Passed over at one time, later used as a trainer, the Northrop F-5 Freedom Fighter has now taken on new stature. The Mach 1.4 aircraft, which combines low cost with high effectiveness, seems to meet the needs of both a cost-conscious DoD and of some of our allied nations who require an inexpensive, dependable fighter-bomber. Not only does the future look bright for the F-5 but, combining versatility, performance, and economy, it may become a pacesetter for future designs . . .

F-5: Little Plane With a Big Future

By J. S. Butz, Jr.

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AIRPLANES that set new trends and leave a big mark on aviation often have stormy and uncertain births, but few of them can match the gestation record of the Northrop F-5.

The basic F-5 design (company designation N-156) survived more than seven years of no sales before the first production order. Northrop made its original presentations to the United States government in 1955. The company has been selling hard ever since then, but the airplane did not start getting official acceptance until the fall of 1962, and it is not due to enter wide service until 1966.

The bright spot in the design's early history was its selection, in slightly modified form, as the USAF's supersonic trainer, the T-38. This 1958 sale was a large one, and it kept the fighter design alive. More than 460 T-38s have been delivered, another 174 have been funded, and still another 126 have been programmed but are not yet covered by a contract, bringing the total to more than 760 aircraft.

In spite of this success as a trainer, however, many aviation people, as little as two years ago, considered the F-5 in its fighter-bomber configuration a dead project. At that time it was argued strongly that the F-5 would never be considered for first-line missions by either the US or NATO air forces, primarily because of a relatively low top speed and maximum altitude. The F-5 is a Mach 1.4, 50,000-foot-altitude airplane, and most of the USAF Century-series fighters are at least 300 mph faster and can operate above 55,000 feet. Most important, the N-156 lost out in key competitions during 1958 and 1959, which ended with the Lockheed F-104 being selected as the new standard fighter for the Netherlands, Norway, Japan, Canada, and West Germany.

Today, the picture has changed remarkably. Since the DoD's 1962 evaluation of the F-5 as a possible fighter-bomber to be supplied to allied nations under the Military Assistance Program (MAP), more than 250 of the aircraft have been ordered for Korea, the Philippines, Taiwan, Iran, Turkey, Greece, and Norway. The F-5 even has begun to eat into the F-104 market. In response to a Norwegian request, the US is allowing that nation to return one of the F-104G squadrons it was to have received and "exchange" it as partial payment for sixty-four F-5s. Norway is paying the balance of that purchase.

Prospects are good for further F-5 orders. Several nations still are evaluating the aircraft, as is the USAF's Tactical Air Command, and there is general enthusiasm over the airplane.

At first glance, the reasons for this latter-day enthusiasm are not apparent. Certainly, the F-5 does not fit the classic description of a pacesetting airplane with great portent for the future. In the past, its ten-year-old design and far from record-contending speed

Northrop F-5 fighter, shown taking off for a ground-support demonstration, was developed under Department of Defense contract to replace subsonic equipment operated by allied nations participating in Military Aid Program.

and altitude performance would have made it an also-ran in the eyes of most military officers for most types of interceptor, air superiority, ground-support, or reconnaissance duty.

But selecting aircraft today is not as simple as it was in the past. Speed, maneuverability, and load-carrying capacity are more important for many missions than high performance at high altitude. The ability to get combat tasks done depends on missile and ground environment as well as on aircraft performance. Costs are being brought into the weapon selection process as never before.

Every new aircraft from the counterinsurgency COIN through the TFX to the new strategic bomber proposals has suffered from disagreements over selection criteria.

The arguments are not going to be settled easily. But there can be little doubt that the F-5 and some of its basic design ideas are going to exert considerable influence on future combat aircraft—bomber as well as fighter. There are sound reasons why the F-5 now is acceptable as a first-line aircraft even though it was passed over a few years ago. There are equally good reasons to expect that the F-5, despite its ten-year-old design, will have unusually long life as a first-line aircraft. And there are also good reasons for believing that the general F-5 design philosophy will become more prevalent.

Basically, the F-5's appeal rests on the fact that it is the most successful "small" airplane yet developed. It has taken the "lightweight" philosophy to new limits. None of the designers who have expounded the "lightweight" theory in recent years has done as well as Northrop with the F-5. There are two prime "lightweight" examples. The first is the Douglas A-4D, which was designed by Ed Heinemann, weighs about 16,000 pounds, and first flew in 1954; the other is Great Britain's Folland Gnat, weighing in at less than 10,000 pounds.

The main objective with small aircraft has been to reduce production costs, fuel consumption, and operating costs, all of which normally take a big downturn as airframe weight and engine power are lowered. Some sacrifice in maximum speed, altitude, and payload-range performance usually has been necessary to get size and costs down to a minimum, but the cost/effectiveness of "lightweight" aircraft generally has been rated high for many fighter missions.

