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FULL SCALE WIND TUNNEL TEST PROGRAM

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REPORT NUMBER 135

FULL-SCALE WINDTUNNEL TEST PROGRAM

U.S. ARMY XV-5A LIFT FAN

RESEARCH AIRCRAFT

ADVANCED ENGINE AND TECHNOLOGY DEPARTMENT
FLIGHT PROPULSION DIVISION
GENERAL ELECTRIC COMPANY
Cincinnati, Ohio 45215

7 APR 1966

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ILLUSTRATIONS

1.0 INTRODUCTION

This report describes the detailed plans for the full-scale windtunnel testing of the U.S. Army XV-5A Lift-Fan Research Aircraft. These tests are part of the Basic Ground and Windtunnel Test Program as required under Contract No. DA44-177-TC-715.

The test program described herein is designed to investigate the aerodynamic and structural behavior of the aircraft during simulated transition, conversion and low speed conventional flight. Detailed test schedules, instrumentation and data requirements and operational limits are described for the tests that will be performed at the NASA - Ames Research Center in the full-scale, 40 by 80 foot, windtunnel facilities.

2.0 PURPOSE AND SCOPE

2.1 Purpose

The purpose of these tests is to investigate the aircraft and propulsion system characteristics during transition, conversion and the conventional flight modes of operation. System functional performance will be obtained coincident with the investigation of the aircraft aerodynamic performance. Particular emphasis will be placed on the investigation of structural temperatures, cooling system performance and the conversion interlock and sequencing system operation.

The resulting aerodynamic and system operational performance will be used to verify the estimated system performance obtained during the numerous full-scale and scale-model tests performed as part of aircraft development. Any large discrepancies in the data obtained as a result of these tests and the estimated performance data will be evaluated as to possible effects on the flight characteristics of the aircraft.

2.2 Scope

This program includes the modification of a flight type aircraft system for windtunnel testing, checkout and calibration prior to conduct of the tests, the actual running of the test program and returning the aircraft to the as-received condition except for changes in original design incorporated during the conduct of the test.

3.0 TEST APPARATUS AND FACILITIES

3.1 Aircraft

The test aircraft to be used during this program shall be the complete Number One aircraft (Army Serial No. 62-4505). The aircraft will be received at NASA - Ames Research Center in a flight type condition. That is, all systems will be installed and previously checked out during Installed Systems Functional Tests. Flight test instrumentation will be included in the aircraft system at the time of delivery.

3.2 Windtunnel

The testing will be performed in the full-scale windtunnel facilities of NASA - Ames Research Center at Moffett Field, California. This windtunnel is a closed cycle system with a 40 by 80 foot test section having semicircular sides of 20 foot radius and a single closed return passage. Testing is performed at atmospheric stagnation pressure with a speed range capability from 0 to 180 knots, continuously variable. During this test program the speed will be limited to 100 knots.

The aircraft will be supported in the center of the test section on a strut mounting system. Two main struts and a collapsable tail strut are provided in the facility with provisions for adjusting for model attachment points. These struts are supported by the balance frame located below the tunnel floor. The balance frame has the capability of recording all six force components with automatic data handling devices.

3.3 Mounting

The aircraft will be mounted by the three strut system provided at the windtunnel facility. Mounting adapters for attachment of the windtunnel ball-socket mounts will be provided with the aircraft. Two of these adapters will be fitted to the wing leading edge spar outboard of the wing fans and the third will be provided for installation at the rear jack pad attachment point, located on the lower fuselage structure just forward of the exhaust nozzles. Each of these mounting pads will be drilled and tapped for direct attachment of the windtunnel ball sockets.

The location of these three mounting points in aircraft station designation are as follows: Each pad will be parallel with the aircraft water lines.

Wing Mounts	WL	96.2
	BL	100.8
	STA	226.5
Tail Mount	WL	79.0
	BL	0
	STA	384.2

3.4 Remote Actuation and Control

Because of the inability to directly operate the aircraft controls during conduct of the tests, provision for remote control must be provided with the aircraft. Since these tests are primarily designed to investigate operation of the aircraft systems, it is desirable to use the existing aircraft control system as much as possible. Therefore, remote actuation will be provided for operation of the conventional pilot operated controls rather than going directly

3.4 (Cont'd)

to the aircraft control surfaces. The pilot operated controls that will be provided with remote actuation are:

* J-85 engine throttle
* Rudder pedal
* Collective stick
* Conventional stick - both longitudinal and lateral

There are additional controls that are pilot operated that will not be provided with remote control capability, such as flaps, landing gear and thrust spoilers. Because of the infrequency of operating these controls, all changes will be made during windtunnel shutdown by direct operation in the cockpit area.

