General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.

- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.

- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.

- This document is paginated as submitted by the original source.

- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

CR151926

(NASA-CR-151926) LIFT CRUISE FAN V/STOL AIRCRAFT CONCEPTUAL DESIGN STUDY T-39 MODIFICATION. VOLUME 2: SCHEDULES AND BUDGETARY DATA (Rockwell International Corp., Columbus, Ohio.) 33 p HC A03/MF A01 G3/05

N77-18133

Unclas 17246

Rockwell International

NASA CR 151926

Bibliographic Control Only

LIFT CRUISE FAN V/STOL AIRCRAFT

CONCEPTUAL DESIGN STUDY

T-39 MODIFICATION

VOLUME II SCHEDULES AND BUDGETARY DATA

November 1976

Prepared under Contract No. NAS 2-9307 by
ROCKWELL INTERNATIONAL CORPORATION
Columbus Aircraft Division
Columbus, Ohio

for

AMES RESEARCH CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TABLE OF CONTENTS

SECTION	TITLE	PAGE
	TABLE OF CONTENTS	i
	LIST OF FIGURES	ii
	LIST OF TABLES	iii
	LIST OF SYMBOLS	iv
	SI CONVERSIONS	v
1.0	INTRODUCTION	1
2.0	SCHEDULE	2
3.0	TEST PROGRAM DEFINITION	7
	3.1 Wind Tunnel Testing	7
	3.2 Simulation	9
	3.3 Structural Verification Tests	10
	3.4 Escape System Substantiation	12
	3.5 Ground Testing	13
	3.6 Hover Rig	15
	3.7 Flight Test Program	15
	3.8 Reliability and Quality Assurance	16
4.0	RISK ASSESSMENT	19
5.0	BUDGETARY FUNDING INFORMATION	21
6.0	REFERENCES	26

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	T-39 Modification Schedule	5
2.2	Manufacturing Plan	6

LIST OF TABLES

TABLE NO.	TITLE	PAGE
I	T-39 Work Breakdown	4
II	Instrumentation List	17
III	Risk Assessment	20
IV	Government Furnished Property	23
V	Summary of Costing Information	24
VI	Detail of Thrust Vectoring Costs	25

LIST OF SYMBOLS

C.G.	Center of Gravity
C_L	Lift Coefficient ($^L/_{qS}$)
C_T	Thrust Coefficient ($^F/qS$)
EGT	Exhaust Gas Temperature
F	Force (newtons)
FBW	Fly-by-wire
$\dot{g}$	acceleration of gravity ($^m/_{sec^2}$)
GFE	Government Furnished Equipment
GG	Gas generator
L	Lift (newtons)
OAT	Outside Air Temperature (also $T_{T\infty}$)
q	dynamic pressure (kPa)
RPM	Revolution per minute
S	Reference area ($\overline{m}^2$)
STOL	Short takeoff and landing
$T_{T\infty}$	Total ambient temperature (°K)
UHF	Ultra high frequency
V/STOL	Vertical and short takeoff and landing
VTOL	Vertical takeoff and landing
α	Angle of Attack
β	Sideslip Angle
δ	Deflection Angle
$\theta, \dot{\theta}, \ddot{\theta}$	Pitch Angle, rate, acceleration
$\phi, \dot{\phi}, \ddot{\phi}$	Roll Angle, rate, acceleration
$\psi, \dot{\psi}, \ddot{\psi}$	Yaw Angle, rate, acceleration

<u>Subscripts</u>

e	elevator
N	nozzle
r	rudder

SI CONVERSIONS

Length	feet x 0.3048 = meters (m)
Mass	pounds x 0.45359 - kilograms (kg)
Volume	gallons x 0.003785 = cubic meters (m^3)
Velocity	knots x 0.51444 = meters per sec
Force	pounds x 4.448 = Newtons (N)
Density	slug/ft^2 x 515.379 = kilograms per cubic meter (kg/m^3)
Pressure	psf x 47.88 = pascals (Pa)
	psi x 0.068965 = Bars
Inertia	slug-ft^2 x 1.3557 = kilogram - square meter (kg-$\overline{m}^2$)
Temperature	°R x 0.5555 = Degrees Kelvin (°K)

1.0 INTRODUCTION

This report contains the schedule and budgetary information for a study conducted by the Columbus Aircraft Division of Rockwell International which investigated the conversion of two T-39 aircraft into lift cruise fan research and technology vehicles. The concept is based upon modifying the T-39A (NA265-40) Sabreliner airframe into a V/STOL configuration by incorporating two LCF-459 lift cruise fans and three YJ-97 gas generators. The propulsion concept provides the thrust for horizontal flight or lift for vertical flight by deflection of bifurcated nozzles while maintaining engine out safety throughout the flight envelope. The configuration meets all the study requirements specified for the design with control powers in VTOL and conversion in excess of the requirement making it an excellent vehicle for research and development.

The study report consists of two volumes; Volume I (Reference a) contains background data detailed description and technical substantiation of the aircraft. Volume II includes cost data, scheduling and program planning not addressed in Volume I. The study guidelines for this contract are summarized and commented upon in Volume I.

This study reflects a conceptual effort, both as to airplane characteristics and the program tasks/cost data presented. Accordingly, such information is subject to refinement and iteration in subsequent proposal and program phases, consistent with a proof of concept technology effort utilizing goals in lieu of operational requirements.

