

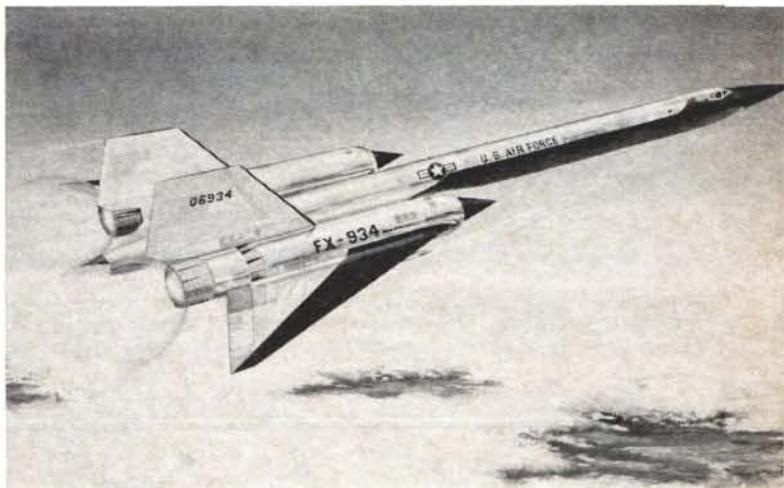
The official pictures and statements tell very little about the A-11. But the technical literature from open sources, when carefully interpreted, tells a good deal about what it could and, more importantly, what it could not be. Here's the story . . .

A - 11

Born in the Skunk Works, Reared in Secret, It Blazes New Heights in Aircraft Performance

By J. S. Butz, Jr.

TECHNICAL EDITOR, AIR FORCE/SPACE DIGEST



—Illustration by Gordon Phillips

THE dramatic disclosure last month that the United States has manned airplanes that are secretly *cruising* at speeds above Mach 3 was good news to the aviation community.

President Johnson, in revealing the Lockheed A-11 program, showed understandable pride in this important US "first." He said that "several" A-11s were being flown "at more than 2,000 mph and at altitudes in excess of 70,000 feet," and are "capable of long-range performance of thousands of miles." The President added that the A-11 "has been made possible by major advances in aircraft technology of great significance for both military and commercial application."

He mentioned only one specific application. He said that the A-11 was being tested extensively to determine its suitability as a "long-range interceptor." Former White House Press Secretary Pierre Salinger and Defense Secretary Robert S. McNamara stressed the interceptor role in their brief expansions of the President's remarks. However, Mr. McNamara, in response to insistent questioning by reporters, has indicated that the A-11 was not designed originally as an interceptor but that he has considerable confidence that it can be adapted to that role.

Beyond these minimum remarks, the secrecy lid has been clamped on. The Administration opened the door on the most tantalizing aviation news since the X-1 proved there wasn't a sonic barrier. But the door was slammed shut immediately.

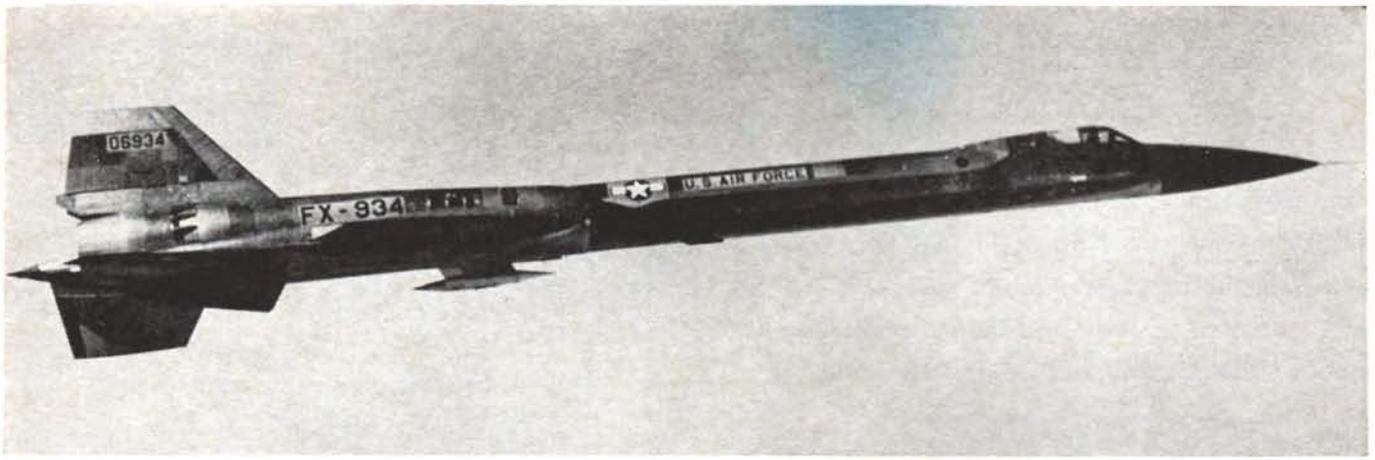
From the technical viewpoint, the A-11 clearly is the most important aircraft since the X-1. It is by far the most efficient airplane yet to fly at supersonic speeds. It is the first to have adequately high aerodynamic efficiency (low drag) and high powerplant efficiency to allow it to carry enough fuel to sustain flight above Mach 1 for more than thirty minutes or so. In the President's words, the A-11 also is extremely important because it led to "the mastery of the metallurgy and fabrication of titanium metal which is required for the high temperatures experienced by aircraft traveling at more than three times the speed of sound."