Remote actuation of the controls will be obtained by either electrical screw jack actuators or pneumatic cylinders. Electrical screw jack actuators will be used to operate the rudder pedals, collective stick and conventional stick controls. This will provide locked control positions when not actuating the system. Pneumatic air cylinders will be provided for the J-85 engine throttles. These actuators will be used because of their inherent fail-safe features. In the event of air system failure, the cylinders will retract because of a built-in spring return system. This retracted position is coincidental with "off" position on the throttles, thereby producing a fail-safe system.

Controls for operating the actuator as well as continuous reading position indicators will be installed on the operators console in the windtunnel control room.

3.5 Operational Instrumentation

The instrumentation systems required during the test are divided into two categories, operational and research. Operational instrumentation is defined as that required for adequate safe operation of all aircraft systems. These instruments, including switching and indicator lights, will be installed in the operators console. Most instruments will simply be the aircraft instrument removed from the aircraft and installed remotely on the operators console. Table 1 is a listing of the operational instrumentation that will be provided for continuous monitoring by the system operators. During conduct of the tests, these measurements will be observed by the system operators.

3.6 Research Instrumentation

All instrumentation, not required for system operation, but recorded during the windtunnel test program will be classified as research instrumentation. This data includes such measurements as:

* Temperatures - structure and cooling air
* Cooling system pressures
* Control surface positions
* Fan and engine stress and vibration
* Fan rotational speeds
* Main fan closure vibrations

Aircraft flight test instrumentation will be utilized wherever possible in these areas of measurement.

In order to facilitate rapid data recording and reduction procedures, all research instrumentation will be recorded using automatic systems when applicable. The temperature, 3.6 pressure and position data will be recorded on an automatic high speed digital readout system. The output will be printed in digital counts for monitoring during testing as well as on a punched tape for automatic data processing and reduction. Fan stress and rotational speeds will be recorded on a 14 channel magnetic tape system. Oscilloscope monitoring during the test will be provided

Table II tabulates the research instrumentation except for stress data that will be monitored and recorded during the conduct of the test program.

3.7 Aircraft Utilities

In order to operate the aircraft system in the windtunnel, especially during system calibration and checkout when the engines are not operating, certain necessary external power sources must be provided. Included in these external systems are:

* Fuel
* Hydraulic oil
* Air start for engines
* AC and DC electrical power
* Fire detection and extinguishing systems

Fuel will be routed into the aircraft through the right wing strut attachment, through the tunnel provided in the wing and to the forward fuel tank shut-off valve where the external fuel will be spliced into the systems. The forward and cross-feed fuel shut-off valves will then be used as part of the test fuel control system.

3.7 Hydraulic oil will be required for system operation when the engines are not operating. This situation will exist only during system checkout and calibration. A portable gasoline powered hydraulic cart will be used to supply remote hydraulic power through the fittings provided in the aircraft. This cart will be installed inside the windtunnel and removed during conduct of the tests.

An air starting capability must be provided when the aircraft is installed in the windtunnel. The air start cart will be used for starting the aircraft engines through the fittings provided in the aircraft. In order to preclude premature operation of the starting system, an interlock will be provided at the operator console.

During conduct of the tests, the aircraft will be operated on external electrical power at all times. DC power will be fed into the system through the external power receptacle provided in the aircraft system. The aircraft generators will be inactive during the tests. Remote AC power will be supplied by direct attachment into the aircraft circuit breaker panels. The aircraft inverters will be disconnected during all the tests.

The fire detection and extinguishing system integral in the aircraft will be utilized during conduct of the tests. All monitoring and switching associated with this system will be routed to the operators consoles. This system provides means of detection and extinguishing any fire that may originate in the engine compartment areas. In addition to the aircraft system, auxiliary fire detection and extinguishing means will be provided. The auxiliary fire detection system is a sampling device for the detection of combustible fuel vapors. This system will be installed in the vicinity of the aircraft

3.7 cross-duct compartment. An auxiliary fire extinguishing system will be provided in this area also. This system will discharge carbon dioxide agents in the vicinity of the cross-duct and pitch fan ducts at commands from the operators console.

3.8 Operational Limits

Because of the restraint system unique to the windtunnel tests, it is possible to subject the aircraft to loads not normally encountered during flight. Also since the loads developed in the aircraft are taken out as concentrated forces at the three mounting points, the strength of the aircraft structure in the vicinity of the mount attachment may also be limiting. Based on these two limits, the following maximum allowable loads have been established for each spar attachment point:

* Axial or Chordwise	± 3000#
* Side or Spanwise	± 2100#
* Vertical	6000# up, 3000# down

Using these loads as limits and the estimated aircraft aerodynamic performance, the operational limits shown in Figure 1 have been established for the windtunnel tests when operating at maximum power. This figure presents the range of allowable angle of attack and yaw versus tunnel speed and fan vector angle. Although these limits appear restrictive, a satisfactory windtunnel program can be performed covering the normal operating envelopes expected during flight of the aircraft. These limits are considerably relaxed at the low power settings where most of the testing will be performed.

3.8 In addition to establishment of these operational limits, the actual loads will be continuously monitored during conduct of the tests. This will be accomplished using the analog computing system presently setup in the windtunnel.

