



‘Howling Howland’: A history of NASA F-104B *Starfighter* N819NA.

By Christopher T. Carey, Crew Chief N819NA

NASA *Starfighters*:

To anyone familiar with the NASA *Dryden Flight Research Center* at Edwards, it would likely seem that *Starfighters* have always played a substantial role in that storied aerospace facility’s history. Indeed, Lockheed F-104s were routinely carrying a lion’s share of the important flight test support work almost from the arrival of the NACA’s (*National Advisory Committee on Aeronautics*, NASA’s precursor organization) very first F-104 *Starfighter* in 1956. NACA’s first operational flight of a YF-104A (SN 55-2961, the #7 aircraft produced, and later designated NASA N818NA) took place on 27 August 1956 and lasted 30 minutes, with Chief Test Pilot Joe Walker at the controls. From that date to the date of the last F-104 *Starfighter* flight conducted by NASA on 3 February 1994, Lockheed Aircraft Company’s radically advanced Mach-2+ ‘*manned missile*’ would fly nearly 38 years of important aeronautical research and support missions at this uniquely important desert flight test facility. The following history is that of those

11 NACA / NASA *Starfighters*, and in particular a two-seat F-104B NASA example (originally produced for use as a training version of the *Starfighter*) that provided important support for NASA's flight research program before being retired and given to the Aerospace Museum of California (by the US Air Force Museum).

NASA N819NA (known to us as '*Howling Howland*', for reasons that shall be explained) is a Lockheed F-104B *Starfighter*, formerly flown for two decades at the Edwards Air Force Flight Test Center's Dryden Flight Research Center in the Mojave desert. Although N819NA began life (intended for the US Air Force) as tail number 57-1303, shortly after it was turned off the Lockheed production line in 1957 it was instead assigned to the nation's civilian flight research organisation, the National Advisory Committee on Aeronautics, whose job it was to explore and document the rapid advances made in aeronautical technological science following the end of the Second World War.

N819NA's story actually begins nearly 42 years before it was built, with the establishment of NASA's predecessor, NACA (*National Advisory Committee for Aeronautics*), in March of 1915. NACA's mission at its inception was to "...supervise and direct the scientific study of the problems of flight with a view to their solution", for it was quickly recognized when the first primitive aircraft took to the air that these new 'flying machines' would present complex challenges to our then rudimentary understanding of the principles of '*manned heavier-than-air, powered flight*'. As aircraft design and engineering knowledge progressed at a very rapid rate, the responsibility for documenting understanding of the many 'unknowns' in the new field of aeronautical science fell upon the NACA's team of scientists and its technological research facilities.

In 1944, prompted by concerns over secret German wartime aviation advancements, Congress approved funds for an experimental research aircraft program to be administered and conducted jointly by NACA, the US Air Force, the US Navy, and private aviation industry. When all of the breakthroughs of Germany's vast wartime aeronautics research programs suddenly became available to the United States at the conclusion of WWII (much of which came to us through what has become known as '*Operation Paperclip*'), many of the Germans' radical new theories in aerodynamic engineering found their way into a whole new series of American research aircraft (many of which came to be known as '*The Century Series*' jets). It was not long thereafter that the first fully documented Mach 1 flight was made by the Bell Aircraft XS-1 (14 Oct 47), and a succession of advanced test aircraft followed that included the Douglas D-558-1 and 2, Bell X-1A & B, the Bell X-2, the Douglas X-3, the Northrop X-4, the Bell X-5, the Convair XF-92A, and many others. The ultimate expression of this near-logarithmic leap forward in aerodynamic research culminated in the famed North American X-15 rocket research aircraft that took flight testing into the fringes of space at speeds of up to Mach 6, from 1958 through 1969.

Meanwhile, in the late 50s and coincident with the establishment of an '*International Geophysical Year*' (IGY) in 1957, efforts were made to establish an entirely new agency on NACA's foundation, to be known as the *National Aeronautics and Space Administration* (NASA). With a simple preamble ("*An Act to provide for research into the problems of flight within and outside the Earth's atmosphere, and for other purposes.*"), the Congress and the President of the United States created the National Aeronautics and Space Administration (NASA) on October 1, 1958. NASA's birth was directly related to the pressures of national defense in this period, since immediately after World War II, the United States and the Soviet Union became engaged in what has become known as '*The Cold War*', a worldwide contest between two opposing ideologies and a monumental struggle to win the allegiances of 'nonaligned' nations. During this period, space exploration emerged as a major arena of this contest that shortly became known to history as '*the space race*'. When NASA first came into being in 1958 it quickly absorbed the earlier NACA mission and from 1958 onwards NASA's presence at the Edwards Air Force Flight Test Facility (near Mojave, California) became established at the Dryden Flight Research Center (formerly known as the NACA '*High Speed Flight Station*').

An important part of NASA's flight test operations was to support the flight testing being done on all the new aircraft designs being produced; in that capacity, certain types of high speed aircraft (usually of the jet fighter type) were employed by that agency both as flight test "safety chase" (aircraft that would closely follow a research aircraft during its flight to document the mission, observe the test flight, and provide direct support to the test aircraft's pilot) and as functional component elements of various programs and projects dealing with advanced high altitude aerospace research. The Lockheed F-104 *Starfighter*, promoted by Lockheed publicists as '*The Missile with the Man in it*' (although no pilot ever called it by that highly imaginative name), was soon selected as the key player on the NASA team that would eventually employ eleven of its type in aeronautical research programs.

In October of 1957, a second *Starfighter* was added to the NASA fleet (F-104A SN 556-0734) on loan from the US Air Force, and a third F-104 (F-104A SN 56-0749) was added in April of 1959. Later the same year, a two-seat F-104B *Starfighter* ('Howling Howland', USAF SN 57-1303) already stationed at the NACA Ames Research Center (at Moffitt Field in the San Francisco Bay Area) was sent to the Edwards facility (NASA had decided to establish all of its high-speed research operations at the new Edwards desert facility) as the fourth member of NASA's Edwards F-104 *Starfighter* research team.