As reported by Claude Witze on page 16 of this issue, a tight information clamp has forestalled meaningful public discussion of the A-11, its genesis, or its proper role in civil and military aviation.

The following questions are typical of those which should be asked, for the answers concern the use of a very large sum of the taxpayers' money. Congress and the public have a legitimate right to frank answers.

- How much did the A-11 and its engines cost? Judging from previous pioneering programs that fought their technical battles out beyond the "state of the art," the A-11, with its Mach-3-plus performance, titanium construction, and high-temperature engines cost at least \$500 million and possibly \$1 billion. That is \$100 to \$200 million per year for the five years the program has been active. (President Johnson said the

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Window arrangement of A-11 may indicate a three-man crew. The large ventral fin shown here raises the possibility of zero-length launch. This takeoff technique may be used for high-performance aircraft to conserve fuel and increase range. Openings at the rear of the nacelles feed air to convergent-divergent nozzles needed for efficient engine operation.

A-11

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A-11 design work started in 1959. The J58 program was initiated several years earlier by the Navy.) This kind of money is in the cost range of the much-criticized and now-defunct nuclear airplane, and programs of this magnitude should get a thorough working over by the Congress.

• The "obvious" conclusion to be drawn from the information available is that the A-11 was originally developed for the CIA as a high-altitude reconnaissance airplane to replace the U-2. Most reporters reached this conclusion, supported largely by the close secrecy on the airplane, Mr. McNamara's refusal to divulge the original design objective, and the fact that the project was not handled in normal management channels. If this conclusion is correct, several questions arise immediately concerning the past and future expenditure of large sums of money:

(1) Does the fact that a given airplane can cruise at Mach 3 also mean that it automatically has a multi-purpose capability — reconnaissance, interceptor, bomber — without a major design change for each type of mission?

(2) If the answer is no, was there coordination between the CIA and the DoD at an early stage to make certain that the A-11 was not hopelessly boxed into one role?

(3) Can the A-11 development expedite the supersonic-transport (SST) program?

(4) Have reconnaissance satellites eliminated the need for reconnaissance aircraft such as the A-11, and will it therefore end up only as a high-cost experimental aircraft with limited capability?

Precise answers will require the most candid discussion of the current version of the A-11 and its design and development history. Certainly no one can judge the exact performance or mission capability of a supersonic-cruise airplane using only the two side-view photographs and brief statements currently available on the A-11.

Estimates of this type are riskier for supersonic-cruise airplanes than they are for subsonic aircraft or for those that are capable of only short dashes at supersonic speed.

Basically, supersonic-cruise airplanes involve extremely difficult design problems. Their payload-range performance is extremely sensitive to engine weight, structural weight, fuel consumption, and aerodynamic efficiency (lift/drag ratio, written L/D). Small mistakes in predicting these values can lead to large errors in payload and range.

Fortunately, the supply of technical literature concerned with these problems is large. This literature points to some general conclusions about the A-11 and places some broad limits on the possible performance of this new aircraft.

The difficulties described in this literature also provide the best tribute to Clarence L. (Kelly) Johnson and his "Skunk Works" colleagues at Lockheed, who, with the J58 engineers at Pratt & Whitney, led the team that first achieved supersonic cruise.

