INTRODUCTION: This report is submitted to obtain approval for procurement of the portion of Program Element 63205F described below and is the technical presentation in support of the contemplated procurement.

DESCRIPTION:

The effort to be accomplished under the Transonic Aircraft Technology (TACT) Advanced Development Program is to provide "proof-of-concept" of recent advances in supercritical wing technology. The "proof-of-concept" will be obtained by using a variable sweep test bed aircraft. The applicable Advanced Development Plan (ADP) was previously submitted 2 July 1970 to HQs AFSC/DL for approval. The results of the TACT program will have direct application to provide the basis or level of confidence for predicting the success of incorporating the technologies into current and future high-performance combat aircraft. The TACT program will be conducted as a joint USAF/NASA program. The NASA participation will support the USAF in the areas of wind tunnel testing, flight testing, flight test instrumentation and other related technical areas. Pre-development research has shown that the application of supercritical airfoil technology potentially offers significant aerodynamic benefits for high performance aircraft which operate in the transonic flight regime. The supercritical wing is a new airfoil which has been tailored through extensive experimental investigations to delay upper surface shock formation, minimize strength of the shock, reduce adverse effects of flow separation and provide additional lift at trailing edge for a near rectangular loading. Experimental results have shown that for a representative high performance combat aircraft the drag divergence Mach number can be increased by 20%, the lift at maximum power can be increased by 30% and buffet onset can be improved by nearly 100%. The overall technical goals are to complete the development and verify the analytical and experimental data obtained on the supercritical wing design obtained during the pre-development/feasibility phase of this program, and to provide improvement validation design data and flight experience necessary for system application.

a. This advanced development effort consists of test article engineering, development, and fabrication; ground test evaluation; and flight test evaluation of a flight set of supercritical aluminum wings on an F-111 test bed aircraft. These wings will incorporate the supercritical airfoil with an advanced planform having span and area compatible with the existing carry-through box geometry and strength. The primary structural components of the wing consist of a wing box, wing pivot fittings, leading edge and trailing edge high-lift devices, spoilers for roll control, and a wing tip. The wing box will be a six-spar arrangement with ribs at the fuel tank boundaries and at points of high load concentration. The upper and lower skins will be of one piece aluminum spliced at the wing pivot fitting. Provisions will be made along the front spar for the attachment of the fixed leading edge and Krueger flap and along the rear spar for attachment
of the fixed trailing edge, flaps, and spoilers. The closure rib at the outboard end of the box is the fuel tank boundary and will incorporate provisions for installation of a basic tip and an extended tip. Provisions will be incorporated in the wing box for two pivoting pylons per side. The pylon actuation-linkage system will be similar to that used on the F-111, with fuel sealing provisions where the linkage enters the fuel tank. The wing box will be designed to serve as an integral fuel tank. The pivot fitting will be an improved version of the current F-111 design, and will require no change to the existing aircraft carry-through structure. The high lift control system will be controlled through the current flap system. The wing sweep control, spoiler control and pylon pivoting will be the same as that of the F-111 test aircraft. The supercritical wing planform and airfoil section for the TACT wing have been evolved through approximately 1600 hours of wind tunnel tests. The technical discussion which supports selection of the F-111 as the TACT test bed aircraft is included in detail in the TACT Advanced Development Program Plan dated 2 July 1970. In conjunction with the TACT program, complementary technology studies will be conducted by the AFFDL under exploratory development, and consideration will be given to incorporating the results of these efforts in TACT follow on flight test activities.

REQUIREMENT:

a. This advanced development program is included in Development Directive No. 188-4 dated 31 July 1970, which is the latest approved technical document.

b. This program will provide the data necessary to verify supercritical airfoil technology and establish the confidence required for application of this technology to advanced combat aircraft systems. Wind tunnel results have shown that large improvements in drag divergence Mach No. and maneuvering capability can be realized through utilization of this new concept in wing design. Potential improvements will be reflected by increased cruise speed, range, and transonic and supersonic maneuvering capability for high performance military aircraft.

