UNCLASSIFIED

| AD NUMBER |
| --- |
| **AD869751** |
| LIMITATION CHANGES |
| TO:<br>**Approved for public release; distribution is unlimited.** |
| FROM:<br>**Distribution authorized to DoD only; Administrative/Operational Use; APR 1966. Other requests shall be referred to Army Aviation System Command, St. Louis, Missouri.** |
| AUTHORITY |
| **USAAVSCOM ltr 12 Nov 1973** |

THIS PAGE IS UNCLASSIFIED

USATECOM PROJECT NO. 4-6-0150-01
USAAVNTA PROJECT NO. 66-01
USAAVNTA 66-02

AND

USATECOM PROJECT NO. 4-6-0150-02
USAAVNTA PROJECT NO. 66-02
(PHASE D)

# ENGINEERING TEST
(PHASES B & D)
(PRODUCT IMPROVEMENT TEST)
OF UH-1B/540 ROTOR HELICOPTER
EQUIPPED WITH T53-L-13 ENGINE

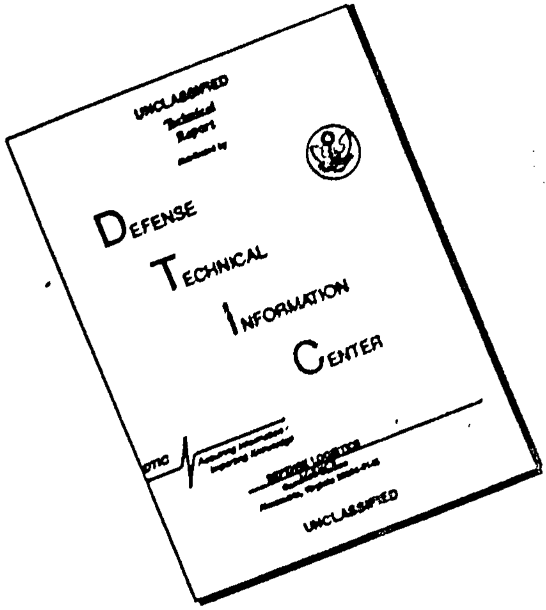
## TEST PLAN

JOHN T. BLAHA

APRIL 1966

U. S. ARMY AVIATION TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA

# DISCLAIMER NOTICE




THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

Statement A

Project Manager, Utility Aircraft (AMCPM-UA)
US Army Aviation Systems Command
St. Louis, Missouri 63166

[illegible]
[illegible] 1970

TABLE OF CONTENTS

Page

## SECTION 1 INTRODUCTION

### 1.1 BACKGROUND

The Army has a continuing requirement to attain the optimum potential from all equipment in the inventory. The ultimate usefulness of the UH-1B/540 helicopter could be enhanced by an improvement in the hover and climb capabilities and the capability of the helicopter to reach placard limit airspeeds under a wider variety of ambient condition-gross weight combinations.

A limited engineering flight test of the YT53-L-13 engine installed in the UH-1D was conducted by the U. S. Army Aviation Test Activity (USAAVNTA) in January 1965. The results of this test were reported in Reference e, Section 3, Appendix IV.

The decision by the Iroquois Project Manager to install the T53-L-13 in future production UH-1B/540 helicopters resulted in the requirement for the test outlined in this test plan.

### 1.2 DESCRIPTION OF MATERIEL

The T53-L-13 is a free turbine engine rated at 1400 shaft horsepower (SHP). The engine has the same physical envelope as, and is interchangeable with, the T53-L-11 engine currently installed in the UH-1B helicopter. The increase in power of the T53-L-13 engine is accomplished by the modification of the axial compressor, addition of a second-stage compressor turbine gas producer, and addition of a second-stage power turbine. The aircraft in which the T53-L-13 engine will be installed for the test is a standard UH-1B equipped with a 540 rotor. The transmission of the UH-1B is limited to 1100 SHP at 324 rotor RPM.

