Against the Wind

90 Years of Flight Test in the Miami Valley

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History Office
Aeronautical Systems Center
Air Force Materiel Command

FOREWORD

Less than one hundred years ago, Lord Kelvin, the most prominent scientist of his generation, remarked that he had not "the smallest molecule of faith" in any form of flight other than ballooning. Within a decade of his damningly pessimistic statement, the Wright brothers were routinely puttering through the skies above Huffman Prairie, pirouetting about in their frail pusher biplanes. They were there because, unlike Kelvin, they saw opportunity, not difficulty, challenge, not impossibility. And they had met that challenge, seized that opportunity, by taking the work of their minds, transforming it by their hands, making a series of gliders and, then, finally, an actual airplane that they flew. Flight testing was the key to their success.

The history of flight testing encompasses the essential history of aviation itself. For as long as humanity has aspired to fly, men and women of courage have moved resolutely from intriguing concept to practical reality by testing the result of their work in actual flight. In the eighteenth and nineteenth century, notable pioneers such as the French Montgolfier brothers, the German Otto Lilienthal, and the American Octave Chanute blended careful study and theoretical speculation with the actual design, construction, and testing of flying vehicles.

Flight testing really came of age with the Wright brothers who carefully combined a thorough understanding of the problem and potentiality of flight with—for their time—sophisticated ground and flight-test methodologies and equipment. After their success above the dunes at Kitty Hawk, North Carolina on December 17, 1903, the brothers determined to refine their work and generate practical aircraft capable of routine operation. Out of their work and its subsequent inspiration can be traced the history of all subsequent powered winged vehicles, just as the lineage of all sophisticated rockets and missiles can be traced back to the work of Robert Goddard in the 1920's.

The Miami Valley has always occupied a special place in the hearts of aviation enthusiasts, for it was here that the great revolution in powered flight that transformed the world was first conceptualized and successfully pursued. Today, the scientists and engineers working amid the sophisticated laboratories at Wright-Patterson Air Force Base toil under skies that witnessed the passage of a host of aeronautical pioneers: the Wrights themselves, "Shorty" Schroeder, Thurman Bane, Jimmy Doolittle, Lee Tower, Al Boyd, Chuck Yeager, Jesse Jacobs, Bob Ettinger, Pete Knight, "Peet" Odgers, to list just a few. The history they and many others made has taken aviation from the wood and fabric biplane droning along at forty miles per hour to blended-body hypersonic conceptualizations of transatmospheric aerospace planes of the present day.

Today, few would openly speak of limits to the future of flight, for those who have—as with Kelvin—have been proven equally naive. Likewise, those who have often confidently predicted some great advance have found—to their pleasure—that the reality of aviation progress has most often outstripped their most optimistic predictions. Between this Scylla of pessimism and Charybdis of optimism, however, lies one eternal truth: whatever progress is made (and whatever limits are challenged and overcome) will be done so by the courage of the flight testers and flight researchers who follow in the wake of all those who have gone before.

Dr. Richard P. Hallion
Air Force Historian

PREFACE

Against the Wind is about flight testing in the Miami Valley. It is a story that begins with the Wright brothers on Huffman Prairie and concludes with the transfer of the 4950th Test Wing from Wright-Patterson Air Force Base to the Air Force Flight Test Center, Edwards Air Force Base, California. This book recounts one of the most interesting and important episodes in the history of American airpower, one in which Dayton and the Miami Valley have played a significant and proud role.

Test flying began in Dayton, Ohio, in 1904, a year after the Wright brothers' first flight, when they moved their flying experiments from the sand dunes of Kitty Hawk to the grassy hummocks of Huffman Prairie, now part of Wright-Patterson Air Force Base. The Wrights sold the Army its first aircraft in 1909 and in the years before World War I trained many a future Army aviator in their flying school on Huffman Prairie. The war cemented Dayton's relation with military aviation when McCook Field was established just north of downtown on the banks of the Great Miami River.

Chapter 1 begins with McCook Field and the "golden age" of flight testing. It proceeds to sketch the history of flight testing at Wright Field during the 1930s through World War II. Beginning with the war, much aircraft prototype testing was transferred to Muroc Field—later Edwards AFB—California. Meanwhile, the Wright Field—from 1948 the Wright-Patterson AFB—flight test mission was enlarged with the addition of all-weather testing. Chapter 2 discusses the all-weather test mission as well as assorted other projects undertaken by the Flight Test Division in the 1950s and 1960s. In 1970 the flight test mission became a wing activity with the establishment of the 4950th Test Wing at Wright-Patterson. Chapter 3 discusses the far-ranging activities of the 4950th from the early 1970s through the early 1990s. Chapter 4 looks behind the flight test mission proper to the contribution of the aircraft modification community to flight testing, from McCook Field to the present. Finally, Chapter 5 presents a pictorial overview of personnel engaged in "functional support" activities of the present-day Test Wing.

This book originated over a year ago in a suggestion by Col. John K. Morris, the commander of the 4950th Test Wing, for a short history summarizing the accomplishments of the modern Test Wing as it prepared to transfer its flying mission to Edwards AFB. Little by little the project grew and the present book took shape.

A book of this size could not have been written in so short a time without the combined energies of ASC's History Office staff. Dr. James F. Aldridge wrote much of Chapter 1. Assisting him with specialized topics placed in "boxes" were Dr. Dean C. Kallander, Dr. Paul C. Ferguson, and the undersigned. In addition to their work on Chapter 1, Dr. Kallander wrote Chapter 2; Dr. Aldridge wrote Chapter 4; and Dr. Ferguson wrote Chapter 5, contributed a box to Chapter 4, and compiled the index. Lt. Col. Laura N. Romesburg, a reservist, wrote Chapter 3. Dr. Henry M. Narducci wrote Appendix 3 on Test Wing facilities. Ms. Corrine J. Erickson, the History Office's editorial assistant, helped compile all front and back matter and edited the entire text.

The departure of the 4950th Test Wing marks the end of an era for Dayton and the Miami Valley. For over seventy years the skies above Huffman Prairie have been alive with the buzz of flight test aircraft. All this comes to an end in March 1994. This book hopes to capture some small part of that story. It will not be the last word.

Diana G. Cornelisse
Chief, ASC History Office
February 1994

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CHRONOLOGY

1903 December 17	Orville Wright makes man's first sustained flight in a powered heavier-than-air craft.
1904-1905	The Wright brothers flight test their A and B model Flyers from Huffman Prairie, northeast of Dayton, Ohio.
1910 -1916	The Wright brothers conduct a flight training school near Simms Station by Huffman Prairie.
1912	Wilbur Wright dies of typhoid fever.
1917 April 6	The United States enters World War I.
1917 May	The Army establishes Wilbur Wright Field, northeast of Dayton, Ohio, for flight training Army aviators.
1917 July	The Army decides to build temporary installation north of Dayton, Ohio, to conduct aeronautical research and development.
1917 December	McCook Field begins operations.
1918	The Packard-Le Pere LUSAC-11 is built and flight tested at McCook field.
1918	Roland Rohlfs sets an American altitude record of 28,900 feet in Wasp triplane.
1918 August	Col. Thurman Bane is assigned to McCook Field to oversee technical liaison activities between the Department of Military Aeronautics' Technical Section and the Bureau of Aircraft Production.
1918 November 11	Armistice on the Western Front marks end of hostilities in World War I.
1919 January	Colonel Bane assumes command of McCook Field.
1919-1920	Maj. Rudolph William "Shorty" Schroeder is the Army's chief test pilot at McCook Field.
1920 February 27	Major Schroeder pilots a Packard-Le Pere LUSAC-11 into the stratosphere.
1921	Lt. Harold Harris makes a high altitude flight in "pressurized cockpit".
1922 December 18	Colonel Bane pilots the de Bothezat helicopter on its maiden flight.
1923 May 2	McCook test pilots Lt. John A. McCready and Lt. Oakley G. Kelly make the first non-stop transcontinental flight in a Fokker T-2 and win the Mackay Trophy.
1923 July	Dr. W. Frederick Gerhardt pilots his Cycleplane at McCook Field.
1923 August 22	Harold Harris and Lt. Muir S. Fairchild pilot the Barling Bomber on its maiden flight from Wilbur Wright Field.
1924	Air Races are held at Wilbur Wright Field.
1924 March	Lt. James H. "Jimmy" Doolittle conducts a series of structural flight tests in a Fokker PW-7.

1925	Lt. Jimmy Doolittle returns in triumph to McCook having won the Schneider Cup from the Navy in a seaplane race.
1925	The Fairfield Air Depot assumes operation of the Air Service's Model Airway System.
1926 April 16	Ground is broken for Wright Field.
1927 October 12	Wright Field is dedicated.
1931 July 1	Patterson Field is established.
1941	Building 206, Patterson Field, is built as an aircraft repair facility.
1941 December 7	Japanese attack Pearl Harbor; United States enters World War II.
1942	The Materiel Command is established at Wright Field.
1942 February 17	477th Base Headquarters and Air Base Squadron (Reduced) move from Wright Field to Muroc Army Air Base, California.
1943	Hangars 1 and 9, Wright Field, are built for aircraft installation and modification.
1943	Building 5, Wright Field, is constructed to house aircraft modification shops.
1944	The Materiel Command merges with the Air Service Command to form the Air Technical Service Command.
1944	Building 4, Wright Field, is constructed for "accelerated" aircraft modification.
1944 October	WASP pilot Ann Baumgartner becomes the first woman to fly the XP-59A jet aircraft in a test flight at Wright Field.
1945	Col. Albert Boyd becomes chief of the Flight Test Division, Air Technical Service Command, Wright Field.
1945	The All Weather Flying Group is established at Wright Field.
1945	The All Weather Flying Group becomes a center operating from Clinton County Army Air Field, near Wilmington, Ohio.
1945 December	The All Weather Flying Center is transferred to Lockbourne Army Air Field.
1946	The Air Technical Service Command is redesignated the Air Materiel Command.
1946	The All Weather Flying Center returns to Clinton County Air Field and is redesignated a division.
1946-1948	The All Weather Flying Center/Division conducts the "On-Time Every-Time Air Line" between Clinton County AFB and Andrews AFB, Maryland.
1947 September	The Department of the Air Force is established.
1948 January 13	Wright and Patterson Fields are redesignated Wright-Patterson AFB.
1948-1949	All Weather Flying Division personnel conduct air traffic control for the Berlin Airlift.
1949 July 14	A C-82 Packet crashes into a parking lot, Area B, at Wright-Patterson AFB.

1949 September	Col. Albert Boyd becomes the commander of Muroc AFB, California.
1949 December 5	Muroc AFB is renamed Edwards AFB.
1950	The Wright Air Development Center (WADC) is established under the Air Research and Development Command.
1951	WADC's All Weather Flying Division becomes part of the Flight Test Division and the new organization is designated the Flight and All Weather Test Division.
1951 December 21	One of two Canberra aircraft, purchased from the British, breaks apart in flight and is completely destroyed.
1952 June 9	Maj. Gen. Albert Boyd becomes commander of the Wright Air Development Center.
1953	The Traffic, Control, Approach, and Landing System (TRACALS) program is established in the Wright Air Development Center.
1955	The TRACALS program becomes a branch under the Directorate of Flight and All Weather Testing.
1955	The Air Force Association presents Maj. Gen. Albert Boyd its Air Power Trophy as the "Test Pilot's Test Pilot."
1957 November 21	The KB-29 water tanker (S/N 44-83951) conducts a simulated icing test of the L-27A (S/N 57 5848) aircraft.
1960	The Air Force and the U.S. Weather Bureau begin a joint project for the U.S. Weather Bureau, called Project Rough Rider.
1961	The Aeronautical Systems Division is established under the Air Force Systems Command.
1963	The Deputy for Test and Support is redesignated the Deputy for Flight Test.
1963 December 1	Textron's Bell Aerospace Division begins development of the Air Cushion Landing System (ACLS) with company funds.
1964 January 10	A B-52, on loan to Boeing to study low altitude turbulence, is struck by an 80-mile per hour wind gust near East Spanish Peak, Colorado, and loses most of its vertical tail section.
1964 March-April	The Deputy for Flight Test conducts a Low Level Gust study, using an F-106A, to examine the frequency and magnitude of low level gusts near mountainous terrain.
1964 June 8	The Deputy for Flight Test conducts tests to determine the pneumatic spray system icing envelope.
1968	The Deputy for Flight Test is redesignated the Directorate of Flight Test.
1969 November 6	Acceptance tests for PAVE GAT are completed and the project is deployed to Eglin AFB, Florida.
1970	The Directorate of Flight Test becomes the 4950th Test Wing, Wright-Patterson AFB.
1970 June	The category II all weather flight test mission is transferred from the Directorate of Flight Test to the Air Force Flight Test Center, Edwards AFB, California.

1972 January	An NKC-135A is selected as the Big Crow test bed for the Army's Electronic Warfare Flying Laboratory.
1973 November 19	The Air Force Flight Dynamics Laboratory, Wright-Patterson AFB, terminates the XC-8A flight test contract with Bell Aerospace Corporation and assumes responsibility for testing the ACLS concept.
1974 January 15	The ACLS test plan for the XC-8A program is published and the aircraft arrives at the 4950th Test Wing.
1974 February	Speckled Minnow is incorporated into the Speckled Trout project.
1974 April 10	The 4950th Test Wing performs the first low speed (10 knots) ACLS taxi test.
1974 April 25	The Test Wing performs a 15-knot ACLS taxi test.
1975	The 4950th Test Wing expands its flight test mission and undergoes an internal reorganization under Project HAVE CAR.
1975 March 31	The XC-8A ACLS aircraft performs its first takeoff from a paved surface.
1975 July	The 4950th Test Wing begins aerodynamic evaluation of the Synthetic Aperture Precision Processor High Reliability (SAPPHIRE) radar.
1975 December	The Advanced Range Instrumentation Aircraft (ARIA) transfers from Patrick AFB, Florida, to the 4950th Test Wing as part of Project HAVE CAR.
1976	Responsibility for the Speckled Trout program is transferred from HQ Air Force Systems Command to the 4950th Test Wing.
1976 April	The 4950th Test Wing conducts flight tests in support of the ultra high frequency Dual Modem Satellite Communications System.
1976 September	The 4950th Test Wing conducts the first Integrated Multi-Frequency Radar (IMFRAD) flight test.
1976-1977	The 4950th Test Wing supports Project STRESS.
1977 March	The 4950th Test Wing begins full scale testing of guidance systems using the Navstar Global Positioning System.
1977 March 31	The 4950th Test Wing completes the test phase of the ACLS program.
1977 May	The 4950th Test Wing's Big Crow program flies the first mission in support of the Patriot Missile.
1977 July	The NKC-135 Airborne Laser Laboratory is transferred to the 4950th Test Wing for cycle III testing.
1978 May	The 4950th Test Wing begins a two-year program to flight test the Dual-Frequency Satellite Communication (SATCOM) system.
1978 June	The 4950th Test Wing is named the responsible test organization for the Air Force Microwave Landing System (MLS) program.

1978 July	The 4950th Test Wing begins flight testing the Laser Infrared Countermeasures Demonstration System (LIDS) program.
1978 November	The 4950th Test Wing completes all data collection requirements for the SAPPHIRE program.
1979	Little Crow flight testing begins.
1979 June	The 4950th Test Wing completes the IMFRAD program.
1979 December	A funding cut terminates the LIDS program.
1979-1980	The entire Prime Electronic Equipment Subsystem is removed from two EC-135N ARIA aircraft and installed in two C-135Bs.
1980	The 4950th Test Wing begins flight test of the Tactical Bistatic Radar Demonstration (TBIRD) program.
1981	The 4950th Test Wing completes testing of the Dual-Frequency SATCOM system.
1981	Phase II of the Navstar program begins.
1981	The 4950th Test Wing modifies a second T-39B to carry Little Crow equipment.
1981 May 6	An EC-135N (S/N 61-0328) explodes and crashes, killing all 21 aboard.
1981 November	The 4950th Test Wing conducts the first flight test of the ASC-30 Satellite Communications Terminal.
1982 February	The 4950th Test Wing begins flight testing for the Mark XII IFF program.
1982 February 1	The 4950th Test Wing receives the first of eight 707-320C/CF (C-18) aircraft, purchased from American Airlines.
1982-1984	Six of seven EC-135N ARIA aircraft are fitted with JT-3D engines.
1983	The 4950th Test Wing begins flying missions for the TBIRD II Bistatic Technology Transfer (BTT) program.
1983 May 5	TBIRD II flight testing records the first-ever bistatic imaging.
1983 November 4	The 4950th Test Wing conducts the final test flight of the Airborne Laser Laboratory (ALL).
1983 November 28	An ARIA aircraft supports the launch of Spacelab I aboard Space Shuttle Nine.
1984	The 4950th Test Wing completes testing for the Mark XII program.
1984	The 4950th Test Wing is named responsible test organization of the Federal Aviation Administration's (FAA) MLS program, following Congress' termination of the Air Force's MLS program.
1984 April	The Navstar Phase II program is terminated.
1984 July	A C-21A replaces the T-39A as the Speckled Minnow aircraft.
1984 September	Flight testing is completed for the Tactical Bistatic Radar Demonstration (TBIRD) II program.

1985 January	The first Cruise Missile Mission Control Aircraft (CMMCA) Phase 0 capable aircraft successfully supports cruise missile tests.
1985 January 4	The Modification Center rolls out the first EC-18B ARIA aircraft.
1985 February	The 4950th Test Wing awards a contract for the Sonobuoy Missile Impact Location System (SMILS) to E-Systems.
1985 February 27	The first EC-18 ARIA aircraft makes its maiden flight.
1985 March	The Speckled Trout program is transferred to Air Force Systems Command.
1985 May	The 4950th Test Wing begins flight testing in support of the B-1 Tail Warning Capability program.
1985 October	The Flying Infrared Signatures Technology Aircraft (FISTA) NKC-135 supports the rescue of two downed airmen northwest of Fairbanks, Alaska.
1985 December	The 4950th Test Wing begins modification of the Big Crow in-flight refueling capability.
1986	The 4950th Test Wing operates the NC-135A Optical Diagnostic Aircraft in support of the Strategic Defense Initiative (SDI).
1986 January	The 4950th Test Wing assumes management of the SMILS program from the Western Space and Missile Center.
1986 January	The first EC-18 ARIA aircraft undertakes its first mission in support of the National Aeronautics and Space Administration (NASA).
1986 January	The 4950th Test Wing begins flight testing for the FAA MLS program.
1986 August	The 4950th Test Wing completes the last phase of the B-1 Tail Warning Capability test program.
1986 August	The FISTA aircraft tracks infrared signatures of four British Polaris ballistic missile launches.
1986-1987	ARIA aircraft support testing of Advanced Medium Range Air-to-Air Missile (AMRAAM).
1987	The 4950th Test Wing identifies a C-141A as the test bed for the Electronic Counter Countermeasures Advanced Radar Test Bed (ECCM/ARTB) program.
1987	From April through September the 4950th Test Wing supports testing of the Mark XV identification friend or foe (IFF) program.
1987	The Modification Center completes work on the fourth and last EC-18B ARIA aircraft.
1987 June	The 4950th Test Wing begins testing Argus, the successor to the Optical Diagnostic Aircraft in support of SDI.
1988	The 4950th Test Wing completes modification of the C-18B for the Milstar program.
1988-1989	Two EC-18Bs are modified as EC-18D test beds.
1989	Two ARIA aircraft support the last military Atlas-Centaur launch.

1989	The 4950th Test Wing transfers responsibility for the Argus to the Air Force Weapons Laboratory.
1989	The 4950th Test Wing is designated a center of expertise for commercial derivative testing.
1989 January	The 4950th Test Wing supports the test of the newly launched British satellite, SKYNET 4B.
1989 October	The ARIA supports the launch of NASA's Galileo spacecraft from the space shuttle Atlantis.
1989 November	The ARIA supports the Delta rocket launch of NASA's cosmic background explorer.
1990	The 4950th Test Wing begins flight testing of the SMILS.
1990	The ARIA supports the Atlantis shuttle launch of the Magellan spacecraft, to study Venus; and the Ulysses, to study Jupiter and the sun.
1990	The 4950th Test Wing conducts flight testing of the VC-25A presidential transport aircraft.
1991	The 4950th Test Wing conducts flight testing of the C-27 short takeoff and landing (STOL) aircraft.
1991	The Department of Defense announces plans to transfer the flying elements of the 4950th Test Wing to Edwards AFB, California.
1991 September	The Argus flies its last operational sortie.
1991 October 31	ASD commander Lt. Gen. Thomas R. Ferguson, Jr., signs an interim directive to establish the Developmental Manufacturing and Modification Facility.
1991-1992	The ARIA supports launch of Pegasus, an experimental winged rocket.
1991-1993	The 4950th Test Wing modifies the ARIA to receive, record, and transmit data from the Titan IV booster and Centaur upper stage.
1992 March	A Little Crow aircraft (S/N 60-344) is destroyed by fire.
1992 April	The 4950th Test Wing completes modification of the Argus II, an EC-135E aircraft.
1992 August 26	Two ARIA aircraft participate in the rescue of two people aboard the Lahela K.
1992 September	Five ARIA aircraft support the launch of the Mars Observer spacecraft.
1992 October 1	The Speckled Trout program is transferred from the 4950th Test Wing to the Air Force Flight Test Center, Edwards AFB, California.
1992-1993	The Developmental Manufacturing and Modification Facility (DMMF) modifies the first OC 135B aircraft for U.S. participation in Open Skies treaty overflight activities.
1993 March	The ARIA uses its horn antenna for the first time during a Peacekeeper test mission.
1993 December 3	The Advanced Radar Test Bed (ARTB) test team performs a DME/P and ECCM DEM/VAL mission on the same day—a first in Test Wing history.

Dedicated to:

The dreamers...

Those who toiled, and dared, and soared;

and sometimes,

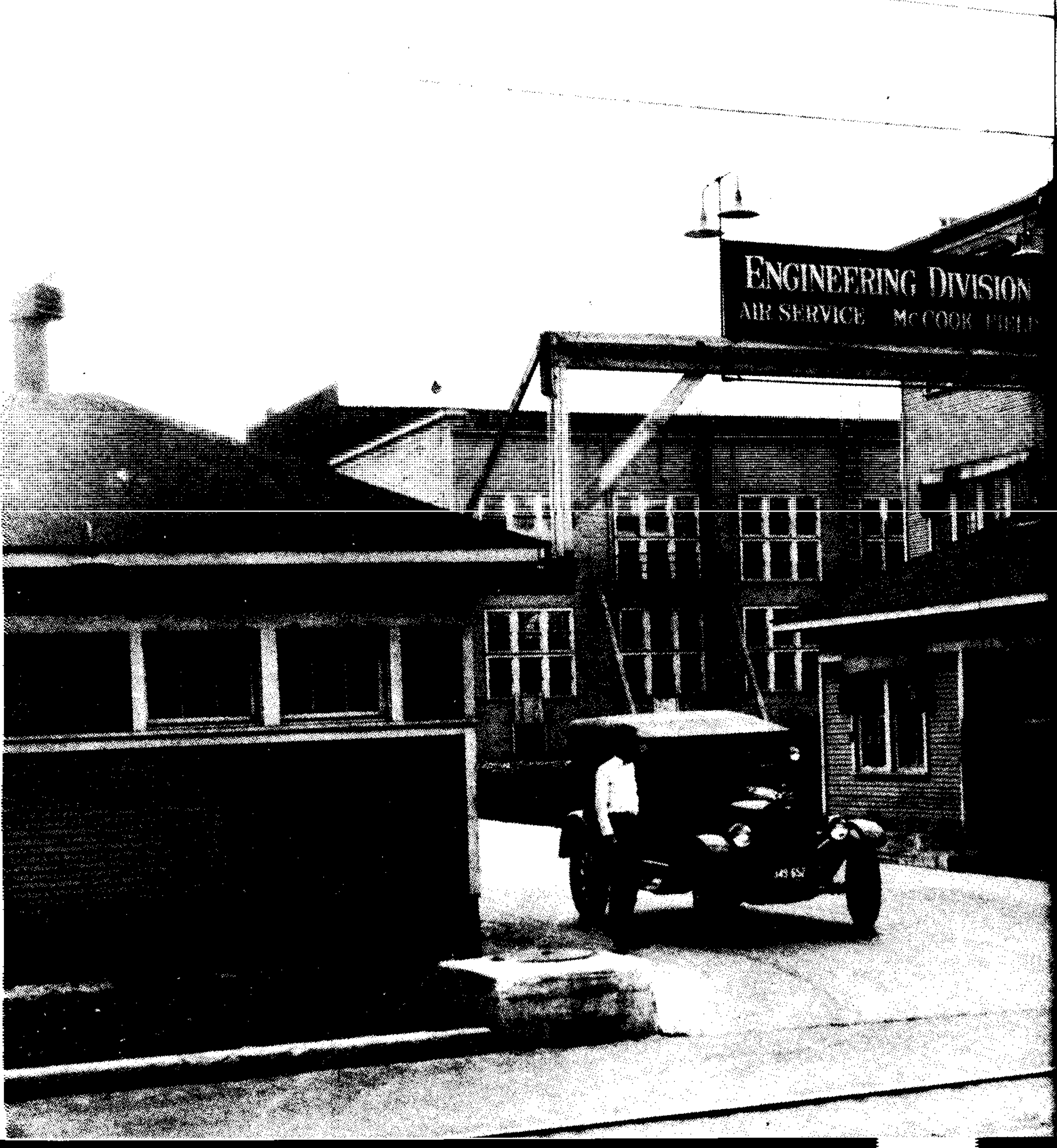
with their eyes on the horizon

and their lives in the balance,

high above the prairie, they flew

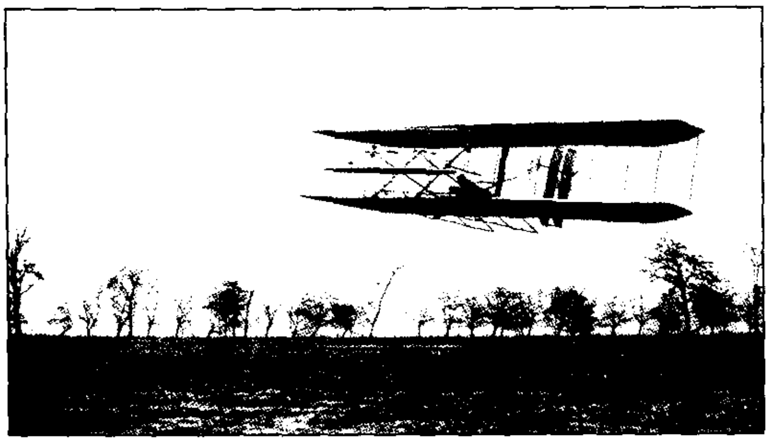
Against the Wind.

CHAPTER 1
The Cradle of Air Force Flight Testing

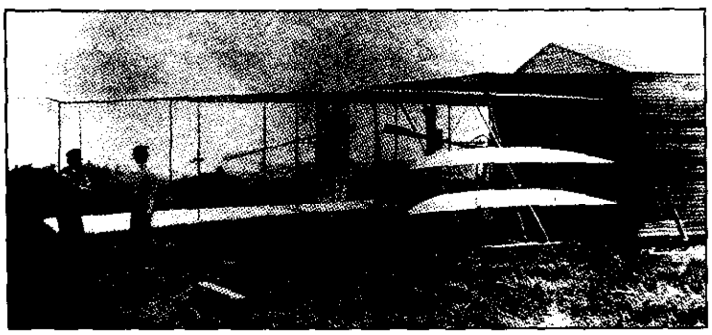


Flight testing has been an integral part of aircraft development from the time when men first dreamed of soaring like birds. The ancient Greek legend of Icarus and Daedalus testifies to the probable antiquity of human attempts to fly—and the often tragic results. In the middle ages and renaissance the adventurous—or foolhardy—jumped from towers and other heights to try out a variety of flying devices. In the eighteenth century, the Montgolfier brothers went aloft in a balloon, but not before a test flight manned by a rooster, sheep, and duck. In the late nineteenth century, the German Otto Lilienthal conducted a remarkable series of test flights in glider craft before crashing fatally in 1896. In the United States Samuel Pierpoint Langley constructed a flying machine—which crashed twice into the Potomac River along with test pilot Charles Manley. Nine days after Langley's second attempt, on 17 December 1903, Orville Wright made the first sustained flight in a powered heavier-than-air flying machine—and changed forever the course of history.

The success of Wilbur and Orville Wright in developing and demonstrating the first airplane was no accident. The Dayton, Ohio, bicycle makers had long experience in mechanics. To this they added an intuitive scientific methodology and uncanny fraternal synergy. They left nothing to chance: they read much, they thought much, and they experimented tirelessly, even developing a primitive wind tunnel to test airfoils and devising their own aeronautical tables. They proceeded just as cautiously when taking to the air. The first flights at Kitty Hawk, North Carolina, in 1903, were followed in 1904 with more test flights in an improved machine, this time on prairieland to the northeast of Dayton, Ohio. The Wrights' flight tests on Huffman Prairie in 1904 and 1905 established their claim as the "fathers of aviation" and Dayton, Ohio, as the "birthplace of aviation." With the Wright brothers, therefore, Dayton also became the birthplace of flight testing. Indeed, for the better part of the twentieth century, the city beside the Great Miami River was a major center of flight test activity for the nation and the world.



Flight testing at Huffman Prairie Flying Field, November, 1904. This site was designated a National Historic Landmark in 1990.

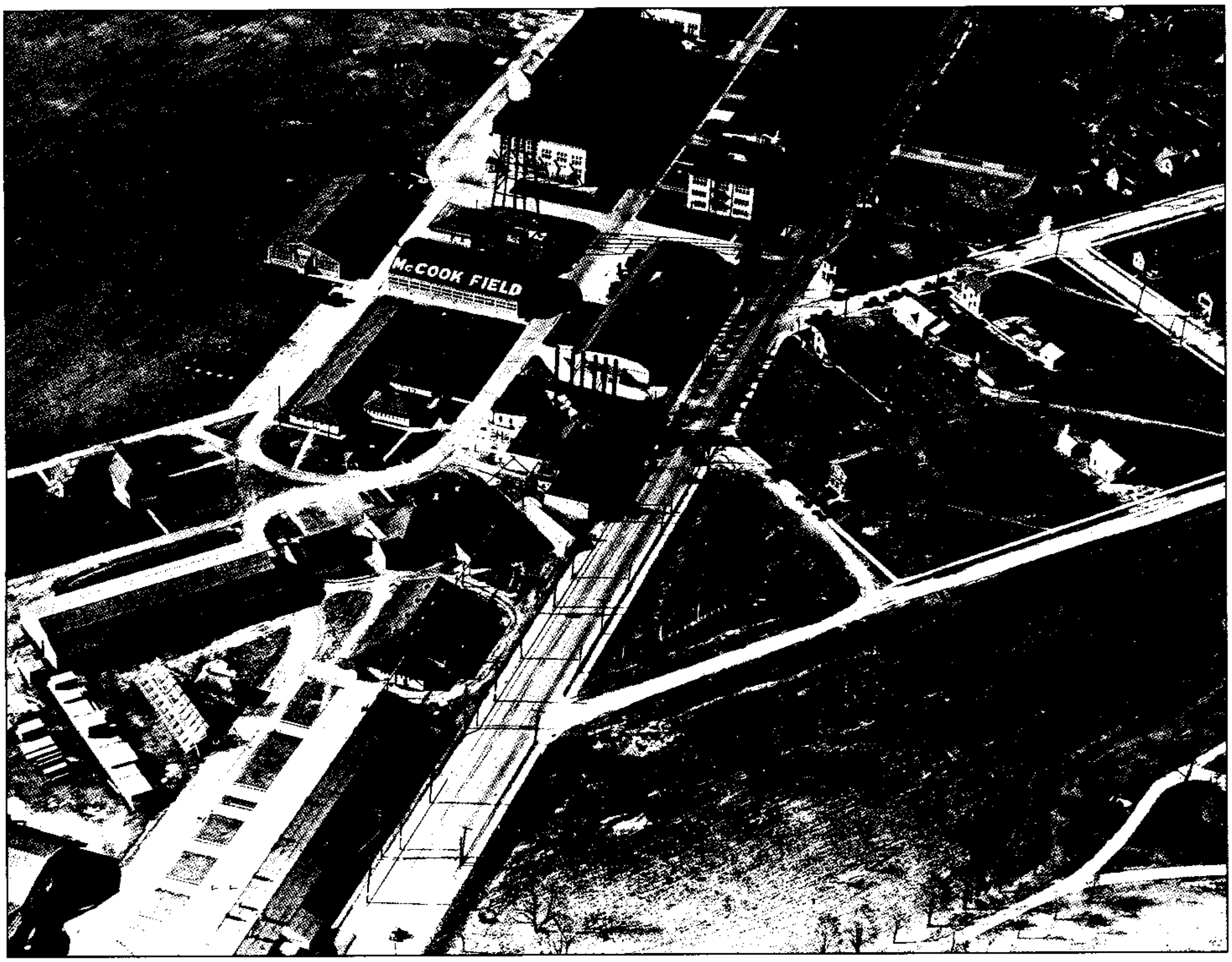


Orville and Wilbur Wright on Huffman Prairie, May, 1904.

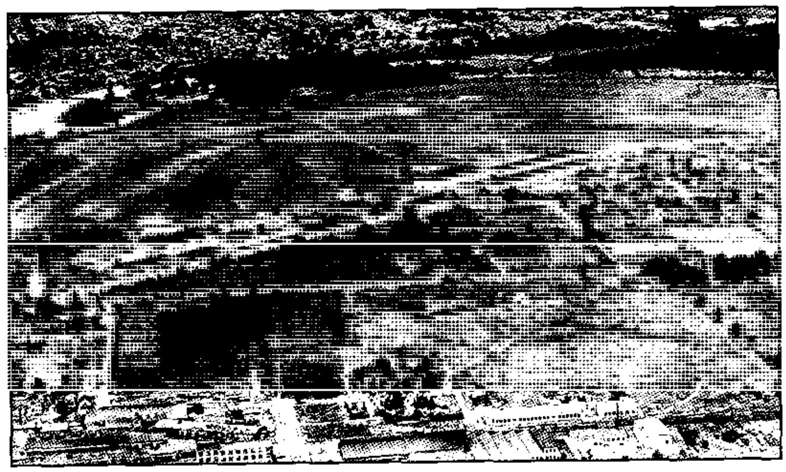
McCook Field

But what firmly established Dayton as a flight test center was the First World War. The United States entered the war against imperial Germany and the other Central Powers on 6 April 1917. Although the U.S. had been first off the mark in manned flight in 1903, by the outbreak of war in 1914, the nations of Europe—Great Britain, France, and Germany—had begun to outstrip the U.S. in aeronautics. Three years of cruel war had further honed Europe's technological edge and operational *savoir faire*. When it, in turn, entered the war, the U.S. had to rapidly catch up in terms of both quantity and quality. In the summer of 1917, the Congress appropriated $640 million for the production of 22,625 aircraft. In July the Army decided to build a "temporary" installation for aeronautical research and development, including flight testing, just north of downtown Dayton. This area, called North Field, was renamed by the Army for the "fighting McCook" family of Civil War renown. McCook Field began operations in December. By the Armistice, 11 November 1918, McCook comprised 69 buildings and employed some 2300 personnel. Far from being temporary, McCook continued operations until 1927, when its facilities and personnel were transferred across town to Wright Field.

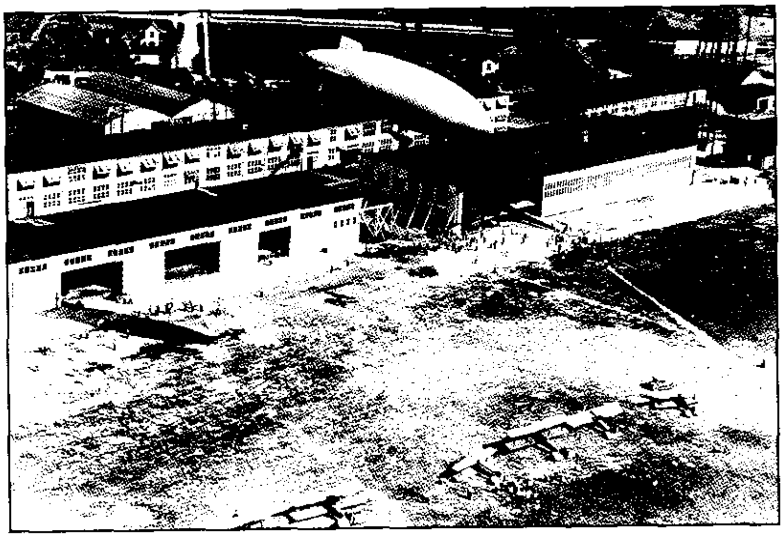
Aerial photograph of McCook Field.



McCook Field was outfitted with the best that money could buy in 1917 for flight testing. This included a sod airfield and a 1,000-foot long by 100-foot wide macadam and cinder runway for use during inclement weather. This rudimentary runway offered improved conditions over the cow pasture that the Wright brothers had to content themselves with a decade before. It was a sign, moreover, of the increased appreciation for controlled conditions in flight testing. Indeed, early McCook Field flight test regulations warned against pilots straying beyond visual range of McCook's airstrip lest they be forced to make a "rough field landing" on a back road or in some farmer's field. Such landings might easily damage the aircraft and the instrumentation, such as it was, that they carried to collect and record flight data. This early flight test instrumentation often amounted to little more than an altitude barograph with an ink pen tracing on a rotating paper drum—this and the pilot's flight test log, which he would balance on his knees when jotting down various data points in mid flight.

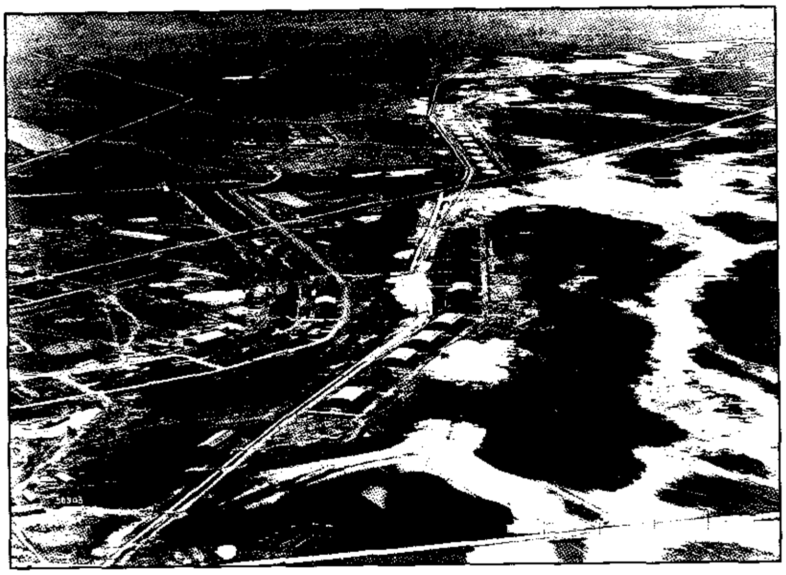


McCook Field, looking west, showing finished runway.



At McCook Field, not everything that flew was an airplane. The assembly hangar is at right, with the test hangars of the Airplane Engineering Division at left, around 1921.

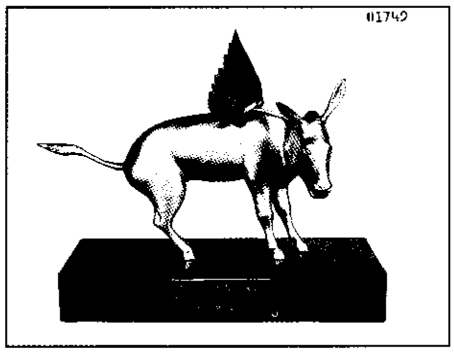
The first flight tests were conducted both at McCook Field and nearby Wilbur Wright Field. Wilbur Wright Field had been established by the Army in May 1917 for the flight training of Army aviators. (It was named in memory of the elder of the two Wright brothers who had died of typhoid in 1912.) It was located just to the north of Huffman Prairie, where Wilbur and Orville had themselves conducted one of aviation's first flight training schools, at what was then known as Simms Station, from 1910 to 1916. Because of McCook's limited size and the volume of flight testing, McCook authorities early on requested permission to fly, when necessary, from Wilbur Wright Field.



Wilbur Wright Field in 1922. Flooding was a recurring problem before a comprehensive drainage system was installed.

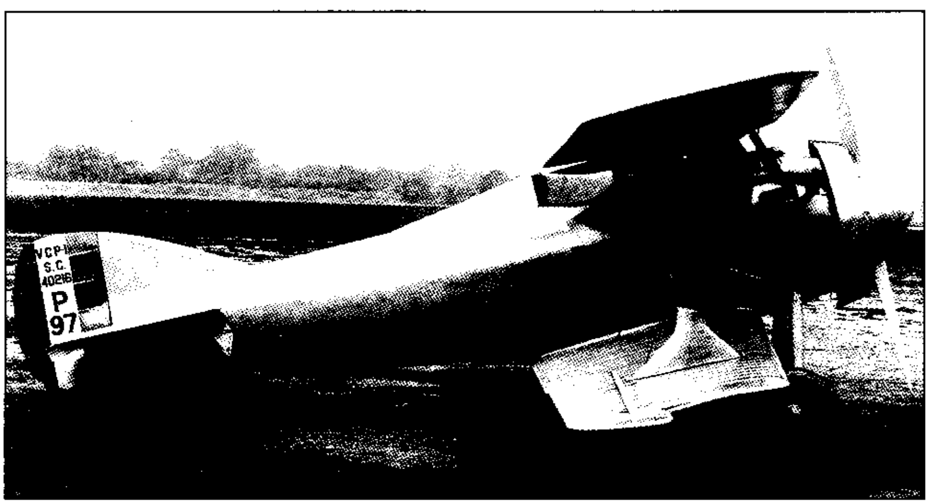
Flight Test Section, McCook Field, 1926. (left to right) R.G. Lockwood, George Tourtellot, William Amis, James Doolittle, H.A. Johnson, J. A. Macready, Hoy Barksdale, James Hutchinson, R.C. Moffat, Louis G. Meister, in addition to the Flying Ass and the Quacking Duck.

McCook saw many of the early pioneers of flight testing pass through its gates. These included Harold Harris, Rudolph "Shorty" Schroeder, John A. Macready, Roland Rohlfs, L. L. Snow, Louis Meister, Eugene "Hoy" Barksdale, Al Stevens, Eddie Allen, and James H. "Jimmy" Doolittle. The camaraderie and *esprit de corps* of these early aeronauts is evident in how they recognized one another's prowess in the air. Woe to the pilot who won the Alibi Trophy, the Bonehead Trophy, the Dumbbell Trophy, the Oilcan Trophy, or the Flying Ass Trophy. Captain Schroeder, during his tenure as Chief of the Flight Test Section, devised the supreme honor, "The Cup of Good Beginnings and Bad Endings," which bore the inscription: "We Crashed Not Because We Ran Out of Gas, but Because We Ran Out of Knowledge." Clearly, this was a group in which intelligence and common sense were expected, where carelessness and recklessness were regarded as the exception.



The Flying Ass: Trophy of Stupidity.

These men and many others kept the skies above Montgomery and neighboring counties constantly humming. (In 1919 alone, there were 1,276 test flights and 3,550 incidental flights recorded by McCook's Flight Test Section.) The aircraft flown included American, allied, and captured enemy planes. One early native model, the VCP-1 was designed by two McCook engineers, Alfred Verville, and Virginius E. Clark. Perhaps one of the most successful and interesting aircraft was the Packard-Le Pere LUSAC-11, designed by Captain G. Le Pere of the French Aviation Mission to the U.S. Army. The prototype was constructed and flight tested at McCook in the summer and fall of 1918. Packard subsequently produced 25 and sent them to France. According to aerospace historian, Richard P. Hallion, McCook's LUSAC-11 program was a major step in the development of American flight test methods and research.



Verville VCP-1 racer, designed by Engineering Division engineer Alfred V. Verville and built at McCook Field.

12 June 1884 - 22 February 1932

COLONEL THURMAN HARRISON BANE

"Gentlemen, when you pass through that gate under the sign reading Engineering Division, Army Air Service,' you leave your rank outside. Here we are all students of aeronautical science, and there is more than one shavetail at the field who has more practical knowledge of aircraft design and construction than any high-ranking officer in the service." So Thurman Bane was accustomed to declare to new officers reporting to McCook Field. He ought to have known. Like many of his generation, he was self-taught in aeronautics, a man whose initial military posting was in the horse-cavalry, but who never forgot his first sight of an airplane.

That was in 1915 during General John J. Pershing's punitive expedition to Mexico. Attached to the 6th Cavalry, Bane was patrolling parched border country, strewn with cactus, sagebrush, and swirling dust, when he caught sight of a flight of Army aircraft and saw his future pass before his eyes. The expedition concluded, Bane transferred to the Signal Corps' Aviation Section. In November 1916, he reported to the Aviation School at North Island, San Diego, California, winning his wings the following June. In 1917 he became first assistant secretary and then secretary of the Aviation School where, without benefit of engineering training and employing only his knowledge of applied mathematics and journal articles on aviation, he devised a course in aeronautics and design. He also assumed direction of North Island's aeronautical shops.

Seven months after America's entry in World War I, in October 1917, Bane was promoted to lieutenant colonel and posted to Washington, D.C. There he served first on the Joint Army and Navy Technical Aircraft Board and then became executive officer of the Signal Corps' Air Division. In May 1918, he was placed in charge of the new Technical Section of the Department of Military Aeronautics. This position carried with it responsibility for procuring technical specifications for all aircraft and their equipment, apprising the Army of their value, and coordinating this with the Bureau of Aircraft Production.

In August 1918, Bane was promoted to colonel. Shortly thereafter, he was sent to Dayton to oversee liaison activities between the Technical Section and the Bureau of Aircraft Production. Two months after the Armistice, in January 1919, Bane was placed in charge of McCook Field, where he organized the Air Service's Engineering Division. At the same time, he founded an Air Service School of Application—the forerunner of the Air Force Institute of Technology—declaring that "the Air Service will never be a complete success until all officers in command of air stations and in staff positions understand the game from its very foundation."

While in charge of McCook, Bane introduced modern industrial methods of research, design, and manufacture and brokered a division of labor between industry and the Army's in-house facilities for the design, testing, and production of aircraft and aeronautical equipment. The success of these arrangements benefitted both Army aviation and industry and resulted in such advances as the first cantilever monoplane, the first all-metal aircraft, the monocoque fuselage, air-cooled engines, reversible and variable pitch propellers, leak-proof fuel tanks, the siphon gasoline pump, and instrumentation aiding adverse weather flying, among other innovations.

In December 1922, Colonel Bane retired from the Army and returned to his native California. He spent the next ten years in consulting work and organized the Aviation Corporation, the progenitor of Pan American Airways and several other nascent airlines. He died in 1932 and was buried in the Army cemetery at West Point, where he had graduated a quarter century before, a second lieutenant in the horse-cavalry.

14 August 1886 - 29 December 1952

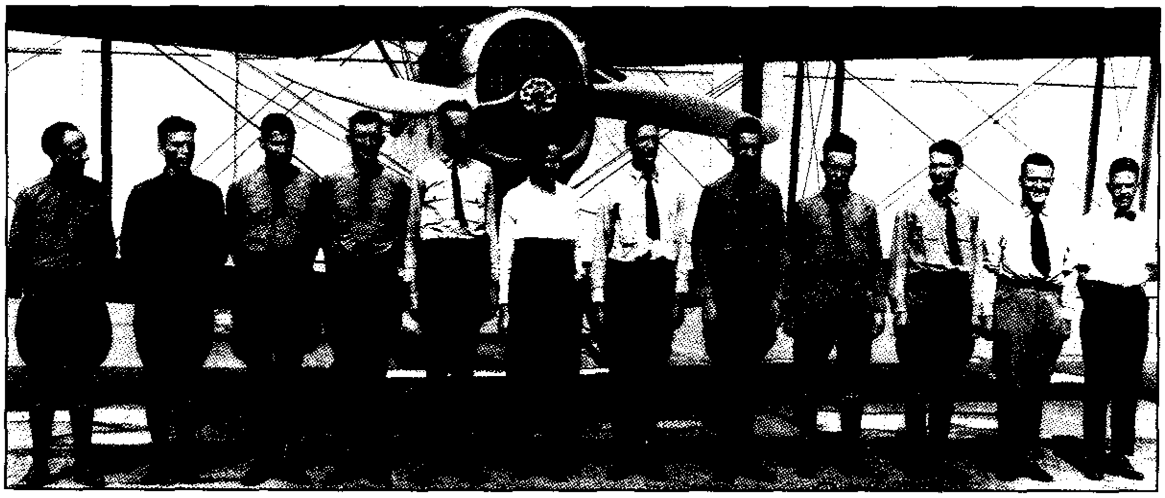
MAJOR RUDOLPH WILLIAM SCHROEDER

Born in Chicago in 1886, Rudolph William Schroeder became one of America's military aviation pioneers. After building several gliders, he met the aviator Otto Brodie in 1910. Brodie taught Schroeder to fly in a Farman biplane powered by a 32-horsepower Gnome engine. From 1913-1916 he engaged in exhibition flying, part of the time accompanying Katherine Stinson. In 1916 Schroeder enlisted in the U.S. Army, serving in the Aviation Section of the Signal Corps. By the end of World War I, Schroeder had risen to the rank of major. During this period Schroeder served at several locations in the United States, coming in 1918 to command test pilots at McCook Field in Dayton, Ohio. Six feet four inches tall, "Shorty" Schroeder was the Army's chief test pilot between 1919 and 1920.

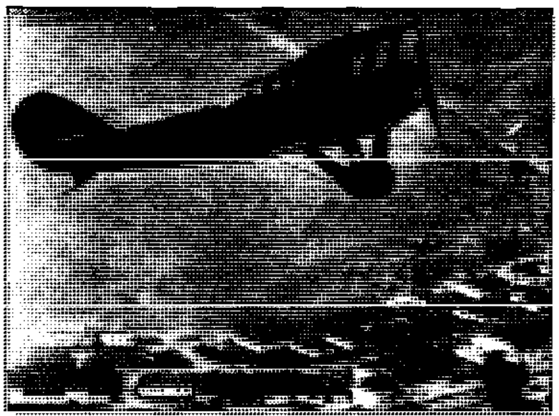
From 1918 to 1920 Schroeder set five world altitude records. His fifth record-breaking flight, on February 27, 1920, nearly ended in his death. Flying an open-cockpit Packard-LePere LUSAC-11 biplane, powered by a Liberty engine with a special turbine supercharger, he climbed for an hour and 47 minutes. At a temperature of 67 degrees below zero Fahrenheit, Schroeder had only heavy clothing and a regulation oxygen mask and goggles for protection. At approximately 33,000 feet, he began to suffer from oxygen deficiency and carbon monoxide poisoning from the engine's fumes. When he raised his goggles momentarily in order to locate his emergency oxygen supply, the cold froze the film of moisture between his eyelids and eyeballs. Schroeder attempted to put the aircraft into a gentle spin to descend, but fell into a vertical dive and passed out. He regained consciousness after diving nearly six miles, and was able to pull out at an altitude of only 2,000 feet. His eyesight still obstructed, Schroeder struggled to a safe landing at McCook Field. His altitude during the flight was officially recorded at 33,113 feet, making him one of the first to reach the stratosphere. Three of the aircraft's four fuel tanks were crushed by pressure difference during the rapid descent. Schroeder spent several weeks in a darkened hospital room. His vision was never the same.

In civilian life, Schroeder was concerned primarily with aircraft safety. He worked first at Underwriters' Laboratories on operational safety standards for pilots and aircraft from 1920-33. After several other projects, he became chief of air line inspection for the Air Commerce Bureau. In 1937 he joined United Airlines, eventually becoming Vice President for Safety until his retirement in 1942.

Schroeder received the Distinguished Flying Cross in 1945 for his high altitude research work at McCook.

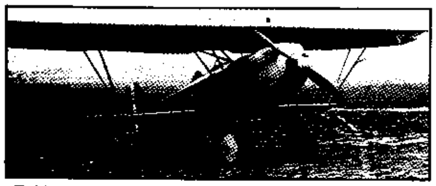


Major Schroeder, fifth from left, was Chief of Flight Test at McCook Field.



LUSAC-11 over McCook Field.

Research at McCook Field included work on turbosuperchargers, high altitude flight, controllable and reversible pitch propellers, bullet-proof and leak-proof gas tanks, radio beam navigation, a non-magnetic aircraft clock, ambulance airplanes, air-cooled and liquid-cooled radial engines, mapping and night observation cameras, free-fall parachutes, night flying techniques, a model airway, and much more. McCook test pilots set many early records while test flying the latest aircraft designs and equipment. In 1918 Roland Rohlfs, for instance, set an American altitude record by flying the Wasp triplane to 28,900 feet. In 1920 "Shorty" Schroeder piloted a LUSAC-11, powered by a Liberty Engine equipped with a new turbo-supercharger for high altitude flight, to 33,113 feet before losing consciousness due to the lack of oxygen. Remarkably, he landed the craft successfully at McCook after coming out of a precipitous dive. Jimmy Doolittle arrived at McCook in 1922 after completing a coast-to-coast flight in a modified DeHavilland DH-4B. At McCook, he performed during 1924 a series of hazardous structural flight tests in a Fokker PW-7. For this he received the Distinguished Flying Cross.

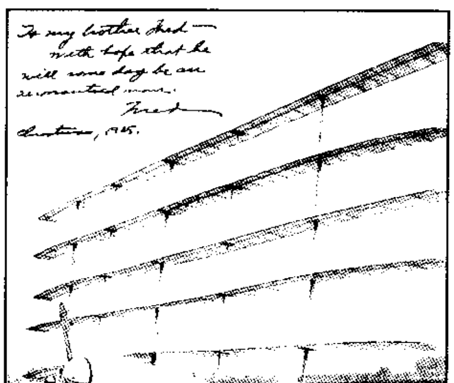


Fokker PW-7, designed by Dutch engineer Anthony H. G. Fokker.

Not all aircraft and aircraft systems passed the test. In 1921 Harold Harris attempted a high altitude flight in a pressurized tank, mounted in the fuselage of a USD-9A biplane. The tank maintained its pressure—indeed increased it—all too well and Harris barely escaped the experiment with his life. On 18 December 1922, McCook witnessed the maiden flight of the de Bothezat helicopter with Col. Thurman Bane, chief of the Flight Test Section, at the controls. The flight lasted one minute and forty-two seconds, the craft attaining an altitude of six feet.

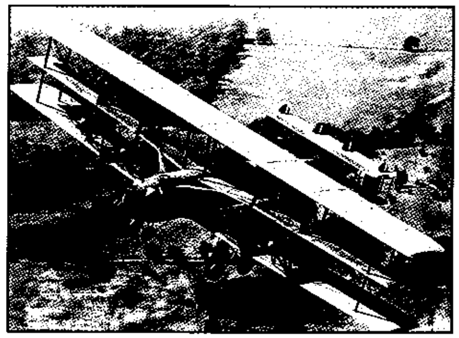
Dr. George de Bothezat (left) and Col. Thurman H. Bane in front of one of the de Bothezat helicopter's rotors at McCook Field in 1921.

Another odd craft was a McCook original. Dr. W. Frederick Gerhardt, with his own funds and on his own time (but using a McCook storage barn and helicopter hangar for assembly) designed the "Cycleplane", a human-powered contraption with seven wings "stacked' vertically. It flew, after a fashion, and was soon forgotten.



Dr. W. Frederick Gerhardt and the Cycleplane at McCook Field, July 19, 1923.

Perhaps the most conspicuous disappointment during this period was the XNBL-1 Barling Bomber. Named for Walter J. Barling, its English designer, the aircraft was too large to fly from McCook and so was tested from Wilbur Wright Field. On 22 August 1923, the Barling made its maiden flight with Harris and Lt. Muir S. Fairchild at the controls. The Barling proved to be underpowered and slow, with a top speed of only 95.5 miles per hour. Like most aircraft ahead of its time, it failed as a system but settled many technical problems that benefitted later aircraft.



XNBL-1, Barling Bomber.

McCook test pilots did not confine exhibiting their aeronautical prowess to the skies above Dayton. Over the years McCook Field pilots participated in a number of aerial races and competitions. On 2 May 1923, McCook test pilots, Lts. John A. Macready and Oakley G. Kelly, made the first non-stop transcontinental flight in a Fokker T-2 transport aircraft; for this they won the prestigious Mackay Trophy and the Distinguished Flying Cross. Other McCook pilots competed in the annual Schneider and Pulitzer Cup aircraft races. Such competitions were considered more than mere sport. A McCook publication regarded these events as "tests of design, endurance and performance," in short, flight testing by other means.

14 December 1896 - 27 September 1993

GENERAL JAMES HAROLD DOOLITTLE

In 1890 the U.S. Census Bureau declared the western frontier closed. For pioneering young Americans, there was only one direction left to go.

James H. "Jimmy" Doolittle belonged to the first generation of Americans to look to the stars in charting a new course in the nation's history. Born in 1896 in Alameda, California, Doolittle grew up with the airplane. Upon America's entry into the First World War, he enlisted in the Aviation Section of the Army Signal Corps. In 1918, after enrolling in the University of California's school of military aeronautics and completing flight training at Rockwell Field, California, Doolittle was commissioned a second lieutenant in the Signal Corps Reserves. He received his bachelor's degree from University of California in 1922 and before the end of the year made history as the first pilot to fly coast-to-coast—from Pablo Beach, Florida, to San Diego, California—in less than a day. For this feat, he received the Distinguished Flying Cross.

Only a few days after that flight in a modified De Havilland DH-4, Doolittle was assigned to the Air Service's Engineering School at McCook Field, from which he graduated in 1923. Doolittle then went on to the Massachusetts Institute of Technology to earn a master's degree and doctorate—one of the first—in aeronautical sciences. He interrupted his studies at MIT to perform a series of grueling flight acceleration tests in a Fokker PW-7 at McCook, in March 1924. Doolittle drove his craft to the point of structural failure—according to the citation accompanying his second Distinguished Flying Cross, awarded in 1929—"in order that the flight loads imposed upon the wings of the airplane under extreme conditions of air combat might be ascertained." He barely escaped with his life but had found the topic of his master's thesis, "Wing Loads as Determined by the Accelerometer." After receiving a doctor of science degree, he returned to flight testing at McCook, from April 1927 to January 1929.

Doolittle, front, pilots a flying advertisement for the 1924 International Air Races in Dayton.

In 1929 the Air Corps granted Doolittle leave of absence, at the request of the Guggenheim Fund, to direct the Full Flight Laboratory on Long Island, New York. There Doolittle conducted a series of epoch-making flight tests using instruments instead of visual cues for take-offs, in-flight navigation, and landings at night and in adverse weather, in a Consolidated NY-2 military trainer aircraft. It was one of his proudest achievements as a test pilot.

During the 'twenties and early 'thirties, Doolittle also competed in a number of air races. In 1925, he won the Schneider Cup Seaplane Race. In 1931, he won the Bendix Trophy for a transcontinental flight from Burbank, California, to Cleveland, Ohio, where he refueled, and then flew on to Newark, New Jersey. He had crossed the continent in less than 12 hours, the first to do so. Finally, in 1932, he won the Thompson Trophy. He retired from racing in 1935.

'Admiral' Doolittle returns in triumph to McCook Field having bested the Navy in the Schneider Cup seaplane race, 1925.

Lt. Col. Doolittle and members of the first B-25 crew to depart the Hornet prior to the Tokyo Raid. Doolittle is wearing the Wright Field patch on his flight jacket.

Meanwhile, Doolittle retired from active service, in 1930, as a Major and entered the Army Air Corps Reserve where he served until his reactivation in 1940.

A champion pugilist in college, Doolittle never retreated from a fight. The Japanese surprise attack on Pearl Harbor, on 7 December 1941, outraged the nation and called for an early and forceful response. On 18 April 1942, Lt Colonel Doolittle commanded 16 B-25 bombers in an attack on the heart of the Japanese Empire. In "thirty seconds over Tokyo" Doolittle and his fellow airmen boosted American morale and flew into cinema legend. Doolittle, who considered the raid a failure, was surprised when on his summons to Washington he was awarded the Congressional Medal of Honor by President Roosevelt and promoted to brigadier general. During the course of the Second World War, he went on to serve as commander of the 8th, 12th, and 15th Air Forces.

Doolittle contributed to the war effort in still another way. In 1934, as chief of the Shell Oil Company's aviation department, he had successfully pressed the business community to develop and produce 100-octane aviation fuel. That fuel provided an important performance edge for American and allied aircraft during the war. Doolittle later considered this his most important contribution to victory.

In retirement after the war, Doolittle lived modestly. An avid sportsman, he was a strong supporter of conservation and the environment. He deeply believed that human beings were placed on earth to leave it a better place than they found it and expressed this often to interviewers, admirers, and six grandchildren.

In 1985 he was promoted to four-star general, the first Air Force reserve officer to attain this rank.

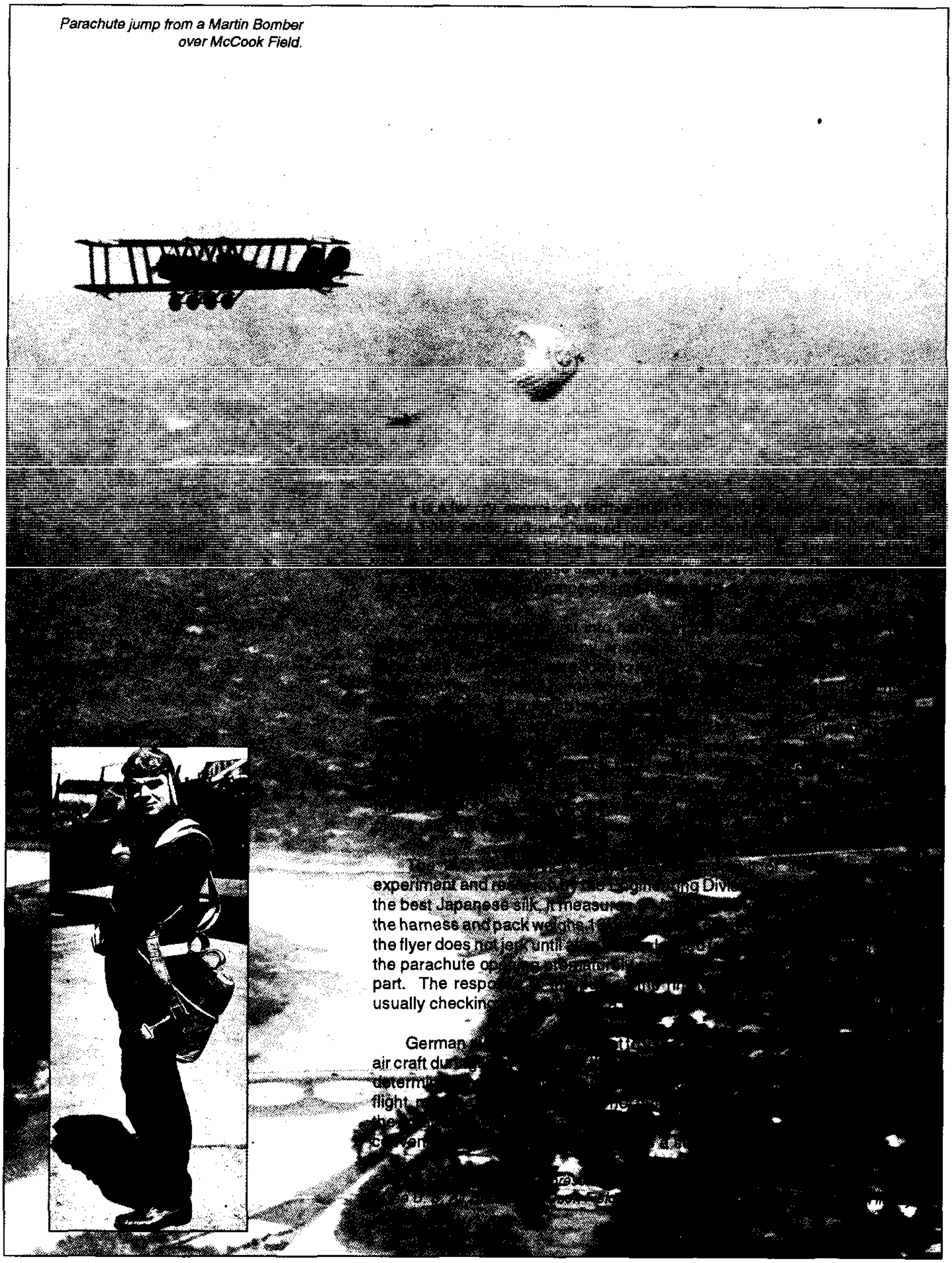
On 27 September 1993, Jimmy Doolittle died in Pebble Beach, California. During 96 years, he had witnessed the birth of manned flight and had himself made signal contributions to its development. Modest of his own accomplishment, he epitomized in every way a unique generation of Americans, who combined intellect with courage in pioneering America's twentieth century frontier.

These early feats of flight testing were not without cost. In May 1918 Lt. Col. Henry J. Damm and Maj. Oscar Brindley died when their DeHavilland DH-4 crashed at Wilbur Wright Field. The following month a DH-4 piloted by Lt. Frank Stuart Patterson and Leroy Swan crashed during gunnery trials at McCook. (Patterson Field was later named in honor of the fallen test pilot.) In March 1922, Lt. Frederick W. Niedermeyer died when his Fokker monoplane experienced structural failure in flight. Niedermeyer was not wearing the parachute that might have saved his life. This incident prompted a sign to be posted in the McCook Operations Room: "Don't forget your parachute. If you need it and haven't got it, you'll never need it again." A dozen or more pilots lost their lives in flight testing aircraft at McCook and Wright Fields from 1919 to 1936.

Lt. Frank Stuart Patterson.

PARACHUTES

Parachute jump from a Martin Bomber over McCook Field.



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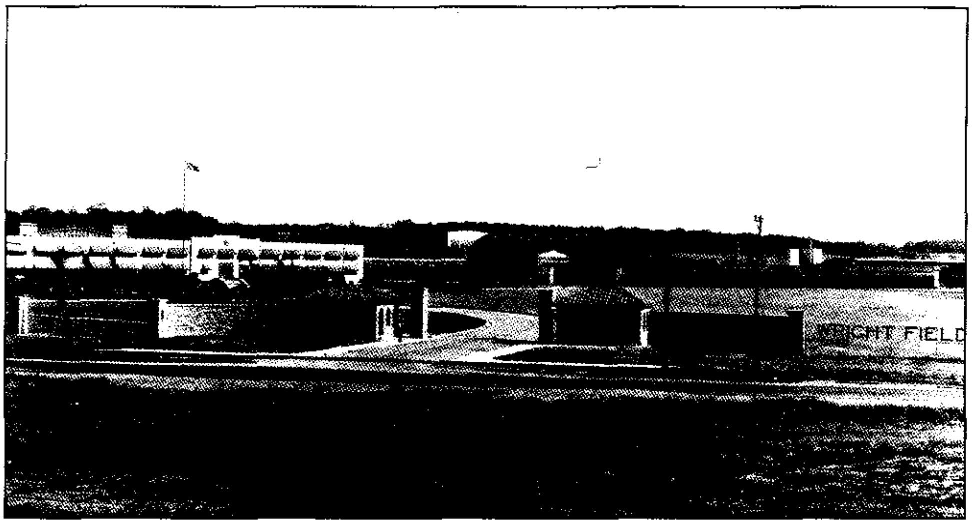
McCook's limitations in size and location became increasingly apparent during the course of the 1920s. Indeed, McCook's main hangar bore the admonition in giant letters over its doors: "THIS FIELD IS SMALL—USE IT ALL." This was no exaggeration. The runway, which traversed the short expanse of the field to take advantage of prevailing winds, was too short to accommodate the larger and more powerful aircraft developed after World War I, and not a few planes "ditched" in the Great Miami River.

McCook's buildings had originally been erected as temporary structures; many were poorly constructed, of wood. They thus presented a fire hazard and required constant maintenance. The field also lacked a rail line nearby for the delivery of outsize equipment and supplies. Finally, McCook was situated on prime real estate, near the center of Dayton's business district. The land was leased to the government, and every year the landlords, anxious to turn their property to more lucrative use, raised the rent.

Wright Field



Main entrance to Wright Field with the Headquarters (building 11) in the background. September 1931.

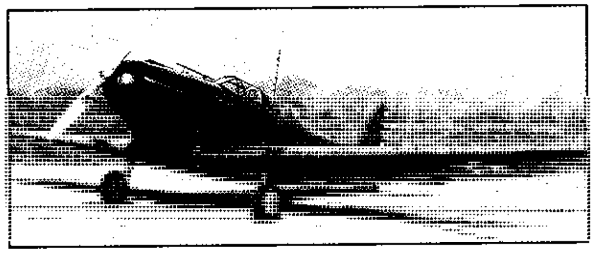
The Air Service began the search for a new site as soon as the war was over. A number of locations were considered, including New Jersey, Maryland, and Michigan. Prominent Daytonians, led first by John H. Patterson, the President of the National Cash Register Corporation, and, after his unexpected death, by his son Frederick, mounted an effort to keep the Air Service's experimental engineering facility in the Dayton area. Under the auspices of the Dayton Air Service Committee, they raised over $400,000 to purchase land to the northeast of Dayton. After considerable lobbying in Washington by the Committee, the Air Service decided upon the Dayton site for its new airfield. On 16 April 1926, ground was broken for the new field. A year and a half later, on 12 October 1927, the new field was dedicated and named "Wright Field" in honor of both Wilbur and Orville Wright. (In 1925 the Air Service had discontinued the name "Wilbur Wright" for its installation near the town of Fairfield. What had been Wilbur Wright Field now became part of Wright Field.) Even before the dedication of Wright Field, the movement of personnel and equipment began from McCook. By 1930, when this had been completed, all trace of the Air Service's activity at McCook was removed. All the buildings were pulled down and the landscape restored to its original condition, and returned to its owners, according to the terms of the lease. McCook Field thus passed into history. Its technical legacy, however, lived on at Wright Field, as it does today at Wright-Patterson Air Force Base.

The inauguration of Wright Field saw the beginning of the "golden era" of aeronautical development in Dayton. For a generation, the nation's aeronautical, industrial, and military circles knew Wright Field simply as "the Field."

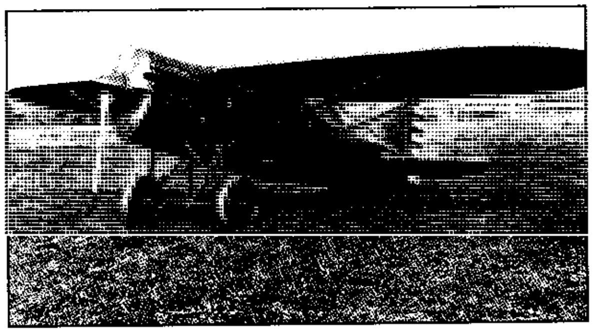
The late 1920s and the 1930s was a momentous period in aircraft design as the aeronautical industry began to introduce metal and monoplane models in addition to improvements in biplane designs. Engineers and test pilots at Wright Field were kept busy with a parade of new military prototypes and commercial craft proposed for military service. The list is long and reads in places like an obituary column of companies long passed from the scene or consolidated into more successful competitors. Among the prototype aircraft flight tested at Wright Field were the Fokker XA-7, Curtiss XA-8, and Consolidated A-11 attack aircraft; the Boeing XP-9, the Curtiss XP-10, the Berliner-Joyce XP-16, the Boeing P-12 series, and the Boeing Y1P-26 pursuit aircraft; the Curtiss B-2 Condor, the Keystone XLB-6, the Ford XB-906, the Boeing XB-901, and the Martin XB-907A ("Flying Whale") bombers. In addition to attack, pursuit, and bomber aircraft, Wright Field also saw the flight testing of trainer aircraft, including the

Consolidated XPT-933, the Inland XPT-930, the New Standard XPT-931, the Spartan XPT-913, the Stearman XPT-912, and the Verville XPT-914 primary trainers and the Stearman XBT-915 and the Consolidated XBT-937 basic trainers. Among the observation craft tested were the Douglas O-38 series, O-25 series, and the O-31; the Fokker YO-27 and Y10-27 monoplanes; and the Curtiss YO-40A aircraft. Finally, Wright Field test pilots also flight tested a series of transport aircraft, including the Ford C-3A, C-4 (and C-49), and C-9; the Atlantic C-5, C-7, and C-7A; the Sikorsky C-6 and C-6A (amphibious transports); the Atlantic-Fokker F-10A; the Fairchild XC-8; the General Aviation Y1C-14; the Fairchild Y1C-24 "Pilgrim"; and the Bellanca Y1C-27 "Airbus." In the high speed transport category were the Consolidated C-11A and Y1C-17 "Fleetstar"; the Lockheed Y1C-12 "Vega" and the Y1C-19 "Alpha"; the Northrop YC-19 "Alpha"; and the Curtiss-Wright C-80. Among the amphibious transports were the Sikorsky C-6A, the Douglas Y1C-21, and the Y1C-26A.

The honor role of test pilots at Wright Field in the 1930s and 1940s is indeed impressive. Among those who put their lives on the cutting edge were Stanley M. Umstead, Donald Putt, Benjamin Kelsey, Fred Bordosi, Frank G. Irvin, Ann Baumgartner, Albert Boyd, and J.S. Griffith. Among those who sacrificed their lives in the service of aeronautics at Wright Field were Hugh M. Elmendorf, Irvin A. Woodring, Ployer P. Hill, Perry Ritchie, Robert K. Giovannoli, Hezekiah McClellen, and Richard Bong.

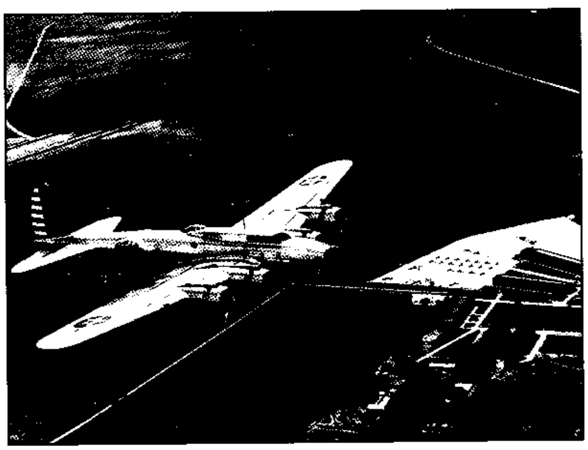


Consolidated XA-11, forerunner of the P-30.

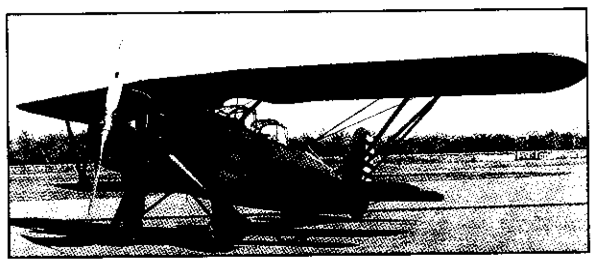


XP-9, building 11 in background.

Personnel at the Fairfield Air Depot preparing one of ten Martin YB-10s for Lt. Col. Hap Arnold's 1934 Alaska flight to demonstrate the bomber's long-range capability.

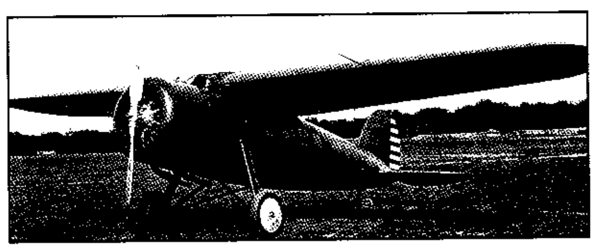


B-17 test flight over Wright Field in the late 1930s, prior to construction of concrete runways.



Curtiss YO-40 "Raven" sesquiplane.

Flight Test Pilots, Wright Field, 1936: Captain Stanley M. Umstead, Captain J.S. Griffith, Captain Harold R. Harris, Lieutenant Eppright, Lieutenant Donald Putt, Major McClellan, and Captain Frank G. Irvin.

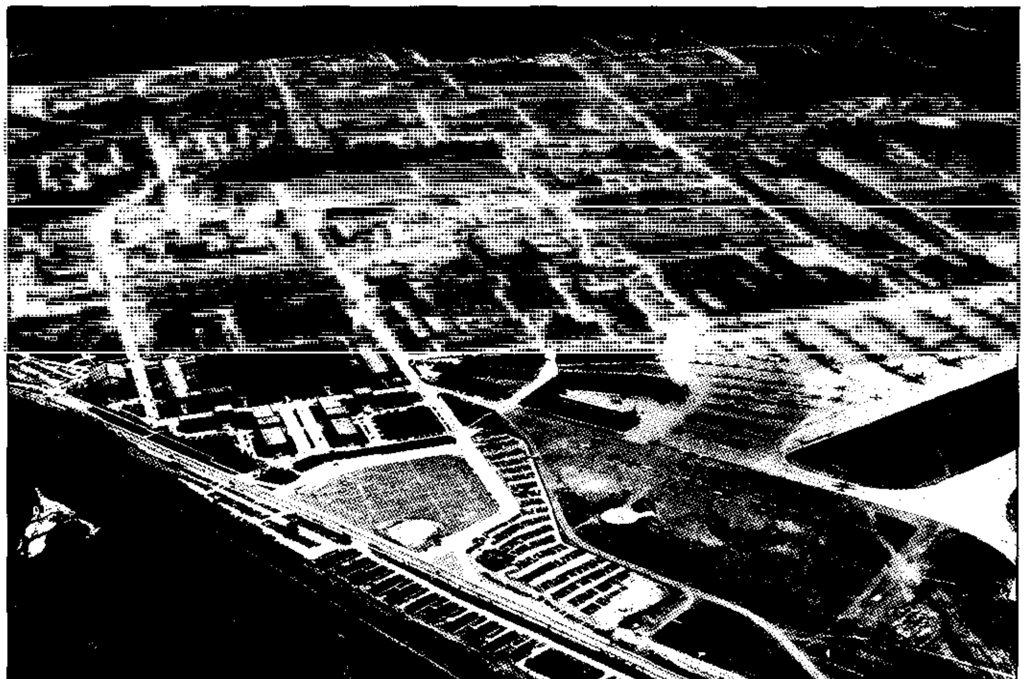


Detroit-Lockheed DL.1 Vega, evaluated at Wright Field as the Y1C-12 in the early 1930s.

World War II

The Second World War worked profound changes at Wright Field and its flight test mission. The war, first of all, transformed the physiognomy of the Field. When Wright Field was opened in 1927, it consisted of 30 buildings and no paved runway. By 1940 the Field had approximately doubled the number of buildings, but was still a rather modest installation. It was in the next four years that Wright Field assumed the architectural contours familiar today. By 1944, Wright Field consisted of nearly 300 buildings, occupying, together with the landing field, over 2,064 acres. Its facilities included the largest wind tunnel in the world with a test section measuring 20 feet in diameter and a structural test building capable, in the immediate postwar period, of stress testing a complete fuselage and wing section of a B-36.

Aerial view of Wright Field, September 1939.

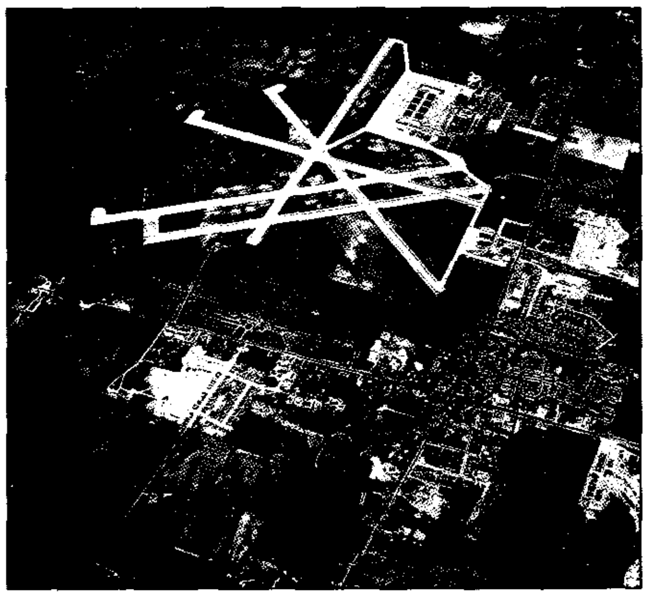


Wright Field, June 1944.

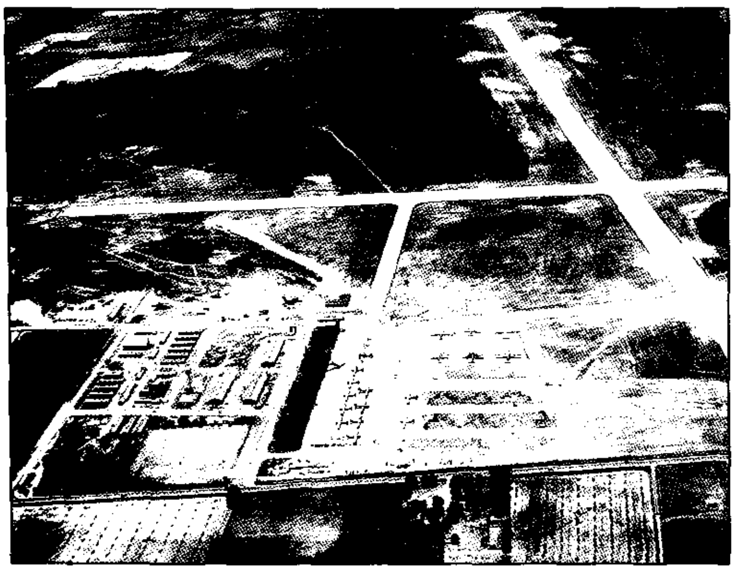
One of the more urgent construction tasks in the spring of 1941 was laying a paved runway capable of accommodating the larger and heavier aircraft of the late 1930s and 1940s, beginning with the Douglas B-19 heavy bomber. The first two runways constructed were each 150 feet in width: the east-west runway measured 7,147 feet in length and the northwest-southeast runway measured 5,569.3 feet. Both runways were completed by mid-February 1942. A third runway of 6,478.5 feet in length, was laid in 1944, thus completing the familiar triangular pattern copied at many other fields, including Patterson Field. Finally, Wright Field engineers decided to construct an inclined runway—a concept developed by the Germans in occupied France. The 10-percent graded runway was designed specifically to test take-offs and landings of the Douglas B-18 Bolo.

During the interwar years (1919-1941), when first the Air Service, then the Air Corps was chronically short of funding, flight testing consisted for the most part of testing prototype models. Indeed, there were more prototype aircraft produced and tested during this period than at any time before or since in American airpower history. Once at war, the United States no longer had the luxury of first prototyping and then mass producing aircraft. Instead, during the war years, Wright Field tested early production models of aircraft for maximum speed, range, rate of climb, ceiling, landing and takeoff runs, while the mass production of the same models continued subject to suggested modifications by Wright Field engineers. Also during the war, the Wright Field test pilot cadre was joined by pilots drawn from various tactical squadrons, flying from Patterson Field. Patterson Field pilots were especially concerned to test aircraft for combat flying qualities, including full thottle, half throttle, fast, slow, high, low—every conceivable maneuver—for the equivalent of a year or more of service life. Bomber aircraft, for instance, were flown with full crews and heavy duds at high altitudes for up to 18 hours non-stop. Meanwhile, Wright Field's Accelerated Service Test Branch conducted accelerated flight testing from the Dayton Army Air Field at Vandalia, Ohio. Troop-carrying glider tests were also conducted by the Glider Branch of the Aircraft Laboratory at the Clinton County Army Air Field near Wilmington, Ohio.

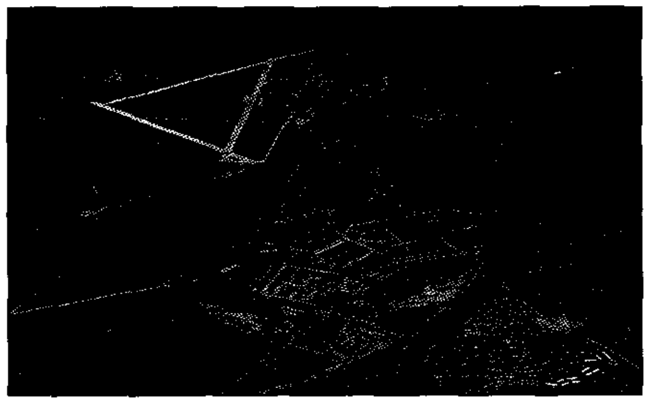
Construction of Wright Field runways in August 1944.



