Tests Planned for New Wing Design

Flight tests of a new experimental wing design that could significantly increase cruise efficiency for both commercial and military jet aircraft are planned for next summer at NASA's Flight Research Center, Edwards AFB, Calif.

Wind-tunnel tests are underway in the 8-ft. wind tunnel at NASA's Langley Research Center, Va., where development of the "super critical wing" is centered.

The Navy reportedly has volunteered use of an LTV-built F8U aircraft that will be modified with the new wing for the flight tests. It is estimated that modification work on the F8U will begin in the spring of 1969, with flight tests slated to get underway at Edwards next July.

The wing design involves a new slotted airfoil. The slot, near the trailing edge of the wing, has the effect of moving the normal position of the shock wave that builds up on an airfoil much further aft, thus producing less turbulence on the wing and less drag. Engineers estimate that this type of airfoil could shift the high drag rise normally encountered by commercial jetliners at about Mach 0.82 to speeds of about Mach 0.9. This, they believe, would translate into either much better fuel economies and operating efficiencies or an estimated 18% increase in speed before once again hitting the high drag region.

Another version of the super critical wing has been developed that accomplishes much the same things, but without the slot, according to NASA. This work is known to be of considerable interest to the military, since it involves a lighter weight and less complex design, and much of the effort is classified at this time.

Also under consideration for the new wing is flight testing on a modified F-111 variable geometry aircraft if funds are made available.

UAL Elects Two VPs

Percy A. Wood was elected vp-employee relations of United Air Lines, and Ralph T. Glasson was elected vp-base maintenance. Wood, who joined UAL in 1940, has been vp-base maintenance in San Francisco, and will now be located in Chicago. Glasson, who succeeds him at San Francisco, has been manager of development engineering at the base.

Wren Retains Mooney As Consultant on O-2

Al Mooney has been retained on a consulting basis by Wren Aircraft, Fort Worth, to work on the Wren conversion of the Cessna O-2. The adaptation would increase STOL capability of the O-2, which is used by the Army as an observation plane in Vietnam.

Mooney, who has had a long career in aviation, retired in February as a Lockheed engineer. The Wren project was under the supervision of A. H. (Doc) Morris, who was killed recently in an airplane crash.

A. H. Pickering, Wren president, said that the Wren adaptation of the O-2 version of the Cessna Super Skymaster should be flying within two to three weeks.

Galaxy and its Escort on Test Flight

Lockheed's C-5A Galaxy in flight is escorted by one of the two Lockheed T-33s used as chase planes for the test flights. The C-5A has made eight flights thus far, amassing 23 hrs. of flying time.
 NOTICE

Description of Legends

In the listing of proposed procurements, whenever a reverse figure appears before the letter code for Services or the two-digit code for Supply, Equipment and Material, the symbol denotes in general the following:

- The procurement item is 100 percent set aside for small business concerns.
- A partial quantity of a portion of the procurement item is set aside for small business concerns.
- The contract is a labor surplus area set aside.
- Notice of Intention to purchase which are published before the IFs are issued directly to those requesting the proposal.
- The procurement will be made under provisions of Defense Manpower Policy No. 4 Revised.
- The procurement will be made in accordance with ASPR part 5, paragraph 2.501 and is the 1st step of a two-step process called a materials pricing statement. Only those firms submitting qualified responses on the 1st step will receive notification when the purchase is made.

U. S. GOVERNMENT PROCUREMENTS

SERVICES

A Experimental, Developmental, Test, and Research Work includes both basic and applied research. [EDIT]

A - Negotiations are being conducted with ILC Industries, 350 Pearl St., Dover, Del., for EXPERIMENTAL PNEUMATIC CO2 CONTROL. See Note 27.

U. S. Army Missile Command, Procurement & Production Directorate, Systems Contracts Division A, 5250 Grant St., Bldg. A, AMSEC-1-W, Redstone Arsenal, Ala., 35809

A - GODDARD SPACE FLIGHT CENTER, proposes to contract with IWS, INC., for CONTINUING DEVELOPMENT AND FABRICATION OF AN ADJUSTABLE TEMPERATURE-INTENSITY PROGRAMMED FAST RESPONSE SOLAR ARRAY SIMULATOR FRAS. For information only, RFP packages are not available.

Goddard Space Flight Center, Glenn Dole Road, Greenbelt, MD 20771

A - The National Air Pollution Control Administration, Washington, D.C., 20460, contemplates the extension of Contract IH 65-68-99 with A. M. Kinney, Inc., for support services and technical writing. Notice: Information only. Request for information only. RFP packages are not available.

DOD/AMC, National Air Pollution Control Admin., Office of General, General Services Branch, 700 Pennsylvania Ave., NW, Washington, D.C. 20460

A - DATING OF VARIOUS SHIP MISSILE SYSTEMS EQUIPMENT originally developed by this contractor. The work requires detailed knowledge of the equipment design and can be performed only by the manufacturer. Schedule 69-1315, OS153-NOTE: For information only. RFP not available.

K - Selected Source Procurement is the Bendix Corp., Missile Systems Div., for the MODIFICATION AND UPDATING OF VARIOUS SHIP MISSILE SYSTEMS EQUIPMENT originally developed by this contractor. This work requires detailed knowledge of the equipment design and can be performed only by the manufacturer. Schedule 69-1315, OS153-NOTE: For information only. RFP not available.

Office in Charge, Navy Purchasing Office

312 N. Sping St., Los Angeles, Calif. 90012

K - RE-COMMISSION C-131 AIRCRAFT -1 ea.-RFP

F05003-69-Q-0079 will be issued to Fairchild Hiller Corp., St. Augustine, Fla. This is the second renewal of an AFC three-year operating policy. See Note 27.

A - Negotiations are being conducted for the supply of A-4D LAND ROVER EQUIPMENT. See Note 27.

U. S. Army Procurement Division, Production Management and Engineering Divisions, Karachi, Pakistan, 32209-30. [EDIT]

K - DOD-CONSTRUCTION C-131 AIRCRAFT-1 ea.-RFP

F05003-69-Q-0153 will be issued to Air National Guard, Miami, Fla., for a supplemental agreement to existing contract. For information only. Werner Bobins Air Material Area, Airbuses Air Force Base, GA 30193 Attn: WPRF

L Technical Representative Services

L - Selected Source Procurement from General Dynamics, Pomona Div., for production of 265 days of DOMESTIC AND OVERSEAS ASSISTANCE AND INSTRUCTION TO MILITARY AND DEFENSE PERSONNEL IN CONNECTION WITH THE INSTALLATION, TEST, REPAIR AND OVERHAUL, OPERATION AND MAINTENANCE OF SIMILAR WEAPONS SYSTEMS EQUIPMENT designed, developed, and purchased by the above contractor. Services are for Naval Ship Systems Engineering Station (Pax River), MD, on an as-needed basis. RFP number is 69-1315. For information only. RFP packages are not available.

Office in Charge, Navy Purchasing Office

312 N. Sping St., Los Angeles, Calif. 90012

NOTICE

Glasgow Air Force Base
Glasgow, Montana

The Department of the Army, Fort Detrick, Frederick, Maryland 21702 reports the availability of a manufacturing facility at Glasgow, Montana, for the repair, reconditioning and manufacturing of the following military items: (A) Weapon, M268, M61A1, M61A2, M61A3, 3,400,000 ea. [EDIT] (B) General Electric, M191, 167,000 ea. [EDIT] (C) General Electric, M191A1, 5,000 ea. [EDIT]

Office in Charge, Navy Purchasing Office

312 N. Sping St., Los Angeles, Calif. 90012

Monday, January 20, 1969

8 PAGE ISSUE

U. S. DEPARTMENT OF COMMERCE

OFFICE OF FIELD SERVICES

Charles F. Boehm, Director

Avco Economic Systems Corp.

1025 Connecticut Ave., N.W., Washington, D.C. 20006

The Avco Economic Systems Corp. will set in motion a program of manufacturing and commercial economic development on the site of the Glasgow Air Force Base, with a goal to transform the facility into a self-sustaining industrial community. Avco has agreed to lease the entire base for a period of five years. As part of Avco's commercial economic development program, the Base, is invited to all industries which can utilize the industrial space. Modern structures of various sizes are available. Modern housing facilities are available for executives and production employees. Facilities for education and recreation are available. Aircraft runways and ramps are available.
Langley-Developed Wing Near Tests

By J o e B l a c k
Daily Press Hampton Bureau

National Aeronautics and Space Administration will evaluate the potential of a new airfoil shape that could substantially improve the performance and efficiency of future aircraft — particularly commercial and transport planes.

A wing, called the NASA supercritical wing, will be tested in flight on a modified Navy F l y jet fighter. The supercritical wing was developed at NASA's Langley Research Center as a result of wind tunnel tests conducted by Dr. Richard T. Whitcomb during the past four years.

The wing utilizes a new airfoil shape with a flat top and a downward curve at the rear section of a conventional wing. If the performance measured in the Langley wind tunnel tests is fully achieved in flight, the new airfoil shape could allow cruise faster with the same highly efficient cruise flight near the speed of sound — approximately 600 miles per hour in an unpowered setting, and more payload on faster

In addition to permitting a substantial increase in cruise speed with no increase in power, the new wing might significantly reduce the operational cost of subsonic jet transport aircraft, particularly those flying at low altitudes. NASA spokesmen said the wing's efficiency of about Mach 0.8 at approximately 630 mph at a cruising altitude of 35,000 feet.

L a n g l ey w i n g tested and analytical studies indicate the NASA supercritical wing has the capability of the aircraft to fly faster, straighter and lower.

Because a jet could shock waves and surface-bound layer separation.

Up to Mach 0.8., these disturbances could cause a substantial loss in flight efficiency due to increases in drag, severe aircraft buffeting (shaking), or disastrous changes in the stability of the aircraft. This loss in efficiency can be swept the wings of the aircraft.

The most widely used method to delay the rise of the drag force and onset of buffeting has been to sweep the wings of the aircraft.

However, excessive wing sweep increases structural weight, creates problems relating to the low speed flying qualities, and possibly creates requirements for longer takeoff and landing distances. The supercritical wing shape has been developed to substantially delay the onset of these adverse effects.

This change, together with the downward curvature at the rear portion of the wing which results in the lift lost by flattening the forward portion, increases the basic speed at which the drag rise and buffeting begins to take place and, thus, results in a more efficient wing for cruise.

Because of the drastically different wing performance, the aerodynamic efficiency and performance of the new wing is substantially improved over the conventional wing.

MODIFICATIONS FOR SUPERCRITICAL-WING FLIGHT STUDIES

SOFIFIED AIRCRAFT

UNMODIFIED AIRCRAFT

THE SECOND FRONT PAGE

NEWPORT NEWS, VIRGINIA, HOLIDAY MORNING, FEBRUARY 10, 1969
Wing
Continued From Page Three

different nature of the airflow over
the supercritical wing, it is neces­
sary supplement the wind tun­
nel studies with flight evalua­
tion.

The flight program will use
an F-8 jet made available to
NASA’s Flight Research Center,
Edwards, Calif., by the Navy.
No date has been set for the
flights.

The aircraft will be modified
by replacing the basic wing with
a supercritical wing.

The wing to be tested will be
shaped to simulate a wing in­
tended for use on a commercial
jet transport. However, the re­
sults obtained will be indicative
of the performance gains possi­
bile for future military aircraft,
according to a NASA spokes­
man.