2.0 SCHEDULE

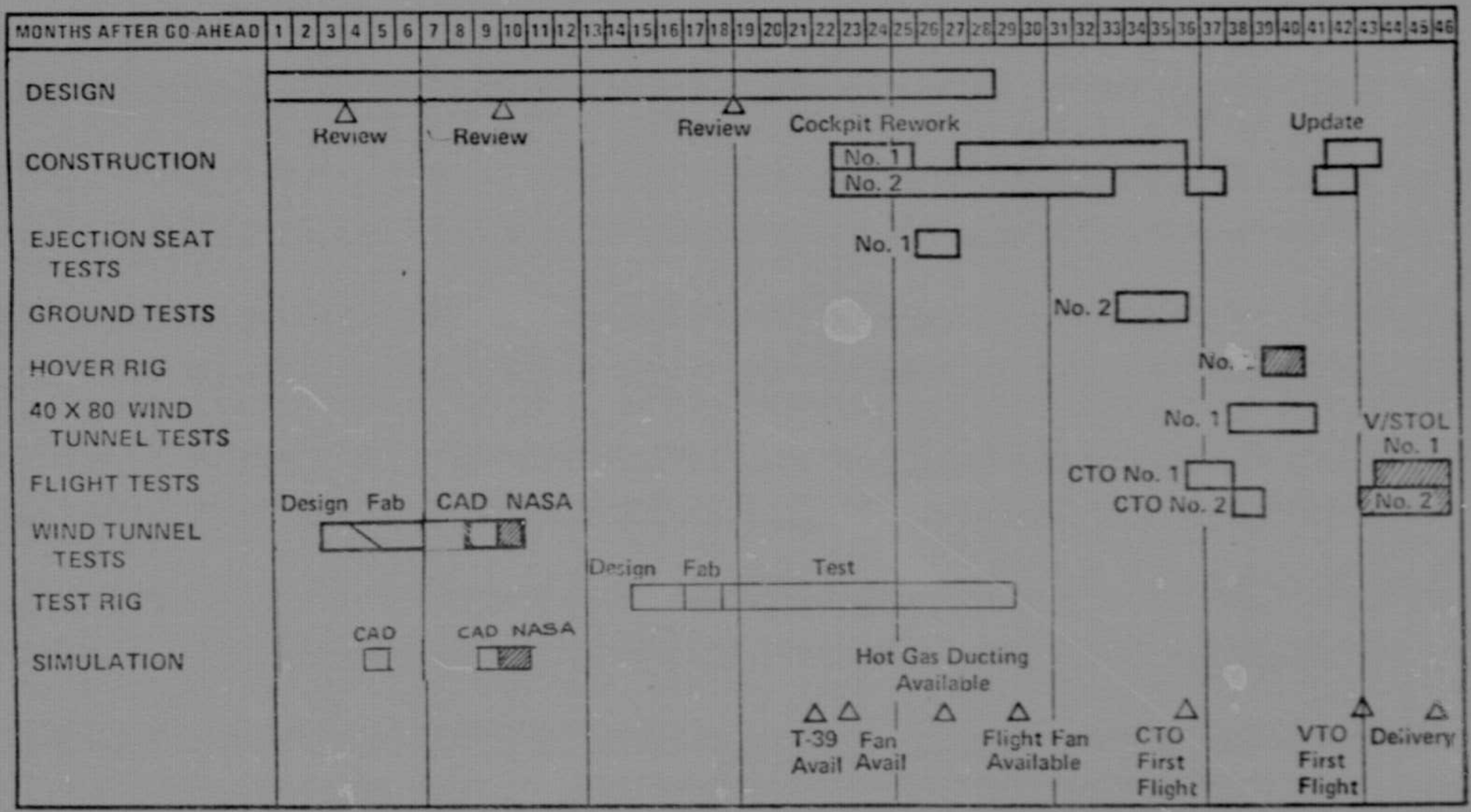
The schedule in Figure 2.1 is set by the time required to receive the hot gas ducting (24 months) and the lift-cruise fans (22 to 31 months). It is required that the Contractor design the vehicle in detail sufficient to be able to define the hot gas duct requirements for a subcontract. Two months will be sufficient to determine the initial sizing requirements for the hot gas ducting design and fabrication. Chronologically, the next event is the design of a wind tunnel model; two months of preliminary design will provide enough information to start model design. The initial NASA review is timed to allow revision to the wind tunnel model design. The model design and fabrication will be completed in 3 1/2 months. Testing will be accomplished in a month and reduced data available early enough to provide information during the design effort. These data will be used to provide aerodynamic inputs to the simulation study. It is imperative that the wind tunnel and simulation effort be early enough to aid in the design. These data will be discussed with NASA at the second review for approval of simulation plans for the NASA-Ames facility. The simulation program initially will be a computer program in-house; subsequently, the simulation study will be shifted to NASA-Ames facility where a man-in-the-loop test will be run. This is approximately 18 months from go ahead. A final design review and approval for fabrication is expected after 18 months.

During the 15th month, the design of the test rig, a nacelle including gas generator, fan, associated ducting and remote control devices will commence. The T-39 airframe will become available during the 22nd month and work on the canopy section to modify the glass, canopy framing, and installation of the seat will start. Number one vehicle will have only the cockpit rework accomplished when the static seat testing (one simultaneous dual seat firing) will be performed. Number one will then go back to be refurbished in the cockpit area and stripped in preparation for the rework effort. By the 27th month, Number two aircraft rework is well underway, the hot gas ducting would have been received and the non-flight-worthy fan installed in the test rig.

Testing of the static nacelle rig will continue from the 22nd month for approximately six months. At the end of this testing, Number two aircraft will have been completed and ready for the series of ground tests including cockpit pressurization, a structural proof test, control proof test and the numerous systems test. It will then have the total propulsion system tested similar to the static rig test. At the conclusion of these tests, Number two will be sent back for flight preparation. Coincidentally, with the end of ground testing on Number two, Number one will be checked out and readied for first conventional flight in the 36th month. The conventional flight test will be performed at the Contractor's facility and is scheduled for 10 to 12 flights for both vehicles. Number two will fly subsequent to Number one and will be flown to Ames or Langley for hover tests. The choice of methods to satisfy the hover test will be made after running a similar program at Langley with the XFV-12. This test is scheduled for the 39th and 40th month and will be coincident with the 40 x 80 foot tunnel, three month test at NASA Ames using vehicle Number one.

After the hover test for Number two and the tunnle test for Number one a three month refurbishing program will be carried out in preparation for the Contractor V/STOL testing. Number one and two will both fly "V" during the 43rd month and delivery to NASA will take place 45 months from go-ahead.

Figure 2.2 is a more detailed breakdown of the schedule in Figure 2.1 and is based on the work breakdown of Table I.



