. Bentonite is colorless, so a pink aniline dye was added so pilots could see their drop patterns and where they had left off on previous drops. Because high concentrations of borate were determined to temporarily sterilize soil, other mixtures were tested in pursuit of an effective, less toxic, and less expensive retardant.[46]

TB-25N

AIRTANKER
FLIGHT EVALUATION

Left: Former TBM torpedo bomber releasing retardant on a fire on the White Mountain National Forest, NH, in 1959. Forest History Society photo. Right: Cover of the agency's "TB-25N Airtanker Flight Evaluation" report. Test results indicated that it was unsatisfactory for use as an airtanker.

In 1960, several AJ-1s were developed as 2,000-gallon airtankers with the ability to cruise at 230 knots, making them a good candidate for long-distance fire response. The Douglas B-26 (1,200 gallons), Lockheed PV-2 (1,200 gallons), and a Douglas SBD/A-24 were also used this year.[47]

While a great deal of progress had occurred in the development of the airtanker fleet, none of the aircraft being flown had been designed for the airtanker mission and problems were occurring—some of them resulting in tragic losses. Two fatal accidents occurred in July 1960 involving an overload structural failure of a B-25J, leading to its grounding as a firefighting aircraft in California. This led to a series of flight tests at Edwards Air Force Base using a TB-25N acquired by the Forest Service. Test results indicated that the TB-25N was unsatisfactory for use as an airtanker because "it cannot accomplish a mission with any degree of safety."[48]

Agency-owned TBMs were thoroughly tested at Edwards Air Force Base in 1961. With the knowledge developed through rigorous testing, TBMs were retained for most of the next decade with modifications and imposed speed limits.[49]

The era of the agricultural airtanker was coming to an end in California. With its millions of acres of mountainous terrain, the Pacific Southwest Region began to require primarily multi-engine airtankers in 1962. This led to large-scale conversion of B-17s to airtankers. Not long afterward, airtanker pilots were required to attend Forest Service schools and acquire a Forest Service airtanker pilot rating that was upgraded based on experience and demonstrated ability. An instrument rating—something an "ag" pilot had never needed—became mandatory.[50]

An airtanker drops borate on a fire in the Wenatchee National Forest, WA, in August 1970. USDA Forest Service photo by Jim Hughes.

The 1963 regional airtanker lineup reflected the incredible growth of the fleet, diversity of aircraft, and demand for aircraft to drop fire suppressant as an aid to firefighters on the ground. Historical airtanker information was found for four regions:

- Southwestern Region—10 single-engine and 8 multi-engine airtankers
- Intermountain Region—13 single-engine airtankers
- Pacific Northwest Region—27 multi-engine airtankers
- Pacific Southwest Region—6 agricultural, 12 single-engine, and 20 multi-engine airtankers

That was a total of 96 airtankers in 1963, not including others that had been "prequalified" in case of a fire. The California Department of Forestry had additional airtankers on contract.[51]

Naval Aircraft Factory N3N-3 Yellow Peril, N45084, cited as the first contracted Forest Service airtanker. Delivered to the U.S. Navy in 1941, it was sold to Jensen Flying Service in the 1950s and modified for use as an airtanker. It is currently on display at the Pima Air & Space Museum in Tucson, AZ. Pima Air & Space Museum photo by Scott Youmans.

From a squadron of 8 in 1956 to a fleet of at least 96 aircraft only 8 years later, the airtanker had found its place in fire suppression operations. The agricultural fleet had been surpassed by larger, faster, and more capable aircraft and, to an increasing extent, twin-engine airplanes. Airtankers were here to stay.

5.5. Regional Program Development (1964–1973)

By 1964 most regions had "solid contractual arrangement[s] with reliable operators"—in fact, every Forest Service region except Alaska had contracted for airtanker services. Some operators on the west coast contracted in the south and northeast, showing their willingness to pursue work a long way from home. Operators had demonstrated an ability to follow regional fire seasons around the country—something that would become common practice in later years.[52]

Regional contracting for airtanker services was a complex task that evolved significantly from 1964 to 1973. In responding to Congress on the practices of the time, Max Peterson (Chief of the Forest Service from 1979 to 1987) said, "We could not meet the requirements of the sealed bid process; therefore, we negotiated with the operator who was located at an airfield where we wanted coverage." According to Chief Peterson, this became known as the "resident base operator" concept and was done "with the knowledge and consent of the U.S. Comptroller General."[53] Operators with established bases where the Forest Service wanted airtanker services were essentially guaranteed contracts to the exclusion of nonresident operators.

Each region pursued its own path in contracting for airtankers. Airtanker sizes and specific equipment were established and documented in the development of each region's contract specifications. In the Pacific Southwest Region close ties were maintained with the California Department of Forestry, with specifications being coordinated and initial attack dispatching zones being developed and published.[54]

One idea from California was to install a siren in airtankers to warn firefighters of an impending retardant drop. This idea began in 1964 in conjunction with the California Department of Forestry and was later adopted by many, but not all, of the regions.[55]

A 5-year study published in 1968 summarized the first 12 years of airtanker use, citing that more than 45 million gallons of water and fire retardant had been dropped. Of the 992 drops evaluated, 79 percent were determined to be probably or definitely helpful in meeting fire control objectives. Retardant was found to be more effective on smaller fires. The study indicated that a careful analysis of the particular situation should guide the decision to use retardant—including whether the drop was actually needed for control and the probability that it would accomplish the intended result. Aerial supervisors performed a key role in this decision-making process.[56]

After a 1968 study recommended that all Forest Service airtankers be multi-engine aircraft, a transition to multi-engine leadplanes and airtankers occurred in the early 1970s. In a decentralized aviation program, a change of this magnitude took some time to implement and the Forest Service contract airtanker fleet was completely multi-engine by 1974.

The TBM fleet of airtankers was important for the Forest Service and the mainstay of the California Department of Forestry—however, by 1970 serious concerns were being raised about their maintainability and associated accident rates. The red flags continued with three TBM accidents in 1973 and three F7F accidents in 1974. This encouraged the California Department of Forestry to pursue the Grumman S-2 Trackers with the assistance of the Forest Service through the Federal Excess Personal Property (FEPP) program. The S-2 became the primary airtanker flown by the California Department of Forestry with the first airtanker conversions entering service as S-2As in 1974.

By 1971 the regions were contracting for at least 44 total airtankers—not including information from the Intermountain and Pacific Northwest Regions.[57]

Notes from the 1971 national fire policy meeting and 1972 national fire chief's meeting indicate that aviation management issues—including safety—were being actively discussed by the Chief, national fire director, regional foresters, and other senior leaders. The decision was made to "complete and implement a national air plan" and to "resolve the issues and reach a decision on (a) national air center."

An audit of Forest Service air operations by the USDA Office of Inspector General (OIG) in 1973 determined that "the management functions of air operations were excessively decentralized" and that "the result was nine autonomous operations, some of which did not provide maximum efficiency, economy, or safety." The regional airtanker programs were a prime example of this decentralized management structure. The OIG report required the Forest Service to make some decisions about the future of the aviation program. The 1974 "National Aviation Plan" implemented a number of key steps, including establishing the Washington Office Aviation Service Group in Boise, ID.[58]

Airtanker accidents were a continuing concern. The mix of aircraft was changing as larger, faster multi-engine aircraft entered the fleet, with World War II-era former military aircraft as a primary source. *Flight Safety Digest* (April 1999) tallied 48 U.S. firefighting airtanker airplane accidents from 1961 to 1975.[59] Forest Service records for this period recorded 17 airtanker accidents.[60]

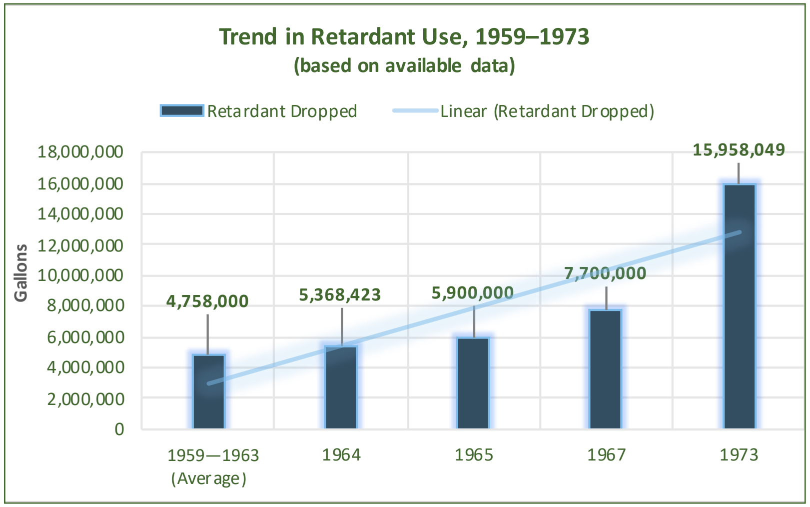


Figure 5.1. Trends in fire retardant use by airtankers. See chapter 3.1.2, "Trends in Early Aircraft Use (1949–1973)" for information on sources.

5.6. National Program Development (1974 to Present)

Implementing the Washington Office Aviation Service Group in Boise, ID, was a key part of the National Aviation Plan. The Chief took control of the following airtanker program responsibilities with the intent of implementing them through the Air Service Group, which was tasked with the following responsibilities:

- National airtanker contract (contracting officer)
- National airtanker inspection team
- National Airtanker Screening and Evaluation Board
- Modular Airborne Firefighting System (MAFFS)[61]

The National Aviation Plan tasked the Washington Office Aviation Service Group with the development of aircraft equipment standards, operating procedures, and administrative requirements. The goal was that all Forest Service and contract aircraft used across multiple regions—including equipment, accessories, and operating procedures—be "uniform" throughout the Forest Service. Other primary responsibilities identified were providing advice to the regions and coordinating with the Bureau of Land Management and Office of Aviation Services (putting authority for departmental level coordination on the Aviation Service Unit in Boise, ID). The work of the new Air Service Group had been defined—now came the challenge of achieving it.[62]

5.6.1. Early Years of the National Airtanker Contract (1974–1980)

A letter from Forest Service Chief Max Peterson to Jim Weaver, U.S. House of Representatives (Oregon), in June 1982, helps shed light on the first year of the national airtanker contract. In this letter, Peterson refers to the first year of the contract as 1974.[63] The Forest Service—with the assistance of the airtanker industry—determined that sealed bid requirements could be met. Furthermore, a "total mobility" concept was identified to replace the resident base operator strategy that had guided much of aviation contracting in the previous 10 years. This created contracting opportunities for airtanker operators regardless of whether they had a presence at an airport or were even in the region where they wanted to bid a contract.[64]

Unfortunately, the 1974 contract did not include information on the number or types of airtankers or the names of the contractors. Sources indicate that there were 80 airtankers the next year in 1975, with a total of "almost 50" Forest Service airtankers under contract.[65] No information was found on the types of airtankers on the 1975 contract.

A common practice in several regions was to require 7 days-per-week availability. This practice increased the number of airtankers available each day, essentially making the fleet 14 percent larger than it would be with a mandatory day-off pattern for the aircraft as well as the pilots. This practice was most likely discontinued after 1978 as a cost-cutting measure, which also served to provide days off to facilitate aircraft maintenance.[66]

Information found about the 1976 national airtanker contract indicates there were 88 airtankers that year, with 49 of these being contracted for the Forest Service.[67] A list of approved airtankers and pilots as of July 1, 1976, indicated a fleet of 64 airtankers, but considering the historical use pattern, this probably includes airtankers for the Forest Service, BLM, and Bureau of Indian Affairs.[68]

Each airtanker had a home base assigned for each bid item in the national contract. In some cases, airtanker schedules were coordinated to fill multiple successive bid items moving from regions with early fire seasons to regions with later ones. Examples include beginning a season in the Eastern or Southern Region in winter and early spring, moving to the Southwestern Region in late spring and early summer, and from there to the Pacific Northwest or Northern Regions. As fire seasons developed, aircraft were frequently moved to the Pacific Northwest and Pacific Southwest Regions when contractual commitments were completed for the Alaska Fire Service in mid-July to mid-August.

The Forest Service contracting approach of the time was to offer contracts by gallon classes. Through 1981, these classes were 900 gallons (1978 only), 1,050 gallons, 1,200 gallons, 1,800 gallons, 2,000 gallons, 2,200 gallons, 2,300 gallons, 2,450 gallons, and 3,000 gallons.[69]

In 1978, total airtanker flight time was 3,171 hours and 26 minutes.[70] When a fire in a lumbermill in Baker City, OR, was burning out of control, a DC-6A airtanker was dispatched in an attempt to prevent the flames from spreading.[71] With no leadplane available, the airtanker pilot did a dry run to assess the situation then dropped retardant in a different direction than the dry run. A boy under the age of 6 was watching the fire from an elevated railroad track near the mill. The child was struck by retardant and significantly injured, resulting in a medical evacuation to Boise, ID.

Fortunately, the child recovered, but the Federal Aviation Administration (FAA) proposed punitive action against the pilot for dropping in a congested area. This resulted in an extensive discussion between the Forest Service and the FAA, with no action being taken against the pilot. The outcome was an agreement between the FAA and Forest Service that was documented in the portion of FAA Grant of Exemption 392 relating to the application of retardant in congested areas below 500 feet. The agreement specifies procedures to be used to safely conduct these operations, which are potentially hazardous to people on the ground. Included was the requirement for a leadplane and the stipulation that the drop run be on the same heading as the dry run.[72]

In the period from 1974 to 1980 there were 8 airtanker accidents with 12 pilot fatalities. Aircraft that were involved in the accidents were the B-17 (two), B-26 (three), DC-4 (one), PB4Y2 (one), and P2V (one).[73]

Table 5.1. National airtanker contracts annual information (1970s)

Year	No. of airtankers	Makes/Models	No. by type	Comments
1974	N/A	N/A	N/A	Source not located for total number and/or makes/models
1975	Almost 50	N/A	N/A	Source not located for makes/models
1976	49	B-17,* B-26,* C-119J,*DC-4/C-54,* DC-6,* DC 7,* F7F,** P2V,* PB4Y2,* PV-2, S-PBY**	Type 1: 1 Type 2: 54 Type 3: 9	
1977	72	B-17, B-26, C-119J, DC-3,*** DC-4/C-54, DC-6, DC-7, PB4Y2, P2V		Significant information missing from sources[74]
1978	48[75]	B-17, B-26, C-119J, DC-4/C-54, DC-6, DC-7, P2V, PB4Y2	Type 1: 1 Type 2: 42 Type 3: 5[76]	
1979	48[77]	B-17, B-26, C-119J, DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, PV-2	Type 1: 1 Type 2: 42 Type 3: 5[78]	

Type categories used are based on the latest airtanker typing system as of 2022: VLAT (very large airtanker) has >8,000 gallons capacity, type 1 (large) has 3,000–5,000 gallons capacity, type 2 has 1,800–2,999 gallons capacity, type 3 has 800–1,799 gallons capacity, and type 4 has up to 799 gallons capacity.[79]

* *first time included in national airtanker contract*

** *last time included in national airtanker contract*

*** *both the first and last time included in national airtanker contract*

Airtanker Screening and Evaluation Board

With objectives of increased safety and standardized performance, the Forest Service Airtanker Screening Board was established in 1972 to assess aircraft and tanking and gating systems for the airtanker mission. In 1977 the board was rechartered as the Interagency Airtanker Screening and Evaluation Board with the Office of Aircraft Services, U.S. Department of the Interior (DOI), and the National Association of State Foresters joining. The airtanker industry was also represented on the board. It eventually evolved into the Interagency Airtanker Board (IAB).

This collaborative effort resulted in the development of common technical specifications for airtankers and their tanking and gating systems. These specifications were incorporated into contracts by member agencies. The result was a high degree of standardization with seamless operational interchangeability between airtankers and host agencies.

When new technologies arose, the solution was to seek approval by the IAB. The board relied on the work of technical experts in the aviation, airtanker drop evaluation, and retardant programs, as well as other disciplines, to provide analysis of the effectiveness and safety of industry proposals. The board would occasionally grant interim approval to promising systems that could operate safely, but which did not meet all of the board's requirements.[80]

5.6.2. The 1980s

Operational Retardant Evaluation Project (1983–1988)

By the early 1980s fixed-wing airtankers had been dropping retardant and water on wildfires for over 25 years. While a great deal of testing and some research had been accomplished, some fundamental questions remained unresolved.

To address these questions, the operational retardant evaluation (ORE) project was implemented. Project objectives sought answers in quantitative terms: determining effective retardant coverage and fuel and fire characteristics; tailoring the chemical or retardant to the need; optimizing tank and gating system performance; and developing use guidelines for airtanker selection, allocation, deployment, and real-time use. In the last 3 years of the project additional objectives were added, including the evaluation of several new retardant formulations, evaluation of fire foams, and using ORE methodology and equipment to assess the operational effectiveness of helicopters.

The project made good use of experienced personnel and state-of-the-art equipment. The aerial observation team consisted of an air attack supervisor and equipment operator with a forward-looking infrared (FLIR) unit. The ground evaluation team consisted of a fire behavior analyst, an experienced line firefighter, and a retardant research specialist. The ground evaluation team was transported to the drop site via helicopter; the helicopter manager was an experienced firefighter who operated a video camera to document on-the-ground evaluation of the drop. Site evaluations included measurement plots to determine effective retardant coverage levels. Airtankers performing the drops were instrumented with a high-precision pulse radar altimeter to provide a continuous record of drop elevation during a flight and an airspeed transducer to record airspeed. Video cameras were installed in some aircraft. Radio and intercom communications were recorded, and interviews were conducted with all involved after drops were made.

The ORE project observed and evaluated a total of 2,763 drops on 427 fires. The performance of airtankers as described in existing airtanker performance guides and retardant coverage computer/slide calculators was partially validated. Assumptions about operational parameters such as drop height, drop configuration, and retardant type were determined to be adequate. The value of increased drop heights to provide a more uniform retardant distribution was confirmed. The value of gum-thickened retardant in windy conditions was confirmed. Continuity between sequential drops was shown to be a problem, often resulting in fires breaching an incomplete retardant line.[81]

Fairchild C-119 "Flying Boxcar," a twin-tailed aircraft, on the Cleveland National Forest, CA, 1975. Courtesy of the National Museum of Forest Service History, Harvey Mack Collection.

Decertification of the C-119 as an Airtanker

In 1987 a C-119 experienced wing separation while on a retardant drop in northern California. Previous C-119 wing failures had occurred in 1979 (California Department of Forestry) and 1981 (Forest Service). The operational retardant evaluation (ORE) showed that C-119s exceeded the speed limit established in their supplemental type certificate for drop runs on over 90 percent of the drops recorded and exceeded the g-force loading parameters on over 25 percent of the drops recorded.

With the data from the ORE project and three wing failure accidents, C-119s were decertified as an airtanker in the fall of 1987. The effect of this was a significant loss of airtanker capacity. Although Forest Service or OAS contracts for 1987 are unavailable, there were likely five to seven C-119s on contract in 1987 between the Forest Service and the Department of the Interior. Airtankers contracted for Alaska Fire Service by OAS were often used on a postseason basis (August through November) as needed in the lower 48, usually by the Forest Service.[82]

Historical Aircraft Exchange Program

The airtanker fleet was significantly diminished with decertification of the C-119s. In December 1987, the Forest Service began discussions with the Department of Defense to determine how Lockheed C-130A Hercules and Lockheed P-3A Orion aircraft—which were being replaced by newer models—could be made available to some of the current airtanker contractors.

Between May 1988 and February 1991, arrangements were made to transfer 28 C-130As and P-3As to 5 airtanker operators in exchange for aircraft understood to have historical value.[83] These "historical" aircraft would then be transferred to museums.[84] This was called the Historical Aircraft Exchange Program (HAEP).[85] Ultimately, 18 of the transferred aircraft were converted to airtankers and 10 were used for parts.

The program was terminated in January 1990 after the USDA Assistant General Counsel determined that the Forest Service did not have the authority to conduct the exchange. In spite of this determination, transfers in progress were allowed to continue with the last one occurring on February 4, 1991.[86]

Audits of the exchange program, legal investigations, and grand jury indictments later determined that not only did the Forest Service lack the authority to conduct the exchange, but laws were broken and some policies were not complied with.

A Forest Service employee and an aircraft broker were indicted by a Federal grand jury in June 1996. They were tried and convicted in Federal court in Tucson, AZ, in October 1997, and served federal prison sentences for conspiracy. In July 2000, their convictions were overturned upon appeal to the Ninth Circuit Court of Appeals based on statute of limitations in charging.[87]

The 1980s ended with the airtanker fleet going through a major transition in aircraft as the transferred turbine aircraft were converted to airtankers. In the 1980s there were eight airtanker accidents with five airtanker pilot fatalities. Aircraft involved were the C-119 (three accidents) and P2V, B-26, C-130B, PB4Y2 and DC-7 (one accident each).[88]

TBM Avengers were among the first former military aircraft converted to airtankers for firefighting duties. This photo was taken between 1969 and 1973 when B19 was owned by Air Tankers, Inc. of Newcastle, WY. USDA Forest Service photo.

Table 5.2. National airtanker contracts annual information (1980s)

Year	No. of airtankers	Makes/Models	No. by type
1980	47[89]	B-17, B-26, C-119J, DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, PV-2[90]	Type 1: 1 Type 2: 44 Type 3: 5[91]
1981	43	B-17, B-26, C-119J, DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, PV-2	Type 1: 7 Type 2: 30 Type 3: 6
1982	43	No information found	
1983	43	B-17, B-26, C-119J, DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, PV-2[92]	Type 1: 10 Type 2: 28 Type 3: 6
1984	42	B-17,** B-26, C-119J, DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, PV-2,** C-123*[93]	Type 1: 7 Type 2: 34 Type 3: 5
1985	40	B-26, C-119J, DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, C-123[94]	Type 1: 7 Type 2: 32 Type 3: 1
1986	40	No information found	
1987	26	No information found	
1988	26	No information found	
1989	26	DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, C-123[95]	Type 1: 6 Type 2: 30

** first time included in national airtanker contract*

*** last time included in national airtanker contract*

5.6.3. The 1990s

The 1990s began with incorporation of the exchanged (formerly military) C-130As and P-3As as airtankers. They were immediately successful and quickly became seen as extremely effective. Their airspeed allowed them to quickly travel from the airtanker base to the incident, and their 3,000-gallon capacity was matched only by the DC-7s.

The Historical Aircraft Exchange Program, which made the highly effective C-130s and P-3s available to contractors, was determined to be legally outside of the authority of the Forest Service by the USDA Office of the Inspector General. This determination began a series of events which reshaped the Forest Service airtanker program, culminating in the removal of the C-130As from service in 2002.

Key events during the 1990s included a decision by the Secretary of Agriculture specifying that:

- The future procurement option for the Forest Service regarding airtankers would be contractor-owned aircraft operated and maintained by the contractor and acquired through the sale of excess military aircraft.
- Airtanker contractors would have “first-in-line” access to future excess military aircraft for conversion to contract airtankers.[96]

The Wildfire Suppression Aircraft Transfer Act of 1996 (Public Law 104–307) was signed by President Clinton on October 14, 1996, to implement the “first-in-line” concept. The intent of this act was to provide newer excess military aircraft to airtanker contractors. Recognizing that the 28 transferred turbine aircraft were already over 30 years old, a replacement schedule was established for the 28 aircraft initially transferred.[97]

The Air Force (with support of the Forest Service) was tasked with developing regulations for implementing Public Law 104–307. Although it was reauthorized several times, the act was ultimately unsuccessful in providing replacement aircraft for the 28 initially exchanged C-130As and P-3As. Following the debacle of the Historical Aircraft Exchange Program, the Air Force was less than enthusiastic and in June 2019 finally removed regulations implementing the law. Up to 2001, no aircraft or parts had been transferred under the act, and no information could be found on transfers between 2001 and 2019.

Once the Historical Aircraft Exchange Program had been found to be illegal, claims were made by the Forest Service, at the direction of the General Services Administration, to physically recover the 28 transferred aircraft, 18 of which were in airtanker configuration and 10 of which had been used for parts.

With much negotiation and delay, attempts to ground the aircraft were overcome and the operators were allowed to bid on the 1999–2002 national airtanker contract with exchanged aircraft. Ultimately, the ownership issue was resolved in the United States Court of Appeals in International Air Response vs. United States, September 4, 2002, which concluded that the operators had legal title to the exchanged aircraft. Just 3 months later, the Forest Service announced the permanent decertification of the C-130A as an airtanker.[98]

National Airtanker Study Phase 1

In 1991 the National Shared Forces Task Force Report (see chapter 3.2.5) established the methodology for justifying a program for shared resources—those fire suppression resources that have high value and are in short supply during high fire activity periods. When the Office of the Inspector General reviewed the Historical Aircraft Exchange Program in 1990, they concluded the Forest Service lacked a programmatic analysis and justification for the airtanker program. To remedy this, the Forest Service launched the National Airtanker Study (NATS), which ultimately provided documentation of Forest Service and DOI direction and intent for the large airtanker program of the era.

NATS was broken into two phases. Phase 1 was to determine the most “efficient number and initial staffing locations for large airtankers to support initial attack and large fire suppression for the 1996-1998 Large Airtanker Solicitation."[99]

Data analyzed during the study was from the National Fire Management Analysis system (from local units), as well as historical data on the use of airtankers to support large fires. The analysis discovered that the average annual number of large airtanker flight hours in the previous 8 years was 7,262 with 3,420,488 gallons of retardant dropped. Flight data revealed that the average round-trip dispatch was 50 minutes. Also considered in the analysis was the 1995 airtanker program, which consisted of 41 total airtankers: 30 for the Forest Service, 6 for Department of the Interior, and 5 for States using the Federal contract.[100]

The study recommended that 64 line items be offered for bid for large airtankers in the 1996–1998 contract period. Line items were grouped together to provide airtanker services when needed based on the usual annual fire season, which transitioned from the South to the Southwest then to the West and Alaska. Forty-one large airtankers were required to perform the contract. Thirty-eight were justified based on initial attack and three on large fire support. Bid items were established as 23 for type 1 airtankers and 41 for type 2.[101]

While not an initial purpose of the study, information on the functionality, capability, and safety of the airtanker bases at the time indicated that many were not well-suited for the current airtanker workload, let alone the future. This issue was carried forward into phase 2 of the study.[102]

National Airtanker Study Phase 2

Phase 2 of the National Airtanker Study followed on the heels of phase 1. While phase 1 determined the agencies' large airtanker contract needs for the 1996–1998 contract, phase 2 was broader and "structured to provide the basis for determining large airtanker and airtanker base improvement needs in the long term (1999–2020)" and to serve as "the basis for the Forest Service and Department of the Interior large airtanker contract solicitation from 1999 into the future or until revised."[103]

Phase 2 produced 16 recommendations approved by the Forest Service and Bureau of Land Management. The most important and impactful of these recommendations were[104]

- **Procurement of military aircraft**—"The committee recommends the procurement of excess military aircraft as this is the most cost-effective way to acquire airtanker platforms."[105] Result: This did not occur as regulations to implement the Wildfire Suppression Aircraft Transfer Act were not established.
- **Turbine-powered fleet**—"The committee recommends a future fleet of 20 P-3A aircraft, 10 C-130B aircraft, and 11 C-130E aircraft. This would provide for a fleet that is essentially 75 percent 3,000-gallon and 25 percent 5,000-gallon."[106] Result: The decision to reach a fully turbine-powered fleet was determined in this recommendation. The overall fleet size of 41 airtankers had previously been determined in phase 1.
- **MAFFS**—"The committee recommends the need for eight Modular Airborne Firefighting Systems (MAFFS)."[107] Result: This affirmed the Forest Service's commitment to continuing the MAFFS program.
- **Airtanker base optimization**— "Restructuring the airtanker base locations and numbers is needed to support the future airtanker fleet and to provide the most efficient use of the capital improvement and maintenance dollars available for physical facilities."[108] This recommendation related to the closure of airtanker bases was considered inadequate. Several new bases were established to handle the fleet of the future.
- **Capital improvement initiative for airtanker bases**—The committee "recommends that a national initiative be developed to fund improvements and investments at airtanker bases."[109] This was proposed as a $38-million-dollar, three-phase investment. It resulted in the closure of 6 airtanker bases, reconstruction of 8, major improvements at 13, and the design of 3 new airtanker bases for future construction. National standards were incorporated in all construction. It turned out to be a $47.5-million-dollar investment, which was the largest single investment in Forest Service history at the time.[110]

In the 1990s there were 6 airtanker accidents with 12 pilot fatalities for incidents where the Forest Service had operational control. Forest Service records also indicate a P2V accident with two pilot fatalities on April 20, 1997. Dr. Patrick Veillette's article in *Flight Safety Digest* also cites this accident. It is believed the accident was a PV2 accident with an aircraft from Hirth Airtankers (T38, National Transportation Safety Board no. IAD97FA065) that occurred in Pennsylvania while on a State contract.[111]

Table 5.3. National airtanker contracts annual information (1990s)

Year	No. of airtankers	Makes/Models	No. by type	Comments
1990	30 plus 3 spares	DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, SP-2H, C-130A,* P-3A*	Type 1: 8 Type 2: 22	No DOI items; spares: type 1 (2), type 2 (1); three of the new type 1 transferred turbine airtankers filled bid items for type 2 airtankers at the type 2 airtanker availability rates; this was done to provide a method of deploying the type 1 turbines without rebidding the entire contract
1991	30 plus 4 spares	DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, SP-2H, C-130A, P-3A	Type 1:10 Type 2: 20	No DOI items; spares: type 1 (3), type 2 (1); implementation of type 1 transferred turbines continues
1992	30	DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, SP-2H, C-130A, P-3A	Type 1:12 Type 2: 18	No DOI items; designated spares no longer shown; implementation of type 1 transferred turbines continues
1993	30	DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, SP-2H, C-130A, P-3A	Type 1:13 Type 2: 17	No DOI items; implementation of type 1 transferred turbines continues; now 6 C-130s and 5 P-3s
1994	29	DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, SP-2H, C-130A, P-3A	Type 1:13 Type 2:16	No DOI items
1995	30	DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, SP-2H, C-130A, P-3A	Type 1:12 Type 2: 18	No DOI items
1996	39	DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, SP-2H, C-130A, P-3A	Type 1:14 Type 2: 25	39 total awarded bid items; 8 BLM or BLM shared bases with Forest Service, BIA, or State of MN; contract reflects the implementation of NATS 1
1997	39	DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, SP-2H, C-130A, P-3A	Type 1: 15 Type 2: 24	39 total awarded bid items; 8 BLM or BLM shared bases with Forest Service, BIA, or State of MN; 12 type 1 turbine airtankers on contract: 6 C-130s and 6 P-3s
1998	39	DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, SP-2H, C-130A, P-3A	Type 1: 15 Type 2: 24	39 total awarded bid items; 8 BLM or BLM shared bases with Forest Service, BIA, or State of MN; 12 type 1 turbine airtankers on contract: 6 C-130s and 6 P-3s
1999	41	DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, SP-2H, C-130A, P-3A	Type 1:16 Type 2: 25	41 total awarded bid items; 5 BLM and 4 BLM shared bases with Forest Service, BIA, or State of MN; 13 type 1 turbine airtankers were on contract: 6 C-130s and 7 P-3s

BIA = Bureau of Indian Affairs; BLM = Bureau of Land Management; DOI = Department of the Interior; NATS 1 = National Airtanker Study, Phase 1

** first time included in national airtanker contract*

5.6.4. The 2000s

In 2002, 44 airtankers were on the national contract, including 6 exclusively for the BLM.

In the 2000s—for incidents where the Forest Service had operational control—there were 4 multi-engine airtanker accidents with 10 flight crewmember fatalities and 4 single-engine airtanker accidents with no fatalities.[112]

Two fatal airtanker accidents occurred 31 days apart in 2002, both involving in-flight structural failures. One was an exchanged turbine C-130A, Airtanker 130; the other was a Consolidated Volte PB4Y-2 Privateer, Airtanker 123.[113]

Effects of the 2002 Accidents on the Airtanker Fleet

Discoveries made in the Airtanker 130 accident investigation led to a reinvestigation of a 1994 fatal accident involving an exchanged C-130A, Airtanker 82, and determined the cause to also be a center wing-box failure that resulted in a breakup of the aircraft in-flight. The National Transportation Safety Board (NTSB) had previously determined the cause to be an explosion following a fuel leak. Airtanker 82 was on a Forest Service contract at the time of the accident but was en route to a California Department of Forestry fire.[114]

Airtanker 130 circa early 2002 at La Grande, OR. Photo by Armen Woosley.

In a March 26, 2003, hearing before a U.S. Senate subcommittee, Forest Service and BLM witnesses testified that the agencies had decided not to renew contracts for nine C-130A and PB4Y-2 airtankers. They also indicated that the remaining 33 contracted airtankers would go through an enhanced inspection program. As part of the inspection process, witnesses at the hearing also indicated that Sandia Laboratories was conducting an analysis of the remaining 33 airtankers under contract with the expectation that most of these would be able to perform their contacts.[115] In addition, the Forest Service retired 11 of their 19 Beechcraft Baron leadplanes.

On May 10, 2004, the Forest Service and BLM terminated the contracts for 33 large airtankers. This decision was based on the cumulative findings of the Blue Ribbon Panel Report from December 2002 and the NTSB report on the 2002 airtanker crashes (April 23, 2004) and causally related 1994 accident.[116]

A hearing on firefighting aircraft safety before the Senate Commerce Committee in June 2004 provides additional information. The hearing record states that the NTSB report of April 23, 2004, acknowledged that significant work had been done by the agencies and vendors but concluded that ultimately "no effective mechanism currently exist[ed] to ensure the continuing airworthiness of these fighting aircraft."[117]

Another hearing focused on fire aviation programs occurred in February 2006 before the Senate Subcommittee on Public Lands and Forests. The testimony of departmental witnesses indicated that 16 large airtankers had been certified and returned to service. These 16 large airtankers—supported by a significant increase in single-engine airtankers (SEATs) and large and medium helicopters—had resulted in initial attack success rates of over 98 percent in 2003, 2004, and 2005. Blue Ribbon Panel Co-Chair and former Chair of the NTSB James Hall commented that "there has been some progress in dealing with safety and effectiveness of aerial firefighting, but much less than we'd hoped for."[118]

During the years 2002 through 2006, the large airtanker fleet went from 44 to 16 contract bid items. Fleet composition had gone from eight to two models of aircraft—the P2V and P-3. Three large airtanker companies remained: Aero Union, Neptune Aviation, and Minden Aviation. All three companies were well-established as Forest Service airtanker contractors. Aero Union had been contracting with the Forest Service since 1959. Neptune Aviation began contracting in 1993 but had purchased all the assets of Black Hills Aviation, which had been contracting with the Forest Service since 1964. Minden Aviation had first contracted with the Forest Service in 1993.[119]

Aviation and Airtanker Strategies (2009)

The National Interagency Aviation Committee (NIAC) developed a comprehensive Interagency Aviation Strategy in three phases, which was published with modifications in 2009. NIAC was responding to this comment in the Blue Ribbon Panel Report:

> **"Possibly the single largest challenge now facing leaders of these federal agencies is to foster cooperation and collaboration among working-level staffs, contractors, and states to raise the standards of aerial wildland firefighting in the United States."[120]**

Appendix 12 of the Interagency Aviation Strategy addressed large airtankers, recommending "a core federal fleet of twenty-five (25) large fixed-wing airtankers, operated and maintained by private industry with the federal government purchasing the aircraft and retaining ownership." This goal of acquiring 25 new aircraft was from the 2005 Wildland Fire Management Aerial Application Study.[121]

Retardant Application Environmental Issues (2003–2011)

Concern about the environmental effects of retardant chemicals developed into a lawsuit in 2003. Claims were made that the National Environmental Policy Act (NEPA) required the Forest Service to analyze potential effects of the aerial application of fire retardants and that the Endangered Species Act (ESA) required consultation with the U.S. Fish and Wildlife Service (FWS). The U.S. District Court determined that the Forest Service had violated both NEPA and ESA.[122]

The Forest Service responded by completing an environmental assessment in October 2007. A decision notice and "Finding of No Significant Impact" was published in February 2008. In April 2008, the Forest Service was sued again on the same issues. In July 2010 the U.S. District Court held again for the plaintiffs and ordered the Forest Service, FWS, and the National Marine Fisheries Service (NMFS) to remedy the NEPA and ESA violations. The court directed the Forest Service to issue a new decision notice no later than December 31, 2011.

The agencies complied with the court order and the FWS and NMFS issued biological opinions in November 2011.[123] Of particular importance to the airtanker program were requirements for "aircraft operational guidance" and "avoidance area mapping," which were established in the record of decision.[124]

Aircraft operational guidance directed incident commanders how to proceed when considering applying wildfire chemicals in areas designated as critical habitats. Incident commanders and pilots were required to avoid aerial application of fire retardant in "avoidance areas" for threatened, endangered, protected, candidate, or sensitive species or within a 300-foot buffer along waterways. Avoidance area mapping required that the Forest Service coordinate annually with FWS and National Oceanic and Atmospheric Administration (NOAA) fisheries offices to ensure that identification of avoidance areas on lands managed by the Forest Service was up-to-date.[125]

Reporting and monitoring requirements directed that the Forest Service report all misapplications of aerially applied fire retardant to FWS and NOAA fisheries (as appropriate). It also directed development of an "Implementation Handbook for the Final Environmental Impact Statement for Nationwide Aerial Application of Fire Retardant on National Forest System Land."[126] The most recent version available at the time of publication is the "Application of Aerial Retardant Guide" (May 2019).[127]

Table 5.4. National airtanker contracts annual information (2000s)

Year	No. of airtankers	Makes/Models	No. by type	Comments
2000	41	DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, SP-2H, C-130A, P-3A	Type 1: 18 Type 2: 23	41 total awarded bid items; 5 BLM and 4 BLM shared bases with Forest Service, BIA, or State of MN; 15 type 1 exchanged turbine airtankers on contract: 6 C-130As and 9 P-3As[128]
2001	41	DC-4/C-54, DC-6, DC-7, P2V, PB4Y2, SP-2H, C-130A, P-3A	Type 1: 16 Type 2: 25	41 total awarded bid items; 5 BLM and 4 BLM shared bases with Forest Service, BIA, or State of MN; 13 type 1 turbine airtankers on contract: 6 C-130As and 7 P-3As[129]
2002	44	DC-4/C-54, DC-6, DC-7, P2V, PB4Y2,** SP-2H, C-130A,** P-3A	Type 1: 18 Type 2: 26	44 total awarded bid items; 6 BLM and 2 BLM shared bases with Forest Service; 14 exchanged turbine airtankers on contract: 6 C-130As and 8 P-3As; 5 PB4Y2s on contract; 1C-130A and 1 PB4Y2 lost due to crashes; remaining 5 C-130As and 4 PB4Y2s grounded[130]
2003	33	DC-4/C-54, DC-6, DC-7, P2V, SP-2H, P-3A	Type 1: 10 Type 2: 23	33 total awarded bid items; 4 BLM and 2 BLM shared bases with Forest Service; 7 exchanged turbine airtankers on contract, all P-3As; 5 spare airtankers bid for Forest Service; 5 P2Vs, 1 DC-7[131]
2004		DC-4/C-54,** DC-6,**, DC-7, P2V, SP-2H,** P-3A		Two items were listed solely with OAS contract numbers and two items were listed with OAS and Forest Service contract numbers, indicating two BLM-based airtankers and two paired with a Forest Service base.
2005	17	DC-7,** P2V, P-3A	Type 1: 8 Type 2: 9	All Forest Service; 7 turbine airtankers, all P-3As[132]
2006	16	P2V, P-3A	Type 1: 7 Type 2: 9	All Forest Service plus 1 spare; 7 turbine airtankers, all P-3As[133] Starting in 2006, the Forest Service began awarding multiple types of national airtanker contracts.[134]
2007	17	P2V, P-3A	Type 1: 7 Type 2: 9	All Forest Service; 7 turbine airtankers, all P-3As[135]
2008	19	P2V, P-3A	Type 1: 8 Type 2: 9	All Forest Service; 8 turbine airtankers, all P-3As[136]
2009	17	P2V, P-3A	Type 1: 7 Type 2: 10	All Forest Service; 8 turbine airtankers, all P-3As[137]

BIA = Bureau of Indian Affairs; BLM = Bureau of Land Management; OAS = Office of Aircraft Services

*** last time included in national airtanker contract*

5.6.5. The 2010s to 2021
Last of the Exchanged Turbine Airtankers

Entering 2011, the large airtanker contract included 24 large airtankers with 8 of these being Aero Union P-3As. Two of these P-3As were removed from the contract. On July 29, 2011, the Forest Service cancelled Aero Union's contract and remaining six P-3As due to "inadequate safety practices." After 24 years, the era of the exchanged turbine airtanker was over.

The remaining large airtanker fleet consisted of 11 P2Vs provided by 2 airtanker companies, neither of which had been involved in the Historical Aircraft Exchange Program.[138]

A P2V airtanker in Missoula, MT, in 2012. Photo by Greg Goebel.

Avro RJ85, Tanker 164, making a drop on the Pioneer Fire on the Boise National Forest in 2016. USDA Forest Service photo by Kari Greer.

Development of "Next Generation" Airtankers

The Forest Service goal of a fleet of turbine airtankers bore fruit in the 2010s. Airtanker companies were pursuing a variety of aircraft to meet the Forest Service's large airtanker needs. The first successful "next generation" airtanker was Airtanker 40, provided by Neptune Aviation in the fall of 2011. Airtanker 40, a jet-powered British Aerospace BAe 146 aircraft, was substituted on an existing contract for a P2V.[139]

Large Airtanker Modernization Strategy (2012)

An ever-increasing wildfire workload with significantly longer annual fire seasons, and an airtanker fleet that had declined from 43 airtankers in 2002 to 11 in 2011, prompted development of the "Large Airtanker Modernization Strategy" in 2012.[140]

The strategy made the following recommendations:

- "The Forest Service and Department of the Interior should replace existing (legacy) large airtankers with a core fleet of next-generation large airtankers (Type 1, >3,000-gallon capacity and Type 2, 1,800-to-2,900-gallon capacity). Continued work is ongoing to determine the optimum number of aircraft to meet the wildfire response need, but studies have shown it is likely that between 18 and 28 aircraft are needed."
- "For large airtankers operated by private companies, there is a need to explore additional acquisition models, such as different contracting instruments and leasing, which could provide more flexibility for private industry and reduce contract costs to the Federal Government."
- "The Federal wildfire firefighting aircraft fleet should be a mix of Type 1, Type 2, Type 3 (800 to 1,799 gallons), and Type 4 (<799 gallons) airtankers; water scoopers; very large airtankers (>8,000 gallons); and heavy (Type 1) helicopters."

The strategy incorporated the ability of current and candidate aircraft to incur the airframe stresses involved in the airtanker mission (maneuver load impacts). Likely candidate aircraft were analyzed in detail. Of concern was the fact that only two vendors were supplying all the aircraft for the large airtanker contract.[141]

Safety Impact Analyses for Large Airtanker and Airtanker Base Operations (2012)

Safety Management Systems (SMS) was adopted by the Forest Service in 2010 (see chapter 3.3.8). One of the four pillars of SMS is risk management. One tool the Forest Service uses for risk management is safety impact analysis (SIA). Conducted for major aviation missions in the agency, an SIA combines risk assessment and safety assurance. Two SIAs related to the airtanker mission were conducted in 2012—one for large airtanker operations and the other for airtanker base operations.[142], [143]

Both SIAs involved site visits to airtanker bases in three Forest Service regions. Interviewees for the large airtanker operations SIA included pilots, group leaders, base and program managers, maintenance specialists, safety officers, and airtanker company representatives. For the airtanker base operations SIA, interviewees included base managers and personnel, regional safety and training managers, forest-level aviation officers, aviation managers, and equipment specialists. The analysis included the first "next generation" airtanker, a BAe 146, which had entered the fleet in September 2011. The operations plan for the BAe 146 addressed issues involved in introducing a turbo-fan aircraft—with its significant and highly-directed engine backblast—into the airtanker fleet.

Each analysis identified dozens of hazards and hundreds of mitigation measures, as well as findings and recommendations that, when implemented, would significantly lower the hazard level rating associated with large airtanker operations.

Programmatic Risk Assessment for Water Scooper Operations (2012)

A programmatic risk assessment was performed for water scooper operations in 2012. It involved the national aviation risk management branch chief, national helicopter operations program manager, multiple aviation management and safety specialists, aviation maintenance and airworthiness specialists, a current and highly experienced water scooper pilot, an aerial supervision module (ASM) pilot, and a State aviation manager with decades of water scooper experience. In addition to the risk assessment and safety assurance evaluation, an outline for a National Water Scooper Operations Plan was developed.

The assessment identified eight findings and six recommendations. Also identified were 28 hazards and 80 mitigation measures. Implementation of the mitigation measures would lower the overall risk level, though five hazards were rated as "high" even with implementation of the mitigation measures.[144]

Water scooping aircraft are a viable wildland firefighting tool but have limited application due to the operational requirement for access to adequate waterways for scooping.

Government Accountability Office Report (2013)

In August 2013, the Government Accountability Office (GAO) released a report titled "Wildland Fire Management: Improvements Needed in Information, Collaboration, and Planning to Enhance Federal Fire Aviation Program Success" (GAO-13-684).

The GAO found that since 1995, nine major efforts to identify the number and type of firefighting aircraft needed had been undertaken by the Forest Service and DOI and that these efforts had been hampered by "limited information and collaboration."

The GAO report recommended three actions:

1. "Expand efforts to collect information on aircraft performance and effectiveness to include all types of firefighting aircraft in the federal fleet."
2. "Enhance collaboration between agencies and with stakeholders in the aviation community to help ensure that agency efforts to identity the number and type of firefighting aircraft they need reflect the input of all stakeholders in the fire aviation community."
3. "Update strategy documents for providing a national firefighting aircraft fleet to include analysis based on information on aircraft performance and effectiveness and to reflect input from stakeholders throughout the fire aviation community."

The report provided a detailed description and analysis of the state of the airtanker program and options going forward. The need for information about aviation programs was echoed in other sources, including the "Interagency Aviation Strategy" and the "Nationwide Aerial Application of Fire Retardant on National Forest System Land: Record of Decision."[145]

Aviation Strategy Implementation (2018–2022)

An "Aviation Strategy Implementation" document for 2018–2022 provides an update on multiple ongoing aviation initiatives, including the 2012 "Large Airtanker Modernization Strategy." In the fire season of 2018, the entire fleet of large airtankers were "next generation," contracted from private industry. The C-130Hs provided by the 2014 NDAA and a purpose-built C-130 large airtanker as directed in the 2015 NDAA were no longer needed. A determination had been made that "a fleet of contractor-owned LATs would be the most cost-effective, efficient, and streamlined approach for providing national LAT resources."

The strategy also projects the number of airtankers and helicopters of all types through fiscal year 2022 and cites anticipated benefits of the aerial firefighting use and effectiveness project (see chapter 3.3.9).[146] The strategy projects a fleet of 18 "next generation" large airtankers by fiscal year 2022.[147]

In the 2010s—for incidents where the Forest Service had operational control—there were two multi-engine airtanker accidents with no flight crewmember fatalities and one single-engine airtanker accident with no fatalities.[148] No Forest Service airtanker accidents occurred in the first 2 years of the 2020s.

C130Q airtanker photo from the National Wildfire Coordinating Group (NWCG) Airtanker Base Directory, June 2018. NWCG photo.

Left: Aerial photo of the Forest Service airtanker base at Helena, MT, in 2017. The base pumped a record 1.3+ million gallons of fire retardant during the 2017 fire season. Helena Regional Airport photo.
Right: RJ85 and MD-87 airtankers at the Silver City Aerial Fire Base in Hurley, NM. USDA Forest Service photo.

Table 5.5. National airtanker contracts annual information (2010s to present)

Year	No. of airtankers	Makes/Models	No. by type	Comments
2010	19	P2V, P-3A	Type 1: 8 Type 2: 11	All Forest Service; 8 turbine airtankers, all P-3As[149]
2011	20	P2V, P-3A,** BAe 146*	Type 1: 9 Type 2: 11	All Forest Service; 9 turbine airtankers, 8 P-3As, and the first next generation airtanker, a BAe 146;[150] 11 legacy airtankers
2012	13	P2V, BAe 146, DC-10	Type 1: 2 Type 2: 11 VLAT: 2	Based on information from the aviation annual report;[151] all Forest Service; 2 turbine-engine next generation airtankers, both BAe 146s; 2 DC-10 VLATS were on CWN contracts
2013			Type 1: 2 Type 2: 11 VLAT: 2	
2014	15	P2V, BAe 146, DC-10, CL-415; probably MD-87 and possibly RJ85	Type 1: 4 Type 2: 8 VLAT: 2	Based on information from the aviation annual report;[152] All Forest Service; 4 turbine-engine next generation airtankers; additionally, 2 turbine-engine next generation airtankers were awarded CWN contracts; 8 legacy airtankers
2015	15	P2V, BAe 146, DC-10, CL-415; probably MD-87 and RJ85	Type 1: 6 Type 2: 7 VLAT: 1	Based on information from the aviation annual report;[153] all Forest Service; 6 turbine-engine next generation airtankers, including 1 VLAT; 7 legacy airtankers; 2 CL-215s; an agency-owned C-13-H was available with a MAFFS unit; 22 additional potential CWN airtankers available
2016	20	P2V, BAe 146, C-130Q, MD-87, RJ85, DC-10	Type 1: 11 Type 2: 7 VLAT: 2	All Forest Service; 7 legacy airtankers, 13 next generation airtankers[154]
2017	20	P2V,** BAe 146, C-130Q, MD-87, RJ85, DC-10	Type 1:11 Type 2: 7 VLAT: 2	All Forest Service; 7 legacy airtankers, 13 next generation airtankers[155]
2018	21	BAe 146, C-130Q, MD-87, RJ85, DC-10	Type 1: 18 Type 2: 0 VLAT: 3	All Forest Service, all next generation airtankers; 13 EU contracts; 8 CWN activations[156]
2019	13	BAe 146, C-130Q, MD-87, RJ85, DC-10	Type 1: 11 Type 2: 0 VLAT: 2	All Forest Service, all next generation airtankers; all EU contracts[157]
2020	28	BAe 146, C-130Q, MD-87, RJ85, DC-10, B747***	Type 1: 23 Type 2: 0 VLAT: 5	All Forest Service, all next generation airtankers; 13 EU contracts, 16 CWN activations[158]
2021	23	BAe 146, C-130Q, MD-87, RJ85, DC-10	Type 1: 19 Type 2: 0 VLAT: 4	All Forest Service, all next generation airtankers; 18 EU contracts; 5 CWN activations[159]

CWN = call-when-needed; EU = exclusive-use ; MAFFS = modular airborne firefighting systems; VLAT = very large airtanker

** first time included in national airtanker contract*

*** last time included in national airtanker contract*

**** both the first and last time included in national airtanker contract*

5.7. Single-Engine Airtankers

When airtankers were first developed, they were all single-engine. Single-engine airtankers continued to make up the majority of the Forest Service's contracted airtankers until the late 1960s. By 1974, all Forest Service contract airtankers were multi-engine.