The primary objective of the
flight program will be to ex­
plore the operational potential of
the supercritical wing. Oth­
er objectives include:

—Validation of present design
 techniques and specific direc­
tion for further ground-based re­
search, leading to practical ap­
plications of the concept;

—Demonstration, through di­
rect correlation with flight test
results, of the improvements in
drag rise and buffet onset in­
dicated from the wind tunnel
tests;

—Evaluation of the behavior
of the wing in actual flight in­
volving both high lift maneu­
vering and off-design perform­
ce;

—Determination of the sensi­
tivity of the supercritical wing
to wing contour variations as­
associated with manufacturing
processes and deformations due
to flight loads.
North American Rockwell entered sole bid to develop flight test wing developed here for transonic airliners. Supercritical foil will be tested with the new wing (solid line) which replaces original (dotted) F8 structure.
WASHINGTON (AP) — White House planning is splendidly for the Apollo 11 astronauts dinner in Los Angeles with a guest list of 1,500 including the 50 governors, diplomats, Charles Lindbergh and Jack Benny.

The black tie dinner Wednesday at 8 p.m., at the Centur Plaza Hotel will be 10 times anything ever held at the White House. No one knows yet how much it will cost, but President Nixon is springing for the check.

Lunar mission astronauts Neil Armstrong, Edwin Aldrin and Michael Collins will find their way to the table through ticker tape parades in New York and Chicago. They get out of quarantine Monday.

Invitations, placecards, the menu, entertainment have been decided by the White House social and protocol staffs. But the hotel, a favorite with Nixon aides, will produce the dinner furnishing the china, crystal and tableware as well.

The White House asked former Presidents Harry S. Truman and Lyndon B. Johnson to be there. Truman sent his regrets for health reasons. Johnson said he wouldn't come because his wife, Lady Bird, would be out of the country visiting friends. President John Kennedy's widow, Mrs. Jacqueline Onassis also sent regrets.

The guest list is intended to reflect a cross section of America with a heavy dose of congressmen and aviation pioneers included.

At one point in the dinner the astronauts and the President will exchange champagne toasts.

The menu: salmon poached in champagne and garnished with prawns, oysters and truffles; fillet of beef, artichokes, baby carrots, California bib lettuce salad with mixed cheeses, and an ice cream dessert called "Claire de Lune (moonlight)."

Music will be provided by the U.S. Marine Band and its Drum and Bugle Corps, the Army and Air Force Strolling Strings and the Army Chorus.
Langley-Designed Wing Promises Faster Planes

By JOE BLACK
T-H Hampton Bureau

A new airfoil shape which could allow more efficient cruise flight near the speed of sound is to be tested in flight by the National Aeronautics and Space Administration.

The NASA supercritical wing was developed at Langley Research Center as a result of four years of wind tunnel tests conducted by Dr. Richard T. Whitcomb.

The test flights will be made on a modified Navy F8 fighter jet at NASA's Flight Research Center, Edwards, Calif.

The supercritical wing utilizes a new airfoil shape with a flat top and sloped rear section of a conventional design.

The wing to be tested will be shaped to simulate a wing intended for use on a commercial jet transport.

The results obtained, however, are expected to apply equally well to possible gains for future military aircraft, according to a NASA spokesman.

In addition to permitting a substantial increase in cruise speed without increases in power, the new wing might also significantly reduce the operational cost of subsonic jet transport flight.

When the speed of an aircraft approaches the speed of sound — approximately 660 mph at a cruising altitude of 45,000 feet — regions of high supersonic airflow develop above the aircraft.

This can cause a substantial loss in flight efficiency, severe buffeting and adverse changes in the capability of the airplane to fly straight and level.

On present subsonic jets this occurs at about Mach 0.8 — 530 mph at 35,000 feet.

Langley wind tunnel tests and analytical studies indicate the supercritical wing can go to Mach 0.95 before these disturbing effects begin to show up.

In addition to exploring the operational potential of the new airfoil design, flight tests will also include validation of present design techniques, evaluation of the wing in actual flight and determination of the sensitivity of the supercritical wing to wing contour variations associated with manufacturing processes.

Requests for proposals to perform the modification work will be issued by the Flight Research Center. No date has been set for the initial test flight.
By RICHARD WITKIN

The man who perfected the
"Coke bottle" design for air-
plane fuselages has de-
voped a radically new wing
that could greatly improve
the performance of future
planes, particularly airliners.

Disclosure of the new de-
gign, the work of a team
headed by Dr. Richard T.
Whitcomb, was made yester-
day by the National Aero-
nautics and Space Admin-
istration. The unorthodox wing
has been thoroughly tested
in NASA wind tunnels and
will be flight-tested next
year on a revamped Navy
jet fighter.

Agency sources said the
new wing—its top side much
less curved (almost flat) over
the central portion than pre-
cent-day wings, but more
curved toward the rear—
should allow airliners much
like today's to fly routinely
at speeds verging on the
speed of sound.

That speed is 660 miles an
hour at jet altitude. Current-
ly, normal cruising speeds
are limited to well under 600
because of the "sound bar-
rier."

For the airlines, the extra
100 miles an hour or so
would translate into large in-
creases in productivity of a
plane—in other words, into
substantial dollar economies.

NASA sources said the de-
velopment should also vastly
improve the subsonic dog-
fighting agility of supersonic
fighters and the subsonic
range of tomorrow's bombers.

"The benefits should be
every bit as large as those
from the 'Coke bottle' de-
sign," said one highly placed
official, reflecting the
general optimism of the agency.

It was almost 14 years ago
that the Government an-
nounced that Dr. Whitcomb,
then an unknown 34-year-old
engineer, had created a new
fashion in aircraft variously
known as the "Coke bottle."

Continued on Page 65, Column 1
**New Wing Designed for Faster Planes**

Continued From Page 1, Col. 3

"Caspaw waist," or "Marilyn Monroe" design.

By working out precise formulas for pulling in a plane's waist, he made it possible for 800-mile-an-hour planes to reach 1,000 miles an hour, or to put it another way, enabled the 800-mile-an-hour plane to extend its range.

The accomplishment was almost universally acclaimed as the most significant advance in flight since man first flew faster than sound in 1947.

Dr. Whitcomb's latest work is geared to do for planes flying at sonic speed or below what the "Coke bottle" did for supersonic planes.

In both cases, the problem had to do with the troublesome behavior of air when planes penetrate the sonic region.

"When a plane is flying subsonically, it in effect "warns" the air in front that it is approaching. When the nose or tail, for instance, strikes the air, the impact is relayed forward precisely at sonic speed, and the air ahead begins to part to allow the plane through.

However, when the plane hits the speed of sound, the air ahead does not have time to start giving out of the way. The plane is traveling as fast as the warning message.

The result is that, when the nose or tail strikes an unprepared patch of air, that air is shoved aside violently and there is a severe shock wave. The forces associated with such waves make up the major part of the enormous increase in drag that occurs when a plane enters the sonic zone.

The slowing effect of these unshakable shock waves is always with a plane flying subsonically. But the "Coke bottle" indentation, by giving the shock wave an extra place to spread, significantly diminishes the slowing effect.

A Different Problem

With a plane designed for speeds up to sonic speed, the problem is quite different. It is intimately connected with the basic shape of an airplane wing.

The classic wing is curved on top and more or less flat on the bottom. The air flowing across the top is accelerated to higher speeds than the normal flow of air along the bottom. It has to flow faster because the portion of the wing behind it is immersed in a flowing stream of water. It causes the once-smooth flow of air farther back along the wing to become extremely turbulent.

The turbulent flow causes a loss of lift in that area, and a great increase in drag, and it can produce severe buffetting. That is why today's airliners have top speeds well below the speed of sound.

How would the Whitcomb wing overcome the problem? The curvature is such that airflow on top reaches sonic speed at about the midpoint of the wing. It is this abrupt peaking that produces a severe enough shock wave to create a storm center of turbulent air on the portion of the wing behind it.

The Whitcomb wing is flattened in the critical area mid-way from front to back. There is no sudden jump of the topside air flow to supersonic speed, and the peak speed does not get as high as on a conventional wing. The shock wave, therefore, does not become severe enough to produce a turbulent airflow toward the rear. The air keeps flowing smoothly across the entire wing, even though it is supersonic over the top.

The wing-tunnel work where the concept was developed has been going on for months at NASA's Langley Research Center at Hampton, Va. Flight tests will be carried out by a Navy FS fighter with wings of the new design substituted for its regular wings.
NEW YORK — The man who perfected the "Coke Bottle" design for airplane fuselages has developed a radically new wing that could greatly improve the performance of future planes, particularly airliners.

Disclosure of the new design, the work of a team headed by Dr. Richard T. Whitcomb, was made yesterday by the National Aeronautics and Space Administration. The unorthodox wing has been thoroughly tested in NASA wind tunnels and will be flight-tested next year on a revamped Navy jet fighter.

The wind-tunnel work where the concept was developed has been going on for months at NASA's Langley Research Center at Hampton, Va. Flight tests will be carried out by a Navy F8 fighter with wings of the new design substituted for its regular wings.

Agency sources said the new wing — its top side much less curved (almost flat) over the central portion than present-day wings, but more curved toward the rear — should allow airliners much like today's to fly routinely at speeds verging on the speed of sound. That speed is 660 miles an hour at jet altitude. Currently, normal cruising speeds are limited to well under 600 because of the "sound barrier."

For the airlines, the extra 100 miles an hour or so would translate into large increases in productivity of a plane — in other words, into sizable dollar economies. NASA sources said the development should also vastly improve the subsonic maneuverability of supersonic fighter planes.

It was almost 14 years ago that the government announced that Whitcomb, then an unknown 34-year-old engineer, had created a new fashion in aircraft variously known as the "Coke Bottle," "Wasp Waist," or "Marilyn Monroe" design.

By working out precise formulas for pulling in a plane's waist, he made it possible for 800-mile-an-hour planes to reach 1,000 miles an hour or to extend their rate. The accomplishment was almost universally acclaimed the most significant advance in flight since man first flew faster than sound in 1947.

The classic wing is curved on top and more or less flat on the bottom. The air flowing across the top is accelerated to higher speeds than the normal flow of air along the bottom. It has to flow faster because it has a suddenly greater (curved) distance to travel. The result is much lower pressure on the top of the wing. It is this lower pressure, or upward suction, that gives a plane most of its lift.

The system runs into trouble when the plane nears the speed of sound. The speed-up of the top-of-the-wing air brings it to sonic speed long before the plane itself is at that speed.

This produces a shock wave on the top side. It does not, of itself, cause anything like the slowing effect of the shock waves generated when an entire plane hits the sound barrier. But it does something else.

The shock wave atop the wing acts much like a stick im-
A Man Develops New Wing

Continued From First Page

mersed in a flowing stream of water. It causes the once-smooth flow of air farther back along the wing to become extremely turbulent. The turbulent flow causes loss of lift in that area, and a great increase in drag, and it can produce severe buffeting that would rattle the teeth of airplane passengers. That is why today's airliners have top speeds well below the speed of sound.

How would the Whitcomb wing overcome the problem? On the classical wing, the curvature is such that airflow on top reaches sonic speed rather abruptly about halfway back along the wing. It is this abrupt peaking that produces a severe enough shock wave to create a storm center of turbulent air on the portion of wing behind it.

The Whitcomb wing is flattened in the critical area midway from front to back. There is no sudden jump of the topside air flow to supersonic speed, and the peak speed does not get as high as on a conventional wing. The shock wave, therefore, does not become severe enough to produce a turbulent airflow toward the rear. The air keeps flowing smoothly across the entire wing, even though it is supersonic most of the way.

The modest sacrifice in lift in the midway area (because of lower peak speed) is compensated for by the extra curvature of the rear wing area. The total effect is to spread the low pressure, upward-suction effects over a greater portion of wing.
0013 1124 A31EC 0 B10CY 0036
EVENDALE OHIO 1/10/67
WARK NICHOLS NASA
LANGLEY FIELD HAMPTON VA

I WISH TO CONGRATULATE YOU AND YOUR PEOPLE ON THE RECOGNITION RECEIVED IN THE EDITORIAL OF THE CURRENT AVIATION WEEK. IT IS FITTING THAT THE WORLD KNOW WHAT WE HAVE ALWAYS KNOWN. GREAT JOB, WARK, AND MY THANKS FOR YOUR WORK AND THE PRIVILEGE OF WORKING WITH YOU.