*Cross hatched line indicate off site testing

Figure 2.1 T-39 Modification Schedule

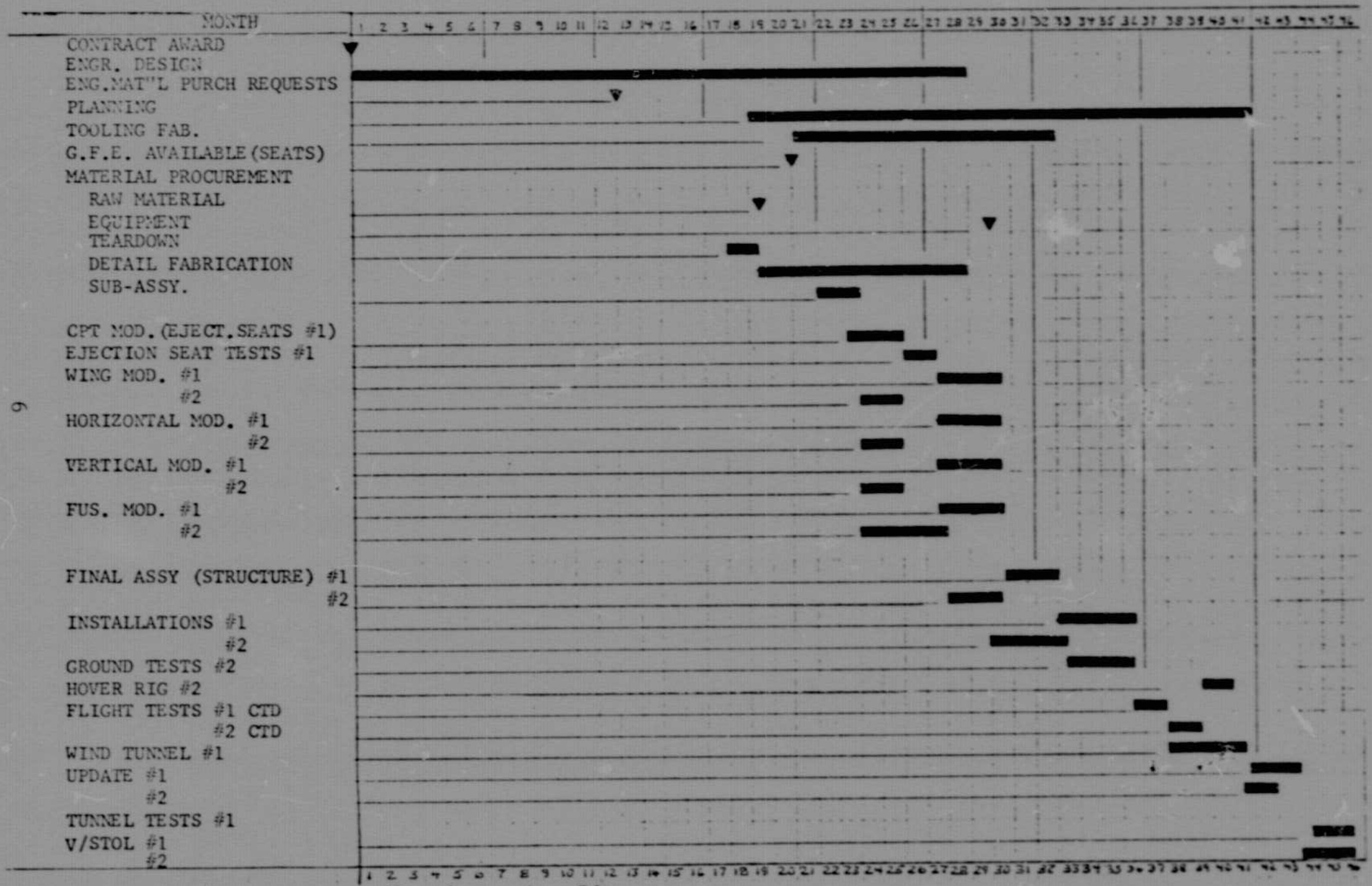


Figure 2.2 Manufacturing Plan

3.0 TEST PROGRAM DEFINITION

The following programs are identified as tests required prior to delivery of two aircraft to the Customer. These tests have been priced based on the data outlined. The future requirement of the Customer could modify these substantially.

3.1 <u>Wind Tunnel Testing</u>

The research airplane configuration will be duplicated in a scale model utilizing existing lift-cruise fans. The fans are Technology Development LC 457 fans of 5.5 inch diameter. The model will be supplied with two external air supply lines, one of which will be utilized to drive the tip driven fans and the second will supply air for the pitch pipe simulation.

The design will begin after completion of the configuration refinement studies with model completion scheduled 5 1/2 months after contract go ahead. Model configuration flexibility will be designed in to allow for testing of later identified or anticipated high risk items without major rework of the model.

The test will consist of three test periods. The initial test will be a static test, the second test period will be a forward speed investigation in the Rockwell 14' x [illegible] V/STOL wind tunnel and the third period will be a forward speed test in the Rockwell 7' x 10' test section. The following is an outline of the testing and objectives of each test.

1. Static Test - Static thrust stand with movable ground plane.

   Objective: Determine the static calibration of the fans and the static model interference in free air and in the near proximity to the ground. Develop fixes as required for favorable interference.

   Procedure: Install the full model in the Rockwell static thrust stand in a normal attitude. Fan calibration will be made primarily with flow exit surveys and verified by force data. Ground proximity will be simulated in symmetrical, rolled and pitched conditions. Interference will be determined by force data.

Variables:	Nozzle angles:	80°, 90°, 100°
	Roll angles:	0, 5°, 10°
	Pitch angles:	-10, 0, 10±
	Ground height:	free air to wheels down height
	Lateral control:	(1) free air
		(2) near ground
		(3) banked conditions

Pitch control: (1) free air
(2) near ground
(3) pitched conditions

Yaw control: (1) free air
(2) near ground

Test Period: approximately 3 weeks

2. Forward Speed - NACAL 14' x 16' V/STOL Tunnel

Objective: Determine the aerodynamic characteristics and performance at for forward speed conditions. Determine fixes for favorable interference characteristics.