By the early 1990s the BLM had developed a single-engine airtanker program. The aircraft and pilots were provided by contracts offered by the Office of Aircraft Services (OAS).[160]

In the mid-1990s the Forest Service and OAS agreed on a "division of labor" in aviation management contracting. The Forest Service agreed to manage the large airtanker contract for all wildfire agencies while OAS managed the single-engine airtanker (SEAT) contracts.

The Air Tractor 802 was originally an agricultural aircraft that has also been adopted for firefighting. National Park Service photo.

5.7.1. Malheur National Forest SEAT Program (John Day Airbase)

One notable Forest Service SEAT initiative began in 1993 on the Malheur National Forest in the Pacific Northwest Region. The national forest began an operational evaluation of a SEAT initially using a turbine Thrush 500 series aircraft contracted through OAS. The evaluation was successful, and the Malheur National Forest made the SEAT a regular component of their initial attack force, funding it with savings from discontinuing a type 6 fire engine.

The Malheur's SEAT and rappel bases were colocated in John Day, OR. The forest organized an innovative, detailer-staffed "Malheur Aviation Training Program" in 1994. Detailers were trained as rappellers, airtanker loaders, and SEAT managers, resulting in well-trained and experienced employees bringing advanced aviation qualifications back to their home units.

During peak activity periods, the SEAT base sometimes had between three and eight SEATS assigned. The Air Tractor 802 was a particularly effective SEAT with its 800-gallon capacity. In some years, gallons of retardant delivered from John Day Airbase was greater than from nearby large airtanker bases.

The administrative costs of contracting a SEAT through OAS became so concerning in 2016 that the Forest Service issued its own SEAT contract. Then in 2019 when the collateral-duty airtanker base manager retired, the SEAT base was transferred to the Oregon Department of Forestry (ODF). The nearby national forests still use ODF's SEAT as well as occasional Federal SEATs from the John Day Airbase.[161]

5.8. Water Scoopers

The first developmental work on amphibious aircraft for use as airtankers was with PBY-6A aircraft in southern California in 1956. In the early and into the regional era of the airtanker program, PBY-5A and PBY-6A airplanes were on regional contracts most years until 1974.[162]

After 1974, water scoopers were often contracted by OAS for the BLM. The Forest Service used these aircraft and occasionally imported Martin Mars airplanes from the Province of British Columbia.

Left: A Canadair CL-215 drops its load over a fire (date unknown). USDA Forest Service photo. Right: Tanker 85, N6453C, a PBY-6A operated by Hemet Valley Flying Service in August 1975 at Lancaster, CA.

An exception to the move to multi-engine aircraft was the Forest Service's de Havilland DHC-2 Beavers located at Ely, MN. Owned by the Forest Service and a year-round part of the permanent fleet in Ely, these airplanes are easily converted from passenger transports to water scoopers. They have functioned as effective airtankers in both water scooping and land-based roles since 1961. (See chapter 2.4.8 for more information about the Beaver program.)

In 2012 the Forest Service held a series of workshops resulting in the development of a programmatic risk assessment and safety assurance evaluation of water scooping aircraft operations. This led to an operations plan for multi-engine water scooping aircraft and the Forest Service proceeded to implement the use of water scoopers.[163]

In 2012 two CL-215s were operated under a contract shared with the BLM for approximately 100 days. There were no multi-engine water scoopers under contract for the Forest Service in 2013. Each year from 2014 through 2020, multi-engine water scoopers were either on exclusive-use contracts or call-when-needed agreements. The aircraft mix has included both CL-215s and CL-415s.

De Havilland DHC-2 Beaver piloted by Supervisory Pilot Joel "Henny" Jungemann at work on the Superior National Forest in Minnesota. USDA Forest Service photo.

5.9. Modular Airborne Firefighting Systems (MAFFS)

The wildfires in southern California in 1970 served as the impetus for a number of innovations, including the incident command system. There was also significant pressure from both Congress and local politicians to use U.S. military aircraft resources in support of wildfire suppression activities.

The Forest Service collaborated with the U.S. Air Force, California Air National Guard, and U.S. Army flight test personnel at Edwards Air Force Base on the design of a modular airborne firefighting system. The Air Force had experience using spray equipment in the Vietnam War. The FMC Corporation produced the first Modular Airborne Firefighting System (MAFFS).[164] The Forest Service contracted with Aero Union Corporation to produce the systems, which consisted of five 500-gallon tanks that could be temporarily installed in a Lockheed C-130.[165]

The tanks were filled with mixed retardant and pressurized by a compressor as part of the loading process on the ground. The retardant was then dropped on a wildfire target through an exhaust manifold.

The system was first tested on the Romero Fire on the Los Padres National Forest in 1971. By 1974 eight systems were purchased and were operated by the North Carolina, Wyoming, and California Air National Guards and the 302nd Air Force Reserve Squadron in Colorado (two systems each).

A MAFFS-equipped C-130 Hercules makes a water drop over New Mexico during a training exercise, May 2007. U.S. Air Force photo by Technical Sergeant Rick Sforza.

One highly visible and unique use of MAFFS was in Indonesia during their historic 1997 wildfires. Indonesia faced a catastrophic number of fires that year, producing health-threatening air pollution levels. The Wyoming National Guard was tasked with sending three C-130s to assist. Two of these carried MAFFS units and the third carried portable airtanker base equipment and support personnel. The Forest Service contributed a fire assessment team, leadplane pilots, and MAFFS system mechanics. The first drop was made on October 21 and all aircraft and personnel were back in the United States by December 1. MAFFS was credited for being a key contributor in suppressing 140 fires.[166]

Annual training of all personnel involved in the MAFFS program has been a key component of operational readiness. A week-long training effort puts MAFFS flight crews and leadplane pilots together in both the classroom and in the field, flying simulated missions.

One tragedy has occurred in the MAFFS program. In 2012, a C-130H with MAFFS Unit #7 from the North Carolina Air National Guard crashed while making a drop on a fire in South Dakota. Four of the six flight crew members were killed.

As of June 2021, the MAFFS lineup is two each at the following locations:

- 302nd Airlift Wing, U.S. Air Force Reserve at Peterson Air Force Base, Colorado Springs, CO
- 153rd Airlift Wing, Wyoming Air National Guard, Cheyenne, WY
- 152nd Airlift Wing, Nevada Air National Guard, Reno, NV
- 146th Airlift Wing, California Air National Guard, Port Hueneme, CA

Wyoming Air National Guard air crews in two C-130 Hercules aircraft follow a USDA Forest Service leadplane during Modular Airborne Firefighting Systems (MAFFS) training in 2012. Wyoming National Guard photo by Dewey Baars.

Aero Union Corporation developed a redesigned and significantly improved MAFFS system (MAFFS 2) and delivered it to the Forest Service in 2008. By 2011 all legacy MAFFS systems had been replaced.[167] System improvements included the ability to deliver a retardant concentration at a higher coverage level. Having onboard compressors meant that MAFFS could operate from most airtanker bases. Its relative simplicity compared to the legacy system reduced installation time in a C-130 by several hours.[168]

Members of the 302nd Airlift Wing loading a USDA Forest Service MAFFS unit into a C-130 Hercules at Peterson Air Force Base in Colorado. Once it is properly aligned, the unit can be easily pushed into the bay of the airplane. U.S. Air Force photo by Tech. Sgt. Justin Norton.

5.10. Very Large Airtankers

5.10.1. Ilyushin IL-76TD

The first potentially usable very large airtanker (VLAT)—one that could carry over 8,000 gallons of retardant—was developed by the Russian Federation as the Ilyushin IL-76TD. Its design concept was to contain the liquid in two adjacent tanks—normally used for natural gas pipelines—laying horizontally on the cargo floor. When full, they contained 11,000 total gallons of liquid. It was demonstrated at the Farnborough (UK) Air Show in 1993.

Forest Service airtanker specialist Joe Madar and airtanker equipment and maintenance specialist Paul Markowitz observed the aircraft and display drop at Boscomb Downs, the British Royal Airforce Proving Grounds. Their report indicated that the aircraft would be difficult to effectively integrate into U.S. operations. The water tanks were unbaffled, making incremental drops impossible, and concerns were raised about the aircraft's ability to maintain flight stability in mountainous terrain.

The IL-76TD was used on a series of intense wildfires near Athens, Greece in 1999. A U.S. Air Force Attaché from the Embassy in Athens monitored the operation and reported that it was not an effective resource in the intense fire situation the Greeks were dealing with. Proponents of the aircraft established an office in the Washington, DC, area to provide advocacy for the IL-76TD as an airtanker. The Forest Service addressed issues related to the use of the IL-76TD as an airtanker numerous times to members of the U.S. Congress.[169]

5.10.2. McDonnell Douglas DC-10

The DC-10 was the first operational VLAT in the United States. Developed by 10 Tanker Air Carrier and partners, it received approval by the Interagency Airtanker Board (IAB) in 2006. The 9,400-gallon retardant load is carried in three center-line belly tanks and dispersed through a gravity-fed system. The tanks have internal baffles to prevent fluid shifting while in flight. The three tanks can be filled in 15 to 20 minutes. The entire load can be discharged in an emergency in 8 seconds. Since 2006, the DC-10 has been considered an effective airtanker and has seen use by U.S. Federal agencies, States, and foreign countries.[170]

5.10.3. Boeing 747 and 747-400

The first Boeing 747 configured as a "supertanker" by Evergreen International Aviation in 2004 had a capacity of up to 19,600 gallons, but never entered service. The second was developed and deployed in Spain and the United States in 2009; it is no longer in service.

McDonnell Douglas DC-10 airtanker. California Department of Forestry and Fire Prevention photos by Wes Schultz.

Boeing 747 supertanker. California Department of Forestry and Fire Prevention photo.

The third was developed by Global Supertanker Services (Global STS) using the physical and intellectual property from Evergreen's original design on a newer airframe, a Boeing 747-400. The Evergreen pressurized system was never fully approved because it had multiple issues related to coverage level, aeration and trail-off after the valves closed, and inability to maintain deck angle, speed, and altitude. These same issues continued in the Global STS operation and prevented full IAB approval. This version had a 17,500-gallon capacity. It was operational in 2010 and supported firefighters during its service in Israel, Chile, and a number of locations in the United States on State contracts.

Because it had not met multiple IAB criteria, the Boeing 747-400 airtanker operated under eight successive interim approvals. The eighth interim approval was clear that a ninth would not be granted. IAB standards were required to be met by December 31, 2020. The 747-400 was activated in 2020 on a call-when-needed contract with an approved tank size of 19,200 gallons with a usable capacity of 17,500 gallons. Global STS ceased operations in April 2021.[171]

5.11. Partnerships

The Forest Service airtanker program developed originally as a partnership with the California Department of Forestry and Fire Prevention (CAL FIRE) and many other cooperating partners. As the program became formalized, two standards were established that led to commonality in operations. These standards were Forest Service long-term fire retardant specifications—which had been in effect since at least the early 1970s—and establishment of the Interagency Airtanker Screening and Evaluation Board in 1972, which evolved into the Interagency Airtanker Board (IAB). These two anchors provided a common point of reference for agencies and States wishing to participate in shared programs and for vendors who wished to provide fire retardant chemicals.[172]

The primary organization ensuring partnership and coordination at the national level is the National Interagency Aviation Committee (NIAC). Subcommittees particularly important to the airtanker program include the following:[173]

- Interagency Airtanker Base Subcommittee
- Interagency Airtanker Board
- Interagency Water Scooper Subcommittee
- Single-Engine Airtanker Board

Some States—including Minnesota and Alaska—participated in the Forest Service's large airtanker contract in various years by funding part or all of an airtanker's availability costs. Other States contracted for airtankers that could be approved for Federal use via a cooperator letter of approval.

On or adjacent to the international border between the United States and Canada, both countries' airtankers have often provided retardant drops to each other in support of fire suppression efforts. Each Forest Service region meets annually to develop a highly detailed operating plan to account for logistical and legal hurdles and notifications that must be followed to authorize and operate international aviation missions.

Over the years, many Canadian airtankers and water scoopers have taken extended assignments at U.S. airtanker bases. Almost annually in recent years, Convair 580 airtankers from the Province of Saskatchewan have been relocated to the United States after their peak fire season.

The Marie Bashir

The Forest Service and interagency wildfire community have exchanged wildfire suppression resources many times with Australia. In 2021 the New South Wales Rural Fire Service in Australia provided a Boeing 737 airtanker during a period of extreme fire activity in the United States. This welcome assistance occurred after several hundred Federal wildland firefighters and managers from the United States were deployed from December 2019 through the spring of 2020 to assist during an extreme bushfire season in Australia. Arriving at the National Interagency Fire Center in Boise in late July, the airtanker was operational for almost 60 days in the United States. The "737 Fireliner" had a capacity of 4,000 gallons with two internal tanks and was named "Marie Bashir" after a former governor of the state of New South Wales.

USDA Forest Service photo.

Source: https://www.nifc.gov/fire-information/news-releases/united-states-welcomes-australian-firefighting-aircraft

The Federal Excess Personal Property (FEPP) Program has provided aircraft that were converted to airtankers by CAL FIRE, including the Grumman S-2T, a highly effective type 3 airtanker.[174]

The National Aeronautics and Space Administration (NASA) has assisted the Forest Service airtanker program in a number of ways. They have evaluated the stresses of missions on airtanker airframes and organized data-gathering efforts, including the Aerial Firefighting Use and Effectiveness Study.[175]

Top: This Convair 580 airtanker from the Province of Saskatchewan assisted with wildfires in Oregon in 2018. Photo by Alex Juorio. Bottom: Grumman S-2T airtanker. California Department of Forestry and Fire Prevention photo by Wes Schultz.

5.12. Airtanker Makes and Models

Table 5.6 lists airtankers used by the Forest Service since the 1950s. Aircraft with the same capacity and appearance may be grouped, for example the DC-4 and C-54, which are the civilian and military versions of the same aircraft. Aircraft that were tested but never used operationally are not included.

Some of the dates are approximate; when a better source couldn't be located, the first known year on a Forest Service contract is used for the "first use" year and last known year on contract for the "last use" year. Major sources include:

- Forest Service airtanker contracts, various years.
- Larkins, W.T. 1964. Forest fire air attack system. American Aviation Historical Society Journal. Glendale, CA: American Aviation Historical Society. 9(3).
- Linkewich, A. 1972. Air attack on forest fires: history and techniques. Calgary, AB: D.W. Friesen. 321 p.
- Goodall, G. Aviation History Site. Warbirds Directory. Version 6. U.S. Fire Bomber Operators, A-Z. https://www.goodall.com.au/warbirds.htm. (8 January 2024)

Table 5.6. Airtanker makes and models

First use (year)	Last use (year)	Make	Model(s)	Owned	Contracted	Type	Amphibious	Engine	Comments
1950s	2010	Martin	JRM2/3, Mars		✓	1	✓	Multi	6,000-gallon capacity; provided by Canadian contractors
1954	Unknown	Grumman	TBM, 1C and 3, Avenger	✓	✓	3		Single	Originally designated TBF, changed to TBM when manufactured by General Motors; Forest Service owned 8 at one time
1955	Mid-1960s	Boeing	PT-17 Stearman, N25S-3 Kaydet		✓	4		Single	125 gallons of water; 100 gallons of borate
1955	Unknown	Piper	Super Cub		✓	4		Single	100-gallon capacity
1956	Unknown	Naval Aircraft Factory	N3N Yellow Peril		✓	4		Single	Name derived from original paint color (yellow) and its principal use by inexperienced flight students ("peril")
1957	Unknown	Consolidated Vultee Aircraft Corporation	PBY6A Catalina	✓	✓	3	✓		Used mostly in the United States; owned to develop prototype tanks and drop systems
1957	Unknown	Fairchild	C-82, Packet		✓	2		Multi	
1957	1968	Ford	Tri-Motor; 4-AT-E		✓	4		Multi	300-gallon capacity
1957	Unknown	Noorduyn	Norseman			4		Single	
1958	Still in use	De Havilland	DCH-2, Beaver	✓		4	✓	Single	Stationed at Ely, MN
1958	1976	Grumman	F7F, Tigercat		✓	3		Multi	
1959	2002	Consolidated	PB4Y-2 Privateer		✓	2		Multi	Retired after airframe failure
1959	1960	North American	B-25 Mitchell and variants		✓	3		Multi	
1960	Unknown	Douglas	SBD-A-24, Dauntless[176]		✓	3		Single	
1960	1988[177]	Douglas	B-26 Marauder and several variants; A-26 Invader		✓	3		Multi	
1960	1984	Lockheed	PV-2/B-34, Harpoon		✓	3		Multi	
1960	1968	North American	AJ-1 Savage		✓	2		Multi	

Table 5.6. Airtanker makes and models (cont.)

First use (year)	Last use (year)	Make	Model(s)	Owned	Contracted	Type	Amphibious	Engine	Comments
1960	Unknown	Beechcraft	Model 18 including the AT-11 Kansan, C-45 Expeditor, and others[178]		✓	4		Multi	Also commonly known as a “Twin Beech”
1960	Unknown	Transland	Ag-2		✓	4		Single	160 gallons
961	Approx. 1996	Boeing	KC-97 Stratofreighter and variants		✓	1		Multi	
1961	Unknown	North American	AT-6, Texan		✓	4		Single	
1962	1962	Consolidated Vultee Aircraft Corporation	PBY5A Catalina		✓	3	✓	Multi	Used mostly in Canada
1962	1973	Grumman	AF-2S, Guardian		✓	4		Single	
1962	1984	Boeing	B-17F and G; Flying Fortress, Dart		✓	2		Multi	
1962	Unknown	Snow	2-SC		✓	4		Single	300 gallons
1963	Unknown	Columbia (Grumman)	J2F-6, Duck		✓		✓	Single	300 gallons
1963	1964	Northrup	P-61 Black Widow and variant		✓	3		Multi	The F-15A Reporter was a reconnaissance version of the Black Widow
1969	Still in use	Canadair Ltd./ Bombardier Viking Air Ltd.	CL-215 and variants		✓	3	✓	Multi	1,400 gallons; turbine engine version is CL-215T
1970	1987	Fairchild Corporation	C-119 variants Flying Boxcar		✓	2		Multi	
1970	2005	Grumman	S-2A Tracker	✓		3		Multi	FEPP to CAL FIRE
1970	2017	Lockheed	P2 Neptune with variants	✓	✓	2		Multi	Forest Service owned one as an evaluation aircraft; primary aircraft were P2V-5, P2V-7, and SP-2H
1976	2004	Douglas	DC4, C-54 Skymaster, numerous variants		✓	2		Multi	Discontinued when original equipment manufacturer declined to support the aircraft as an airtanker

Table 5.6. Airtanker makes and models (cont.)

First use (year)	Last use (year)	Make	Model(s)	Owned	Contracted	Type	Amphibious	Engine	Comments
1977	1977	Douglas	DC-3 Dakota[179]		✓	3		Multi	
1984	1989	Fairchild Corporation	C-123 Provider		✓	2		Multi	
1990	2002	Lockheed	C-130A Hercules		✓	1		Multi	Retired after airframe failure
1990	2011	Lockheed	P-3 Orion		✓	1		Multi	Contract terminated due to safety concerns
Early 1990s	Still in use	Air Tractor, Inc	802A land based; 802F Fire Boss, amphibious version		✓	4		Single	On contract at John Day, OR, through 2019
1994	Still in use	Canadair Ltd./ Bombardier, Viking Air, Ltd.	CL-415		✓	3	✓	Multi	Approximately 1,600 gallons
2002	2020	Boeing Commercial Airplanes	B-747 various models		✓	VL		Multi	VLAT
2005	Still in use	Grumman	S-2T Tracker	✓		3		Multi	Turbine conversion of S2As began in 1987 and was completed in 2005; FEPP operated by CAL FIRE
2006	Still in use	McDonnell Douglas	DC-10, several models		✓	VL		Multi	VLAT
2011	Still in use	British Aerospace	BAe 146		✓	1		Multi	
2013[180]	Still in use	Avro International Aerospace	RJ85		✓	1		Multi	
2013[181]	Still in use	Lockheed	C-130Q Hercules		✓	1		Multi	
2014	Still in use	McDonnell Douglas	MD-87		✓	1		Multi	
Unknown	Still in use	Ayers Corporation	Turbine Thrush 500 Series		✓	4		Single	On contract at John Day, OR, beginning in 1993
Unknown	Unknown	Douglas	B-18 Bolo[182]		✓	4		Multi	

CAL FIRE = California Department of Forestry and Fire Prevention; FEPP = Federal Excess Property Program; VLAT = very large airtanker

Lockheed SP-2H Neptune, Airtanker 03, dropping retardant. USDA Forest Service photo by Robert Manis.

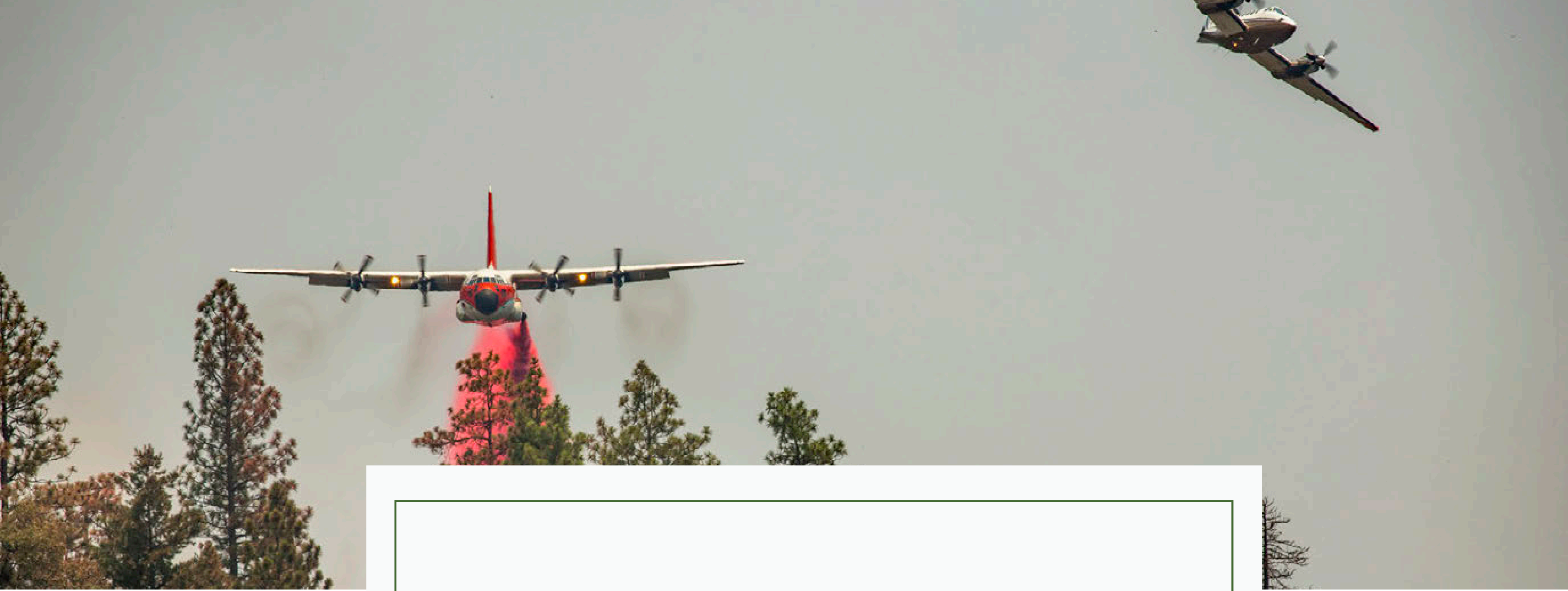
Tanker 10, a BAe 146 owned by Neptune Aviation, making a drop on a wildfire on the Sequoia National Forest in California in 2016. The speed brake, deployed to slow the aircraft to drop speed, is visible just below the tail number. USDA photo by Lance Cheung.

Name that airtanker. *A selection of airtanker photos from the collection of Paul Linse, assistant director of aviation, USDA Forest Service. First row: P2V, N128Z, Forest Service (left); C-130A, T-63, TBM, Inc. (right). Second row: PB4Y-2, T-121 (left); C-54E (per FAA, despite the DC-4 marking), T-160, AeroFlight (right). Third row: C-54, Aero Union, Spirit of America, painted and numbered for the bicentennial (left); DC-6, T-16, Ex Aero Retardant (right).*

First row: Two N3Ns (left); F7F, a modified military aircraft (right). Second row: P2V, T-38, with two A-26s, T-24 and T-23 (left); PB4Y-2, T-30, "Charlie 30" (right). Third row: C-130A, T-81, Hemet Valley (left); B-17, T-17, with a leadplane on the left (right).

B-25 (top left); B-17, T-22, Evergreen (top right); AF-2S Grmman Guardian, Aero Union (bottom).

N3Ns (top left); C-119, T-12, Aero Union (top right); AF-2S Grumman Guardian, T-21, Aero Union (bottom).



A C-130 airtanker (left) being guided by a King Air leadplane. USDA Forest Service photo.

CHAPTER 6

AERIAL SUPERVISION

6.1. Significant Events

1956—First air attack supervisor, Joe Ely, Mendocino National Forest, in a Piper Tri-Pacer.

1957—Operational guidelines begin to be developed.

Late 1950s—T-34s, a military version of the Beechcraft Bonanza, acquired for use as leadplanes.

1959—A Piper PA 24-205 and Beechcraft K-35 Bonanza acquired for use as leadplanes.

1963—"Smoke Marker" system developed for the T-34s.

1967—Beechcraft Baron C-55 airplanes acquired for use as leadplanes.

1970s—Transition to multi-engine airtankers and leadplanes.

1971—U-3As, the military version of the Cessna 310, acquired for use as leadplanes.

1971—Federal Aviation Administration (FAA) established procedures for requesting a temporary flight restriction over sites, including wildfires, allowing the Forest Service to restrict nonparticipating aircraft from a designated airspace during air attack missions.

1971—Bureau of Land Management (BLM) begins using a single aircraft for the dual role of leadplane and air attack group supervisor (beginning with a Cessna 180 and evolving through a variety of aircraft).

1974—First female leadplane pilot hired by the Forest Service.

1978—9,600-channel programmable radio introduced into the wildland fire community.

1978–1984—Purchase of 20 Beechcraft Baron 58P airplanes.

1980–1987—Forest Service conducts structural analysis of Barons to determine fatigue life of aircraft.

1985—Full implementation of the incident command system establishing the current air attack group structure.

1992—BLM begins using the OV-10 Bronco as their combined air attack platform.

1998—Tactical Aircraft Resource Management Study (TARMS).

1998—Aerial supervision modules established based on TARMS.

2001—Midair collision on the Bus Fire results in development of fire traffic area (FTA) concept.

2003—Forest Service grounds 11 of 19 Beechcraft Baron 58P leadplanes.

2003—Aerial supervision module (ASM) program begins on a trial basis.

2004—Approval and expansion of the ASM program.

2007—Airworthiness directive issued grounding the entire fleet of Barons.

2008—Forest Service begins contracting for Beechcraft King Air ASM/lead aircraft.

2013—NightWatch Program implemented in southern California.

Air Attack 12, a Rockwell 690A turboprop Twin Commander, in 2020. USDA Forest Service photo by Lisa Cox.

6.2. Background—Why Aerial Supervision?

Since the first use of airtankers, ensuring that suppressant drops are accurate, well-coordinated, and safe continues to be the objective of aerial supervision. Aerial supervisors provide the bridge between the firefighters on the ground and the aircraft dropping suppressants. Some drops can be made safely and effectively without aerial supervision, particularly in relatively simple situations where drop objectives are clear and there are only a few aircraft over the fire. As incidents become more complicated—with multiple aircraft, multiple types of aircraft, and/or limited visibility—the skills of aerial supervisors are required. In high-tempo operations, they are critical.

During the Army Air Patrol era (1919–1928), some aerial scouting was accomplished. But its effectiveness was hindered due to limited two-way communication between the aircraft and the incident. With the development of the two-way air-to-ground radio in 1929, the effectiveness and use of aerial scouting of fires increased. Firefighters on the ground appreciated and valued the "eyes in the sky." Aerial scouting continued to develop over the years that followed, and, by the time airtankers were introduced in 1955, it was a standard expectation that aerial scouts could provide information to firefighters on the ground.

In designing the first airtanker squadron in 1956, Fire Control Officer Joe Ely also incorporated a "bird dog" Piper Tri-Pacer, piloted by Lee Sherwood. A forest officer flew in the front seat of this aircraft to direct the airtankers and correlate with ground attack.[1] Joe Ely's work in 1956 and 1957 pioneered many of the aerial firefighting concepts still in use today.[2]

6.3. Initial Testing

There was no formal project dedicated to the development of aerial supervision in the initial years of the airtanker program. The program evolved from lessons learned, mostly in California. The value of aerially applied suppressants was quickly appreciated by experienced fire personnel, and the demand for drops increased, particularly on emerging fires. From there, a systematic approach to airtanker use developed. This led to the development of training for aerial supervisors, fire overhead, dispatchers, and other agency personnel.

6.4. Early Years (1955–1963)

In 1956 and 1957 the agricultural aircraft converted for use as airtankers had no radios. Calls for airtankers were made to Mendocino National Forest Dispatcher Charlie Lafferty using the designation "Willows 80." Once Lafferty received a request, he would call one or more of the contracted flying services participating in the airtanker squadron and communicate the location of the fire and closest reload airstrip. Often the dispatch request was to "go out and see what you can do with it."[3]

When more than one aircraft was required to suppress a fire, Joe Ely would function as the air tactical coordinator in the front seat of the Piper Tri-Pacer. Once over the fire, Ely would have the pilot "waggle his wings" to point out where he wanted retardant dropped. The pilots quickly learned how to work with ground forces to create an effective fireline.[4]

Lacking radios and aerial supervision standards, deficiencies in procedures were soon identified. In 1956, airtankers were used on 25 fires from Oregon to the Mexico border. On one of the fires, a retardant drop was mistakenly applied to an otherwise successful backfire operation, causing the line to be lost. On other larger fires where airtankers were being used, serious operational problems were encountered, including not having enough retardant and mixing capability and inadequate coordination with ground forces and air traffic control.[5]

The lessons learned in 1956 informed the early development of operational guidelines in 1957. These guidelines specified that "four to six airtankers make an effective, manageable airtanker squad" and "if possible, they should be led by an experienced firefighter in a reconnaissance airplane." The need for close coordination with other fireline activity was emphasized. Occasionally, it was necessary for the firefighter on the ground to direct airtankers to a low-visibility target. Other operational norms were yet to be instituted. For example, initially it was thought that free-falls of water or borate were not harmful to personnel on the ground, and that the target area did not need to be evacuated.[6]

During this early period without radios, the Forest Service also developed the leadplane system for directing airtankers. Leadplanes were used to lead the airtanker from the orbit position, through the descent, final run, and exit. The target would be pointed out in an initial pass over the fire, with a subsequent "pull-up" over the target. The airtanker would follow the leadplane in an astern position through the entire run.[7]

By 1957, the air attack organization in the large fire organization (precursor of the incident command system) in the Pacific Southwest Region included the following positions:

- Airtanker pilots
- "Bird dog" pilot (functioned as the air unit leader for airtankers and led airtankers through the drop sequence)[8]
- Air control chief (now called the air operations branch director)
- Air attack boss (now called the air tactical group supervisor)
- Air traffic manager (located at the airtanker base, received airtanker requests from the air control chief)
- Fire boss (now called the incident commander)
- Line boss (now called the operations section chief)

Collectively, these positions managed and directed the airtankers and leadplanes assigned to a large fire.[9]

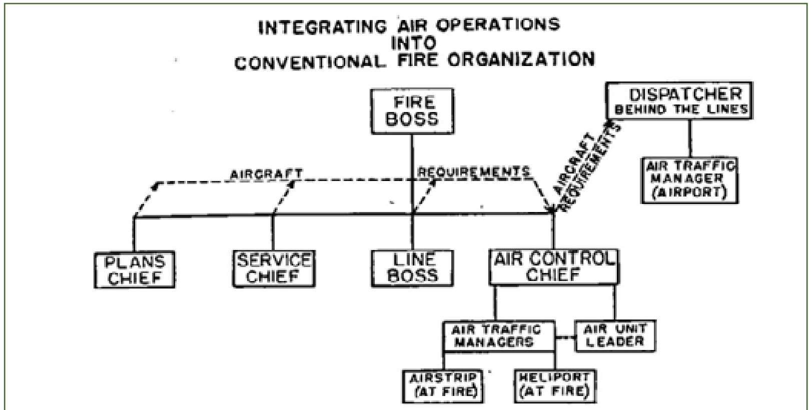


FIGURE 1.—How the suggested air operations positions fit into conventional large-fire organization. The solid lines indicate the direct command relationship in a fire operation. The dash lines show coordinating or advisory relationships. This proposed organization for air operation in fire fighting was field tested in California in 1957.

Organization chart showing how air operations fit into the large fire organization. From "Control of Aircraft on Forest Fires" by Carl C. Wilson in Fire Control Notes, Vol. 19, No. 2, April 1958.

Training and policy materials were developed, including films, slide shows, and handbooks. Direction was given that "airtanker attacks should never be used until contact and control are established," and initial attack without a leadplane was determined to be "a job for experienced fire pilots only." Importance was placed on the need to review accidents and near-misses and that "training to the point of perfection" was imperative.[10]

During this time period, the most efficacious use of airtankers was being debated. The realization emerged that a complete "system" of aerial supervision was needed. Success included reliable radio communications, with not only air-to-air but also air-to-ground capability. Additionally, the need for an "initial attack" endorsement for pilots became apparent.

As this era was drawing to a close, the emerging conventional wisdom was that airtankers are "perhaps most valuable for initial attack" and that the use of airtankers on large fires "should be limited to situations where the chance for successful action is high and benefits will more than offset costs."[11] Often, decisions had to be made when an airtanker was already over a fire, and in many cases by the initial attack pilot.[12]

Development of the "Smoke Marker System" by the Arcadia Equipment Development and Testing Center in 1963 dramatically increased the ability of leadplane pilots to communicate understandable instructions to airtanker pilots. Installed in T-34s (and subsequent leadplanes), the system produced highly visible bursts of "smoke" (consisting of an oil-soluble dye and oil), which gave airtanker pilots a positive target fix.[13]

By 1963, an incredible amount of experience had been gained—at a terrible cost. In addition to a number of airtanker accidents throughout the 1950s, an accident occurred during a leadplane training qualification flight in 1958 on a fire on the Cleveland National Forest in the Pacific Southwest Region—a structural failure of the Beechcraft Bonanza leadplane resulted in the death of both pilots.[14] In the Rocky Mountain Region, a leadplane pilot was killed in 1962 following a midair collision with a PB4Y2 airtanker. Although airtankers coupled with aerial supervision had proven to be very beneficial in the wildland fire arena, it was clear that refinements in the aerial supervision support mission were warranted.

6.5. Regional Program Development (1964–1973)

With airtankers now being contracted in all regions in the lower 48, some standardization of the air attack organization was occurring. Day-to-day initial attack and extended attack air organizations varied widely between regions. Often, an air observer would be pressed into duty to facilitate communication between airtankers and ground forces. When needed and available, qualified air attack bosses with extensive fire suppression experience and airtanker coordinators/leadplane pilots were deployed.

The large fire organization approach to air attack was developing. A 1967 report from the Cleveland National Forest described a combination helitanker-airtanker attack as being highly effective, if well managed, on a very complex fire. Two required features were radio communications between all aircraft and direct supervision of all retardant drops by the airtanker boss/leadplane pilot in a single-engine Beechcraft T-34 Mentor. The organization established to manage air attack included an air attack boss (with fire experience) who was responsible to the line boss and established the flight pattern over the fire and set the priorities for attack.

As was typical of the era, two radio frequencies were available to the air attack organization. AirNet was used for communication between all aircraft, while Forest Net was used among the air attack boss, helicopter manager, and fireline personnel. With altitude separation, helitankers were deployed in the same manner as airtankers. In some cases, two aircraft were led at the same time.[15]

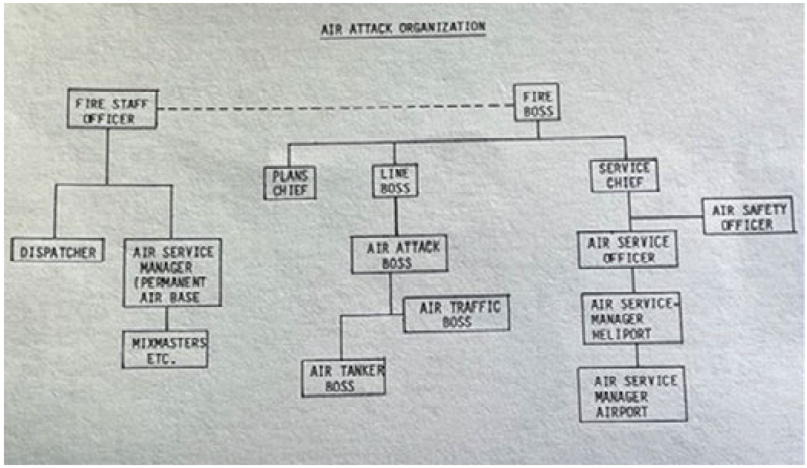


Diagram of air attack organization (large fire organization), from the National Wildfire Coordinating Group's "Fireline Handbook."

This air operations structure in the large fire organization remained much the same until implementation of the incident command system was completed in 1985. The air attack boss was responsible to the line boss for the tactical deployment of all aircraft. The airtanker boss/leadplane pilot was supervised by the air attack boss and responsible for supervising airtanker operations and piloting the leadplane. Due to radio communication limitations of the time, an air traffic boss was often assigned with the primary duty of communicating with aircraft in the traffic pattern.[16]

In 1967 the Forest Service acquired twin-engine Beechcraft Baron C-55 airplanes for leadplane work. After a 1968 study recommended that all Forest Service airtankers be multi-engine aircraft, a transition to multi-engine leadplanes and airtankers occurred in the early 1970s. Implementation of this recommendation changed many aspects of the leadplane program. Twin-engine leadplanes offered much better performance at higher altitudes and the benefit of increased speed. They were nearly as fast as most airtankers of the era and able to quickly relocate over long distances when needed.

In 1971 the Forest Service acquired military U-3As (the military designation for the Cessna 310) for use as leadplanes. Decentralization was obvious during this time of transition. For example: "All regions used the U-3As except [the Pacific Southwest Region] which acquired additional Beechcraft Barons. [The Pacific Northwest] augmented its U-3As with leased Cessna 310s, and [the Southwestern Region] used leased Barons instead of U-3As."[17]

Air attack bosses often flew in a high-wing aircraft such as a Cessna 180, 185, or 210 and occasionally in a Cessna 337 or Rockwell Aero Commander. Because of radio limitations at the time, the air attack role on large fires was often performed by two people in one aircraft. The primary air attack—tasked with determining drop targets—would sit in the front seat and talk to firefighters on the ground via the Forest Net or a Fire Net. The air traffic boss would sit in the back seat and talk to the airtankers, directing them into and out of a pattern.[18]

Unfortunately, the era began and ended with leadplane accidents. In 1964 a leadplane pilot was killed in a midair collision while flying a T-34 on a fire in the Southwestern Region.[19] In 1973 a TBM airtanker crashed after a midair collision with a Cessna 310 leadplane on the Lassen National Forest in the Pacific Southwest Region. The airtanker pilot was killed and the leadplane pilot survived a crash landing.[20]

Artwork at NIFC Aviation Office in Boise, ID

Cessna 310A/U-3A by Steven R. Whitby. Forest Service leadplane N135Z experienced a midair collision with an airtanker while working on a fire near Chester, CA, in 1973. Artwork courtesy of Steven R. Whitby.

There is a fabulous collection of Whitby's artwork at the Forest Service's national aviation offices at the National Interagency Fire Center. Drawings purchased by the Forest Service include over 40 different firefighting aircraft used throughout the years, including 28 airtankers, 6 aerial supervision airplanes, 4 helicopters, and 4 smokejumper aircraft. Manufacturing dates of the aircraft displayed range from 1929 to 2018.

The drawings include background information such as aircraft dimensions, powerplant, performance, range, capacity, mission, and date of operations. Some of Whitby's earlier drawings were done by hand, while later drawings were produced electronically.

6.6. National Program Development (1974–2000)

Flight activity was steadily increasing in the early 1970s, exceeding 100,000 hours of flight time annually in busy years. Forest Service aviation equipment, procedures, and management had not kept pace, often resulting in unsafe, inefficient, and uneconomical operations. The National Aviation Plan—implemented beginning in 1974—identified 15 major focus areas, including the need to "develop national standard leadplane procedures." Despite this, development and use of the air attack boss position remained a regional or local effort.[21]

In 1978 when a fire in a lumbermill in Baker City, OR, was burning out of control, a DC-6A airtanker was dispatched. No leadplane was available. A child observing the fire was significantly injured during the drop. Following this incident, the Forest Service and Federal Aviation Administration (FAA) reached an agreement documented in FAA Grant of Exemption 392, including a requirement for a leadplane during the application of retardant in congested areas below 500 feet.[22] (For more details about this incident, see chapter 5.6.1.)

Two major transitions began in 1978: implementation of the 9,600-channel programmable FM radio and acquisition of Beechcraft Baron 58Ps to fulfill the leadplane role.

6.6.1. Aircraft Radio Systems

Refinement of aerial supervision standards and procedures continued from the late 1970s through the 1990s. One significant limiting factor was FM aircraft radio systems. At the beginning of this era, most airtankers, contract helicopters, leadplanes, and air attack aircraft relied on Forest Service PT-300 pack sets mounted on the floor of the aircraft. Most systems used two pack sets—one set to Forest Net for tactical communications with ground forces, and the other set to AirNet for air-to-air communications. These systems were almost immediately overloaded in a multi-aircraft initial attack.

By the mid-1970s, 6-channel FM radios mounted under the aircraft's panel were available and used in most agency-owned and contracted aircraft, but only occasionally available in call-when-needed (CWN) aircraft. Forest Service-owned and contracted smokejumper aircraft, leadplanes, and airtankers often had multichannel radios while other aircraft did not, including CWN type 1 and 2 helitankers and aircraft used by air attack bosses. This resulted in overloaded and self-limiting radio systems.

The Transition to 9,600-Channel Radios

The introduction of programmable 9,600-channel radios in 1978 was a huge leap forward. The transition to this radio system occurred first in agency-owned aircraft, then in exclusive-use contracted aircraft. Call-when-needed aircraft were not required to have 9,600-channel radios—to overcome this discrepancy, some portable systems were developed that could be installed in the field. Without a national standard for aircraft used by air attack bosses, the radio capability of any individual aircraft was up to the owner. CWN aircraft that did have 9,600-channel FM radios were highly valued and well used.[23]

Air attack group supervisors occasionally used helicopters for their air attack platform. Helicopters offered a significant advantage over fixed-wing aircraft in their ability to land near the incident command post. Helicopters allowed the air attack group supervisor to be based near the incident command post where they could participate in briefings and planning meetings (rather than at a distant airport as with fixed-wing aircraft). Contract helicopters also had the 9,600-channel capability. Helicopters used for these missions were often the Hughes 500D and Bell 206B3.[24]

The need for better radio systems became apparent with the increased use of type 1 and type 2 helitankers in the early 1970s. Helitankers provided ground firefighters an incredibly effective and accurate tool that often had an immediate positive effect on fire suppression. In addition to airtankers and leadplanes on large fires, there were often one or more helitankers dipping and dropping in closely sequenced flight patterns that required precise coordination for safe operations. The 9,600-channel radio provided the ability to monitor multiple radio channels, increasing situational awareness for all participants in a high-tempo operation.

6.6.2. Acquisition of Beechcraft Baron 58P Leadplanes

In 1975, as a part of implementing the National Aviation Plan, the Forest Service decided to purchase a standardized fleet of leadplanes that would be multi-engine and multi-purpose, with the capability of transporting passengers. Candidate aircraft were the Beechcraft Baron 58P, Cessna 340, and Piper Aerostar 601. The Beechcraft Baron 58P was selected, with 20 aircraft purchased by 1984.

Mary Barr sitting in her cockpit in 1975. Barr was the first female leadplane pilot hired by the Forest Service in 1974, based in Redding, CA. Barr later became the national aviation safety officer and regional aviation safety officer for the Pacific Southwest Region. She was inducted into the Women in Aviation, International Pioneer Hall of Fame in 2001. San Diego Air and Space Museum photo.

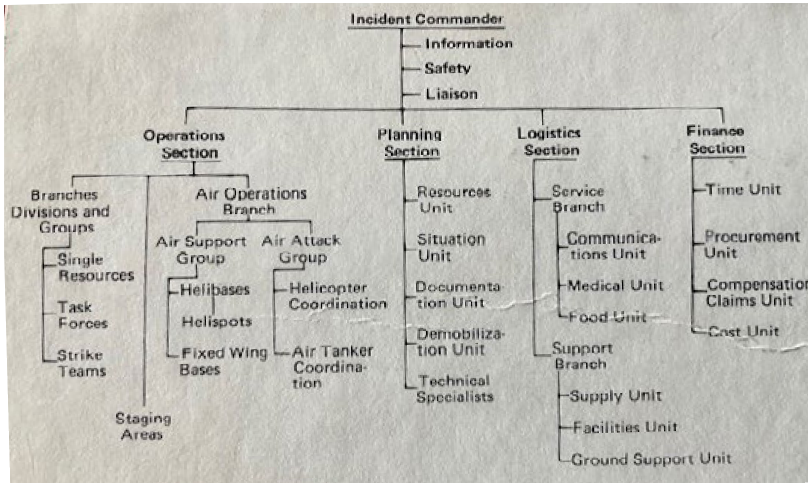
The Beechcraft Barons were purchased new with a manufacturer-designated life expectancy of 10,000 flight hours. During their Forest Service life, there was one major upgrade to the avionics system and two additional modifications to the navigation system.

Five of these Beechcraft Baron 58Ps were destroyed in accidents from 1981 to 1995:[25]

- 1981, Pacific Southwest Region, Redding, CA: Mechanical failure on takeoff caused the aircraft to crash into the parachute loft. The pilot and three passengers were fatally injured.
- 1988, Pacific Southwest Region, Sequoia National Forest, Havilah Fire: Leadplane pilot was fatally injured.
- 1991, Southwestern Region, Cibola National Forest, Ziplock Fire. Leadplane pilot was fatally injured while observing an airtanker drop.
- 1991, Pacific Northwest Region. Aircraft was destroyed while landing in a large meadow following fuel starvation. Pilot and passengers were uninjured.
- 1995, Pacific Southwest Region, Butterfield Fire, Ramona, CA. Leadplane pilot was involved in a midair collision with an airtanker while landing. The leadplane pilot and both airtanker crew members were fatally injured.

6.6.3. Air Attack Group Structure

With full implementation of the incident command system in 1985, the air attack group structure was established. This structure is still used today.[26]



Incident management team organization chart from 1985. This structure is still in use today.

Increased emphasis on national coordination and standards was bringing the era of independent, primarily regional leadplane operations to an end. However, air attack boss procedures and aircraft were still primarily directed by each region.

6.6.4. Tactical Aerial Resource Management Study (1998)

Throughout the 1990s, the interagency community was realizing the need for a greater emphasis on all components of aerial supervision. The interest was in developing a deliberate "systems" approach to aerial firefighting, rather than relying on an evolutionary process of program development. This interest resulted in the establishment of a committee to complete a "National Study of Tactical Aerial Resource Management to Support Initial Attack and Large Fire Suppression" (TARMS).[27]

Results of the study were documented in a final report in October 1998. The study was comprehensive and based on a mission task analysis that considered the skills, technologies, communications, and team coordination necessary to supervise and direct the air attack mission. Developing the committee report into management options was assigned to a TARMS management options team.

The TARMS report generated a total of 19 recommendations—7 related to the organizational structure to support aerial supervision, 6 related to human-aiding technology, 4 related to aircraft, and 2 general recommendations related to training and overall report implementation. At the time TARMS was developed, the Forest Service had 10 full-time air tactical group supervisor positions in the agency.

6.6.5. Development of the Aerial Supervision Module

One of the biggest enhancements to the aerial supervision program recommended by TARMS was the establishment of aerial supervision modules (ASMs). ASMs are composed of two people: a fully qualified air tactical group supervisor (ATGS) and a fully qualified air tactical pilot (ATP). The goal was to create more efficient and safe aerial supervision operations by leveraging the synergy between the two positions.

Benefits associated with ASMs include:[28]

- Training and familiarization between the ATGS and ATP could be accomplished quickly and efficiently because both individuals were highly experienced.
- Because both the fire and aviation experts arrive at the fire at the same time (in the same aircraft), sizing up the fire and developing strategies and tactics could be done concurrently with maximum communication.
- By having the ATGS and ATP in a single aircraft, fewer aircraft were required over the fire.
- Having two individuals sharing the workload helped reduce fatigue.
- By putting the ATGS and ATP in the same aircraft, the two individuals could communicate via the aircraft intercom without using fire radio frequencies, lessening frequency congestion.