The first four NACA / NASA F-104 *Starfighters* (including 'Howland') had been acquired from the US Air Force under terms that designated them as research 'loan' airframes. In 1963 three additional Lockheed F-104G model type single seat *Starfighters* were personalized to NASA's specific requirement and delivered to the Dryden facility, having been purchased directly by NASA; these

three aircraft were designated *F-104N* models (N811NA, N812NA, and N813NA) and had no US Air Force numbered designations. They conformed to the G specification then being built on the Lockheed production lines, having all the features of that model, but lacked standard military features like weapons and a fire control and targeting system, and also had their internal compartments configured to suit NASA flight test mission requirements. Although these three aircraft were more often used as proficiency trainers and 'safety-chase', they also figured significantly in many of the advanced research projects.

In December of 1966, still another *Starfighter* (SN 56-0790, an F-104A model) was acquired by NASA on loan from the Air Force, due to the loss of N813NA (piloted by Joe Walker) in the much publicized accident involving loss of the North American XB-70A *Valkyrie* on 8 June 1966. The addition of an F-104G model *Starfighter* (NASA N820NA, a G type produced for West Germany's Air Force) in July of 1975 brought the NASA Dryden *Starfighter* fleet to a total of eight, but this was shortly reduced to seven again, when N818NA (the pioneering YF-104A and NASA's very first *Starfighter*, USAF SN 55-2961) was retired to a place of honor at the Smithsonian's *National Air and Space Museum* in Washington, DC. [In 1977, single seat N820NA was retired from service and was eventually consigned to the US Air Force Museum at Dayton, Ohio.]

Somewhat later, NASA acquired three F/TF-104G *Starfighters* that had been used in training German Air Force pilots. Two of these were tandem-seat TF-104Gs and one was a single-seat F-104G; they were given NASA designations N824NA (USAF SN 61-3065), N825NA (USAF SN 61-3628), and N826NA (German SN KG200), respectively. The last *Starfighter*, a single-seat RF-104G model, was originally built by the Fokker Aircraft Company for the Luftwaffe and had been used for Luftwaffe pilot training at Luke AFB in Arizona. After having been demilitarized, they were used then used by NASA for various flight test purposes. Since 57-1303's ("Howling Howland") retirement in 1978, the lack of a two-seat high-speed research support *Starfighter* had been keenly felt, so the addition of the two new tandem TF-104G models to the NASA Dryden fleet was very beneficial.

'Howling Howland', a rare F-104B bird.

One of only 26 two-seat B model *Starfighters* ever made by Lockheed, during the 1957-58 time frame, with the addition of this two-seat Mach 2 aircraft another important dimension was added to the Center's research capability. The two-seat B model *Starfighter's* mission consisted initially of carrying instrumented individuals and/or life support experiments in the aft cockpit (with a safety pilot flying the aircraft from the front cockpit), however, that role was soon greatly amplified. As a result of this expanded concept, the conduct of numerous bio-medical experiments was enabled, many of which were directly applicable to the

space program and which would prove to be of important use both to the aerospace and the civilian medical community. These researches were conducted under the direction of the Center's Dr. William Winter.

Among these important biomedical programs was the development of biomedical physiological recording instrumentation that would enable the crew of an aircraft or spacecraft to be actively monitored for vital signs. Miniaturised pulse-oximetry was one important development in this area, as were miniaturised physiological recorders and monitoring systems, and pulse-wave velocity study instruments (enabling determination of pilot work-load factors). Many of the results of these tests would additionally result in highly valuable commercial sector applications for the civilian health care and medical treatment fields.

A further important result of studies carried out in 57-1303 was the development of real-time electrocardiogram capability, now widely used as a critical emergency medical diagnostic aid by most paramedics across the nation and in many regional hospitals and clinics. Among the numerous additional correlated benefits of these studies was the development of a 'spray-on' electrocardiographic electrode and the associated equipment needed to quickly attach monitoring devices for capturing usable, artifact-free signals from actively working and diaphoresing (sweating) subjects.

Still further biomedical systems enabled by aft cockpit research done in 57-1303 included a miniaturised mass-spectrometer used for measurement of exhaled gas concentrations, and a liquid cooled flight ensemble that would have future applications in the design of space suits for orbital use. Various key crew components of the *Apollo* spacecraft's crew member life support systems (the *Apollo* spacesuits) were also flight tested as part of their proof-of-concept evaluation in the aft cockpit of this two-seat B model *Starfighter* and on a number of occasions, NASA astronauts would fly in the aft cockpit to test those systems under actual high altitude atmospheric conditions.

A further important area of special research carried out in NASA N819NA (57-1303) involved precursor studies for the development of the Ground Command Guidance System (GCG), which was a forerunner of the Remotely Augmented Vehicle System (RAVS) now in use at the Dryden Center. This program finds many resulting applications today in modern 'remotely piloted vehicle' operations using unmanned reconnaissance and attack aircraft (such as the 'Predator').

One important program enabled by the GCG system in NASA N819NA was known as the Focused Boom Experiment (known to Dryden personnel as the 'Big Boom' project). The experiment required that a very specific flight profile (loaded in a ground-based computer) with certain precise aerodynamic parameters be flown, so that energy from the 'sonic boom' generated by the aircraft would be focused on a specific target below. The flight portion of the program took place above the Ely, Nevada, radar tracking site and the aircraft was temporarily

deployed to Michael Army Airfield at Dugway, Nevada, for the duration of that particular test program. During this project a flight test milestone was achieved when a total of six test flights was achieved in 57-1303 in a regular work-day (with first flight take-off at 0845 and final flight landing at 1600 hours). [NASA pilots Tom McMurty and Hugh Jackson were the key personnel assigned to this project, with Flight Engineer Vic Horton liaising with the Center's research partner China Lake NOTS facility throughout. The aircraft's crew chief for the program was Don Guilinger.]

Some early studies 57-1303 participated in involved zero-G experiments using a small tank designed to supply fuel continuously under null-gravity conditions. Another important project involving 57-1303 was a study of indirect viewing systems, anticipating the need for such 'fly-by-monitor' capabilities in future earth-reentry vehicles. This project incorporated a binocular-periscopic apparatus installed in the aft cockpit to substitute for direct 'out-the-canopy' viewing that a pilot would normally use for visual reference to the ground. At hypersonic speeds (those reached by an earth orbital vehicle, for instance), the windscreen of an aircraft can exceed 2000 degrees F. and needs heavy and specialized glass to withstand the enormous dynamics of thermal heating effects. The thought was that if the aircraft's windscreen could be done away with and an indirect viewing system utilized as a replacement, then a large savings in weight and structural complexity could be realized. With the binocular periscopic viewing system flight tested on 57-1303, it was found that the field of view was an excellent 180 degrees laterally and about 60 degrees vertically. Aside from some minor concerns with parallax and depth perception, and some difficulty with the need for a pilot to keep his face pressed against eyepieces during elevated G maneuvers, the system was quite successful and flight test pilots in the aft cockpit used the apparatus to make simulated X-15 unpowered (glide) descents and landings. This research later greatly aided development of the STS Space Shuttle's flight control and guidance systems.

