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AD  
RDTE PROJECT NO. 1X179191D684  
USAAVCOM PROJECT NO. 67-07  
USAAVNTA PROJECT NO. 67-07

AD 300  
A

**ANALYTICAL STUDY  
OF RANGE PERFORMANCE  
OF A UH-1C HELICOPTER EQUIPPED  
WITH A LYCOMING T53-L-13 ENGINE**

**LETTER REPORT**

**RODGER L. FINNESTEAD  
PROJECT OFFICER**

**MAY 1968**

**US ARMY AVIATION TEST ACTIVITY  
Edwards Air Force Base, California 93523**

DEPARTMENT OF THE ARMY  
US ARMY AVIATION TEST ACTIVITY  
Edwards Air Force Base, California 93523

SAVTE-P

1 September 1968

SUBJECT: Change No. 1 to Letter Report for Analytical Study of Range  
Performance of a UH-1C Helicopter Equipped with a Lycoming  
T53-L-13 Engine, USAAVNTA Project No. 67-07.


SEE DISTRIBUTION (INCLOSURE II)

The following change is made to subject letter report:

- a. Page 4, paragraph 6b, change "b. For high altitude heavy weight, long range missions at range performance are improved (para 5c)." to read
- b. For high altitude heavy weight, long range missions, the range performance is improved (para 5c and 5d).

FOR THE COMMANDER:

1 Incl  
as

  
CURTIS W. PIERCE  
1LT, AGC,  
Adjutant

RDTE PROJECT NO. 1X179191D684  
USAAVCOM PROJECT NO. 67-07  
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U. S. ARMY AVIATION TEST ACTIVITY  
Edwards Air Force Base, California 93523

SUBJECT: Letter Report of Analytical Study of the Range Performance of a UH-1C Helicopter Equipped with a Lycoming T53-L-13 Engine.

Commanding General  
US Army Aviation Materiel Command  
ATTN: AMSAV-ER

1. **REFERENCES:**

a. Technical Report, US Army Aviation Test Activity (USAAVNTA) Project Number 62-28, "Engineering Flight Test of the UH-1B Helicopter Equipped with the Model 540 Rotor System, Phase D," December 1960.

b. Technical Report, USAAVNTA Project Number 66-04, "Interim Report Engineering Flight Test of the UH-1H Helicopter, Phase D Product Improvement Test," August 1967.

c. Technical Report No. 204-947-125, "Detail Specification for UH-1B Utility Helicopter, FY 64 Procurement," Bell Helicopter Company, 20 May 1963, as amended 20 January 1965.

d. Technical Report No. 204-100-149, "Flight Test Results of a Lycoming Model T53-L-13 Engine Installed in a UH-1C Helicopter, P.I.P. Task No. 6-11A," Bell Helicopter Company, 27 January 1967.

e. Specification No. 104.33, "Model Specification T53-L-13 Shaft Turbine Engine," Lycoming Division of AVCO Corporation, 30 September 1964, as amended 6 May 1966.

f. Technical Manual, TM 55-1520-211-12, "Operator's Manual Army UH-1A and UH-1B Helicopters," Department of the Army.

2. **BACKGROUND:**

On 25 May 1967, the USAAVNTA was directed to analytically evaluate the range performance of a UH-1C helicopter equipped with

SUBJECT: Letter Report of Analytical Study of the Range Performance of a UH-1C Helicopter Equipped with a Lycoming T53-L-13 Engine.

a Lycoming T53-L-13 shaft turbine engine. The T53-L-13 engine Model Specification (ref e, para 1) was to be used when developing the fuel consumption and power relationships. The engine inlet characteristics presented in reference a, paragraph 1, were to be incorporated into the analysis.

3. **TEST OBJECTIVES:**

The objective of this study was to analytically evaluate the range performance of the UH-1C helicopter when equipped with a Lycoming T53-L-13 shaft turbine engine.

4. **DESCRIPTION OF MATERIEL:**

The T53-L-13 is a free turbine engine rated at 1400 shaft horsepower (shp) derated to 1100 shp for installation in UH-1 series helicopters. The increase in power and improved acceleration characteristics of the T53-L-13 engine are accomplished by modification of the axial compressor, addition of variable inlet guide vanes, addition of a second-stage gas producer turbine, and addition of a second-stage power turbine. This modification results in a weight increase of approximately 34 pounds which includes 30 pounds increase in engine weight.

