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The United States Army Aviation Engineering Flight Activity conducted takeoff performance tests on an OV-1C aircraft, serial number 67-18918, from 11 April through 19 July 1978. The aircraft was tested at Edwards Air Force Base (field elevation 2273 feet) and South Lake Tahoe, California (field elevation 6262 feet). Twelve flights totaling 6.9 productive flight hours were conducted. Takeoff performance tests were conducted on the OV-1C to substantiate the performance data currently incorporated in the operator's manual. Tests were conducted using two

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20. Abstract

normal takeoff techniques and a minimum run takeoff technique at each of three gross weights. All takeoffs were made from hard, dry, paved level runways. Test results show that the estimated data for normal takeoff is satisfactory but the data for the minimum run technique in the operator's manual is optimistic.

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DEPARTMENT OF THE ARMY
HQ, US ARMY AVIATION RESEARCH AND DEVELOPMENT COMMAND
P O BOX 209, ST. LOUIS, MO 63166

DRDAV-EQ 19 MAY 1979

SUBJECT: *Airworthiness and Flight Characteristics Test, OV-1C Takeoff Performance, Final Report, USAAEFA Project No. 78-07*

SEE DISTRIBUTION

1. The purpose of this letter is to provide the Directorate for Development and Engineering's position on the subject report.

2. We agree with the conclusions of the report and with the recommendation stated in paragraph 17b. We do not agree with the recommendation of paragraph 17a which proposes additional testing to be performed on the OV-1 under additional conditions of gross weight, density altitude, and external stores configurations. This report contains sufficient takeoff performance to adjust any aerodynamic estimates so that all practical data regarding takeoff performance can be incorporated in the operator's manual. It should be pointed out that the use of the energy technique for analyzing this data (See paragraph 16 of Appendix B) is an excellent method established by the Air Force Flight Test Center. This technique enables expansion of the information and will assist in the preparation of a revised operator's manual without additional testing. Therefore, this Headquarters plans no additional takeoff test measurements on the OV-1 series aircraft.

FOR THE COMMANDER:

WALTER A. RATCLIFF
Colonel, GS
Director of Development
and Engineering

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INTRODUCTION

BACKGROUND

1. The OV-1C operator's manual (ref 1, app A) contains takeoff performance data which has been questioned as a result of previous tests conducted by the United States Army Aviation Engineering Flight Activity (USAAEFA). Additional takeoff performance data were required to substantiate the data depicted in the operator's manual. In April 1978, the United States Army Aviation Research and Development Command (AVRADCOM) directed USAAEFA to plan, conduct, and report on the takeoff performance of the OV-1C aircraft (ref 2). A letter test plan for the tests was published in April 1978 (ref 3).

TEST OBJECTIVE

2. The objective of this test was to obtain limited takeoff performance data to substantiate the data presented in the OV-1C operator's manual.

DESCRIPTION

3. The test aircraft, S/N 67-18918, is a production OV-1C. The OV-1C is a two-place, triple-vertical-stabilizer, mid wing, twin-engine turbo prop airplane. The aircraft is powered by two Lycoming T53-L-15 turbine engines, each rated at 1160 shaft horsepower (shp) with Hamilton-Standard 53C51-23 three-bladed propellers. Martin-Baker ejection seats are provided for the crew. The missions of the OV-1C are visual, photographic, and infrared surveillance. A detailed description of the airplane and mission equipment is contained in the operator's manual.

TEST SCOPE

4. The takeoff performance of the OV-1C was evaluated at Edwards Air Force Base, California (field elevation 2273 feet) and South Lake Tahoe, California (field elevation 6262 feet). Twelve flights totaling 6.9 productive flight hours were conducted between 11 April and 19 July 1978. All tests were conducted in one configuration: basic aircraft with two 150-gallon external drop tanks. USAAEFA was responsible for aircraft maintenance and test instrumentation. Flight restrictions and operating limitations were established by the OV-1C operator's manual.

TEST METHODOLOGY

5. Three different takeoff test techniques were used during the conduct of this test and are discussed in the Results and Discussion section of this report. Data reduction and analysis methods are described in appendix B. Flight test data were recorded manually and with a movie camera from calibrated and standard cockpit instruments. A listing of test instrumentation is contained in appendix C. Recording optical instruments (ROI) were used to acquire takeoff distances.

RESULTS AND DISCUSSION

GENERAL

6. Takeoff performance tests were conducted on the OV-1C to substantiate the flight test performance data currently incorporated in the operator's manual. Tests were conducted using two normal takeoff techniques and a minimum run takeoff technique at each of three gross weights and two altitudes under the general conditions shown in table 1. All takeoffs were made from hard, dry, paved level runways. Test results show that the estimated data for the minimum run technique in the operator's manual are optimistic.

PERFORMANCE

Normal Takeoffs

7. The normal takeoff technique was defined as 15 degrees flaps, holding the brakes, stabilizing torque on both engines at 30 pounds per square inch (psi) prior to starting the ground roll and using a rotation and climb-out attitude of 5 degrees and 10 degrees. Brakes were released and maximum power was applied within 1.0 to 1.5 seconds. Longitudinal control remained essentially fixed at neutral until the desired rotation airspeed was attained. The control stick was then moved aft to obtain the desired climb attitude expeditiously. The landing gear was retracted when

Table 1. Takeoff Test Conditions.[1,2]

Field Elevation (ft)	Gross Weight (lb)	Indicated Rotation Airspeed (kt)			
		Normal[3]		Minimum Run[4]	
		Minimum	Maximum	Minimum	Maximum
2273	13,500	80	95	77	85
	15,000	80	96	70	81
	16,500	86	100	87	93
6262	13,500	80	100	75	85
	16,500	85	100	85	95

[1] Configuration: Basic aircraft with two 150-gallon drop tanks installed.
[2] 15-degree flaps for all takeoffs; forward cg (station 159).
[3] 30 psi torque pressure at brake release.
[4] 60 psi torque pressure at brake release.

a positive rate of climb was assured and the flaps were raised when airspeed passed 110 knots indicated airspeed (KIAS). Takeoff power was maintained until an altitude of 500 feet above ground level (AGL) was obtained.

