

Lockheed NF-104A Aerospace Trainer

By: Tony R. Landis



Paths to the Present
FLASHBACK

In October 1961, the USAF Test Pilot School at Edwards AFB received the new designation of Aerospace Research Pilot School (ARPS) which reflected the increasing role relative to manned spaceflight. Recognizing early that a need for a vehicle to give students a realistic spaceflight training experience engineers used the X-15 program as a baseline, but they understood this new program would have additional requirements. The expense of flying an X-15-like vehicle on a routine basis would be cost prohibitive, so an alternate solution would be to modify an existing production airframe.

Former ARPS students Major Frank Borman, Major Tom McElmurry and William Schweikhard are credited with the NF-104A Aerospace Trainer (AST) idea. The NF-104A, a modification of the basic Lockheed F-104A Starfighter with rocket engine and reaction controls. In November 1961, a \$5.34M contract awarded to Lockheed



Rocket-assisted climb of approximately 70 degrees AOA at the beginning of a zoom profile flight of NF-104A 56-0756 on October 4, 1964. Barely visible are the non-standard gray upper wing surface later changed to the standard white upper surfaces. (AFTC History Office, Edwards AFB)

California Company to modify three existing F-104A aircraft for the NF-104A role. The “N” in the NF-104A designation stood for “non-standard”. It is interesting to note that Northrop Aircraft proposed a similar modification to their T-38, known as the ST-38, three years prior in May 1958 and again in April 1963 but the USAF did not appear interested.

Numerous internal and external modifications were required to transform the F-104A into the NF-104A. Reaction control thrusters to control pitch and yaw added to a modified nose cone, twenty-four inch wing tip extensions housed the roll thrusters, an extended dorsal spine for rocket engine plumbing, inlet cone extensions added to better control airflow and an LR121-NA-1 rocket motor was added to an F-104G-model tail. Designers added H₂O₂ tanks added internally to the forward and mid-fuselage, while modifying the cockpit to include a control stick for the Reaction Control System (RCS) as well as an Attitude and Azimuth Reference System which provided inertial attitude and aircraft aerodynamic attitude information. Due to the extreme altitudes being flown on zoom missions, pilots required the use of a David Clark AP22S-2 full pressure suit.

The NF-104A AST rocket-powered zoom mission was extremely demanding for the pilot.



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Artist concept of the proposed Northrop ST-38, known internally as N-205B Aerospace Trainer. (Northrop via Tony Chong)

All ARPS NF-104A zoom missions were flown from and recovered to Edwards AFB. The typical zoom climb mission began with a full afterburner take-off out to 400 KIAS (Knots Indicated Air Speed) and was then throttled back to military power out to 450 KIAS. The climb continued at .86 Mach number to 35,000 feet and outbound approximately 100 miles from Edwards AFB and then executed a 180-degree turn to align for the inbound zoom profile. At 35,000 feet, the throttle was advanced to full afterburner with rocket power used briefly to pass through the transonic region, once the aircraft passed 1.8 Mach and reached the pull-up mach number, rocket power was used to augment the zoom climb at approximately 70 degrees until hydrogen peroxide was depleted near the zoom apex. As the aircraft passed through 63,000 feet the throttle was brought back to military power and the set in OFF detent as it passed 80,000 feet.



The LR-121-NA-1 rocket engine in NF-104A 56-0762 is test fired on the ground prior to in-flight testing. (Photo by Ed Kopowski ,Sr.)



Lockheed pilot Jack Woodman looks over the reaction control system port in the 24 inch wing tip extension on NF-104A 56-0762 prior to first flight. Note the yellow zinc chromate primer used on the extension for corrosion prevention as well as the natural metal flap on the inboard trailing edge. (Lockheed)

Through the apex of the climb at around 90,000 to 118,000 feet, reaction controls were used to keep the aircraft on the correct flight path. The pilot was required to maintain a constant angle-of-attack of 5 to 11 degrees through pull-out. Engine restart attempts began at approximately 70,000 feet with completion of reentry and pullout varying between 55,000 and 40,000 feet. On rare occasions air start could not be accomplished and dead stick landings would occur. The typical zoom mission lasted around 30 minutes.