It took a few years for the Forest Service to embrace the concept of the ASM. Despite the benefits, concern was expressed about placing two people in the low-level environment in the same aircraft. At the time, Forest Service policy did not allow ATGS personnel to operate below 500 feet above ground level (AGL) when in the leadplane mission profile. Although TARMS recommended establishing 41 ASMs, it would take until the mid-2000s to begin to approach that level of capacity.

6.7. The 2000s to 2021

The Forest Service began an aerial supervision module (ASM) program on a limited basis during the 2003 fire season. The success of this trial period resulted in full approval and expansion of the program beginning in 2004.[29]

In February 2004 a letter was issued that adjusted Forest Service policy to allow ATGS personnel to operate below 500 feet AGL while performing leadplane missions, clearing the last policy obstacle for ASM implementation. By 2007, there were eight Forest Service-qualified air tactical supervisors with another four trainees in the system.[30] Based on TARMS, momentum was slowly building to bolster the numbers of permanent aerial supervision positions.

In the modern era, aerial supervision has come to be defined with four structural components: leadplane pilots (air tactical pilots), air tactical group supervisors, aerial supervision modules, and helicopter coordinators.

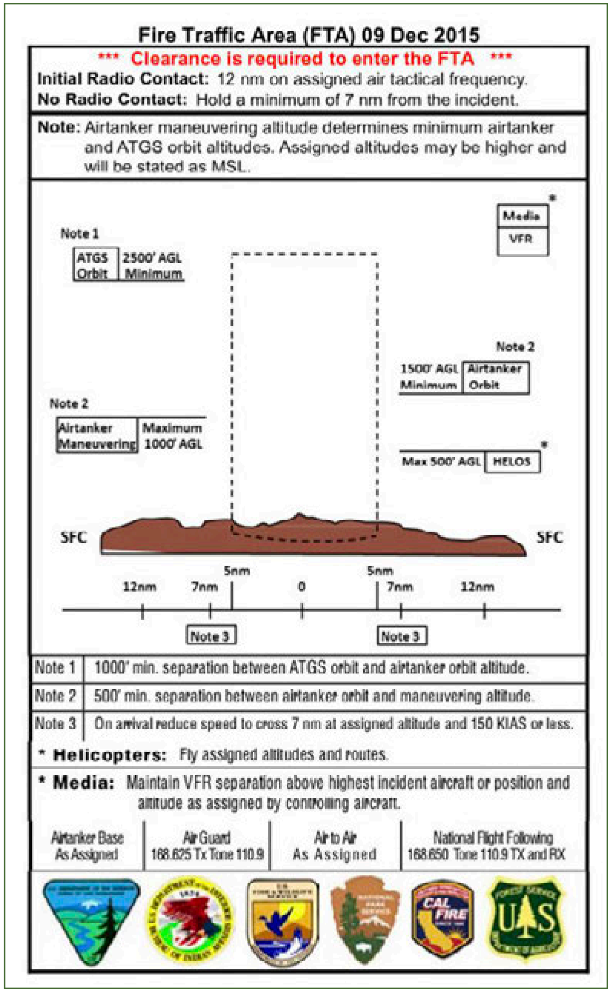
6.7.1. Development of the Fire Traffic Area

On August 27, 2001, a tragic midair collision occurred with two California Department of Forestry (now CAL FIRE) airtankers. The Grumman S-2 airtankers were both assigned to and working on the Bus Fire in Mendocino County close to Ukiah, CA. The airplanes collided in smoky conditions, resulting in the death of both highly experienced pilots.[31] The accident highlighted the need for more structured airspace management around incidents (fires or other events) using multiple aircraft.

In the fall of 2001 and winter of 2002, Bob Coward, a CAL FIRE leadplane pilot, proposed the first rendition of more restrictive procedures. Working with Federal partners from the Forest Service and Bureau of Land Management, operational procedures were refined to govern airspace around incidents. These procedures became known as the fire traffic area (FTA) and were implemented beginning in the 2002 fire season, with CAL FIRE being the first adopter.[32]

The National Wildfire Coordinating Group's "Standards for Airspace Coordination" provides a relatively succinct yet thorough explanation of the FTA:

> “The FTA was developed by aerial firefighting personnel to provide a standardized initial attack airspace structure to enhance air traffic separation over wildfire (or all risk) incidents. The structure and communications requirements are patterned after Class D airspace with some specific differences. The structure emphasizes established communications, received and understood clearances, and compliance with the clearances. The intent is that an aircraft will NOT enter the FTA until it receives a clearance.
>
> “The FTA utilizes a 5-[nautical-mile] (NM) radius from the incident latitude and longitude. Five NM is the minimum radius, although a radius greater may be used to adapt to unique incident demands. The uppermost limit of the FTA can flex vertically depending on operational requirements of participating incident aircraft.
>
> “There is an ‘initial contact ring’ established on a 12-NM radius from the incident latitude and longitude. There is a ‘NOCOM ring’ or holding ring established on a 7-NM radius from the incident latitude and longitude. If no communications (hence the coined term ‘NOCOM’) are established, the aircraft will hold at 7 NM and not penetrate the FTA any further. The NOCOM holding options include a 7 NM option or a quadrant option.
>
> “The FTA concept provides for arriving aircraft to be at the assigned altitude given by the air tactical group supervisor or leadplane prior to penetrating the FTA. For a standard shape FTA, the penetration point would be 5 NM from the incident.
>
> “Large incidents often will have airspace requirements and temporary flight restrictions (TFR) that exceed the dimensions of a standard FTA. In this case, initial points (IPs) are used in conjunction with transition routes to and from the incident. An IP is a physical location based on geographic or coordinate reference such as a latitude/longitude. Unless otherwise directed, arriving aircraft will reference the IP for initial communications and NOCOM procedures.”[33]



Fire traffic area depiction from the National Wildfire Coordinating Group's "Standards for Airspace Coordination."[34]

In 2002 the Forest Service acquired 25 excess military Bell AH-1 Cobra helicopters. The helicopters were equipped with enhanced technology packages and were evaluated in the aerial supervision role. The program became known as the FireWatch Program (see chapter 7.9).

Two significant events happened in 2002 that would impact aerial supervision assets. Two separate airtankers crashed due to structural failures in flight. On June 17, 2002, a C-130A crashed in California. A month later, on July 18, 2002, a PB4Y crashed in Colorado (see chapter 5.6.4). These events led the Forest Service to partner with the BLM and jointly establish an independent, five-member Blue Ribbon Panel to "identify weaknesses and fail points in the current aviation program, focusing on safety, operational effectiveness, costs, sustainability, and strategic guidance."[35]

6.7.2. Transition to Beechcraft King Air Airplanes

When the Blue Ribbon Panel was commissioned in 2002, the Forest Service owned 19 pressurized Beechcraft Baron BE-58P aircraft used as leadplanes. One of the limitations of the Barons that was highlighted in the panel's report was the single-engine service ceiling of the aircraft. An aircraft performance measure, the single-engine service ceiling is the maximum altitude that a multi-engine aircraft can maintain a 50-foot/minute rate of climb on one engine. The fleet of Barons had a single-engine service ceiling of about 7,300 feet when weighing 5,500 pounds and flying in standard-day air temperature (59° F and pressure of 29.92 inches of mercury).[36]

The unfortunate reality was that the Barons routinely flew in mission profiles that exceeded this limitation. This meant that they could not maintain flight if one engine were lost. Part of the reason the Baron was originally selected for the leadplane mission was because it had two engines and theoretically afforded a pilot the ability to return to base if one engine was lost. Another reality of the Baron fleet was the escalating rate of maintenance problems. In 2002 there were only 10 Barons available for the fire season. It was reported that of these 10, 2 sustained engine fires, 1 had a severe fuel leak, 2 experienced engine failures, and 1 sustained permanent wing-skin deformity due to overstress.[37]

An additional concern with the fleet of Barons was their structural life expectancy. Since the Barons flew in a more environmentally severe mission profile (tactical flying over wildfires) than most aircraft, there were concerns about the prolonged effect on the structure of the Barons. Many (including the aircraft manufacturer) shared these concerns, which would eventually lead to an FAA-issued Airworthiness Directive (AD) that would reduce the service life of the aircraft and ground the entire fleet.

An effort to analyze the typical flight spectrum of leadplanes occurred from 1980 to 1987. The Forest Service contracted with Beech Aircraft for four flight recorders and the necessary engineering analysis of the collected data. The contract lasted 26 months and provided foundational data for the Forest Service to continue their structural analysis. The results of the analysis were summarized in a 1987 report titled "Beech Baron 58P Fatigue Life Program," and resulted in a recommendation to reduce the service life of Forest Service Barons from the original 10,000 to 6,000 hours.[38]

Based on this 1987 fatigue report and the Blue Ribbon Panel findings, the Forest Service began to reevaluate the efficacy of the Baron fleet. A decision memo was issued on February 4, 2003, that directed all Barons exceeding 6,000 hours to be suspended from use.[39] Of the 19 Barons, 11 were grounded because they exceeded 6,000 hours. The irony of the decision was that the regions that flew the most were the ones with the high-time Barons, so the regions with the most active aviation programs lost their leadplanes. As the Barons began to be retired, regions filled the void with contracted aircraft. Regions contracted for Barons,[40] Aero Commanders, King Air 90s, and U-21s (the military designation of the nonpressurized King Air 90).

On November 15, 2007, the FAA issued an Airworthiness Directive (AD) that effectively grounded the entire fleet of Forest Service Baron BE-58P aircraft. Because of the severity of the flying environment that the Barons operated in for decades, the FAA was concerned that the fleet had been continuously exposed to rigors beyond what would be considered a normal flying environment. In the summary section of the AD, it stated, "This AD results from the FAA's analysis and determination that the operational history and usage of the affected airplanes requires a reduction in the structural life limit to 4,500 hours time-in-service (TIS) for the airframe (wing, fuselage, empennage, and associated structure)."[41] The FAA's AD was even more restrictive than the Forest Service's decision memo. By 2007, all Forest Service Barons exceeded this reduced limit and the entire fleet was grounded.

In 2008, the Forest Service began nationally contracting for Beechcraft King Air 90s. The initial contract was issued on June 27, 2008, with Greenwood Group, Inc. The solicitation was for up to 15 King Air 90s, and the Forest Service opted to start with 12. The contract continued through December 2011, with 12 airplanes contracted through that period.

After the initial King Air contract expired in 2011, a new contract was awarded to Greenwood Tenax, LLC, for up to 15 aircraft. The effective date of the contract was January 2012, and the vendor provided 14 King Air 90 aircraft. That contract remained in effect through December 2014, with 14 aircraft throughout the entirety of the contract.

A safety impact analysis (SIA) was conducted for the aerial supervision program in 2012. Participants included leadplane pilots, air tactical pilots, airtanker pilots, aerial supervision modules, air tactical group supervisors, and regional aviation officers and safety and training managers. Site visits were made to airtanker bases in three regions during active operations. The analysis produced 8 findings and 15 recommendations, identifying 39 hazards with 137 mitigation measures.[42]

A Beechcraft Baron 58P, circa 1983. The Forest Service used a fleet of Barons, purchased in the 1970s and 1980s, for aerial supervision. A 1987 report indicated that the wildfire environment was too stressful for these aircraft. The agency and the FAA gradually reduced the service life of the Baron leadplanes, and the entire fleet was grounded by 2007. San Diego Air and Space Museum photo.

Top: Air Attack 51, N40Y, is a King Air 200 that provides aerial supervision and infrared mapping in southern California. USDA Forest Service photo by Jed Smith. Bottom: This King Air 250, N147Z, was delivered to the Forest Service in 2018 and used as a leadplane. Photo by Allen Hess.

As one response to the Station Fire (see chapter 3.3.7), the Forest Service began the "NightWatch" program on the Angeles National Forest in southern California in 2013. The Forest Service contracted for a King Air 200 equipped with many technological enhancements. In addition to the airplane, NightWatch consists of a contracted pilot and mechanic, an agency ATGS trained as a sensor operator, and an additional sensor operator (either a contracted or agency employee).

The primary mission of NightWatch is to provide aerial supervision/command and control of aircraft and personnel in night firefighting operations. The NightWatch program is only approved for use in southern California and is designated as Air Attack 51 (AA 51). The suite of technology affords state-of-the-art data collection and mapping capability (see chapter 8.4).[43] The NightWatch program has been a positive addition to the arsenal of firefighting assets in southern California.

In January of 2017 a new contract was awarded to Greenwood Tenax, LLC, for 15 aircraft. The contract covered 2017, 2018, and 2019.

There was no formal process or analysis used to decide on the Beechcraft King Air as the next aerial supervision module (ASM) platform (see chapter 6.8.3). As the Forest Service has continued to contract for aerial supervision aircraft, contract specifications have evolved to target King Air 200 series aircraft. The avionics package that came as standard equipment in the King Air 200 was not intended for use in a tactical environment, resulting in some agency pilots not being completely supportive of the platform.

One of the biggest differences between the era when the Barons were acquired and the contemporary wildland fire environment was the addition of ASM. Any leadplane platform needed to be conducive to a multi-person crew. The versatility of the King Air 200, coupled with the recent experience with the King Air 200 as a contracted aircraft, resulted in that platform becoming the aircraft of choice for aerial supervision in the Forest Service.

In 2022, the Forest Service had 22 permanent ATGS positions stationed in 6 different regions. Five additional ATGS were scheduled to become permanent aerial supervision assets in 2023, and two ATGS/HLCO positions were added to replace the FireWatch Cobra helicopters that retired in 2021 (see chapter 7.9). The Forest Service had 16 ASM leadplanes.

Table 6.1. Aerial supervision exclusive-use contracted aircraft (2022–2023)

Forest Service region	Base	ATGS LFW	ASM Leadplanes	HLCO	Comments	Total
Northern	Coeur d'Alene, ID	1			Includes one modified CWN ATGS light fixed-wing that became EU in 2023; leadplane models: B90GT, B200, B200	7
	Grangeville, ID	1				
	Grass Valley, MT	1				
	Helena, MT	1				
	Missoula, MT		3			
Rocky Mountain	Casper, WY	1			Includes two modified CWN ATGS light fixed-wing that became EU in 2023. Leadplane model: B200GT	4
	Jeffco, CO	1	1			
	Pueblo, CO	1				
Southwestern	Albuquerque, NM	1	1		Includes one modified CWN ATGS light fixed-wing that became EU in 2023; leadplane model: B200	5
	Mesa, AZ	1				
	Sierra Vista, AZ	1				
	Prescott, AZ	1				
Intermountain	Boise, ID	1	1		One leadplane WCF since 2017 (Ogden, UT); leadplane models: B250GT, B200, B200GT	5
	McCall, ID	1				
	Ogden, UT		2			
Pacific Southwest	Chester, CA	1			2 helicopters replacing Cobras will become EU in 2023; leadplane models: B200GT	12
	Fresno, CA	1				
	Lancaster, CA	1				
	Redding, CA	1	2	2		
	San Bernardino, CA	2				
	Santa Maria, CA	1				
	Siskiyou, CA	1				
Pacific Northwest	Klamath Falls, OR	1			Leadplane models: B90GT, B200GT	10
	La Grande, OR	1				
	Medford, OR	1				
	Redmond, OR	2	4			
	Wenatchee, WA	1				
Southern	Atlanta, GA		1		Leadplane model: B200	1
Washington Office	Boise, ID		1		Leadplane model: B250GT	1
TOTALS		**27**	**16**	**2**		**45**

ASM = aerial supervision module; ATGS = air tactical group supervisor; CWN = call-when-needed [contract]; EU = exclusive-use [contract]; HLCO = helicopter coordinator; LFW = light fixed-wing; WCF = working capital fund

Beechcraft King Air 200 leadplane, June 2020. USDA Forest Service photo by Lisa Cox.

Top left: Cessna TU 206F, tail no. N111Z. Top right: Beechcraft T-34, tail no. N144Z. Bottom left: U3A/Cessna 310, tail no. N133Z. Bottom right: Beechcraft 58TC, tail no. N152Z. Photos courtesy of Paul Linse.

6.8. Aerial Supervision Missions

6.8.1. Air Tactical/Air Attack

By the mid-1970s, aerial supervision during initial attack varied widely depending on the region and location of the fire. Airtanker pilots carded for initial attack were authorized to make drops unsupervised, while pilots not qualified for initial attack required leadplane supervision. During multiple ignition situations, an air attack supervisor often provided overall priorities as well as instructions on which fires to attack and in which order. Smokejumper spotters frequently served as air attack bosses.

During project fires, the large fire organization was used until 1985 when the incident command system was fully implemented nationwide in the Forest Service.

6.8.2. Airtanker Lead

In 1996 four models of fixed-wing aircraft and one model of helicopter were used to fly leadplane missions for the Forest Service and BLM. Of the 5,010 hours of leadplane flight time, 4,297 were in Beechcraft Baron 58s or 58Ps. The helicopter used as a leadplane was a Bell 206B, which flew 99 hours.[44]

By 1998 a leadplane was required over a wildland fire when any of the following were present:[45]

- Airtanker pilot was not rated for initial attack.
- Operations were over a congested area (required by Forest Service, the Bureau of Land Management required that a resource order be submitted).
- Modular Airborne Firefighting System (MAFFS) C-130s were assigned.
- Two or more airtankers were over an incident.
- A leadplane pilot was requested by an airtanker pilot or ATGS.

Either an ATGS or leadplane pilot was required on a wildland fire if any of the following were present:[46]

- Foreign government airtankers were being used.
- Single-engine airtankers (SEATs) were operating with other tactical aircraft.
- Retardant drops were being made in low ambient light conditions.

Mount St. Helens Eruption (1980)

One of the most unique air attack boss missions of the era occurred at Mount St. Helens in Washington State. On March 20, 1980, a significant bulge with associated steam and smoke venting appeared on the north side of Mount St. Helens on the Gifford Pinchot National Forest. The then 3-year-old Federal Emergency Management Agency (FEMA) tasked the Forest Service to organize the emergency response. The Forest Service would lead and coordinate the response as the "principal Federal agency."

High-hazard zones were identified and evacuated. To provide real-time information on the location and direction of anticipated ash eruptions/clouds and debris flows in waterways, a daily, 24-hour Volcano Reconnaissance Program was undertaken. Staffing for the flights included a Forest Service air attack boss, a geologist from the U.S. Geological Survey in the backseat, and initially a contract pilot in a Cessna 337. Due to the relatively mild fire season that year, the Cessna 337s were quickly replaced by the newly purchased Beechcraft Baron 58Ps with leadplane pilots. This went on much of the summer of 1980 until monitoring systems could be put in place to provide the information that the Volcano Reconnaissance Program had been gathering.

Helicopters were also used to transport scientists with the U.S. Geological Survey after the Mount St. Helens eruption. USGS photo.

6.8.3. Aerial Supervision Modules

The 1998 Tactical Aerial Resource Management Study (TARMS) report analyzed the aerial supervision workload and recommended that agencies consider the aerial supervision module (ASM) concept. The ASM was to be staffed by an air tactical group supervisor and an air tactical pilot. The intent was to create a synergistic team.[47] See chapter 6.6.5. for more information on ASMs.

6.8.4. Helicopter Coordinator

The helicopter coordinator position was developed in the 1980s to ensure positive coordination for complex helitanker operations. It was sometimes performed from a helicopter and at other times from a high vantage point on the ground. The position was evaluated in the 1998 Tactical Aerial Resource Management Study (TARMS), which deemed it to be working well and with no additional recommendations made.[48]

The most recent National Wildfire Coordinating Group description of the helicopter coordinator (HLCO) position says the following:

> "HLCO coordinates, directs, and evaluates tactical/logistical helicopter operations. This position is responsible for establishing and managing the Fire Traffic Area and/or Temporary Flight Restriction in the absence of the ATGS. The HLCO position should be activated whenever necessary or beneficial for the ATGS when only helicopters are assigned or in instances where visibility from smoke is a limiting factor for fixed-wing effectiveness. When an ATGS is assigned, the HLCO is a subordinate position to the ATGS. If no ATGS is present, the HLCO works for the IC, OSC, AOBD or designee."

6.9. Partnerships

The Bureau of Land Management (BLM) began developing aerial supervision in Alaska in 1971 with their partner, the State of Alaska Division of Forestry. The BLM began using a single aircraft with the leadplane pilot and air attack boss in the same aircraft. This started with the Cessna 180 with later upgrades to the Cessna 185 and 402; Piper Navajo; de Havilland Twin Otter; Grumman Goose; Beechcraft Baron; Aero Star 600, 601 and 601P; and since 1992, the North American OV-10A.[49] Many of the Alaska leadplane pilots and some of the aircraft were approved for use nationally, which resulted in assignments in the lower 48.

In the early days of the airtanker program, the California Department of Forestry (CDF, now CAL FIRE) developed an air coordinator position. In the mid-1970s this position was changed to air attack supervisor and in 1997 changed again to air tactical group supervisor. This position performs the duties of both the air tactical group supervisor and the airtanker coordinator but does not lead airtankers.[50]

Today, after a multidecade partnership between the Pacific Southwest Region and CAL FIRE, a tradition of trust has developed between the aerial supervision programs of both agencies. Many of the aircraft used in the CAL FIRE aerial supervision program are provided through the Forest Service Federal Excess Personal Property (FEPP) Program. Joint training is the norm and many airtanker bases host aircraft from both agencies.

For their air attack supervision aircraft, CAL FIRE acquired 20 Cessna O-2 Skymaster aircraft (previously used during the Vietnam War) from the U.S. Air Force via the FEPP Program. In 1993, CAL FIRE obtained an additional 16 North American OV-10A aircraft from the U.S. Navy through FEPP. The OV-10s had turbine-powered twin engines that helped meet the needs for a next-generation air attack platform.[51]

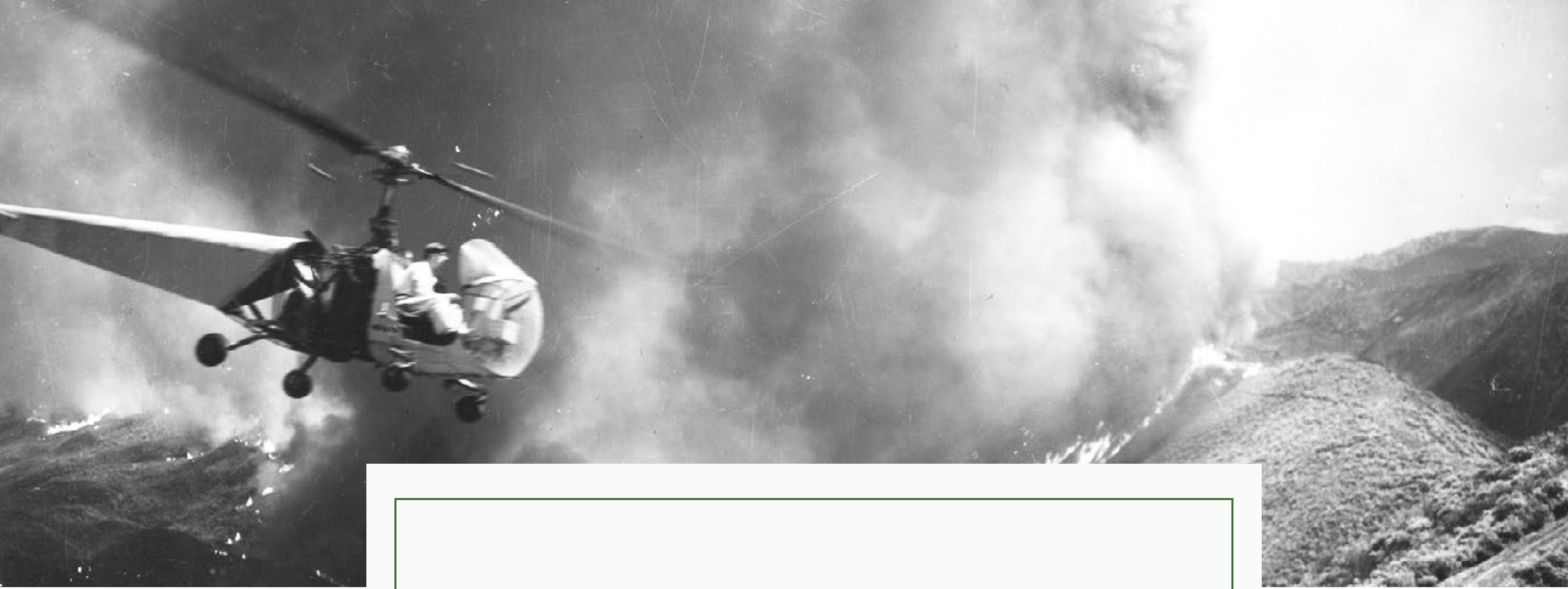
6.10. Aerial Supervision Aircraft Makes and Models

The aerial supervision mission can be performed using a myriad of aircraft—the following table 6.2 represents the most commonly used aerial supervision platforms. Some of the dates are approximate or estimated. Lacking better information, the date the aircraft became available is used as the first year of use.

Table 6.2. Aerial supervision aircraft makes and models

First use (year)	Last use (year)	Make	Model(s)	Owned	Contracted	ATGS	Leadplane	ASM	Engine	Comments
1956	Unknown	Piper	PA 24-205		✓		✓		Single	
1964	Unknown	Rockwell	Aero Commander 500B		✓				Multi	
1960s	Unknown	Beechcraft	T-34 Mentor		✓		✓		Single	
1967	Unknown	Beechcraft	Baron C-55						Multi	
1967	Unknown	Bell	206B3		✓				Single	Helicopter
1967	Unknown	Hughes	500D		✓				Single	Helicopter
1968	Unknown	Rockwell	Aero Commander Shrike		✓				Multi	
1968	Unknown	Beechcraft	K-35 Bonanza		✓				Single	
1971	Unknown	Cessna	U-3A		✓				Multi	Military version of Cessna 310
1975	Unknown	Beechcraft	Baron 58S		✓				Multi	
1975	Still in use	Rockwell	690A Twin Commander				✓		Multi	
1976	Unknown	Beechcraft	Baron 58P	✓					Multi	
2008	Still in use	Beechcraft	King Air 90		✓		✓	✓	Multi	
2010s	Still in use	Beechcraft	King Air 200		✓		✓	✓	Multi	
Unknown	Unknown	Cessna	310		✓				Multi	
Unknown	Unknown	Cessna	180		✓				Single	
Unknown	Unknown	Cessna	185		✓				Single	
Unknown	Unknown	Cessna	210/210T		✓				Single	
Unknown	Unknown	Cessna	337		✓				Multi	
Unknown	Unknown	Cessna	340		✓				Multi	

ASM = aerial supervision module; ATGS = air tactical group supervisor



Scouting a wildfire by helicopter in 1948.
Forest History Society photo.

CHAPTER 7

HELICOPTERS

7.1. Significant Events

1931—First recorded use of a rotary-wing aircraft (autogyro) on a forestry mission.
1939—Igor Sikorsky designs and pilots the first practical helicopter.
1945—Forest Service and U.S. Army begin joint testing of helicopters in mountainous terrain.
1945—Bell Helicopters begins developing Bell G47B (47-B) helicopter.
1946—Bell 47-B used for reconnaissance on a wildfire in Ontario, Canada.
1946—Sikorsky R-5A helicopters used in limited capacities on fires in Alaska and California.
1947—First fully operational, extended use of helicopters (two) on the Bryant Fire.
Late 1940s—Forest Service begins helijumping (no source found for exact date).
1949—First helicopter training film developed for firefighters.
1951—First turbine-engine helicopter manufactured.
1954—Operation FIRESTOP developed best practices for use in fire suppression.
1954—Limited initial helijump testing begins.
1956—"Helishot" crew (four) hired for contracted Bell 47-D helicopter.
1957—Helicopter use in fire suppression moves beyond experimental phase.
1957—First fully operational helitack crew (five) hired to staff contracted Bell 47G-2.
1957—Los Angeles County Fire Dept. uses helicopters (seven) on Gale Fire on Angeles National Forest.
1957—Allouette II helicopter introduced.
1958—Two helicopters lay a 10,000-foot hose on the Morris Fire.
1958—Standardized lesson plans developed for helicopter safety and helispots.
1958—California trains 300 firefighters in helicopter use.
1958—Official helijump test program begins.
1959—Ten helicopters used on Woodwardia Fire on the Angeles National Forest.
1959—First helitack training film.
1961—Drop tank, hover-fill, and bucket operations begin.
1961—Bell 47G-3B and Hiller 12E helicopters introduced.
1964—Extensive use of helicopters (19) on the Coyote Fire on the Los Padres National Forest.
1964—First use of Bell 204-B medium-sized turbine-engine helicopter.
1964—Redding smokejumpers experiment with nonoperational rappelling.
1965—First comprehensive "Helitack Training Guide" developed.
1966—Klamath National Forest experiments with rappel.
1967—First documented fire rappel by BLM-Alaska smokejumpers.
1969—Fifty helicopters used on Swanson River Fire in Alaska.
1968–1973—Forest Service experiences 104 helicopter accidents.
Mid-1970s—Helijumping discontinued (no source found for exact date).
1972—Redmond smokejumpers tasked to study rappelling in mountainous terrain.
1973—Office of Aviation Services created (initially titled Office of Aircraft Services).
1973—Pacific Northwest Region established two rappel bases (Chelan and Santiam).
1973—First operational fire rappel by Forest Service.
1974—National Helicopter Operations Study.
1974—Rappel base established in La Grande, OR; Santiam Crew moved to Detroit, OR.
1975—Alternative 4B of the National Helicopter Operations Study implemented.
1975—Rappel crew added at Cave Junction, OR.
1975—Bell 205 replaced with Bell 212 helicopters for rappel.
1976—Use of rappel formally authorized for all regions by National Office.
1976—Rappel base added at Hyak, WA, in Pacific Northwest Region.
1979—First use of Simplex Helitorch on the Mendocino National Forest.
1982—Don Arney patents the Bambi Bucket.
1983—Rappel terminated due to reduced budgets.
1986—Type 3 helicopter rappelling initiated.
1986—Premo Mark III aerial ignition device approved for use.
1986—Simplex Helitorch single-point attachment designed and approved for use.
1980s—Implementation of national call-when-needed contracting option.
1990s—Rapid expansion of the rappel program.
1994—Interagency Helicopter Operations Guide completed and adopted.
2002—Type 1 helicopter contracted for personnel transport in California.
2002—FireWatch Program begins.
2004—First operational use of rope-assisted deployment system (RADS) on the Eldorado National Forest.
2007—Letter issued by Deputy Chief directing regions to establish regional rappel training.
2008—Iron 44 helicopter crash with nine fatalities; personnel transport in type 1 helicopters suspended.
2009—Rappel fatality in California.
2010—Rappel and RADS programs suspended pending risk assessment (March 2010).
2010—Partial reactivation of rappel in the Pacific Northwest Region (June 2010).
2011—Reactivation of rappel across the agency.
2011—First national rappel training in John Day, OR.
2012—First National Rappel Academy in Salmon, ID.
2015—Short-haul implemented at two bases.
2017—National Night Air Operations Plan approved.
2021—FireWatch Program ends.

A turbine engine Boeing Vertol prepares to takeoff with a sling load of fire cargo for the Mitchell Creek Fire, Wenatchee National Forest, in August 1970. USDA Forest Service photo by Jim Hughes.

7.2. Background—Why Helicopters?

Although autogyros had been around since the early 1920s, the first practical helicopter took flight on September 14, 1939. Designed and piloted by Igor Sikorsky and built by the Vought-Sikorsky Aircraft Division of the United Aircraft Corporation, the VS-300 was the first with a single main rotor and tail rotor design.[1] The helicopter was tethered to the ground and the flight lasted only a few seconds, but the new technology took off and it wasn't long after this initial flight that the usefulness of helicopters in fire suppression was discovered.

Igor Sikorsky piloting the first practical helicopter in 1939. Connecticut Historical Society photo.

7.3. Early History and Initial Testing (1930–1940s)

The first recorded use of a rotary-wing aircraft for any forestry-type mission occurred in 1931, when Forest Supervisor A. Nash-Boulden of the Los Padres National Forest flew in an autogyro for a partial reconnaissance of the forest.[2]

In 1945, the Forest Service and U.S. Army began joint testing of Sikorsky R-5A and R-5D helicopters in mountainous terrain on the Angeles and San Bernardino National Forests. General H.H. (Hap) Arnold, Commander of the Army Air Forces at the time, was a primary proponent of the joint testing. The tests helped determine appropriate allowable payloads for the helicopters and demonstrated that helicopters were viable in a wildland fire environment.[3] As these tests were being conducted, Bell

The Story of the Helicopter Skid

Early helicopters were usually designed with a wheeled undercarriage, probably due to the assumption they would be operating out of airports. Pilots soon discovered that wheels were not ideal for landing on slopes (for obvious reasons) and that level landing areas could be difficult to find in mountainous terrain.

Bell Helicopters began testing skids as a solution to this problem in May 1949 and were issued a patent for skid landing gear in 1953. Skids also had the advantage of being lighter than wheels.

Source: Petite, B. 2019 (July 5). The evolution of helicopter landing gear. Vertical Mag. https://verticalmag.com/features/the-evolution-of-helicopter-landing-gear/. (March 2024)

Helicopters was developing the Bell G47B (47-B) helicopter. On June 26, 1946, the Ontario Department of Lands and Forests in the Province of Ontario, Canada, used a Bell 47-B for reconnaissance. Interestingly, the helicopter was donated through the cooperation of Larry Bell of Bell Helicopters, who was interested in expanding the role of helicopters into fire suppression work.[4]

On July 12, 1946, the Alaska Fire Service used a Sikorsky R-5A on a wildfire near Fairbanks, AK, for limited reconnaissance and crew/cargo transport.[5] Similarly, on the Red Rock Fire on the Angeles National Forest on September 9–10, 1946, a Sikorsky R-5 helicopter from March Air Force Base in Riverside County, CA, (now March Air Reserve Base) was used for scouting, mapping, and dropping cargo. The helicopter did not land on the fire.[6]

The Forest Service and the U.S. Army Air Forces cooperatively tested two Bell 47-B helicopters on national forests in southern California in 1946. USDA Forest Service photo by W.I. Hutchinson.

Bell 47-B helicopter approaching a helispot on the Bryant Fire, Angeles National Forest, CA, 1947. USDA Forest Service photo.

7.4. Program Implementation—The Early Years

7.4.1. Initial Use (1940s)

Although rotary-wing aircraft were used in a limited capacity in fire suppression missions in North America in the mid-1940s, the first fully operational, extended use of a helicopter by the Forest Service for fire suppression occurred in August 1947.

Over a period of several weeks, two Bell 47-B helicopters were assigned to the Bryant Fire on the Angeles National Forest in California. The helicopters were used to deliver hundreds of firefighters and 1,000 pounds of cargo; evacuate sick, injured, and entrapped firefighters; fly reconnaissance and scouting missions; and "hover jump" firefighters for the purpose of helispot construction.[7]

The Bryant Fire clearly demonstrated the efficacy of helicopters in fire suppression, especially in logistical missions. The helicopters operated in temperatures up to 107 degrees Fahrenheit and altitudes up to 5,400 feet mean sea level (MSL).[8] Hotter temperatures and higher altitudes limit helicopter performance—although the helicopters on the Bryant Fire had limited payloads due in part to environmental conditions, it was becoming clear that rotary-wing aircraft had many beneficial uses in wildland firefighting.

The success of helicopter operations in the mid-1940s prompted development of the first helicopter training film in 1949. This film was created to train firefighters on safety around rotary-wing aircraft and covered the principles of helispot location and construction. Helicopters were here to stay.

Helicopter Use on the Bryant Fire

The first (limited) use of a helicopter in wildland fire operations was on June 26, 1946. A Bell 47-B helicopter being used for a geophysics survey was seen by a fireline supervisor who then drove to the landing zone to ask if he could use it to recon the perimeter of the fire.

The first fully operational use of helicopters on a wildfire occurred during the Bryant Fire on the Angeles National Forest in 1947. The two Bell 47-B helicopters were piloted by Knute Flint and Freddie Bowen (who later became known as “Mr. Helicopter” in the wildland fire community).

In August 1997, a ceremony was held at the Rose Bowl in Pasadena, CA, to commemorate this historic event. Organized by Greg Greenhoe, fire management officer for the Angeles National Forest, and Ralph Johnson , retired Forest Service helicopter specialist, the ceremony included Bell 47-B, Bell 212, and Sikorsky S-64 helicopters.

Sources: National Wildfire Coordinating Group. First use of a helicopter for firefighting—June 26, 1946. https://www.nwcg.gov/committee/6mfs/first-use-of-helicopters-firefighting. (March 2024)

Biddison, L. 1998. A historical view of our present fire organization. Fire Management Notes. Washington, DC: USDA Forest Service. 58(3): 17.

One of the two Bell 47-B helicopters on the Bryant Fire near Big Tujunga Canyon on the Angeles National Forest in southern California in August 1947. Owned by Armstrong-Flint Helicopters based in Pacomia, CA, pilot Knute Flint is shown here looking out the window. This is considered the first official use of helicopters by the USDA Forest Service. Missions performed included fire spotting, mapping, water carry to ground teams, and general availability. USDA Forest Service photo.

Bell 47-B helicopter on the Saugus Ranger District, Angeles National Forest, CA. Note the change to skid landing gear instead of wheels. Passenger Thelmas “T.L.” Biddison is seated closest to the camera, with unknown pilot to his left. T. L. Biddison was the father of Lynn Biddison who played a part in the important National Helicopter Operations Study of 1974. Courtesy of the National Museum of Forest Service History.

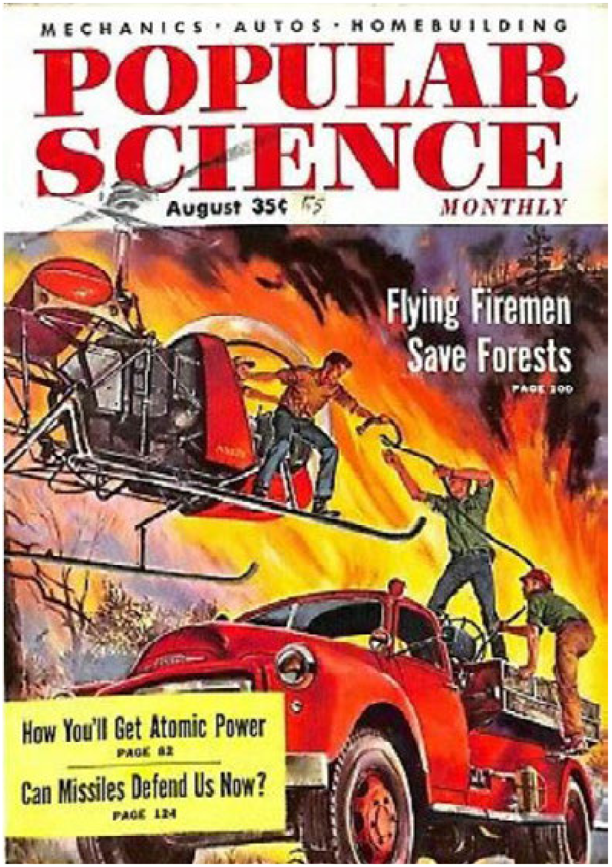
7.4.2. Transition from Experimental to Institutional Use (1950s)

Operation FIRESTOP was initiated in California in 1954 by a group of Federal, military, State, county, and private organizations. One of the tasks in Operation FIRESTOP was to develop new tools, methods, and best practices for helicopter use in fire suppression. Experiments were conducted with both small and large helicopters in tactical missions such as laying fire hose, delivering firefighters, and using aerial pumping equipment.[9]

These initial helicopter trials led to the first four-person crew specifically hired to staff a contracted Bell 47-D helicopter.[10] Stationed on the Angeles National Forest, this crew was charged with the field testing of helijumping, dropping water, and laying fire hose from the air. Although not technically considered an operational crew, it was designated as a "helishot" crew, terminology that was later changed to "helitack" (derived from "helicopter initial attack").

The first decade of helicopter use for fire suppression was primarily in a logistical support role. Although the first turbine-engine helicopter was manufactured in 1951, it would be approximately another decade before turbine-engine helicopters were readily available. Piston-engine helicopters had substantially less performance capability than their turbine-engine successors.

The testing and experimental phase of helicopter use for fire suppression had been a success. By 1957, the use of helicopters had become institutionalized by the Forest Service. Missions such as laying fire hose, dropping water, slinging cargo, helipumping water, dropping paracargo, and helijumping were all considered ready for operational implementation. A Bell 47G-2 helicopter was contracted, and a five-person crew was hired to staff it. This helitack crew was the first operational crew using tacitly approved equipment, accessories, and procedures.[11]



Cover of the August 1955 issue of Popular Science, which featured Operation FIRESTOP.

Many helicopter accessories, including the hose tray, helitank, and paracargo family of hardware, were researched and developed by the Arcadia Equipment Development Center in Arcadia, CA.[12]

Other fire organizations were concurrently learning how to incorporate helicopters into their arsenals. The Los Angeles County Fire Department had also begun pioneering a helicopter firefighting program, using seven light piston-engine helicopters in 1957 on the Gale Fire on the Angeles National Forest. These helicopters transported 3,000 firefighters over a 10-day period.[13]

The use of helicopters was continually expanding. The use of light helicopters on fires increased in 1958, and the use of large military and commercial helicopters such as the Sikorsky S-55, S-58, and Piasecki H-21 was beginning to happen at select locations. One notable milestone was the introduction of the Aerospatiale Allouette II helicopter—this light turbine-engine helicopter was the first that had good payload capability at high altitude, a desirable characteristic for wildland fire suppression.[14]

Chilao Helitack Crew, 1957. The Forest Service's first helitack crew and their Bell 47G-2 helicopter. Based at Chilao Camp on the Angeles National Forest in California, the crew worked alongside the Chilao Hot-shots. Ralph Johnston was the first supervisor for the crew (third from right). Pilot Pete Miller (kneeling) and unknown mechanic at far right. Courtesy of the National Museum of Forest Service History.

Left: Bell 47-D helicopter—the first helicopter with a "goldfish bowl" canopy and open tail boom (certificated in February 1948). Right: Allouette III helicopter, date and location unknown. USDA Forest Service photos.

Another notable achievement occurred in 1958 on the Morris Fire on the Angeles National Forest. Two Bell 47G-2 helicopters were used to lay a 10,000-foot hose. One helicopter was on contract to the Forest Service, and the other belonged to the Los Angeles County Fire Department. It took the combined efforts of the helitack crews from both agencies to continuously load the hose trays. This accomplishment possibly represents the longest and fastest laying of fire hose on record.[15]

Also during 1958, additional standardized lesson plans were developed for helicopter safety and helispot location and construction. That year, James Murphy from the Pacific Southwest Forest and Range Experiment Station trained 300 California firefighters in helicopter use.[16]

On the Woodwardia Fire on the Angeles National Forest in 1959, 10 light- and medium-sized helicopters were used—one of the largest uses of helicopters on a fire at the time. Over 3,000 firefighters, 56,000 gallons of water and retardant, and 45 tons of cargo were transported. That year also saw the advent of the first helitack training film.[17]

7.4.3. The 1960s

By 1961 helicopters of all sizes were being used by fire agencies in several areas of the United States. A fixed 100-gallon drop tank for light helicopters was ushered into service, and the Canadians manufactured a “hover-fill” system for helicopter buckets that was used by several fire organizations in the United States. Larger helicopters began using buckets with a 500-gallon capacity.[18]

The Bell 47G-3B helicopter, introduced in 1961, greatly improved upon the high-altitude capability of rotor-wing aircraft. The Hiller 12E was also introduced to the fire community, providing increases in performance, especially the speed of the aircraft. Helicopter use for fire suppression had become a mainstay, with annual use predicated on the severity of the fire season.[19]

Bell 47G-3B helicopter with improved high-altitude capability. Bell Textron, Inc. photo.

The Hiller 12E helicopter, shown at the Lakeview Airport in Oregon in 1962, offered better performance, especially in speed. USDA Forest Service photo by Peter W. Orr.

During 1962 and 1963, increased numbers of helicopters were contracted by various fire organizations and assigned to strategic locations in forested areas of the United States.

The Forest Service and National Park Service (NPS) used 19 helicopters and 14 helitack crews on the Coyote Fire on the Los Padres National Forest for approximately 2 weeks in 1964. In 12 days they accrued 1,172 flight hours, transported over 8,900 firefighters, and delivered a quarter-million pounds of cargo. In addition, 28,000 gallons of water and retardant were dropped, 18 miles of telephone line were deployed for communication purposes, and 13 helijumps were executed for hot spotting and helispot construction.[20]

The first use of the Bell 204-B medium-sized turbine-engine helicopter also occurred in 1964. This helicopter played an invaluable role in helicopter program development for the Forest Service. It proved to be an outstanding platform for transporting a larger number of firefighters and thousands of pounds of cargo. The Bell 204 was also used in the first trials of helicopter parachuting and rappelling of firefighters.[21]

Other agencies had similar expanding uses of helicopters during this period. In 1964, the Bureau of Land Management (BLM) used a large fleet of helicopters in north-central Nevada.

The first comprehensive “Helitack Training Guide” was developed in 1965 with the goal of providing consistent, proven helicopter management methods and techniques for efficient and safe helicopter use.

The Bell 204-B helicopter offered increased capacity and capability. Shown here is a crew in Alaska unloading gear from a Bell 204 on the Bleakspot Fire in 1968. Courtesy of the National Museum of Forest Service History, photo by Ron Welsh.

As the 1960s were drawing to a close, larger numbers of helicopters were being used by all firefighting agencies. In 1967 the NPS used seven U.S. Air Force Huey F Model helicopters and three light commercial helicopters on a fire in Glacier National Park. New, light turbine-engine helicopters such as the Hughes 500, Hiller FH-1100, and the Bell 206A were introduced to the helicopter industry. These machines provided increased speed and payload capability, increasing the value of this aerial asset.

A 350-gallon external fixed tank was developed in 1968 for the Bell 204-B. A collaboration between the Forest Service and Los Angeles County Fire Department, it was the finest tank developed to that point for dropping water and retardant.

In 1968, national forests in Oregon and Washington began using Kaman H-43A helicopters with buckets for fire suppression, and a next-generation helicopter training film was developed. The following year in 1969, the BLM used over 50 helicopters for both tactical and logistical missions on the Swanson River Fire in Alaska. At the time, this was the largest number of helicopters assigned to one fire in the history of helicopter firefighting.

According to the "Annual Fire Report for the National Forests" for 1968, helitankers "were used on a greater proportion of fires than ever before" and helicopters were being used "for more and more fire jobs, where their versatility makes them highly efficient for personnel and supply transportation, scouting, and application of retardants." The report went on to say that "in fact, helicopters now account for nearly 25 percent of the total aircraft flight hours for fire control activities."[22]

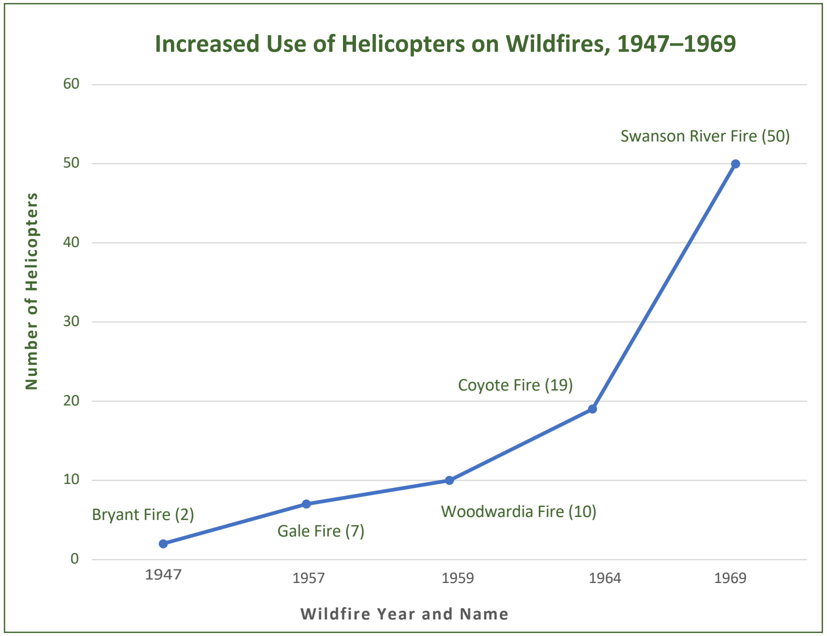


Figure 7.1. The number of helicopters used on any single fire increased steadily in the 1950s and dramatically in the 1960s as advances in speed, altitude, payload, and other factors improved.

7.4.4. The Early 1970s

From 1970 to 1973, substantial helicopter use continued as dictated by fire season severity. In 1970 the Okanogan and Wenatchee National Forests in Washington State used over 50 light, medium, and heavy helicopters on numerous fires over the course of the season. In 1971 Federal fire agencies reported initial attack and successful control of over 1,500 forest and range fires using helicopters. In 1973, a multitude of project fires in northern Idaho and western Montana triggered the need for more than 50 helicopters.[23]

In northern Montana on the Caribou Fire, a Boeing Vertol 107-11 was used, perhaps for the first time, as a helitanker. The helicopter was equipped with an 800-gallon bucket with hover-fill capability. The Vertol was able to draft from a small lake at the head of the fire and deliver 9,500 gallons of water per hour. This capacity was instrumental in controlling the head of the fire.[24]

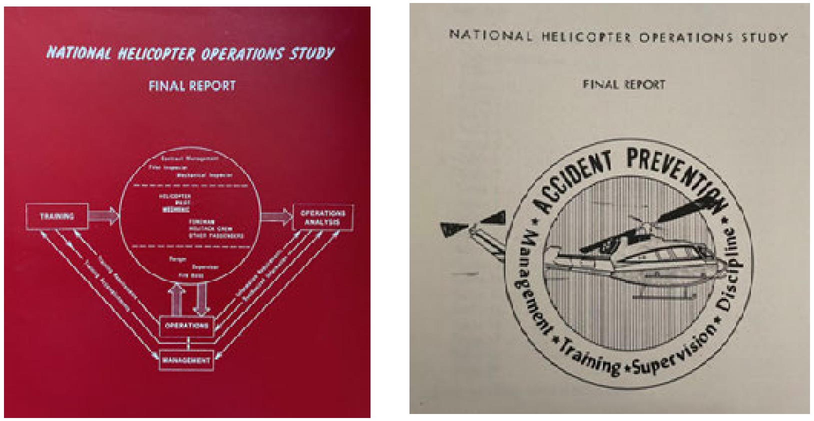
A Boeing Vertol 107-11 helicopter, circa early 1970s. USDA Forest Service photo.[25]

The expansion of the program was not without its challenges. In a 6-year period between 1968 and 1973, the Forest Service experienced 104 helicopter accidents, injuring 47 people and killing 19. That was an accident rate 77 percent greater than the general aviation community. If the Forest Service was to continue using helicopters, substantial programmatic changes were needed.[26]

7.5. Program Development and Implementation (1974–2021)

7.5.1. National Helicopter Operations Study of 1974

The 1974 "National Helicopter Operations Study" is the foundation of the Forest Service's helicopter program as we know it today.[27] Alternative 4B, as implemented by Forest Service Chief John McGuire, formally established major components of the Forest Service helicopter program—maintenance and pilot standards, positions including helicopter manager and maintenance inspector, and more.