Procedure: Install in the 14' x 16' test section. Thrust coefficients will be varied by tunnel speed and fan thrust. Ground proximity will be varied.

Variables: C_T - Thrust coefficient - varied by tunnel speed and fan RPM
δ_N - Nozzle angle - 0, 30, 60, 80, 90, 100, 135 degrees
α - angle of attack

Tail incidence, and vert. position, elevator and rudder defl.
pitch control - pitch pipe thrust (third engine)
ground height - free air to wheel height

Test Period: Approximately 6 weeks

3. NACAL 7' X 10" Test Section

Objective: Obtain high velocity aerodynamic data and control forces, hinge moments.

Procedure: Install in 7' x 10' test section on external balance, hinge moment instrumentation.

Variables: C_T - Thrust Coefficient
δ_N - Nozzle angle 0, 30, 60 degrees
α - Angle of attack
Tail incidence and position
δ_e - elevator angle
δ_r - rudder angle

Test Period: approximately 3 weeks

3.2 Simulation

A computer simulation of the aircraft and controls will be performed during the early weeks of this design. The simulation will be a six degree of freedom, non-linear aerodynamic model of the aircraft plus a model of the control system that includes rate limits, travel limits and other significant non-linearities. The system will represent the aircraft from hover to slow speed conventional flight.

The model will be capable of continuous solution over the speed range. This will permit evaluation of trim change with speed and angle of attack. The simulation will also be used to evaluate the flight profile characteristics expected during conversion, and the duct angle control rates and positions needed for smooth, continuous conversions. These tests will be performed for both increasing and decreasing speeds.

The simulation model will also be used for fixed point evaluation of the aircraft performance. That is, the characteristics will be evaluated about several selected values of speed, thrust, angle of attack, and angel of sideslip. Dynamic solutions will be obtained about selected fixed points. This will include transient response, damping required, control power required, and first order coupling effects. These tests can be used to substantiate the mathematical model and as aids in the aircraft and control system design.

In addition to aiding in the lift fan design and development, the computer simulation tests to be performed will be used as an aid in developing a mathematical model of the T-39 lift fan aircraft for better use in piloted simulation tests. The model development will be planned to be compatible with the six-degrees of freedom V/STOL motion simulator located at NASA Ames. The 35 degrees of angular freedom and nine feet of motion freedom available in this simulator will provide an excellant opportunity to evaluate the aircraft handling qualities prior to flight.

3.3 Structural Verification Tests

A series of ground and flight tests will be performed to verify the static and dynamic integrity of the modified T-39A airframe for operation in the proposed V/STOL flight evaluation program. Ground vibration and selected proof load tests will be performed prior to flight release to verify structural integrity of control systems and structural assemblies which have undergone major modifications. These will be followed by flight test monitoring of instrumentation installed at key locations on the airframe as the flight test operating envelope is expanded. The instrumentation will be calibrated to provide data for comparison with analytical loads used in the design of the airframe and to evaluate flutter response of the structure.

The following types of proof load tests are proposed to provide adequate verification of the strength of the aircraft prior to first flight.

Horizontal Tail Load - A simulated airload will be applied to the horizontal stabilizer and elevator with the fuselage restrained at tie down points in the vicinity of the front and rear wing attach frames. Strain gages will be installed at the root of the horizontal stabilizer rear spar to measure bending and shear strains as critical up bending and down bending loads are applied to 110% of design limit load. This test will provide strength verification of the new horizontal tail attachment and aft fuselage structure, and will provide calibration data for measuring horizontal tail loads in the flight test program. This horizontal tail load data will be useful in evaluating the aerodynamic characteristics of the vehicle and in verifying fuselage design loads.

Vertical Tail Load - A simulated airload will be applied to the vertical stabilizer and rudder with the fuselage supported at the same points as in the horizontal tail load test. Strain gages will be installed at the base of the horizontal stabilizer rear spar and lateral deflection of the stabilizer will be measured as loads are applied to 100% design limit load. This test will verify the torsional strength and stiffness of the stabilizer attachment and aft fuselage modification.

Nacelle/Wing/Fuselage Attachment - This test is designed to verify the structural integrity of the nacelle to wing and wing to fuselage attachments and supporting structure when subjected to critical landing load conditions. The test also allows calibration of the wing to fuselage attachment loads for evaluation in the flight test program. Vertical and drag loads are to be applied to the main landing gear attach points with the fuselage restrained at tie down points at the front and rear wing attach frames. Strain gages and/or strain bolts are to be installed in the vicinity of the forward and aft wing attach fitting and on the wing front and rear spar to measure bending and shear strains as critical landing loads are applied to 110% design limit load. A unit load case is also to be applied to the main gear trunnion to produce a known shear bending moment and torsion at the side of the fuselage for flight load calibration purposes.

Flight Control Systems - The longitudinal, lateral and directional flight control system will be proof tested to verify the strength and stiffness of the system. The control system will be proof tested for the VTOL and conventional flight modes. Pilot effort will be applied to the control stick and rudder pedals and reacted on either the blocked control surface or at other applicable points within the system. The deflections of the control stick and rudder pedals will be measured to determine the stiffness of the control system. Instrumentation may be installed and calibrated in portions of the control system linkage to provide specific loads data such as rudder, elevator and aileron hinge moments, and linkage load data for nozzles and valves.

Cockpit Pressurization - A cockpit pressurization test will be conducted as part of the manufacturing check out of the sealing of the new cockpit enclosure and cockpit pressure bulkhead. Leakage rates and functioning of pressure relief valves will be checked as the enclosure is pressurized to 5.0 psi limit load.

Ejection Seat Load - Proof test loads will be applied to the installed LW-3B ejection seats support structure to verify the strength of the seat support structure under simulated crash and emergency ejection loadings.

