HELP SAVE THE NT-33A

Please help insure the NT-33A will be preserved and displayed at the Air Force Museum. The Wright Lab plans to retire the NT-33A in the Spring of 1995, after over 40 years of very productive research flying, including over 35 years as an in-flight simulator.

The Air Force Museum is our primary choice for the NT-33A's final resting place. However, the museum does not want this truly historic aircraft for their main facility at Wright-Patterson AFB because of limited space and their feeling that the museum should only display aircraft that are representative of fleet-wide use. The museum is willing to accept the NT-33A, but would display it elsewhere.

In 1901, Wilbur Wright stated that "The inability to balance and steer still confronts the student of the flying problem...When this feature has been worked out, the age of flying machines will have arrived..." As an in-flight simulator, the NT-33A spent its career helping to expand our knowledge of flight control, one of aviation's earliest known problems.

We feel the NT-33A has earned the right to be properly preserved and displayed indoors with other research aircraft at the Air Force Museum. It has been one of the most productive research aircraft ever used and has been a vital tool in shaping the development of modern fighter aircraft.

I'm sure you agree and your help is needed to make this happen. Please write to the Air Force Museum, especially if you have been involved in any NT-33A research programs, or have flown the the NT-33A as an evaluation pilot or as a student test pilot. Emphasize the historic value of this aircraft, using any of the following points, and relate any personal experiences:

a. The aircraft has been in continuous service as an in-flight simulator since 1957 and is probably the longest-lived research aircraft in history.

b. It has supported development of aircraft such as the X-15, X-24, A-10, F-15, F-16, F-18, F-117, and F-22. It has also supported the development of several foreign fighter aircraft.

c. It was used to develop the military specification and standard for handling qualities for all U.S. fighter aircraft, which essentially has become a world-wide standard.

d. It was used to develop standardized Head-Up Display (HUD) symbology for fighter aircraft, which will soon allow the HUD to be used as a primary flight instrument.

e. It has been used at the Air Force and Navy test pilot schools to train new test pilots since the mid-1970s. Virtually every military test pilot since then has been trained using the NT-33A. It has been used to teach them to evaluate aircraft handling qualities and HUD design, and how to design and evaluate the flight control system of a new aircraft.

f. The NT-33A has been the oldest USAF aircraft flying, as well as the oldest and last T-33, since the late 1980s. Its mission was so critical for research, development, and test pilot training that it was operated without depot support for the last five years of its life.

Feel free to use these thoughts, but please use your own words and expand as much as you can. Any personal experiences you had with this aircraft, especially your thoughts regarding how its use helped you become a better test pilot, or helped you make decisions that impacted the development of other aircraft, would help greatly.

The Air Force Museum's mission is to preserve and display the Air Force's history for future generations. Flight research aircraft have always been an essential part of that history, but are easily overlooked due to the small number of research aircraft used, compared to the masses of other aircraft needed to fulfill the Air Force's mission.

The NT-33A's role as an in-flight simulator in performing flight research has had a significant impact on the design of military aircraft for over thirty five years. It has earned its place at the Air Force Museum, not as an oddity, but as an integral part of telling and preserving the Air Force's history.

Letters can be sent to the Air Force Museum's director, Mr. Richard Uppstrom (Col, USAF, Ret), at the following address:

USAFM/DR
Wright-Patterson AFB OH
45433-6518

If you need any additional information from me, please feel free to call me at 513-255-8512 (DSN 785-8512). Thank you in advance for your help.