5. **RESULTS AND DISCUSSION:**

a. General - This report presents the analytical evaluation of the range performance of a UH-1C helicopter equipped with a T53-L-13 free turbine engine. The stability and control characteristics presented in reference a, paragraph 1 were also reviewed for possible problem areas that might be encountered when installing the T53-L-13 engine in the UH-1C helicopter.

b. The range summary of the UH-1C helicopter equipped with a T53-L-13 was analytically evaluated using references a and e, paragraph 1. The inlet characteristics and shp required for level flight were derived from reference a and the fuel flow versus shp was obtained from reference e. The data presented in this report are applicable to an inlet that does not have a particle separator installed. Figure 1 and 2, inclosure 1, present the estimated range performance summary.

SUBJECT: Letter Report of Analytical Study of the Range Performance of a UH-1C Helicopter Equipped with a Lycoming T53-L-13 Engine .

c. The range performance of the UH-1C helicopter equipped with the T53-L-13 engine was analytically found to be substantially increased over that equipped with the T53-L-11 engine and is presented in table 1.

Table 1. Standard Day Range Performance Comparison.

Altitude = 5000 feet  
Rotor Speed = 324 rpm  
C.G. Mid

Gross Weight lb	Cruise Airspeed $V_T$ - knots			Specific Range at Cruise Airspeed - nautical air mile/lb		
	T53-L-11	T53-L-13	% Increase	T53-L-11	T53-L-13	% Increase
7500	111.5	126.0	13.0	.211	.214	1.5
8500	109.5	125.5	14.6	.195	.204	4.6
9500	105.5	115.0	9.0	.166	.181	9.0

d. The greatest increase in recommended cruise airspeed occurred at a gross weight of 8500 pounds. However, the specific range increased with increasing gross weight. This calculated increase in cruise airspeed and specific range will greatly enhance the mission capability of UH-1C helicopters. The increase in mission capability would also be dependent on satisfactory handling qualities, vibration characteristics and component service life at the increased cruise airspeed. The affect of increased weight must be considered in assessing the effects of improved power economy. If mission takeoff gross weight is held constant at 8500 pounds, payload is reduced at mission ranges below 150 nautical air miles and increased at greater ranges.

e. The hovering and climb performance should also be significantly increased with the installation of the T53-L-13 turbine engine when the vehicle is operated at atmospheric conditions where transmission torque limits cannot be reached.



SUBJECT: Letter Report of Analytical Study of the Range Performance of a UH-1C Helicopter Equipped with a Lycoming T53-L-13 Engine .

f. Performance and stability and control testing should be conducted on a UH-1C helicopter with the T53-L-13 engine installed. After reviewing the findings in references a, b and d, paragraph 1, this testing is mandatory. The testing will evaluate any changes in the aircraft flight envelope that may be realized with the installation of the T53-L-13 engine. The test program would also yield necessary information to update the appropriate US Army manuals and verify that no safety-of-flight conditions exist.

6. **CONCLUSIONS:**

a. The T53-L-13 engine installed adds to the aircraft empty weight and may compromise the pay load capability (para 5d).

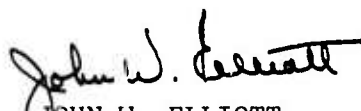
b. For high altitude heavy weight, long range missions at range performance are improved (para 5c).

c. The increased power available should improve the performance capability; greater benefits being derived as atmospheric conditions become more severe (para 5e).

7. **RECOMMENDATIONS:**

Engineering flight testing of the UH-1C helicopter with the T53-L-13 engine installed be performed to determine if the previously established flight envelope will be affected and to verify the calculation performance .