Dynamic integrity of the airplane will be verified by a program of analysis, ground vibration test and flight flutter testing. A ground vibration test will be conducted on the complete airplane to determine the dynamic characteristics of each of the primary structural components. The resonant frequencies and mode shape will be compared with predicted analytical data for the lift fan configuration and with previous analytical and test data for the T-39A configuration. Accelerometers will be installed at key locations on the airframe and the airplane will be suspended from hoist points with a sling supported by a soft bungee system. The structure will be excited by multiple, electronically controlled shakers. Correlation of primary frequencies and mode shapes with mathematical analysis is required prior to first flight.

The flight flutter test program will consist of monitoring accelerometer readings during the initial phases of the VTOL and conventional flight test program to establish frequencies and mode shapes as the operating envelope is expanded.

Functional and proof tests will also be conducted on all the subsystems of the aircraft. These include hydraulics, fuel, electrical, instrument, environmental control, fire detection, etc. Temperature will be monitored on specific portions of the airframe adjacent to hot gas ducting during ground run up and flight operation modes to insure that temperatures do not exceed material design allowables.

3.4 Escape System Substantiation

Two LW-3B zero-zero seats provide the escape capability for the modified T-39 research and technology aircraft. The recent demonstration of side-by-side simultaneous firing of a similar configuration in the NASA research aircraft XV-15 provides a basis for this austere ejection seat installation substantiation. The T-39 airframe will be modified in the cockpit area only to provide a satisfactory cockpit canopy with adequate ejection clearance. The airframe will then be used as a static test article to substiantiate the simultaneous side-by-side ejection. The test firing is to verify satisfactory through-the-canopy seat penetration. Two contingency seats will be provided to accommodate any retesting.

Photographic coverage will be provided of the ejection tests and will be utilized for the measurement of position, velocity, and attitude of the ejected seat. In addition, documentary and special event cameras shall be used to record the complete test sequence, including the complete trajectories and behavior of pertinent or critical components of the escape system sequence during pre-ejection, ejection, separation, free flight, and recovery. Still photographs will be taken prior to and after completion of each test firing.

The Contractor shall instrument the test vehicle, using instrumentation as necessary to record data on the following parameters of the emergency escape system during the ejection tests:

- System initiation
- Initial seat movement
- Catapult pressure
- Vertical acceleration (during catapult stroke only)
- Seat velocity at tube separation
- Pitch rate of seat at tip off
- Harness release gun actuation
- Parachute pack opening.

3.5 Ground Testing

3.5.1 Propulsion System Test Rig - The use of a non-flight test rig will provide early identification of any problems in the hot gas ducting, gas generator to fan interface and nacelle cooling. Before fan delivery, the rig will provide a test facility to evaluate hot gas duct components. The test rig will provide the Contractor with the equivalent of on line conditions 15 months prior to the installation of the propulsion system in the airframe for ground testing. When the initial fan becomes available (month 22) the rig will be converted to a static duplicate of a nacelle. This rig consists of the equivalent of a nacelle, with a gas generator, fan and the prime connecting ducting having two valves and three universal joints. This rig provides early information on the performance of the propulsion system installation. The static ground test will provide an initial look at an installed duct run and an evaluation of the components, method of connecting and supporting them and a measure of the thermal deflection. The effectiveness of compartment cooling, insulation, and fire warning system will be evaluated. The benefit of this rig lies in the early assembly and operation of hardware components without jeopardizing the structure of the flight article. This rig provides a static fan survey of the inlet and exhaust for thrust and distortion data. Considerable test time will be saved by providing remote control of the swivel nozzle actuators, spoiler vanes actuators and exhaust area actuator. The following performance conditions will be quantified:

Nozzle coefficient,
Thrust decrement due to spoiler,
Thrust deflection due to vane deflection,
Thrust variation due to area variation,
Thrust variation due to control valve deflection,
Nozzle losses due to nozzle deflection angle,
Water injection operation.

A comprehensive static temperature survey will be made for various engine duty cycles. This would provide the data base for eventual flight surveys.

3.5.2 Installed Propulsion System Ground Test - Ground testing of the hot gas ducting system installed in airplane No. 2 will be conducted after rollout. The rig test will have provided information on the normal operation loop from gas generator to fan. This will be the first opportunity to check out the total system. By closing the backflow valves and the two roll control valves, the system will be pressurized and leak checked. Any deviation from a baseline reading will indicate a potential problem. The following check will be accomplished prior to ground testing and all flights.

System

After installation is complete and before the first engine run, inspect for th· following:

Handling damage

Proper alignment

Proper clearance

Proper torque level on couplings and attachments

Total system leakage

Initial ducting position

During engine run:

Monitor ducting position indicators to verify adequate growth accommodation

After engine run:

Check leakage against initial baseline reading

If leakage increase is excessive, check for source and overheat damage

Check ducting position against initial reading

Recheck torque on all couplings and attachments

Leakage will be checked before and after each flight

Ducting position indicators will be monitored during the first three or four flights

Run up test will provide a time history of temperatures, pressures and deflection based on specific engine schedule. The installed system will be evaluated for vibration induced by power system dynamics. The ground test will include functional test of the seven valves and the two pitch nozzles. Static tests of the engine out procedure will simulate the operational modes from Level 1 to 2. These ground tests will include assessment of the auxiliary water system, fire extinguisher and warning system; and test of the "high flow" pitch pipe system discussed in Section 5.0 of Reference (a) for attenuation of exhaust conditions.

3.5.3 Systems Checkout - All systems will be ground tested prior to flight. Included in these tests will be the oxygen system, fire extinguisher system, utility and prime hydraulic system, electrical, avionic, environmental system and fuel system. These systems will be functionally checked at normal conditions with no effort to simulate extreme conditions usually required by formal demonstrations.

3.6 Hover Rig

Vertical flight characteristics under full scale conditions can be obtained by using one of two NASA facilities, the lunar landing research facility at Langley or the static ground effects test stand at Ames. The test at the Langley facility would suspend the aircraft in such a way that it is free to move in a given vertical and horizontal envelope. The Ames facility provides an instrumented static test stand that allows aircraft operation at various heights and attitudes above the ground. Both facilities can provide aerodynamic data in the presence of the ground. The Contractor will be using the Langley facility prior to the scheduled time for the Research and Technology Aircraft. The usefulness of this test will influence the final decision on the more cost effective facility to evaluate hovering characteristics. A cost to support either program has been included.