Vandalia Army Air Field, 1952.



Clinton County Army Air Field, July 22, 1944.



Patterson Field runways, 1944.

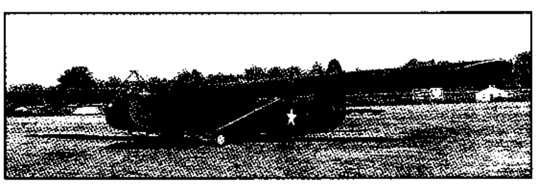
MILITARY GLIDERS

The glider as a military weapon was an innovation of the Second World War. The American military had little experience flying gliders. However, Hitler's Luftwaffe employed gliders as an integral component of its battle tactics. Seeing the effectiveness of German glider forces, General Hap Arnold, commander of the Army Air Forces, sought comparable gliders from the Materiel Center at Wright Field. General Arnold called for:

> a small light jeep constructed...to carry two men and have light armor and guns. This jeep should be designed and constructed with a view of fitting wings to it so that we can take it off as a glider and drop it as a glider. Having dropped as a glider, it lands on a field somewhere, sheds its wings and goes around as a jeep.

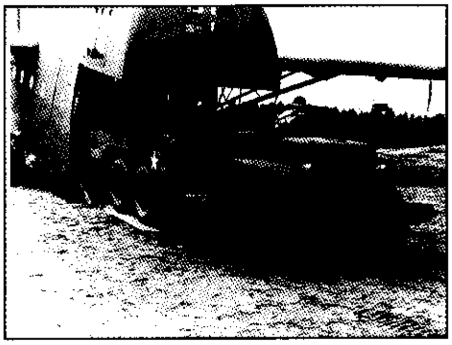
Air Corps glider development, test, and procurement was managed at Wright Field through the Materiel Center's Aircraft Laboratory, Experimental Engineering Section which, in 1942, was headed by Major Fred R. Dent, Jr. Major Dent translated General Arnold's request for a flying jeep into more practical terms and initiated development of a glider capable of carrying a fully loaded 1/4-ton truck with three crewmen or a maximum of 15 troops.

As the Materiel Center initiated the military glider program, it found that companies most capable of delivering a flyable glider were committed to powered aircraft production. The notable exception was the WACO Aircraft Company of Troy, Ohio. Prior to the war WACO was a low volume producer of high quality commercial aircraft. WACO had also produced a kit version of a glider in the prewar years and had the expertise needed to design and build a successful military aircraft. The Flight Research Unit of the Aircraft Laboratory's Glider Branch at Wright Field flight tested the WACO model in addition to several others submitted by other companies.



WACO CG-4A glider.

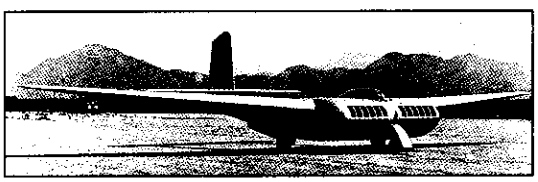
WACO's design, known as the XCG-4, satisfied General Arnold's requirement for an air-transportable jeep. The entire nose section could be hoisted upward, allowing a fully loaded truck to drive into the fuselage. It was the most successful glider design submitted and the only one procured in numbers. At war's end, over 13,909 CG-4As had been purchased. Subsequently WACO designed a successful 30-man glider, the CG-13A.



WACO CG-13A.

WACO's small plant in Troy could produce only a fraction of the gliders needed, so while WACO held the design contract, fifteen other manufacturers received production contracts to produce CG-4As. Unfortunately, lack of aircraft production experience on the part of many contractors, combined with the urgent need for thousands of gliders, the scarcity of raw materials, lack of quality control, and frequently changing requirements from Washington, resulted in poor construction of many gliders.

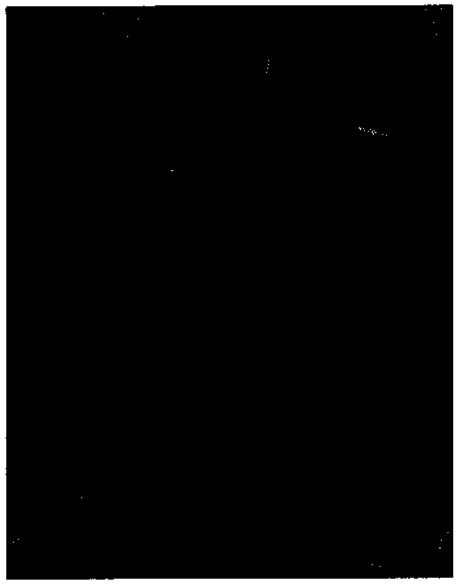
Glider Branch test pilots were keenly aware of the shortcomings of many gliders submitted by some manufacturers. Some were so poorly engineered they were unusable after one flight.



General Airborne Transport MC-1, flying wing glider.

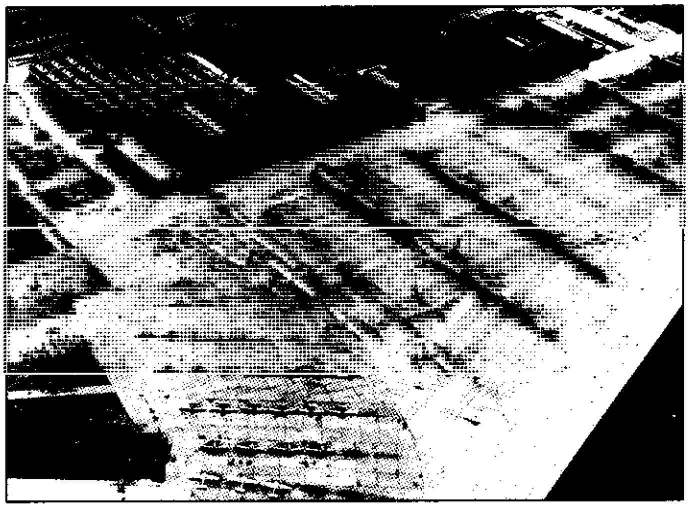
During the war years numerous other training and tactical gliders were tested at Wright Field and Clinton County Army Air Field, including the General Airborne Transport MC-1 (which became the XCG-16, a twin boom flying wing). Another was Dayton-based Cornelius Aircraft Corporation's XFG-1, with forward swept wings and no horizontal tail surface. The XFG-1 had a habit of spinning out of control.

Much effort was devoted to the glider program, but at war's end interest in gliders ceased as quickly as it had begun. However, data garnered from flight testing the new, experimental designs proved invaluable in later years as unconventional aircraft shapes were explored.

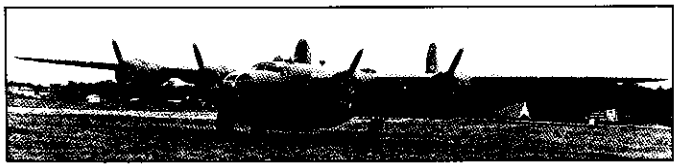


Robertson CG-4A crash, Lambert Field, August 1, 1943.

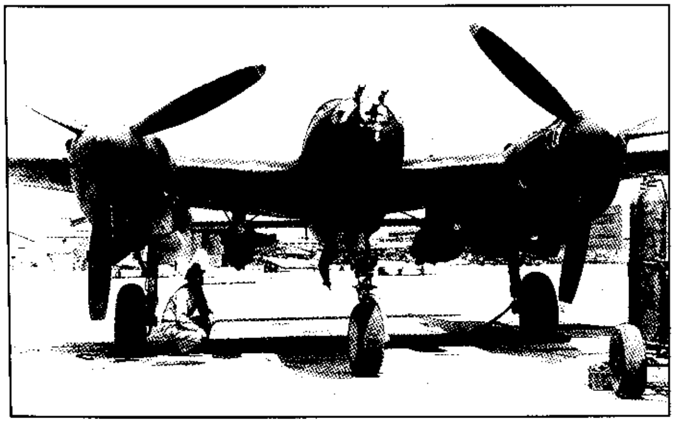
Among the bomber aircraft tested at Wright Field and flown during World War II were the Consolidated B-24 Liberator, the North American B-25 Mitchell, the Martin B-26 Marauder, and the Boeing B-29 Superfortress. Pursuit aircraft tested at Wright Field included the Curtiss P-36 Hawk, the Curtiss-Wright P-40 Warhawk, the Bell P-39 Airacobra, the Lockheed P-38 Lightning, the Republic P-47 Thunderbolt, the North American P-51 Mustang, and the Northrop P-61 Black Widow. Transport aircraft tested included the C-32, C-33, C-45, C-46, C-47, C-54, and C-87. Trainers included the Fairchild Cornell series aircraft, the PT-19, PT-23, PT-26; the Ryan series, PT-20, PT-21, and PT-22; the North American BT-9 and AT-6 Texan; and the Beechcraft AT-7 Navigator and AT-11 Kansan. Among the observation aircraft were the Stinson O-49, the Curtiss O-52 Owl, and the Taylorcraft O-57 Grasshopper. In addition to fixed-wing aircraft, Wright Field test pilots also flew autogiro and helicopter craft that were intended for observation, reconnaissance, and photography. Among these were the Kellett Gyroplane (YG-1) and the Vought-Sikorsky R-4. The latter craft was the first full production helicopter purchased by the U.S. military.



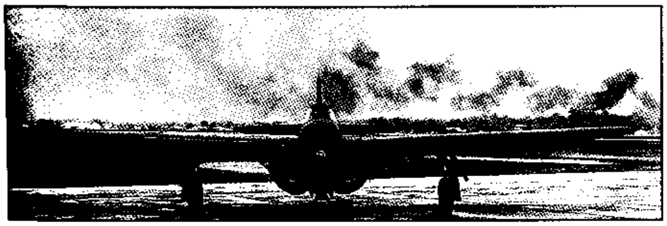
Aircraft parked in front of flight test hangars, Wright Field, May 5, 1948. (Dave Menard collection)



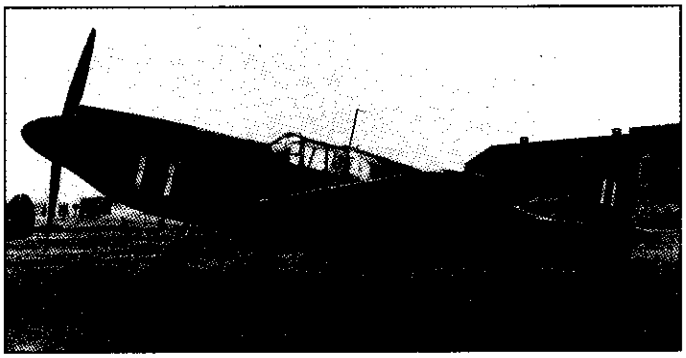
Consolidated B-24D at Wright Field. The Materiel Division eventually purchased 18,188 Liberators.



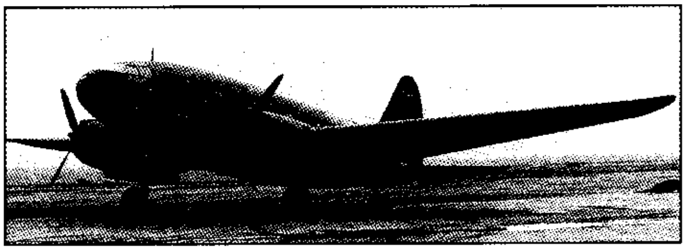
P-38 Lightning at Wright Field in 1943. (Dorothy Kirschner photograph)



The jet-powered XP-59A arrived at Wright Field for testing in 1944.



North American P-51A Mustang on Patterson Field, Building 201 in background.



Initial production model of the Curtiss C-46.

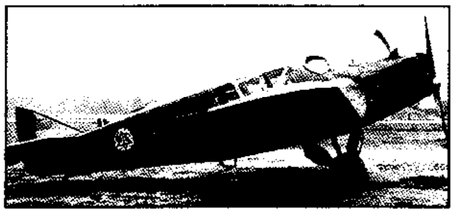
Finally, the war years also saw the development and flight test of the first American jet aircraft, the Bell XP-59A Airacomet. The Wright Field Chief of the Aircraft Projects Branch, Lt. Col. Laurence C. Craigie, was the second American—the first Army Air Force pilot—to fly the XP-59A, in flight tests conducted at Rogers Dry Lake, in 1942. Ann Baumgartner, a Women's Airforce Service Pilot, became the first woman to fly the XP-59A, in October 1944, at Wright Field.

FOREIGN AIRCRAFT EVALUATION

The history of military flight test in the Miami Valley has been, for the most part, the history of testing American aircraft and designs. From the First World War on, however, American military aviators and engineers also maintained a keen interest in foreign aircraft development. Thus when the United States obtained examples of foreign aircraft—either from friendly countries through cooperative arrangements or from enemies via capture or defection—they were likely to wind up at McCook Field or Wright Field for a thorough evaluation which included flight testing, if possible.

Fokker D-VII fitted with Packard 1237 for flight test at McCook Field, 1921. 1st Lt. Muir S. Fairchild (later first commander of Air University) noted in his test report: "On the whole from the pilot's standpoint it is a delightful engine to fly and maintain."

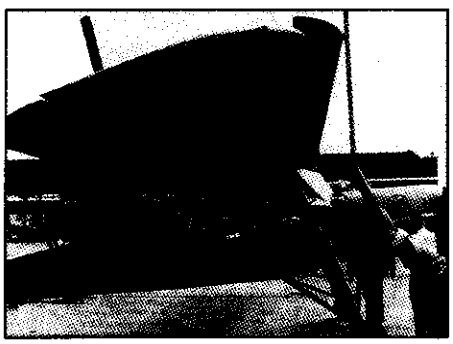
Foreign aircraft testing at McCook Field began during the First World War with aircraft obtained from America's allies as the U.S., which entered the war with virtually no combat aircraft, rushed to catch up with the technology developed over three years of murderous warfare in Europe. An American Commission, headed by Maj. Raynal C. Bolling, visited Britain, France, and Italy, selecting and sending back sample aircraft for evaluation. Ultimately, with the American aircraft industry still in its infancy, the U.S. contribution to the war effort came in the form of several thousand DeHavilland DH-4 airplanes, powered by American-developed Liberty engines. The Armistice opened up further possibilities, as the victorious allies acquired numerous German aircraft, some of which likewise found their way to McCook Field for testing. As the 1920s progressed, additional foreign aircraft were purchased or otherwise obtained for evaluation.



Junkers JL-6 tested at McCook by Lts. J. A. Macready and Harold R. Harris, 1920.

Much of McCook Field's testing during and after the war concentrated on performance testing of aircraft with several alternative engines, as when Maj. R. W. Schroeder took a Bristol fighter equipped with a 300 horsepower Hispano-Suiza engine to 29,000 feet one week after the war's end. Similarly, in 1920-1921 McCook pilots flew Fokker D-VII's variously fitted with Mercedes, Liberty Six, and Packard 1237 engines. Rosters of aircraft at McCook during the early 1920s show a wide variety of foreign types and manufacturers, including Bristol (Fighter and Scout D), Caproni, Salmson, Fokker (D-VII, D-VIII, T-2, TW-4, TW-6, PW-5, and PW-7), Spad (VII and XIII), Nieuport (16, 27, and 28), SE-5, Sopwith Snipe, Junker (JL-6), and Morane Saulnier.

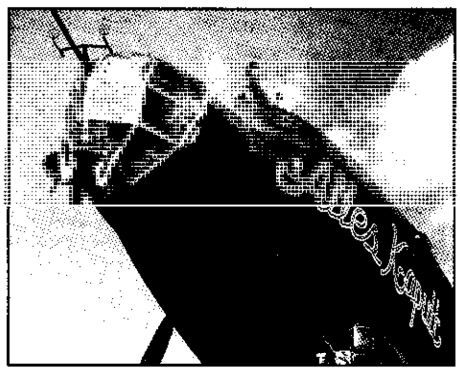
Wright Field succeeded McCook Field in 1927, and the tradition of foreign aircraft evaluation continued.



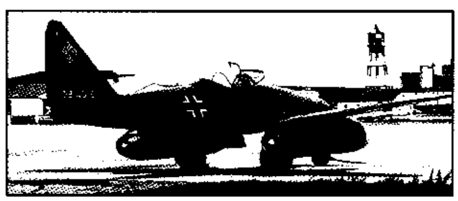
Wright Field personnel examine a Fiesler Storch Fi-156 at the 1938 Air Races in Dayton.

During World War II evaluations at Wright Field included allied aircraft like the Russian YAK-9 and the British Spitfire and Mosquito, and enemy aircraft including the German JU-88, ME-109, FW-190, ME-262, and the Japanese Zero and Betty. The end of the war again brought large numbers of captured aircraft for evaluation. As with other test flight activities, much of the foreign aircraft evaluation moved west to Muroc Air Base (later Edwards AFB) after the war, but even then the occasional foreign aircraft came to the Miami Valley for testing, as a MiG-15 (courtesy of a North Korean defector) at Patterson Field attests.

A Junkers Ju -88 during wartime testing at Wright Field.



German Ju 290 on display at Wright Field, 1945.

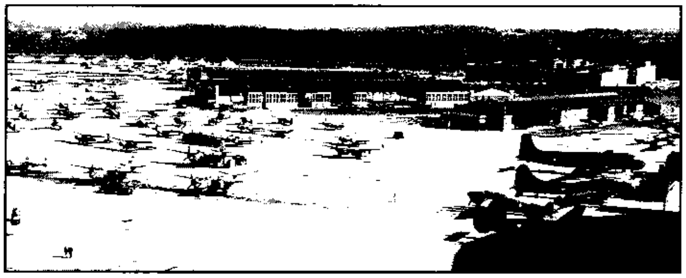


Captured Messerschmitt Me-262 at Patterson Field at the end of World War II.

MiG-15 at Wright-Patterson AFB, ca. 1953.

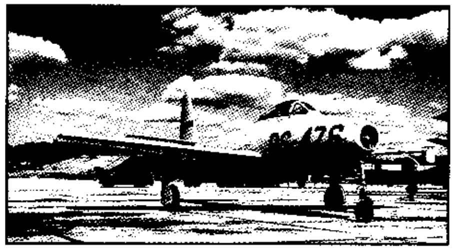
Postwar Missions and Reorganizations

The Second World War and its aftermath brought a number of important changes to the flight test mission at Wright Field. This was not simply an order of magnitude increase in the volume of flight testing during the war. There were also changes in the kinds of testing performed at Wright Field and an expansion of testing elsewhere. During the same period, the flight test mission was also subject to considerable organizational change.



Wright Field, shortly after World War II.

Lockheed P-80A Shooting Star at Wright Field.

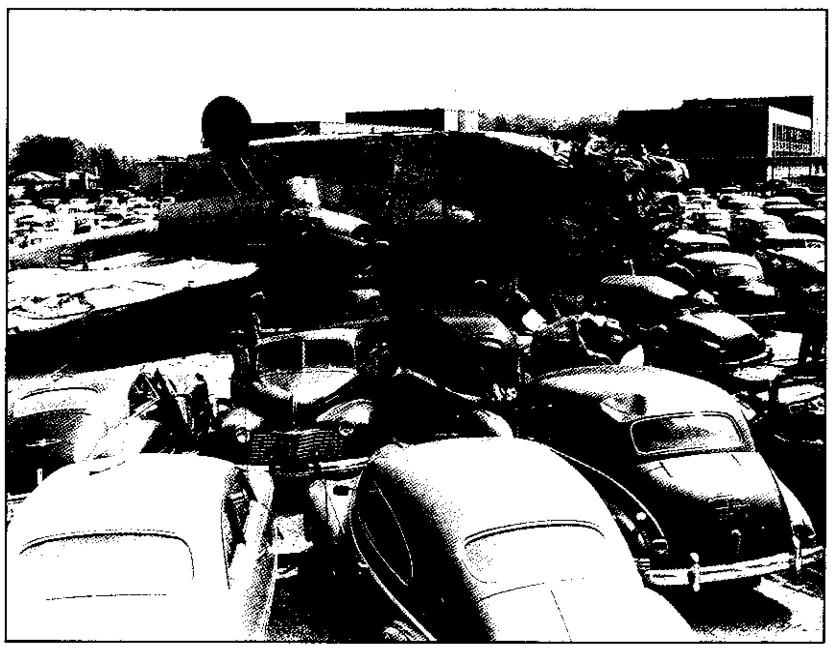


The second YP-84 built for testing at Wright Field.

During World War II Wright Field began to lose some of its flight test mission. The principal reason was the increasing unsuitability of Wright Field and nearby Patterson Field for certain kinds of flight testing. This unsuitability arose from the Fields' proximity to Dayton, an expanding metropolitan area. There were concerns, first of all, for safety, both in the increasingly congested skies overhead, and on the ground. (Inevitably, there were crashes of aircraft during flight testing. On one occasion, a test aircraft crashed into a schoolyard near Wright Field. Fortunately, this incident resulted in no civilian casualties.)

CRASH!

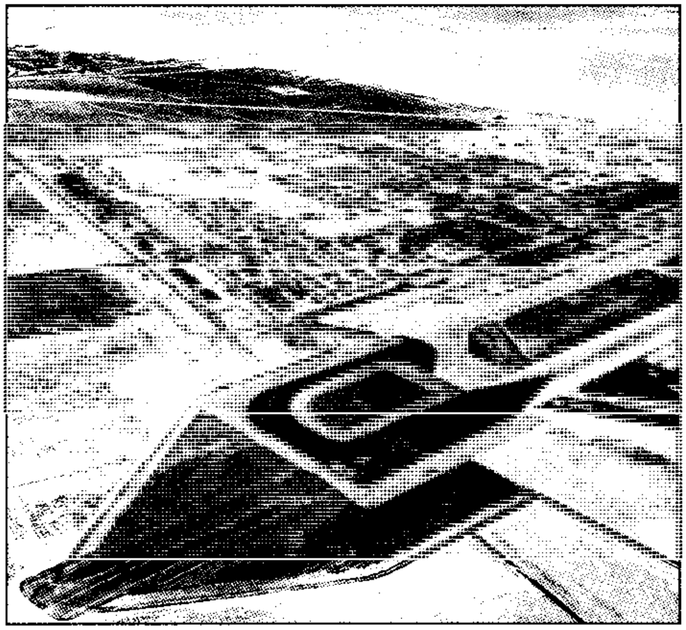
A C-82 Packet, conducting routine drop testing in Area C, Wright-Patterson AFB, on 14 July 1949 attempted an emergency landing in Area B. With its electrical system down and the right engine on fire, the plane landed about three-quarters down the runway. It ran off the end of the runway across a grassy area, plowed through a steel fence, and ran over a number of cars in the main parking lot near Highway 4 before flipping onto its back. The fire crews were on the scene immediately putting out the fire. The only person killed was MSgt Lubitz, Flight Test Division, who jumped from the plane just before it hit the fence. The other four members of the crew were only slightly injured and no one on the ground was hurt.



Wright Field in late 1940s suffered from both congested airspace and groundspace. Crash of C-82 into crowded parking lot, 14 July 1949.

Then, too, during wartime, there were concerns about possible espionage and sabotage. On all three counts, Wright and Patterson Fields were conspicuously deficient, as McCook Field had been a generation earlier. What the Army needed was a remote location for flight testing, especially the testing of advanced, experimental aircraft.

The Army found such a place at Rogers Dry Lake, Muroc, California. On 17 February 1942, the 477th Base headquarters and Air Base Squadron (Reduced) moved from Wright Field to Muroc. In the postwar period, this installation would become the Air Force Flight Test Center, Edwards Air Force Base.


Muroc Army Air Field, October 10, 1946.

THE FATHER OF MODERN FLIGHT TESTING

Albert Boyd loved to fly, and he never passed up an opportunity. Although he rose through the ranks of command to jobs that put him in the conference room more often than in the cockpit, by the end of his life he had racked up more than 23,000 hours flying time in more than 723 distinct types and models of aircraft. In 1955 the Air Force Association presented him with its Air Power Trophy to honor his status as the "Test Pilot's Test Pilot." Throughout a 30-year career he was never far from the flightline and the cockpit.

During World War II the lanky Tennessee native served in Europe as Deputy Commander of the 8th Air Force Service Command, in support of Lt. Gen. James H. Doolittle's 8th Air Force combat units. He returned from Europe in 1945 with a Distinguished Flying Cross and became Chief of the Flight Test Division of the Air Technical Service Command at Wright Field. From his office on the flightline he directed all bomber and fighter flight test activity. Under his command, Wright Field pilots tested high-performance propeller driven airplanes arriving from U.S. manufacturers plus new jet-powered aircraft just entering the inventory. He oversaw and assisted in testing captured German, Japanese, and Soviet aircraft. Although Chief of Flight Test, he retained his status as an experimental test pilot, and flew nearly all the airplanes that came to Wright Field for testing. During his tenure as Chief of Flight Test he became the first American in 24 years to set an aerial speed record when he flew 628.3 miles per hour in a jet powered Lockheed P-80R.

Boyd realized that experimental test flying of increasingly powerful aircraft was too dangerous an activity to continue indefinitely over the population centers of the midwest and was instrumental in establishing a new center for experimental flight test in the Mojave Desert at Muroc Air Force Base. In 1949 he became the commander of Muroc, soon renamed Edwards Air Force Base. Upon arrival he made plans to transfer the Air Materiel Command Experimental Test Pilot School from Wright Field to Edwards.

In 1952 he was called again to Wright Field to serve as Commander of the Wright Air Development Center (predecessor of today's Aeronautical Systems Center). From his second floor office in Building 14 he directed activities of the Center while keeping a watchful eye on the flightline and in the air. He remained in that job until 1955 when he was named Deputy Commander for Weapon Systems of the Air Research and Development Command.

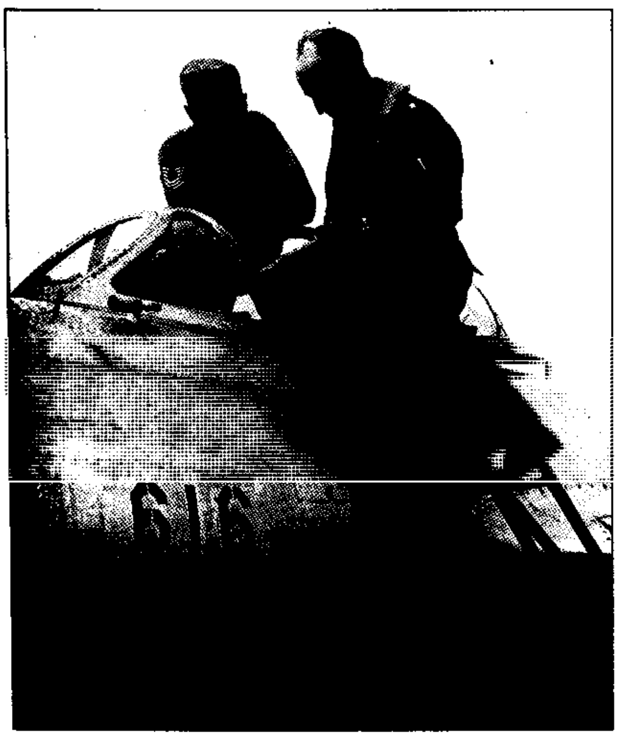
Every promotion required more time in the conference room and less time in the cockpit, except on weekends which frequently started with a pre-dawn Saturday visit to Flight Test hangars at Wright Field in search of an aircraft in need of flight hours. A typical weekend took him from Baltimore to Wright Field to Edwards and back again, with several stops and aircraft changes along the way. His weekly staff meetings invariably included a full report on the good and bad points of all aircraft he had flown the previous weekend.

Boyd demanded perfection from his pilots, and earned the respect of those who worked for him. He was a tough commander who knew how to maintain disci-

Not all flight testing, of course, was removed to Muroc. Wright and Patterson Fields remained very busy throughout the course of the war and for many years thereafter. Increasingly, however, flight testing in the Dayton area was confined to component and instrument testing and other specialized kinds of flight test. Indeed, in the immediate postwar period, Wright Field added significantly to this specialized flight test mission.

The most important addition to postwar flight testing at Wright Field was all weather testing. This activity was originally established as the All Weather Flying Group in 1945. It represented the first major attempt to solve the many problems encountered in flying under all weather conditions, both day and night. The All Weather Flying Group was designated a center, operating out of Clinton County Army Air Field, in 1945. At the end of 1945, the center was moved, briefly, to Lockbourne Army Air Field, but was returned to Clinton before the end of 1946, where it was redesignated a division.

For two years the division operated the All Weather Air Line between Clinton County and Andrews Air Force Base. The air line operated on an established schedule of takeoffs and landings and achieved notable success, demonstrating the importance of radar in air traffic control. The lessons learned from the research and activities of the division were applied, spectacularly, during "Operation Vittles," when division personnel were responsible for implementing air traffic control during the Berlin Airlift (June 1948 to May 1949).

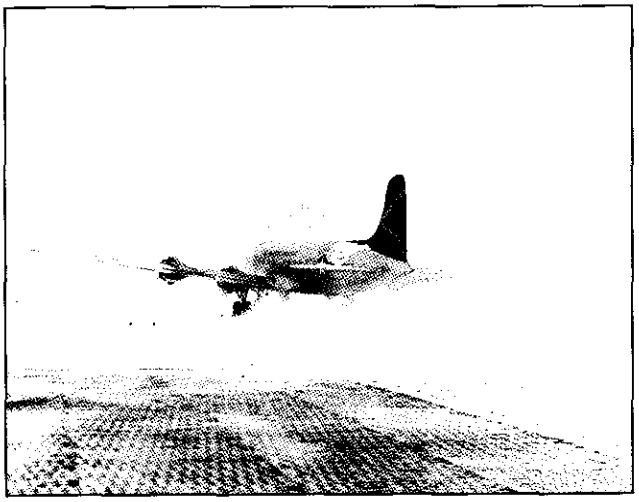


Maj. Gen. Boyd climbs aboard a Russian MiG 15 at Wright-Patterson AFB, October 1953.

pline within the ranks of enterprising test pilots. Boyd knew how to keep high spirited pilots serious enough about their job so they would not destroy themselves, property, and his program. In describing Boyd, test pilot Chuck Yeager said: "Think of the toughest person you've ever known, then multiply by ten, and you're close to the kind of guy the old man was." "There were some tough characters among the pilots at Wright, but when the old man sent for any of us, we stood at attention with sweaty palms and knocking knees." "And he was one helluva pilot." Al Boyd would have been pleased with that assessment.

THE ALL WEATHER FLYING CENTER

Following an idea initially proposed by General Curtis LeMay, the Center operated the experimental All Weather Air Line from 1 August 1946 until 10 September 1948, providing a regular scheduled service five days a week from Clinton County AFB to Andrews AFB, Maryland. Nicknamed "The On-Time Every-Time Air Line" in the press, the experiment compiled a record any airline would envy. In the course of 1,128 flights, with 5.5 million passenger-miles, the average error time for both take-offs and landings was less than one minute. No scheduled flight was ever canceled, and during one 48-hour period of severe weather in the Washington D.C. area, two flights of the All Weather Air Line were the only aircraft, military or commercial, to land there. As with its predecessor of the 1920s, the All Weather Air Line served to develop equipment and techniques as prototypes for future commercial service.



The All Weather Air Line departs for Andrews in snow.

In addition to the modification of the flight test mission during the Second World War, the flight test mission was also subject to considerable reorganization after the war. This reorganization eventually resulted in the establishment of the 4950th Test Wing a quarter century after the end of World War II.

During the First World War, flight testing had been conducted under the Equipment Division of the U.S. Army Signal Corps. Following the war, the Equipment Division gave way to the Engineering Division and finally, from 1926, the Materiel Division. Under the Engineering Division flight testing was conducted by the Flying Section, and under the Materiel Division by the Flying Branch.

In World War II, the Materiel Division became the Materiel Command (1942) and then the Air Technical Service Command (ATSC) when the Materiel Command merged with the Air Service Command (logistics) in 1944. Under the Materiel Command, flight testing was conducted by the Experimental Flight Test Branch of the Engineering Division. Under the Air Technical Service Command, Flight Test and All Weather Testing were separate divisions under the Deputy Commanding General for Engineering. A similar arrangement prevailed when the Air Technical Service Command was redesignated the Air Materiel Command (AMC), in 1946. In AMC the two divisions fell under the Directorate of Research and Development.

13 February 1923 -

BRIGADIER GENERAL CHARLES E. YEAGER

Major Chuck Yeager (left) with WADC Commander, Major General Albert Boyd.

Chuck Yeager is best known for launching the era of supersonic flight in 1947 by exceeding the sound barrier in the rocket-powered Bell X-1. However, long before that historic flight Yeager had made his mark on the Army Air Corps and the Flight Test Division at Wright Field.

After graduating from high school in 1941 the West Virginia native enlisted in the Army Air Corps. A combination of uncanny mechanical ability, superb eyesight, excellent hand-eye coordination, and good luck made him a double ace fighter pilot in Europe. Returning stateside, Yeager made the transition from combat pilot to test pilot at Wright Field where new military aircraft were designed, procured, delivered, and tested.

Yeager, a twenty-two year old Captain in 1945 with 1,100 flying hours, lacked the college education and formal training necessary to qualify as a test pilot. His schooling on the flightlines, in maintenance hangars, and in airplane cockpits in the European theater nevertheless qualified him for the job of Assistant Maintenance Officer in the Fighter Test Section of the Flight Test Division at Wright Field where his job was to ensure each test airplane was flight ready. This included test flying the plane after maintenance to ensure it was in top condition prior to turning it over to a test pilot.

In this capacity Yeager often flew six to eight hours a day, more hours than most Wright test pilots. Before long he was infamous for hovering high in the sky awaiting test pilots as they performed their carefully calibrated maneuvers. Upon spotting one he would dive and engage him in a dogfight. Many test pilots lacked combat experience and none had his extensive background, so, before long, Yeager had "waxed the tail" of nearly every Wright Field test pilot.

While this behavior annoyed the test pilots, his aggressiveness, flying skill, coolness under pressure, and intuitive knowledge of aircraft soon gained the confidence of Col. Albert G. Boyd, then Chief of the Flight Test Division. Seeing Yeager's potential he dispatched him to test pilot school for intensive training in the data gathering and reporting methods necessary for determining specific limits of aircraft. Following his graduation in 1946 Boyd named him principal test pilot for Flight Test's most important project, flying the Bell X-1 past the speed of sound. With that assignment, Captain Yeager moved on to Muroc Army Airfield and into history and Wright Field test pilots could resume their work without constantly monitoring their tails.

Following World War II, flight testing was caught up in even more extensive reorganizations. After the Air Force became an independent service in 1947, the Air Force leadership decided to create an independent command for research and development. This resulted in the establishment of the Air Research and Development Command (ARDC) in 1950. At Wright-Patterson Air Force Base, the Wright Air Development Center (WADC), within ARDC, continued the research and development mission, including ground and flight testing, of Air Materiel Command.

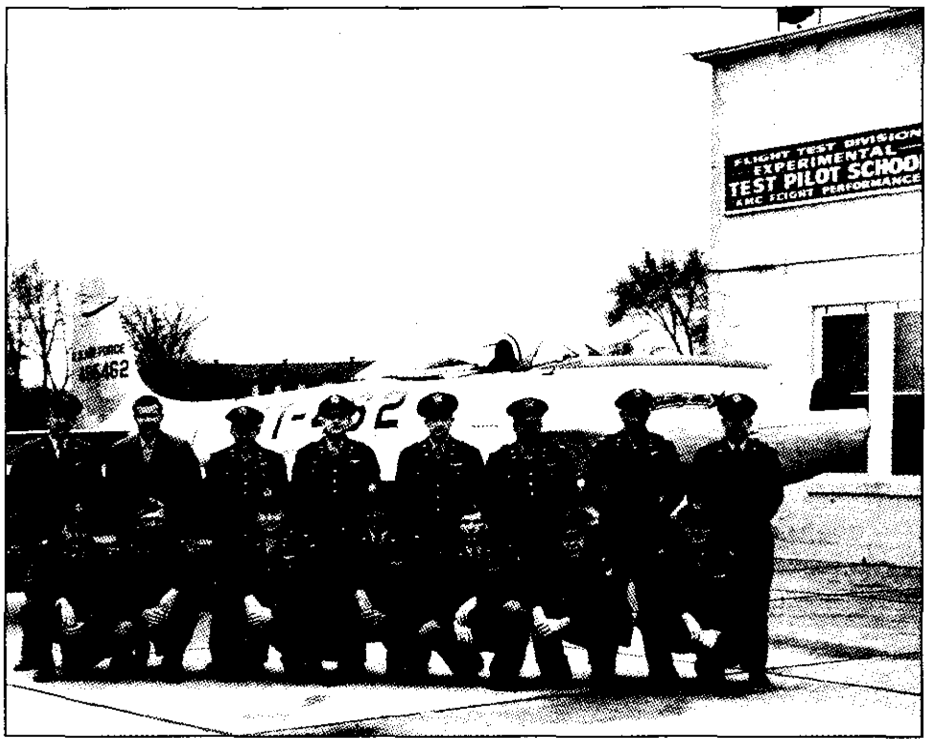
TEST PILOT SCHOOL AT WRIGHT FIELD

Prior to the 1940's test pilot training lacked rigidly defined requirements. The Flight Test Section at Wright Field had pilots whose experience ranged from hundreds of hours as airline pilots before entering the Air Force to those having just graduated from flight school. In 1942, a new test pilot coming to Wright Field simply flew the available planes on the flight line and joined experienced pilots in multi-engined planes to improve his knowledge. Testing aircraft involved becoming checked out in the airplane, putting the airplane through its paces, working up the data after returning to the ground, and discussing the data with an engineer. As a pilot became more experienced he would move from those tasks not requiring a high degree of skill or knowledge to more advanced testing. It was obvious to the test pilots, however, that a more formal test pilot education program was needed.

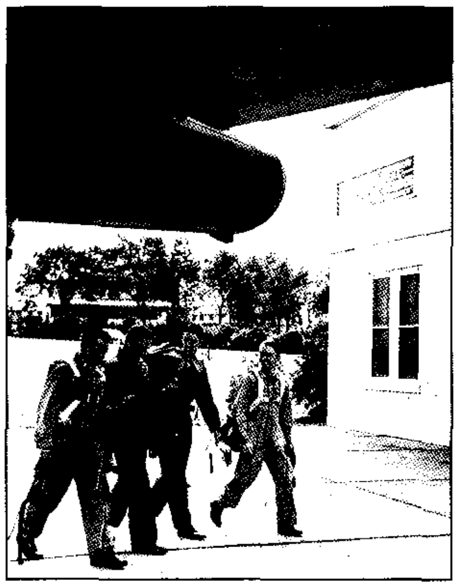
The first tentative steps involved a pilot and a flight test engineer teaming up to teach each other about basic flight test performance. This was followed by a brief flight in the AT-6 basic trainer and the submission of a flight test report. The real changes in the curriculum came as a result of the creation of the British Royal Air Force's Empire Test Pilot School. After discussions with a veteran test pilot from this school, the Flight Test chief, Col. Ernest K. Warburton, went to England to visit the school. When he returned to Wright Field he established the Flight Test Training Unit. This unit now provided a formal three-month curriculum that featured classroom courses on performance flight test theory and technique, and performance evaluations in the AT-6. After the first class completed the course, the training moved for one year to the Vandalia Army Airfield before returning to Patterson Field. In addition, more airplanes were added to the training program, including P-51s, B-17s, and B-25s. The really significant changes occurred with the arrival in 1945 of the school's new chief, Col. Albert Boyd.

Colonel Boyd, who has been called the "father of modern flight test," established exacting standards for experimental test pilots at Wright Field. A new pilot coming to the Flight Test Division was examined closely on his flying skills, intelligence, temperament, and his interest in the job before he could be assigned into the four-month long curriculum. What Colonel Boyd wanted were highly skilled pilots who had the talents of the engineer. As the aircraft became faster and more complex, it was necessary for pilots to improve their powers of observation and to discipline their piloting skills. The problems of stability and control of the new aircraft, especially with the dawn of the jet age, demanded highly skilled test pilots. It was soon evident that college level training in the engineering sciences was almost a prerequisite for completion of the course. Even as the curriculum was developing, there was a decision to transfer the school, redesignated in 1949 as the Air Materiel Command Experimental Test Pilot School.

Colonel Boyd began pressing for the school to be transferred to Muroc Air Force Base, California (renamed Edwards AFB on 5 December 1949), in the high desert region. Two reasons were given as the basis for the move: the airspace around Wright Field was becoming more and more congested, and the weather around Wright-Patterson AFB was poor during part of the year. In September 1949, Colonel Boyd assumed command of Muroc and in February 1951 the school, soon to be named the Air Research and Development Command Experimental Test Pilot School, was officially transferred to Edwards AFB, ending the test pilot school at Wright Field.



Test Pilot School Class of 1949D at Patterson Field. Front: Capt. J. R. Amann, Maj. J. C. Wise, Maj. G. V. Lane, Maj. P. P. Haug, Lt. R. J. Harer, Lt. R. D. Hippert, Capt. S. P. Parsons. Back row: Maj. K. O. Chilstrom, J. Krug, Capt. G. B. Quisenberry, Maj. D. A. Johnson, Capt. L. K. Nesselbush, Capt. R. M. Roth, Capt, R. L. Stephens, Capt. R. M. Howe. (USAF Flight Test Center History Office.)

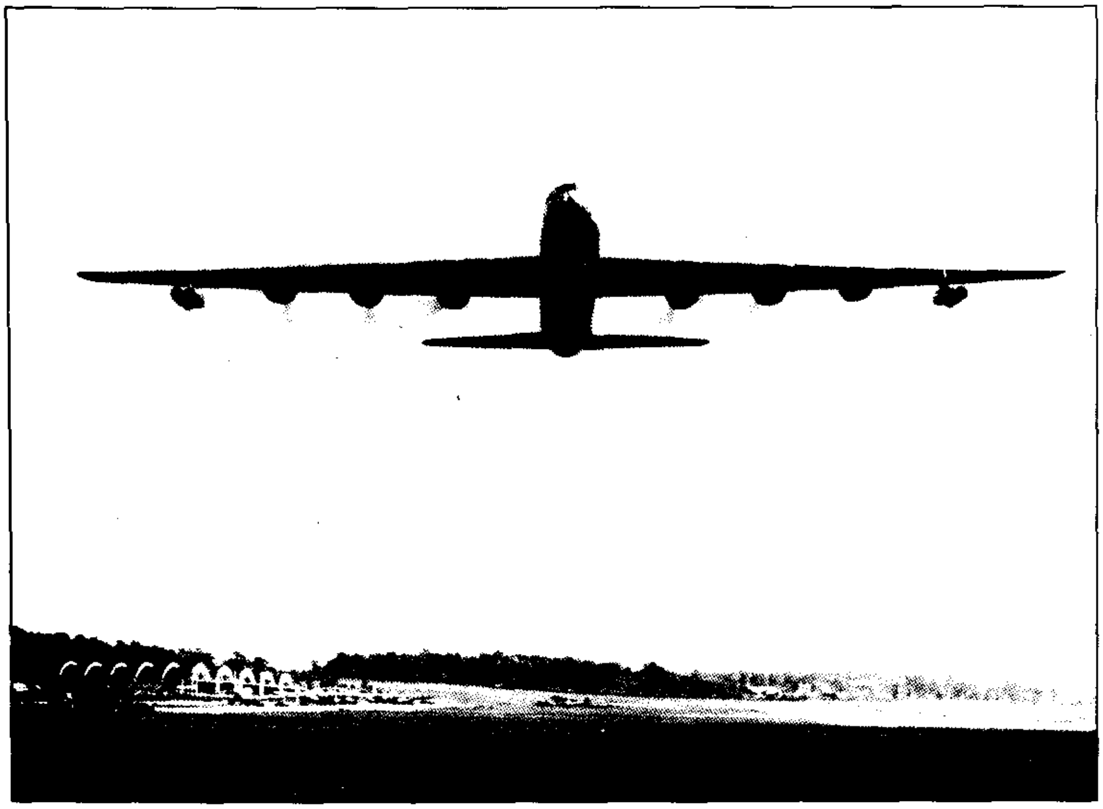


Student test pilots return from a flight and head toward the classroom. Building 88, now known as the Foulois House, is in the background. (USAF Flight Test Center History Office.)

Under WADC, flight testing was initially organized, as under Air Materiel Command, in two directorates, one for Flight Test and the other for All Weather Testing. However, by 1952 the two directorates had been united into the Directorate of Flight and All Weather Testing. The directorate had three branches, for Engineering, Flight Operations, and Maintenance. In 1955 a fourth branch was, briefly, added to manage development of the Traffic, Control, Approach, and Landing System (TRACALS).

The TRACALS program began in 1953, when ARDC directed the integration of numerous research and electronic development projects. The basic objective of the TRACALS program was the development of an air traffic control, approach, and landing system for the Air Force, consisting of integrated navigation and traffic control facilities and procedures. ARDC designated the Wright Air Development Center as the responsible organization with the Rome Air Development Center and the Air Force Cambridge Research Center in supporting roles.

At first the TRACALS System Office was a staff function of WADC's Directorate of Flight and All Weather Testing. In 1955, the directorate organized a TRACALS branch to provide operating personnel to perform a portion of the development and testing programs.



B-36D flies low over Loop Road, Area B, WPAFB, with six churning and four burning.

1960s

The early 1960s witnessed the most far-reaching organizational changes at Wright-Patterson since the late 1940s. In 1961, the Air Research and Development Command was redesignated the Air Force Systems Command (AFSC). At the same time, the Wright Air Development Center (which in 1959 had been redesignated the Wright Air Development Division) became the Aeronautical Systems Division (ASD). The new command and its divisions took over from the Air Materiel Command all its responsibilities for systems acquisition. In place of AMC was created the Air Force Logistics Command.

Under ASD flight test was initially conducted by a new organization, called the Deputy for Test and Support. The new deputate combined the functions of the Directorate of Flight and All Weather Testing and the Directorate of Support. This was significant for it marked the first time that the flight testing mission was combined with the maintenance and aircraft modification functions. This combination would form the core of the test wing of the 1970s and 1980s.

In 1963, ASD redesignated the Deputy for Test and Support the Deputy for Flight Test. The deputate consisted of five directorates, for Flight Test Operations, Test Data, Aircraft Maintenance, Test and Integration Analysis, and Supply Services. In 1968 the deputate was redesignated a directorate; its subelements thereupon became divisions, but otherwise remained the same.

The twenty years from the late 1940s to the late 1960s were far from uneventful in flight testing at Wright-Patterson, despite the transfer of most aircraft prototype testing to Edwards Air Force Base. First WADC and then ASD conducted a variety of in-flight testing of aircraft and aircraft components under various atmospheric conditions, including icing, turbulence, and thunderstorms. The flight test directorate tested everything from windshield rain repellents to combat traction systems for landing on wet runways. The directorate also tested an adverse weather aerial delivery system for the C-130E, frangible canopies for pilot ejection, electronic location finders for downed airmen, tow wires for the accurate aerial delivery of cargo, and an air cushion landing system. The directorate also conducted flight tests of the first gunships, developed by the directorate. Finally, the directorate also supported the U.S. space effort by conducting zero-gravity testing and by testing such devices as the lunar rover vehicle for the Apollo lunar missions. (These programs and others are discussed more fully in Chapter 2.)

4950th Test Wing

Several important changes occurred to the flight test mission in the 1970s. In 1970, the Directorate of Flight Test lost the all weather flight test mission, which it had conducted for nearly two and a half decades. The all weather mission was transferred to Edwards Air Force Base, in California. The following year the directorate became a wing, located at Wright-Patterson and reported to the Aeronautical Systems Division. Designated at first the 4950th Test Wing (Technical) and shortly thereafter simply the 4950th Test Wing, the new organization, with its own commander, enjoyed greater visibility and responsibilities than the old directorate. The 4950th Test Wing, as originally constituted, consisted of ten organizational subelements: a Headquarters Squadron Section, Administrative Security Office, Computer Center, and Plans and Programs Office; and six divisions, for Test Engineering, Test Operations, Engineering Standards, Civil Engineering, R&D Procurement, and Logistics.

In 1974 and 1975, the 4950th Test Wing underwent a major reorganization. This reorganization was part of an Air Force-wide reorganization and realignment of functions following the United States' withdrawal from the Vietnam War and resultant drawdown of military forces. Originally called Project Realign and finally Project HAVE CAR, this reorganization brought a number of major changes to Wright-Patterson, including the creation of the Air Force Wright Aeronautical Laboratories (AFWAL). In anticipation of Project Realign, the 4950th began a reorganization in late 1974, transferring its Administrative Security Office, Computer Center, and R&D Civil Engineering and R&D Procurement divisions to other ASD organizations. At the same time, the Test Wing reorganized its remaining subelements. Three new deputates were created, for Operations, Aircraft Modification, and Maintenance. This was significant for it clearly separated for the first time aircraft modification from maintenance (see Chapter 4). The reorganized Test Wing also included a Headquarters Squadron Section, Safety Office, Administrative Office, Directorate of Flight Test Engineering, and Directorate of Support. With several minor changes, this organization remained stable for the remainder of the 1970s and 1980s.

In addition to a transfer of some subelements and a reorganization of others, HAVE CAR also bestowed upon the 4950th Test Wing new resources and mission responsibilities. The Test Wing received 20 additional aircraft, including 10 C-135s from Patrick AFB; two C-135s from Edwards AFB; one T-39 from Eglin AFB; and two C-135s and five C-131s from Griffiss AFB. Eight of the

AFSC's First All-Female Flight Crew

On 10 December 1987 a 4950th Test Wing KC-135 aircraft took off from Wright-Patterson AFB and achieved a first for the Air Force Systems Command. It was the first flight with a crew composed entirely of women. The pilot was Captain Monica "Nickie" Vaughn, co-pilot Captain Cathy Caseman, and flight engineer Staff Sergeant Ofelia Elliot. Their NKC-135A lifted off at 4:00 p.m. on a training mission to Wurtsmith AFB, Michigan.

4950th Test Wing flight crew: Sergeant Elliot, Captain Caseman, and Captain Vaughn.

C-135s comprised the Advanced Range Instrumentation Aircraft (ARIA) fleet. The ARIA aircraft had served as the tracking station for the Apollo space launches beginning in 1968, and operated around the world to receive and transmit the astronauts' voices in addition to tracking and recording information from the spacecraft. The 4950th used the ARIA aircraft to receive, record, and retransmit telemetry data on orbital, re-entry, and cruise missile missions. In 1982 the 4950th acquired four retired Boeing 707 aircraft, which it converted to the EC-18B configuration. The EC-18Bs, which had greater range and capabilities than the C-135s, continued and expanded the ARIA flight test mission.

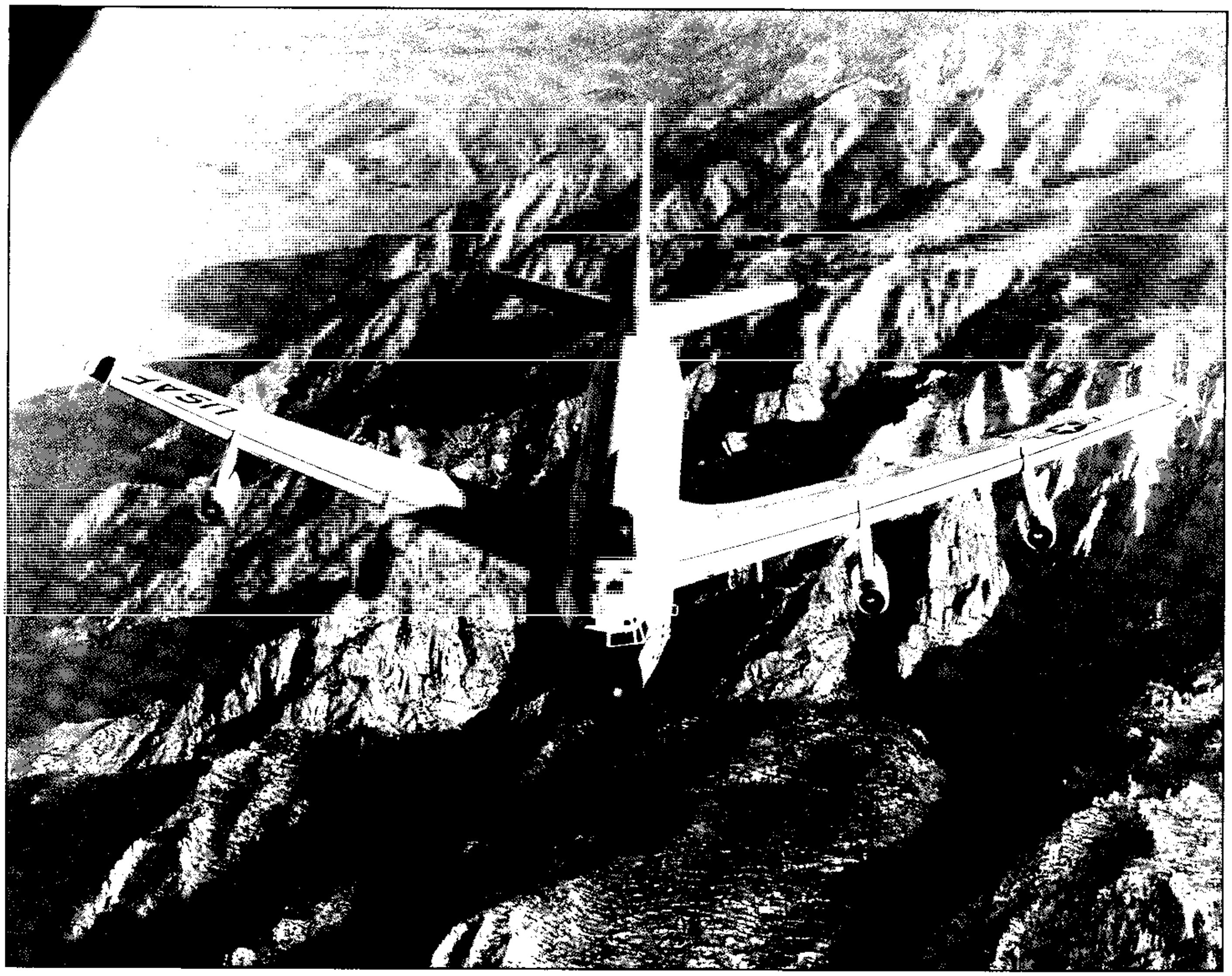
During the 1970s and 1980s the 4950th Test Wing conducted a diverse flight test mission, in addition to its ARIA program. This included flight testing of improved radars and other avionics systems; the testing of electronic warfare systems, infrared missile guidance systems, and lasers. The Test Wing also flight tested satellite systems and their components, including those for the Navstar global positioning system and the Milstar system for military strategic and tactical relay. The Test Wing further participated in testing systems for the Strategic Defense Initiative (SDI) using the Optical Diagnostic and Argus aircraft. Finally, 4950th aircraft continued to serve as testbeds for multiple research and development projects flown in support of Wright-Patterson and other USAF laboratories and research centers. (These programs are treated in depth in Chapter 3.)

The end of the Cold War in the late 1980s ushered in plans for downsizing the nation's armed forces. These plans included base closures, transfers of functions, consolidations, and realignments unprecedented since the end of the Second World War. Among the more dramatic actions taken as part of this process was the realignment of the Strategic Air Command and the Tactical Air Command to become the Air Combat Command, while the Military Airlift Command was restructured and redesignated the Air Mobility Command. Meanwhile, the Air Force Systems Command and the Air Force Logistics Command combined missions to form the Air Force Materiel Command, headquartered at Wright-Patterson Air Force Base. As part of this realignment, the Aeronautical Systems Division was redesignated the Aeronautical Systems Center.

The Air Force flight test mission at Wright-Patterson did not emerge unscathed from this process. In 1991 the Department of Defense announced its intention to move the 4950th Test Wing's flight operations to Edwards Air Force Base, California. Only the Modification Center, which served both flight testing and the laboratories, was to remain at Wright-Patterson and transition to the Aeronautical Systems Center. The 4950th Test Wing would thereupon cease to exist as an independent Air Force unit.

The transfer of the 4950th's flight test mission westward marked the end of an era. For the first time since 1917—since 1904—the skies above Dayton would be silent to the sound of flight test aircraft.

The 4950th Test Wing and its predecessor organizations at Wright-Patterson Air Force Base, Wright and Patterson Fields, McCook and Wilbur Wright Fields can look back on a solid record of achievement. The foundation of this record has only been glimpsed in this chapter. Flight testing in the Miami Valley made significant contributions to the winning of two world wars, helped break the nuclear stalemate of the last 40 years, and whetted the Air Force's terrible swift sword as this was wielded for all the world to see in Operation Desert Storm. Air Force flight testing also contributed substantially to civil aviation in the areas of all weather flying as well as air traffic control and tracking technologies. The remaining chapters in this book discuss some of these achievements and their importance for American air power in the second half of the twentieth century.



CHAPTER 2

Test Flying Operations (1950 - 1975)

The origins of flight testing by the 4950th Test Wing can be traced to the first experiments of the Wright brothers as they flew their aircraft from Huffman Prairie and later to the test flying from McCook Field. The aircraft flying from Wright Field and later Patterson Field and Wright-Patterson AFB have been fully documented in several publications. This chapter covers primarily the story of the testing done in the 1960s and 1970s, tracing some of it back to the 1940s and 1950s.

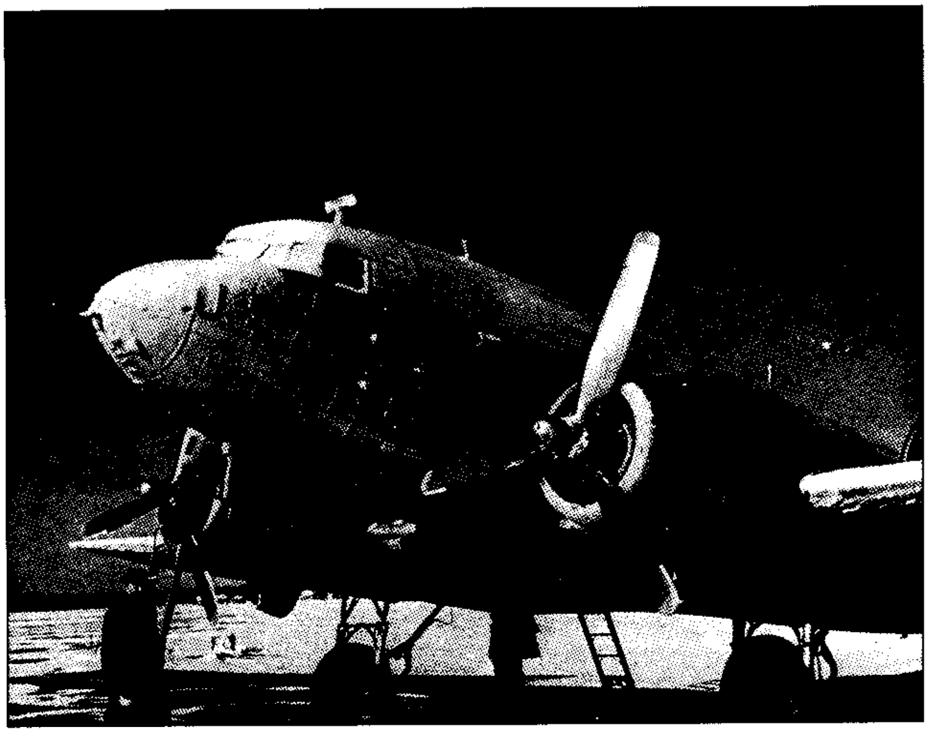
Flight testing and all-weather testing, separate during the 1940s, were joined together by the early 1950s. In the 1970s the Flight Test Division became the 4950th Test Wing and the all-weather testing moved to Edwards AFB, California. During WWII flight testing was conducted at Wright Field under the Flight Test Section. On 11 October 1945 it became the Flight Test Division, under the jurisdiction of the Engineering and Procurement Division, Air Technical Service Command. In 1946 the Air Technical Service Command gave way to the Air Materiel Command with the Flight Test Division being placed under the Directorate of Research and Development. The All Weather Flying Group, on the other hand, was constituted in 1945 at the Clinton County Army Airfield, near Wilmington, Ohio, moved to the Lockbourne Army Air Base (now Rickenbacker Air National Guard Base) in October 1945 and returned to Clinton County at the end of January 1946 where it became the All Weather Flying Division. Its Headquarters was at Wright Field until 1 August 1946 when it moved to Clinton County. In 1951 the All Weather Flying Division became part of the Flight Test Division and the organization was designated as the Flight and All Weather Test Division, under the newly created Wright Air Development Center (WADC). In 1952 it became the Directorate of Flight and All Weather Testing. In 1963 the Deputy for Flight Test was formed with all-weather testing becoming the Adverse Weather Section until June 1970 when the Category II weather testing was transferred to Edwards AFB. The Flight Test Division, predecessor to the 4950th Test Wing, conducted hundreds of programs. In this chapter, we will examine the most significant operations conducted between 1950 and 1975 beginning with weather testing.

AIR STARTING JET ENGINES

In 1961 the Flight Test Division ran a series of tests on a method of starting jet aircraft by directing the wake blast of another jet toward its inlet. Two attempts to start a "disabled" F-86A airplane, first in the wake of another F-86 and then in the rear of an F-84 were successful. The skin temperatures recorded by the receiving F-86A were not dangerously high.

WEATHER TESTING

When human beings first took to the air one of their primary concerns was what effect weather would have on their airplanes. Three of the major concerns, to be discussed below, were aircraft icing, turbulence, and thunderstorms. As aircraft became more sophisticated, flying higher and faster, these concerns became more critical. The Air Force needed to understand these phenomena if it was to avoid or to operate despite potentially hazardous weather conditions. At Wright-Patterson AFB, the Flight Test Division investigated these weather problems until the Category II weather testing moved to Edwards AFB, California.



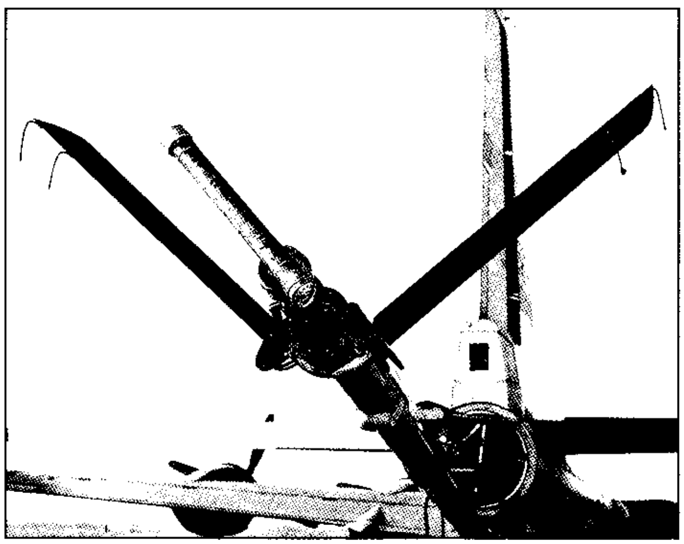
Flying in severe icing conditions over the mid-west this C-47 aircraft became covered with ice and was forced to land at Terre Haute, Indiana.

The Air Force learned from experience that environmental testing was extremely important for aircraft management. When an aircraft was exempted from testing for readiness, too often problems arose later that had to be corrected quickly and expensively. For example, in the 1950s the C-124, "Old Shakey," was exempted from all-weather testing. During its first year of operation the Military Air Transport Service (MATS), the operating command, placed serious restrictions on the aircraft because aircraft icing problems created a safety hazard. This resulted in a hurried test program. The C-97, an off-the-shelf aircraft, was given superficial tests and later "fell apart" when a Strategic Air Command mission required its visit to the bitter cold of Thule, Greenland. The all-weather testing of all aircraft was not a luxury but a necessity and the Flight Test Division successfully fulfilled that requirement.

AIRCRAFT ICING

Since 1948, when a T-6 trainer aircraft was flown behind a C-54 aircraft with a propeller icing rig installed, the Flight Test Division developed equipment to create aircraft icing under other than natural conditions. The artificial icing would eliminate the need to wait for, or hunt out, natural icing conditions for the tests and decrease the time required for testing. Initially, attempts to create artificial icing conditions used an in-flight refueling system, allowing the air streaming behind the aircraft to break up the water into small drops. It was difficult, however, to produce the proper drop size and liquid water content with the available water dispensing systems. These two parameters were critical if the natural icing conditions were to be reproduced artificially. Unfortunately, the initial methods used tended not to reflect the real world of icing. Practical tests included flights behind a spray rig on a C-54, flights behind a B-24 in a cloud created from forcing water through a fire hose and fire hose nozzle, and flights of a fighter aircraft behind a Constellation tanker using a two-inch pipe for a nozzle. This resulted in very heavy icing. In the 1950s the Flight Test Division, which had absorbed the All Weather Section, primarily used a KB-29, but also a KC-97 and a KB-50 aircraft, to provide the stream of water.

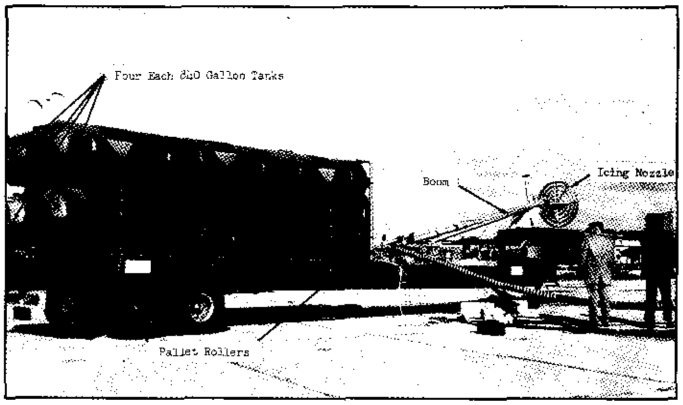
The next step involved using a more advanced spray mechanism on the KB-29 aircraft. The water spray mechanism developed by Flight Test engineers consisted of a "T-bar" arrangement at the end of a refueling boom. The T-bar had a series of 3/16-inch holes on each end of the T where water was discharged into the air stream. The T-bar was used primarily for ice crystal formation at high altitudes and for heavy rain at low altitude. In addition, the T-bar could be used for icing tests where heavy accumulation or a high rate of accumulation was the primary test requirement. Another spray system was developed consisting of two concentric rings with the outside ring having a diameter of 40 inches. These two rings with cross members contained 66 individual spray nozzles. The rings could be fitted with three different nozzle heads, one with 60 holes of 1/16 inch in diameter, one with 16 holes of 1/8 inch in diameter, and one with 16 holes of 1/4 inch in diameter, depending on how large a stream of water the program demanded. The resultant water droplets from the sprayer, however, were very large, the majority considerably in excess of 40 microns with extremes from 80 to 100 microns. Consequently, this icing pattern was unlike the real world. MATS pilots remarked that they seldom encountered ice impingement as far aft as that caused by the sprayer.



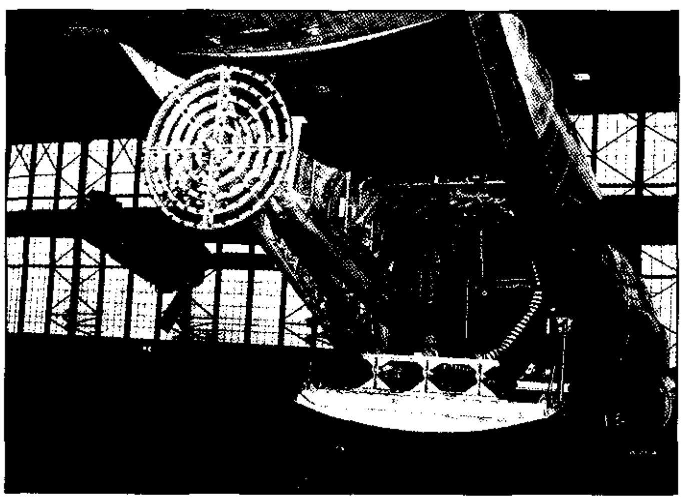
T-bar at the end of a KB-29 refueling boom with holes in each end to spray water into the atmosphere.

The Flight Test Division believed that the use of tankers to simulate icing conditions that were reasonably consistent with nature ensured a controlled means of testing aircraft ice removal systems to their design limits. Tanker icing also was perceived as much safer since exposure to a potentially hazardous icing condition could be accomplished under controlled conditions. The icing testing, though much safer than testing under actual weather conditions, was not totally accident free. On 21 November 1957 the KB-29 water tanker, S/N 44-83951, was conducting a simulated icing test of an L-27A, S/N 57-5848, aircraft. Around 10 o'clock in the morning the tanker took off and rendezvoused with the L-27A at about 5,000 ft. Immediately, the L-27 began his first icing run but after about 2 minutes he reported his windshield was iced up and pulled out of the spray. About 8 minutes later the L-27 pilot began a second run but 3 minutes later the pilot of the chase plane, a T-37, reported that the L-27 had lost both engines and the aircraft had to make an emergency landing in a field.

In the latter half of the 1950s the Division's KB-29 was becoming an old aircraft and needed to be replaced. In addition, it was necessary to design a suitable spray rig that would create proper droplet size. There were several possible airplanes in addition to the C-123, which was used for low speed icing tests up to 18,000 feet, namely the KC-97 and the KB-50J. Both airplanes would provide improved speed and altitude capability though neither would improve the capability to create the important types of icing conditions most pilots faced. There was even some thought of converting a B-47 into a tanker aircraft. The Air Force decided on testing two aircraft, the KC-135 for high speed icing and the C-130 aircraft for low speed icing tests. The C-130 was fitted with a sled that provided a great improvement in icing simulation capability. The sled consisted of tanks, water pumps, and spray nozzles. Fortunately, the C-130 could provide an adequate supply of hot air for air-water type nozzles to keep the spray rig free of ice accumulation. The constant heat allowed the spray to be turned on and off without the fear of internal icing and possible spray rig destruction by blockage. Also, the sled required only a short fixed boom. The spray rig was stored on a flat-bed trailer and then placed in a C-130 when needed and was used on an average of two to three times each icing season. The KC-135 aircraft was used for icing tests at speeds between 150 and 300 KIAS at altitudes below 30,000 feet.

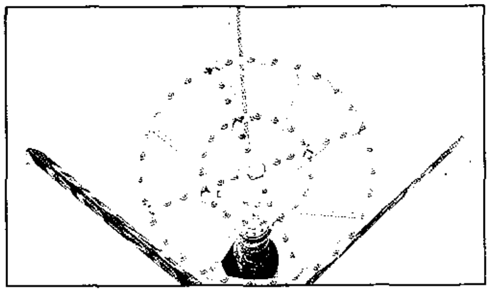


Water Spray Sled for insertion into a C-130 to be used for low speed icing tests. It consisted of tanks, water pumps, and spray nozzles.


Water Spray Sled installed in a C-130 had a fixed boom for spraying water to create icing conditions for following aircraft.

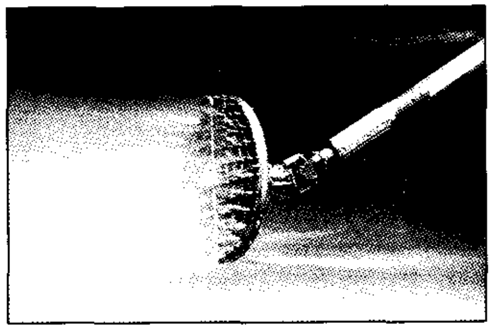
The engineering technicians were also able to develop more adequate nozzles. In 1956 M/Sgt Andrew R. Rader, engineer on the Artificial Ice and Rain Support project, designed, developed, and supervised fabrication of a unique spray nozzle for the tanker. It was composed of circular rings and cross bars of aluminum tubing into which he set fuel injection nozzles. The first new spray rig consisted of a 20-inch aluminum ring, drilled with 32

1/8-inch holes. The liquid water content was lower because of an increased spray diameter. The next rig design was a 40-inch aluminum ring, holding 66 jet type nozzles, rated at 100 micron droplet size each. A third rig consisted of 100 nozzles welded into five concentric rings with the nozzles placed approximately 4 inches apart on the face of each ring. Calculating the liquid water content from the nozzles the technicians determined that an aircraft that was 750 feet behind the tanker nozzle would experience the same moisture as a cumulus cloud in the 0 - 10,000 foot range. In order to discover the size of the drops created by the nozzle, the Division arranged for an F-94 aircraft to fly in a spray behind a tanker and then measure the ice impingement areas compared with the known maximum icing impingement areas possible for different drop sizes. The results indicated that the majority of drops from the new rig were on the order of 50 microns in size, which was close to the drops found in the natural world.



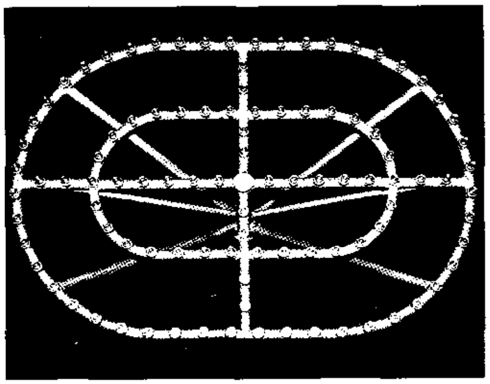
Water spray aluminum ring with 66 nozzles that could be attached to the refueling boom of a KC-135 aircraft.

In 1964 the KC-135 aircraft, S/N 128, was modified to permit the simulation of aircraft icing conditions. The aircraft's power plants were four Pratt-Whitney J57s which provided the source of bleed air used for water atomizing. Once the fabrication work was completed the Directorate of Flight Test completed ground testing to determine the basic physical capacities of the system and then conducted flight testing to establish the in-flight icing envelope. The first ground test involved weighing the KC-135 as tap water was put into the aft main tank to pre-marked levels. At each level the weight was recorded and a water load calibration obtained. During the weigh-in process a gage was calibrated to provide remote indication of total water left in the tanks. Water tank calibrations were followed by engine runs and system activation using aircraft power. The first check was boom extension and retraction. The major point of concern was to discover whether the flexible water hose would slide in and out as the boom moved. There were no difficulties. This was followed by bleed air system activation and water pump hydraulics tests.

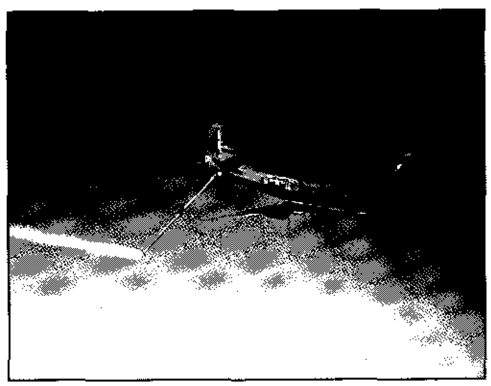


Spray rig with 100 nozzles welded into five concentric rings with nozzles placed approximately four inches apart on the face of each ring.

Once these were completed the next step was to conduct flight testing. The first flight occurred on 5 May 1964 but was not without problems. When the aircraft exceeded 300 knots-indicated-air-speed (KIAS) excessive aerodynamic loads bent the spray rig boom attachment structure, aborting the test. The modification branch changed the design of the spray rig attachment structure to incorporate a one degree of freedom hinge to enable self alignment perpendicular to the airstream. The aircraft flew again on 14 May 1964 with relatively few problems at first. While the spray system worked well, maximum flow was not reached because of a kink in the waterhose inside the boom. To check for rig flutter and other unfavorable characteristics the crew extended and retracted the boom several times while an observer in a chase aircraft watched. As long as the aircraft remained between 180 and 300 KIAS none were seen. The crew did discover that they could not retract the boom until the airspeed as reduced to 220 KIAS or less. The aircrew terminated the test and dumped the remaining water. As the aircraft was flying at approximately 290 KIAS the crew felt a sudden deceleration jerk and heard a slamming sound throughout the aircraft. When the pilot

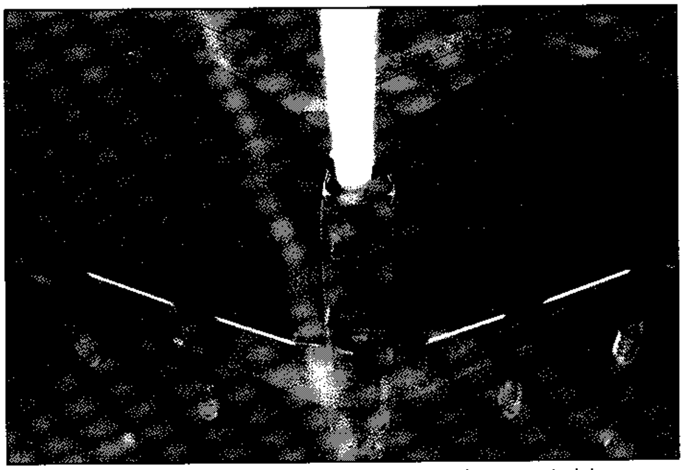


Oval spray rig with 100 nozzles for use on a KC-135 aircraft.



KB-29 spraying water through a 66 nozzle spray rig to create icing conditions for following aircraft.

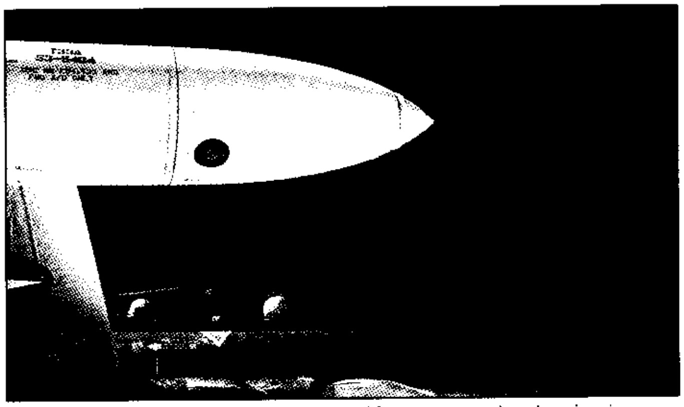
began to land, the tower operator notified him that the boom was extended. It was discovered later that a hydraulic safety valve had released because of the high drag load imposed by the spray rig. It was necessary to install a new boom and to perform modifications as well as to impose airspeed limits to insure against the destruction of the boom. There were no further difficulties with the boom during flight testing.



KC-135 spraying water from a 100 nozzle spray rig to create icing conditions for high speed aircraft.

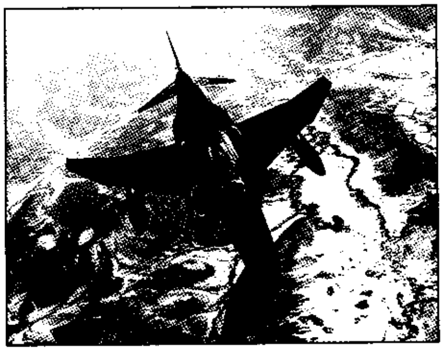
The next step in the testing process involved determining the pneumatic spray system icing envelope. These tests began on 8 June 1964. To perform these tests the Directorate used an instrumented T-33 aircraft to fly in the KC-135's spray and to collect photographic documentation by a chase aircraft. An operator in the back seat of the T-33 monitored the instrumentation.

Even these tests were not without problems as the spray rig developed stress relief cracks and also lost a nozzle head. The stress relief cracks were difficult to solve but after many hours of frustrating effort the maintenance people determined that high residual stress in the spray rig welds were the cause of the failures. When the welds became cold and contracted, the stress levels increased to the failure point. This occurred as the aircraft climbed to icing altitudes. Also, it was discovered that bonding materials had been applied poorly resulting in the loss of the nozzle head. The modification branch solved both of these difficulties. Once the problems were worked out the KC-135 proved to be an able aircraft in flying icing missions that reflected the natural icing environment. The Flight Test organization conducted numerous icing tests on a variety of aircraft.



An instrumented T-33 flying behind a KC-135 spray rig, showing ice on wing and tip tank as it collected photographic documentation.

Over the years the Adverse Weather Section, in addition to conducting weather tests at Wright-Patterson AFB, Ohio, conducted Category II climatic tests of Air Force aircraft at the Climatic Projects Laboratory, Eglin AFB, Florida, as well as cold weather flight tests at Ladd and Eielson AFBs, Alaska, and hot weather flying in the California desert. Later Ladd would be dropped from testing and the hot weather testing moved to Yuma, Arizona. In 1956 the Air Force also took complete responsibility for what used to be a joint Air Force-Navy effort at Mt. Washington, New Hampshire. The Programs Unit of the Engineering organization managed and controlled all aspects of Air Force testing conducted at the contractor-operated test facility on the summit of Mt. Washington. In August 1956, the management of the Mt. Washington function was transferred to the Wright Air Development Center (WADC) Laboratories since it was not a flying function. The Adverse Weather Section, however, continued to conduct Category II Weather testing in Arizona, Florida, and Alaska until 1970. It then was deleted from the mission of the Flight Test Division and was phased out after 1970 with a transfer of the function to Edwards AFB, California.



F-4 undergoing cold weather flight testing over Alaska.

TESTING THE CANBERRA

The Flight Test Division would test aircraft from other countries but not always with good luck. In September 1951 it tested two Canberras purchased from the British. In preliminary test runs, handling, take-off, and climb characteristics proved to be good. But on 21 December 1951 one aircraft broke apart in flight and was completely destroyed. Because the parts were widely scattered, it was impossible to determine the cause of the structural failure. The British Electric Company, manufacturer of the Canberra, performed flight tests with another Canberra but the operation of the aircraft was normal under the conditions in which the accident occurred. The cause of the crash was never discovered.

Icing tests were not only in the interest of the USAF but also other countries. In the early 1960s the Flight Test Division used Canadian test facilities to conduct helicopter icing tests since it was not known if the helicopter blades needed icing protection. The Canadian facility was a stationary spray rig structure at Uplands Airport, Ottawa, run by the National Research Council of Canada. When temperatures were below freezing, the engineers turned on the rig dispensing steam and water into the atmosphere which formed a cloud laden with minute water droplets. Prevailing winds moved the cloud across the landscape at an altitude of about 100 feet. The helicopter hovered in the cloud while tests were conducted on blades and rotor mast, windscreen and other parts of the aircraft. The Test Division might have used the site on Mt. Washington for similar tests if it had not abandoned it.

In the first half of 1962 the Division developed a program to evaluate an ice protection system for a helicopter. A flight test by an HU-1B helicopter flying behind a water spray tanker aircraft was the first flight conducted on a helicopter flying behind a tanker. The object of the test program was to determine the adequacy of the deicing system in both controlled icing and natural icing conditions.

In 1969 the Adverse Weather Section conducted icing tests for the Canadian Buffalo aircraft CC-115, built by DeHavilland Aircraft of Canada, Limited. The Buffalo aircraft completed nine hours of flying time behind the tanker while evaluating propeller, engine, and wind screen icing tests and continuous engine ignition. On the whole, the Royal Canadian Air Force (RCAF) was satisfied with the tests. It had wanted to establish a flameout envelope (a plot of water content and time required to produce an engine flameout) with recovery by continuous ignition of the engines. Unfortunately, the procedures they tried resulted in some compressor stalls and a lot of propeller vibration but no engine flameouts. Icing was, of course, only part of the all-weather tests the Air Force was interested in. It was also concerned with turbulence.

TURBULENCE

In the early 1950s there was little information on the turbulence present at altitudes over 30,000 feet. The turbulence had been divided into three classes: turbulence encountered in thunderstorms penetrating high altitudes; turbulence associated with the tropopause layer; and clear air turbulence. The challenge was to search for and determine the characteristics of clear air turbulence, and to find and penetrate visible high altitude thunderstorms. From 1948 to 1950 the All Weather Flying Division conducted several investigations into the factors affecting gust loads experienced by jet fighter aircraft in clear air turbulence. In 1950 the All Weather Flying Division directed flight tests on the effects of wing surface roughness on accelerations experienced in low level turbulence. It also initiated a program to conduct high altitude turbulence research. Between 1950 and 1960 it conducted several programs to test the use of the autopilot when experiencing clear air turbulence. Since these were part of other programs, the results were included as part of other test reports.

In 1960 and 1961 the Air Force managed several studies of clear air turbulence. The researchers wanted to know: "Was there evidence of wing stall while flying in turbulence?" In 1961 Flight Test Engineering fastened tufts of yarn at selected locations on a T-33's right wing and a camera mounted in the rear cockpit to record the effect of any turbulence. Unfortunately, the program was less than satisfactory and was cancelled without having gained any usable data.

TESTING JP8

One of the interesting programs managed by the Adverse Weather Section in 1968 was testing the effects of using kerosene type fuel, designated JP8, in selected turbine powered aircraft. The goal was to provide a qualitative comparison of JP4 and JP8 in the areas of fuel control adjustment, ground starting, relighting capability, and emission of visible smoke. On cold days, where the ground temperature was plus 20 degrees, some engines would not start at all on JP8, some would not relight in flight, while others were extremely slow relighting. As a result the flying phase of the program was cancelled.