Steve Markman

Steven R. Markman

Key Points about the USAF NT-33A
In-flight Simulator Aircraft

- Airframe was built in 1951 by Lockheed as a jet trainer.
- In 1954-57 Cornell Aeronautical Lab (now Calspan SRL Corporation) modified the aircraft into a research aircraft used for flight control and handling qualities research.
- The most obvious modification includes installation of an F-94 nose to hold the additional electronics.
- The front cockpit was modified to have fly-by-wire controls that can be changed in-flight to simulate other aircraft flight characteristics.
- The front cockpit is also equipped with a side stick and a programmable Head-up Display.
- Since its original modification it has been updated numerous times and is still being used for flight control system research.
- One of its first programs was to simulate the re-entry flight characteristics of the X-15.
- It was used to simulate the YF-16, YF-17, F-18, A-9, A-10, and YF-22 before they flew for the first time.
- Nearly every test pilot trained in the U.S. military from 1963 to 1994 has flown this aircraft.
- In April of this year it completed its last assignment at Edwards AFB where it completed two research projects on the flight characteristics of advanced aircraft.
- Later this year it will be inducted into the Air Force Museum at Wright-Patterson AFB.

A suggested narrative for the fly-over is:

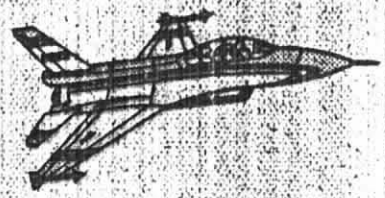
"This highly modified T-33 jet trainer is used to simulate new experimental airplanes. It has an F-94 nose section to house the computers and electronics. Its front cockpit was one of the earliest "fly-by-wire" set of controls. Some of its projects include the X-15 during the early 60's and the F-22 in the early 90's. It is still in use today for research and is the oldest actively flying Air Force aircraft."

IN-FLIGHT SIMULATION

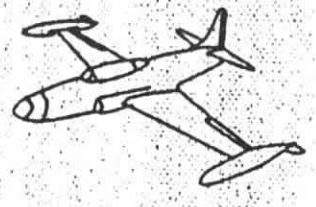
NT-33A: LOOKING BACK

VISTA/F-16: LOOKING AHEAD

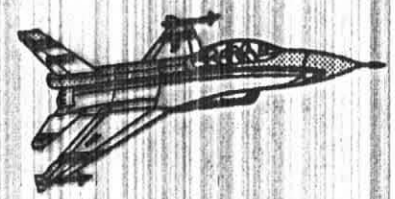
Steven R. Markman
Wright Laboratory
Wright-Patterson AFB Ohio



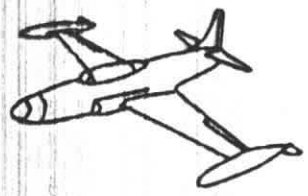
EARLY HISTORY



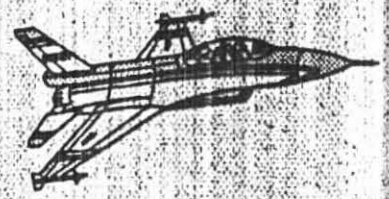
- 51-4120
- Delivered to Air Force Oct 51
- Engine/Airframe Testbed
  - Lockheed: Oct 51 - Jun 52
  - Allison: Jun 52 - Oct 54
- Transferred to CAL: Oct 54
- First Flight as IFS: Feb 57



MAJOR MODIFICATIONS



- F-94 Nose
- Artificial Feel System
  - Front Seat
  - Stick & Rudder
- Variable Stability System
  - Analog Computer in Nose
  - Gain controls in Rear Cockpit
- Hydraulic Actuators
  - Elevator
  - Ailerons
  - Rudder
- Recording System



EARLY HISTORY
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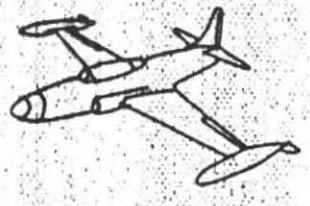
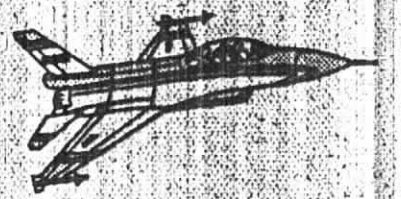
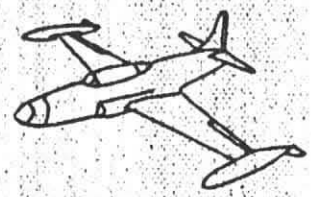