Here is what can be deduced about the A-11, based on this literature:

• **Size.** The airplane is about ninety feet long based on scaling of the A-11 pictures, using published data on the J58 diameter and estimating the size of the pilot's helmet visible in the front window. There is room in the slim fuselage and in the wing stub areas for more than 70,000 pounds of fuel, with space left over for substantial mission equipment. Since efficient supersonic-cruise airplanes have to carry at least fifty percent of their weight in fuel, the A-11 takeoff weight apparently is more than 150,000 pounds. This is roughly the same as that of the B-58 bomber.

• **Wing.** Densely loaded aircraft such as the A-11 need large wing areas; otherwise their wing loadings will quickly rise above 100 pounds per square foot and severely reduce both cruise altitude and flight efficiency.

The side-view photographs obscure most of the A-11 wing, and published drawings of the A-11 have not indicated a large lifting surface. However, the aircraft must have an effective wing area in the neighborhood of 2,000 square feet. This includes not only the area outboard of the engine nacelles (see *drawing on the front cover*) but also the area between the engines, and the area of the long, very narrow wings



Twist and camber in outboard wing section is visible in this photo of A-11 configuration rigged for conventional takeoff with standard-length landing gear and minus the large ventral fin shown on model at left. Flight tests of the X-15 revealed that X-15 did not need its large ventral fin for adequate directional stability at supersonic speed.

on the fuselage, which have been referred to in some reports as fairings. The long and narrow wings form the forward section of a large double-delta wing similar to that used by Lockheed in its supersonic-transport proposal. At supersonic speeds these long, narrow wings plus the fuselage area between them generate much more lift than they do at subsonic speeds.

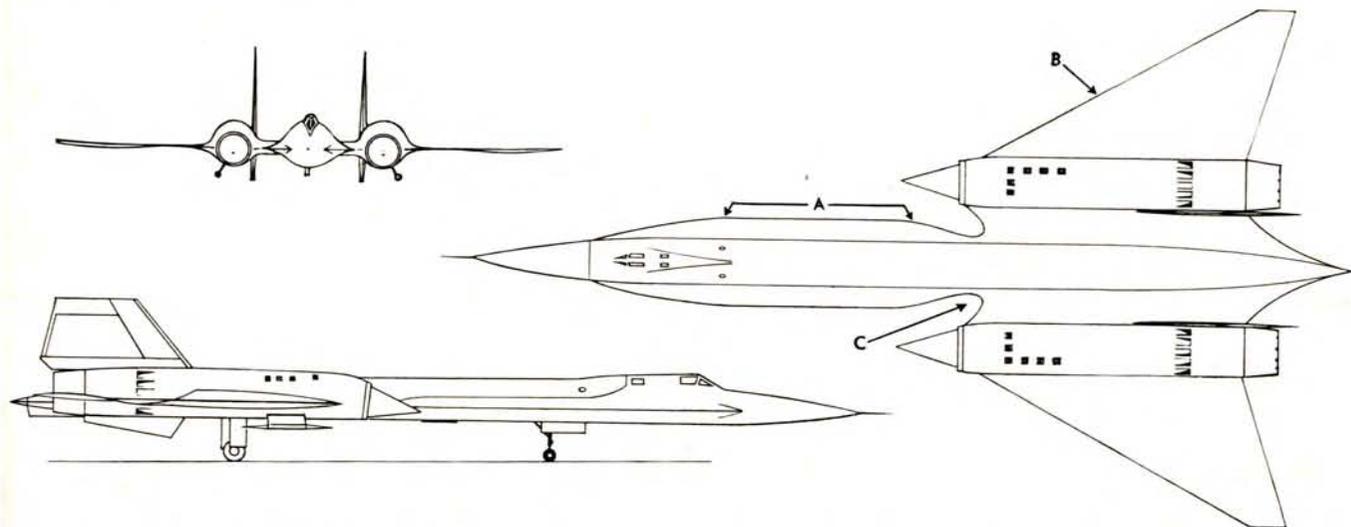
This generation of additional lift up forward is important in maintaining control over the airplane above Mach 1. The controllability problem arises because the rear portion of the double delta acts like a conventional lifting surface at supersonic speeds, and its center of lift moves abruptly aft, a long distance away from the center of gravity. This can make the aircraft so stable that it can't be controlled by a normal-size horizontal tail. In any event, it calls for a large deflection of the tail and an unacceptably big trim drag, which eats into range. On the A-11, lift on the long, narrow wings counteracts the shift of center of lift on the main surface and keeps the center of lift near the center of gravity. On some designs a small canard (horizontal) surface near the nose serves this

purpose. The Swedish Saab Draken, the Mach 2 fighter operational for several years, was the first of the so-called "tailless" (no conventional horizontal tail and no canard) airplanes to use the double-delta planform.