J. T. BUTCHER GET 1126 00 PPD

TO FSRD BRANCHES:

This telegram and the Av. Wk. editorial to which it refers are samples of the favorable recognition which the division team is receiving for its research and evaluation support of SST. I would like to acclaim the executive council credit and, at the same time, take this opportunity to express thanks to you who did the work for a job well done.

WAV
The Supersonic Decision

The U.S. supersonic transport program is now in position to enter the important phase of prototype construction. With the selection of Boeing for the airframe and General Electric Co. for the engine, the U.S. program assumes a more clearly defined shape and becomes a firm competitor in the international market. It should be clear to the airlines of the world, particularly those who participated in the final design selection, that the U.S. program is indeed a sound technical effort that will press forward at the best possible pace to certification and airline service.

The Federal Aviation Agency, which made the final choice in this hotly contested design competition, deserves considerable praise for the swift and sure way it handled the selection process. It allowed the airlines full expression of their opinions in the evaluation and it met its avowed goal of choosing a final pair of contractors by the beginning of 1967. In this difficult task, the FAA benefited considerably from the prior Air Force development program and procurement experience of its current administrator, Gen. William F. McKee, and Brig. Gen. Jewell C. "Bill" Maxwell, who headed the agency's supersonic transport program office. Bill Maxwell earned the respect of the design competitors and the customer airlines for the manner in which he directed this crucial program phase, combining firm technical integrity with flexibility and reasonable accommodation to a wide variety of conflicting interests. Special note should also be made of Mark Nichols, head of the Full-Scale Research Div. of NASA's Langley Research Center, and his group for their work in wind tunnels and theoretical analysis. They helped both airframe competitors to refine their designs and also provided an impartial validation of their technical claims.

Design Refinements

It appears there will now be a slight, but necessary, hiatus between the prototype contractor selection and the official word to start construction. First and most important is the need for the executive branch of the government to present its position on supersonic transport development to the new Congress that convenes this week. The 90th Congress contains many new faces who are not familiar with the goals or progress of this program. There is also some residue opposition from the 89th Congress that must be countered before a formal request for prototype construction funds is sent to Capitol Hill.

Boeing, which went through a major design change in its proposal last summer, is still busy refining many details of its new configuration. It can use a few extra months to complete this job before it will really be ready to cut metal on the prototype. Despite the late-hour design change, Boeing received extremely strong support from the airlines, which have been riding to new crests of prosperity with fleets of Boeing subsonic jets. Boeing's late decision to voice preference for the General Electric engine also played a key role in selecting the powerplant.

It may appear to the casual observer that the delay between contractor selection and prototype funding represents a stretchout for the program. But a closer examination of the situation does not support this thesis. The interval—and we predict it will be several months at the most—is necessary to do additional technical and legislative homework. Failure to do this work now could result in permanent damage to the program by the Congress, which must approve development funding, and by the world airlines, which are correctly demanding a superior U.S. product.

Growing Prospects

There are many critics of the supersonic transport program who will remain vociferous until the performance of this vehicle in airline service refutes their theories with facts. We would be more impressed with most of the arguments now advanced against the supersonic transport program if we had not heard most of them before—warning against the dangers of switching from piston engine to jet transports. That was just 10 years ago, when the subsonic jet transport was at about the same stage in its development cycle as the supersonic transport is today.

Looking back over the four years since the U.S. supersonic transport program was launched, it is apparent that its prospects have grown visibly brighter with each passing year. Technology has progressed much farther and faster than seemed possible at the program's inception. In that same interval the air transport business has experienced the greatest expansion of any business in world history, creating an economic climate for the supersonic transport market far bigger than anybody originally imagined.

The U.S. supersonic transport will prove to be an important element in the future of this country's domestic economy. It will also play a vital role in alleviating the international balance of payments problem. It should be pushed firmly now at the fastest technically feasible pace to realize the full potential that it offers for this nation.

—Robert Hotz
Will the First "A" in NASA Be Given the Go-Signal?

Possible loss of U.S. preeminence in aviation is causing a new look at NASA's aeronautical programs.

by C. V. GLINES
Associate Editor

IT IS NO government secret that the National Aeronautics and Space Administration, preoccupied with putting men on the moon, had neglected the first "A" in NASA in favor of the "M". But the wind may change. Pressures generated by the airways crisis of last year, an ever-growing divergence between civilian and military aeronautical R&D requirements and applications and concern for loss of U.S. preeminence in aeronautics are demanding that attention be given to national aeronautical research and development policies.

As a result, it was announced recently that the Nixon Administration has set a study timetable for a long-range NASA/DOT program for civil aeronautics R&D, which is scheduled for completion by Sept. 30, 1970. The results will undoubtedly affect the make-up of the NASA and DOT/FAA budgets in FY 1972.

While the study proceeds, quiet gains are being made in the aeronautics side of the NASA house. The NASA aircraft technology budget will increase from $94.9 million in FY 1969 to over $100 million this fiscal year. The budget should increase further next year and reach a new high in FY 1972 when the long-range study gives new directions for aeronautical research.

The responsibility for aeronautical research resides in NASA's Office of Advanced Research and Technology (OART) under the aegis of Charles W. Harper, Deputy Associate Administrator for Aeronautics. The overall program conducted by OART accounts for approximately 10 per cent of NASA's budget, a third of all NASA personnel and more than 3,500 separate advanced research tasks that cover the spectrum from atomic physics to structural dynamics. The Aeronautics Division, the only organizational element in NASA responsible for aeronautical research, concerns itself chiefly with the advancement of subsonic, supersonic and hypersonic flight as well as flight safety, jet noise, sonic boom, cockpit instrumentation, aircraft handling qualities and operating environment.

"Our job at the headquarters level is to prevent duplication of effort among the NASA research centers," Harper told AFM, "and identify research areas that need amplification or define new areas that have appeared."

But NASA's management concern for aeronautics goes deeper than this.

"There is a need for assessment of our national transportation goals," Harper says. "The whole spectrum of air transportation doesn't seem to be developing its full potential. The basic question is: What role should Govern-
ment play in sponsoring research and development in air transportation?

"As civil aviation problems mount, more people are asking for the answers that the National Advisory Committee for Aeronautics (NACA), NASA's predecessor organization, used to provide. The public wants safer and quieter aircraft. They want to fly faster, over longer distances, at lower cost without delay. They want to move quickly over short distances and escape from the frustrations of ground congestion. As military development programs run into trouble, DOD and the military contractors are pointing out that NASA's aeronautics R&D is not providing the technical base that NACA used to provide."

It is on Harper's shoulders that the responsibility falls for providing an aeronautical technical base within NASA's capability and budget. Faced with the need to modernize obsolete research facilities and outdated analytical methods on one hand and a tightened national budget on the other, Harper's task is not an easy one. "We find that old materials and old methods will not meet future requirements," he said. "It is no longer feasible to design an airplane and then go shop for an engine. Airplanes and engines must be developed together. Regardless of the advances that have been made, aeronautical research is primitive now compared to what it should be and could be if national priorities would allow it to progress."

NASA officials freely admit that much aeronautical research was pushed aside while the race to the moon was in full swing. "What has suffered is looking at new things," Albert J. Evans, Director of NASA's Aeronautical Division of OART says. "We are not taking an advanced look at the future as we should, but there are enough external pressures developing now so that aeronautics will soon be getting the attention it deserves."

Evans cites a number of research areas which have been neglected: "V/STOL possibilities must be exploited. We should not only be concerned with the vehicles, but must look at the environment into which they fit, such as the airports, traffic control and economic needs to be served.

"While subsonic jets are certainly here to stay, much work needs to be done to make them more efficient and less difficult to fly. Ironically, the satisfaction of speed demands has caused problems which have not been solved satisfactorily, such as cockpit instrumentation, the ability of air traffic controllers to handle large numbers of planes converging on one airport, and 'flyability' problems, such as buffet control.

"The supersonic area presents problems in noise and sonic booms which must be studied. Since the supersonic transport is definitely coming, the first one to fly is sure to present new problems we don't even know about yet."

"And hypersonic flight, an area which is still mysterious, but within our grasp, needs much research attention. We must get down to fundamentals here because for too long the basics have been pushed aside. We must know more about the mechanics of hypersonic flight and fluid dynamics in this speed realm."

Solving Aeronautical Problems

Solving specific aeronautical problems is a function of five NASA research centers. Most, but by no means all, of NASA's aeronautical testing is accomplished at the Langley Research Center, Hampton, Va., its oldest field establishment. Established in 1917 as the major test facility of the National Advisory Committee for Aeronautics, it was named for aeronautical pioneer Samuel Pierpont Langley, first to build and fly a powered model aircraft.

Ever since its beginning, the Langley Center has made significant contributions to flight. Airplanes of World War I vintage wore the earliest flight research vehicles; ground facilities included highly specialized wind tunnels developed to simulate the many structural stresses encountered in actual flight.

As aviation technology progressed, the demand for speed eventually brought aeronautics to the threshold of supersonic flight. A joint NASA-Air Force program to build and fly airplanes specifically intended to produce high speed, high altitude research information was begun after World War II. The first of these—the Bell X-1—initially accomplished supersonic flight in 1947. The North American X-15 which NASA terms "the most successful research aircraft ever built," has been retired after reaching a peak altitude of 354,200 feet (67 miles) and a top speed of 4,520 mph (6.7 mach).

The passing of the X-15 from the skies is another reason why there is growing concern in aviation circles that the U.S. is falling behind in aeronautical research. It was the X-series of research planes that had led to the supersonic fighters in today's military inventory and laid the groundwork for the aircraft of tomorrow such as the F-14, F-15, B-1A and the SST. However, there is no replacement on the horizon for the X-15 and for the first time since World War II, the U.S. does not have an advanced research craft leading the way for future aircraft development. This has been due, according to John V. Becker, chief of Langley's Aero-Physics Division, to "NASA's almost total involvement with space while military agencies were unable to prove the cost effectiveness of such a research effort."

Today, there is an atmosphere of quiet urgency at Langley. About one-third of its scientists now concentrate on aerodynamic performance and associated problems of noise control, safety, approach and landing instruments and runway surfaces. The others are involved in space, solid propulsion, polymer chemistry and computer research, although the shifting of emphasis is causing some to be transferred to aeronautical problems that are now more pressing.

Perhaps the best known aerodynamicist at the Langley facility is Dr. Richard T. Whitcomb, Chief of the 8-Foot Tunnels Branch, whose most recent achievement was the development of a radically new wing that will allow subsonic jet aircraft to fly faster and more efficiently. The new wing, designated the "NASA supercritical..."
wing.” will be flown a year from now on a modified Navy F-8 jet fighter.

The 48-year-old Whitcomb had achieved fame a decade and a half ago through his development of the “Coke bottle” fuselage design which made it possible for 800 mph jets to reach 1,000 mph without an increase in power. Whitcomb was honored for this design breakthrough, which was acclaimed at the time as the most significant aerodynamic advance in flight since the X-1 broke the sound barrier in 1947.

Whitcomb, ahead of his time, reasoned that no matter how fast an airplane could go, supersonic or hypersonic, it still had to do a lot of subsonic flying. Military aircraft, even though capable of flight several times the speed of sound, spend 90 per cent or more of their flight time in the subsonic realm. The Supersonic Transport (SST), which the Nixon Administration is currently pushing for funding by Congress, will fly supersonic only over unpopulated areas because of the sonic booms striking the earth’s surface. Thus, even though aircraft can be built supersonic flight, most air time will be spent below Mach 1.

“I went backward in my research interests, in terms of speed,” Whitcomb told AFM, “because I saw too many unsolved problems in the subsonic regime where aircraft will be flying most of the time. Subsonic aircraft had serious buffeting problems when they got beyond the 0.8 mach number which I thought should be investigated. Nobody else in this country seemed to be worrying about them so I thought I’d see what I could do.”