Beautiful overhead view of Lockheed NF-104A 56-0760 which gives a nice perspective of the nose and wing tip modifications made to the Aerospace Trainer aircraft. (AFTC History Office, Edwards AFB)

Three F-104A aircraft chosen for the program, USAF serial numbers 56-0756, 56-0760 & 56-0762 which were all former test aircraft at Edwards AFB. They were delivered to Lockheed in August & September 1962 for modification work. The first NF-104A to fly was 56-0762 on July 9, 1963 out of Lockheed's Palmdale, CA facility with Lockheed pilot Jack Woodman at the controls. This was followed by 56-0756 on August 10 and 56-0760 on September 13. Lockheed performed the functional test flights at Palmdale prior to delivery to the USAF. Woodman shared check flight duties with Major Robert Smith. It was Smith who flew the highest Category 1 zoom flight reaching 118,860 feet on October 22nd in A/C 56-0756. Smith would later be assigned as test director for the NF-104A program and was also responsible for writing the NF-104A flight manual. Woodman followed the next day with a zoom flight to 118,400 feet in A/C 56-0760. The USAF took receipt of the three NF-104A's by October 29th with flight testing continuing with Smith. All flights were now being made from Edwards AFB. During testing, both Smith and Woodman had experienced zoom-induced departed flight and both recovered the aircraft after some very exciting moments.



NF-104A 56-0756 in flight at the beginning of another zoom profile check flight out of Edwards AFB, CA. (Courtesy of Jerry Singleton)

After taking notice of the unique performance capabilities of the NF-104A, ARPS Commandant, Colonel Charles Yeager suggested that the aircraft be used to reclaim the world absolute altitude record from the USSR. The existing record of 113,892 feet established in April 1961 in an E-66A (modified MiG-21) by Georgi Mossolov. USAF command accepted the proposal and appointed Yeager as the record-attempt project pilot despite the fact that Yeager had yet to make a single NF-104A flight. Yeager flew his first NF-104A zoom flight on December 4 in A/C 56-0760 reaching a maximum altitude of



Captain John Michael Loh shakes hands with Captain James Rhoades, Jr. Loh had become the first ARPS student to fly an NF-104A rocket-powered zoom profile flight in aircraft 56-0756 on June 13, 1968 to an altitude of 93,000 feet. Loh went on to command Tactical Air Command (March 1991) and Air Combat Command (June 1992) after receiving his fourth star on June 1, 1990. (AFTC History Office, Edwards AFB)



NF-104A 56-0760 is all buttoned up, Col. Charles Yeager finalizes his checklist prior to taxiing out to the runway at Edwards AFB. (AFTC History Office, Edwards AFB)

94,500 feet. The highest altitude Yeager achieved is 110,500 feet on December 6 in A/C 56-0760. Smith zoomed the same aircraft on the same day to an altitude of 120,800 feet, which stands as the highest altitude achieved by the NF-104A. Although this altitude surpassed the Russian's, the record was unofficial because neither the FAI record-verifying process nor equipment were in place for this flight.

Yeager made two more attempts on December 9, reaching 110,000 feet and the morning of December 10, reaching 108,700 feet in A/C 56-0760. Yeager made another attempt that afternoon in A/C 56-0762 and nearly lost his life. Around 1400 hours Yeager departed Edwards AFB on another zoom flight this time reaching 101,600 feet. Yeager reported that the angle-of-attack was 50 degrees, which is well past the NF-104A pitch-up

Yeager made two more attempts on December 9, reaching 110,000 feet

angle but one that

he had used on previous flights.