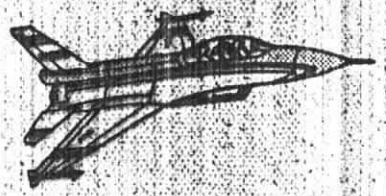
- One Year System C/O & Verification
- Mishap July 58
  - Wing Replaced
  - Flying Again Oct 58
- VSS Upgrade, Early 59
  - Vacuum Tubes Replaced with Transistors



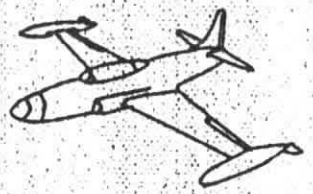
EARLY PROGRAMS



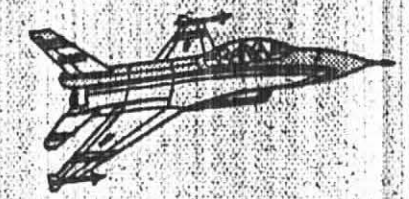
- Lifting Body Re-Entry (1959)
- X-15 (1960)
- Variable Drag Brakes (1961-2)
- TSR-2 (Great Britain, 1962)
- Ground Simulator Development (1962-3)
- Flying Quality Research (1963-4)
- M2F2 (1965)
- X-24 (1966)
- Relaxed Static Stability/Stability Aug (1967-70)



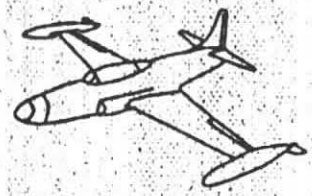
MORE PROGRAMS



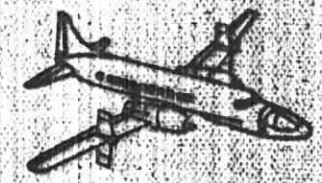
- Side Force Development (1971)
- A-9/A-10 Simulations (1971)
- F-15 (1972)
- Modifications (1973)
  - In-Flight Refueling Probe
  - Side Stick
- YF-16/YF-17 Simulations (1974)
- USAF & USN TPS (1975 - present)
- Flutter Incident (1976)



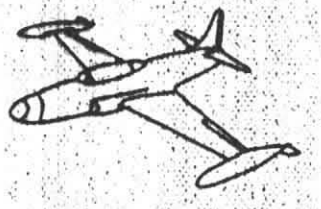
STILL MORE PROGRAMS

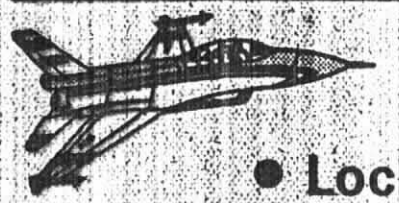


- F-18 (1978)
- HUD Installation (1979)
- AFTI/F-16 (1981)
- SAAB/RSAF Mini-Stick (1983)
- LAVI (1985)
- VISTA Tactile Cueing (1987)
- JAS-39 Gripen (1989-90)
- FY-22 (1990)
- IFR HUD Symbology (1991-2)
- Light Combat Aircraft (India) (1994-5)

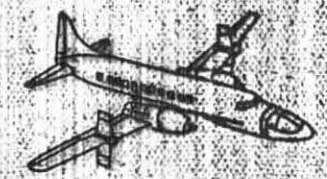


VISTA DEVELOPMENT

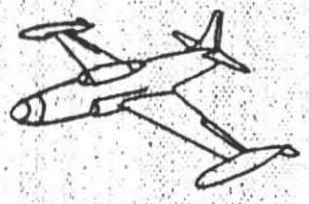


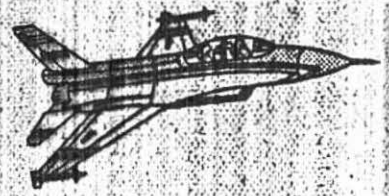


- Lockheed/Calspan Team
- First Flight April 92
- Development Stopped for Financial Reasons
- Airframe Loaned to MATV Program
- VISTA Development Resume Feb 94
- Operational Jan 95