- 3 Incl  
1. Test Data  
2. Distribution  
3. DD Form 1473

  
JOHN W. ELLIOTT  
Colonel, TC  
Commanding

**INCLOSURE I. TEST DATA**

FIGURE NO. 1  
 LEVEL FLIGHT RANGE SUMMARY  
 UH-1C  
 5000 FT STANDARD DAY  
 324 ROTOR RPM  
 MID CENTER OF GRAVITY

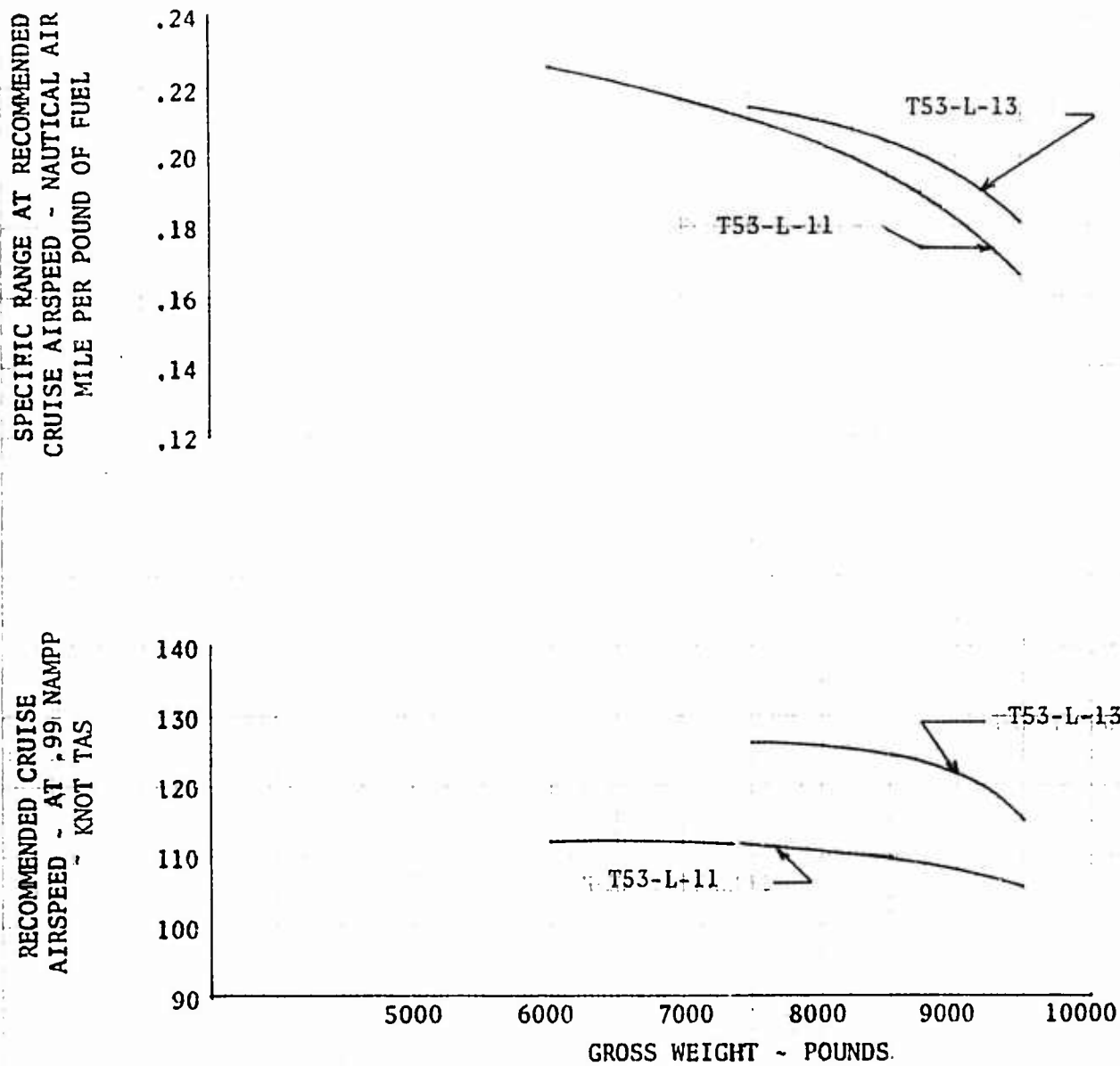
SPECIFIC RANGE AT RECOMMENDED  
 CRUISE AIRSPEED - NAUTICAL AIR  
 MILE PER POUND OF FUEL