Investigate them, Whitcomb did. Noting that the source of the buffeting was the turbulence over the top of an aircraft wing, Whitcomb and his research team concentrated on the flow of air over a wing’s upper surface. Experimenting with various wing shapes, Whitcomb finally hit on the solution: increase the curvature of a wing near the underside of the trailing edge and flatten the upper portion of the wing slightly. Wind tunnel tests revealed that lift was not affected but drag was reduced as much as 25 percent.

“What this means in terms of aircraft operation,” Whitcomb said, “is that a transport airplane with a supercritical wing can safely fly in excess of 0.95 Mach—an increase of more than 20 percent over its present permitted speed. As a result, the new wing will significantly reduce operation costs. Since an airplane could cruise faster on the same amount of fuel, its range could be increased or it could carry less fuel and more payload.”

The significance of Whitcomb’s discovery is not lost on the military. Although the costs of putting modified wings on aircraft already flying would probably be prohibitive, the next generation of transports, bombers and fighters will no doubt take advantage of this new breakthrough. Whitcomb believes the B-1 (formerly AMSA) would be “ideal” for such a wing since, although designed to go supersonic, it will still fly most of its mission subsonically. However, he thinks the mission of the F-15 as an air superiority fighter might preclude its use on that aircraft. Tests are planned for the F-14 configuration and a cargo model will soon be tested in Whitcomb’s wind tunnel. His discovery will also contribute significantly to propeller, rotor and jet compressor blade design.

Another Langley program, which actually started in the early Fifties, is V/STOL research centering on the several concepts in vogue: propeller-powered and fan-powered configurations and turbojets. Of these, the turboprop tilt-wing will now receive new impetus since the Air Force has zeroed in on the tilt-wing as the way to go for the Light Intratheater Transport (LIT). A vertical wind tunnel, first of its kind, is under construction at Langley and will be used to test this and other configurations under consideration when completed early next spring.

Research in acoustics is also receiving much attention as noise pollution becomes a national issue. Recognizing that noise levels are fast approaching the human discomfort level where action must be taken to prevent the nation from becoming slowly deafened, much research is going on in collaboration with the Department of Transportation to stop the escalation of noise caused by aircraft operations. Quieter engines are slowly evolving through NASA’s experiments with acoustic absorptive linings along engine nacelles. In addition, noise reduction research is being conducted with landing approaches to determine the capability of transport aircraft to operate safely on steeper-than-normal landing approaches.

So, at Langley and throughout the NASA organization, the space program seems to be going into a sort of fast idle while aeronautical problems beg for much needed attention. Now that man’s footprints are on the moon, it is time to answer serious questions of near-earth flight which have, ironically, been posed by the leaps ahead that prior research has permitted. NASA’s aeronautical scientists, who have been standing by so patiently for so long, look for the green light now. The signal is long overdue.

The Langley Research Center (above) is co-located with Langley AFB near Hampton, Va. Established in 1917, it is the oldest NASA field facility.
Tooling Begins On LRC's Test Wing

Tooling for a test version of Langley Research Center's supercritical wing has started in the Los Angeles plant of North American Rockwell.

Gordon Sundlee, program manager for his firm's $1.8 million construction contract, today said detailed drawings have been released to manufacturing departments.

Fabrication of assembly jigs is underway for the wings which will be flight tested on a Crusader jet loaned to the National Aeronautics and Space Administration by the Navy.

Plaster masters required for some tooling jigs are now being formed, as are masters for the glass fiber fairings which will fit the experimental wing to the F8 aircraft.

Developed at Langley Research Center by Dr. Richard T. Whitcomb, the supercritical wing uses an airfoil about opposite those now in service.

The rounded bottom and flat top of the transonic airfoil is expected to reduce drag and buffering, and thus provide more efficient flight at speeds just below the speed of sound.

Initially viewed for airline operation, the supercritical wing is expected to be about 25 per cent more efficient than the conventional airfoil.

Tests in Langley wind tunnels have indicated commercial aircraft using the new concept could add about 100 miles per hour to the normal cruise of 530 mph without increasing power. Alternatively, the wing could increase payload by 20 per cent or range by 18 per cent.

North American Rockwell received a construction contract for the full scale wing last Sept. 8.

The company expects to begin fabrication of the wing next spring, in time for the Crusader to meet operational schedules in California's Antelope Valley next fall.

Tests by the Flight Research Center in Edwards are aimed at evaluating operational potentials, validating design and indicating areas for added research, demonstrating performance in the transonic speed area, evaluating flight performance in maneuvering and determining sensitivity to the design to changes in contour associated with manufacturing and flight processes.

N.N. "Times HERALD"
NOV. 25, 1969
NASA Finds Use For Navy's Crusader

The Navy's fleet of Vought F-8 Crusader fighters has passed the equivalent of 200 years' flight time.

The Crusader, now in its 13th year as one of the Navy's primary air-to-air combat fighters, has amassed more than 1.9 million hours in the air with Navy and Marine Corps pilots.

Since 1953, when the F-8 left the drawing boards with its revolutionary two-position wing design, the sleek, single-seat, single-engine fighter has established its place in aviation history.

The F-8 was the aircraft that boosted U. S. Naval aviation from subsonic range to supersonic speeds. It was the first aircraft to set a Thompson Trophy speed record of more than 1,000 m.p.h.

F-8s are built by the LTV Aerospace Corporation's Vought Aeronautics Division.

Nearly 1,300 Crusaders in 12 versions have served on U. S. aircraft carriers around the world. Another version is serving aboard two carriers with the French Navy.

In 1957, a Marine major named John Glenn — later to become the first American astronaut to orbit the earth — made the first supersonic transcontinental flight, flying an F-8U-1P Crusader from Los Angeles to New York. He did it in three hours, 23 minutes and averaged 725.55 mph.

Crusaders so far have shot down 17 Soviet-built MIGs in air-to-air battle over North Vietnam — a Navy record for a single type of aircraft.

During the 1962 Cuban crisis, one Crusader helped ferret out its cameras the Communist missile bases.

In Vietnam since the earliest days of U. S. involvement, Vought F-8s have performed as day fighters, attack, all-weather and photo reconnaissance aircraft.

Engineers at Vought designed the Crusader to keep pace with the future. They did the job so well that succeeding models were easily modified to incorporate the latest weapons, avionics and other modernizations.

Because of that design for the future, Crusader service life has been extended at least through 1975 through remanufacture at Vought.

Although the F-8 is a fighter it can serve the infantryman. The F-8's potential armament includes either twelve 250-pound bombs, eight 500-pound bombs, four 1,000-pound bombs or two 2,000-pounders.

The F-8 can carry 24 "Zuni" five-inch air-to-ground rockets plus four "Sidewinder" air-to-air missiles. Four 20mm cannon are mounted inside the fuselage.

The swept-wing, "near Mach-2" fighter is getting an even newer role supporting the design of future aircraft. An F-8 is being used by the National Aeronautics and Space Administration (NASA) to test a wing design concept that promises to boost future aircraft cruising speeds (military and commercial) by 1 per cent.

NASA is using the Crusade to test the "supercritical wing" designed to reduce 'aerodynamic buffet and drag on an aircraft as it approaches the supersonic speed.

This is RF-8A Crusader, flown in 1957 by Marine Maj. John H. Glenn, in the first supersonic transcontinental flight.
Modern Wing Test Begins Next Year

By BILL DELANY

Dick Whitcomb's supercritical wing will be flown in a long range version next year on a Navy T-2C jet trainer. Navy officials said contract negotiations are expected to be concluded by the end of the year. Delivery of the modified twin-jet trainer is scheduled for July.

"The program is a little vague at present," the Navy official said. "As a matter of fact, the contract hasn't even been written." Initial negotiations are between the Navy and the National Aeronautics and Space critical airfoil was developed at the Langley Research Center and NASA will contribute funds for the test. Contractor negotiations are expected to involve North American Rockwell, which built the tandem seat trainer in the firm's Columbus Division.

The company already is tooling up for production of an airliner styled supercritical wing to be mounted on a F8 Crusader jet. North American Rockwell received a $1.3 million order for the Crusader wing last September.

The F-8 program is aimed at commercial applications through extension of cruise speed to just below the speed of sound without requiring additional power.

The new T-2 project is viewed at testing the range extending potential of the airfoil developed by Dr. Richard Whitcomb. The airfoil resembles a conventional cross-section mounted upside down. This places a flat surface on top in lieu of the normal curve which generates the lift-giving vacuum. The change is seen as a way of delaying buffet and turbulence in a more efficient air flow.

Wind tunnel testing over a four year period indicates the change has a potential for increasing speed by 25 per cent, range by 18 per cent or payload by 20 per cent. Speed is a major goal of designers working on commercial transports. For this reason, the Crusader wing was designed close to the form followed new airliners. This includes both sweep, angling back at 42 degrees, and thickness, which averages about 10 per cent. Normally aircraft average about 12 per cent in thickness ratio derived from dividing width of the wing into its thickness.

Buckeye tests which include Navy participation are targeted on range experiments which provide a somewhat different design. Long range aircraft normally have a fairly thick wing with a ratio of about 17 per cent. Among other advantages, this thick wing provides additional internal space for fuel tanks.

The thick wing also permits light weight, potentially greater span and high lift at the land-takeoff speeds.

New contour for the Buckeye supercritical wing currently envisions encasing the existing structure with a layer of fiberglass. This would simplify production and permit use of such aircraft systems as landing gear.

It was this latter point that dictated use of the Crusader in constructing the transport versions of the supercritical wing.

The shoulder-high wing design of the F8 kept landing gear in the fuselage. This permits the aircraft to operate without change in this complex assembly of mechanical joints and hydraulic valves—and did not require space for wheel wells.
Ultimate wing for subsonic jets may be major breakthrough

A daring new wing shape, first proposed last year and now entering the prototype stage, promises to boost performance of jet aircraft that still fly at subsonic speeds. The new wing, invented by Dr. Richard T. Whitcomb, a staff scientist at NASA's Langley Research Center, Hampton, Va., has a flattened upper curve to reduce the tendency for the air flow to break away as it approaches Mach 1. However, because this step would cause a loss of lift, Dr. Whitcomb designed a large concave curve on the aft bottom edge of the wing. The new wing is being built by North American Rockwell Corp.

Conventional wing shapes have a pretty good convex curve on the upper surface and a lesser one on the lower surface. But it is a surprising incongruity in today's technology-oriented aerospace society—where optimum performance and cost effectiveness are key design goals—that current jetliners still fly at only 80% of their potential capability. Most planes in the 707 and DC-8 class cruise at Mach 0.8, or about 530 mph at an altitude of 35,000 ft.

Performance problem not new. The principal reason for this "restrained" performance is an aerodynamic phenomenon that occurs on the wings of aircraft as they approach the Mach 1 region. Air flows over the upper wing surfaces faster than it does over the lower surfaces, which produces the lift that results in flight. But the air flow over the upper wing surfaces also goes supersonic before the rest of the plane, creating shock-wave patterns on the top of the wing.

The change in pressure caused by the shock pattern results in a sharp increase in drag and sometimes severe buffeting. The speed at which this occurs is called the drag-divergence Mach number. Drag increases so quickly above this Mach number that it becomes inefficient to fly at the higher speeds. For instance, it might require 50% more power to push the jetliner 10% faster. Also, since the air flow is disturbed in this velocity range, the smoothness of the flight is affected.

Since the advent of commercial jet aviation more than a decade ago, this problem has been accepted and lived with, although there have been some improvements. The most widely used methods of delaying the rise of the drag force and the onset of the buffeting have been to sweep the wings backward or to reduce the wing thickness. Both approaches, however, increase structural weight and create additional problems related to low-speed flying. Longer takeoff and landing distances are also required.