4.0 TEST PROGRAM

4.1 General

The aircraft, when received at NASA - Ames, will be a complete flight ready system having underwent complete systems functional tests prior to shipment. The system will then be fitted with all windtunnel modifications including instrumentation and remote actuation in preparation for the tests. Prior to installation in the windtunnel, a ground run-up and checkout must be performed in order to preclude unnecessary delays once the system is installed in the windtunnel. At the conclusion of the windtunnel tests, the aircraft will be refitted into its original condition and a modified systems functional test will be performed to insure proper systems operation.

4.2 Pre-Tunnel Checkout Run

Upon receiving the aircraft at NASA - Ames all windtunnel modification will be performed. These modifications include:

* Installation of the remote actuation system
* Hookup of the research instrumentation system
* Hookup of the operational instrumentation system
* Routing of fuel and electrical lines
* Setup of aircraft and auxiliary fire extinguisher system.

At the conclusion of these modifications, the pre-tunnel checkout tests will be performed.

For these tests the aircraft will be lashed to the ground at three points. All instrumentation channels will be functionally checked and calibrated where applicable. The remote actuation will be operated, limits of travel set and position indicators calibrated. Following all setup and calibrating the ground runups will be performed. These will include:

4.2 * Start up and operation of the engines to 60% speed in the turbojet mode

* Operation of all cockpit remote control systems

* Operation of flaps, thrust spoilers and all con ventional trim controls and set trim to zero.

* Conversion to the fan mode at idle engine power

* Accelerate engines to 60% RPM in fan mode

* Operate all remote cockpit controls including fan vector controls and tail incidence

* Operate trim controls and return to center.

* Convert from fan mode to turbojet mode at idle power and repeat one complete cycle of conversions.

* Shutdown engines in conventional flight mode with exit louvers and pitch fan closed.

During these checkouts all instrumentation and recording equipment will be setup with the wiring and systems as will be used in the windtunnel setup. Satisfactory operation of all systems must be insured prior to moving aircraft to windtunnel.

4.3 <u>Windtunnel Test Program</u>

After completion of the pretunnel checkout tests and approval by NASA - Full-Scale Windtunnel Engineering, the aircraft will be installed in the windtunnel The test program to be performed in the windtunnel will be controlled by NASA engineering and run according to the standard operating procedures established for the facility. During conduct of the test all research instrumentation will be monitored and any indications of problem

4.3 areas in the aircraft will be noted and immediate corrective actions undertaken.

The test program to be performed in the windtunnel is divided into two parts:

I - Transition and Conversion
II - Conventional

Part I, transitional flight, will be primarily concerned with total propulsion plus aircraft system performance during the fan mode at air speeds from hover through maximum conversion speed. Most of the testing will be performed at 65% main fan rotational speeds. This reduced power setting is selected as a good compromise for obtaining valid aerodynamic data without subjecting the system to undue high power operation. The concluding part of the test program will be performed at near maximum power for investigation of high power structural behavior of the system. Table III presents the run schedule planned for this phase of the testing. As is the case for any test program, deviations from this schedule may become necessary as the testing progresses. This run schedule therefore serves only as an initial guide to test planning. Included in this test phase are investigations of all flight attitude variables, propulsion system variables and control system deflections.

Part II, conventional flight, will be concerned with the investigation of aircraft aerodynamics with the system in the conventional flight configuration. The effects of air speed, flight attitude, flap deflection, and control surface deflection will be investigated in this phase of the test program. Included in the program is an investigation of conventional aerodynamics during the interval immediately prior to and after the conversion

4.3 cycle. These tests include investigations of thrust spoiler operation and opening the pitch fan and exit vane systems. The majority of this aerodynamic performance will be obtained with the turbojets off or at a relatively low power setting. This test condition will be dictated by the ease of operation of the aircraft on the external power system as compared to internal power.

The conversion part of the program will be concerned with investigation of aircraft performance during the short interval between the time the conversion sequence is initiated and when the fan speed transients have decayed to zero.

It is anticipated that very little aerodynamic performance will be obtained during these tests since they will be more of a functional type of test arrangement. During these tests several conversion cycles, in both directions - fan to turbojet and turbojet to fan, will be performed. During each cycle because of the transient nature of the system, the data must be recorded on a continuous reading system. For these tests an eight channel oscillograph will be setup and the following recorded on continuous traces:

* Main and pitch fan speed
* Horizontal tail incidence
* Main fan door position
* Diverter valve position
* Event marker indicating conversion switch operation.

Simultaneous with these cycles, the windtunnel force measuring system will be set at a fast reading cycle. In this case, force data will be taken at 0.6 second intervals throughout the transients. It is anticipated that the oscillograph traces and force data, plus any steady state data obtained in the Part I tests will yield a trace of transient lift, drag and

4.3 pitching moments experienced by the aircraft.