- **Design Mach Number.** The centerbodies of the engine air inlets on the A-11s in the photographs released by the White House appear to have a ramp angle suitable for a maximum economical cruise speed slightly above Mach 3.

- **Cruise Altitude.** Most press reports have placed the A-11's maximum cruise altitude between 90,000 and 125,000 feet. This appears to be a serious error. There is a well-established procedure for checking maximum cruise altitude. It indicates that the A-11 must cruise between 70,000 and 80,000 feet or its range will severely suffer. Thus, the A-11 can be expected to get its maximum range while cruising about 5,000 to 10,000 feet below the U-2. The U-2's superior wing and lower wing loading give it better altitude capability in unaccelerated flight. But in a zoom climb the A-11 would outperform it.

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A-11's modified double-delta wing shows in this three-view drawing. The forward delta extends straight back from just ahead of the pilot's canopy, rearward to the engine air inlets (letter "A"). The rear delta is outside of the engine nacelles (letter "B"). A cutout similar to that shown at "C" must be used to keep low-energy boundary layer air passing along the forward delta from entering the engine inlet, lowering engine efficiency and creating heavy unbalancing forces on the compressor. Such a cutout would be critical in creating favorable flow on rear fuselage ramp.

To figure maximum cruise altitude you have to know two characteristics of any aircraft—the wing loading (written W/S and equal to the gross weight divided by the wing area), and the lift coefficient (written C_L , a dimensionless number indicating the lifting power of the wing) generated when the aircraft is flying at the proper angle of attack for maximum range (maximum aerodynamic efficiency). When the W/S is divided by the C_L , it equals the dynamic pressure required to keep the aircraft in level flight. The dynamic pressure is the term that fixes the altitude of flight for any given speed.

There is enough information on the A-11 to put the above relationships to work. For instance, when the A-11 is flying at Mach 3 at 70,000 feet, the dynamic pressure is nearly 600 pounds per square foot. The lift

its structure could not be any heavier than that of a Piper Cub.

Or, if the A-11 tried to fly at 125,000 feet at a wing loading of about thirty pounds per square foot, corresponding to an end-of-cruise weight, its speed would have to be at least Mach 8 to maintain level flight and to keep it from stalling out.

The same procedures can be used to show that the U-2's altitude during maximum range cruise will vary from about 75,000 feet to a little more than 90,000 feet.

Another check on the operational altitude of the A-11 can be made by examining the engine air inlets which appear to be about six feet in diameter at the most. Therefore, the maximum capture area for both inlets to take in air is between fifty and sixty square