The F-5's superiority as a "lightweight" comes mainly from its superior powerplants. From the beginning of the design in 1954 Northrop contended that only two engines in development, or even being considered for development, would be light enough to give a small aircraft truly outstanding performance. These were missile engines, the Fairchild J83 (scheduled for the long-

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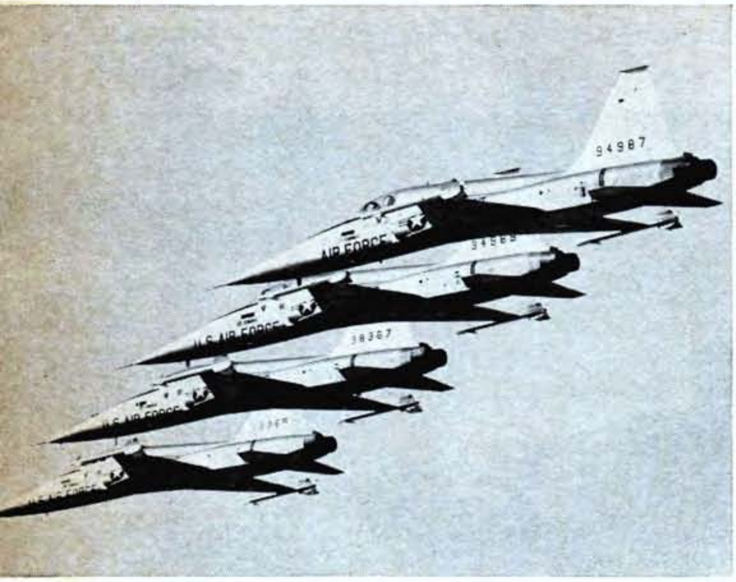

Formation of F-5s above carry Sidewinders in their basic air-to-air-combat configuration. F-5 has a sea-level rate of climb of more than 24,000 feet per minute and a turn radius about 30% less than MIG-21 under most conditions.

canceled Goose) and the General Electric J85 (under development for the Green Quail). Only the J85 reached production, and the Northrop design activity was instrumental in expanding the program to include development of a long-life, afterburner version suitable for supersonic manned aircraft.

The resulting engine is impressive. Each J85–GE-13 in the F-5 produces 4,080 pounds of thrust yet weighs only 585 pounds. Its thrust-to-weight ratio of 7 to 1 is by far the highest of any operational gas turbine today. By comparison, the Orpheus engine in the Gnat has a 4.8 to 1 thrust-to-weight ratio, and the US-built Sapphire in the A-4D is even lower, at 3.5 to 1.

A substantial reduction in aircraft size has been achieved by Northrop through use of the J85. It is difficult to be exact about this reduction, but it is in the neighborhood of 5,000 to 6,000 pounds according to an old rule of thumb. This is the rule that says that if the F-5 were powered by engines with a thrust-to-weight ratio of 3.5, or half that of the J85, the aircraft's engine weight would go up immediately by more than 1,000 pounds. This added load would necessitate an increase in structural weight. Fuel weight also would have to go up if the range were not to suffer. This added weight would call for a heavier, more powerful, engine to keep top speed from dropping. Experience has shown that the spiral of engine, structure, and fuel weight increase results in a total aircraft weight of five to six pounds for every pound of dead weight that must be added in any form.

By this rule, the F-5 should fly as fast, climb as rapidly, and carry as big a load over as great a range as an aircraft that weighed 5,000 to 6,000 pounds more but was powered by engines only half as efficient from the thrust-to-weight standpoint and about equal in the fuel-consumption department. Applying this rule is tricky because excellence of aerodynamic and structural design and the weight of electronic systems and accessories also can have a large effect on aircraft weight.

The fact that Northrop has taken commendable advantage of the J85's potential can be illustrated by comparing the F-5 with the F-100. The first F-100 flew in 1953. Its C model has a powerplant thrust-to-weight ratio of about 3.5. Takeoff weight is around 30,000 pounds for most missions, yet the F-100C is directly comparable to the F-5, which takes off in the clean configuration at 12,000 pounds and has a maximum flight weight of 20,000 pounds.

Maximum ordnance payload is 5,000 pounds for the F-100C and 6,200 pounds for the F-5A. For most attack missions their range-payload performance is comparable. The F-5A is 0.03 Mach number faster in level flight. It lands twenty knots slower and it has a 28,600 feet-per-minute (fpm) unaccelerated rate of climb at sea level, compared with 19,000 fpm for the F-100C.

The F-5's small size gives it an extremely powerful cost/effectiveness advantage in lower fuel consumption. It uses about thirty percent less fuel on any given mission than the F-100. Such a logistical savings is difficult to ignore in modern operations. For instance, in a thirty-day emergency operation an eighteen-airplane F-5 squadron would use 2,700,000 pounds of fuel, or 1,380,000 pounds of fuel *less* than a similar F-100C squadron. This does not include the fuel consumed in delivering the squadron's supply.