One of the difficulties the Flight Test Division encountered in directing tests was not owning the type of aircraft needed for testing. A program had been devised by Flight Test Engineering to gather information on KC-135 aircraft procedures for reacting to turbulence and it needed an aircraft. The Strategic Air Command was asked to furnish a test aircraft but it refused because it lacked an available aircraft, resulting in the cancellation of the project.

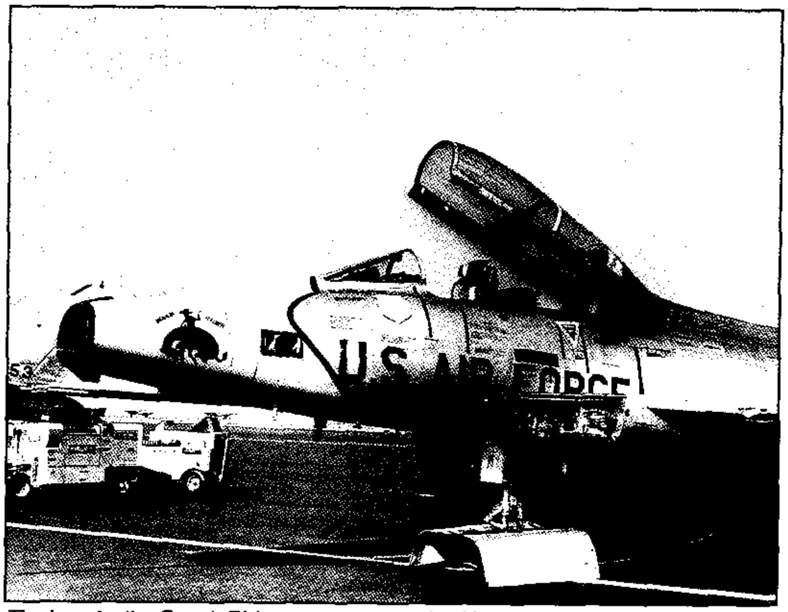
In 1964 the Air Force took the opportunity to study clear air turbulence at low levels as it related to mountain waves. The study had its beginning in the 10 January 1964 experience of a B-52H, on loan to Boeing to study low altitude turbulence. Flying along the eastern side of the Sangre De Cristro Mountains, the aircraft had turned north at Wagon Mound, New Mexico, when it encountered turbulence progressing from light to moderate, forcing the pilot to climb to a higher altitude. As the B-52H passed through 14,000 feet the air became smoother and the aircraft increased its speed to 350 knots. Near East Spanish Peak, in Colorado, the aircraft was struck by an 80 miles per hour gust of wind, losing most of its vertical tail section. Fortunately, the pilot was able to land safely at an alternate airfield.

In response to this event and a rash of turbulence-caused crashes, Flight Test Operations began a Low Level Gust Study from 7 March to 28 April 1964 using an F-106A to examine the frequency and magnitude of low level gusts in the vicinity of mountains. Flying out of Kirtland AFB, New Mexico, the F-106A's instruments recorded its time, position, weather, and all pilot conversations as it covered an area alongside the Sangre De Cristo Mountain range that stretched from Las Vegas, New Mexico, to Pueblo, Colorado. During this period there were 59 flights logging a total of 89 hours. The findings revealed that turbulence was a significant problem in this area because of the character of the wind gusts. The results of the study showed that the turbulence near the mountains was strong enough to destroy an aircraft and needed to be taken into account in the future by aircraft design engineers. Besides clear air turbulence, pilots were faced with turbulence caused by thunderstorms. To examine this phenomena the Flight Test Division developed the Rough Rider project.

Beginning in 1967 for 15 months the Adverse Weather Section also worked on a low level clear air turbulence program (LO LO CAT). The program involved using four C-131 aircraft flying out of four bases and covering four different routes. The program called for four areas of investigation: the mountainous west, flying out of Peterson Field, Colorado; the desert and ocean areas, flying out of Edwards AFB, California; the midwest, flying out of Wright-Patterson AFB to the vicinity of Wichita, Kansas; and the northeast, flying out of Griffiss AFB, New York. The program called for the pilots to fly a rectangular course at levels of 250 to 1,000 ft above the terrain. Its purpose was to develop turbulence design criteria that could be used in active aircraft design work, especially in light of the B-52 accident, and in the assessment of the adequacy of existing aircraft for use on low level missions in Southeast Asia. The Air Force, however, had the B-52 tail strengthened so there was little interest in the turbulence information gathered during this project and the data remains unused.

Also beginning in 1967, the Flight Test Operations began studying medium altitude clear air turbulence, employing an instrumented F-100F aircraft. It continued to examine the mountain regions from Hill AFB, Utah, to the northwest U.S. From 19 March to 23 April 1968 the F-100F investigated clear air turbulence in the southeast U.S. and on 17 June 1967 moved to Griffiss AFB, New York, to complete the study.

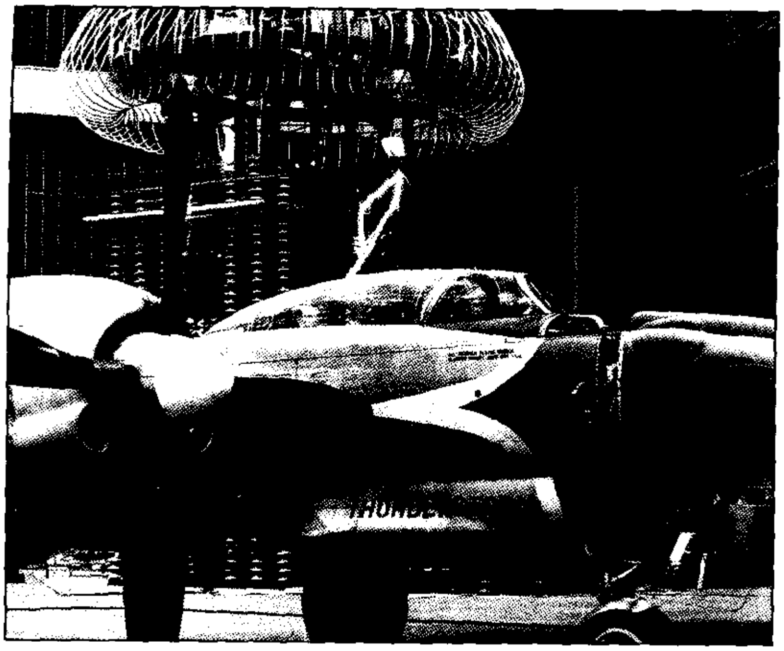
In addition to studying clear air turbulence, the Air Force was interested in turbulence associated with thunderstorms. With aircraft flying higher and faster, the Air Force wanted more information about these dangerous weather phenomena. The National Severe Storm Laboratory (NSSL), Oklahoma City, Oklahoma, of the U.S. Weather Bureau was also interested in thunderstorms. These joined forces in the program called Rough Rider with a bucking bronco as its logo; a tribute to what it was like flying through these storms.



The logo for the Rough Rider program was a bucking bronco, here on the nose of the F-100 used to penetrate thunderstorms over Oklahoma. It was an apt characterization of what it was like to fly through these storms.

ROUGH RIDER

The Air Force had been working with the U.S. Weather Bureau to gather data on thunderstorms since WWII. In 1946 the Air Force conducted a thunderstorm project at Pinecastle, Florida. It continued the project in the spring and summer of 1947 out of Wright Field, concluding the program on 26 September 1947. The purpose of the project was to place instruments in an F-15 aircraft, a Northrop Reporter, S/N 45-59318, to record the magnitude, wave shape, and duration of lightning strikes to the aircraft. The project was jointly sponsored by the All Weather Flying Division and the Communications and Navigation Laboratory, Electronics Subdivision, Wright



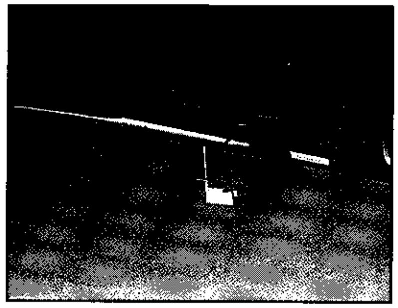
F-15 Northrop Reporter, an unarmed photo reconnaissance version of the P-61, receiving an electrical charge at the Navy's Research Hangar Minneapolis, Minnesota. The program involved testing the effects of lightning strikes on the canopy of an aircraft.

Field. The Lightning and Transient Research Institute at Minneapolis, Minnesota, cooperated in the program and was selected as the contractor to develop and provide the necessary instrumentation. In this test the F-15 aircraft, outfitted with probes or lightning rods, was placed under a lightning generator at the Navy's Research Hangar, Minneapolis, and the effects of the electrical strikes on the aircraft were noted.

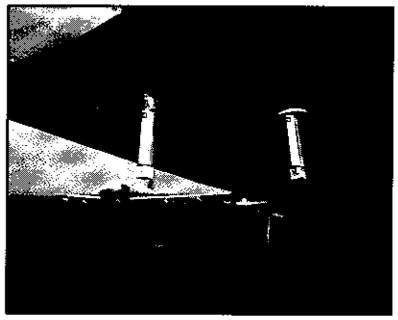
In 1960 the Air Force and the U.S. Weather Bureau began a joint project for the U. S. Weather Bureau, called the Rough Rider program. It was conducted by the National Severe Storm Project to gain information about thunderstorms. In 1961 the Air Force Cambridge Research Laboratory became an equal participant, and in 1964 the Sandia Corporation began participation on a small scale with Sandia's effort continuing through 1966. The purpose of the project was to gain data on thunderstorm electricity, cloud structure dynamics, and weapons effects vulnerability. The Weather Bureau was interested in the correlation of thunderstorm radar echoes with thunderstorm phenomena of discernible intensity, prediction of tornado potential thunderstorms by radar echo, quantitative analysis of the internal physics of a thunderstorm, and forecasting the intensity of turbulence in and around thunderstorms.

Equipment to measure meteorological phenomena inside thunderstorms was designed, fabricated, installed, and operated in a variety of aircraft: T-33, F-102, F-106, and F-100F. Devices were used to continuously measure normal acceleration, vertical gust velocity, cloud temperatures, differential static pressure, and to photograph cloud particles. Several patches of material were cemented to the leading edges of the wings and empennage of aircraft for the Air Force Materials Laboratory to determine their erosion capabilities and characteristics in extremely severe rain and hail conditions.

The instrumentation of the airplanes provided the researchers with a significant amount of information. To gather wind gust information the F-100 aircraft had gust vanes attached to a boom affixed to the nose of the aircraft. These vanes measured instantaneous angle of attack and angle of yaw. In conjunction with gyros and accelerometers they were used to determine gust velocities. On the underside of the fuselage, under the nose of the aircraft, were hail probes. These probes were cantilever beams shielded except at the tip where hail was allowed to strike. Measuring of the probes deflection with a strain gage allowed the computation of the hail mass striking the probes. Also, on the underbelly of the aircraft were the total temperature probes. These standard resistance wire-type probes measured the total temperature of the free air. One was de-iced and the other was not. Under the left wing was the pressurized tank containing a camera to take pictures of water droplets or ice crystals. On the leading edge of the wings was rain erosion tape. Designed to protect the leading edges of the wings from rain erosion the tape eroded away rapidly in thunderstorms. Near the end of each wing were the ice crystal detectors. They recorded the static charge generated by water droplets or ice crystals striking it. On the end of each wing tip were the electric field mills. They measured horizontal and vertical electric field and total electrical charge on the airplane. At the trailing end of each wing were the static dischargers. They were designed to carry off the static electrical charge that accumulated on the aircraft as it flew through a thunderstorm.

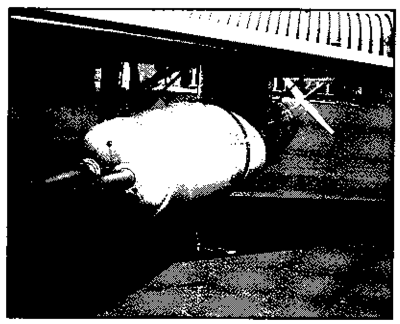


Gust vanes attached to a boom fastened to the nose of an F-100 aircraft to measure gust velocities in thunderstorms.

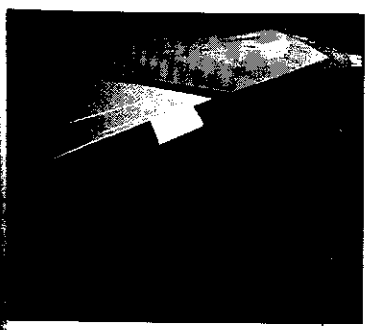


Hail probes on the underside of the F-100 aircraft. These cantilever beams, shielded except at the tip, used strain gages to measure the probes deflection which allowed the computation of the hail mass striking the probes.

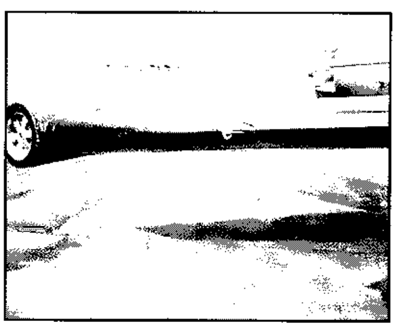
These total temperature probes were on the underside of the F-100 aircraft. They measured the total temperature of the free air.



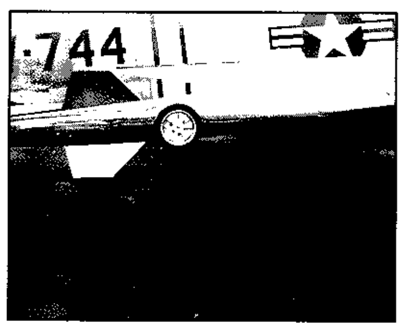
This tank, attached to the left wing of the F-100, housed cameras. On the inboard tube was a hole, visible in the photograph, for a light to shine on the narrow opening between the tubes. An opening on the outboard tube enabled a camera to take pictures of water droplets or ice crystals streaming by the lighted opening.



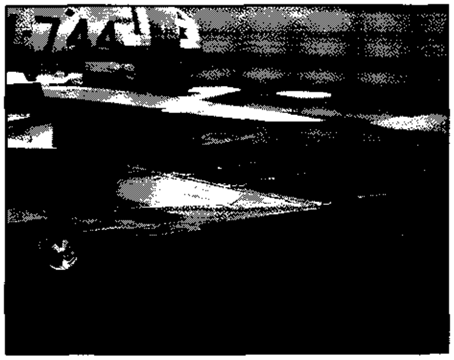
Fastened to the leading edge of each wing of the F-100 was erosion tape. It was designed to protect the edges from rain erosion.



The small cylinder on the leading edge of the F-100's wing was an ice crystal detector, recording static charges generated by water droplets or ice crystals.



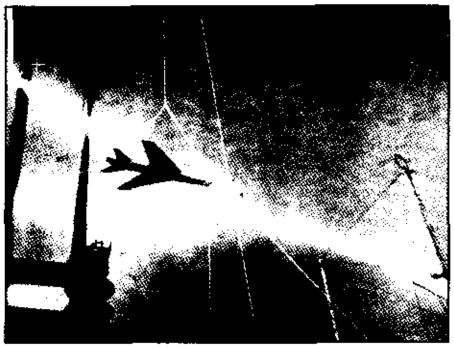
On the end of each wing were devices to register the electric field. They measured the horizontal and vertical electric field and total electrical charge on the airplane.



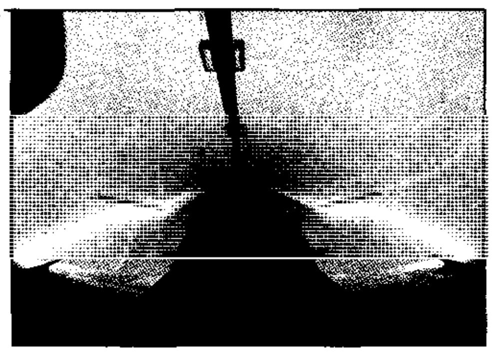
Static dischargers, attached to the trailing edge of each wing were designed to carry off the static electrical charge that accumulated on the aircraft flying through a thunderstorm.

Flying through thunderstorms did have its peculiar dangers, including lightning strikes, damaging hail, torrential rain, violent wind gusts, severe updrafts and downdrafts. The Air Force was particularly concerned with the danger to the pilot of lightning strikes to the aircraft. The Lightning and Transient Research Institute conducted numerous tests to discover the dangers involved in lightning strikes. Using a salvaged F-100 the Institute conducted tests using artificial lightning discharges to discover what effect a strike on a canopy, protected with an aluminum foil protective strip, would have on the pilot. The tests revealed that electrical discharges did not penetrate the canopy in the initial high voltage tests. But a severe stroke vaporized the protective strip and damaged the canopy sufficiently so that a subsequent high voltage discharge did puncture the canopy. Tests also revealed that a solid conductor protective strip held slightly off the canopy, similar to that used by the RCAF's Arcas observer dome, was necessary for adequate protection.

The researchers also examined the dangerous possibility that a lightning strike might cause an aircraft fuel explosion. To evaluate this possibility the Research Institute conducted tests on a small scale model aircraft and discovered that lightning strikes to the fuel vent area would have a low probability. It was possible, however, that an explosive mixture could be ignited by a strike directly on the fuel vent, which was located in the trailing edge of the vertical stabilizer about two feet down from the top. In a 31 May 1965 letter to the Adverse Weather Section, the Research Institute conducting the tests recommended that there needed to be a restoration of the nitrogen inerting system, the placing of a shield ring on the fuel vent, and the installation of a lightning protective strip along the top of the canopy. Pictures taken from the inside of an F-100 flying through a thunderstorm show the electrical charge striking the wings. The picture also shows the protective strip on the canopy.

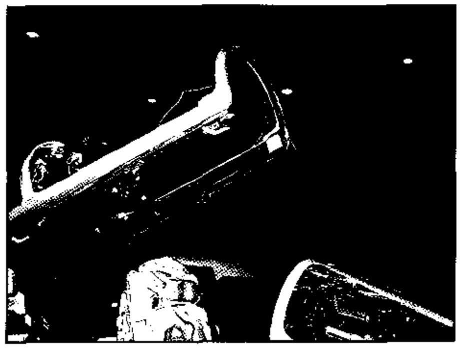


A small scale aircraft was used by the Lightning and Transients Research Institute to conduct lightning strikes on aircraft to discover possible dangers to the pilot and aircraft.

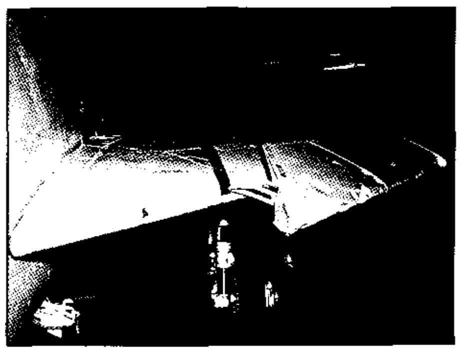


Lightning striking the wings of an F-100 aircraft flying through a thunderstorm. The protective aluminum strip can be seen running the length of the canopy.

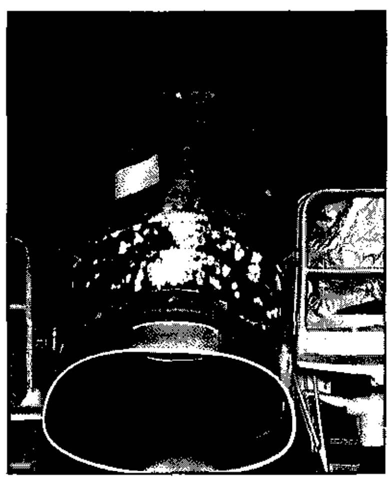
Pilots flying through thunderstorms experienced rain erosion and hail damage to their aircraft. In one case the windshield and canopy were shattered. On other occasions there was damage to the wings and the nose. The vertical stabilizer of a T-33 shows hail damage. Nevertheless, not one aircraft was destroyed during the program.



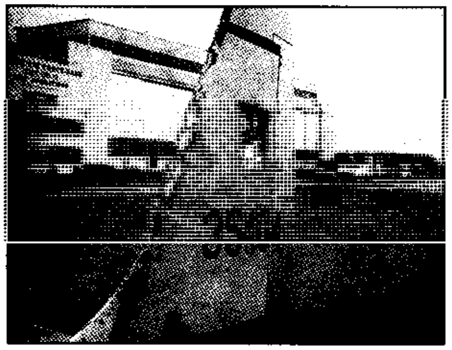
The canopy and windshield of an F-100 was damaged by hail as it flew through a thunderstorm.



The F-100's wing was damaged by hail.



The nose of the F-100 shows rain and hail damage.

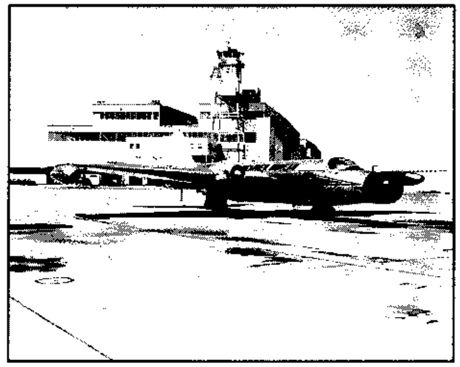


The vertical stabilizer of a T-33 was damaged severely by hail during a flight through a thunderstorm.

The project began in 1960 with the penetration of severe storms in and around Oklahoma and continued unabated until 1967. It began again in 1973 and continued until 1978. The tests were conducted initially using a T-33, an F-102, and an F-106 aircraft. The project claimed a number of firsts associated with these tests. It was the first scientific collection of turbulence data in high altitude thunderstorms and resulted in the first instrumented flights through storms that contained tornadoes, either during or after penetration. The aircraft performed the first instrumented flights of delta-wing aircraft through thunderstorms and the first deliberate supersonic thunderstorm penetration. The F-102 performed the first successful extended penetrations of a natural ice-crystal environment. Finally, it was the first collection of structural design data in high-altitude thunderstorms.

In 1961 the Air Force used an F-106 to discover how a thunderstorm would affect a supersonic aircraft. In 1962 the Air Force used an instrumented F-100 with a T-33 or other aircraft as a chase plane to assist the F-100 in the event the penetrating aircraft lost any flying instruments and needed assistance to return to Tinker AFB, Oklahoma. The project supplied the Air Force, the Weather Bureau, and various other interested agencies with much valuable information that could be used to predict the formation of severe storms, their unusual characteristics, and the problems associated with flying in these natural disturbances. The program was of such interest to the British that they joined in and sent two of their own aircraft to participate in the tests.

British Canberra aircraft with nose probe to gather data.



British Weather Bureau Canberra with radar in the nose, used in weather tests.

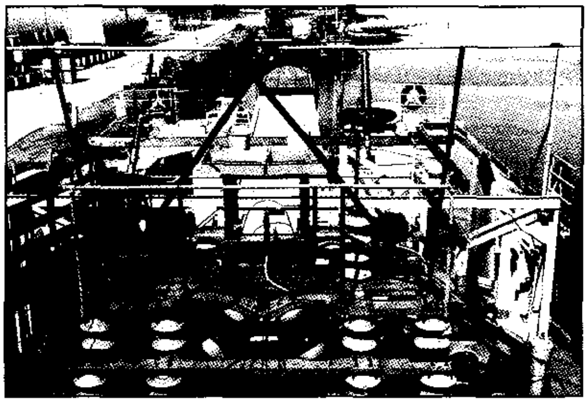
The first four years of the program can be summarized in the following statistics:

Year	Penetration Aircraft	Minutes of Data	Naut. Mi. Inside Thunderstorms	Number of Thunderstorms
1960	T/33/F-102	277	1852	96
1961	B-66/F-106	105	806	42
1962	T-33/F-100	459	2829	104
1963	F-100	197	1305	53

The Rough Rider 64 program, flying out of Patrick AFB, Florida, also conducted studies of tropical thunderstorms. The aircraft flew 21 sorties to measure electrical field strength and to record lightning signatures of tropical thunderstorms. The method for quantitative recording of lightning signatures inside an electrical storm using an aircraft was an aviation first. They also used the F-100 aircraft to measure the strength of lightning strikes and to record location of the strikes on the aircraft, especially in the vicinity of the fuel vent.

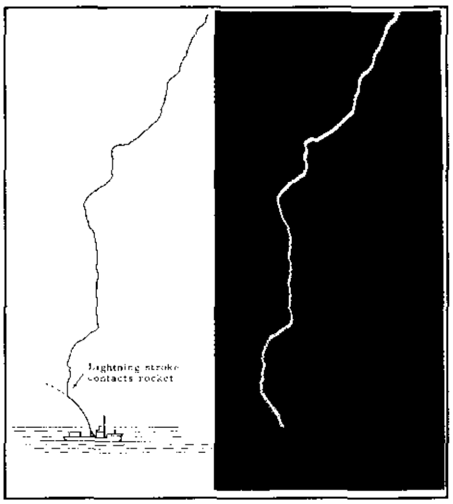
One of the interesting projects that developed during 1964 was to find a way to trigger lightning to study the discharge process. Using a ship, the Thunderbolt, owned by the Lightning and Transient Research Institute, researchers were able to move around off the coast of Florida to where there were active thunderstorms. The plan was to trigger lightning discharges through an aircraft flying overhead, to a wire launched from the ship by a rocket, down the wire to instruments on the ship. The plan called for a rocket to be launched from the ship bearing fine wire while an airplane circling overhead would trigger a natural lightning discharge through the airplane to the wire and then down the wire to measuring equipment on the ship. In 1965 the program was successful as the ship launched rockets with their attached wires. Two rocket guns were used so that the F-100 could quickly make a second pass over the ship in the event the first pass did not initiate a strike, and another rocket would be ready. The spools of wire were arranged so that the wire, with a 25 foot leader, could be pulled off by the rocket harness.

The Thunderbolt in Florida's waters launches a rocket with attached wires in hopes of channelling a lightning strike back to the ship.



Launch platform on the ship, Thunderbolt, showing rockets and trays in the center. The trays contained 5,000 foot spools of 0.008 inch stainless steel wire in plastic containers. The spools were arranged so that the wire could be pulled off by the rocket using the "spinning reel" principle.

The resulting lightning discharge and the schematic of the rocket firing are shown in the photograph.



Schematic and picture of how the rocket, attached wire, and circling airplane caused a lightning strike to the ship.

The wire itself was vaporized but the subsequent discharge followed the spiral ionized path left by the wire. With the completion of the 1965 season the program using the ship ended.

To meet the Weather Bureau's desire for higher aircraft speeds and altitudes in the 1965 Rough Rider program, the Adverse Weather Section requested HQ AFSC to provide an F-4C aircraft. HQ AFSC denied the request but did approve the continued use of the F-100F, S/N 744, for thunderstorm penetrations and included a B-47 to drop chaff through the storms. Unfortunately, these aircraft did not satisfy all the needs of the NSSL.

During the test program, in 1966, the instrumented F-100F aircraft, operating out of Tinker AFB, penetrated a one season record of 76 thunderstorms. It was not without its problems, however. The aircraft experienced moderate tail damage on one flight and a cracked windshield on another.

At the end of the program in 1967 the NSSL was preparing models of thunderstorms from the data that was obtained simultaneously from the flight tests and from its ground based radar stations, sferics network, rain gages, and hail reporting stations. As a result of this project the NSSL by using a specially adopted WSR-57 type ground-based weather radar was able to predict with reasonable accuracy the severity of meteorological factors which comprised a thunderstorm. In 1973 the program resumed with an emphasis on discovering the potential for generation of tornados that existed in various thunderstorms. During 1973 pilots flew the F-100F aircraft but in 1974 they began flying RF-4C. The aircraft flew out of Edwards and Eglin AFBs in 1973 through 1975 and in 1976 through 1978 only out of Eglin AFB, Florida.

RF-4C SONIC BOOM INVESTIGATION

This seemingly innocent title covers the "biggest bucket of worms" of 1966. There were two reported incidents of property damage which occurred during low level, subsonic, high speed flight of an RF-4C. To discover if an RF-4C at high speed but below the speed of sound (Mach 1) could cause a sonic boom, the Fighter Operations Branch flew an RF-4C around the supersonic speed course operated by the national sonic boom project at Edwards AFB, California. Flying three times over the course at airspeeds of .9M to .96 M at about 1,000 feet the testers had their information. The .96M pass, however, resulted in an extremely severe shock wave (over 100 pounds per sq ft). The shock propagated into the Edwards AFB main base building area and caused some damage. The most serious was the discomfort of Maj. Gen. Hugh B. Manson, Air Force Flight Test Center Commander. When the testing crew met General Manson later at the base, he was reported to have smiled through his anger and graciously invited them back, but with a different aircraft.

Besides thunderstorms there were other weather related tasks that the Adverse Weather Section conducted, of which rain repellent and combat traction were the most interesting.

WINDSHIELD RAIN REMOVAL

The Adverse Weather Section conducted tests on rain repellents beginning in the mid 1950s. Windshield rain removal was a concern of pilots because adequate visibility during landing was essential to safety. The problem was that during flight in rain the water spread over the windshield on impact, forming a film of varying thickness. The film, with all its ripples and surface variations, affected the ability of the pilot to see, distorting or completely obscuring the images of objects seen through the windshield. To solve this problem, the Weather Section evaluated several systems, including chemical rain repellents, pneumatic or jet-blast rain removal, and windshield wipers. The first chemical repellents were applied in paste form to the windshield prior to flight. These repellents caused the rain to collect and run off in rivulets instead of hitting against the windshield and then spreading out unevenly, blurring the pilot's visibility. There were drawbacks on these initial chemicals. Forward visibility was improved considerably but application of materials was tedious and time consuming, and the material would only bond to glass and not to plastic windshields. In the 1960s the aerosol can appeared and the repellent was placed in pressurized containers. In the course of the tests, the testers examined 20 different repellent solutions, of which three were outstanding. These repellents offered better visibility over a larger area of the windshield than either wipers or jet-blast and they could be renewed in flight at will. The pilots conducted both day and nighttime landings in rain using the repellents, and visibility through the windshield was excellent.

In 1968 the Adverse Weather Section undertook several windshield rain removal projects in support of Southeast Asia operations. One was an evaluation of chemical rain repellents for fighter aircraft. Some of the difficulties faced by chemical rain repellents included lack of uniform distribution and providing adequate coverage of the windshield. The researchers discovered that the varieties that were applied to the windshield by a ground crewman prior to flight had a long life and provided enough protection for an entire flight of several hours duration, sometimes for several days. Varieties that were packaged in aerosol containers were distributed over the windshield via a plumbing system on demand as needed by the pilot. The life of each application varied from a few seconds to several minutes, but there were about 75, 0.4-second applications in each quart bottle, enough for several flights in continuous moderate to heavy rain for fighter aircraft.

COMBAT TRACTION

The Adverse Weather Section also took on the testing to improve traction of aircraft landing on wet runways. Aircraft skidding accidents became significant during the 1960s because of increased landing speeds and an increase in the number of landings in bad weather conditions. The situation was aggravated by a lack of methods to measure hydroplaning on wet runways. In 1969 the Air Force and NASA initiated a program to investigate the problem. The approach was to test many tire groove patterns, runway surfaces and construction methods, traction measuring devices, and high pressure air jets in front of the tire to remove the water. The testing evaluated about 20 different bases and commercial fields in the continental United States and 10 European sites using a highly instrumented C-141 and an automobile. Initial results indicated that tire grooves were ineffective when more than 50 percent of the tire surface was worn. The air pressure approach was inadequate on smooth surfaces. Runway grooving, however, did provide a significant increase in friction on damp, wet, or flooded runway surfaces.

Over the years the Flight Test Division conducted thousands of test programs that involved numerous aircraft and a variety of techniques, so many that it is impossible to cover adequately even the most interesting or most important. Therefore the following is a selection of a few of the more interesting programs.

OTHER SELECTED PROGRAMS

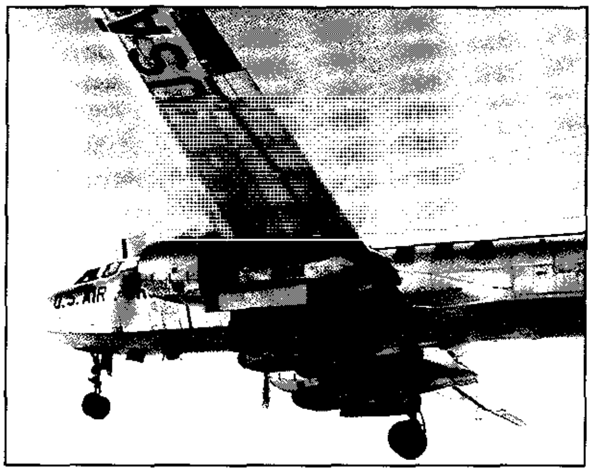
The Test Division and Test Wing also conducted the following programs: the aircraft expandable tire, the Category II Testing of the C-130 AWADS, the ARD-21 Air Rescue Hovering Set, AC-130A Gunship II Category II tests, Range Extension, Zero-G (Weightlessness), RC-135 Aerodynamic Test, RF-4C Sonic Boom Investigation, Rotorglider Discretionary Descent Concept, Long Line Loiter Program, Hound Dog II propagation, Air Cushion Landing System, and the TRAP program.

AIRCRAFT EXPANDABLE TIRE

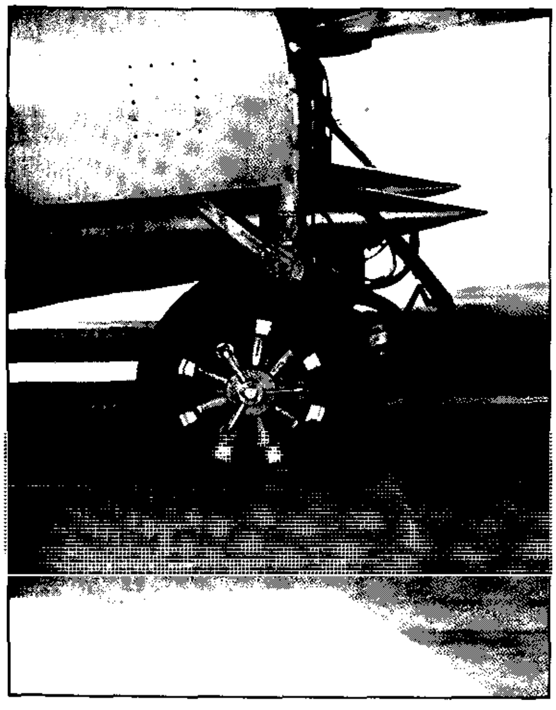
A C-131 aircraft was fitted with a modified main landing gear subsystem and expandable tires that were capable of being inflated and deflated in flight by compressors and pneumatic reservoirs mounted in the aircraft. The deflated tire occupied between one-half and two-thirds the space of one that was inflated, thus allowing considerable reduction in the wheel well storage space on an aircraft. Beginning in April 1970, the aircrew flew regularly three times each week, evaluating the tires and brakes during various phases of taxiing, takeoff, and landing. Cycles of inflation and deflation showed the inflatable tires to be as reliable as regular tires. In general, the tires, brakes, and associated gear performed above expectations initially. A TV monitor was installed inside the aircraft to observe both the main landing gear and to record the performance of the tire.

Expandable Tire Cross Section in the deflated position.

The Test Section ran a total of 115 test missions with 459 landings to demonstrate the applicability and operational suitability of Type III expandable tires and, in general, the tires performed very well. Ground handling characteristics of the aircraft during landing were good at both 35 percent and 50 percent tire deflation. Some taxi runs were even made while the tires were flat to evaluate combat survivability. The pilots reported that they had no difficulty controlling the aircraft during rollout. As the test continued two serious problems appeared with the test tires: one, breaks and cracks appeared in the rubber on the side walls and in the shoulder of the tire, exposing the cord; and second, some of the tires in time leaked air in excessive amounts through the side walls. Having discovered these problems, the testing program was terminated in 1971. On 26 October 1971 the airplane was ferried to Wright Field to be modified.



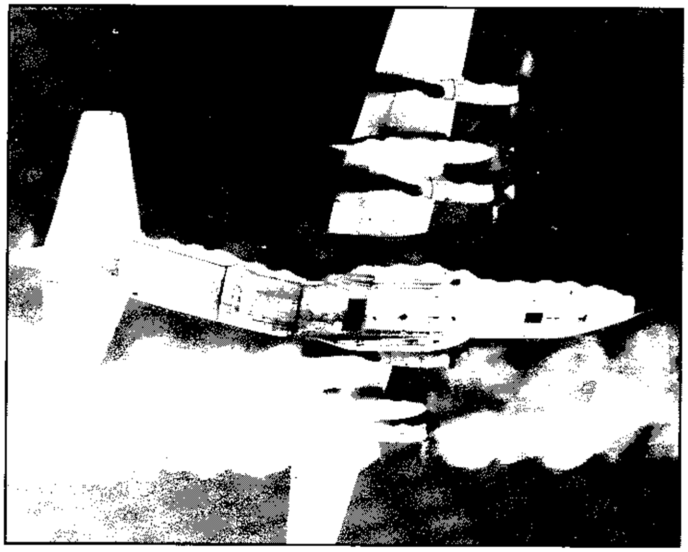
C-131 with the expandable tires landing at Wright-Patterson AFB.



Expandable Tire on C-131 aircraft in a deflated condition.

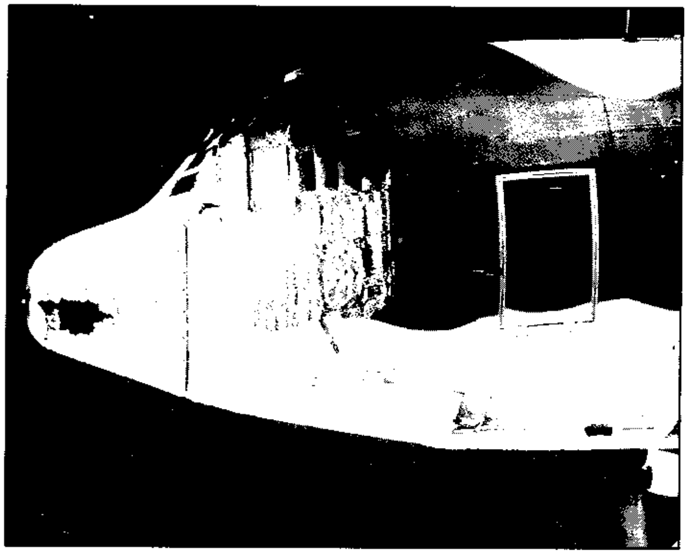
CATEGORY II EVALUATION OF C-130E AWADS

The C-130E Adverse Weather Aerial Delivery System was flight tested to evaluate characteristics and limitations in its role of airdropping troops and/or supplies. These tests involved taking off and rendezvousing with another AWADS equipped aircraft. The test aircraft maintained a designated position in the formation with other aircraft, navigating over long distances. The aircraft made an approach to a predetermined drop zone and executed a drop with a circular error probability of 113 meters or less and then navigated to a recovery base and landed. All of this was accomplished without benefit of any external navigation aids. In general, the Test Section demonstrated that the AWADS system possessed the functional capability to perform its intended mission and to meet most of the required performance specifications. Equipment reliability, however, was a serious problem. Based on the experience gained during the test program, the Test Section determined that at least one out of every two missions would be affected by a significant AWADS component failure or malfunction.



C-130 AWADS aircraft flying in the water sprayed from a C-135 aircraft.

The tests included discovering the effects of icing on the radome of the AWADS aircraft. Flying in the water behind a C-135 aircraft, ice accumulated on the radome of the aircraft. The icing test revealed that icing accumulation on the radome decreased its effectiveness and that the deicing equipment could not adequately shed the ice from the radome.



C-130 AWADS aircraft with ice accumulation on the radome.

FRANGIBLE CANOPY

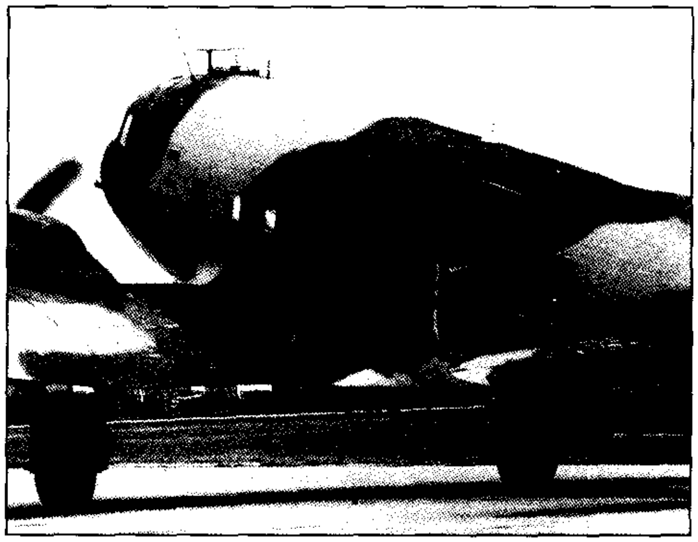
The Flight Test Division performed a study for the Life Support program office on the feasibility of ejecting through a canopy that would shatter into non-cutting glass particles. The advantages of this development would be: to lower the time it would take for the pilot to eject; to enable an easy ground egress in emergency; and to create a canopy system that was marked by simplicity and low weight. Two types of canopies were tested, each built like a double pane storm window. The air gap canopy had an air space between the two panes while the second type was an interlayer canopy that contained a transparent jelly between the two panes. Aircraft with the two canopies were flown over Patterson Field at airspeeds between 200 and 500 knots and a dummy ejected through the canopy. At the lower airspeeds the canopy remained as a glass cloud around the cockpit while the interlayer canopy, designed to hold the particles together, opened into a nice hole at low airspeeds. At high airspeeds, the air gap canopy was blown past the dummy, but the interlayer canopy delayed and hit the dummy in chunks, breaking the dummy's visor and cutting its face. At all speeds, the tests showed the pilot could inhale glass particles. The inability to guarantee the safety of the pilots from the glass particles forced a re-evaluation of the program. In 1970 the program was ended and the F-101B test aircraft was retired to the Air Force Museum, Wright-Patterson AFB, Ohio.

ARD-21 AIR RESCUE HOVERING SET

Rescuing downed pilots in Southeast Asia was a significant issue in the late 1960s and into the 1970s. The Aero-Subsystems Test Section performed extensive evaluation of the ARD-21, Air Rescue Hovering Set, over all types of terrain in Ohio and over the slopes and jungles of Panama. The ARD-21 was an electronic location finder that allowed a rescue helicopter to hover directly over a standard rescue radio beacon with extreme accuracy without visual sighting. It was a dual UHF radio receiver capable of providing left/right and fore/aft information to a pilot with sufficient accuracy so that a helicopter hovering 150 feet above a downed airman could lower a jungle penetrator and rescue the person. In open terrain it would locate the beacon up to 14 nautical miles away, depending on the ground beacon used. Over wet or dry, heavy, double canopy foliage, the acquisition range was about three to four nautical miles at 3,000 feet altitude. This invention greatly enhanced rescue operations in Southeast Asia.

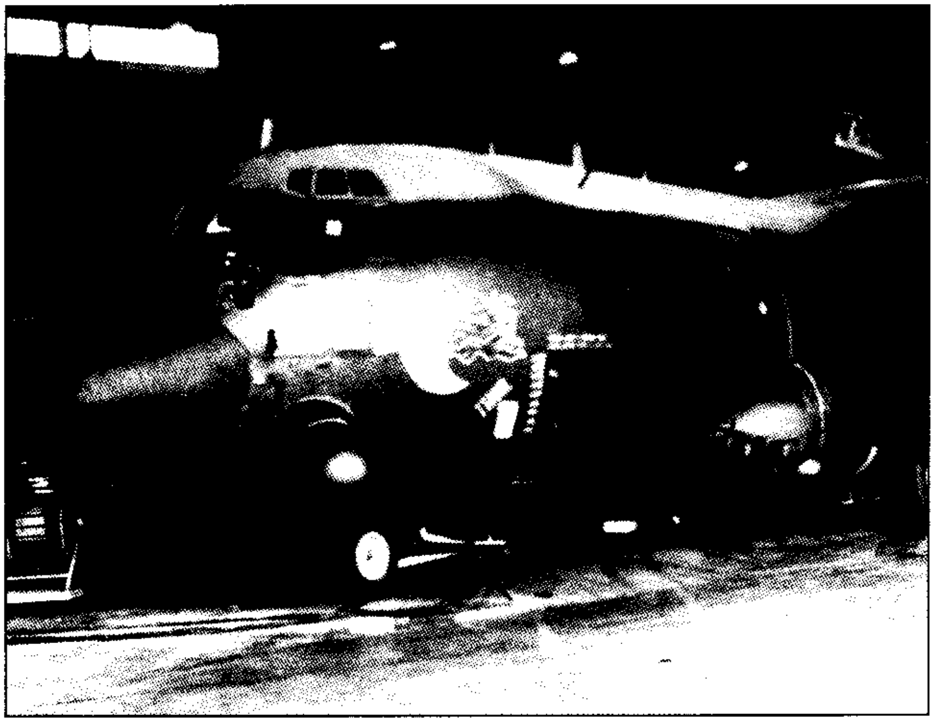
AC-130A, GUNSHIP

Beginning in 1967 the Flight Test Division was called upon to conduct in-flight tests to demonstrate AC-130 system capabilities in support of the U.S. effort in Southeast Asia. Using a modified C-130A tests were conducted at Eglin AFB, Florida. This program was an expansion of the use of heavily armed C-47s in Vietnam, known as "Puff, the Magic Dragon." Live firing tests were conducted at Eglin AFB as well as the Atterbury Range, Indiana. The tests involved a 40mm gun, special ammunition, and the inertial targeting system. The purpose was to determine weapons accuracy, munitions effectiveness, and to improve the fire control system. During the ground firing of the 40mm gun there was some damage to the aircraft. Engineers believed the intensity of the damage could be attributed to the static conditions of no air flow and the encapsulating effect of the concrete ramp on the muzzle blast. When the tests were conducted in-flight they were successful, proving the feasibility of the gun installation.



C-47 aircraft used as a gunship with Gatling guns protruding from the windows and doors. Used in the Vietnam War, it was nicknamed, "Puff the Magic Dragon".

The Adverse Weather Section in 1968 performed Category II testing of the AC-130 Gunship II Follow-On. It was a brief, overall evaluation of the weapon system and not the quantitative acquisition of data which normally constitutes an Air Force Category II test. The Gunship II was found to be a dependable weapon system when employed with a knowledge of its inherent limitations. Two of these limitations were the inability of the Forward Looking Infrared System (FLIR) to rapidly locate and track targets, and the computer's limited capacity to accurately compensate for wind and offset inputs.



AC-130 Gunship, with the Pave Crow sensor system protruding from the area above the nose landing gear, being readied for Southeast Asia.

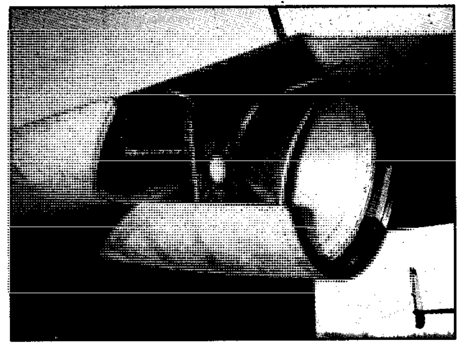
The Flight Test Division outfitted an AC-130A for Southeast Asia, called "Surprise Package." It included the Pave Crow sensor to locate vehicles on the ground. It was extremely successful resulting in the destruction of thousands of trucks on the ground.

The next step was to investigate the inclusion of a large caliber gun in the AC-130. In 1971 the Test Engineering Division performed a feasibility and flight test on the installation of a 105mm howitzer. Further tests on ECM and flares to provide an improved gunship protection system were conducted in 1972. These successful tests led to the immediate deployment of the howitzer, ECM, and flares in aircraft in Southeast Asia and their inclusion in new gunships. In addition, the Cargo Operations Branch began an extensive stability, control, and performance evaluation using an AC-130E that had modified new engines and several experimental items designed to decrease the aircraft's vulnerability.

In 1973 the Test Engineering Division completed Pave Spectre II (Engine Fairing Evaluation) on a prototype AC-130H. The flight test program was completed on 25 January 1973 with a total of fifty flight hours. The engineers determined that the installation of the engine fairings had no noticeable effect on the stability and control of the aircraft. The various store configurations did not affect drag counts with or without fairings. The final result showed that there were no unusual or unsuspected changes to the performance or stability and control because of the addition of stores or fairings.

RANGE EXTENSION

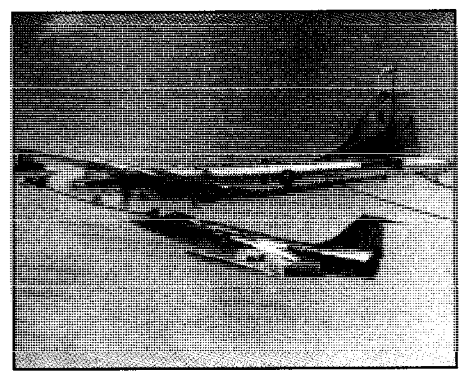
During the 1950s the Air Force was interested in extending the range of aircraft through various means. In 1951 the Flight Test Division performed an investigation of the possibility of towing helicopters to their areas of operation because of their limited range. The theory was that a helicopter could be towed to the area of operation with its engine off and its blades in autorotation. Once on station the helicopter would be released, perform its mission, re-attach to the tow plane and return to base. After investigating the hook-up problem, Division engineers were convinced that methods of aerial hook-up would be more satisfactory than towing from take-off, a hazardous procedure that had caused a fatal accident. The Division decided to concentrate on devising a practical method of aerial hook-up. The Flight Test Division ran two tests with an H-5H helicopter and a C-47 as the towing aircraft. The first test involved the C-47 carrying a coupling device on its right wingtip to pick up the end of a 250-foot tow rope trailed by the helicopter. Once coupled securely, the helicopter would fall back in trail. This system, however, proved unsatisfactory because the end of the tow rope swung so widely that the C-47 found it almost impossible to make contact. In addition, the C-47 had to fly at the relatively slow speed of 75 miles per hour, the top speed of the helicopter. A second method had the helicopter approach to within 10 feet of the C-47s vertical tail section, where the coupling device was installed. The slow speed required of the C-47, from 65 to 70 miles per hour, would not be an important factor because the more maneuverable helicopter was the active member of the pair. This also proved not to be feasible and the project was abandoned.



Attached to the outer wing of the aircraft the cone shaped device, attached to a fuel hose, would be released to allow aircraft to refuel in flight.

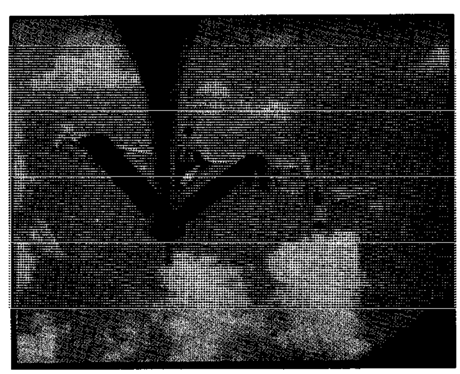
Three drogue lines stretch from a KB-29P aircraft for refueling aircraft in flight.

The solution to the range extension problem was found in aerial refueling from a tanker while in flight. One method investigated was borrowed from the British, the multipoint drogue technique, and consisted of using a drogue, a funnel or cone shaped device towed behind the aircraft. The aircraft would intersect the cone with a refueling probe attached to a wing or body of the aircraft. Another method was to use a "boom" attached to the aft fuselage of the tanker which could be maneuvered from inside the tanker.



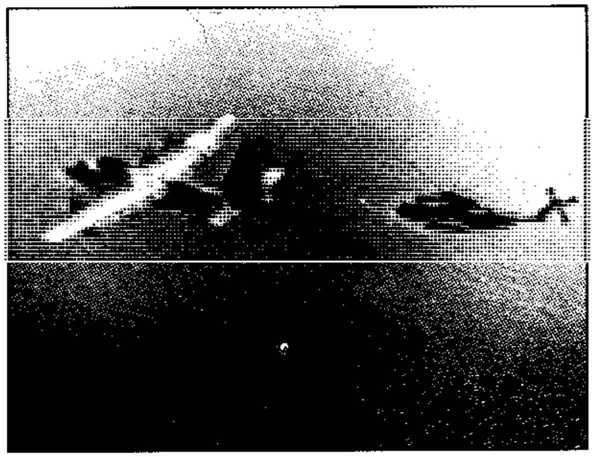
F-104 being refuelled from a KB-29P tanker using the drogue method.

The Division ran tests to determine the best technique for Air Force use. A B-50D receiver airplane and a KB-29P tanker flew three refueling missions using a "boom" during September 1951. The Division first attempted to determine how much additional power was needed by the receiver while flying in the downwash of the tanker aircraft. Pilots of the tanker aircraft discovered that it was necessary to maintain a gradual descent during the fuel transfer to keep from exceeding the normal rated power limitation of the receiver aircraft. After testing at altitudes of 15,000, 21,000, and 25,000 feet, pilots ascertained that the refueling process could be more easily accomplished if begun at reasonably low altitudes. The flights also furnished valuable information on the best means of approach and the best boom position for the tanker during refueling. The Division



The flying boom used to refuel aircraft in flight. Note the two wings on either side of the boom to aid in controlling the boom.

completed preliminary tests on the British multipoint probe and the drogue techniques for refueling positions. The receiver pilots reported that the centerline receptacle was the best position for boom receptacle refueling. For those pilots using the probe and drogue method, they reported that an overhead right of center position of the probe nozzle on the receiver aircraft was the best position for probe and drogue refueling. The Flight Test Division also tested the probe and drogue method for refueling helicopters. Using a C-130 it determined that it was possible to refuel a helicopter.



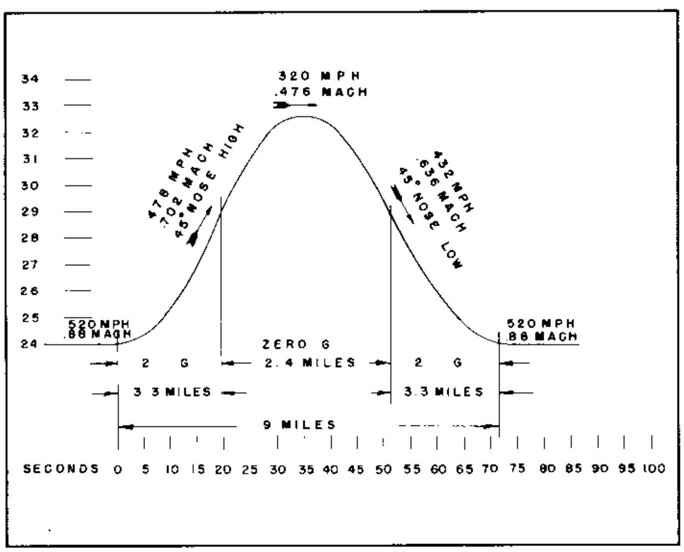
C-130 aircraft refueling an HH-53B helicopter.

LOW LIGHT LEVEL TELEVISION PROJECT

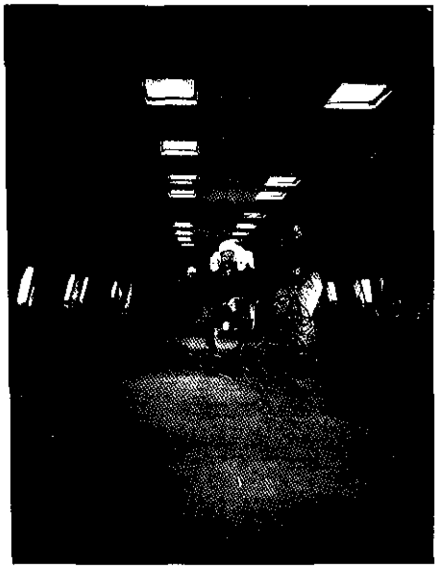
In 1972 the Cargo Operations Branch had a C-131B outfitted with a television camera housing under the aft fuselage and mounted a laser illuminator in the right wing pod. The purpose was to use the camera to find targets on the ground. The initial flight tests revealed a strong airframe buffet resulted from turbulent flow created by the camera housing. A styrofoam fairing was installed aft of the camera housing and it eliminated the buffet and substantially reduced the drag caused by the camera housing. This camera had the capability of operating in the absence of any ambient light (moon, flares, etc.) with the laser illuminating the target area viewed by the camera.

ZERO-G

The Zero Gravity program was started by the Air Force at the Flight Test Division in 1957 to provide an accurate simulation of the weightlessness of actual space flight. The Division maintained that every part of the spacecraft or task the astronauts were to perform during a space mission could be simulated in the aircraft flying Keplerian trajectories (parabolas) to provide short periods of low or zero gravity. The parabola could be modified to provide any gravity field desired, such as lunar gravity (.167g) and Mars gravity (.38g). No other means of simulation could provide the 30 seconds of simulated weightlessness or reduced gravity here on earth as well as this technique.

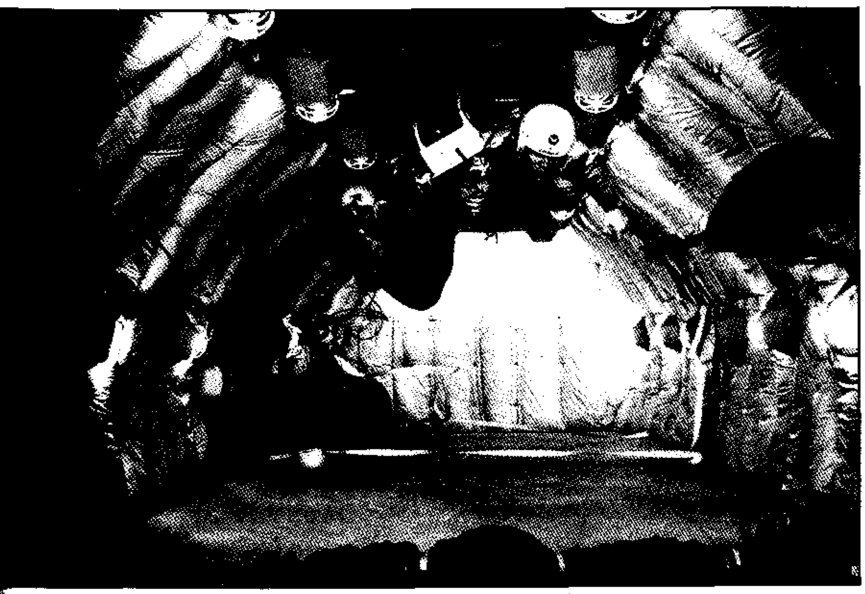


Altitude, speed, and path for an aircraft to achieve zero-g.



Scene aboard C-135 during the testing of a back pack self-maneuvering unit.

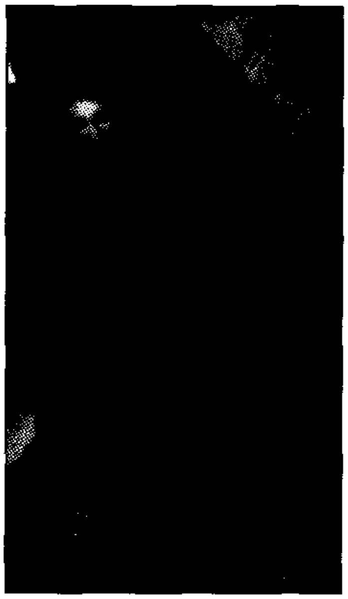
The Division was given the responsibility by NASA to perform tests for astronauts and space equipment that would be used by astronauts on the Gemini and Apollo missions as well as on Skylab (Manned Orbital Laboratory). Two aircraft were modified for use in the zero-g tests: a specially outfitted KC-135, and a C-131. They were used for weightlessness research tests with an average of 20 programs in the first half of 1962. The KC-135 aircraft was modified with the installation of a zero-g kit which included complete padding of the test compartment, installation of photo lights for film taking by the Technical Photo Section of the Division, and instrumentation racks. The smaller C-131 had little padding. The first mission was flown on 5 February 1962 and by the end of June the Division had flown 942 zero-g parabolas, each yielding a test period of 25-32 seconds during which a zero-g environment was maintained. These first tests conducted programs on the following: movement sensations, which were a study of body maneuvers; fluid configuration, which was a study of fluid behavior in a weightless environment to establish tank design criteria; and boiling liquids and condensing vapor under weightless conditions. The researchers discovered that boiling in a zero-g environment produced vapor bubbles which came off perpendicular to the heating element. The tests also involved two self-maneuvering units, one of which was a back pack for a person's individual maneuvering in space and which contained an autopilot for attitude stabilization and jets for controlled rotation and linear movement and the other a hand-held propulsion unit. The test program evaluated several models of pusher type propulsion units, one of which was dubbed the space jeep.



archer practices maneuvers using a hand-held propulsion unit during htlessness orientation in a KC-135 aircraft.

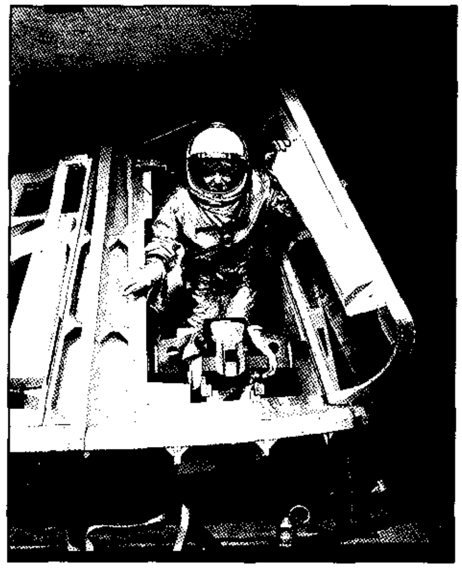
Researcher experiments with a space jeep in the C-131 aircraft to determine if one could use it to maneuver in weightlessness.

Astronaut Neil Armstrong experiences zero-g in the Test Wing's KC-135.



A woman from the Aero Medical Laboratory shown experiencing weightlessness in the C-131 aircraft.

In 1964 the Flight Test Operations conducted flight tests for Apollo, Gemini, and Skylab that involved testing methods of crew transfer. One method tested involved opening three hatches and negotiating a six foot long tunnel. A second method consisted of an expandable tunnel attached to the outside of the spacecraft at the location of the main hatch. The next step was to test full-scale cabin mock-ups of the Gemini, Apollo, and Lunar Excursion Module. It also tested the Gemini B or proposed orbiting laboratory module as well as versions of equipment that would be used in these vehicles. Other tests involved testing egress-ingress procedures for extravehicular activity, returning to the spacecraft from the end of a 25-foot tether line, and getting back into the capsule and closing the hatch. One of the astronauts who experienced zero-g in a Division aircraft was Neil Armstrong who eventually landed on the moon. A member of the Aero Medical Laboratory, Wright-Patterson AFB, also got involved in the fun.



Under weightless conditions, a tester evaluates ways of exiting a model of a space capsule.

The Flight Test Operations also tested the Lunar Roving Vehicle that was used on the moon. The vehicle was tested under lunar gravity conditions in one of the zero-g aircraft. It was operated between two bumpers located at each end of the aircraft cabin and was secured by an arresting rope run through a caliper brake used for stopping the vehicle. The Lunar Rover was operated and steered by a control stick attached to the vehicle by a long electrical cable. It was operated over 2x4- and 4x4-inch obstacles to determine the dynamic characteristics under lunar gravity conditions. The engineers found the vehicle to be under-powered when the pneumatic tires were deflated to provide sufficient traction to prevent slippage during starts. It was shoved manually to help accelerate it to 8-10 miles per hour in the test area. In running the vehicle over the obstacles, the testers discovered it was bouncing as much as two to three times the values predicted by the John C. Marshall Space Test Flight Center's computer and needed to be modified.

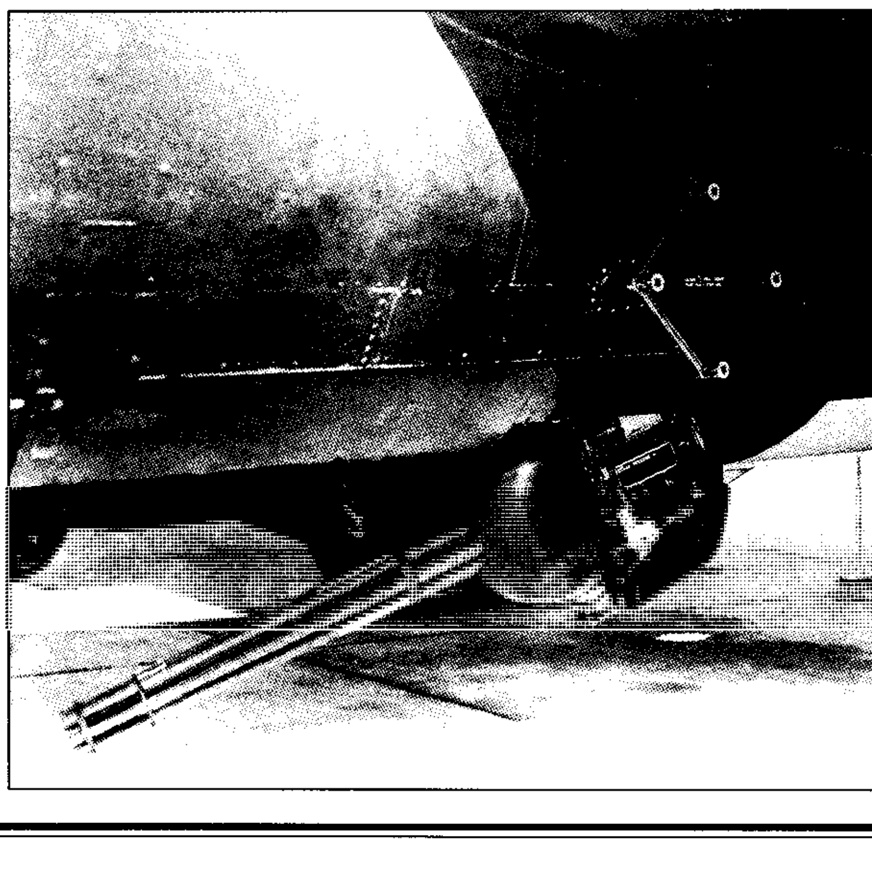
In 1968 the final design verification of hardware and procedures for Apollo flights leading up to and including the lunar landing were completed. During 1969 the zero-g aircraft flew 2,526 maneuvers in support of NASA. The Apollo effort consisted primarily of training astronauts in the use of lunar surface equipment and the formulation of procedures for film retrieval from lunar mapping equipment, located in the service module, during the return flight from the moon. One area of investigation that began during this time was testing the lunar rover, especially the wheel design. A one-tenth scale model of a wheel was tested on a simulated lunar surface.

The tests in the zero-g aircraft during 1970 involved support of Skylab through the use of part-task mockups. For example, the researchers tested modular transport equipment for Apollo 14 and conducted training for extra vehicular activities for Apollo 15 with retrieving lunar mapping film as the main effort. The testing continued on the lunar roving vehicle involving wheel development and crew performance. In 1971 tests continued in support of Skylab and the lunar rover, and expanded to cover experiments for manufacturing in space as well as space showers, orbital fluid transfer, and space food. In 1972 the zero-g section continued to support Skylab and also focused on training the Apollo 16 flight crew members as well as performing final design verification.

By 1972 the program had flown approximately 48,000 parabolas, which would have been the equivalent of 15 days of space flight. Testing continued as the program sought to prove the feasibility of using an Apollo vehicle to rescue a crew that was stranded on Skylab. The plan called for the launch of an Apollo vehicle with a two man crew, a rendezvous with the Skylab, the transfer of three stranded astronauts, and the return to earth with five men in the Apollo Command Module. The test proved that putting five men and equipment in a module designed for three men was difficult, but possible. A second project was the Viking Program. This was to land a vehicle and hardware softly on Mars to perform scientific experiments including soil sampling. In fact, five individual functions of soil sampling were tested. Other tests performed included a waste management test for the Space Shuttle, radiator/condenser panes for a future space station, and fuel configuration tests. The Apollo 17 crew was also trained during this period.

PAVE GAT

In 1969 Flight Test Engineering worked on the PAVE GAT project which concerned the mating of a low light TV sensor with a Gatling gun on a B-57 aircraft. The Technical Photographic Branch also was involved, recording ground targets, ground strikes, and pod mounted fire control system data to demonstrate the technical and engineering capabilities during the flight test evaluation of PAVE GAT. The acceptance tests were completed on 6 November 1969 and the project was deployed to Eglin AFB, Florida.



The PAVE GAT flexible Gatling gun and turret on a B-57 aircraft.

RC-135 AERODYNAMIC TEST

In 1966 Flight Test Engineering performed aerodynamic tests on the RC-135C. The RC-135C had some modifications that needed testing. It contained a chin radome, a barrel radome located on the bottom fuselage centerline aft of the nose wheel, antenna housings running forward of the leading edge of the wing to just aft of the entrance hatch, electronics gear, wing tip antennas, and an equipment cooling package. The refueling boom and one cell of the forward body tank had been removed. The test was to calibrate the aerodynamically compensated pitot-static tubes to gather Flight Manual performance data; to qualitatively evaluate stability and control; and to establish the aerodynamic envelope of the aircraft. During the tests the pilot discovered the aircraft tended to roll to the right during the approach to stall speed but controls were adequate to prevent an actual roll off. Pitot-static tubes, however, failed to meet specifications. The antenna housing was not stiff enough to withstand the air pressure and caused excessive noise, deformation of the housing, and drag. The housings were later reinforced which reduced the noise level, deformation, and drag. The aircraft with the additional modifications was certified as a result of the tests.

LONG LINE LOITER PROGRAM

In 1968 Flight Test Operations tested the idea of dropping supplies from an airplane with pinpoint accuracy by sliding them down a rope to the ground. The idea was to keep the airplane circling about 3,000 feet above the ground to reduce the risk of small arms fire. The wire would be spiraled down and anchored inside the perimeter of an outpost to guarantee that supplies would fall into friendly hands. The technique involved using up to 10,000 feet of rope, similar to that used to tow water skiers. The first tests involved establishing tracking and flight control techniques for spiraling a weighted long line to a particular point on the ground by analytically determining with a computer the reasonable distance, ranges, and mass weights for the concept. In the spring of 1969 Flight Test Engineering conducted tests by deploying different kinds of lines from an aircraft and using articles of various configurations and weights. The weighted articles with parachutes would be guided by a ring which slid along the rope to the ground.

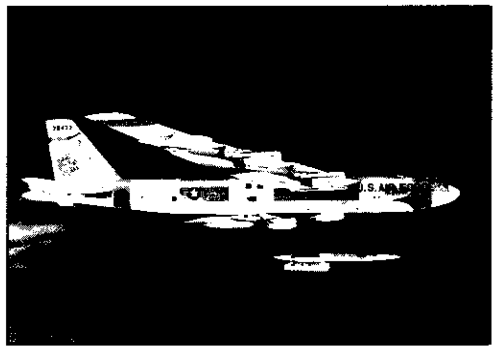
During the test season of 1970 Flight Test Division's Flight Test Operations Section used successfully a small, orbiting aircraft that used a bombsight method to spiral a line to a predesignated target area on the ground. If the pilot missed his mark an airman in the aircraft would cut the rope and the pilot would try again. It would take only about 45 seconds for a package to slide down from the plane to the ground with as many as four bundles on the rope at the same time. When the supplies reached the ground the troops would unhook the packages, bundle up the chutes and attach them to the line, and the airplane would then fly back to its base, trailing the rope and the parachutes. The Air Force also looked into the possibility of using the same long rope method to pick up downed airman. The researchers used dummies and weighted articles, and dummies with parachutes that were retrieved by the system after the parachute was deflated. The end of the Vietnam War, however, resulted in less interest in this technique and the program was ended.

ROTORGLIDER DISCRETIONARY DESCENT CONCEPT

With the war raging in Southeast Asia and with the loss of many aircraft, the Air Force sought ways to improve the chances of rescuing downed airmen. To improve the capability of rescuing flight crews ejecting over hostile territory, the Flight Test Division considered a discretionary descent vehicle with rotary wings to aid in the rescue. It began feasibility tests in 1968 using Benson's gyrocopter and gyroglider (designated X-25B and X-25A). The tests extended into 1969 but with the winding down of the Vietnam War there was less interest in the program and eventually it was terminated.

HOUND DOG II PROPAGATION

On 5 July 1972, the Test Wing Planning Board considered preliminary estimates and schedules for the HOUND DOG II missile propagation tests. The HOUND DOG II program was an improvement of the HOUND DOG, an air-to-surface weapon. The test, requested by the HOUND DOG II SPO, was to obtain data to confirm design assumptions for the seeker system. The specific objectives were to measure attenuation of an L-band Continuous Wave (CW) radio signal through and beyond the line of sight horizon, and to measure characteristics of a multipath-reflected RF pulse signal under various attitude and separation conditions for transmitting and receiving aircraft. The tests would be done over open seas and also over Arctic ice packs. When the Planning Board submitted its schedule to the SPO it was rejected, forcing additional study of the situation and the development of an alternative plan. The new plan involved a different transmission aircraft and on 1 September 1972 the SPO approved the flight test.

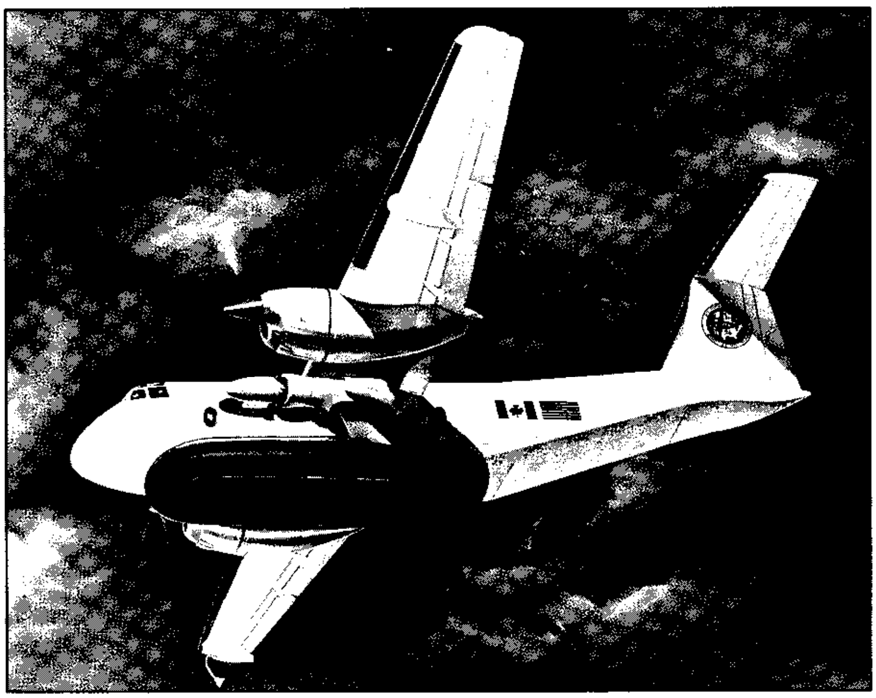


A B-52 launches a HOUND DOG missile.

Although the new schedule called for the modification of the transmit aircraft, a C-135, by the middle of November and of the receiver aircraft, a C-141, by February 1973, the modifications took longer than expected. The installation of equipment on the transmit aircraft took place from mid-October to mid-December 1972. As a phase inspection began on the aircraft in late December, concurrent minor revisions to the test equipment were made to prepare the aircraft to support a seeker system evaluation flight test until completion of the modifications of the other propagation test aircraft. Prefabrication of test equipment into equipment racks for the C-141 was delayed nearly two weeks by the unavailability of equipment, notably the three-channel receiver being built especially for the test by the Air Force Avionics Laboratory, and some equipment supporting an active project on another aircraft. Installation of the equipment into the C-141, however, was never begun. In December 1973 the Air Force cancelled the HOUND DOG II development program. A request by the Air Force Avionics Laboratory to continue the program as a basic propagation test in pursuit of data that would be applicable to other Laboratory projects was disapproved in December by Hq AFSC. An unusual aspect of the propagation test was the absence of a prime system or equipment contractor. The selection and integration of military and commercial electronics into the propagation aircraft transmitter and receiver systems were accomplished by the Avionics Laboratory.

AIR CUSHION LANDING SYSTEM

One of the projects of the Test Engineering Division was the testing of the Air Cushion Landing System (ACLS). Textron's Bell Aerospace Division began development of the ACLS with a company-funded effort on 1 December 1963. It was soon joined by the Air Force Flight Dynamics Laboratory. The ACLS became an Advanced Development Program jointly sponsored by the Flight Dynamics Laboratory and the Canadian Department of Industry, Trade, and Commerce which contracted with Bell Aerospace to develop and test an Air Cushion Landing System on the "Buffalo" CC-115 aircraft, redesignated as the XC-8A aircraft. The purpose was to demonstrate the feasibility of an air cushion as a landing system on large transport aircraft. The technology was to confine air under the aircraft by an air cushion trunk. In 1973 the air cushion trunk was mated to the XC-8A, a highly modified Canadian DeHavilland CC-115 "Buffalo" aircraft, at Bell Aerospace Corporation, Buffalo, New York. The air generated by two ASP-10 auxiliary engines and fan packages escaped the trunk through about 6,800 small holes around the ground contact area. The escaping air created a layer of air that elevated the trunk above the surface. During actual flying the pilot would deflate the trunk. On landing there were six skids on the bottom of the trunk, made of a tire tread material, which operated when the pilot applied his brakes.


An Artist's Rendition of the Air Cushion Landing System.

The 4950th Test Wing's testing of the ACLS discovered some significant problems. During static ground test of the air cushion trunk, a tear occurred on the inner trunk surface. This tear occurred at an air pressure of 425 pounds per square foot. After the failure, the trunk was removed for repair and a design review of the trunk portion was initiated. Also, the aircraft was sent to DeHavilland Aircraft Ltd for Beta propeller modifications to give the pilot direct control of the propeller blade angle to allow precise speed and directional control during ground maneuvering on the air cushion. The next step was the reinstallation of the trunk and the start of contractor flight testing.

Problems continued to plague the program through the rest of the year. Engineers solved air supply problems and several ground inflations of the air cushion bag were accomplished successfully at Bell Aerospace. Ground crew training for 4950th personnel was initiated in Canada and the ASD Engineering Program Office convened a flight release board on 15 October 1973. Results of the flight release board indicated that the aircraft would be released for its first flight as soon as the contractor rectified the identified discrepancies in the flight test plan.

On 31 October 1973 the ACLS Advanced Development Program Office stated that the funds necessary to employ Bell Aerospace to conduct the flight test program were expected to be expended by 2 November 1973. It requested that the 4950th Test Wing assume responsibility for the total test program. The Test Wing personnel identified numerous system deficiencies and informed the Test Wing Commander. He decided to accept the program and work out the details of supporting the testing through the Air Force Flight Dynamics Laboratory (AFFDL). On 19 November 1973, AFFDL terminated the XC-8A Flight Test contract with Bell Aerospace Corporation and assumed responsibility for testing the concept. The XC-8A aircraft was flown to DeHavilland Aircraft Ltd on 20 November 1973 for subsystems updating and correction of the known deficiencies. In addition, key people of the Test Wing and AFFDL, responsible for the overall conduct of the flight test program on the XC-8A, visited Bell Aerospace on 29-30 November 1973 for an engineering review of the Bell program. From 10-14 December 1973, the Test Wing XC-8A test team members visited DeHavilland to receive training and perform system checkouts and inspections on the XC-8A.

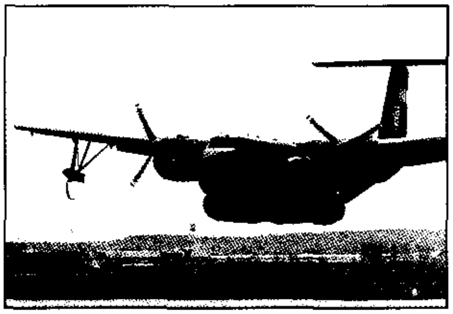
The testing program began in a concentrated way in January 1974. On 15 January 1974 the test plan for the XC-8A program was published and the aircraft arrived at the 4950th Test Wing. From 16 January to 27 February 1974 the aircraft instrumentation was recalibrated, numerous subsystem discrepancies on the Air Cushion System and ASP-10 engine control box were corrected, and the contractors conducted subsystem training courses for the 4950th personnel. From 27 February to 30 June 1974 the 4950th personnel performed 32.2 hours of testing on the aircraft covering such areas as trunk flutter, aircraft propulsion, system vibration, airspeed calibration, aircraft performance, stability and control, and ACLS park and taxi tests. The aircrew performed the first low speed (10 knots) ACLS taxi on 10 April 1974 and a 15 knot taxi test on 25 April 1974.

WING AIRCREW LOST OVER THE PACIFIC

In 1971 the 4950th Test Wing (Technical) operated a C-135B aircraft for the Space and Missile System Office (SAMSO) to gather classified information in the South Pacific area. The aircraft had been modified by several contractors and supplied to the Wing. Because the Wing had reservations about contractor modifications of the aircraft, it placed restrictions on its use. In June 1971 a Test Wing crew accompanied by several contractor personnel flew to American Samoa in the South Pacific. On 13 June 1971, during the flight from Samoa to Honolulu the aircraft was lost with all hands. A second aircraft was modified under Test Wing supervision and a year later this aircraft flew the mission and successfully gathered the data desired by SAMSO. The following Test Wing personnel were lost over the Pacific:

Maj William H. Unsderfer	Maj William E. Page, Jr.
Capt Perry T. Rose	Lt Col Victor J. Reinhart
Maj John R. McGinn	TSgt Hubert Miles, Jr.
SSgt Elno R. Reimer	SSgt Kenneth S. Kowal

In the midst of the testing some problems arose. In June the 4950th engineers decided to remove trunk number one and install trunk number two because of numerous tears in trunk number one. Before this occurred it was necessary to perform a structural inspection of the aircraft. Once trunk number one and its associated hardware were removed the aircrew flew the aircraft to DeHavilland Aircraft of Canada for structural inspection of the fuselage trunk attachment area and Beta-prop control change. When the aircraft returned, the maintenance personnel installed trunk number two and performed modifications on the bladder vent valves and control trim valves. The aircraft then entered the testing program and the aircrew flew 26 testing hours. These tests involved post trunk installation functional system checks, stretch-anneal of trunk number two, and crew proficiency flights. There were still a number of problems with the aircraft. The crew resolved problems of trunk vibrations, the parking system, ACLS trim control system, and excessive hydraulic pressures within the ASP-10 system. The crew also accomplished numerous configuration modifications, flight manual changes, and instrument calibrations and improvements. All of this, however, caused a delay in performing taxi, take-off, and landing operations on trunk number two.



The Canadian Buffalo aircraft, the XC-8A, outfitted with the Air Cushion Landing System, preparing to land at Wright-Patterson AFB, during its initial flight tests in March.

In the first half of 1975 the Test Wing faced more problems with the ACLS system. The three major problem areas were trunk flutter, ASP-10 stall performance, and parking system operation. These were investigated and resolved sufficiently to permit ACLS 15 knot and 30 knot speed taxi tests to be conducted on paved and grass surfaces. The big day was 31 March 1975 when the ACLS performed its first takeoff on a paved surface. Unfortunately, the trunk experienced abrasive wear during the taxi and take-off. As a result, the aircrew conducted the ACLS high speed (50 knot) acceleration/deceleration taxi tests, touch and go landing test, and the first ACLS landing to a full stop on the less abrasive grass surfaces. Next, the crews performed prerequisite stability and control flights tests in the expected takeoff and landing configurations and then began landings and take-offs. Through June 1975 the crews performed five additional ACLS touch and go landings and six full stop landings and take-offs. Unfortunately, the ingestion of grass into the ASP-10 and T-64 engines during lower speed taxi conditions limited grass surface test operations. When the third T-64 engine was lost because of grass ingestion the aircraft was limited to paved surfaces.

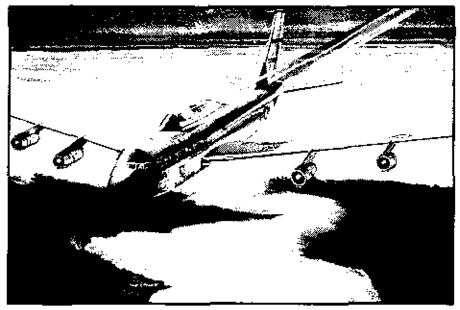
During the last half of 1975 the Test Wing performed pitch dynamic tests, traversing craters, and medium sink rate landings. The aircrews flew 13.8 hours and performed 23 tests during the period. During January and February 1976 the XC-8A underwent cold weather testing in Cold Lake, Alberta and Yellowknife, Northwest Territory, Canada, meeting most of the objectives despite the lack of the normally intense cold weather in the northern regions.

