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AUTHORITY
USAAVSCOM ltr 12 Nov 1973
ENGINEERING TEST
(PHASES B & C)
(PRODUCT IMPROVEMENT TEST
OF UH-1B/AH-64 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

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Statement #4

Priest, 306-715-6611, Aircraft (AMCP-184)

Engine Control Systems, Command

St. Louis, Missouri 63126

Signed

1. Oct. 1976
### TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INTRODUCTION</td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>BACKGROUND</td>
<td>1</td>
</tr>
<tr>
<td>1.2</td>
<td>DESCRIPTION OF MATERIAL</td>
<td>1</td>
</tr>
<tr>
<td>1.3</td>
<td>TEST OBJECTIVES</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>DETAILS OF TEST</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>INTRODUCTION</td>
<td>3</td>
</tr>
<tr>
<td>2.2</td>
<td>PERFORMANCE</td>
<td>3</td>
</tr>
<tr>
<td>2.3</td>
<td>STABILITY AND CONTROL AND ENGINE CHARACTERISTICS</td>
<td>7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>APPENDICES</td>
<td></td>
</tr>
<tr>
<td>TEST Directive</td>
<td>SUPPORT REQUIREMENTS AND TEST INSTRUMENTATION</td>
<td>12</td>
</tr>
<tr>
<td>TEST Schedule</td>
<td>REFERENCES</td>
<td>16</td>
</tr>
<tr>
<td>DISTRIBUTION</td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>REFERENCES</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>DISTRIBUTION</td>
<td></td>
<td>22</td>
</tr>
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</table>
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-IIB 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 T53-L-13 engine installed in the UH-1D was conducted by the U.S. Army Aviation Test Activity (USAAVTA) in January 1966. 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 MATERIAL

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 insufficient testing. Insufficient testing has been accomplished to define the stability and control of the UH 1B at the payload 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 1).

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 11 engine and to determine the installed horsepower available in the helicopter.

2.2.2  Method

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

<table>
<thead>
<tr>
<th>Weight (lb)</th>
<th>Rotor Speed (RPM)</th>
<th>Center of Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>7000</td>
<td>Optimum N2</td>
<td>Mid</td>
</tr>
<tr>
<td>8600</td>
<td>Optimum N2</td>
<td>Mid</td>
</tr>
<tr>
<td>9500</td>
<td>Optimum N2</td>
<td>Mid</td>
</tr>
</tbody>
</table>
The climb schedules developed in Reference c will be used during these tests. Sufficient tests will be conducted to determine the maximum power turbine speed ($N_2$) as a function of altitude.

2.2.1.3 Data Record

The following data will be recorded continuously during the climbs and related 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 point 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 414 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 in a non-dimensional form (power coefficient \(C_p\), thrust coefficient \(C_T\), and advance ratio \(J\)) 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 JSJ-11 engine.

2.2.3.2 Method

Lethored 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 \(N_g\) tests described in Paragraph 2.2.1.2).

2.2.3.3 Data Required

The following data will be recorded for each point:
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 153-13 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 7 feet at 324 RPM and at 35 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 height, 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) Airspeed
b) Altitude

This data will be reduced to standard day conditions and to a non-dimensional form (Co, L1, skid height) to supplement the data of Reference c.
d. Outside Air Temperature

f. All Engine Parameters

This data will be recorded from standard day conditions and to a non-dimensional excess power coefficient available (Cp) form to complement the data of Reference 9.

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, 2000 pounds and a mid center of gravity (Cg) 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 characteristics at the placard limit airspeeds which have been up to now unattainable in the UH 1H/540 rotor helicopter. Each of the tests in the following paragraphs will be conducted to determine longitudinal 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:

<table>
<thead>
<tr>
<th>Initial Trim Condition</th>
<th>Airspeed</th>
<th>Altitude</th>
<th>Rotor RPM</th>
<th>Center of Gravity</th>
<th>Gross Weight</th>
<th>Speed Range of Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$V_{\text{max}}$</td>
<td>5000</td>
<td>324</td>
<td>Aft</td>
<td>7500</td>
<td>$V_{\text{max}}$ to $V_{\text{max}}$ 20 kt</td>
</tr>
<tr>
<td></td>
<td>$V_{\text{max}}$</td>
<td>9 Service Ceiling</td>
<td>324</td>
<td>Aft</td>
<td>7500</td>
<td>$V_{\text{max}}$ to $V_{\text{max}}$ 20 kt</td>
</tr>
<tr>
<td></td>
<td>$V_{\text{max}}$</td>
<td>5000</td>
<td>314</td>
<td>Aft</td>
<td>7500</td>
<td>$V_{\text{max}}$ to $V_{\text{max}}$ 20 kt</td>
</tr>
<tr>
<td></td>
<td>$V_{\text{max}}$</td>
<td>5000</td>
<td>324</td>
<td>Fwd</td>
<td>7500</td>
<td>$V_{\text{max}}$ to $V_{\text{max}}$ 20 kt</td>
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<tr>
<td></td>
<td>$V_{\text{max}}$</td>
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<td>Aft</td>
<td>9500</td>
<td>$V_{\text{max}}$ to $V_{\text{max}}$ 20 kt</td>
</tr>
</tbody>
</table>