Cover and title page of the pivotal "National Helicopter Operations Study" released in 1974.

In the 6 years leading up to the 1974 study (1968–1973), the Forest Service was averaging over 17 accidents per year. At the time, the Forest Service helicopter accident rate was 59 percent greater than that of Helicopter Association of America (now Helicopter Association International), and 77 percent greater than that of the general aviation community. In today's world, it's hard to imagine that any program or piece of equipment with that failure rate would remain in use.

During this same 6-year period, the nine Bureaus within the Department of the Interior (DOI) were experiencing a similar helicopter accident rate. As a result, on July 1, 1973, the Secretary of the Interior created the Office of Aircraft Services, later renamed twice and now known as the Office of Aviation Services (OAS). OAS provides the same aviation oversight and support for the DOI Bureaus that the Forest Service executes internally (see chapter 3.1.8.).

There are several reasons why there were so many accidents during that 6-year period, but one of the major drivers was the proliferation of helicopters and pilots generated by the Vietnam War. The availability of the asset had outpaced the agency's ability to manage its accelerated use.

In 1973 Chief McGuire commissioned a national study to address the unacceptable accident rate. A steering committee was established consisting of four individuals, with Associate Deputy Chief Russell McRorey serving as chair.

The steering committee developed a study prospectus and on May 2, 1973, a study team of 11 individuals was selected. The team included people with a wide range of backgrounds, including field practitioners, program specialists, pilots, researchers, and engineers.

The basic objectives of the study were to:

1. Reduce helicopter accidents in Forest Service work through improved operational criteria and guidelines.
2. Through identification and analysis of past accidents and risks, develop operational criteria and guidelines having the highest probability for success in making helicopter operations as safe as other forms of transportation now in use.
3. Provide action recommendations, each with a cost-benefit analysis for use as a decision-making tool.
4. Provide direction for a continuing program of analysis of accidents and risks that would yield feedback for necessary alterations of operational criteria as the "state-of-the-art" changes.
5. Set forth changes and improvements required to provide necessary skill levels for the people responsible for operational tasks—from field user to top management.

During the course of the study, it was determined that the causes of the accidents during the 6-year period were human error (60 percent), mechanical failure (30 percent), and environmental or other causes (10 percent).

The study proved to be very thorough. Nine separate alternatives were developed that considered 36 action items. Some of the 9 alternatives had variations, which in effect created 22 different alternatives.

Chief McGuire selected alternative 4B as the one to implement, and on January 22, 1975, issued a letter directing all regions to implement the 4B alternative. Of the 22 alternatives, 4B was the third most impactful in terms of proposed changes to the agency's helicopter program. Alternative 4B enacted 25 of the 36 action items (and several of the omitted action items have since been rectified).

Alternative 4B established the following:

1. A national aircraft accident/incident reporting system (for many years the system was known as the Aircraft Incident Reporting System, but it was later changed to Safety Communiqué (SAFECOM) because of the negative connotation associated with the term "incident report")
2. Pilot inspector procedures for aircraft approval
3. Mission parameters or "helicopter use policies," including allowable gross weight, wind and visibility limits, and radio communication standards
4. Helitack supervisor standards and carding
5. Helicopter manager requirement for all helicopter missions
6. Maintenance inspector positions for all regions with helicopter contracts
7. Maintenance inspector requirement on all fires and projects using helicopters
8. Fire-resistant (Nomex) clothing for all flight crew members
9. Helicopter operations specialist position for all regions using helicopters
10. Pilot flight checks and carding
11. Helitack supervisor training requirements.
12. Helicopter maintenance standards
13. Enhanced helitack training for helitack crewmembers
14. Helicopter training for fire boss personnel (now incident commanders)
15. Particle separators for applicable helicopters
16. Engine oil analysis requirement
17. Engine trend analysis requirement (power checks)
18. Standardized and approved helicopter accessories
19. Risk analysis procedures
20. Fire management officer helicopter training requirement
21. Air attack boss helicopter training requirement (now air tactical group supervisor)
22. Helitack crewmember training requirement
23. Enhanced training aids
24. Dust abatement procedures
25. Standardized helicopter contractual requirements

Virtually all foundational pieces of the modern helicopter program were established by implementation of the 4B alternative. Although the emphasis of the study was on helicopters, implementation of 4B had a positive effect on the entire aviation program. For example, the accident reporting and airworthiness practices that were implemented had positive repercussions for all facets of the aviation program.

Unloading firefighting equipment from a Bell 212 in Alaska, date unknown. USDA Forest Service photo.

7.5.2. The 1980s

By the 1980s the helitack programs across the wildland firefighting agencies had matured. Although there were still minor operational and policy differences between different crews and agencies, helicopters had become a standard component in the wildland firefighting arsenal. Crews across all agencies trained to the same standards found in the Interagency Helicopter Training Guide, and helicopter operations on large fires were compatible across Federal organizations.

National Call-When-Needed Helicopter Contract

In the mid-1980s the Forest Service introduced the national type 1 and 2 call-when-needed (CWN) helicopter contract. As the name implies, helicopters acquired under this hiring authority are only used when the need exists, with no guarantee of employment. Because there is no guarantee of employment, vendors have the option of whether or not to accept an assignment when offered. Additionally, because of the no guarantee of work, CWN rates are higher than for helicopters hired under exclusive-use contracts, the premise being that CWN helicopters would only be used for short duration during surge activity.

The CWN contract provided a mechanism for type 1 and 2 helicopter vendors to offer many helicopters for potential hire in a more streamlined process. Prior to this, there was not an overarching national contract that consolidated the acquisition of type 1 and 2 helicopters.

The establishment of the CWN contract dramatically increased the number of available type 1 and 2 helicopters. It also created a major challenge in the agency—the availability of qualified helicopter managers. Exclusive-use helicopters were staffed with a permanent crew of trained helitack personnel. The staffing of CWN helicopters relied on trained agency "militia" who were often taken from exclusive-use crews, creating potential shortages of helitack personnel. From 1988 into the 1990s, the availability of CWN helicopters increased almost 450 percent.[28] Fire seasons were continuing to escalate; it was becoming clear that the need for all firefighting assets was increasing.

7.5.3. The 1990s

National Shared Forces Task Force Report (1991)

As a way to address the escalating need for firefighting assets, the Forest Service commissioned a National Shared Forces Task Force report. Completed in 1991, this report was used to justify the programmatic components for national shared resources.[29] All type 1 helicopters are considered national shared resources, while type 2 may be national or regional resources, depending on how and why they were acquired. Type 2 helicopters hired under the CWN contract for large fire support are considered national shared resources. The biggest difference between national and regional resources is who has the final authority for mission assignments. As the name implies, national shared resources are allocated nationally through the National Interagency Coordination Center (NICC) located at the National Interagency Fire Center (NIFC) in Boise, ID.

National Study of Type 1 and 2 Helicopters to Support Large Fire Suppression (1992)

The National Shared Forces Task Force report recommended a number of studies to determine the most optimal staffing levels for national shared resources. The first study chartered under that process was the "National Study of Type 1 and 2 Helicopters to Support Large Fire Suppression." The overarching purpose of the study was to examine and recommend the most efficient number and staffing of type 1 and 2 helicopters to support extended attack and large fire suppression.

An 11-person team was assembled, including representatives from the Forest Service (8), DOI (2) and State of Alaska (1). The National Shared Forces Task Force Oversight Committee established three objectives for the study:

1. Examine the last 5-year historical use of type 1 and 2 helicopters for extended attack and large fire support.
2. Identify current (1–3 years) and future (4–10 years) type 1 and 2 helicopter needs nationally for extended attack and large fire support.
3. Determine the most cost-effective procurement method and deployment strategy of type 1 and 2 helicopters to meet a range of anticipated fire needs other than initial attack.

The group spent several months in the analysis process. One of the factors considered was the percentage of use the Forest Service generated with type 1s and 2, versus use by DOI and the States. At the time, data indicated that the Forest Service accounted for 73 percent of total type 1 and 2 use, while DOI accounted for 23 percent and the States 3 percent.[30] The conclusion was that the Forest Service had the biggest stake in enhancing the availability of these assets going forward.

The final national type 1 and 2 study was completed in 1992. The committee offered several recommendations in their final report, both for helicopter numbers and management considerations. Initial recommendations were that two type 1s be located at NIFC, seven type 2s be geographically dispersed in the lower 48 States, and three type 2s be located in Alaska. The Forest Service decided to start by establishing seven national type 2 helicopters dispersed across four regions and six States. Table 7.1 shows the national type 2 helicopter assets established by the 1993 field season.

Table 7.1. National type 2 helicopter locations (1993)

Region	Base location
Region 1	Dillon, MT
Region 1	St. Regis, MT
Region 2	Durango, CO
Region 4	Challis, ID
Region 4	Ogden, UT
Region 6	Chelan, WA
Region 6	John Day, OR

Increased Rappel Capability

Many helitack crews began to add rappel capability to their programs in the 1990s (see chapter 7.7.6). This escalation prompted internal discussions about what the optimal "mix" of aerially delivered firefighters should be in the Forest Service. Several efforts would be undertaken in the years to follow that would attempt to address this question.

Interagency Helicopter Operations Guide (1994)

In 1994 a major milestone in interagency helicopter operations became a reality when the agency adopted the newly completed "Interagency Helicopter Operations Guide" (IHOG). The IHOG had been developed over a 6-year period with the collaboration and expertise of over 100 subject matter experts from across the entire spectrum of wildland fire organizations, including DOI and the States. The IHOG contained standards, best practices, and interagency processes for implementing helicopter operations.

The IHOG was unique in that it was the first interagency aviation guide and became the model for many other guides that followed. The IHOG was not immediately adopted holistically by all Federal wildland firefighting agencies. The BLM and Forest Service were early adopters, but agencies such as the National Park Service would not fully implement the IHOG until the mid-2010s. Other agencies such as the U.S. Fish and Wildlife Service have only adopted parts of the IHOG as their policy. The last document with the title of IHOG was issued in 2016. In 2019 the National Wildfire Coordinating Group (NWCG) conducted an effort to standardize the nomenclature of all their documents, and the IHOG became the "NWCG Standards for Helicopter Operations," PMS 510.

Bell 204B Redesignation to Restricted Category

Another significant event occurred in the late 1990s related to Bell 204B helicopters. After a series of crashes, Forest Service inspector pilots and maintenance personnel began to suspect that parts from military UH1 helicopters—not designated by the FAA as Standard Category—were being used on Standard Category 204Bs. Court cases were filed, and executives from Bell Helicopter confirmed the suspicion. Bell 204Bs were redesignated as Restricted Category, effectively ending approval for them to transport personnel.

7.5.4. The 2000s

As the new century arrived, the Forest Service was fielding an extensive fleet of exclusive-use and call-when-needed contract helicopters. With an occasional exception, extended fire seasons had become the new normal. The fire season of 2000 was especially severe, and a National Fire Plan was developed that increased the presuppression funding of many programs.

An AS 332 Super Puma at a helispot loading a type 2 crew, circa 2000. This was one of the first test runs of using a type 1 helicopter for personnel transport. USDA Forest Service photo.

In 2002 the Forest Service acquired 25 Bell AH-1 Cobra helicopters that had been excessed by the military. The purpose of the acquisition was to establish a technology demonstration project for intelligence gathering and enhanced aerial supervision (see chapter 7.9).

In 2003 the Big Hill Helitack Crew on the Eldorado National Forest began testing an aerial delivery system for helicopter firefighters known as the rope-assisted deployment system (RADS), colloquially referred to as "fast rope." This system proved successful and would remain operational for 6 years (see chapter 7.7.8).

The Forest Service was continually refining helicopter operations and seeking greater efficiency in the program. There was interest in increasing the use of type 1 helicopters for personnel transport. Until the early 2000s, the most routine use of type 1 helicopters was for retardant/suppressant delivery and cargo transport. In the Yellowstone wildfires of 1988, the military used Boeing CH-47 Chinook helicopters for transport of Federal firefighters. Likewise, the Payette National Forest used military type 1 helicopters for personnel transport in 1994, and in 1998 the Pacific Southwest Region used an Aerospatiale Super Puma for personnel transport on large fires. In 2002, southern California contracted for an exclusive-use Sikorsky S-61 specifically for personnel transport. As an exclusive-use helicopter, it was staffed with a fully functional helitack crew trained and endorsed to rappel. This contract continued through 2006.[31]

During the mid-2000s the Forest Service made the decision to significantly increase its fleet of approved personnel transport type 1 helicopters. From 2002 to 2006, the Forest Service had one type 1 helicopter approved for personnel transport, but that number increased to seven in 2008.[32]

In April 2008, the Forest Service established a national helicopter coordinator position at NICC for oversight of costly helitankers, resulting in more effective decisions regarding helitanker use.[33] Although the title of the position is "national aircraft coordinator," the impetus of the position is to focus on minimizing the ferry costs of type 1 helicopters while assuring efficient asset distribution to all geographic areas.

In the late 2000s several high-profile events would substantially influence the Forest Service's emergency medical extraction capability, policy on using type 1 helicopters for personnel transport, and the composition of the agency's rappel assets.

The first event occurred on July 25, 2008, when a fatality occurred due to inadequate medical extraction protocols and assets. By 2015 the Forest Service would have operational medical extraction assets established (see chapter 7.7.9).

The second event occurred in August 2008 when a type 1 helicopter crashed on the Shasta-Trinity National Forest, killing 9 of the 13 onboard. This would prompt the Forest Service to reassess using type 1 helicopters for personnel transport (see chapter 7.7.5).

The following year the Forest Service suffered a fatality in another specialty aviation program. On July 21, 2009, while performing a proficiency rappel at the Willow Helibase on the Six Rivers National Forest, a rappeller fell to his death in an unarrested descent to the ground. This prompted a reexamination of the rappel program and was the catalyst for streamlining and realigning the rappel mission.

7.5.5. The 2010s to 2021

As the Forest Service entered the 2010s, rappel-capable crews had been consolidated into 12 crews with the Bell Medium platform as the standard. Over several years, a National Rappel Academy was established (see chapter 7.7.6).

The 2010s saw the addition of more aerial ignition devices (see chapter 7.7.7). By 2015, the Forest Service had operational medical extraction assets established (see chapter 7.7.9), and by 2017 a Night Air Operations Plan had been approved for night helicopter operations (see chapter 7.8). In 2021 the FireWatch Program ended (see chapter 7.9).

The number and locations of Forest Service helicopter crews has remained fairly static over the first two decades of the 21st century; table 7.2 shows a list from 2022.[34] Helicopters remain an integral part of the Forest Service firefighting arsenal.

Table 7.2. Helicopter program status, exclusive-use contracted aircraft

Forest Service region	National type 1	National type 2	Rappel type 2	Regional type 3	Short-Haul type 3	Base locations	Total aircraft
Northern	4	1	2	6	1	Coeur d' Alene, ID; Grangeville, ID; Hamilton, MT; Helena, MT; Hungry Horse, MT; Libby, MT; Missoula, MT; Wise River, MT; Gallatin Gateway, MT	14
Rocky Mountain	2	1	0	3	0	Custer, SD; Durango, CO; Broomfield, CO; Rifle, CO; Monument, CO	6
Southwest	2	1	0	7	1	Payson, AZ; Pittman Valley, Prescott, AZ; Round Valley, AZ; Sandia, NM; Los Alamos, NM; Sierra Vista, AZ; Silver City, NM; Tucson, AZ; Williams, AZ	11
Intermountain	5	1	5	9	3	Cedar City, UT; Challis, ID; Garden Valley, ID; Ketchum, ID; McCall, ID; Boise, ID; Pocatello, ID; Price Valley, ID; Salmon, ID; Swan Valley, ID; Morgan, UT; Jackson Hole, WY; Minden, NV	23
Pacific Southwest	11	15	2	3	0	Arroyo Grande, CA; Bishop, CA; Casitas, CA; Chester, CA; Cold Springs, CA; , Frazier Park, CA; Fresno, CA; Happy Camp, CA; Heaps Peak, Hemet Valley, Independence, CA; Keenwild, CA; Kernville, CA; Lancaster, CA; Lewiston, CA; Mariposa, Montague, Nevada City, CA; Quincy, CA; Pollock Pines, CA; Pine Valley, CA; Placerville, CA; Porterville, CA; Ramona, CA; San Bernadino, CA; Santa Ynez, CA; Scott Valley, CA; Siskiyou, CA; Springville, CA; Sky Forest, CA; Trimmer, CA; Truckee, CA	31
Pacific Northwest	4	0	6	3	1	John Day, OR; La Grande, OR; Grants Pass, OR; Prineville, OR; Wenatchee, WA	14
Southern	0	0	0	21	0	Aiken, SC; Alexandria, LA; Anniston, AL; Blacksburg, VA; Clarksville, AR; Copperhill, TN; Cornelia, GA; Greenwood, SC; Forest, MS; Huger, SC; Huntsville, TX; Lufkin, TX; Mena, AR; Mount Ida, AR; New Bern, NC; Ocala, FL; Sterns, KY; Tallahassee, FL; Wiggins, MS	21
Eastern	0	0	0	5	0	Alpena, MI; Ely, MN; Marion, IL; Rolla, MO	5
Totals	**28**	**19**	**15**	**57**	**6**		**125**

Note: The number of helicopters isn't necessarily equal to the number of bases; a base may have more than one helicopter assigned to it and, in some instances, helicopters may be shared between multiple bases.

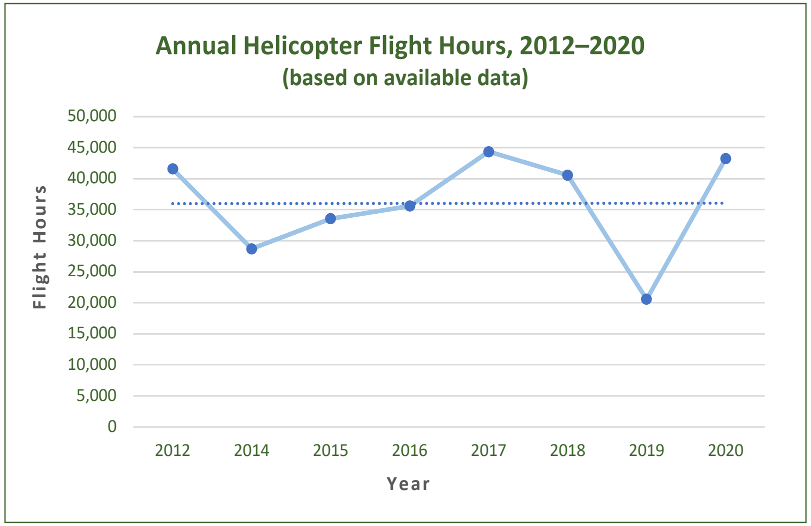


Figure 7.2. Flight hours remained steady in the 2010s, demonstrating that helicopters were an established and valuable resource in wildland firefighting. Source: USDA Forest Service. Annual Aviation Reports. No report found for 2013.

7.6. Acquisition Methods

Helicopters are generally more expensive to acquire and operate than fixed-wing aircraft of comparable size. Because helicopters are some of the most expensive aviation assets used by the Forest Service, acquisition methods have been a limiting factor in the number of helicopters available to the agency. Historical and current Federal Acquisition Regulations require that funding be obligated to pay for the entire cost of the helicopter. For an agency like the Forest Service that can employ hundreds of helicopters at once during a busy fire season, that can mean sequestering hundreds of millions of dollars just to have the helicopters available.

As fire seasons have escalated in intensity and duration—with a corresponding increased demand for helicopters—Federal land management agencies need as much flexibility as possible to secure helicopter assets. The Forest Service can acquire aviation assets by purchasing them with allocated agency funding, securing them via exclusive-use or call-when-needed (CWN) contracts, leasing them with or without flight crews, and/or participating in interagency agreements to share assets with other Federal agencies.

7.6.1. Agency-Owned Aircraft

Compared to the number of fixed-wing aircraft, the Forest Service has owned very few helicopters. The first evidence found confirming ownership of a helicopter was in a 1973 USDA audit that was completed on Forest Service Air Operations. This audit indicates that in the early 1970s the agency owned one helicopter in the Pacific Northwest Region. It was a Hiller 12E-4 with the tail number N160Z. No evidence was found to indicate how or when this helicopter was divested from the agency.[35]

The next agency helicopter that was acquired was a Bell Jet Ranger 206A, N106Z. It was manufactured in 1970, certificated by the FAA in April 1972, and acquired by the Forest Service in the mid-1980s.

In 2022, the Forest Service owned three helicopters—the Bell Jet Ranger and two Bell Cobras—none of which were operational. The Cobras, N107Z and N109Z, are remnants of the FireWatch Program (see chapter 7.9) and were stored in Tucson at the U.S. Air Force Aircraft Maintenance and Regeneration Group for potential future use. The Jet Ranger N106Z was being prepared for sale.

7.7. Helicopter Missions

The Forest Service has several requirements for employees wanting to use helicopters. The helicopter and pilot must be inspected and approved by agency maintenance and pilot inspectors. In order to be an approved pilot, a minimum of 1,500 hours of flight time is required. Additionally, pilots are given a check-ride in the typical operating environment prior to agency approval.

For a helicopter to be approved for use, all equipment and systems listed in the acquisition document must be viable. All helicopter missions require oversight by approved helicopter managers, and depending on the mission, approved helicopter crewmembers. The Forest Service uses only turbine-powered helicopters.[36]

Early literature often described helicopters in terms of “light, medium, or heavy” which now equate to “small, medium, and large.” As with most other firefighting resources, NWCG established typing for helicopters, ranging from type 1 to type 3 (table 7.3, adapted from “NWCG Standards for Helicopter Operations”).

Table 7.3. Type specifications for helicopters

Attributes	Type 1	Type 2	Type 3
Useful load at 59 °F at sea level	5,000 pounds	2,500 pounds	1,200 pounds
Passenger seats	15 or more	9–14	4–8
Retardant or water carrying capacity	700 gallons	300 gallons	100 gallons
Maximum gross takeoff/landing weight	12,501 pounds	6,000–12,500 pounds	Up to 6,000 pounds

7.7.1. Helitack

Helitack is a somewhat generic term derived from “helicopter initial attack.” It generally refers to wildland firefighting personnel whose primary job is to work with helicopters. Helitack personnel must complete required classroom and field training prior to qualification. All helicopters on contract to the Forest Service are managed by qualified helicopter managers. The helicopter manager position is an Incident Qualifications and Certification Systems (IQCS) position and is a requirement for all helicopters operating in the interagency wildland fire environment.

Depending on the agency, or even within different regions of the same agency, helitack crews may have different configurations in terms of grade structure and tours of duty. For example, the Southern Region of the Forest Service contracts some helicopters primarily as aerial ignition platforms. As a result, smaller crews are warranted compared to a primary initial attack crew. The Forest Service continues to work towards standard configurations for crew size, grade structure, and tours of duty. See table 7.2 for a list of Forest Service helitack crews from 2022 (chapter 7.5.5).

As a general statement, Forest Service employees must be qualified as a helicopter (helitack) crewmember as a prerequisite to more stringent qualifications in specialty helicopter missions.

7.7.2. Helijumping (Late 1940s to Mid-1970s)

Helijumping (also referred to as "hover-jumping" in some literature) was a legacy specialty mission that involved personnel jumping off the skid of a hovering or slow-flying helicopter into predesignated landing zones.[37] The landing zones consisted of various types of brush and other vegetation designed to cushion the helijumper upon landing. A special jumpsuit was developed and used in conjunction with thick, padded gloves and a helmet with a mesh face covering.

As helicopters were becoming more prevalent in the wildland fire arena in the late 1940s, Forest Service personnel began experimenting with helijumping. Initially considered a way to easily deploy personnel for purposes of helispot construction into areas where helicopters could not land, the Forest Service placed a moratorium on helijumping in 1949 due to a lack of standardized procedures and equipment.

In 1954, the Forest Service began to informally test the efficacy of helijumping. The helitack crew on the Angeles National Forest developed preliminary techniques for the helijumping mission. They also developed a protective, coverall suit, but it became apparent that it had many limitations. The crew enlisted the help of the Missoula Aerial Equipment Development Center, and by early 1958 a revised jumpsuit was designed and manufactured. A research plan was developed to determine specific helijump parameters, including jump heights, helicopter speeds, vegetation cover types, and acceptable slope percentage. The decision was made to use mannequins for the initial mission testing, and the Forest Service borrowed two electronic mannequins from the College of Engineering at the University of California. The stage was set to initiate the test program.

A test program was officially launched in 1958. Initial tests were conducted at the Chilao Flats area on the Angeles National Forest. The elevation at the test area was 5,300 feet, but adjusting for density altitude, conditions were actually 7,500 feet, thought to be representative of many Western forested areas.

A mannequin was used during the tests that weighed 175 pounds and was 5-feet, 10-inches tall. It was named the "95 Profile" because the movement of the mannequin's body was 95 percent that of a human. The study group documented the test jumps using slow-motion movies, large black and white photos, and visual inspections of each mannequin after every test jump.

The mannequin was put into the specially designed protective suit and an outer parachute harness. Suspension straps were extended from the shoulders of the jumpsuit and attached to a pilot-controlled "bomb shackle" (precursor to a cargo hook) so the mannequin could be released over various test sites. Once the helicopter was over the test site, the pilot would jettison the mannequin and, when it came to rest, the study team would document all aspects of the landing.

Left: "The dummy [sic] was suspended from a pilot-controlled bomb shackle underneath the ship." From page 6 of "The Helijump: The Research and Development of the Helicopter Hover Jump Technique" by James L. Murphy, April 1959. Right: Helijumper, also referred to as a "smokehopper," with padded suit, helmet, and tools, circa 1958. Courtesy of the National Museum of Forest Service History, Harvey Mack Collection.

Tests were performed at 20 different sites. In terms of airspeed, mannequins were deployed either in a hover, or at 5 to 10 miles per hour. Five different brush types were evaluated as landing zones, and three representative slope percentages were assessed (15, 30, and 60 percent). The U.S. Air Force at the Wright Air Development Center in Ohio had already researched the maximum safe jump height for humans, and results indicated 10 feet was the limit, so this was deemed the maximum jump height. It should be noted that this maximum height included the vegetation—if the vegetation was 6 feet tall, the jump could be no more than 4 feet off the canopy.

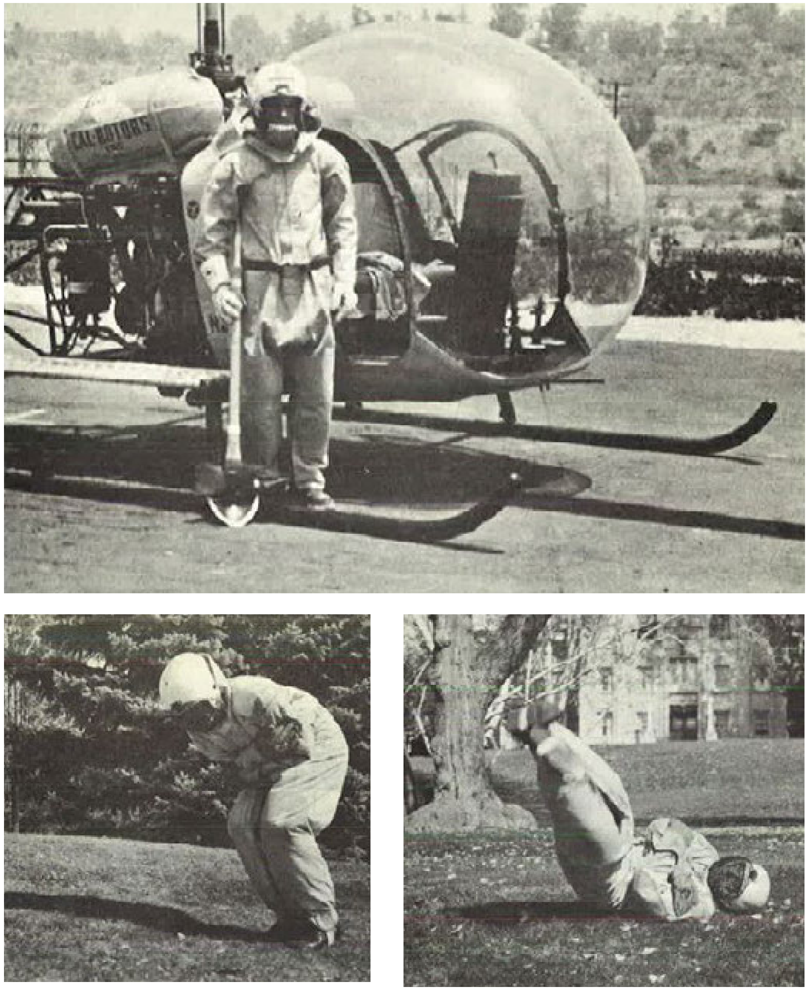
The tests resulted in a reinforcement in the padding of the jumpsuits as well as operational parameters, including jumping at helicopter speeds of 10 mph or less, no more than 10 feet off the ground, in the flattest spot possible, and into only certain vegetation types. A four-pass technique was developed consisting of a (1) high-level reconnaissance pass, (2) low-level reconnaissance pass, (3) tool drop pass (separate from the jump zone), and (4) jump pass.

> **Helijumping was stupid. People were getting hurt all of the time. The problem was some pilots didn't know the difference between manzanita and madrone." —Duane Sidebottom, a helijumper in the Pacific Southwest Region during the 1970s, as quoted in "History of Helirappelling 1964-1995" by Scott Whitmire.**

Jumping from a Sikorsky helicopter into brushy terrain on the Angeles National Forest in California, 1959. The helijumper stays "prone until the helicopter passes by." Courtesy of the National Museum of Forest Service History.

The research and development of helijumping is well documented in "The Helijump: The Research and Development of the Helicopter Hover-Jump Technique" by James Murphy. Murphy's report was published in April 1959, after which helijumping was approved for use by the agency. No literature was found documenting the extent of the helijumping program or when it was discontinued; however, in a letter dated January 20, 1976, then-Pacific Northwest Regional Fire Director Carl Hickerson commented that helijumping was still operational in southern California.[38]

Written in support of helicopter rappelling, in his letter Hickerson cited his personal experience with helijumping on the Los Padres National Forest from 1951 to 1955. He stated that "the 1950s were disastrous from an accident/injury standpoint" and that injuries related to helijumping were also frequent during the 1960s.[39] No official documentation was found about the cessation of the helijump program, but by the mid-1970s, helijumping ended as helicopter rappelling became a more viable initial attack tool.



From pages 18 and 20 of "The Helijump: The Research and Development of the Helicopter Hover-Jump Technique" by James L. Murphy, April 1959.

7.7.3. Suppressant/Retardant Delivery

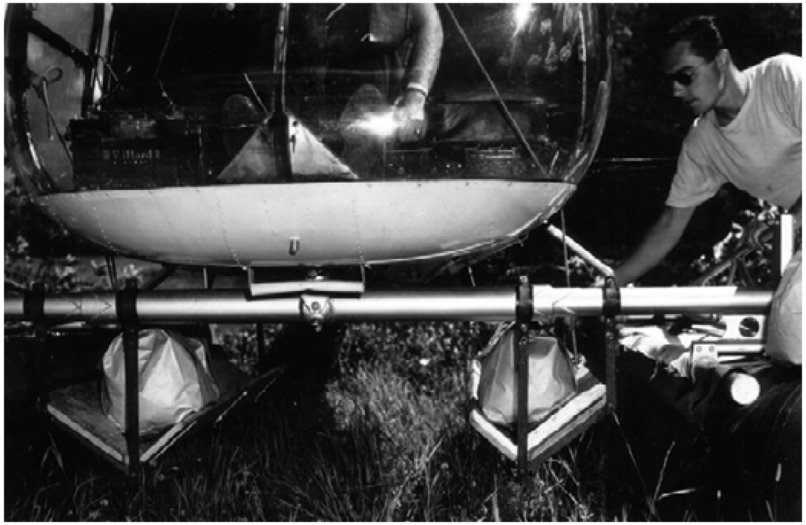
Helicopters are routinely used to deliver water and suppressants to wildfires using either buckets or fixed tanks. There are advantages and disadvantages to both systems. Helicopters with fixed tanks are often preferred in densely populated areas or areas with heavy infrastructure because fixed tanks cannot be inadvertently jettisoned. Helicopters with buckets—especially on longlines—can more easily penetrate heavy forest canopies, getting the water or suppressants closer to where they are needed. Additionally, buckets on longlines can often access water from sources inaccessible to helicopters with tanks that must get closer to a water source to "hover-fill." Depending on the system, both fixed tanks and buckets can hover-fill over water sources, and smaller buckets usually "scoop" water by allowing the bucket to tip and fill without suction. Buckets range in size from 70 to 2,600 gallons, while fixed tanks can carry up to 2,000 gallons.

Buckets

The Forest Service has been perfecting helicopter buckets for decades. Much of the early literature describes designing "tanks" for water and suppressant delivery; however, most of these early tanks were not affixed to a helicopter but suspended like modern-day buckets. As the technology evolved, the word "tank" would be used to describe systems permanently mounted to a helicopter (although removable), while "buckets" are attached via cargo hook.

In January 1954, Operation FIRESTOP was initiated in California by a conglomeration of State and Federal partners. With the Forest Service as a full partner, Operation FIRESTOP's primary objectives were to develop methods to protect the public from wildland fires while minimizing resource losses. One of the five areas of emphasis in the study was aerial application techniques, including the delivery of suppressants and water by helicopter.[40] Operation FIRESTOP used three different helicopters for the study: a Sikorsky S-55, Hiller 12B, and Bell 47. The Sikorsky was used "to drop 100 gallons of water by free fall on spot fires," although the container used to deliver the water is unknown.[41]

During this same time, many other entities were researching helicopter delivery systems. In 1954, the Ontario Provincial Air Service used a Hiller 360 to drop water-filled wax paper bags from a rack under the fuselage. This method proved ineffective as the bags tended to spread embers along the fire's edge.[42]



Wax paper bags of water loaded onto a platform underneath a Hiller 360. Ontario Department of Lands and Forests photo, Bob Petite Collection.

Herb Shields from the Arcadia Fire Equipment Development Center (now of the National Technology and Development Program) developed the first "helitank" designed to drop water from a helicopter. The tank was made of a nylon fabric coated with neoprene and could carry up to 35 gallons. Although it was called a helitank, it was actually attached to the "sling release" (cargo hook) under the helicopter. Once over the fire, the pilot could press a button that released a neck on the tank that delivered the water.[43] Some literature referred to this helitank as "the elephant snout."[44] Many helitank demonstrations occurred throughout 1957.[45]

As the 1950s were drawing to a close, many different entities continued experimenting with different tank applications for helicopters—even though most of these devices were described as tanks, they would be thought of as buckets today.

During 1961 and 1962, the Forest Service partnered with the Los Angeles County Fire Department to develop a fixed, mounted tank. Herb Shields represented the Forest Service, and a 100-gallon metal tank was constructed for light helicopters, including the Bell 47.[46]

A square metal "tank" was developed in 1961 that was slung under the helicopter and held 258 gallons. Dominion Helicopters of Ontario, Canada, used its Vertol H-21 as the delivery platform. The system used a rope to tip the bucket for filling and dumping water, and a water source at least 6 feet deep was required for dipping.[47]

In the early 1960s Okanogan Helicopters spent a few years developing and perfecting the Monzoon Bucket. The system was a 55-gallon barrel modified as a helicopter bucket slung underneath the helicopter. The bucket could be filled while hovering over the water source, and in later versions a solenoid-controlled bottom hatch was added as a water-release mechanism. Hundreds of Monzoon conversion kits were sold in the United States, Canada, and Australia.[48]

Other innovations continued during this time period. The California Department of Forestry experimented with the Bowles Bag, a neoprene tank that carried 80–100 gallons. It was used with light helicopters and attached to the landing skid.[49]

The introduction of the turbine-powered Bell Jet Ranger, Hughes 500, and Fairchild Hiller FH-1100 in 1967 allowed helicopters to carry larger volumes of water. Around this same time, Boeing introduced an 800-gallon bucket for the Vertol 107, which was considered enormous at the time.[50]

Other innovations continued to occur. In 1970 the Ontario Department of Lands and Forests developed and refined an aluminum-framed, fabric-bodied tank for the Bell 47G. The tank was collapsible and could be folded away when not in use. The tank had "hover-fill" capability, with two electric pumps that could fill the tank, and a capacity of 90 gallons.[51]

The 1970s saw a proliferation of manufacturers marketing helicopter buckets. The buckets ranged from collapsible to rigid and were constructed out of various materials, including aluminum, fiberglass, polyurethane, and fabric. They ranged in size from 54 to 110 gallons. Some of the more common bucket types were manufactured by companies such as Chadwick, Hawkins & Powers, Sims, and Griffith. Alberta Forest Service developed a 360-gallon aluminum tank for use with Bell medium helicopters.[52]

Left: One of the original Monzoon Buckets from the 1960s. The distinctive spelling was part of the branding.[53] *Below: A 205 fills a Chadwick bucket on the Wenatchee National Forest, WA, in August 1970. USDA Forest Service photo by Jim Hughes.*

One of the biggest challenges associated with helicopter buckets was the logistics of transporting them. Because of their bulk, most buckets could not be easily transported inside the helicopter, so they had to be transported via ground transportation or slung underneath the helicopter to a job site. Efficiency was compromised since helicopters with attached buckets cannot fly as fast as they would normally cruise. Additionally, passengers are not authorized to fly in helicopters with sling loads, including buckets. While a helicopter slings a bucket, only the pilot can be onboard.

Left: Griffith Big Dipper Model 100 helibucket, 100 gallons, used with type 3 helicopters. Photo courtesy of Terry "Tar" Lesmeister (date unknown). Bottom left: Drop testing gum-thickened retardant with a Columbia BV-234 helicopter using a modified 3,000-gallon Griffith helibucket.[54] *USDA Forest Service photo. Bottom right: Sikorsky S-64 Skycrane with a fixed tank. USDA Forest Service photo.*

In 1982 Don Arney's invention of the Bambi Bucket revolutionized the bucket mission. The Bambi Bucket was the first fully collapsible aerial firefighting bucket—which meant it could be stowed inside the helicopter for transport. Modern Bambi Buckets come in 20 different capacities, ranging in size from 72 to 2,590 gallons. The 12 smallest Bambi Buckets are all under 200 pounds in weight, allowing one or two people to easily manipulate them. The Bambi Bucket, manufactured by SEI Industries, has become the de facto industry standard and commands 95 percent of the international market.[55]

Pilot Mike Ward fills a Bambi Bucket on the Chattahoochee-Oconee National Forest. USDA Forest Service photo by Thomas H. Anderson.

Snorkel Tanks

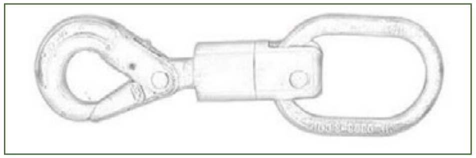
Beginning in the late 1990s several helicopter and equipment vendors began to develop fixed tanks for type 1 helicopters. Fixed tanks are permanently mounted to the helicopter but can be removed. All fixed tanks have hover-fill capability—helicopters hover over the water source and using a snorkel and pump, the tank is filled by suction.

When fixed tanks first appeared, the Forest Service used an approval process similar to fixed-wing airtankers for tank approval. From 1999 to 2005 the Forest Service tested seven different tanking systems and issued approval letters based on the testing criteria.

7.7.4. Cargo Transport

Cargo transport is a routine mission for helicopters. Cargo can be transported internally as long as it is properly secured, externally with various equipment attached to the helicopter cargo hook, or depending on the helicopter, in baskets or clamshells attached to the helicopter. The cargo hook has both an electronic and manual release. Under normal circumstances, external cargo is electronically jettisoned by the pilot once the cargo is placed on the ground.

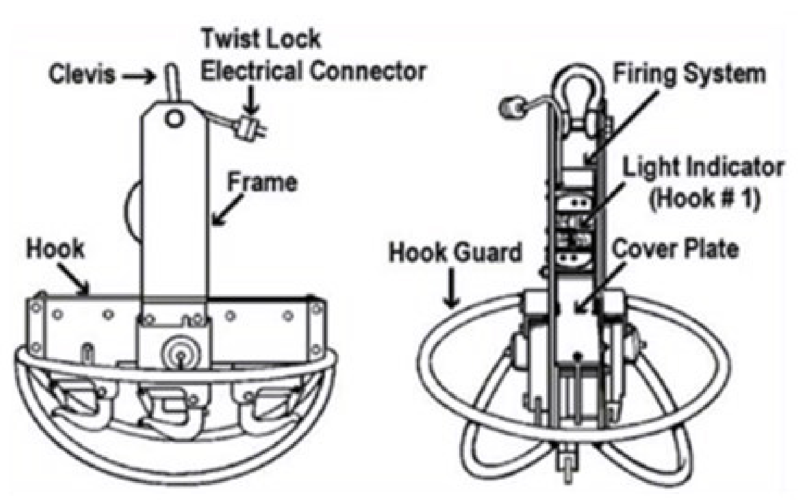
Standard equipment for external cargo includes a cargo net or other approved container, a leadline and/or longline, and a swivel that attaches the load to a cargo hook. A swivel is crucial when slinging cargo. Depending on the cargo and the amount of drag, some loads have the potential for substantial oscillation. As the name implies, a swivel allows the cargo to oscillate without applying any torque to the cargo hook. Without a swivel, a cargo hook can be damaged or—in severe cases—be ripped from the helicopter.



Examples of a typical cargo hook that is installed under the fuselage of a helicopter (on the left) and a typical swivel (on the right). Images from the National Wildfire Coordinating Group "Standards for Helicopter Operations" (exhibits 9.3 and 9.4).

One piece of equipment that has become a mainstay for external cargo is the longline and remote hook. The remote hook at the bottom of a longline is essentially an extension of the cargo hook. Longlines usually come in sections of 50 feet, and sections can be attached together to accommodate the length of line needed. A longline allows cargo to be delivered to spots that might otherwise be inaccessible. The pilot can place loads through canopy openings while still maintaining appropriate rotor clearance from the canopy top.

Like the cargo hook on the helicopter, the remote hook at the end of the longline has an electronic release controlled by the pilot. Once cargo placement has occurred, the pilot releases the load. There are “carousel” remote hooks with multiple gates that can be released separately, allowing for multiple loads to be transported and dropped at different locations. One advantage of the longline for ground crews is the reduction in rotor wash since the hovering helicopter is much higher than when using standard leadlines.



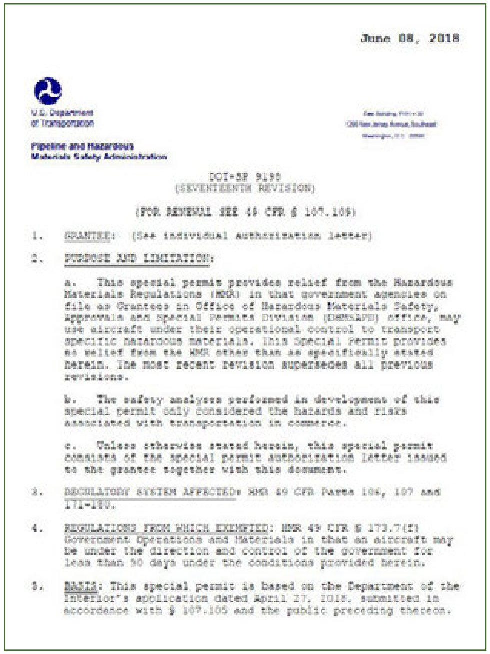
Typical four-hook carousel system. Image from the National Wildfire Coordinating Group “Standards for Helicopter Operations” (exhibit 9.7).

The standard practice and policy during external load cargo operations is that the pilot is the only one allowed on the aircraft. This is one consideration when planning a cargo mission. If a crew has the need to transport both people and equipment simultaneously, internal cargo transport is the only option. In addition, helicopters cannot fly as fast with external loads, and external loads over densely populated areas are problematic due to the potential for inadvertent load release.

In the modern era, virtually all helicopter contracts require a longline with remote hook. A longline with remote hook is usually a vendor-supplied piece of equipment, while all other external cargo equipment is owned and supplied by the Forest Service. Any equipment used in external load operations reduces the allowable payload by however much the equipment weighs and must be factored into mission planning. All external cargo equipment is rated to a certain capacity, with recurring inspection requirements for all equipment.

One reality of wildland firefighting is the need to transport hazardous materials. The Hazardous Materials Transportation Act was enacted by the 93rd U.S. Congress on January 3, 1975. This resulted in U.S. Department of Transportation (DOT) regulations for transporting hazardous materials in the Code of Federal Regulations, Title 49 (49 CFR). The Forest Service could not fully comply with 49 CFR and still accomplish its wildland firefighting mission. On a typical helicopter initial attack or crew transport, fire crews are equipped with items classified as hazardous materials, such as chainsaws, fuel, fusees, and batteries (including lithium).

The Department of Transportation recognized that the wildland fire community had a legitimate need for relief from 49 CFR and granted a special permit (DOT-SP 9198) to the Forest Service and DOI agencies with wildland firefighting responsibilities. DOT-SP 9198 allows for routine and recurring transport of hazardous materials needed for fire suppression as long as certain stipulations are met, the first being the aircraft must be under the exclusive direction and control of the Government (owned or contracted). The special permit has been in place for decades and is periodically reissued.



June 08, 2018

U.S. Department
of Transportation

Pipeline and Hazardous
Materials Safety Administration

DOT-SP 9198
(SEVENTEENTH REVISION)

(FOR RENEWAL SEE 49 CFR § 107.109)

1. GRANTEE: (See individual authorization letter)

2. PURPOSE AND LIMITATION:

a. This special permit provides relief from the Hazardous Materials Regulations (HMR) in that government agencies on file as Grantees in Office of Hazardous Materials Safety, Approvals and Special Permits Division (OHMSAPD) office, may use aircraft under their operational control to transport specific hazardous materials. This Special Permit provides no relief from the HMR other than as specifically stated herein. The most recent revision supersedes all previous revisions.

b. The safety analyses performed in development of this special permit only considered the hazards and risks associated with transportation in commerce.

c. Unless otherwise stated herein, this special permit consists of the special permit authorization letter issued to the grantee together with this document.

3. REGULATORY SYSTEM AFFECTED: HMR 49 CFR Parts 106, 107 and 171-180.

4. REGULATIONS FROM WHICH EXEMPTED: HMR 49 CFR § 173.7(f) Government Operations and Materials in that an aircraft may be under the direction and control of the government for less than 90 days under the conditions provided herein.

5. BASIS: This special permit is based on the Department of the Interior's application dated April 27, 2018, submitted in accordance with § 107.105 and the public preceding thereon.

First page of the 17th revision of the DOT special permit for the transportation of hazardous materials during wildfire suppression. This special permit has been in place since the Hazardous Materials Transportation Act was enacted in the mid-1970s.

One of the requirements of DOT-SP 9198 is that all parties must adhere to procedures in "NWCG Standards for Aviation Transport of Hazardous Materials" (PMS 513), an interagency document that prescribes appropriate procedures for hazardous materials transportation. Periodically reviewed and updated, PMS 513 is stewarded by the National Interagency Aviation Committee (NIAC). Under the law governing public aircraft operations (Public Aircraft Operations AC 00-1.1A), employees can be onboard aircraft transporting hazardous materials as long as they are essential to the mission.

7.7.5. Personnel Transport

Helicopter personnel transport in the Forest Service, with very few exceptions, occurs only with FAA-certificated aircraft. All certificated helicopters are authorized to transport people, and the Forest Service has many requirements in place to enhance personnel safety.

Historically, helicopter personnel transport has been accomplished using type 2 and 3 helicopters. During the mid-2000s the Forest Service decided to implement the personnel transport mission using type 1 helicopters, and by 2008 there were seven type 1 helicopters approved to transport people.

In August 2008 the Forest Service suffered a tragic helicopter crash in northern California when a Sikorsky S-61 helicopter transporting firefighters from a helispot on the Shasta-Trinity National Forest crashed, killing 9 of the 13 people onboard. Seven of the nine were contract firefighters. The other two fatalities included a vendor pilot and Forest Service inspector pilot. This tragedy is often referred to as "Iron 44" because the helicopter was departing Helispot #44 on the Iron Complex of wildfires. Although it was later determined that the cause of the crash was fraudulent helicopter performance data provided by the vendor, the severity of the crash in terms of lives lost compelled the Forest Service to reassess using type 1 helicopters for personnel transport.

In the winter of 2009, the Forest Service commissioned an "Independent Risk Assessment for Personnel Transport in Type 1 Helicopters."[56] The study was completed in the spring of 2009, and the final report issued on May 13, 2009. The gist of the risk assessment was that the consultant group believed the Forest Service could perform successful personnel transport with type 1 helicopters, but only with "successful implementation of mitigation measures that address the specific hazards posed by this mission."[57] The assessment developed 34 separate mitigation measures, and the agency decided not to use type 1 helicopters in this mission profile until all measures could be completed.

7.7.6. Rappel

Helicopter rappelling is a system used to aerially deliver personnel safely to the ground for a variety of missions and is composed of an aircraft, rappeller(s), a spotter, and approved equipment and procedures. With approval of the pilot, and under the direction and supervision of a spotter, the rappeller descends from the helicopter by sliding down a rope routed through a descent control device. The rope is attached to an FAA-approved hard-mounted anchor. Equipment for mission support can be let down before or after personnel.