Solution may be breakthrough. Dr. Whitcomb's solution is a more satisfactory, non-compromising one. The work being done on his "super-critical" or "ultimate" wing at North American's Los Angeles Div. will culminate in a series of in-the-air tests at NASA's Edwards Flight Research Center in the Mojave Desert later this year. This may lead to a major aviation breakthrough—one that will allow subsonic aircraft to burst the Mach 0.8 barrier and to increase their cruise-speed capabilities by 10% or to cruise at the same speed with a thicker wing. A thicker wing would reduce structural weight, allowing higher payloads.

Dr. Whitcomb has been working on the project for five years. When his colleagues first learned he was doing subsonic flight research in a supersonic era, they chided him: "Don't you believe in progress?"

"What isn't realized," he replies, "is that even when the SST is in operation, 80% or more of the people traveling by air will still fly in subsonic planes."

Two applications. There are two types of wing being constructed using the new concept: one for an F-8 Crusader, and one for a T-2C airplane. These wings are not to go on these planes on a production basis," says Dr. Whitcomb. "The planes are to be test-beds for the wings. A larger version of the F-8 wing will be used on transport planes, and a larger version of the T-2C wing will be..."
used on Navy search or attack planes and perhaps on V-STOL aircraft.”

“The main difference between the two wings,” Dr. Whitcomb explains, “is that the one for the T-2C is thicker. Here we are not trying for speed but depth of wing structure; if you can make the wing structure deeper, you can make it lighter.”

History-maker repeats. Dr. Whitcomb is recognized as a leading aeronautical engineer. It was his wasp-waist, “area-rule” fuselage configuration—designed 16 years ago—that reduced wave drag on high-speed aircraft such as the F-102 and the B-58, enabling them to pass through Mach 1 with more ease.

This was considered the greatest single advance in aviation since the birth of jet engines. Experts now say the ultimate inventive stride since the area-rule fuselage. Flight tests are designed to prove the wind-tunnel data, which shows that by using an ultimate wing, it will be possible to cruise at more than Mach 0.95—about 630 mph at 35,000 ft—before any adverse aerodynamic effects occur.

The gains in performance can be directed either toward increased cruise speed, or increased wing thickness, or both. A thicker wing can carry significantly more fuel without external wing tanks, and therefore to increase its range. Furthermore, with a thicker wing box, the basic structure can be more efficient and weigh less for a given stiffness. As with I-beams, a wing’s bending moment of inertia increases with the cube of the wing thickness so that the amount of weight saved can be sizable. [3.26; 1.262]

**Failsafe computerized switch guides new mass-transit system**

A key to the success of tests on Pittsburgh’s new mass-transit system is a switch that handles the routing of the rubber-tired bus-like vehicles (PE-June 22’70, p14). Designed by the Transportation Div. of Westinghouse Electric Corp., the switch uses commercially available components that have been proven in hundreds of hours of service.

At a press demonstration last month, a vehicle on the Westinghouse system rounded a 150-ft, 10% grade curve and entered the switch at the design speed of 17 mph. Raymond Snyder, Westinghouse project manager at South Park (demonstration facility for the Port Authority of Allegheny County), says “the simplicity of the design permitted rapid assembly, and it offers high reliability regardless of weather.”

The switch is heated, and it will operate at temperatures in the full range from -30 F to 120 F.

**Switching the program.** In operation, a 5-hp motor drives a gear-and-pinion assembly attached to the guide beams. Solenoid-activated pins within the switch align the guide beams for either straight-through or branch operation. If the pins are not located correctly, system power will not flow, and the train will stop.

In addition, the switch is failsafe. If for any reason the vehicle enters a partially opened switch, the car’s leading guide wheels will become wedged in the natural “V” created by the guide beams, and the rear guide wheels will remain locked on the guide beams. This keeps the car from moving forward and, more important, keeps it firmly on its concrete roadbed.

“The wedging action is a highly important safeguard,” says Ralph Mason, project engineer at Westinghouse, “because the vehicles operate by computer control and without an operator. We had to design a foolproof system or people just wouldn’t ride it.”

About 250,000 people have already ridden on the demonstration line. “They think of it as a horizontal elevator,” says Snyder, “and nearly everyone has been in a self-service elevator.”

**Fast reaction time.** The Port Authority of Allegheny County, sponsor of the system, plans to build and operate an 11-mile, 10-station line from South Hills Village to downtown Pittsburgh. The system is called the Transit Expressway Revenue Line (TERL), and it is part of an overall concept for moving people rapidly in and out of Pittsburgh by public transportation on specially designed roadways. Follow-
Man's first view of the rising earth, as seen by the Apollo-8 astronauts as they came from behind the moon after their lunar orbit insertion burn during the December mission. On the earth, 240,000 miles away, the sunset terminator bisects Africa.
In Prospect: The 'Supercritical' Wing

Today, the aircraft industry is on the verge of taking another giant step in designing advanced aircraft, with the opportunity to incorporate a new type of wing that holds great promise to both military and civil aircraft. Particularly relevant, then, is the almost unanimous opinion in the aeronautical engineering community that the heavy dependence on analytical techniques in aircraft design must be backed up by a strong program of evaluation...

There's No Substitute for Flight-Testing

By J. S. Butz, Jr.
TECHNICAL EDITOR, AIR FORCE/SPACE DIGEST

NASA is requesting funds, in its FY 1970 budget, for construction of a new experimental aircraft, shown here in artist's conception. It will have an F-101 fuselage and will test a version of the "supercritical" wing devised by NASA's Richard Whitcomb. Some aeronauts believe the new aircraft will have a greater impact than did Whitcomb's area rule fifteen years ago.
I. VARIABLE-SWEEP AIRCRAFT

The variable-sweep wing has been involved in great controversy since it reached a usable state some ten years ago. Such a wing is on the F-111, and was selected winner on the Boeing SST entry the company later dropped. Reportedly, this wing will not be on USAF's new F-15 (FX), because a fixed wing can be superior for the single-design-point, high-altitude, air-superiority mission. A bright future is predicted for the concept, however, by most US designers who believe much progress can be made in the next decade. They want to step up flight-testing. France has the model low-cost program in the Mirage IIIG, which cost less than $25 million for design, modification of an existing fighter, and dozens of flights. The Sukhoi appears to be a similar project, but the Mikoyan is a completely new design with good operational potential. (PLANFORM DRAWINGS BY ROBERT L. FINES)

A supersonic airplane designer could get the ear of Richard M. Nixon today, there is little doubt about what he would tell the new President. Most important, he would report that there has been far too much analysis and not enough experimental flying in the past decade. The US is following a most unscientific procedure in an effort to save money—that is, relying primarily on theory to produce engineering data without checking it properly by experiment.

Mathematical techniques for conducting the most complex phases of aircraft design have become extremely sophisticated and will become far more powerful in the future, but it is impossible to escape the fact that they are essentially an improved tool of the theorist. Flight experiments still must be used to show where theory is in error, to give the designer some clue to his mistakes as he heads back to his computer. Nearl all of the dozens of US jet aircraft projects over the past war years attest to the validity of this view. The B-47, for example, pushed the technology of the late 1940s near the breaking point and had to be mainly designed to move within original price and schedule estimates, primarily because it rode in on a sturdy technical base of B-17 experience plus a major prototype flight-test program. The most recent case in point is the F-111 multi-purpose airplane. The heavy cost overruns on this program could have been reduced to a substantial degree if production had been delayed until a prototype airplane, or an experimental aircraft of similar layout, had been thoroughly tested. At least this is the majority opinion in the industry.

Designing the F-111 must be recognized as a difficult problem because the aircraft has completely new features, notably the variable-sweep wing. Its over-all mission requirements are also more severe than for any previous aircraft so that all components, including this wing, must operate at very high efficiencies. In spite of this unusually heavy load of design problems, the powers that were in the Department of Defense in the early 1960s believed that analytical techniques could be used to resolve them quickly without a strong backup of experimental flying. Consequently, their plan called for a rapid commitment of the F-111 to production. They were asking for trouble—and the military and General Dynamics got it.

Most observers experienced in aircraft development disapproved thoroughly. They contended that a large number of major changes were inevitable before such an advanced design could be ironed out, and that program costs inevitably would go well above the estimates if these changes had to be made along an entire production line rather than in a few prototype airplanes.

At any rate, the aeronautical engineering community (Continued on page 39)
Most supersonic airplanes built to date have had conventional tails. This group is far larger than the other major categories: tailless deltas, canards, and variable-sweep configurations. In most instances the aircraft with conventional tails are more maneuverable, and have more reserves of control power for landing and takeoff and for off-design situations such as engine failure at high speed. Boeing made a conservative decision when it chose to develop its variable-sweep SST and go ahead with the configuration at upper left. This wing is a compromise between subsonic and supersonic requirements that has respectable, but not top, performance in either speed range. Control problems with this design will be relatively minor. The major task will be designing an extremely light structure, which is needed on all SSTs. These airplanes have high fineness ratios and are about twice as long in comparison to their diameter as any transport or fighter now in service. In addition, they are designed for low allowable loads, only about 2.0 Gs as in ordinary transport practice (compared to about 8.0 Gs for fighters). This long, lightly loaded structure gives SSTs the most severe bending problems of any high-speed airplanes. Every pound added to the structure and control the bending decreases from the over-all efficiency and eats into range and payload. Soviet supersonic research and design has paralleled that of the United States to a surprising extent. The modified arrow wings, on Tupolev's Blinder and Fiddler (opposite page) are almost identical to a family of wings developed at the Langley Research Center in 1956. It isn't possible to say that the Russians copied us because the detailed information on these wings was not released until 1960, and the Blinder and Fiddler appeared in sizable numbers at a Moscow air show in 1961. The basic idea of the arrow wing has been a secret, with aerodynamicists in Europe and the United States discussing its advantages for years. The disturbing aspect is that the Russians had the technical skill and worked hard enough during the mid-1950s to develop these two aircraft, which give every indication of being first class. In terms of range, they could outclass the B-58 substantially, for their type of arrow wing has about a thirty percent better aerodynamic efficiency at both subsonic and supersonic speeds than the delta shape on the B-58, which is about four years older. If the engines and the other aspects of the design are equal, the Russians could have a range edge. Yakovlev's Firebar is the latest model in a large family of aircraft that first appeared more than fifteen years ago with the supersonic YAK-25 Flashlight. NATO sources regard the Firebar as an excellent multipurpose supersonic aircraft. If this is true, then it provides evidence that the Soviets can combine every trick to boost performance, including the area rule, wing fences, leading-edge extensions, camber, twist, kinks, and cut-outs. Best evidence of such skill in the US is the F-4, which has most of these features plus a drooping tail. The F-3H and F-101, beside the F-4 at lower left, illustrate the tendency of most companies to improve on their old designs. Mikoyan's MIG-23 is more of a departure from the MIG-21 that preceded it. However, the MIG-23 is believed to be nearly 1,000 mph faster than the -21, with a top speed above Mach 3. The British Aircraft Corporation Lightning has a good record, but no other aircraft to date has used its unusual configuration. The North American Rockwell A-5 is an area-ruled airplane with no volume penalty due to the "Coke-bottle" shape.
As the situation stands now, the Nixon Administration's position on high-speed aircraft development will become clear at an early date. No one will be kept in suspense very long, for the new government has inherited the longest list of question marks in supersonic aerodynamics since Capt. Charles E. Yeager first flew faster than Mach 1, on October 14, 1947.

The opportunity for performance improvement appears as bright as at any time in the past, and there is good reason to believe that the supersonic airplanes of the 1970s will completely outclass those operational today. But no one can establish just what the potential is without extensive experimental flying.

The Next Generation of Fighters

Most pressing high-speed problem for the military is a new generation of fighters—the Air Force's F-15 (called the FX until recently) and the Navy's F-14 (VFX). These aircraft aren't intended to set speed records, as they probably won't top Mach 3, but they are aimed at revolutionary performance improvements as important as supersonic flight itself. The chief goal is to achieve a completely new order of maneuverability at supersonic speeds, which will make all current fighters obsolete insofar as air-to-air combat is concerned.