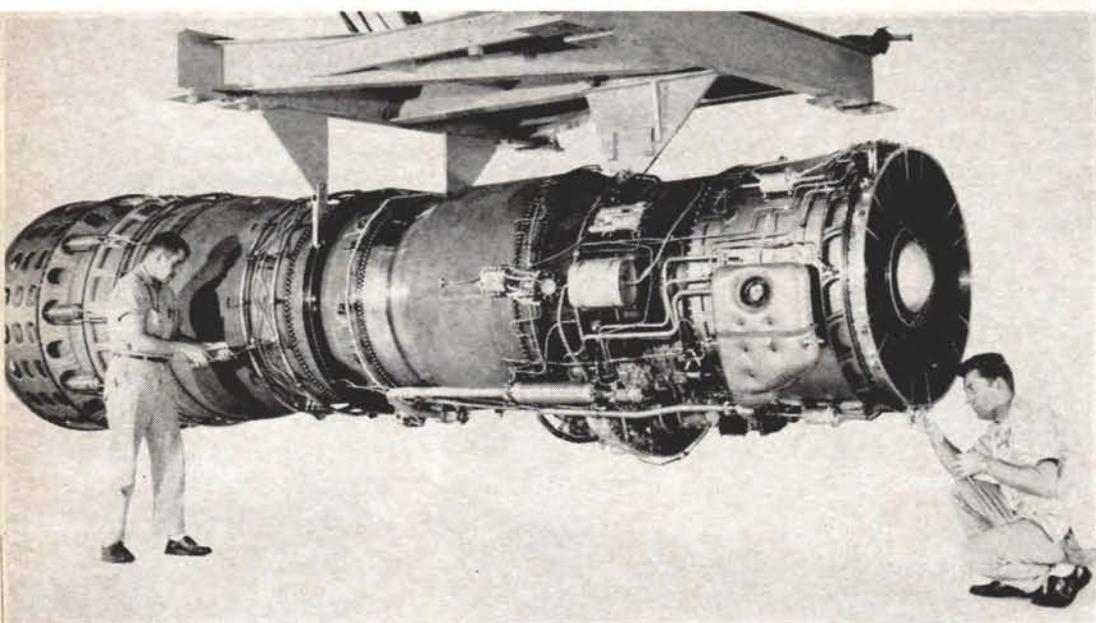


Photo shows early model J58 turbojet. One of few showings of this engine was at AFA's 1959 Convention in Miami. Soon afterward project was highly classified. Thrust is at least 30,000 pounds without afterburner. Efficient use of this engine in a Mach 3 cruise aircraft requires both variable-geometry inlet and exhaust nozzle. A-11 seems to have such systems with a movable centerbody in the inlet and a nozzle that changes the exit area. Altitude performance would improve if the inlet lips opened to enlarge the "capture" area and admit more air.

coefficient for maximum L/D is about .1 (this has been confirmed in many NASA reports on aircraft similar to the A-11). So 600 may be multiplied by .1 to give a maximum possible wing loading of about 60 pounds per square foot. This is about the wing loading the A-11 would have if it had a 2,000-square-foot wing area, weighed 150,000 pounds at takeoff, and burned about one-third of its 75,000-pound fuel load during its climb to altitude.

This procedure can be run through again to show that the A-11's wing loading would be a little better than thirty pounds per square foot once it had burned all its fuel. It, therefore, would end its cruise at Mach 3 at 80,000 feet.

Speed would not change this picture too much. If the A-11 were capable of Mach 4, it would begin its cruise at about 82,000 feet and in the lightened condition at the end of cruise would be flying at nearly 95,000 feet.

The press reports of 125,000-foot altitude completely fall apart under check. If the A-11 flew at that altitude at Mach 4 it would need a wing loading of less than ten pounds per square foot. In other words

feet. This is just about enough to fly an airplane like the A-11 at 80,000 feet at Mach 3. At 100,000 feet at Mach 3 the required capture area goes well over 100 square feet. At 125,000 feet the inlets would become truly gigantic.

In recent years, the ability of Century-series fighters to zoom higher than 100,000 feet has tended to distort the picture as far as maximum cruise altitude and maximum level flight altitude are concerned. Most of the Century-series fighters cruise best between 35,000 and 45,000 feet, and their maximum level flight altitude is around 60,000 feet. Therefore, the A-11's ability to cruise in the 70,000- to 80,000-foot level is certainly not to be disparaged. With the A-11 cruising at Mach 3 at those altitudes, on a gentle dog-leg course, it would be essentially impossible for any operational fighter in the world to intercept it. And it is doubtful that any existing ground-based missile system could down the airplane.

● **Aerodynamic Efficiency.** The A-11 came along in time to benefit from several years of inspired aerodynamic research during the middle and late 1950s. By 1960 the unclassified literature had made it clear that

the old idea that L/D (aerodynamic efficiency) was certain to be less than five at Mach numbers above 3 had to be discarded. There were strong indications that L/Ds of seven and eight and possibly higher could be attained.

These were still well under the L/Ds of eighteen to twenty-three at which subsonic transports and bombers operate. However, an L/D of eight is enough to bring the total flight efficiency (and range) of a supersonic airplane up close to that of the subsonic jet because propulsive efficiency increases rapidly at supersonic speeds. The idea that an economical supersonic transport (SST) was possible grew out of supersonic L/D research in the late 1950s, and the idea of the A-11 undoubtedly had the same beginning.

The basic rules for obtaining high L/D have been discussed exhaustively in NASA reports and the publications of the technical societies. The A-11 appears to use all of them. First, the wing leading edges are as sharp as possible, even sharper than those of the F-104. Second, the fuselage has a fineness ratio (length divided by diameter) of around eighteen, which gives it a very high internal volume for carrying fuel and equipment. Such design was found to be the optimum means for carrying any given weight at supersonic speeds, and the A-11 has the highest fineness ratio yet used on any aircraft.

Third, proper distribution of the pressure forces, the lift and drag forces, is a key to getting high L/Ds with any airplane. Several important techniques which bring pressure distributions closer to the ideal were developed during the 1950s. They primarily involved "twisting" and "cambering" the wing. The side-view photographs of the A-11, both looking endwise at the wing, clearly show its "twists" and "cambers."