Two other areas in which this aircraft made important contributions were the development of the low lift/drag approach and landing patterns used by the X-15 and lifting bodies, as well as the testing of a *ballute* system. NASA N819NA was a major player in the early work done on simulated Shuttle landing approaches, including night flights, to develop and standardize the low-lift/hi-drag approach and landing techniques used so successfully in a number of advanced programs flown at Dryden.

The principal *ballute* (a 'ballute' is a cross between a balloon and a parachute, thus 'ballute' used to slow an atmosphere-reentering vehicle) experiment involved obtaining data to evaluate a towed high-speed *decelerator* through a Mach number range from 0.7 to approximately 2.0 (7/10ths to twice the speed of sound), as a system that could be used to increase the drag of an asymmetrical vehicle on entry to Earth's atmosphere. The ballute itself was a semi-spherical shaped device, 4 feet in diameter, similar to a small balloon that self-inflated with

the air picked up by the small air scoops located around its circumference when deployed. It was installed in the drag-chute compartment of 57-1303 and released in a manner similar to that of a conventional drag chute. Up until these tests, the state-of-the-art research on ballutes was limited to wind-tunnel studies and rocket flight tests of ballutes behind symmetrical bodies. The two-seat F-104B *Starfighter* (57-1303) presented a flying test platform through which study of the ballute concept could be expanded. Investigated intensely as a means of decelerating the atmospheric descent of space vehicles (such as orbital capsules and lifting body type spacecraft), the ballute system was eventually ruled out for use on atmosphere re-entering American spacecraft, but much of the applied theoretical investigation into its suitability was carried out by 57-1303 as the principal ballute 'proof of concept' test aircraft.

One last area of research that 57-1303 participated in was the lifting body flight research program that took place initially in the late 60s. As data was gathered for the development of space reentry vehicles such as the X-20 *DynaSoar* Project and the later STS Space Shuttle orbiter vehicle, it became quite clear that ground based flight simulators were not fully adequate to prepare pilots for operation of aerodynamic 'lifting body vehicles (essentially aerodynamically shaped gliders), nor were the actual flights themselves, which were very brief. Future moon lander Neil Armstrong was at Dryden at the time, conducting a series of tests to simulate the very steep glide parameters of a returning space vehicle using an aircraft. The F-104 was found to be the perfect aircraft for this purpose, since due its already substantially high rate of descent, with its gear down and control surfaces suitably configured, a very high lift-to-drag aspect could be contrived that quite adequately simulated the distinctive lifting body glide parameters.

One interesting highlight in the operational career of "Howling Howland" occurred on April 11th 1975, when a day with no scheduled flight tests was selected for a pure 'photo opportunity' flight by a formation of the Center's *Starfighters*. This formation flight of all the NASA *Starfighters* was documented extensively by NASA and there are a number of excellent photographs of the Center's *Starfighters* in formation fly-bys over Dryden on that date. A photo-chase T-38 was on hand to carry the photographer, and the 'photo-op' mission lasted just over an hour. Participants in that notable flight included Bill Dana in N818NA, Tom McMurtry in N812NA, Einar Enevoldson in N818NA, Gary Krier in N820NA, and Don Mallick and photographer Bob Rhine in the photo-chase T-38. Leading this 5 *Starfighter* formation was 'Howling Howland' (N819NA), our F-104B model two seater, being flown by Fitz Fulton in the forward cockpit and Flight Test Engineer Ray Young in the aft position. Our bird (57-1303/N819NA) was distinctive not just as the formation leader, but also due to the fact that it was the only one of the five NASA *Starfighters* wearing its wing-tip fuel tanks during those memorable photo shoots!

Throughout its more than 18 years of NASA flight test work, 57-1303 (NASA N819NA) flew 1,731 research flights and was flown by at least 19 different pilots (sixteen from Dryden, two from Ames, and one from the US Air Force). These individuals included *Apollo* astronauts (Schweikert, Armstrong etc.), X-15 pilots (Bill Dana, Joe Walker), Chuck Yeager, and lifting body as well as XB-70 and YF-12 pilots.

Eventually, after nearly 19 years of extensive use, 57-1303 (NASA N819NA) was retired from active service in April of 1978 (last NASA flight: April 21, 1978) and flown to the US Air Force's AMARC (Aircraft Maintenance and Recovery Center) facility in Tucson, Arizona. Although most of the 26 surviving B model *Starfighters* retired to AMARC were transferred to the Jordanian and Taiwanese air forces (such was the fate of 57-1304, N819NA's sister ship) in the late 70s and early 80s, 57-1303 somehow escaped this fate and was put in the hands of the US Air Force Museum at Wright-Patterson AFB, Dayton, Ohio, which then allocated it to the Aerospace Museum of California's aircraft collection.

Flown to McClellan AFB in the hold of a cargo aircraft in 1983, after having its General Electric J79-GE-3B engine removed and subsequent to having undergone required 'de-mil' procedures, 'Howling Howland' was put on display as the star of the museum's 'Century Series' fighter row. In 1991, the aircraft received a new paint job provided by the McClellan Sacramento ALC, although it is a generic *Starfighter* paint scheme that is not representative of the aircraft's appearance either in its original 'bare metal' configuration (when first used by Dryden) or of the final three-color white, dark blue, and sky-blue NASA paint scheme it was retired in. For a full-color illustration of the three correct paint schemes worn by this aircraft throughout its 19 years of NASA service, please refer to an excellent painting done by NASA Dryden artist and photographer Tony Landis, elsewhere in this folder. The museum eventually plans to have 57-1303 repainted in the correct three-color NASA livery it wore on its final flight at Dryden FRC, but due to the considerable expense involved (estimated at about \$15,000.00), this plan has not yet been carried out.