The ACLS program, however, continued to experience difficulties because of trunk deterioration. The second ACLS trunk was removed because of deterioration after 45 hours of operational use. The removal of the second and installation of the third trunk was initiated on 21 June 1976 with the installation and trunk stretch-anneal test completed on 2 September 1976, and the final trunk installation was completed on 26 October 1976. The systems operational check was accomplished on 1 December 1976. The third trunk also had difficulties. Excessive trunk flutter on both concrete and grass surfaces was encountered during ACLS cushion borne static tests. The flutter was unacceptable for ACLS taxi operations utilizing both ASP-10s to supply cushion air, though it was acceptable operating at low airflows obtainable with single ASP-10 operation. In addition to the flutter, the T-64 grass ingestion problems continued to plague the program and a modification was proposed to the Canadians. They, however, decided not to incorporate the modification. Nevertheless, the restriction which had all but eliminated ACLS taxi operations on other than paved surfaces were relaxed permitting limited operations on a well maintained grass area.

The Test Wing proposed a new area of operation for the ACLS; overwater tests. Planned to be conducted at Elizabeth City Coast Guard Station, North Carolina, the program was disapproved by the Flight Dynamics Laboratory's Commander. On 22-24 November 1976 the Laboratory's Overwater Engineering Design Review Board was convened. Pending Canadian review, the Board found no technical objections to accomplishing ACLS water tests. It was the Board's general feeling, however, that the ACLS water tests would not be approved and the idea was dropped. On 31 March 1977 the test phase of the program was completed with no plans to continue the program. The XC-8A aircraft was demodified and on 12 May 1977 returned to the Royal Canadian Air Force.

TRAP

One of the tasks of the Flight Test Division, beginning in 1967 was to acquire data on vehicles returning from space. The data was collected from re-entry to impact. The system to acquire optical and radiometric signatures of Intercontinental Ballistic Missile (ICBM) re-entry vehicles consisted of one KC-135 and one C-135 aircraft each with 20 ballistic cameras. The cameras were mounted in five banks, and each bank covered a different but overlapping field of view. The cameras recorded the trace of moving luminous bodies against a stationary star background. Project TRAP (Terminal Radiation Airborne Measurement Program) was an airborne optical instrumentation platform capable of recording data in the near ultraviolet, visible, and near infrared spectrum on photographic emulsions and magnetic tape. The primary use for this system was to support ballistic missile reentry system tests.



An artist's portrayal of the TRAP aircraft recording data from re-entry of missiles, shown in the background.

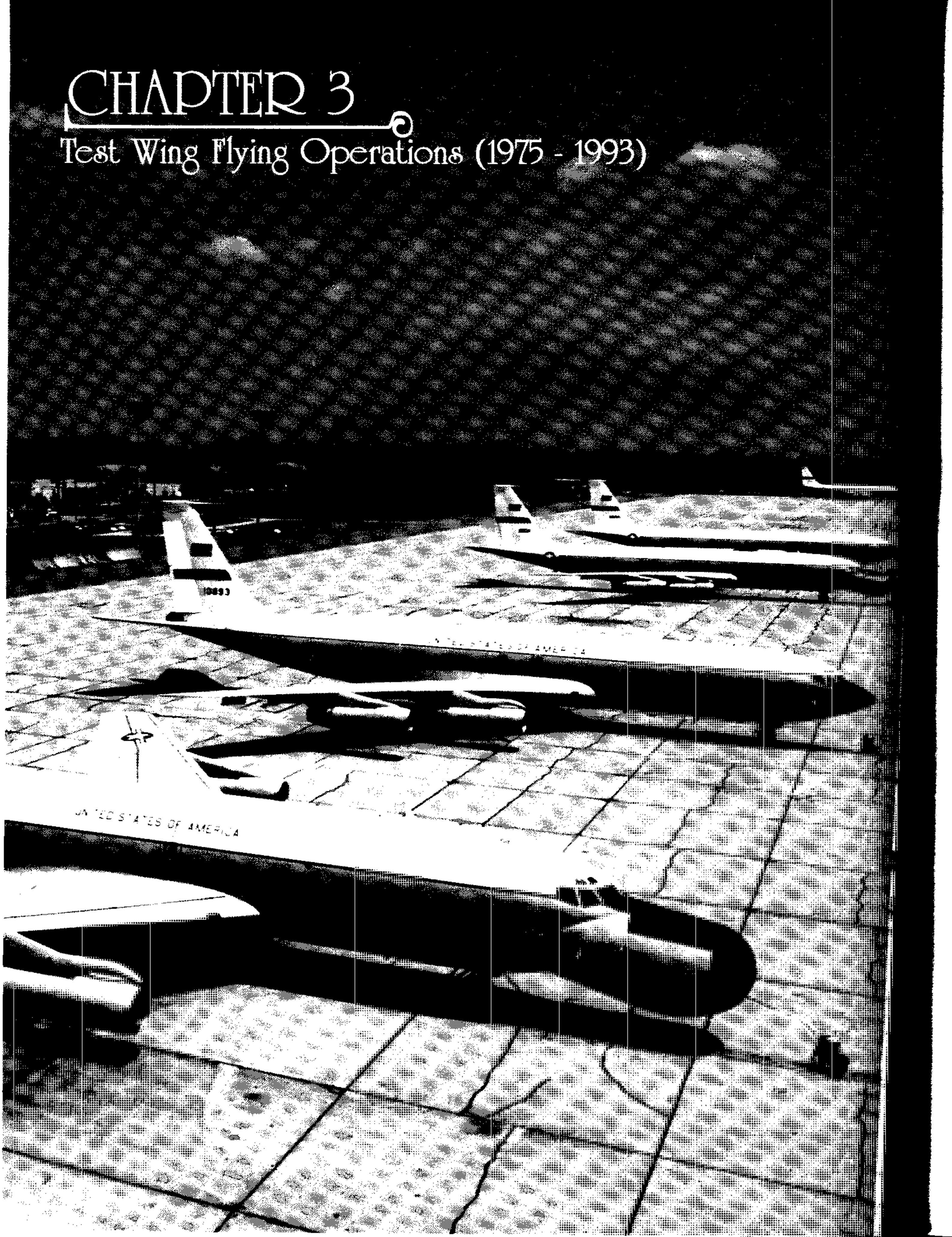
On a mission the two TRAP aircraft would orbit the area of expected missile impact with the plan to have the re-entry vehicle fall between the two aircraft. The goal was to determine the location of warheads, decoys, and rocket parts to discover whether the decoys were ahead of the warheads or if there were rocket parts ahead of the decoys or warheads.

The C-135 aircraft equipment with optical equipment to record data from missiles entering the atmosphere.

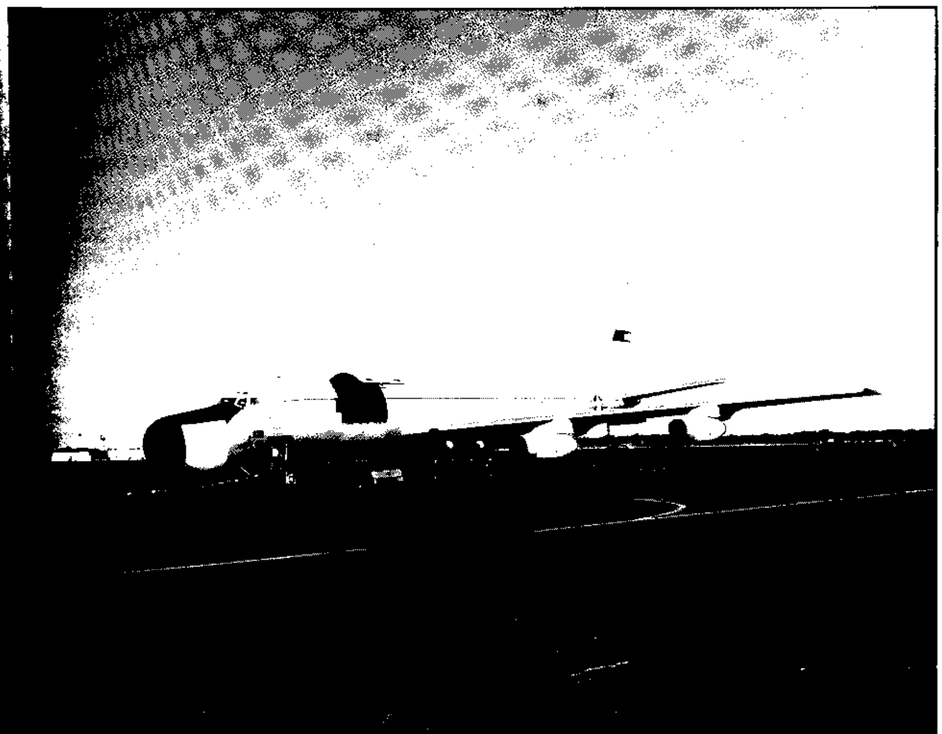
The task of covering reentry vehicles involved the crew in numerous trips with varying degrees of success. In 1964, for example, the program involved a trip to Puerto Rico to measure the re-entry of an advanced Polaris missile. Another flight went to Ascension Island for the re-entry of a Minuteman ICBM but the missile was destroyed on take-off causing the mission to be terminated. A third trip saw the aircraft fly to Patrick AFB to cover the launch of an unmanned Gemini vehicle but the launch was aborted. Another flight took the crew to the White Sands Missile Range where they were able to observe a re-entry vehicle launched from Green River, Utah. During the 1970s the Flight Test Division became the 4950th Test Wing and in 1975 it underwent a significant reorganization that included the transfer of the ARIA aircraft from Patrick AFB, Florida where the program continued its mission as part of the ARIA program.

CHAPTER 3

Test Wing Flying Operations (1975 - 1993)



Several important changes occurred to the flight test mission in the 1970's. First, after nearly two and a half decades, the all weather flight test mission moved out to Edwards AFB, California. In 1971, the Aeronautical Systems Division's flight test organization, the Directorate of Flight Test, became a wing, first the 4950th Test Wing (Technical), and then simply the 4950th Test Wing. In 1974 and 1975, the Test Wing underwent a major reorganization. In addition to a transfer of some subelements and a reorganization of others, this major reorganizational effort, called HAVE CAR, reallocated new resources and mission responsibilities to the Test Wing. As for new resources, the Test Wing received thirty-one additional aircraft, including two NKC-135s and five C-131Bs from Rome Air Development Center at Griffiss AFB, New York; ten C-135s from the Eastern Test Range at Patrick AFB, Florida; two NKC-135s from the Flight Test Center at Edwards AFB, California; and four C-130s, seven C-135s, and one T-39 from the Special Weapons Center at Kirkland AFB, New Mexico.

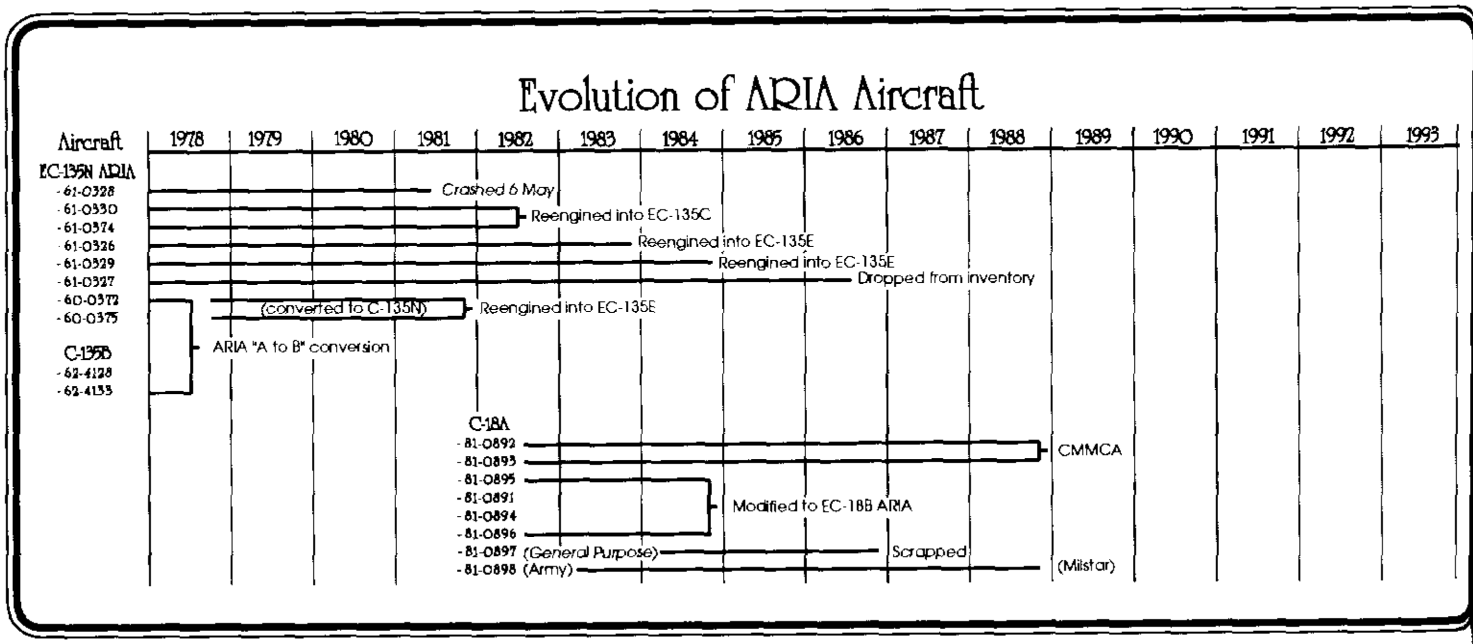


1975, the 4950th Test Wing received eight EC-135N aircraft from Patrick AFB, Florida.

ARIA

In the early 1960's, the National Aeronautics and Space Administration (NASA) realized that the lunar missions of the Apollo program would require a worldwide network of tracking and telemetry stations, many positioned in remote regions of the world. This requirement had already been identified by the Department of Defense (DoD) in its management of unmanned orbital and ballistic missile reentry test programs. To meet these requirements, a new concept in tracking stations was developed - a high speed aircraft containing the necessary instrumentation to assure spacecraft acquisition, tracking, and telemetry data recording. This concept became a reality in the Apollo Range Instrumentation Aircraft (ARIA). This highly mobile station was designed to operate worldwide, receive and transmit astronaut voices, and record telemetry information from both the Apollo spacecraft and other NASA and DoD unmanned space vehicles. To implement the concept, NASA and DoD agreed to jointly fund modification of eight C-135 jet transport/cargo aircraft. The ARIA, designated EC-135N, became operational in January 1968, after being modified at the basic cost of $4.5 million per aircraft.

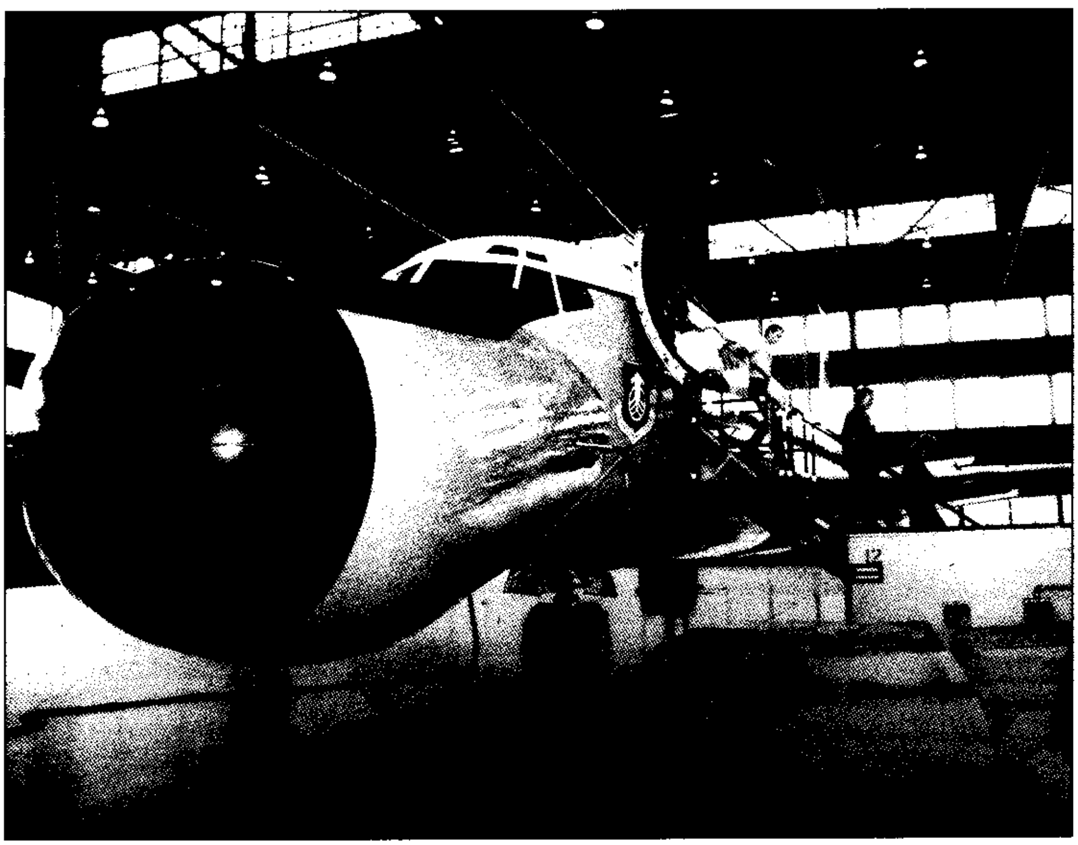
The management responsibility for the initial modification program was shared by both civilian and military agencies. NASA participated in all phases of development and simulation testing. DoD developed policy considerations and assigned overall responsibility for procurement to the Electronic Systems Division of the US Air Force. The Air Force Eastern Test Range (AFETR) at Patrick AFB, Florida, was selected to operate and maintain the system in support of the test and evaluation community. The McDonnell-Douglas Corporation and the Bendix Corporation were selected



as the contractors for the design, aircraft modification, and testing of the electronic equipment. In December 1975, after seven years of operation by AFETR, the ARIA (redesignated Advanced Range Instrumentation Aircraft following completion of the Apollo program) was transferred to the 4950th Test Wing at Wright-Patterson AFB, Ohio, as part of an Air Force consolidation of large test and evaluation aircraft. By the early 1980's, the ARIA fleet consisted of eight modified aircraft, six EC-135N aircraft with J-57 turbojet engines and two EC-135B aircraft with TF-33 turbofan engines.

Dedicated to support of worldwide missile and space testing, the aircraft modifications included a 7-foot diameter telemetry antenna, housed in a 10-foot radome in the nose of the aircraft. It also included extensive telemetry/communications instrumentation which could be configured to perform telemetry tracking of dynamic objects, telemetry signal reception and recording, on board data processing and reformatting, real-time or post-mission (retransmission) data relay through communication satellites via high frequency radio or direct line-of-sight relay to ground stations, and voice communications relay. In addition to the antenna in the nose, the ARIA had a probe antenna on each wingtip as well as a trailing wire antenna on the bottom of the fuselage, all used for high frequency radio transmission and reception. Further external modifications included antennas for post-mission data retransmission and satellite communications. The internal modification to the cargo compartment included all of the instrumentation subsystems (Prime Mission Electronic Equipment) installed in the form of a 30,000 pound modular package. Modifications also included provisions for eight to nine additional crew members to operate the instrumentation equipment.

The current Prime Mission Electronic Equipment was organized into six functional subsystems and a master control console to provide the ARIA mission support capability. The Antenna Subsystem acquired and tracked, either manually, automatically, or by computer, the launch vehicle using the 7-foot dish antenna mounted in the nose radome. The Telemetry Subsystem was configured as a set of six dual-channel AN/AKR-4 receivers that received the vehicle telemetry signals. The Record Subsystem was designed to use Inter-Range Instrumentation Group-standard equipment to meet user requirements for data recording, monitoring, and playback. The Timing Subsystem, physically collocated with the Record Subsystem, served as the central timing facility for the ARIA electronic suite, generating time codes to permit time correlation of vehicle events during tape processing. The Communications Subsystem provided the voice communications through three 1,000-watt single sideband high frequency transmitters and receivers, and data transmission through a 1,000-watt AN/ARC-146 UHF satellite terminal. The Data Separation Subsystem



The Antenna Subsystem acquired and tracked the launch vehicle using the 7-foot dish antenna mounted in the nose radome.

further processed the telemetry signals, generally a combination of several channels of analog and/or digital information, into individual measurements for onboard display. The last module, the Master Control Console, was operated by the ARIA mission coordinator, to control on board management of the instrumentation crew (See Figure 1).

The ARIA has been designed to provide telemetry coverage from locations around the world. Ballistic missile reentry tests have required the ARIA to provide support over both the Atlantic and Pacific Oceans for submarine and land-based missile launches. Satellite launches from Cape Canaveral usually have required support along the equator in the Atlantic, Pacific, and Indian Oceans, whereas polar satellite launches from Vandenberg AFB, California, have required support in the Pacific Ocean from California to New Zealand, and in the Indian Ocean from Capetown, South Africa to Nairobi, Kenya. Tests of Army Pershing and Air-Launched Cruise Missiles have limited required coverage in or near the continental United States (see Figure 2).

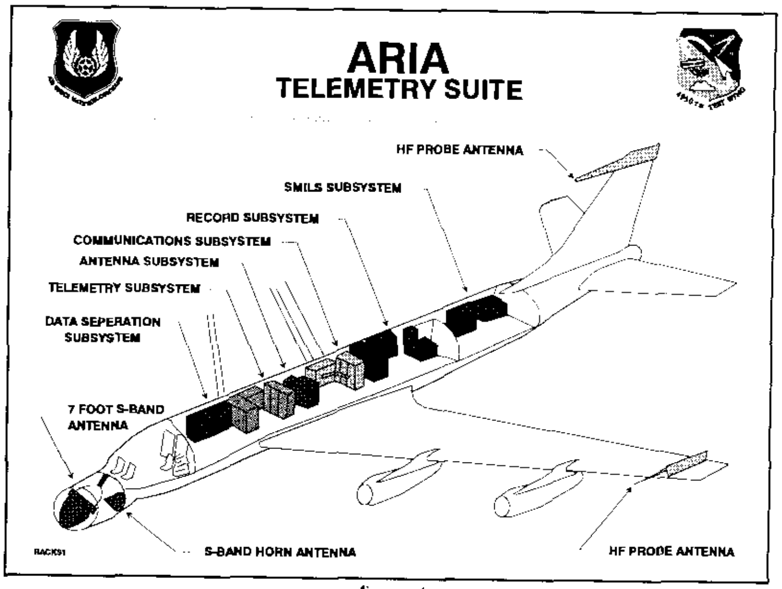


figure 1

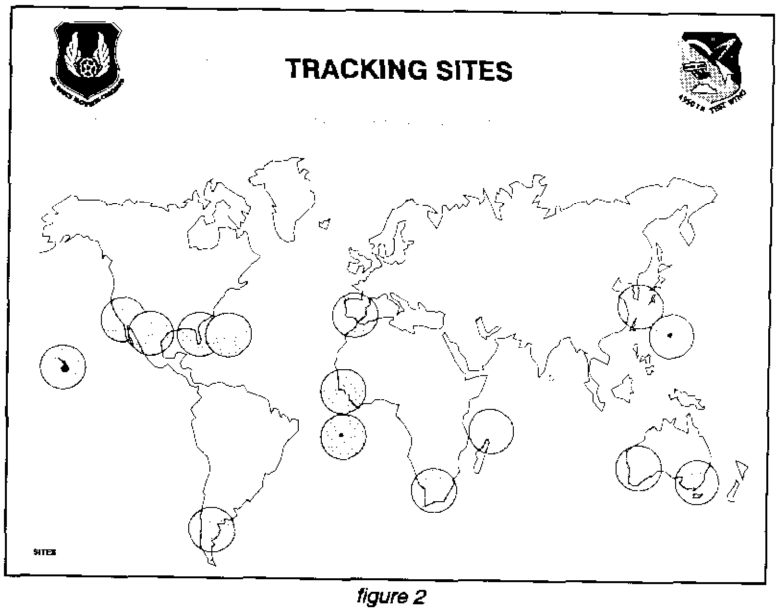


figure 2

CAUGHT IN THE MIDDLE - REVOLUTION IN SURINAM

In February 1980, three EC-135 ARIA aircraft with 57 persons aboard, were at an airport near Paramaribo, Surinam, when a group of Surinam Army sergeants, disgruntled over pay and working conditions, seized power in a pre-dawn coup, killing 15 people in shelling and gunfights. The three aircraft had stopped there for refueling and crew rest before flying out over the Atlantic Ocean to support a launch from Cape Canaveral. Although the ARIA planes left Surinam without incident, the sporadic fighting and mob looting, with occasional shelling from a gunboat and frequent small arms and machine gun fire in the vicinity of the hotel where the Test Wing crews were billeted, made the "short, no problem TDY" a trip to remember. Major Toby A. Rufty, a pilot with the 4952nd Squadron, flew the trip as the Wing Planner as well as instructor pilot. This is his story...

Maj Toby Rufty poses in "left seat" of an ARIA cockpit.

The mission to Surinam was supposed to be quick, easy, in and out in four days. We would fly to Zanderij airport, refuel, spend the night in crew rest and a nine-hour support mission for the Eastern Space and Missile Center over the Atlantic Ocean the next day. The Wing Commander, Colonel Don Ward, had not been out on the road with an ARIA deployment since taking over the Test Wing almost a year earlier. I worked in mission plans at the time and flew for the 4952nd Test Squadron as an instructor pilot in the C-135 aircraft. A new major, Al Grieshaber, needed to fly an overseas ARIA mission so I was to fly the mission as the instructor pilot, in addition to being the Wing Planner for the three-ship deployment. Since Col Ward hadn't seen what the guys have to deal with out on the road, I went up and talked him into going on this short, no problem TDY.

My aircraft, an EC-135N with water injected J-57 engines, was to be the first aircraft to depart WPAFB and arrive in Surinam. Unfortunately the water injection system failed several times that Sunday morning and I ended up getting to Surinam last, around midnight. The other two aircraft had already landed and the crews had gone into town to the hotel. The airport at Zanderij was about 35 km out in the jungle from the capital city of Paramaribo-no gas stations, no restaurants, no hotels... just a terminal building, aircraft fuel tanks, ramps, and maintenance hangars. After fueling the aircraft for the mission, we all (23 people) boarded a bus and drove into town to the hotel, arriving about 0130 hours Monday morning. Tired, I fell in bed - I was sharing a room with Major Grieshaber.

I awoke the next morning around 0630 to the sound of fireworks. There was a gentle breeze blowing through the windows of the 5th floor of the Krasnapolski Hotel and it was very comfortable to lie back and listen to the locals begin to celebrate their independence day. Across the room I noticed Al was awake and listening too. As I thought about it, it seemed like it was still another month or so until their independence day and it was about that time that Al said it sounded more like small arms fire in Vietnam. We both jumped out of our beds and met on the balcony. Sure enough, there were people down there shooting at each other, hiding behind trash cans, clinging to the corners of buildings. The city of Paramaribo reminds one of what 1890's America must have looked like. Many streets were unpaved with a few rough sidewalks or no sidewalks at all. The buildings were all two or three stories, wooden, painted white, most with tin roofs, a few with asphalt shingles. Only two structures, the bank building (which housed the American Embassy) and the Krasnapolski Hotel were higher than three stories. About this time Col Ward called from the Embassy. Ambassador Ostrander had sent the Embassy staff car for Lt Col Hartsock (the task force commander) and Col Ward at about 0545. The Ambassador had been informed of the uprising early that morning and the three of them were trying to determine how to best protect all Americans in Surinam, including the 65 people in our three ship deployment. Col Ward asked me to ensure all our people stayed inside the hotel, and he would call later to let us know the Ambassador's intentions. We got word to everyone to stay inside the botel, which wasn't hard to do because most of the guys were still sleeping off the Parbo beer from the night before.

You have to remember here we are talking 65 GIs who were always underpaid. One of the advantages of staying at the Krasnapolski (in addition to the fact that it was one of only two hotels in town deemed suitable for habitation) was the free continental breakfast that came with the room. By eating toast, cereal, fruit and milk instead of ordering eggs and bacon, a guy could save $6 to $7. So nobody was going to miss the free breakfast. Unfortunately, you had to go out on the third floor balcony by the restaurant. Not a big problem because it was surrounded by a five-foot cement block wall, and since all the other buildings were three floors or less no one could shoot directly at you. So as we sat there discussing what we should do next, eating muskmelon and jam covered toast, bullets could be heard ricocheting in the streets below. No problem. Besides some of the locals were out there and we couldn't let them outdo us!

We had been out on the balcony for about 35 minutes and it was approaching 0830. All of a sudden we heard a new and different sound, that of an incoming shell. The shell had been shot by a gunboat on the river. The gunboat had been captured by the rebels and they were a pretty good shot. It struck the police headquarters about 900 feet from the Krasnapolski. The police were the only opposing force in the country. For a short while we stood looking over the wall of the balcony as two more shells succeeded in setting the police station afire, and then decided perhaps we should move inside since the gunboat was now pointing its gun directly at the hotel.

Inside the maids were scurrying around and rumors were running rampant. The rumor that got our attention was that the American marines had landed and were staying at the Krasnapolski Hotel. The biggest weapon I had was my survival knife and I had already cut my finger with that trying to spear a chunk of cheese. Besides that, most of the guys were still feeling the effects of the previous night's Parbo beer. Only my crew had gotten in too late to exchange some money and hit the bar.

The phone rang about 0930; it was Col Ward. He needed some volunteers. One of the rumors floating around said the airport had been overrun, the aircraft destroyed and the bridges to the airport blown up. We couldn't call outside Surinam or even to the airport because the rebels controlled the communications stations, so we had no way of knowing the situation at the airport. Col Ward wanted a volunteer to go with him to the airport to survey the situation.

(continued on next page)

CAUGHT IN THE MIDDLE - REVOLUTION IN SURINAM (CONT)

If all was well, he would return to town, get everyone into the buses, and leave the country to settle its own problems. Basically a good plan. I, along with my crew chief, HF radio operator, and the systems analysts (SA) volunteered to go with him and get as many things done as possible to facilitate leaving. The radio operator and SA would establish communications with the outside world if possible. I would file flight plans and arrange weather briefings for all three aircraft. Around 1000 the Embassy car with flags waving pulled up in front of the hotel. Lt Col Hartsock got out, we got in and proceeded to the Ambassador's residence. Col Ward had not yet convinced Ambassador Ostrander it was safe to try going to the airport and it was another hour before we left the Ambassador's house for the airport.

The Ambassador was an extremely gracious lady. Her priorities were for the safety of all Americans first, any other considerations second. Actually, they were right in line with my priorities. She withstood the pressures of the moment, carefully analyzing the options we discussed and finally agreed with Col Ward's recommendation that we proceed to the airport to assess the situation first hand.

As the embassy car sped down the back streets of Paramaribo, the driver was constantly turning and working his way to the outskirts of this city of 400,000 people. The main streets had been blocked off with checkpoints and he wanted to avoid them if at all possible. Most of the stores were closed and the gas stations had been ordered closed. The embassy car had only enough gas to reach the airport and not enough for the return trip to town. We checked each gas station we passed and finally found one open on the outskirts of town. Our only problem was we had no Surinamese guilders to pay for the gas with — my crew had been the last to arrive and had not had a chance to exchange any currency. So we all scrambled through our pockets, digging out coins and bills in Surinamese guilders from previous trips that we had brought along to spend this trip. When we finally had enough to pay for the gas, I leaned back, rested my head against the door frame and read the sign on the gas station proclaiming "We take American Express, Mastercharge, and Visa". Working under pressure we had overlooked the obvious!

The remainder of the trip to the airport was uneventful. We stopped along the road near Cy Rubenstein's house to discuss with him transportation for the 60 crewmembers in the hotel and to see if he knew the situation at the airport. Cy had retired from the US Air Force in 1963 and lived in Surinam as a business man ever since. He provided our normal transportation needs on our visits to Surinam and coordinated our purchase of local products, primarily Surinamese shrimp and Dutch Gouda cheese. But Cy knew little of the events of the morning and had heard nothing from the airport.

When we arrived at the airport, George, our normal contact who spoke good English and worked in the terminal operations department, was at the gate to let us in. He had seen nothing of the Army rebels and could not call into town. Our aircraft were OK and we explained to George our plan was to leave until the situation calmed down. We swung by the maintenance hangar and requested an electrical power cart and a pneumatic start cart be brought out to our aircraft. Surinamese Airways only had two electrical and two air carts on the airfield.

The crew chief, HF operator and SA were dropped off at the aircraft to set up communications and pre-flight the aircraft. Col Ward and the embassy driver dropped me off 1000 feet away at the terminal building to arrange weather briefings and file flight plans for the three aircraft. They then proceeded back into town to get the remaining guys on the buses and to the airport.

Five minutes later the rebels overran the airport. Inside the terminal building on the second floor were two offices on opposite sides of a long wide room. One office housed the teletypes for filing flight plans, the other was the weather briefing room. I first checked with the flight planning people. They said their teletypes were up and I could file. I stepped across the big room into the weather office and gave the meteorological guy our planned flight data back to Patrick AFB in Florida. By returning to Patrick we could coordinate easily with the rest of the Eastern Test Range on the next best staging location to gather their data. As I came out of the weather office, two soldiers in full jungle dress jumped through the doors at the end of the room with their guns aimed directly at me, gesturing with their rifles in an upward motion. Pointee-talkee works real well in those situations and I put my hands up. There was no doubt in my mind what they wanted me to do, even though they spoke no English. Next they motioned by moving their rifles sideways for me to go through the doors at the end of the room. I could hear shots being fired outside. Once outside, in the hallway at the top of the stairs, they pointed again with their rifles, first at me, then at the floor and I knew they wanted to search me so I "spread-eagled" on the floor, face down. One guy slid his foot up between my legs and stuck the end of the rifle barrel low in the back of my head. And I think all the good memories of my life passed through my mind. For a moment I thought it was all over. The two soldiers said a few words in Surinamese talkie-talkie, and the second guy took his rifle over and stood it in the corner, then came back, got down on his knees and searched my entire body very carefully. He felt my wallet extensively but did not remove it. Fortunately, we had decided it might not be a good day to wear flight suits so I was dressed in a short-sleeve shirt, slacks and had a baseball hat in my hand. As he searched me I began to feel perhaps they weren't going to shoot me after all, otherwise why would they bother to search me? His professional manner in searching me gave me more hope.

As he finished searching me, George and a Surinamese Lieutenant came up the stairs. When George saw me he started telling the Lieutenant who I was, and I could pick up enough Surinamese talkie-talkie to know he was telling him we just wanted to fly away and not interfere. They allowed me to get up and I only said "We just want to leave and let you settle your own affairs." They talked a little longer and then ordered me to go to my aircraft. Out the windows I had seen several small pickups with what looked like 5000 but more likely was 15 soldiers, each with guns running everywhere. So I said "Is it safe?" The Surinamese Lieutenant turned to me and said in perfect English "Go to your Aircraft!"

So off I went down the stairs and stepped outside, where I was immediately grabbed by two soldiers and placed in a lineup with about 18 civilians. They kept me separated by about ten feet from the civilians and one soldier guarded me while three or four guarded the civilians. It was 12:00 noon, in the middle of the jungle near the Equator, and boy was it hot! They kept us there for about 20 minutes, and after one of the civilians collapsed, they moved us inside the open air terminal building and sat us on the conveyor belts the luggage moves on. Again I was kept separated from the others with one soldier dedicated to guarding me. At first the soldiers pointed their rifles directly at us. After about twenty minutes, an order came from somewhere that they could no longer point guns at civilians and they all went to parade rest position. George had been brought down with us and kept trying to slide over next to me and they kept making him move away but he finally worked his way over about five feet from me and kept whispering to just stay calm and he thought we would be OK. Hell, I was calm but I figured if George kept moving closer to me we were both going to be shot. George was worried about the effect this would have on his country's relationship with the United States. After a while he came up with the best line of the day, "You realize, these things happen, even in the best of families".

While we were sitting in the terminal one soldier came through carrying a hand-grenade, pin pulled, but trigger held down by his thumb. He carried it very slowly in front of everyone, and the only reason I can figure was just to ensure the people knew they had access to bigger weapons. Normally the police force controlled all weapons, and no weapons were issued to the 800-man army. So it was important for them to make known that they controlled the weapons.

The Surinamese Lieutenant questioned the civilians in a nearby room, and after about two hours I was again allowed to go to the aircraft. All this time I had no idea what had happened to my crew at the aircraft, and they had no idea what had happened to me. The walk from the terminal building to the aircraft was probably the straightest walk I've ever made. I could see soldiers on top of the buildings with rifles and knew I would never hear a shot if it was fired. But all the shooting had stopped about an hour before. The only thing on the ramp with me was "Zanderij Dog". This stupid, mangy dog, totally deaf from being around aircraft with their engines running, walked right beside me most of the way to the aircraft.

At the aircraft I found Sgt Busse standing at parade rest firmly planted in front of the crew entrance ladder. Two soldiers had tried to come up but he held his position and they just tried to peer up the ladder around him. And a good thing. Had they known my HF and SA were talking to ARIA control at WPAFB, and they were relaying to the State Department in D.C., who in turn, was relaying everything going on to the Dutch; they would have probably shot us and asked questions later. Upstairs the HF and SA had stripped down to their underwear in the hot aircraft, and they were worried about the radios overheating. They couldn't get the Embassy downtown on the frequency the Ambassador had given us so we asked ARIA control to get the frequency from the State Department. Within minutes we were relaying events from Paramaribo through Zanderij to Dayton where it was relayed to the State Department and they relayed it to the Dutch. I finished pre-flighting the aircraft and Col Ward arrived with our people on two buses at 3:00 PM.

I got out of the aircraft and started across the ramp to meet the buses which had stopped about 100 feet from the terminal building. One of the rebels stopped me with his gun pointing at me but allowed me to proceed after a little pointee-talkee — a couple of "mi amigos", "comrades", and my pointing at myself, then him and saying "we go - va". So he and I walked back across the ramp to where the buses had stopped.

At the buses we decided to allow two navigators to go back upstairs in the terminal building to try for weather and flight plans and have the buses drop everyone else off close to the aircraft. Don't ever tell a driver in a foreign country to drop you off close to the aircraft. He got so close to the aircraft he had to back up and move away from the aircraft so the door on the bus would open.

My crew quickly loaded, received permission to start engines from the control tower and gave the air and electrical carts to the third aircraft so they could get their aircraft going. You've got to remember all of this was happening just after the Iranians had held our embassy personnel hostage for months in Iran. So I was not exactly pleased when our call to ground control for permission to taxi got the following response - "AGAR 21, the rebel leader has closed our borders and ordered no one to enter or leave the country, shut down your engines". The next thing said was by the navigator who didn't realize everything I had already been through that day, and I'm afraid I was a little short with him when he said "ARIA held hostage, Day 2". I just didn't view the statement with a whole lot of humor at that point.

We were able to leave one engine running to maintain electrical power for about 15 minutes, and then they ordered us to shut all engines down, at which point Col Ward decided to go back into town in the embassy car and try to convince the rebel leader to allow us to leave. At this point all three aircraft commanders huddled on the ramp and the embassy security guy came up to us with a bag of classified asking if we would take it out of the country. He threw it first to Lt Col Hartsock who threw it to me and I threw it to the other aircraft commander who immediately threw it back to Lt Col Hartsock. After we had all said about two more times "Hell I don't want it" and threw it to the next guy, Lt Col Hartsock finally threw it back to the embassy guy and told him to lock it up in the safe since we didn't even know if we would be allowed to leave.

Col Ward got about half-way back into town when he heard over the embassy car radio that we would be allowed to leave and turned around and headed back to the airfield. We got the word at the airport as Col Ward drove through the gate, and 13 minutes later I was airborne . . . which is pretty remarkable when you consider we had to install a cartridge, and change the cowlings between #3 and #4 engines because the wrong cowling was on the wrong engine.

Taxiing out was extremely close between a light pole and a DC-8 on the ramp. Takeoff roll was normal, everyone was worried about my water injection, but for once it worked perfectly. Lift off was about the best moment of the day. It was accompanied by absolute shouts of joy from all the backenders, and I could hear it over the roar of the engines. Shortly after takeoff they brought me 13 cups of water and two soft drinks, I hadn't realized how dehydrated I had become. Each time the guys in my aircraft heard the next airplane get airborne it was the same shouts again.

Since we were arriving after Patrick AFB's closing hours, there were some interesting conversations that night between Col Ward in the aircraft and Col Wolf, the acting Deputy Chief of Operations, on the ground at WPAFB during the calls that were made to get the field open. Lets just say we can't repeat the words that were said over HF that night. But I will say the Eastern Test Range commander threatened the Captain at Patrick who ran the airfield, with a tour at Thule, Greenland if the field at Patrick was not open in 15 minutes.

On landing at Patrick we had to clear customs since we had been outside the US. This turned into a hilarious event. As we pulled into the chocks, the customs guy was standing out behind the Marshaller. As soon as the stairs were pushed up, I went down, gave him the aircraft general declaration and asked him how he wanted to handle the individuals. But before I could say anymore, all the crewmembers piled off the aircraft, some kissed the ground, others kissed the customs agent and all piled their declarations on him. He just threw his hands up in the air, picked up the "decs" and left.

We got into a hotel at Cocoa Beach about 1:00 AM, and at 5:30 AM I got a call from the Dayton Daily News, asking what had happened. Of course we had all been told the right answer was "no comment". They persisted so I finally said "Look, you know I can't say anything about what happens on our missions, but I can tell you we are all safe and sound, and looking forward to a warm sunny day at the beach. We'll be home in a couple of days". I guess they figured I wasn't going to say more, so they let it go at that. We went home the next day. A week later I got my travel voucher back - for the 19 hours I spent on the ground in Surinam, they paid me $6.80 — Figures!!

The ARIA has supported customers from around the world. In addition to tracking NASA spacecraft and DoD's Army, Navy, and Air Force missiles, ARIA has supported projects of other US government agencies such as the National Oceanographic and Atmospheric Administration. Outside the US, the ARIA has tracked launches of Italian, Canadian, Japanese, and European space agency satellites, as well as ballistic missile testing of other North Atlantic Treaty Organization (NATO) countries (see Figure 3).

HISTORY OF ARIA
MISSIONS SUPPORTED

NASA		DOD
ACTS	NATO II	ALCM, GLCM, SLCM
APOLLO	NOAA	AMRAAM, ACM,
APOLLO-SOYUZ	PEGASUS	ATLAS CENTAUR
CRRES	PIONEER	BRILLIANT PEBBLES
DMSP	PIONEER-VENUS	DELTA I,II
DSCS	RCA SATCOM	DOD SHUTTLE
GALILEO	SATCOM	ERIS
GEOTAIL	SEASAT	IUS
GPS	SHUTTLE(STS)	LOSAT, DELTA STAR
HAWKEYE/NPE	SKYLAB	MIDGETMAN
HEAO	SKYNET	MINUTEMAN I,II,III
HELIOS	SMS	PEACEKEEPER
IMP	TAURUS	PERSHING I,II
INTELSAT	TDRS	POLARIS, POSEIDON
LANDSAT	TIROS	SCOUT
LUNAR SOUNDER	TOS	TITAN 2,3C,34D,4
MAGELLAN	ULYSSES	TRIDENT I,II
MARINER	VENUS-MERCURY	**FOREIGN**
MARINER MARS	VIKING	
MARS OBSERVER	VOYAGER	ARIANE
	WESTAR	UK POLARIS

MISSIONS

figure 3

Improvements and Modernization

Periodically, mission requirements evolved that could not be met with existing ARIA instrumentation, necessitating modification to the basic electronic systems. Between 1976 and the present day, several modifications have been implemented, increasing the overall ARIA capability to support a wide variety of missile and space operations. These modifications have allowed support of research and development testing in the Air Force and Navy cruise missile programs, the Navy's Trident program, the Army's Airborne Bistatic Receiver program, and other missile operations involving frequencies and support requirements not normally encountered. During the ALCM program, for example, the ARIA was designated as the prime data link between the missile and the ground stations. In order to accommodate this tasking, modifications were made that provided a more accurate timing capability including three L-band transmitters; a remote command and control system for ARIA control of the missile during special tests; and displays in the cockpit to provide the pilot with aircraft ground speed, and the navigator with direction and distance from the ARIA to the missile.

Modification has also included conversion to different airframe models. In 1979, the entire Prime Electronic Equipment Subsystem was removed from two of the EC-135N aircraft and reinstalled into a C-135B aircraft already modified with the nose radome. The second B Model was operational by 1980. The newly designated aircraft, EC-135B, equipped with fanjet engines, gave the ARIA increased performance, longer time on station and reduced operating cost. The 1980 ARIA baseline fleet consisted of six EC-135N models with J-57 engines, three of which contained the standard ARIA configuration plus special ALCM equipment; and two EC-135B models with standard ARIA configuration, equipped with the TF-33 turbofan engine, providing extended range and improved aircraft performance.

IN MEMORY

"In Memory"

Twenty-one have died
No more to know
A loved ones kiss
A sunset's glow -

A robin's song
A friendly smile,
The squeals of laughter
Of a happy child.

So in their memory
These trees shall grow
And for them bask
In sunset's glow -

Welcome the rain
The robin's song,
Proclaim our love
To the milling throng.

And as they bloom,
Their petals fall -
Each petal a loving
Memory recall.

Our twenty-one friends
Who now must be
Assured of our love
Through eternity.

By Violet Nauseef

On 6 May 1981, EC-135N (61-0328), departed Wright-Patterson AFB, Ohio at 10:05 AM on a routine training mission. The mission was designed to provide training for the navigator and the primary mission electronic equipment (PMEE) operators. The planned route of flight was eastbound to a point near Sea Isle, New Jersey; then westbound to Charleston, West Virginia. This portion of the mission, scheduled for approximately two hours, was for a navigation leg and calibration time for the PMEE operators. At this point, the plan was to delay in the Charleston area to practice timing orbits and to gather telemetry data, and then return to Wright-Patterson. Total mission duration was planned for approximately five hours.

On board the aircraft were 17 crew members and 4 authorized passengers. Among the passengers were two spouses, Peggy Emilio, wife of Capt Joseph Emilio, the aircraft commander; and Linda Fonke, wife of Capt Donald Fonke, one the aircraft navigators. The two women were participating in the HAVE PARTNER Spouse Orientation Program, a voluntary program, whereby the spouses fly regularly scheduled proficiency training flights to increase their understanding of the mission of the USAF and the 4950th Test Wing. By increasing the spouse's familiarity with the member's work, the Air Force hoped to promote retention of military aircrew members.

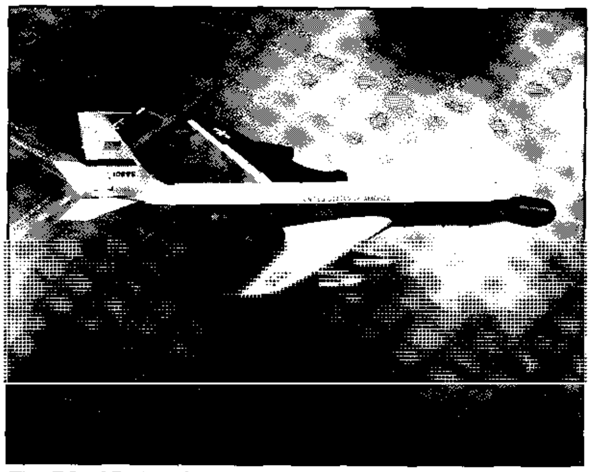
After tracking the flight for approximately 45 minutes, the Federal Aviation Administration, at 10:49 AM, lost radar contact with the EC-135N. The aircraft was cruising at 29,000 feet at approximately 530 miles per hour, while performing the navigation leg. The aircraft commander, Capt Joseph Emilio occupied the right seat, and his wife, Mrs Peggy Emilio, occupied the left seat. Also in the cockpit were the two navigators, Lt Col Benjamin Frederick and Capt Donald Fonke, and two passengers, Mrs Linda Fonke and SSgt Joseph Brundige.

For undetermined reasons, the aircraft pitch trim moved to the full nose-down position. The aircraft then rapidly pitched over, most likely upon release of the autopilot, and induced sufficient negative forces to cause the generators to trip off line, resulting in the loss of all aircraft electrical power. The pitch trim could not then be moved electrically. This condition, while unusual, could have been corrected if action had been taken in the first eight seconds. After that, the aircraft pitch angle would exceed 30 degrees nose-down, and the airspeed, 350 knots, thus preventing control of the aircraft until the pitch trim was moved toward neutral. Without apparent corrective action, the EC-135N became uncontrollable and entered a steep descent. During the rapid descent, an explosion occurred at approximately 1300 feet above ground level, followed immediately by catastrophic failure and complete break-up of the aircraft. The aircraft impacted at a site 1.7 nautical miles north-northeast of Walkersville, Maryland. All 21 aboard perished in the crash.

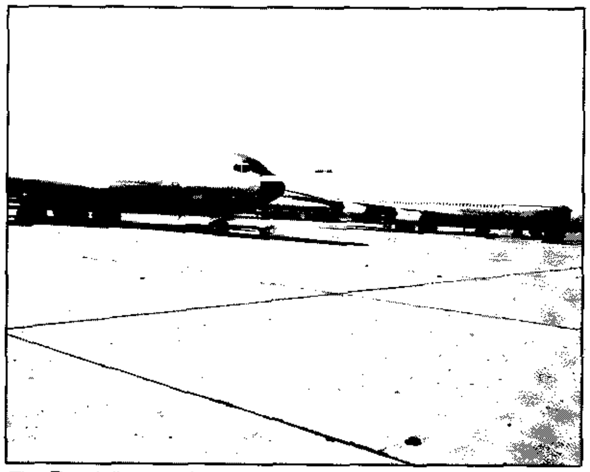
On 17 July 1981, the base paid a final tribute to the deceased. At the memorial service, the Officers Wives Club presented 21 trees, planted in the Memorial Park at the Air Force Museum, as a living remembrance to the loved ones lost:

Capt Thomas E. Bayliss
SSgt Joseph T.Brundige, Jr.
SSgt Michael W. Darling
SSgt Douglas A. Dibley
Maj Joseph C. Emilio
Mrs Peggy A. Emilio
Capt Donald V. Fonke
Mrs Linda M. Fonke
Lt Col Benjamin B. Frederick
lLt Charles E. Gratch
SSgt Timothy L. Harris
SSgt George M. Henninger
TSgt Gregory C. Hodge
2Lt Clayton F. Jones
Capt Walter T. Lusk
CMSgt Larry D. Middleton
A1C Randall C. Moffett
SMSgt Eddie W. Presley
SSgt Glenn S. Resides, Jr.
Mr Michael W. Riley
TSgt Larry G. Wetzel

— Taken from "The Report", Dayton Daily News, 6 September 1981; 4950th Test Wing Staff Digest, 3 June 1981; and Dedication Program, 17 July 1981.



The EC-18B aircraft provided the ARIA fleet with greater range and more cargo capacity. During conversion, one wing was painted black to prevent glare to the optical sensors.



The Test Wing purchased eight 707/320/C/CF aircraft from American Airlines in fiscal year 1982.

During 1984, the American C-18 aircraft were modified into EC-18Bs.

Beginning in 1982, the Test Wing upgraded the older ARIA aircraft. Six of the seven EC-135N were scheduled for refit with JT-3D engines, as well as other minor improvements in their flight systems. The JT-3D offered a more powerful, fuel-efficient operation, giving the ARIA approximately 15-20 percent greater range. The reverse thrust capability allowed aircrews to land and take off on shorter runways. The new engine also eliminated the need for water injection take-offs. Previous requirements added 670 gallons of water weight to the aircraft and created black smoke which gave the appearance of environmental pollution. In addition, the upgrade program included installation of a five-rotor modulated; an anti-skid braking system; an improved yaw damper; and a larger horizontal stabilizer, the type normally used on a commercial Boeing 707.

Meanwhile, early in fiscal year 1981, the Air Force announced plans to replace the EC-135N aircraft with seven Boeing 707-320C/CF commercial freighters equipped with JT3D-3B engines. Six of these were to replace the seven remaining EC-135N aircraft, while the seventh was to become a general purpose aircraft for the 4950th Test Wing. The 707s were to have greater range and cargo capacity. The Test Wing actually purchased eight 707-320C/CF aircraft from American Airlines during fiscal year 1982. Six of the aircraft, designated C-18, replaced its seven EC-135N ARIAs. The seventh C-18 aircraft was for general purpose, and the eighth was to be utilized for the Army. The aircraft provided the ARIA fleet with greater range and more cargo capacity, allowing for more equipment to be carried. The Test Wing received the first new aircraft on 1 February 1982.

During 1984, the newly procured aircraft, a mixture of cargo convertible and freighter configurations, were modified into EC-18s by the Test Wing, one at a time, so that the ARIA fleet could continue its full mission support. The Test Wing predicted a final fleet of six EC-18Bs and two EC-135Es. The EC-135E did not use as much fuel as the EC-18B, thereby adding flight time to some missions. In addition, the EC-135E had been modified to support cruise missile testing, with three needed for the project. In the meantime, the Air Force had also been directed to equip the ARIAs with a system of tracking reentry vehicles. This necessitated launching an array of sonobuoys to locate the missile impact, a task only capable by the EC-18B. Based on this projected workload, the Test Wing proceeded with configuring a fleet of four EC-18Bs and three EC-135Es (see Figure 4 for current configuration). In modifying the C-18 into an EC-18B, Test Wing personnel redesigned the C-18A cockpit including the lighting, instruments, and electronics; developed flight manuals; determined operational procedures; verified technical orders; and established requirements for logistical support. They

ARIA FLEET
CONFIGURATION

THE ARIA FLEET CURRENTLY CONSISTS OF FOUR EC-135E AIRCRAFT AND THREE EC-18B AIRCRAFT. TWO EC-18B ADVANCED CMMCA AIRCRAFT ARE BEING DEVELOPED AND ARE CURRENTLY IN SYSTEMS FLIGHT TESTING. THE FLEET CONFIGURATION IS SUMMARIZED AS FOLLOWS:

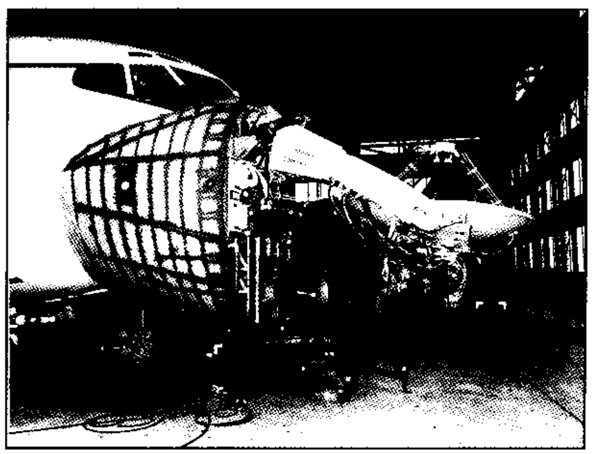
AIRCRAFT	TELEMETERY	SMILS/ OPTICS/MET	PHASE ZERO CMMCA CAPABLE	ARIA HORN ANTENNA
EC-135E/326	YES	NO	YES	NO
EC-135E/329	YES	NO	YES	NO
EC-135E/330	YES	NO	NO	NO
EC-135E/374	YES	NO	YES	NO
EC-18B/0891	YES	NO	NO	NO
EC-18B/0892	YES	YES	NO	YES
EC-18B/0894	YES	YES	NO	NO
EC-18D/0893	YES-ADV. CMMCA	NO	NO	NO
EC-18D/0895	YES-ADV. CMMCA	NO	NO	NO

CONFIG

figure 4

also had to remove electronic equipment from the EC-135s, no longer a part of the ARIA fleet, for installation on the C-18s. Rollout of the first aircraft was scheduled for January 1985. The first flight of the first EC-18B (81-0891) occurred on 27 February 1985. This flight marked the beginning of a 120-hour test program from which performance manuals were derived. For its first mission, the aircraft deployed to Kenya to support a National Aeronautics and Space Administration mission in January 1986.

The first flight of the EC-18B occurred on 27 February 1985.



The EC-18B ARIA's large bulbous nose housed the world's largest airborne steerable antenna.

To meet the directive to track reentry vehicles, the Test Wing released a draft Request for Proposal for the sonobuoy missile impact location system (SMILS) in May 1984. In addition to the continued capability of tracking signals from the reentry vehicle, the ARIA fleet would use SMILS to acquire, and process sonobuoy missile impact data in order to score reentry vehicle impacts over broad areas of ocean. These two functions, previously split between the ARIA EC-135 and the Navy's P-3 aircraft, would now be accomplished together, and more economically, by the EC-18. Impact locations of multiple entry bodies would be precisely determined by SMILS using either deep ocean transponders or Global Positioning Satellites. Associated ARIA systems would collect optical data on reentry vehicles during the terminal phases of flight and sample meteorological parameters from the surface to 80,000 feet. The SMILS contract was awarded to E-Systems during February 1985. The development of prototype meteorological sondes was initiated with size, weight, and capabilities defined during 1985 (See Figure 5).

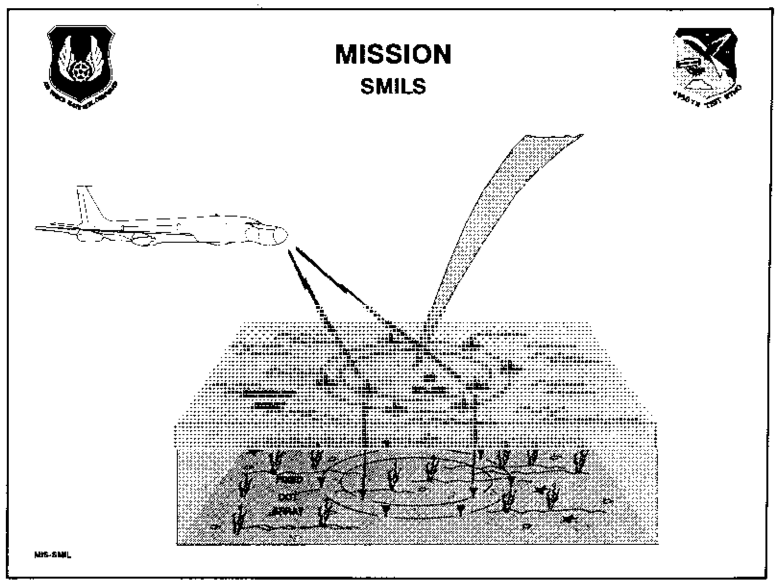
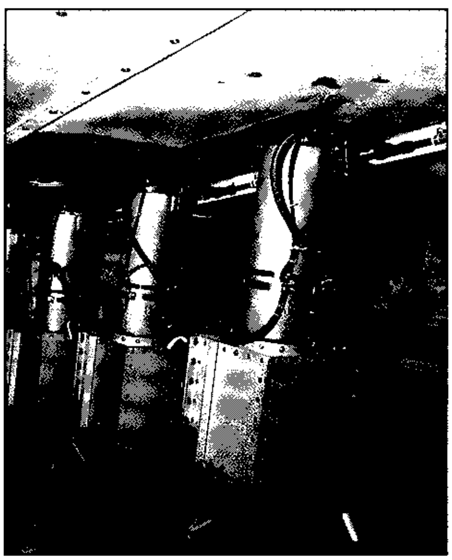


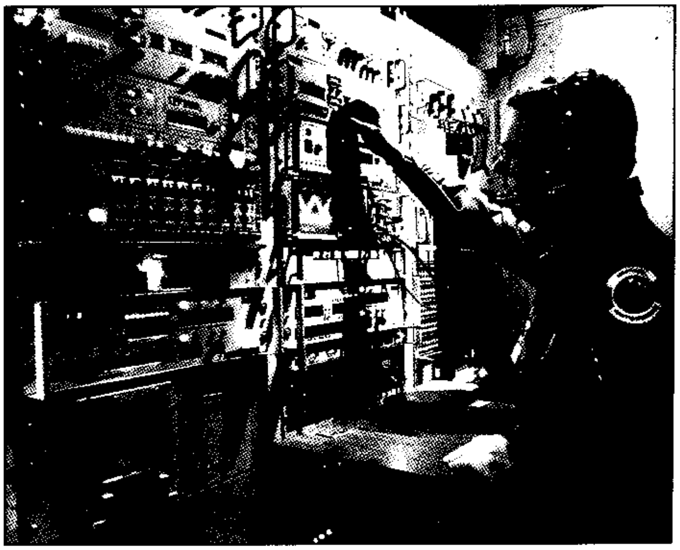
figure 5


The SMILS would consist of air-deployable sonobuoys positioned in launch tubes, exiting out of the underbelly of the aircraft.

Pegasus, the EC-18A (81-0896) was the test bed for the SMILS/Optics System.

The Test Wing assumed management of the SMILS program from the Western Space and Missile Center in January 1986. The Test Wing, the Applied Physics Laboratory, and E-Systems continued SMILS development throughout the year. The SMILS would consist of air-deployable sonobuoys, sonobuoy launch tubes, airborne electronic equipment, and a ground data processing station. A typical mission would involve cruising to the target area, descending to sonobuoy pattern laying altitude, launching the sonobuoys, and then retreating to a test support area for receiving and recording radio frequency signals from the sonobuoys. Right at the end of 1986, the Office of the Secretary of Defense, during budget formulation, cancelled the requirement for SMILS

Missions



Electronic equipment aboard the EC-18B ARIA receives, processes, and records telemetry data needed to support worldwide NASA and Department of Defense missions.

Typical support of an orbital mission launched from the Eastern Space and Missile Center, formerly the Air Force Eastern Test Range, required staging the ARIA from Ascension Island in the southern Atlantic Ocean. Generally three days prior to the scheduled mission, the ARIA would depart Wright-Patterson AFB, Ohio, and arrive on Ascension Island approximately 12 hours later, via a route stop at either Roosevelt Roads Naval Air Station, Puerto Rico, or Barbados, West Indies. On mission day, the ARIA would depart Ascension Island with the maximum allowable fuel load and arrive at a pre-planned test support position just prior to the scheduled spacecraft launch time. Once airborne, the ARIA maintained continuous high frequency communications with the mission planner and test operations controller, located at the control center at Wright-Patterson. Data was gathered from the orbital trajectory vehicle over its travel of approximately 2,000 miles. As the spacecraft flew over the horizon, the ARIA flew perpendicular to the ground track of the spacecraft and received its signal until it disappeared over the opposite horizon. After returning to Wright-Patterson AFB, the recorded data was processed and distributed for analysis. Subsequent orbital tracking missions have required staging the ARIA out of Hickam AFB, Hawaii (See Figure 6).

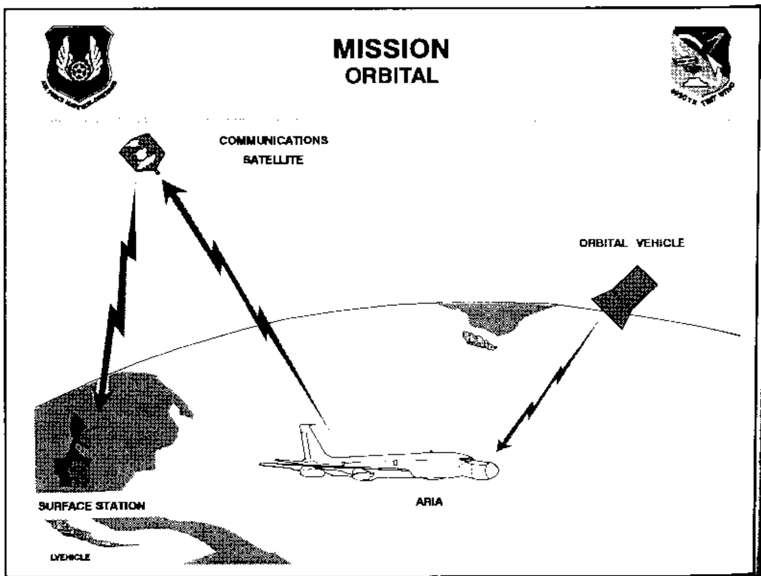


figure 6

ARIA SUPPORTS SPACELAB 1

The penning of another chapter in aviation and space history began at the Kennedy Space Center on Monday with the 11:00 AM blast off of Space Shuttle Nine, carrying Spacelab 1, a billion-dollar scientific laboratory...

On Monday, 28 November 1983, one of the Test Wing's ARIA aircraft was used to support the launching of Spacelab 1 aboard Space Shuttle Nine. The launch was the first with an European aboard, marking the first time that a non-astronaut had flown in space in the US program. The ARIA orbited about 100 miles from the launch site where the flight crew received and recorded radio signals from one of the two solid rocket boosters for post flight engineering analysis by NASA personnel.

"Monday's ARIA mission went like clockwork," reported Major John W. Jamison, the aircraft commander. Although the launch took place at 11:00 AM, the day began before 7:00 AM for the ARIA crew at Wright-Patterson. After the usual briefings and weather checks, the crew boarded the aircraft at 8:00 AM for preflight, instrument checks, and a final mission briefing. With a 9:00 AM take-off planned, the crew began its taxi roll at 8:41, its take-off roll at 8:59, and was off the ground at 9:00 sharp. Instrumentation technicians checked and synchronized their stations thoroughly during the early part of the flight to a point off the Florida coast. When the final minutes of the shuttle countdown began, they were ready. At lift-off, they simultaneously began collecting, separating, and recording signals being emitted from the booster rocket.

A1C John Nakos leans back to relax and reflect following the critical moments of a successful ARIA mission in support of a Space Shuttle launch carrying Spacelab 1.

The flight crew in the cockpit had a spectacular view of the shuttle rocket "burn" as it propelled the spacecraft up over the horizon, arcing eastward near their aircraft. They watched as the boosters separated and descended nearby to splash into the ocean where ships stood by to retrieve them. Once the solid rocket boosters hit the water, the ARIA flew directly to the Kennedy Space Center and delivered their tape recorded data to the NASA engineers.

— Taken from article by Gene Hollingsworth, "4950th Test wing Supports Spacelab 1 Launch," ASD/PA News Release, PAM #83-206, 30 November 1983.

Typical support of an reentry mission launched from the Western Space and Missile Center (WSMC) at Vandenberg AFB, California, involved staging the ARIA from Anderson AFB, Guam. Leaving five days prior, and traveling 18 hours, the ARIA then flew to a test support position in the vicinity of Kwajalein Island, with approximately 125,000 pounds of fuel for a planned maximum flight of nine hours. During reentry missions, the position of the aircraft was critical due to the antenna tracking and steering limitations, and the close proximity of the aircraft to the impact point. Data acquisition was normally executed during the first three minutes of the reentry vehicle's flight, and required antenna tracking from the edge of space to impact. To avoid multipath reception of the data transmitting frequencies, caused by signals reflected from the ocean's surface, it was necessary for ARIA to fly at low altitudes, usually 15,000-20,000 feet, during the actual support phase. The data was again processed and distributed after return to Wright-Patterson AFB (see Figure 7).

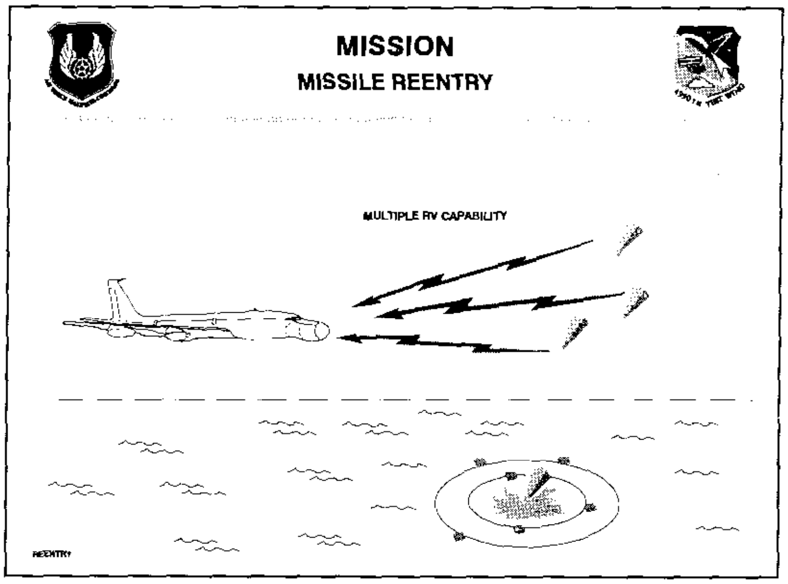
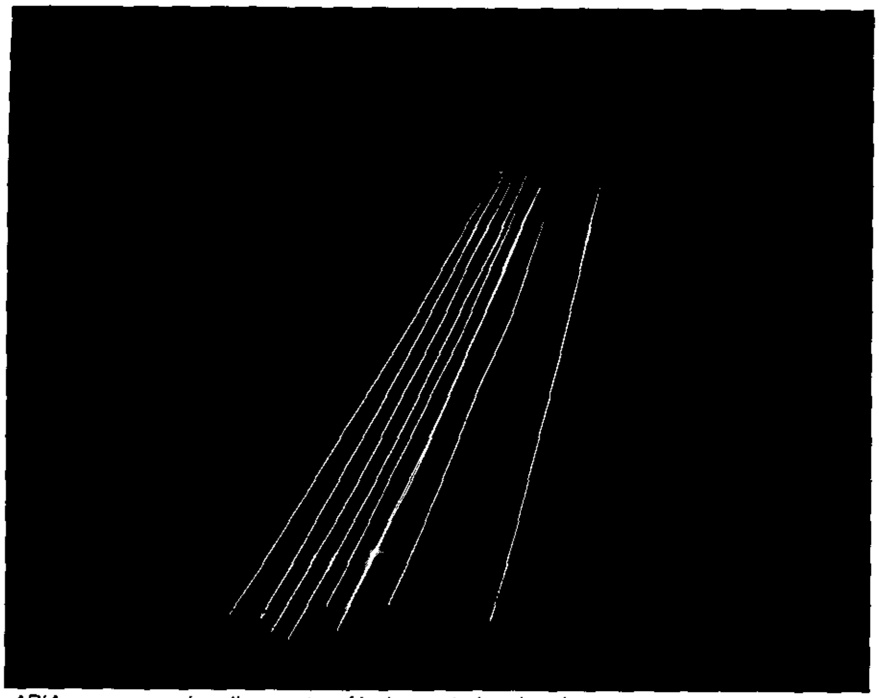


figure 7



ARIA cameras capture the reentry of instrumented warheads.

Support of the cruise missile mission was somewhat different than orbital or ballistic missile tracking. The mission involved continuous automatic monitoring (occasionally assuming the role of command and control) for more than five hours, tracking a vehicle that flew below the aircraft, and relaying real-time data directly to ground stations, while maintaining voice communication between mission aircraft and mission control through remote ground stations. The ARIA would deploy to Edwards AFB, California, several days prior to the ALCM launch. The B-52 launch aircraft would depart one hour prior to the ARIA takeoff. The ARIA would then join the B-52 and acquire telemetry from the cruise missile beginning approximately launch minus 90 minutes. At the launch point, mission control would use the ARIA telemetry data to evaluate the missile's status. After the launch, the ARIA would continue to receive and relay data from the missile, and UHF voice communication from the chase plane to mission control, via high frequency radio to an ARIA coordinator, until termination of the mission. During special tests, the ARIA supplied the remote command and control/flight termination signal to the missile. During those tests, a second ARIA was used in order to insure that the missile was tracked within the RCC/FTS antenna beamwidth (See Figure 8).

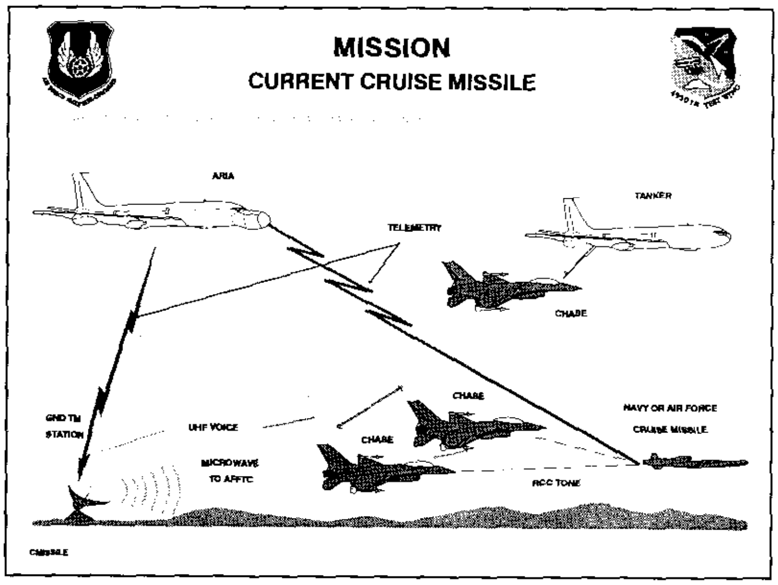


figure 8

AMRAAM look-down/shoot-down testing in late 1986 and early 1987 illustrated the ways in which an ARIA aircraft could be used. In the first test, the ARIA flew at an altitude of 20,000 feet mean sea level offset to the left and behind the shooter by 15-20 miles. The shooter and QF-100 target drone were both below 5,000 feet mean sea level. The ARIA collected the telemetry data starting with the shooter versus the target and finishing with the AMRAAM versus the target. The test itself went well, but the ARIA recorded multipath signals, making reduction of the data difficult. To prevent this problem on future missions, the ARIA was moved farther behind the shooter as well as to a lower altitude to prevent recording of multipath signals bouncing off the water. The new position kept ARIA safe from a wayward AMRAAM while it collected the necessary telemetry data without multipath. Subsequently, two ARIA's went to Eglin AFB to track two AMRAAM's ripple-fired against multiple targets. The live test, conducted in February 1987, proved successful. Both ARIA's acquired and retransmitted telemetry data on both missiles from launch until intercept. These developmental test and evaluation flights however, continued to present the Wing with telemetry multipath problems. The Wing learned that a characteristic of the missile antenna prevented acquisition of data unless the missile was aimed directly at the ARIA. Not wanting any of its aircraft shot down, the Test Wing sought a way to collect the telemetry data without placing the ARIA in the path of the missile. Tests in June 1987 examined new flight profiles and mission equipment changes that would allow successful tracking and data collection.

During 1988, ARIA continued to support a variety of missions including Titan II, Titan 34D, Pershing II, the Space Shuttle, the Defense Meteorological Satellite Program, the National Oceanographic and Atmospheric Association, the Global Positioning Satellite Scout, the Air-launched Cruise Missile, the Sea-launched Cruise Missile, the Advanced Cruise Missile, Trident I and II, the Poseidon and Delta Missions. Support of cruise missile testing included tracking of a live launch in April 1988.

During 1989, the ARIA, in addition to similar missions performed in 1988, supported the Arcane, Delta, and Delta II missions. In the fall of 1989, two ARIA aircraft participated in the last military Atlas-Centaur launch which boosted a fleet communications satellite into orbit. Another mission involved the Atlantis Shuttle launch of the spacecraft Magellan. Magellan's mission was to map the planet Venus in 1990. Three ARIA deployed to an airborne location where the steerable dish antennas tracked the launch and relayed trajectory data to NASA. This data allowed NASA to make the necessary course adjustments using small rockets aboard Magellan to ensure the right speed, position, and direction on its course to Venus. ARIA crews also participated in the launch of NASA's Galileo spacecraft in October 1989. Launched from the Shuttle Atlantis, Galileo's mission was to orbit Jupiter and drop an exploratory probe. Scientists, who believed that Jupiter had remained in the same state as when it was formed billions of years ago, wanted to study its surface and magnetic properties, as well as its satellites. Again, ARIA data helped NASA guide Galileo to its destination. In November 1989, an ARIA aircraft supported the Delta rocket launch of NASA's cosmic background explorer. Nasa planned to use the satellite to measure the background microwave radiation remaining after the creation of the universe. This was the first of five satellites to be launched over the next decade.

In 1990 and again in 1991, the ARIA aircraft supported the launch of the Pegasus, the experimental winged rocket designed to carry military payloads into earth orbit. The ARIA tracked the rocket's twelve-minute, three-stage launch from the right wing of a NASA B-52 based at Edwards AFB, California, recording telemetry data as Pegasus ascended to 43,000 feet, and traveled 11,000 miles down range to release its 422-pound payload. Data included distance, speed, external and internal pressures on the rocket, booster ignition, and satellite deployment; and in 1991, information verifying the first of two ignitions by a new hydrazine auxiliary propulsion system.

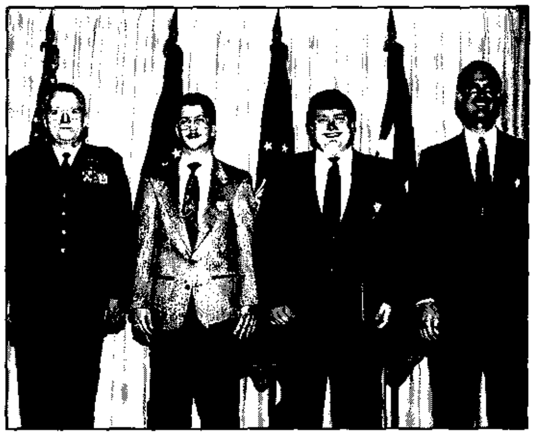
During 1990, the ARIA continued its support of cruise missile testing. In May, an ARIA served as mission control, providing the sole source of remote command and control of an Air Launched Cruise Missile during a follow-on operational test and evaluation free flight. In March and October 1990, ARIA supported two NASA Space Shuttle missions. The first was the launch of a DoD payload from the Atlantis, in which mission delays required multiple day coverage. The second mission was support of the launch of Ulysses, the $300 million European Space Agency probe intended for space exploration near Jupiter and the Sun. Deploying near Mombasa, Kenya, and near Fiji, the crews tracked the inertial upper stage of the Ulysses after its deployment from the Space Shuttle Discovery. For 15 minutes the crews tracked Ulysses, and in real-time, transmitted flight trajectory telemetry data using software developed by ARIA computer experts. The Air Force Consolidated Space Test Center interpreted the data to ensure that Ulysses remained on course.

During 1991, the ARIA continued its support of tracking the Air Force and Navy cruise missile test program including, in February 1991, a joint Canadian Air Force-US Air Force cruise missile test. Also in 1991, ARIA participated in the Defense Meteorological Satellite Program, and the planning for Peacekeeper missions. In April 1991, the ARIA aircraft supported the first successful launch of the small intercontinental ballistic missile by providing telemetry, meteorological, and SMILS support.

RESCUE OF THE LAHELA K

The two people aboard the Lahela K had been missing for over a week. Rescue teams had searched over 80,000 square nautical miles without success, when an ARIA, in transit to Wake Island, detected a weak distress call...

The aircrews aboard the ARIA aircraft, call sign AGAR 21 and AGAR 27, were outbound from Hickam AFB, Hawaii, in support of a Command-directed test over Wake Island on 26 August 1992. As the task force was departing Hickam, the aircrews were alerted by the Coast Guard to an ongoing search and rescue effort for the surface vessel "Lahela K", that had been missing since 17 August. The boat had been transmitting distress calls on channel 23 of a citizen's band radio, reaching ham radio operators as far away as the Marshall Islands. The two people on board had been without food and water for several days. The Coast Guard, Navy, and Army had extensively searched over 80,000 square nautical miles looking for the vessel.



Three civilians (in order left to right), Mr Christopher D. Lesniak, Mission Commander of AGAR 21; Mr Dwayne E. Reeves, Mission Specialist and Program Manager on AGAR 21; and Mr Ronald C. Stogdill, Mission Commander of AGAR 27 are awarded the Command Civilian Award for Valor by Lieutenant General Fain, Commander of Aeronautical Systems Center.

While in transit to Wake Island, the aircrews detected a weak, intermittent distress call from the lost boat. Responding immediately to the call, the crews initiated a search effort which entailed flying a grid pattern, with the navigator mapping the strength of the distress calls. This narrowed the search area down to a 1,000 square nautical mile area. In communication with the boat, AGAR 27 instructed her to fire a flare. After two flares were fired without making visual contact, both aircraft coordinated and executed independent search patterns at low altitude for over five hours.

Unsuccessful in their search, the crews devised a plan to utilize the cross-dipole antenna mounted on the seven-foot steerable telemetry antenna in the nose of the aircraft. Making the decision to change the aircraft's precise mission configuration in order to accommodate the rescue effort, both Mission Commanders led their crews in developing an electronic configuration modification real-time, taking only hours to accomplish what normally took many days. They continued working until they developed an effective method of homing in on the distress calls. The signals from the ARIA's antenna were routed directly to the HF radios tuned into the citizen's band channel 23. While sweeping the antenna on AGAR 27 left to right, the Mission Commander monitored a signal strength meter and assisted the antenna operator in determining the origin of the Mayday calls. The crew then computed the heading and vectored the aircraft. After two passes, the survivors aboard the boat spotted AGAR 27 and fired a flare, later exclaiming "it was the most beautiful aircraft they had ever seen." AGAR 27 then radioed the vessel's coordinates to the primary rescue forces. Both of the aircraft then circled over the lost vessel until help arrived.

Of the many accomplishments one is capable of achieving in a lifetime, none can compare with saving the life of another human being. General Yates, Commander of Air Force Materiel Command, in recognizing this heroic effort, stated, "to be involved with saving human life is reason enough for recognizing the efforts of the crews; however, the ingenious way in which this event was accomplished deserves special accolade." By capitalizing on the ARIA's high tech systems in unconventional configurations, the crews not only demonstrated their ability to adapt to high-demand, short-notice taskings, but their willingness to apply their knowledge for the sake of others.

A noteworthy accomplishment for 1992 was the ARIA support for the NASA Mars Observer spacecraft. The September 1992 launch of the spacecraft to Mars was the first for NASA since Project Viking in 1975. The Test Wing, providing 125 people to support this mission, sent five ARIA's to three different locations: Dakar, Senegal; Harare, Zimbabwe; and the independent island state of Mauritius in the Indian Ocean. The deployment required five operating locations and ten overflight clearances. Flying a total of 24 sorties in 189.3 hours, the ARIA provided telemetry coverage for the Mars Observer launch and served as an airborne tracking station over land and ocean areas where tracking stations either did not exist or had limited capability. One ARIA, with a back-up, operating out of Dakar, received telemetry over the middle of the Atlantic Ocean when the Titan deployed the Transfer Orbital Stage (TOS), and retransmitted to Cape Canaveral via satellite. Meanwhile, the ARIA aircraft, stationed in Harare and Mautitius, waited for the initial TOS telemetry information in order to track the ignition and burn of the TOS. Because the TOS burn could occur anywhere over an expanse of 1,600 miles, ranging from the Indian Ocean east of Madagascar to South Africa, the initial information was crucial in establishing subsequent ARIA mission support points. The secondary telemetry information, in turn, was vital in aiding the engineers at Cape Canaveral in locating the spacecraft after it left Earth's orbit. Events did not proceed as planned. Although three ARIA crews observed the second stage's separation, and a bright orange flash consistent with ignition and burning of the spacecraft, they did not receive any telemetry data because the spacecraft's TOS transmitter malfunctioned. Fortunately, the next land station, located at Canberra, Australia, received transmissions from the Mars Observer showing a correct orbit path.