Supersonic vehicles offer designers one unique opportunity for reducing drag and improving L/D. This is to arrange the vehicle components (fuselage, wing, tail, nacelles, etc.) so that they "interfere favorably" with each other. At subsonic speeds interference effects are negligible at a distance of more than a few inches away from any surface.

However, at supersonic speeds strong shock waves and pressure fields spread away from all objects. Pressure fields spreading from an aircraft's components can combine unfavorably to make the total vehicle drag much higher than the drag of the components taken separately.

Happily, this situation can be reversed. The components can be arranged so that their pressure fields and shock waves "cancel" out each other and reduce total drag. For instance, an engine nacelle outboard from a fuselage can throw a high-pressure field on the curved aft side of the fuselage to create a "thrust" force and reduce fuselage drag. The "ultimate" in favorable interference is a theoretical supersonic biplane postulated by Adolph Busemann in the 1930s. This was an arrangement of two wings, properly shaped and spaced apart, which canceled all of each other's wave drag at one particular Mach number.

In the 1950s supersonic interference effects were the object of intensive research, notably by Antonio Ferri of the Polytechnic Institute of Brooklyn and A. J. Eggers, Jr., of NASA. Their basic information was applied on the B-70, which is arranged so that a power-

ful positive pressure field is created on the lower wing surface by the engine air duct during Mach 3 cruise to increase lift and improve L/D. Design techniques for favorable interference have been under continuous refinement and are very important in the SST proposals now being evaluated by the FAA.

On the A-11, the area on the back of the fuselage between the engine nacelles is a highly critical flow area in which several strong pressure fields meet. Undoubtedly, the fuselage slopes off continuously in this area and forms a gentle ramp ending in the sharp point visible in the photographs. It would be possible to reduce drag, improve L/D, and increase the effectiveness of the vertical tails by creating favorable pressure fields along this ramp. The slope and contour of the ramp, the spacing and shape of the engine nacelles, the location of the vertical tails, and the flight speed all would be important in creating a favorable flow field and a high L/D. This leads to the conclusion that the A-11 is a single design point airplane. That is, it has a high L/D at its cruise Mach number, but its aerodynamic efficiency falls off at both lower and higher speeds. Consequently, the airplane probably doesn't have much growth potential in speed and would be in serious trouble about making its range if one engine were lost.

● **Structure.** The extent and the manner in which titanium is used in the A-11 has not been disclosed. However, the President's remarks hinted that titanium was the main load-bearing metal. If this is true, the A-11's airframe must be relatively light and efficient for a high-temperature structure. According to data from the SST program, it would have been possible to design the airframe for Mach 4 temperatures with only a slight increase in weight and probably the installation of new leading edges made of higher temperature material. The refractory metal alloys developed in the Dyna-Soar program, for example, would have a long life on a Mach 4 airplane.

After the heating problems the most important structural question about the A-11 is its design load factor. If the load factor were low, say two Gs at cruise, the structure would be extremely light, and amount to only about twenty percent of the airplane's total weight, or even less. Consequently, maneuverability would be sharply limited and the aircraft certainly would be marginal as an interceptor even if its missiles were extremely maneuverable. However, the light structure would result in a low-wing loading and a high cruise altitude, and it would allow a greater percentage of the airplane's weight to be carried as fuel, which would increase range.

If the design load factor were high, to allow seven-G turns, for instance, the structural weight would go up sharply. Such design would make the aircraft very useful as an interceptor or a bomber, but it would substantially reduce maximum cruise altitude and range.

The question of adapting the A-11 to an interceptor or a bomber mission depends largely upon the design

NOTE: In order to accommodate this important story in full, we have expanded the planned size of this issue of AIR FORCE/SPACE DIGEST. Please turn to page 50-A for continuation.—
THE EDITORS

load factor, which, of course, is a closely held secret. Structural strength is more important in this case than the problem of incorporating the necessary electronics and missiles, for the A-11 is big enough.

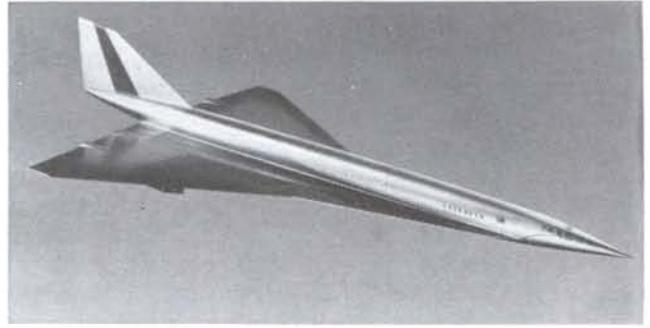
● **Engine.** Official reports dating back several years describe the Pratt & Whitney J58 as a simple supersonic turbojet with an afterburner. An early version lost the B-70 competition to the General Electric J93. If an early version is powering the A-11, the specific fuel consumption (SFC) is high and the range is low. Simple turbojets of the middle 1950s all ran on afterburner at Mach 3, and their SFC was more than two pounds of fuel consumed per pound of thrust per hour, compared to an SFC of about 0.8 for the best fan engines on subsonic jet transports.