Lockheed F-104B *Starfighter* SN 57-1303 / NASA N819NA is today maintained in generally excellent static condition and is regularly looked after by its present museum crew of three. The cockpit is authentically restored to the functional appearance it had upon retirement, complete with the upwards-firing Lockheed-Stanley C-2 ejection seats (replacing the original C-1 downward-firing model that proved very dangerous in actual flight operations) that it flew with, 140000-44 model seat-survival kits, and all key control instrumentation intact.

On special museum 'open-cockpit days' (typically, the first Saturday of each month), the canopies of *Starfighter* 57-1303 are opened and museum visitors are allowed to view the cockpit area of the aircraft. Visitors are not normally allowed actual entry into the cockpit (that is, sitting in the cockpit is not permitted), however, due to cramped space and safety considerations.

The major structural differences between the single seat 'A' model *Starfighter* and the two-seat 'B' model consisted of elimination of the 20 mm Vulcan cannon so that a second seat could be added, reduction of internal fuselage fuel capacity for the same reason, the installation of an extended canopy glazing over both seats, an increase in the size of the vertical stabilizer by about 21% (identical to that used on the later F-104G model) with power boost system, and replacement of the forward-retracting nose gear by a rearward-retracting system. All F-104B *Starfighters* were initially produced with a simplified extended canopy glazing and were fitted with two downward firing Lockheed C-1 ejection seats (the original C-1 seat ejected downwards out of the aircraft's belly—a technique later found to be inherently hazardous at low altitudes). When these seats were replaced by the safer upwards firing rocket-catapulted C-2 seats in 1961, a newer, somewhat reconfigured multi-piece canopy glazing was installed that allowed the canopies of fore and aft seats to be explosively blown off, each separately, for emergency egress upwards. [For information on the *Starfighter* egress history, see additional material presented at the end of this paper.]

Performance specifications of the two-seat F-104B model *Starfighter*

Wing span: 21 feet, nine inches

Length: 54 feet, 8 inches

Height: 13 feet, 5 inches

Wing area: 196.1 square feet (resulting in VERY high wing loading of about 90 pounds per ft. sq—the highest of any aircraft ever built!)

Empty weight: 13,327 pounds

Maximum weight: 14,912 pounds

Combat weight: 17,812 pounds

Maximum speed at altitude: At least 1,145 mph at 65,000 feet

Cruise speed: 516 mph

Maximum rate of climb: 50,000+ feet per minute!

Service ceiling: 64,795 feet

Normal range (with internal fuel only): 460 miles (internal fuel capacity 897 US gallons, or 2,847 lbs)

Maximum range: 1,225 miles (fitted with external twin wingtip drop tanks)

Engine: General Electric J79-GE-3A or 3B axial flow turbojet with afterburner

Rated power (without afterburner): 9,600 pounds static thrust`

Rated power (with full afterburner): 14,800 pounds static thrust

Some odd 57-1303 anecdotal history (as yet unconfirmed):

One curious thing that came to light in researching the past of this aircraft is the following: At least a few of the Dryden and/or Lockheed personnel apparently knew this aircraft during its service life as *'Howling Howland'*. The strange name might be somewhat puzzling, as it indeed was to us when this fact was first uncovered. A possible and in fact very likely partial explanation of the name may be found in the fact that the General Electric J79-GE-3A/B turbojet (with afterburner) that is fitted to the F-104B *Starfighter* produces a very unusual sound that is unique to these aircraft (F-104s) alone. This sound, variously described as *'howling'*, *'shrieking'*, *'high-pitched moaning'*, or even as a *'wounded banshee scream'*, resulted from the passage of fuel from the primary and secondary fuel jets in the exhaust section of engine as the airflow is disturbed by the engine bypass flaps during various throttle positions. Somewhat the same principle is responsible for the sound that is produced by pursing the lips and blowing over the top of a glass bottle neck (*Venturi* effect). Whatever the cause, the *'howling'* sound was a most unique characteristic of the F-104 aircraft and could be produced at will by the pilot either in the air or on the ground by certain settings of the throttle.

A further curious fact is that the name "Howland" was the name of a certain owlish character in 1950s era cartoonist Walt Kelly's cartoon strip *POGO*. "Howland Owl" was depicted as a somewhat pretentious, bookish, effete character who was always a bit uncertain about his acquired learning and feigned sophistry in the *POGO* strip. However, the name "Howland" was *also* the last name, interestingly enough, of a very distinguished Lockheed Aircraft Company Flight Test Engineer whose full name was *Dr. W. L. Howland*. Over the course of Dr. Howland's 25 years of work with Lockheed, his participation in the 5 year F-104 *Starfighter* Phase One flight testing is most notable as having had critical importance in the developmental research done on the *Starfighter*. A large body of Dr. Howland's personal records and flight test documentation was recently disclosed to the public in which his key role in *'making the Starfighter fly properly'* was clearly documented, thus adding to the mystery behind the name *'Howling Howland'*.





Returning to the cartoon character, 'Howland Owl' was coincidentally featured on the first (unofficial) emblem of the newly founded US Air Force Test Pilot School, when it moved from Ohio to its new Muroc Army Air Base location (Edwards) in the mid 40s. On that emblem, "Howland" is shown disconcertedly riding what was at that time a new P-80 *Shooting Star* as it plunged downwards in an uncontrolled dive (see illustration adjacent). This use of the Howland Owl character in association with the Edwards Test Pilot School, together with the *Starfighter* engine's known tendency to 'howl' and the importance of Dr. W. L. Howland in the Lockheed F-104 flight test program, presents strong circumstantial evidence for the origin of the name apparently associated with NASA F-104B, N819NA/ 57-1303 (i.e. '*Howling Howland*').

Whether this speculation is correct or not remains as yet to be determined, since no *conclusive* corroboration of these findings has yet been uncovered. It does remain a most intriguing possibility, however, and if the story is true, it is also a most amusing 'personalisation' and a further fascinating bit of history attached to this uniquely important aircraft in NASA's Dryden stable of Lockheed F-104 *Starfighters*. As to its status as the only two-seat 'B' model *Starfighter* ever to be used at Dryden (as has been previously noted, NASA later acquired several ex-Luftwaffe TF-104G two-seat trainers for use at the DFRC, after 'Howland' was retired), it is very easy to misidentify an F-104B model in flight for a TF-104G, if tail numbers are not distinctly viewable.