The above tests will be repeated for a range of aircraft angles of attack from zero to about eight degrees. This data will then permit evaluation of the aircraft attitude during a conversion cycle from the fan mode to turbojet and in the reverse direction.

4.4 <u>Post Tunnel Checkout</u>

Following completion of the windtunnel tests the aircraft will be removed for refitting into a flight type condition. This will include removal of all test type hardware and refitting of flight type hardware where applicable. Following refitting of the aircraft, ground functional tests will be performed to verify proper installation of those aircraft components either removed or modified during the windtunnel test program. The aircraft will then be prepared for shipment to Edwards Air Force Base for inclusion in the flight test program scheduled to be in progress during these windtunnel tests.

5.0 DATA REDUCTION, ANALYSIS AND REPORT

5.1 Data Reduction

Data reduction shall include reduction to Engineering units, all measurements obtained from the windtunnel force balance and the digital recording systems. Automatic data reduction facility using electronic computers will be utilized whenever possible. The force data will be reduced by NASA full-scale windtunnel personnel using existing data processing methods.

The punched tape output, as obtained from the research instrumentation system, will first be converted into a card system and then reduced into useable units by electronic computing machines.

During conduct of the test both force and research instrumentation will be continuously monitored to insure satisfactory operation of the aircraft and windtunnel systems.

5.2 Data Analysis

Data analysis will include correlation of all test results, using non-dimensional coefficient where applicable, into a form suitable for comparison with previously estimated performance and for use in future flight test evaluation. The data will be plotted in appropriate curves showing the effects of each of the test variables.

5.3 Report

Following completion of the test and evaluation of the data, a report summarizes the results of the complete test program including test setup and procedures, calibrations, test results and conclusions will be prepared and submitted as required under contract No. DA44-177-TC-715.

6.0 SCHEDULE

Figure 2 presents the estimated schedule for conduct of the windtunnel tests. This schedule is based on a start date when the aircraft is received at NASA - Ames. It should be noted that this schedule is largely dependent on the availability of the 40 x 80 windtunnel facility at the time the aircraft is ready for tests. Because of the high work loads in the facility, the availability of the facility for these tests is difficult to predict and may exert some influence on the test schedule.

TABLE I

OPERATIONAL INSTRUMENTATION

To Be Installed On Operators Console -

J-85 RPM - left and right

J-85 EGT - left and right

Fuel Flow - left and right

J-85 Oil Pressure - combination

Diverter Valve - "Diverted Indicator"

Hydraulic Pressure - combination

Wing Fan RPM - dual

Pitch Fan RPM

Vector angle indicator

Fire warning lights and extinguisher switches

J-85 ignition switches - left and right

VTOL - CTOL conversion switch

Exit louver vector control

Horizontal tail incidence control switch and position indicator

Remote actuation switching and position indicators

Structure overheat warning indicator

Fan bearing overheat warning indicator

TABLE II

RESEARCH INSTRUMENTATION

TEMPERATURES

Code No	Measurement	Thermocouple Type
TG-2	Exhaust gas temp. (RH Engine)	C-A
TG-3	Exhaust gas temp. (LH Engine)	C-A
TG-5	Wing fan scroll compartment (LH)	I-C
TG-15	Cooling fan compartment	I-C
TG-17	LH Fwd. cooling fan exhaust	I-C
TG-4	Electronics comp. inlet	I-C
TG-7	Pitch fan comp. inlet	I-C
TG-16	Pitch fan ejector inlet	I-C
TG-19	LH Aft cooling fan exhaust	I-C
TG-21	LH Engine turbine section	I-C
TG-25	LH Engine tailpipe ejector	I-C
TG-11	Cross-duct compartment	I-C
TG-27	LH wing fan aft ejector	I-C
TG-29	LH wing fan fwd. ejector	I-C
TG-6	Wing fan scroll compartment (RH)	I-C
TL-1	L.H. engine oil	I-C
TL-2	R.H. engine oil	I-C
TL-3	L.H. hydraulic oil	I-C
TL-4	R.H. hydraulic oil	I-C
TS-301	Pitch fan side mount, STA 59.0	I-C
TS-302	Pitch fan aft mount, STA 78.0	I-C
TS-303	Pitch fan aft hinge frame, STA 85.5	I-C
TS-306	Pitch fan front frame	I-C
	(all LH wing)	
TS-601	Rear spar lwr. cap, BL24	I-C
TS-603	Rear spar lwr. cap, BL44	I-C
TS-605	Rear spar lwr. cap, BL61	I-C
TS-607	Rear spar lwr. cap, BL71	I-C
TS-609	Rear spar upr. cap, BL44	I-C
TS-611	Rear spar upr. cap, BL61	I-C
TS-613	Rear mount support, BL61	I-C

TABLE II

(Cont'd)