Outstanding new engines will be available for the F-14 and F-15 because government and industry have cooperated closely in a strong analytical program backed by extensive testing of experimental engines. These powerplants will have approximately twice the thrust-to-weight ratio of any engines now in service, and they alone are enough to guarantee an outstanding new fighter.

Improvements in aerodynamic design of the airframe are not as much a known quantity as the powerplant, but they could easily be a bigger factor. A steady stream of new ideas is being generated in government and industry theoretical studies and small-scale experiments. Flight verification is the missing link.

The aerodynamic tinkering even extends to the basic airfoil, which apparently has an almost unlimited potential for delivering less drag and more lift. Systematic development of airfoils was begun in the early 1930s by the National Advisory Committee for Aeronautics (predecessor organization of today's NASA), and the work still isn't finished.

Richard T. Whitcomb, originator of the area rule for reducing airplane drag at transonic and supersonic speeds, the so-called "Coke-bottle" configuration, is the latest NASA scientist to try his hand and the results appear somewhat staggering. Whitcomb has devised a family of "supercritical" airfoils that theoretically will allow a transport airplane to cruise very eco-

(Continued on following page)
flight at high altitudes. That is, a fighter with a “supercritical” wing should be able to make much tighter turns at supersonic speeds and high altitudes than any of today's aircraft. Apparently it has the potential to extend a fighter's buffet limit and maneuvering altitude to the point that such an aircraft would be unbeatable in the high-altitude air-superiority role. This is the mission of the F-15, which has been described by Air Force leaders as a single-design-point airplane with the capacity to sweep the skies clear of all enemy aircraft during the 1970s.

Technical details of Whitcomb's airfoils have not been made public, but they are a substantial departure from conventional shapes, and some aerodynamicists working with them call them “weird.” In simplest terms, their shape produces a pressure field, which prevents the separation of airflow from the top of the wing that is induced by the shock wave that forms as an aircraft nears Mach 1. This separation of flow from the wing is the cause of high drag. It is also a cause of buffetting, which shakes a fighter aircraft fiercely when its wing nears the limit of its lifting capacity during maneuvers at high speed and high altitude.

NASA's regard for Witcomb's work is evident in the space agency's new budget, which requests funds for construction of its first major research aircraft in several years (see illustration on page 36) to flight-test the supercritical wing. Industry's interest is displayed by the fact that most major companies are trying to improve on the basic idea and adapt it to practical configurations.

Configuration Integration

The other fertile avenues for aerodynamic design improvement can be lumped under the name of configuration integration. This isn’t a serious problem on subsonic airplanes because the major parts, i.e., the wing, fuselage, tail, engine inlet, and engine exhaust, don't affect each other unless one part is directly in the wake of another part.

During supersonic flight, however, a completely different situation exists since each part creates a strong pressure field that radiates outward. The interaction of the pressure fields from the various parts can seriously degrade, or substantially improve, the performance of a supersonic aircraft.

A widely publicized example of favorable interference between fields was the B-70’s “riding” of its own shock wave. In this case the large engine nacelle was placed below the wing and shaped so that it would throw a positive pressure field of maximum intensity on the lower wing surface to increase lift and raise the aircraft’s aerodynamic efficiency (lift/drag ratio) to the point that long-range flight at supersonic speeds was possible.

Since the B-70, configuration integration has become far more sophisticated. Designers have much better mathematical techniques for predicting the interaction of flow fields. Now it is recognized that the engine inlet and exhaust exit can be the biggest source of supersonic drag. More satisfactory methods are available for reducing this drag at all speeds and altitudes and in the most severe maneuvers.
III. TAILLESS DELTA AIRCRAFT

If one looks at the highlights, supersonic design can be said to be entering its fourth phase. These phases overlap in time, but each has had quite distinct objectives.

Supersonic Design History

- Phase I — Extend Top Speed. The initial step was to create operational airplanes that could make dashes to at least Mach 2. At this speed they would be completely bled in supersonic flow and would be beyond the troublesome transonic region in which subsonic and supersonic flows were mixing over the aircraft's surfaces in unpredictable fashion, causing high drag and erratic piloting qualities.

An intensive effort was made on this problem in the aircraft industry's design offices through the late 1940s and until about 1953. The Bell X-1 led the way in flight experience and provided invaluable information, but it fell far short of clearing up all the questions. A major technical battle arose regarding the most efficient wing shape for supersonic flight, and at that time there were three main contenders—the delta, swept, and straight planforms.

As it turned out, all of these wings were used on successful operational airplanes. In terms of air-superiority-type performance, the straight-wing Lockheed F-104 was the premier design of the era. It was laid down in 1951 as a result of an urgent USAF request for a fighter that could clearly outclass the Soviet fighters in Korea and the ones certain to be on the (Continued on following page)

The tailless-delta configuration has ardent supporters around the world. Its major advantages include good drag savings due to elimination of the horizontal tail, and the potential of building a very light wing that is very thin. On some SST designs the thickness ratio drops near 2% (i.e., the depth of the wing at the fuselage is only 2% of the length of the wing along the fuselage). A big disadvantage is relatively poor control effectiveness during landing and with an engine out. Problems also arise because deflection of the control surfaces on the wing trailing edge makes an input to roll as well as pitch, and it is difficult to separate the motions. On most of these designs fuel has to be pumped to new tanks during flight to maintain proper balance. These problems reportedly have been solved satisfactorily on the Concorde and the TU-144. The Soviet SST flew December 31, and a rapid test program is planned with VIP passenger service scheduled to begin early in 1970.
Canard control surfaces on the nose of airplanes have fascinated designers for decades. At one time the favored SST configurations of Lockheed, Boeing, and North American carried canards, and NASA spent much research effort on them. Despite their exceptional power as controls, they create other problems, such as disturbing airflow over the wing and aggravating the bending problems of long, flexible fuselages. The SAAB Viggen and the B-70 are the only supersonic aircraft to date in the West to carry canards. Wings on subsonic cruise airplanes (opposite page) have changed since the B-47 was designed in the late 1940s. The slender swept planform has been modified by lengthening the root chord to reduce wing thickness and allow cruise speed closer to Mach 1. The TU-154 is the first Soviet transport to use a full complement of leading and trailing edge flaps to lower landing speed. The Boeing 727 commercial transport aircraft is the third generation in this respect.

Drawing boards. The F-104 set ten world records for speed and time to climb and still is regarded as a formidable fighter over short ranges.

All aircraft of this period, including the F-104, had their problems, however. During very tight turns, for example, aircraft with highly placed horizontal tails often "pitched-up," with the nose rising uncontrollably to throw the aircraft out of the maneuver. Some supersonic airplanes experienced uncontrollable "coupling" of the controls, e.g., when the pilot would pull back on the stick to nose-up, the aircraft also would roll over. Such problems were handled primarily through electronic "black-box" automatic controls, but this sort of artificial stability usually restricts maneuverability unacceptably.

Many drag miscalculations occurred, the most serious of which involved the Convair F-102. Theory showed that the F-102 should have had respectable supersonic speed, but when the first one flew it could not even make Mach 1. NACA's Richard Whitcomb's area rule, which had previously been turned down for the design, was applied, and the aircraft met its specifications.

The area rule was immediately applied to the Convair B-58 bomber and since then has become a standard supersonic-design technique in all nations.

• Phase 2—Two-Design-Point Wings. About 1953 the military made urgent requests for supersonic aircraft with greater range, and the industry worked hard on this problem during the mid-1950s. The immediate effort was made toward improving the technique of Phase 1, cruising subsonically for long periods and dashing to supersonic speeds for brief periods of combat. This problem was formidable because it meant compromising between two widely different wing requirements. The most efficient subsonic wing has a long span (high aspect ratio) and is relatively thick, while the best supersonic wing has a short span and is very thin.

Successful wings from this period generally were modified deltas. The most efficient compromise was the so-called arrow wing, which is highly swept, has a long root section next to the fuselage, tapers down to a point at the tip, and looks like an arrowhead (see illustrations, page 39).

Most prominent US fighter of this period was (and still is) the McDonnell Douglas F-4 Phantom. In addition to excellent range and maneuverability, its stability and handling qualities are substantially better than those of the earlier series of supersonic airplanes. The F-4 set eight world records for climbing and for speed at both high and low altitudes, and its record for adaptability to many missions is unexcelled.

A more powerful means of satisfying the two-design-point requirement, the variable-sweep wing, was an
object of intensive research a decade ago. This wing can be moved through large sweep angles in flight to provide the proper span and good aerodynamic efficiency at both subsonic and supersonic speeds.

Many people contributed to the long effort to perfect this truly revolutionary wing, but today’s successful version is based primarily on research conducted during the late 1950s at NASA’s Langley Research Center by a group headed by John Stack.

- Phase 3—Supersonic Cruise. By the mid-1950s research was showing the way to very large improvements in wings that were designed primarily for supersonic speeds with little subsonic compromise. For example, the F-104 airplane had a supersonic aerodynamic efficiency, or lift-to-drag ratio, of about 4, while wind-tunnel tests were showing ways to push this over 8.

The gains came through design for favorable interference, as discussed above; the use of very large delta wings, which can be thinner than other shapes; and an improved understanding of the drag reductions possible by twisting and cambering supersonic wings.

The North American B-70 was the first supersonic cruise project to be announced. It did not enjoy the success of the Lockheed A-11, which was developed in secret as a follow-on to the U-2 reconnaissance airplane. Now designated the SR-71 (or YF-12A), this aircraft is the only one in the world known to be cruising regularly at supersonic speeds over intercontinental ranges.

The supersonic transport (SST) design competitions of the last five years in the United States are theoretical extensions of the practical experience gained from the SR-71 and to some extent from the B-70. The B-70 flew 1.8 hours at Mach 3. (Two B-70s were built. One crashed in June 1966; the other was recently retired to the Air Force Museum, Wright-Patterson AFB, Ohio.) The SST requires substantially better design efficiencies than those of the SR-71 or the B-70 if it is to meet the present specifications.

- Phase 4—Supersonic Maneuvering. A completely new order of supersonic efficiency is needed to meet the requirements of this phase, which is seeing maximum activity as McDonnell Douglas, North American Rockwell, and Fairchild compete for the F-15 contract. Last month Grumman was picked for the F-14.

To the untrained eye, the aircraft that are finally produced probably won’t look much different from today’s models, but they could represent one of the biggest steps yet in jet aviation. The potential appears that great.

The Situation Today

Today, a company’s techniques for supersonic design, and the means by which it is trying to improve these techniques, are among the most closely held proprietary secrets. By all reports, there usually are significant differences in company techniques, and interesting new ideas appear regularly.

The situation in aerodynamic design appears as fluid as in the early 1950s when every company had its own distinct ideas about supersonic flight—and in those days this meant only a short dash at supersonic speeds. Lockheed, for example, favored the straight wing of the F-104, Convair argued for the delta of the F-106, and North American stood with the F-100’s swept wing.

Making a selection in those days wasn’t a real problem for the military because the Administration gave the highest priority to supersonic development and hedged all bets by building more than a dozen supersonic aircraft. In addition, a sizable stable of research airplanes fed data into all of the projects.

Building as many separate designs in the 1970s would be as unnecessary technically as it would be impossible politically or financially. Understanding of supersonic aerodynamics certainly is advanced enough to eliminate the necessity of a scatter-shot approach in development.

On the other hand, there is little reason to expect that understanding of supersonic flight today is clear enough to allow even the most expert selection board to focus on the exact fighter design that will provide air superiority a decade ahead. A good deal of experimental flying must bolster the theory to have any hope of getting such a clear view.