However, great strides have been made in engine design, and it seems highly unlikely that a 1955 vintage supersonic engine would still be in the A-11. The J58 undoubtedly has been improved in many ways through higher operating temperatures, the use of advanced turbine-cooling techniques, better compressor blading, and possibly the addition of a fan and new thrust-augmentation systems.

If such engine improvements have been incorporated in the A-11, the SFC during cruise is down near 1.5 pounds of fuel per pound of thrust per hour. Figures almost this low are being quoted for the SST engines. And, in 1962, three Lockheed engineers—F. S. Malvestuto, Jr., P. J. Sullivan, and H. A. Mortzschky—in a most interesting paper before the Institute of the Aeronautical Sciences gave Lockheed's views of what could be done in the way of optimizing supersonic and hypersonic-cruise configurations in the near future. On the key question of achievable SFCs they said, "Propulsive efficiency [Mach number divided by SFC] of 2.0 . . . appears to be a reasonable value for any chemically-fueled pure-turbojet or dual-cycle propulsive system now available or projected in the near future." According to this estimate, the best expected SFC is 1.5 in the near future for Mach 3 airplanes.

One point, continually emphasized in the literature, is that the "match" between airframe and engine on supersonic-cruise airplanes is much more critical than on any aircraft of the past. Engine weight becomes a larger percentage of the total airplane weight, and fuel consumption rises sharply compared to subsonic powerplants, so the engine becomes relatively more important in achieving long range. Consequently, tailoring the airplane to achieve the best possible engine air inlet and exhaust flow conditions has a large payoff. This tailoring must be balanced by airframe considerations, however. On the relatively narrow-span supersonic airplanes the placement of engine nacelles, inlets, and exhaust flows can seriously affect the total flow pattern over an aircraft, which is the determining factor in achieving a high L/D.

On the A-11, the fuselage and the forward and aft portions of the double-delta wing apparently ride at an angle of attack of about four to five degrees during cruise. This angle gives maximum L/D for the A-11 type configuration. The openings of the engine air inlets and the inlet spikes are canted forward through



Lockheed proposed a double-delta wing for its supersonic transport (above). This is a Mach 3 aircraft weighing more than 400,000 pounds and capable of carrying 218 passengers more than 3,500 miles. A-11 can play a vital role in development of the SST by serving as systems test bed.

the same angle to face directly into the airflow and maximize inlet efficiency during cruise. The engine exhaust flow, however, nearly parallels the fuselage and is directed downward at an angle of about four degrees to the line of flight. Therefore, about seven percent of the thrust force is realized as lift to improve L/D and range.

In addition, the A-11 powerplants apparently have been placed so their thrust line is slightly below the airplane's center of gravity during most of the cruise flight. Therefore, the engines produce a nose-up pitching moment and reduce the amount of elevator deflection needed to trim the airplane. NACA reports have estimated that the proper placement of the engine thrust line to reduce trim drag of the elevator can increase range five to ten percent in aircraft of the A-11 type.

● **Fuel.** Several years ago there were reports that the J58 was being tested with boron fuel. If pentaborane were burned in the J58 afterburner—and research has shown this to be possible—then a thousand miles or more could be added to the A-11's range.

US production of borane fuels has been stopped, but Defense Secretary Robert S. McNamara last year told the Congress that enough was stockpiled to satisfy projected needs for the foreseeable future. The boranes are now being used in rocket-engine research, primarily by the Air Force, and conceivably the A-11 could draw from this reservoir.

Borane fuels are expensive compared to the hydrocarbons, and this is a major reason why the use of pentaborane was dropped from the B-70 plans. How-

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Air Force Association honored the designer of the A-11 last fall for earlier U-2 work. Here Lockheed's Clarence L. (Kelly) Johnson accepts trophy from USAF Vice Chief of Staff, Gen. W. F. McKee, at AFA Convention.

ever, on a relatively small aircraft such as the A-11, with relatively limited numbers involved, the extra cost could be justified by the large performance improvement.