Rappelling in 1974 from a Bell medium helicopter with "RAPPELLERS" emblazoned on the tail. Photo courtesy of Terry "Tar" Lesmeister.

As with many specialty aviation missions, the first substantial use of helicopter rappelling was by the military. In the late 1950s, both the Army and Marines began using this insertion method to enter dense jungle canopies. Their original system used nylon ropes and carabiners as the descent control device.[58]

Top: Rappel training "mock-up" from a Bell 205 helicopter on the ground. USDA Forest Service photo. Bottom: A rappeller pushes away from the skid and begins his descent while the spotter monitors the rappel and communicates with the pilot. This photo was taken by Ben Croft during a training rappel on the Salmon-Challis National Forest in 1999 using a helmet camera. Croft took a series of these photos by biting down on a remote cord in his mouth, to ensure that both hands were free for the rappel. This rappel was from an AStar helicopter owned by Era Aviation and piloted by Len Paur.[59]

Initial Testing by Smokejumpers (1964–1972)

The first experimentation with rappelling in the Forest Service occurred in the mid-1960s. In 1964, the Redding smokejumpers began a pilot program, due in part to the injuries they were sustaining from helijumping. The smokejumpers used a Bell 204 helicopter, and the first tests were completed over Shasta Lake by rappelling into the water. This proved to be a less-than-optimal test environment—once the rope became wet, the Sky Genie descent control device would not slide over it. The crew performed over 50 rappels; however, none were operational. In 1966 the Klamath National Forest briefly experimented with rappelling as well.[60]

The first documented fire rappel occurred just inside the Canadian border with the BLM-Alaska smokejumpers in 1967. They were working on a 20,000-acre, heavily timbered fire. They improvised a rappel system for purposes of helispot construction, routing ropes through the "D" rings on their pants and tying the ropes to the helicopter skids. They successfully used this system for about a week and were able to construct helispots around the entire fire.[61]

The Sky Genie descent device, used extensively by rappellers in the Forest

The BLM-Alaska smokejumpers continued to pursue rappel, and by the spring of 1970 were using Sky Genies and Sky Slides as descent control devices. Unfortunately, the smokejumpers suffered a serious accident when a Sky Slide failed and a rappeller fell 60 feet to the ground, suffering severe injury. This effectively ended BLM-Alaska rappelling and was also the end of using the Sky Slide. In addition, rappelling wasn't considered cost-effective in Alaska due to the sheer size of the initial attack area.

During this same time period, the Canadians were also working to develop a viable rappel system. They were successful, and in 1972 rappelled to four fires near Revelstoke, BC. The system they used was developed in partnership with a private company known as International Forest Fire Systems, Ltd.

In 1972 the Forest Service began another effort to determine the feasibility of helicopter rappelling. The Redmond Air Center in the Pacific Northwest Region was tasked to study the practicality of rappelling into timbered, mountainous terrain. In order to proceed, some operational parameters needed to be established. A debate occurred as to what type of platform (helicopter) should be used for rappel. The Canadians had developed their program using only light, type 3 helicopters (Bell 206 Jet Rangers). The practitioners at Redmond were of the opinion that light (either reciprocal or turbine-powered) helicopters lacked sufficient reliability and high-altitude performance. As a result, the decision was made to pursue rappel using medium, type 2 helicopters, namely the Bell 205A-1.

During the field season of 1972, the Redmond smokejumpers began rappel testing in earnest. After a series of practice rappels and procedural refinement, a highly publicized timber rappel occurred near Glaze Meadows on the Deschutes National Forest on September 20, 1972. Unfortunately, after an injury was sustained by the project leader (not rappel related), no opportunities for an operational fire rappel were realized that year.

Rappel Becomes Operational (1973–1982)

In 1973 the Pacific Northwest Region made the decision to move into the operational phase of program development. Two rappel bases were established in the region, one at the Lake Chelan Airport in north-central Washington, and one at the Santiam Airstrip in west-central Oregon. The Chelan crew was administered by the Wenatchee National Forest, and the Santiam crew was administered by the Willamette National Forest. Both crews used a Bell 205A-1 helicopter and had 12 rappellers. There were actually 35 total rappellers in the region after an additional 11 were trained for the Santiam crew in anticipation of seasonal firefighters returning to school.

The first operational fire rappel was performed on July 21, 1973. The Santiam rappellers initial-attacked the Garrison Butte #402 Fire on the Deschutes National Forest with six rappellers. This lightning-caused fire was 7 miles north of Sisters, OR, and the elapsed time from initial dispatch to the start of fireline construction was 27 minutes. Don Callahan, Deschutes National Forest dispatcher at the time, reported that "the crew got there quick and did an excellent job on the fireline." The crew was credited with stopping a growing 3-acre fire, and helicopter rappelling was solidified as a viable initial attack option.

During the 1973 fire season, 140 operational rappels were accomplished on 27 fires on 5 national forests. Other notable events that year included rappelling for large project fire support in eastern Oregon and eastern Washington, mainly for helispot construction, highlighting the viability of rappelling in otherwise inaccessible terrain.

Total training and operational rappels in 1973 were 782, with no injuries reported. As would be expected in program development, there were many lessons learned, including the value of routine rope inspections. For example, on one operational fire rappel, tree sap on the rope prevented it from sliding through the descent control device and the rappeller had to be lifted from the rappel spot to an open area before being lowered to the ground.

Training rappels in Siskiyou National Forest, OR, July 1975. "Leg bags" have since been replaced with more secure "belly bags." Courtesy of the National Museum of Forest Service History.

Rappelling vs. Smokejumping

The first to test rappelling as an option for the Forest Service was another group of aerially delivered firefighters—the smokejumpers. Ian D. McAndie summarized their findings in an article titled "Rappelling, An Alternative" for the summer 1973 issue of Fire Management (Fire Control Notes). McAndie was supervisor of Fire Management (Aerial) at the Redmond Air Center during this initial testing phase of rappel.

McAndie's article ends with a summary titled "Use Defined" which lists five conclusions from the testing (p. 7):

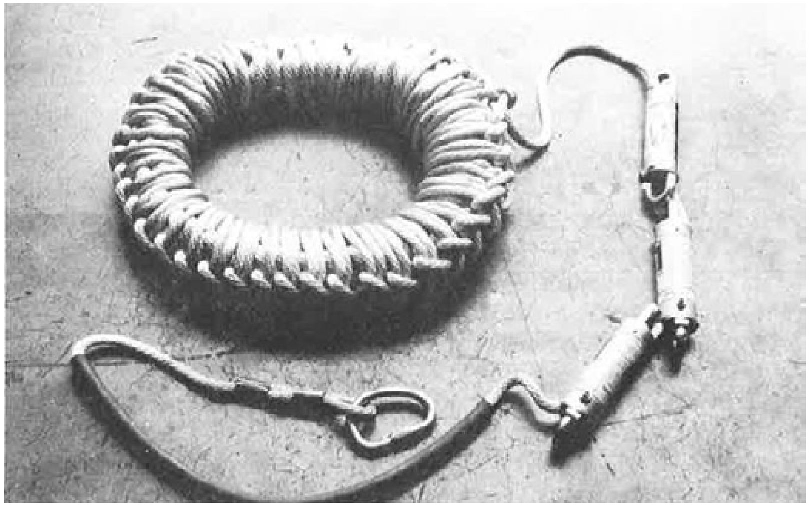
4. The helicopter is another means of delivering firefighters to a fire, either by rappelling or landing nearby.
5. Rappelling will not likely replace smokejumping because (a) the [Bell] 205A-1 can only carry a 6-man crew compared to 16 in a DC-3, (b) the 205A-1 costs $850.00 per hour as opposed to $167.00 per hour for a DC-3, and (c) the helicopter is limited to 78 miles one-way due to fuel weight restrictions; jumpers have a much larger range. Larger helicopters may balance the manpower advantage in the future, but cost will probably remain much higher.
6. Rappelling should not be done if the helicopter can land within 8 to 10 minutes walking time of the fire. The time that the ship is "on station" completing rappels and cargo delivery is hazardous to the men on the ground and to the aircraft because it is operating below safe autorotational elevation. Eight minutes is the maximum time to spend at hover elevation due to turbine heat being forced down onto the tail boom.
7. Rappellers are not restricted to airfield facilities as are jumpers.
8. Rappelling from helicopters is a practical means of delivering firefighters when other means are not possible.

The emphasis in McAndie's conclusions on dispelling any idea that rappelling might replace smokejumping suggests that there may have been people at the time who were concerned this might be the case. In fact, as the rappel program developed in the Forest Service in the 1970s and 1980s, there was understandably some rivalry between the proponents of each method of aerial delivery. Today, both missions have proven their unique value in the Forest Service's initial attack arsenal.

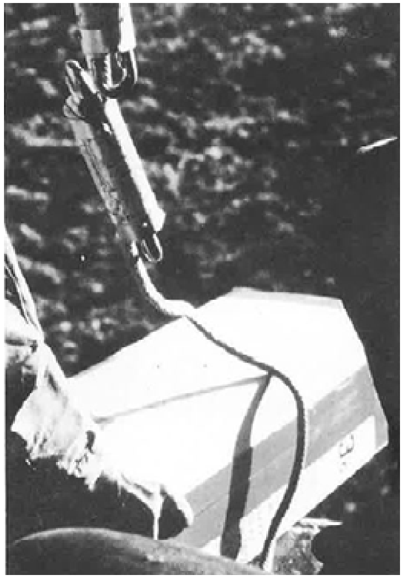
Source: McAndie, I.D. 1973. "Rappelling, an alternative." Fire Management. Washington, DC: USDA Forest Service. 34(3): 5–7.

Left: A 10-lb sandbag is released down the rope to ensure it is free of kinks, clear of brush, and on the ground. Right: Due to rotor downwash, rappelling wasn't recommended closer than 300 feet from a wildfire.

Left: Rappeller retrieving the letdown rope. Total equipment weight including fire pack was 45 pounds. Right: Sky Genie descent device. The number of wraps around the center shank determined the rate of descent. Descent was controlled by amount of handgrip and angle applied to the free end of the rope.



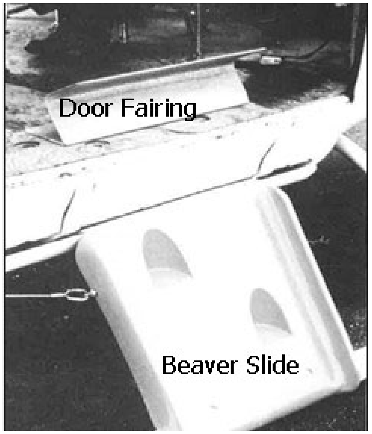
Left: A rappelling rope in a series of crochet loops to prevent tangles. Right: Rappeller descending from a hovering helicopter. USDA Forest Service photos.



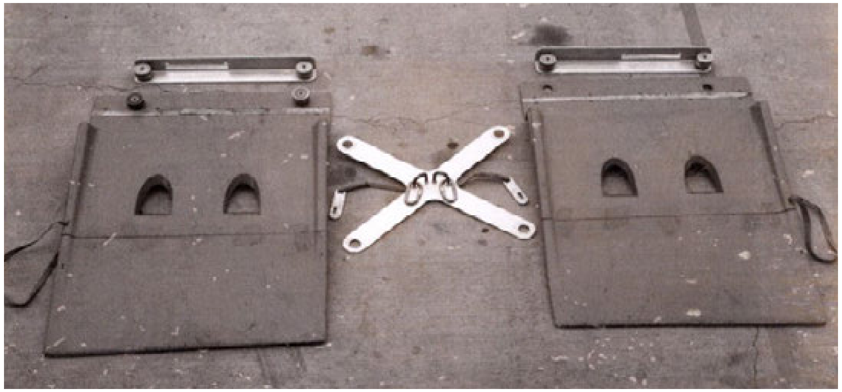
Left: A fire pack for two firefighters (approximately 55 lbs) is lowered to the ground using the same letdown rope the rappellers used. Right: A rappel harness made of parachute harness webbing. USDA Forest Service photos.[62]

The initial implementation of rappel provided the Forest Service the opportunity to develop equipment and procedures unique to that program. Initial analysis completed by the Pacific Northwest Region led them to decide to use only medium-sized helicopters for rappel. Concerns centered on the power required to lift a rappeller to an open area if he/she could not proceed with the rappel due to a knot in the rope or other issue. It was thought that type 3 helicopters may be under-powered for this scenario. Procedures developed at the Redmond Air Center were predicated on using a medium Bell 205A-1 helicopter.

The equipment developed for the Bell 205 had some unique components and required extended landing gear for installation. Perhaps the most unique feature of the early system were "beaver slides" and door fairings. The slides were used to facilitate the rappeller's exit from the helicopter. The door fairings were mounted over the doorsills of the helicopter to prevent the ropes from being damaged. Both were made of fiberglass and installed on both sides of the aircraft to accommodate rappelling from both doors. Installed prior to departure, the slides were hinged to accommodate the skid flexing during lift-off and had recessed steps for foot placement. The door fairings were installed in the air during the rappel sequence. As the rappel program developed, crews established exit procedures that eliminated the need for the slides and fairings, and within a few years of the start of the program, they were no longer being used.



Beaver slide and door fairings used during the early days of the rappel program.[63]



Closeup of beaver slides and ceiling anchor, and the equipment in action during practice rappels. Photos courtesy of Terry "Tar" Lesmeister (dates unknown).

Other refinements and innovations in procedures and techniques were being evaluated. Assessments were made regarding the efficacy of pulling ropes back into the helicopter as opposed to disconnecting and dropping them—the thought being it might be faster to pull ropes rather than disconnect them. Although the technique was tried on two fires on August 9, 1973, it wasn't determined to be the optimal method. As the 1973 fire season drew to a close, helicopter rappelling had proven to be a viable and successful firefighter delivery method.

The success of the two "experimental" rappel bases was sufficient to warrant expansion of the program, and in 1974, a third base was established in La Grande, OR, while the Santiam crew moved to Detroit, OR. From 1972 to 1974 (including the testing phase in 1972), a total of 2,059 rappels were made by the rappel crews, including 317 fire rappels. No attributable injuries were documented.

During the first two operational seasons of rappel, two spotters were used in the helicopter, one in the back with the rappellers to direct the rappel sequence, and one in the front passenger seat to monitor gauges. After the 1974 field season it was determined the need for additional monitoring of gauges was not warranted.

Another initial procedure that would prove less than optimal was wearing a helmet with a mesh face covering. After a few seasons of rappelling it was determined that it was more advantageous for rappellers to have enhanced visibility versus face protection. Unlike smokejumping, rappelling did not require that degree of face protection.

During this same time period, several studies were conducted comparing rappelling and smokejumping, mainly focused on cost and speed of initial attack. The main finding of the analyses was that rappelling was a faster form of initial attack with distances 40 miles or less, but due to the high cost of helicopters, rappelling was more expensive than smokejumping. Other recommendations included using only twin-engine Bell 212s for added performance and safety. The decision was made to give the rappel mission operational status, with a transition to Bell 212 helicopters.[64]

First Female Rappeller

The first female rappellers in the Forest Service were Kitty Hyatt and Christina Byrd in 1977 in the Pacific Northwest Region. A pictorial article on the Chelan Smokesliders published in the Seattle Times on July 2, 1978, included a photo of Kitty Hyatt captioned as "Ms. Hiatt [sic] is one of the first women to participate in the program." Here she is shown returning from a rappel mission with fellow crewmember Mark Miller. Sources: (1) Whitmire, S. History of Helirappelling: 1964–1995. p. 7; (2) Seattle Public Library digital archives.

In 1975 a fourth rappel base was added at Cave Junction, OR, with a complete phase-out of the Bell 205, replacing it with the Bell 212. A fifth base was added in 1976 at Hyak, WA, and the Washington Office authorized the use of rappel for all regions in the Forest Service.[65]

The approval of rappel did not come without opposition. During the mid- to late-1970s various concerns were raised. Although by 1975 the Canadians had amassed some 50,000 rappels with only one minor mishap due to a communications issue, safety concerns were still voiced from some agency personnel. A primary concern was single-engine rappelling and operating in the "out-of-ground" effect mission profile. Regional Forester Douglas R. Leisz of the Pacific Southwest Region is quoted as saying, "Until the Forest Service can contract for a twin-engine helicopter capable of hovering on one engine, I recommend that rappelling from helicopters be discontinued." Despite these concerns, the mission remained operationally approved into the 1980s.

An even greater challenge to the new rappel program emerged in the form of budget cuts and downsizing in the late 1970s. Implementation of the 1972 National Fire Plan resulted in a significant increase in presuppression (preparedness) costs. By the late 1970s it was clear this significant increase in programmatic costs did not translate to lower suppression costs. As a result, the Forest Service made the decision to scale back funding to the fire program. By 1978 the Pacific Northwest Region had gone from five to two rappel helicopters, one at the Ridgon Ranger District on the Willamette National Forest and one in Chelan, WA. By 1983, operational costs associated with the Bell 212 had become cost-prohibitive and rappelling in the Forest Service was terminated.[66]

Top: Spotting from the front seat of the helicopter. In 1973 and 1974, the Forest Service required a spotter in the left front seat to monitor and record helicopter temperature readings during rappel operations. If there was time available between readings, they would assist the primary spotter in the back of the aircraft. By the end of 1974, it was determined that enough information had been collected and the "front seat spotter" practice was discontinued. Bottom: Bell medium helicopter with Forest Service shield. Photos courtesy of Terry "Tar" Lesmeister (dates unknown).

Top left: Rappeller Jimmy Engstrom shown in an early rappel harness and screened helmet (date unknown). Top right: Rappel training from the tower at North Cascades Smokejumper Base in 1973. Bottom left: The tower at North Cascades Smokejumper Base after being replaced with a metal tower (date unknown). Photos courtesy of Terry "Tar" Lesmeister.

Smokesliders to the Rescue!

Smokey the Bear sometimes travels by helicopter these days. If the terrain is too rugged for the helicopter to land, Smokey just slides down a long rope and pounces on a forest fire before it gets out of hand. The technique is called rappelling, and it is fast gaining acceptance as another effective means in the Forest Service arsenal of fire-suppression methods.

Rappelling is limited to Washington and Oregon. Since 1973 there has been a base at Chelan, [Washington] where the 20-member Chelan Smokesliders operate from a modified hangar at the Chelan Airport, northeast of town.

Rappellers work in crews of six. To round out a flight, there is a pilot and a spotter, who helps locate the fire, selects a hovering position for the helicopter and dispatches the rappellers two at a time. Firefighters can rappel from as high as 220 feet above the ground in winds up to 35 miles an hour. As few as two or as many as six may slide from the helicopter, depending on the size of the fire.

The teams work from June to September, and they are busiest when thunderheads blacken the skies above the Cascade Mountains. Lightning strikes may ignite more than 50 fires overnight under tinder, dry conditions on the Wenatchee National Forest.

"We have much unroaded country where helicopters can't land and jumpers can't jump safely," said Bob Hetzer, Chelan District ranger. "We can't afford to take a couple of hours to get people to a fire – if we don't get our fires when they are small, we can plan on a major burn."

The fire record in the Wenatchee National Forest last summer during the worst drought in history supports the philosophy of aggressive initial attack. There were 316 fires, yet the total acres burned were only 988.

"Our rappellers have to know how to fight fire, understand fire behavior and they must be in top physical shape," said Terry Lesmeister, Chelan base foreman. When the rappellers are not out fighting fires, they burn logging slash or clear heliports in remote areas.

"This crew is like a fine basketball team – it's really close," said Tony Montoya, a rappeller. "It's dangerous work, but it's exciting. Who wants to work an 8-to-5 job, anyway?"

—Paul Hart, Jr., Seattle Times, July 2, 1978

Move to Type 3 Rappelling (1980s)

Even though the Forest Service terminated helicopter rappelling in 1983, the Department of the Interior's National Park Service (NPS) continued with the rappel mission. NPS opted to rappel using type 3 helicopters—something the Forest Service hadn't considered due to concerns about helicopter performance. In 1982 Yosemite National Park employed an Aerospatiale Twin-Star AS-355 as their rappel platform, Yellowstone National Park used an Aerospatiale Lama, and Hawaii Volcanoes National Park contracted for a Hughes 500.[67] "The [NPS] filled a gap for us between 1983 and 1986," said Lanny Allmaras, former aerial attack systems specialist in the Forest Service's Washington Office. "That's how we kept rappelling alive—we would have lost a lot of knowledge and background."[68]

In 1983 the Southwestern Region decided to pursue rappelling using type 3 helicopters. A concerted effort was made by many individuals in the region, with Helicopter Operations Specialist Noel Pyers playing a pivotal role in support of the concept. "He kept on the Washington Office about single-engine capabilities, but it was like pushing a rock uphill," said Mike Hopf, former helicopter operations specialist for the Southwestern Region.[69]

It took many individuals at different levels in the organization to make the case for type 3 rappelling. Understandably, the Southwestern Region was concerned about the risk associated with a test program. Pyers remained a strong proponent of the concept, and other regional personnel were also very supportive. Important advocates were Mike Rotunda, district fire management officer on the Sandia Ranger District, Cibola National Forest, and John Roberts, fire staff on the Coronado National Forest. "Roberts kept smoothing things over for us," said then-Tucson Helitack Supervisor Brett McGee.[70]

Left: In the early days of rappelling, various exit techniques were used. Here rappellers are shown using a "pivot" exit on a type 3 Bell Long Ranger helicopter. The technique was to crouch down on the skid then pivot off, slipping between the skid and fuselage of the helicopter. Photo courtesy of Terry "Tar" Lesmeister (date unknown). Bottom: Exiting from a type 2 Bell 205 during rappel training in 2014. The modern exit technique is to descend backwards until sufficiently clear of the skid. USDA photo by Lance Cheung.

One of the main concerns was single-engine rappel and the reliability of turbine engines. Pyers enlisted the help of maintenance specialist Paul Markowitz to do reliability testing on an Allison C-30 turbine engine. In the 1970s the Pacific Northwest Region had done similar tests, reporting that given the reliability of turbine engines (using the known failure rate), the Forest Service could "expect one engine failure during the hover operation [part of the rappel sequence] every 2,000 years." The reliability of the turbine engine helped justify the efficacy of single-engine, type 3 rappel.[71]

After a 2-year effort, the Southwestern Region was finally "given the green light" to initiate a type 3 rappel crew in 1986. Pyers approached the Gila National Forest as the initial location for a base, mainly due to the extent of designated wilderness on the forest. The smokejumper program was scaling back during this time period, and according to then-Gila Helicopter Manager Hank Dominguez, "We wanted to fill a niche that was created when the jumper program was cut back."[72]

Subject matter experts were enlisted to help initiate type 3 rappel. In the spring of 1986, Terry "Tar" Lesmeister, one of the original rappel trainers and spotters in the Pacific Northwest Region, was coincidentally in Mexico training fire personnel in the northern states of Mexico on helitack, helitorch operations, and rappelling. He was contacted and agreed to help with the initial training in the Southwestern Region. The stage was set—and with the help of regional personnel and outside expertise—training rappellers for the new Gila crew was successfully completed. Rappelling had reemerged in the Forest service.

"It was very successful that first year," said Dominguez. "It was supposed to be a 2-year pilot program, but it was approved for other bases after one year. We had standards to make sure that rappelling was used wisely and safely." The Gila crew had 38 operational rappels in 1986.[73]

The successful reemergence of rappel sparked interest in other regions. With a decade of rappel experience, the Pacific Northwest Region was a logical choice for program expansion. In 1987 they reinstituted their rappel program at Chelan, WA, and sent two rappellers to the Southwestern Region to receive initial type 3 rappel training. The Northern Region sent an employee as well, but due to the smokejumping capability in that region, they would not initiate rappel for another 15 years.[74]

The Southwestern Region continued program expansion in 1987 as the Tucson crew became rappel qualified, and in 1988 the Rucker crew on the Coronado National Forest followed suit. During this same time the Pacific Southwest Region became interested in exploring the rappel option. They had already been experimenting short-hauling people with a Billy Pugh rescue net and decided to pursue rappel as well.

Left: Rappellers on the Chelan crew, including Mari Ward and Steve Farrar, prepare for takeoff in their rappel gear. This photo shows how Sky Genies were stacked and how ropes were braided rather than bagged. Photo courtesy of Terry "Tar" Lesmeister (date unknown). Right: A Forest Service rappeller uses the Sky Genie descent device to lower himself from a helicopter. USDA Forest Service photo by Dylan Kane.

In 1988 the Klamath National Forest put forth a proposal to rappel. Bruce Detrick, a helicopter manager on the forest, was one of the main proponents of the proposal, which received approval at the forest level. Detrick was quoted as saying, "We were approved for a 2-year evaluation, but we were really under a magnifying glass. We had to keep careful records of everything—costs, times, dispatch times, things like that."[75]

The Pacific Southwest Region also sent employees to the Southwestern Region to receive initial rappel training. Scott Valley on the Klamath National Forest emerged as the lead rappel crew in the Pacific Southwest Region, spearheading the effort to organize training for other crews in the region. They also conceptualized and implemented a rappel booster program, whereby the Klamath National Forest trained an additional 25 employees to rappel. The booster concept was very popular on the Klamath National Forest but had very limited implementation elsewhere. One more base was added in the Southwestern Region in 1990 when the Prescott National Forest implemented rappel in Prescott, AZ.[76]

Accelerated Growth of the Program (1990s)

By 1991 helicopter rappelling had become well established in the Forest Service fire community. The Intermountain Region began rappelling at the Dutch John Helibase on the Ashely National Forest in Utah, bringing the total to four regions with operational rappel crews (Southwestern, Intermountain, Pacific Southwest, and Pacific Northwest). Likewise, the Department of the Interior had five rappel crews in two Bureaus: the National Park Service had rappel crews at Yosemite, Yellowstone, Hawaii, and the Grand Teton National Park; and the Bureau of Land Management had a rappel crew at Apple Valley, CA. The Intermountain Region would soon add rappel capability to bases at Bridgeport, CA, on the Toiyabe National Forest; at Challis, ID, on the Challis National Forest; and two on the Payette National Forest at Krassel and Price Valley.[77]

Throughout the 1990s the Forest Service rappel program experienced accelerated growth. In the Pacific Southwest Region, bases were established on the Plumas, Inyo, Shasta-Trinity, and Los Padres National Forests. The Arroyo Grande Base was the first rappel crew in the South Zone of California. Some questioned the viability of rappel in the South Zone ecosystem with its flashy fuels and dense brush, but the use of rappel on large fires was becoming more prevalent. In 1994 the crew stationed at Arroyo Grande logged 66 operational rappels—38 of which were large-fire support missions.[78]

Other regions were expanding their rappel capability in the early to mid-1990s. The Pacific Northwest Region added rappel to the John Day Helibase on the Malheur National Forest, Grants Pass Helibase on the Rogue River-Siskiyou National Forest, Frazier Helibase on the Umatilla National Forest, and at the Sled Springs Work Center on the Wallowa-Whitman National Forest. By 1995 there were 32 rappel bases throughout 4 western regions of the Forest Service.

1996 to 2010

As rappel base numbers were beginning to plateau in the 1990s, several standardization issues began to surface between different crews and regions. When type 3 rappel reemerged in the Southwestern Region, some of the crews adapted a rock-climbing "sit-harness" which did not cover the upper torso of a rappeller. During the previous decade of rappel in the Pacific Northwest (1973–1983), the crews in that region used full-body harnesses, adapted from the smokejumper program, for rappelling. In terms of equipment, this created a big impediment to national standardization.

In early November 1992 a meeting was convened in Boise, ID, with rappel stakeholders. One of the primary purposes of the meeting was to decide on a standardized rappel harness. Several harnesses were considered, including sit-harnesses, full-body harnesses adapted from the smokejumper program, and other commercially available full-body harnesses. After physically testing each harness—and after much debate—it was decided that the Rock-N-Rescue HR4 harness would be the only harness officially approved for Forest Service helicopter rappelling.

Rappeller Simon Driskell in his rappel gear in May 2022. Along with an HR4 harness, he wears a flight helmet, fire clothes, sturdy leather gloves, and a "belly bag" containing essential gear. USDA Forest Service photos by Elliott Loucks.

Other rappel equipment was fairly standardized, most being mandated by policy. All crews used the Sky Genie descent control device with a 250-foot, half-inch nylon rope made especially for the Sky Genie. Some crews had experimented with helmet options other than a flight helmet, but most crews were satisfied with the standard SPH-4 or 5. All crews wore standard fire-resistant clothing in the form of fire pants and shirts or flight suits, and all rappellers used specialized "heater gloves" to facilitate hand-breaking (stopping).

During the 1990s several different helicopters were used as rappel platforms, almost all type 3. The Bell Long Ranger (206L3 and 4), Bell 407, and Eurocopter AS-350 AStar (B2 and B3) were among the most common makes and models used. Although the type 3 helicopters worked well in the rappel mission, there were concerns with some models. For example, in the AS-350 B2 and B3 AStar, there was no way to separate the spotter from the proximity of the flight controls, and the fear was the spotter could inadvertently fall on the collective pitch control lever located between the two front seats and cause loss of lift. As the rappel mission matured, this type of consideration would influence what models of helicopter would be used for rappel.

Bell Long Ranger helicopter. Photo courtesy of Terry "Tar" Lesmeister (date unknown).

The Pacific Northwest Region still had an interest in using Bell medium helicopters for the rappel mission. When the seven national type 2 helicopters came online in 1993, John Day, OR, was one of the base locations. A Bell 212 was contracted, and the base requested and received permission to integrate that platform into the mix of rappel platforms. By 1999 the Pacific Northwest Region was contracting for Bell medium platforms at multiple bases.

In the late 1990s the rappel community recognized the need to consciously focus on maintaining the integrity of the rappel mission, especially given the number of rappel bases throughout four regions in the Forest Service. A National Rappel Working Group was established. Composed of management representatives and rappel practitioners from all rappelling regions, the purpose of the group was to foster the exchange of ideas and techniques to improve and refine the rappel mission.

The National Rappel Working Group had a significant positive impact on the rappel mission. One of their accomplishments was to standardize rappel anchors to an overhead system versus a floor-mounted system. Not only did this facilitate getting rappel equipment off the floor of the helicopter and thus improving safety, but it also allowed for the standardization of exit procedures from the helicopter. In the mid-2010s, when NWCG reorganized and established new group nomenclature, the National Rappel Working Group was renamed as the Interagency Rappel Unit. The Interagency Helicopter Operations Subcommittee is the parent subcommittee to the Interagency Rappel Unit.[79]

In the late 1990s, the anchor system for rappelling was modified from a floor-mounted system (as shown above) to a safer and more efficient overhead system. Photo courtesy of Terry "Tar" Lesmeister (date unknown).

Pacific Northwest Region Rappel Academy

By the end of the 1990s the Pacific Northwest Region pioneered the concept of a singular regional rappel training that would train all regional crews at a single location. The impetus of the concept was to eliminate—to the extent possible—variation in operational procedures between regional crews. The long-term goal of the Pacific Northwest Region was the seamless "boosting" of rappellers between all regional bases. In other words, the region wanted the ability to move rappellers between bases to bolster base numbers when activity warranted it, so that any rappeller could rappel out of any regional helicopter, not just the one assigned to their base. The concept was essentially to mirror the way the smokejumper program moved personnel to bases with high levels of activity.

The first attempt at regional training in the Pacific Northwest occurred in 2000 in La Grande, OR, but that training did not include all regional crews. The first year the Pacific Northwest Region trained all five crews in one location (La Grande) was in 2001, and that was considered the first Regional Rappel Academy. By 2002 the training had moved to John Day, OR, and the academy became institutionalized in the region.

Refined Exit Technique

Another refinement to programmatic procedures occurred in 2002 when Assistant Rappel Base Manager Eric Bush at the John Day Rappel Base refined and greatly improved the technique for over-the-skid helicopter exiting regardless of aircraft type. The innovation received much acclaim, and the Pacific Northwest Regional Rappel Working Group received the Chief's National Fire Plan Award for Excellence in Firefighter Preparedness, Training, and Safety.[80]

Above: The primary mission of the national rappel program is initial attack, but crews may also be used for large fire support, all hazard incident operations, and resource management objectives. USDA photo by Lance Cheung. Right: National Fire Plan award "for excellence in firefighter preparedness, training, and safety" presented to the Pacific Northwest Rappel Academy Cadre in 2004—evidence of the success of their efforts to standardize rappel training. The academy appreciated "the support of the [Washington Office] Aviation staff in allowing the academy an opportunity to think outside the box." [81]

Pacific Northwest Regional Rappel Academy 2007 participants. Photo courtesy of Ken Ross.

By the 2000s major expansion of the rappel program had subsided, but rappel capability continued to be added at select bases. In 2001 the Northern Region activated its first rappel base on the Gallatin National Forest at the Shenango Work Center. By 2002 there were 38 rappel bases in 5 regions, with 38 helicopters and 476 rappellers.[82]

As the rappel mission continued to evolve in multiple regions, philosophical differences began to surface regarding the status of rappellers. The program in the Pacific Northwest Region had evolved into a regional program, meaning their rappellers and helicopters were viewed as regional shared resources whose mission priorities and assignments were controlled by the Geographic Area Coordination Center (GACC). Most other regions considered rappellers local forest resources with mission priorities determined by the local host forest. In some regions, rappel was an endorsement for helitack crewmembers versus a primary mission.

Aviation Activities Management Efficiency Assessment

In the mid-2000s the Forest Service conducted a feasibility study of its aviation program now known as the "Management Efficiency Assessment of Aviation Activities in the USDA Forest Service" (see chapter 3.3.6). One of the recommendations from the study was to "consolidate helicopter rappel training to one location in each region in order to promote standardization and efficiency." On July 11, 2007, the Deputy Chief of State and Private Forestry issued a letter directing all regions to consolidate rappel training. However, it would take a few more years and a tragic rappel fatality to drive the agency to national standardization.

In 2005 the Rocky Mountain Region established its first rappel base on the Pike-San Isabel National Forest at Monument, CO. By 2009 rappel base numbers had reached an all-time maximum of 48 rappel bases in 6 regions and 663 helicopter rappellers.[83]

Rappel Fatality

On July 21, 2009, the Forest Service rappel program experienced a tragic fatality when a rappeller perished in an unarrested descent to the ground. The tragedy occurred on the Willow Helibase on the Six Rivers National Forest in northern California. The rappeller was participating in a rappel proficiency exercise. The cause of the tragedy was procedural in nature, caused by a rigging error with the Sky Genie and rappel harness (the Sky Genie was not properly attached to the harness). Prior to this fatality, the Forest Service had never experienced a severe injury from rappel.

Understandably, this had a major impact on rappel operations. For the remainder of the 2009 field season all regions except the Pacific Northwest opted to suspend rappel. After analyzing the failure that caused the fatality, the Pacific Northwest Region made a deliberate decision to remain operational, due mostly to the fact that the procedural failure that occurred at the Willow Helibase had been engineered out of operations in the Pacific Northwest Region years earlier. The fatality compelled the agency to reassess the extent of the rappel program.

In the fall of 2009 a concerted effort was initiated by the Forest Service to assess rappelling needs and to review program standardization. In November 2009 the Safety Investigation Team that investigated the fatality presented their findings to the Chief's Accident Review Board. In February of 2010 the Chief approved a safety action plan that had been developed by the Accident Review Board and direction was given that the rappel mission be "stood down" until all provisions of the plan were completed.

In March of 2010 a Helicopter Rappelling Risk Assessment and Quality Assurance Plan was completed. Along with the Willow Helibase Accident Review Board recommendations and the Interagency Helicopter Rappel Guide, these documents were used to develop a rappel standardization document that provided a blueprint for rappel reactivation.

In the early years of the program, 1973 through 1983, the number of bases ranged from one to five, with two active bases for 6 of those 11 years (1973, 1978–1982). Figure 7.3 shows the rapid growth of the rappel program from the mid-1980s through 2009, and the dramatic reduction in the number of bases in 2010 after the rappel fatality. Since 2010, the program has stabilized, with 12 total rappel bases from 2011 to 2020 (with a minor change in 2016 when there were 13 bases).[84]

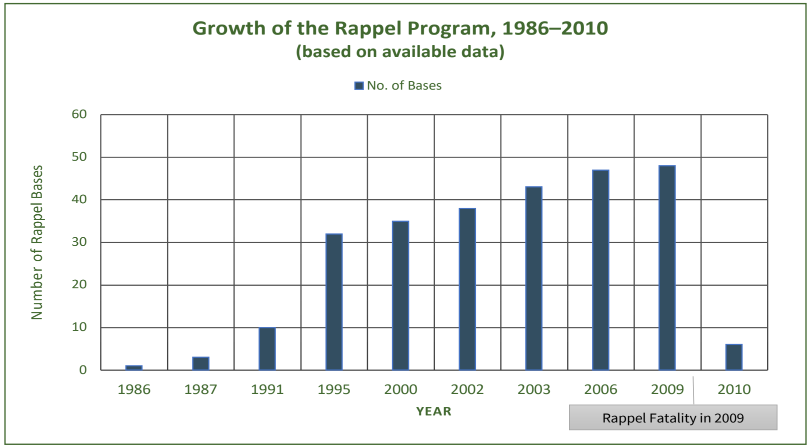


Figure 7.3. The rappel program grew rapidly in the 1990s. A fatality in 2009 drastically reduced the use of rappelling in the Forest Service, but numbers increased and stabilized after 2010.

National Program Standardization (2010–2021)

During the week of April 19, 2010, a "National Review of the Helicopter Rappelling Program" was completed in Boise, ID. The review was conducted to satisfy recommendation 01 of the Accident Review Board's safety action plan that was developed from the Willow Helibase rappel accident fatality. The review focused on three areas: the overall rappel mission, the risk versus benefit of rappel, and the adequacy of standardization oversight. During this review process, the Forest Service determined that a mission statement for rappel did not exist. It also determined that the agency lacked a process for determining the cost and benefit of rappel, and that oversight and standardization of rappel was inadequate. These conclusions would drive future program initiatives.[85]

In 2010 the Pacific Northwest Region was the only region to request reactivation of their rappel crews. In June 2010, a meeting was held in John Day, OR, with the Pacific Northwest Region's deputy regional forester, regional fire and aviation managers, rappellers, and a national rappel quality assurance team (QA team) from the Washington Office. The purpose of the meeting was to ensure that the region had complied with recommendations from the Willow Helibase Accident Review Board, the Rappel Risk Assessment Action Plan, and to ensure adherence to the Interagency Helicopter Rappel Guide.

The meeting culminated in a memorandum issued on June 28, 2010, by then-Deputy Chief for State and Private Forestry James Hubbard approving a partial reactivation of the rappel program in the Pacific Northwest with consolidated regional training using Bell medium helicopters.[86] In July 2010, Fire and Aviation Management Director Tom Harbour concurred with the recommendations of the QA team, and the Forest Service edition 1 version of the Interagency Helicopter Rappel Guide was approved as policy for calendar year 2010.

The Pacific Northwest Region conducted consolidated rappel training in John Day, OR, and all regional rappel crews were certified as operational. During the 2010 field season from July through September, the region staffed a total of 86 wildfires using 6 Bell medium helicopters with no lost-time accidents reported.

In October 2010 a "National Rappel Program Reactivation Process" was created. This document served two purposes—it defined and described the national rappel program and provided processes and procedures for rappel reactivation. It also established the first Forest Service rappel mission statement. The mission statement was a departure from the way most regions viewed rappel and shifted the culture from rappel as a local resource to a national program.

Rappel Program Mission Statement

The primary mission of the interagency helicopter rappel program is the consistently safe and efficient aerial delivery of firefighters in support of local, regional, and national firefighting efforts, when appropriate.

- Rappellers will be a national shared resource as part of the Forest Service's national rappel program.
- Rappel training will be consolidated intraregionally or interregionally to maintain national standardization. There will be no more than one rappel location/academy per region. Consolidated training will be defined in the National Rappel Reactivation Process 4.2.
- The national rappel program is standardized nationally. All rappel and cargo letdown equipment, operational rappel procedures, helicopters, helicopter configuration, training procedures, training practices, and training standards are identical at every base and will conform to the standards.
- The national rappel program will maintain the ability to move rappel resources between geographic areas, to provide an effortless exchange of any rappeller or group of rappellers, their equipment, procedures, and helicopter with any other rappel operation anywhere in the Nation and be operational with minimum delay.
- All rappel bases have the capacity to host booster rappellers and outfit them with firefighting equipment configured in a standard package.
- A national standardized database will be developed and adopted that produces efficient and accurate reports and documents rappel equipment use.
- The number of rappel bases, rappellers, and platforms will be determined to meet regional and national needs.

First Nationally Consolidated Rappel Training

As the 2011 fire season approached, three more regions decided to pursue reactivating rappel using the reactivation process. The first national consolidated training occurred in the summer of 2011. Twelve crews from four regions were "green-lighted" to rappel. Because of increased scrutiny of the program, the Forest Service got a later start on the training than would normally have been the case, but 2 national sessions were conducted to train the 12 crews, with the last session ending in early July. The training sessions were held in John Day, OR, and were successfully completed. By midsummer the Forest Service had 12 crews approved to operationally rappel:

- Gallatin Helibase, Gallatin National Forest, Northern Region
- Lucky Peak Helibase, Boise National Forest, Intermountain Region
- Price Valley Helibase, Payette National Forest, Intermountain Region
- Salmon Helibase, Salmon National Forest, Intermountain Region
- Sierra Helibase, Sierra National Forest, Pacific Southwest Region
- Scott Valley Helibase, Klamath National Forest, Pacific Southwest Region
- Central Oregon Helibase, Deschutes National Forest, Pacific Northwest Region
- Frazier Helibase, Umatilla National Forest, Pacific Northwest Region
- John Day Helibase, Malheur National Forest, Pacific Northwest Region
- Siskiyou Helibase, Rogue River-Siskiyou National Forest, Pacific Northwest Region
- Sled Springs Helibase, Wallowa-Whitman National Forest, Pacific Northwest Region
- Wenatchee Valley Helibase, Wenatchee National Forest, Pacific Northwest Region

The Forest Service was resolute in its pursuit of a standardized national rappel program. In 2012 two rappel training towers were constructed in Salmon, ID, and that became the location of the National Rappel Academy. In 2012 the same 12 crews were authorized for rappel, and at 2 bases an additional helicopter was added. The base in Salmon, ID, on the Salmon-Challis National Forest added an additional Bell medium helicopter, as did Price Valley on the Payette National Forest. In 2012 the Forest Service had 12 rappel bases with 14 Bell medium helicopters.

The Forest Service's National Rappel Academy has emerged as a showcase for program standardization. A national cadre of trainers represents all bases. All new rappellers are trained in exactly the same way, and all experienced rappellers are recertified in exactly the same way. At the training, it is practically impossible for a casual observer to discern which crew a rappeller or trainer is affiliated with. The level of standardization across all Forest Service crews is exceptional.

Throughout the rest of the 2010s, infrastructure and personnel numbers for the Forest Service rappel program remained fairly static. Through 2015, rappel base and aircraft numbers did not change with 12 bases fielding 14 aircraft. In 2016 a base was added at Libby, MT, bringing the number to 13 bases and 15 aircraft. In 2017, the Frazier and Sled Springs bases in northeastern Oregon combined and relocated to La Grande, OR. Those combined crews became the Grande Ronde crew, changing the number of bases to 12 with 15 aircraft, which remained consistent through 2022.

National Rappel Academy 2016 group photo of participants. USDA Forest Service photo by Charity Parks.

Training at the National Rappel Academy includes descending from a tower (top), practicing emergency tie-offs (middle), and exiting from a helicopter (bottom). Training is standardized so all Forest Service rappellers receive the exact same instruction.. USDA Forest Service photos by Charity Parks.

Descent Control Systems

As with any specialty mission, rappellers are constantly striving to improve procedures and equipment. Since the inception of rappel, practitioners have sought a descent control device that required a physical action for the device to function. With the Sky Genie system, a physical action (hand braking) was required to stop a rappeller. (Once the rope is passing through the device it requires the physical action of a rappeller to stop.) The rappel community was interested in a device where the rope would move through the descent control devise only with a deliberate physical action. In other words, rappellers wanted a device whereby if a rappeller became incapacitated, the rappeller would stop with no physical action required.

Smokejumping uses air resistance in the form of a parachute to overwhelm the downward force of gravity—rappelling relies on friction to do the same thing. An unfortunate byproduct of friction is heat. One of the biggest challenges in helicopter rappelling was finding a descent control device that would not get too hot, potentially melting the rope.

For years, the National Technology and Development Program sought a device to replace the Sky Genie. Although the Sky Genie was incredibly reliable with hundreds of thousands of rappels and zero failures, the device was adapted from the window washing industry and a better system was sought. In 2019 a new device was finally approved—the ISC D4 Descender. The D4 Descender requires the rappeller to pull a lever for the rope to feed through the device. If the lever is not engaged, the rappeller doesn't move.

The ISC D4 Descender replaced the Sky Genie in 2019.

Additionally, a new rope was identified for use with the D4 Descender. The new rope is a Bluewater Armortec 11-mm kernmantle rope made of aramid, polyester, and nylon, available in lengths of 250 or 300 feet. The rope has a 5-year service life from date of manufacture; the service life of the descent device is based on visual inspections. The ISC D4 Descender and Bluewater Armortec rope are the only approved descent control system for Forest Service rappelling as of 2022. A list of all approved equipment can be found in the latest version of the Interagency Helicopter Rappel Guide.

7.7.7. Aerial Ignition

Aerial ignition is a tool used by land managers and firefighters to reduce hazardous fuels, improve wildlife habitat, and accomplish burnouts on wildland fires. The biggest advantage of aerial ignition is that larger areas can be ignited much more rapidly than lighting by hand. Aerial ignition devices can be categorized as either a delayed action ignition device (DAID) or as a "flying drip torch" slung underneath a helicopter.

The Australians were among the first to undertake the challenge of developing aerial ignition systems. During the 1960s they developed a DAID system as a way to burn large swaths of eucalyptus to reduce ground litter thus reducing hazardous fuels.[87] Although almost all contemporary DAID systems are delivered by rotor-wing aircraft, in 1971 the Australians developed a system using fixed-wing aircraft to dispense plastic vials that had delayed ignition and would ignite once on the ground.[88] Australian DAID systems have been used in the United States since the early 1970s by private industry and some State forestry organizations, but the Forest Service did not have an approved DAID system until the mid-1980s.[89] The Forest Service did experiment with several DAID systems in the 1970s, but none were ever pursued in a holistic way.[90]

A DAID uses an exothermic chemical reaction as a way to ignite plastic spheres. A plastic sphere (resembling a ping pong ball) containing potassium permanganate is injected with ethyl glycol. The concentration of injected glycol dictates how long the delayed ignition will take. Devices approved for use by the interagency community have approximately a 30-second ignition delay. The most common and familiar DAID is the Premo Mark III aerial ignition device. The speed by which the spheres are ejected can be varied to accommodate fuel type or to adjust for environmental conditions.

Left: Weyerhaeuser igniting woody debris in 1975 with a "flying torch" suspended from a Bell Jet Ranger. A 55-gallon version of a hand-held drip torch, this system could accomplish in 10 minutes what would normally take 7–10 employees 2–3 hours to ignite by hand. Forest History Society photo. Right: Helitorch operation. USDA Forest Service photo.

A Premo aerial ignition device mounted onto an AStar helicopter. USDA Forest Service photo.

The most familiar "flying drip torch" is the Simplex Helitorch Model 5400, which can be coupled with a batch mixer. The Simplex Helitorch is essentially a 55-gallon drum mounted on an aluminum frame. The drum is filled with a "gelled" gasoline mixture and a small electric motor drives a small positive displacement pump. The fuel is mixed with aluma-gel, giving it the consistency of runny gelatin. The fuel is pumped out of a nozzle with a mounted ignitor and is ignited as it is pumped from the helitorch. The contemporary helitorch attaches to the helicopter using a single point connection. A "pear ring" is attached to the cargo hook, and an electric cord is plugged into the helicopter to provide power to the pump.

The Simplex Helitorch was first tested on the Mendocino National Forest in California. In March 1979, the Forest Service's Missoula Equipment Development Center teamed up with the Mendocino National Forest to commence field testing. The helitorch was initially tested as a prescribed burning tool in fuels described as "brush-covered lands." As the testing progressed, the Angeles and Cleveland National Forests in southern California were added as participants. It soon became obvious that the helitorch was a viable tool for prescribed burning.[91]

Testing the use of the helitorch on wildland fires was the next phase in the process. Prior to the 1979 fire season, the Pacific Southwest Region established a committee of land and fire managers to develop testing and evaluation procedures on wildland fires in California. The committee recommended that two helitack crews be equipped with helitorches for use on wildland fires. Crews from the Mendocino and Cleveland National Forests were selected, partly because they had experience using the helitorch during spring burning, and partly based on their geography—the Mendocino is in northern California while the Cleveland National Forest is in southern California.[92]

The committee had placed several stipulations on the wildland fire testing. They required a trained fire boss with helitorch experience and a fire behavior officer for any helitorch testing on a wildfire. Additionally, a helitorch firing plan was required using predesignated, prescriptive environmental firing parameters.[93]

The first test was on the Nacimiento Fire on the Los Padres National Forest on September 4, 1979. The helitorch was subsequently used on six more wildfires in California in the fall of 1979, all with successful outcomes.[94] As the 1979 fire season drew to a close, a regional helitorch committee recommended that the helitorch be officially approved for operational use. The committee also recommended that a total of nine crews be equipped with helitorches in 1980. The Simplex Helitorch had arrived.

Above: A worker fills a Simplex Helitorch for testing. Left: Testing the Simplex Helitorch at the Missoula Equipment Development Center. Dates unknown. USDA Forest Service photos.

As the viability of aerial ignition became apparent, there was interest in finding other methods. The helitorch was effective, but it required a fairly extensive ground crew, and mixing the gasoline with the thickening agent was labor intensive. Prior to the batch mixer, all barrels had to be mixed by hand. This involved dumping alma-gel in each individual barrel, and then stirring each barrel by hand. A minimum of four people had to change each barrel—and once mixed, a barrel weighed around 400 pounds. The development of the batch mixer vastly improved the efficiency of the helitorch mission. It made the operation easier—larger quantities of liquid could be prepared, and barrels could be filled while in place on the helitorch by pumping the gas mixture from the batch mixer directly into the barrels.