c. This program complements the Navy T-2C and the NASA F-8 supercritical wing flight test programs and in no way duplicates those efforts. The T-2C program objective is to demonstrate through the application of a supercritical airfoil the ability to increase wing thickness ratio from 12% to 17% with no degradation in transonic performance. The NASA F-8 program utilizes a thick airfoil high aspect ratio wing with a highly blended wing body junction specifically tailored for a transport type aircraft with primarily two dimensional airflow. The TACT program utilizes a thin airfoil with variable aspect ratio, is not restricted to one wing sweep and is specifically designed for a highly maneuverable fighter aircraft with primarily three dimensional flow.

d. Development of technologies like those to be accomplished under TACT, requires long lead times in order to demonstrate capabilities and provide adequate confidence for incorporation in new systems. Review of present and
advanced systems indicates that significant improvements in maneuvering performance while maintaining comparable or improved range performance is an extremely desirable goal. Although the proposed program schedule will not provide results to support the initial F-15 or B-1 development programs, it may be timely for application to follow on or production programs.

c. The TACT Advanced Development Program has been widely coordinated through government organizations. This coordination includes the Air Force Materials Laboratory, Aeronautical Systems Division, Tactical Air Command, Aeronautics and Astronautics Coordinating Board, key members and Chairman of the Scientific Advisory Board, and National Aeronautics and Space Administration. The NASA coordination included NASA headquarters and all participating Centers (Langley, Ames and Flight Research). The Deputy for Development Planning (ASD/XR) has been given approval to initiate contracted studies as part of the Category D planning activity to apply supercritical airfoil technology to projected aircraft weapons systems. A discussion of what other organizations are doing in demonstrating supercritical wing technology is preceded in paragraph c. of this section. This program will not duplicate any other on-going government financed efforts.

d. The technology developed by this program will have only limited commercial applications in the foreseeable future. Some additional discussion on this subject is contained in REQUIREMENT, paragraph c.

e. The quantities of aluminum, steel and other miscellaneous material to be procured will be strictly limited to whatever is necessary for the fabrication of wind tunnel models, test fixtures, tooling and one ship set of supercritical wings for the test bed aircraft.

f. The Government Furnished Equipment for this program includes a F-111E test aircraft (probably F-111E-3), manufacturing and test facilities at General Dynamics Corporation, Fort Worth, Texas, ground and flight test instrumentation, excluding that instrumentation to be installed during wing fabrication, wind tunnel facilities and some basic F-111 wind tunnel models.

BACKGROUND:

a. The tactical requirements for Air Force aircraft have altered to the point where major emphasis is now placed on carrying multiple conventional weapons for the primary mission with emphasis on the need for operating in the high-transonic speed region. Present design capability restricts aircraft operation in this region as a result of drag rise and buffet onset which occurs at relatively low Mach number. It is increasingly clear that improved maneuverability would be of value in the demanding low altitude, high speed, conventional weapon delivery assignment, as well as in the ability to engage or disengage enemy interceptors as the situation may demand. The capability for strike aircraft to operate freely without need for escort is measurably enhanced by incorporating these improvements. As a result, fewer support sorties would be required.
b. It is not considered practical to accomplish this task in-house because of the magnitude and complexity of the effort.

c. This is part of a balanced program (see paragraph c. under REQUIREMENT section) of demonstrating recent advancements in transonic aerodynamics.

(1) Supercritical airfoil research has been underway since 1964, with successive refinements in concept. The supercritical airfoil developed by Dr. R. T. Whitcomb at the NASA Langley Research Center potentially offers significant aerodynamic benefits in the transonic region. Aerodynamic efficiency is improved at the higher subsonic speeds and large gains are made in drag-divergence Mach number. Exploratory test results indicate that airplane range performance may be extended to higher cruise speeds. Penetration capability is therefore increased in this speed regime. In addition, the supercritical wing offers potential for improved transonic maneuverability.

(2) Since June of 1969, a joint USAF/NASA/General Dynamics effort has been conducted to investigate the feasibility of advancing aerodynamic technology by using the F-111 as the test vehicle. During this period wind tunnel investigations, structural laboratory tests, and analytical predictions have demonstrated that an aluminum wing can be built having good range performance, delayed drag rise, excellent buffet characteristics, improved transonic maneuverability, and increased military power speed.

(3) Related exploratory and General Dynamics/Fort Worth sponsored work has been performed and future work is planned as previously discussed in paragraph a. of the DESCRIPTION section.