Code No	Measurement	Thermocouple Type
TS-617	Front spar lwr. cap, BL61	I-C
TS-619	Wing panel, upr, fwd, inbd	I-C
TS-621	Wing panel, upr, aft, inbd	I-C
TS-623	Wing panel, lwr, fwd, inbd	I-C
TS-625	Wing panel, lwr, aft, inbd	I-C
TS-627	Faring inbd, BL25	I-C
TS-629	Faring inbd BL56	I-C
TS-651	Flap fitting, inbd	I-C
TS-661	Flap spar lwr flange, BL61	I-C
TS-663	Flap spar, lwr flange, BL100	I-C
TS502	Spare frame - 41 member	I-C
TS503	Spare frame - 73 member	I-C
TS504	Spare frame - 29 member	I-C
TS506	Center wing spar, lower cap	I-C
TS713	MLG Door, - 3 panel, STA 284	I-C
TS715	MLG Door, - 3 panel, STA 314	I-C
TS717	MLG Door, - 1 panel, STA 284	I-C
TS701	MLG Support Structure, WL83-5	I-C
TS705	MLG V brace, WL 87	I-C
TS453	Aft fuse. exhaust shroud	C-A
TS451	Aft fuse. exhaust duct	C-A
TG101	Wing fan inlet (RH)	I-C
TG102		I-C
TG103		I-C
TG104		I-C
TG105		I-C
TG106		I-C
TG107		I-C
TG108		I-C
TG111	Wing fan inlet (LH)	I-C
TG112		I-C
TG113		I-C
TG114		I-C
TG115		I-C
TG116		I-C
TG117		I-C
TG118		I-C

TABLE II
(Cont'd)

Code No	Measurement	Thermocouple Type
TG-121	J-85 Inlet	I-C
TG-122			I-C
TG-123			I-C
TG-124			I-C
TG-125			I-C
TG-126			I-C

TOTALS	I - C	69
	C - A	4
Spare	I - C	7

PRESSURES

Code No	Measurement
PG-26	Cooling fan compartment inlet
PG-27	Cooling fan inlet
PG-29	Foreward cooling fan exhaust
PG-28	Electrical compartment inlet
PG-24	Pitch fan compartment inlet
PG-30	Pitch fan ejector inlet
PG-31	Aft cooling fan exhaust
PG-25	Cross-duct compartment
PG-35	Wing fan aft ejector
PG-37	Wing fan forward ejector

TABLE II
(Cont'd)

POSITIONS

Code No	Measurement
PO-3	Elevator
PO-4	Rudder
PO-6	Aileron, LH
PO-9	Horizontal Stabilizer
PO-13	Exit louver, LH, Odd
PO-14	Exit louver, LH, Even
PO-15	Exit louver, RH, Odd
PO-16	Exit louver, RH, Even
PO-17	Vector Angle
PO-22	Pitch Fan exit doors
PO-30	Throttle, LH
PO-31	Throttle, RH
PO-32	Lateral stick
PO-33	Longitudinal stick
PO-34	Rudder pedal
PO-35	Collective stick

TABLE III
APPROXIMATE TEST RUN SCHEDULE

Part I - Transition and Conversion

RUN	VAR	Vo	α	β_v	ψ	RPM	i_t	δ_{se}	δ_{sa}	δ_{sr}	δ_{sc}	Nose Fan
1	RPM	0	0	- 3*	0	1200/Max	20	0	0	0	0	On
2	Bv			-10/45		1700						
3	Bv	20										
4	Bv	30										
5	Bv	40										
6	Bv	60										
7	Bv	70					18					
8	Bv	80					15					
9	α	30	-10/25	12*			20					
10	α	40		20*								
11	α	60		32*								
12	α	70		45*			18					
13	ψ	30	0	12*	-10/+10		20					
14	ψ	40		20*								
15	ψ	60		32*								
16	ψ	70		45*			18					
17	ψ	40	-4	20*			20					
18	ψ	60		32*								
19	ψ	70		45*			18					
20	ψ	40	+8	20*			20					

TABLE III
APPROXIMATE TEST RUN SCHEDULE

RUN	VAR	Vo	α	β_v	ψ	RPM	i_t	δ_{se}	δ_{sa}	δ_{sr}	δ_{sc}	Nose Fan
21	ψ	60	+8	32*	-10/+10	1700	20	0	0	0	0	On
22	ψ	70		45*			18					
23	Bv	40	-4	0/45	0		20					
24	Bv	60										
25	Bv	80					15					
26	Bv	40	+8				20					
27	Bv	60										
28	Bv	80					15					
29	i_t	40	0	20*			-5/+20					
30	i_t	60		52*								
31	i_t	80		45*								
32	δ_{se}	0		- 3*			20	+100/-100				
33	δ_{se}	30		12*								
34	δ_{se}	40		20*								
35	δ_{se}	60		32*								
36	δ_{se}	70		45*			18					
37	δ_{sa}	0		- 3*			20	0	+100/-100			
38	δ_{sa}	30		12*								
39	δ_{sa}	40		20*								
40	δ_{sa}	60		32*								