3.7 Flight Test Program

The flight program is divided into a conventional mode and a V/STOL mode. Between these two programs one aircraft will be run in the NASA-Ames 40 x 80 foot wind tunnel to investigate the vertical and transitional handling qualities characteristics.

The initial flight test program is designed to open the flight envelope using only conventional takeoffs and landings (i.e., fixed nozzle-position). This program will involve both aircraft and be performed at the Contractor's facility in Columbus, Ohio. Approximately 20 to 25 percent of the total flight program will be devoted to these tests. Both vehicles will be instrumented; however the complement is not proposed to be identical. Table II is a representative list of instrumentation parameters. The following performance items will be evaluated by the Contractor for cruise flight only:

Takeoff and landing distances,
Rate of climb for various climb schedules,
Service ceiling,
Range and endurance fuel flows at various altitudes,
Engine air starts,
Engine out operation.
System checkout.

The following flying qualities will be evaluated at more than one center-of-gravity extreme in cruise configuration:

Stalls in all configurations,
Static and dynamic longitudinal stability,
Static and dynamic lateral directional stability,
Maneuvering stability,
Trim changes due to gear extension, nozzle deflection, slat deployment and pitch pipe operation.

A survey of air loads, particularly on the vertical and horizontal tails, will be monitored during the build-up phase of the conventional flight testing. These strain gages will be compared with data from similarly instrumented T-39A vehicles. The basic stress analysis will be based on analytical computations and the 0.1 scale wing tunnel results and corroborating proof load tests. In-flight monitoring of critical items will provide a means of checking these preliminary analysis and insure a safe test program.

The V/STOL portion of the flight program will have been preceded by a hover test, and the 40 x 80 tunnel test so the basic vertical flight characteristics should be well defined. The transition data received during the NASA Ames tunnel test will provide the guidelines for the V/STOL flight testing. This phase of the flight testing will be done at the Customer's facility by Contractor pilots. The purpose of the test is to define the vertical flight characteristics, determine control power, and establish a comfortable level of augmentation for the stability system. Transition profiles for landing and takeoff will be investigated. The third engine use will be defined with engine out procedures recommended.

3.8 Reliability and Quality Assurance

The Contractor will provide reliability and quality assurance functional support of design, modification, and test of the T-39 modified lift cruise aircraft. While R&QA requirements as typically applied to operational aircraft developments will not be invoked for this program, the Contractor's existing Quality Assurance and Inspection program in accordance with MIL-Q-9858A will be applied. Specific attention will be directed to material and components relative to the identified risk areas, to assure the maximum probability of success. Modification type drawings to Contractor practices will be used in the program and released by engineering order.

Table II

Instrumentation List

I. FLIGHT PARAMETERS
- Voice Intercom.
- Airspeed
- Mach
- Altimeter
- OAT (T_{T_∞})
- Airspeed, $Low_{Longitudinal}$
- Airspeed, $Low_{Lateral}$
- Radar Altimeter
- Vertical Airspeed
- Attitude - Pitch θ (angle)
  - Roll ϕ
  - Yaw (Sideslip) ψ, (β)
- Attitude Rates
  - Pitch $\dot{\theta}$ (rate)
  - Roll $\dot{\phi}$
  - Yaw $\dot{\psi}$
- Clock
- Normal "g's" (Accel.)

II. COCKPIT CONTROLS
- Longitudinal, Stick Displ.
- Lateral, Stick Displ.
- Directional, Pedal Displ.
- Power Quadrant Displ.
- L/C Nozzle Position Displ. (Power Quadrant rotate)
- Longitudinal Stick Force
- Lateral Stick Force
- Directional Pedal Force

III. CRUISE SURFACE CONTROL SENSORS
- Elevator Position
- Horizontal Position
- Aileron Position
- Rudder Position
- Longitudinal "g's"
- Slat Position
- Directional Trim

IV. VERTICAL CONTROL SENSORS
- L/C Nozzle Position
- Roll Valve Position
- L/C Spoilers Position
- L/C Area Eyelid Position
- Pitch Nozzle Position

V. POWER PLANT INSTRUMENTATION
- Fuel $Quantity_{Wing\ LH}$
- Fuel $Quantity_{Wing\ RH}$
- Fuel $Quantity_{Fuselage}$
- Fuel $Flow_{RH}$
- Fuel $Flow_{LH}$
- Fuel $Flow_{℄}$
- EGT - RH
- EGT - LH
- EGT - ℄
- RPM_{GG} - RH
- RPM_{GG} - LH
- RPM_{GG} - ℄
- Fuel Temperature
- RPM_{Fan} - RH
- RPM_{Fan} - LH
- Fuel Control Position - RH
- Fuel Control Position - LH
- Fuel Control Position - ℄
- Inlet Pressure $Rake_{Fan}$
- Exit Pressure $Rake_{Fan}$
- Inlet Pressure $Rake_{GG_3}$
- Exhaust $Pressure_{GG}$
- Pressure Hydraulic Pump
- Temperature Hydraulic Reservoir

Table II (Continued)

Instrumentation List (Continued)

VI. STRUCTURAL LOADS

- Strain Gages:
  - Vertical Spar @ Root
  - Vertical Front Spar
  - Vertical Spar Web
  - Horizontal Spar Caps
  - Horizontal Spar Web
  - Gear Trunnion Mounting (Main)
  - Gear Trunnion Mounting (Aux.)
  - Wing Spar Webs
  - Wing Spar Caps (Upper, Lower)
  - Outer Panel Gust Instrumentation
- Dynamic Transducer: Aileron
  - Elevator
  - Horizontal

VII. STRUCTURAL TEMPERATURES

- Fuselage under Pitch Pipe (Various F.Sta.)
- Rear Spar, Wing
- Upper Longeron, Fuselage
- Engine Component Compartment - Prime LH
- Engine Component Compartment - Prime RH
- Engine Component Compartment - Secondary ℄
- Engine Turbine Compartment - Prime LH
- Engine Turbine Compartment - Prime RH
- Engine Turbine Compartment - Secondary ℄
- Nacelle Fan Support Frames
- Nacelle G.G. Longeron Supports
- Nacelle Above Fuel Bay
- Nacelle Exhaust Panel LH & RH
- Horizontal L.E. Skin

VIII. DUCT TEMPERATURE AND PRESSURE

- All Valves
- Fan Inlets
- Pitch Pipe Nozzles

4.0 RISK ASSESSMENT

The objective of this risk assessment is to establish and recognize specific items of the proposed T-39 Research and Technology aircraft which represent a potential risk to achievement of the performance goals or the program costs and schedule. A further objective through the recognition of risk items is to establish design and development plans to control and minimize risk. The identified risks and the design and program alternatives are discussed in detail in the respective sections of this study.