The Southern Region of the Forest Service was one of the primary drivers behind adoption of the Premo Mark III aerial ignition device. The Missoula Equipment Development Center began initial safety testing of the device in the mid-1980s with results published in May of 1985.[95] The center worked with the Southern Region, who agreed to develop an Operational User's Guide prior to formal approval by the agency. The region completed the guide in February 1986, and an 8-hour training requirement was established for anyone wishing to use the device. [96] The Premo Mark III was added to the aerial ignition arsenal. Often referred to by different names, colloquial terms such as "ping pong ball machine" and "plastic sphere dispenser (PSD) machine" are synonymous with the Premo Mark III.

During this same time period, the Simplex Helitorch attachment system was redesigned. In August 1986 the Missoula Equipment Development Center issued an "Equip Tips" describing the retrofit in detail. Prior to the redesign, the attachment system included a spreader bar that rested on the skid in addition to the cargo hook attachment point. Engineers determined that the spreader bar placed "excessive load on the helicopter skid and could affect stability and control."[97] Engineers at the development center were successful in designing a single point attachment system that eliminated the spreader bar. The new attachment system proved to be superior to the original design and became the new standard for the Simplex Helitorch.

In terms of risk, there are differences between the helitorch mission and the dropping of plastic spheres. The slinging of a helitorch underneath a helicopter is considered an external load, and as a result (under normal circumstances) only the pilot can be onboard the aircraft. In addition, if needed, a helitorch can be jettisoned during flight. During a PSD mission, there can be up to three individuals aboard the helicopter: the pilot, the PSD machine operator, and an individual directing the firing operation. A PSD machine can be jettisoned, but it requires a "cut away" procedure and is more involved than jettisoning a helitorch. Either aerial ignition option requires the helicopter to fly in a "low and slow" mission profile, which is never optimal for a helicopter.

Since the inception of aerial ignition, the Forest Service has recognized the risk involved in the mission. With the implementation of the Safety Management Systems approach to risk management, the Forest Service completed a "Programmatic Risk Assessment and Quality Assurance Evaluation for Aerial Ignition Using the Plastic Sphere Dispenser" in 2010. Since then, two fatal accidents have occurred in the PSD mission. Two people were killed in Mississippi in March 2015, and one person was killed in Texas in March 2019. Practitioners continue to seek improvements in all aerial ignition systems.

Aerial ignition accounts for a substantial amount of annually treated acreage for the Forest Service. In fiscal year 2021, over 1.8 million acres were treated with prescribed fire; approximately 1.5 million of those acres (83 percent) were accomplished with the help of aerial ignition by helicopters.[98]

Interagency Aerial Ignition Unit

The National Wildfire Coordinating Group (NWCG) was established in 1976 to provide "a formalized system to agree upon standards of training, equipment, aircraft, suppression priorities, and other operational areas."[99]

As NWCG evolved over the decades—and as more specialty areas within wildland firefighting emerged—subcommittees were added. Aerial ignition systems are complex and require a great deal of scrutiny, and the need to actively manage this specialty mission has long been recognized by the Forest Service.

In the mid-2010s NWCG reorganized, and from that process the Interagency Aerial Ignition Unit was established. A subset of the Interagency Helicopter Operations Subcommittee, the unit reflects the current interagency organizational structure. It is responsible for providing interagency leadership for all aspects of aerial ignition, including stewardship of "NWCG Standards for Aerial Ignition" (PMS 501). PMS 501 includes a list of approved aerial ignition systems, as well as the process for new system approval.

Approved Devices

The list of approved devices has grown over the years. As of 2022, the following devices were approved in PMS 501 for interagency use. Approvals change over time, and practitioners should verify the approval status of any system with the most current version of PMS 501.

Plastic Sphere Dispenser (PSD)

- Premo Mark III Aerial Ignition Device
- SEI Red Dragon
- Aerostat PSDS Mark V (new purchases of Aerostat PSDS Mark V equipment are not authorized)
- Raindance R3 Aerial Incendiary Device
- Drone Amplified Ignis Version 2

Helitorches and Mix Systems

- Simplex Helitorch Model 5400 and Batch Mixer
- Fire Spec Systems: Spec 2000 Helitorch and Spec 2000 Modular Mix Transfer System (new purchases of Fire Spec equipment are not authorized)
- Isolair Helitorch
- Firecon Batchmixer and Portable Mix Transfer System (now GelFire Systems)
- Western Helicraft Helitorch (Barrel Helitorch)
- Northern (Canadian) Helitorch (Barrel Helitorch)
- T&T Helitorch (Barrel Helitorch) (new purchases of T&T equipment are not authorized)
- USDA Forest Service Helitorch M-2015

As technology evolves, the probability of an efficacious unmanned aerial ignition system seems inevitable—an advancement that could greatly reduce employee exposure and risk.

7.7.8. Rope-Assisted Deployment System (2003–2009)

In 2003 the Pacific Southwest Region became interested in evaluating a new system for the aerial delivery of helitack firefighters. The system was known as the rope-assisted deployment system (RADS), also referred to as "fast rope" or "fast roping." It consisted of an agency-approved rope attached to an FAA-approved anchor system installed in the helicopter. Firefighters would slide down the rope using established techniques to reach the ground safely and quickly.

The advantages of RADS were the low equipment and training costs (as compared to other aerial delivery systems) and the ability to deliver up to eight firefighters with a minimum amount of hover time, reducing employee exposure.

In March 2003 the Pacific Southwest Region made an official request to the Washington Office (WO) to evaluate the program. Approval was given, and the Big Hill Helitack Crew on the Eldorado National Forest was designated as the crew to implement RADS. Standard operating procedures were drafted in the fall of 2003, and in February 2004 the forest and region completed a job hazard analysis and risk assessment. Both were submitted to the WO for consideration. In July 2004 personnel from the Pacific Southwest Region and WO conducted a site visit to the Big Hill Helitack Base, culminating in a decision to designate RADS as operational for the crew.

Rope-assisted deployment systems, also known as fast roping, allow helicopters to quickly and safely deliver firefighters to remote locations. USDA Forest Service photos .

The first operational RADS occurred on July 24, 2004, in the Mokelumne Wilderness Area on the Eldorado National Forest. The program remained operational for 6 years from 2004 to 2009, until the rappel fatality in 2009 compelled the Forest Service to cease the program. During the 6 years that the crew was operational with RADS, the program was very successful, with over 200 operational and 1,200 proficiency slides with no serious injuries.

Rope-assisted deployment systems, also known as fast roping, allow helicopters to quickly and safely deliver firefighters to remote locations. USDA Forest Service photos .

7.7.9. Medical Extraction

The Forest Service has historically been responsible for medical extraction of injured or sick employees. Unlike some other Federal agencies, the Forest Service does not have a mandate to extract injured civilians from lands managed by the agency. Local sheriff departments or other jurisdictional organizations have that responsibility.

Remote medical extraction of injured individuals can be accomplished in a number of ways. Many organizations, including active military and select national guard units, are trained and equipped to perform hoisting missions. As the name implies, a helicopter is equipped with a hoist, and trained personnel that can hover over a victim lower a basket from the hoist and lift the injured person into the helicopter. The downside of hoisting is the extended amount of time a helicopter has to stay in a hover. Other extraction systems include some form of longlining injured personnel to more accessible areas.

For decades various organizational units within the Forest Service have had an interest in formalizing medical extraction techniques. In July 1988 the Wenatchee National Forest submitted a letter to the regional forester in the Pacific Northwest Region requesting approval to evaluate a "short-haul" technique for employee medical evacuation.[100] In the early 2000s several different extraction techniques were being explored, with instances of actual extractions using longlines and improvised techniques. The Billy Pugh Rescue Net was researched as a potential way to extract both injured and healthy personnel.

In the early 2000s, the Inyo National Forest performed two extractions using a longline. A fairly high-profile extraction occurred in 2011 when a National Park Service crew short-hauled an injured person off the Las Conchas Fire on the Santa Fe National Forest in New Mexico. The victim was severely injured and time was critical—using the short-haul technique enabled the injured employee to be successfully treated. Another high-profile extraction occurred in 2012 on the Pole Creek Fire in Oregon. A firefighter on the Deschutes National Forest was extracted from the fireline in a helicopter bucket as the fire front approached.[101]

Momentum was building in the mid-2000s to institute more formal extraction methods. In 2008 a group was convened in Boise, ID, to discuss ways to improve internal extraction capability. The group focused on an evacuation mission defined as "emergency human extraction by longline (EHELL)."[102] The general premise was that the risk of a ground extraction often exceeds the risk of a timelier air extraction. The group was included seven individuals with representation from all stakeholders, including the hotshot community—much of the momentum for these efforts was driven by ground firefighters.[103]

The meeting in 2008 generated a course of action for moving the process forward. The group defined the EHELL mission and divided it into three levels depending on available resources. It was agreed that EHELL should be used only in "life and death" situations, with victim transport time in the air limited to the shortest time possible.[104]

The three levels of EHELL were predicated on available resources. Level 1 was using outside resources trained in aerial medical extraction (i.e., military, NPS, etc.). Level 2 was using resources such as rappel or helitack crews trained and proficient in longline missions. Level 3 was using resources not normally equipped or trained for longline or EHELL. The decision was made to move forward with conducting a "qualified risk analysis and some type of decision document."[105]

During this same period, the Forest Service experienced a tragic wildland fire fatality. On July 25, 2008, an NPS employee assigned to the Eagle Fire on the Shasta-Trinity National Forest in California was struck by a tree during a felling operation. The firefighter was critically injured and eventually died. A timely medivac was not possible, delaying treatment that could have potentially saved the firefighter's life. This accident became known as the Dutch Creek Incident and highlighted the need for enhanced medical extraction capability. The resulting investigation yielded the "Dutch Creek protocols," which provided direction on deliberate planning for medical extraction.

The need for enhanced medical extraction capability was a continuing topic of discussion in the agency. On February 20, 2013, the Forest Service issued a decision memorandum to move forward with evaluating three options for aerial medical extraction. The three options were:

1. **Short-haul:** Develop a short-haul program similar to the NPS program or the program employed by Forest Service law enforcement using agency-owned equipment. This option would consider both type 2 and type 3 helicopters as platforms.
2. **Hoist:** Develop a hoist program using contractor-owned equipment. This option would require type 2 helicopters with a higher startup cost compared to option 1.
3. **Haul-line:** Using agency-owned equipment, develop an emergency helicopter extraction procedure using standard longlines and type 2 or type 3 helicopters. This option would have the lowest startup costs.[106]

All three options had pros and cons. After much internal debate, the Forest Service choose to institute a short-haul program.

Short-Haul

Helicopter short-haul techniques were developed by the U.S. Army Special Forces in the 1960s. Other countries such as Switzerland also developed air rescue techniques that would be considered short-haul today. In the 1980s various law enforcement agencies took an interest in short-haul for tactical missions beyond search and rescue.

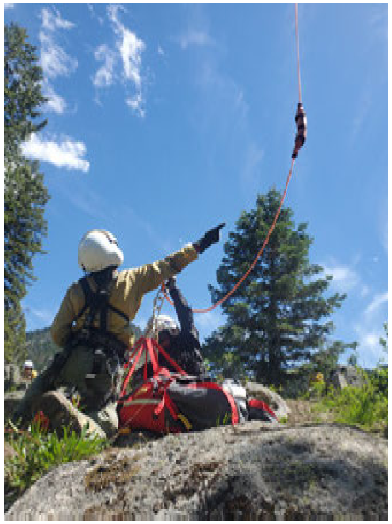
The National Park Service (NPS) did their first short-haul operations in 1981 at Grand Teton National Park; the official start of the program came the following year at Yosemite National Park. By the early 1990s, NPS had a handbook and operations guide for short-haul. The NPS interest was twofold, for medivac and law enforcement. The Bureau of Land Management was also interested in exploring medivac and search and rescue capability.

In 2002, the Pacific Southwest Region of the Forest Service approved a regional short-haul program to support the Campaign Against Marijuana Planting (CAMP). In 2012, the region's law enforcement short-haul program became nationally sanctioned with the approval of the "National Law Enforcement and Investigations (LEI) Short-Haul and Hoist (S-H/H) Guide" by Washington Office Fire and Aviation Management. The program proved very successful, with over 13,000 short-hauls by 2013.[107]

Once the decision was made in 2014 to move forward with short-haul for medical extraction, the Forest Service chartered the National Emergency Medical Short-Haul Working Team. Comprised of personnel with a variety of backgrounds, including aviation, risk management, and medical care, the team created a subgroup of operational practitioners to review and evaluate all facets of a short-haul operation. This subgroup became the National Short-Haul Operations Subcommittee (NSHOS), officially chartered on March 6, 2014. Implementation of short-haul had begun.[108]

The primary mission of NSHOS was "to establish a formal process for review and evaluation of current and proposed helicopter short-haul equipment, training, operating procedures, and standardization for the Forest Service." They began their evaluation by visiting several national parks that had established medical short-haul programs, including Grand Canyon, Mount Rainier, Yellowstone, Zion, Yosemite, and Grand Teton National Parks.

NPS was committed to helping the Forest Service establish short-haul capability to ensure that both agency programs would be standardized—especially important for a specialty mission like short-haul. It is not uncommon for helicopter vendors to have concurrent contracts at different bases, often with multiple agencies or departments. Some vendors routinely rotate relief pilots through multiple bases—it's a virtual certainty that in any given field season pilots fly at different locations. Identical programs were a must—if an emergency situation during short-haul occurred, the response needed to be the same regardless of location or base affiliation.



Left: Short-haul extraction on the Las Conchas Fire on the Santa Fe National Forest in New Mexico in 2011. Right: Short-haul hand signal. USDA Forest Service photos.

NSHOS began to establish parameters for short-haul and decided that high-performance type 3 helicopters would be used. The Forest Service already had a number of these platforms on exclusive-use contract, so it made sense to designate some of these crews for medical extraction. Consideration was given to adding short-haul to the rappel crews, but it made more sense to keep the two missions separate, if for no other reason than to manage workloads. There was also a concern that cross-training rappellers and short-haulers would increase the likelihood of a procedure-related mistake.

Other organizational decisions were established as well. It was decided that the crew size would be 7–10 employees, with 3–5 trained and qualified as emergency medical technicians (EMTs). Although the remaining crew members would not be required to have medical qualifications, at least one EMT would be assigned to any operational short-haul mission.

The Forest Service implemented operational short-haul in 2015 at two bases: one in Wenatchee, WA, and another in Jackson Hole, WY. Over the next several years three more crews were added bringing the total to five operational short-haul crews. Locations of Forest Service short-haul crews (as of 2015) are:[109]

- Krassel Helitack, Payette National Forest, central Idaho
- Teton Interagency Helitack, Bridger-Teton National Forest, northwest Wyoming
- Wenatchee Helitack, Wenatchee National Forest, central Washington
- Tucson Helitack, Coronado National Forest, southern Arizona
- Central Montana Helitack, Helena National Forest, central Montana

Hoisting

As previously mentioned, hoisting was one of the three alternatives considered by the Forest Service for internal medical extraction capability. Many organizations successfully execute the hoist mission, but it requires a great deal of organizational commitment. As a general statement, larger helicopters are used for hoisting due to their increased performance. With any hoist, the consideration of its weight must be factored in. Many hoists weigh over 150 pounds. Installing a hoist reduces the allowable payload of a helicopter by however much the hoist weighs. In lower performing type 3 helicopters, losing allowable payload is not desirable.

The Forest Service does periodically use assets with hoisting capability. Usually, these assets are National Guard helicopters with a guard unit specializing in search and rescue. Many geographic areas have agreements in place that allow activation of these units during periods of high activity. Often, the Forest Service will seek to strategically place extraction assets when there are large numbers of employees working in remote areas, such as during major wildland fire activity.

7.8. Night Vision Flying Technology

7.8.1. Initial Testing (1960s)

In the early 1960s the Forest Service became interested in exploring night vision technology and its potential benefits for wildland firefighting. The hypothesis was that night operations could be advantageous in reducing fire rate of spread and intensity, allowing aircraft to take advantage of cooler temperatures and lower density altitudes and reducing competition for airspace over a fire.[110]

In 1963 the Forest Service began a concerted effort to determine the feasibility of night helicopter operations. The Missoula Equipment Development Center led the effort and began studying military use of helicopters at night. It was determined that nearly all military helicopter night operations used large helicopters equipped with large, expensive navigational systems. The use of similar helicopters and systems was not feasible in the Forest Service, so other commercially available options were sought. By 1964 several pieces of equipment were being tested, and by 1965 tentative general requirements and guidelines were developed for night operations.[111]

The guidelines focused on pilot qualifications and training, helicopter requirements, helispot construction standards, flight routes and emergency landing zones, visibility, and terrain. Additionally, the Pacific Southwest Forest and Range Experiment Station studied physiological phenomenon that affect humans using night vision technology such as motion vertigo and autokinesis (apparent but false movement of a light).[112]

By 1966 the Forest Service completed their study at the Missoula Equipment Development Center, and it was determined that "while flying is more hazardous at night, results of these studies indicate that night flying can be done safely under favorable environmental conditions by using well-trained and qualified personnel, special guidance equipment, and careful planning."[113] However, the report went on to say that more analysis was needed before night helicopter flying would be approved for use.

7.8.2. Testing and Early Program Development (1970s to 1983)

In April 1972 the Forest Service and California Department of Forestry (CDF) met in Sacramento to discuss electronic support systems for flying at night. In particular, both organizations were interested in evaluating a new system used by the military. The system was known as Iroquois night fighter and night tracker (INFANT). The meeting participants wanted to compare the new INFANT system with three other known systems: the Fire Scan fixed-wing-mounted unit; the forward-looking infrared (FLIR) helicopter-mounted unit; and Mohawk, another fixed-wing-mounted unit.[114]

INFANT, developed by Hughes Aircraft Company, was a new technology referred to as a "night vision" or light-gathering, image-intensification electronic system. The unit weighed 445 pounds when fully installed and mounted to the nose of an aircraft. The external part of the system had two periscope-type scanners, which could be operated either separately or in tandem and both rotated horizontally and vertically. The outside unit connected to eye pieces and a television screen inside the aircraft for tracking and navigation. Since it was a light-gathering "intensification" system, it was unable to penetrate smoke or clouds, a major disadvantage in the wildland fire environment.[115]

The Fire Scan system was a Forest Service infrared unit mounted on fixed-wing aircraft. Because it was an infrared system, it had the ability to penetrate smoke, but not clouds or fog. The imagery had to be reproduced on film then manually delivered to the end user.

A U.S. Army UH-1M with a Hughes INFANT system installed. U.S. Army photo.

A more advanced system than the Fire Scan, the Mohawk was a military fixed-wing aircraft equipped with infrared sensing equipment that was made available to select civilian organizations. The Mohawk's biggest advantage was the ability to transmit imagery to video receivers on the ground.

The agencies evaluated the night vision systems using 11 criteria. The INFANT system proved equal or superior in most categories; however, in the presence of smoke, the system rated poor or fair at best. There were enough positives with the INFANT system that the group recommended continued exploration of all night vision imaging systems for further testing.

As the testing progressed, various agency personnel raised concerns. If night operations reduced daytime use of a helicopter, fire personnel were not supportive. If a helicopter couldn't be used in the day so that it could be used at night (due to pilot duty limitations, etc.) then the preference was clear: daytime operations. Other concerns included the additional training required for night operations, insufficient staffing for night operations, and some pilots being reluctant to fly at night. Some of these concerns would eventually contribute to discontinuation of the program in the 1980s.

By the fall of 1972 a preliminary steering committee had been established, and the group began to develop a study plan for helicopter firefighting at night. Some preliminary testing was completed as the plan was developed, with 117 night flights occurring in southern California's mountainous terrain. The steering committee developed the plan with some severe fire seasons as a backdrop—in 1964 a fire occurred in Santa Barbara that destroyed 100 homes and cost $20 million, and 1970 was an extreme fire season in California and Washington.

The initial objectives of the plan were twofold: (1) demonstrate and test night navigational aids such as INFANT and FLIR systems and (2) develop guidelines and techniques for integrating medium and large helicopters for night flying into conventional fire organizations.

The plan objectives were to determine or evaluate the following:

1. Applicability of both INFANT and FLIR systems for night operations under variable weather and smoke conditions
2. Use limitations
3. Pilot acceptance of night flying risks
4. Auto-rotation limitations, if any, in night operations
5. Optimal cargo delivery methods (e.g., landing, free-fall, or heli-chute)
6. Feasibility of retardant and suppressant delivery with the aid of ground markers or lights, without the aid of ground markers, and/or with ground voice direction
7. Potential to perform night reconnaissance for mapping and remote sensing
8. Feasibility of other firefighting tasks such as laying hose, backfiring, and equipment resupply
9. Any other potential effects generated by night air operation activities

As a final objective, the group was also interested in evaluating the costs associated with a 24-hour helicopter operation.

The stage was set for the beginning of a structured testing process. The next step was to acquire an INFANT system for evaluation. The Forest Service placed a formal request with the commanding general of the Army Materiel Command headquarters for the loan of an INFANT surveillance system. The request was for a year-long loan, with the possibility of extending it to 3 years. The system included one AN/AS 132 image intensification system and one UH-1M Iroquois helicopter.

Surprisingly, the request was denied. Correspondence from that time indicates that the executive director of Helicopter Association of America (HAA) had influenced the Army to deny the request. This denial came despite the approval of the cooperative night firefighting project by the HAA Forest Committee. The HAA denial stemmed from a group of helicopter vendors who feared the helicopter loan would spawn a Forest Service fleet of helicopters. They also expressed concerns regarding helicopter maintenance and piloting duties.

A series of conversations and negotiations ensued. The HAA board of directors remained adamant in their opposition to the military equipment "whenever the application of such equipment represents possible interference with private enterprise." In the Army's denial statement, they wrote, "We shall be happy to sit down and attempt to work out a way to cooperate with . . . the U.S. Forest Service, as long as the vehicle which carries the test equipment be contracted from private industry."[116]

The impasse was eventually resolved with the compromise of evaluating the Army's INFANT system with the stipulation that the aircraft be supplied by a commercial vendor. A UH-1M helicopter was acquired from a commercial vendor, and the INFANT system was loaned to the Forest Service for a 7-month period from May through November in 1973, with the option of a 1-year extension as long as commercial vendors were used to acquire the helicopter.

By January 1973 the night helicopter test group had developed a list of seven missions they believed warranted testing for night operations:

1. Visual reconnaissance with medium helicopters
2. Infrared mapping with medium helicopters
3. Transportation of fire management personnel with medium helicopters
4. Burnout operations with medium helicopters using aerial ignition devices
5. Emergency rescue missions with medium helicopters
6. Transportation of personnel and supplies using medium and large helicopters
7. Retardant dropping with medium and large helicopters

In February of that year Deputy Chief Arnold gave the approval to proceed with the test project for helicopter firefighting at night . A steering committee was formally established, with an initial allocation of $350,000 for the project. Funding was provided by three Forest Service offices (San Dimas Technology and Development Center, Rocky Mountain Research Station, and Pacific Southwest Research Station) and four external organizations (California Department of Forestry, Los Angeles County Fire Department, Aerospace Corporation, and Oregon Department of Forestry).

The steering committee convened their first meeting in March 1973 and began developing a list of preliminary tasks such as gathering data and making initial contact with industry experts. The committee also developed a three-phase approach for determining the efficacy of night operations:

PHASE 1

Early 1973

- Equipment selection
- Training and test equipment
- Demonstration
- Fire operation (bailed aircraft, agency pilots)

PHASE 2

Mid 1973 to end of 1974

- Engineering modifications
- Policy and "tactics" development
- Contractor training
- Fire operation (bailed aircraft, agency pilots)

PHASE 3

Mid 1975

- Operationlly proven equipment
- Establish policy and tactics
- Operations implemented (contractor-piloted aircraft)

As the committee was working through the inventory process of available night vision technology, they were introduced to the military's AN/PVS-5 night vision goggles. Primarily a night vision system for ground personnel, these googles were being used by Army aviators with very favorable reviews. The system was immediately added to the list of systems to be evaluated.

The committee met again in August 1973, with the purpose of developing future plans for potential implementation of night operation systems by fiscal year 1974. A course of action was soon devised that included securing two UH-1M Iroquois helicopters from the States of Virginia and New Jersey. The initial plan was to fly one helicopter to Corpus Christi, TX, so an INFANT system could be installed, and fly the other helicopter to California to be fitted with a FLIR system. Once the systems were installed, the helicopters were to be repositioned to the Yuma Proving Ground for 2 weeks of training six pilots. These pilots became the foundation of the testing program and received training in the night vision goggles, FLIR, and INFANT systems.

During another meeting to review FLIR and INFANT imagery, the committee was able to experience night vision technology firsthand. After the meeting, committee members participated in a demonstration flight in the dark into Big Dalton Canyon (Los Angeles County) with a helicopter and pilots from Los Angeles County. The pilots used night vision goggles to land in the dark canyon. The committee members were duly impressed and came away from the flight with the realization that goggles could play a major role in helicopter night operations.[117]

The committee made steady progress throughout the testing period. Between October 1972 and February 1974, the project had progressed from developing a study plan to full implementation of a training program using two UH-1M helicopters and acquisition of two pairs of night vision goggles. Unfortunately, during installation of the INFANT system, it was discovered that the helicopter needed major repairs. As a result, the Forest Service did not receive the aircraft until April 1974. However, the testing could continue with the helicopter that had been fitted with the FLIR unit.

Extensive testing of both the FLIR and INFANT systems was accomplished during the 1974 fire season. The committee was very interested in determining the "operating envelope" for the two systems. Extensive imagery was recorded from both day and night flights throughout the fire season, and the committee was able to document issues encountered while working in a wildland fire environment.

Timeline of Night Operations Steering Committee Activities (1973–1975)[118]

October 1973

Huey (UH-1M) helicopter obtained on load from U.S. Army.

February 23, 1974

First night viewing of wildfire with night vision goggles on Angeles National Forest.

March 1974

Committee conducts experimental flying in Arizona and trains two pilots (Forest Service and BLM)

June 16, 1974

First water drops made at night on the Rock Fire by Los Angeles County pilots.

Spring 1974

FLIR system in Army helicopter provides information on fire spread and demostrates navigational potential at night and under smoky conditions.

Spring 1974

Demonstration of potential for portable instrument landing system and IR light under nocturnal conditions.

July 1, 1974

Pilots from Western Helicopters, Inc. assume responsibility for conducting tests with Army helicopter.

August 28–29, 1974

Successful night fire suppression on Soboba Fire by Los Angeles County pilots (50 drops, 16,000 total gallons).

October 1974

3,600-mile tour of the Western United States in Army helicopter to demonstrate night navigational capability with night vision goggles and FLIR.

Winter 1974

Two night rescues made in San Gabriel Mountains by Los Angeles County pilots.

April 1975

UH-1M helicopter returned to Sacramento Army Depot after 150 hours of useful flight time.

June 1975

Lightweight FLIR system delivered to Forest Service and installed in Los Angeles County 204-B helicopter for operational testing; training syllabus developed.

As 1975 approached, the evaluation period and funding for the INFANT system was expiring. Although the committee was unanimously impressed with the night vision goggles, the decision was made to end the study and return the aircraft and INFANT system to the Army. By the summer of 1975, much data had been amassed about night vision technology. Agency personnel began to translate the research and development data into operational and instructional plans. The research and development stage of the project had yielded clear results, with five systems emerging as the front runners for further consideration. These five systems were:

- Starlight scope
- INFANT (Iroquois night fighter and night tracker)
- FLIR (forward-looking infrared)
- Night vision goggles
- TALAR (a portable instrument landing system)

By November 1975 the committee established an operational implementation plan for moving forward with a three-part package, including night vision goggles, a FLIR unit, and a TALAR landing system. They concurrently developed personnel training and qualification guidelines for both pilots and agency personnel and established equipment guidelines, helispot standards, and operational requirements.

The night vision system became operational in 1976; however, very few actual missions were flown. Two programs were established, one by the Los Angeles County Fire Department and one by the Forest Service with aircraft stationed at Rose Valley in California. Through the course of the summer, the Los Angeles County aircraft did not perform any night helicopter operations, and the Rose Valley helicopter flew four missions—two each on the Sequoia and Los Padres National Forests. Although these missions totaled only 7.1 hours of flight time and delivery of 2,100 gallons of water, the committee still deemed them a success. The recommendation was made to add an additional night operations helicopter if funding allowed.

By the 1977 field season, both Los Angeles County and the Forest Service were actively flying operational night missions. Unfortunately, on the night of July 24, tragedy struck when a midair collision occurred on the Middle Fire on the Angeles National Forest.[119] The Forest Service and Los Angeles County helicopters were operating out of the same helibase. The collision occurred as both aircraft were approaching the helibase for landing, resulting in the death of the Los Angeles County pilot. This accident had a significant impact on the program—Los Angeles County withdrew from the program and the Forest Service did a major reevaluation of the program, including authority, policies, and operational procedures.

After the accident, the steering committee and San Dimas Equipment Development Center reevaluated and developed a more detailed “Helicopter Night Flying Operations Policy” which became effective in November 1977. The policy became more stringent. A go/no-go checklist was developed that had to be personally signed by the fire boss or his/her deputy prior to each mission.

During this same time the region and steering committee decided to transfer all night operations equipment from San Dimas Equipment Development Center to the South Zone Air Unit in California. During the 1978 fire season, two Pacific Southwest helitack crews had night vision approval, the helicopter at Rose Valley and another assigned to Chantry Flats. The steering committee continued to gather operational data from the crews, and as the 1979 fire season approached, 10 policy and procedure recommendations were made to the regional forester. One of the recommendations was to dissolve the steering committee with the South Zone Air Unit inheriting responsibility for the program.

As the 1980s approached and the steering committee was dissolved, the night operations program continued successfully. That year the region had two night operation helitack crews, both using Bell 212 helicopters. By this time the region had acquired 12 night vision goggles and was able to loan 3 to Los Angeles County. During the fire season, the 2 aircraft flew on 13 fires accounting for 86 flight hours and dropped a total of 125,000 gallons of water. No accident or incidents occurred, and the consensus was that the future of night operations looked promising.

An extensive night flying helicopter training program was developed in 1982 that included both classroom and field instruction. The 2-day training was targeted at night air attack supervisors, night helibase managers, and other personnel associated with night operations.

Perhaps one of the biggest refinements in night vision equipment occurred when Rob Harrison from San Dimas Equipment Development Center modified night vision goggles so the visor could be flipped up and out of the way when not needed. Several pilots tested the flip-up feature, all of whom agreed it was a superior system.

In 1983 another team was assembled to evaluate night helitorch operations. In September of that year the team assembled at the Garden Valley Helibase in Idaho to refine helitorch procedures. Specifically, they were evaluating aircraft-mounted lights, attempting to determine the cause of excessive torch oscillation, assessing helibase lighting needs for ground support crews, evaluating transition challenges between dark and lighted areas, and further evaluating the Penny NVIS flip-up goggles. Several recommendations were made to improve helitorch procedures, one being to convert all goggles owned by the Forest Service to the flip-up modification.

7.8.3. The Mid-1980s to 2021

Despite the successful testing and operational use of a night operations program for 8 years (1976–1983), the operational portion of the program ended in 1983 due to limited use and program cost.[120] Some limited nonoperational testing continued until 1985. The work accomplished and knowledge gained by employees associated with night operations would turn out to be the foundational groundwork for future endeavors by the Forest Service.

Helicopter night operations in the Forest Service were not an agency priority and thus inactive from the last half of the 1980s through the 2000s. In 2001, Los Angeles County reinstated their helicopter night flying program using night vision goggles and resumed night fire operations in 2005. By 2009 the cities of San Diego and Los Angeles and the four surrounding counties would collectively have approximately 17 helicopters capable of night operations. [121]

In August of 2009, fatalities of two Los Angeles County firefighters occurred on the Station Fire in southern California, and the agency was heavily criticized for its lack of night flying aircraft capacity (see chapter 3.3.7).

The Station Fire rekindled interest in helicopter night operations. In 2010 the National Night Air Operations Steering Committee was formed. In conjunction with contracted consultants, the committee developed a "Helicopter Night Operations Study." The study included a programmatic risk assessment and quality assurance components to inform findings and recommendations. The final report was issued in August 2010 and included eight recommendations. Using information in the study, in 2012 the Chief of the Forest Service approved a night helicopter program limited to one helicopter for the mission of water delivery with specific operational criteria.

Beginning in 2013, the Forest Service implemented night operations in southern California. The Forest Service contracted for one night flying helicopter stationed on the Angeles National Forest. The helicopter was staffed with a seven-person crew and was designated as Helicopter 531 (H-531). In 2018 an additional Bell 205A-1 was added to the crew to augment daytime operations, allowing for greater flexibility for both the day and night crews. Since its inception, H-531 has responded to over 158 wildland fires, flying both with and without night vision technology.[122]

By 2017 the Forest Service had developed and approved a "National Night Air Operations Plan" that applied to both rotor- and fixed-wing operations.

7.9. FireWatch

One of the specialty aviation missions in support of wildland fire operations is aerial supervision/command and control of airspace and resources. Since the 1990s many practitioners executing these missions recognized that opportunities existed to leverage rapid advances in technology to enhance aerial supervision capacity over wildland fires. Many individual efforts occurred in various regions, but the Forest Service was interested in sponsoring a more unified approach in researching ways to improve mission capabilities.

In 2002 the Forest Service acquired 25 Bell AH-1 Cobra helicopters from the Army excess property program. The acquisition was pursued to have access to helicopter platforms that could be modified or reconfigured easily within the purview of the Forest Service. The agency used the Cobras to establish a demonstration project to study emerging technologies that could improve the efficiency of incident air operations. This project was called FireWatch.

FireWatch Bell AH-1 Cobra helicopter. USDA Forest Service photo.

The intent of the project was to evaluate the Cobra with advanced technological capability in three mission profiles:

- Aerial supervision module/leadplane.
- Air attack (airborne command and control over fires).
- Geo-referenced, infrared video mapping of wildland fires with real-time downlink.

As more and more of the Forest Service budget was shifting to the fire and aviation program, the agency was exploring ways to achieve significant cost reductions in large fire expenditures. Additionally, the emerging technologies showed real promise for enhanced firefighter and public safety, especially with a real-time downlink of data to the incident.

The scope of technologies that the demonstration project evaluated included a ground module receiver vehicle crewed by experienced firefighting and incident command personnel. The ground vehicle was equipped with state-of-the-art multispectral imaging systems and communications equipment.

Although the Forest Service acquired 25 platforms, the intent was never to have a fleet of helicopters. One prototype helicopter was initially modified with the technology package, with the option to modify more platforms only if needed for evaluation. Questions were raised as to why this evaluation couldn't be performed using helicopters acquired in the private sector. The answer was that based on the potential need to routinely modify the helicopter and technology package, it would not be economically or operationally feasible to modify contracted helicopters in a timely fashion. In the original transfer agreement between the Forest Service and Army, the agreement was that after completion of the evaluation the Forest Service would either destroy or return to the Army any remaining helicopter platforms.

As the demonstration project matured, the Forest Service equipped and evaluated two Cobra platforms, N107Z and N109Z. The demonstration project remained viable from 2002 to 2021. As the project aged, the lifespan of the Cobras became a reality. Both airframes were reaching the end of their service life—N109Z was manufactured in 1969 and N107Z in 1983. Over their 19 years of service, both platforms reached their maximum lifespan, logging approximately 7,600 flight hours during the Cobra program. The last FireWatch flight occurred on October 16, 2021.

The Cobra demonstration project had been a success and helped inform the agency on optimal strategies for the future. The agency is transitioning to a modern era of aerial supervision using state-of-the-art technology in helicopters and fixed-wing aircraft. The future will most likely include unmanned aircraft system (UAS) platforms in this mission profile as well.

7.10. Partnerships

Since the inception of helicopter use in the Forest Service, the agency has partnered with many organizations for both program development and mission accomplishment. In the 1940s the agency did initial testing with the Army. In the 1950s Operation FIRESTOP in California was a conglomeration of many State and Federal entities.

With the adoption of the Interagency Helicopter Operations Guide (IHOG) by most Federal wildland fire agencies in 1994, helicopter policies and procedures became standardized. This provided helicopter users a common set of operating rules, reducing or eliminating operational impediments across Federal and State agencies.

In the modern era, interagency helicopter crews are well established. For example, the Bridger-Teton National Forest and Grand Teton National Park have an interagency crew with two AS-350 B3 AStar helicopters, with both Forest Service and National Park Service employees certified for the short-haul mission.

7.11. Federal Excess Personal Property Helicopters

The Forest Service acquires excess military helicopters for several States using the Federal Excess Personal Property (FEPP) Program (see chapter 3.1.3). Under the law, the Forest Service retains ownership of the aircraft.

As of 2022, eight States are using the FEPP authority to acquire helicopters for wildland firefighting: California, Florida, Maine, Montana, North Carolina, New Jersey, Nevada, and Washington.[123]

7.12. Helicopter Makes and Models

Table 7.4 summarizes the makes and models of helicopters used by the Forest Service. Sometimes there are many versions of a model within each make; these are grouped where possible. For example, there are six different models listed in the Conklin and de Decker list for the AStar (AS-350B, AS-350BA, AS-350, AS-350B1, AS-350B2, AS-350B3, and AS-350D). These were combined in a single entry, with the number of variants noted.

It is difficult to determine exactly when the Forest Service first started using many makes of helicopters. In this case, the date they came into service is used. Some of the dates are estimated.

Helicopter manufacturers are often acquired by other companies. For example, Aerospatiale became American Eurocopter, which became Airbus. Table 7.4 shows the name that was used at the time.

7.13. Helicopters Contracted by Year and Type

Most of the data in table 7.5 is from national aviation or helicopter use annual reports. Possible sources for missing data include Forest Service contracting records

Table 7.4. Helicopter makes and models

First use (year)	Last use (year)	Make	Model(s)	Owned	Contracted	Military	Type	Comments
1945		Sikorsky	R-5A, R-5D			✓	3	8 variants, all piston engines, no longer used; military aircraft
1947		Bell	47		✓		3	16 variants, all piston engines, no longer used
1949	1967	Piasecki	H-21			✓	1	17 variants, all piston engines, no longer used; military aircraft
1953	Early 1970s	Kaman	H-43A		✓		2	22 variants, piston and turbine powered; fleet retired
1954	1969	Sikorsky	S-55			✓	2	7 variants, all piston engines, no longer used; mostly military aircraft
1954	Late 1960s	Hiller	12	✓	✓		3	13 military variants, 11 civilian variants, piston powered, no longer used; the Forest Service once owned a Hiller 12E-4
1958	1975	Aerospatiale	SA 318 Allouette II		✓		3	8 variants, turbine powered, no longer used
1960		Aerospatiale	SA 316/319 Allouette III				3	5 variants, turbine powered
1958	1970	Sikorsky	S-58		✓		2	40 variants, piston powered, no longer used
1958		Boeing	Vertol 107-II		✓		1	20 variants, turbine powered
1959		Bell	UH-1		✓	✓		Over 20 variants, first aircraft in the Huey series of Bell medium helicopters
1961		Sikorsky	S-61		✓		1	6 variants, turbine powered
1962		Bell	234		✓		1	6 civilian variants, turbine powered
1962		Sikorsky	CH-54 Tarhe		✓	✓	1	
1964	1998	Bell	204-B		✓		2	Lost FAA Standard Category certification in late 1998 due to comingled aircraft parts
Mid 1960s		Bell	205		✓		2	4 variants, turbine powered; replaced by Bell 212 for rappel mission in 1975
1967	2021	Bell	AH-1 Cobra	✓		✓	1	15 variants, turbine powered; military aircraft
1967		Hughes	500		✓		3	11 variants, turbine powered

Table 7.4. Helicopter makes and models (cont.)

First use (year)	Last use (year)	Make	Model(s)	Owned	Contracted	Military	Type	Comments
1967		Hiller	FH-1100		✓		3	5 variants, turbine powered
1967		Bell	206 Jet Ranger	✓	✓		3	9 variants, turbine powered
1969		Bell	212		✓		2	5 variants, turbine powered
1970		Messesschmitt-Bolkow-Blohm (MBB)	BO 105		✓		3	29 variants, turbine powered; first light twin-engine helicopter ever produced
1971		Sikorsky	S-58T		✓		2	7 variants, turbine powered
1971		Aerospatiale	SA 315B Lama		✓		3	4 variants, turbine powered
1972		Bell	214		✓		2	4 variants, turbine powered
1973		American Eurocopter	SA 341 Gazelle		✓		3	16 variants, turbine powered
1975		American Eurocopter	AS-350 AStar		✓		3	17 variants, turbined powered
1975		Bell	206L Long Ranger		✓		3	7 variants, including the Twin Ranger, turbine powered
1978		Aerospatiale	SA 330 Puma		✓		1	Turbine powered
1978		American Eurocopter	AS 365 Dauphin		✓		1	12 variants, turbine powered
1979		American Eurocopter	AS 355 Twin Star		✓		3	11 variants, turbine powered
1979		Bell	222		✓		2	9 variants, turbine powered
1979		Sikorsky	S-70 Blackhawk		✓		2	7 variants, turbine powered
1980		American Eurocopter	AS 332 Super Puma		✓		1	15 variants, turbine powered
1981		Bell	412		✓		2	15 variants, turbine powered
1982		MBB/Kawasaki	BK 117		✓		2	13 variants, turbine powered

Table 7.4. Helicopter makes and models (cont.)

First use (year)	Last use (year)	Make	Model(s)	Owned	Contracted	Military	Type	Comments
1990s		Sikorsky	S-64 Skycrane		✓		1	Erickson Aircrane acquired the type certificate to develop this aircraft from the CH-54 in 1992
1994		MD Helicopters	MD 600N		✓		3	Turbine powered
1996		Bell	407		✓		3	10 variants, turbine powered
1996		American Eurocopter	EC 135		✓		3	12 variants, turbine powered
1998		American Eurocopter	EC 120		✓		3	2 variants, turbine powered
1999		AgustaWestland	EH 101		✓		2	37 variants, turbine powered
1999		American Eurocopter	EC 155		✓		2	5 variants, turbine powered
1999		Kaman	K-Max		✓		1	Turbine powered
2000		AgustaWestland	AW 119 Koala		✓		3	2 variants, turbine powered
2000		American Eurocopter	EC 225 Super Puma		✓		1	4 variants, turbine powered
2001		American Eurocopter	EC 130		✓		3	3 variants, turbine powered
2002		American Eurocopter	EC 145		✓		3	6 variants, turbine powered
2003		AgustaWestland	AW 139		✓		2	11 variants, turbine powered
2005		Bell	210		✓		2	Turbine powered

Sources: Conklin and de Decker list.

Table 7.5. Helicopters contracted by year and type

Year(s)	Type 1 (Heavy)		Type 2 (Medium)		Type 3 (Light)		Comments
	EU	CWN	EU	CWN	EU	CWN	
1947						2	First use; minimal information found
1948–1956							No information found
1957					1		Minimal information found
1958–1998							No information found
1999		64		119		223	No information found for EU
2000							No information found; 68 EU crews
2001							No information found
2002		93		147			No information found for EU or type 3 CWN
2003	7		24		61		No information found for EU
2004	7		29		57		No information found for EU
2005	16	111	31	114	58		No information found for type 3 CWN
2006	18	113	32	128	59		No information found for type 3 CWN
2007	35	114	31	123	63		No information found for type 3 CWN
2008	28	114	33	123	60		No information found for type 3 CWN

Table 7.5. Helicopters contracted by year and type (cont.)

Year(s)	Type 1 (Heavy)		Type 2 (Medium)		Type 3 (Light)		Comments
	EU	CWN	EU	CWN	EU	CWN	
2009	29		32		65		No information found for CWN
2010	26		39		63		No information found for CWN
2011							No information found
2012	34		33		59		Of 59 type 3 helicopters, 10 contracted specifically for prescribed fire services in the Southern Region but were also available for fire suppression assignments; no information found for CWN
2013							No information found
2014	34	85	33	100	29	94	One type 2 EU helicopters was night flying
2015	34	121	33	112	29	107	One type 2 EU helicopters was night flying
2016	34	18	34	40	45	150	One type 2 EU helicopters was night flying
2017	28	34	33	22	56	102	One type 2 EU helicopters was night flying
2018	28	34	34	22	53	95	Two type 2 EU helicopters were night flying
2019	28	34	34	22	40	87	
2020	28	185	34	91	40	80	
2021	48						Minimal information found

CWN = call-when-needed; EU = exclusive-use

Notes: Exclusive-use (EU) and call-when-needed (CWN) or comparable contract type. Type 4 helicopters are included in the "Light" column and noted in "Comments." Sources include Forest Service annual aviation program reports (2012–2020) and national exclusive-use helicopter operations reports (2000, 2003, and 2004).

Sikorsky S58E (Pirate Airlift Construction Helicopters). USDA Forest Service photo.

Last slideshow photo from the Chelan/Wenatchee Rappellers Reunion 1973–2003. Originally designed to operate in the Himalayas, the superior altitude performance of the Aerospatiale SA 315B Lama made it one of the most successful and beloved helicopters in the USDA Forest Service firefighting arsenal. In 1972 an Aerospatiale test pilot flew a Lama to 40,820 feet absolute altitude, a record for its class of helicopter. After reaching this great height, the engine "flamed out," but the pilot was able to bring it to a landing, setting another record for highest altitude autorotation. The Lama was eventually phased out by the advent of the American Eurocopter AStar.[124] Photo courtesy of Terry "Tar" Lesmeister (date unknown).

Firefighters leaving for the fireline in August 1928 on the San Bernardino National Forest, CA. Technological advancements in the nearly 100 years since this photo was taken help ensure that firefighters on the ground have the information they need for safe and successful operations. Aerial infrared mapping is one of these many advancements. Forest History Society photo.

CHAPTER 8

AERIAL INFRARED DETECTION AND MAPPING

8.1. Significant Events

1962—Forest Service begins research on the use of infrared (IR) systems for fire detection and mapping in "Project Fire Scan" at the Intermountain Forest and Range Experiment Station, Northern Fire Laboratory in Missoula, MT.

1964—First operational use of IR by the Forest Service. IR imagery is dropped from a Twin Beechcraft AT-11 to a fire camp on the Union Ranger District, Wallowa-Whitman National Forest.

1966—With research a success, effective IR coverage now available to high-priority fires as an operational tool.

1966—Operations base for IR mapping unit established in Boise, ID.

1975—First telemetry of IR imagery from a Beechcraft King Air, N104Z, to fire camp, Prospect Fire, Angeles National Forest, Pacific Southwest Region.

1976—Forest Service and Communications Satellite Corporation (Comsat) laboratories demonstrate remote-site satellite communication.

1979—First hand-held IR system used by the Forest Service.

1980s—Fire Logistics Airborne Mapping Equipment (FLAME) IR system acquired (hard copy printable deliverable product).

1992—Firefly IR system acquired (hard copy printable deliverable product).

1996—Firefly IR system begins to deliver digital imagery.

2000—FLAME IR system begins to deliver digital imagery; digital imagery becoming standard for IR program.

2003—FireWatch program begins; Cobra helicopters equipped with electro-optical (EO) and IR sensors.

2003—Phoenix IR System acquired.

2003—The name National Infrared Operations (NIROPS) adopted.

2005—IR aircraft and pilots reassigned to Intermountain Region in Ogden, UT.

2005–2007—Program transitions to digital-only imagery delivery, but IR aircraft still need to land to download the imagery.

2009–2012—Imagery downloading via AirCell system eliminates the need for multiple landings to deliver imagery.

2013—NightWatch Program begins in California, fixed-wing aircraft with EO and IR sensors.

2015—Memorandum of understanding with National Guard to use distributed real-time IR (DRTI) aircraft with data-streaming capabilities.

2019—End product contract for IR services.

2020—Exclusive-use contract with Tenax Aerospace for two King Air 350s.

8.1.1. Timeline of Infrared Products, Delivery, and Ordering Methods

The following is an overview of how infrared imaging products, delivery, and ordering have evolved from 1969 to the present.[1]

Deliverable Product

- 1969–1972 "Stitched" Polaroid photos
- 1972–1993 5-in. continuous dry silver film
- 1993–2005 8.5-in. continuous thermal paper
- 2004–Present Digital GIS-ready orthoimages

Deliverable Methods

- 1976–2005 drop tubes when necessary
- 1969–2007 Hand-delivered imagery
- 2006–Present Files uploaded to server site
- 2009–Present Files uploaded to server in-flight via AirCell

Ordering Methods

- 1969–2006 Faxed form
- 2006–Present Online ordering via NIROPS website

8.2. Background—Why Aerial Infrared Detection and Mapping?

Infrared (IR) systems can detect thermal energy (how hot something is) and produce a picture of the thermal energy content (heat) of a scene. These systems can perform this function through smoke and from a distance.[2]

Images obtained using IR systems benefit fire managers in numerous ways. They provide and document observations that cannot be obtained by the human eye. For example, IR images help identify hotspots and define the perimeter of a fire in smoke-covered areas—items of critical importance in the safe and effective deployment of firefighters.[3]

IR systems provide real-time intelligence. Knowing the specific location of an active fire, and the heat intensity, plays an important role in fireline decisions. For example, suppression crews can be assigned to areas based on the threat of hotspots escaping control. IR imagery can also confirm when hotspots have been extinguished, allowing fire suppression resources to be deployed where needed.[4]

Knowing the exact locations of the fire perimeter and hotspots has become a necessity in the planning process for the suppression and control of large wildland fires. Mapping fires based on information acquired from IR systems provides a level of accurate information that firefighters and fire managers have come to rely on.[5]

More than half a century after beginning IR research, the Forest Service is still using fixed-wing aircraft, helicopters, and unmanned aircraft systems (UAS) to obtain a variety of IR products in support of wildfire suppression.