TABLE III

APPROXIMATE TEST RUN SCHEDULE

RUN	VAR	Vo	α	β_v	ψ	RPM	i_t	δ_{se}	δ_{sa}	δ_{sr}	δ_{sc}	Nose Fan
61	Bv	0	0	-10/20	0	2400	20	0	0	0	0	On
62	Bv	20		-5/25								
63	Bv	40		0/30								
64	Bv	60		10/40								
65	Bv	80		20/45								
66	Bv	100		30/45			18					
67	α	40	-8/+8	12*			20					
68	α	60		21*								
69	α	80		32*								
70	α	100		45*			18					
71	ψ	80	0	32*	-10/+10		20					
72	ψ	100	0	45*	-5/+5		18					
73	Vo	20/100		45	0	2000	20					
74	RPM	100	-4			2400/0	15*					
75	RPM		0									
76	RPM		+4									
77	RPM		+8									
78	i_t		0			2000	-5/+20					
79	i_t					1200						
80	Bv	80		20/45		2400	20					Off

TABLE III

APPROXIMATE TEST RUN SCHEDULE

RUN	VAR	Vo	α	β_v	Ψ	RPM	i_t	δ_{se}	δ_{sa}	δ_{sr}	δ_{sc}	Nose Fan
41	δ_{sa}	70	0	45*	0	1700	18	0	+100/-100	0	0	On
42	δ_{sr}	0		- 5*			20		0	+100/-100		
43	δ_{sr}	30		+12*								
44	δ_{sr}	40		20*								
45	δ_{sr}	60		32*								
46	δ_{sr}	70		45*			18					
47	δ_{sc}	0		- 3*			20			0	0/100	On
48	δ_{sc}	30		12*								
49	δ_{sc}	40		20*								
50	δ_{sc}	60		32*								
51	δ_{sc}	0		- 3					+100/-100	+50	0	
52	δ_{sa}	30		12*								
53	δ_{sa}	40		20*								
54	δ_{sc}	60		32*								
55	δ_{sa}	0		- 3*						+100		
56	δ_{sa}	30		12*								
57	δ_{sa}	40		20*								
58	δ_{sa}	60		32*								
59	δ_{sc}	0		- 3					+100	0	0/100	
60	δ_{sc}	30		12*			30					

TABLE III

APPROXIMATE TEST RUN SCHEDULE

RUN	VAR	Vo	α	β_v	ψ	RPM	i_t	δ_{se}	δ_{sa}	δ_{sr}	δ_{sc}	Nose Fan
81	Bv	100	0	30/45	0	2400	18	0	0	0	0	Off
82	Bv					2000	15					
83	α	80	-5/+8	30*		2400	20					
84	α	100		40*			18					
85	α			45*		2000	15					
86	ψ		0	40*	-5/	2400	18					
87	ψ			45*		2000	15					
88	δ_{sc}	80		30*	0	2400	20	-100/+100				
89	δ_{se}	100		40*			18					
90	RPM	0		- 3*		200/Max	20	0				
91	Gear	100		45		2400	18					On/Off
92	Vo	20/100				2000	20					Off
93	RPM	100				Single Engine 1700	15					On
94	Bv	30		0/45			20					
95	Bv	40										
96	Bv	60										
97	Bv	70					18					
98	Bv	30					20					
99	Bv	40										
100	Bv	60										

TABLE III

APPROXIMATE TEST RUN SCHEDULE

RUN	VAR	Vo	α	β_v	ψ	RPM	i_t	δ_{se}	δ_{sa}	δ_{sr}	δ_{sc}	Nose Fan
101	Bv	70	0	0/45	0	1700	18	0	0	0	0	On

Run 94 - 97, δ_F = 30°, Run 98 - 101, δ_F = 0°

δ_{se} - longitudinal stick position, ± 100% throw

δ_{sa} - lateral stick operation, ± 100% throw

δ_{sr} - rudder pedal position, ± 100% stroke

δ_{sc} - collective stick position, 0 (full up), 100% (down)

* - trimmed conditions

Run Nos.	Purpose of Run
1	Static Lift Calibration
2-8	Louver Effectiveness
9-12	Longitudinal Stability
13-22	Lateral Stability
23-28	Louver Effectiveness, Angle of Attack Variable
29-31	Tail Effectiveness
32-36	Pitch Control Effectiveness
37-41	Roll Control Effectiveness
42-46	Yaw Control Effectiveness
47-49	Collective Control Effectiveness
51-58	Combined Roll-Yaw Control Effectiveness
59-60	Combined Roll-Collective Control Effectiveness
61-72	Hi Fan Speed Checkout
73	Fan Speed Changes With Vo
74-77	Conversion Between Fan and Turbojet Mode
78-79	Tail Effectiveness - Hi Speeds
80-89	Pitch Fan "Off" Performance
90	Static Calibration, P.F. "off."
91	Gear Drag Increment
92	Fan Speed Changes P.F. "off"
93	Sequential D/V Operation
94-101	Variable Flap Settings