- **Range.** Maximum range on the A-11, if it is hydrocarbon fueled and powered by a J58 model only slightly better than the original version, probably is around 3,500 miles. This assumes an L/D of six, an SFC of 2.0, and fifty percent of the aircraft weight in fuel, with about one-third of it being consumed in the climb to altitude. Boron fuel would add around 1,000 miles to the range.

If it has been possible to achieve the maximum L/Ds and SFCs suggested in the Lockheed paper mentioned above, the range would go over 5,000 miles on hydrocarbon fuel. This assumes an L/D of eight and an SFC of 1.5. But this level of performance probably will not be achieved for some time.

- **Development Schedule.** It has been reported that the A-11 was delivered and flown for the first time in 1961; that is slightly more than two years after design



The world's first operational double-delta aircraft is the Swedish Air Force's SAAB J-35 Draken, a Mach 2 all-weather interceptor and ground-attack aircraft whose prototype first flew in October 1955. The aircraft, still in production, entered military service in early 1960.

work started. The same report also claims that the A-11 has been operational for two years, meaning 1963 and most of 1962. That would leave about one year, early 1961 to early 1962, for flight testing.

If this report is true, it would have been necessary during this one year to move in relatively small speed increments toward Mach 3 to make sure that all systems were responding properly to all speed, temperature, and vibration conditions. The inevitable "fixes" would have been made and the modified systems rechecked. Finally, it would have been necessary to move slowly toward maximum-range flights, by cruising at Mach 3 for longer and longer periods to ensure that all systems were withstanding the high-temperature "soaking."

Under any conceivable set of circumstances, designing, fabricating, flight testing, and bringing a pioneering, first-generation, Mach 3 cruise airplane to operational status in three years would be an almost miraculous achievement. True, the CIA-type management system is conducive to rapid developments. In effect, the CIA simply says to the contractor, "Bring us one of 'these.' We are making you responsible for performing all tests and making all technical decisions."

The U-2 was designed this way and delivered for first flight in little more than one year. But the U-2 was a completely straightforward project with a well-known type of wing, aluminum construction, and a slightly modified version of a well-developed turbojet. The A-11 designers were breaking new ground in every department, although they did have access to development data from the B-70 and J93 projects.

It seems reasonable that design, fabrication, and ground testing of the A-11 and its systems took nearly four years and that the first flight took place in 1963. Less than a year of flight testing probably would have allowed President Johnson to say that the aircraft "has been tested in sustained flight at more than 2,000 mph," and is "capable of . . . long-range performance of thousands of miles. . . ." He didn't say the range had been achieved.

But if the shorter development time reported is true, the SST program certainly bears review. If any Mach 3 cruise airplane can be brought to operational status from scratch in three years, then maybe the FAA is correct in taking the position that SST costs, technical uncertainties, and development time will be much lower than industry estimates.

Development of an economic supersonic transport is a much more difficult problem than the A-11, but if the CIA's hands-off management concept can indeed get us a Mach 3 airplane in three years, this concept certainly should be considered for the SST. And the Pentagon could benefit from this example as well.

- **Supersonic Transport.** The A-11 probably can spell the difference between success and failure in any US Mach-2.5-plus supersonic-transport program. The A-11 provides an immediately available means of getting vital flight-test time on all SST systems. It will yield data on the performance of titanium structure at Mach 3 that could not be obtained by any other means. And, when the SST engines are ready, the A-11 will allow them to be exhaustively tested in flight in a known vehicle and not an unproven SST airframe. By allowing such testing, the A-11 will fill a gap in the government's SST plan that has worried many in industry. The A-11 experience should make it possible to go ahead in an orderly manner and build the SST, which must be a true second-generation, supersonic-cruise airplane that has high aerodynamic and propulsive efficiency at all subsonic and supersonic speeds, and an extremely rugged titanium structure which can last through ten years of airline flying.

By any standard the A-11 is a magnificent technical achievement. Quite obviously it can outfly any known aircraft in the world by a substantial margin. It is a natural for reconnaissance. However, if the A-11 is from the U-2 mold and built with an extremely light airframe, it will not have significant combat potential as a bomber or an interceptor without major redesign. Even if such redesign is not forthcoming, the A-11 will play a key research role in building the technology of Mach-3-plus cruise airplanes of all types—transports, fighters, and bombers. In this role its ultimate importance to aviation and the nation may be as great as any aircraft ever built.—END