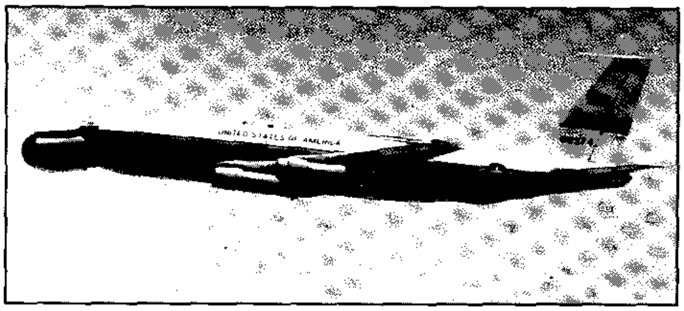
The following crew members contributed to this effort:

AGAR-21 (61-0326)	AGAR-27 (60-0374)
Lt Col Mark Nelson	Maj Kevin Calt
Lt Col Dave Ross	Maj Phill Collins
Capt Dave Meador	Capt Marvin Blankenship
Capt Vince Orlando	Capt Jules Hoehn
Capt Lou Volchansky	Capt Frank Albanese
Capt John Hambel	SMSgt Larry Lowe
2Lt Chris Miller	MSgt Charles Haschke
MSgt Bill Fessler	MSgt Bill Ringle
MSgt Jerome Klark	TSgt Van Adams
MSgt Allen Riek	TSgt Donald Bonesteel
TSgt William Lesuer	TSgt Larry Matts
SSgt Robert Barens	TSgt Guy Smith
SSgt Diane Dunlap	SSgt John Mackey
SSgt Dave Majors	SSgt Mark Rambis
SSgt Lester Pease	SSgt Larry Richardson
SSgt Richard Perez	SSgt Scott St. John
SSgt Steve Raines	SSgt Brian Wiedman
Sgt Christy VanCamp	SSgt Jim Woodruff
SRA Jeff Fuller	Sgt Tom Kimmet
SRA Robert Guere	SRA Oscar Moreno
Mr Chris Lesniak	Amn Marty Groves
Mr Dwayne Reeves	Mr Jack Henry
Mr Bob Schutte	Mr Mark Simpson
	Mr Cliff Stogdill

In March 1993, flying from Wake Island, an ARIA flew a Peacekeeper test mission, using for the first time, the ARIA horn antenna. This antenna provided ARIA with increased flexibility in supporting multiple-instrumented reentry vehicle tests. During this mission the dish antenna collected data on two reeentry vehicles, and the horn antenna collected data on three reentry vehicles. The ARIA also recorded impact scoring data. The Test Wing scored the SMILS data tapes within three days, thereby demonstrating the speed of the ground-based processing system.

Cruise Missile Mission Control Aircraft

To originally meet the requirement to track and monitor cruise missiles, two EC-135E ARIA aircraft were modified into Cruise Missile Mission Control Aircraft (CMMCA), designated Phase 0. This program involved installing redundant real-time telemetry display systems and redundant remote command and control/flight termination systems (see Figure 8). The first CMMCA Phase 0 capable aircraft was successfully supporting cruise missile tests by January 1985. The second aircraft became operational in July 1986.


The CMMCA Phase 0 aircraft, EC-135E (60-0374), was successfully supporting cruise missile testing by January 1985.

To improve upon the mission of tracking cruise missiles, the CMMCA program identified two EC-18Bs (81-0893 and 81-0895) to be used for surveillance and tracking, remote command and control as well as telemetry display during cruise missile test flights of the Air Force's Air Launched Cruise Missile (ALCM) and the Navy's Tomahawk Cruise Missile. The aircraft, redesignated EC-18D, would have telemetry, radar surveillance and tracking, and mission control functions including remote command and control and flight termination systems (RCC/FTS) (See Figure 9). The Office of the Secretary of the Defense advocated this program but provided little money and no manpower to support it. Early in 1986, the Test Wing wrote a draft program management directive, and began a requirements study. On 15 May 1986, the Test Wing Commander; and ASD program office representatives of Airlift and Trainer Systems, Reconnaissance/Strike and Electronic Warfare Systems, and Strategic Systems met with the ASD Vice Commander. They decided that the Test Wing would continue the requirements study but no further work could be done until OSD assigned people to the program.


The first shorter radome, shown on EC-18D (81-0893), proved to have both aerodynamic and transmissivity problems. A corrected design will be completed and installed in 1994.

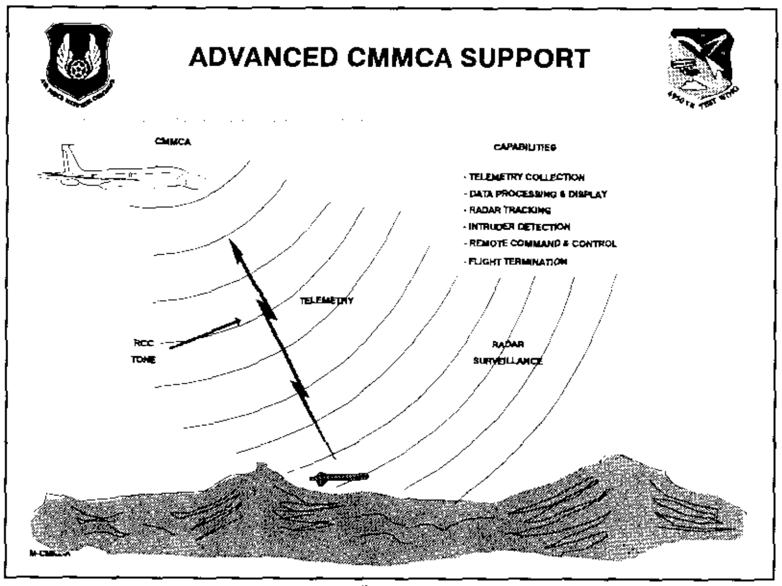


figure 9

Based on a recommendation from Calspan, the Hughes APG-63 radar was selected for the program. The planned modifications included installation of the APG-63 radar, as well as instrumentation for telemetry collection, processing, and display. The contract for modification was awarded to Electrospace Systems, Inc., in September 1988. Modification continued in 1989. By the beginning of 1990, the Test Wing's Aircraft Modification Center had installed military cockpits on both EC-18D test beds. The contractor, now called Chrysler Technology Airborne Systems (CTAS), had difficulty planning airworthiness and structural flight tests. In early 1990, CTAS hired a civilian flight test engineer to assist. After an acceptable flight test plan was submitted in August, the Test Wing convened a Safety Review Board in September. After reconvening in October, the board reviewed aircraft ownership and accountability, accelerometer thresholds, fuel flow indicator calibration, and acoustic measurements. The board resolved all safety and technical issues by 15 October.

On 22 October, the Wing Commander approved the test program. Flight testing began in November 1990. The Test Wing completed high speed taxi, handling qualities, and pitot-static tests, but delays resulting from aircraft pressurization problems and suspected poor or contaminated JP-4 fuel, pushed the remaining tests into January 1991. In 1991, flight testing continued, although flow separation from the nose radome caused a strong buffet against the bottom of the aircraft. The contractor tried using vortex generators mounted on the radome to stop the buffet, but that did not work. By December, CTAS had redesigned the radome.

Integrated flight tests began in January 1992. Although the first two flight tests validating test procedures were successful, problems with virtually every major system on the aircraft led to additional test flights. The telemetry processing system worked fairly well, but it had problems updating from the Global Positioning System. The overall unsatisfactory status of the aircraft led the System Program Office to suspend testing until the contractor corrected the system discrepancies. By June, the System Program Office and the contractor had agreed to a contract modification to accommodate the problems. Upcoming events included the airworthiness evaluation and testing of the new radome. Following the aero-evaluation, systems flight testing would be completed in its entirety for both aircraft. Anticipated delivery of both CMMCAs was expected for November 1993.

Improved Radar Capability

Radar remained the primary long-range search sensor for targets in space, in the air, on land and on the surface of the sea. It was also used for mapping and navigation, and for the guidance of interceptors, missiles, and other weapons. During the late 1970's, the Test Wing flight tested components of two state-of-the-art all-weather radars onboard a NC-141 aircraft. The NC-141 (61-2777) carried a complete radar system called Integrated Multi-Frequency Radar, an operational camouflage-penetrating radar developed by the Air Force Avionics Laboratory, and parts of the Synthetic Aperture Precision Processor High Reliabililty AN/APD-10 radar system. In 1979, the Test Wing utilized the same test bed to conduct a flight test program on the Tactical Bistatic Radar Demonstration, to explore the feasibility of using airborne bistatic synthetic aperture radar to detect and locate tactical targets on the ground.

The NC-141 (61-2777) carried the IMFRAD equipment (shown on the right interior side), and the SAPPHIRE processor (shown on the left interior side).

Integrated Multi-Frequency Radar

Began in 1969, under joint development with the Air Force Cambridge Research Laboratory, the Naval Research Laboratory, and Control Data Corporation, the Integrated Multi-frequency Radar (IMFRAD) was a new, wide-angle, multi-frequency synthetic aperture radar that could see through dense foliage to seek out tactical targets. The system differed radically from conventional radars in that it used a simple antenna to transmit and receive low-power pulses on a number of frequencies along the flight path of the aircraft. IMFRAD's unique capabilities were made possible due to the unusually long radar wavelengths at which it operated. These wavelengths provided a natural filtering effect that rejected echoes from very small objects, but permitted penetration of foliage cover. This natural filtering permitted effective reconnaissance at reduced data rates, leading to lighter-weight, comparatively low cost airborne equipment.

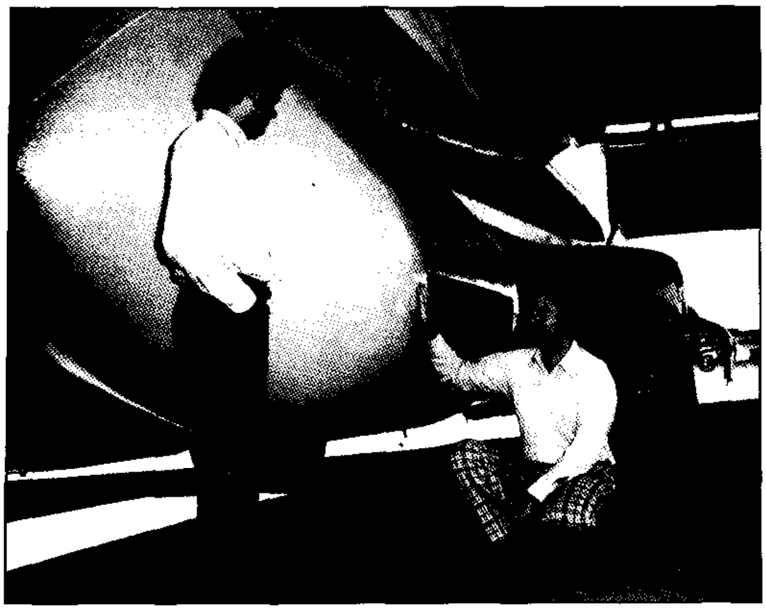
The IMFRAD was a new, wide-angle, multi-frequency synthetic aperture radar that could see through dense foliage to locate tactical targets.

Once operational, the IMFRAD had three independent frequencies for multiple-look processing of radar returns. The digital processing was displayed in real time on a color television-like screen for interpretation by the airborne radar operator. IMFRAD was capable of looking sideways as well as perpendicular to the flight path of the aircraft. Due to the specialized digital electronics in IMFRAD, an aircraft could fly a less-constrained flight path, even a zigzag course, and still make a digitized, repeated radar map of an area.

After major modification to the NC-141 test bed, the Test Wing flew the first IMFRAD flight test, in a single antenna configuration, in September 1976. The installation of the low and intermediate frequency antennas was completed as scheduled in September and October 1977. Airworthiness flights continued during December 1977, with the final flight flown in early 1978. Optimization test flights began in 1978 with missions flown over Wright-Patterson AFB, Ohio; Jefferson Proving Ground, Indiana; and in jungle-type terrains in Florida in early 1979. The IMFRAD Program was completed in June 1979 after a successful deployment to Eglin AFB, Florida, in March. After demodification, the aircraft was scheduled to fly in support of another radar improvement program, the Tactical Bistatic Radar Demonstration.

Synthetic Aperture Precision Processor High Reliability Radar

The Synthetic Aperture Precision Processor High Reliability (SAPPHIRE) Radar Processor was a new digital radar processor for ground stations, developed under the joint effort of the Aeronautical Systems Division's Air Force Avionics Laboratory, and Goodyear Aerospace Corporation, in the early 1970's. SAPPHIRE was designed to make the radar interpreter's job easier by presenting the data more simply, while processing the information faster than traditional analogue displays. The SAPPHIRE equipment was smaller, lighter-weight and easier to maintain than previous radar processors. The SAPPHIRE-related electronics on board the NC-141 was a side-mounted, AN-APD-10 radar antenna, a pre-processor, and a 28-track tape recorder for automatic processing, that could store 20,000 bits of data per linear inch. After each flight, the SAPPHIRE ground unit would automatically process the tape into a television display, a continuous black and white strip picture, and a digital tape for historical records, all within minutes.



The side-mounted SAPPHIRE radar antenna on the NC-141 test bed gathered and transmitted data to a ground processor for analysis.

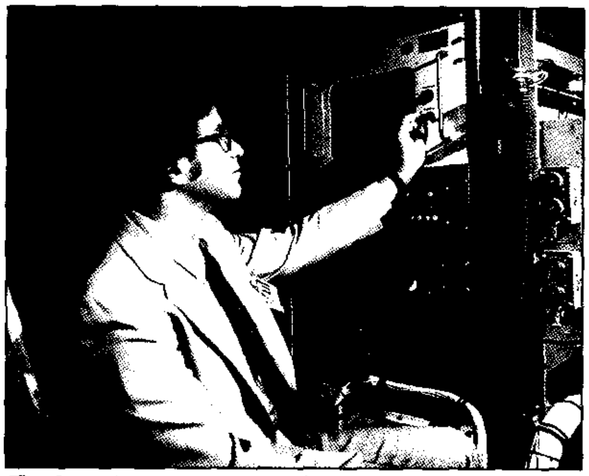
The Test Wing conducted the aerodynamic evaluation of the NC-141 test bed with the SAPPHIRE side-mounted radome during July and August 1975. During that time, delaminations of the radome were detected and repaired with the final flight test report prepared in late 1975. During 1976, the Test Wing continued testing of SAPPHIRE system optimization, flying 17 missions. During August 1977, SAPPHIRE digital data was collected for the Advanced Simulator and Pulse Doppler Map Match Programs. This data collection effort completed the SAPPHIRE Program as directed in the 1975 Test Plan. However, a new directive was received in November 1977, which extended the test program until September 1978.

After the completion of the equipment installation and the related checkout calibration, the Test Wing began flights to gather acceptance data over Gila Bend and Fort Huachuca, Arizona, in April and May 1978. Phase I of foliage investigation, as well as missions against simulated threats, followed in July and August 1978. After flying five missions, the Test Wing completed all data collection requirements and published the final report in November 1978. The aircraft was demodified in preparation of support of the Tactical Bistatic Radar Demonstration.

Tactical Bistatic Radar Demonstration

Beginning in 1979, the Tactical Bistatic Radar Demonstration (TBIRD) was an Air Force Wright Aeronautical Laboratories program to demonstrate the feasibility and utility of airborne bistatic synthetic aperture radar for detecting and locating tactical targets on the ground. A continuation of the program, designated TBIRD II, investigated in-flight image processing and system performance under ECM (electronic countermeasures) conditions.

The TBIRD flight test profile utilized several modes including wide bistatic angle, forward looking synthetic aperture radar (SAR) and moving target indication modes. The operational concept of bistatic technology was for a host aircraft to illuminate a target area with radar energy while an attack aircraft received and displayed the reflected radar energy from the target area. One advantage of the attack aircraft being in the "passive" mode was that, by not transmitting high-powered radio frequency signals, it did not reveal its location to radar-seeking missiles. The planned effort included utilization of an AN/APD-10 SAR in a NC-141A (61-2777) as the bistatic transmitter, and a modified AN/APD-10 SAR in a C-130 (55-0022) as the bistatic receiver.



The C-130 test bed carried the AN/APD-10 Synthetic Aperture Radar Bistatic receiver for the TBIRD program.

The Test Wing began the flight testing in the latter half of 1980. The necessity of maintaining specialized avionics equipment and the requirement for timely data reduction dictated that the flight testing be conducted in the vicinity of the Goodyear Aerospace Corporation facility in Arizona. Flight testing was completed in May 1981, with two out of the three original objectives completed: the forward looking SAR, and the wide bistatic angle SAR testing. The final report was released in November 1981.

TBIRD II was a continuation of the program which investigated the capabilities of the system to operate in the presence of electronic countermeasures (ECM), to demonstrate inflight real time SAR image processing, and to locate and track targets. Later called Bistatic Technology Transition (BTT), the program, like the TBIRD, used the NC-141A as the standoff transmitter and the C-130A as the tactical receiver. It operated in the three similar modes as TBIRD, forward looking SAR (FLSAR), wide bistatic angle (WBA), and moving target indication (MTI).

The Test Wing began testing during the first three months of 1983, flying missions with monostatic objectives to check the inertial navigation system accuracy and processor application. On 5 May 1983, the first-ever bistatic imaging was recorded. Between June and December, low clutter background tests were completed; the FLSAR and MTI modes and the inflight real time processing were demonstrated; and the ECM performance was evaluated. In 1984, both aircraft were slightly modified to allow accurate time/position tracking. The Test Wing continued testing at Davis-Monthan AFB, Arizona, to collect new imagery with circular polarization, demonstrating range doppler and monopulse targeting. After testing in Arizona, the test team deployed to North Island Naval Air Station, California to collect bistatic radar imagery on the Naval Order of Battle targets, (i.e., cruisers, aircraft carriers, freight ships, etc.). The imagery collected was used to persuade Navy officials to invest more resources in subsequent bistatic testing efforts. The flight testing was completed in September 1984.

Improved Avionics

Over the years, there have been continued efforts to improve other avionics capabilities. In the early 1970's, the Test Wing was responsible for testing a landing guidance system called the Microwave Landing System, designed to be a great improvement over the then used, Instrument Landing System. Also during this time, the Test Wing flight tested two Identification Friend or Foe systems, the Mark XII, and the Mark XV, intended to identify friendly aircraft. Later in the early 1980's, the Test Wing tested a defensive avionics system for the B-1B, the B-1 Tail Warning Capability, crafted to detect airborne threats approaching the rear of the aircraft.

Microwave Landing System

Conceived in the early 1970's, the Microwave Landing System (MLS) Program was a new type of precision approach, missed approach, departure, and landing guidance system that was designed to replace the dated Instrument Landing System (ILS). It provided the capability to fly high-angle approaches, curved approaches, and segmented approaches, thus reducing noise, and allowing precision approaches in areas of high terrain. The MLS was designed to send out signals that varied slightly in frequency for each degree or other unit of measurement away from a central point. Unlike the ILS that sent out single vertical and horizonal beams, the MLS sent out an almost infinite number of beams. Pictorially, the MLS could be seen as an ever-expanding screen or latticework in which the holes became tighter and more definitive as the aircraft approached the antennas. MLS could be accurate to within a few feet, even at ranges of several miles. The accuracy and flexibility were such that an aircraft could be routed through any path, around obstacles, over close-in hills, or around populated areas, to a landing.

In June 1978, the Test Wing was named the Responsible Test Organization (RTO) for the Air Force MLS Program. The purpose of the testing was to evaluate specialized equipment for Air Force use as part of the national MLS program managed by the Federal Aviation Administration. In May and June, the 4953rd Test Squadron received two Bendix modified T-39 aircraft equipped with area digital navigation systems (DNS) and digital flight control systems (DFCS). The aircraft were also equipped with the required receivers to use space position information from the Time Reference Scanning Beam Microwave Landing System (TRSB MLS). The next phase of the flight profile investigation was the Flight Analysis of Complex Trajectories. This phase investigated and determined the pilot factors, flight control, and display requirements to fly complex paths. Test flights were conducted at the Atlantic City Airport, New Jersey, staging out of Atlantic City or Teterboro Airport, New Jersey, if testing required being near the Bendix plant. This phase continued through August 1978.

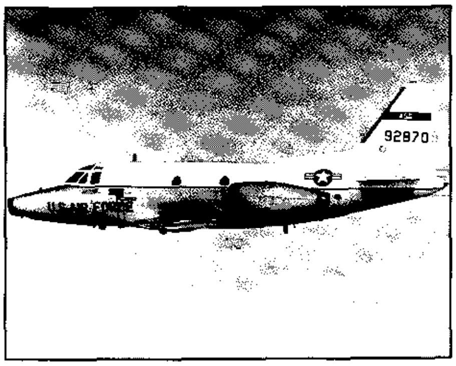
A promising major test program, the Air Force's MLS Program was terminated after Congress disapproved appropriations for further Air Force efforts. The T-39A (61-0649), instrumented for MLS, was transferred to the FAA as instrumented, for further testing. As of 1984, the Test Wing was named the RTO to conduct testing of the MLS for the FAA. The Air Force and the FAA provided funds to the Air Force Flight Dynamics Laboratory, who contracted with Lear Siegler, Inc., to design and fabricate Group A and Group B equipment. In February 1984, a Fuel Savings Advisory System (FSAS) computer was installed in C-141A (61-2779) as the first step in modifying the aircraft to fly complex flight paths using MLS signals. In August 1984, the Test Wing conducted a laser tracking test at the NASA facility at Wallops Island, Virginia, which verified the capability of the tracker to meet accuracy requirements.

The Test Wing began flight testing in January 1986. From January 1986 to January 1987 the Test Wing flew 705 approaches over 256 flying hours at Wallops Island. During that time the Test Wing performed data reduction of both airborne and ground tracking tests for publication of the FAA's terminal instrument procedures (TERPS) criteria for category D aircraft.

Related programs which are in current testing include the Military Microwave Landing System Avionics Program, and the Commercial Microwave Landing System Avionics Program. These are two of four microwave landing systems being procured by the Management Systems Program Office at Hanscom AFB, Massachusetts. The other two MLS systems are ground systems, the Fixed Base MLS, and the Mobile MLS. These four systems will provide DoD with an advanced landing system that meets adverse weather landing requirements at airfields worldwide, supports the tactical missions of resupply and medical evacuation, and is designed to be interoperable with civil and North Atlantic Treaty Organization landing systems.

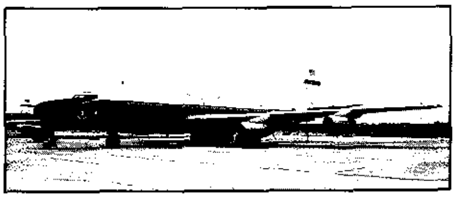
Identification Friend or Foe System

In accordance with the Office of the Secretary of Defense (OSD) approved Combat Identification System (formerly US Identification System) Charter, dated 20 November 1980, the Air Force was designated the lead service in a multi-service program for identification systems development. This program required coordinated efforts by the Air Force, Army, Navy, National Security Agency, and the Electromagnetic Compatibility Analysis Center to satisfy all individual user requirements including cooperation with NATO allies to develop a NATO Standardization Agreement for NATO Identification Friend or Foe (IFF) interoperability.



Beginning in the early 1980's, the Test Wing began testing the Mark XII Identification Friend of Foe System with a NT-39A test bed.

Beginning in the early 1980's, the Test Wing began testing the Mark XII IFF with a NT-39A (59-2870) test bed. The purpose of this program was to develop a new system to identify friendly aircraft. After numerous delays in the modification phase, the first successful checkout flight was flown in November 1981. The Test Wing began flight testing at Eglin AFB, Florida, during February 1982, with all test objectives on the APX-76, APX-101, and KY-532 transponders completed by March. Additional flight testing on the APX-64 transponder was completed in early 1983. The Mark XII Program for the Test Wing was finished by 1984.



Like the Mark XII, the Mark XV IFF Program was a tri-service and NATO project to develop a new system to identify friendly aircraft. After fielding the Mark XII, however, the users found that the system had certain limitations that made it difficult to identify friendly forces in all situations. For example, certain types of hostile electronic countermeasures could thwart the system. The idea behind the improved Mark XV was to develop a core system that could be tested on specified aircraft, ground installations, and naval craft. Once the core system proved itself, it could be adapted for use on other platforms. For the Mark XV program, the Test Wing utilized the NKC-135A (55-3127) as the interrogator aircraft, two NC-141A (61-2775, 61-2777) for the transponder aircraft (one for use by each of the contractors, Bendix and Texas Instruments), and a ground mobile interrogator.

The electronic interrogator equipment for the Mark XV IFF was installed on a NKC-135A (55-3127), nicknamed "Thunder Chicken."

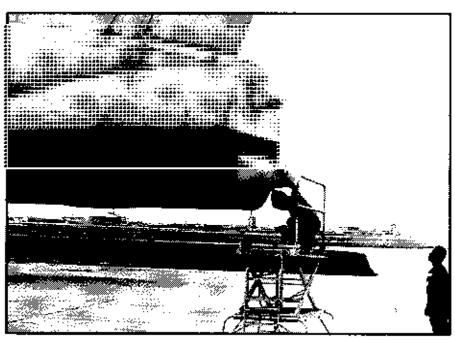
The Test Wing began flight tests in April 1987, despite some stringent Federal Aviation Administration (FAA) restrictions. The FAA feared that the waveforms generated by the Mark XV might adversely affect the transponder systems used on commercial aircraft. The first flights served both as shakedown flights and testing to see if any such interference occurred. At the same time, the FAA Technical Center in Atlantic City conducted compatibility tests measuring the effects of the Mark XV waveforms on several different kinds of transponders. The FAA wanted to verify compatibility analyses and simulations that would insure that the Mark XV would not interfere with air traffic control systems. Although the first test was described as only 75% successful because of some instrumentation problems, the FAA did not notice any interference with regional air traffic control centers. This led the FAA to remove most of the flight restrictions in May 1987. Because of integration and data recording incompatibility problems between the contractor and government equipment, flight testing at the Naval Air Test Center at Patuxent River, Virginia, did not begin until July 1987. Despite several equipment malfunctions, the Test Wing drew the conclusion that the transponders and instrumentation worked well. The Test Wing flew the final Mark XV core mission in September 1987.

Service unique testing for the Navy began again in September 1987. Both the Navy tests and the unfinished core tests proved successful despite some problems. The NATO interoperability testing of a British transponder and a US interrogator proved successful. General satisfaction with the system led to the recommendation for full scale development in late 1987.

B-1 Tail Warning Capability

The "Gambler", NC-141A (61-2777) was the third and last pre-production C-141 built. This aircraft had a cylindrical aft end, 6-7 feet in diameter, extending from the rear of the aircraft at the top of the petal doors, and was often called the "Beer Can."

In 1982, a B1-B General Officer Steering Group decided to provide the B1-B with a tail warning capability by increasing the scope of the AN/ALQ-161, the defensive avionics system. The tail warning system would detect airborne threats approaching from the rear of the aircraft. Adding this function to the ALQ-161 offered several advantages compared with having a separate system: fewer line replaceable units, lower weight and fuel consumption, and allowance for future increases in capability. On 6 December 1982, the AIL Division of Eaton Corporation, the defensive avionics contractor, received a change order for Phase I design work. Because a B-1 aircraft would not be available to evaluate the system, officials of the Deputy for B1-B System Program Office and the Test Wing agreed to install the receiver and transmitter antennas on the unique tail of an NC-141A (61-2777).



Shown on the NC-141A test bed, the B-1B Tail Warning System detected airborne threats approaching the rear of the aircraft with one transmitter (top) and two receivers (bottom).

In December 1984, Electrospace Systems was awarded a contract to modify the NC-141A during February and March 1985. Modifications to the aircraft were completed in March and flight testing began in May 1985. Test missions consisted of background-clutter flights over Strategic Range 3 at Ellsworth AFB, South Dakota, and the water range at Eglin AFB, Florida, and moving-target flights over the water ranges at Eglin. These moving-target flights involved firing a 2.75 inch Folding Fin Aircraft Rocket at the NC-141A test bed. The warheads were inert, and the distance and firing angle were controlled to insure that the rockets always fell short of the aircraft. The flight testing consisted of three phases. Phase I allowed contractor system optimization and system capability demonstration. It flew a total of 16 missions, including nine background clutter flights and seven moving targets in 117.9 hours with 180 rockets expended. Phase II entailed government assessment of the system's performance. It started testing in August 1985 and was completed in September 1985. During Phase II, the NC-141A flew 55.1 hours for a total of eight missions, including two background clutter flights and six moving target flights with 200 rockets expended. Phase III was a limited, additional government assessment following contractor changes, based upon the results of Phase II testing. After looking at the data from Phase II, the contractor proposed changes and convinced the B-1B System Program Office to flight test these changes in what became Phase III. Phase III consisted of one background clutter flight and one moving target flight at Eglin AFB, Florida, flying 12.0 hours and expending 20 rockets. Phase III was cut short due to restrictions imposed by the Federal Communications Commission. After 180 hours of flight test, the three phases were completed on 18 November 1985. The Phase II results were published as a final report in June 1986, with the Phase III results published in March 1987.

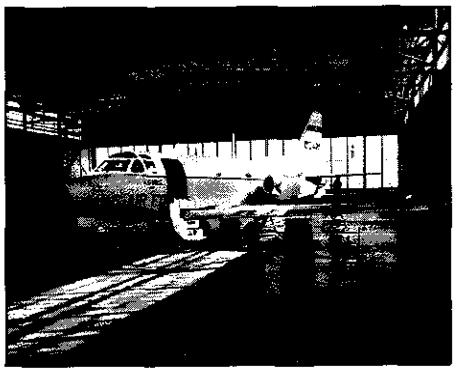
The program continued in 1986, when frequent false alarms and false warnings prompted the B-1B System Program Office to ask for testing of an ALQ-161 doppler radar with software and hardware modifications. Accordingly, the Test Wing installed the modified equipment in the same test bed NC-141A, and conducted Phase IV testing in June, July, and August 1986. The nine missions, five testing background clutter and four testing moving targets, took seventy-three hours at three locations. The aircraft flew four background clutter tests at Strategic Range 3 near Ellsworth AFB, South Dakota, one background clutter test at Edwards AFB, and a moving target test at Eglin AFB, Florida.

Electronic Warfare

In the mid-1970's, the Test Wing began supporting testing of the Army's Patriot tactical air defense missile system. At the heart of the Patriot systems fire unit was the AN/MPQ-53 radar, which combined the target search, detection, and track and identification functions, as well as the missile tracking and guidance; and an electronic counter-countermeasures function (ECCM). To test the ECCM effectiveness, the Test Wing flew Little Crow to simulate a jamming, or electronic countermeasures opposition. Also during this time, the Test Wing, in conjuction with the Army Office of Missile Electronic Warfare, owned and operated a test bed called Big Crow, equipped with the Army's Airborne Electronic Warfare Laboratory to provide ECM support to general testing in the electronic warfare community. Later in the 1980's, the Test Wing modified and flight tested the ECCM Advanced Radar Test Bed, which had the capability of evaluating airborne fire control radars and sensors in an ECCM environment.

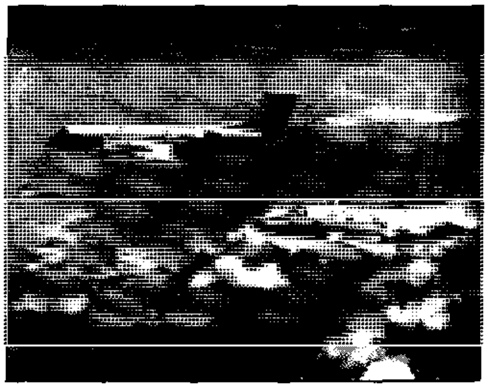
Little Crow

In the mid 1970's, the Test Wing modified a T-39B (60-3474) to simulate standoff jamming threats during the developmental testing of the Army's air defense Patriot missile system. The test bed was nicknamed Little Crow. Beginning in 1976, the Test Wing deployed to White Sands Missile Range in New Mexico to perform the flight testing. Deployments continued through 1979. In 1980, problems with the software on the missile began to hamper the mission. In addition, the Little Crow aircraft lost the capability of one of its two expensive "one of a kind" traveling wave tubes. Despite the loss, however, the jamming power level remained adequate for support of the Patriot. During that time, Little Crow also provided jamming and target functions for the Digitally Coded Radar and Multiple Sidelobe Cancellor programs, conducted at Griffiss AFB, New York.



The first T-39B Little Crow (60-3474) simulated standoff jamming threats during the developmental testing of the Army's air defense Patriot Missile. In March 1992, the aircraft was nearly destroyed by an inflight hydraulic fire in the aft fuselage, and was later replaced by T-39B (60-3476).

During 1981, predicting that the Army would need a second Little Crow in the near future, the Test Wing modified a second T-39B (59-2873) to carry Little Crow equipment. During 1984, Little Crow supported Patriot III testing at Biggs AAF, Texas, followed by support of collective training for Army missile battalions. In 1985, the first Little Crow (60-3474) was modified with an improved standoff jammer. During 1987, deployments continued in support of Patriot missile testing, including the jamming of a live fire missile. In March 1992, Little Crow (60-3474) caught fire inflight in the aft fuselage and was nearly destroyed. It was subsequently removed from the program and its equipment was transferred to T-39B (60-3476). Normal operations are projected into 1999.

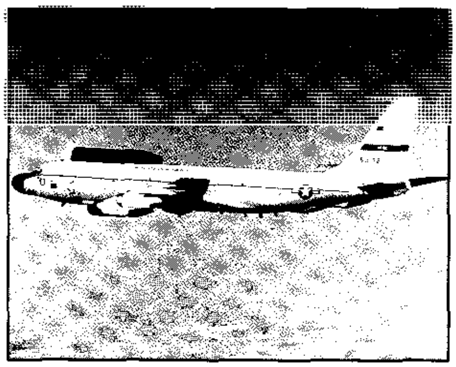


During 1981, the Test Wing modified a second T-39B (59-2873) to carry Little Crow equipment.

Big Crow

During the 1960's and early 1970's, the US Army Missile Electronic Warfare Technical Area's (MEWTA) mission was to provide electronic warfare (EW) vulnerability assessments of all Army weapon systems, including airborne EW environments and electronic support measures (ESM). The orginal test bed aircraft, a C-130A (54-1622) and a C-131B (53-7797) were staged out of Holloman AFB, New Mexico, with MEWTA providing all the EW equipment and operators.

In September 1971, HQ Air Force Systems Command proposed discontinuing the program with the C-130A and C-131B, because of budget contraints. Since the Army needed to retain the EW test capability because of upcoming requirements with the Patriot Missile program, MEWTA, along with representatives from the Air Force Special Weapons Center, traveled to Patrick AFB, Florida to inspect a NKC-135A as a replacement test bed. In January 1972, NKC-135A (55-3132) was selected as the new EW support aircraft, and was transferred from the 4950th Test Wing to the Air Force Special Weapons Center and flown to General Dynamics in Fort Worth, Texas, to be modified into the "EW Flying Laboratory." The purpose of this laboratory was to provide electronic countermeasures (ECM) capability to test the vulnerability, and defensive characteristics of various weapons systems. Costing the Army close to $5.7 million, the modified NKC-135A, renamed Big Crow, flew its first flight test in April 1972. Continuing flight testing on 20 June, while simulating a takeoff in a cross wind, the aircraft lost its number four engine at approximately 22,000 feet and 60 miles west of Albuquerque. By exceeding the side slip limit, the aircraft inadvertently went into a descending spiral. The aircraft recovered safely, but not before ripping the engine off. The aircraft was consequently grounded for approximately one year for wind tunnel tests and analyses. The results of these tests defined a restricted flight envelope for future Big Crow operations.



The purpose of Big Crow, the Army's Electronic Warfare Laboratory, was to provide electronic countermeasures capability to test the vulnerability and defensive characteristics of various weapons systems.

In 1976, the Air Force Special Weapons Center consolidated with Eglin AFB, Florida; Hill AFB, Utah; and Wright-Patterson AFB, Ohio; resulting in Big Crow being transferred back to the 4950th Test Wing, and operated out of Detachment 2 at Kirtland AFB, New Mexico. While the Test Wing owned and operated the test bed, the Army owned the laboratory on board and the support equipment Although the Army was the primary user, any government agency could use Big Crow. In April 1977, Big Crow began supporting the Air Force Program MPS-T1 at Carswell AFB, Texas, followed in May 1977, with the first mission in support of the Patriot missile. In 1980, the Big Crow system was validated for multi-aircraft tracking.

During 1983, there was a change in policy concerning control and use of the laboratory between the Test Wing and the Army's controlling Office of Missile Electronic Warfare. This change placed increased responsibility on the Test Wing to "market" and control the aircraft. In response, the Test Wing created a slide presentation on Big Crow, and began selling it to the DoD electronic warfare community. Also in 1983, Big Crow provided ECM for the initial operational test and evaluation of the NATO E-3A Airborne Warning and Command System (AWACS) aircraft, and the SEEK IGLOO radar system; and the developmental test and evaluation of the Navy's E-2C flying command post aircraft. In 1984, Big Crow supported the NAVSTAR Program.

In December 1985, Big Crow began modification of an in-flight refueling capability. Costing approximately $1.7 million, this change allowed the aircraft to fly missions lasting up to 22 hours, thus increasing its ECM test and training utility. With this new capability, Big Crow flew in support of Exercise AMALGAM BRAVE out of Elmendorf AFB, Alaska, in June 1985. This was followed by an ambitious test schedule whereby, after testing new electronic systems for the Navy on the USS Virginia, Big Crow returned to Alaska to participate in Exercise AMALGAM CHIEF. In 1986, in support of Over-the-Horizon Backscatter (OTH-B) Radar, the Army funded the installation of a trailing wire. During 1987, Big Crow continued to operate flawlessly in disrupting the performance of the Advanced Medium Range Air-to-Air Missile (AMRAAM) at White Sands Missile Test Range. In February, it supported the Navy's Aegis class combined ship system qualification testing in the Pacific. Additional missions during this time included testing of the Joint Tactical Information Distribution System (JTIDS); and support of PEACE SHIELD, the GPN-20 radar, the Ballistic Missile Early Warning System (BMEWS), and the Navy Aegis class cruiser system testing.

In December 1985, Big Crow was modified with in-flight refueling capability, allowing the aircraft to fly missions lasting up to 22 hours.

During 1988, Big Crow continued support of the Patriot missile testing, the North American Air Defense Command's AMALGAM BRAVE Exercise, the demonstration of the automatic Adaptive Radar Control Program, and the Navy Aegis testing. In the Aegis tests, Big Crow jammed the Aegis system while fighters simulated attacking the equipped cruiser. In 1989, Big Crow continued its mission of supporting Navy Aegis testing, as well as the Global Positioning System, the Air Defense Exercise AMALGAM CHIEF for North American Aerospace Defense Command, the OTH-B Radar, and the Army's tactical airborne countermeasures system. During 1990, Big Crow continued tests of the Army's Patriot missile and the Navy's Aegis missile cruisers as well as participating in the High Power Technology Risk Reduction Program, the E-3A ECM tests, the OTH-B Radar tests, and the JTIDS tests.

In 1991, Big Crow returned from a three-phase upgrade started in 1990. The replacement of the engines with JT-3D's, at a cost of $7.2 million, transformed the aircraft into an E model of the NKC-135. This modification, classified as major, resulted in the loss of certification, and the ability to fly with the top and bottom radomes which held the heart of the EW system. After months of negotiations with an Independent Modification Review Board, a limited instrumented flight test was approved for the bottom radome in February 1991. After successful testing, with the bottom radome and symmetrical pods installed, Big Crow supported tests of the first destroyer with the Aegis system, the USS Arleigh Burke. During 1992, Big Crow continued supporting Patriot missile tests, tracking modifications made to the missile after its use in the Gulf War. In support of another AMALGAM CHIEF Exercise, Big Crow served as both a standoff jammer and a Bear bomber. To date, in the 20 years of existence, the Big Crow program has supported over 104 major DoD weapon systems programs of the Air Force, Army, and Navy, resulting in over 3,143 electronic counter countermeasure fixes to those weapons.

Electronic Counter-Countermeasures/Advanced Radar Test Bed

The Test Wing's Electronic Counter-Countermeasures/Advance Radar Test Bed (ECCM/ARTB) had the capability of evaluating airborne fire control radars and sensors in an electronic counter-countermeasures (ECCM) environment. Although the combat would be simulated, the electronic countermeasures and electronic counter-countermeasures would be real. The concept of the test bed was to have a reimbursable, generic testing capability that could be used by many different customers at a relatively low cost. Specifically, the Air Force planned to use the ECCM/ARTB to assess the capabilities of electronic countermeasure avionics in the Advanced Tactical Fighter and the Integrated Electronic Warfare System.

Early in 1987, the Test Wing received a draft program introduction document for the developmental flight test of the ECCM/ARTB program. Although the preferred test aircraft was a C-9/DC-9, the Test Wing, because of time constraints, identified a C-141A (61-2779) aircraft as the test bed, and scheduled initial operational capability for fiscal year 1989. The main modification to the airframe was the addition of a nose transition section that would accept the B-1 radome with its radar system, and incorporate an adapter section that would accommodate the F-15 and F-16 radomes and radar systems (see Figure 10).

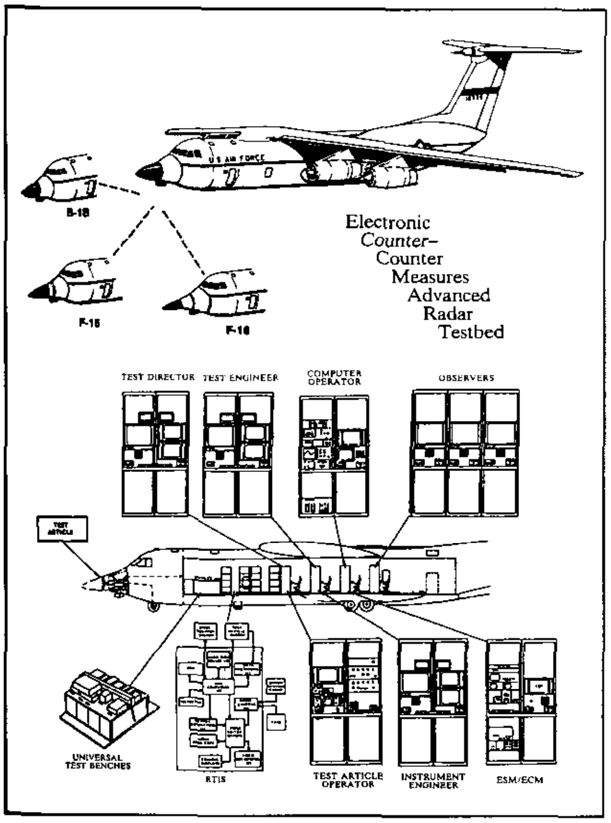
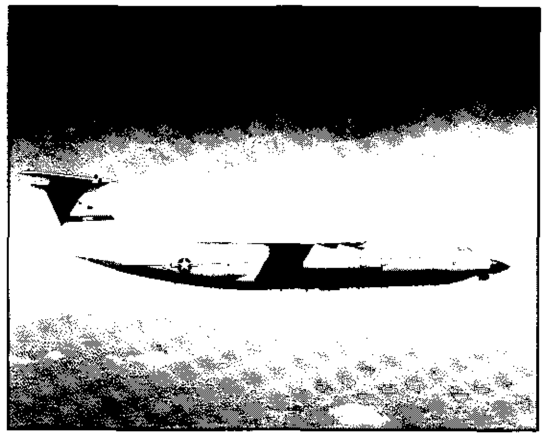
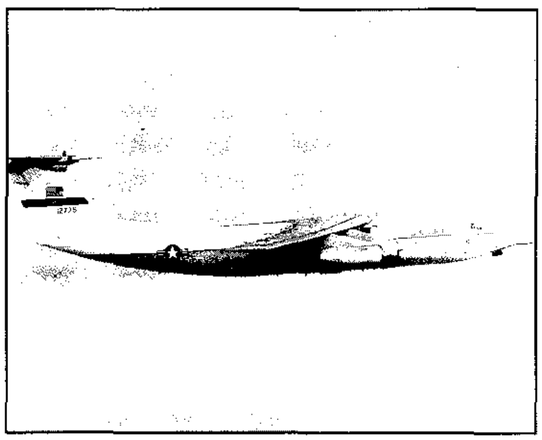
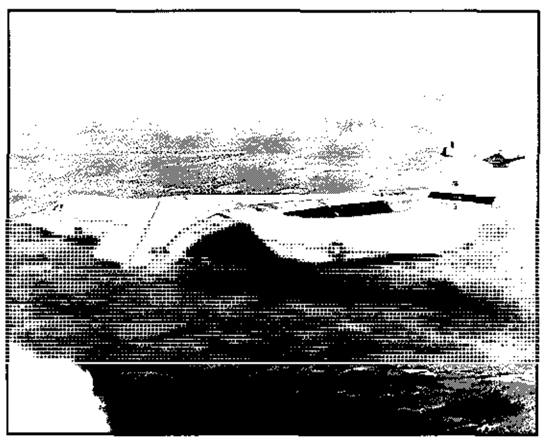


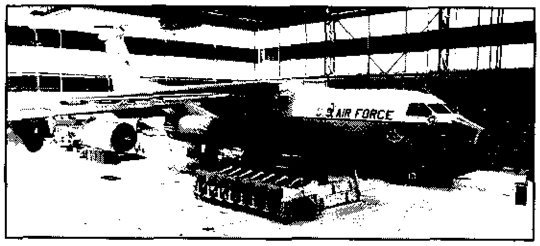
figure 10

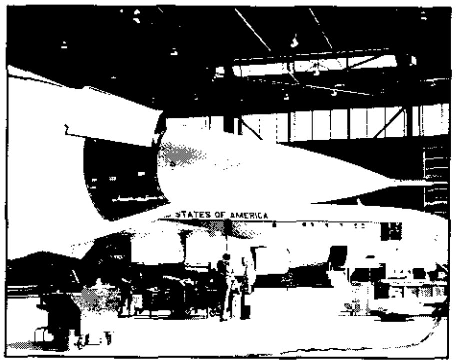


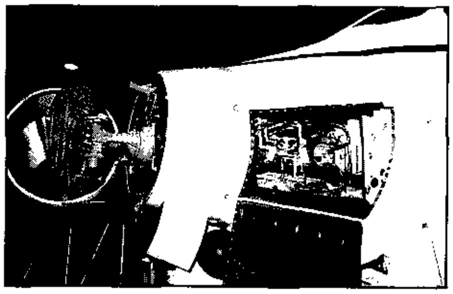




The ARTB had the capability of evaluating airborne fire control radars and sensors in an ECCM environment. B-1B (top), F-16 (center), F-15 (bottom).







The main modification to the airframe was the addition of a nose transition section that could accommodate radomes from three different radar systems.

The second modification was the design and installation of the Radar Test Instrumentation System (RTIS). The Test Wing defined the RTIS as an airborne test laboratory that would be used to evaluate new technologies and capabilities of sensors while airborne and subject to ECM, verifying the operational effectiveness of the sensor systems. The Test Wing planned to test a full range of systems including the AN/APG-63, 66, 68, and 70, and the AN/APQ-164 radars, as well as infrared search and track, forward looking missile sensor systems. Testing would include collecting and recording all test data including real-time display and analyses. The contract for the design of RTIS went to a team from Lockheed Aeronautical System Company and Hughes Aircraft Corporation.

In January 1988, the Aeronautical Systems Division (ASD) Deputy for Avionics Control and the Productivity, Reliability, Availability, and Maintainability Office, which provided half the total funding for the program, proposed to withdraw almost the entire fiscal year 1988 budget. Between the immediate efforts of the ASD Comptroller for the remaining fiscal year, and efforts by the Air Force to reprogram $2.8 million from another program for fiscal year 1989, the ECCM/ARTB program remained active. Nonetheless, the program remained unfunded for $6.2 million for fiscal year 1989. HQ Air Force Systems Command provided $1.793 million in late April 1989. This money forestalled immediate termination of the program, but left $4.4 million unfunded. By Air Force Systems Command (AFSC) submitting an unfunded requirement to the US Air Force Acquisition Director, the Test Wing received the US Air Force program authority to transfer funds to cover unfunded fiscal 1989 program costs. Despite these efforts, a $1.75 million requirement for fiscal 1990 remained unfunded. The Test Wing planned to pay for minimum contractual requirements from its own Improvement and Modernization funding while seeking a source of money. This left open the possibility that the contractor would deliver the ECCM/ARTB without flight testing, spare parts, or support equipment. In June 1990, the F-16 System Program Office transferred $1.65 million to the program. This again forestalled contract termination, and the aircraft moved from the plant to Wright-Patterson AFB in October .

Meanwhile during July 1988, the Test Wing completed the universal nose modification, followed by successful airworthiness tests of the F-16, F-15, and B-1B radomes. After reinstalling the F-15 radome following the B-1B test, the Test Wing performed the initial operational capability with the F-15's APG-63 radar. The ECCM/ARTB, now shortened to ARTB, was officially accepted by DoD in July 1991, and began its first flight test missions supporting Warner Robins Air Logistic Center's Copper Grid program during the second half of 1991. In 1992, the Test Wing continued to correct extensive in-house system deficiencies plaguing the program. During the second half of 1992, the test crew conducted a flight test for the CMMCA program, providing a baseline of the CMMCA's modified APG-63 radar against the ARTB's standard system. Also within this time, the Test Wing continued aircraft modification design and test planning for the Wright Laboratories' HAVE CENTAUR program, scheduled to fly in fiscal year 1995.

During the first half of 1993, the ARTB flew tests for the Wright Laboratory's Advanced Tracking Algorithms Program, an effort to advance radar technology; as well as over 20 flight hours for a classified program managed by Warner Robins Air Logistics Center. During the last half of 1993 the ARTB flew missions that included the ECCM demonstration/validation (DEM/VAL) testing of new ECCM techniques for the APG-63 radar, and the Distance Measuring Equipment/Precision (DME/P) program testing. The ARTB aircraft underwent modification from August to November and then performed the first DME/P mission on 16 November 1993, and the first ECCM DEM/VAL mission on 18 November 1993. A first-ever occurred on 3 December 1993 when the ARTB test team demonstrated its versatility and flexibility by adding, with only four-hour notification, an ECCM DEM/VAL mission to the already scheduled DME/P mission. Terminated on 30 November 1993, causing the cancellation of two scheduled missions, the ECCM DEM/VAL program was reinstated on 1 December 1993. Anxious to take advantage of every flying opportunity because its customer, Wright Laboratories, had to complete the project as scheduled by 22 December 1993 or lose its $12 million in investment, the ARTB test team executed the two tests the same day.

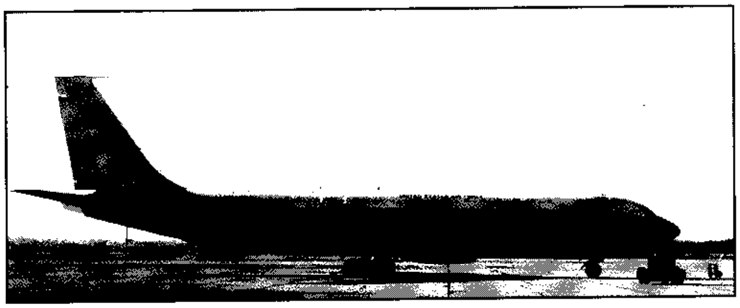
Following the transition of the ARTB to Edwards AFB, California in the spring of 1994, the Test Wing, after completing APG-70 radar software enhancements, is scheduled to conduct flight tests for the HAVE CENTAUR program, as well as testing for several smaller Wright Laboratories' programs.

Infrared

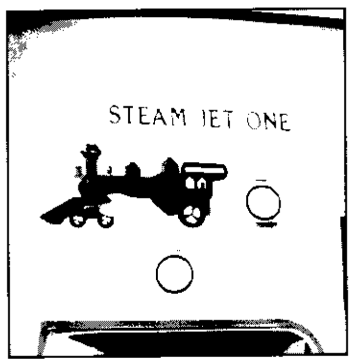
Electro-optically guided weapons, which relied on a minature TV sensor in the nose, were limited in effectiveness during foul weather conditions. To overcome this, developers utilized imaging infrared technology to guide and lock-on to a target. The imaging infrared seekers were virtually infrared TV cameras which built up a "heat image" of the target, then relied on sophisticated signal processing to lock on to a designated part of the image. Unlike TV systems, imaging infrared sensors worked equally well in total darkness, and were better than visual systems in coping with haze and smoke. But fog and clouds consisting of suspended water vapor which attentuated infrared, continued to plague the effectiveness of the technology. The Test Wing, working with the Air Force Geophysics Laboratory, sought to address these and other obstacles by examining the properties of infrared. One of the most advanced applications of the infrared system was TEAL RUBY, an attempt to devise a reliable method of detecting low-flying bombers and cruise missiles. The Test Wing supported this and other infrared programs with its flying infrared signatures technology aircraft.

Infrared Properties Program

During 1986, the Test Wing managed the Infrared (IR) Properties Program in support of other organizations. The purpose of the program was to improve the understanding of background radiance, clutter, and atmospheric absorption effects on the contrast of a target viewed through an infrared surveillance and detection system. The Air Force Geophysics Laboratory (AFGL) was the primary customer who collected and analyzed the data. The results of the testing could be used to improve the performance of existing infrared surveillance and detection systems as well as applied to those on the drawing board. The Test Wing used a Flying Infrared Signatures Technology Aircraft (FISTA), NKC-135A (55-3120) to support the IR programs, developing unique test procedures and flight profiles and making modifications to the FISTA aircraft whenever improved flight safety, more effective performance, or specific mission requirements dictated.



The Test Wing used a Flying Infrared Signatures Technology Aircraft (FISTA) to support the Infrared Properties Program. The NKC-135A (55-3120) was nicknamed "Steam Jet One" because of its water-injected turbojet engines.



The Test Wing also supported other various organizations involved in infrared properties research. These included the Defense Advanced Research Projects Agency's (DARPA) infrared target and background program; the Air Force Systems Command Space Division's Project TEAL RUBY; and the National Aeronautics and Space Administration's (NASA) HI-CAMP. The DARPA program analyzed the background of targets as they would appear in space as an aid in designing space detection systems. Likewise, TEAL RUBY was a test of the feasibility of using space-based infrared systems to detect targets. Because TEAL RUBY depended on the use of the space shuttle, Space Division suspended operations after the Challenger accident. HI-CAMP missions used a U-2 aircraft with an infrared detector flying a matching ground track at the same speed but at a higher altitude than the test aircraft.

TEST WING TO THE RESCUE

A 4950th Test Wing aircraft, while on temporary duty to Alaska in October 1985, located and directed the rescue of the occupants of a single-engine Cessna 206, that had crash-landed on a sand bar island 130 miles northwest of Fairbanks. Capt Paul Wingo, pilot of the NKC-135, monitoring the distress call, reported, "When the Cessna crew stopped transmitting and they disappeared from the radar screen, we knew they were down..."

The NKC-135 crew was operating from Eielson AFB, near Fairbanks, Alaska, on a mission in support of the Air Force Geophysics Laboratory. The crew had just completed its mission, and was returning to Eielson when it learned that a Cessna, piloted by Howard Holland, and carrying one passenger, was experiencing engine problems. Capt Paul Wingo, the NKC-135 pilot, radioed the Air Traffic Control Center, and reported his location at about 80 miles southeast of the Cessna, and volunteered assistance. "When the Cessna crew stopped transmitting and we heard that they'd disappeared from the radar screens, we knew they were down," Capt Wingo said. "We then picked up the small plane's emergency beacon and homed in on it. We then dropped down to an altitude where we could safely conduct a search, flying in a circular flight pattern where the transmission was the strongest."

TSgt Gerald Minnick, the NKC-135 flight engineer, was the first to spot the downed plane. It was upside down in the Tozitna River at the end of a sand bar island. The NKC-135 crew surmised that the Cessna pilot had attempted to crash-land on the island, and overshot dry land, flipping the aircraft upside down into the water at the end. Both the Cessna's occupants were standing on the island, apparently unharmed. Capt Wingo then called in and reported the Cessna's position. Next, he flew the NKC-135 to a higher altitude to conserve fuel resources until a rescue helicopter arrived; then dropped back down and led it to the crash scene. "We were getting a little low on fuel ourselves at that point and didn't want to join our new friends in the river. So, we climbed out and headed for Eielson. We didn't get to see the actual rescue, but we knew the downed Cessna crew was safe," he said.

The Alaskan Air Command Rescue Coordination Center, based at Elmendorf AFB, Alaska, credited the NKC-135 crew with saving the lives of the downed aviators. With no provisions or firewood, and overnight temperatures expected to drop as low as 15°F, the Cessna crew would likely have perished, had it not been for the well-coordinated efforts of this heroic Test Wing flight crew.

— Taken from ASD/PA News Release, PAM #85-222, 5 November 1985.

During 1986, the Test Wing deployed several times in support of the IR program. These deployments included 132 flight hours in support of HI-CAMP, and collection of IR data from an Air Launched Cruise Missile launched over the Utah Test Range. In August, the 4950th and the AFGL IR teams deployed to NASA's shuttle landing facility at the Kennedy Space Center where they tracked four British Polaris ballistic missile launches. The first mission successfully observed the boost phases of two launches, where the second mission successfully observed the terminal phase of the third launch, but aborted the fourth data run due to abnormalities in the trajectory of the Polaris Missile. In October, the teams supported three different research programs. At Hill AFB, Utah, the teams gathered data for the Air Force and DoD safety offices by observing the detonation and fragmentation pattern of a cluster of 16 Mark-84 bombs. At Edwards and Mather AFBs, California, the teams observed different types of ground vehicles against an early evening background. The third mission, called Seek Aerosol, measured the effect of sub-visual cirrus clouds on long range infrared transmissions by tracking B-52s.

During 1987, the IR team collected HAVE SHAVER data for Strategic Air Command's and Rome Air Development Center's Joint Strategic Relocatable Target Program. Operating from Pease AFB, New Hampshire, the crew flew many missions at 3,500 feet above ground level over a site in northern Michigan where military vehicles were dispersed. Some of the vehicles were "cold soaked", while others had their engines and equipment running. The testers used camouflage techniques to hide or mask the vehicles. The data gathered was to be used to compare data collected from other types of sensor systems observing the same site. Also during 1987, the FISTA collected data from submarine launched ballistic missiles as well as HI-CAMP signature data on Grumman's newly developed F-14D aircraft.

During 1988, the FISTA aircraft participated in cruise missile support, missile launches, F-16 infrared emissions, and testing of a new infrared sensor. The new sensor worked well on bridges, mountains, farmland, power plants, ships, cities, coastlines, and a KC-135. In January 1989, the IR Properties team recorded infrared data on a B-1B during operational test and evaluation of its navigation system. Additional tests at Eglin Test Range recorded the infrared signature data on the F-15E GE-220 engines, and the signature series on the B-1B. While at Eglin, the team responded to an urgent request by the Strategic Defense Initiative Office (SDIO) to collect data on a chemical release from a Black Brant VB sounding rocket.

In 1990, the FISTA captured the infrared signatures of the KC-10 and KC-135R tanker aircraft, allowing the Air Force to build computer-generated infrared models of the aircraft, and Strategic Air Command to devise evasive tactics for the tankers. In June and July, the infrared team participated in a SDIO basic research test, collecting data on high altitude hydroxide. Later, supporting DARPA, the team collected data on a coating designed to reduce infrared signature of an aircraft. For the F-15 Short Takeoff and Landing/Maneuvering Technology Demonstration tests, the FISTA collected basic signature series data on the two-dimensional nozzles that allow in-flight thrust vectoring and the capability to utilize reverse thrust during flight. The Air Force would later compare the signature to F-15E signature data to see if the nozzles made a difference. During 1991, the IR Properties aircraft flew two separate deployments for the SDIO Red Tigress program. The team flew 30 hours to determine the IR signature of the boost phase of an Aries rocket, maintaining a precise orbit maneuver at a specific bank, at a steady airspeed, and with accurate timing to obtain data on the reentry vehicles.

In early 1993, the Test Wing collected IR signature data on the B-2 to aid in the design of certain surfaces that reduced IR signature. Also during this time, flight crews collected data on two Red Tigress II rocket launches from Cape Canaveral, which will be utilized in the future development of a theater missile defense system. In the summer of 1993, flying at a low altitude and high airspeed, the Test Wing collected IR data on the F-117A and the F-15, both which were coated with a special covering to reduce heat signatures. Also during this deployment, the crew collected IR data on the C-17, information that will later be used to determine the best method to employ the aircraft. In the late summer of 1993, the Test Wing gathered IR data on AIM-7 and AIM-9 missiles fired by a F-15 at a drone. The F-22 System Program Office will use this information in the development of their missile launch detection system. The Test Wing completed IR testing with the FISTA aircraft, collecting data from an AC-130 Gunship and a KC-10 Extender in various configurations. At the end of this testing, the aircraft was demodified, and was scheduled to be excessed in early fiscal year 1994.

Lasers

In the 1960's, shortly after the invention that made high energy lasers possible, the Department of Defense began investigating its application to a laser weapon system. A high energy laser weapon was a system which attempted to inflict damage on a target by placing large amounts of thermal energy on a small area. Since light traveled at a speed of 186,000 miles per second, the lethal flux would arrive on target almost instantaneously, eliminating the need to "lead" the target. It took six millionths of a second for laser light to travel one mile, and in that time, a supersonic aircraft traveling at twice the speed of sound would travel only a little more than one-eighth of an inch. To distinguish these high energy lasers from the more common low energy types, DoD defined a high energy laser as one with an average power output of at least 20 kilowatts or a pulsed power of at least 30 kilojoules.

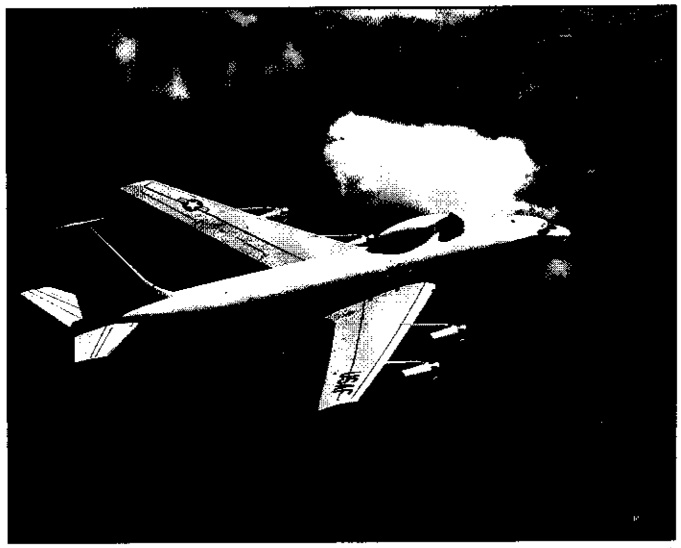
A laser weapon could single out, attack, and destroy single enemy targets located in the midst of a host of friendly vehicles, while simultaneously monitoring a large number of other targets coming from other directions. For each "shot" the laser took, it used relatively small amounts of fuel to generate the beam. Thus, a single weapon could store a large number of "shots" (a large magazine). Finally, since the beam was steered by mirrors, the laser weapon could move rapidly from target-to-target over a wide field of view.

Although many different lasers were discovered in the 1960's, none were suitable for high-energy applications until 1967, with the carbon dioxide (CO_2) gas dynamic laser, or CO_2 GDL. This type was the first gas-phased laser which could be scaled to very high energies, paving the way for serious consideration of a laser damage weapon system. Efforts to apply this to damage of a weapon system, however, had to address some limiting factors. The laser would be successful as a weapon only if it could engage the target and burn through the target surface and destroy a vital component, or ignite the fuel or warhead. In order to do this, the laser would have to dwell on the target to destroy it. Jitter over the focused spot would smear the energy in the beam over a larger focal area, increasing the time required to destroy the target. Therefore, a beam control subsystem (BCS) would be required to hold the beam steady on the designated aim point. Since lasers must be pointed with great accuracy, the fire control subsystem (FCS) must be especially accurate in telling the BCS where to point. In addition, to utilize the lasers most efficiently, the FCS must quickly direct the laser to disengage once the target is destroyed. Today, real-time feedback with advanced computers has improved the BCS function, reducing jitter, and increasing accuracy at longer distances. Another limiting factor on lasers was the effect of the atmosphere. Depending on the wavelength of the laser energy, the atmosphere absorbed more or less of the laser's energy, and caused the beam to "bloom" or defocus, as well as cause jitter. This interaction increased the spot size on the target, lowering the peak intensity and increasing the dwell-time. The net effect, therefore, was that for a given range there was a critical power level, beyond which, intensity on-target decreased as laser power was increased. To compensate for this, lasers with shorter wavelengths were designed that were transparent to the atmosphere. Overcoming these limitations, the ultimate goal was to produce a laser weapon in a high-density threat environment that would methodically move from target to target over its all azimuth coverage, focusing the beam on target, holding the selected aimpoint despite the target's speed and maneuver, burning through the target skin and destroying an integral component. Then, with instructions from its sophisticated FCS, the weapon would switch the beam to the next target, continuing to engage successive targets until the fuel was expended.

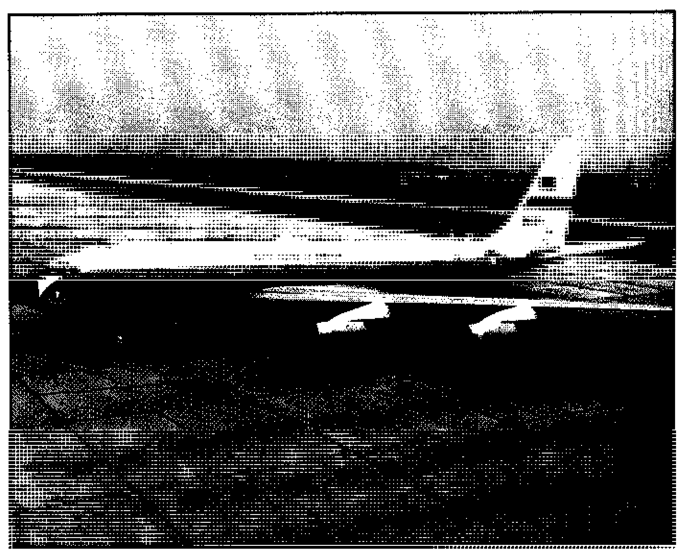
In the course of developmental efforts, laser weapon test beds have scored "firsts" in engaging flying objects. The first such success was in 1973 when the Air Force used a high energy gas-dynamic laser and an Air Force-developed field test telescope to shoot down a winged drone on the Sandia Optical Range at Kirtland AFB, New Mexico. In 1976, the Army, using a high energy electric laser in their Mobile Test Unit, successfully destroyed winged and helicopter drones at Redstone Arsenal, Alabama. Later, in 1978, the Navy, using a chemical laser it jointly developed with the Defense Advanced Research Projects Agency (DARPA) and a Navy-developed pointer/tracker, successfully engaged and destroyed, in flight, a TOW antitank missile, during the Unified Navy Field Test Program at San Juan Capistrano, California.

Airborne Laser Laboratory

The Air Force High Energy Laser (HEL) program, supporting research efforts of the Air Force Weapons Laboratory at Kirtland AFB, New Mexico, began in 1973. The test bed for the Air Force program was the Airborne Laser Laboratory (ALL), a highly instrumented NKC-135 (55-3123) aircraft, augmented by a NC-135A (60-0371) ALL Diagnostic Aircraft. The Air Force was investigating not only the integration and operation of high energy laser components in a dynamic airborne environment, but also the propagation of laser light from an airborne vehicle to an airborne target. The program was divided into three phases or cycles. The first two cycles were completed at Kirtland. In 1975, the aircraft returned to the contractor, General Dynamics, for modification of Cycle III. In 1977, the test bed was transferred to the Test Wing at Wright-Patterson AFB, Ohio, for testing of Cycle III.



The aircraft for the Airborne Laser Laboratory was a highly instrumented NKC-135 (55-3123). The new canopy was the first such design that could trap the Von Karman vortices.

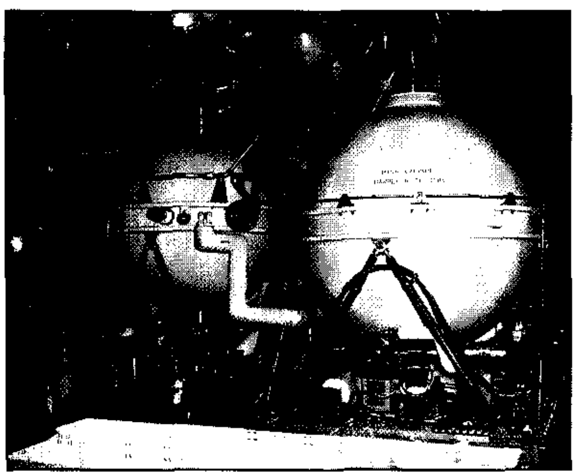


The Airborne Laser Laboratory (ALL) was supported by the ALL Diagnostic Aircraft, NC-135A (60-0371)

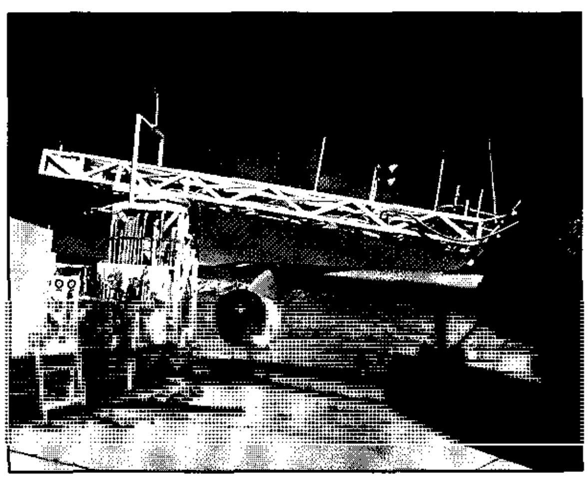
Cycle III involved major modification to the canopy design in order to install a weapons quality laser, the Gas Dynamic Laser (GDL) system. The modification contract for the Cycle III ALL modification was awarded to General Dynamics, Fort Worth Division, Texas. The forecasted manhours to be used by the contractor during the modification was estimated at 507,000 hours; the contract cost was forecasted at $11,500,000. A test compartment pressure relief system was added to the contract because of a possibility of over-pressure of the structure if a large leak occurred in the cryogenics helium storage tank.

Installation of the laser required modification and redesign of major portions of the aircraft. Installing the laser involved cutting large holes in the floor and ceiling of the pressure capsule for the laser turret and exhaust stores. The force of this exhaust could cause the aircraft to pitch its nose up, creating a stability and control problem. The large holes cut into the fuselage required a structural redesign, resulting in a new stress analysis. This, in turn, necessitated that all of the control cables be relocated. This consequently changed the plane of the cables, causing friction, and required a change in tension. To do this, the test program borrowed tension regulators from a F-111 flight control system. To increase the electrical power of the aircraft, the program borrowed elements of the B-52 electrical system. The new canopy was the first such design that could trap the Von Karman vortices coming off the laser turret, preventing degradation to the flight dynamics. To insure that the aircraft was not affected, high-pressure Kissler transducers in the vertical stabilizer were installed to monitor the airstream. This airstream was constantly tracked by a fast, free transform capability in the form of a microprocessor.

Meanwhile, the materials needed to actuate the laser were considered toxic, asphyxiant, and explosive. The combination of liquid methane to start the laser, nitrogen, and rocket propellant fuel equated to having two liquid rocket engines onboard, giving the ALL a 1,000 percent greater chance of exploding than a conventional C-135. Because of these hazards, the aircraft had to be cut into three pressurization zones, the nose area for the pilots, the laser area, and the aft area for the experimenters, with pressure bulkheads in between. Unlike those found in a submarine, the bulkheads had to be designed to float so as not to crack the airframe upon landing. Because of the volatile levels of hazardous materials, the first quadri-pole mass spectrometer ever to be utilized airborne, was installed to constantly sample and monitor the atmosphere at microscopic levels.



The fuel for the laser, a combination of Carbon Dioxide and Methane, was stored in high vacuum, spherical tanks.



The Airborne Laser Laboratory was serviced at the Transfer Control Module which refueled and defueled the gas dynamic laser bottles of propellant and oxidizer located in the fuselage.

To operate the laser, the Test Wing engineers overexpanded the exhaust in the rocket engine, so that the energy was pumped into the fluid, artificially elevating the photon molecules to a higher energy state. Next, by using mirrors at both ends of the laser cavity, the photons were aligned in a concentrated stream. Then by simply removing one end of this cavity, the high energy laser shot was released. Earlier versions of these mirrors absorbed a certain amount of the energy, and consequently, had to be cooled with liquids so as not to become distorted and misdirect the laser beam. Later versions were treated with a special coating to decrease the absorption and increase the reflectivity.

The ALL aircraft was assigned to the Test Wing in July 1977. After approximately six months of brake tests, functional checkout flights, instrumentation installation, flight tests to obtain a baseline flutter and wake turbulence data, airspeed calibration data, and takeoff performance data, as well as data on the Airborne Pointing and Tracking Systems (APTS) in the Cycle II final external configuration, performance testing was scheduled for January 1978.

In January 1978, the ALL aircraft resumed flight testing at Edwards AFB, California, for a series of takeoff and climbout tests to clear the aircraft flight envelope in preparation for flights out of Wright-Patterson AFB. In February 1978, however, due to a harsh blizzard, the program manager moved the entire test effort to Edwards. On 3 February 1978, the aircraft arrived at Edwards AFB to begin a series of performance, stability ,and control tests. Areas tested included cruise and climb performance, static/dynamic longitudinal stability, static/dynamic lateral/directional stability, airborne minimum control speed, stalls, maneuvering flight, go-around, and additional takeoff/climbout testing. Also during this time, the Fluid Supply System, designed to store, condition, and deliver fluids necessary for the operation of the GDL, was installed. During the last half of 1979, the ALL underwent installation of a new laser. Modification and flight testing continued in 1980.

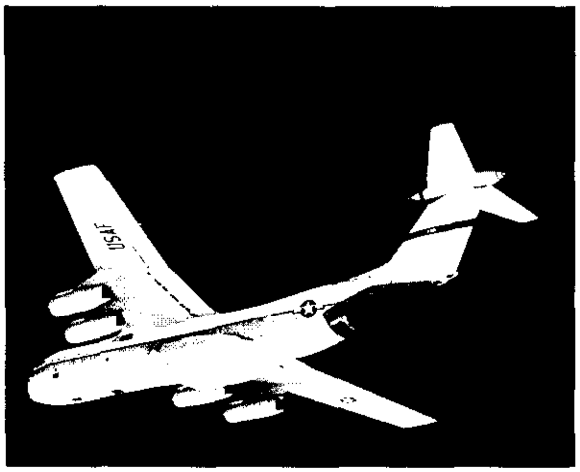
In April 1981, the ALL accomplished the first successful laser beam extraction from an aircraft on the ground, followed in May by a successful laser beam extraction from an aircraft in the air. In June, the laser was partially successful in firing from an aircraft in the air against an air-to-air missile. Due to the problems from this partial success, the ALL project equipment was completely reevaluated. This culminated in a successful test mission at Edwards in December.

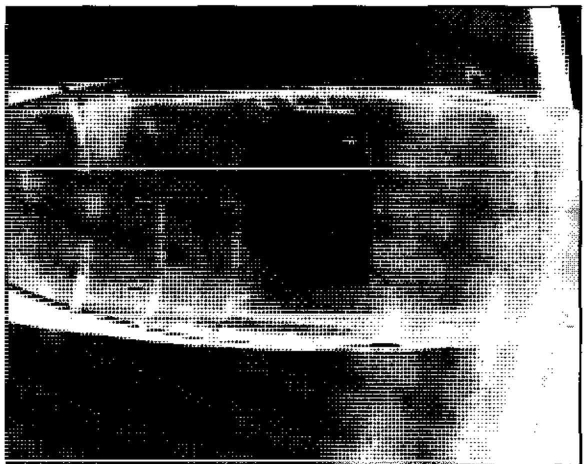
After a programmed depot maintenance in 1982, the ALL met two significant milestone tests in 1983. The first laser test against Navy drones in a sky/water background was completed in April at the Pacific Missile Test Range at Point Mugu, California. The second test came in May, against AIM-9L missiles in a sky/land background at the Naval Weapons Center at China Lake, California. The Test Wing flew the final test flight on 4 November 1983. The ALL aircraft was placed in flyable storage at Albuquerque, New Mexico, while the ALL Diagnostic Aircraft continued to fly support missions for other programs. The program was highly successful and all objectives were accomplished. The Test Wing provided excellent support without a maintenance cancellation or abort. The test bed is now housed in US Air Force Museum Annex at Wright-Patterson AFB, Ohio.

In 1993, the Air Force Weapons Laboratory developed a concept for a test bed to be used in a follow-on program. Under consideration was a C-135C aircraft that would be modified with an external, side-mounted, "splitter plate", having an optical window for the laser; as well as be modified internally for laser and data collection. This test bed would be used to prove the effectiveness of airborne lasers as a theater missile defense system. If successful, the systems would be employed on a larger, Boeing 747 type aircraft, with the capability for longer range, higher altitude, and heavier loads. Planning for the Test Wing modification of the C-135C test bed was terminated when funding was withdrawn in the fiscal year 1994 budget.

Laser Infrared Countermeasures Demonstration System

Also during the mid-1970's, the Test Wing began work for the Air Force Avionics Laboratory on the Laser Infrared Countermeasures Demonstration System (LIDS) program, an effort to flight test advanced development hardware designed as a non-expendable system to counter an infrared guided missile threat. The test item consisted of a low-power chemical laser and associated pointing and tracking optical systems, built by Hughes Aircraft Company. The laser was mounted in the rear of a C-141 (61-2779), and fired through the aft port. An F-4, equipped with an Airborne Infrared Decoy Evaluation System (AIDES) pod flew as the chase aircraft.





The laser was mounted in the rear of a C-141, and fired through an optical opening in the petal doors. Pipes protruding from either side of the aircraft allowed for the escape of laser exhaust.

Although the laser passed an acceptance test in April 1976, design work on the aircraft modification continued when the original mounting design proved unsatisfactory, and a new cantilever structure had to be designed. Later, the airworthiness test plan was revised, calling for the addition of strain gauges and pressure transducers in the laser cavity. A major portion of the modifications were completed in late 1977.

During the first half of 1978, the Test Wing conducted a LIDS ground operational checkout at Wright-Patterson AFB, Ohio, and Eglin AFB, Florida. This included five successful ground laser firings from the test bed. The Test Wing began flight testing LIDS in July 1978, completing aeronautical evaluation flights in August. In September, the aircraft deployed to Eglin AFB for vibration and gas flow testing, as well as additional ground firing tests to verify systems operations and boresighting. In October, the first airborne live firing was successfully accomplished. In December, the test bed flew three successful flights firing at the specially instrumented AIDES pod carried by the F-4, demonstrating the airworthiness of the chemical combustion laser. The AIDES pod carried an infrared missile seeker head with instrumentation and data recording equipment.

The Test Wing completed the Flight Test and Evaluation Phase in the first half of 1979. After the Air Force Avionics Laboratory notified the Test Wing that funding had been cut for the follow-on LIDS II program, the effort was terminated in early December 1979.

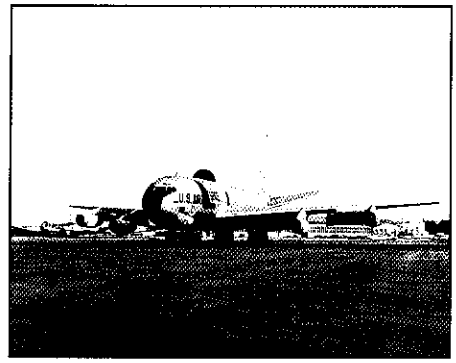
Satellites

The military's use of satellites has contributed to improved communications between air, land, and sea forces. Specifically, the Air Force Satellite Communcation System Program has aimed at providing global communications for command and control of military forces through all phases of a general war. Several satellite systems have been utilized, including those dedicated to military missions such as Milstar. The Test Wing has supported and continues to support testing of satellite communications developments. Satellites have also been used to facilitate navigation and guidance, such as the Navstar Global Positioning System, a constellation of 18 satellites. Again, the Test Wing has provided flight testing of the related tracking equipment as each satellite was launched.

Airborne Satellite Communication Terminal

Beginning in the 1960's, Satellite Communication (SATCOM) Systems were being developed to provide highly survivable, secure, and continuously available, two-way command and control communications between the National Command Authority, appropriate commanders, and the nuclear capable and support forces. During this time, the Air Force Avionics Laboratory (AFAL) was instrumental in the development of airborne terminal technology and airborne SATCOM systems in the Ultra High Frequency (UHF), Super High Frequency (SHF), and Extremely High Frequency (EHF) bands.

To support SATCOM testing, the Test Wing utilized a KC-135A (55-3129) and a C-135B (61-2662). From these platforms, the AFAL proved the feasibility of airborne anti-jam communications, accomplished the first demonstration of controlling a satellite from an aircraft, developed a passive antenna pointing system with .1 degree accuracy, and demonstrated sufficient system reliability to allow transition of the several SATCOM systems to the operational arena. A wide variety of satellites were used during testing including the LES-3, 5, 6, 8 and 9; IDCSP, DSCS II, III; NATO III, SDS, MARISAT, TACSAT-COM, ATS-3, 6; DNA-002; and FLTSATCOM.

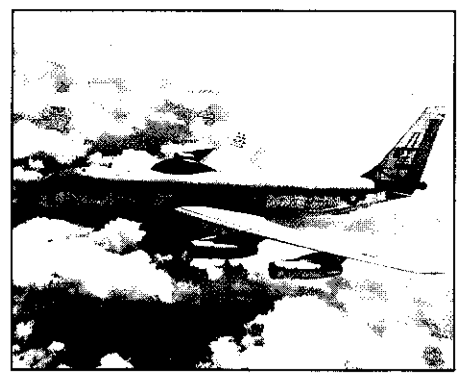


From the KC-135A (55-3129) platform, the AF Avionics Laboratory demonstrated sufficient system reliability to allow transition of the several SATCOM systems to the operational arena.

During the 1970's, the Test Wing flew numerous test flights to test and evaluate the performance of several airborne terminals, including the various modems and antennas used by these terminals. Designed for communicating by satellite relay, these terminals utilized links established between two or more aircraft and between aircraft and ground stations. Two of the systems developed by AFAL and tested by the Test Wing were the SHF SATCOM System (AN/ASC-18), and the EHF SATCOM System (AN/ASC-22). In 1971, the two project aircraft began test missions over the Pacific, Atlantic, and Indian Oceans, over the Arctic, and along the Equator. During this time, while flying 2,000 miles southwest of Hawaii and performing tests on the airborne Satellite Communications Strategic Terminal and the TACSAT Communications projects, the test crew demonstrated a reliable voice link from the Apollo 15 recovery force to Houston Control Center.

In the late 1970's, two satellite communications systems were in development, the Air Force Satellite (AFSAT) that provided global communications for command and control of the Single Integrated Operational Plan (SIOP) forces through all phases of a general war; and the Survival Satellite Communication (SURVSATCOM) System, that provided anti-jam communications capability to the National Command Authorities and Commander-in-Chief for command and control of force elements. Both systems, whether transmitting from fleet or force element aircraft, employed UHF. In order to provide a modem for the SIOP forces which, for economy of weight, volume, and cost, was capable of operation in either system, the AFAL developed an UHF dual modem.

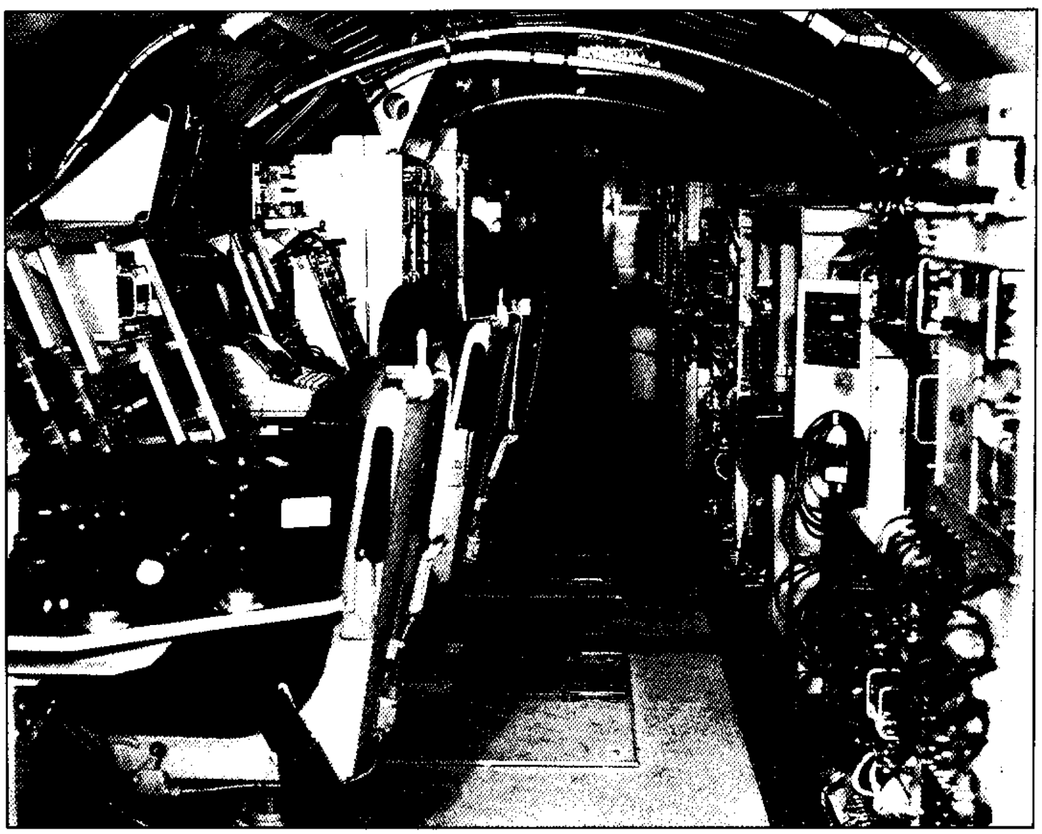
In 1976, the Test Wing conducted flights tests on this advanced development modem. On both test bed aircraft the modem interfaced with an AN/ARC-171 transceiver and Tracor teletypewriter. On the KC-135 the modem utilized a Collins AFSAT antenna. On the C-135 the modem utilized numerous UHF antennas which were part of the test bed modification. In order to simulate Airborne Command Post functions for adequate testing of the modem in its SURVSATCOM mode of operation, the Test Wing utilized a developmental Ka-band terminal on the C-135. To test linked communication to ground terminals, the Test Wing interfaced with the AFAL Rooftop Facility and communications Systems Evaluation Laboratory, the Lincoln Laboratory's Ground Facility, and the ESD/MITRE Test Management Facility, while using the satellite terminals of LES-8, LES-9, and the UHF Test Satellite Package B.