By 1997, all 11 aircraft in the NASA F-104 *Starfighter* fleet had been retired. Most are today preserved in air museums (one is located at the Edwards museum, another sits on a pylon in front of the Edwards Test Pilot School, still another is preserved at the Estrella Air Museum in Paso Robles, two are at the National Air and Space Museum, and one more is located at the Grass Valley, CA, airport).

Due to early engine development problems and high crew losses in foreign service, the *Starfighter* received much unfair and unqualified criticism as an inherently 'dangerous airplane'. The fact is that although the F-104 demanded absolute *mastery* of its systems in flight and required highly qualified aircrew to fly it, it was a spectacular performer throughout its service career. There is little question about the fact that the Lockheed F-104 *Starfighter*, contrary to all the bad publicity it unfairly received as a 'pilot killer', was perhaps one of the most useful and valuable research aircraft ever used by NASA. We at the Aerospace Museum of California are especially proud to have a rare and storied 'B' model former NASA *Starfighter* in our aircraft collection!

The Aerospace Museum of California has at this time two patches specific to USAF 57-1303 / NASA N819NA. These are now available at a cost of \$10 each and both are professionally made and fully embroidered emblems suitable for use on a flight suit or for collecting:

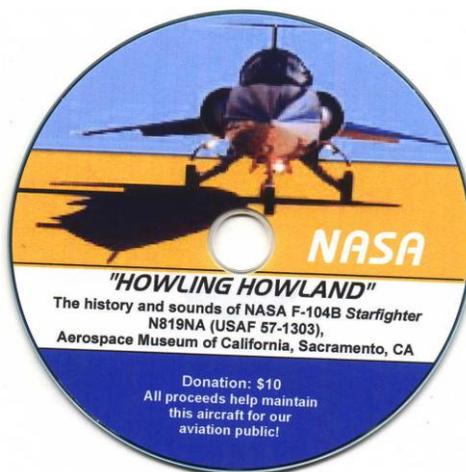
Patch #1



Patch #2



Also available is a CD that contains 57-1303's printed history and many photos of the aircraft throughout its service life, as well as actual audio file recordings of the distinctly unearthly howling sounds made by the *Starfighter's* General Electric J79 jet turbine engine. Copies of the CD may be purchased for \$10 at the museum gift shop, with all proceeds going towards the upkeep and maintenance of NASA F-104 *Starfighter* N819NA (see label below):



Below is a guide to the color schemes worn by 59-1303 in its NASA service (reproduced with the generous permission of NASA Dryden artist Tony Landis):

NASA F-104B #57-1303 / N819NA

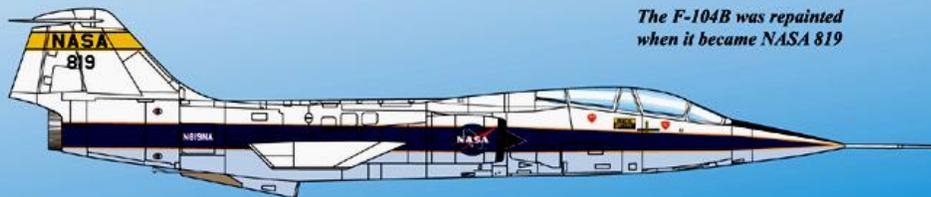
Wing tank omitted for clarity



*Marked As Originally Flown
Note the early canopy layout and
small block NASA on tail*



*Majority of Flight Test Career
spent in these markings*



*The F-104B was repainted
when it became NASA 819*

The following selection of images show N819NA as it appeared at various times in its service life with NASA:



Above: Original configuration of 57-1303, with one piece canopy and original down-ward firing C-1 ejection seats fitted (1960).



Above: On Dryden ramp, early 1960s.



Above: On Edwards dry lake (note new two-piece canopy and upward firing C-2 seats), early 60s.



Above: Over Lancaster area, near Tehachapi Mountains, mid-late 1960s (note periscopic view optical system over mid-canopy section).



Above: Howland's sister ship, 57-1304, later sold to Jordanian AF in 70s.



Above: Al Eggers and Bill Dana with 57-1303 in 1967 (note periscopic systems lenses)



Above: Between missions on Dryden ramp, mid-1970s.



Above: Flight Test of GCG ground control system in mid 70s, over Edwards range.



Above: Astronaut Rusty Schweikert in rear cockpit of 57-1303 for pressure suit test (Bill Dana in front as safety pilot).



Above: NASA's Dryden Starfighter fleet in mid-70s, 'Howland' in bare metal, upper right



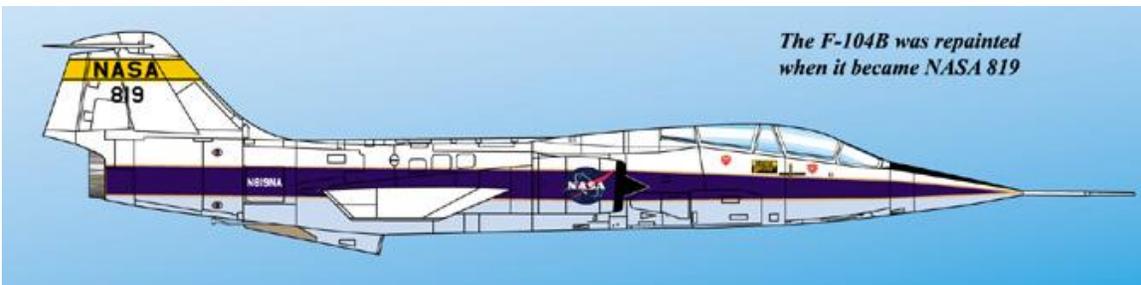
Above: 'Howland' leading the Dryden pack in 11 April 1975 'photo-op', 3 years before retirement.



Above: N819NA with NASA Dryden crew commemorating her last flight in 1978.



Above: N819NA with famed NASA test pilot Bill Dana (right), day of last flight, 1978.





Above: Glory days—chasing X-15 mother ship over Edwards, late 70s



Above: 'Howland' on display at McClellan Air Park in 2004 (note incorrect 'generic' USAF paint).



Above: 'Howland' at McClellan Air Park, Christmas of 2004



Above: 57-1303 / NASA 819NA, the 'Lion in Winter', McClellan Air Park 2005.