"Fly before you buy" would still seem to make a lot of sense.—End
NASA Receives Supercritical Wing

First supercritical wing has been delivered to NASA's Flight Research Center, Edwards, Calif. The wing, shown above at North American Rockwell Corp.'s Los Angeles facility, has been under construction for the past year under a $1.8-million NASA contract. It was developed at Langley Research Center, Hampton, Va., to increase subsonic cruising speeds of aircraft. Main features of the wing are a rounded upper surface to slow the flow of air and a concave curve at the rear of the bottom edge to compensate for loss of lift. Preliminary wind tunnel tests indicate the wing could enable aircraft to cruise at about 660 mph at 35,000 ft. with no increase in fuel usage. The wing shown here is 43 ft. long and shaped to simulate a wing on a commercial transport. It will be instrumented and installed on an extensively modified LTV Aerospace F-8. NASA said flight testing of the wing is scheduled to start early next spring.

Replaceable Tire Tread Tested

B. F. Goodrich Co. is developing a replaceable tire tread for the Air Force's folding sidewall tire. The tread has a built-in high fatigue and high strength capability, according to the Air Force, and can be installed on an aircraft tire within minutes without the necessity of removing the tire or wheel from the aircraft.

The replaceable tread development is an outgrowth of an earlier USAF Flight Dynamics Laboratory program at Goodrich on a folding sidewall tire which is now being tested on a Convair C-131B.

Expandable tire and replaceable tread in photo below are for a Cessna O-2A aircraft main wheel and will be ready for the performance of flight tests in mid-spring 1971.

The O-2A-size expandable tire body and replaceable tread have been tested at Wright-Patterson AFB dynamometer facilities in simulated takeoffs and landings, high speed roll tests up to 200 mph and a full series of brake tests including a rejected takeoff stop.

The folding sidewall tire is designed primarily to save space in future aircraft wheel wells. The tire will be inflated for takeoff, deflated for stowage during cruise and re-inflated for landing. An aircraft could land on a deflated tire, which would react as a solid rubber tire, USAF said. It also can be partially inflated for landing on unprepared fields. The expandable tire and replaceable treads are expected to provide the Air Force sizable savings in space, money and maintenance time.

In addition to replacing worn treads quickly, replaceable treads can be used to change summer tires into winter tires with the wheels and tires still on the aircraft. The new treads will also cut down on the discard of tires in which only the treads have been cut or damaged.
The major research and technology office within NASA has been reorganized to provide increasing emphasis on improving aeronautical research and more effective support of space activities.

Aeronautical research, for example, had been centered in one division. Now there will be three offices and three divisions concerned exclusively with specific aspects of aeronautical research. Complementary support of aeronautical research will continue to be provided from other OART offices and divisions in such areas as controls, information systems, materials and structures.

On the purely aeronautics side, the new organizational units are as follows: Short Landing and Take-Off (STOL) Program Office, Advanced Technology Experimental Transport (ATET) Program Office, Lifting Body Program Office; Aeronautical Operating System Division; Aeronautical Research Division and Aeronautical Propulsion Division. (The STOL and ATET Program Offices will study the design of future short and long haul aircraft.)

New organizational units which will support technology in space or the atmosphere are: Shuttle Technologies Office; Nuclear Systems Office, Space Propulsion and Power Division; Environmental Systems and Effects Division; Guidance: Control and Information Systems Division and Materials and Structures Division.

A Research Council has been formed that will serve as a focal point for planning future research efforts. It will include as members the directors of NASA's four principal research centers: Langley, Lewis, Ames, and Flight Research Center.

ADDITIONS: Two new building additions are located on the calibration hangar (bldg. 4801) and the loads laboratory (bldg. 4820). They will be completed around December 1.

New Additions Add Needed Space

Over 12,000 square feet of new floor space will soon go into active use at the Flight Research Center. Construction of two new building additions is expected by the end of this month that will provide the needed space.

The smaller of the two is a 35 x 104 foot structure adjacent to the north east side of the calibration hangar. The added 3600 square feet of floor space will cost about 100,000 dollars.

The new room will be used to house the various people and equipment that are used to support the Jetstar, General Purpose Airborne Simulator as well as such ground based simulators as the General Aviation simulator and the control systems simulator.

Presently used hangar space will be made available to the calibrations hangar.

At the present time, over one-half of the 18,000 square feet of the High Temperature Loads Calibration Facility is being used for storage of test equipment used on the facility. This includes hydraulic jacks, vibration equipment and the test jigs themselves.

All of this storage area is seriously limiting the available test area. At the present time the entire YF-12 is being tested and the supercritical wing will be entering soon. Scheduling of these tests, because of available space, is a problem.

The new addition will add almost 9,000 square feet for the storage of these materials.
SUPERCritical WING: The supercritical wing, developed at Langley Research Center in wind tunnels under the direction of Dr. Richard T. Whitcomb, Head of 8-Foot Transonic Tunnel Branch, is shown installed on a modified F-8 airplane. The wing was delivered to Flight Research Center early last month from the North American Rockwell Corp. Tunnel tests indicate that the new airfoil shape could allow highly efficient cruise flight near the speed of sound, approximately 660 mph at a cruising altitude of 35,000 feet.
SUPERCritical Wing Arrives at Flight Center for Tests

A new aircraft wing that may permit jet transport aircraft of the future to cruise substantially faster has been delivered to NASA for future flight tests. Called the NASA supercritical wing, it arrived last week at NASA's Flight Research Center, Edwards, California.

The wing was shipped from the North American Rockwell Corporation, Los Angeles, where it has been under construction for the past year under a $1.8 million NASA contract.

The supercritical wing was developed at Langley Research Center in wind tunnels under the direction of Dr. Richard T. Whitcomb, Head of 8-Foot Tunnels Branch, High-Speed Aircraft Division.

Because the upper surface of a conventional wing is curved, air flows over the surface at a faster speed than the aircraft is traveling. This causes a negative pressure that helps create lift that enables flight.

At the cruise speed of modern day jet transport aircraft, approximately Mach 0.8 or about 530 mph at a cruising altitude of 35,000 feet, the air flowing over the upper surface eventually reaches supersonic speed. When this happens, local shock waves are generated that cause significant increases in aerodynamic drag and a resulting loss of efficiency. Severe buffeting can also occur.

In the past, the most widely used method to delay the rise in drag was to sweep the wings. However, excessive wing sweep can increase the structural weight, create low speed (Continued on page 3)

SUPERCritical Wing: A wind tunnel model shows the modified F-8 Crusader with the NASA supercritical wing installed. The supercritical wing was developed at Langley Research Center as a result of wind tunnel studies conducted by Dr. Richard T. Whitcomb. The flight program will use an F-8 jet aircraft made available to the Flight Research Center by the U.S. Navy.
SEMINAR SERIES PLANNED

The Gas Physics Section of Hypersonic Vehicles Division has been conducting a survey of research done in the field of air pollution control or abatement. The purpose of this survey has been to determine those areas and problems within the field which are important and which are amenable to analysis and solution using the capabilities as well as the experimental facilities available at the Center.

In order to facilitate this effort a seminar series of six lecturer-consultants, prominent in their fields, has been planned. The lecturer-consultants will visit the Center and during a one to two-hour lecture in the morning, will address persons actively interested in studies in the field of air pollution control. During the afternoon, the speakers will be available for more informal discussions with interested individuals.

The lectures will be held in the conference room of Building 1212 at 10 a.m. The first lecture was held Tuesday. The schedule for the remaining lectures are as follows:

November 16 - “Supersonic Transport and Pollution of the Upper Atmosphere” by Lester Machta, Air Resources Laboratory, Environmental Science Services Administration, Silver Springs, Maryland.

November 23 - “Chemistry of Air Pollution” by A. P. Altshuller, Division of Chemistry and Physics, NAPCA, Research Triangle Park, North Carolina.

January 4 - “Pollution Work at MIT” by James A. Fay, Massachusetts Institute of Technology, Cambridge.

January 12 - “General and Urban Modeling” by Arthur C. Stern, Department of Environmental Sciences and Engineering, University of North Carolina.

February 5 - “Laboratory Simulation of Atmospheric Effects” by Jack E. Cermac, Fluid Mechanics Program, Colorado State University.

It is hoped that these talks will result in a broad and balanced understanding of the state of the art of air pollution research and its relationship to the disciplines of fluid dynamics, equilibrium and non-equilibrium chemistry, radiation, convective transfer, turbulence and diffusion, and experimental and theoretical modeling techniques. It is also hoped that new directions will be pointed out regarding the application of Langley’s talents and future research efforts.

can you solve this problem?

In order to combat heart disease, the major cause of death in this country, research efforts are being devoted to understanding the heart and its associated system. It is felt that on-line, real-time volume measurements of the left ventricle (largest chamber of the heart) would provide essential information in diagnosing heart disease. A new method for measuring the volume of the left ventricle to an accuracy of ±10% is needed. Refer to TU-14. Contact the T. U. Office, extension 3281, for the problem statement or if you have a contribution.

CONGRATULATIONS

The following persons are to be congratulated for their contributions or suggestions to the Technology Utilization Office toward the solution of biomedical and public sector problems:

Felix L. Pitts, Charles E. Scott, Jag J. Singh, Charles Husson, Richard F. Mulliken, Otto F. Trout, Randall L. Harris, and John C. McFall.

TECHNOLOGY AWARD: David Smith (center), Instrument Research Division, was recently presented a $25 award for his Tech Brief 70-10298, “Hall Effect Transducer.” T. Melvin Butler, Director for Administration, is shown presenting the award while John Samos, T. U. Officer, looks on. The initial $25 award is automatically given on a published Tech Brief. It is the first step in the T. U. Awards system which leads to higher awards ($250 minimum up to $100,000) in the event of technology having great impact on industry.

SUPERCritical WING TESTS

(Continued from page 1)

flying problems, and even increase the runway length requirements for take off and landing.

On the supercritical wing, the upper surface is flattened to slow the speed of air flowing across the surface. This delays onset of the adverse shock waves until the airplane itself is traveling at a higher speed. To compensate for the resulting loss of lift from flattening the upper surface, the rear portion of the bottom edge has been shaped in the form of a concave curve.

Langley wind tunnel tests indicate that the new airfoil shape could allow highly efficient cruise flight near the speed of sound, approximately 660 mph at a cruising altitude of 35,000 feet.

If the improved efficiency measured in the wind tunnels can be achieved in flight, it should be possible for future aircraft to cruise at the higher speeds with no increase in fuel usage. This advantage could be converted into increased range and/or, by carrying less fuel, greater payload resulting in lower operating costs per mile.

The flight test wing is 43-feet long and shaped to simulate a wing intended for use on a commercial jet transport. It will be instrumented and installed on an extensively modified F-8 at Flight Research Center. Installation and ground testing will take several months and first flight is not expected until early next spring.

Prime purpose of the flight test program is to verify the wind tunnel predictions and to explore the operational potential of the supercritical wing in flight. Additional studies will determine the sensitivity of the new wing shape to contour variations associated with manufacturing processes and deformations due to loads induced in flight.

FALSE FRIENDS are like our shadow, keeping close to us when we walk in the sunshine, but leaving us the instant we cross into the shade.

- Bovee
Radical wing may undercut SST jetliner

By Eric Burgess

Staff correspondent of
The Christian Science Monitor

Edwards, Calif.

A new generation of faster passenger jets before the supersonics—that is the vision of flight-test engineers here.

They are testing a radically new wing for installation on a modified F-8 aircraft at this desert test center of the National Aeronautics and Space Administration.

The new “supercritical wing was developed by NASA’s Langley Research Center, Hampton, Virginia. If it proves as well in flight tests as it did in the wind tunnel, it may add as much as 100 miles per hour to the top speed of subsonic jet transports. That would cut half-an-hour from cross country flights.

Today’s jets carry passengers at a top air speed of about 530 miles per hour cruising at 35,000 feet. They are limited because the air flowing over the top of a curved wing must go faster than the aircraft itself to get around the curve. It is analogous to wind howling round a sharp corner.