TABLE III
APPROXIMATE TEST RUN SCHEDULE

Part II - Conventional

RUN	VAC	Vo	α	ψ	δ_F	i_t	δ_{se}	δ_{sa}	δ_{sr}	REMARKS
1	α	100	-10/20	0	0	0°	0	0	0	Power "Off" or @ Idle
2	α				15					
3	α				30					
4	α				45					
5	ψ		0	-10/+10	0					
6	ψ		+8							
7	ψ		0		45					
8	ψ		+8							
9	i_t		0	0	0	-5/20				
10	i_t				45					
11	i_t		+8							
12	δ_{se}		0			0	+100/-100			
13	δ_{se}		+8							
14	δ_{sa}		0				0			
15	δ_{sa}		+8					+100/-100		
16	δ_{sr}		0						+100/-100	
17	δ_{sa}		0		30			+100/-100	0	
18	δ_{sa}				0					
19	α		-10/20		45			0		Conversion Config.
20	α									VTOL Config.

TABLE III

APPROXIMATE TEST RUN SCHEDULE

RUN	VAC	Vo	α	ψ	δ_F	i_t	δ_{se}	δ_{sa}	δ_{sr}	REMARKS
21	ψ	100	0	-10/10		0	0	0	0	Conversion Config.
22	ψ									VTOL Config.
23	α		-10/20	0	45					Power @ Military
24	α									} Geardown
25	ψ			-10/+10						
26	Power		0	0						Power @ Idle/Mil.
27	α		-10/20							} Thrust Spoilers Set For Trim
28	ψ		0	-10/+10						