'DOWNWARDS AND BACKWARDS!': A study of egress evolution in the Lockheed F-104 *Starfighter*

By Christopher T. Carey

[Not only is the Lockheed F-104 Starfighter one of the most fascinating modern aeronautical designs ever to come off a drafting table, the aircrew ejection (egress system) development that accompanied it is an engaging story in its own right.]

The Lockheed F-104 *Starfighter* originated in the perceived need for a high performance dedicated air superiority fighter by US Air Force pilots engaged in Korean War air combat. Although the Air Force itself did not have such a requirement in the very early 50s, Lockheed's Kelly Johnson personally visited the Korean Theatre early in the war and soon concluded that superior speed, light weight, and altitude were the three most critical needs of the American airmen who had found themselves facing the surprisingly capable Russian designed MiG-15 fighter, itself a product of Russia's excellent utilization of German World War Two advances in aeronautical science.

Returning to the United States, Johnson's design team began studies for such a 'super-fighter' that drew heavily on the Douglas Aircraft's experimental research X-3 design. Incorporating the super-thin wing design of that aircraft, along with other aspects of its developmental data produced during its 1952 flight testing. After nearly 14 different combinations of features had been explored, Lockheed finally produced their Model 83, which would gain fame as the F-104 *Starfighter*. When the first flight of the XF-104 prototype took place, in March of 1954, the design had been formalized in a form very close to what the very last production *Starfighter* would look like. The short, stubby wings (each only 7.5 feet long) were optimized for low-drag, high-speed flight over a broad Mach environment (as was the high horizontal stabiliser), although the relatively high wing-loading (about 92 pounds per foot) yielded limited maneuvering capabilities and glide. Nevertheless, the concept evolved and was proposed to US Air Force planners as a point interceptor to counter relatively slow and un-agile Russian bomber intrusion.

Due to the aircraft's anticipated supersonic performance, clearly some sort of effective aircrew ejection system would have to be a mandatory feature of the F-104, despite the fact that US Air Force pilots in Korea insisted that they neither wanted nor needed 'ejection seats' in their aircraft (this was principally due to pilot mistrust of these new systems)! Again, the Douglas X-3 experimental research aircraft appeared to provide a feasible approach to the anticipated need with its downward firing pilot ejection seat. The downward firing catapult gun was also conveniently available as an 'off-the-shelf' item, additionally, having been originally developed for the B-47 navigator's seat and the Douglas X-3 seat.

In the early 1950s, the technology of egress systems for high-speed aircraft was still in its infancy and most experienced pilots would rather take their chance bailing out manually than trust their lives to the new and still largely unproven high-speed escape systems. Much of the knowledge that had led to the very first USAF production ejection seat (that used in the Republic F-84 *Thunderjet*) had come directly from captured German WWII aeronautical research and the marginal capabilities of the existing ballistic catapults were such that great concerns existed over the ability of these catapults to loft a pilot safely up and over the high tail of a Mach-2+ aircraft like the *Starfighter*. Since it was also felt that safe ejection would be most needed at *high* altitudes and speeds, the basic Douglas X-3 downward firing ejection system was used as a design inspiration for the F-104 seat. Since the Douglas X-3 seat had been reasonably well flight tested and shown to be safe to use (given sufficient altitude), it seemed to make sense to install a similar system in the new F-104 point-interceptor. Regrettably, the critical importance of safe low altitude ejection was largely overlooked as the downward firing seat system concept was adopted (despite substantial criticism).

Thus it was that Lockheed subcontracted the Stanley Aircraft Company (the firm that had developed the X-3's downward firing seat for Douglas Aircraft) to engineer the *Starfighter's* egress system. The Stanley "B-seat", closely based upon the X-3 system, was the very first ejection seat installed in the new *Starfighter*. This seat was fitted to the prototypes and the first 26 production F-104A aircraft. It was a system that featured retention for the pilot's legs similar to the Stanley seat used in the X-3, since arm and leg flail due to wind-blast effects had been shown in ejection seat tests to be serious concerns. The Stanley "B-seat" required the pilot to manually move his feet back against the seat's foot recesses to activate clamps that would hold the feet to the seat before ejection could take place. This maneuver, plus a pull on the seat pan's triangular grab-ring located between the knees, would initiate the sequence of events that would fire ballistic thrusters to rotate thigh guards into position, tighten restraints, and lock the pilot's inertia reel harness. The seat would thereupon begin to move down the seat rails and mechanically unlock the belly hatch under the seat, which would then be swept away by the windblast. When this sequence of actions had been completed, a pyrotechnic M-3 initiator would ignite the catapult's explosive charge to fire the seat clear of the aircraft in a downward trajectory. A gravity release back-up system was also incorporated, in the event the ballistic charge in the catapult failed. Separation from the seat was through manual release of the pilot's belts and restraints; after falling clear of the seat, an automatic system would release the pilot's parachute at a preset altitude.

The next seat used in the *Starfighter* was called the Stanley "C-seat" and it was installed in the 15 subsequent F-104A production aircraft. The C-seat added a set of spurs that were worn on the pilot's shoes, to which were attached cables that would automatically retract the pilot's feet (when the grab-ring initiator was pulled) as part of the ejection sequence. It also featured an improved automatic seat belt and restraint release system, as well as an anaeroid parachute

deployment system that would activate automatically when a certain altitude was reached.

A further refinement of the Stanley “C-seat” resulted in the Stanley “C-1 seat”, which closely resembled the previous two seats in general appearance, but which featured a number of further advanced safety systems. Whereas many contemporary ejection systems required a separate action to release the aircraft’s canopy prior to initiating ejection, the C-1 egress system’s entire sequence of ejection events was initiated with a single pull on the triangular grab-handle. Upon pulling up on the ring (known to some pilots as the “chicken-ring”), the thigh guards would rotate into position, the feet would be retracted and held securely to the seat (via cable connected spurs on the pilot’s boots), the pilot’s seat belts and shoulder restraints would be tightened and locked, the belly escape hatch would be ejected and the seat fired down and out. Once clear of the aircraft, an automatic system would cut the foot spur cables, release the seat restraints, and push the pilot out of the seat, whereupon his BA-18 barometrically activated chute would deploy at the right altitude. There were reportedly less than 100 of the C-1 seats manufactured and installed in early F-104A production aircraft. One of the chief overall benefits of the C-1 system was a reduction of actuation-to-full-deployment time.