Northrop pushed hard to expand the F-5's basic cost advantage. Every effort was made to make maintenance simple and to keep the required mechanics' skills relatively low. Maximum use was made of early Century-series flight experience in developing a configuration which has exceptionally docile handling characteristics at both subsonic and supersonic speeds. Twin-engine design was planned from the first to improve the attrition rate as well as to keep the engines small.

The accomplishments of this effort include a T-38 accident rate that is the lowest of any USAF super-

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Emergency engine change in Saudi Arabia during recent F-5 demonstration tour illustrates the relative ease of F-5 maintenance. Each engine weighs less than 600 pounds. Changes have been made in the field by four-man crews without use of special tools or without even crude hoists.

nic aircraft. Large-scale T-38 operations have demnstrated an operational readiness around seventy-four ercent, at a utilization rate of sixty hours per month nd a maintenance man-hour expenditure of about leven hours per flight hour.

Maintenance materials costs for the F-5A are about 45 per hour, or about the F-84 and F-86 level comared to more than $100 per hour for the F-100 and early $250 for some Century-series fighters. Direct aintenance man-hours per flight hour again is at the -84, F-86 level and about half that of the F-100.

Personnel strength (less pilots) of an F-5 squadron forty-two percent less than an F-100 unit—144 men 210. On an equivalent manning basis it would be ssible to operate seven F-5 wings with the personnel four F-100 wings.

When all costs are considered—fuel, personnel, traing, maintenance, attrition, etc.—a unit of 400 F-5s uld be operated for seven years for forty-eight pernt less than an equal number of F-100s.

Over-all the cost arguments for the F-5 are about as pressive as those ever advanced for any airplane. ertainly, it has ushered in a new era of low-cost supernic operations and has set some standards that are ing to be difficult to top in the future.

Undoubtedly, the sales effort on the F-5 was slowed ecause the savings claims were so large and because ey were the key selling points. Airplane performance ta is relatively easy to come by with a prototype or o, but it takes years to gather reliable, verifiable cost ta that can stand up under the type of checking and checking common today in military evaluations. ithout the good services of the T-38 trainer force it obably would not have been possible to bring the 5 costs down to their present level and to verify em adequately.

The continuous reappraisal of military requirements uring the last ten years also has had its effect on the ce of the F-5 program. Today, it has become acceptle to divide military operations into at least ree basic types which overlap considerably. They nge from Vietnam-type guerrilla actions through rge Korean-type operations to general or all-out war.

Two-seat version, the F-5B, sits on the ramp at Williams AFB during Tactical Air Command evaluations. Area-ruled tip tanks conform to the aircraft's basic area-rule design. F-5B serves as a trainer and can perform most of the single-seat F-5A missions, but does not have 20-mm. cannons.

Each type places unique requirements on airpower. The COIN fighter, recently contracted to North American for development, is the first recent design aimed for guerrilla wars. The F-5A is among the aircraft now being evaluated by the Tactical Air Command as a "super-COIN," which could control the air effectively and inexpensively in Korean-type operations.

Broadening military requirements has broadened the attractiveness of the F-5, which also would be useful in a general war. For instance, in the words of the Norwegian government, the F-5 is considered on the basis of "an over-all evaluation of cost and operation . . . more suitable for the tasks of the Norwegian Air Force," which includes defending against a swiftly striking, nuclear-armed attacker. Northrop reports that the Norwegian flight tests showed that an F-5 was able to handle the faster F-104 consistently by using its superior turning and climbing ability at most altitudes to stay in position to launch its missile armament which compensated for the speed disadvantages.

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F-5 FAMILY COMPARATIVE PERFORMANCE SUMMARY

		F-5A	Improved F-5	STOL F-5
Sea-level Static Thrust	Engine Pounds	J85-GE-13 4,080	J85-13/J5 4,300	J85-J1A 5,000
Takeoff Gross Weight (Clean)	Pounds	13,000	13,550	16,892
Empty Weight	Pounds	7,733	8,283	10,609
Takeoff Distance	Feet	2,410	2,050	1,190
Sea-level Rate of Climb	Feet Per Minute	28,600	29,500	29,400
Maximum Speed	Mach Number	1.40	1.42	1.50
Touchdown Speed	Knots	130	135	99
Landing Distance	Feet	2,050	2,150	1,500
Ferry Range (Tanks Dropped / Tanks Retained)	Nautical Miles	1,515 1,230	1,495 1,215	2,400 1,710

Basic performance figures on the F-5A, the "Improved F-5," and STOL F-5 are listed at left. Performance gains are achieved with more powerful engines and a larger, more efficient wing on the STOL F-5. Both new aircraft also would have large "maneuvering" flap to make tighter turns.