ESTIMATED OPERATIONAL LIMITS FOR
XV-5A WINDTUNNEL TESTS
FAN SPEED = 2400 RPM

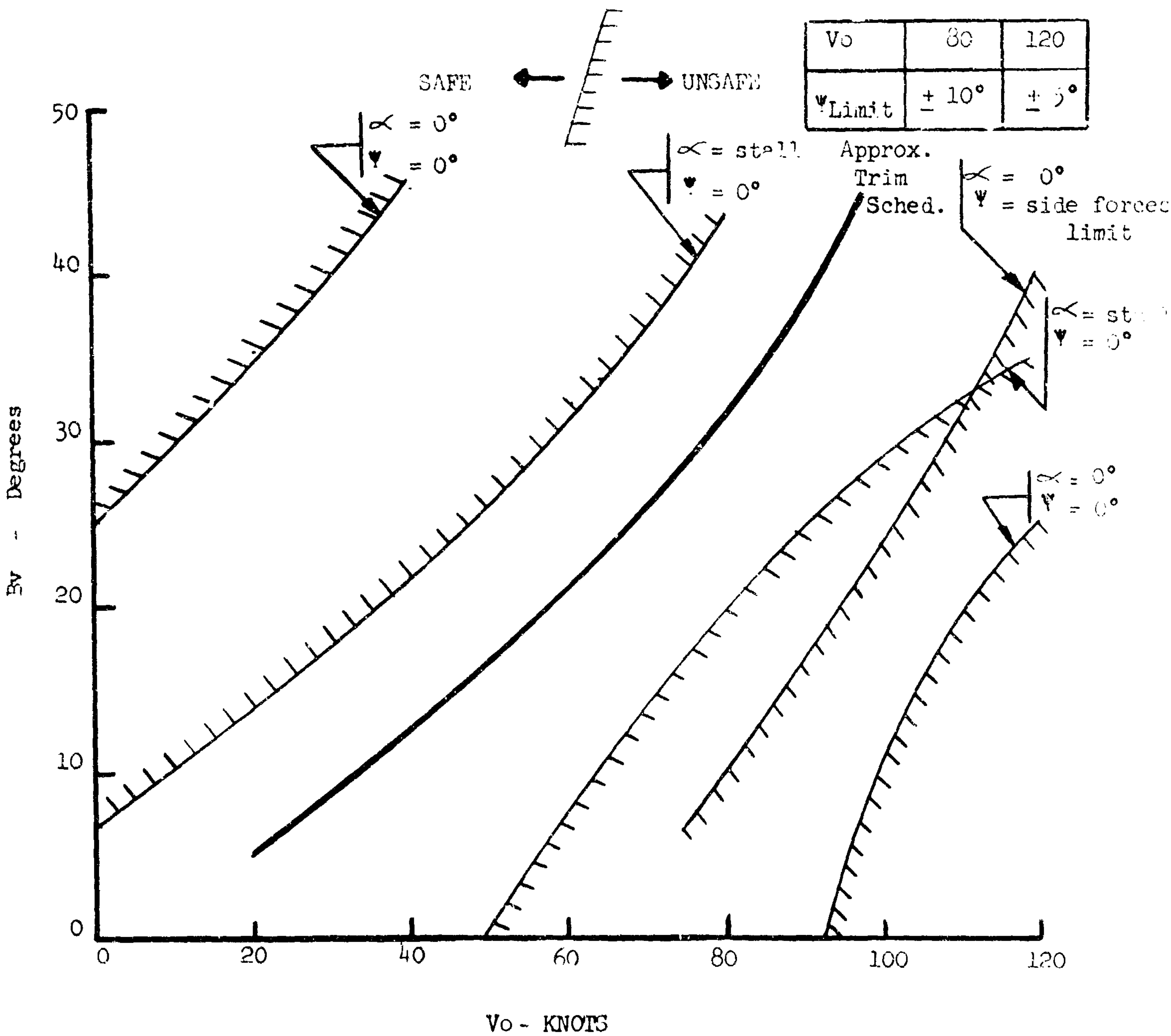

FIGURE 1

WIND TUNNEL TEST SCHEDULE

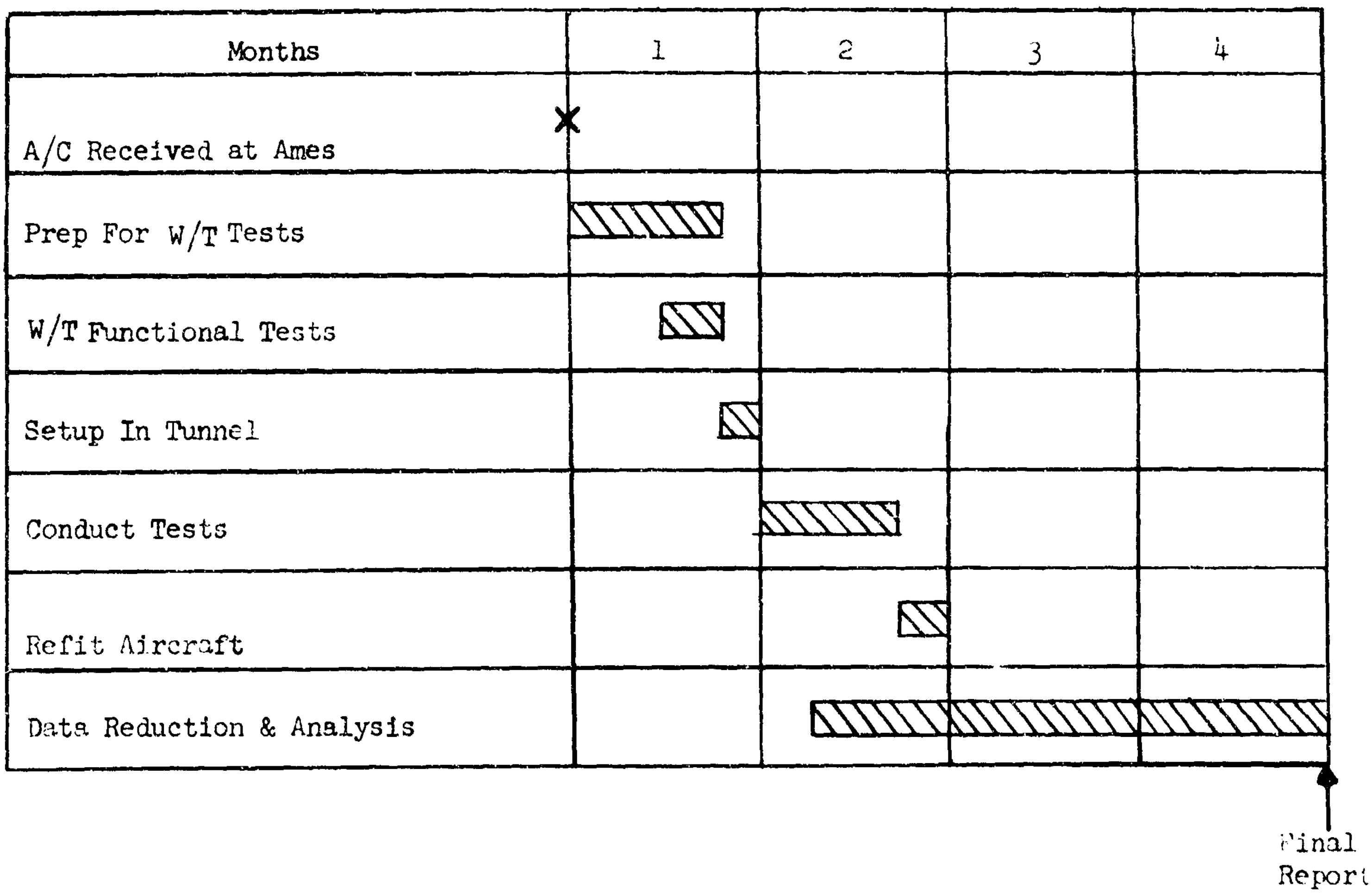

FIGURE 2