### 1.3 TEST OBJECTIVES

The objective of these tests is to conduct engineering tests (product improvement tests) to meet:

a. The detailed objectives of Phase B - Contractor's Compliance Flight Tests.

b. The detailed objectives of Phase D - Airworthiness and Performance Tests.

These tests will be limited to that portion of the helicopter flight envelope in which differences may be expected to exist as a result of the new engine installation

Specific objectives are to:

a. Provide sufficient performance data so that the increased performance provided the UH-1B by the T53-L-13 can be defined.

b. Determine if engine operating characteristics are satisfactory throughout the flight envelope.

c. Determine if any flying quality deficiencies exist as a result of the expanded flight envelope of the UH-1B/540 rotor helicopter

## SECTION 2 DETAILS OF TEST

### 2.1 INTRODUCTION

The operating envelope of the UH 1B/540 rotor helicopter with the T53 L 11 engine installed is under most operating conditions limited by [illegible] available  Insufficient testing has been accomplished to define the stability and control of the UH 1B at the placard limit airspeed  Stability and control tests which will be quantitative in nature are planned for this evaluation

Aircraft performance and stability and control and engine characteristics will be determined from sensitive test instruments which are listed in Appendix II

Test results will be compared with the requirements of Military Specification MIL H 8501A (Reference f)

This test plan should be interpreted as a guide only and tests will be added or deleted as prior test experience dictates

### 2 2 PERFORMANCE

#### 2 2 1 Climb

##### 2 2 1 1 Objective

The objectives of these tests are to determine the climb performance of the UH 1B/540 rotor helicopter with the T53 L 13 engine and to determine the installed horsepower available in the helicopter

##### 2 2 1 2 Method

Two continuous climbs will be flown from sea level to the service ceiling at military rated power at each of the following conditions

| Gross Weight lb | Rotor Speed RPM | Center of Gravity |
|---|---|---|
| 7000 | Optimum $N_2$ | Mid |
| 8600 | Optimum $N_2$ | Mid |
| 9500 | Optimum $N_2$ | Mid |

The climb schedules developed in Reference c will be used during these tests. Sufficient tests will be conducted to determine the [illegible]um power turbine speed ($N_2$) as a function of altitude.

2.2.1.3 Data Required

The following data will be recorded continuously during the climbs and reduced to standard atmospheric and gross weight conditions:

a. Altitude (Ship and Boom)

b. Time to Climb

c. Airspeed (Ship and Boom)

d. Outside Air Temperature

e. Fuel Used

f. All Engine Power Parameters

2.2.2 Level Flight

2.2.2.1 Objective

The objective of these tests is to supplement the level flight performance data of Reference c with data obtained at aircraft loading ambient condition combinations not attainable with the T53-L-11 engine.

2.2.2.2 Method

Data will be taken in stabilized level flight from maximum airspeed to approximately 30 knots indicated airspeed (KIAS) in 10 knot increments. Each speed power will be flown at a constant thrust coefficient by increasing altitude for successive data points as fuel is consumed. Speed power polars will be flown at an altitude of approximately 90 percent of the service ceilings determined in Paragraph 2.2.1.2 at gross weights of 7000 pounds, 8600 pounds, and 9500 pounds and rotor speeds of 314 RPM and 324 RPM for each gross weight.

2.2.2.3 Data Required

The following data will be recorded for each point.

a. Altitude

b. Airspeed

c. Outside Air Temperature

d. Fuel Used

e. All Engine Power Parameters

This data will be reduced to standard day conditions and to a non-dimensional form (power coefficient ($C_P$), thrust coefficient ($C_T$), and advance ratio ( )) to complement the data of Reference c.

2.2.3 Hover

2.2.3.1 Objective

The objective of these tests is to supplement the hovering performance data of Reference c with data obtained at gross weight ambient condition combinations not attainable with the T53-L-11 engine.