During 1976, the Test Wing conducted flight tests on the advanced development modem. On the SATCOM support aircraft, C-135 (61-2662), the modem utilized numerous UHF antennas.

The flying phase of the program, which started in April 1976, had the objective of establishing modem performance in both modes of operation under as close to actual operational conditions as possible. The Test Wing determined performance limitations using various jamming, propagation, and flight conditions. Thirty-five flights and 189 flight hours were accumulated in project testing over the period July-December 1976, a large part involving an extensive test series flown from Florida, Bermuda, Peru, and Hawaii. These totals included continued testing on the Ka-band terminal. In April 1978, the SURVSATCOM project was replaced by the Dual-Frequency SATCOM System (AN/ASC-28).

In late 1977, UHF and SHF/EHF SATCOM equipment was delivered, and installed in the C-135B in early 1978. A two-year flight test program to test the operation of the Dual-Frequency SATCOM System through the LES-8/9 and DSCS-II/III satellites began in May 1978. The purpose of the testing was to validate the feasibility of using a single airborne SATCOM terminal to operate with either the DSCS satellites at SHF, or the AFSAT satellite at EHF. This capability would provide the E-4 Airborne Command Post with a more survivable SHF/EHF capability without the prohibitive weight of two complete SATCOM terminals. The Test Wing conducted approximately 500 hours of airborne flight testing, including not only the AFAL and the Test Wing, but the Space and Missile System Organization, the Naval Research Laboratory, the MIT Lincoln Laboratory, the Air Force Geophysics Laboratory, and the Electronic Systems Division (ESD). The purpose of the flight test was to evaluate the feasibility of operating the Airborne SATCOM Systems in a simulated operational environment, observing the effectiveness of the anti-jam modulation in both jammed and non-jammed conditions, as well as the general propagation effects on the UHF, SHF, and EHF signals, such as multi-path and ionospheric scintillation. The project was completed in early 1981.



In late 1977, UHF and SHF/EHF SATCOM equipment was delivered and installed in the C-135B in early 1978.

In 1976 and 1977, AFAL and ESD conducted Project STRESS (Satellite Transmission Effects Simulations), a communication experiment sponsored by the Defense Nuclear Agency. The purpose of the experiment was to evaluate satellite communication links under conditions that simulated the many aspects of a post-nuclear-burst environment. During STRESS tests, the Test Wing's C-135B transmitted communications signals through an ionized barium cloud to an LES satellite in orbit 25,000 miles over the Atlantic Ocean.

In the late 1970's, the Test Wing began flight testing the Small SHF Satellite Communications Terminal (AN/ASC-18). The terminal utilized the extensively deployed DSCS satellite system, providing the E-4 Advanced Airborne Command Post with greatly improved command, control, and communication. The smaller SHF terminal adapted well to the crowded EC-135 test bed. The 1 KW, 8 GHz terminal consisted of an air-cooled transmitter, three low noise receivers, radome, and two SHF antennas, one of which was low profile, flush mounted; the other a dish type enclosed in a 30-inch high by 12-foot long radome. The equipment included a command post modem/processor to provide jam resistant 75 bps communications through the DSCS III satellite. Additional equipment associated with modem/processor for operation at UHF included AN/ARC-171 UHF transceivers, UHF power amplifier, wideband modem, UHF antennas, control boxes, and command post processor. Five hundred hours of flight testing were planned, starting in late 1980.

The Test Wing conducted the first flight test of the ASC-30 Satellite Communication Terminal in November 1981. The ASC-30 SATCOM Terminal was a small SHF and EHF satellite communications system designed to provide EC-135 command post aircraft with improved command, control, and communication capability via the DSCS and STRATCOMM satellite systems. The C-135B test bed, transferred to Strategic Air Command for Exercise COBRA BALL, had been replaced by a C-135E (60-0372). Electrospace Systems, Inc., completed modification of the C-135E 20 days ahead of schedule and $200,000 below cost.

In late 1982, the C-135E deployed to the Pacific for testing with the newly launched DSCS III satellite. In late 1983, the Test Wing conducted evaluation of a rotation problem with the Low Profile Antenna; testing of the Command Post Modem/Processor, antenna pointing and satellite commanding; and performance of a classified sortie concerning the DSCS III satellite.

A FRIGID FLIGHTLINE

When CMSgt Burch, the maintenance supervisor for the C-135 SATCOM aircraft, told Allen Johnson from the Avionics Laboratory that he was going to have to change #2 engine before they could get out of Frobisher Bay, Canada, Johnson had the uneasy feeling that he would be stuck in the Canadian Arctic for the rest of the winter....

They had left Wright-Patterson AFB, Ohio, on 5 December 1983 on the first leg of an 18-day polar/Pacific satellite communications test mission. On the flight up to Frobisher Bay, Johnson had collected data on the performance of a new communication satellite, DSCS II, launched in October. The mission had gone routinely until Chief Burch had discovered that #2 engine was bad while on the ground at Frobisher Bay. The problem could not have occurred at a worse place. They were up on Baffin Island along the Arctic Circle in mid-winter with 30-knot winds and a minus 30° F temperature. To further complicate matters, Frobisher Bay did not have a large enough hangar to house the SATCOM aircraft, nor the specialized tools needed to change the TF-33 engine. Everything that was needed would have to be flown in.

Time was of the essence, since, the longer the aircraft sat in the minus 30° temperature, the more problems there were likely to occur. For example, hydraulic seals tended to do funny things at extremely low temperatures — fittings and fuel lines that had never leaked, might start leaking after a few days of "cold soaking" in frigid weather. With this in mind, the Task Force Commander, Major Bean, was on the phone shortly arranging with the Test Wing Deputy Commander for Maintenance for transport of the engine, tools, heaters, lights, and needed personnel to complete the engine change.

The next morning, a 4950th Test Wing C-141 was prepared for its "mercy" flight to Frobisher Bay. By mid-afternoon it was airborne, and by evening, the cargo plane had touched down at its destination. With the help of the Canadian Armed Forces, the maintenance personnel forklifted the engine out of the C-141 and into a nearby hangar. In the Arctic night, with winds that ran the chill factor down to minus 100°F, the maintenance crew removed the bad engine from the SATCOM aircraft, hauled it into the hangar, and swapped the accessories to the new engine. Working straight through the night, the crew had the replacement engine ready to hang shortly after midnight.

With lights and heaters positioned around the C-135, the replacement engine was moved into place and hung on the aircraft. Working in relays, the maintenance crew connected the hydraulic and electrical fittings, being careful not to touch the minus 30°F metal with their bare hands lest the flesh freeze to the surface. By periodically getting warm with the heaters or in the cabin of the aircraft, the crew had the engine hung by early morning. As the Arctic sun rose around ten o'clock, the C-135 crew ran up the engine to check for leaks. After encountering no problems, the engine change was signed off as complete before noon. The process had only taken a record 36 hours, from the first phone call to the completion of the engine change, a time seldom accomplished in the best of conditions. Thanks to this first rate team effort, the SATCOM aircraft was able to get off on schedule, and continued the rest of its mission without incident.

As Allen Johnson sat in the transient maintenance trailer waiting for transportation to the aircraft, he heard one of the engine specialists say:

> It was so cold out there last night that every time Chief Burch said something to me, his words froze before they got out of his mouth. I would have to carry them into the hangar and thaw them out to see what he wanted.

—Taken from a report written by Allen Johnson, "4950th Test Wing Rescues SATCOM Aircraft Stranded in Arctic," 15 January 1983.

In January 1985, the Test Wing deployed to Thule, Greenland, to successfully test the Low Profile Antenna. During April, the Test Wing tested the Squint (Low angle reception) on the dual-band radome. The tri-band radome from Hitco was installed at Electrospace Systems, Inc., at Waco, Texas, from 30 April through 16 May. The radome had transmission problems due to a new graphite paint, and was removed and returned to the radome contractor for rework in June. Prior to the rework, the Test Wing performed a capability demonstration for SAC personnel at Offutt AFB, Nebraska, in May.

Beginning in late 1986, The Test Wing began using the SATCOM aircraft to support the Milstar program, a high priority program to develop the next generation military satellite communications system. In December 1986, the Test Wing deployed to Hickam AFB, Hawaii, to perform the initial on-orbit checkouts of the newly launched FLEETSAT EHF Package (FEP) on the FLEETSAT 7 satellite with the ASC-30 terminal. Tests of the FEP continued to 1987, with the Test Wing deploying to Cold Bay, Alaska, and Pago Pago, Samoa in August 1987; Kelly AFB, Texas, and Barbados, in September 1987; and Farnborough, England, and Sondrestrom, Greenland, in October 1987 to test such parameters as atmospheric attenuation at low elevation angles, Doppler effects, and signal performance at the edge of the spot beam.

While the dedicated C-18B aircraft (81-0898) was being modified in 1987-1988, the Test Wing continued to provide support for the Milstar program, preparing for the Developmental Test and Evaluation (DT&E) of the ARC-208 Airborne Command Post Milstar terminal in the C-18B. After the completion of the C-18B modification in 1988, the Test Wing used the C-135E as a cooperating terminal, testing the two aircraft together. During the DT&E of the ARC-208, the C-135E deployed with the C-18B to such places as Pease AFB, New Hampshire; Lajes AB, Azores; and Ascension Island. On January 1989, the Test Wing deployed to Lajes AB, Azores, and RAF Fairford, England, in a test of the newly launched British satellite, SKYNET 4B. This latter mission capitalized on the unique qualifications of the C-135E, the only test bed capable of performing this type of SATCOM support.

At the completion of the Milstar DT&E program in April 1990, the ARC-208 was removed from the dedicated C-18B and modified into the C-135E. This effort was completed in October 1991, at which time the Test Wing resumed testing of the terminal for the Milstar program. The C-135E provided the perfect platform for evaluating future changes to the terminal, such as major hardware and software upgrades. The Test Wing deployed to Eielson AFB, Alaska, and Easter Island (Chile) in November 1991, to accomplish regression tests on the newly installed ARC-208.

During 1992-1993, the C-135E test bed underwent modification to have a new antenna and composite window installed in the cargo door. The aircraft then deployed to Hickam AFB, Hawaii, to test the new antenna and window in performing an EHF noise test for the Navy. Subsequent deployments supported the gathering of intelligence imagery and traffic for Exercise GREEN FLAG at Hanscom AFB, Massachusetts; the gathering of ionospheric scintillation data at Sondrestrom, Greenland; and the testing of the newly acquired Milstar Engineering Developmental Model terminal.

Navstar Global Positioning System

Satellites were not only used to enhance communications between airborne and ground terminals, but were used to facilitate navigation of air, ground, and naval forces. In March 1977, the Test Wing began full scale testing of guidance systems using the Navstar Global Positioning System (GPS). The Navstar GPS was to consist of 18 Navstar satellites placed at regular intervals around three orbital rings, each inclined at 63° to the Equator, with an altitude of 12,425 miles and a period of 12 hours. Each satellite was designed to transmit in two different codes, one for military use, and the other for civilian use. The military code enabled the user to establish a position on Earth in three dimensions to within 16 yards and a velocity to within a few centimeters per second. The military signal was encrypted, highly resistant to jamming, and could be used in an all-weather environment.

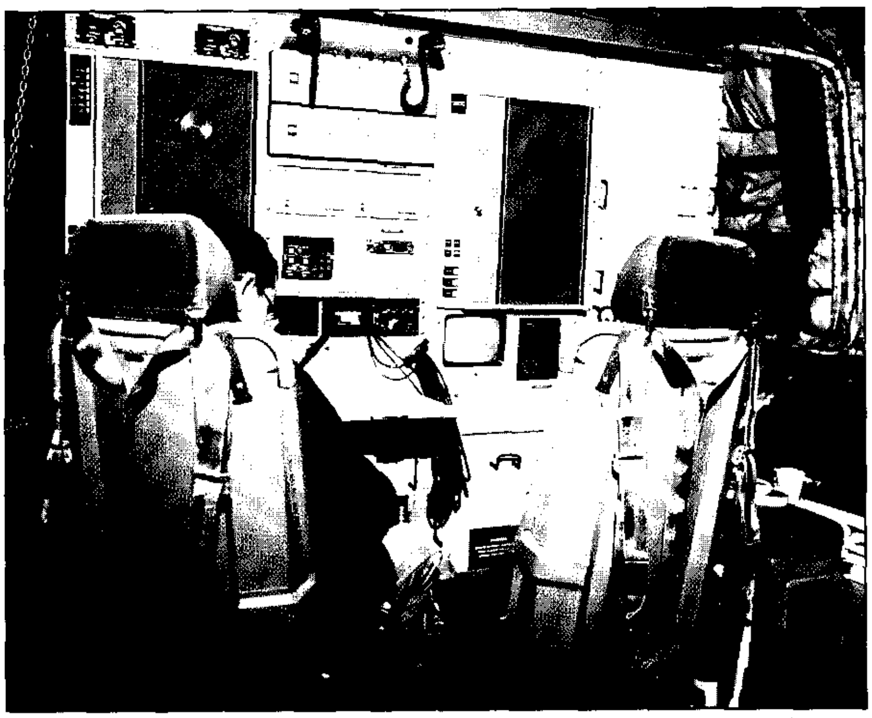
In the late 1970's, testing was conducted at the Yuma Proving Ground, Arizona, with an orbiting Navstar Satellite using a NC-141A (61-2776) as the test bed. In the second half of 1977, the Test Wing flew 38 flights in 84 hours. In August, the crew accomplished the first airborne lock-on to a GPS satellite signal, and demonstrated the simultaneous operation of the four-channel inertially-aided receiver, with one channel tracking the satellite signal. Meanwhile, the test bed underwent modification to accommodate the AFAL Generalized Development Model and associated antenna system.

In the late 1970's, testing was conducted at the Yuma Proving Ground, Arizona, with an orbiting Navstar Satellite, using a NC-141A (61-2776) as the test bed. It was nicknamed "Desert Rat" because of the amount of time spent supporting test programs in the southwest.

In early 1978, a second Navstar satellite was placed into orbit, and testing continued using the Yuma Proving Ground. In July, a third satellite was launched. Four different guidance systems were evaluated. In addition to the two original versions of GPS user equipment from General Dynamics, the Test Wing evaluated the Collins Jam Resistant Set, and the Texas Instruments High Dynamic User Set. The sets were tested in flying landing profiles, airborne rendezvous, and simulated Air Defense Identification Zone penetrations.

During the last half of 1979, the test bed first used GPS in a parachute aerial delivery to identify the air drop release point, while demonstrating the potential for using GPS navigation in all-weather parachute delivery. During the first half of 1980, the Test Wing gathered data on electronic countermeasures testing and tactical air drops. Also during this time, the Test Wing demonstrated the Navstar system to the Undersecretary of Defense for Research and Development. The reviewing party was impressed when the demonstrated air drops were well within the tolerances established for tactical performance. Also during 1980, the Test Wing installed and flight tested two variants of the null steering antenna system. Both versions demonstrated their capability to reduce the effects of external jamming sources, both ground-based and airborne, with GPS operation. A subsequent demonstration of the airdrop of training bundles using GPS, for the Assistant Secretary of Defense for Command Control and Communications, and Intelligence, led to the start of modification design work to provide a totally automated airdrop command and release capability on the test bed. This new capability was initially tested in December 1980, using a 4,000 pound cargo pallet.

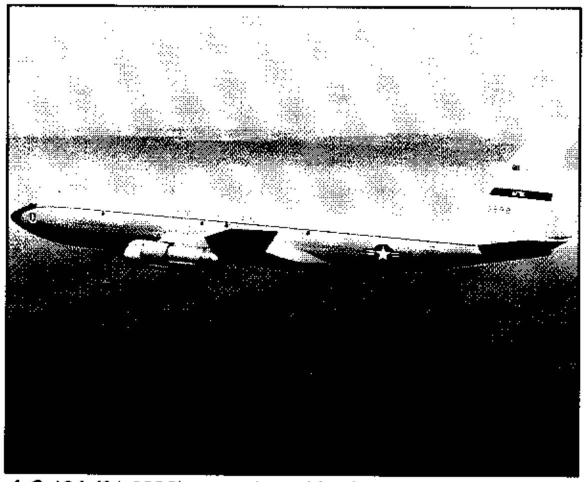
In 1981, Navstar Phase II was initiated. Managed by a Joint Program Office, the testing was divided between the Naval Air Test Center and the Test Wing. The purpose of this phase for the Test Wing was to provide flight test support for Developmental Test and Evaluation for the pre-production prototype of the airborne user equipment (receivers and antennas). In addition, the Test Wing was to maintain this capability so as to support special testing during and after Operational Test and Evaluation of the user equipment. After extensive testing in 1982 and 1983, the project was terminated in April 1984.



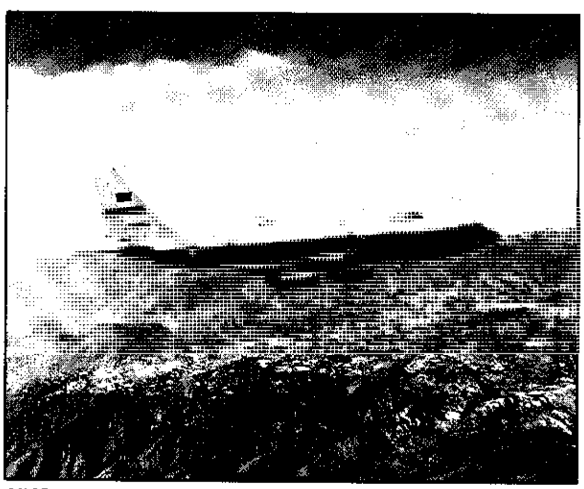
The purpose of Navstar Phase II was to provide flight test support for the pre-production prototype of the airborne user equipment.

Milstar

In the late 1980's, the Test Wing participated in the Milstar program (originally called MILSTAR for Military Strategic and Tactical Relay, but the acronym was later dropped), a high priority program to develop the nation's next generation military satellite communications system. The Test Wing's mission was to test and prove the feasibility of using an extremely high frequency/ultra high frequency (EHF/UHF) communications terminal for a fleet of PACER LINK aircraft. The object of the program was to develop a secure, survivable communications system using Milstar satellites. Electronic Systems Division (ESD) was the responsible development office, with Raytheon Company and Electrospace Systems, Inc., providing contracting support; and the Test Wing and Air Force Wright Aeronautical Laboratories (AFWAL) providing test and evaluation support.



A C-18A (81-0898) was selected for the terminal evaluation because it had similar operational characteristics of the EC-135.



NKC-135A (55-3122) was selected for the Milstar radome test.

The Test Wing's responsibility was to test the ARC-208 Full Scale Engineering Development (FSED) Airborne Command Post Milstar terminal, and to test the radome which would house the 26-inch Milstar satellite dish antenna on top of the aircraft fuselage. These two missions were essentially separate efforts and were run independently of each other. Although the operational aircraft would likely be an EC-135, a C-18A (81-0898) was selected for the terminal evaluation since it had very similar operational characteristics. An NKC-135A (55-3132) was selected for the radome test. The terminal test was divided into two phases. Phase I was the conversion of the C-18A to a C-18B, installing a military cockpit and navigation equipment. Phase IIa was the design of the Class II Milstar modification, and Phase IIb was the actual installation of the Milstar Class II modification.

Although the NKC-135A would be used for the complete radome test, the C-18B would also have a radome and would therefore require a radome flight test to clear a minimum operational envelope so the terminal test could proceed. The early C-18B radome flight tests in 1988 ended early when it appeared that the instrumentation and procedures were inadequate to ensure safe testing. Low damping ratios coupled with several uncertainties in material properties and fatigue analysis led to a suspension of the remaining tests until the completion of the wind tunnel testing and material properties analysis. The radome underwent a successful test flight in October 1988, but the second flight ended with six new areas of damage to the radome. Subsequent evaluations continued into 1989. During the final C-18B radome flight test in mid-1989, the crew, establishing the flight envelope at 0.78 indicated Mach number and 356 knots indicated air speed, performed several dynamic maneuvers testing the radome under extreme conditions, without the damage previously sustained.

With the basic envelope established for the C-18B, the Test Wing could begin testing of the ARC-208 Milstar terminal. The testing of this command, control, and communications terminal proved more successful with the establishment of the downlink and uplink communications with the satellite, and successful communications with the SATCOM aircraft, C-135E (60-0372) via satellite. Tests of the basic functionality of the ARC-208 at Pease AFB, New Hampshire, using both the C-18B and the SATCOM C-135E, went well, demonstrating consistently the ability of the terminal to establish successful downlinks and uplinks with the satellite. Follow-on tests included testing of the Navy Milstar terminal located at the Naval Ocean Systems Center, and participation in MILCOM '89, where the crew successfully passed secure EHF voice traffic to the Army terminal in Virginia during the flight home.

In January 1990, the C-18B deployed to Hickam AFB, Hawaii, to satisfy various test objectives including EHF low elevation performance. In April 1990, the C-18B completed a ten-day deployment to Lajes AB, Azores; Ascension Island; and RAF Mildenhall, England. The aircraft collected Milstar Developmental Test and Evaluation (DT&E) data with the SATCOM C-135E, providing airborne and ground support. While at RAF Mildenhall, the C-18B participated in an EHF multi-service interoperability test with the Army Milstar terminals located at the Pentagon and contractor facilities in Virginia. Participants successfully passed voice and teletype messages over the FLEETSAT EHF Package 8.

Between November 1989 and March 1990, the Test Wing performed airworthiness tests of the Milstar radome on the NKC-135A. Although the crew found that the radome could fly safely throughout the envelope defined for the C-135, it experienced delamination during certain tests. The resulting test report recommended that prior to the radome being declared airworthy without restrictions, a structural integrity program, including completion of the on-going materials characterization program, be conducted. At the end of 1990, the Test Wing planned to conduct hot-wet testing of the Kevlar-polyester radome material in January 1991.

At the conclusion of the terminal DT&E in April 1990, the C-18B was designated to support AFWAL on the Stellar Sensor Inertial System test program. At the conclusion of the Milstar radome tests, the NKC-135A was programmed to support AFWAL on the Airborne Bit Imagery Transmission program. Beginning in 1990, the ARC-208 Milstar terminal was installed in the SATCOM C-135E for continued support to the Milstar program.

Strategic Defense Initiative

In March 1983, President Reagan called upon America's scientists to provide the means to make nuclear weapons obsolete. Soon afterward, the United States reorganized its Ballistic Missile Defense (BMD) research programs and placed them under the heading of the Strategic Defense Initiative (SDI). The purpose of SDI was to investigate a range of BMD-related technologies to assess their potential. The research projects in SDI were grouped into five major categories: attack monitoring, directed energy weapons, kinetic energy weapons, systems analysis, and support programs. The Test Wing supported SDI during the Delta 180 testing, using its Optical Diagnostic Aircraft, and later Argus, to collect data critical to the design of small kinetic energy weapons that could destroy ballistic missiles during launch.

Optical Diagnostic Aircraft

In 1986, the Test Wing operated an NC-135A (60-0371), called the Optical Diagnostic Aircraft, for the support of the Strategic Defense Initiative. The SDI Organization (SDIO) controlled the testing, since the levels of classification often restricted the Test Wing's knowledge of the nature and purpose of the tests. Usually, the ODA crew flew the aircraft in flight patterns and operated the equipment in accordance with SDIO directives. SDIO itself, would then reduce the data and analyze the results. One of ODA's missions was to support space shuttle launches. At the beginning of 1986, however, the loss of the Space Shuttle Challenger postponed further ODA involvement in space shuttle launches.

Another important mission that ODA supported was the SDIO Delta 180 Test. For this test, the ODA was one of three Test Wing aircraft to cover the mission. The other two, EC-18B ARIAs, recorded data as the SDI spacecraft separated from the second stage of the Delta 180 rocket over the Indian Ocean. The Delta SDI mission provided data critical to the design of small kinetic energy weapons that could destroy ballistic missiles during launch. The scope of the test effort was impressive: six airborne aircraft, 38 radars, 31 satellite communications links, and coordination between the White Sands Missile Range with the Kwajalein Missile Range, and the Eastern and Western Test Ranges. The four objectives of the mission were to 1) identify a solid propellant booster plume in the upper atmosphere from 200 miles away, 2) identify liquid fueled booster upper stage plumes to prove that kill vehicles could attack Intercontinental Ballistic Missiles (ICBM), 3) identify a simulated Soviet reentry vehicle that at different times was either maneuvering or coasting in space, and 4) use various sensors and advanced computer programs with radar homing devices to demonstrate a kinetic energy kill.

In 1986, the ODA aircraft participated in the last test of the SDI spacecraft. After the Maverick infrared system on the SDI spacecraft identified the hot spot of an ascending Minuteman second stage launched from White Sands, the spacecraft and the Delta second stage separated at about 120 miles. At this time, the SDI spacecraft used its Phoenix radar to identify the Delta second stage. While ground controllers kept the Delta second stage on a stable path, the SDI spacecraft actively maneuvered toward it. The SDI spacecraft, moving at 6,500 miles per hour, managed a direct hit on the Delta second stage, right while the ODA aircraft and a Gates Learjet photographed the collision. The television view of the collision showed two plumes of fire merging and a brilliant flash as they collided. Both the President and the Secretary of Defense viewed the "visually spectacular imagery" taken by the equipment on the ODA. The Delta 180 mission was the last SDI program for the ODA. Subsequent SDIO missions were supported by the Argus program.


The Test Wing operated this NC-135A (60-0371) in support of the Strategic Defense Initiative as first, the Optical Diagnostic Aircraft, and later as Argus. The aircraft had previously been utilized as the Airborne Laser Laboratory Diagnostic aircraft with the forward right set of patterns used for laser targeting.

Argus

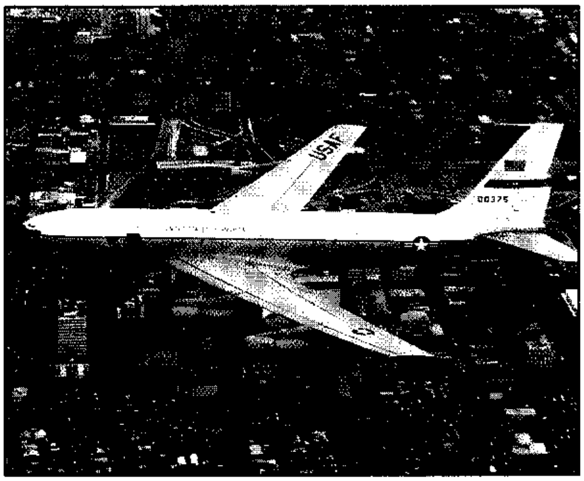
The NC-135A, previously used as the ODA, continued to support SDIO testing directed by the Phillips Laboratory under the Argus program. Modifications to the Argus aircraft, named after the Greek mythical god with multiple eyes, included replacement of the star cast camera system with a high resolution camera system, consisting of a 100-inch focal length telescope with a zoom video camera, to be used for target acquisition and tracking. A cast glance IIA camera system, a ballistic camera, and a wide field of view camera remained on the aircraft. Despite numerous technical difficulties in installing the modifications, the aircraft was ready for testing by the end of June 1987. In August 1987, the Wing installed the components of an infrared spectrometer system, except for the camera, which was to be added later in New Mexico. In December, the Wing installed equipment from Lawrence Livermore National Laboratory that gave Argus enhanced optical capabilities. SDI planned to use the Argus aircraft in November 1987 for both a Delta 181 program and a program called Superglide. Also in November 1987, Argus deployed to the United Kingdom where it participated in the classified Royal Shield missions, as well as gathered signature data on British aircraft.

During 1988, the Argus crew flew equipment shakedown missions, viewing targets of opportunity, as the project team completed most of the Lawrence Livermore National Laboratory Phase II modifications. In February 1988, SDIO scheduled Argus for a program called Janus 1A, and a support mission for the Delta 181 Program. Also during this time, a private contractor relocated an IR camera so that three sensors, the IT imaging camera, the IR spectrometer, and the dual wave infrared radiometer, could operate simultaneously.

In 1989, technical responsibility of Argus transferred from the Test Wing to the Air Force Weapons Laboratory. The Test Wing retained responsibility for the cockpit and many flight aspects of Argus test missions, while the Air Force Weapons Laboratory managed the test equipment and the sensor suite aboard the aircraft. Argus supported numerous missions during 1989, including SDIO missions, a Royal Shield test, a shakedown flight for a new high-resolution camera, the Delta Star mission, and the Global Positioning Satellite Delta launch.

In 1990, Argus deployed three times; once for NASA's space shuttle program, providing reentry vehicle attitude and roll rate of the external tank as it reentered the atmosphere and broke up south of Hawaii; and twice for SDIO tests. Also in 1990, the Air Force Weapons Laboratory and the Test Wing modified Argus with new optical disc recorders, global positioning system, wide angle camera pointing system, and a central air data computer.

During 1991, Argus flew two missions for the Defense Nuclear Agency, which aided the Agency's ongoing efforts to support Conventional Forces of Europe and Open Skies treaties. During this effort, Argus pointed its sensors at simulated and actual Soviet Bloc weaponry on the ground to determine whether the United States could verify treaty compliance. It was on a DNA mission that the Argus aircraft (60-0371) flew its last operational sortie in September 1991, completing its service life.

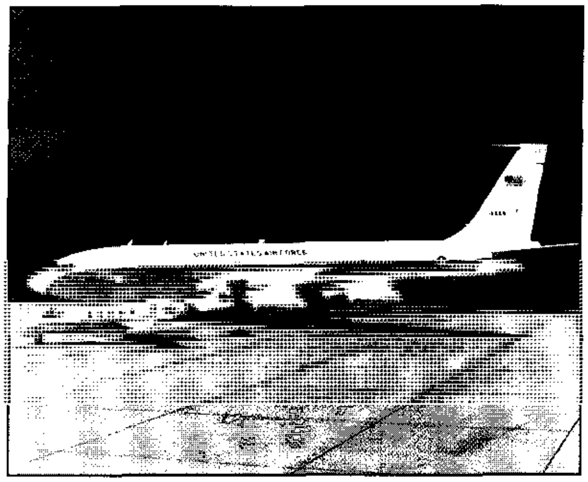

The success of the Argus program led DoD to approve modifying an EC-135E (60-0375) to continue the Argus mission.

The success of the Argus program led DoD to approve modifying another aircraft to perform the Argus mission. Modification of Argus II, an EC-135E (60-0375) neared completion at the end of 1991. The modifications included installing an aft personnel door, test racks, a cargo door, two steerable mirrors, a cryogenic pallet, a safe, bunks, and antennas; and removing the ARIA nose. By the end of 1991, the Test Wing had spent approximately $1.85 million on the modification. The Test Wing completed final modification in April 1992. Despite the fact that the Test Wing judged the modification to be somewhat incomplete and inadequate, the aircraft flew its first test mission in July 1992. During the mission the aircraft flew with a waiver for the sensor modules that did not meet 9G crash requirements. Over the next few months, these shortcomings were resolved to produce Argus II as a viable data gathering tool.

In 1993, Argus II continued its mission. The Airborne Laser Exercise (ABLEX) missions flown out of Fairchild AFB, Washington, provided data vital to the development of a laser weapon system capable of destroying airborne missiles.

Special Projects

The Test Wing also conducted programs, that while not dedicated to a sole test objective, provided a test bed for multiple research and development projects that applied advanced technology to making aircraft systems more reliable and easier to support in the field. The two test beds were named Speckled Trout and Speckled Minnow. In 1989, the Test Wing was designated the center of expertise for testing commercial aircraft for military application. This effort, which had been conducted by the Test Wing for years prior, focused on procuring "off-the-shelf" commercial aircraft and modifying them for military use, using established Federal Aviation Administration certification standards.



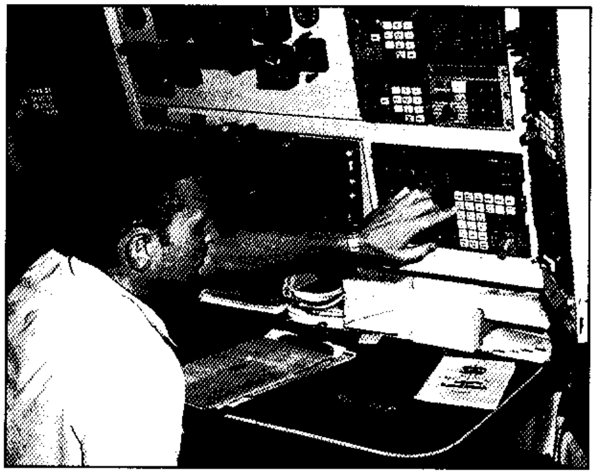
Speckled Trout, a C-135C (61-2669), and Speckled Minnow, a C-21A (84-0098) were multi-purpose test beds that flight tested advanced technologies for application in the field.

Speckled Trout

In mid-1957, Gen. Curtis E. LeMay, the newly appointed Air Force Vice Chief of Staff, ordered the transfer of the last test bed KC-135 from Edwards AFB, California, to Andrews AFB, D.C. Although the aircraft continued to have a test and evaluation mission during the first few years at Andrews, it was also used to transport numerous distinguished civilian and military leaders. Within six months of its formation, the unit was named Speckled Trout in honor of a program monitor, Faye Trout, who was instrumental in many phases of the project. The adjective "speckled" came from Ms. Trout's numerous freckles. In November 1957, the Speckled Trout aircraft received national recognition by breaking a world speed record with General LeMay and crew flying from Buenos Aires to Washington National Airport in 11 hours and 5 minutes.

In its 36-year history, Speckled Trout has been assigned to numerous commands and organizations. Originally, General LeMay placed it under the 1st Airborne Command and Control Squadron, Military Air Transport Service, until 1961 when it was transferred to the Headquarters Command. In 1976, after the Command inactivated, Speckled Trout was transferred to Air Force Systems Command as Detachment 1 of the 4950th Test Wing. The original KC-135 was replaced in July 1975 by the current C-135C (61-2669). It could accommodate 20 passengers and featured a distinguished visitor and staff compartment. There was a limited baggage storage area because a significant portion of the aircraft was reserved for avionics and test equipment.

Under the Test Wing, Speckled Trout continued as a research and development test bed for the Air Force Wright Aeronautical Laboratories' Flight Dynamics Laboratory. Its projects included the testing of autopilot systems, automatic navigational systems, radar evaluations, and, in the mid 1980's, voice-activated control systems. Aside from AFWAL-related projects, the Federal Aviation Administration (FAA) and private industry also utilized the test bed aircraft in the mid-1970's, to acquire and reduce navigation information to study radical position errors, based on the position data of the reference system used. In 1976, there were ten navigation systems being evaluated, involving six contractors, Teledyne, Litton, Collins, C. Marconi, Global and Honeywell. Sperry Rand was later added to the list. The project utilized the reference systems by Collins (overland) and Honeywell (over water). Other systems evaluated included the Ring Gyro Laser, a laser navigational system to determine accuracy over various flight durations and locations; the Safe Flight Wing Shear program, a prototype system to determine the adequacy of wing shear warning; the Center of Gravity Fuel Level Advisory System, a program to evaluate the relationship between center of gravity and fuel level readings; and the Auto Throttle System, a project to determine flight safety implications.



One of the navigation systems tested on Speckled Trout was the Standard Precision Navigator/Gimballed Electrostatic Aircraft Navigation System (SPN/GEANS), developed by the Air Force Avionics Laboratory under contract to Honeywell, Inc.

During 1985, adjustments in the program made it more cost effective for the users. Supervision of the project was transferred from the Test Wing to Air Force Systems Command during March in response to instructions from the Vice Commander. The new memorandum of agreement removed the Aeronautical Systems Division and the Test Wing from any responsibility for operational oversight of the project. Consequently, the unit began operating in an autonomous mode with the Detachment Commander having the authority to direct flight operations and approve Class II modifications.

In 1988, Speckled Trout underwent the first of two aircraft modifications titled Transport Aircraft Avionics Cockpit Enhancement, Phases A and B. Ultimately these modifications resulted in a $42 million upgrade including a Boeing 757/767 glass cockpit, a CRT-based engine indication and crew alerting system, a fully integrated flight management system, and an auxiliary power unit. These upgrades formed the basis of the avionics architecture for the KC-135 avionics modernization program.

In an effort to optimize mission reliability, integrating the functions of operations, test/engineering and logistics under one commander, and as a result of DoD test consolidation initiatives, Speckled Trout was transferred to Edwards, AFB, California, on 1 October 1992, and placed directly under the Air Force Flight Test Center Commander in a detachment status. The unit retained all of its authority, functional capabilities, and both test and airlift missions.

Speckled Minnow

Speckled Minnow, a smaller transport, was incorporated into the Speckled Trout Project at the direction of Gen. George S. Brown, Air Force Chief of Staff, in February 1974. In the early 1980's, the Test Wing used this T-39A (62-4478) for testing of research and development projects. The purpose of this effort was to apply state-of-the-art technology to aircraft systems in order to make them more reliable and easier to support in the field. Research areas included radar, telemetry, communications, scoring systems, data processing, and electromagnetic interference. After recording 298 flying hours in fiscal year 1984, the Air Force decided to retire the T-39A.

In July 1984, the Air Staff informed Air Force Systems Command that a C-21A would be the new Speckled Minnow aircraft. On 31 July, Air Force personnel met with the contractor, Gates Learjet, to discuss the conversion. The test bed aircraft would have a crew of three: pilot, copilot, and crew chief. The Air Force accepted the C-21A (84-0098) in November 1984, and it was delivered to Detachment 1 of the Test Wing at Andrews AFB, D.C. In August 1991, Speckled Minnow was excessed from the Test Wing inventory, remaining stationed at Andrews AFB, D.C.

Testing Commercial Aircraft for Military Applications

In 1989, Air Force Systems Command formally designated the Test Wing the center of expertise (COE) for commercial derivative testing. The Testing Commercial Aircraft for Military Application (TCAMA) mission had already been performed since 1983 by the Test Wing, as evidenced by previous records indicating that 16 of the past 19 models of USAF transport aircraft had been procured, configured, and tested using commercial aircraft already in existence (See Figure 11 for list of general types). This increasing tendency to buy "off-the-shelf" aircraft led the Test Wing to create a TCAMA office to support flight test for these procurements. The new organization saved the Air Force time and money by using commercial or Federal Aviation Administration validated data already in existence. Test Wing personnel attended the FAA's training academy to learn FAA certification standards. Accepting FAA certification, the Air Force then proceeded to conduct only those tests specifically required to meet military requirements.

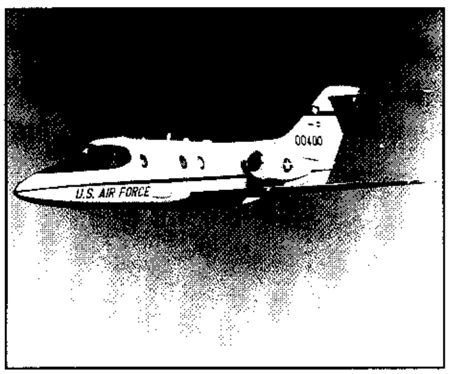
COMMERCIAL TESTING

MILITARY DESIGNATION	COMMERCIAL VERSION
C-130	
C-5B	
C-17	
KC-10	DC-10-30
C-12F	BEECH KING AIR
C-18	707-320
C-20'S	GULFSTREAM III
C-21'S	LEAR 35
C-22'S	BOEING 727
C-23	SHORTS 330
VC-25A	BOEING 747
C-26	METRO III
C-27	C-STOL
C-29	BAe-125

figure 11

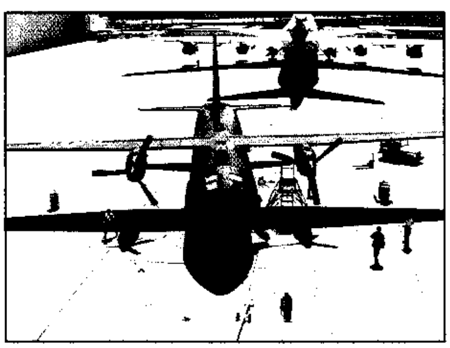
The TCAMA office managed the Air Force One Replacement program, selecting a uniquely modified Boeing 747 to replace the aging Boeing 707 which had been used for Presidential travel for 30 years.

In 1990, the TCAMA office managed three major programs, the Air Force One, the Tanker Transport Training System (T1-A), and the Commercial Short Takeoff and Landing (CSTOL) C-27. Continuing to manage a program previously managed by the ASD's Directorate of Transport and Trainers, the Test Wing conducted the qualification test and evaluation of the system functional requirements, as well as technical order verification for the Air Force One Replacement Program. The prospective aircraft were two VC-25A (Boeing 747-2G4B). Modifications to the aircraft included new General Electric CF-6-80 engines, a new three-position communications suite, a microwave landing system, dual auxiliary power units, a triple ring laser inertial navigation system, a global positioning system, an electronic flight instrument system, air refueling, and self defense systems. When the FAA imposed new requirements for the fire suppression systems on board, the delivery schedule was threatened and the rollout delayed. Boeing proceeded to redesign the lower lobe fire suppression system, rolling out the first aircraft in September 1989. In all, the aircraft underwent over a year's worth of ground testing, and 200 hours of flight testing. The first aircraft was delivered to the President in August of 1990 with the second in December. The Test Wing continued to work on the technical orders until late in 1991.



The Beech 400A was selected as the new Air Training Command's T-1A Jayhawk trainer.

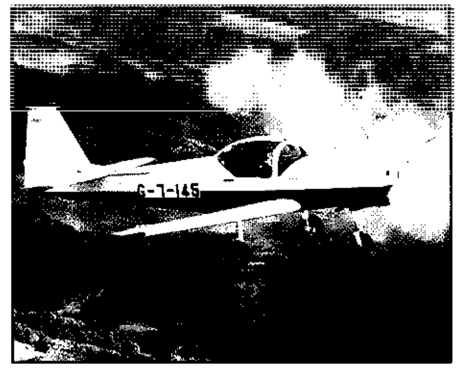
In 1991, the TCAMA office managed the T-1A Jayhawk (formerly called the Tanker Transport Training System). This aircraft was designed to provide support for Air Training Command. Out of the three candidate aircraft produced by Learjet, Cessna, and Beech, the Beech 400A was selected. During this time, the T-1A underwent 30 hours of qualification test and evaluation flight testing. This included evaluating performance and handling qualities, addressing differences in military performance requirements as well as defining common student errors. Because the air-to-air tactical air navigation function did not satisfy performance requirements, the Test Wing delayed formation flying, air-to-air tactical air navigation testing, and systems checks. At the end of the year, the test organizations were planning the required stall tests. The stall program, or low speed handling/flying qualities flight test program was completed by February 1993. During 1993, the Test Wing also conducted the Barrier Roll-over Test, to determine if the T-1A could roll over a BAK 12/13 arresting cable on the runway without damaging the nose gear.



The Alenia G-222, redesignated C-27 STOL, provided airlift and airdrop of personnel and equipment in an intratheater scenario.

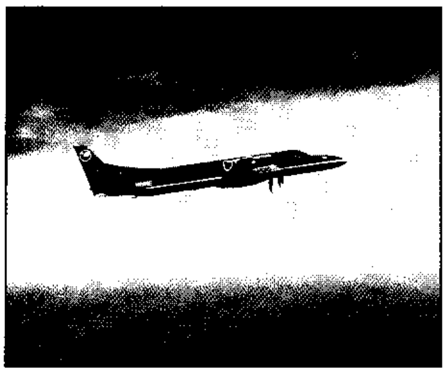
The C-27 Short Takeoff and Landing (STOL) intratheater airlift aircraft program involved the procurement of ten Aeritalia (later Alenia) G-222 aircraft for Military Airlift Command. Beginning in 1991, flight testing, conducted in Italy and Waco, Texas, evaluated loading capabilities, airdrops of equipment and personnel, and STOL operations. In September 1991, the hung jumper retrieval tests required retrieving 13 duffel bags and a 300-pound jumper through the right paratroop door. This met with better success than the second test, retrieving 23 duffel bags through the cargo ramp door that got caught on externally mounted hooks. Subsequent problems necessitated additional operational test and evaluation. The aircraft was determined to be operational in October 1991.

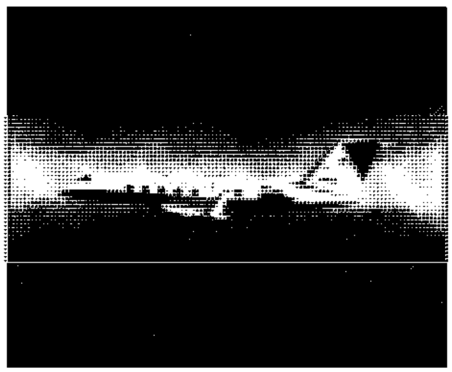
Another TCAMA program was the Enhanced Flight Screener, a replacement for the T-41A. The Air Force planned to buy 120 aircraft for flight training. Evaluated by the US Air Force Academy in 1990, and the Test Wing in 1991, the Slingsby's T-3A "Firefly" was selected out of eight manufacturers. Qualification test and evaluation was scheduled to begin in October 1993.



The Slingsby T-3A "Firefly" was selected out of eight competitors for the Air Force's Enhanced Flight Screener.

In 1991, the TCAMA office continued to manage other test programs including the Mission Support Aircraft, similar to the existing C-26A; and the C-20, a follow-on to the original C-20 Special Airlift Mission Program which went from being a competitive procurement to a sole source purchase of the Gulfstream IV. The test team completed Phase I testing on the C-20H in October 1992, with Phase II scheduled for fall of 1993.





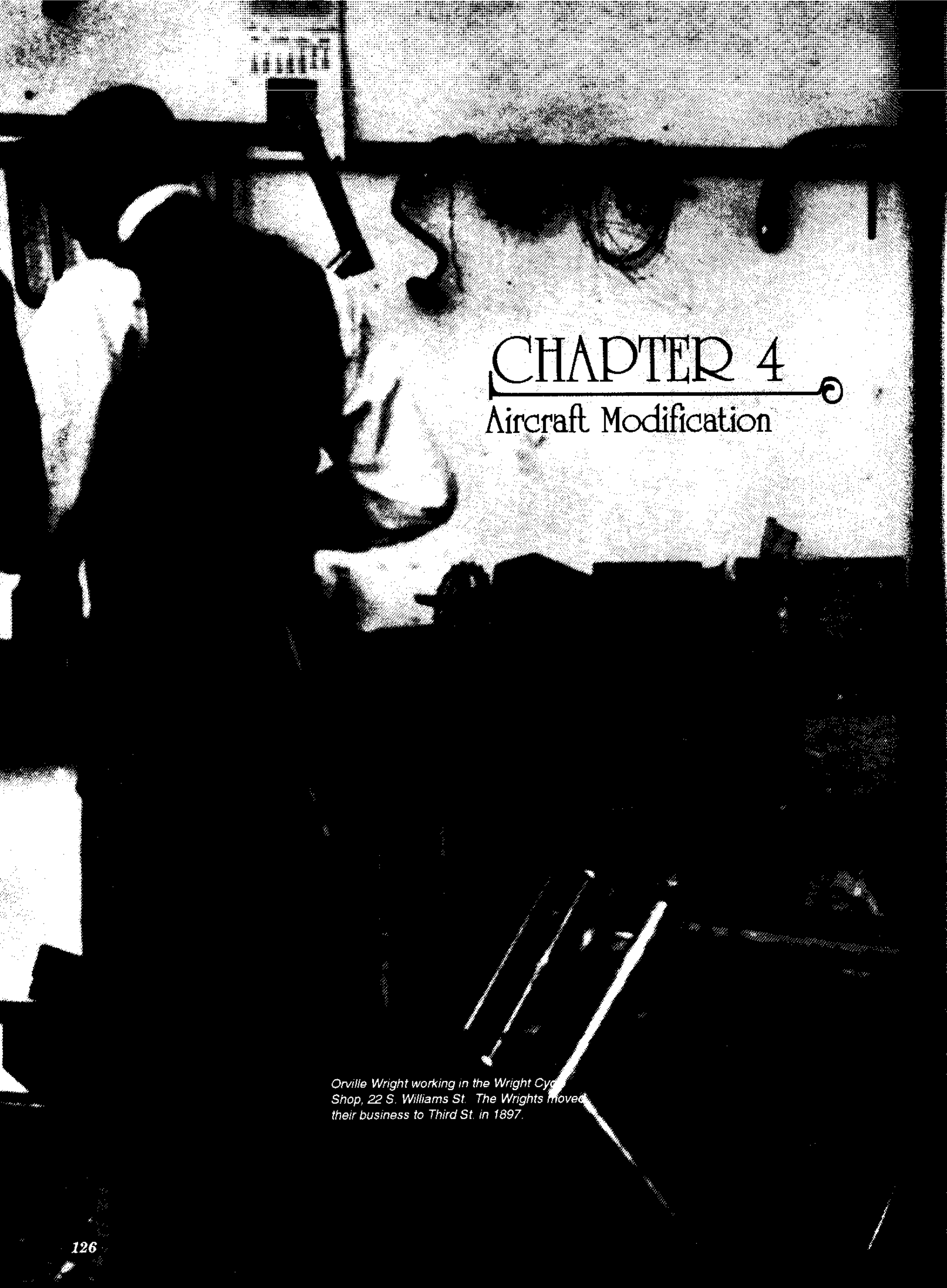
The TCAMA office managed and tested replacements for mission support aircraft such as the C-26B, the Metro 3 by Fairchild (left); and the C-20B, the Gulfstream 3 (right).

The Joint Primary Air Training System (JPATS) Program is another procurement being handled by the TCAMA office. Determined to be the largest DoD commercial acquisition at $7.5 billion, this aircraft will be used by the Air Force and Navy for initial flight training. In July and August 1992, the test team completed the operational demonstration, with source selection scheduled for 1994. Qualification Test and Evaluation will follow in 1994-1995.

Conclusion

Testing tomorrow's technology today is the mission of the 4950th Test Wing. As the Test Wing moves on to its new home at Edwards AFB, California, the members of this integrated test team will continue to apply their experience and expertise to realize that objective. As the Cold War ceases to pose a threat, the military will face new and different missions. This unique test team will no doubt be instrumental in testing and evaluating the new weapon systems needed to meet the challenges of tomorrow.

CHAPTER 4
Aircraft Modification



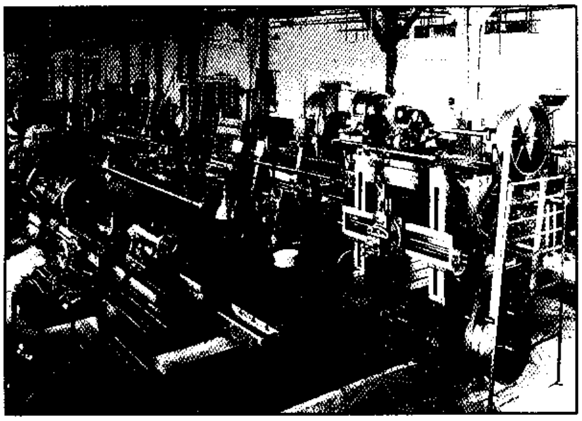
Orville Wright working in the Wright Cycle Shop, 22 S. Williams St. The Wrights moved their business to Third St. in 1897.

The history of aircraft modification begins in a back room at 1127 West Third Street, Dayton, Ohio. There, in the workshop of the Wright Cycle Company, Wilbur and Orville Wright and their mechanic, Charles Taylor, worked and reworked the contours and mechanisms of the world's first successful heavier-than-air flying machines. Beginning with kites and glider craft and proceeding ultimately to the engine-powered Flyers familiar to history, the Wright brothers embarked upon a quest to perfect aeronautical form and performance that continues to this day. That quest has involved tireless experimentation with demonstrator aircraft and equipment, experimentation that would be unthinkable without the skilled hands and agile minds of craftsmen and engineers, experts in the modification of aircraft and their components.

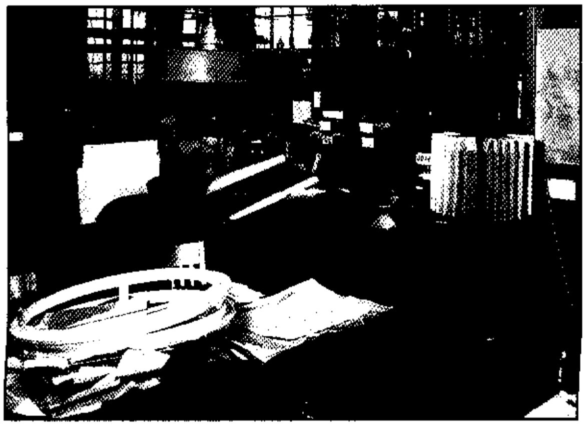
Today Dayton, Ohio, is still the home of aircraft modification. Rising above the tarmac of Wright-Patterson Air Force Base's Area C is Building 206, the headquarters of the Aeronautical Systems Center's Developmental Manufacturing and Modification Facility (DMMF). This massive building of concrete, steel, and glass, over three stories high and covering several acres, dwarfs the replica of the Wright hangar at the other end of Huffman Prairie. The juxtaposition of these two structures expresses better than words how far aircraft modification has come since the dawn of the twentieth century and the birth of the airplane. From three men in a cramped workshop strewn with bicycle gear, aircraft modification today is a multi-million dollar concern, employing some of the most skilled craftsmen and competent engineers in both government and industry and commanding some of the most sophisticated computer-driven precision machinery in the world. The center of this activity is Wright-Patterson Air Force Base and will remain so even after the flying elements of the 4950th Test Wing decamp to the high desert country of southern California.

From Factory to Mod Center, 1917 to 1975

There is thus something appropriate in the fact that the first buildings constructed at McCook Field in the autumn of 1917 were for shops. There were four of these originally, for metal, wood, unit assembly, and final assembly. Together, they constituted what was called the "Factory." During World War I and for several years thereafter, the Factory was responsible for the construction of entire demonstrator aircraft, from nuts and bolts to wings and fuselage. For this reason, it recruited all over the United States for "finished mechanic[s] looking for new worlds to conquer." How exciting this opportunity must have appeared for "resourceful, self-dependent, experienced and intelligent" journeymen, skilled in woodworking and metalworking—even blacksmithing. This was an age when "every piece has to be formed and worked out by hand," where the fate of test pilots and expensive experimental equipment depended upon the experienced eye and trained hand of men whose fathers and grandfathers had crafted iron horses and conestoga wagons.



Machine Shop, McCook Field.



Machine Shop office, McCook Field.

McCook's Metal Shop consisted of four branches: the Machine Shop, the Airplane Fittings Branch, the Sheet Metal Branch, and the Heat Treatment Department. In the Machine Shop the machinery was arranged to avoid unnecessary trips from one end of the shop to the other. Machines included the Niles vertical boring mill, the Lucas and Giddings and Lewis horizontal boring machines, the LeBlond 25-inch lathe, the Newton slotter, the 30-inch Gray slotter, two Etna swaging machines, automatic and hand screw machines, and a Toledo compound press. The shop also included two electric furnaces, two gas furnaces, two brazing furnaces, and a blacksmith forge. In the machine shop, craftsmen machined castings; built and repaired bomb sights, reversible propeller hubs, and machine guns; and stamped out metal propeller tips. They also manufactured—literally made by hand—bolts, screws, nuts, turnbuckle ends, barrels, and clevis pins of nonstandard shapes and sizes for use in demonstrator aircraft and equipment. The Metal Fittings Branch manufactured and repaired metal fittings for the fuselage, wings, landing gear, stabilizer, elevator, and rudder sections of airplanes. In the Sheet Metal Shop, otherwise known as the "Tin Shop", skilled workers made all the oil and gas tanks, cowlings, fairings, ammunition cases, chutes, and radiators. They performed intricate tube bending, difficult welds, and beautiful metal spinning. The Heat Treatment Department was furnished with furnaces and anvils. Here were forged all aircraft and gun parts.

MODIFICATION (mod-i-fi-CA-shun), n.

What is a "modification"? What does it mean to "modify" an airplane? Webster's Third International Dictionary (unabridged) defines modification with great brevity as an "alteration or change of a partial character" or the "result of such alteration." The Air Force is less concise, but more precise, in defining its use and understanding of this term.

Members of Wright-Patterson's modification community refer to "Class II" modifications as their line of expertise. In fact, the Air Force recognizes five classes of modifications. Class I modifications are temporary removals or installations of, or changes to, equipment for special missions or purposes. Class III modifications are those required to insure production continuity. Class IV modifications are made to insure the safety of flight, to correct deficiencies that impede mission accomplishment, or that improve logistics support. Class V modifications involve the installation or removal of equipment in order to change the mission capability of present (aircraft) system configuration. Class II modifications, on the other hand, are primarily temporary modifications in support of research, development, and operational test and evaluation efforts.

Although Class II modifications are those most frequently performed at Wright-Patterson, as a research, development, and testing installation, they have not been the only kind performed here. During the Second World War, the Materiel Command's Production Division's Modification Section managed a nationwide network of modification centers. The centers had been established to modify aircraft in response to changing operational requirements and to alleviate aircraft manufacturers from the necessity of expensive and time-consuming retooling of production lines. The centers were operated by the repair and maintenance shops of the nation's major airlines. By 1944 the Production Division had established standard procedures for modifications down to the last rivet on the production line—the so-called "block system."

Unlike these more or less permanent modifications during the production process of aircraft, most of what the current modification community at Wright-Patterson does is temporary in nature. Indeed, much of the DMMF's installation work force's time is spent in "demodifying" aircraft, following flight test. Demodification involves the removal of equipment or otherwise restoring aircraft to the configuration existing prior to their original modification and testing. Ironically, one of the modification community's most challenging modifications, the OC-135B Open Skies, was a Class V permanent modification.

The Wood Shop was divided into five subunits, for fuselage, wings and empennage, propellers, and pattern and woodworking machinery. The war years and the first half of the 1920s, when aircraft were still made mostly of wood and fabric, were the glory days for those skilled in woodworking. The Wood Shop crafted the C-1, XB-1, XB-2, USD-9, and the USD-9A, each having a different type of body. The shop was especially proud of its share in producing the fuselage of the Verville pursuit airplane, which was entirely different from any other produced up to that time. Shop workers also cooperated with engineers in the Material Section in the development of wood parts of greater strength, lighter weight, and the use of cheaper, more abundant woods. With the development of better glues, plywood came increasingly into use as well.

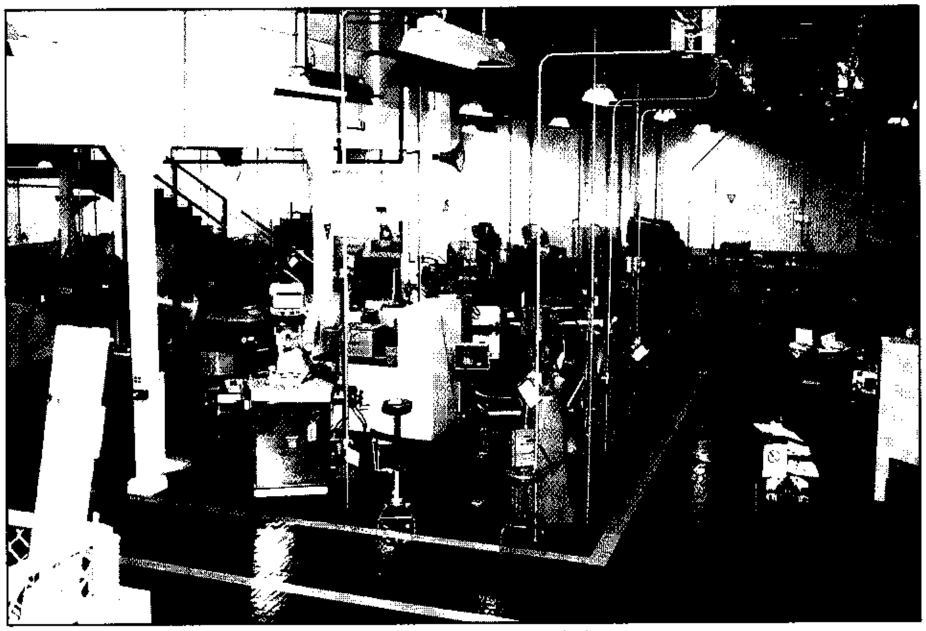
Wood Shop, McCook Field.

The variety of work performed in the Metal and Wood Shops easily exceeded that done by any production plant of the time. In 1919 there were approximately 150 men in the shops. They were kept busy by no fewer than 50 big jobs on the books at all times.

Aircraft Assembly, McCook Field.

Like most other organizations at McCook and Wright Fields, including the Flying Section, the shops were redesignated and reorganized many times over the years. In 1918 the shops were listed under the Engineering Section of the Equipment Division. In 1923 the Factory Section, including the shops, reported to the Assistant Chief of the Engineering Division. This arrangement apparently remained the same until 1926, when the Shops Branch was placed under the Repair and Maintenance Section of the Chief of the Materiel Division. In 1928, the Shops Branch, including the Machine, Wood, and Sheet Metal shops and Planes Assembly and Planning subdivisions, reported to the Repair Section. By the mid-1930s, the shops once again had been placed under the Engineering Section, this time as the Engineering Shops Branch. The Engineering Shops Branch included the Machine Shop, Sheet Metal and Metal Fitting Shop, the Wood and Propeller Shop, in addition to Final Assembly, Fuel Injection, Ignition, and Supercharger sections. By 1939, the Engineering Shops Branch had been redesignated the Engineering Shops Laboratory reporting to the Experimental Engineering Section. Also included in the Experimental Engineering Section were the Wright Field laboratories, for Armament, Materials, and Power Plants and Propellers. We thus see at an early date the close association of the shops, on the one hand with maintenance and repair and, on the other, with research and engineering. This "see saw" association would continue throughout reorganizations during the 1940s, '50s, '60s, and '70s. In fact, the shops served both communities from the very beginning in 1917.

THE ZONE SHOPS

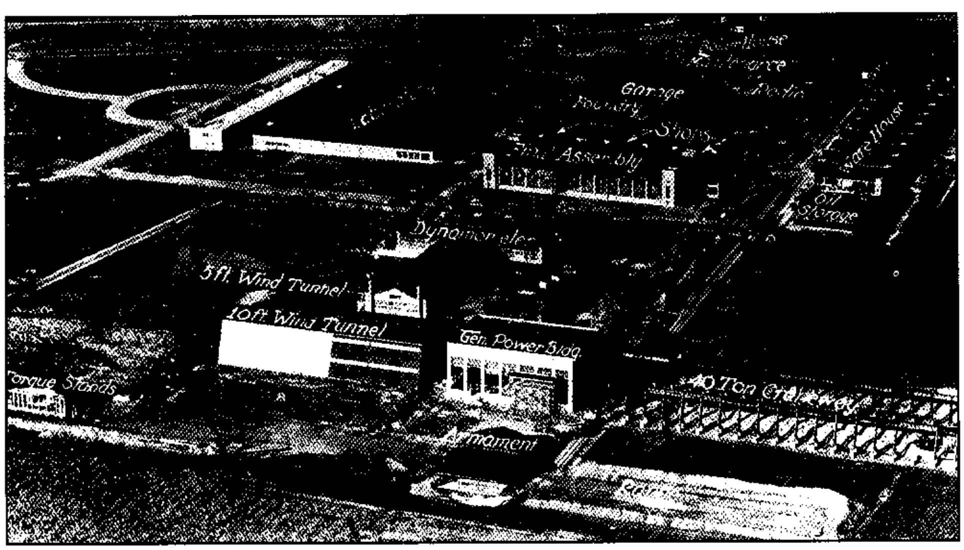

Zone Shop #2, Supporting the Materials Directorate, Wright Laboratory.

As early as McCook Field days, the fabrication shops provided support to both the flight test community and the laboratories. Although much of the support provided to the laboratories consisted of experimental equipment and devices for flight testing, the shops also fabricated components for laboratory facilities, indeed, sometimes built entire facilities—such as wind tunnels—from scratch. Much of this work was accomplished by the main shop complex, which from 1944 was located in Building 5 of Wright Field (now Area B). However, in addition to the shops in Building 5, there were also smaller shop operations located in other buildings. These were the so-called "zone shops." Their purpose was primarily to serve the laboratories, providing them with quick turn-around service on projects large and small.

At one time there were as many as 30 zone shops. By 1975, when the Modification Center was established, this number had dwindled to five. Zone Shop #1 was located in Building 18 and served the Aero Propulsion Laboratory. Zone Shop #2 was located in Building 5 and served the Materials Laboratory. Zone Shop #3 was in Building 620 and provided support to the Avionics Laboratory. Zone Shop #4 was in Building 24C and supported wind tunnel research by the Flight Dynamics Laboratory. Zone Shop #5 was located in Building 145 and supported the Flight Dynamics Laboratory's cockpit and flight simulation programs. Although each zone shop was dedicated to a specific laboratory or technology area, they would also share work when one shop was overbooked, working an extended project, or when a zone shop was closed. In 1979 when Zone Shop #3 was discontinued, other zone shops, such as Zone Shop #5 assumed much of the workload for the Avionics Laboratory.

There are fewer zone shops today than there were in the past. There are also fewer personnel assigned to them. The typical zone shop in 1993 had between eight to ten journeymen machinists, including the supervisor. This contrasted with the shops in the 'sixties and 'seventies that might have upwards of 30 workers. This reduction in the size of the shops was due to overall reductions in shop personnel, from the mid 1970s; it was also due to the installation of less labor intensive, computer driven, precision machinery. All the zone shops had at least one computer numerically controlled machine as well as other state-of-the-art equipment.

For the most part, the work of the zone shops consisted of small jobs such as milling flat plate models for wing simulation tests in wind tunnels (Zone Shop #4). On occasion, however, the shops were called upon to machine parts for entire facilities. Zone Shop #1 fabricated a complete ducted rocket water tunnel for ramjet testing at the request of the Aero Propulsion Laboratory. Zone Shop #5 machined all the parts for the Flight Dynamics Laboratory's Large Amplitude Multimode Aerospace Research Simulator (LAMARS) facility, with the exception of the dome, and recently completed work on the MS-1 simulator, also for the laboratory.



Aerial View, Wright Field, ca. 1935, showing buildings for final assembly, shops, and the foundry.

With the inauguration of Wright Field in 1927, the shops took up quarters in brand new facilities at the corner of what is now D Street and 5th Avenue, Area B. Unlike the facilities at McCook, which were largely built of wood, the new shop facilities were constructed of concrete and brick. The most conspicuous part of the new shops structure was the final assembly building (Building 31). Rising three stories, this spacious structure served not only for final assembly of experimental aircraft but also housed a facility for static and dynamic structural testing, performed on aircraft before they entered flight test. During World War II, it also acquired a facility for testing landing gear. Atop its southeast corner was Wright Field's first aircraft control tower. Adjoining the final assembly building were three one-story structures housing the metal, machine, and wood shops. Originally considered part of the final assembly building, they were enlarged in 1941 and subsequently designated a separate structure (Building 32). Behind the shops along D Street was the foundry building (Building 46). At first, this was a temporary structure, constructed of corrugated sheet iron salvaged from McCook Field. In 1929 the sheet iron was replaced with brick, and in 1938 the entire structure was lengthened. The foundry served both the shops and the Materials Laboratory. (Indeed, in 1943, after the shops once more relocated—see below—the Materials Laboratory moved into this structure, where portions of the lab remained until 1990 when Materials Laboratory complex was completed.)

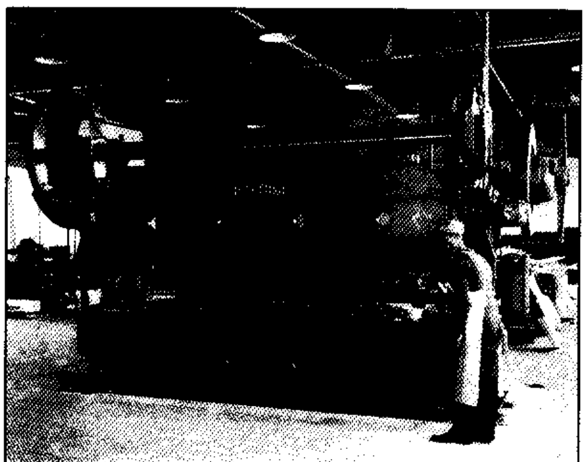
MACHINE SHOP, EARLY WRIGHT FIELD

STRAIGHT SIDE POWER PRESS
CAPACITY 88 TON TABLE 32"x48"

PUNCH AND FORMING PRESS
CAPACITY 35 TON

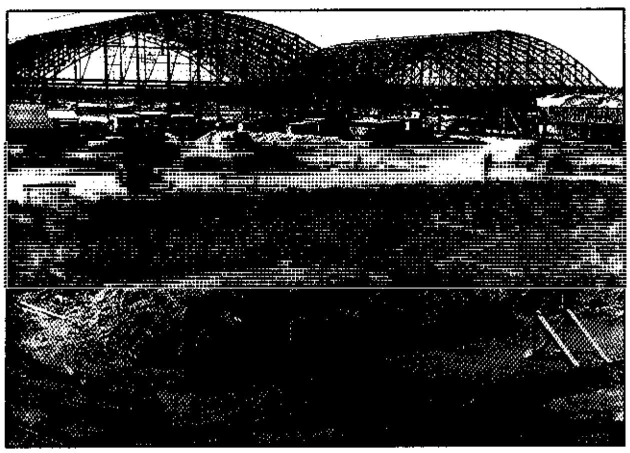
SHEET METAL CUTTER
3/16" CAPACITY. 33" THROAT.

DRILL POINTER
CAPACITY 1/4" TO 1 3/4"

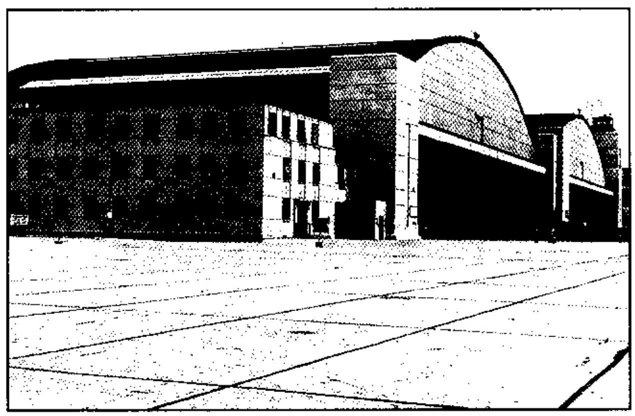


POWER PRESS BRAKE
3/16" x 14 FT. CAPACITY

The Second World War generated a frenzy of activity at Wright Field. To accommodate the increase in workload, there was a nearly tenfold increase in the number of structures (see Chapter 1). A number of functions moved to new quarters during the war, including the engineering shops. The new shops complex was sited along the new concrete flightline, running northwest-southeast. It consisted essentially of two large hangars (Hangars 1 and 9), and two modification shop buildings (Buildings 4 and 5). The two hangars were virtually identical in construction and size. Both were made of steel reinforced concrete with a three-hinged barrel vault roof supported by composite trusses of wood and steel. Each hangar was 191 feet deep, 593 feet wide, and 90 feet high in the center. The main doors of each were 250 feet wide and 38 feet high. Hangar 1, designated "Flight Test Hangar No. 1", served bomber maintenance. Hangar 9, designated "Experimental Installation Hangar No. 9", served the final assembly of experimental aircraft. (Hangar 9 was also known as the "689 Hangar" after Form 689, which modification engineers completed when evaluating a manufacturer's aircraft for design, safety, and specification compliance.) Hangar 9 was connected with the shops (Building 5) through a large doorway in the rear. Building 5 was a vast, square one-story structure housing the wood, machine, and metal shops. It was covered by a nine-section barrel vault roof, each vault pierced by a long gable-style skylight. Building 5 was extended twice to the south in 1953 and again in 1954 to incorporate the foundry (Building 72) and then a two-story covered craneway, which was added to provide access to heavy freight and equipment delivered by means of a railroad spur on the east side of the building. Both hangars and the shop building were constructed in 1943. In 1944, a second shop facility (Building 4) was added for so-called "accelerated" modifications. Building 4 was a hangar-like structure built mostly of concrete since metal and seasoned wood were becoming scarce and expensive. It consisted of five hangar bays all of which originally housed modification activities. (Modification continued to be performed in bays A and B until the early 1960s; in the 1980s they were taken over for use by the Avionics Laboratory. In 1973, the Air Force Museum acquired bays C, D, and E for aircraft restoration and the preparation of museum displays.)

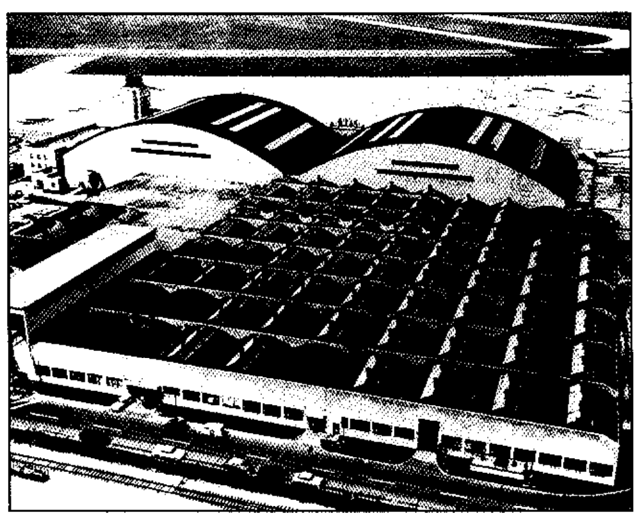


Installation hangars (Buildings 1 and 9) under construction, ca. 1943.



Installation hangars shortly after completion. Sign (far left, center) reads: "Headquarters, Engineering Shops, Engineering Division."

Engineering Shops building (Building 5) under construction, 1943.



Aerial View of Engineering Shops building, shortly after completion.

At the outset of World War II the Engineering Shops Laboratory continued as a part of the Engineering Division of the Materiel Command. The Laboratory included a Machine Shop, Wood Shop, Sheet Metal Shop, and Installation Branch. Under the Air Technical Service Command (ATSC), which superseded the Materiel Command in August 1944, the Engineering Shops joined the Aircraft Projects and Engineering Standards in the Service Engineering Section. In 1945 the Engineering Shops Laboratory consisted of the Machine Shop Branch, Pattern and Model Branch, Metal Shop Branch, Installations Branch, and Planning Branch. In the reorganization of ATSC in 1946, the shops were placed in the Engineering Division together with the Flight Test and All Flying divisions, and the Maintenance Division, under the Deputy Commanding General for Engineering. This organizational structure continued under the Air Materiel Command (AMC), which superseded the ATSC later in 1946.

THE FAIRFIELD AIR DEPOT

Although the history of flight test in the Miami Valley up to the 1940s was primarily the history of activities at McCook Field and Wright Field, the "other side" of what later became Wright-Patterson AFB played a role as well.

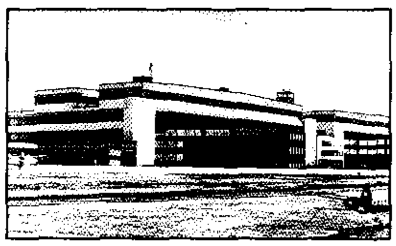
American military aviation on the site of the present Wright-Patterson AFB began in 1917 with the creation of Wilbur Wright Field. Nearby, the U.S. Army Signal Corps soon constructed the Fairfield Aviation General Supply Depot, where the primary mission was providing supply support to America's wartime training operations. After the end of the First World War, the depot changed names several times, finally becoming the Fairfield Air Depot (FAD) when the site was designated Patterson Field in 1931. The Fairfield Air Depot remained a separate organization until 1946. During their existence, FAD and its predecessor units occupied the major portion of Patterson Field, and functioned as a major logistical center for American military aviation through the end of the Second World War.

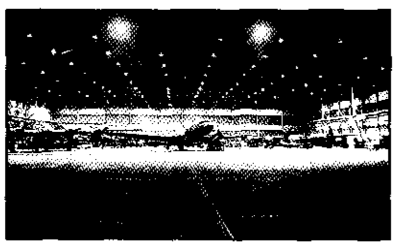
In that role, FAD personnel were often called upon to provide the support necessary to major test activities and demonstrations. In 1924 Fairfield depot personnel packed and shipped supplies and equipment to locations all over the world to support the Army Air Service's "Round-the-World Flight" of four Douglas "World Cruiser" aircraft. The supplies necessary for this flight—the first circumnavigation of the globe by air—were placed in boxes specially constructed of selected ash, spruce, and plywood which could be used to repair wooden aircraft components in the field, if necessary. In 1925, the Fairfield depot assumed control for the Air Service's Model Airway System, an experimental airway which was the first in the nation to operate regularly-scheduled flights between fixed points. Other notable activities in the interwar years included support to the 1924 Air Races held at Wilbur Wright Field, the 1931 Air Corps maneuvers, and to the 1934 long-distance Alaskan flight organized by then Lt Col Henry H. "Hap" Arnold. Throughout the 1920s and 1930s aerial demonstration flights such as these served to supplement the flight test activities conducted at McCook and Wright Fields.

The Second World War brought enormous expansion to the Fairfield Air Depot, as it did to every Army Air Forces facility. The legacy of that expansion lasted long after the war in physical facilities that went on to serve the 4950th Test Wing. Building 206 in Area C at Wright-Patterson AFB, for example, was constructed in 1941 as an airplane repair facility, while also providing offices for Patterson Field Operations. Also located in Building 206, the FADO (Fairfield Air Depot—Operations) Hotel became a welcome, if cramped resting place for transient pilots during the war.

Hotel FADO, World War II.


World War II pilots relax at Hotel FADO.


Building 206, shortly after construction.


Minor Repair Air Dock, Building 206, during World War II.

The Second World War and its immediate aftermath not only affected the shops organizationally. The period also witnessed considerable dislocation in personnel. Many younger workers, recruited just prior to the war, either volunteered or were drafted into the armed forces after 7 December 1941. Their places were taken by others, who served their country, albeit as civilians, working in the shops throughout the conflict. With the drawdown in manpower following the war, however, many of these workers as well as many older hands were displaced by returning veterans, who, because of their military service, could claim priority in reductions-in-force. This procedure worked some hardship and caused considerable ill-feeling, especially among older workers, who found themselves "going out the gate" after twenty or more years work for the government. Many veterans, on the other hand, who had been guaranteed their old positions on returning to work at Wright Field, found management unwilling or obstructionist in fulfilling these guarantees. It would take several years before war's disruptions were smoothed out and the shops returned to even keel.

The postwar period witnessed several major organizational changes that affected either directly or indirectly the work of the shops at Wright Field. In 1947, the Air Force became an independent service. In 1951 the Air Force leadership decided to separate the research and development activities from AMC and place them under a new command, the Air Research and Development Command (ARDC). At Wright-Patterson AFB, this led to the creation of the Wright Air Development Center (WADC), which included the shops. Under WADC the shops were initially placed in the Materiel Division, which included branches for Fabrication and Maintenance. In 1952, WADC placed the shops in the Directorate of Support, which included an Experimental Fabrication Branch and an Air Installation Branch. In 1955 the Directorate of Support was redesignated the Directorate of Materiel. In 1957, the Directorate of Materiel reverted to its previous designation. The Support directorate included an Experimental Fabrication Division and an Experimental Modification Division. This was the first time that the term "modification" was used to designate organizationally a function of the shops.

The end of the 1950s brought with it another round of reductions in force (1958-1960). The manpower drawdown was occasioned by a combination of continued fiscal restraint by the Eisenhower administration—which did not spare the Department of Defense (DOD) to keep the national budget in balance—and a more urgent emphasis on missile and space systems technology in the wake of recent Soviet successes in space. The result was reduced funding for aeronautical research and development for WADC's flight test and modification communities. The ensuing manpower reductions were substantial, upwards of 50 percent in some areas of the shops. As in the case of the reductions in the immediate postwar period, this drawdown caused considerable hardship for both younger workers with insufficient seniority to retain their jobs and even older workers, if they were not veterans of World War II or Korea.

In the early 1960s the Air Force once more reshuffled its deck of organizations. In 1961 ARDC became the Air Force Systems Command (AFSC). At Wright-Patterson, WADC was superseded, first by the Wright Air Development Division (1959), and then by the Aeronautical Systems Division (ASD). Under ASD, the shops and flight testing were combined in one line organization for the first time since the late 1940s, in the Deputy of Test and Support. Within this deputate, the Fabrication and Modification Division, which had the shops, was located under the Directorate of Maintenance, together with divisions for Bombers, Fighters, Cargo Aircraft, Armament, and Aerospace Ground Equipment. In 1963 the Deputy for Test and Support was renamed the Deputy for Flight Test. By 1968, the Deputy for Flight Test was redesignated the Directorate of Flight Test.

The 1960s had thus witnessed the close association, within one organization, of the shops with flight testing. This association formed the foundation of the 4950th Test Wing. The 1970s would see the modification function of the shops form its own line organization for the first time since the Factory Branch of McCook Field days. When the 4950th Test Wing was created in 1971, the shops were still included with the maintenance function in the Materiel Division, which was renamed the Logistics Division before the end of 1971. This organizational arrangement remained the same until 1975. In that year, the Air Force once more underwent a major reorganization and drawdown of forces under the code name Project HAVE CAR. The Test Wing acquired additional assets and an expanded mission as a result of these developments (see Chapter 1).

BIRTH OF THE GUNSHIP

One of the most dramatically effective weapon systems ever developed by the Air Force was the gunship. The gunship was not a new idea. Indeed, the concept of an aircraft capable of side firing in a pylon-turn maneuver had been around since the 1920s. Nor was the gunship the result of advanced technology. In fact, the first gunship was concocted entirely from an ancient airframe and spare parts by the Deputy for Flight Test's Fabrication and Modification Division.

The time was the 1960s during the height of America's Vietnam involvement. The Air Force needed an aircraft capable of air-to-ground operations in adverse weather and at night. The aircraft had to be capable of hitting relatively small targets, such as trucks in convoy used by the North Vietnamese to resupply their forces in the South. It had to be able to loiter for considerable time over target without itself being especially vulnerable to groundfire. Remarkably, no such weapon system existed in the Air Force arsenal up to that time.

Building upon a C-47 airframe (the venerable DC-3), the Fabrication and Modification Division produced the first gunship, the AC-47, in a matter of weeks. The Division's modification personnel took an old gun sight (purportedly from a display aircraft in the USAF Museum at Wright-Patterson) and mounted it in a side window of the airframe. The Division designed and installed an electrical system for firing the guns, three 7.62 millimeter gun pods using the Gatling gun principle, secured by gun mounts also fabricated by the Division. The firing mechanism was operated by a DC motor, actuated by the pilot.

Following a brief series of flight tests, conducted by ASD's Deputy for Flight Test, the AC-47 was sent to Vietnam for operational testing. There, in some 52 combat missions, the gunship proved dramatically successful and won the affectionate appellation "Puff the Magic Dragon," for the fearsome noise of its guns. Pacific Air Forces (PACAF) immediately ordered 16 gunships; the Air Staff supplied twenty.

Characteristically the Air Force soon wanted a larger gunship with improved range and firepower. Again, the task of developing this was given to the Fabrication and Modification Division's engineers and shop workers. This time things went more slowly, and it was over a year before the first AC-130 was ready for operational use. The main challenge arose in developing the fire control computer, which allowed the pilot to fire only when all the on-board sensors were in alignment. The computer was developed by the Air Force Avionics Laboratory at Wright-Patterson and fabricated by the Division. Meanwhile, the Division modified a Cessna 337 aircraft to test the concept of using a side firing small caliber gatling gun in a light aircraft. Another problem was finding a battery system to run the gun turret's DC motor. The motor, designed by General Electric specifically for the AC-130, ran on a 12-volt battery. Unfortunately, the gunship's other electrical systems all operated on 24 volts. The Fab and Mod Division got around this difficulty by requisitioning old 12-volt lead-acid batteries from B-47 and T-33 aircraft, where they had been employed for engine starting. The Division's electrical engineers also surmounted sticky problems in designing switches for the gunship's on-board sensors.