Shock waves develop

If the air speed over the wing reaches the speed of sound, the air develops shock waves. Then it is harder to push the plane through the air, so that its efficiency falls. Like a boat plowing through rough water, more fuel is needed to travel a given distance.

And because of the roughened air flow the passengers get a rough ride; the aircraft is buffeted by severe turbulence from the self-generated waves.

An SST overcomes the problem by the brute force of going much faster than sound. Present jets travel only eight tenths of the speed of sound. Even to reach this speed, subsonic jets have to use swept back or v-shaped wings to delay the onset of the transonic forces. The sweep wing helps, but not enough. And it leads to higher structural weight of the aircraft, to control problems at low speeds, and to a need for long runways for take-off and landing.

NASA says that the new supercritical wing will allow jets to fly faster by its special shape. The top surface is not curved so much as on a normal wing, so the air flow is not speeded up across the wing so much. It is like the difference between wind blowing round a smooth curve compared with a sharp corner.
HOW TIME HAS FLOWN SINCE ORVILLE AND WILBUR

A full size replica of the Wright Brothers first powered aircraft made a successful flight in Cape Hatteras, N.C. Plane was built and flown for a TV documentary on their lives. Orville and Wilbur would have been proud to see NASA's supercritical wing, an airfoil that might significantly reduce cost of air travel, tested on a modified F8 jet fighter. The flight was made at Edwards Air Force Base.
F8-SCW First Flight Narrative

The first flight of the F8-SCW took place on March 9, 1971. Takeoff was from Lakebed Runway 15 and occurred slightly after 9:00 a.m., Pacific Standard Time. Takeoff was made using 20° flaps and military thrust. Rotation occurred at 125 knots and lift-off was at about 180 knots with a measured ground roll of about 6200 feet. Gear and flaps remained down for the climb to 10,000 feet at 220 knots, indicated. At 10,000 feet and 220 knots (M≈0.4) gear and flaps were retracted, and the speed brake was cycled. All pitch-trim changes were as expected. Stick and rudder pulses and a check on handling qualities were accomplished. The aircraft was then accelerated to 300 knots (M≈0.56) and similar handling qualities checks were made. After a deceleration to 220 knots, gear and flaps were lowered (α = 20°) and a descent to 5,000 feet was made for the first of two low approaches to Lakebed Runway 15. The first approach was made at 180 knots with 20° flap and 15° on the speedbrake on a shallow (1.5°) glideslope. On the second approach, the speed was reduced to 175 knots. During this approach, the chase plane pilot noticed a slight dutch-roll tendency, however, the F8-SCW pilot indicated it did not bother him and so he made no attempt to correct it. The final landing approach was made at 175 knots. Angle of attack during the approaches was on the order of 8° to 9°, however, once during mild turbulence an angle of 12° was experienced. Measured ground landing roll was about 12,100 feet.

The flight totaled about 50 minutes and after the flight, there were 1,200 pounds of fuel remaining of an initial 4,700 pounds. The pilot indicated the airplane performed as expected based on the simulator studies and that there were "no surprises." He indicated he felt the aircraft could be taken-off from the main runway on succeeding flights.

Thomas C. Kelly
March 17, 1971
F8-SCW Second Flight Narrative

The second flight of the F8-SCW took place on March 17, 1971. Takeoff was from the main runway and landing was on the dry Lakebed. Handling qualities checks were made at Mach numbers 0.75 and 0.85 at 25,000 feet with the augmentation system on. Wind-up turns were also made, with maximum load factors achieved being about 2.6 and 2.4 for Mach numbers 0.75 and 0.85, respectively. Corresponding lift coefficients were about 0.68 and 0.75 using an aircraft estimated weight of 23,000 pounds. Based upon discussions with both the project engineer and project pilot, it appears that no buffet was encountered during the wind-up turns although the tip accelerometer did indicate an increase in level and it was referred to as "buffet onset." Rather, the pilot said he experienced a "smooth buzz" at the higher load factors. No asymmetric conditions occurred and the effect was not classical buffet as would be experienced in a basic F8 or an F-104, for example. The "buzz" intensity did increase, however, with increasing load factor. The writer suspects what is involved is the onset and increase in trailing-edge separation which was noted in the wind-tunnel tests at angles of attack noticeably lower than those associated with pitch-up and buffet onset for this configuration. In response to a question by the writer, the pilot said the "buzz" or "ripple" would not interfere with a gun-tracking task as an example.

After the higher Mach number checks, the airplane was flown at a Mach number of 0.40 at an altitude of 10,000 feet in both the augmented and unaugmented modes. Pilot comments indicate the airplane flew nicely at low speed unaugmented and he would have no hesitancy in landing the aircraft unaugmented if the need arose. Both a dutch roll tendency and the high dihedral effect were noted but these were expected. In the unaugmented mode, the airplane appeared more highly damped than the simulator experience had indicated; however, the pilot felt this may well be involved with visual cues he had in flight which were not present during the simulation.

Thomas C. Kelly
March 24, 1971

[Signature]
FB-SCW Third Flight Narrative

The third flight of the FB-SCW took place on April 2, 1971. Takeoff was from the main runway at Edwards and the aircraft was climbed to 25,000 feet at 240 knots, indicated, then to 35,000 feet at 300 knots indicated. At 35,000, the airplane was decelerated to $M = 0.70$ ($V_i = 235$ knots) and attempts were made to excite the wing natural bending frequencies through rapid aileron and rudder pulses. This preliminary flutter evaluation resulted in essentially no response. An evaluation of the handling qualities was conducted and wind-up turns to about 1.4 g's were accomplished with the characteristic "ripple" or buzz occurring at 1.4 g's. Wings level steady sideslip at a sideslip angle of about 3° showed the expected high dihedral effect, but aileron control was adequate for performing the maneuver.

Similar checks were made for a Mach number of 0.80 at 35,000 feet with wind-up turns to 2.0 g's with a slight ripple at 2.0 g's occurring again. The airplane then was slowed to $M = 0.70$ followed by a descent to 25,000 feet and a repetition of the handling qualities checks and wind-up turns at $M = 0.70$ and $M = 0.80$. At $M = 0.70$, the ripple was noticed at 2.3 g's, the wind-up turn going to 2.4. At $M = 0.80$ the maximum load factor was 2.8 with ripple onset noticed at about 2.6.

Augmentation system off handling qualities were evaluated at $M = 0.40$ and 10,000 feet, and the pilot indicated that although the airplane "could use some improvement" he felt that it generally handled all right with the augmentation off.

Landing occurred on the main runway with a slight (6 knot) tail wind. The landing roll used 14,000 feet of the hard surface runway plus an additional 4,000 feet of the dry lake bed. Approach speed was about 175 knots. As with all landings of the FB-SCW, the extended roll-outs result from the fact that no brakes may be applied until the aircraft has decelerated to 90 knots (a limitation of the basic airplane) and the deceleration from touchdown at 170 knots to the 90 knot speed requires a considerable distance. Total flight time was about 1 hour and 4 minutes.

Thomas C. Kelly
April 6, 1971
F8-SCW Fourth Flight Narrative

The fourth flight of the F8-SCW took place on April 13, 1971. Takeoff was from the main runway at Edwards and the climb pattern to 35,000 feet was identical to that used on flight number 3. At 35,000 feet and a Mach number of 0.85, the usual handling qualities checks were made including a wind-up turn to about 1.8 g's ($C_L \approx 0.6$). At this condition, although the pilot indicated he thought he felt the characteristic ripple, ground instrumentation showed no change in tip accelerometer readings. A slight overspeed occurred during the acceleration to a Mach number of 0.90 at this altitude, the Mach number reaching 0.925, and since the aircraft was in level, steady flight at 0.925, the pilot checked control effectiveness before reducing his speed to $M = 0.90$. No ripple was experienced in a wind-up turn to 1.9 g's at this Mach number-altitude combination ($M = 0.90$, $h = 35,000$ feet). The airplane was then decelerated to $M = 0.80$, was flown with and without augmentation, and wind-up turns augmentation on, were made with flaps deflected 5° and 10° to determine flap hinge moments. The characteristic ripple occurred for flap down wind-up turns at about 1.7 g's. The airplane was then accelerated to $M = 0.90$ and a level flight deceleration to $M = 0.60$ was conducted for the airspeed system calibration. The pilot indicated the presence of a slight ripple at the low-speed point, which would correspond to a lift coefficient of about 0.68 for an estimated wing loading of 85 psf. After a descent to 10,000 feet, wind-up turns at a Mach number of 0.50 were made with flaps up and with 5° and 10° flap deflections to load factors of about 2.2. The airplane was then slowed to 165 knots at 10,000 feet with 20° of flaps and handling qualities checks were made. The pilot indicated the airplane handled well at this relatively high angle of attack condition ($\alpha = 12^\circ$). Landing was made on the dry lakebed and the flight time was 1 hour, 6 minutes.

The writer, in a discussion with the pilot, attempted to gain further information on the characteristics of the "ripple" experienced during the wind-up turns. The pilot indicated that the frequency is difficult to estimate, but analyses are underway at FRC to attempt to relate it to a known airplane frequency. Also, the pilot judges the ripple to be experienced by the whole airplane rather than, for example, being a vibration transmitted to him through the control stick.

Thomas C. Kelly
April 19, 1971
F8-SCW Narrative; Flights 6, 7, and 8

The final three flights in the first series of F8-SCW flights were made on April 29, May 24, and May 26, 1971. The fairly long interval between flights No. 6 and No. 7 was associated with the need to change engines in the airplane, the first engine having received minor foreign object damage. All flights were involved with clearing the flutter boundary and investigating the handling qualities as Mach number and altitude were increased. The attached figure summarizes the test points obtained in the first 8 flights, and shows the progression on the last three flights to an altitude of 46,000 feet and a Mach number of 0.975 and a maximum Mach number point of 1.10 at 35,000 feet. On flight No. 8, rapid stick pulses were made beginning at 42,500 feet and Mach numbers of 0.925 and 0.95. At 45,000 feet, pulses were made at Mach numbers of 0.90, 0.925, 0.935, and 0.95. At 46,000 feet pulses were made at 0.925 and 0.95 and since all indications were good, the pilot went to military power and the maximum indicated Mach number obtained at this thrust level was 0.975. It should also be noted that, with the air data probe in use on the airplane, at Mach numbers near 1.0, the true Mach number would be slightly higher than the indicated value and could be as high as 0.99. This level flight point, based upon an estimated wing loading of 85 psf, results in a lift coefficient of about 0.44 or somewhat higher than the design cruise $C_L$ of 0.40.

Having cleared the flutter boundary, the airplane descended to 35,000 feet and starting at a Mach number of 0.95, the afterburner was lit. The pilot commented the airplane "went supersonic very nicely," the acceleration taking 3 to 5 seconds and with throttling, was stabilized at an indicated Mach number of 1.10. The pilot noted that no buffeting was experienced during this acceleration. The pilot also noted a slight wing drop during the acceleration which was "easily handled." Control effectiveness was checked at this condition, the pilot noting some loss in lateral control power. After similar checks at a Mach number of 1.05, an airspeed check deceleration to $M = 0.60$ was made and the flight terminated with a landing on the lakebed.

The airplane will now be cleaned up, all instrumentation installed and connected, and the data flights should begin in approximately 6 to 8 weeks.

Thomas C. Kelly
May 27, 1971
F8 SCW Flight Envelope Expansion

Estimated 1° Pitch-Up Boundary - Cruise Config

Estimated 1° Pitch-Up Boundary - Land Config

Flight No. 33 1 (3-9-71)
34 2 (3-17-71)
35 3 (4-2-71)
36 4 (4-13-71)
37 5 (4-27-71)
38 6 (4-23-71)
39 7 (5-24-71)
40 8 (5-26-71)