2.2.3.2 Method

Tethered hovering tests will be conducted at a 10,000-foot (or higher) test site at skid heights of 2 feet, 5 feet, 15 feet and out of ground effect (OGE). A load cell will be placed in series with the tethering line and the thrust resulting from various power settings will be recorded. Tests will be conducted at each skid height at rotor speeds of 324 and 314 RPM. (These RPM's are subject to change based on the optimum $N_2$ tests described in Paragraph 2.2.1.2)

2.2.3.3 Data Required

The following data will be recorded for each point.

a Altitude

b Load Cell Reading

c Outside Air Temperature

d Fuel [illegible]

e All Engine Power Parameters

f Skid height

This data will be reduced to standard-day conditions and to a non-dimensional form ($C_P$, $C_T$, skid height) to complement the data of Reference c

2.2.4 Takeoff

2.2.4.1 Objective

The objective of these tests is to supplement and verify the takeoff performance data of Reference c with data obtained using the T53-L-13 engine

2.2.4.2 Method

Takeoff tests will be conducted at a 10,000 foot or higher test site The aircraft will be loaded so that takeoff power available is sufficient for hovering at 2 feet at 324 RPM and at 15 feet at 324 RPM Takeoff performance will be defined by using the recommended technique of Reference c, the "level acceleration from a 2 foot skid height" technique This technique involves establishing a 2 foot hover then accelerating at constant height until a predetermined climbout airspeed is reached Several climbout airspeeds will be used to determine a recommended climbout airspeed

2.2.4.3 Data Required

The following data will be recorded for each takeoff

a Fairchild Flight Analyzer Plate

b Altitude

c Airspeed

d Outside Air Temperature

e Fuel Used

f All Engine [illegible] Parameters

This data will be reduced to standard day conditions and to a non-dimensional excess power coefficient available ($\Delta C_p$) form to complement the data of Reference [illegible]

2.2.5 Airspeed Calibration

2.2.5.1 Objective

The objective of these tests is to determine the position error of the test airspeed system.

2.2.5.2 Method

A trailing bomb with a known zero position error airspeed system will be used for calibration. This test will be flown at 324 RPM, 7000 pounds and a mid center of gravity (C.G.) in climb, level flight and autorotation at any convenient altitude.

2.2.5.3 Data Required

The following data will be recorded for each calibration point:

a Trailing Bomb Airspeed and Altitude

b Test System Airspeed and Altitude

c Fuel Used

d Outside Air Temperature

e Flight Condition

2.3 STABILITY AND CONTROL AND ENGINE CHARACTERISTICS

2.3.1 Stability and Control

2.3.1.1 Objective

The objective of these tests is to insure that there is no deterioration of handling qualities due to the expanded flight envelope.

#### 2.3.1.2 Method

Tests will be conducted to evaluate the stability and control character[illegible] at the placard limit airspeeds which have been up to now unattainable in the UH-1B/540 rotor helicopter. Each of the [illegible] in the following paragraphs will be conducted to de[illegible] [illegible]ular stability and control characteristic.

#### 2.3.1.2.1 Static Longitudinal Stability

The apparent static longitudinal stability will be evaluated by slowing the helicopter from a selected trim speed by the use of the longitudinal cyclic control. The collective pitch control will be maintained in the trim position. Altitude will be allowed to vary. Stabilized data points will be recorded every 4 knots through the speed range of interest. Tests will be conducted at the following conditions:

| Initial Trim Condition | | | | | |
|---|---|---|---|---|---|
| Airspeed | Altitude ft | Rotor RPM | Center of Gravity | Gross Weight lb | Speed Range of Interest |
| $V_{max}$ | 5000 | 324 | Aft | 7500 | $V_{max}$ to $V_{max}$ - 20 kt |
| $V_{max}$ | 0.9 Service Ceiling | 324 | Aft | 7500 | $V_{max}$ to $V_{max}$ - 20 kt |
| $V_{max}$ | 5000 | 314 | Aft | 7500 | $V_{max}$ to $V_{max}$ - 20 kt |
| $V_{max}$ | 5000 | 324 | Fwd | 7500 | $V_{max}$ to $V_{max}$ - 20 kt |
| $V_{max}$ | 5000 | 324 | Aft | 9500 | $V_{max}$ to $V_{max}$ - 20 kt |

#### 2.3.1.2.2 Static Lateral Directional Stability

The static lateral directional stability characteristics will be evaluated during steady, non turning sideslips. Data will be recorded in approximately 3-degree sideslip increments. Airspeed will be maintained at a constant value. Tests will be conducted to the placard sideslip limit at each of the trim conditions listed in Paragraph 2.3.1.2.1.