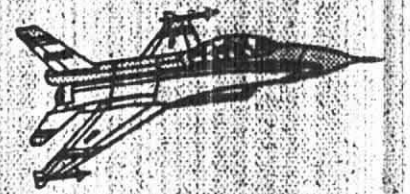


OPERATING CONCEPT

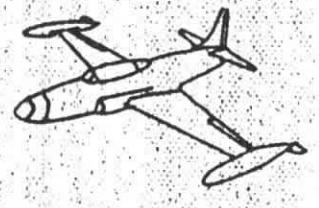




- Government Ownership
- Contractor Operation
- Base at Contractor's Facility
- Tasking Contract



NT-33A RETIREMENT



- EAFB Museum?
- NASM?
- USAF Museum?

Chapter from upcoming book "One-of-a-Kind: The Story of Modern Research Aircraft" By Steve Markman & Bill Holder

NT-33A IN-FLIGHT SIMULATOR

AIRCRAFT TYPE: T-33A "Shooting Star" Military Jet Trainer
MISSION: In-Flight Simulation, Research
OPERATING PERIOD: 1957 - Present
RESPONSIBLE AGENCY: Wright-Patterson Air Force Base, Ohio
PRIMARY CONTRACTOR: Calspan Corporation
THE STORY:

The NT-33A surely holds the record as far as being the longest continuously-operated test aircraft in history, as well as being the most productive in-flight simulator ever. Having been operated as an in-flight simulator since 1957, it has been used to support the development of aircraft from the X-15 up to the YF-22. In addition, it has supported a large amount of aeronautical research and been used to train most U.S. Air Force and U.S. Navy test pilots since the mid-1970s. With the retirement of the T-33 fleet in the late 1980s, the NT-33A became the last remaining T-33 in Air Force service. With a 1951 tail number, it has been the oldest flying aircraft in the Air Force since the mid-1980s.

The NT-33A was delivered to the Air Force in October 1951, but remained at the Lockheed factory as an engine-airframe testbed. In June 1952 it went to the Allison Division of General Motors to continue engine test work. In October 1954 it was delivered to the Cornell Aeronautical Laboratory (now Calspan Corporation) in Buffalo, New York, to be re-built as an in-flight simulator. This work was to be performed under a contract from the Wright Air Development Center (now Wright Laboratory) at Wright-Patterson Air Force Base in Ohio.

The aircraft was extensively modified over the next several years. The major modifications included:

* Replacement of the original nose with the larger nose from an F-94 aircraft (the F-94 was an interceptor based on the T-33 airframe). The larger nose was needed to house all the recording equipment and analog computers needed to create the variable stability responses and produce the control stick feel characteristics.
* Removal of the front-seat flight controls and installation of an electro-hydraulic artificial feel system, i.e., control stick and rudder pedals, in the front cockpit. This was needed to duplicate the simulated aircraft's feel characteristics and to direct the front seat pilot's stick inputs to the computer (the rear seat pilot's controls remained attached directly to the control surfaces as on a normal T-33).
* Installation of hydraulic actuators connected to the elevator, ailerons, and rudder. These are controlled by the computers to make the aircraft respond in the desired manner.
* Installation of variable stability gain controls in the rear cockpit. These controls are similar to the volume controls on a television or radio and are connected directly to the variable stability computer. They allow the safety pilot to adjust the aircraft flight characteristics and control stick's feel. Thus the safety pilot can increase or decrease the abruptness of the aircraft response, make the stick feel light or heavy, and make oscillations die out quickly or slowly.

The aircraft made its first flight in this modified configuration in February 1957. The flight was completed without a single maintenance write-up, a significant accomplishment considering that the aircraft had not flown for over two years while it was being modified. A year of

checkout flights followed in which the operation of the variable stability system was checked and the full capabilities of the aircraft were verified.