8.3. Initial Testing and Early Program Development (1962–1991)

The Forest Service infrared program originated as a research effort at the Intermountain Forest and Range Experiment Station in 1962, with most of the work being done in Missoula, MT, at the Fire Sciences Laboratory. The original research team included electronics engineers and technicians, physicists, and foresters. Before this effort, there were no airborne systems specifically designed to detect heat using infrared and process the data into field-usable maps in time for use in planning the next day's fire suppression operations. Warren and Celarier (1991) state that during this research, "the basic theory of fire mapping and detection with thermal infrared systems was developed. There are now new technologies and methods available for use, but the basic tenets still apply."[6]

Forest Service infrared systems (as of 1991) had "always used basic line-scanned 'front end' rotating mirror optics and dewar-detector assemblies from military systems, with some unique, critical Forest Service modifications. The Forest Service IR systems [were] the only ones in the world known to be designed and developed specifically for fire detection and mapping."[7] Development of these systems required extensive testing to adapt the technology to the unique needs and demands of the fire management environment.

The research and development team weren't the only ones working on the infrared mapping and detection concept—an operations team was also at work. The team was led by Bob Bjornson (later assistant director of fire management in Boise, ID) and included Fire Management Officer and Technician Bob Cook and Pilot Eldon Down. The technology was state-of-the-art military grade, so security clearances and secure custody of all materials were required.

An early infrared aircraft was an Aero Commander 500B, N142Z. A drop tube system was developed to deliver the polaroid imagery directly to the fire camp. The first Forest Service infrared interpreter course was held in the winter of 1964.[8]

Although a base of operations was established in 1966 in Boise, ID, under the supervision of the Division of Fire Control, Intermountain Region, research aspects of Project Fire Scan continued in Missoula, MT.[9] The infrared program became part of the Washington Office Aviation Service Group at the National Interagency Fire Center (NIFC) in 1974.

Tail Numbers

Very soon after airplanes came on the scene, people began labelling them with unique identification numbers. Similar to a license plate on a car, the identifier facilitates tracking the ownership and history of an aircraft and serves as its name when flying.

Originally painted on the tops and bottoms of the wings, this identifier is now applied to the side of the fuselage or tail and has become known as the aircraft's tail number. The tail number frequently serves as the aircraft's name or radio call sign when flying (usually with a phonetic alphabet).

In 1913 the format was a single letter prefix followed by four numbers, and then evolved to include a second letter in the prefix indicating the category of aircraft. In 1944, the International Civil Aeronautics Organization (ICAO) developed a system with a unique prefix for each country. All U.S. aircraft tail numbers now start with the prefix letter "N." Hence, in the United States they are commonly referred to as "N numbers." The U.S. Navy had used the "N" prefix as early as 1909.

The first known sequence of Forest Service tail numbers was for a series of TBMs acquired in 1956 beginning with N102Z. By 1960, the Federal Aviation Administration (FAA) had reserved the numbers N100Z through N199Z at the Forest Service's request.

The FAA now handles all aircraft registration. Tail numbers can be reused; for example, if an aircraft is destroyed or relocated to another country, the FAA may reassign its tail number to another aircraft. The second numeral in Forest Service tail numbers was used to designate the assigned region, but this has changed in recent years in an effort to nationalize the working capital fund fleet.

Technology continued to improve and in the 1980s new systems were being developed. In the early 1980s the Forest Service partnered with the Jet Propulsion Laboratory to develop the Fire Logistics Airborne Mapping Equipment (FLAME) system.[10] The FLAME system was completely analog and initially produced thermal imaging output on 5-inch film strips, later upgrading to an output of strip charts on thermal paper. In 1985 the Forest Service began using the Fire Mouse Trap system, which would evolve through several iterations (see chapter 8.5).

8.4. Program Development (1992–2021)

From the 1980s to the mid-2000s, the IR program was headquartered in Boise, ID, at the National Interagency Fire Center (NIFC). In the 1990s, the Forest Service acquired a Rockwell Sabreliner jet aircraft, N773W, that had been excessed by the Air Force.[11] In addition to the Sabreliner, the program used two Beechcraft King Air airplanes, a B90 and a B200.

The Forest Service used this Sabreliner jet for the infrared program in the 1990s. It was sold in 2001 due to excessive maintenance issues. USDA Forest Service photo.

In 1992 the Forest Service began using an IR system called the Firefly. The system provided near real-time fire information to fire managers and suppression forces. Components included an airborne infrared sensor, automatic onboard signal and data processing, telecommunications link, and integration into a ground data terminal. Firefly was an improvement over the FLAME system, increasing the timeliness of data delivery and providing more consistent and reliable data.[12]

In 1994 modifications to the Sabreliner were completed and it was placed in service as a “proof of concept” infrared mapping aircraft, the first true jet to be evaluated in that mission. Although the mapping capability of the aircraft proved to be very valuable, in 2001 the Sabreliner was sold due to excessive maintenance issues. It was replaced with a Cessna Citation Bravo.[13] Maintaining IR capability with a true jet (as opposed to a turboprop) was important to program personnel. Because jets are substantially faster, IR imagery can be collected for more wildfires during an operational period.

Table 8.1 lists aircraft that have were assigned to the IR program in the early 21st century, including their status as of 2022.

Table 8.1. Infrared aircraft of the early 21st century

Make/Model	Number	Status
Rockwell Sabreliner jet	N773W	Sold in 2001 due to maintenance issues
Cessna Citation Bravo (2001) jet	N144Z	Excessed in 2019
Beechcraft King Air B90 (1969)	N148Z	Converted to leadplane in 2005
Beechcraft King Air B200 (1985)	N149Z	In service

In 2003 the Forest Service acquired a new IR system called the Phoenix. The Phoenix was the first wholly digital system used by the Forest Service. The Phoenix operates on a Windows-based computer, has a data acquisition system, runs on specially developed software, and uses the same scan head as the FLAME system (RS-25). This was the same year the Forest Service infrared unit adopted the name National Infrared Operations (NIROPS).

At the request of the National Incident Commander Group, a typing standard for IR systems was developed and published in 2003. The typing includes type 1 and type 2 systems intended for multiple incident/large fires and types 3a, 3b, and 3c for single incidents.[14] The IR program continued with two King Air airplanes and the Citation until 2005. In 2005 N104Z, a 1969 King Air B90, was removed and converted to a leadplane, leaving just two aircraft in the program.

In 2005 a decision was made to relocate the IR aircraft and pilots to the Intermountain Aviation Group. The Office of Management and Budget (OMB) was encouraging the Forest Service to shift budgeted dollars from the Washington Office to the regions—this move was part of that effort. Additionally, some senior leaders in Fire and Aviation Management believed that oversight of an operational aviation unit should be done at a regional, not national, level.[15]

Although the program was making the transition to all digital imagery from 2000 to 2007, the aircraft still had to land to download the images. Significant cost savings could be realized by minimizing landings. The lead supervisory pilot "determined it was unsafe to feather or shut down a single engine to do what was known as a 'hot handoff,' so NIROPS discontinued this practice" at the end of 2006. A few airdrops still occurred, but delivery of images was mainly accomplished by landing and shutting down the aircraft. Due to budget constraints, there was a need to become more efficient. The program began downloading imagery to the NIFC server site, but would often fly multiple incidents before landing, delaying the timely receipt of images. Finally, from 2009 to 2012, NIROPS began using the AirCell system to download imagery from the aircraft in flight, eliminating the need for multiple landings and significantly reducing costs.[16]

In 2012 the National Aeronautics and Space Administration (NASA) transferred a newly developed airborne imaging technology known as the autonomous modular sensor (AMS) to the Forest Service. The AMS is a scanning spectrometer designed to detect heat signatures and was added to the arsenal of IR tools to supplement other systems.[17]

In 2013 the Forest Service implemented the NightWatch program in southern California, partly in response to the 2009 Station Fire (see chapter 3.3.7). The NightWatch program employs a King Air 200 with enhanced technology for aerial supervision and data collection. The suite of technology installed in the aircraft includes six radios and an integrated 3D mapping system. The mapping system displays and records data such as aircraft positions, fire perimeters, and other information such as distance, elevation, and latitude/longitude. The integrated system includes an infrared imager, short-wave IR cameras, a low-light electron multiplying device, a laser rangefinder, and automatic video tracking.[18]

Designated as Air Attack 51, this King Air 200 is equipped with enhanced technology for infrared detection and mapping. USDA Forest Service photo by Jed Smith.

In 2015 a memorandum of understanding (MOU) was created between the Forest Service and Department of Defense that allowed the use of Air National Guard distributed real-time infrared (DRTI) aircraft. The aircraft used in this mission are Fairchild C-26 Metroliners, known as a C-26 in the military. The aircraft are equipped with an EO/IR camera ball and can be ordered under a NIFC request for assistance to the Department of Defense. One of the best uses of DRTI aircraft are to detect new fires over large geographic areas (e.g., flying a geographic area after a major lighting event). DRTI aircraft do not generate fire perimeter maps in realtime—they must be produced after the data is collected. The aircraft used for DRTI are no longer supported by the Air National Guard and will soon be retired.

By the mid-2010s aircraft issues were becoming more prevalent in the IR program. The Forest Service hired a vendor to upgrade the avionics package in the Citation jet, but the upgrade failed and the aircraft was excessed in 2019. The IR program began contracting for aircraft and services to augment their program in 2016. In 2019 an end-product contract was issued for IR services. (An end-product contract means that a vendor is contracted to provide a tangible product with no specifications on how to acquire or create the product.) The contract can be renewed for up to 5 years. Beginning in 2020 the IR program started contracting for King Air 200 aircraft to supplement their depleted fleet. The contract was with Tenax Aerospace and reached its final year in 2022.

As figure 8.1 indicates, the severity of fire seasons continues to worsen and the corresponding demand for IR is increasing. Having adequate IR capability will continue to be a challenge into the future.

Air National Guard Fairchild C-26 aircraft equipped with distributed real-time infrared. U.S. Air Force photo by Senior Airman Sean Campbell.

In 2022, the IR program had one functional aircraft. The Citation jet, N144Z, operated until 2019 but was then sold after a failed avionics upgrade. The King Air B200, N149Z, continues to fly missions. The IR program is scheduled to take delivery of two new King Air 260GT aircraft in 2022. The new aircraft will be equipped with the Phoenix system, Overwatch TK-9, and AMS.

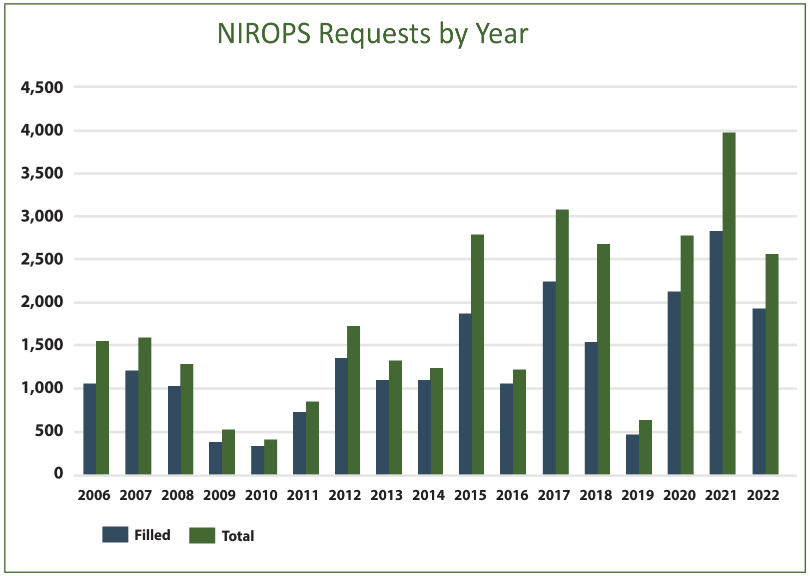


Figure 8.1 Requests for infrared operations generally outpace capacity to meet those requests, which are increasing with more severe fire seasons.

8.5. Infrared Mapping Missions

Through 1990, the primary system used for infrared (IR) mapping was airborne IR line scanning (table 8.2). Highly reliable and with exceptional capability for identifying small hotspots, these systems could scan large areas—over 1,000 square miles per hour—and produce excellent hard copy imagery. An infrared technician, specially trained in the operation of the line scanner, accompanied the flight crew. The imagery was usually delivered to an IR interpreter at an airport, although in some cases it could be transmitted directly to a ground receiving station or dropped directly to a fire camp. In either case, the trained IR interpreter was a key part of the team, with the responsibility for interpreting imagery and accurately posting information to an aerial photo or map. The work was typically done at night.[19]

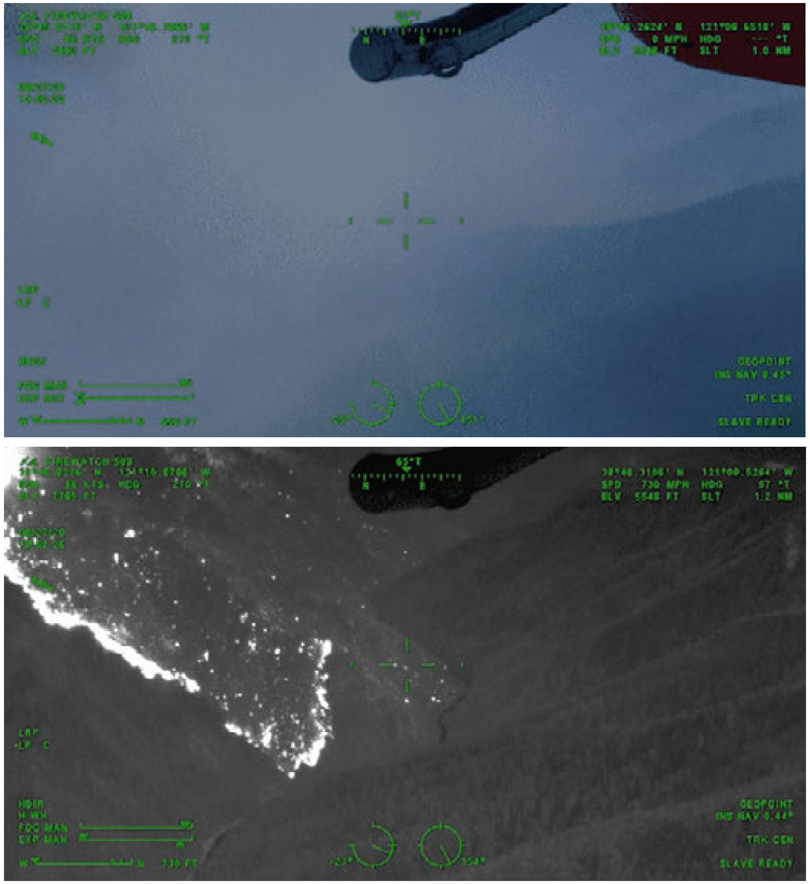
Forest Service IR Beechcraft King Air 200, tail number N149Z, in 2013. USDA Forest Service photo.

Table 8.2. Development and attributes of IR line scanning systems, through 1993[20]

	HRB Singer	Texas Instruments RS-7	Texas Instruments RS-25	Fire Logistics and Mapping Equipment (FLAME)	Firefly
Aircraft	Queen Air	King Air	Sweringen Merlin	Any infrared aircraft	Any infrared aircraft
Scanner (Receiver)					
Design age	1962	1962–1969	1962–1973	1962–1981	1990
Date acquired	1964	1965	1974	1983	1991
Operational	1966	1971	1974	1983	1993
Source	Purchased by Office of Civil Defense and “given” to the Forest Service	Purchased by Forest Service R&D, used about 6 years, then transferred to NFS	Modification of RS-7 and AAS-18 to produce RS-25	Basic RS-7 scanner with improved signal processing	Daedalus Corp
Image Producer					
Design age	1965	Late 1960s	1969–1970	1981	1990
Type	Polaroid	KD-14 wet chemical	Electro Mechanical Research dry silver	Dry silver	No hard copy image; video monitor on aircraft and fire data transmitted to the ground on a map
Source	Laboratory prototype built by Northern Forest Fire Laboratory (NFFL)	One of 14 military prototypes built then dropped; went to dry silver, then back to wet chemical	A later model dry silver image producer was procured by NFFL for FIRESCOPE in 1975; modified for wet chemical in 1975–1976	EDO-Western	N/A

NFS = National Forest System (Deputy Area); R&D = Research and Development (Deputy Area)

The forward-looking infrared (FLIR) system became commercially available in 1979. With a much smaller field of view and coverage of a smaller area than the airborne line scanning system, this system produced a clear IR image that could be recorded on a standard portable videocassette recorder (VCR). Used with helicopters mostly during daylight hours, this system proved to be a versatile source of tactical information.[21]



Stills from FLIR Star SAFIRE 380-HDc video footage. Top is a visual image (fire not visible due to smoke) and on the bottom is the corresponding thermal image. Teledyne FLIR, LLC, photos.

The first generation of the "Flying InfraRed Enhanced Maneuverable Operational User Simple Electronic Tactical Reconnaissance And Patrol," dubbed the "Fire Mouse Trap," was first used operationally in 1985. This system collected IR data in a computer. A FLIR system was mounted on a helicopter or small, fixed-wing aircraft that then flew the perimeter of a fire using the long-range navigation system of the time, LORAN-C. Upon landing, the computer was connected to a plotter that produced a map of the fire perimeter. It also produced a color video, which was particularly valuable for viewing terrain and vegetation.[22]

A second generation Fire Mouse Trap was developed in the late 1980s. This system included a Global Positioning System (GPS) receiver and notebook-sized computer. This system offered increased precision over the first generation and was simpler to operate.[23]

The Fire Mouse Trap Super System added the capability to transmit a FLIR or color video to an incident command post (ICP) or other location in realtime. A mobile receiving station can be driven to the location where the information will be received.

Pyroelectric units (PVE) are IR systems using a different physical phenomenon for IR detection called the pyroelectric effect. These are simple systems that are useful but not as accurate as FLIR.[24]

The Hughes Probeye infrared thermal viewer. Photos courtesy of Brooke Clarke.

Other systems used included the Hughes Probeye (1970s) and Firefly airborne IR line scanner (1992). The Hughes Probeye is a portable and easy-to-use system with poorer image quality than other systems.[25] The Firefly airborne IR line scanner system offered significant improvements, including the use of GPS to allow air-to-ground transmission of the IR data.[26]

8.6. Partnerships

Early research and development was carried out in cooperation with the Department of Defense (DOD) Office of Civil Defense and the Defense Advanced Research Projects Agency (DARPA). Military technologies and other systems that became commercially available by the late 1980s were considered classified information in the 1960s.[27]

Various IR systems from other agencies were used, including several from the Department of the Interior, Bureau of Land Management.[28]

One notable mission was flown by a U.S. Air Force SR-71 in 1979. The Pacific Northwest Region was experiencing a large number of new ignitions and asked NIFC to fly regionwide detection missions with infrared aircraft. With Forest Service infrared aircraft being committed to ongoing large fires, the Air Force offered to provide the SR-71. The mission was flown, and the imagery was delivered to the Forest Service infrared interpreter at Beale Air Force Base in California. Effectively interpreting imagery covering about 25,000,000 acres proved to be impossible to accomplish in a short time. While no fires were detected, plotted, and located in the field, the idea of regionwide IR scanning was tested and found not practical at that time.

8.7. Aircraft Makes and Models

Important attributes for aircraft being used for infrared platforms include:

- twin engines (for redundancy and altitude performance);
- pressurization (to be able to fly at altitudes above the terrain and for flight crew comfort);
- speed (to cover large geographic areas in one night); and
- night flying capability (to enable operation during the time of greatest thermal contrast between the fire and adjacent land features).

Over the years, aircraft with increased capability came into the program. In 2001, a Cessna Citation Bravo was incorporated into the IR aircraft fleet with significantly increased speed. This aircraft was retired in 2019.

By 2020, this Beechcraft Super King Air 200 was the only agency aircraft in the infrared program. USDA Forest Service photos.

Table 8.3. Infrared aircraft makes and models

Unless otherwise noted, aircraft used in the infrared program up through 1991 were sourced Warren and Celarier (1991).

First use (year)	Last use (year)	Make	Model(s)	Owned	Contracted	IR equipment	Comments
1962	1964	Beechcraft	AT-11 "Twin Beech"			AAS/5 scanner	1962: first imagery through smoke and preliminary detection of small fires under forest canopy; 1964: scanner modified for Polaroid readout, 16 flights over wildfires, imagery dropped to fire camp, and data collected on detection probability versus scan angle in four coniferous forest types
1964	1967	Aero Commander	500B	✓		AAS/5, Polaroid, Reconofax XI, Dual Polaroid	1964: 49 flights over wildfires; experiments in use for fire control; 1965: preliminary evaluation; no data due to equipment problems; 1966: system delivered to Division of Fire Control; fully operational in 1967
1964	1968	Convair	T-29			AAS/5, KD-14 rapid film processor, RS-7 scanner, Litton CRT, KD-14, tape recorder, APN 81 Doppler, TDM, Bendix DRA-12 Doppler	Loaned by U.S. Air Force; 1964: no data due to equipment problems; 1965: data collected on detection probability versus scan angle in three coniferous and three deciduous forest types; 1967: 21 fire detection patrols; 1968: equipment modified for 2-color system and to reduce size and weight for installation in smaller aircraft
1965	1979	Beechcraft	Beech 99	✓			
1966	1985	Beechcraft	Queen Air	✓			1985: older model aircraft retired from IR service, reducing IR line scanner capacity from 3 to 2 aircraft
1969	1983	Beechcraft	King Air B90	✓		RS-7, Litton CRT, KD-14, TDM, DRA-12 Doppler, 2-color, Fire Logistics Airborne Mapping Equipment (FLAME) line scanner	1969: testing and 25 regular fire detection patrols; 1970: resolved detector problems, successful testing, including 41 regular detection patrols and 15 large forest fires mapped; FLAME unit built to Forest Service specifications of FIRESCAN Research, with the Forest Service supplying the line scanner main frame and image recorder in 1983; Jet Propulsion Laboratory updated the electronics and assembled the system

Table 8.3. Infrared aircraft makes and models (cont.)

First use (year)	Last use (year)	Make	Model(s)	Owned	Contracted	IR equipment	Comments
1970s	Unknown	Piper	Navajo	✓			
1974	Unknown	Sweringen	Merlin	✓		FFS-1 Forest Fire Surveillance (modified RS-7 to RS-25), FLAME, preliminary Firefly system, Firefly system No. 1 and No. 2	1974: system procured for National Forest System Deputy Area; 1991: initial airborne testing of Firefly electronics, coupled with FLAME IR system; 1992: Firefly acceptance testing completed and scheduled for use
1985	Still in Use	Beechcraft	King Air 200	✓		FLAME line scanner	1985: 2 total aircraft (reduced from 3 with retirement of older Beechcraft Queen Air); 1 King Air in service as of 2022
1994	2001	Rockwell	Sabreliner	✓			Excessed in 2001 due to excessive maintenance needs
2001	2019	Cessna	Citation Bravo	✓		All IR systems in use	Retired in 2019 after a failed avionics upgrade
2014	Unknown	Pilatus	PC-12			Wescam MX-15 electro-optical camera ball with perimeter mapping software	Cooperator, State of Colorado
2015	Still in Use	Fairchild	C-26			Electro-optical camera ball	National Guard aircraft
2020	Still in Use	Beechcraft	King Air 350		✓		Tenax Aerospace

Airplanes pictured here are not necessarily those used by the Forest Service, but are included to illustrate various makes and models. Left: The Beechcraft Queen Air preceded the King Air and was produced in several different models between 1960 and 1978. Photo by Johnny Comstedt. Right: The Swearingen Merlin was produced by Swearingen Aircraft and then later by Fairchild Aircraft from 1965 to 1998. Photo by Tomás Del Coro.

Left: Aero Commander 500B. Photo by Greg Goebel. Right: Convair T-29B at the Pima Air & Space Museum in Tucson, AZ. The U.S. Air Force used the T-29 for navigation and radar training from 1950 to the mid-1970s. Pima Air & Space Museum photo by Scott Youmans.

Appendix A. Significant Firsts

The following list of "firsts" in Forest Service aviation is by no means a complete list, but a summary of those mentioned in previous chapters. Some of these achievements are based on known documentation, and earlier instances may be discovered with more extensive research.

1905—First practical airplane developed (Wright Brothers).
1919—First airplanes used in forest patrol in conjunction with U.S. Army.
1920—First fatal aviation accident in history of Forest Service aviation.
1926—First documented instance of cargo being airdropped on a wildfire.
1929—First use of airplanes by Forest Service in Lake States.
1931—First recorded use of an a utogiro on a forestry mission.
1931—First testing of parachute drops and live jumps.
1932—First a utogiro contracted for fire protection.
1938—First airplane acquired by the Forest Service, a Stinson Reliant SR-10.
1939—First practical helicopter developed by Igor Sikorsky.
1940—First smokejumper fire jumps (from a Travel Air).
1945—First smokejumper fatality in the history of the smokejumper program.
1946—First helicopter used on a wildlife.
1947—First extended helicopter use on a wildfire.
1949—First helicopter training film for firefighters.
1951—First turbine-engine helicopter manufactured.
1954—First fire retardant chemical developed by U.S. Borax Company.
1955—First operational airtanker, Stearman 75 Kaydet.
1955—First fixed-wing water "air drop" made on Mendenhall Fire in California.
1956—First airtanker squadron in Willows, CA.
1956—First fixed-wing retardant drop on a wildfire.
1956—First air attack supervisor, Joe Ely, Mendocino National Forest, in a Piper Tri-Pacer.
1956—First airtanker contracted.
1956—First use of airspace coordination (for incident-assigned aircraft).
1957—First fully operational helitack crew.
1957—First airtanker numbering system developed.
1958—First aircraft accident during an active smokejumping mission.
1959—First helitack training film.
1964—First operational use of infrared (IR) by Forest Service.

APPENDIX A. SIGNIFICANT FIRSTS

1964—First Forest Service IR interpreter training course.
1964—First use of Bell 204-B medium-sized, turbine engine helicopter by Forest Service.
1965—First comprehensive helitack training guide.
Early 1970s—First helicopter owned by Forest Service.
1973—First operational fire rappel by the Forest Service.
1973—First rappel bases established.
1974—First year of the national airtanker contract.
1974—First female leadplane pilot.
1975—First telemetry of IR imagery from airplane to fire camp.
1977—First female rappellers.
1979—First use of Simplex Helitorch by Forest Service.
1979—First hand-held IR system used by Forest Service.
1981—First female smokejumper and smokejumper pilot.
1982—Invention of the Bambi Bucket, the first fully collapsible helicopter bucket.
1989—First use of "mixed loads" during smokejumper operations.
1991—First DC-3 in Forest Service converted from piston to turbine engine.
1994—First interagency aviation guide (Interagency Helicopter Operations Guide (IHOG).
2003—First use of a completely digital IR system by Forest Service.
2004—First operational use of rope-assisted deployment system (RADS).
2006—First use of a very large airtanker (VLAT).
2007—Forest Service acquires first Joint Precision Airdrop System (JPADS) unit.
2009—First (and only) fatal rappel accident in the history of the rappel program.
2011—First "next generation" airtanker on contract.
2011—First national rappel training.
2011—First risk management workbook developed.
2012—First female smokejumper base manager.
2012—First National Rappel Academy in Salmon, ID.
2015—First operational JPADS drop on Bear Lake Fire in Montana.

B-17 rigged with a "midair catcher," circa 1975 at the Missoula Airport. The feasibility of retrieving firefighting personnel using a midair catching device was briefly studied in the mid-1970s. The idea was to have a balloon lift a line that the airplane could "catch." This method had been used by the U.S. military to recover crewmembers whose aircraft had gone down in the ocean. The evaluation soon determined that "recovery of a person from the ocean versus the forest is very different" and the experiment was abandoned. Courtesy of the National Museum of Forest Service History.

Drawing of a firefighter jumping from a helicopter, circa 1958. While the "helijumper" here appears to be headed for a large rock, the technique—which was employed from the 1950s into the mid-1970s—actually focused on landing in brush that would help break their fall. Courtesy of the National Museum of Forest Service History, Harvey Mack Collection.

Appendix B. Fire Management Today

This publication relied heavily on the articles in *Fire Control* Notes, a quarterly publication started by the Forest Service in December 1936. The first publication of its kind, it became *Fire Management* and *Fire Management Notes* in the 1970s and then *Fire Management Today* in 2000. Transitioning to an online resource only in 2019, all back issues from December 1936 to December 2021 are available online at: https://www.fs.usda.gov/managing-land/fire/fire-management-today. Individual articles used for references in this publication are cited in the endnotes, and the series as a whole deserves special mention for documenting myriad aspects of wildland firefighting work for over 80 years.

According to the 25th anniversary issue of *Fire Control Notes* (January 1962, vol. 23, no. 1), the publication was established because "the widely scattered, creative efforts of individuals and separate groups in fire control work could not be fully effective unless they were shared with others." It is now a treasure trove of historical information related to Forest Service aviation. The following is a list of subject indexes (based in part on a summary in vol. 60, no. 1).

1936–1942 (volumes 1–6)

Fire Control Notes, unnumbered and undated, includes a combined author-subject index for 1936–1942 (volumes 1–6).

1946–1955 (volumes 7–16)

Fire Control Notes, October 1955 (vol. 16, no. 4) includes a combined author-subject index for 1946–1955 (volumes 7–16). https://www.fs.usda.gov/sites/default/files/legacy_files/fire-management-today/016_04.pdf.

1956–1963 (volumes 17–24)

The April 1958 (vol. 19, no. 2) issue of *Fire Control Notes* is entirely devoted to aerial firefighting. https://www.fs.usda.gov/sites/default/files/legacy_files/fire-management-today/019_02.pdf.

Fire Control Notes, 1964, unnumbered, includes a combined author-subject index for 1956–1963 (volumes 17–24).

The fourth issue of each volume of *Fire Control Notes*, 1956–1966 (volumes 17–27), also includes a combined author-subject index.

1964–1969 (volumes 25–30)

Fire Control Notes, July 1970, unnumbered, includes separate author and subject indexes for 1964–1969 (volumes 25–30).

1970–1999 (volumes 31–59)

The years 1967–1999 (volumes 28–59) include separate author and subject indexes in the first issue of the subsequent volume (except for skipped years 1973, 1974, and 1980, for which indexes appear in subsequent volumes).

The fall 1998 issue of *Fire Management Notes* (vol. 58, no. 4) has a specific focus on "Wildland Fire Aviation: Past, Present, and Future." https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_018933.pdf.

Fire Management Today, winter 2000 (vol. 60, no. 1) includes a subject index for 1970–1999 (volumes 31–59), including a list of 186 aviation-related articles on pp. 34–36. It groups articles by subtopic, including airtankers, helicopters, etc. https://www.fs.usda.gov/sites/default/files/legacy_files/fire-management-today/060-1_0.pdf.

2000–2020 (volumes 60–78)

The summer 2007 issue of *Fire Management Today* (volume 67, no. 2) has a specific focus on "Aviation—Yesterday, Today, and Tomorrow." https://www.fs.usda.gov/sites/default/files/legacy_files/fire-management-today/67-2.pdf.

Fire Management Today, June 2021 (vol. 79, no. 2) includes a subject index for 2000–2020 (volumes 60–78), including a list of 27 aviation-related articles on p. 13. It also includes an author index for 1970–2020. https://www.fs.usda.gov/sites/default/files/fire-management-today/FMT-79-2.pdf.

Appendix C. Contracting

Specifications in a Typical Forest Service Contract (1942)

The following is a 1942 Forest Service contract solicitation for smokejumper and cargo-hauling aircraft. This is the earliest known record of Forest Service aircraft contract specifications for passenger and cargo hauling and smokejumping. (Source: Smith, S. 1979. Fly the Biggest Piece Back. Missoula, MT: Mountain Press Publishing. 278 p.)

SERVICE REQUIREMENTS:

(1) The Forest Service requires a forest fire control unit of six planes, five of which are to be based at Missoula, Montana, and one plane based at McCall, Idaho. These airplane units will be used primarily for the rapid transportation of men and supplies to forest fires. The reduction of elapsed time to the minimum practicable requires that these units be available at all times during the fire season. Single planes located at widely separated points would not be considered a suitable fire control unit, and consequently will not be acceptable under the specifications of this bid.

(2) In order to train personnel and maintain this fire control unit of planes for a profitable period of time to contractors, it is planned to use these planes for the transportation of regular Forest Service personnel and supplies before and after the fire season, as well as during the emergency period, and to transport and deliver parachute jumpers to the vicinity of forest fires.

(3) Kind of planes required:

(a) Three planes shall be suitable for the transportation of a fire overhead unit of 12 men exclusive of pilots, or freight in the amount of licensed pay load, or a smokejumper unit of nine men, exclusive of pilots.

(b) Three planes suitable for the transportation of *six* firefighters or smokechasers without baggage, or *five* men with 25 pounds of equipment per man, or 1000 pounds freight, or a smokejumper unit of three men, all exclusive of pilot. These planes shall be properly bonded and shielded for the use of two-way voice radio equipment. (Radio equipment will be furnished and maintained by the Forest Service at no expense to the contractor.) Two of these planes will be based at Missoula, Montana, and one at McCall, Idaho.

(c) For detection and observation use, it is essential that pilot and observers have a clear and unobstructed view of the ground slopes over which they are flying which makes it necessary that these planes have windows the full length of the cabin compartment, and wings above the line of downward vision, such needs indicate the necessity for furnishing closed cabin high-wing monoplane types of airplanes.

(d) For freight use, it is essential that at least three planes be capable of handling such items as 16 foot lumber, 20 foot pipe, etc., and that all planes have doors sufficiently large to admit rations and other boxed goods measuring up to 26” x 36” end sizes, that doors shall be so fastened that they can be quickly removed for dropping objects from plane in flight, when required.

(e) Airplanes offered under this contract shall have one regular door opening of not less than 1200 square inch surface area, and not less than 26 inches wide at bottom of door serving pay load compartment. Must be licensed by the Aeronautic Branch, U.S. Department of Commerce, for trips with pay loads, as required under specified items of bid.

(f) The greatest amount of flexibility and reserve power is desirable to safety perform the work of dropping supplies to firefighters, as it is necessary for the ship to approach within a few hundred feet of the ground before releasing cargoes, and have sufficient reserve power to again gain flying altitude.

(g) Landing fields in Region One are small, some located at high altitudes, and in order to perform the required jobs with the maximum degree of safety, it is essential that the larger planes called for in this bid be so constructed, designed, and powered, as to meet the following specifications.

1. Planes shall be capable of “taking off” with a run of not more than 625 feet. This distance to be measured between the point where wheel first start movement and point where the wheels last touch the ground in starting flight.

2. Planes shall be capable of “landing” with a run of not more than 525 feet. This distance to be measured from point where wheels first touch ground to point where plane comes to complete stop.

3. Planes shall be capable of making a complete circle with a diameter of not to exceed 700 feet, without loss of elevation, between point of beginning and completing of circle. This circle to be measured at not less than 500 feet above ground.

a. These specifications shall apply to fields of 3000 to 3800 feet above sea level, with planes carrying ballast load of 2040 pounds, exclusive of pilots, and with not less than two hours’ fuel supply, and full oil supply; tests to be made on dirt surfaced runways in calm air (calm air shall mean air movement of less than 3 miles per hour).

b. Performance tests to ascertain that bidder’s planes fully meet these specifications shall be made by the Regional Forester, or his designated representative, before bids are accepted. Test will be conducted at Missoula, Montana, or on any other landing field of similar characteristics and elevations.

c. All expenses incident to operation of airplanes during test will be assumed by bidder. Travel expenses of the Regional Forester's designated testing officers will be assumed by bidder if tests are requested at points other than Missoula, Montana.

(h) All planes shall be equipped with the latest accepted type of flying instruments, including: magnetic compass, clock, air speed indicator, bank and turn indicator, rate of climb indicator, sensitive altimeter, tachometer, oil pressure gauge, oil temperature gauge, fuel quantity gauge, and equipped with wheel brakes, and fire extinguishers.

(i) The contractor shall be responsible for and pay all of the cost of operation and maintenance on all planes used as well as the expenses of his personnel that are essential to the work.

(4) Pilots:

The contract shall furnish for each plane, duly licensed pilots, who have a minimum of 1200 hours flying experience over country covered by this bid, or over country having the same mountainous characteristics.

(5) Ground Crews and Maintenance Facilities:

Contractors must provide at Missoula, Montana, and McCall, Idaho, sufficient ground crews, mechanics, and shop equipment to facilitate keeping planes in satisfactory flying condition during period covered by this contract. As this is a relative requirement, bidders must show to the satisfaction of the Regional Forester that they have or will have within ten calendar days after acceptance of bid, sufficient mechanics, ground crews, and shop equipment to adequately service and overhaul the planes covered by this contract, to insure continuous and dependable operation of these planes. Flight time from operating fields to other fields for the purpose of servicing and repairing of airplanes, will be at the expense of the contractor.

(6) It is the intent of this invitation for bids, to secure unit prices on transportation facilities on an hourly basis for different size airplanes between indefinite or unforeseen supply points, and on a pound basis between common supply points, and, since it is impossible to accurately estimate the actual requirements as needed throughout the term of this contract, the Government cannot guarantee to purchase a definite quantity of items A1, A2, A3, B and C, but the Forest Service will guarantee, subject to clause (7) below, to purchase a minimum of $24,500.00 of services in the aggregate of these items, or will pay a sufficient amount at the end of the period to equal the minimum amount guaranteed. The Forest Service agrees to purchase a minimum of $3000.00 of services in the aggregate of items A1, A2, A3, B and C before July 1, 1942, same to be a part of the minimum guarantee above specified.

(7) This contract is conditional upon the passage of an appropriation by Congress from which expenditures thereunder may be made and shall not obligate the United States upon failure of Congress to so appropriate.

(8) The contractor agrees to furnish any number of the planes covered by this contract and their operating personnel upon notice given verbally or in writing by the Regional Forester, within one hour during the period of fire danger as determined by the Regional Forester, or his designated representative, or within five hours, if required, during the remainder of the contract period. All such airplanes and pilots to be duly licensed by the Aeronautic Branch, U.S. Department of Commerce, for trips with pay loads as required under specified items of bid, at the rate bid for each item.

(9) Liquified damages:

If the contractor refuses or fails to make delivery of the items herein specified (Items A1, A2, A3, B and C) within the time specified, (Item 8 above), the actual damage sustained by the Government for the delay will be impossible to determine, and in lieu thereof the contractor shall pay the Government as fixed, agreed and liquidated damages of $5.00 per hour for each hour, and at the rate of $5.00 per hour for fractions of an hour of delay in making delivery of any item of this contract.

Provided, further, that the contractor shall not be charged with liquidated damages when the delay in delivery is due to causes beyond the control and without the fault or negligence of the contractor. Including, but not restricted to acts of God or the public enemy, acts of the Government, hazardous flying conditions, such as low ceiling, fog, smoke, and unusually severe weather, if the contractor shall notify the contracting officer or his authorized representative, in writing of the cause of any such delay within three days from the beginning of such delay. The contracting officer or his authorized representative, shall then ascertain the facts, and extend the time for making delivery, when in his judgment the findings of facts justify such an extension, and his findings of facts thereon shall be final and conclusive.

(10) Payments under this contract:

(a) On or before the 15th day of each month, the Regional Forester will voucher to the contractor through the Regional Fiscal Agent of the Forest Service, the sums due the contractor for the preceding month; provided, the contractor shall submit to the Regional Forester a written statement by the 5th day of each month showing by items the total amounts claimed by him for services rendered daily in the said preceding calendar month. Formal numbered purchase orders will be issued as flights are ordered out.

(b) Flying time on Items B and C will be calculated in hours and minutes from the time of each authorized take-off from the home airport or elsewhere until the next landing thereafter.

(c) Fractions of hours of flying time will be calculated in minutes and paid for at a rate which is proportionate to the hourly rate.

(d) Payment for transportation of men on freight planes under Items A1, A2, A3, will be made on the basis of weight of 170 pounds per man.

(11) General Information

It is realized that the use of Forest Service landing fields presents an extra hazard as compared with landing in commercial fields, but it is not thought that this extra hazard is sufficient to warrant the Forest Service assuming liability for damage or destruction on this class of service. However, as some of the services required under this bid present higher hazards than encountered in the use of Forest Service landing fields, the following policies shall govern the amount of liability assumed by the Government under this contract in accordance with the type of flying service required.

(a) For detection and reconnaissance service under conditions normally expected in air travel over forested areas: i.e., under no necessity of flying at less elevation above terrain than would be considered prudent in general flying; and under no necessity of flying through smoke, fog, or clouds which a prudent pilot would avoid.

(b) For passenger and freight transportation involving delivery at commercial or Forest Service landing fields, as distinguished from service requiring the dropping of freight or men from a plane in flight.

(c) For flights under sections (a) and (b) above, neither the Regional Forester nor the United States of America shall be held liable for any damage, loss or destruction to real or personal property which results from the operation of or accident to the airplanes or their equipment.

(d) For observation of scouting service which may require flights at low elevations over forested terrain or through smoke and low visibility.

(e) For transportation of freight and/or men to be dropped near forest fires, or for training purposes within designated areas, while plane is in flight, and therefore necessarily involving abnormal and hazardous flying conditions not existing in normal flight.

(f) For flights under sections (d) and (e) above, claims for loss, damage or destruction of equipment occurring in flight will be considered under the Act of January 31, 1931, (46 Stat. 1052; 16 U.S.C. 502) provided (1) the loss, damage or destruction is not the result of any mechanical defect of the plane or fault of the contractor or pilot, and (2) the claim is supported by a certificate of the supervisory Forest Officer that the flight from which claim resulted was of a specially hazardous nature. Planes will be appraised at the time of bid acceptance by a Board of Appraisers consisting of three members appointed by the Regional Forester. Reimbursement consideration under paragraph 11(f) will be based on this appraisal.

(12) a. Neither the Regional Forester nor the United States of America shall be held liable for any personal injury sustained by the personnel furnished by the contractor or other parties in connection with the work performed under these specifications and conditions or for any injury sustained by any person other than Forest Service employees which results from the operation of the airplanes or their equipment.

b. The contractor will not be held liable for any personal injury sustained by the personnel supplied by the Regional Forester in connection with the work performed under these specifications and conditions.

c. The contractor shall assume all liability for any damage to persons, other than employees of the Forest Service on official duty, or to real or personal property which results from the operation of or accident to the airplanes or their equipment, except as provided for in paragraphs 11(a) to (f).

d. The contractor shall hold and save the Government, its officers, agents, servants, and employees harmless from liability of any nature or kind for or on account of the use of any copyrighted or uncopyrighted composition, secret process, patented or unpatented invention, article, or appliance furnished or used in the performance of this contract, excepting patented articles required by the Government in its specifications, the use of which the contractor does not control.

e. It is mutually understood and agreed that the term "Regional Forester," wherever used herein, shall be interpreted to include any agent designated in writing by the Regional Forester to act in his behalf in directing and supervising the services to be furnished by the contractor hereunder.

f. Upon request, the Regional Forester will supply the contractor with a list and description of all landing fields which he will be expected to use aside from those in common use by commercial agencies flying in the region. Such fields will be appropriately designated by the Regional Forester with a "T" and sock, and the contractor must use such fields unless he investigates them in advance and an agreement is reached with the Regional Forester that they are unsafe for use. If such an agreement cannot be reached, the decisions of an inspector of either the United States Army Air Corps or of the Aeronautics Branch of the United States Department of Commerce shall be accepted as final.

g. These airplanes will be used over rough mountainous country, which requires powerful planes of efficient design to get down into narrow canyons for observation purposes, and have sufficient power to pull out of such places without danger of crashing into the sides of the canyon; to land and take off from small landing fields in this mountainous country, with maximum pay loads specified where air currents are known to be dangerous, and dead air may be encountered, landings may be necessary at relatively high speeds, and satisfactory wheel brakes are essential. As the territory over which flying will be required is particularly hazardous for airplanes, safety as reflected in specifications for power, design of planes and experience of pilots is essential in providing a reasonable degree of safety for personnel and Government property using this service.

h. The transportation under this bid will be used on various requirements as necessary throughout the season; therefore, the exact amounts to be transported to each field cannot be definitely stated, and when demands are encountered, the time element necessary in securing competitive bids would necessarily delay work and cause loss to the Government.

i. Due to the above facts and to secure for the Government the lowest possible cost, bid will be accepted in the *AGGREGATE* rather than by items, as bidders can quote lower prices on larger quantities.

j. On account of the foregoing facts and in order to determine the lowest bidder, bid will be awarded on basis of aggregate total cost of the following:

k. 20,000 pounds at the 3,000 pound load rate to Big Prairie Ranger Station under Item A1.
0,000 [sic] pounds at the 1,000 pound load rate to Big Prairie Ranger Station under Item A1.
20,000 pounds at the 3,000 pound load rate to Moose Creek Landing Field under Item A1.
10,000 pounds at the 1,000 pound late rate to Moose Creek Landing Field under Item A1.
3,000 pounds at the 3,000 pound load rate to Shearer (Bear Creek Field) under Item A1.
1,000 pounds at the 1,000 pound load rate to Shearer (Bear Creek Field) under Item A1.
6,000 pounds at the 3,000 pound load rate to Moose Creek Landing Field under Item A2.
2,000 pounds at the 1,000 pound load rate to Moose Creek Landing Field under Item A2.
6,000 pounds at the 3,000 pound load rate to Big Prairie Ranger Station under Item A3.
4,000 pounds at the 1,000 pound load rate to Big Prairie Ranger Station under Item A3.
40 hours of flying time under Item B1.
20 hours of standby service under Item B2.
40 hours of flying time under Item C1.
20 hours of standby time under Item C2.

l. The Government reserves the right to accept bids deviating slightly or in minor details, from these specifications where such acceptance is to the interest of the Government. However, any alternate bid must be labeled "alternate quotation" and signed by bidder and attached to original of his bid prior to opening date of bid.

m. Before final award, the person or company submitting the most acceptable bid may be required to show to the satisfaction of the Regional Forester, that he has immediately available, or will have available within 10 calendar days after opening of bid, airplanes, other equipment and personnel necessary to enable him to meet the requirements of the agreement.

Item A1.

Transportation of freight and/or passengers between the Missoula airport, Missoula, Montana, and the following points: It being understood that the minimum weight per trip will be not less than 1,000 pounds for planes furnished in accordance with page 2, paragraph 3 (b), and not less than 3,000 pounds for planes furnished in accordance with page 2, paragraph 3 (a) of this bid, and that payment will be on the basis of these minimums in the event that the successful bidder is required to deliver loads weighing less.

Contractors on the National Airtanker Contract (1974–2022)

Table C.1. Contractors on Forest Service national airtanker contract

Year	Contractors
1974	No information found.
1975	No information found.
1976	Hawkins and Powers, Inc.; Black Hills Aviation, Inc. (predecessor to Neptune); Aero Union Corporation (Airstrike has some of Aero Union's assets); Ralco; Lynch Air Tankers, Inc.; SIS-Q Flying Service, Inc.; Bruce Kinney; Hemet Valley Flying Service; TBM, Inc. (assets purchased by Erickson); Aerial Applicators; T&G Aviation, Inc. (successor is International Air Response); Globe Air; Evergreen Helicopters, Inc.; Sergio Aviation; Schaefli.
1977	Hawkins and Powers Aviation, Inc.; Black Hills Aviation, Inc. (predecessor to Neptune); Aero Union Corporation (Airstrike has some of Aero Union's assets); Lynch Air Tankers, Inc.; SIS-Q Flying Service, Inc.; Bruce Kinney; TBM, Inc. (assets purchased by Erickson); T&G Aviation, Inc. (successor is International Air Response); Globe Air; Evergreen Helicopters, Inc.; WAIG, Aircraft, Inc.; Hillcrest; Transwest Air Service; Reeder.
1978	Hawkins and Powers Aviation, Inc.; Black Hills Aviation, Inc. (predecessor to Neptune); Aero Union Corporation (Airstrike has some of Aero Union's assets); Ralco; Lynch Air Tankers, Inc.; SIS-Q Flying Service, Inc.; TBM, Inc. (assets purchased by Erickson); T&G Aviation, Inc. (successor is International Air Response); Globe Air; Evergreen Helicopters, Inc.; WAIG, Aircraft, Inc.; Hillcrest; Trans West Air Service; Reeder.
1979	Hawkins and Powers Aviation, Inc.; Black Hills Aviation, Inc. (predecessor to Neptune); Aero Flight; Aero Union Corporation (Airstrike has some of Aero Union's assets); Ralco; Lynch Air Tankers, Inc.; SIS-Q Flying Service, Inc.; Bruce Kinney; TBM, Inc. (assets purchased by Erickson); T&G Aviation, Inc. (successor is International Air Response); Globe Air; Evergreen Helicopters, Inc.; WAIG Aircraft, Inc.; Central Air Services.
1980	Hawkins and Powers Aviation, Inc.; Black Hills Aviation, Inc. (predecessor to Neptune); Aero Flight; Aero Union Corporation (Airstrike has some of Aero Union's assets); Ralco; Hemet Valley Flying Service; Lynch Air Tankers, Inc.; SIS-Q Flying Service, Inc.; Bruce Kinney; TBM Inc. (assets purchased by Erickson); Douglas County Aviation, Inc. (T&G) (successor is International Air Response); Evergreen Helicopters, Inc.; WAIG Aircraft, Inc.; Central Air Services; Trans West Air Service
1981	Hawkins and Powers Aviation, Inc.; Black Hills Aviation, Inc. (predecessor to Neptune); Aero Flight; Aero Union Corporation (Airstrike has some of Aero Union's assets); Ralco; Hemet Valley Flying Service; Lynch Air Tankers, Inc.; SIS-Q Flying Service, Inc.; Bruce Kinney; TBM, Inc. (assets purchased by Erickson); Douglas County Aviation, Inc. (T&G) (successor is International Air Response); Evergreen Helicopters, Inc.; WAIG Aircraft, Inc.; Central Air Services; Trans West Air Service
1982	No information found.
1983	Hawkins and Powers Aviation, Inc.; Black Hills Aviation, Inc. (predecessor to Neptune); Aero Flight; Aero Union Corporation (Airstrike has some of Aero Union's assets); Hemet Valley Flying Service; Lynch Air Tankers, Inc.; SIS-Q Flying Service, Inc.; Bruce Kinney; TBM, Inc. (assets purchased by Erickson); Douglas County Aviation, Inc. (T&G) (successor is International Air Response); Evergreen Helicopters, Inc.; WAIG Aircraft, Inc.; Central Air Services.
1984	Hawkins and Powers Aviation, Inc.; Black Hills Aviation, Inc. (predecessor to Neptune); Aero Flight; Aero Union Corporation (Airstrike has some of Aero Union's assets); ARDCO, Inc.; SIS-Q Flying Service, Inc.; TBM, Inc. (assets purchased by Erickson); Douglas County Aviation, Inc. (T&G) (successor is International Air Response); Evergreen Helicopters, Inc.