2.3.1.2.3 Sideward and Rearward Flight

Hovering characteristics in crosswinds and tailwinds will be simulated [illegible] [illegible]ward and rearward flight. Data will be recorded in stabi[illegible] [illegible]deward and rearward flight using a pace vehicle as a [illegible] [illegible]. Unless control limitations are encountered, sideward and rearward flight will be conducted to airspeeds of 30 knots. Tests will be conducted at a 10,000 foot or higher altitude test site at a gross weight which results in a hovering skid height of 15 feet or 9500 pounds, whichever is lower.

2.3.1.2.4 Autorotative Entries

The helicopter response to sudden engine failure at high speed will be evaluated by means of the [illegible] [illegible] at each of the trim conditions listed in Paragraph 2.3.1.2.1. The controls will be held fixed for 1 second or until recovery becomes necessary.

2.3.1.2.5 Dynamic Stability

The aircraft reaction following an abrupt (gust) disturbance will be evaluated by rapidly displacing a control 1 inch from trim, holding it for 1 second, then returning the control to the original trim position. A control jig will be used to insure accurate inputs. Tests will be conducted about all three axes in two directions at the trim conditions listed in Paragraph 2.3.1.2.1. After the input the controls will be held fixed until the resulting motion damps out or recovery becomes necessary.

2.3.1.2.6 Controllability

The controllability will be evaluated by analyzing the motion of the helicopter after abrupt step type control inputs are applied. The parameters of particular importance in evaluating the controllability are the response (maximum rate) and sensitivity (maximum angular acceleration) and the times after control input at which these maximums occur. Tests will be conducted about all axes in two directions at the trim conditions listed in Paragraph 2.3.1.2.1. Control inputs of approximately 1/4, 1/2 and 1 inch will be used. A control jig will be used to insure precise inputs. All inputs will be held until maximum rate is obtained or recovery becomes necessary.

2.3.1.3 Data Required

The following data will be recorded continuously during each test.

a. Test Airspeed

b. Test Altitude

c. Outside Air Temperature

d. Fuel Used

e. Angles of Sideslip and Attack

f. Angles of Pitch, Roll and Yaw

g. Rates of Pitch, Roll and Yaw

h. All Control Positions

i. C.G. Normal Acceleration

This data will be analyzed and presented in the format specified in Reference f.

2.3.2 Engine Characteristics

2.3.2.1 Objective

The objectives of these tests are to insure that no objectionable characteristics result from installing the T53-L-13 in the UH-1B and to obtain an estimate of the static engine characteristics and compliance with the guarantees of the engine model specification (Reference d).

2.3.2.2 Method

Any objectionable characteristics of the T53-L-13 observed during other tests will be noted and investigated further during these tests.

The presence of any compressor stall or other undesirable features will be evaluated by using rapid engine accelerations or decelerations at both a high and a low altitude. Recovery from autorotations will be simulated with at least three rates of power demand at each of the two altitudes. Engine response following an autorotational entry will be evaluated.

In conjunction with other tests, measurements of compressor inlet total pressure and temperature will be taken to determine installation losses with the T53-L-13 engine installed.

The sea level performance of the installed engine will be evaluated by using a series of static runs at several rotor RPM's and power settings. Corrections will be made for the various installation losses to determine whether the uninstalled power available and corresponding fuel flow meet the appropriate guarantees of the engine model specification (Reference d).

