Artist's concept shows approximate contour of transonic wing as it would appear on a Ling-Temco-Vought F-8 aircraft (top) compared with a standard F-8 wing (bottom). Note curved shape of underside of transonic wing and sharply cambered trailing edge. Forward upper surface of the wing is flattened to give uniform chordwise supersonic flow velocity and delay boundary layer separation.

New Design for Transonic Wing To Be Tested on Modified F-8

By Warren C. Wetmore

Washington—Improved version of the National Aeronautics and Space Administration's "supercritical" wing designed to permit subsonic aircraft to cruise very close to Mach 1 will begin flight tests in mid-1970 on a modified Ling-Temco-Vought F-8A fighter airframe.

A request for proposals (RFP) for detail design and construction of the revolutionary wing will be issued before the end of this month by NASA's Flight Research Center at Edwards AFB, Calif., where the flight tests will be conducted. Several companies have already requested copies of the RFP. Winner of the fixed-price contract will be chosen before autumn.

The new supercritical wing differs from the design originally described in Aviation Week & Space Technology (July 24, 1967, p. 25) in the substitution of a sharply cambered trailing edge for the fixed, trailing-edge slat.

"The slat was too complicated," according to the inventor of the wing, Dr. Richard T. Whitcomb of NASA's Langley Research Center. "In aerodynamics, you can find many aerodynamic improvements, but if they're not practical to build, no one will use them."

Whitcomb, who also developed the area rule, determined that by properly shaping the flattened upper surface of the supercritical wing, including the trailing-edge camber, the same delay of boundary layer separation could be obtained as with the slat. The latter permits high energy flow from the cambered lower surface of the wing to mix with the lower energy flow across the top of the wing. But the high-lift loads generated on the slat to compensate for the reduced lift on the flattened forward part of the wing gave rise to concern about the structure.

On a conventional wing flying at its critical Mach number, Whitcomb explained, the camber at mid-chord on the upper surface gives a region of high supersonic flow near that point, and a shockwave where the flow decelerates to subsonic speed. There, the boundary layer separates and becomes highly turbulent. This causes buffeting and the rapid drag rise at critical Mach number because of the extra energy that the wing is putting into the turbulent airflow. Adverse stability changes can also result.

The solution to this problem, Whitcomb says, is to flatten the mid-chord region and put in camber near the trailing edge. The camber induces a uniform supersonic flow velocity across the wing from the leading edge almost to the trailing edge when the aircraft is flying at high subsonic speeds. The shockwave formed when the flow is finally decelerated in the area of the trailing-edge camber is "greatly reduced in strength and produces very little turbulence and no boundary layer separa-

tion," Whitcomb said. The rapid drag rise is thus delayed to speeds very close to the speed of sound where wave drag from the strong bow shockwave becomes important. The aircraft can cruise faster at the same power setting. Alternatively, this extra speed could be traded off for longer range, heavier payload or lower gross weight. The term "supercritical" stems from the increase in the critical Mach number.

The camber also increases the lift of the wing—though NASA will not reveal the amount of extra lift obtainable—as well as reducing the drag. As a result, the wing's efficiency, measured in terms of lift-to-drag ratio, is substantially enhanced.

The wing's center of lift is shifted aft about 10% of the chord length. The higher loads on the cambered section mean that it will need proportionately greater structural strength built into it. Additionally, it is conceivable that curved trailing edge would facilitate the installation of cambered flaps.

The Navy gave two F-8As to Flight Test Center for the tests. The early version of the aircraft is being phased out of the Navy inventory, and the two air craft given to NASA have seen combat duty in Vietnam.

The first, after reconditioning, will fly in about two months, Whitcomb said. It will be used for transitioning the NASA test pilots who will fly the aircraft with the supercritical wing, for familiarization of the maintenance crews and calibration of such instrumentation as the speed probe.

The industrial contractor will only build the wing for the second F-8, according to present plans. Flight Test Center will perform the modifications to the fuselage, including the area-rule bulge at the leading edge of the vertical stabilizer root. It will also install the wing.