A summary of the risk items and their respective decision points, options, importance, level of risk, and program impact are presented in Table III. A qualitative assessment may be construed from the combined importance, risk, and impact estimations in order to establish greater visibility for program controls. Definitions of Importance, Risk, and Impact are as follows:

Importance - The sensitivity of the item to meeting the performance or safety requirements of the airplane.

1. Mandatory to meet safety.
2. Mandatory to meet performance goals.
3. Desirable to meet performance goals.
4. Tolerable.

Risk - The degree of uncertainty of performing as planned by following the postulated course of action.

Low - Fully developed; in current use; extensive operating experience

Minor - Current state-of-the-art; significant testing but not fully developed.

Moderate - Feasibility well established but limited testing

High - Similar to programs having serious difficulties.

Extreme - Feasibility unknown; serious difficulties anticipated.

Impact - The effect on program schedules or costs if a decision to implement the option is required.

Major - Significant increase in program cost and/or schedule extension.

Minor - Minimum program delay and cost increase.

Minimal - Little, if any, effect on program cost or schedule.

Table III

Risk Assessment

Item	Decision Point	Options	Importance	Risk	Impact
AIRCRAFT					
Location of Horizontal Stabilizer	Wind Tunnel Tests	Design and Fabricate new Vertical and Controls	3	Minor	Minor
Flaps (Low $C_{L_{STO}}$)	Wind Tunnel Tests	Add Split Flap	3	Low	Minimal
Fountain Effect	Wind Tunnel Tests	Add Strakes	3	Moderate	Minor
Control Power (Cruise)	Wind Tunnel Tests	Increase Surface Deflection or Area	3	Minor	Minor
Escape	Escape System Tests	Interface Redesign	1	Low	Minor
FBW Hardware/ Software	Simulation Tests	Add Mech. Backup	1	Minor	Minor
Control Harmony	CTOL Flight Test	Resize Bungees/ Control Gearing Revisions	4	Low	Minimal
PROPULSION					
Inlet Configuration	Wind Tunnel/Ground Tests	Add Aux. Inlets	4	Moderate	Minor
Hot Gas Ducts (Includes Elbows, Valves, etc.)	Test Rig	Redesign	2	Minor	Major
Lift Nozzle	Prior Program	-	2	Low	Minor
Pitch Nozzle	Ground Test	Internal Changes	3	Minor	Minimal
Insulation	Test Rig	Add Insulation/ Shrouds, Forced Air	1	Minor	Minimal
Control Power (Roll/Yaw)	Wind Tunnel/ Ground Tests	Vane Redesign or Nozzle Actuation	2	Moderate	Minor

5.0 BUDGETARY FUNDING INFORMATION

The cost of the T-39 Lift Fan Aircraft has been estimated by use of parametric estimating techniques based on the conceptual design of the aircraft generated under Contract NAS 2-9307. The program as currently defined is similar in scope to the Contractor's XFV-12A Thrust Augmented Wing program, therefore, the estimates contained herein are based on the cost history and projections of the XFV-12A program. In addition, XFV-12A has been used as a basis for the cost estimates because the adjustments that are usually required, in other parametric cost estimates, to normalize the data base to the estimating requirement are minimal.

The XFV-12A Thrust Augmented Wing is similar to the proposed T-39 Lift Fan program in the following ways:

1. Both are Proof-of-Concept test programs.
2. Both programs utilize assets from existing aircraft.
3. Both programs involve VTOL Technology.
4. Hot air ducting is common to both programs.
5. The tooling approach is a minimum tooling basis adequate for the fabrication of two aircraft.
6. An existing ejection seat and pilots compartment is used on both aircraft.
7. The programs are planned on a basis which exclude the configuration, testing, documentation and reporting requirements applicable to full-scale development or prototyping of operational aircraft.

The estimates have been based on the following pricing assumptions:

1. Government Furnished Equipment - as defined by Table IV
2. Fiscal Year 1976 Dollars.
3. Flight Test Program consisting of approximately six (6) months of flight time in two phases spanning an approximate one year period.
4. Use of GFE Wind Tunnel Facilities.
5. Rent-free use of Government Owned Facilities.
6. Minimum Technical and Management data submittals.

Consistent with the above, the Contractor's Summary Cost Estimate of the T-39 Lift Fan Program is as shown in Tables IV, V and VI.

Design and Construction	$49.1M
Ejection Seat Test	.2
Ground Tests	3.0
Wind Tunnel Tests	.5
Flight Tests	4.5
Test Rig (Propulsion)	2.5
Simulation	.1
Spares	.6
Total	$60.5M

Attached hereto is the cost breakdown as required by Reference (b).

The cost data herein is for program evaluation and planning purposes only, and as such does not constitute a commitment on behalf of Rockwell International Corporation. Continuing refinement and iteration in subsequent proposal and program phases is contemplated.