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.
2.3.2.5 Dynamic Stability

The aircraft reaction following an abrupt (last) disturbance will be evaluated by rapidly displacing a control in a given direction from trim holding it for 1 second, then returning the control to the original trim position. A control input will be used to ensure accurate input tests will be conducted about all three axes in two directions at the trim conditions listed in Paragraph 2.3.1.7. After the input the control will be held fixed until the resulting motion damps out or recovery becomes necessary.

2.3.2.6 Controllability

The controllability will be evaluated by observing the motion of the aircraft 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 maximum occur. Tests will be conducted about all axes in two directions at the trim conditions listed in Paragraph 2.3.2.1 control input of approximately 1.4 in and 1 inch will be used. A control input will be used to ensure 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 Air
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 ensure that no objectionable characteristics result from installing the J85-L 13 in the UH-1B and to obtain an estimate of the static engine characteristics and compliance with the guarantee of the engine model specification (Reference d).

2.3.2.2 Method

Any objectionable characteristics of the J85-L 13 observed during other tests will be noted and investigated further during these tests.
The presence of any compressor stall or other undesirable feature will be evaluated by using rapid engine accelerations or deaccelerations at both a high and a low altitude. Recoveries from autorotations will be simulated with at least three rates of demand at each of the two altitudes. Engine entry and ensuing an autorotational entry will be evaluated.

In conjunction with other tests, measurements of compressor inlet oil pressure and temperature will be taken to determine installation issues with the engine installed.

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

2.3.2 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
APPENDIX I - TEST DIRECTIVE

1. References.
   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
AMSTE-06
9 FEB 1966
SUBJECT: Test Directive, Project Improvement Test (Phase B & D), T53-L-13 Engine

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 Material. The T53-L-13 is a gas turbine engine rated at 7400 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.
AMSTE-BG

9 FEB 1966

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

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.
AMSTE-BG  9 FEB 1966
SUBJECT: Test Directive, Product Improvement Test (Phase B & D), TS3-13 Engine

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.


10. Security. These tests are unclassified.

FOR THE COMMANDER:

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

Copies furnished:
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w/incl 2
CG, USAVCOM, SMOSM-EAA
w/incl 2
CG, USAVCOM, SMOSM-EGPT
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w/incl 2
PRES, USAATB, STEBG-TP
w/o incl

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APPENDIX II SUPPORT REQUIREMENT AND TEST INSTRUMENTATION

1 SUPPORT

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

2 TEST INSTRUMENTATION

Instrumentation items involved in test:

2.1 Specialized support items include:

All instruments will be calibrated before and after the test.

An undetermined amount of this instrumentation will be installed by the aircraft 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 swinging pivot system and static pressure taps 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:

e. Boom System Airspeed
f. Boom System Altitude
i. Outside Air Temperature
d. Fuel Flow Stepper Motor
m. Fuel Indicator
h. High Torque Indicator
j. Low Torque Indicator
k. Exhaust Gas Temperature
l. Gas Producer RPM
3. Sensitive Rotor Tachometer
k. Collective Stick Position
l. Angle of Attack
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 SIDE

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

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<th>Event Description</th>
<th>Date</th>
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</tr>
<tr>
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<td>February 1966</td>
</tr>
<tr>
<td>Test Plan Submission Date</td>
<td>April 1966</td>
</tr>
<tr>
<td>Test Item Delivery Target Date</td>
<td>September 1966</td>
</tr>
<tr>
<td>Instrumentation and Calibration Completion Target Date</td>
<td>September 1966</td>
</tr>
<tr>
<td>Test Beginning Target Date (Phases B &amp; D)</td>
<td>October 1966</td>
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<tr>
<td>Test Termination Date (Phases B &amp; D)</td>
<td>January 1967</td>
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<td>Final Test Report</td>
<td>March 1967</td>
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<td>TIME INCREMENTS (PRODUCTIVE FLIGHT HOURS)</td>
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<tr>
<td>Climb</td>
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<tr>
<td>Airspeed Calibration</td>
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</tr>
<tr>
<td>Stability and Control</td>
<td></td>
</tr>
<tr>
<td>Engine Characteristics</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX IV - REFERENCES


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