The area rule on the aft fuselage, Whitcomb said, was required because the F-8 was designed to fly much faster or slower than transonic speed, and therefore little attention was necessary to performance in this region. The cross-sectional area of the vertical stabilizer, situated on top of that of the horizontal stabilizer, "gave a bad bump in the area diagram," he said. The tail reached critical speed before the wing.

He emphasized that the tail area rule would not be required on an aircraft designed from the outset to stagger the positions of the vertical and horizontal stabilizers to prevent the addition of their cross-sectional areas on the area diagram.

The supercritical test wing specifications include:
- Sweep at quarter-chord: 42 deg.
- Span: 43 ft.
- Thickness ratio: 12% at root, 9% at...
Show Costs Increase

Washington—Total cost of the U.S. pavilion at the 1969 Paris air show is estimated at $1.76 million as compared with $1.4 million at the 1967 exhibition. With larger firms playing a bigger role in the pavilion exhibits, industry also will pay a greater proportionate share of the costs.

Commerce Dept. estimates that its costs will total $500,000 as compared with $302,000 in 1967. But, with the absence of Defense Dept. participation, funding from other government agencies will slip from $575,000 at the previous show to an estimated $156,000. Industry, on the other hand, will contribute $1.1 million as opposed to $575,000 in 1967.

had allocated approximately $365,000 to carry the costs of its individual chalet and exhibition booth in the general show area where the Commerce Dept., citing "national interest," suggested that it also should be represented in the U.S. "institutional" pavilion. Cost for this is $7,500 for the individual space plus the expense of assembling the additional exhibit and shipping it to Paris along with the necessary personnel to man it.

A number of the larger companies, agreeing to participate in the "national interest," also asked for permission to write off at least a portion of the cost as "allowability" on existing government contracts on the products to be pushed in the U.S. exhibit. The contention here was that, with individual exhibits of their own elsewhere in the show, their U.S. pavilion displays were, in fact, designed to be in the "national interest" alone and that some rebate should be available. Government attorneys replied that this would be illegal under existing legislation.

An added factor of resentment, perhaps unavoidable, resulted from the rush the Commerce and Transportation Depts. were forced into in organizing the U.S. pavilion after the Johnson Administration belatedly decided that the government should participate in the show despite the Defense Dept. withdrawal (AWST Sept. 9, 1968, p. 28).

Others complained that Commerce also was taking an approach too nationalistic to permit the participation of their firms. Many of them want to stress internationalism and licensed production rather than pure off-the-shelf buys from U.S. inventories.

This forced at least one U.S. firm, Communications Satellite Corp. (Comsat), to withdraw from earlier plans to take part in the pavilion exhibit. Comsat had planned a mockup of its Intelsat 4 communications satellite, in which a number of countries participated in the fabrication and are paying dues to use a telecommunications link. The Commerce Dept. said such an exhibit was too "international" in nature. Comsat, already besieged by charges that it is too "nationalistic" in its efforts to promote international communications satellite systems, decided, in turn, that it could not afford to participate on a strictly national basis.

As of late last week, two of the available 21 "institutional" booths still had to be sold. While concentration on the promotion of "big" sales, the U.S. pavilion still will contain a "by-invitation-only" section for use by components manufacturers, with the government in many cases offsetting much of the exhibit cost. All 40 of the available spaces in this area have been sold.

On the flight line, Transportation Dept. plans to have a formidable array of U.S. aircraft to represent this country's military and civil might to partially counter the expected appearance of the Soviet Tupolev Tu-144 supersonic transport prototype. Hoped-for entries include the Air Force/Lockheed C-5A Galaxy heavy logistics transport and the 400-passenger-plus Boeing 747.

Tactical Satcom Orbited by USAF

Cape Kennedy—Tactical communications satellite, built by Hughes Aircraft Co. for Defense Dept., was launched Feb. 9 by a USAF/Martin Titan 3C booster into a synchronous orbit.