2.3.2.3 Data Required

The following data will be recorded continuously during each test:

a. Airspeed (Test System)

b. Altitude (Test System)

c. Outside Air Temperature

d. Fuel used

e. Time

f. Collective Stick Position

g. All Engine Power Parameters

SECTION 3. APPENDICES

APPENDIX I - TEST DIRECTIVE

C O P Y

DEPARTMENT OF THE ARMY
HEADQUARTERS, U. S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

AMSTE-BG
4-6-0150

9 FEB 1966

SUBJECT: Test Directive, Product Improvement Tests (Phase B & D), T53-L-13 Engine

TO: Commanding Officer
U. S. Army Aviation Test Activity
ATTN. STEAV-PO
Edwards Air Force Base, California 93523

1. References.

a. T53-L-13 Test Planning Meeting, 18 November 1965, Iroquois Field Office, St. Louis, Missouri.

b. Letter, AMCPM-IR-T, dated 29 November 1965, subject: T53-L-13 Test Planning Meeting.

c. Letter, AMCPM-IRFO-T, dated 27 December 1965, subject: T53-L-13 Test Program, Control Chart.

d. USATECOM Project No. 4-3-0150-17.

2. Background. A continuing product improvement program is being pursued by the Iroquois Project Manager. A portion of this program has led to the development of the T53-L-13 engine which

is designed to improve the high ambient temperature and/or altitude performance of the UH-1 series helicopter. The T53-L-13 engine is scheduled to be qualified by the contractor by May 1966. The subject tests are several of a series of tests to be conducted for the purpose of verifying that essential military characteristics of the UH-1 series helicopters have not been adversely affected and to establish the durability, operational capability, and maintainability of the T53-L-13 engine.

3. Description of Materiel. The T53-L-13 is a gas turbine engine rated at 1400 shaft horsepower derated to 1100 shaft horsepower for installation in the UH-1 series helicopter. The T53-L-13 engine envelope and mounting points are the same as the previous standard T53-L-11 engine and require only minor installation modifications. The increase in power is accomplished by modification of the axial compressor, addition of a second stage compressor turbine (gas producer), and the addition of a second stage power turbine.

4. Test Objectives.

a. Conduct product improvement tests on the UH-1B (540) and UH-1D helicopters equipped with the T53-L-13 engine to meet:

(1) The detailed objectives of Phase B - Contractor's Compliance Flight Tests.

(2) The detailed objectives of Phase D - Airworthiness and Performance Tests.

b. These tests will be limited to that portion of the flight envelopes of the two helicopters where differences may be expected to exist as a result of the new engine installation.

5. Responsibility. The U. S. Army Aviation Test Activity is assigned the responsibility for planning, conducting and reporting of the subject tests.

6. Coordination. Coordinate the test plans with the following agencies as a minimum.

a. Iroquois Project Manager.

b. Iroquois Project Manager Field Office.

c. U. S. Army Aviation Materiel Command, ATTN: SMOSM-EAA and EGPT.

7. Special Instructions.

a. These are Category II tests.

b. USATECOM Project Numbers assigned to these tests are:

(1) 4-6-0150-01, Phase B. UH-1B/540 T53-L-13.

(2) 4-6-0150-02, Phase D, UH-1B/540 T53-L-13.

(3) 4-6-0150-03, Phase B, UH-1D T53-L-13.

(4) 4-6-0150-04, Phase D, UH-1D T53-L-13.

c. Planned initiation of the Phase B tests is 26 September 1966 and the scheduled completion date is 10 October 1966.

d. Planned initiation of the Phase D tests is 17 October 1966 and the scheduled completion date is 15 January 1967.

e. Two test helicopters will be used for these tests; specifically, UH-1B/540 S/N 64-14105 and UH-1D S/N 60-6029.

f. Supply support for the T53-L-13 engine peculiar parts will be provided by separate contract.

g. Additional support requirements will be identified and forwarded to the appropriate action agencies.

h. Unprogrammed funds necessary for the conduct of this test will be requested from the Iroquois Project Manager.