Flight testing was initially conducted by the Directorate of Flight Test; the aircraft was then sent to Vietnam for operational testing. On its return from Vietnam, where like the AC-47 it proved dramatically effective, the AC-130 underwent further modification at Wright-Patterson. This time, the Fab and Mod Division reinforced the floor against gun vibrations and replaced a searchlight on the rear door, used in nighttime operations, with a sensor capable of detecting ignition discharges from enemy ground vehicles.

The Air Force acquired a dozen AC-130s. Indeed, so successful did this weapon system prove that the Congress authorized the acquisition of a dozen more in the early 1980s.

The Fabrication and Modification Division especially benefited from HAVE CAR. The transfer of the 17th Bombardment Wing of the Strategic Air Command from Wright-Patterson AFB, opened up Building 206, Area C. There the Division moved its aircraft installation operation from hangars 1 and 9, Area B, which it had occupied since World War II. (Hangars 1 and 9 had proved inadequate in housing the larger aircraft developed after World War II, especially the C-141 transport, whose tail section was too high for the 38-foot high hangar doors. Building 206's 49-foot doors offered a 10-foot clearance to the Starlifter.) The Division also moved its engineering department to Building 206, where it took up quarters in rooms once used, during World War II, for transient pilots (see box).

Under the aegis of Project HAVE CAR, the Test Wing itself underwent an internal reorganization. One result of this reorganization was the creation of a separate Deputy for Aircraft Modification, called the "Mod Center," for short.

The Mod Center, 1975-1991

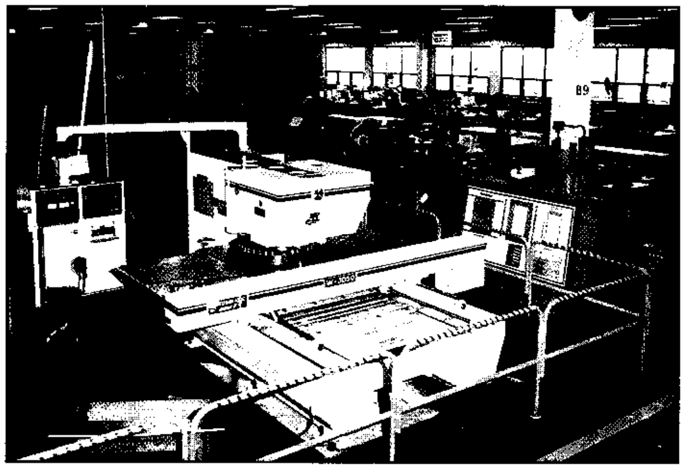
The creation of the Mod Center in 1975 was not just another reorganization. It marked the beginnings of a "corporate culture" within the aircraft modification community at Wright-Patterson that would lead ultimately to the creation of the Developmental Manufacturing and Modification Facility in the early 1990s. More immediately, the creation of the Mod Center resulted in the formalization of management and the introduction of new techniques and equipment, in short, a whole new way of doing business for a community whose methods and processes had changed little from techniques learned before World War II.

These older techniques could best be called "cut and fit." Great reliance was placed on the experienced eye and the trained hand. The skill of individual shop workers was at a premium because their equipment was often old—some even dating back to McCook Field—and, by modern standards, imprecise. There was, moreover, a corresponding informality between the engineers and scientists and the shop floor workers. When an engineer wanted a part made in the shops, he would talk it over with the worker who would make that part. Often there were no formal blueprints or drawings—a rough sketch would do. This system had worked well enough for over half a century. However, beginning in the 1970s it came up short in face of a revolution in business management and computerization of the workplace.

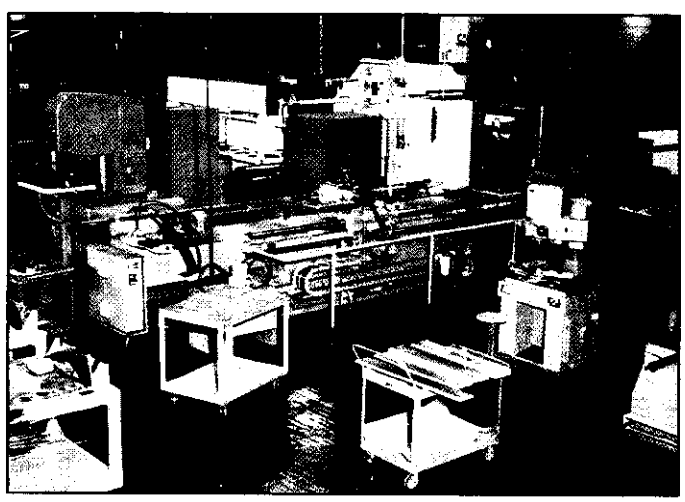
It had, moreover, not worked all that well even in days of yore. Much of the shops' reimbursable business came from "captive customers"—the flight test and laboratory communities—that were compelled by regulation to bring their projects to the shops before going elsewhere. This system was both inflexible from the customer's standpoint and failed to provide sufficient incentives for innovation on the shop floor.

The old system, furthermore, placed far too much emphasis on skilled craftsmen, men who had honed their skills over a lifetime of work in the shops. In the late 1970s these men, largely World War II veterans, were beginning to retire. Indeed, by 1980 there was a turnover of over 75 percent of the Mod Center's work force due to retirements. This presented both problems and opportunities to Mod Center management. In the short term, the Mod Center was confronted with the difficulty of replacing skilled personnel at a time of Air Force downsizing following the Vietnam war. In the long term, Mod Center management was given the opportunity to mold a future work force, one more easily adapted to new technologies and processes.

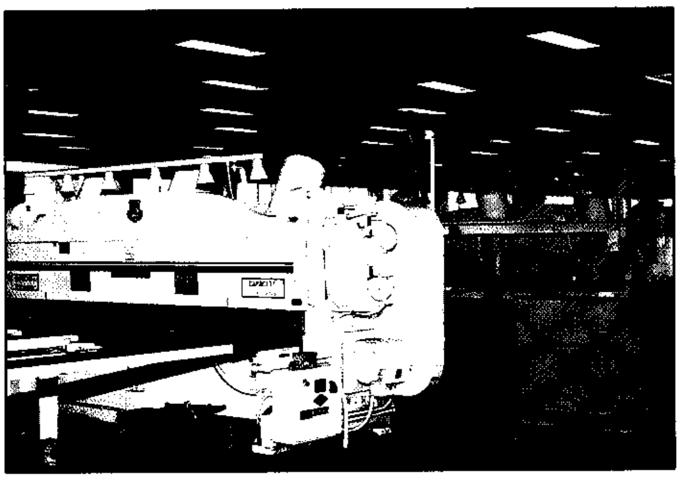
The computerization of the workplace offered the greatest prospect for increasing the overall efficiency of the Mod Center's operations. Computerization promised to assist both the Mod Center's engineering and shops functions. Engineering would benefit from computer aided design (CAD) processes. In the late 1970s and early 1980s, the Mod Center remade its engineering and shop operations with the introduction of CAD/CAM (computer aided manufacturing) networks.


Overview of Modern Sheet Metal Shop, Building 5.

The Mod Center began to install the first CAD workstations in 1980. Engineering design work that had taken months and yards of linen paper for blueprints could be accomplished in weeks or days with CAD. This not only increased the efficiency of producing such plans. It also allowed a greater "paper trail" to be constructed in the machining and manufacture of required parts.

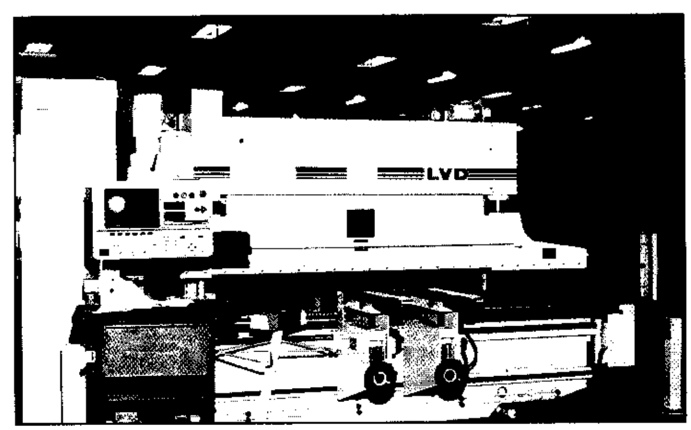

Tube Bending Machine, used for both tubing and waveguide forming, Building 5.

The Mod Center followed the installation of the CAD system with the introduction of CAM machinery on the shop floor. Prior to this time, the shops had installed several small numerically controlled milling machines. To these were now added computer numerically controlled (CNC) machines, that were microprocessor controlled on the shop floor, and direct numerically controlled (DNC) machines that were controlled from a central computer. Installation of these new systems began in the sheet metalworking and machining areas, where the majority of major flight modifications were performed. The installation of CAM machinery resulted in dramatically greater productivity. Projects that had taken days or weeks could now be done in a matter of hours or days. The new computer driven machinery also enhanced the reproducibility of parts, ensuring that when more than one of a particular part was needed, they were more nearly identical in size and shape than those crafted by hand. Finally, the new equipment permitted minor modifications to be made on the shop floor, as needed, thus obviating unnecessary engineering turnaround time and saving material from what might have become scrap parts.



Two CNC aluminum and steel sheers, Building 5.

By 1986 the Mod Center had 54 interactive CAE design workstations and 21 computer aided machines for manufacture. However, well before this the new system began to show dramatic dividends. One early use of the system was in modifying the cockpit of the T-39 trainer aircraft. The CAD system, first of all, revealed the optimum placement of instruments, thus avoiding the earlier practice of making cardboard or wooden iterative mockups. On the shop floor CAD reduced the number of engineering change orders, thus saving time, material, and the number of workers assigned to the task. The first major test of the new system, however, was the ARIA conversion modification (see box). The CAD system alone reduced costs nearly 40 percent while producing more than 800 drawings involving more than 2,500 separate parts in record time.



CNC LVD brake, a five-axis programmable production brake, Building 5.

Mod Center Projects and Programs

Despite the dramatic advances in aeronautics over the years since 1917, the essential work of the modification shops changed little. Indeed, the most important change occurred at the outset of their history, in the 1920s. Up to about the middle of the decade, the metal and wood shops that comprised the Factory were responsible for the actual manufacture of prototype aircraft for flight testing. Due to the protests of the nascent American aeronautical industry, anxious to secure government contracts in the depressed post-World War I marketplace, the Engineering Division transferred the responsibility of designing and building prototypes to industry; the Engineering Shops henceforth would content themselves with inspecting, modifying, and repairing these commercially produced aircraft. This still left much for the shops to do, and the work required journeymen and engineers of the highest caliber. Nor did it exclude the shops from occasionally producing a prototype weapon system, testing platform, or specialized mission aircraft. In the 1960s the Fabrication and Modification Division designed and configured the first gunships, using C-47 and C-130 aircraft (see box). Likewise, in the 1980s, the Modification Center designed and reconfigured the 4950th Test Wing's Advanced Range Instrumentation Aircraft (ARIA) fleet (see box), building on the Boeing 707 (C-18) airframe. Finally, in the 1990s the Developmental Manufacturing and Modification Facility designed and built the OC-135B to secure U.S. compliance with the Open Skies international overflight treaty (see box).

CNC strippit combination 30-ton punching center with 1500-watt CO2 laser, Building 5.

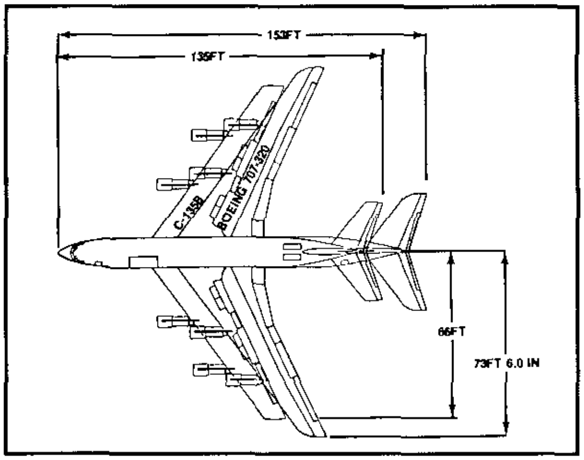
In addition to modifying aircraft, however, the modification community was kept busy supporting ongoing research and development conducted by the many laboratories at Wright-Patterson AFB. This included, among other things, the design and fabrication of propellers for testing by the Propeller Laboratory in the 1920s, '30s, and '40s. (Not to be overlooked, of course, was work in repair of damaged propellers or the manufacture of replacement propellers for test aircraft.) This support of the laboratories was performed both by the central shops as well as by special "zone shops," collocated with the laboratories for more immediate support (see box). The shops also lent support to the maintenance community. In the 1930s, for instance, they designed and built a jack capable of lifting the largest aircraft then extant.

Overview of CNC milling machine, Building 5.

The shops also worked on some truly extra-ordinary projects. In the early 1950s, the shops fabricated an experimental space capsule mock-up for the Aero Medical Laboratory. (The capsule would have been a complete success had its electrical disposal apparatus worked properly. Not to worry, however: the shops maintenance crew exchanged the defective article for a chemical device, much to the relief of the five-man "astronaut" crew!) In 1976, craftsmen of the Mod Center were called upon to design and fabricate a time capsule in honor of the nation's bicentennial. The capsule was made of corrosion resistant steel covered with lead and fiberglass. The cover created a hermetic seal and was bolted in place. Filled with documents, prints, and microfilm of aircraft developed at Wright-Patterson as well as newspaper and magazine articles of contemporary events, the capsule was buried in front of the USAF Museum.

THE ARIA MOD

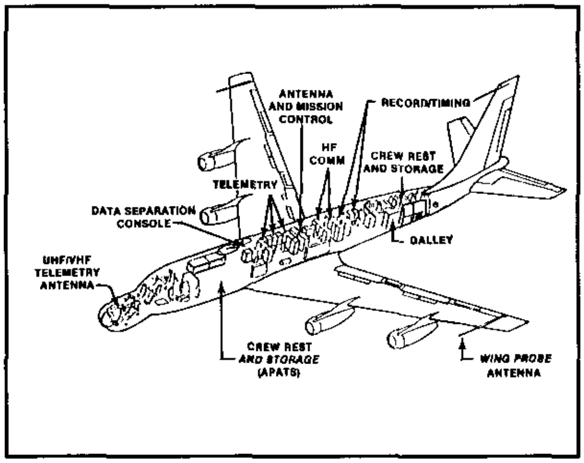
In the early 1980s, the Modification Center undertook the most ambitious project in its history. This project involved upgrading the 4950th Test Wing's Advanced Range Instrumention Aircraft (ARIA) fleet.



Comparison of C-135B with Boeing 707-320 aircraft.

ARIA had originally stood for *Apollo* Range Instrumentation Aircraft. The ARIA fleet consisted of eight C-135s configured by McDonnell Douglas and the Bendix Corporation to receive and transmit astronaut voice communications and record telemetry data for NASA's Apollo space program. The ARIA fleet operated out of Patrick AFB, Florida, home of the Air Force's Eastern Test Range (AFETR). As part of Project HAVE CAR in 1975, the ARIA aircraft were transferred to Wright-Patterson AFB, and assigned to the 4950th Test Wing.

The ARIA fleet that the Test Wing inherited consisted of six EC-135N and two EC-135B aircraft. They were conspicuous for their elongated, bulbous radomes, protruding from the nose of the aircraft. The 10-foot long radomes housed a 7-foot tracking antenna that was vital in performing the ARIA mission: gathering telemetry data from ballistic missile reentry tests, satellite launches, and Army Pershing and air launched cruise missile tests, and spacecraft. In addition to the military services, the ARIA also collected data for the National Oceanographic and Atmospheric Administration and NASA.



C/EC ARIA Configuration.

The Test Wing's ARIA fleet underwent continual modification. For the most part this involved the addition of specialized equipment in response to changing data gathering requirements (see Chapter 3). However, in 1981, the Test Wing embarked on a more ambitious upgrade of its ARIA fleet. This consisted of the replacement of four of the original ARIA with larger airframes to extend mission range and provide more room for test crews and equipment.

The "new" airframes were retired Boeing 707-320C aircraft purchased by the Air Force from American Airlines in 1982. Indeed, the first step in the conversion from the EC-135N to the EC-18B—the designation for the new ARIA—was the repair of corrosion damage and strengthening other parts of the 707 structure. Mod Center engineers also redesigned the 707 cockpit to conform to Air Force standards. Other modifications included the installation of an improved environmental control system, modified electrical system, and the addition of a small radome to the top of the aircraft for real-time telemetry relay and the installation of wingtip probe antennas for high frequency radio transmission and reception.

Wherever possible, instrumentation and components were transferred from the EC-135N to the EC-18B. This included the large nose radome and all prime military electronic equipment (PMEE) such as consoles, antennas, and unique supporting equipment. Mod Center installation experts also transferred the EC-135N's flight control instrumentation, engine instrumentation, communication equipment, navigation equipment, and support equipment, replacing that of the 707. All this, of course, required Mod Center engineers and shop workers to design and manufacture special fittings, wiring, and other interface components.

Mod Center engineers were assisted in their work on the ARIA by computer aided design (CAD) equipment. Using CAD workstations, they generated more than 800 drawings involving more than 2500 different parts in less than two years. This first major use of the new CAD equipment by the Mod Center helped reduce the number of engineering changes from four or five to less than two per drawing and reduced estimated design costs nearly forty percent. The Mod Center rolled out the first EC-18B ARIA to the 4950th Test Wing on 4 January 1985. Speaking at the roll out ceremony, Lt General Thomas McMullen, commander of ASD, declared it an "Air Force first." The new aircraft was in operation by the end of 1985, following a series of flight tests conducted by the Test Wing's Flight Test Division.

The Mod Center completed the fourth and last EC-18B in 1987. The total cost to the Air Force was $25 million: $6 million for the purchase of the 707 aircraft and $19 million for the conversion process. Although this project placed great demands on Modification Center personnel and facilities for nearly five years, the final bill was pleasing to the Air Force. The entire modification was accomplished for the same amount as the cost of a single new Boeing aircraft—unmodified—had the Air Force chosen to procure an entirely new ARIA fleet.

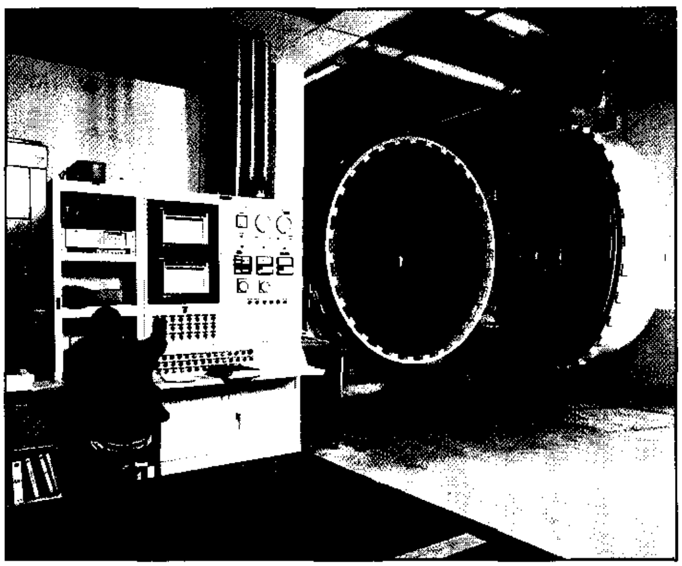
Unlike many Air Force laboratories and facilities, the Mod Center and its predecessor organizations did the majority of their work in-house. Indeed, work was let out on contract only in cases when the Center's work force was "booked" to capacity. Thus the amount of work contracted out fluctuated with in-house work load. During the 1980s the amount of work contracted out was relatively heavy due to the in-house work on the massive ARIA modification, which severely taxed the Mod Center's work force. (Even with all the overtime paid out to Mod Center workers, however, the ARIA job was completed well within the estimated cost (see box).) Whenever possible, in fact, the Test Wing and laboratories preferred to have their work done by the Mod Center due to its proven record of schedule and budgetary discipline. Indeed, the Center's reputation was such that it was chosen to design and modify the OC-135B Open Skies aircraft in 1992 (see box).

Transition to the '90s

At the outset of the 1990s, the Mod Center presented an awesome assemblage of capabilities. It owned a host of in-house resources, many of which were unique both in the military services and in private industry.

The Mod Center's most important asset was its people. In 1991 the Mod Center had 448 total personnel. One hundred seventy-six of this number were managers, engineers, and technicians. Of these 75 were designers and engineers, 35 were program or product managers, 26 were technicians and management support personnel, 14 were quality assurance experts, 14 were school programs personnel, and 12 were configuration management experts. Two hundred seventy-two of all personnel were skilled craftsmen. Of these 102 were machinists, 52 were sheet metal craftsmen, 54 were electronics experts, 20 were model makers, 17 were metal processing experts, 14 were aircraft mechanics, 8 were machine repairmen, and 5 were fabrication inspectors.

The Mod Center's facilities comprised buildings in areas B (Wright Field) and C (Patterson Field) of Wright-Patterson Air Force Base. These facilities included three modification hangars with floorspace of 144,000 square feet, including Building 206, and a 220,000 square foot fabrication facility (Building 5). The Mod Center also occupied work space in Wright Laboratory buildings to house three zone shops (Buildings 146, 18A, and 24C). Within these buildings, the Mod Center operated some of the most advanced computer and precision machinery in the nation. This included 54 computer assisted engineering (CAE) workstations, the core of the Mod Center's computer assisted design (CAD) capability. The Mod Center's extensive shop capabilities included an 8-foot by 20-foot autoclave that could operate at 800 degrees fahrenheit at 300 pounds per square inch pressure; a wire electrical discharge machine (EDM); a 6-axis milling machine; a laser cutter with a 0.005 repeatable tolerance; and 631 machines of which 44 were computer numerically controlled (CNC).


Autoclave, Building 5.

In 1991 the Mod Center's budget stood at $25.7 million. Nearly half of this went to fund the Center's manpower account. This also accounted for most of the center's so-called "direct budget authority" (DBA), which the Center received from the Test Wing. The remainder of the budget was made up of "earned income" (reimbursable budget authority—RBA) from customers' projects. The Mod Center's largest single customer in 1991, in terms of number of projects both large and small, was the Wright Laboratory (36.2%), followed closely by ASD's system program offices (32.9%), and then in rapidly descending order, the air logistics centers (ALCs) (10%), the 4950th Test Wing (7.4%), other Air Force (4.6%) and DOD (2.8%) organizations, the National Aeronautics and Space Administration (NASA) (2.6%), other test and evaluation centers (2.3%), and other laboratories (1%). The Mod Center's greatest source of business income was the aircraft modification business (50.2%), followed closely by R&D fabrication (including the zone shops) (29.6%), and limited manufacturing support (20.2%).

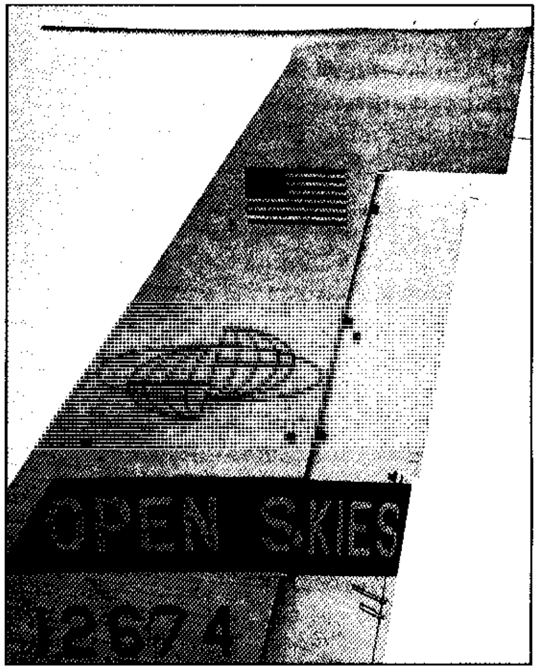
OPEN SKIES

For many elements of the U.S. defense establishment, the end of the Cold War spelled cutbacks and consolidation. For ASC's Developmental Manufacturing and Modification Facility, however, the easing of East-West tensions brought an increase in business.

In 1992 the DMMF began one the most ambitious modification programs since its overhaul of the 4950th Test Wing's ARIA aircraft fleet in the 1980s. The occasion was a treaty entered into by the United States and 24 other nations, signed on 24 March 1992 in Helsinki, Finland, establishing procedures for overflights of one another's territory using specially configured observation aircraft. The idea, proposed by the Bush administration in 1989 as a confidence-building gesture among former adversaries, hearkened back to President Eisenhower's "Open Skies" proposal at the 1955 Geneva Conference.

The Open Skies Treaty of 1992 required that aircraft chosen for this mission could not have been previously configured for intelligence gathering. The U.S. chose a WC-135B aircraft, supplied by the 55th Weather Reconnaissance Squadron, McClellen AFB, California. To transform the WC-135B to the OC-135B configuration, the Air Force selected the DMMF, because of its reputation for timely and cost-effective operations.

Time, in fact, was short. The Air Force needed the OC-135B within a year of the treaty's signing, and the DMMF did not receive final specifications until July 1992. DMMF engineers began preliminary design work in July and had finalized designs by February 1993. Meanwhile, in November the DMMF's fabrication shops began the manufacture of parts and in December began installation. Installation was completed by April and the OC-135B entered flight testing in May. Flight testing, conducted jointly by the 4950th and the Air Force Operational Test and Evaluation Center (AFOTEC) both at Wright-Patterson AFB and Cannon AFB, New Mexico, continued through the end of June 1993.



Tail logo of OC-135B Open Skies aircraft.

The modification of the OC-135B involved the installation of equipment, such as cameras, high altitude radar altimeter, an auxiliary power unit, and avionics. The DMMF's shops fabricated special brackets, panels, and racks for equipment storage. Shop craftsmen and installation experts fabricated and installed two operations consoles, a special oxygen system, windows for cameras, special seating, a film storage compartment, a four-channel interphone system, and miles of wiring. The DMMF received help from the Wright Laboratory in applying computational fluid dynamics (CFD) codes to a modified segment of the aircraft's external contour.

Altogether the modification of the OC-135B cost the Air Force $11 million. Although the modification work tied up much of the DMMF's manpower and equipment resources, the final product was delivered to the Air Force on time. Upon delivery of the first OC-135B, the Air Force planned several more for the modification experts of the DMMF.

C-135B Open Skies aircraft in flight over Dayton, Ohio.

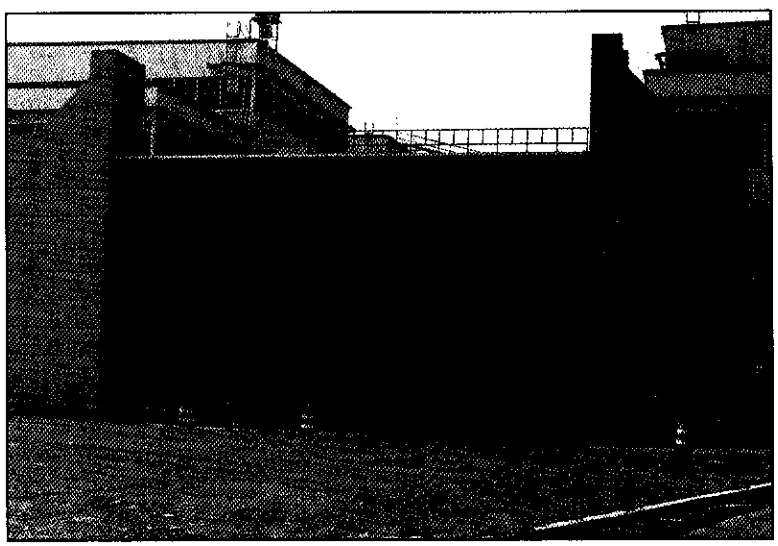
Developmental Manufacturing and Modification Facility

The end of the Cold War ushered in a time of change for the U.S. defense establishment, including the Air Force. The early 1990s witnessed the consolidation and restructuring of the Air Force's major commands, the reduction in military and civilian personnel, the closure of bases and other installations, and the transfer of functions from one location to another with a view to greater efficiency and economy of operation. Among the organizations most dramatically affected by this realignment was the 4950th Test Wing. In early 1991, the Base Realignment and Closure Committee announced its decision to transfer the Test Wing's flying elements to the Air Force Flight Test Center (AFFTC) at Edwards Air Force Base, California. The decision did not, however, affect the Test Wing's Modification Center. It would be too costly to transfer the massive infrastructure—the shops with all their equipment and assembly hangars, not to say skilled personnel—elsewhere, and so it was determined to leave the Modification Center at Wright-Patterson Air Force Base.

The Committee's decision confronted Wright-Patterson's modification community with both a challenge and an opportunity. For over seventy years, the shops had supported the flight test mission, first at McCook and then at Wright Field. Would this continue once the Test Wing's aircraft were a continent away? Would not the Flight Test Center at Edwards AFB, if not immediately then perhaps over time, develop and enhance its own in-house capability for modifying test aircraft? Clearly, the modification community at Wright-Patterson would have to offer compelling reasons for the Air Force to continue to have its test aircraft undergo modification in Dayton, Ohio. This might be mandated at first or agreed to in memoranda of understanding, but over the years, the Modification Center would have to show itself uniquely capable of performing such modifications, in terms of cost, schedule, and quality to stay in the aircraft modification business.

Of course, aircraft modification was only a part—if the most visible and significant part—of the Mod Center's business. Also important was the work that the Mod Center had performed in support of the Air Force's research and development community, preeminently that of the laboratories at Wright-Patterson. In 1991 alone the Mod Center allocated a third of its work (see above) in support of laboratory projects. In addition to this work, the Mod Center, since the 1970s, had developed substantial in-house computer capability in support of design engineering and prototype manufacturing. This capability supported, in part, the Air Force's Manufacturing Technology program. However, it also promised significantly to assist the Air Force's logistics centers as well as the nation's defense technical and industrial base.

These possibilities certainly influenced the Aeronautical Systems Division's senior management when, beginning in late 1990, it met to plan for the Modification Center's future. Subsequent meetings occurred throughout the winter, spring, and summer of 1991. On 31 October 1991, Lt. Gen. Thomas R. Ferguson, Jr., the commander of ASD, signed an interim directive that set the future course for Wright-Patterson's modification community. The Modification Center was henceforth to be called the Developmental Manufacturing and Modification Facility (DMMF) and be assigned to ASD as a line organization after the departure of the Test Wing from Wright-Patterson in October 1993.


Entrance to Building 206, headquarters of the Developmental Manufacturing and Modification Facility.

The new organization continued the Mod Center's aircraft modification mission as the test community's primary modification facility. The Air Force Flight Test Center and the Air Force Development Test Center (Eglin AFB, Florida) were to be the DMMF's principal customers for Class II modifications that exceeded their own, limited in-house capabilities. The DMMF, moreover, would also continue its support of the Air Force laboratories at Wright-Patterson AFB. It would also continue the Mod Center's small lot manufacturing, where this was practical and necessary.

At the same time, the DMMF was structured to serve the newly reorganized, post Cold War Air Force, especially the new Air Force Materiel Command, formed in the summer of 1992. The new Materiel Command was created by combining the Air Force's logistics, acquisition, and R&D communities under a management philosophy called Integrated Weapon System Management (IWSM). Under IWSM, the Air Force sought to establish the seamless management of its weapon systems. A major element of this new philosophy was much closer cooperation between the system program offices (SPOs) that developed and procured new weapon systems and air logistics centers (ALCs) that supported and maintained them. But IWSM went farther and included laboratory critical experiments (CEs) and advanced technology transition demonstrators (ATTDs) in support of nascent weapon systems. In short, IWSM included every step in the conception, development, production, and maintenance of weapon systems—"from cradle to grave."

DMMF'S ELECTRONIC HIGHROAD TO THE FUTURE

The 1990s was the decade of the electronic highway. The early years of the decade witnessed efforts to combine and rationalize electronic networks in computerized communications that had grown up and proliferated in previous years. Indeed, the net result of these efforts promised to be every bit as revolutionary as the linking up of regional railroad systems in the nineteenth century had proved for the development of American business and industry.

One of the most promising attempts to forge such a network was undertaken by the Department of Defense (DOD) in conjunction with private industry. Called the Computer Aided Acquisition Logistic Support system or "CALS", for short, this project sought to transform DOD's logistics operations by reducing paper work and, more importantly, integrating the various computer aided engineering (CAE) systems of the air logistics centers (ALCs) and that of Wright-Patterson's Developmental Manufacturing and Modification Facility (DMMF).

Until the advent of CALS, for instance, the DMMF's CAE system could not "talk" with that of Warner Robins ALC. Three-dimensional computerized "blueprints" developed by the DMMF's engineering staff had to be reduced to two-dimensional paper copies and sent to Warner Robins. There ALC engineers had to "scan" the 2-D blueprints for use in their own CAE system. In the transition from 3-D to 2-D to 3-D once again, information was necessarily lost; recovering this information required thousands of extra manhours—and precious taxpayer dollars. Under the CALS system, on the other hand, DMMF engineers could transfer their electronic blueprints to the initial graphics exchange specifications (IGES) standard, a neutral format usable by other CAE users, such as Warner Robins. In a recent project, where the DMMF designed and prototyped a portable on-board loader for the KC-10A aircraft, DMMF engineers used ICES software to transfer data to Warner Robins, thereby shortening the entire manufacturing process by nearly 50 percent.

Central to the CALS program were CALS Shared Resource Centers (CSRCs). Initially there were two of these, one in Johnstown, Pennsylvania, which began operations in 1991, and a second in Palestine, Texas, that opened in 1992. The Johnstown center was operated by the Concurrent Technologies Corporation in association with the National Center for Excellence in Metalworking Technology, the National Defense Center for Environmental Excellence, and the University of Scranton. The Palestine center was collocated with the Center for Excellence for Scanning and Conversion (COESAC). The central mission of the centers was to provide CALS support and training to government and industry clients. The Palestine center had the additional mission of scanning existing weapon system paper documents and to convert them into electronic format for use in the CALS network. In addition to these first two centers, there were five more planned for near future operations. These were to be located in San Antonio and Orange, Texas; Fairfax, Virginia; and Cleveland and Dayton, Ohio.

The DMMF had much to offer the IWSM concept, especially the critical role of the ALCs. The five air logistics centers, at Warner Robins, Georgia; Oklahoma City, Oklahoma; San Antonio, Texas; Ogden, Utah; and Sacramento, California, presented a tremendous in-house production and maintenance capability for the Air Force. The DMMF offered these centers a "manufacturing laboratory" where new fabrication and production methods could be experimentally tested for risk and cost reduction. At the center of this prototype manufacturing and experimental capability was the computer aided logistics system (CALS) for which the DMMF had been designated a Center of Expertise (see box).

The DMMF also served as a center for integrated product development (IPD) in support of the command's system program offices. Indeed, the DMMF was designed to form a link between the SPOs and industry in the cultivation of IPD and integrated business methods (IBM).

The future success of the DMMF would depend in large measure on the degree to which it was able to adapt to a new, more competitive business environment. As part of the 4950th Test Wing, the DMMF received nearly a third of its annual funding from the Wing. This constituted what was called "direct budget authority." In 1991 this amounted to nearly $14 million. In the future, however, the DMMF would have to rely increasingly on money that it earned from outside customers, whether in the Air Force or the private sector. This was called "reimbursable budget authority." The greater reliance that the DMMF placed on this earned income, the greater its annual budgetary uncertainty; greater risk entailed, in turn, higher charges on each unit of work accomplished.

Indeed, as the day and hour neared for the Test Wing's departure from Wright-Patterson, plans were afoot to go beyond this financial system to one that would be completely "fee for service," much like that which prevailed in the air logistics centers. Reimbursable dollars, although earned, were still controlled, or "capped" through ASC's financial management office.

Whether or not these arrangements would come to pass depended on a number of factors. The shrinking defense dollar led defense contractors to demand an increasing share of the business once reserved to DOD in-house facilities, such as the ALCs. These demands were not without precedent: they were advanced at the end of World War I when a nascent aircraft industry yearned for government dollars and would probably have arisen at the conclusion of World War II as well had not the Cold War intervened. DMMF planners had, furthermore, to allay the fears of the ALCs that the DMMF would encroach on their business. Finally, the go-ahead for a fee-for-service enterprise depended upon Congressional and higher DOD approval. This was still under study and debate even as the aircraft of the 4950th began their final journey westward, leaving the DMMF in sole possession of uncertain, untrod terrain.

Epilogue

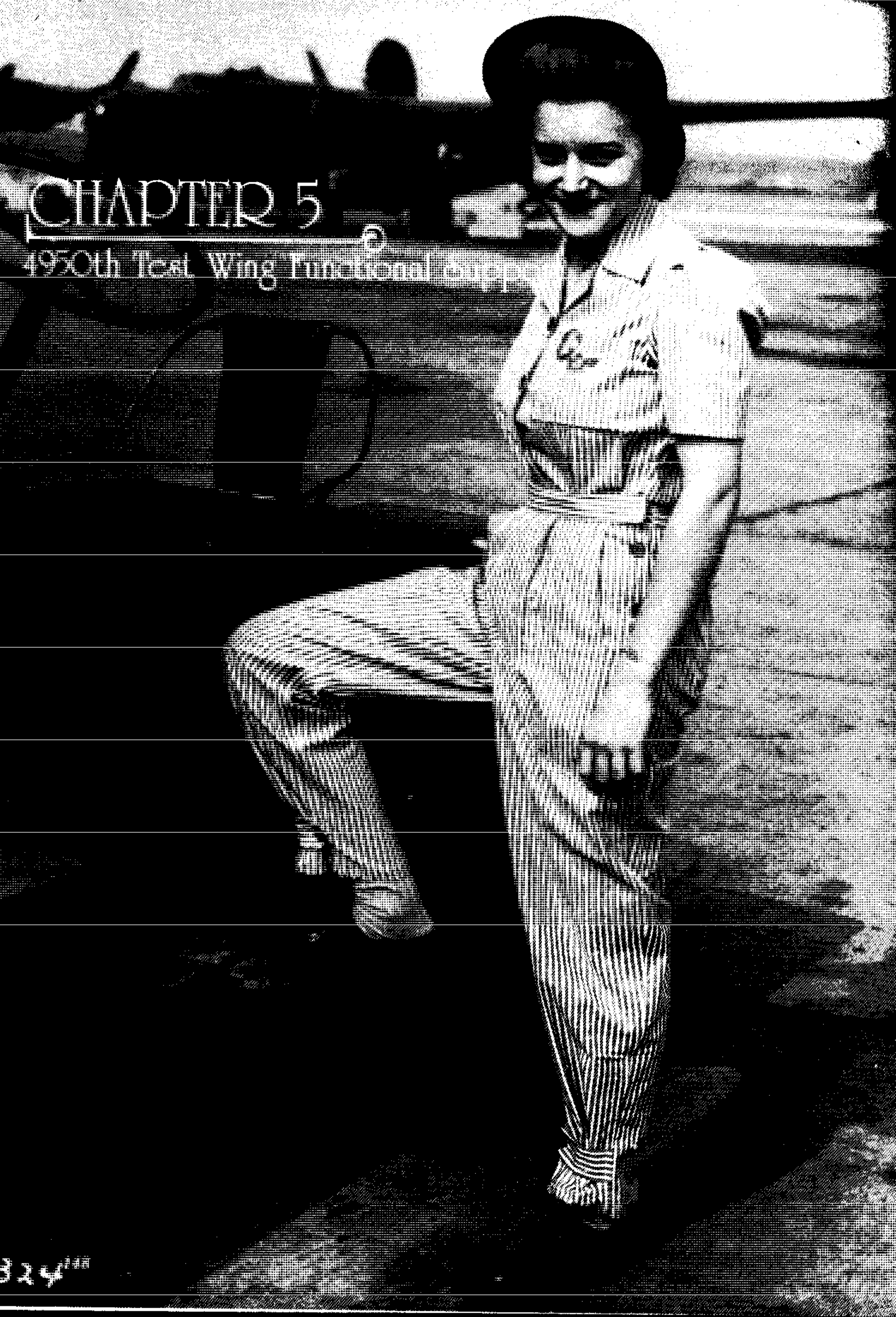
The aircraft modification community underwent many changes in the 70-odd years from its establishment in 1917 at McCook Field to the present day. During that period of time it experienced frequent changes in organization and designation: in a curious way, its early designation as a "factory" was prophetic of its role in the post Cold War world. During that time, it also developed new shop floor techniques and business practices: the slide-rule gave way to the computer; new precision equipment replaced World War I and World War II vintage machines; software replaced the crude sketch on the table napkin. Finally, the modification community at Wright-Patterson AFB changed its focus from a wholly in-house concern, dependent for its success upon captive customers and government job-work to an outward-looking enterprise, eager and confident to enter the very competitive marketplace of the 1990s and beyond.

What had not changed over the decades, however, was the dedication and skill of the hundreds of men and women who comprised the Wright-Patterson modification community. It was their commitment to excellence that launched the United States on the road to airpower supremacy in the 1920s and 1930s; their hard work and sacrifice that saw America victorious in World War II; their adaptability in the face of ever-changing defense postures, technology trends, and business practices that created the one-of-a-kind capability of the Modification Center of the 1970s and 1980s, and the Developmental Manufacturing and Modification Facility of the future. The basis of this accomplishment lay with individual workers, whether managers, engineers, or craftsmen—the quality of their work and their pride in it. This fact was perhaps best summed up at the very outset of their history, in a sentiment published on the cover of the 1 September 1921 issue of *Slipstream*, McCook Field's base newspaper. It reads:

> A bit of work of the highest quality is a key to a man's life. What a man does is, therefore, an authentic revelation of what he is, and by their works men are fairly and rightly judged. —H.W. Mabie

CHAPTER 5

4950th Test Wing Functional Suppo



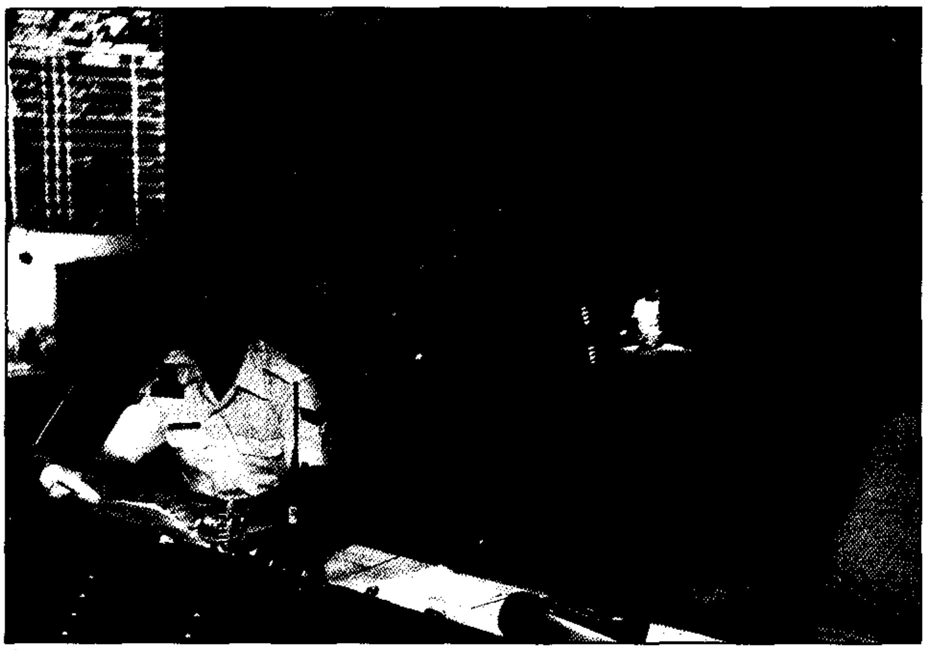
Each test flight accomplished by the 4950th Test Wing has depended upon the support of a large team of people spread throughout the Wing's directorates. Too often in the histories of flying units such people disappear altogether in the rush to tell the stories of the flight crews and their accomplishments. The following photographs show the work of the 4950th Test Wing's support personnel, mainly in the period just prior to the Wing's relocation to Edwards AFB, California.

4953rd Test Squadron with NC-141A (61-2775), two years prior to deactivation of the squadron in April 1993. "First of the Fleet" was the first prototype C-141 built by Lockheed.

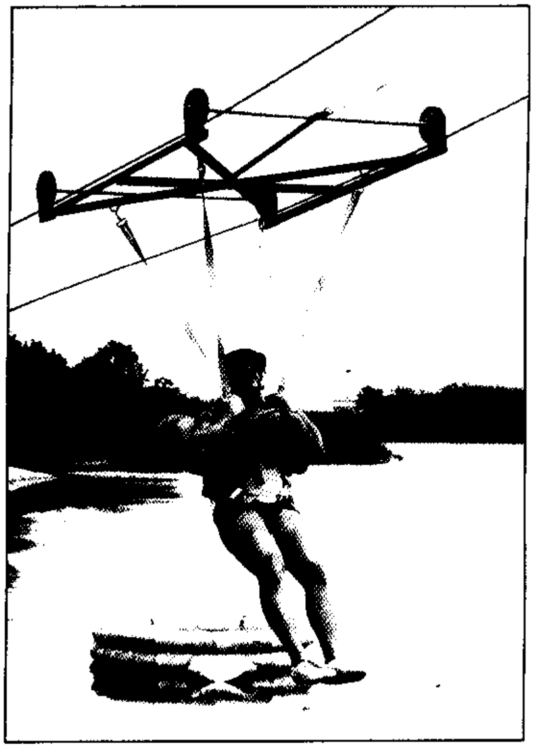
Operations

Directorate of Operations personnel lay out plans for Advanced Range Instrumentation aircraft (ARIA) deployment to Africa and the Indian Ocean.

From the ARIA Mission Control room at Wright-Patterson AFB, 4950th personnel communicate directly with airborne ARIA aircraft in the South Atlantic and the Cape coordinating the telemetry gathering and relay support for a Space Shuttle mission.

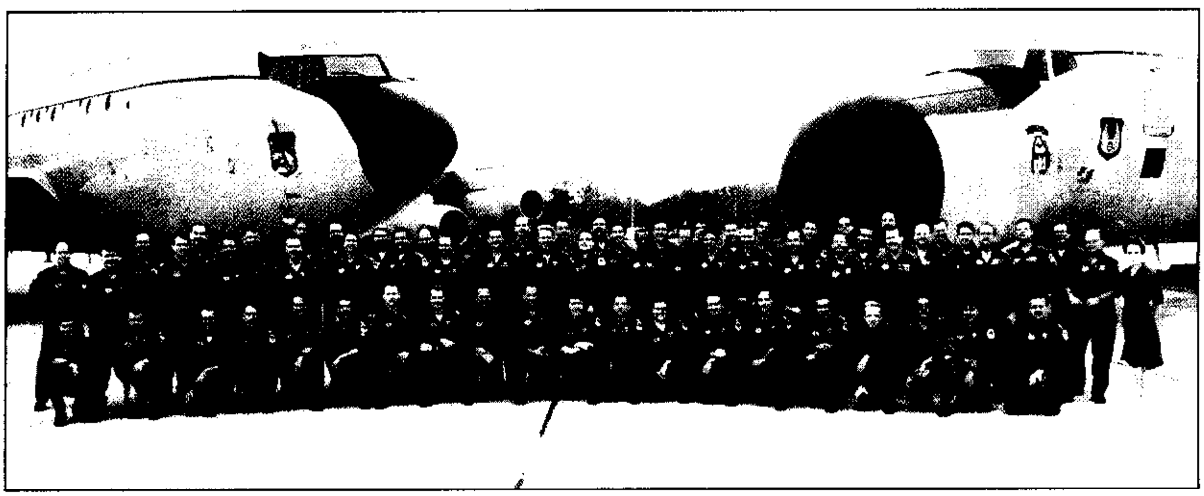


Day-to-day operations in the ARIA Control Command Post. From this location 4950th Test Wing personnel communicates with ARIA aircraft world-wide. In addition, the wing's flight test radar acted as the air traffic control agency for Restricted Area 5503 in southeastern Ohio.

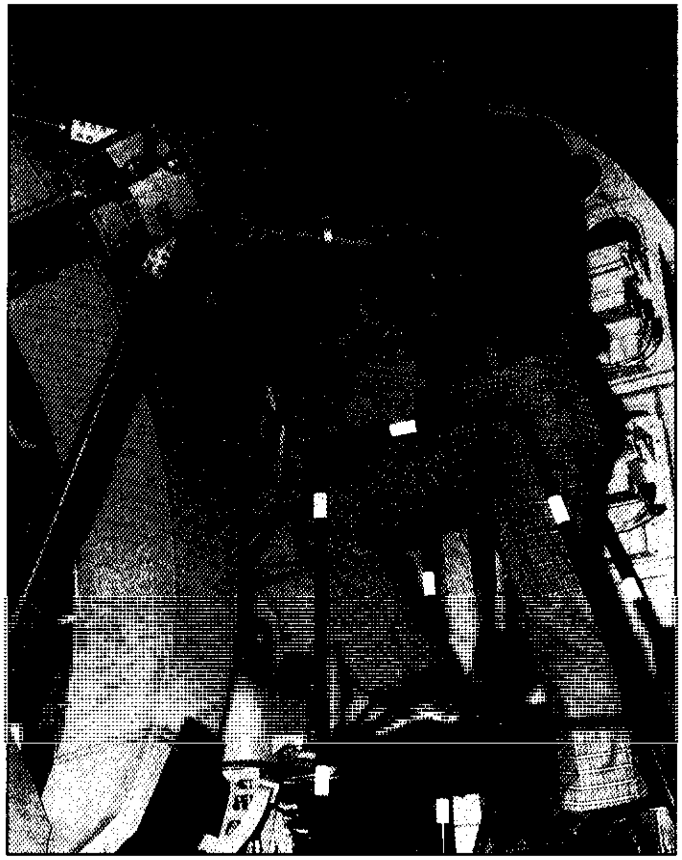


The Wing also provides Water Survival Training at numerous other locations to personnel from other organizations who participated in Test Wing flights.

Demonstration of parachute descent into waters of Bass Lake at Wright-Patterson AFB, ca. 1988. 4950th personnel train in parachute descent, canopy disentanglement, and life raft boarding techniques as part of Water Survival Training.

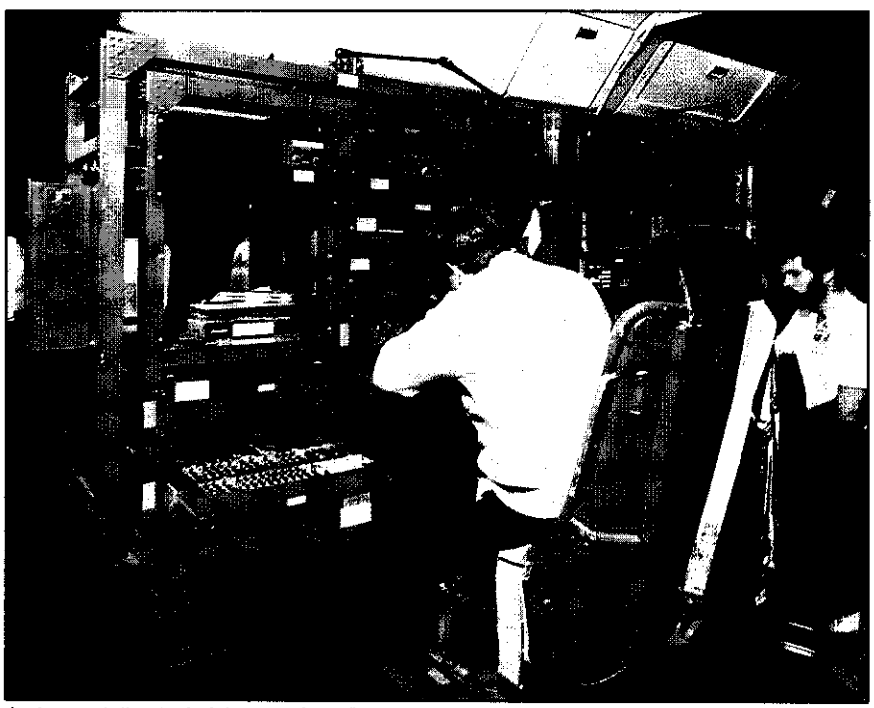


4952nd Test Squadron with NKC-135 (55-3120) on the left and EC-18B (81-0892) on the right. The squadron deactivated in June 1994.



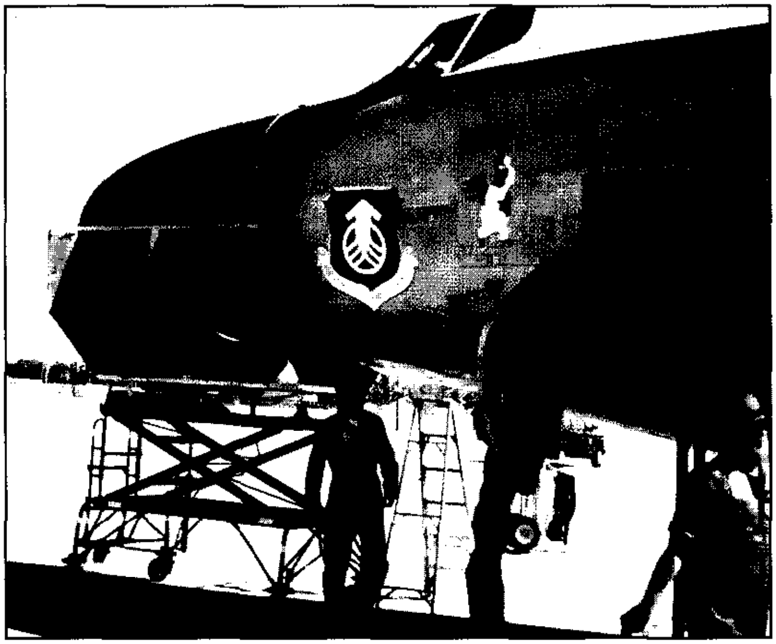
An electronics engineer inspects the antenna feed system for an Advanced Range Instrumentation Aircraft (ARIA), ca. 1976.

Reviewing instrumentation installation drawings, ca. 1985.

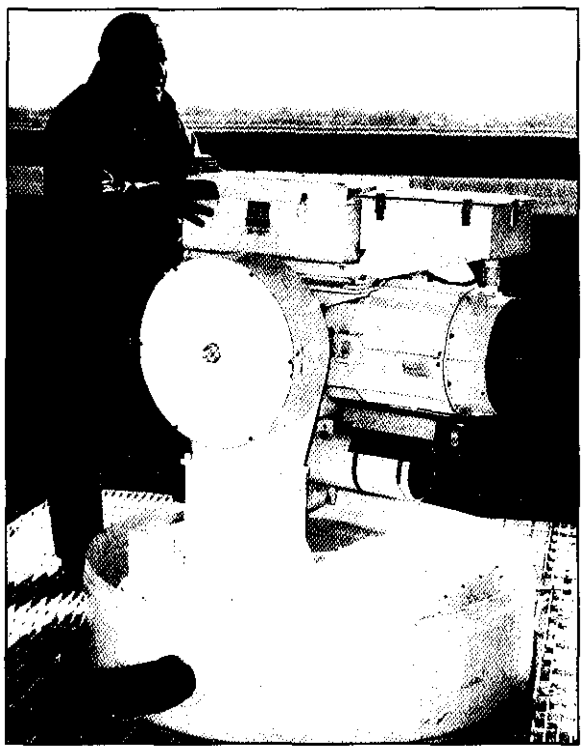


Instrumentation technicians perform final instrumentation system check-out and calibration for the ARIA EC-18 conversion flight test project, ca. 1984.

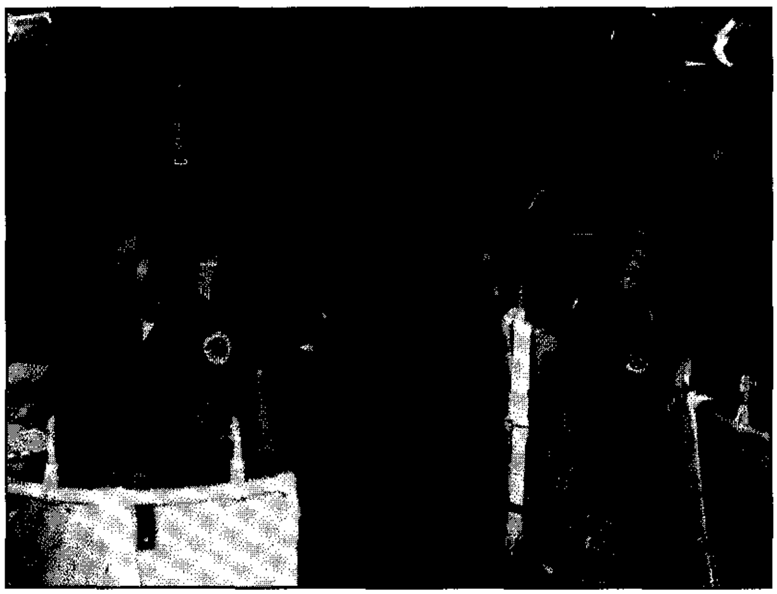
Personnel of the Ground Based Laboratory, Test Analysis Division, develop software for the Advanced Radar Testbed (ARTB) and analyze mission data in Building 4014 at Wright-Patterson AFB.



Preparing the NASA Combined Release and Radiation Effects Satellite (CRRES) test bed aircraft for a mission in the South Pacific, 1990.

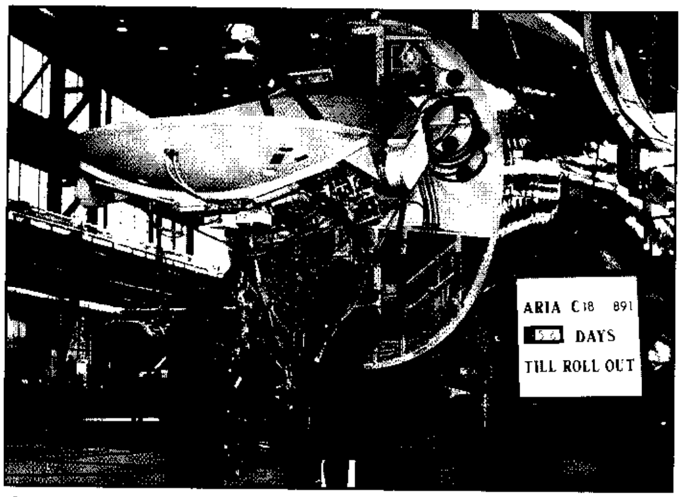


Instrumentation technician examines the laser optics system for the Precision Automatic Aircraft Tracking System (PAATS).



Equipment checkout on aircraft modified to support the "Open Skies" Treaty, 1993.

Modification



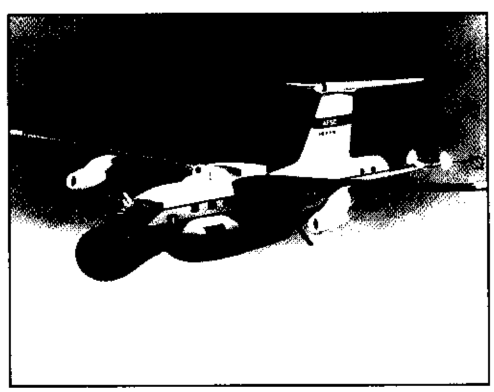
Converting former American Airlines Boeing 707s into ARIA C-18 aircraft.

Modification team at work preparing aircraft to support the Treaty on Open Skies.

Modification personnel pose with the completed "Open Skies" aircraft.

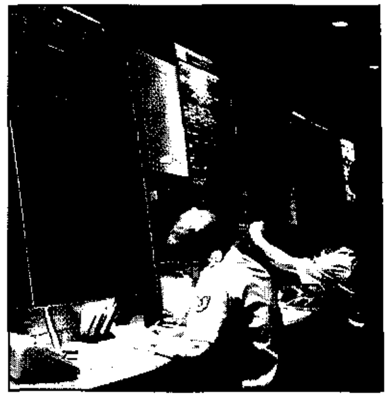
Modification Activities in Building 5, Area B, Wright-Patterson AFB. Here 4950th Test Wing modification personnel operate a manufacturing facility covering more than 200,000 square feet, which support both the Test Wing and numerous other Air Force organizations.

Combining skills to produce the product.



The "ideal" Test Wing aircraft after modification which incorporate fifteen years of Test Wing activity.

Maintenance



Job Control personnel of the Plans and Operations Branch update and maintain the status of all maintenance actions underway in the Test Wing.

A member of the 4950th's Technical Order Verification Branch observes as a technician performs work on a C-5B Aircraft Air Cycling Machine at the Oklahoma City Air Logistics Center. Much of the work of the Technical Order Verification Branch takes place at contractor or other Air Force facilities.

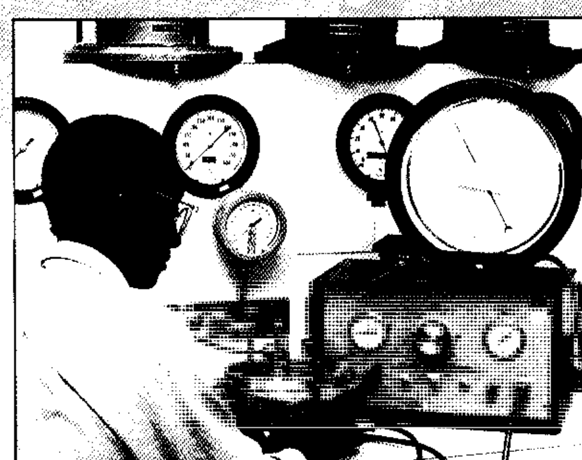
Members of the 4950th's ARIA Systems Branch at work on a complete tear-down and rebuild of an ARIA steerable antenna. The ARIA Systems Branch, composed entirely of enlisted personnel, was responsible for maintenance and inflight operation of the ARIA aircraft Prime Mission Electronic Equipment (PMEE).

Plumbing repair on an aircraft deicing truck.

Airborne Radio Frequency Operator/Maintainer monitors a signal received during a pre-mission calibration of the telemetry subsystem on an Advanced Range Instrumentation Aircraft, ca. 1991.

Operating the Engine Test Cell controls, 1988.

The Wing's Precision Measurement Equipment Laboratory (PMEL) maintains over 38,000 line items of test, measurement, and diagnostic equipment for customers in a five-state region. Shown here is calibration of a sine wave generator.



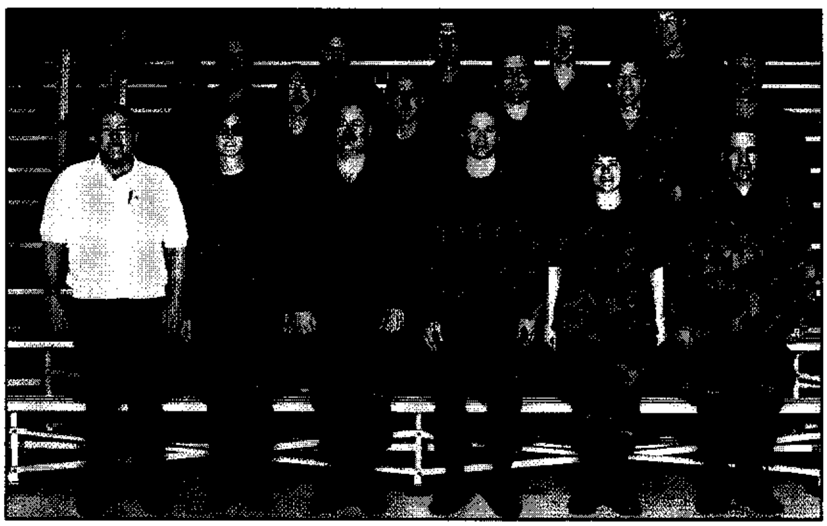
Calibrating a precision pressure gauge.

Maintenance

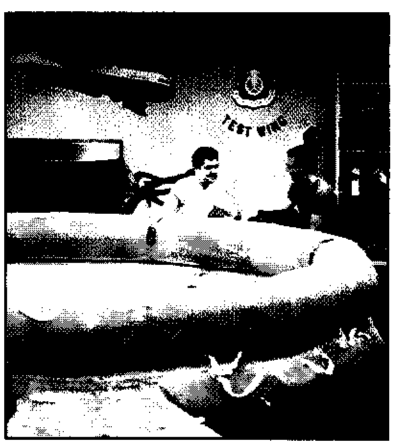
Aligning a C-135 Radio Altimeter in Avionics Section. The Avionics section provides organizational and intermediate level maintenance to the Test Wing's test bed aircraft, supports world-wide deployments, and establishes a maintenance capability for both Test Wing projects and non-Air Force systems.

Snow removal at the Aerospace Ground Equipment ready line parking area.

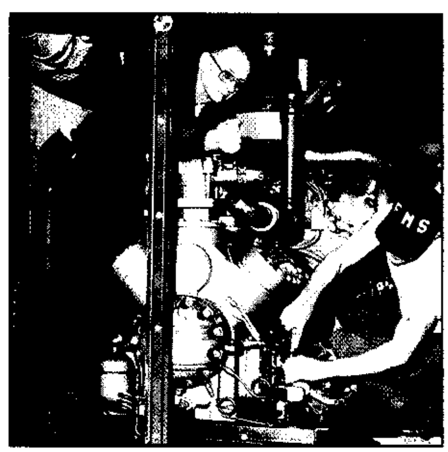
Minor repair on a Test Wing Aircraft with TF33 engines installed.



The Training and Standardization Branch exploits the natural relationship between training and quality improvement to create a "One Stop Shopping" work center.



Condition inspection of an aircrew life raft in the Survival Equipment Shop.



Installation of compressor on a 100-ton mobile air conditioner used to support ground operations of the ARIA aircraft fleet.

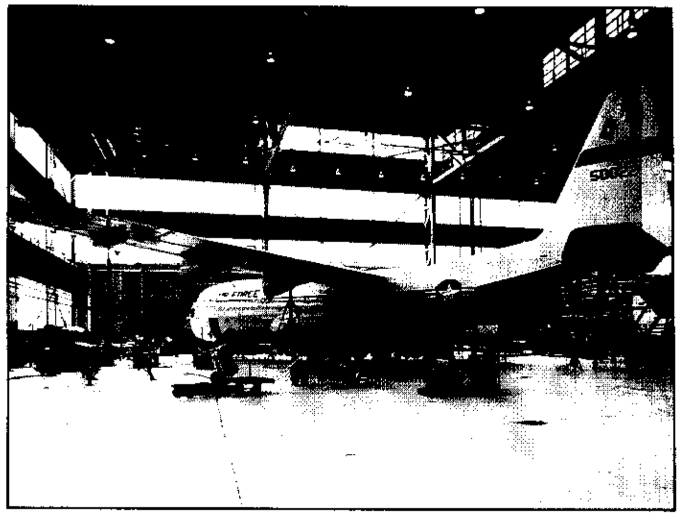
Quality Assurance specialist performs inspection on recently completed jet engine maintenance.

Phased inspection of a 4950th Test Wing C-135A aircraft with J57-43W engines installed.

Crew Chief inspects main landing gear strut during preflight inspection.

Maintenance

Maintenance and ground support for transient aircraft arriving at Wright-Patterson AFB was also a part of the 4950th Test Wing mission. Here members of the Transient Maintenance Branch examine circuit breakers on an A-7 aircraft.

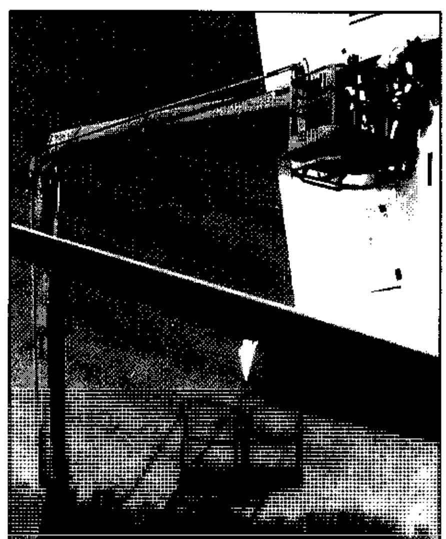


A C-130A model aircraft awaits final jacking and leveling for extensive modifications and testing in the Pneudralic/Aero-Repair Shop.

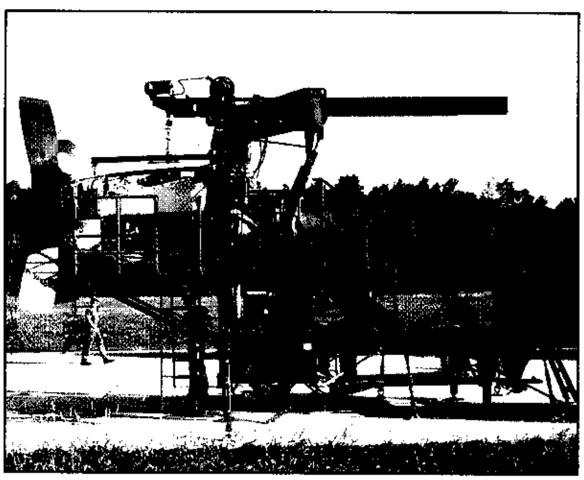
Members of the 4953rd Aircraft Maintenance Unit (AMU) read through technical orders before a C-141 engine run. The 4953rd AMU was responsible for on-aircraft maintenance and generation of 11 highly-modified C-141A and T-39A and T39B aircraft. The 4953rd AMU deactivated in May 1993 and its assets transferred to the 412th Test Wing at Edwards AFB, California.

Personnel from the Aircraft Inspection Dock unload an Advanced Range Instrumentation Aircraft (ARIA) radome after maintenance by the non-destructive inspection, sheet metal, and corrosion shops.

The Transient Alert team serves an unusual customer, a replica of the Wright "B" Flyer.

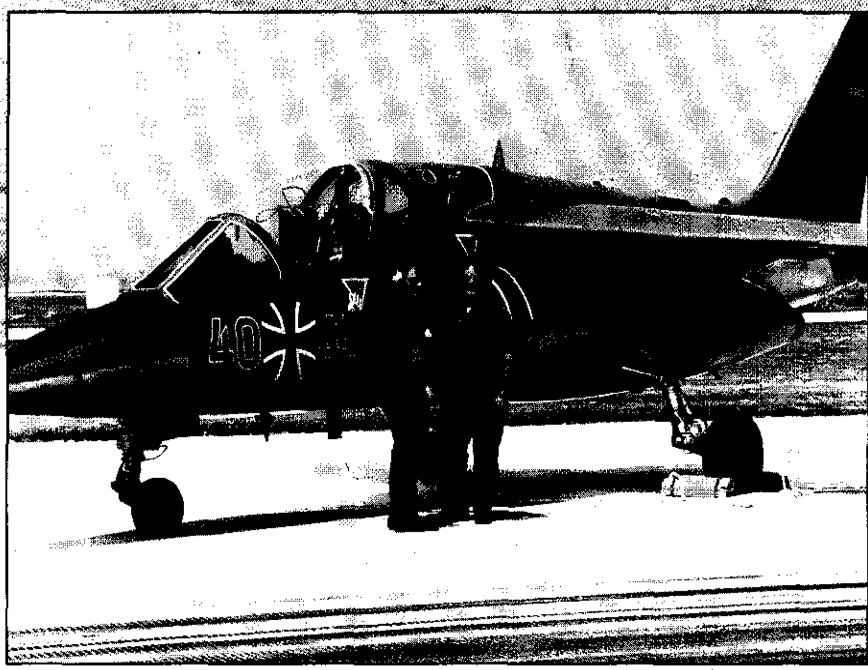


Aircraft Inspection Dock personnel remove panels from an EC-135E aircraft for periodic inspection.



The Jet Engine Intermediate Test (JEIM) Shop and the Jet Engine Test Cells performed intermediate level repair and maintenence in support of the 4950th Test Wing and numerous other organizations. Here a team prepares for test of a T56 engine.

Team for foreign aircraft maintenance, Wright Field, 1944.



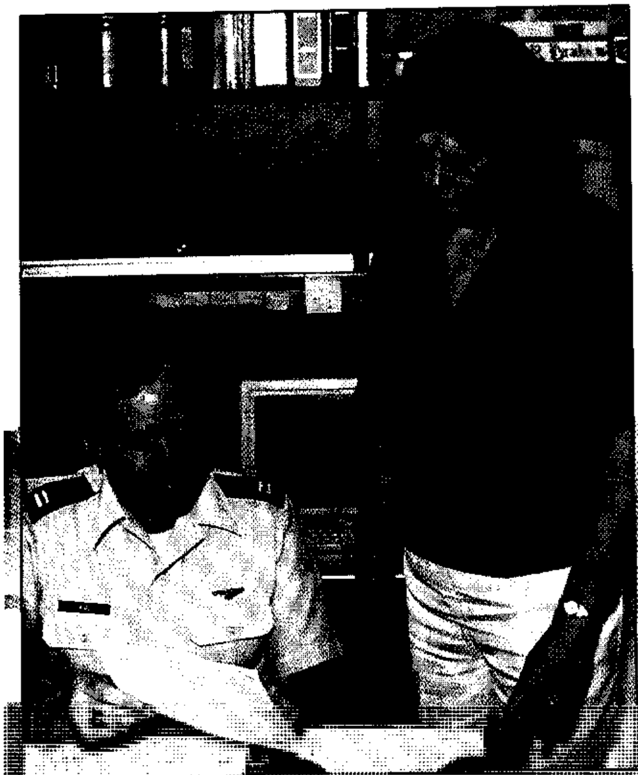
The 4950th also extended support to aircraft at the Dayton Air Show—in this case a German Air Force "Alpha Jet".

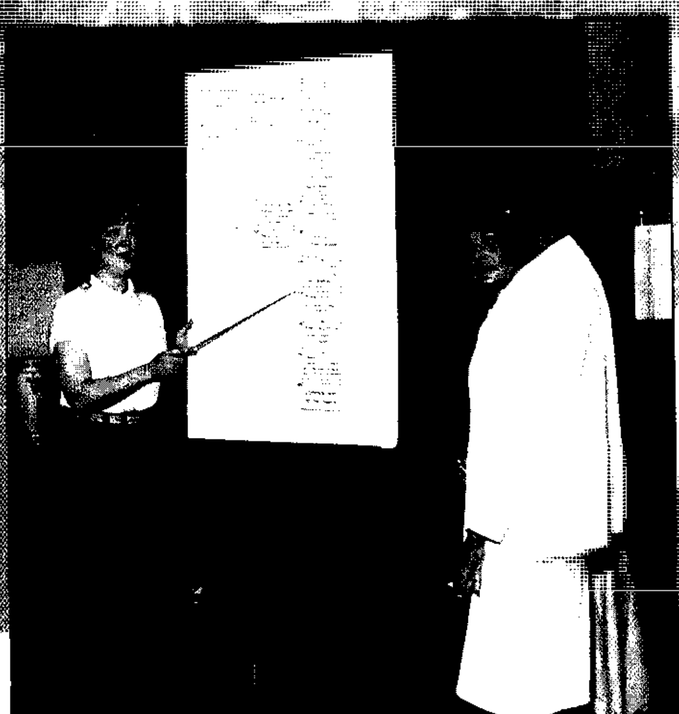
Resource Management

Installation of the Wing Information System in Building 4008, Area C, at Wright-Patterson AFB.

Budget [illegible]

Members of the Cost Accounting Branch gather for a formal photo.





Management Operations briefing.