The NT-33A suffered its first mishap in July 1958 that could have ended its career. While attempting a landing on a short wet runway with high gusty winds, the aircraft skidded and hit the concrete base of a runway light with one of its main landing gears. The impact resulted in the wing spar being twisted beyond repair. A replacement wing was obtained and modified. The aircraft was flying again in October.

The first of many upgrades to the variable stability system was performed early in 1959 when the vacuum tube circuitry was replaced with germanium transistors.

The NT-33A finally performed its first research program in November and December of 1959. It was ferried to the Air Force Flight Test Center at Edwards AFB in California where it performed a generic study of the predicted handling qualities of lifting body re-entry vehicles. In less than six weeks, 100 hours of test flights were performed, a tribute to the rugged design of all the modifications.

During the summer of 1960, the first of many unique programs was performed, this one to support development of the X-15 research aircraft (the word "unique" tends to be overused, because many NT-33A research programs incorporate some new capability or use the aircraft in some way not envisioned in the original design). It was desired to simulate the X-15 during descent. The simulation run had to begin when the X-15 was in a ballistic reentry at 0g, supersonic speed, and 70,000 feet altitude! During the evaluation, the pilot had to perform a wings-level pull-up, reaching a maximum of 4g. The simulation was accomplished by tricking the pilot, who flew the simulation under a hood, by reference to aircraft instruments only. The flight profile, which lasted about 100 seconds, was programmed on the NT-33's computers, starting at the initial altitude and Mach number. The NT-33's flight instruments were controlled by the computer. As the simulated X-15 descended, the NT-33's instruments indicated the X-15's condition. Since the handling qualities changed drastically as the X-15 descended and slowed, this was accomplished by changing the NT-33's variable stability system gains as a function of time to reflect the X-15's characteristics at any time during the data run. To produce the g's needed to simulate the sustained pull up, the NT-33A slowly banked in a turn, but the pilot's attitude instrument indicated a wings-level pull up! Many of the test pilots who eventually flew the X-15 participated in this simulation.

During 1961 and 1962, the NT-33A underwent another system upgrade. This time, the standard tip tanks were replaced with ones that were modified into drag brakes. The back end of each tank was rebuilt with hydraulically-actuated surfaces that could be extended into the air stream to produce high drag. This modification would be required for future simulations of lifting body reentry vehicles that flew very steep approaches.

During 1962 and 1963, the ground simulator capability was developed in which the aircraft became part of a ground-based flight simulator. The basic aerodynamics of the NT-33A were programmed on an auxiliary computer that connected on the ground to the NT-33A's computer system. With these two computers working together, the front-seat pilot could now sit in the NT-33A on the ground and fly the simulation that he would later fly in the air. This capability allowed most of the simulation to be checked on the

ground, greatly reducing setup time and costs for each experiment. It also allowed the results of the NT-33A simulation to be compared more easily with other ground-based simulations, greatly enhancing the credibility of test results.

A number of generic handling qualities experiments were performed in 1963 and 1964. These were performed to determine acceptable and unacceptable handling characteristics for various sizes of aircraft. In 1965, simulations were again performed to support the development of lifting body vehicles. This time, the M2F2, one of the early predecessors of the X-24, was simulated. In 1966, the X-24 itself was simulated.

By the late 1960s, it was realized that future military aircraft would have to make extensive use of stability augmentation in order to retain acceptable handling qualities while performing their missions over tremendous ranges of airspeed, altitude, weight, external loading, and center of gravity locations. The late 1960s was spent performing many research programs investigating the use of relaxed static stability and electronic stability augmentation. This research contributed directly to the design and development of the F-15, F-16, and YF-17, which were to follow in a few years.

Another new capability was developed during 1971. The controls for the tip-tank-mounted speedbrakes were modified so they could be deployed asymmetrically to produce yaw. By then counteracting the yaw with the rudder, a net side force resulted! In late 1971, the NT-33A participated in the A-9/A-10 flyoff competition by simulating both aircraft. The side force capability was essential for simulating the A-9, because the A-9 used a similar sideforce generating scheme to allow precision aiming for ground attack.