8. Test Plans and Reports.

a. Prepare and forward two test plans to the Iroquois Project Manager for approval by 1 March 1966. One plan will cover USATECOM Project Number 4-6-0150-01/02 and one plan will cover USATECOM Project Numbers 4-6-0150-03/04.

b. Establish interim project manager reporting requirements.

c. Prepare and distribute a final test report within 60 days following completion of the flight test on each helicopter and phase. A test report for each specific USATECOM Project No. reference paragraph 7.b. above, will be prepared.

d. Distribute the approved test plans and reports in accordance with inclosure 2.

9. Safety. A safety of flight release is scheduled for 26 September 1966.

10. Security. These tests are unclassified.

FOR THE COMMANDER:

/s/ David M. Kyle
DAVID M. KYLE
Colonel, GS
Dir, Avn Mat Testing

2 Incl
1. TSMS Forms
2. Distr List

Copies furnished:
CG, USAMC, AMCPM-IR w/incl 2
CG, USAAVCOM, SMOSM-EAA w/incl 2
CG, USAAVCOM, SMOSM-EGPT w/incl 2
CG, USAAVCOM, AMCPM-IRFO w/incl 2
PRES, USAATB, STEBG-TP w/o incl



C O P Y

## APPENDIX II. SUPPORT REQUIREMENT AND TEST INSTRUMENTATION

### 1. SUPPORT

Present resources available to the U. S. Army Aviation Test Activity (USAAVNTA) are adequate to conduct this test.

### 2. TEST INSTRUMENTATION

Instrumentation items specified in Paragraph 2.3 are specialized sensitive test instrumentation. All instruments will be calibrated before and after the test.

An undetermined amount of this instrumentation will be installed by the airframe contractor prior to delivery of the aircraft to the USAAVNTA.

A test airspeed system will be installed. The system consists of a 6 foot boom installed at the front of the aircraft with a swiveling pitot system and static system (YAPS head) mounted at the end of the boom.

### 2.1 PILOT ENGINEER PANEL

The following items will be required on the pilot engineer panel for visual recording and in-flight reference.

a. Boom System Airspeed

b. Boom System Altitude

c. Outside Air Temperature

d. Fuel Flow Stepper Motor

e. Fuel Totalizer

f. High Torque Indicator

g. Low Torque Indicator

h. Exhaust Gas Temperature

i. Gas Producer RPM

j. Sensitive Rotor Tachometer

k. Collective Stick Position

l. Angle of [illegible]

m. Photo Panel Frame Number

## 2.2 PHOTO PANEL

The following items will be required on a photo panel equipped with an intervalometer to vary film speed.

a. Boom System Airspeed

b. Boom System Altitude

c. Outside Air Temperature

d. Fuel Totalizer

e. High Torque Indicator

f. Low Torque Indicator

g. Exhaust Gas Temperature

h. Gas Producer RPM

i. Sensitive Rotor Tachometer

j. Collective Stick Position

k. Stop Watch

l. Clock

m. Photo Panel Frame Number

n. Correlation Counter

o. Engineer and Pilot Events

2.3 OSCILLOGRAPH

The following items will be required on an oscillograph.