Unfortunately, by the time the first three years of service had been completed by production F-104A models, it had become dreadfully clear that the original downward firing ejection seat concept was seriously flawed. The early GE J-79-3A engine used in the *Starfighter* was prone to frequent engine failures, flame-outs, compressor stalls, and other malfunctions, many of them occurring on take-off and at very low altitudes and speeds. In the event of such a loss of power the *Starfighter* emergency protocol required that an F-104 pilot roll the aircraft to the side (ideally undergoing a 180 degree inversion) so that the downward firing seat would then shoot “upward” out of the belly. As might be predicted, reality almost always varied from the ideal escape scenario given in the manual, and a number of Air Force pilots were sadly lost in these abortive escape attempts. With those escalating losses it became inescapably clear that an upward firing seat system was sorely needed, since the majority of F-104 in-flight emergencies were occurring at low speed and low altitude, rather than at higher altitudes and faster speeds. One fortunate pilot who used the downward firing C-1 seat escape system was Air Force pilot Norvin “Bud” Evans, Chief Test Pilot for Category I, II, and III *Starfighter* flight tests at the Edwards facility, who in the late fifties successfully escaped from his stricken F-104A at about 7,000 feet. His testimony on his experiences in the C-1 seat helped prioritise concerns to rethink the *Starfighter*’s potentially dangerous downward firing egress system

However, it wasn’t until after well known USAF flight test pilot Iven Kincheloe (ironically one of the most strident critics of the downward firing seat from its inception) was lost in a *Starfighter* accident at Edwards AFFTC on 26 July of 1958 that Lockheed finally admitted the urgency of the need, and a hasty

program was initiated to remove the dangerous downward firing seats in *Starfighters* and replace them with a new upward firing design designated the Lockheed C-2 seat. At about this time, much additional progress had been made in ejection seat catapult technology that enabled the upward firing seat mode to be reconsidered. By then, Stanley Aviation had licensed Lockheed to produce their seats, hence the common reference to these Stanley/Lockheed seats today as "Lockheed seats". The new upward firing C-2 seat, although it closely resembled the earlier seats in general appearance, incorporated a much improved rocket charge catapult that finally allowed the *Starfighter's* high vertical fin assembly to be cleared upon ejection at higher supersonic speeds. The seat's headrest box was strengthened so as to allow it to blow through a canopy that wouldn't jettison properly and certain other refinements were incorporated into the C-2 seat's design. A half-circular "D-ring" was substituted for the original triangular pull handle and a rotary actuator system actively separated the pilot and seat after clearing the aircraft. While the new C-2 system was far better than any of the downward firing predecessor designs, it was still not a ZERO/ZERO seat (that is, a seat capable of saving an ejecting pilot at zero altitude and zero knots speed). For the record, the C-2 seat nominally required a forward speed of at least 80 knots and an altitude of at least 50 to 100 feet to insure a safe recovery.

A final refinement of the basic Lockheed C-2 upward firing ejection seat system was the S/R-2 seat. In addition to a substantially upgraded RAPEC type rocket catapult, this seat also employed a *stabilization & retardation*' (S/R) system that deployed a fast-acting drogue chute to keep the seat from tumbling out of control upon ejection and also helped slow the seat/man package sufficiently to allow safe main chute deployment at higher speeds where a chute might be damaged by more severe aerodynamic forces. The S/R-2 system allowed a faster, safer egress from a disabled aircraft at either high or low altitude and also featured an improved high-altitude life support (oxygen) capability. A ballistic deployment system firing a slug out of the upper right corner of the seat's chute pack would quickly drag the pilot chute out into the slipstream at the man-seat separation moment, providing the correct altitude had been reached (this function was barometrically controlled for both low and high altitude egress). The ballistic deployment chute system (USAF Designation: BA-24) was developed by the Weber Aircraft Company and was subsequently used on F-104, F-105 and F-106 aircraft. It was also retroactively fitted to some C-2 seats, hence evidence of such modifications on a seat does not necessarily identify the seat as an S/R-2 model. [A somewhat similar seat known as the SR-1 seat was used in the Lockheed SR-71 *Blackbird* Mach III recon aircraft; sharing many design advancements with the *Starfighter's* S/R-2 seat, it was optimized for the SR-71's exceptionally high and fast operational performance envelope.]

The seat shown in the second accompanying image is a specimen of the early Lockheed C-2 ejection seat, as used in both late model USAF F-104s and early German F-104G models. It used a Bendix contracted seat-survival kit (it could

also be used with the USAF P/N 140000-44 seat survival kit that was very similar to the Bendix kit, or a Scott Aviation kit of like design) that carried an enhanced emergency bailout oxygen system (15 minutes of emergency breathing oxygen) for escape at high altitude. The earliest and original F-104 *Starfighter* operations were envisioned as being carried out at high altitude, requiring use of a partial pressure suit that the Bendix seat survival kit interfaced with. After the *Starfighter* evolved from its high altitude mission to a lower altitude profile (ground attack, etc.), the seat kit's emergency bailout oxygen system was frequently removed as a pressure suit was no longer needed. Of particular interest is the oval ring mounted on the left side of the seat's headrest; this was a back-up manual foot-spur cable cutter deployment initiator that allowed the pilot to free his feet from the seat in an abortive ejection or emergency. Note the two massive swing-arms located on either side of the seat. These were thigh protector guards that automatically swept forward on ejection; when they moved into place they pulled a protective web net out on both sides of the seat to also restrain the pilot's arms from wind-blast. Of additional note are the unique "spurs" that are found in the footrest recesses. These are attached to the seat via cables that automatically retract the pilot's feet and secure them upon ejection. During regular flight the cables would draw forth freely under minimal tension so that the aircraft could be piloted with only very slight tension on the cables, thus allowing full use of rudder controls in normal operation. These "spurs" were the status symbol of a *Starfighter* pilot and were worn on the flight boots whenever an F-104 pilot was on alert and ready to scramble.