** first time included in national airtanker contract*

*** last time included in national airtanker contract*

**** both the first and last time included in national airtanker contract*

Table C.1. Contractors on Forest Service national airtanker contract (cont.)

Year	Contractors
1985	Hawkins and Powers Aviation, Inc.; Black Hills Aviation, Inc. (predecessor to Neptune); Aero Flight; Aero Union Corporation (Airstrike has some of Aero Union's assets); ARDCO, Inc. ; Lynch Air Tankers, Inc.; SIS-Q Flying Service, Inc. TBM, Inc. (assets purchased by Erickson); Douglas County Aviation, Inc. (T&G) (successor is International Air Response); Evergreen Helicopters, Inc.
1986	No information found.
1987	No information found.
1988	No information found.
1989	Hawkins and Powers Aviation, Inc.; Black Hills Aviation, Inc. (predecessor to Neptune); Aero Flight, Inc.; Aero Union Corporation, Inc.; (Airstrike has some of Aero Unions assets); ARDCO, Inc.; Mac Avia International Corporation, Inc.; (Successor to SIS-Q Flying Service, Inc.); TBM, Inc. (assets purchased by Erickson); Douglas County Aviation, Inc. (Successor is International Air Response).
1990	Hawkins and Powers Aviation, Inc.; Black Hills Aviation, Inc.; Aero Flight, Inc.; Aero Union Corporation, Inc.; ARDCO, Inc.; Mac Avia International Corporation, Inc.**; (Successor to SIS-Q Flying Service, Inc.); TBM, Inc.; Douglas County Aviation, Inc. (Successor is International Air Response). Hemet Valley Flying Service, Co.
1991	Hawkins and Powers Aviation, Inc.; Black Hills Aviation, Inc. (predecessor to Neptune); Aero Flight, Inc.; Aero Union Corporation, Inc.; ARDCO, Inc.; TBM, Inc.; Douglas County Aviation, Inc. (Successor is International Air Response). Hemet Valley Flying Service, Co.
1992	Hawkins and Powers Aviation, Inc.; Black Hills Aviation, Inc.); Aero Flight, Inc.; Aero Union Corporation, Inc.; (Airstrike has some of Aero Unions assets); ARDCO, Inc.; TBM, Inc.; Douglas County Aviation, Inc.** (successor is International Air Response); Hemet Valley Flying Service, Co.
1993	Hawkins and Powers Aviation, Inc.; Black Hills Aviation, Inc. (predecessor to Neptune); Aero Flight, Inc.; Aero Union Corporation, Inc.; ARDCO, Inc.; TBM, Inc.; Hemet Valley Flying Service, Co.; Minden Air Corporation.*
1994	Hawkins and Powers Aviation; Neptune Aviation* (successor to Black Hills); Aero Flight, Inc.; Aero Union Corporation, Inc.; ARDCO, Inc.; TBM, Inc.; Hemet Valley Flying Service, Co.
1995	Hawkins and Powers Aviation; Neptune Aviation; Aero Flight, Inc.; Aero Union Corporation, Inc.; ARDCO, Inc.; TBM, Inc.; Hemet Valley Flying Service, Co.
1996	Hawkins and Powers Aviation; Neptune Aviation (successor to Black Hills); Aero Flight, Inc.; Aero Union Corporation, Inc.; ARDCO, Inc.; TBM, Inc.; Hemet Valley Flying Service, Co.
1997	Hawkins and Powers Aviation; Minden Aviation (returns after two-year absence), Neptune Aviation; Aero Flight, Inc.; Aero Union Corporation, Inc.; ARDCO, Inc.; TBM, Inc.; Hemet Valley Flying Service, Co.**
1998	Hawkins and Powers Aviation; Minden Aviation; Neptune Aviation; Aero Flight, Inc.; Aero Union Corporation, Inc; ARDCO, Inc.; TBM, Inc.
1999	Hawkins and Powers Aviation; Minden Aviation; Neptune Aviation; Aero Flight, Inc.; Aero Union Corporation, Inc; ARDCO, Inc.; TBM, Inc.
2000	Hawkins and Powers Aviation; Minden Aviation; Neptune Aviation; Aero Flight, Inc.; Aero Union Corporation, Inc; ARDCO, Inc.; TBM, Inc.
2001	Hawkins and Powers Aviation; Minden Aviation; Neptune Aviation; Aero Flight, Inc.; Aero Union Corporation, Inc; ARDCO, Inc.; TBM, Inc.

Table C.1. Contractors on Forest Service national airtanker contract (cont.)

Year	Contractors
2002	Hawkins and Powers Aviation; Minden Aviation; Neptune Aviation; Aero Flight, Inc.; Aero Union Corporation, Inc; ARDCO, Inc.; TBM, Inc.
2003	Hawkins and Powers Aviation; Minden Aviation; Neptune Aviation; Aero Flight, Inc.; Aero Union Corporation, Inc; ARDCO, Inc.; TBM, Inc.; International Air Response (reappears, last Forest Service contract was 2002 as Douglas County Aviation).
2004	Hawkins and Powers Aviation**; Minden Aviation; Neptune Aviation; Aero Flight, Inc.**; Aero Union Corporation, Inc; ARDCO, Inc.**; TBM Inc.**
2005	Minden Aviation; Neptune Aviation; Aero Union Corporation, Inc.; Butler Aviation*** (Since the 1970s Butler Aviation had contracted through TBM, Inc.).
2006	Minden Aviation; Neptune Aviation: Aero Union Corporation, Inc.
2007	Minden Aviation; Neptune Aviation; Aero Union Corporation, Inc.
2008	Minden Aviation; Neptune Aviation; Aero Union Corporation, Inc.
2009	Minden Aviation; Neptune Aviation; Aero Union Corporation, Inc.
2010	Minden Aviation; Neptune Aviation; Aero Union Corporation, Inc.
2011	Minden Aviation; Neptune Aviation; Aero Union Corporation, Inc.
2012	No information found.
2013	No information found.
2014	No information found.
2015	No information found.
2016	Neptune Aviation; Coulson Aircrane; Aero Flite Inc.; Aero Air, LLC; 10 Tanker.
2017	Neptune Aviation; Coulson Aircrane; Aero Flite Inc.; Aero Air, LLC; 10 Tanker.
2018	Neptune Aviation; Coulson Aircrane; Aero Flite Inc.; Aero Air, LLC; 10 Tanker.
2019	Neptune Aviation; Coulson Aircrane; Aero Flite Inc.; Aero Air, LLC; 10 Tanker.
2020	Neptune Aviation; Coulson Aircrane; Aero Flite Inc.; Aero Air, LLC; 10 Tanker; Global Supertanker Services (STS).
2021	Neptune Aviation; Coulson Aircrane; Aero Flite Inc.; Aero Air, LLC; 10 Tanker.
2022	No information found.

Sources (in order by year): USDA Forest Service. U.S. Forest Service Airtanker Study Statistical Compilation, **1977–1981;** Airtanker (contracting) information for **1980–1981, 1983, 1984, 1985, and 1989**, Boise, Idaho; **2000** Schedule of Items, 02/24/2000, Forest Service; **2001** Schedule of Items, Airtankers, Effective January 16, 2001, Rev 2, 03/13/2001; **2002** Schedule of Items, Airtankers, Version 05, 07/23/2002; **2003** Schedule of Items – Airtankers, Version 05 CORRECTED, 06/02/2003; **2003** Schedule of Items, Spare Airtankers, Version 03, 07/30/2003; **2004** Schedule of Items, Airtankers, Version 2, Dated 03/19/2004; **2005** Schedule of Items for Airtankers, Section B, May 27, 2005, Version 3; **2006** Schedule of Items for Airtankers, February 1, 2006, Version 1; **2007** Schedule of Items for Airtankers, February 16, 2007, Version 01; **2008** Schedule of Items for Airtankers, Effective March 1, 2008, Version 1; **2009** Schedule of Items, Year 2, January 1, 2009; **2010** Schedule of Items, Year 3, January 1, 2010; **2011**,Schedule of Items, Year 4, January 26, 2011; **2016** Airtanker Schedule of Items, revised June 7, 2016; **2017** Airtanker Schedule of Items, revised June 29, 2017; **2018** Airtanker Schedule of Items, revised August 3, 2018; **2019** Airtanker Schedule of Items, revised April 26, 2019; **2020** Airtanker Schedule of Items, revised August 6, 2020; **2021** Airtanker Schedule of Items, revised July 22, 2021.

Airtanker pilot communicating with base personnel at Prescott Airtanker Base (date unknown). USDA Forest Service photo.

Contractors on the Forest Service National Smokejumper Aircraft Contract (2014–2022)

Leading Edge Aviation Services and Bighorn Airways, Inc., provided all contracting services for smokejumper aircraft from 2014 to 2022.

Sources: USDA Forest Service. 2015–2021. Aviation annual report; National Interagency Fire Center. 2022. National interagency mobilization guide. Information not found for other years.

Appendix D. Smokejumping History

Letter from Regional Forester Evan Kelley (July 19, 1935)

The following is a letter written in 1935 by Regional Forester Evan Kelley of the Northern Region, expressing displeasure with the idea of smokejumping. Four years after this letter was written, the Parachute Jumping Experiment showed that smokejumping was a feasible method for attacking fires in remote areas. (Source: Cohen, S. 1983. A Pictorial History of Smokejumping. Missoula, MT: Pictorial Histories Publishing Company. 180 p.)

The letter is addressed to Earl Loveridge. Loveridge was the assistant chief of the Division of Operations (which supervised the Division of Fire Control). He later became Assistant Chief in the 1940s. J.B. Bruce was a professional parachutist who collaborated with Intermountain Region Fire Control staff member T.V. Pearson. Together, they conducted parachute experiments including live jumps. In the early 1930s, they were the most vocal advocates of the possibility of delivering firefighters via parachute.

July 19, 1935

Mr. Earl W. Loveridge

Forest Service, Washington, D.C.

Dear Earl:

Enclosed is a copy of a letter from J.B. Bruce.

The file in this case is in Spokane, but for purposes of identification of this letter, I will remind you that you wrote some time ago about J.B. Bruce's scheme of dropping men from airplanes for fire fighting. Pearson of Region Four was a party to the scheme.

I am willing to take a chance on most any kind of a proposition that promises better action on fires, but I hesitate very much to go into the kind of thing that Bruce proposes. In the first place, the best information I can get from experienced fliers is that all parachute jumpers are more or less crazy – just a little bit unbalanced, otherwise they wouldn't be engaged in such a hazardous undertaking; accordingly, I discount materially the practicability of Bruce's ideas.

As applied to the average situation, in our country at least, we wouldn't have any great need for dropping men from the air; moreover, it is too risky an undertaking to experiment in. I do not want to be responsible for a lot of compensation cases which, in all probability, might develop from such experimentation in the rough mountain country where Bruce proposes to experiment.

We have had some of the experienced fliers familiar with parachute designing look over the diagram submitted by Pearson. They say that Pearson's design has merit over the regulation chutes ordinarily used today. However superior it might be it wouldn't rescue a man from hanging up on a snag or a tree top, or prevent him from falling off of a cliff if, by some mishap, he should land on such a topographical feature in his descent from a plane.

The point of my letter is that I have no hankering to assume the responsibility for men risking their lives in any such undertaking.

Of course, there are a number of other points to consider. To make the thing practicable at all we would have to have a trained bunch of parachute jumpers who also are skilled firefighters. These men would be called upon for service over a period of possibly two months a year.

I think we can use our available money very much more productively than investing in that kind of service, even admitting the practicability of the scheme. If the Washington Office wishes to carry on further experimentation in this line, it is my request that you assign the project to other quarters.

Very sincerely yours,

/s/ Evan W. Kelley EVAN W. KELLEY, Regional Forester

History of Smokejumper Equipment (1939–2015)

The following summary of the history of smokejumper equipment is adapted from the "U.S. Forest Service National Smokejumper Training Guide, 2016," pp. 1-1-12 through 1-1-13.

1939—The main parachute canopy was a 30-ft-diameter backpack, manufactured by the Eagle Parachute Company. The reserve was a 27-ft chest pack. Both parachutes were constructed so they would face into the wind automatically. They could be turned but had negligible forward speed. Both parachutes were activated by ripcords. A one-piece heavy canvas suit was tried first. A lighter, two-piece, felt padded suit proved to be more practical. A wire mask was fitted on a leather football helmet to protect the head. A cotton webbing, quick attachable harness was used. The outfit also included a wide leather and elastic belt to guard against back and abdominal injuries during parachute opening. Leather ankle braces were used over the logger style boots. One trouser leg of the suit had a pocket to carry a rope for tree letdowns.

1941—The static line was adopted.

1942—Frank and Chet Derry invented the Derry slotted parachute. These slots increased stability, turning speed, and forward speed.

1945—The FS-1 parachute was first used. This parachute was a 28-ft flat circular canopy with 7-ft Derry slots, 7 gores apart. These parachutes were manufactured by the Irving Parachute Company.

1953—Drawings for crepe paper streamers were made. The Missoula Aerial Equipment Development Center was founded. It was later changed to Missoula Equipment Development Center and then to Missoula Technology and Development Center, which was the focal center for development of smokejumper equipment.

1954—The FS-2 parachute was first used incorporating "slots and tails." This canopy was nearly identical to the FS-1 except it had material extensions on the back three gores.

1956—The FS-5, a 32-ft flat canopy with 7-ft slots and tails, was first used. The H-3 harness was also incorporated.

1960—The FS-5A was introduced. This canopy was identical to the FS-5 except that it had 10 ft. steering slots. A white nylon jump suit was adopted. Fire shelters were made available but were not required until 1978.

1963—This was the first year that D-bags were used. This greatly reduced the opening shock experienced by smokejumpers.

1969—The FS-9 was an experimental canopy. The final version was designated the FS-10.

1970—The FS-10, a military style 35 ft. parabolic canopy, was adopted. It had a 7-TU modification in back that gave it more forward and turning speed than the FS-5A. The FS-10R reserve was adopted in conjunction with the FS-10.

1977—The FS-11 was an experimental parachute which went through testing, but never made the cut.

1978—Anti-inversion netting was first used on Forest Service personnel parachutes. This netting has greatly decreased partial malfunctions and the occurrence of partial inversions has been rare in Forest Service smokejumping operations.

1980—The FS-12, a 32-ft flat circular, multiple porosity parachute was adopted. It also had Russian-style turning slots with the addition of two large drive windows.

1983—The ram-air parachute system became operational for BLM smokejumpers.

1997—After several versions of the Concept 7, the FS-14 was adopted as the Forest Service parachute. It has three sizes, small, medium, and large, which are 28 ft, 30 ft, and 32 ft in diameter, respectively. A size chart was developed for use depending on weight of the smokejumper. The new design allows for much quicker flat turns with a forward speed of 10 miles per hour.

2015—The Fire and Aviation Management director decides to begin a measured transition to a ram-air parachute system.

Decision Memo for the Move to the Ram-Air Parachute (July 1, 2015)

DECISION MEMORANDUM FOR THE DIRECTOR, FIRE AND AVIATION MANAGEMENT

FROM: Arthur W. Hinaman
Assistant Director, Aviation

SUBJECT: Implementation of Ram-Air Parachute Delivery System in Support of Continuous Improvement and Innovation in the U.S. Forest Service Smokejumper Program

FILE CODE: 5100/5700

Background

In order to improve the safety and effectiveness of our smokejumpers, the U.S. Forest Service is proposing a transition to the ram-air parachute delivery system. This transition is part of an overarching continuous improvement and innovation effort to expand the mission capability of the smokejumper program and take advantage of emerging technology. The Director, Fire and Aviation Management, has the authority to make this decision, per FSM 5704.

The environment in which U.S. Forest Service wildland firefighters operate continues to increase in complexity due to hazardous fuel build-ups; insect and disease infestations; non-native species invasions; climate change; drought; the presence of approximately 70,000 communities in the wildland-urban interface; and other factors. U.S. Forest Service and other scientists have confirmed that the number, size, intensity, and duration of wildfires have increased and that fire seasons have become longer. Many U.S. Forest Service and other scientists predict these trends to continue, with some forecasting the number of acres burned to double or triple by mid-century; fire seasons continuing to lengthen; and another 17 million housing units to be built within 30 miles of national forests, national parks, and wilderness areas by 2030.

The increasing complexity in the wildland fire environment has resulted in some sobering statistics. In 2006, 9.87 million acres of federal, state, and private land burned nationwide, the highest number of acres since 1960, as far back as reliable records go. Since 2000, more than 5,000 structures have been lost in one year three times. In 2013, a total of 34 wildland firefighters perished in the line of duty, the highest loss of life of wildland firefighters in one year since 1994.

The U.S. Forest Service must seek continuous improvement and innovation in our equipment, aircraft, training, and other areas to ensure that we maintain sufficient operational capability to meet the challenges associated with increasing complexity in the wildland fire environment. While continuous improvement and innovation can increase risk, so can stagnation in terms of potential escalating loss of lives, property, and valuable natural and cultural resources.

The U.S. Forest Service smokejumper program is an elite program, born of innovation. Of the 10,000 firefighters in the U.S. Forest Service, approximately 320 are smokejumpers. The U.S. Forest Service smokejumper program was born in 1934 when visionary Intermountain Regional Forester T.V. Pearson first proposed it as a means to quickly provide initial attack on forest fires. U.S. Forest Service smokejumpers have been leaders in innovation since the first fire jump was made in 1940 on the Nez Perce National Forest. For the last 75 years, U.S. Forest Service smokejumpers have played a vital role in wildfire suppression by providing a unique capability to deliver large numbers of highly skilled, qualified firefighters over large distances in a short amount of time. U.S. Forest Service smokejumpers are envisioned to continue to be a critical component of the U.S. Forest Service Fire and Aviation Management program in the future. It is critical to ensure that they have the appropriate equipment, aircraft, and organizational configuration to ensure that they can support the mission of getting the right assets to the right places at the right time. Based on extensive study and discussions with the smokejumper community, I believe that it is necessary to seek continuous improvement and innovation in each of these program elements, beginning with a measured transition to the ram-air parachute delivery system.

Discussion

Round parachutes, which U.S. Forest Service smokejumpers have been using since the program's inception in 1939, have reached the limits of their performance while ram-air parachute technology is still evolving. Ram-air parachutes are more maneuverable and enable smokejumpers to jump in higher winds than round parachutes. This supports an earlier response to critical wildfires, reducing the chances that they will become large, costly, and dangerous to other firefighters and the public. Investment in the ram-air parachute delivery system at this time is expected to yield further improvements in safety and efficiency in the future.

Since 2008, the U.S. Forest Service has gained extensive experience in ram-air parachute technology through a pilot program in the Northern Region (R1) and has developed the expertise to transition the agency's smokejumper program to ram-air parachute technology. Over the last seven years, approximately 55 U.S. Forest Service smokejumpers made approximately 5,000 training and operational jumps using ram-air parachutes.

Firefighter and public safety are the U.S. Forest Service's top priorities in wildland fire management. The U.S. Forest Service has gathered and thoroughly examined extensive data on injuries and fatalities experienced by smokejumpers on both round and ram-air parachute delivery systems and has concluded that a transition to the ram-air parachute delivery system will improve overall safety in the long term. Due to ram-air parachute technology allowing for slower vertical landing speeds, it is expected that the Forest Service will see a reduction in injuries to the ankles, legs and hips during parachute landings. Analysis of information from 2001 through 2014 in NTDP's parachute landing data base shows the overall likelihood of injury on any given jump is 0.33% using round parachutes and 0.21% using ram-air parachutes. The overall minor injury rate is 0.22% using round parachutes and 0.15% using ram-air parachutes. The overall serious injury rate is 0.10% for round parachutes compared to 0.06% for ram-air parachutes.

The ram-air parachutes that U.S. Forest Service smokejumpers are currently using, and will continue to use, are equipped with a reserve static line (RSL), which automatically opens the reserve container when the main parachute is cut away due to a malfunction, as well as an automatic activation device (AAD) that will automatically open the reserve container if the jumper is unable to open the primary ram-air chute.

At this time, initial investment in a ram-air parachute delivery system is estimated at approximately twice the cost of the current FS-14 system. However, procurement efficiencies on the scale of the entire program have not yet been explored. Procurement strategies will be monitored and adjusted to capitalize on costs-savings opportunities, but not at the expense of quality or safety. The handful of times that ram-air jumpers have been able to jump when others couldn't, and may have been able to suppress wildfires while they were still small, may have translated to savings equal to the cost of the entire U.S. Forest Service smokejumper program.

Alternatives

1. Seek continuous improvement and innovation in smokejumper equipment, aircraft, and organizational configuration, beginning with a measured transition to ram-air parachute technology in 2016.

2. Keep Forest Service on the round parachute delivery system and revisit parachute technology in ten years.

3. Continue the ram-air program only in Region 1 and continue to capture data on the effectiveness and efficiency of ram-air parachute technology.

Decision

The U.S. Forest Service will begin a measured transition to a ram-air parachute delivery system at smokejumper bases, to replace round FS-14 parachutes currently in use. A change management and implementation plan will be developed to start transition at the beginning of Fiscal Year 2016. There will be continual assessment and management of the associated risks of this transition.

Key to the success of this transition is to continue to support smokejumpers and their equipment throughout the transition. This includes supporting both the round parachute system and the ram-air parachute system for the duration, and ensuring that smokejumpers who do not successfully transition to ram-air are given appropriate employment assistance within the agency.

DECISION BY THE DIRECTOR, FIRE AND AVIATION MANAGEMENT:

Approve X   Date Ø1 JULY 2Ø15

Disapprove ____

Source: USDA Forest Service. USFS Ram-Air Parachute System Transition Operations Plan 2019. Appendix E, pp. 97–100.

Smokejumping References

Research for chapter 4 of this publication relied heavily on the Eastern Washington University Digital Commons. This free online resource houses dozens of publications and thousands of photos that capture the history of smokejumping. Of special note are the collection of magazines produced quarterly by the National Smokejumper Association, called *The Static Line* from 1993 until 1999, then simply *Smokejumper* from 1999 to present. Individual articles used in this publication are cited in the endnotes.

Appendix E. An Infrared Primer

This information was originally published in:

Warren, J.R.; Celarier, D.N. 1991 A salute to infrared systems in fire detection and mapping. Fire Management Notes. Washington, DC: U.S. Department of Agriculture, Forest Service. 52(3): 3–18.

Forest Service Special Infrared Requirements

The Forest Service has special infrared requirements not available on military or commercial systems:

- **Dual-band detectors**—Gives the Forest Service a unique method with about a 10-to-1 advantage in the detection of small hot spots. The target detection method and circuitry, using a special combination of two thermal bands, are not known to exist in any other systems.
- **Rectilinearization of the imagery**—Aids in the interpretation and transposing of fire features to maps. (The interpretation task is still performed manually and requires specially trained interpreters.) The scale of imagery is different in both the X and Y dimensions from the scale of the maps, and the X scale of imagery is constantly changing in a nonlinear manner.
- **Roll compensation and mileage markers**—Assists in making images more useful and easily interpreted.
- **DC (direct current) response-coupled systems rather than AC (alternating current) coupled systems**—Prints terrain features of low thermal differences quickly, following exposure to extended high temperatures of 600 °C or more. (With DC coupling, the imagery is “washed out” around very hot areas, precluding accurate location of the firefront position with respect to firebreaks, roads, and other identifiable features.)
- **Target detection circuitry**—Through a special circuitry mentioned under “dual-band detectors,” gives the capability of detecting very small hot spots (capability of detecting a hot spot of 600 °C as small as 0.0225 square meter (0.24 ft2) against instantaneous terrain background variations between 0 to 50 °C from 5,000 meters (16,404 ft) altitude).
- **Rapid processing of imagery on board aircraft**—Produces good quality images to ensure the fire is adequately covered and to minimize aircraft and crew operational time. (Fire staff needs to have imagery interpreted within 1 hour of flight over active fire.”
- **Large total field of view**—Covers large areas in a short time for detection missions and large fires in a single frame of imagery, rather than a mosaic, for mapping missions.

Inaccurate Ideas About Infrared

1. **Thermal IR imagery is like black-and-white photography**. Thermal IR images resemble black-and-white photos or black-and-white television, but the images represent radiated energy levels in the thermal IR part of the electromagnetic spectrum, not reflected energy levels in the visible part of the spectrum. Some thermal IR images look somewhat like black-and-white pictures, but others look completely different.
2. **IR imagery should be as good in the daytime as it is at night**. At night, all the energy received in the thermal IR bands is radiated energy, giving a true indication of temperature levels (when emissivity is accounted for). In the day, in addition to the radiated energy, reflected solar energy and energy radiated from solar-heated rocks or bare spots may be confused with fire spots.
3. **IR imagery is just like film—everything is right where you see it**. IR imagery from the line scanners always has terrain distortions. FLIR imagery also can contain similar distortions but usually to a much smaller degree. When “looking” straight down or at a low angle, the distortion is much less.
4. **One brand of IR “sees” through moisture or clouds better than another brand**. IR systems, whether line scanner, FLIR, or other type, are all subject to the same laws of physics, including atmospheric attenuation of IR energy. For this condition, various brands do not differ much, as has been shown in side-by-side demonstrations.
5. **All IR systems are just alike; it doesn’t matter which type is ordered**. (Converse of number 4.) Design concepts and designs of various types of IR systems differ appreciably. Some are better suited for certain applications and conditions than others. The best choice can usually be made by considering the situation and conditions and choosing the type of IR system based on its capabilities and limitations.

The 10 Most-Asked Questions on Infrared

After a quick review of the answers to these ten questions, you'll know more about infrared technology than most people do.

1. **What is infrared radiation?** Infrared radiation is electromagnetic radiation with wavelengths longer than those of the visible part of the spectrum and shorter than radio or microwave frequencies.
2. **Does an object have to be "hot" to emit infrared radiation?** No. All objects emit infrared radiation, which is related to the temperature of the object. Only at absolute zero (-273 °C) will an object cease to emit any radiation.
3. **Does the amount of infrared radiation vary with temperature?** Yes. Infrared radiation is emitted over a wide band of wavelengths, but the amount of energy emitted at any one wavelength increases as the temperature is increased.
4. **What is a blackbody?** A blackbody is an object that completely absorbs all of the radiant energy striking it; that is, it is a perfect absorber, and also emitter of energy.
5. **What is emissivity?** Emissivity is the ratio of the radiant energy emitted by an object at temperature T to the radiant energy emitted by a blackbody at temperature T.
6. **What is the relationship between emissivity, reflectivity, transmissivity, and absorptivity?** All radiant energy striking an object must be either absorbed, reflected, or transmitted (on through the object). The sum of energy absorbed (A), reflected (R), and transmitted (T) must equal 100 percent of the total incident energy: $A + R + T = 1$
7. **Are the FLIRs and IR line scanners basically IR cameras?** No. Thermal IR sensors are not cameras. They do not directly expose film to electromagnetic energy and do not depend on reflected energy for their usefulness. They are fairly sophisticated electro-optical instruments, displaying information from a part of the electromagnetic spectrum that we do not perceive without instruments.
8. **Can we determine temperatures with IR?** Yes and no. Temperatures can be determined with IR under some conditions using special instruments usually called radiometers, but in the usual application of thermal IR for fire purposes temperature cannot be determined. We can, however, distinguish relative temperature differences.
9. **Does white indicate hot or cool areas?** Either—with most forward-looking infrared (FLIR) systems. Usually, the user selects the polarity of the video display so that either white or black may indicate hot areas.
10. **Can we "see" through clouds and smoke?** Most thermal IR systems "see" fairly well through smoke but not well at all through clouds.

ENDNOTES

Chapter 2. Early History Through 1930s

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9 Ibid.
10 Ibid, p. 133. Regarding the fatality, the only recorded fatality that comes close is Everett S. Wisdom. Army records list Wisdom as crashing on May 30, 1919, flying a JN-4 from Rockwell Field in Coronado, CA, and crashing at Mussey Canyon, CA, near the Cleveland National Forest. The records say that he "hit [a] mountain in flight."
11 Ibid, pp. 133–136.
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18 Brown, Sr., W.S. 1945. History of the Modoc National Forest. San Francisco, CA: U.S. Department of Agriculture, Forest Service, California Region. p. 69. Robie is the first documented Forest Service aviation fatality. This has been overlooked internally. Forest Service accident records start at 1940. Also the director of Fire Control wrote in a 1940 article in Fire Control Notes that no fatalities had occurred in Forest Service aviation. See Headley, R. 1940. Wings and parachutes over the national forests. Fire Control Notes. U.S. Department of Agriculture, Forest Service. 4(4): 183.
19 (1) Hardy, p. 23. Hardy cites the crash without names. (2) The Timberman Magazine. July 1920. p. 40. Reports vary on the exact names of those who perished in the crash. The Timberman Magazine in 1920 lists Sergeant Wayman Haney, Corporal Antonio A. Salcido, and Harold Robie. An American Forestry article in 1920 lists Sergeant Wayman T. Haney, Corporal Salcida, and Forest Guard Benjamin H. Robie. The Modoc National Forest History compiled in 1945 lists Sergeant Wayman Haney, Corporal A.A. Salcido, and Forest Observer Harold B. Robie. Accident-report.com, a website that includes military accident records, lists Sergeant Wayman Haney, Benjamin H. Robie, and doesn't include the Salcido. A July 23, 1920, edition of the Coconino Sun (Flagstaff, AZ) announces the death of Salcido and gives his name as: Corporal Antonio Salcido. Based on all these sources, the authors decided that the following names are most likely to be correct: Sergeant Wayman Haney, Corporal Antonio Salcido, and Benjamin H. Robie.
20 Maurer, pp. 136–137.
21 Ibid.
22 Ibid, p. 137.
23 Ibid, pp. 137–138.
24 Ibid, p. 138.
25 Ibid.
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27 Hardy, pp. 7–36.
28 Ibid, p. 37.
29 Ibid, p. 42.

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32 Ibid, p. 40.
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34 Ibid.
35 Ibid, p. 42.
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37 Ibid, p. 50.
38 Ibid.
39 Hardy, pp. 51–52.
40 San Pedro News Pilot. September 21, 1928. Vol. 1, No. 172.
41 Hardy, pp. 42, 73.
42 Ibid, pp. 45–46, 48.
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48 Ibid, p. 74.
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51 Ibid, pp. 75, 77, 82–83, 94.
52 Ibid, pp. 85–86.
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67 (1) Pyne, p. 371. (2) USDA Forest Service. 1950. History of smoke jumping, 1939–49. Fire Control Notes. Washington, DC. 11(3): 2.
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Chapter 3. Major Programmatic Events

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7 USDA Forest Service. 1968. Annual fire report 1967. Washington, DC. pp. 5–6.
8 USDA Forest Service. 1969. Annual fire report 1968. Washington, DC.
9 USDA Forest Service. 1973. Aircraft use report. Washington, DC.
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24 Chambers, p. 8.
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Chapter 4. Smokejumping

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10 History of smoke jumping, 1939–49, p. 4.
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14 Hardy, p. 107.
15 Moody, p. 15.
16 History of smoke jumping, 1939–49, p. 4. It is fair to say that the Forest Service smokejumper program preceded U.S. Army paratroopers. The Army used some parachutes in World War I as a pilot escape mechanism. During the 1930s, the Russian and German military developed paratroop units with the Germans jumping in the early days of World War II (June 1940). The U.S. Army credits its first jump in June 1940. A key to the relationship between the Forest Service and Army in 1940 is that the Army wanted to understand how to select, equip, and train their parachute trainees. The Forest Service had already figured this out and the Army then modeled their equipment and training largely on the Forest Service's program. A huge difference was that—except for a few special units—the Army's plan was to drop a large number of paratroops in an open area rather than "rough entry" parachuting.
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Chapter 5. Airtankers

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Chapter 6. Aerial Supervision

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ACRONYMS

AAD – automated activation device
AAHS – American Aviation Historical Society
AAR – after action review
AD – Airworthiness Directive
AFUE – Aerial Firefighting Use And Effectiveness [Report]
AGL – above ground level
AMC – Aviation Management Council
AMS – autonomous modular sensor
AOBD – air operations branch director
ASM – aerial supervision module
ATGS – air tactical group supervisor
ATP – air tactical pilot
BIFC – Boise Interagency Fire Center
BLM – Bureau of Land Management
CDF – California Department of Forestry
CFR – Code of Federal Regulations
CMIP – change management and implementation plan
CWN – call-when-needed
DAID – delayed action ignition device
DARPA – Defense Advanced Research Projects Agency
DOD – Department of Defense
DOI – Department of the Interior
DOT – Department of Transportation
DRTI – distributed real-time infrared
EHELL – emergency human extraction by longline
EO – electro-optical
ESA – Endangered Species Act
EU – exclusive-use
EWU – Eastern Washington University
FAA – Federal Aviation Administration
FEMA – Federal Emergency Management Agency
FEPP – Federal Excess Personal Property [Program]
FLAME – Fire Logistics Airborne Mapping Equipment
FLIR – forward-looking infrared
FS – Forest Service
FSH – Forest Service Handbook
FSM – Forest Service Manual
FTA – fire traffic area
FWS – Fish and Wildlife Service
FY – fiscal year
GACC – Geographic Area Coordination Center
GACG – Geographic Area Coordinating Group
GAO – Government Accountability Office
GPS – Global Positioning System
GSA – General Services Administration
HAA – Helicopter Association of America
HAEP –Historical Aircraft Exchange Program
HLCO – helicopter coordinator
IAB – Interagency Airtanker Board
IAIU – Interagency Aerial Ignition Unit
IC – incident commander
ICAP – Interagency Committee on Aviation Policy
ICP – incident command post
IFPM – Interagency Fire Program Management [Standard]
IHOG – Interagency Helicopter Operations Guide
INFANT – Iroquois night fighter and night tracker
IP – initial point
ISMOG – Interagency Smokejumper Operations Guide
IQCS – Incident Qualifications and Certification Systems
IR – infrared
JPADS – Joint Precision Airdrop System
LAT – large airtanker
LEI – Law Enforcement and Investigations
LFO – large fire organization

ACRONYMS

MAFFS – Modular Airborne Firefighting Systems
MMA – multi-mission aircraft
MOU – memorandum of understanding
MSL – mean sea level
MTDC – Missoula Technology and Development Center (now NTDP)
NAFTA – North American Free Trade Agreement
NASA – National Aeronautics and Space Administration
NATS – National Airtanker Study
NCSB – North Cascades Smokejumper Base
NDAA – National Defense Authorization Act
NEPA – National Environmental Policy Act
NFACG – National Fire Aviation Coordination Group
NFFE – National Federation of Federal Employees
NFMAS – National Fire Management Analysis System
NFS – National Forest System
NIAC – National Interagency Aviation Committee
NIFC – National Interagency Fire Center
NIROPS – National Infrared Operations
NM – nautical miles
NMAC – National Multi-Agency Coordinating Group
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NPS – National Park Service
NSA – National Smokejumper Association
NSHOS – National Short-Haul Operations Subcommittee
NTDP – National Technology Development Program
NTE – not-to-exceed
NTSB – National Transportation Safety Board
NVG – night vision goggles
NWCG – National Wildfire Coordinating Group
OAS – Office of Aviation Services
ODF – Oregon Department of Forestry
OIG – Office of Inspector General
OMB – Office of Management and Budget
ORE – operational retardant evaluation
OSC – operations section chief
OSHA – Occupational Safety and Health Administration
PMS – publications management system
PNW – Pacific Northwest
PSD – plastic sphere dispenser
PSW – Pacific Southwest
PVE – pyroelectric units
QA – quality assurance
RAC – Redmond Air Center (Redmond, OR)
RAISC – Ram-Air Implementation Steering Committee
RAOP – Ram-Air Parachute Systems Operations Plan
RATT – ram-air transition trainee
SAFECOM – Safety Communiqué
SAP – safety action plan
SASEB – Smokejumper Aircraft Screening and Evaluation Board (now SASES)
SASES – Smokejumper Aircraft Screening and Evaluation Subcommittee (formerly SASEB)
SEAT – single-engine airtanker
SIA – safety impact analysis
SME – subject matter expert
SMS – Safety Management Systems
SW – Southwest
TARMS – Tactical Aerial Resource Management Study
TDM – target discrimination module
TFR – temporary flight restriction
TIS – time in service
UAS – unmanned aircraft system
USDA – United States Department of Agriculture
USFS – United States [USDA] Forest Service
USGS – United States Geological Survey
VLAT – very large airtanker
WCF – working capital fund
WO – Washington Office

The important role of aircraft in wildland firefighting is undisputed. Aircraft have often been displayed in conjunction with Smokey Bear, the well-known mascot of the advertising campaign to prevent wildfires. Smokey's message is one of the longest running public service announcement campaigns in U.S. history. In the above photo, a young Smokey Bear, a bear cub rescued from a forest fire, is perched on the nose of a State of New Mexico Department of Fish and Game Piper PA-12 Super Cruiser in 1950. The airplane was used to transport Smokey to a veterinarian in Santa Fe. USDA Forest Service photo, Smokey Bear Collection.*

Kaman HH-43 Huskie helicopter in a parade with Smokey Bear. Date and location unknown. USDA Forest Service photo.

GLOSSARY

Aerial ignition – Ignition of fuels by dropping incendiary devices or materials from aircraft.

Aerial supervision – Coordination and direction of tactical aircraft engaged in dropping suppressants on wildfires.

Aerial supervision module – A functional unit assigned to wildfires made up of a qualified and current leadplane pilot and air tactical supervisor.

Agency – Any Federal, State, or county government organization with jurisdictional responsibilities.

Air attack – Deployment of fixed-wing and/or rotary aircraft on a wildland fire to drop retardant or extinguishing agents, shuttle and deploy crews and/or supplies, or perform aerial reconnaissance. Also refers to a person in an airplane who coordinates aerial firefighting and provides information to forces on the ground during a wildland fire.

Air patrol – A mission in which aircraft are flown over an area for the purpose of detection—in the case of the Forest Service, for detecting wildfires. In the early days of aviation, air patrol was performed for the Forest Service by military cooperators.

Air tactical – Another term for "air attack."

Airfield – An area of land designated for the takeoff, landing, and/or maintenance of aircraft. Also referred to as an airstrip or landing field.

Airtanker – An airplane equipped with tanks for carrying and dropping water or retardant during aerial firefighting operations.

Airtanker lead – Aircraft and pilot used to make "dry runs" over a target area to check wing and smoke conditions, topography, and to lead airtankers to targets and supervise their drops. Also referred to as a leadplane and leadplane pilot.

Autogyro – A type of rotary-wing aircraft that predates the modern helicopter. An unpowered rotor moves in free autorotation to develop lift; forward thrust is provided by a separate engine-driven propeller. Also spelled "autogiro." Also known as a gyroplane or gyrocopter.

Bambi Bucket – A collapsible bucket slung below a helicopter and used to dip water from a variety of sources for fire suppression.

Biplane – An early type of airplane with two pairs of wings, usually one above the other.

Detail – A temporary assignment for a given period of time, often 120 days.

Detection – The act or system of discovering and locating fires.

Empennage – An arrangement of stabilizing surfaces at the tail of an aircraft.

Firebombing – A term once used for dropping water or other substances onto a wildfire as a firefighting measure.

Fireline – A linear fire barrier that is scraped or dug to mineral soil.

FireWatch Program – A program in operation from 2002 to 2021 using Cobra helicopters in missions including air attack, leadplane, and providing video mapping of wildland fires.

Fuselage – The main body of an aircraft.

Great Basin – A geographic area roughly bounded by the Sierra Nevada Mountains on the west, the Rocky Mountains on the east, the Snake River to the north, and the Mojave Desert to the south. Parts of Nevada, Utah, California, Oregon, Idaho, and Wyoming fall within the Great Basin.

Heavy helicopter – A helicopter is categorized based on the payload it is capable of lifting. A "heavy" helicopter (or "heavy-lift" helicopter) is able to lift up to 5,000 pounds (based on elevation and temperature) or carry up to 700 gallons of retardant or water. They are the largest helicopters, able to seat 15 or more passengers. An example is the Boeing CH-47 Chinook. Heavy, medium, and light categories have since been replaced with NWCG typing: type 1, type 2, and type 3.

Helibase – The main location within a general incident area for parking, fueling, maintaining, and loading helicopters.

Helibucket – A bucket suspended from a helicopter and used for dropping water or fire retardant during firefighting operations. Same as "helicopter bucket."

Helicopter coordinator – A position in the incident command system responsible for coordinating helicopter mission(s), ensuring safe operations and communication.

Helicopter manager – (Previously "helicopter foreman.") An individual with the required background and qualifications to manage the operation of a helicopter, including those on exclusive-use or call-when-needed contracts or used for resource missions. Helicopter managers are often the government representative on scene during helicopter operations to ensure contract compliance.

Helijumper – An aerially delivered firefighter using the *helijumping* technique. Also referred to as a smokehopper.

Helijumping – A technique used by the Forest Service from the 1950s through the mid-1970s in which firefighters in specially padded suits would jump from a hovering helicopter in order to initial attack a wildfire. The technique was eventually discontinued and replaced by *helirappelling*.

Helirappelling – *See* definition for *rappel*.

Helishot crew – Synonymous with *helitack crew;* no longer in use

Helispot – A temporary landing spot for helicopters.

Helitack – The use of helicopters to transport crews, equipment, and/or fire retardants or suppressants to the fireline during the initial stages of a fire.

Helitack crew – A group of firefighters trained in the technical and logistical use of helicopters for fire suppression.

Helitank – A specially designed tank, generally of fabric or metal, fitted closely to the bottom of a helicopter and used for transporting and dropping suppressants or fire retardants.

Helitanker – A helicopter used to drop water or retardant on a wildfire.

Hose lay – An arrangement of connected lengths of fire hose and accessories on the ground, beginning at the first pumping unit and ending at the point of water delivery.

Hover-fill – The ability of a helicopter equipped with either a fixed tank or bucket to hover over a water source and fill the container using a pump and suction.

Human-aiding technology – Technological tools that enhance human awareness, understanding, and efficiency.

Incident command system (ICS) – A combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure, with responsibility for the management of assigned resources to effectively accomplish objectives pertaining to an incident.

Initial attack – Actions taken by the first resources to arrive at a wildfire to protect lives and property and prevent further extension of the fire.

Infrared detection and mapping – The use of heat sensing equipment, known as infrared scanners, for detection and mapping of heat sources that are not visually detectable by the normal surveillance methods of either ground or air patrols.

Jet engine – An engine using jet propulsion for forward thrust, mainly used for aircraft. *See* also *turbine engine*.

Jump zone – Selected landing area for smokejumpers. Also referred to as a jump spot.

Knot – Standard measurement of aircraft speed equal to 1.15 miles per hour.

Large fire organization (LFO) – A precursor to the incident command system.

Leadplane – Aircraft with pilot used to make dry runs over the target area to check wing and smoke conditions, topography, and to lead airtankers to targets and supervise their drops.

Light helicopter – A helicopter is categorized based on the payload it is capable of lifting. A "light" helicopter (or "light-lift" helicopter) is able to lift up to 1,200 pounds (based on elevation and temperature) or carry up to 100 gallons of retardant or water. They are the smallest helicopters, able to seat up to eight passengers. An example is the Bell 407. Heavy, medium, and light categories have since been replaced with NWCG typing: type 1, type 2, and type 3.

Medium helicopter – A helicopter is categorized based on the payload it is capable of lifting. A "medium" helicopter (or "medium-lift" helicopter) is able to lift up to 2,500 pounds (based on elevation and temperature) or carry up to 300 gallons of retardant or water. They are mid-sized helicopters, able to seat 9-14 passengers. An example is the Bell 212. Heavy, medium, and light categories have since been replaced with NWCG typing: type 1, type 2, and type 3.

Mixed load – A smokejumper flight comprised of personnel equipped with a mix of square and round parachutes.

Modular Airborne Firefighting Systems (MAFFS) – A portable, self-contained unit—pressurized retardant tanks and associated equipment—that can be loaded onto a C-130 military cargo transport airplane allowing it to be used as an emergency backup airtanker.

Monoplane – An airplane with one set of wings.

Overhead – Personnel assigned to supervisory positions, unit leaders, managers, and other specialists assigned to wildfires or other emergency situations; overhead play a key role in fire suppression but are not directly involved in performing activities on the fireline.

Pat Kelly videotapes the Skyhook Fire on the Mt. Hood National Forest using state-of-the-art videotape recording equipment in 1971. Fire Behavior Officer John Dell dictates a simultaneous voice recording to share with fire strategists on the ground. USDA Forest Service photo by Jim Hughes.

Paracargo – Equipment and/or supplied dropped from an aircraft by parachute or free fall.

Piston engine – An engine powered by pistons, short cylinders that move up and down in a closely fitted tube. As a piston moves down, it draws in fuel and air though an intake valve. The intake and exhaust valves close and the piston moves up, compressing the fuel-air mixture. The fuel-air mixture is then ignited by an electrical spark and expands. The force of this expansion drives the piston back down, which turns the crankshaft and propeller. When the piston reaches the bottom of the tube, the exhaust valve opens and the piston moves back up, pushing the burned fuel-air mixture out. Similar to most automobile (internal combustion) engines.

Place – Measurement of normal passenger seating capacity in an aircraft. For example, "6-place" means a six-passenger seating capacity.

Rappel – A method of aerial delivery of firefighters in which they descend from a rope attached to a helicopter. Also referred to as *helirappelling.*

Reconnaissance – To examine a fire area—often from the air—to obtain information about current and probable fire behavior and other related fire suppression information.

Retardant – A aerially applied substance used to slow down or stop the spread of wildfire or reduce its intensity.

Scouting – An earlier term for *reconnaissance*.

Short-haul – A medical extraction technique in which an injured or ill person is air-lifted by helicopter from a remote location and transported the shortest possible distance to medical/transportation resources.

Sling load – Any cargo carried beneath a helicopter and attached by a longline and swivel.

Smokechaser – An early term no longer used for an initial attack firefighter who seeks out or "chases" the smoke of wildfires and attempts to control any discovered fire before it gets large.

Smokejumper – A firefighter who travels to fires by aircraft and parachute.

Smokejumper aircraft – An aircraft used during smokejumping operations.

Smokejumping – A technique first developed in the late 1930s for delivering firefighters to wildfires by aircraft and parachutes.

Smokeslider – An early term no longer used for *helirappelling*.

Spike base – A site for conducting smokejumper operations on a temporary basis.

Spotter – In smokejumping and rappelling, the person responsible for selecting drop targets and/or landing zones and supervising all aspects of the drop or descent.

Turbine engine – An engine in which air is compressed in the front then sprayed with fuel and ignited. The burning gases then expand and blast out the back of the engine. As the gases shoot backward, the engine and aircraft are thrust forward. Turbine engines are generally more reliable and powerful than piston engines.

Suppressant – An agent, such as water or foam, used to extinguish the flaming and glowing phases of combustion when directly applied to burning fuels.

Water scooper – An amphibious aircraft that skims the surface of a body of water while in flight, "scooping" up water into an onboard tank and then dropping it on a wildfire.

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Patrick J. Kelly

Pat holds a Bachelor of Science degree in history from Eastern Oregon College (1968) and served as a combat infantryman in the 101st Airborne Division in Vietnam (1969). His 30-year career in the Forest Service included a multitude of assignments at all levels of the organization.

Pat's career path included assignments as a wildland firefighter, aerial observer, fire dispatcher, and assistant fire management officer on the Hood River Ranger District, Mount Hood National Forest; assistant fire coordinator for the Pacific Northwest Region; assistant fire staff officer and forest aviation officer on the Mount Hood National Forest; fire management officer on the Wallowa Fire Zone, Wallowa-Whitman National Forest; fire coordinator and training officer for the Intermountain Region; manager of the Redmond Air Center on the Deschutes National Forest; and the regional aviation officer for the Pacific Northwest Region. Pat's culminating position in the agency was as assistant director, aviation in Washington, DC.

Pat's service in the Forest Service included international assignments in southern Africa and Canada. Since 2000 Pat has consulted from his home in Portland, OR, on fire and aviation management topics for nonprofit and government organizations with a variety of clients, including the U.S. Congress, National Academy of Public Administration, Brookings Institution, U.S. Department of the Interior agencies, wildland firefighting agencies in France and Australia, and the USDA Forest Service. He has authored or co-authored over 35 publications.

Jonathan M. Rollens

Jon began his career as a seasonal firefighter in Wyoming for the Bureau of Land Management. After his first season on an engine crew, he began working on a helitack crew and spent the rest of his career in aviation-related positions. In 1988 Jon received an appointment with the Forest Service, serving as assistant supervisor, then supervisor, of a rappel crew in Oregon. In 1994 he became the helicopter operations specialist in the Intermountain Region, then moved to the National Office in the position of aerial attack systems specialist in Boise, ID. From there, he did a tour in Washington, DC, as an aviation management specialist before moving to the Pacific Northwest Region as the regional aviation officer in 2003. In 2011 Jon was hired by the National Park Service, retiring as the aviation branch chief in December 2017.

Peggy Rollens, Editor

Peggy has served as a writer/editor on many aviation-related reports for the Forest Service as a contractor since 2014. Her most recent projects include reports for the National Aviation Strategic Planning Branch, smokejumper program, and unmanned aerial systems program. She was also the writer/editor for a report on fire season preparedness for the Pacific Northwest Region in 2020. In her younger days, she worked briefly for the Forest Service as a fire warehouse operator, engine and helitack crew member, fire dispatcher, and then as a writer/editor for Hells Canyon National Recreation Area. This history of aerial firefighting is the most extensive—and perhaps most interesting—project she's completed for the Forest Service, and she hopes that readers will enjoy and benefit from it.

A HISTORY OF THE USDA FOREST SERVICE AVIATION PROGRAM