On prior flights, he was able to lower the nose using the RCS, but on this

flight the RCS did not have the authority to bring the nose down

and the aircraft began reentry in a very nose-high

attitude. The aircraft departed controlled flight and began to spin. Yeager deployed the drag chute which arrested the spin and then he restarted the J79 engine. At 12,000 feet he jettisoned the chute and the aircraft immediately pitched up and entered a flat spin. Yeager ejected at 8,000 and received serious burns to his hands and face during ejection but later recovered. The aircraft was a total loss.

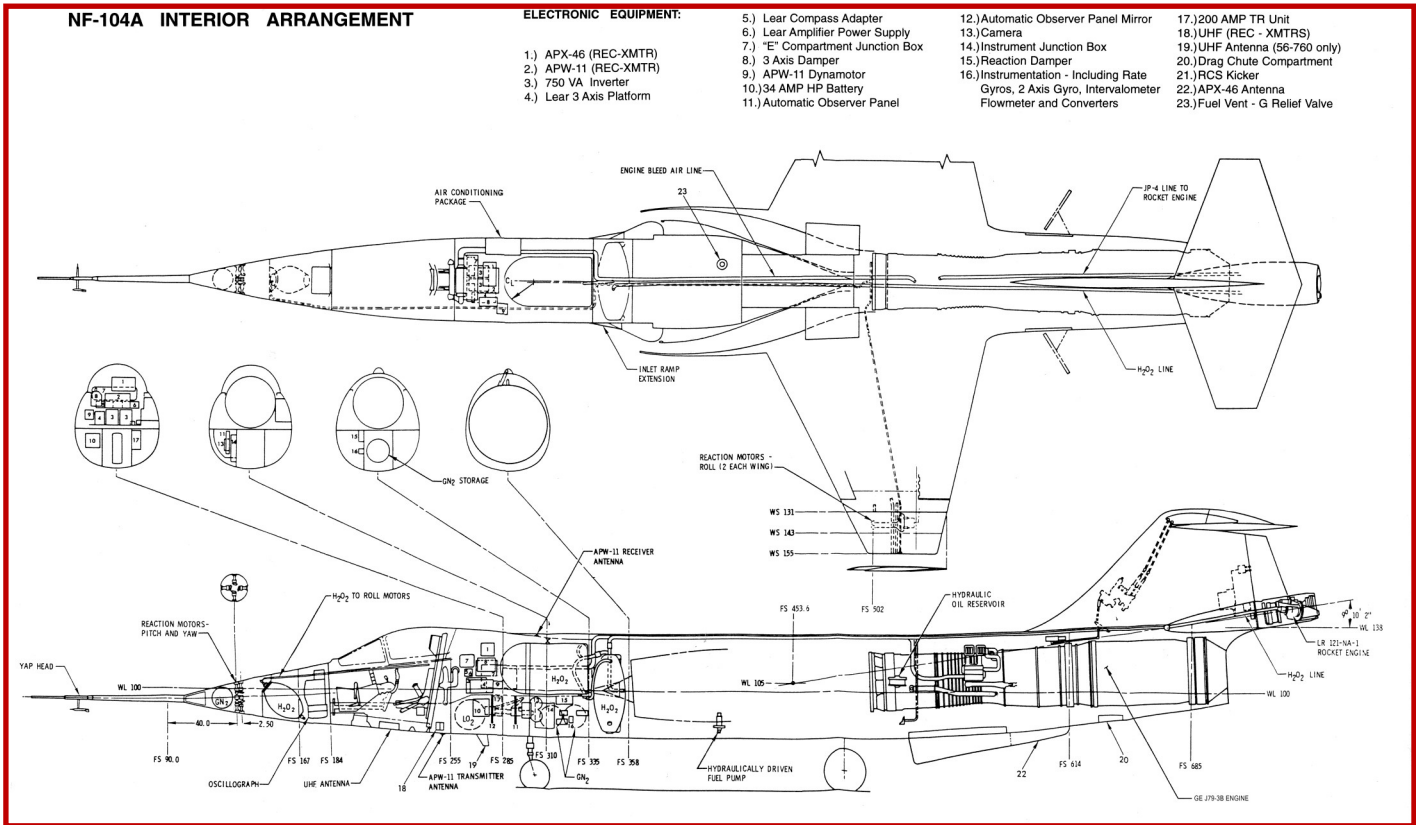
Col. Charles Yeager begins the acceleration run prior to activating the LR-121-NA-1 rocket engine to begin his first zoom profile flight in the NF-104A on December 4, 1963. (AFTC History Office, Edwards AFB)