.24  
 .22  
 .20  
 .18  
 .16  
 .14  
 .12

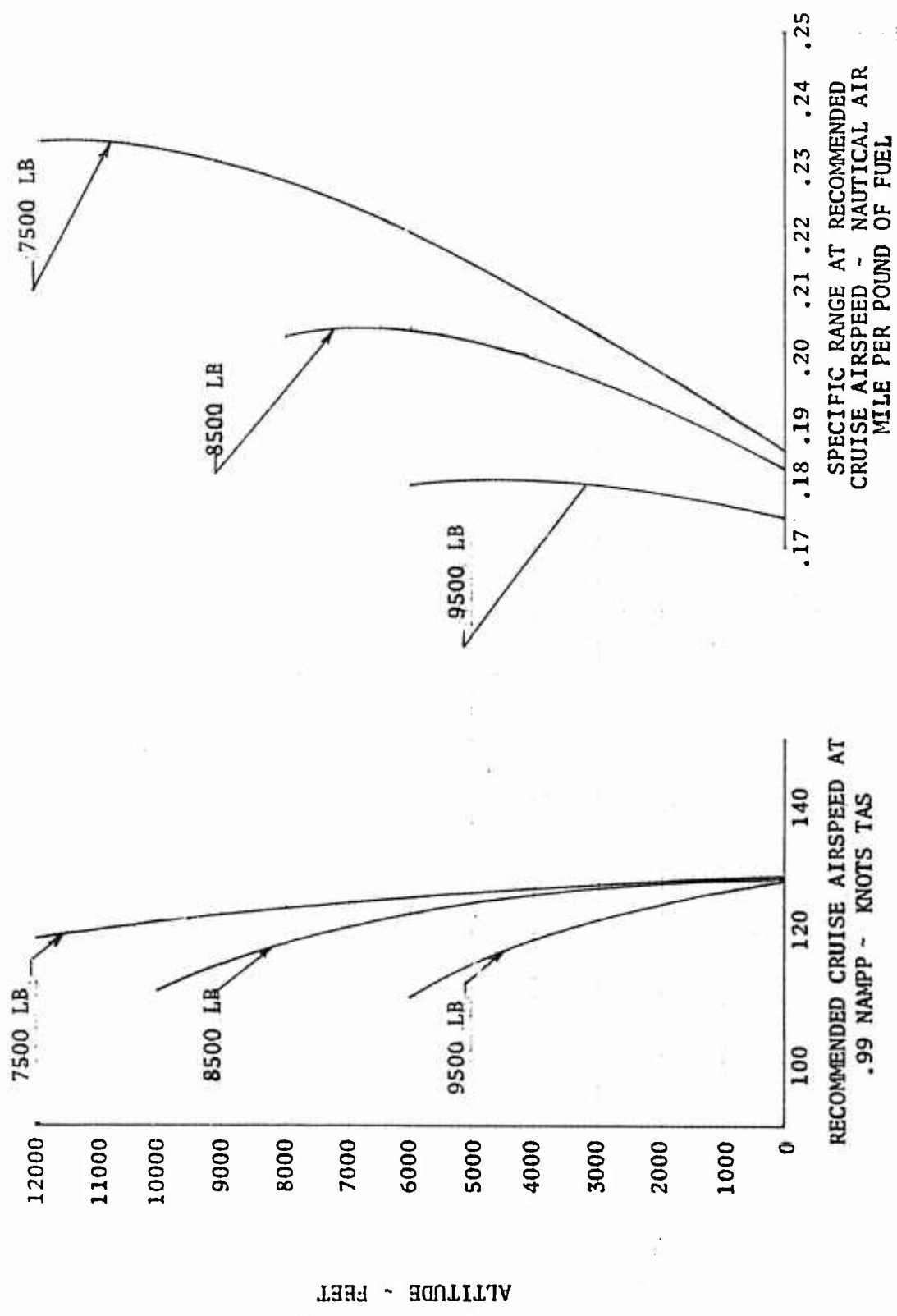
RECOMMENDED CRUISE  
 AIRSPEED - AT .99 NAMPP  
 - KNOT TAS

140  
 130  
 120  
 110  
 100  
 90

5000 6000 7000 8000 9000 10000  
 GROSS WEIGHT - POUNDS.



**FIGURE NO. 2**  
**LEVEL FLIGHT RANGE SUMMARY**  
**T53-L-13**  
**STANDARD DAY**  
**324 ROTOR RPM**  
**CENTER OF GRAVITY**



INCLOSURE II. DISTRIBUTION

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13. ABSTRACT This letter report presents the estimated range performance of the UH-1C helicopter equipped with a Lycoming T53-L-13 engine. The range performance was analytically found to be substantially increased. This calculated increase in cruise airspeed and range factor will greatly enhance the mission capability of this helicopter. However, this increase would be dependent on satisfactory handling qualities and vibration characteristics at the increased cruise airspeed. Therefore, engineering flight testing of the UH-1C helicopter is considered to be mandatory when the T53-L-13 engine is installed.		

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Range performance UH-1C T53-L-13 engine Handling qualities and vibration characteristics						