Table IV

GOVERNMENT FURNISHED PROPERTY

		Items required	
		Total for 2 A/C Program	Total Spares
NA 265-40 Sabreliner Aircraft (Complete)		2	-
Landing Gear and Actuators	T-2 Nose Gear	2	2 Tires
	A-4 Main Gear	4	4 Tires
Electrical Generators *		4	-
Hydraulic Pumps		4	-
Fuel Boost Pumps *		4	-
Fans	LCF 459	4	2 + 1 Test
Engines	YJ-97	6	2 + 1 Test
Research Instrumentation		TBD	TBD
LW-3 Seats		4	-
Engine Instruments		2	-
(Exhaust Gas Temperature Gage) (Tachometer) (Fuel Quantity Gage) (Fuel Flow Gage)			
Avionics		2	-
UHF Comm AN/ARC-159 * Compass AN/ASN-75 * Radar Altimeter AN/APN-194 *			

*Included in NA 265-40 Sabreliner Airframe

Table V
Summary of Costing Information Two Aircraft Buy
1976 $ (In Millions)

	Engr. Labor	Mfg. Labor	Mat'l & Purch. Items	Sub-Contr.	Spares	Total
Airframe Design and Mod						
Landing Gear	.129	.120	.028			.277
Subsystem & Conv. Controls	2.158	2.007	.469			4.634
Cockpit	.203	.189	.044			.436
Ejection Seats	.129	.120	.028			.277
Wings	.811	.754	.176			1.741
Fuselage	2.764	2.571	.601			5.936
Empennage	.549	.511	.119			1.179
Miscellaneous	2.319	2.157	.504			4.980
Nacelle	4.020	3.738	.874			8.632
Propulsion System						
Transmission Components) Transmission Subsystems)	5.085	4.731	1.107	1.951		12.874
Thrust Vectoring	2.461	2.289	.535			5.285
Miscellaneous	.344	.320	.075			.739
Control System						
Fly-by-Wire System	.229	.213	.350			.792
Augmentation System	.259	.241	.056			.556
Miscellaneous	.338	.314	.073			.725
	21.798	20.275	5.039	1.951		49.063
Propulsion System Testing						
Transmission Components	SubContr.					
Thrust Vectoring	2.518					2.518
Qualification Tests	SubContr.					
Aircraft Ground Tests	.833					833
Miscellaneous	.368					.368
	3.719					3.719
Control System Aircraft Tests						
Component Tests	.252					.252
System Integration	.425					.425
Aircraft Ground Tests	.075					.075
	.752					.752
Aircraft Ground Tests	1.033					1.033
Ejection Seat Tests	.195					.195
Flight Tests	4.524					4.524
Wind Tunnel	.524					.524
Simulation	.127					.127
Subtotal	32.672	20.275	5.039	1.951		59.937
Spares					.599	.599
TOTAL	32.672	20.275	5.039	1.951	.599	60.536

Table VI

Detail of Thrust Vectoring Cost

	Engr. Labor	Mfg. Labor	Mat'l & Purch. Items	Other Direct Costs	Total
Ducting					
Data Base Requirements	2.595	2.413	.559		5.567
Design and Manufacture	.129	.485	.162	.155	.931
Component Testing	.031		.005		.036
Unit Qualification Testing	.065	.038	.013		.116
Valves					
Data Base Requirements	.864	.804	.190		1.858
Design and Manufacture	.039	.182	.061	.021	.303
Component Testing	.016		.002		.018
Unit Qualification Testing	.031	.011	.005		.047
Bellows					
Data Base Requirements	.508	.473	.112		1.093
Design and Manufacture	.026	.023	.008	.026	.083
Component Testing	.010		.003		.013
Unit Qualification Testing	.010	.002	.001		.013
Socket					
Data Base Requirements	.864	.804	.190		1.858
Design and Manufacture	.044	.105	.035	.039	.223
Component Testing	.016		.005		.021
Unit Qualification Testing	.013	.008	.002		.023
Reaction Valve					
Data Base Requirements	.254	.237	.056		.547
Design and Manufacture	.013	.062	.020	.006	.101
Component Testing	.004		.001		.005
Unit Qualification Testing	.011	.004	.003		.018
	5.543	5.651	1.433	.247	12.874
Nozzles					
Data Base Requirements	-	-	-	-	-
Design and Manufacture	1.993	1.854	.437		4.284
Component Testing	.468	.435	.103		1.006
Unit Qualification Testing	-	-	-	-	-
	2.461	2.289	.540		5.290

6.0 REFERENCES

(a) Elliott, D. W., "Lift Cruise Fan V/STOL Aircraft Conceptual Design Study T-39 Modification, Volume I Technical Report." NASA CR 151925, November 1976

(b) Anon; "Life/Cruise Fan V/STOL Aircraft Conceptual Design." Contract NAS 2-9307, July 1976

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER NASA CR 151926	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* LIFT CRUISE FAN V/STOL AIRCRAFT CONCEPTUAL DESIGN STUDY T-39 MODIFICATION, VOLUME II SCHEDULES AND BUDGETARY DATA		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) ANON.		8. CONTRACT OR GRANT NUMBER(s) NAS 2-9307
9. PERFORMING ORGANIZATION NAME AND ADDRESS ROCKWELL INTERNATIONAL CORPORATION COLUMBUS AIRCRAFT DIVISION 4300 E. FIFTH AVE., COLUMBUS, OHIO 43216		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS TASK II
11. CONTROLLING OFFICE NAME AND ADDRESS NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AMES RESEARCH CENTER MOFFETT FIELD, CALIFORNIA 94035		12. REPORT DATE NOVEMBER 1976
		13. NUMBER OF PAGES 26
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

DISTRIBUTION OF THIS REPORT IS PROVIDED IN THE INTEREST OF INFORMATION EXCHANGE. RESPONSIBILITY FOR THE CONTENTS RESIDES IN THE AUTHOR OR ORGANIZATION THAT PREPARED IT.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

UNCLASSIFIED - UNLIMITED

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

LIFT CRUISE FAN (GAS)
V/STOL
T-39 MODIFICATION
RESEARCH AND TECHNOLOGY AIRCRAFT

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Cost data, scheduling and test programs are described to support the modification of two T-39's to a V/STOL gas driven lift cruise fan research and technology aircraft.

The cost are based on 1976 dollars and the program duration is identified as 45 months. Design details are described in NASA CR 151925.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*