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The flight test career of NF-104A 56-0762 was cut short after an accident involving Col. Charles Yeager on December 10, 1963. During Yeager's world record altitude attempt, he flew to an altitude of only 101,600 feet and upon reentry allowed the aircraft to exceed the maximum allowed angle-of-attack (AOA) of 11 to 15 degrees by allowing the nose to pitch up to over 50 degrees AOA. On previous flights he had been able to overcome this with the nose RCS, but on this day the RCS did not have the control authority to lower the nose. The aircraft began to spin and Yeager was forced to eject at approximately 8,000 feet. (AFTC History Office, Edwards AFB)





NF-104A general arrangement drawing showing the reaction control modifications to the nose and wing tips as well as the addition of the LR121-NA-1 rocket engine to the tail.



The NF-104 program flown by the USAF Research Pilot School at Edwards AFB fell under the control of Air Force Systems Command.



Still wearing his David Clark AP22S-2 full pressure suit, Lt. Col. Jerry Singleton poses next to NF-104A 56-0756. (AFFTC History Office, Edwards AFB)



After the loss of NF-104A 56-0762, the two remaining aircraft were evaluated by the Air Force for risk and safety. At the conclusion of these tests the two remaining NF-104A's 56-0756 and 56-0760 were essentially hangar queens for the next two years from March 1965 to April 1967. (Marty Isham Collection)

Following the mishap, the USAF conducted an extensive flight evaluation of the NF-104A. Though it concluded that pilot error played a major role in the mishap, flight restrictions placed on the NF-104A would restrict future NF-104A pilots from achieving an altitude of more than 108,000 feet. A combination of USAF politics, ARPS apathy, and technical problems kept the aircraft mostly grounded through April 1967 with only sporadic check flights occurring, it would be another 3 years before ARPS pilots would fly NF-104A zoom flight training. Flights resumed again on June 13, 1968 with Captain Michael Loh making the first rocket-powered zoom flight to an altitude of 93,000 feet. Over the next 42 months,

approximately 50 ARPS students experienced zoom climb flights to an average altitude of 106,000 feet in the NF-104A.



Tail damage of NF-104A #56-0756 on June 15, 1971. (AFTC History Office, Edwards AFB)

NF-104A #56-0756 became permanently grounded after a flight on June 15, 1971. Captain Howard 'Whitey' Thompson, beginning his rocket-assisted transonic run when he heard a loud explosion and immediately shut the engine down. He felt a second explosion and his chase pilot reported that the rocket and part of the rudder had disappeared. Captain Thompson made an emergency landing at Edwards AFB but the aircraft never flew again. The final NF-104A flight took place on December 20, 1971 when Major Ralph Graham took A/C 56-0760 to an altitude of 100,200 feet. Changing national priorities made it clear that the USAF would not be sending anyone into space aboard an air force spacecraft.

In a fitting tribute the NF-104A program, the surviving NF-104A aircraft is placed on static display in front of the USAF Experimental Flight Test Pilot School at Edwards AFB where it remains today as an inspiration to all future test pilots and astronauts.

In a fitting tribute the NF-104A program, the surviving NF-104A



For further reading, see: Air Force Legends Number 204; "Lockheed NF-104A", Steve Ginter Publications, 1999

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