(4) The results from this advanced development program offer significant potential improvements in any follow-on or production of high performance aircraft systems currently under development as well as providing usable technology for such advanced systems as the 1980 Advanced Strike Concept. The current low risk philosophy of weapons system acquisition makes it mandatory that uncertainties of new technologies be resolved before application; without full-scale testing, little improvement in transonic operational efficiency can be expected.

TECHNICAL APPROACH:

a. The technical approach to be pursued in the TACT program is designed to accredit advanced technologies, increase confidence through flight test and allow for translation of the subject technologies into air-vehicle design. The use of the variable-sweep F-111 will provide highly desirable configuration flexibility not possible on any fixed wing aircraft. This aircraft as a development flight test tool for these technologies provides valid test conditions, environment, and configuration so that the program results can be directly
applicable to current and future high performance combat aircraft. The specific wing design to be flight tested is noted in paragraph a. under DESCRIPTION. The wing will be highly instrumented to determine aerodynamic performance, to correlate aeroelastic structural behavior and to facilitate wind tunnel/analytical/full scale flight test comparison.

b. The stability and control characteristics will be determined thru wind tunnel test. These data will be used to define the adequacy of the high-lift devices in the take-off and landing modes and the degree of compliance with MIL-F-8785B through handling qualities analysis. Flight test verification will be performed throughout the flight envelope. To provide assured flight safety for the test bed vehicle, a complete flutter safety evaluation program will be conducted. Preliminary flutter analyses will be conducted for subsonic thru supersonic speeds prior to configuration freeze. A complete flutter analysis and transonic wind tunnel flutter model test program will be conducted early in the program to provide the necessary design guidance. This approach of combined analyses and wind tunnel tests is the current state-of-the-art practice for all aircraft development. The requirements of specification MIL-A-8870 will be met.

c. Static aeroelastic data will be obtained utilizing the best available aerodynamics methods for wing design and correlated with wind tunnel model results for verification of airload predictions. An aeroelastic model will be fabricated early in the program and wind tunnel tests will be performed to obtain data to verify the design approach and to obtain confirmation data. Dynamic loads imposed by landing, taxi, store ejection and response to atmospheric turbulence will be determined by current analysis methods and included in the structural design of the aluminum wing. Dynamic measurements for these loading environments will be made during the flight test phase. In the area of structural design and strength verification, structural design criteria will be similar to the F-111D with minor modifications. Initial design loads will be determined and incorporated with maneuver and component load trend analyses to obtain final design load distributions. Structural margins of safety and operational flight envelopes will be established. A stress analysis of all structural components will be performed and fatigue analyses will be conducted for the aluminum wing. Subsequent to USAF approval of the design and stress analysis, the flight-article aluminum wings will be fabricated, installed on the aircraft, and proof tested prior to flight.

d. The TACT program will be conducted as a joint USAF/NASA program. Specifically, Langley Research Center has conducted extensive wind tunnel tests to develop the supercritical airfoil and to develop the TACT planform. Additional tests and engineering support will be provided to define the final flutter characteristics of the TACT configuration. Final configuration development and wind tunnel tests for low-speed high-lift devices and transonic and supersonic conditions will be obtained in the Ames Research Center facilities. In addition, they will provide engineering and data analysis support and assistance for wind tunnel to flight test data correlation. Flight-test
evaluation of the supercritical aluminum wing will be conducted at Edwards AFB by NASA Flight Research Center (FRC) and the Air Force Flight Test Center (AFFTC). The FRC will conduct the flight test evaluation; provide, install, calibrate and maintain the flight test aircraft; assist in flight test data reduction and analysis; and provide flight crews and associated equipment. The AFFTC will provide flight test technical support to AFFDL; assistance in flight test planning; test pilots and associated equipment; on-site monitoring of flight tests; chase aircraft and ground support; and data analysis and correlation. Existing NASA wind tunnel facilities or their equivalent which will be used to conduct wind tunnel tests are 16 foot Transonic Dynamics and 8 foot Transonic facilities at Langley; and the 11 foot Transonic, 12 foot Pressure and 9X7 foot Supersonic facilities at Ames.

e. Key milestone events and dates of occurrence:

(1) Program Approval                              Feb 71
(2) Contract Award                                Mar 71
(3) Program Statement of Work Definition          Apr 71
(4) Aero Configuration Freeze & Preliminary Design Review Aug 71
(5) Detail Design Review                           Dec 71
(6) Flight Test Aircraft Available to AFFDL        Aug 71
(7) Complete Fabrication                           Jan 73
(8) First Flight                                   Feb 73
(9) Complete Flight Test                           Dec 73
(10) Final Report                                  Feb 74

d. The risks involved in this program are no greater than those encountered in any flight-test effort wherein new airfoil designs are being tested. These risks will be minimized by extensive analysis, wind tunnel tests and hardware flightworthiness testing prior to commitment to flight. During the actual flight-testing established test procedures will be adhered to and critical test conditions will be approached incrementally to reduce the risk of encountering unpredicted difficulties.

g. At the completion of these efforts, the supercritical wing technology should have been adequately developed through flight test demonstration on a variable sweep test-bed aircraft and correlation of wind tunnel results with flight test data should allow direct application to future high performance
military aircraft weapon system development and to follow on development of B-1 and F-15.

FUNDING:

a. The total estimated dollar amount of this contemplated procurement is TWELVE MILLION DOLLARS AND NO CENTS ($12,000,000.00) and is being partially funded with TWO MILLION FIVE HUNDRED FORTY THOUSAND DOLLARS AND NO CENTS ($2,540,000.00) of FY 71 monies. The balance of the procurement will be funded with $5,000,000.00 of FY 72, $4,200,000.00 of FY 73 and $260,000.00 of FY 74 monies. No prior funding involved.

b. Funds required for AFFDL in-house support are estimated to be $60,000.00 of FY 72 and $50,000.00 of FY 73 monies.

c. Additional estimated dollars for Air Force Flight Test Center service funding is $200,000.00 of FY 72 and $300,000.00 of FY 73 monies.

d. The citation of funds to be obligated is 57X3600 2814702 P61484A 63205F S595600; the program element is 63205F and project number is 484A and no task number is assigned.

PROCUREMENT DATA:

a. The desired contract obligation date is 15 March 1971.

b. Sole source justification:

(1) Much of the wind tunnel data and analysis previously accumulated is proprietary to General Dynamics/Fort Worth and would require an estimated $3,000,000.00 and one year of wind tunnel tests and pre-development effort by another contractor to attain an equivalent level of knowledge. In addition, the technology gained by General Dynamics/Fort Worth on the test bed aircraft and available F-111 resources places General Dynamics well ahead of any other potential source and would result in substantial savings to the government.

(2) The General Dynamics/Fort Worth organization is the only contractor source having access to the specific wind tunnel and other background data.

(3) This program is based on an unsolicited proposal number FZP-1124-III-1, Revision A, dated 7 Dec 1970, subject: "Supercritical Wing Research Program."

(4) The proposed contractor is in the position of sole source selection by virtue of the extensive effort (described in the BACKGROUND section above) in which General Dynamics/Fort Worth participated financially to the extent of approximately $3.5 million over the past two years. General
Dynami~slFort Worth participation in the pre-development phase of TACT and in related contracts provided personnel to complement NASA/LRC personnel in conducting approximately 1600 hours of wind tunnel tests in the configuration development program, data analysis of wind tunnel test results, wind tunnel model design and fabrication, and preliminary structural design and analysis. The experience General Dynamics/Fort Worth personnel have gained, existing analysis, and wind tunnel models are available only to GD/FW. The technology gained by the proposed contractor on the test bed aircraft and available F-111 resources places General Dynamics/Fort Worth well ahead of any other potential source.

(5) The size classification of General Dynamics Corporation, Convair Aerospace Division Fort Worth Operation, Fort Worth, Texas, is a large business and is not located in a Labor Surplus Area (LSA).
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**Program Schedule**

**System (Project) Number**: 484A

**Subsystem**: Transonic Aircraft Technology

**Type of Schedule**: Master

**As of Date**: 28 Jan 71

**AUTHENTICATION**

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SIGNATURES:

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AF Flight Dynamics Laboratory

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AF Flight Dynamics Laboratory

CHARLES J. COSENZA
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