Due to changing US Air Force air defense requirements and the fact that the *Starfighter* had a relatively small internal fuel load, the F-104 did not see much operational use in US Air Force service. It was used only briefly and in limited numbers as an air defense point interceptor until later and more capable interceptors came into use (notably the Convair F-106 *Delta Dart*). In the late 60s, however, Lockheed managed to sell the F-104 aircraft to NATO allies, most particularly to Germany, in a transaction that has come to be known to aviation historians as "*The sale of the century*". This led to the production of a large number of improved 'G' model *Starfighters* under license overseas, but the requirement Germany imposed on the F-104 was for a ground attack aircraft, a role for which it had never been originally intended. Due to this fact, the consistently terrible European weather, insufficient aircraft maintenance, and pilot and ground crew training issues (German crews trained at sunny Luke AFB in the USA, where the weather is always perfect for flying, and then returned to face the marginal European weather conditions which were seldom clear or ideal for VFR operations), Germany lost a disproportionately large number of its F-104G (German) *Starfighters*. Most accidents and emergencies predictably occurred at very low altitude and close to the ground, where the Lockheed C-2 and S/R-2 seats were less suited for safe recovery.

Even the replacement of the C-2's catapult with the improved, higher-performance S/R-2 rocket catapult system did not satisfy the German Luftwaffe

and it consequently selected the Martin Baker Aircraft Company of the UK to develop and produce a suitable, safe, and true Zero/Zero seat system for their *Starfighters*.

Martin Baker took their basic Mark 5 seat design (already in use), added a rocket catapult system to it, repositioned the main chute pack, and reconfigured the seat to fit the small confines of the F-104's cockpit. After some initial brief but serious problems concerning pilot knee clearance that required moving the seat further aft (about 6 inches, so as to clear the instrument panel sun-shield), the new Martin Baker GQ-7A ejection seat was found to perform excellently in almost all emergency egress situations, and this seat (with some additional modifications) remained the last ejection seat used in all Lockheed F-104 *Starfighters* through the retirement of the last NATO *F-104S* models flown by Italy until 2004.

The Lockheed C-2 seat specimen on view at the Aerospace Museum of California was manufactured in 1964 and weighs about 85 pounds; it was considered a relatively light design for its day, compared to some of the far heavier 1950s and 60s seat designs (such as the Weber and Stanley seats used in the Boeing B-52 "BUFF"). Fully loaded with seat survival kit and contents, the seat could weigh close to just over 175 pounds installed in an F-104 aircraft. The Aerospace Museum of California's C-2 specimen is regarded by those who have specialized knowledge in egress technology as one of the most accurately restored seats of its type anywhere in the world today.

Joining the museum's C-2 seat is an excellently restored example of the last American Lockheed-Stanley seat used in the Lockheed F-104 *Starfighter*, the S/R-2 system. These seats may be seen when they are not on actual display, by special arrangement with the *Aerospace Museum of California*, and are available to aviation historians and researchers actively engaged in projects focusing on aeronautical egress systems technology.

[A rare and fully intact specimen of the extremely rare and original C-1 downward firing ejection seat (formerly owned by the writer) is presently owned by GM Bell of Bell Aviation. To the best of this writer's knowledge there are no other surviving specimens of this historically notorious design in either private or museum collections today. The seat specimen in reference (C-1) is shown in the first of the images of seats that follows this paper.]

[The image immediately below shows then Colonel Chuck Yeager (at Edwards AFFTC) exiting a single-seat (F-104C) *Starfighter* in the late 60s. The seat just barely viewable behind him is of the C-2 upward firing type. Some idea of the relatively small size of the F104 cockpit that Lockheed-Stanley engineers had to work with in designing the seat is gained herein. The *Starfighter's* external manually actuated main canopy release lever is to be seen at the bottom of the picture, just below the front canopy windscreen bow. The *Starfighter's* emergency canopy ejecting release mechanism is located on the opposite side of the cockpit's exterior



[Images of the 3 main Lockheed-Stanley family of F-104 Starfighter seats maintained in the Aerospace Museum of California collection appear on the following pages.]

Lockheed Stanley C-1 downward firing ejection seat (1955):



Lockheed-Stanley C-2 upward firing ejection seat (1958):



Lockheed-Stanley S/R-2 upward firing ejection seat (1962):



Martin-Baker GQ-7A upward firing ejection seat (1970)
used in German Luftwaffe (and other NATO) F-104s:



Use of the existing 'off-the-shelf' downward firing seat system technology may be better understood by viewing the Douglas X-3 'Stiletto' (left), which incorporated such a seat, in comparison to the Lockheed F-104 (right). There were more than a few similarities between the two designs.



Shown below is an early F-104. The "Downward Ejection Seat" warning triangle is quite apparent, as the seat in use on that aircraft was the early C-1 seat. Note that the triangle points downward. When the first upward firing seat was installed, the triangle was left pointing downward, even though the seat fired upwards. All subsequent US jet aircraft have continued to use the downward pointed ejection seat triangular warning, despite the fact that no American aircraft except the Boeing B-52 continued to use a downward egress system after 1968. Seated in cockpit is NASA's Bill Dana.



Shown below in an actual flight test is the downward firing ejection seat used in the Douglas X-3 '*Stiletto*', a concept first developed in the very early 50s and concurrent with unsuccessful ejectable capsule egress systems, a variation of which was initially intended for use on the F-104 *Starfighter*. The downward firing seat idea gained momentum when it was anticipated that the most need for an aircrew ejection system would occur at extremely high altitude, since a major focus of early 50s advanced aviation research was directed at the thorny problems associated with allowing an aviator to escape a craft stricken while it was flying at the uppermost edges of its flight envelope. In the rush to develop safe systems that would withstand the extreme hazards of high-Mach and high-altitude flight, it was overlooked that due to continuing problems with the new jet engines, a disproportionate number of in flight emergencies would occur at extremely low altitude (usually on landings and takeoffs, when a downward exiting crew seat is less than absolutely useless!).



Access to the Douglas X-3's very small cockpit was gained through a removable blast-hatch in its belly. A similar ejectable hatch was configured below the Lockheed F-104's equally small cockpit for use with the early B, C, and C-1 type Stanley downward firing seats. When the F-104 *Starfighter* received its first upward firing seat (the type C-2), the F-104's belly hatch was left intact and although it exited upwards during an emergency ejection, all routine maintenance on the seat was performed by lowering it downwards from the cockpit through the belly hatch. The image below shows the Douglas X-3 downward firing seat as it is about to be raised into the X-3's cockpit before a flight (which unlike the F-104, had no removable canopy section covering it).



The image below shows an upward firing C-2 seat that has just been lowered from A Belgian F-104G belly hatch for maintenance.