Tests to determine the feasibility of using the satellite for tactical communications with small mobile terminals are scheduled to begin early next month.

Planned location for the spacecraft is 22,300 mi. above the Galapagos Islands west of Ecuador.

Tests will utilize two frequency bands: ultra-high frequency (225-400 mc.) and super-high frequency (7-8 mc.). The satellite is equipped with transponders operating in both bands, and it will be possible to transmit to the spacecraft in one band and have the message relayed down in the other (AWST Jan. 15, 1968, p. 28).

The 1,600-lb. spacecraft is designed to provide a worldwide tactical communications capability between military units in the field, ships at sea and aircraft. Developed under the management of the Air Force's Space and Missile Systems Organization for tri-service operations, the satellite has a design lifetime of five years.

Two days before the launch, a TRW Intelsat 3 communications satellite entered a synchronous orbit over the Pacific at 174 E. Long. The satellite, the second in a series of four, was launched Feb. 5 from Cape Kennedy.
Changes in configuration of test-bed LTV F-8A fighter fitted with the NASA transonic wing are apparent in drawing. Humptail of cockpit is the forward glove extension of wing, required for smooth penetration of near-sonic airflow. NASA's Flight Research Center also will add area-rule bulge at root of fin. Wing planform is intended to be similar to that of conventional jet transport and can be compared with normal F-8 wing (dashed line).

The mean aerodynamic chord and 7% at the tip.

These were made deliberately close to those of a conventional jet transport so that a realistic performance comparison could be made. The wing probably will be no lighter per square foot than a conventional swept transport wing, Whitcomb said, since additional cruise speed is the desired result, "and you can't have both higher speed and higher efficiency."

Nor does he expect that the wing will be more expensive, except for its forward "glove" extension. It is designed for gradual penetration of near-sonic airflow to avoid a supersonic velocity peak near the leading edge. But, he noted, the extra cost will be amortized by the economics of higher speeds.

A fighter aircraft was chosen as the test bed for a transport type of wing, Whitcomb said, because "it's a lot cheaper to put it on a fighter than on a [Boeing] 707."

A fighter also has the thrust needed to go to higher altitudes, where the lower air density gives approximately the same dynamic pressure—and therefore profile drag—at the higher cruise speed as would be encountered at lower altitudes and lower cruise speed. Tests will be flown at 45,000 ft., Whitcomb said.

This is approximately the altitude at which a transport aircraft with a supercritical wing would operate most economically.

In addition to the primary test objective of determining the operational potentials of the wing, other aims include:

- Proof in actual flight of wind tunnel results which showed delayed drag-rise and improved buffeting boundary.
- Investigation of the wing's behavior in high-lift maneuvering and off-design performance.
- Examination of the wing's sensitivity to deformations arising from flight loads and contour variations due to manufacturing processes.
- Confirmation of current design techniques. The tests should also indicate fruitful paths for additional ground-based research that would lead to practical applications of the supercritical wing concept.

Test results sufficient to prove the concept should be in hand about two months after the beginning of flights of the heavily instrumented F-8, Whitcomb said. Measurements of drag in flight are always difficult, he said, but can be done indirectly by measuring the speed and engine thrust. Additionally, "hundreds" of pressure distributions will be measured, he said. If these are the same as those determined on the wind tunnel model of the supercritical-wing F-8, then the drag on the full-scale aircraft is the same.

Resorts International, Inc. has an agreement to buy 1,500,000 additional shares of Pan American World Airways stock worth $40 million at current market prices. It has already purchased 900,000 shares from Gulf & Western Industries (AWST Feb. 10, p. 23), and has an option to buy another 900,000 shares owned by the same conglomerate.

Spot checks are planned by the Federal Aviation Administration to sift potential hijackers from passengers boarding airliners, according to Acting FAA Administrator David D. Thomas. Thomas said the FAA is considering the use of X-rays, infrared detectors and magnetometers.