APPENDICES

Commanders of the 4950th Test Wing

Col Robert A. Rushworth
February 1971 - May 1973

Col James A. Abrahamson
July 1973 - March 1974

Col Donald I. VanDerKarr
March 1974 - July 1974

Col Tommy I. Bell
August 1974 - May 1977

Col Peter W. Odgers
June 1977 - June 1979

Col Donald T. Ward
June 1979 - July 1981

Col Ronald W. Yates
July 1981 - June 1983

Col Joseph K. Glenn
June 1983 - July 1985

Col Gerald A. Blake
July 1985 - June 1987

Col Francis C. Gideon Jr.
June 1987 - August 1988

Col Robert F. Raggio
August 1988 - May 1990

Col David M. Phillips
May 1990 - September 1992

Col John K. Morris
From September 1992

Aircraft Assigned to the Aeronautical Systems Division 1961 - 1992

As of 31 January 1962:

Aircraft Type	Serial Number	Number Assigned
NB-47E	53-2104	1
JB-47E	53-2108	2
	53-2280	
NRB-47E	51-5258	3
	53-4257	
	53-4261	
NB-52C	53-0399	1
JB-52H	60-0005	1
JC-54D	42-72724	1
YC-123H	54-2956	1
JC-124C	53-0006	1
NT-29B	51-7912	1
C-130A	57-0453	1
NC-130B	58-0712	1
JKC-135A	55-3121	3
	55-3127	
	55-3134	
NKC-135A	55-3122	4
	55-3123	
	55-3128	
	55-3129	
KC-135A	59-1491	1
JC-131B	53-7788	10
	53-7789	
	53-7790	
	53-7791	
	53-7795	
	53-7806	
	53-7813	
	53-7819	
	53-7820	
	53-7823	
NF-100F	56-3725	1
JF-100F	56-3744	3
	56-3909	
	56-3953	
JF-101B	56-0235	2
	56-0282	
NTF-102A	54-1361	1
NF-102A	54-1390	1
JTF-102A	55-4032	1
JH-43B	58-1845	1
JT-3A	53-5404	1
NT-33A	49-0913	1
T-33A	51-6687	2
	51-6742	
JT-39A	59-2870	1
	Total:	47

As of 30 June 1962:

Aircraft Type	Serial Number	Number Assigned
NB-47E	53-2104	1
JB-47E	53-2108	2
	53-2280	
NRB-47E	51-5258	3
	53-4257	
	53-4261	
NB-52C	53-0399	1
NRB-57D	53-3973	1
JC-54D	42-72724	1
JC-124C	53-0006	1
NT-29B	51-7912	1
NC-130B	58-0712	1
JKC-135A	55-3121	4
	55-3127	
	55-3134	
	55-3144	
NKC-135A	55-3122	4
	55-3123	
	55-3128	
	55-3129	
JC-131B	53-7788	9
	53-7789	
	53-7790	
	53-7791	
	53-7806	
	53-7813	
	53-7819	
	53-7820	
	53-7823	
YHC-1B	59-4985	1
YHU-1B	58-2078	1
YHU-1D	60-6033	1
NF-100F	56-3725	1
JF-100F	56-3744	3
	56-3909	
	56-3953	
JF-101B	56-0235	2
	56-0282	
NTF-102A	54-1361	1
NF-102A	54-1390	1
JTF-102A	55-4032	1
JT-3A	53-5404	1
NT-33A	49-0913	1
T-33A	51-6687	2
	51-6742	
JT-39A	59-2870	1
	Total:	46

As of 31 December 1962:

Aircraft Type	Serial Number	Number Assigned
NB-47E	53-2104	1
JB-47E	53-2108	2
	53-2280	
NRB-47E	51-5258	3
	53-4257	
	53-4261	
NB-52C	53-0399	1
NRB-57D	53-3973	1
JRB-57D	53-3964	1
JC-54D	42-72724	1
JKC-97G	52-0834	1
C-123B	54-0575	1
NT-29B	51-7912	1
NC-130B	58-0712	1
JKC-135A	55-3121	5
	55-3127	
	55-3134	
	56-3596	
	59-1491	
NKC-135A	55-3122	5
	55-3123	
	55-3128	
	55-3132	
	55-3129	
JC-131B	53-7788	10
	53-7789	
	53-7790	
	53-7791	
	53-7795	
	53-7806	
	53-7813	
	53-7819	
	53-7820	
	53-7823	
JT-28A	49-1494	1
YHC-1B	59-4985	1
YHU-1D	60-0033	1
NF-100F	56-3725	1
JF-100F	56-3744	3

	56-3909	
	56-3953	
JF-101B	56-0235	2
	56-0282	
NTF-102A	54-1361	1
NF-102A	54-1390	1
JTF-102A	55-4032	1
NF-106A	56-0455	1
JT-33A	53-5404	1
NT-33A	49-0913	1
T-33A	51-6687	2
	51-6742	
JT-39A	59-2870	3
	59-2871	
	61-0649	
	Total:	54

As of 30 June 1963:

Aircraft Type	*Serial Number*	*Number Assigned*
NB-47E	53-2104	1
JB-47E	53-2108	2
	53-2280	
NRB-47E	51-5258	3
	53-4257	
	53-4261	
NB-52C	53-0399	1
NRB-57D	53-3973	1
JRB-57D	53-3964	1
JC-54D	42-72724	1
JKC-97G	52-0834	1
JC-121C	51-3837	1
C-121C	54-0160	2
	54-0178	
NC-121D	56-6956	1
C-123B	54-0575	1
NT-29B	51-7912	1
JKC-135A	55-3127	2
	56-3596	
NKC-135A	55-3122	6
	55-3123	
	55-3128	
	55-3132	
	55-3134	
	55-3129	
JC-131B	53-7788	10
	53-7789	
	53-7790	
	53-7791	
	53-7795	
	53-7806	
	53-7813	
	53-7819	
	53-7820	
	53-7823	
JT-28A	49-1494	1
YCH-47A	59-4985	1
NF-100F	56-3725	1
JF-100F	56-3744	3
	56-3909	
	56-3953	
JF-101B	56-0235	1
F-101B	56-0255	2
	56-0282	
NTF-102A	54-1361	1
NF-102A	54-1390	1
JTF-102A	55-4032	1
NF-106A	56-0455	1
JT-33A	53-5404	1
NT-33A	49-0913	1
T-33A	51-6687	2
	51-6742	
JT-39A	59-2870	3
	59-2871	
	61-0649	
	Total:	55

As of 31 December 1963:

Aircraft Type	Serial Number	Number Assigned
NB-47E	53-2104	1
JB-47E	53-2108	2
	53-2280	
NRB-47E	51-4258	3
	53-4257	
	53-4261	
NRB-57D	53-3973	1
JRB-57D	53-3964	1
JC-54D	42-72724	1
NC-97K	52-0834	1
JC-121C	51-3837	3
	54-0160	
	54-0178	
JC-130E	62-1858	1
NC-121D	56-6956	1
NT-29B	51-7912	1
JKC-135A	55-3121	3
	55-3127	
	56-3596	
NKC-135A	55-3122	6
	55-3123	
	55-3128	
	55-3132	
	55-3134	
	55-3129	
JC-131B	53-7788	10
	53-7789	
	53-7790	
	53-7791	
	53-7795	
	53-7806	
	53-7813	
	53-7819	
	53-7820	
	53-7823	
JT-28A	49-1494	1
YCH-47A	59-4985	1
NF-100F	56-3725	1
JF-100F	56-3744	4
	56-3909	
	56-3921	
	56-3953	
JF-101B	56-0235	2
	56-0282	
NTF-102A	54-1361	1
NF-102A	54-1390	1
JTF-102A	55-4032	1
NF-106A	56-0455	1
F4C	63-7407	1
JT-33A	53-5404	1
T-33	51-6687	2
	51-6742	
JT-39A	59-2868	3
	59-2871	
	61-0649	
C-130A	57-0453	1
C-130B	61-2649	1
	Total:	57

As of 30 July 1964:

Aircraft Type	Serial Number	Number Assigned
NB-47E	53-2104	1
JB-47E	53-2108	2
	53-2280	
NRB-47E	51-5258	3
	53-4257	
	53-4261	
NB-52C	53-0399	1
JKC-135A	55-3121	4
	55-3127	
	55-3134	
	56-3596	
NKC-135A	55-3122	5
	55-3123	
	55-3128	
	55-3129	
	55-3132	
JT-39A	59-2868	3
	59-2871	
	61-0649	
NB-66	54-0477	1
JC-54D	42-72724	1
NC-97K	52-0834	1
JC-121C	51-3837	3
	54-0160	
	54-0178	
NC-121D	56-3956	1

JC-130B	61-2649	1
JC-131B	53-7788	9
	53-7789	
	53-7790	
	53-7791	
	53-7795	
	53-7806	
	53-7813	
	53-7819	
	53-7820	
JT-28A	49-1494	1
T-28A	51-7800	1
JCH-3C	62-12578	2
	62-12579	
YCH-47A	59-4985	1
NF-100F	56-3725	1
JF-100F	56-3744	4
	56-3909	
	56-3921	
	56-3953	
JF-101B	56-0235	2
	56-0282	
NTF-102A	54-1361	1
NF-102A	54-1390	1
JTF-102A	55-4032	1
T-33A	51-6742	1
JT-33A	53-5404	1
NF-106A	56-0455	1
F-5A	63-8368	1
JF-4C	63-7408	1
	Total:	56

As of 31 December 1964:

Aircraft Type	Serial Number	Number Assigned
NB-47E	53-2104	1
JB-47E	53-2108	2
	53-2280	
NRB-47E	51-5258	3
	53-4257	
	53-4261	
NB-52C	53-0399	1
JB-57B	52-1499	1
NB-57B	52-1584	1
JKC-135A	55-3121	4
	55-3127	
	55-3134	
	56-3596	
NKC-135A	55-3122	5
	55-3123	
	55-3128	
	55-3129	
	55-3132	
JT-39A	59-2868	3
	59-2871	
	61-0649	
JC-141A	63-8076	1
NB-66	54-0477	1
JC-54D	42-72724	1
JC-121C	51-3837	4
	51-3841	
	54-0160	
	54-0178	
NC-121D	56-6956	1
JC-124C	53-0006	1
JC-130E	64-0513	1
JC-131B	53-7788	10
	53-7789	
	53-7790	
	53-7791	
	53-7795	
	53-7806	
	53-7813	
	53-7819	
	53-7820	
	53-7823	
JT-28A	49-1494	2
	51-7800	
JCH-3C	62-12579	1
JUH-1F	63-13143	1
JF-100F	56-3744	4
	56-3909	
	56-3921	
	56-3953	
JF-101B	56-0235	2
	56-0282	
NTF-102A	54-1361	1
NF-102A	54-1390	1
NF-106A	56-0455	1
T-33A	51-6742	1
JT-33A	53-5404	1
JF-4C	63-7408	1
NF-5A	63-8368	1
F-5A	63-8374	1
	Total:	59

As of 30 June 1965:

Aircraft Type	Serial Number	Number Assigned
NB-47E	53-2104	1
JB-47E	53-2280	1
NRB-47E	51-5258	3
	53-4257	
	53-4261	
NB-52C	53-0399	1
JB-57B	52-1499	1
NB-57B	52-1581	2
	52-1584	
JKC-135A	55-3121	5
	55-3127	
	55-3134	
	55-3135	
	56-3596	
NKC-135A	55-3122	5
	55-3123	
	55-3128	
	55-3129	
	55-3132	
JC-135A	60-0376	1
JT-39A	49-2868	3
	59-2871	
	61-0649	
C-141A	63-8076	1
NB-66	54-0477	1
JC-54D	42-72724	1
JC-121C	51-3837	3
	54-0160	
	54-0178	
NC-121D	56-6956	1
C-124C	53-0006	1
JC-131B	53-7788	10
	53-7789	
	53-7790	
	53-7791	
	53-7795	
	53-7806	
	53-7813	
	53-7819	
	53-7820	
	53-7823	
C-133A	56-2000	1
JT-28A	49-1494	1
CH-3C	62-12581	1
UH-1F	63-13143	1
UH-19B	51-3943	1
JF-100F	56-3744	4
	56-3909	
	56-3921	
	56-3953	
JF-101B	56-0235	3
	56-0282	
	57-0410	
NTF-102A	54-1361	1
NF-106A	56-0455	1
T-33A	51-6742	1
JT-33A	53-5404	1
T-37B	60-0141	1
T-38A	59-1602	1
JF-4C	63-7408	1
RF-4C	63-7742	1
NF-5A	63-8368	1
	Total:	62

As of 31 December 1965:

Aircraft Type	Serial Number	Number Assigned
NB-47E	53-2104	1
JB-47E	53-2280	1
NRB-47E	51-5258	2
	53-4257	
NB-52C	53-0399	1
NB-57B	52-1581	2
	52-1584	
JKC-135A	55-3121	6
	55-3127	
	55-3134	
	55-3135	
	55-3136	
	56-3596	
NKC-135A	55-3122	4
	55-3128	
	55-3129	
	55-3132	
JC-135A	60-0376	1
JT-39A	59-2868	3
	59-2871	
	61-0649	
NB-66B	54-0477	1
C-54G	54-0495	1
JC-121C	51-3837	3
	54-0160	
	54-0178	
NC-121D	56-6956	1
C-124C	53-0006	1
MC-130H	64-14853	1
JC-131B	53-7788	10
	53-7789	
	53-7790	
	53-7791	
	53-7795	
	53-7806	
	53-7813	
	53-7819	
	53-7820	
	53-7823	
C-133B	57-1613	1
NT-29B	51-5164	1
CH-3C	62-12581	1
UH-19B	51-3943	1
JF-100F	56-3744	4
	56-3909	
	56-3921	
	56-3953	
JF-101B	56-0235	3
	56-0282	
	57-0410	
NF-106A	56-0455	1
JT-33A	53-5404	1
T-33A	57-0581	1
T-37B	60-0141	1
T-38A	59-1602	1
JF-4C	63-7408	1
RF-4C	63-7742	1
	Total:	57

As of 30 June 1966

Aircraft Type	Serial Number	Number Assigned
NB-47E	53-2104	1
JB-47E	53-2280	1
NRB-47E	51-5258	2
	53-4257	
NB-52C	53-0399	1
NB-57B	52-1581	2
	52-1584	
JKC-135A	55-3121	6
	55-3127	
	55-3134	
	55-3135	
	55-3136	
	56-3596	
NKC-135A	55-3122	4
	55-3128	
	55-3129	
	55-3132	
JC-135A	60-0376	1
JRC-135A	63-8058	1
JT-39A	59-2868	3
	59-2871	
	61-0649	
NB-66B	54-0477	1
WB-50D	49-0310	1
C-54G	54-0495	1
JC-121C	51-3837	3
	54-0160	
	54-0178	
NC-121D	56-6956	1
C-123B	54-0664	1
C-124C	53-0006	1
C-130H	64-14853	1
JC-131B	53-7788	9
	53-7789	
	53-7790	
	53-7791	
	53-7795	
	53-7806	
	53-7813	
	53-7820	
	53-7823	
CH-3C	62-12581	2
	62-12580	
JF-100F	56-3744	4
	56-3909	
	56-3921	
	56-3953	
JF-101B	56-0235	3
	56-0282	
	57-0410	
NF-106A	56-0455	1
JF-111A	63-9775	1
JT-33A	53-5404	2
	57-0581	
JT-37B	60-0141	1
JT-38A	59-1602	1
JF-4C	63-7408	1
JRF-4C	63-7742	2
	63-7744	
	Total:	59

As of 31 December 1966:

Aircraft Type	Serial Number	Number Assigned
NB-47E	53-2104	1
JB-47E	53-2280	1
NRB-47E	51-5258	2
	53-4257	
NB-52C	53-0399	1
NB-57B	52-1581	2
	52-1584	
JKC-135A	55-3127	5
	55-3134	
	55-3135	
	55-3136	
	56-3596	
NKC-135A	55-3122	4
	55-3128	
	55-3129	
	55-3132	
JC-135A	60-0376	1
JRC-135A	63-8058	1
RC-135A	63-8060	1
JT-39A	59-2868	3
	59-2871	
	61-0649	
NB-66B	54-0477	1
C-47A	43-15983	1
C-47D	43-48953	1
WB-50D	49-0310	1
C-54G	54-0495	1
JC-121C	51-3837	3
	54-0160	
	54-0178	
NC-121D	56-6956	1
C-123B	54-0664	1
C-124C	53-0006	1
JHC-130P	65-0988	1
JC-131B	53-7788	9
	53-7789	
	53-7790	
	53-7791	
	53-7795	
	53-7806	

	53-7813	
	53-7820	
	53-7823	
HH-3E	65-12777	1
CH-3C	62-12581	1
UH-1F	65-7961	1
JF-100F	56-3744	4
	56-3909	
	56-3921	
	56-3953	
JF-101B	56-0235	3
	56-0282	
	57-0410	
NF-106A	56-0455	1
JF-111A	63-9775	1
JT-33A	53-5404	2
	57-0581	
JT-37B	60-0141	1
JT-38A	59-1602	2
	58-1196	
JF-4C	63-7408	1
JRF-4C	63-7742	2
	63-7744	
	Total:	63

As of 30 June 1967:

Aircraft Type	Serial Number	Number Assigned
NB-47E	53-2104	1
JB-47E	53-2280	1
NRB-47E	53-4257	1
NB-52C	53-0399	1
NB-57B	52-1581	2
	52-1584	
JKC-135A	55-3127	4
	55-3135	
	62-3536	
	56-3596	
NKC-135A	55-3122	5
	55-3128	
	55-3134	
	55-3129	
	55-3132	
JC-135A	60-0376	1
RC-135A	63-8058	2
	63-8060	
C-141A	61-2779	1
JT-39A	59-2868	3
	59-2871	
	61-0649	
T-39A	61-0636	1
RB-66B	54-0477	1
C-47A	43-15983	1
C-47D	43-48953	1
WB-50D	49-0310	1
JC-121C	51-3837	3
	54-0160	
	54-0178	
NC-121D	56-6956	1
C-123B	54-0664	1
C-130A	54-1626	1
JC-131B	53-7788	9
	53-7789	
	53-7790	
	53-7791	
	53-7795	
	53-7806	
	53-7813	
	53-7820	
	53-7823	
CH-3C	62-12581	1
UH-1F	65-7961	1
JF-100F	56-3744	4
	56-3909	
	56-3921	
	56-3953	
JF-101B	56-0235	3
	56-0282	
	57-0410	
NF-101B	56-0242	1
JF-111A	63-9775	1
JT-33A	53-5404	2
	57-0581	
JT-37B	60-0141	1
JT-38A	59-1602	2
	58-1196	
JF-4C	63-7408	1
JRF-4C	63-7742	2
	63-7744	
YRF-4C	62-1268	1
	Total:	62

As of 31 December 1967:

Aircraft Type	Serial Number	Number Assigned
NB-47E	53-2104	1
JB-47E	53-2280	1
NRB-47E	53-4257	1
NB-52C	53-0399	1
NB-57B	52-1581	2
	52-1584	
KC-135A	55-3127	4
	55-3135	
	55-3136	
	56-3596	
NKC-135A	55-3122	5
	55-3128	
	55-3129	
	55-3132	
	55-3134	
C-135A	60-0376	1
C-135B	61-2662	3
	61-2663	
	62-4113	
C-141A	61-2779	1
T-39A	59-2868	3
	59-2871	
	61-0649	
RB-66B	54-0477	1
C-47A	43-15983	1
C-47D	43-48953	1
WB-50D	49-0310	1
C-121C	51-3837	3
	54-0160	
	54-0178	
NC-121D	56-6956	1
C-123B	54-0664	1
C-130A	54-1626	1
JC-131B	53-7788	9
	53-7789	
	53-7790	
	53-7791	
	53-7795	
	53-7806	
	53-7813	
	53-7820	
	53-7823	
CH-3C	62-12581	1
UH-1F	65-7961	1
O2-A	67-21295	1
F-100F	56-3744	4
	56-3909	
	56-3921	
	56-3953	
F-101B	56-0235	3
	56-0282	
	57-0410	
T-33A	53-5404	2
	57-0581	
T-37B	60-0141	1
T-38A	59-1602	2
	58-1196	
F-4C	64-0928	2
	63-7408	
RF-4C	63-7742	2
	63-7744	
YRF-4C	62-1268	1
F-4E	66-0286	1
	Total:	63

As of 30 June 1968:

Aircraft Type	Serial Number	Number Assigned
NB-47E	53-2104	1
B-47E	53-2280	1
NB-52C	53-0399	1
NB-57B	52-1581	2

	52-1584	
KC-135A	55-3127	4
	55-3135	
	55-3136	
	56-3596	
NKC-135A	55-3122	5
	55-3128	
	55-3129	
	55-3132	
	55-3134	
C-135A	60-0376	3
	60-0377	
	60-0378	
C-135B	61-2662	2
	61-2663	
C-141A	61-2779	1
T-39A	59-2868	4
	59-2871	
	61-0649	
	61-0636	
C-47A	43-15983	1
C-47D	43-48953	1
C-121C	51-3837	3
	54-0160	
	54-0178	
NC-121D	56-6956	1
C-123B	54-0664	1
C-131B	53-7788	9
	53-7789	
	53-7790	
	53-7791	
	53-7795	
	53-7806	
	53-7813	
	53-7820	
	53-7823	
CH-3C	62-12581	1
UH-1F	65-7961	1
O2-A	67-21295	1
X-25A	68-10770	2
	68-10771	
F-100F	56-3744	4
	56-3909	
	56-3921	
	56-3953	
F-101B	56-0235	3
	56-0282	
	57-0410	
T-33A	53-5404	2
	57-0581	
T-37A	60-0141	2
	58-1948	
T-38A	59-1602	2
	58-1196	
F-4C	64-0928	2
	63-7408	
RF-4C	63-7742	2
	63-7744	
YRF-4C	62-1268	1
F-4E	66-0286	1
	Total:	64

As of 31 December 1968:

Aircraft Type	Serial Number	Number Assigned
NB-47E	53-2104	1
B-47E	53-2280	1
NB-57B	52-1581	2
	52-1584	
KC-135A	55-3127	4
	55-3135	
	55-3136	
	56-3596	
NKC-135A	55-3122	5
	55-3128	
	55-3129	
	55-3132	
	55-3134	
C-135A	60-0376	3
	60-0377	
	60-0378	
C-135B	61-2662	2
	61-2663	
C-141A	61-2779	1
T-39A	59-2868	3
	59-2871	
	61-0649	
C-47A	43-15983	2
	43-48953	
C-121C	51-3837	3
	54-0160	
	54-0178	
NC-121D	56-6956	1
C-123B	54-0664	1
C-130A	53-3134	1
RC-130S	56-0493	1
AC-130A	54-1626	1
C-131B	53-7788	9
	53-7789	
	53-7790	
	53-7791	
	53-7795	
	53-7806	
	53-7813	
	53-7820	
	53-7823	
CH-3C	62-12581	1
UH-1F	65-7961	1
O-2A	67-21295	1
X-25A	68-10770	1
X-25B	68-10771	1
F-100F	56-3744	4
	56-3909	
	56-3921	
	56-3953	
F-101B	59-0462	4
	56-0235	
	56-0282	
	57-0410	
T-33A	53-5404	2
	57-0581	
T-37A	60-0141	2
	58-1948	
T-38A	59-1602	2
	58-1196	
F-4C	64-0928	2
	63-7408	
RF-4C	63-7742	2
	63-7744	
YRF-4C	62-1268	1
F-4E	66-0286	1
	Total:	66

As of 30 June 1969:

Aircraft Type	Serial Number	Number Assigned
NB-47E	53-2104	1
B-47E	53-2280	1
NB-57B	52-1581	3
	52-1584	
	52-1518	
KC-135A	55-3127	5
	55-3128	
	55-3135	
	62-3536	
	56-3596	
NKC-135A	55-3122	4
	55-3129	
	55-3132	
	55-3134	
C-135A	60-0376	3
	60-0377	
	60-0378	
C-135B	61-2662	1
C-141A	61-2777	2
	61-2779	
C-5A	66-8307	1
T-39A	59-2868	3
	59-2871	
	61-0649	
C-121C	51-3837	3
	54-0160	
	54-0178	
NC-121D	56-6956	1
C-130A	56-0490	2
	53-3134	
AC-130A	54-1626	1
C-131B	53-7788	8
	53-7789	

	53-7790	
	53-7791	
	53-7806	
	53-7813	
	53-7820	
	53-7823	
CH-3E	62-12581	1
UH-1F	65-7961	1
A-7D	68-8222	1
F-100F	56-3744	4
	56-3909	
	56-3921	
	56-3953	
F-101B	59-0462	4
	56-0235	
	56-0282	
	57-0410	
T-33A	53-5404	2
	57-0581	
T-37A	60-0141	2
	58-1948	
T-38A	59-1602	2
	58-1196	
F-4C	64-0928	2
	63-7408	
RF-4C	63-7742	2
	63-7744	
YRF-4C	62-1268	1
F-4E	66-0286	1
	Total:	62

As of 31 December 1969:

Aircraft Type	Serial Number	Number Assigned
NB-57B	52-1581	3
	52-1584	
	52-1518	
KC-135A	55-3122	6
	55-3128	
	55-3129	
	55-3132	
	62-3136	
	56-3596	
C-135A	60-0377	2
	60-0378	
C-135B	61-2662	1
C-141A	61-2775	3
	61-2777	
	61-2779	
C-5A	66-8307	1
T-39A	59-2868	2
	61-0649	
C-121C	54-0160	2
	54-0178	
C-130A	53-3134	1
AC-130A	54-1626	1
C-131B	53-7788	9
	53-7789	
	53-7790	
	53-7791	
	53-7806	
	53-7813	
	53-7820	
	53-7822	
	53-7823	
UH-1F	65-7961	1
O-2A	67-21295	1
HH-53C	68-10354	1
CH-3E	62-12581	1
A-7D	68-8222	1
F-100F	56-3744	5
	56-3909	
	56-3921	
	53-3953	
	56-3972	
F-101B	59-0462	3
	56-0235	
	57-0410	
T-37A	60-0141	2
	58-1948	
T-38A	59-1602	2
	58-1196	
F-4C	64-0928	2
	63-7408	
RF-4C	63-7742	2
	63-7744	
YRF-4C	62-1268	1
	Total:	53

As of 30 June 1970:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3122	4
	55-3123	
	55-3129	
	55-3132	
KC-135A	55-3128	3
	62-3536	
	56-3596	
C-135A	60-0377	2
	60-0378	
C-135B	61-2662	1
C-141A	61-2775	3
	61-2777	
	61-2779	
C-5A	66-8307	1
T-39A	59-2868	2
	61-0649	
C-121C	54-0160	2
	54-0178	
C-130A	53-3134	1
AC-130A	54-1626	2
	56-0490	
C-131B	53-7788	8
	53-7789	
	53-7790	
	53-7791	
	53-7806	
	53-7813	
	53-7820	
	53-7823	
UH1F	65-7961	1
O-2A	67-21295	1
HH-53C	68-10354	1
CH-3E	62-12581	1
A-7D	68-8222	1
F-100F	56-3744	5
	56-3909	
	56-3921	
	53-3953	
	56-3972	
T-37A	60-0141	1
T-38A	59-1602	1
NT-38A	58-1196	1
F-4C	64-0928	2
	63-7408	
RF-4C	67-0465	3
	63-7742	
	63-7744	
YRF-4C	62-1268	1
	Total:	48

As of 31 November 1970:
(December 1970 was unavailable)

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3122	5
	55-3123	
	55-3128	
	55-3129	
	55-3132	
KC-135A	56-3596	1
C-135A	60-0377	2
	60-0378	
C-135B	61-2662	1
NC-141A	61-2775	2
	61-2777	
C-141A	61-2779	1
C-5A	66-8307	1
T-39A	59-2868	2
	61-0649	
C-121C	54-0160	2
	54-0178	
C-130A	53-3134	1
	54-1626	1
C-130E	63-7885	2
	69-6566	
C-131B	53-7788	8

	53-7789	
	53-7790	
	53-7791	
	53-7806	
	53-7813	
	53-7820	
	53-7823	
UH-1F	65-7961	1
O-2A	67-21295	1
CH-3E	62-12581	1
F-100F	56-3744	5
	56-3909	
	56-3921	
	53-3953	
	56-3972	
T-37B	60-0141	1
T-38A	59-1602	1
NT-38A	58-1196	1
F-4C	64-0928	2
	63-7408	
RF-4C	63-7742	2
	63-7744	
YRF-4C	62-1268	1
	Total:	45

As of 30 June 1971:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3122	6
	55-3123	
	55-3128	
	55-3129	
	55-3132	
	56-3596	
C-135A	60-0377	2
	60-0378	
C-135B	61-2662	3
	62-4133	
	62-4128	
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
T-39A	61-0649	1
EC-47Q	44-76304	1
C-121C	54-0160	2
	54-0178	
AC-130A	54-1626	1
AC-130E	59-6567	1
C-131B	53-7788	8
	53-7789	
	53-7790	
	53-7791	
	53-7806	
	53-7813	
	53-7820	
	53-7823	
UH-1F	65-7961	1
O-2A	67-21295	1
CH-3E	62-12581	1
F-100F	56-3744	5
	56-3909	
	56-3921	
	53-3953	
	56-3972	
T-37B	60-0141	1
T-38A	59-1602	1
NT-38A	58-1196	1
F-4C	63-7408	1
RF-4C	66-0469	4
	63-7742	
	63-7744	
	69-0356	
YRF-4C	62-1268	1
	Total:	46

As of 31 December 1971:

Aircraft Type	Serial Number	Number Assigned
NKC-135	55-3122	6
	55-3123	
	55-3128	
	55-3129	
	55-3132	
	56-3596	
C-135A	60-0377	2
	60-0378	
C-135B	61-2662	3
	62-4133	
	62-4128	
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
T-39A	61-0649	1
C-121C	54-0178	1
AC-130A	54-1626	1
C-131B	53-7788	8
	53-7789	
	53-7790	
	53-7791	
	53-7806	
	53-7813	
	53-7820	
	53-7823	
UH-1	65-7961	1
O-2A	67-21295	1
CH-3E	62-12581	1
F-100D	56-3110	1
F-100F	56-3744	5
	56-3909	
	56-3921	
	53-3953	
	56-3972	
T-37B	60-0141	1
F-4C	63-7408	1
RF-4C	63-7742	4
	63-7744	
	69-0356	
	69-0361	
	Total:	41

As of 30 June 1972:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3122	5
	55-3128	
	55-3129	
	55-3132	
	56-3596	
C-135A	60-0377	2
	60-0378	
C-135B	61-2662	3
	62-4133	
	62-4128	
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
T-39A	61-0649	2
	60-3491	
AC-130A	54-1626	1
C-131B	53-7788	5
	53-7789	
	53-7790	
	53-7820	
	53-7823	
UH-1F	65-7961	1
O-2A	67-21295	1
CH-3E	62-12581	1
F-100F	56-3744	5
	56-3909	
	56-3921	
	53-3953	
	56-3972	
T-37B	60-0141	3
	58-1948	
	57-2280	
F-4C	63-7408	1
RF-4C	63-7742	2
	63-7744	
	Total:	36

As of 31 December 1972:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3122	4
	55-3128	

	55-3129	
	56-3596	
C-135A	60-0377	2
	60-0378	
C-135B	61-2662	3
	62-4133	
	62-4128	
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
T-39A	61-0649	2
	60-3491	
AC-130A	54-1626	1
C-131B	53-7788	5
	53-7789	
	53-7790	
	53-7820	
	53-7823	
UH-1F	65-7961	1
O-2A	67-21295	1
CH-3E	62-12581	1
F-100F	56-3744	5
	56-3909	
	56-3921	
	53-3953	
	56-3972	
T-37B	60-0141	3
	58-1948	
	66-7994	
F-4C	63-7408	1
RF-4C	63-7742	2
	63-7744	
	Total:	35

As of 30 June 1973:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3122	2
	55-3129	
C-135A	60-0377	1
C-135B	61-2662	3
	62-4133	
	62-4128	
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
T-39A	61-0649	2
	60-3491	
AC-130A	54-1626	1
C-131B	53-7789	4
	53-7790	
	53-7820	
	53-7823	
UH-1F	65-7961	1
CH-3E	62-12581	1
F-100F	53-3953	1
T-37B	60-0141	2
	58-1948	
F-4C	63-7408	1
RF-4C	63-7742	3
	63-7744	
	68-0600	
T-39A	59-2868	1
	Total:	27

As of 31 December 1973:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3122	2
	55-3129	
C-135A	60-0377	1
C-135B	61-2662	3
	62-4133	
	62-4128	
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
AC-130A	54-1626	1
C-131B	53-7789	4
	53-7790	
	53-7820	
	53-7823	
CH-3E	62-12581	1
T-37B	60-0141	1
F-4C	63-7408	1
F-4E	66-0284	1
RF-4C	63-7742	2
	63-7744	
T-39A	61-0649	3
	60-3491	
	60-3480	
	Total:	24

As of 30 June 1974:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3122	3
	55-3129	
	55-3124	
C-135A	60-0377	1
C-135B	61-2662	3
	62-4133	
	62-4128	
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
AC-130A	54-1626	1
C-131B	53-7789	4
	53-7790	
	53-7820	
	53-7823	
CH-3E	62-12581	1
HH-53B	66-14433	1
XC-8A	115451	1
0-1A	51-12297	1
T-37B	60-0141	1
F-4C	63-7408	1
F-4E	66-0284	1
RF-4C	63-7742	3
	63-7744	
	68-0594	
T-39A	61-0649	2
	60-3491	
	Total:	28

As of 31 December 1974:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3122	3
	55-3124	
	55-3129	
C-135A	60-0377	1
C-135B	61-2662	3
	62-4128	
	62-4133	
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
AC-130A	54-1626	1
C-131B	53-7789	4
	53-7790	
	53-7820	
	53-7823	
CH-3E	62-12581	1
HH-53B	66-14433	1
XC-8A	00-115451	1
T-37B	60-0141	1
F-4C	63-7408	1
F-4E	66-0284	1
RF-4C	63-7742	3
	63-7744	
	68-0594	
T-39A	61-0649	2
	60-3491	
	Total:	27

As of 30 June 1975:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3122	3
	55-3124	
	55-3129	

C-135A	60-0377	1
C-135B	61-2662	3
	62-4133	
	62-4128	
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
AC-130A	54-1626	1
C-131B	53-7789	3
	53-7790	
	53-7820	
CH-3E	62-12581	1
HH-53B	66-14433	1
XC-8A	115451	1
T-37B	60-0141	1
F-4C	63-7408	1
F-4E	66-0284	1
RF-4C	63-7742	2
	63-7744	
T-39A	61-0649	2
	60-3491	
	Total:	25

As of December 1975:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3119	10
	55-3120	
	55-3122	
	55-3124	
	55-3125	
	55-3127	
	55-3128	
	55-3129	
	55-3131	
	55-3135	
C-135A	60-0377	1
C-135B	61-2662	3
	62-4128	
	62-4133	
AC-130A	54-1626	1
C-130A	55-0022	2
	53-3133	
C-130E	64-0571	1
C-131B	53-7790	7
	53-7799	
	53-7808	
	53-7817	
	53-7818	
	53-7819	
	53-7820	
C-141A	61-2779	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
CH-3E	62-12581	1
HH-53	66-14433	1
EC-135N	61-0326	8
	61-0327	
	61-0328	
	61-0329	
	61-0330	
	60-0372	
	60-0374	
	60-0375	
T-39A	59-2870	2
	61-0649	
T-37B	60-0141	1
XC-8	00-115451	1
	Total:	43

As of 30 June 1976:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3119	12
	55-3120	
	55-3122	
	55-3123	
	55-3124	
	55-3125	
	55-3127	
	55-3128	
	55-3129	
	55-3131	
	55-3132	
	55-3135	
EC-135N	61-0326	8
	61-0327	
	61-0328	
	61-0329	
	61-0330	
	60-0372	
	60-0374	
	60-0375	
C-135A	60-0377	1
NC-135A	60-0369	3
	60-0370	
	60-0371	
C-135B	61-2662	3
	62-4128	
	62-4133	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
AC-130H	69-6577	1
C-130A	55-0022	2
	55-0024	
C-130E	64-0571	1
C-131B	53-7790	3
	53-7817	
	53-7819	
CH-3E	62-12581	1
HH-53B	62-14433	1
XC-8A	115451	1
T-37B	60-0141	1
T-39A	61-0649	2
	62-4478	
NT-39A	59-2870	1
T-39B	60-3474	1
T-37B	58-1948	1
	Total:	48

As of December 1976:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3119	12
	55-3120	
	55-3122	
	55-3123	
	55-3124	
	55-3125	
	55-3127	
	55-3128	
	55-3129	
	55-3131	
	55-3132	
	55-3135	
EC-135N	61-0326	8
	61-0327	
	61-0328	
	61-0329	
	61-0330	
	60-0372	
	60-0374	
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
C-135B	61-2662	3
	62-4128	
	62-4133	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
AC-130H	69-6577	1
C-130A	55-0022	2
	55-0024	
C-130E	64-0571	1
C-131B	53-7817	2
	53-7819	
CH-3E	62-12581	1
HH-53B	62-14433	1
XC-8A	115451	1
T-37B	60-0141	1

T-39A	62-4478	1
NT-39A	59-2870	1
T-39B	59-2874	2
	60-3474	
T-37B	58-1948	1
	Total:	45

As of 30 June 1977:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3119	12
	55-3120	
	55-3122	
	55-3123	
	55-3124	
	55-3125	
	55-3127	
	55-3128	
	55-3129	
	55-3131	
	55-3132	
	55-3135	
EC-135N	61-0326	8
	61-0327	
	61-0328	
	61-0329	
	61-0330	
	60-0372	
	60-0374	
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
C-135B	61-2662	3
	62-4128	
	62-4133	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
AC-130H	69-6577	1
C-130A	55-0022	2
	55-0024	
MC-130E	64-0571	1
CH-3E	62-12581	1
HH-53B	66-14433	1
T-37B	60-0141	1
T-39A	62-4478	1
NT-39A	59-2870	1
T-39B	59-2873	4
	59-2874	
	60-3474	
	60-3476	
T-37B	58-1948	1
T-38A	65-10402	1
T-39A	62-4465	1
	Total:	46

As of 31 December 1977:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3119	11
	55-3120	
	55-3122	
	55-3123	
	55-3124	
	55-3125	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
	55-3135	
EC-135N	61-0326	8
	61-0327	
	61-0328	
	61-0329	
	61-0330	
	60-0372	
	60-0374	
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
C-135B	61-2662	3
	62-4128	
	62-4133	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
AC-130H	69-6577	1
C-130A	55-0022	2
	55-0024	
MC-130E	64-0571	1
CH-3E	62-12581	1
T-37B	60-0141	1
T-39A	62-4478	1
NT-39A	59-2870	1
T-39B	59-2873	4
	59-2874	
	60-3474	
	60-3476	
	Total:	41

As of 30 June 1978:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3119	11
	55-3120	
	55-3122	
	55-3123	
	55-3124	
	55-3125	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
	55-3135	
EC-135N	61-0326	8
	61-0327	
	61-0328	
	61-0329	
	61-0330	
	60-0372	
	60-0374	
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
C-135B	61-2662	3
	62-4128	
	62-4133	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
AC-130H	69-6577	1
C-130A	55-0022	2
	55-0024	
MC-130E	64-0571	1
CH-3E	62-12581	1
T-37B	60-0141	1
T-39A	60-3478	3
	61-0649	
	62-4478	
NT-39A	59-2870	1
T-39B	59-2873	4
	59-2874	
	60-3474	
	60-3476	
C-130E	72-1298	1
F-4E	66-0287	1
	Total:	45

As of 31 December 1978:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3119	11
	55-3120	
	55-3122	
	55-3123	
	55-3124	
	55-3125	
	55-3127	

	55-3128	
	55-3131	
	55-3132	
	55-3135	
EC-135N	61-0326	8
	61-0327	
	61-0328	
	61-0329	
	61-0330	
	60-0372	
	60-0374	
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
C-135B	61-2662	2
	62-4128	
EC-135B	62-4133	1
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
C-130A	55-0022	3
	55-0024	
	63-7769	
MC-130E	64-0571	1
CH-3E	62-12581	1
HH-53C	67-14994	1
T-37B	60-0141	1
T-39A	60-3478	3
	61-0649	
	62-4478	
NT-39A	59-2870	1
T-39B	59-2873	4
	59-2874	
	60-3474	
	60-3476	
F-4E	66-0287	1
	Total:	45

As of 30 June 1979:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3119	11
	55-3120	
	55-3122	
	55-3123	
	55-3124	
	55-3125	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
	55-3135	
EC-135N	61-0326	8
	61-0327	
	61-0328	
	61-0329	
	61-0330	
	60-0372	
	60-0374	
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
C-135B	61-2662	2
	62-4128	
EC-135B	62-4133	1
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
C-130A	55-0022	3
	55-0024	
	63-7769	
MC-130E	64-0571	1
CH-3E	62-12581	1
HH-53C	67-14994	1
T-37B	60-0141	1
T-39A	60-3478	2
	62-4478	
NT-39A	59-2870	1
T-39B	59-2873	4
	59-2874	
	60-3474	
	60-3476	
B-52G	58-0207	1
	Total:	44

As of 31 December 1979:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3119	11
	55-3120	
	55-3122	
	55-3123	
	55-3124	
	55-3125	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
	55-3135	
EC-135N	61-0326	6
	61-0327	
	61-0328	
	61-0329	
	61-0330	
	60-0374	
C-135N	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
C-135B	61-2662	1
EC-135B	62-4128	2
	62-4133	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
C-130A	55-0022	2
	55-0024	
MC-130E	64-0571	1
CH-3E	62-012581	1
T-37B	60-0141	1
T-39A	60-3478	2
	62-4478	
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	59-3474	
	59-3475	
	59-3476	
	59-3477	
B-52G	58-0207	1
	Total:	44

As of 30 June 1980:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3119	11
	55-3120	
	55-3122	
	55-3123	
	55-3124	
	55-3125	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
	55-3135	
EC-135N	61-0326	6
	61-0327	
	61-0328	
	61-0329	
	61-0330	
	60-0374	
C-135N	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
C-135B	61-2662	1
EC-135B	62-4128	2
	62-4133	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	

	61-2777	
C-141A	61-2779	1
C-130A	55-0022	2
	55-0024	
MC-130E	64-0571	1
UH-1F	66-1223	1
T-37B	60-0141	1
T-39A	60-3478	2
	62-4478	
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
B-52G	*58-0207*	*1*
	Total:	44

As of 31 December 1980:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3119	11
	55-3120	
	55-3122	
	55-3123	
	55-3124	
	55-3125	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
	55-3135	
EC-135N	61-0326	6
	61-0327	
	61-0328	
	61-0329	
	61-0330	
	60-0374	
C-135N	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
C-135B	61-2662	1
EC-135B	62-4128	2
	62-4133	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
C-130A	55-0022	2
	55-0024	
MC-130E	64-0571	1
UH-1F	66-1223	1
T-37B	60-0141	1
T-39A	60-3478	2
	62-4478	
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
	Total:	43

As of 30 June 1981:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3119	12
	55-3120	
	55-3122	
	55-3123	
	55-3124	
	55-3125	
	55-3127	
	55-3128	
	55-3129	
	55-3131	
	55-3132	
	55-3135	
EC-135N	61-0326	5
	61-0327	
	61-0329	
	61-0330	
	60-0374	
C-135N	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-135B	62-4128	2
	62-4133	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
C-130A	55-0022	2
	55-0024	
MC-130E	64-0571	1
UH-1F	66-1223	1
T-37B	60-0141	1
T-39A	60-3478	2
	62-4478	
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
HH-53C	69-5793	1
HC-130H	65-0962	1
	Total:	44

As of 31 December 1981:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3119	12
	55-3120	
	55-3122	
	55-3123	
	55-3124	
	55-3125	
	55-3127	
	55-3128	
	55-3129	
	55-3131	
	55-3132	
	55-3135	
EC-135N	61-0326	5
	61-0327	
	61-0329	
	61-0330	
	60-0374	
C-135N	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-135B	62-4128	2
	62-4133	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
C-130A	55-0022	2
	55-0024	
UH-1F	66-1223	1
T-37B	60-0141	1
T-39A	60-3478	2
	62-4478	
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
HH-53C	69-5793	1
HC-130H	65-0962	1
	Total:	43

As of 30 June 1982:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3119	10
	55-3120	
	55-3122	
	55-3123	
	55-3124	
	55-3125	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135N	61-0326	3
	61-0327	
	61-0329	
EC-135E	61-0330	2
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-135B	62-4128	2
	62-4133	
C18A	*81-0891*	*6*
	81-0892	
	81-0893	
	81-0895	
	81-0897	
	81-0898	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
C-130A	55-0022	2
	55-0024	
UH-1F	66-1223	1
T-37B	60-0141	1
T-39A	60-3478	2
	62-4478	
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
C-18A	81-0894	2
	81-0896	
	Total:	48

As of 31 December 1982:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	9
	55-3122	
	55-3123	
	55-3124	
	55-3125	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135N	61-0326	3
	61-0327	
	61-0329	
EC-135E	61-0330	2
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-135B	62-4128	2
	62-4133	
C-18A	81-0891	8
	81-0892	
	81-0893	
	81-0894	
	81-0895	
	81-0896	
	81-0897	
	81-0898	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
C-130A	55-0022	2
	55-0024	
DC-130A	56-0527	2
	57-0461	
T-37B	60-0141	1
T-39A	60-3478	2
	62-4478	
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
	Total:	48

As of 30 June 1983:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	8
	55-3122	
	55-3123	
	55-3124	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135N	61-0326	3
	61-0327	
	61-0329	
EC-135	61-0330	2
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-135B	62-4128	2
	62-4133	
C-18A	81-0891	8
	81-0892	
	81-0893	
	81-0894	
	81-0895	
	81-0896	
	81-0897	
	81-0898	
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
C-130A	55-0022	2
	55-0024	
DC-130A	56-0527	2
	57-0461	
T-37B	60-0141	1
T-39A	62-4478	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
	Total:	45

As of 31 December 1983:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	8
	55-3122	
	55-3123	

Aircraft Type	Serial Number	Number Assigned
	55-3124	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135N	61-0326	2
	61-0327	
EC-135E	61-0329	3
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-135B	62-4133	1
C-135C	61-2669	1
C-18A	81-0891	8
	81-0892	
	81-0893	
	81-0894	
	81-0895	
	81-0896	
	81-0897	
	81-0898	
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
C-130A	55-0022	2
	55-0024	
DC-130A	56-0527	2
	57-0461	
T-37B	60-0141	1
T-39A	62-4478	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
	Total:	45

As of 30 June 1984:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	8
	55-3122	
	55-3123	
	55-3124	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135N	61-0326	2
	61-0327	
EC-135E	61-0329	3
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
C-18A	81-0891	8
	81-0892	
	81-0893	
	81-0894	
	81-0895	
	81-0896	
	81-0897	
	81-0898	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
C-130A	55-0022	2
	55-0024	
DC-130A	56-0527	2
	57-0461	
T-37B	60-0141	1
T-39A	62-4478	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
	Total:	44

As of November 1984:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	8
	55-3122	
	55-3123	
	55-3124	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135N	61-0327	1
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
C-18A	81-0891	8
	81-0892	
	81-0893	
	81-0894	
	81-0895	
	81-0896	
	81-0897	
	81-0898	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
C-130A	55-0022	2
	55-0024	
DC-130A	56-0527	2
	57-0461	
T-37B	60-0141	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
C-21A	84-0098	1
	Total:	44

As of 30 June 1985:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	8
	55-3122	
	55-3123	
	55-3124	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135N	61-0327	1
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
C-18A	81-0891	8
	81-0892	
	81-0893	
	81-0894	
	81-0895	

	81-0896	
	81-0897	
	81-0898	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
C-130A	55-0022	2
	55-0024	
DC-130A	56-0527	2
	57-0461	
T-37B	60-0141	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
C-21A	84-0098	1
	Total:	44

As of 30 September 1985:

(December 1985 report was not available)

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	8
	55-3122	
	55-3123	
	55-3124	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-18B	81-0891	2
	81-0896	
C-18A	81-0892	5
	81-0893	
	81-0894	
	81-0895	
	81-0898	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
NC-130A	55-0022	1
C-130A	55-0024	1
DC-130A	56-0527	2
	57-0461	
T-37B	60-0141	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
C-21A	84-0098	1
	Total:	42

As of 30 June 1986:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	8
	55-3122	
	55-3123	
	55-3124	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-18B	81-0891	2
	81-0896	
C-18A	81-0892	5
	81-0893	
	81-0894	
	81-0895	
	81-0898	
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
NC-130A	55-0022	1
C-130A	55-0024	1
DC-130A	56-0527	1
T-37B	60-0141	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3473	
	60-3475	
	60-3476	
	60-3477	
C-135C	61-2669	1
C-21A	84-0098	1
	Total:	41

As of 1 December 1986:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	8
	55-3122	
	55-3123	
	55-3124	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-18B	81-0891	3
	81-0894	
	81-0896	
C-18A	81-0892	4
	81-0893	
	81-0895	
	81-0898	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
NC-130A	55-0022	1
T-37B	60-0141	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
C-21A	84-0098	1
KC-135A	54-1423	1
	Total:	40

As of 30 June 1987:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	8
	55-3122	

	55-3123	
	55-3124	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-18B	81-0891	3
	81-0894	
	81-0896	
C-18A	81-0892	4
	81-0893	
	81-0895	
	81-0898	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
T-37B	60-0141	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
C-21A	84-0098	1
	Total:	38

As of 31 December 1987:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	8
	55-3122	
	55-3123	
	55-3124	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-18B	81-0891	4
	81-0892	
	81-0894	
	81-0896	
C-18A	81-0893	3
	81-0895	
	81-0898	
C-135C	61-2669	1
NC-141A	61-2775	3
	61-2776	
	61-2777	
C-141A	61-2779	1
T-37B	60-0141	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
CT-39A	62-4463	1
C-21A	84-0098	1
C-130E	63-7829	1
	Total:	40

As of 1 June 1988:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	7
	55-3122	
	55-3124	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-18B	81-0891	4
	81-0892	
	81-0894	
	81-0896	
C-18A	81-0893	3
	81-0895	
	81-0898	
C-135C	61-2669	1
NC-141A	61-2775	4
	61-2776	
	61-2777	
	61-2779	
T-37B	60-0141	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
CT-39A	62-4463	1
C-21A	84-0098	1
	Total:	38

As of 31 December 1988:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	6
	55-3122	
	55-3124	
	55-3127	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-18B	81-0891	4
	81-0892	
	81-0894	
	81-0896	
C-18A	81-0893	3
	81-0895	
	81-0898	
C-135C	61-2669	1
NC-141A	61-2775	4
	61-2776	
	61-2777	
	61-2779	
T-37B	60-0141	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
CT-39A	62-4463	1
C-21A	84-0098	1
	Total:	37

As of 30 June 1989:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	6
	55-3122	
	55-3124	
	55-3127	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-18B	81-0891	4
	81-0892	
	81-0894	
	81-0896	
C-18A	81-0893	3
	81-0895	
	81-0898	
C-135C	61-2669	1
NC-141A	61-2775	4
	61-2776	
	61-2777	
	61-2779	
T-37B	60-0141	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
CT-39A	62-4463	1
C-21A	84-0098	1
	Total:	37

As of 31 December 1989:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	7
	55-3122	
	55-3124	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-18B	81-0891	4
	81-0892	
	81-0894	
	81-0896	
C-18A	81-0893	3
	81-0895	
	82-0898	
C-135C	61-2669	1
NC-141A	61-2775	4
	61-2776	
	61-2777	
	61-2779	
T-37B	60-0141	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
CT-39A	62-4463	1
C-21A	84-0098	1
C-141B	66-0201	1
T-38A	65-10454	1
	Total:	40

As of 30 June 1990:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	7
	55-3122	
	55-3124	
	55-3127	
	55-3128	
	55-3131	
	55-3132	
NKC-135E	55-3135	1
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-18B	81-0891	4
	81-0892	
	81-0894	
	81-0896	
C-18A	81-0893	3
	81-0895	
	81-0898	
C-135C	61-2669	1
NC-141A	61-2775	4
	61-2776	
	61-2777	
	61-2779	
T-37B	60-0141	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
CT-39A	62-4463	1
C-21A	84-0098	1
T-38A	65-10454	1
	Total:	39

As of 31 December 1990:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	7
	55-3122	
	55-3124	
	55-3127	
	55-3131	
	55-3128	
	55-3132	
NKC-135E	55-3135	1
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-18B	81-0891	4
	81-0892	
	81-0894	
	81-0896	
C-18D	81-0893	2
	81-0895	
C-18B	81-0898	1
C-135C	61-2669	1
NC-141A	61-2775	4
	61-2776	
	61-2777	
	61-2779	
T-37B	60-0141	1
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	

	60-3476	
	60-3477	
CT-39A	62-4463	1
T-39A	62-4476	1
C-21A	84-0098	1
T-38A	65-10454	1
	Total:	40

As of 30 June 1991:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	5
	55-3122	
	55-3127	
	55-3131	
	55-3128	
NKC-135E	55-3132	2
	55-3135	
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-18B	81-0891	4
	81-0892	
	81-0894	
	81-0896	
C-18D	81-0893	3
	81-0895	
	81-0898	
C-135C	61-2669	1
NC-141A	61-2775	4
	61-2776	
	61-2777	
	61-2779	
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
CT-39A	62-4463	1
C-21A	84-0098	1
	Total:	36

As of 31 December 1991:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	5
	55-3122	
	55-3127	
	55-3128	
	55-3131	
NKC-135E	55-3132	2
	55-3135	
EC-135E	61-0326	4
	61-0329	
	61-0330	
	61-0374	
C-135E	60-0372	3
	60-0375	
	60-0377	
NC-135A	60-0371	1
EC-18B	81-0891	4
	81-0892	
	81-0894	
	81-0896	
C-18D	81-0893	2
	81-0895	
C-18B	81-0898	1
C-135C	61-2669	1
NC-141A	61-2775	4
	61-2776	
	61-2777	
	61-2779	
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
CT-39A	62-4463	1
C-21A	84-0098	1
	Total:	36

As of 30 June 1992:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	5
	55-3122	
	55-3127	
	55-3128	
	55-3131	
NKC-135E	55-3132	2
	55-3135	
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
NC-135A	60-0371	1
EC-18B	81-0891	4
	81-0892	
	81-0894	
	81-0896	
C-18D	81-0893	2
	81-0895	
C-18B	81-0898	1
NC-141A	61-2775	4
	61-2776	
	61-2777	
	61-2779	
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
CT-39A	62-4463	1
	Total:	34

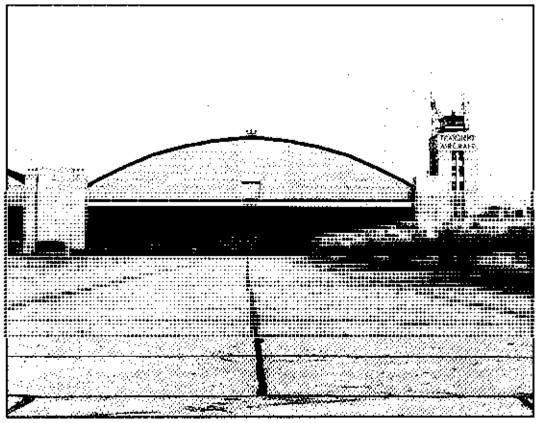
As of 1 November 1992:

Aircraft Type	Serial Number	Number Assigned
NKC-135A	55-3120	3
	55-3122	
	55-3128	
NKC-135E	55-3132	2
	55-3135	
EC-135E	61-0326	4
	61-0329	
	61-0330	
	60-0374	
C-135E	60-0372	2
	60-0375	
C-135A	60-0377	1
EC-18B	81-0891	4
	81-0892	
	81-0894	
	81-0896	
EC-18D	81-0893	2
	81-0895	
C-18B	81-0898	1
NC-141A	61-2775	4
	61-2776	
	61-2777	
	61-2779	
NT-39A	59-2870	1
T-39B	59-2873	6
	59-2874	
	60-3474	
	60-3475	
	60-3476	
	60-3477	
CT-39A	62-4463	1
	Total:	31

Flight Test and 4950th Test Wing Facilities at Wright-Patterson AFB

HANGARS 1 AND 9, AREA B

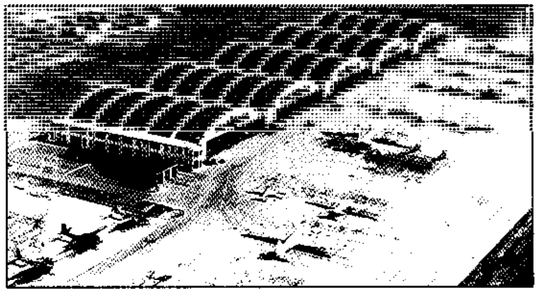
Flight Test Hangar No. 1 and Experimental Installation Hangar No. 9 were constructed in 1943. They faced the Northwest-Southeast runway which had been built with the East-West runway in 1942. The concrete runways had replaced grass runways and were among the first in the country. Both hangars remained in active service as aircraft test facilities until the mid-1970s. In 1976, they were reassigned to the Air Force Museum and used as annexes.



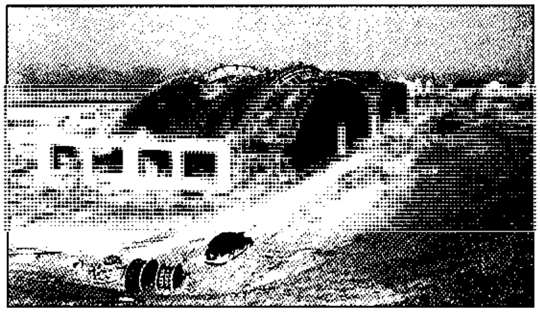
Hangar 9, Area B, and the adjacent control tower (Building 8). Hangar 1 is to the left.

HANGAR 4, AREA B

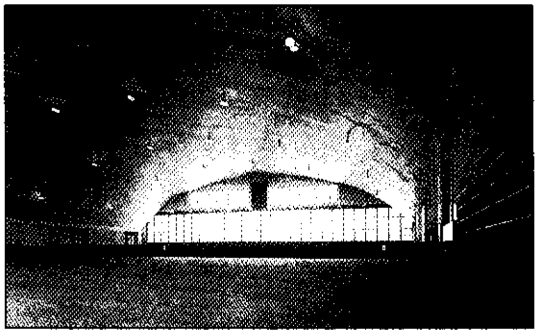
Hangar 4 was constructed in 1944 as the Wright Field Aircraft Modification Facility for aircraft modification and flight research. Upon completion, it was immediately occupied by the Flight Research Laboratory. It was isolated at the south end of the flightline and much of the work performed there was classified. Many allied and captured foreign aircraft were worked on in its five bays, designated Hangars 4A-E. Hangar 4A was partially destroyed and reconstructed following a 1945 plane crash. Experimental aircraft modification work continued in 4A and B until the early 1960s and in 4C-E until the early 1970s when military aircraft became too large for both the hangar and runway. The Air Force Orientation Group used Hangars 4A and B from 1962 to 1981. The two bays were then assigned to the Avionics Directorate of Wright Laboratory which operated a radar range, anechoic chamber, and laser laboratory in them. The Air Force Museum moved into Hangars 4C-E in 1973 and used them to restore aircraft and prepare displays. Hangar 4E hosted the Air Force Flight Test School from 1945 until the school moved to Edwards AFB. Building 4F, an attached two-story administration building, originally served the Flight Research Laboratory. The 4950th Test Wing had its Storage Material Management Division in this part of the complex.



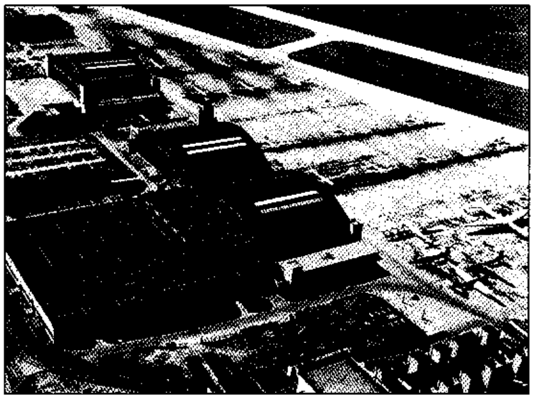
Hangar 4, Area B.



Hangar 4 under construction.



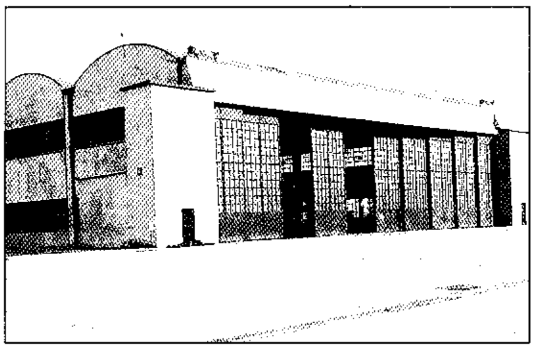
Hangar 4 interior.



Building 5, Area B, in October 1948. Building 7, Hangars 1 and 9, and the control tower (Building 8) are located to the right. Building 22 is the next major structure to the upper left.

BUILDINGS 5 AND 7, AREA B

Building 5 was erected in 1943 as part of an expanded Wright Field World War II flightline complex. It provided engineering shops for the metal, machine, and wood fabrication activities that supported the aircraft test and modification functions in Hangars 1 and 9. The mezzanine was also added in 1943. An extension to the south was constructed in 1953 and the following year Building 5 was combined with Building 72 (which contained a foundry and engineering shops) and a two-story covered craneway was added. The structure remained in continuous use as an aircraft shops facility. The 4950th Test Wing moved its Fabrication and Modification Shop into the facility in 1987 and occupied a large portion of the building. Building 7 was constructed in 1943 to provide office space for the engineering shops.



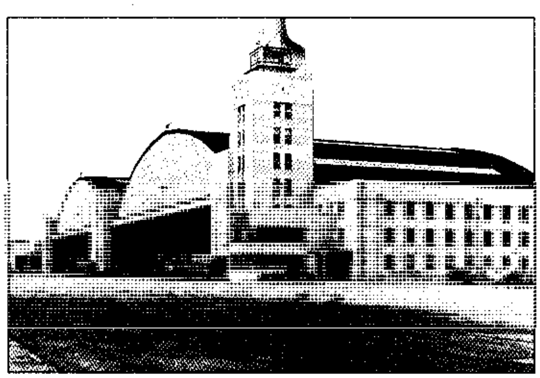
Building 6, Area B.

BUILDING 6, AREA B

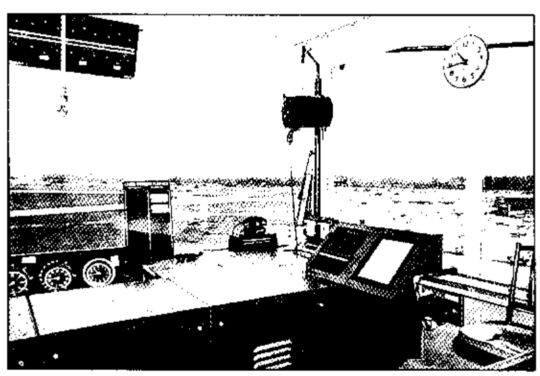
The Signal Corps Special Hangar constructed in 1943. A tower and control room, added in 1948, were demolished in 1986. The Wright Air Development Center and Aircraft Maintenance Organization Shop occupied the building in 1959. From 1964 to 1981 the Air Force Orientation Group used the facility and in 1974 it added a sound studio. Building 6 now serves as the Wright Field Fitness Center.

BUILDING 8, AREA B

Building 8 was constructed in 1943 as part of the complex that included Hangars 1 and 9 and Buildings 5 and 7. It housed Wright Field Operations and the new Flight Test Division which consolidated flight testing of experimental and production aircraft. The Pilot Transition Branch transferred here from Area C in 1954. The control tower remained operational until 1976 when the Wright Field flightline closed and Base Operations transferred to Building 206, Area C.



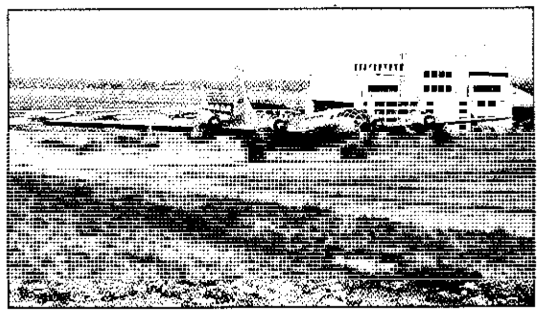
Building 8, Area B.



View from control tower, 25 May 1943.

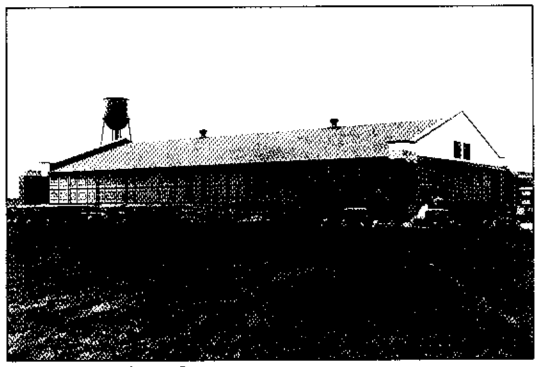
ACCELERATED RUNWAY

As the Wright Field runways were being constructed, captured intelligence information revealed that the Germans were planning to build inclined runways along the coast of France. Such runways, it was believed, could shorten take-off and landing distances. A decision was made to test the concept by constructing an inclined runway at Wright Field. The runway contract was modified to include the Accelerated Runway which was completed in 1943. Built adjacent to Building 6, the runway was constructed with a 10 percent grade and wide enough to accommodate the Douglas B-19 bomber which was undergoing testing at the time. Extensive testing found the concept to be impractical and use of the runway was discontinued.


A B-50 taxis up the Accelerated Runway, 24 September 1953.

BUILDING 13, AREA C

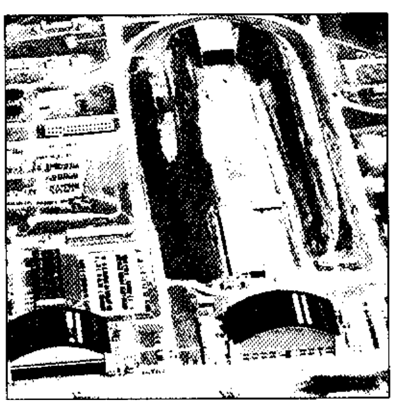
Building 13 was originally constructed in 1930 as an engineering shops facility to repair and overhaul aircraft at the Fairfield Air Depot. It reflected the transition that had taken place in 1926 when the hangar system of overhaul replaced the assembly-line method. The structure was expanded from 1941 to 1943 by consolidating and connecting several existing buildings to create the engineering factory for aircraft assembly and repair. The building continued to serve as an aircraft maintenance shop both before and after the 4950th Test Wing acquired it in 1975. It accommodated the Test Wing's Jet Engine Inspection and Maintenance Shop and aircraft general purpose shops. Under the wing's management, it housed the Lightning Strike Project, several maintenance shops, equipment storage, and a tennis court.


Building 13, Area C.

Machinist at work in Building 13.

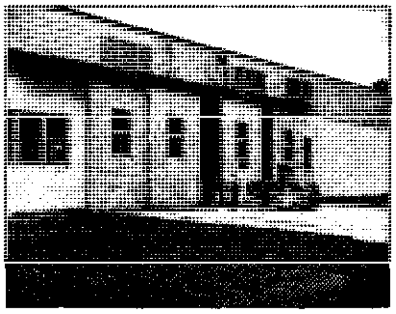
BUILDING 22 COMPLEX, Area B

Building 22 was constructed in 1942 to support the Materiel Command Armament Laboratory housed in Building 21. It contained laboratories for testing and developing weapon guidance systems and had ten test chambers to simulate a variety of environments. Immediately to the east through its large hangar doors lay a 500-yard gun range in the form of an elongated "U" open area surrounded by an earthen berm on three sides. The complex also supported a 25-yard and a 200-yard gun range (Building 22B). Over the years, the complex has housed a variety of laboratory activities, including electronic, electronic warfare, avionics, navigation, guidance, and reconnaissance. Currently, Building 22 houses the Avionics Laboratory's offices and the Wright Field technical library which moved there in 1976.

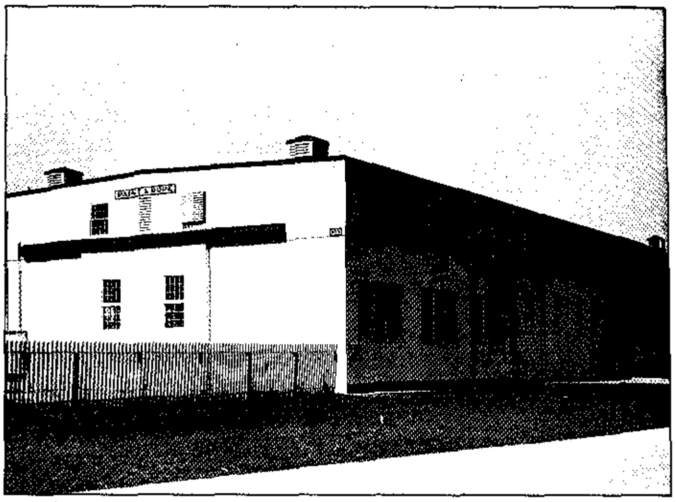

Aerial view of Building 22 and its adjacent U-shaped gun range, June 1946.

BUILDING 105, AREA C

Building 105 was constructed in 1943 as a paint and dope issue center. It was also known as the fabric shop in the late 1940s . Its close proximity to the flying field kept it in continuous service as a flight line support facility. The 4950th Test Wing occupied the building from 1975 to 1982 and again from 1987 to 1993, using it as an aircraft corrosion control center.



Building 105, Area C, May 1952.

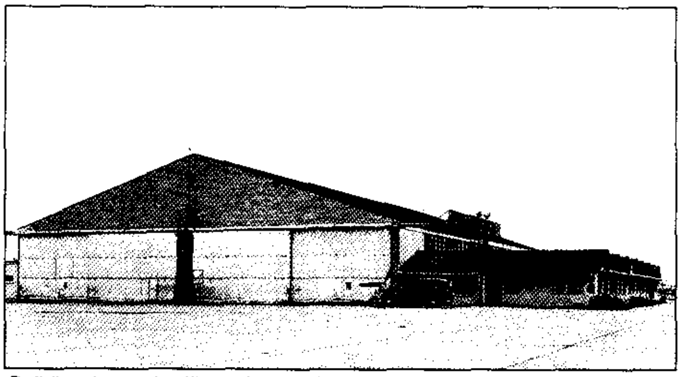


Building 105, Area C, May 1952.

BUILDING 145, AREA C

The Steel Hangar is Wright-Patterson AFB's oldest surviving hangar. Built in 1928, it served as a maintenance hangar to many base organizations. During World War II, Bob Hope aired one of his CBS radio program "Cheers from the Camps" broadcasts from it. The 4950th Test Wing's Transient Maintenance Branch began using the facility in 1987.

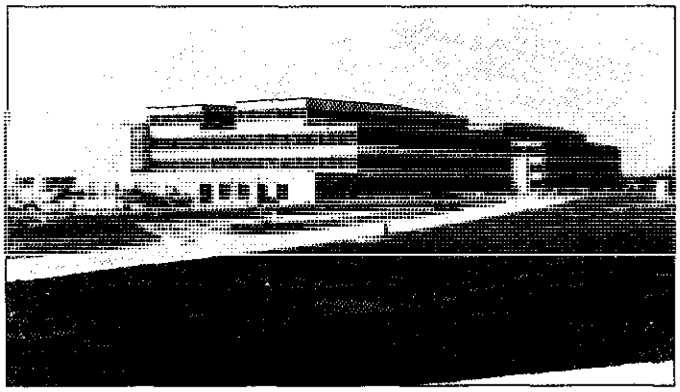
Building 145, Area C, February 1930.



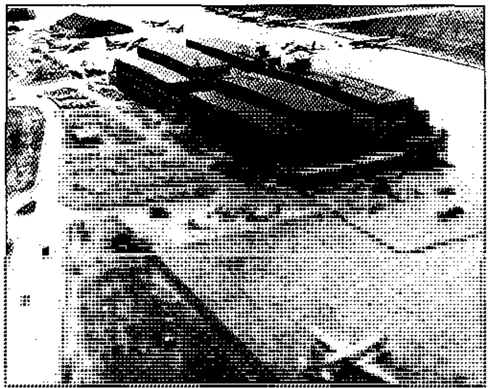
Building 145 with office addition, January 1952.

BUILDING 206, AREA C

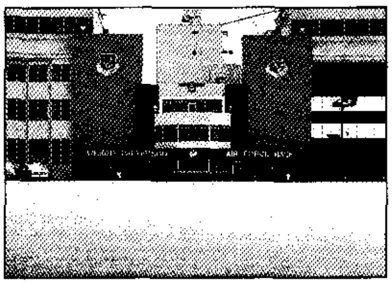
Constructed in 1941 as the main air dock and base operations facility for Patterson Field, Building 206 has maintained a continuous association with Wright-Patterson AFB flight operations, including air traffic, flight test, tactical air operations, and logistics airlift. It was the hub of World War II air operations and it housed the Fairfield Air Depot Operations (FADO) Hotel for transient pilots. Additions to the north and south sides were made in 1948 and 1949. In the 1960s, the bays functioned as experimental modification test and maintenance hangars. Responsibility for the northern portion of the structure transferred to the 4950th Test Wing in 1975. The wing modified aircraft here and in 1991 added 14,760 square-feet of office space to consolidate its Aircraft Modification Center. The Center housed the wing contracting office, Aircraft Modification Division, Modification Engineering Division, Product Integration Division, Program Control Division, and Quality Assurance Division.



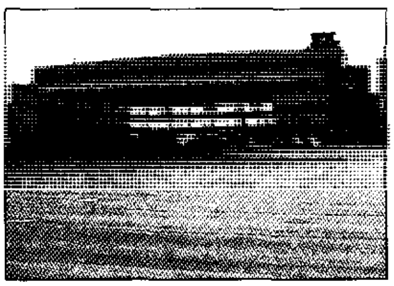
Building 206, Area C, looking north.



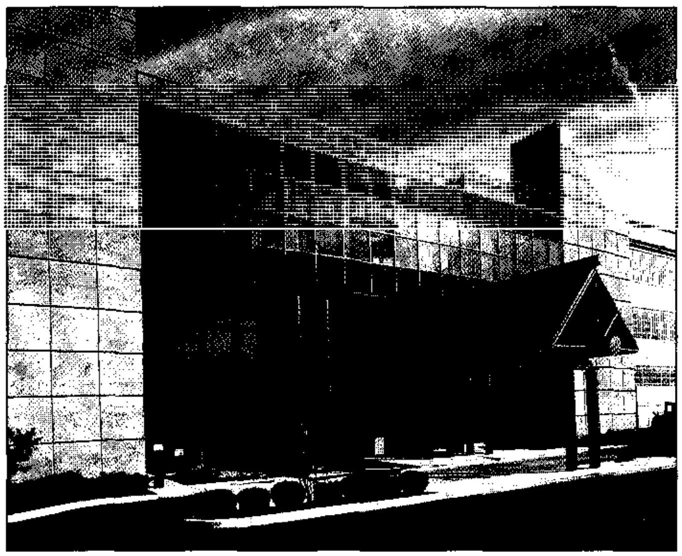
Building 206 as it appeared in the 1950s (Note the steel hangar, Building 145, in background).



Flightline entrance to Building 206.



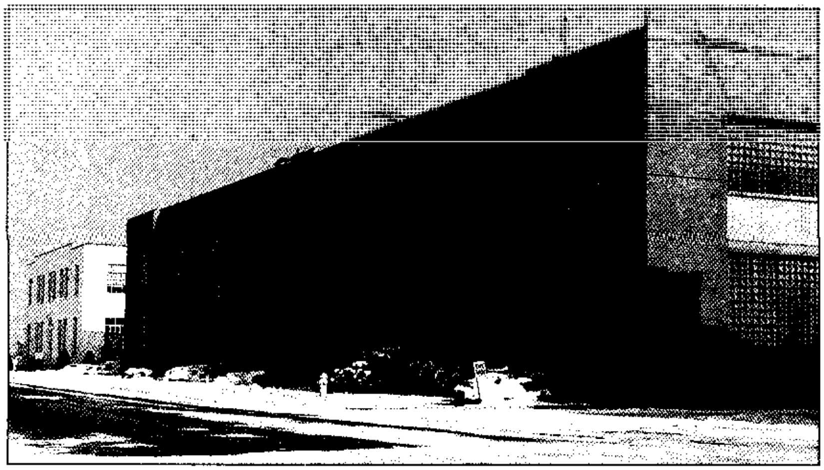
4950th Test Wing aircraft undergoing maintenance in Building 206 hangar.



Skeel Avenue entrance to base operations complex, constructed in 1991.

BUILDING 207, AREA C

Building 207 was built in 1941 as an instrument repair facility. Since its construction, it has remained in continuous use as an instrument and equipment repair shop and contains highly sophisticated repair equipment. In 1987, the 4950th Test Wing moved its Instrumentation Support Division into the facility.



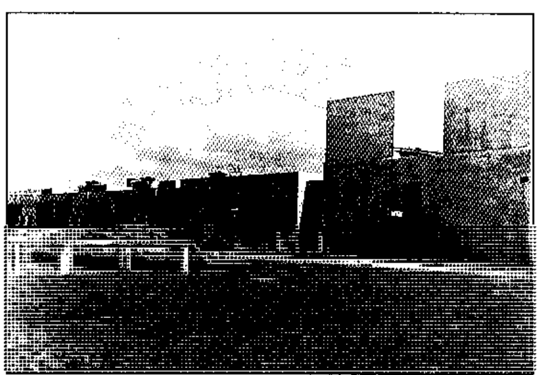
Building 207, Area C.

Instrument repair shop, Building 207.

Equipment repair shop, Building 207.

BUILDING 256, AREA C

The Vertical Engine Test Building was constructed in 1941. Its individual test cells were used to test reciprocating and jet engines. In 1975, the base relinquished its administrative aircraft and transferred responsibility for the Test Cell Shop and several other buildings to the 4950th Test Wing. Under the Test Wing, Building 256 was operated as an engine testing and storage facility.



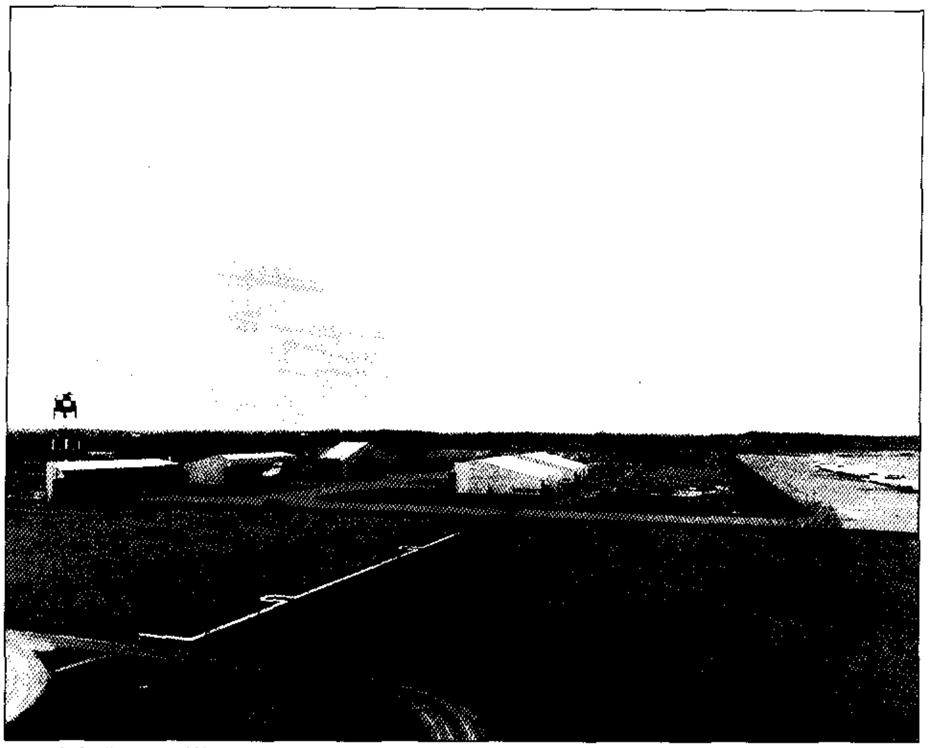
Building 256, Area C, and engine test spray pool.

Building 256, interior view.

BUILDING 4004, AREA C

The 4950th Test Wing moved into Building 4004 in 1977. The structure housed the wing's Operations and Training Division and served as an aircrew facility. The building was constructed in 1960 as an operations and alert scramble facility for Strategic Air Command's 4043d Strategic Wing. The 19,895 square foot structure also contained an underground aircrew facility. The "mole hole", as the underground portion was commonly called, was equipped with kitchen, showers, sleeping facilities, back-up generator, and back-up water supply to house SAC crews who were performing B-52 bomber and KC-135 tanker alert duty. The building was converted to offices after SAC ceased alert operations and departed Wright-Patterson in 1975.

4950th sign welcomes visitors to the west ramp.


4950th facilities on Wright-Patterson's west ramp.

BUILDING 4010, AREA C

Building 4010 was constructed in 1960 as the headquarters for Strategic Air Command's 4043d Strategic Wing. Headquarters, 4950th Test Wing took up residence in 1977. The Test Wing also located its Deputy Commander for Operations, Resource Management, Test Management Division, Standardization Evaluation Division, and Safety Office in the building.


Headquarters, 4950th Test Wing.


Building 4010, Area C.

OTHER AREA C FACILITIES USED BY THE 4950TH TEST WING

FACILITY	FUNCTION
Building 152	Special Programs Division
Building 884	Precision Measurement Equipment Laboratory
Building 4008	Small Computer Management Branch Management Information Systems Branch
Building 4012	Director of Maintenance Quality Assurance Division Maintenance Management Division Component Repair Branch
Building 4014	Flight Test Engineering Project Support Division Test Analysis Division Experimental Flight Test Division Life Support Officer
Building 4021	Mission Support Branch Aerospace Ground Equipment
Building 4022	4950th Organizational Maintenance 4952d Aircraft Maintenance Unit
Building 4024	Wash and Lubrication
Building 4026	4953d Aircraft Maintenance Unit
Building 4035	ARIA Programs Division Survival Equipment
Building 4042	ARIA Systems Branch Training/Standardization
Building 4044	Vehicles
Building 4046	Aircraft Equipment

GLOSSARY

A-	attack aircraft
AT-	advanced trainer
ABLEX	Airborne Laser Exercise
ACLS	Air Cushion Landing System
AFAL	Air Force Avionics Laboratory
AFETR	Air Force Eastern Test Range
AFFDL	Air Force Flight Dynamics Laboratory
AFFTC	Air Force Flight Test Center
AFGL	Air Force Geophysics Laboratory
AFOTEC	Air Force Operational Test and Evaluation Center
AFSAT	Air Force Satellite
AFSC	Air Force Systems Command
aft	rear of the aircraft
AFWAL	Air Force Wright Aeronautical Laboratories
AGL	above ground level
AIDES	Airborne Infrared Decoy Evaluation System
ALC	Air Logistics Center
ALCM	Air Launched Cruise Missile
ALL	Airborne Laser Laboratory
AMC	Air Materiel Command
AMRAAM	Advanced Medium Range Air-to-Missile
AMU	Aircraft Maintenance Unit
APTS	Airborne Pointing and Tracking Systems
ARDC	Air Research and Development Command
ARIA	Advanced Range Instrumental Aircraft; originally stood for Apollo Range Instrumentation Aircraft
ARTB	Advanced Radar Test Bed
ASD	Aeronautical System Division
ATSC	Air Technical Service Command
ATTD	advanced technology transition demonstrator
AWACS	Airborne Warning and Command System
AWADS	Adverse Weather Aerial Delivery System
B-	bomber aircraft
BCS	beam control subsystem
BMD	Ballistic Missile Defense
BMEWS	Ballistic Missile Early Warning System
BTT	Bistatic Technology Transition
C-	cargo aircraft
CAD	computer aided design; computer assisted design
CAE	computer assisted engineering
CALS	Computer Aided Acquisition Logistic Support
CAM	computer aided manufacturing
CE	critical experiments
CFD	computational fluid dynamics
CMMCA	Cruise Missile Mission Control Aircraft
CNC	computer numerically controlled
CO2GDL	carbon dioxide gas dynamic laser
COE	center of expertise
COESAC	Center for Excellence for Scanning and Conversion
CRRES	Combined Release and Radiation Effects Satellite
CSRC CALS	Shared Resource Centers
CSTOL	Commercial Short Takeoff and Landing
CTAS	Chrysler Technology Airborn System
DARPA	Defense Advanced Research Projects Agency
DBA	direct budget authority
DME/P	Distance Measuring Equipment Precision
DMMF	Developmental Manufacturing and Modification Facility
DFCS	digital flight control systems

DNC	direct numerically controlled
DNS	digital navigation systems
DoD	Department of Defense
DOT	deep ocean transponder
DT&E	Developmental Test and Evaluation
ECCM	electronic counter-countermeasures
ECCM/ARTB	electronic counter-countermeasures advanced radar test bed
ECM	electronic countermeasures
EDM	electrical discharge machine
EHF	Extremely High Frequency
ESD	Electronic Systems Division
ESM	electronic support measures
EW	electronic warfare
F-	fighter aircraft
FAA	Federal Aviation Administration
FADO	Fairfield Air Depot Operations
FCS	fire control subsystem
FEP	FLEETSAT EHF Package
FISTA	Flying Infrared Signatures Technology Aircraft
FLIR	Forward Looking Infrared System
FLSAR	forward looking SAR
fore	front
FSAS	Fuel Savings Advisory System
FSED	Full Scale Engineering Development
g	gravity
GDL	Gas Dynamic Laser
GHz	gigahertz (one billion hertz)
GPS	Global Positioning System
HEL	High Energy Laser
HF	high frequency
HOUND DOG	air-to-surface missile
HU-	Helicopter Utility
IBM	integrated business methods
ICBM	intercontinental ballistic missile
IFF	Identification Friend of Foe System
IGES	initial graphics exchange specifications
ILS	Instrument Landing System
IMFRAD	integrated multi-frequency radar
IPD	integrated product development
IR	infrared
IWSM	Integrated Weapon System Management
JEIM	Jet Engine Intermediate Test (Shop)
JPATS	Joint Primary Air Training System
JP8	kerosene type fuel
JTIDS	Joint Tactical Information Distribution System
KIAS	knots-indicated-air-speed
L-	Liaison
LAMARS	Large Amplitude Multimode Aerospace Research Simulator
LIDS	Laser Infrared Countermeasures Demonstration System
LO LO CAT	low level clear air turbulence
MATS	Military Air Transport Service
MEWTA	Missile Electronic Warfare Technical Area
MILSTAR	Military Strategic and Tactical Relay
MLS	Microwave Landing System
MTI	moving target indication
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NSSL	National Severe Storm Laboratory
O-	Observation aircraft
ODA	Optical Diagnostic Aircraft
OSD	Office of the Secretary of Defense

OTH-B	Over-the-Horizon Backscatter (Radar)
P-	pursuit
PAATS	Precision Automatic Aircraft Tracking System
PACAF	Pacific Air Forces
PMEE	primary mission electronic equipment
PMEL	Precision Measurement Equipment Laboratory
PT-	pursuit trainer
PW-	pursuit, watercooled
R&D	Research and Development
RAF	Royal Air Force
RBA	reimbursable budget authority
RCAF	Royal Canadian Air Force
RCC/FTS	remote command and control flight termination systems
RTIS	Radar Test Instrumentation System
RTO	Responsible Test Organization
SA	systems analysts
SAPPHIRE	Synthetic Aperture Precision Processor High Reliability
SAR	synthetic aperture radar
SATCOM	Satellite Communication
SDI	Strategic Defense Initiative
SDIO	Strategic Defense Initiative Office
SHF	super high frequency
SIOP	Single Integrated Operational Plan
Skylab	manned orbital laboratory
SMILS	sonobuoy missile impact location system
SPN/GEANS	Standard Precision Navigator Gimballed Electrostatic Aircraft Navigation System
SPO	System Program Office
STOL	short takeoff and landing
STRESS	Satellite Transmission Effects Simulations
SURVSATCOM	Survival Satellite Communication
T-	trainer aircraft
TBIRD	Tactical Bistatic Radar Demonstration
TCAMA	Testing Commercial Aircraft for Military Application
TERPS	terminal instrument procedures
TOS	Transfer Orbital Stage
TRACALS	Traffic, Control, Approach, and Landing System
TRAP	Terminal Radiation Airborne Measurement Program
TRSB	Time Reference Scanning Beam
UC	University of California
UHF	ultra high frequency
U.S.	United States
USAF	United States Air Force
WADC	Wright Air Development Center
WBA	wide bistatic angle
WSMC	Western Space and Missile Center
X-	experimental model aircraft
Y-	prototype model aircraft
Z-	planning model aircraft
ZERO-G	Zero Gravity

SOURCES

The written source material for this project was plentiful, originating with an abundant collection of primary material and secondary works. The authors were fortunate to establish contacts with many past and present 4950th Test Wing employees who generously provided primary source documents to clarify and support the descriptions of the various test activities. These, coupled with the comprehensive historical collection of data maintained in the Aeronautical Systems Center (ASC) archives, were instrumental in allowing us to construct this retrospect of flight testing. In addition, several secondary sources were used to complete the research effort.

The examination of the beginnings of flight test, and the subsequent evolution of technology, drew on several published secondary sources. *From Huffman Prairie to the Moon: The History of Wright-Patterson Air Force Base*, by Lois E. Walker and Shelby E. Wickam (WPAFB: Office of History, 2750th ABW, 1986); and *Test Flying at Old Wright Field*, edited by Ken Chilstrom (Omaha: Westchester House, 1993), offered a valuable look from the early beginnings of the Wright brothers to the flight test activities under the auspices of the 4950th Test Wing. Dr. Richard P. Hallion's *Test Pilots: The Frontiersmen of Flight* (Washington, D.C., Smithsonian Institution Press, 1988) provided insight into the history of early test efforts and the psyche and motivation of the pilots who risked all. Supplemental information covering organizational changes over the years drew on primary documentation contained in the ASC History Office archives.

An excellent source of information for test flying operations under the Directorate of Flight Test during the 1960's and 1970's came from primary source material contained in the personal files of Mr. Larry Roberts, a 4950th Test Wing engineer. His vast collection of notes, logs, published reports, and photographs were invaluable in covering the all-weather testing in Project Rough Rider. Information for other programs and projects during this period was found in official historical records maintained in the ASC archives.

The chapter on test flying activities of the 4950th Test Wing drew on several sources. Published and unpublished histories, both from ASC archival records, and unit files, provided a majority of the information on specific programs. This was supplemented by in-house studies, reports, and briefings; news releases and fact sheets; and personal interviews. A valuable overview of the principles of military technology was found in Advanced Technology Warfare, by Col. Richard S. Friedman, *et al* (New York: Harmony Books, 1985).

The project team was fortunate in having a vast collection of photographs at its disposal. They originated from numerous sources, ranging from official archives and publications to personal collections and working files. An invaluable collection of current aircraft photographs came from Mr. Joe Moser in the 4950th Test Wing's Program Management Division. The extensive collection of pictures reflecting functional support to the Test Wing are the result of the generous contributions of many within and out of the Test Wing. Additional photographic support was provided by the USAF Air Force Museum's Mr. Dave Menard, who not only supplied appropriate photographs but first-hand descriptions of many Wright Field flight test activities since World War II. Unless otherwise noted, all pictures are official U.S. Air Force photographs.

The success of this project was due to the collaborative effort of many dedicated people. It could not have been produced in so short a time without the assistance and cooperation of the entire Wright-Patterson flight test community. Their voluntary outpouring provided a vast and invaluable source of information. Any errors of fact or content contained in this book are solely the responsibility of the ASC History Office.

A great debt of thanks is owed to Col. John K. Morris, Commander of the 4950th Test Wing. He first suggested the ASC History Office write this book as an effort to record the eventful years of flight test under the 4950th Test Wing at Wright-Patterson AFB, in anticipation of its relocation to Edwards AFB in 1994. As the undertaking grew in scope he remained an unstinting supporter of the project and an astute source of advice and assistance throughout the research, writing, and publishing effort. Col. James H. Doolittle, III, Vice Commander of the 4950th Test Wing, generously contributed his time and expertise, reviewing each chapter and offering personal insight, documentation, and much cogent advice.

Special recognition goes also to several retired individuals who contributed their time to let the project team draw on their corporate memory of many of the past and current programs and activities. Mr. Oscar Niebus, retired from the 4950th Test Wing's Program Management Division, provided an invaluable overview of his forty-plus years of experience with the Test Wing. Mr. Charles Weiskittel, former assistant chief of the Fabrication and Modification Division, generously offered his time and expertise including a personally guided tour of the Test Wing's modification shops. Lt. Col. Charles Buechele loaned us several pictures and mementoes from his years in flight testing. Maj. Toby Rufty provided his files and shared his personal experiences as a member of the ARIA crew. In addition, TSgt. Deborah Schotter, formerly of the 4950th Test Wing, sketched the illustration of Wright Field that graces the cover.

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Many people—military and civilian, active duty and retired—came forward to provide information and insight. Coordinating their efforts was not always easy since, as the 4950th Test Wing was preparing to move, many people had already moved onto other programs and locations. Hopefully we are not overlooking anyone in extending our sincere thanks to the following individuals:

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California, here I come!