First F-5B takes off for delivery to TAC last April. Structure is conventional semimonocoque with stressed skin, longerons, and frames. Seventy-five percent of the F-5B structure is common to the F-5A and the T-38. Most major systems are more than 80 percent common on the aircraft.

Certainly there won't be universal agreement about the validity of the Norwegian tests, but it does illustrate some truths about airpower and point up some reasons why the F-5 probably will be around for many years. Air warfare today, of the super-COIN and general war varieties, is much faster than anything of the past. Missiles have not taken it over by any means. Tactical doctrine, imaginative leadership, swift decisions, numbers of aircraft, human skill, courage, and perseverance count more than ever. The true criterion of performance is getting the job done. And it does not necessarily follow that the fastest airplane at 40,000 feet will meet this standard.

High theoretical survivability during ground-support operations is another advantage credited to the F-5. The F-5's small-size, high-speed, twin engines appear to give it a significant and at least an officially unrecognized advantage in this type of operation, which is critical across the complete spectrum of hostile air operations from COIN to general war.

Two new F-5 models now are being offered—one the "Improved F-5" and the other the "STOL F-5." The first one features about five percent more engine power than the F-5A, a "maneuvering" flap to cut down turn radius, more advanced fire control, and other improvements. The STOL version has J85s uprated to provide twenty-two percent more power than the F-5A's engines, increased wing area, and the other features of the "Improved" model. Takeoff distance drops from 2,410 feet to 1,190 feet on the clean STOL configuration. Ferry range goes up from a maximum of 1,515 nautical miles for the F-5A to 2,400 for the STOL F-5.

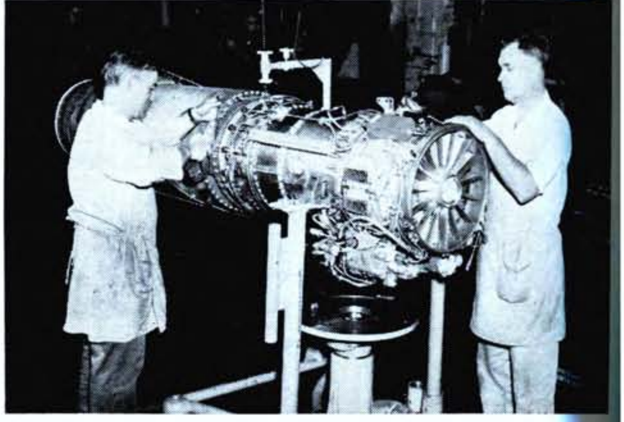
Other improvements undoubtedly will be made in the future to increase the airplane's utility and service life. However, one fact over which Northrop has no control probably will be the biggest factor in giving the F-5 a long, useful life. This is the sad shape of the US gas-turbine development program. The Air Force and Navy programs have both slowed down drastically since the middle 1950s. The only really advanced work has been done in the Air Force's lightweight gas-turbine technology program, which has resulted in the construction of "demonstrator" engines by five manufacturers. These engines feature advanced compressors, combustion chambers, and turbines. The basic objective in each is to use a level of technology that is at least twice that of any operational engine. While this program is a major step in building technology the "demonstrator" engines are far from operational models. Extensive and expensive development programs will be required if we are to put any of these advanced ideas to use.

No plans for developing these engines have been approved. It will be many years then before engines are ready which have thrust-to-weight ratios significantly better than the J85. Until then it will not be possible to build a "lightweight" fighter significantly better than the F-5.—End

TACTICAL ORDNANCE FOR THE F-5

A major F-5 requirement is to upgrade allied air forces receiving aircraft under the Military Aid Program (MAP) by providing supersonic interceptor, air superiority, and reconnaissance capability while performing all of the heavy ground-support missions now accomplished by F-84 and F-86 fighters. More than fifteen basic combat ordnance loads and two training loads are now provided for the F-5. The maximum external load is 6,200 pounds, and it is exclusive of the two M-39 20-mm. cannon and ammunition totaling 420 pounds. The major loads that can be carried in various combinations include:

- Two GAR-8 Sidewinders.
- Two Shrike antiradar missiles.
- Four GAM-83A Bullpups.
- Three Walleye guided bombs.
- Fourteen 30-gal. napalm containers.
- Five 110-gal. napalm containers.
- Sixteen 250-lb. bombs.
- One 2,000-lb. bomb, two 1,000-lb. bombs, and two 750-lb. bombs.
- Four rocket pods.
- Bomblets—5,500 lb. total.
- Four special stores.



First YJ85-5 afterburning turbojet is shown above as it is being prepared for shipment from the General Electric Co. to Northrop in 1959. The high thrust-to-weight ratio of this engine is the key to the small size of the F-5.