Top-level assistants in the Transportation Dept. have been named. They include James M Beggs, associate administrator for the office of advanced research and technology of the National Aeronautics and Space Administration, who will be No. 2 man as under secretary; Dr. Paul Cherington, James J. Hill Professor of Transportation at the Harvard Business School, who will become assistant secretary for policy and international affairs, and James D'Orma Braman, mayor of Seattle, Wash., who will be assistant secretary for urban systems and environment.
Japan Presses Pacific Demands

Asian nation blocked U.S. airline expansion in recent case with pressure in economic talks, sought further route growth

By Laurence Doty

Washington—Japanese government is continuing to exert the same stiff resistance against implementation of new air services into Tokyo that has prevented an expansion of U.S. airline operations on Pacific routes for the past 10 years.

Last week, President Nixon attempted to take full command of the international phase of the controversial Transpacific Route Investigation. He earlier had instructed the Civil Aeronautics Board to rescind all certificates in the case and made it clear that any White House action taken would be based solely on foreign policy or national security considerations.

But it is now apparent Nixon will face the same obstacles in dealing with Japan that forced President Eisenhower to nullify one Board decision and President Johnson to reduce the number of carriers recommended by the CAB to serve Tokyo in the present case.

Johnson's decision to reverse that part of the CAB recommendation granting Tokyo rights to American Airlines (AWST Jan. 6, p. 40) was based on issues outside the realm of aviation. Japan has advised that it would drop current negotiations with the U.S. in three major economic areas if any new carriers were authorized to serve Tokyo. These negotiations include:

- Reduction of Japanese tariffs on pharmaceutical products shipped from the U.S. for sale in Japan.
- Reduction in the volume of Japanese steel shipped for sale in the U.S.
- Expanded freedom for the sale and construction of U.S. automobiles in Japan.

These matters were considered sufficiently broad in economic scope and popular interest by the Johnson Administration to justify the change in the Board order. They were the actual foreign policy considerations which Johnson referred to in his letter to CAB Chairman John H. Crooker, Jr., as reasons for his action (AWST Dec. 23, 1968, p. 23).

A later move by the Japanese government further underscores its determination to withstand any significant increase in competition against Japan Air Lines. On Dec. 24, the U.S. State Dept. advised all governments involved in the transpacific case of an intent to add new services in accordance with the route awards made by the CAB and approved by the President.

A secret clause in the U.S.-Japan bilateral air transport agreement calls for an automatic consultation between the two governments within 60 days after the announcement of an intent to operate new routes into the Asian country. In most other bilateral pacts, consultation may be requested but is not compulsory.

Consultations with the Japanese were scheduled for Feb. 24. These have now been postponed indefinitely because of the Nixon effort to vacate the certificates.

But, meanwhile, Japan had informed the State Dept. what it would expect in return for allowing Pan American World Airways to serve Tokyo on a great circle route and Northwest Airlines on a central Pacific route, the only new services into Tokyo authorized by Johnson. Included in the Japanese demands were:

- Great circle route between Japan and the U.S. for Japan Air Lines.
- Traffic rights or blind sector authorization between Vancouver and San Francisco and between San Francisco-Los Angeles and Mexico City.
- Authority to serve Chicago.

Soviet Charter Tour

Washington—Overseas National Airways will begin its all-inclusive charter tours between New York and four cities in the Soviet Union Mar. 28 under a package plan operated by Vacations West, Inc., at a cost of $625 per person (AWST Jan. 13, p. 34).

The 14-day tour includes round-trip transportation between New York and Leningrad on an Overseas McDonnell Douglas DC-8 and Aeroflot flights from Leningrad to Moscow, Sochi, Kiev and return to Leningrad. Overseas crews will be accompanied by a Russian pilot and navigator as flight escorts.

Negotiations between the U.S. and Russia on the charter flights lasted over a year before agreement was reached. In addition to air fares, cost of the tour covers all meals, entertainment, tour guides and hotel accommodations.