The NT-33A's contribution to current fighter aircraft continued by simulating the F-15 shortly before it made its first flight in 1972. In 1973, an in-flight refueling probe was installed to allow in-flight refueling tasks to be evaluated (in-flight refueling is a very demanding piloting task...if an aircraft has a poor handling characteristic, in-flight refueling is one of the tasks where the problem will probably show up). Also in 1973, a hydraulically actuated side stick was installed to support YF-16 development. Several handling qualities deficiencies in the YF-16 design were predicted and corrections to the flight control system were made. In 1974, a simulation of the YF-17 was performed. On one landing, an "explosively" unstable oscillation began, resulting in an extensive redesign of the YF-17s flight control system before the YF-17 ever made its first flight.

In 1975, both the Air Force and Navy test pilot schools began using the NT-33A to train new test pilots. The in-flight simulator is an ideal tool for this purpose, because it's flight characteristics can be changed easily. It is essential for a test pilot to describe what he sees and feels when testing a new aircraft. Although test pilots train in a wide variety of aircraft, understanding subtle differences can be difficult when going from one aircraft to another. Using an in-flight simulator, these subtle effects can be exaggerated while holding all other characteristics constant, thus helping the new test pilot to identify them and understand their significance. The NT-33A is also used to teach flight control system design. New test pilots see the effects of various types of stability augmentation on the flight characteristics of a baseline aircraft being simulated. They also fly the aircraft with both a centerstick and sidestick to experience the differences. Last, recent

problems encountered with real aircraft can be demonstrated, as well as the corrective actions that were taken to correct the problem.

The NT-33A had it's closest bout with disaster in 1976 while performing a research project near St. Louis. As the aircraft was climbing to the test area, the wings began to flutter and the tip tanks snapped off, taking with them outboard sections of the wing. Ready to eject, the pilots performed a controllability check and determined the aircraft still had enough control power to attempt a landing. The Air Force came very close to recommending the NT-33A be retired following this mishap. Fortunately, farsighted people within both Government and industry saw the ongoing value of the aircraft and convinced the Air Force to rebuild it and keep it flying. The aircraft was disassembled and the wing was replace. However, to keep the cost down, the tip tanks were not modified into drag brakes because there was no immediate need for them at the time (nor did the need materialize again and the aircraft retained standard tip tanks ever since).

In 1978, the Navy was developing the F-18, which was based on the YF-17. When problems with roll control developed, the NT-33A was used to simulate the F-18 and help develop a correction to the flight control system.

A programmable head-up display (HUD) was installed in 1979. This device projects the attitude and other essential flight information in front of the pilot so he can keep his head out of the cockpit. An evaluation then was performed of several different HUD symbologies. Since this system was installed, most test programs have included the HUD display of the aircraft being simulated.

The NT-33 remained active through the 1980s. Many research programs were flown in attempts to determine why modern aircraft design techniques often still failed to predict poor flying qualities. With the introduction of digital computers as the heart of the flight control system on most new aircraft, new problems emerged that needed to be resolved. Specific aircraft developments that were supported were the AFTI/F-16 (a special test aircraft with many unconventional flight control capabilities), the Lavi (a fighter to be built by Israel, eventually cancelled), the JAS-39 Gripen (a fighter built by Sweden, currently entering service), and the YF-22. During 1991 and 1992, the NT-33A performed research programs making extensive use of the programmable HUD. Despite the fact that all current Air Force fighter aircraft use HUDs, there is no standard display and the HUD may not be used as a primary flight instrument while performing instrument flight. Extensive flying was performed to evaluate proposed display configurations to help establish a standard HUD format for all Air Force fighter aircraft.

With over 35 years of dependable service, the NT-33A remains active in the mid-1990s. Although technical support, spare parts, and engines are no longer available through the Air Force depots, adequate stocks of parts have been set aside to keep the aircraft flying and performing much-needed research until it is replaced by the VISTA/NF-16D in-flight simulator.