a. Angle of Attack

b. Angle of Sideslip

c. Longitudinal Control Position

d. Lateral Control Position

e. Pedal Position

f. Angle of Yaw

g. Angle of Pitch

h. Angle of Roll

i. Rate of Pitch

j. Rate of Roll

k. Rate of Yaw

l. C.G. Normal Acceleration

m. Engineer's Event

n. Pilot's Event

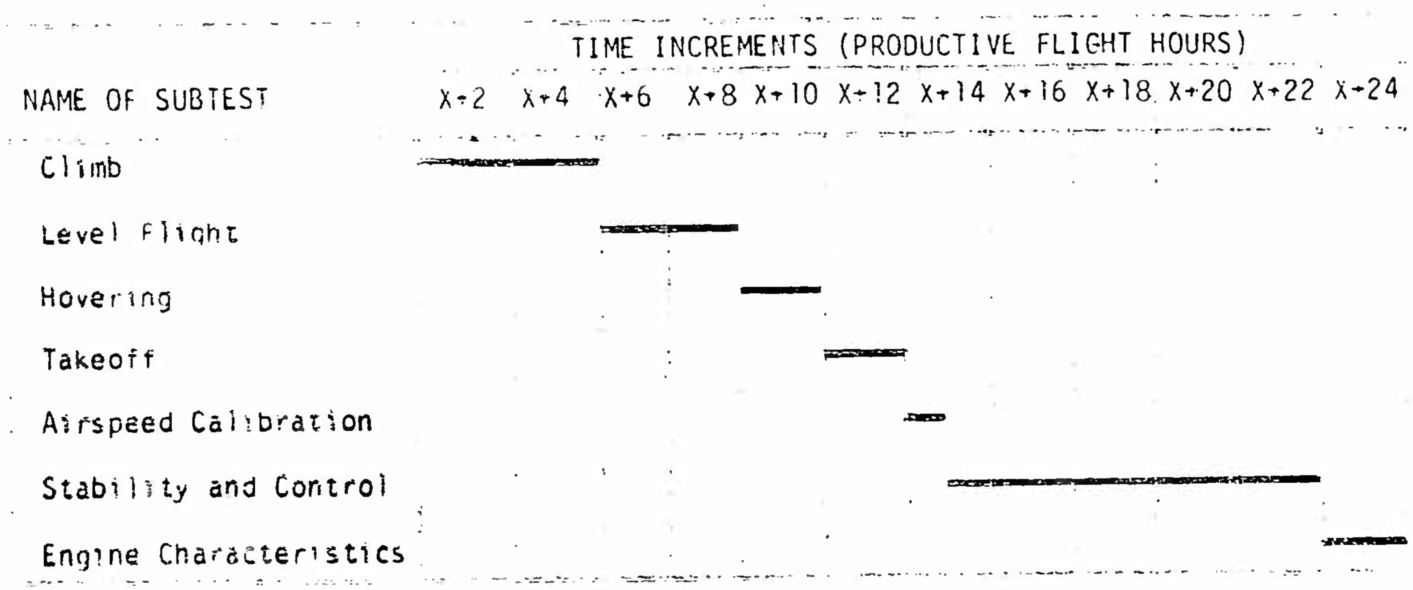
o. Collective Pitch Position

## APPENDIX III TEST SCHEDULE

1 Schedule of Events

| | |
|---|---|
| Preliminary Planning | March 1966 |
| Test Directive Issued | February 1966 |
| Test Plan Submission Date | April 1966 |
| Test Item Delivery Target Date | September 1966 |
| Instrumentation and Calibration Completion Target Date | September 1966 |
| Test Beginning Target Date (Phases B & D) | October 1966 |
| Test Termination Date (Phases B & D) | January 1967 |
| Final Test Report | March 1967 |

2 Detailed Test Schedule



## APPENDIX IV. REFERENCES


a. Letter, AM[illegible]-BG, Hq, U S Army Test and Evaluation Command, 9 February 1966, subject "Test Directive, Product Improvement Tests (Ph[illegible] and D) T53 L 13 Engine."

b. Letter, AMS[illegible], Hq, U S Army Materiel Command, 28 February 1966, subject: "UH-1 Project Management Control Program - UH-1/T53 L-13 Test Program."

c. Final Report of Phase D Performance Tests of the UH-1B Equipped with a 540 Rotor, U S Army Aviation Test Activity (USAAVNTA), Report Not Yet Published.

d. Specification No 104 33, "Model Specification T53-L-13 Shaft Turbine Engine," Lycoming Division of AVCO Corporation, 30 September 1964.

e. "Final Report of Engineering Test of the YT53-L 13 Engine Installed in the UH-1D Helicopter," USATECOM Project No 4-3-0150-10, USAAVNTA, March 1965.

f. MIL-H-8501A, "General Requirements for Helicopter Flying and Ground Handling Qualities," Revised January 1961 and amended 3 April 1962.