8. The aircraft response in pitch was very sluggish at rotation airspeeds below 85 KIAS. At airspeeds greater than 90 KIAS, forward stick was required to hold weight on the nose wheel to effect more rapid acceleration. A rapid aft stick input was utilized to effect aircraft rotation at all airspeeds.

9. Using a 10-degree rotation and climb-out attitude technique, larger positive longitudinal control movements were required to attain the desired rotation attitude as compared to the 5-degree attitude technique. At airspeeds below 90 KIAS, aircraft rotation could not be attained rapidly because of insufficient elevator effectiveness, and a positive rate of climb could not be established until airspeed had increased 5 to 10 knots above lift-off airspeed. Using a 10-degree rotation and climb-out attitude did not affect the ground roll distances compared to using a 5-degree rotation and climb-out.

10. Test results are presented in figures 4 through 8, appendix D, and are summarized in figures 1, 2, and 3. Increasing gross weight from 13,500 pounds to 16,500 pounds resulted in an increased ground roll of 600 feet at a 2000-foot density altitude and 710 feet at a 6000-foot density altitude. Increasing density altitude. Increasing density altitude from 2000 to 6000 feet caused only a 250-foot increase in ground roll at light gross weight and a 360-foot increase at heavy gross weight. Maximum engine torque was available at both test altitudes. The 10-degree rotation and climb-out attitude resulted in a decrease in total distance to clear 50 feet compared to the 5-degree climb-out attitude. At the lighter gross weight, the decrease in total distance was 90 feet at the 2000-foot test site and 120 feet at the 6000-foot test site. At the heavier gross weight the decrease in total distance was 120 and 210 feet, respectively. The data also indicated that takeoff runway distances were approximately 230 feet greater at 13,500 pounds and 220 feet greater at 16,500 pounds than predicted by the operator's manual, regardless of the rotation and climb attitude used.

11. The test results for the total distance to clear a 50-foot obstacle agree with the operator's manual very closely at the light gross weight. There was no measurable difference at the 2000-foot altitude and 100 feet less distance required at the 6000-foot altitude. At the heavy gross weight the test results show somewhat better performance than the operator's manual. At the 2000-foot altitude the total distance required was 160 feet less than the operator's manual and 370 feet less at the 6000-foot altitude. The normal takeoff technique used during this test program produced slightly better performance. However, the performance distances and the technique currently incorporated in the operator's manual are satisfactory.

Minimum Run Takeoff

12. Minimum run takeoff tests were conducted using the technique described in the operator's manual and standardization board maneuver guide. The aircraft was aligned with the runway, brakes applied, and power stabilized at 60 psi torque. Brakes were then released and maximum power was applied within 1 second. At 3 to 4 knots slower than desired rotation airspeed a rapid aft control input was made to assure rotation was completed upon reaching the rotation airspeed. When a positive

rotation was completed upon reaching the rotation airspeed. When a positive rate of climb was assured, the landing gear was retracted. Climb airspeeds of approximately 5 knots faster than rotation airspeed were used and maintained until the obstacle was cleared.

13. Using the minimum run takeoff technique, the aircraft response was very sluggish at airspeeds below 85 KIAS. A very large (almost full aft), abrupt longitudinal control input was required for rotation. After lift-off, there was a rapid apparent increase in indicated airspeed of approximately 5 knots and the aircraft had a tendency to fly just above the ground for some distance prior to establishing a climb. Attempting to maintain slower airspeeds during climb-out required an uncomfortably high pitch attitude and obscured the forward field of vision. The aircraft handling qualities are marginal at the minimum airspeeds tested. For this reason lower airspeeds were not attempted. The minimum run takeoff technique is totally impractical at the handbook recommeded airspeeds due to the marginal handling qualities and uncomfortably high pitch attitude restricting the forward field of view. The operator's manual should be changed to reflect the recommended climb-out airspeeds shown below.

At gross weights up to 15,000 pounds - 85 KIAS

At gross weights between 15,000 and 16,500 pounds - 90 KIAS

14. Figures 4 through 8, appendix D, show a comparison of the test results and the data contained in the operator's manual. An analysis of the test data indicated reasonable agreement with the corresponding operator's manual distance and airspeed. However, as previously discussed the operator's manual airspeeds are dangerously low. At both test altitudes results at the airspeeds recommended in paragraph 13 show that at the 13,500-pound gross weight the total distance required to clear a 50-foot obstacle was approximately 400 feet greater than predicted at the airspeeds recommended in the operator's manual. At the 16,500-pound gross weight the increase in distance required was approximately 500 feet. The estimated takeoff performance data for the minimum run technique incorporated in the operator's manual are optimistic.

15. To obtain minimum run takeoff performance data for incorporation in the operator's manual, additional flight testing with performance and stability and control instrumentation should be accomplished on the OV-1D under various conditions of gross weight, density altitude, and external stores configurations.

CONCLUSIONS

16. The following conclusions were reached upon completion of this test:

a. The normal takeoff data presented in the operator's manual are satisfactory (para 11).

b. The estimated takeoff performance data for the minimum run technique incorporated in the operator's manual are optimistic (para 14).

c. The minimum run takeoff technique is totally impractical at the handbook recommended airspeed due to the marginal aircraft handling qualities and uncomfortably high pitch attitude restricting the forward field of view (para 13).

RECOMMENDATIONS

17. The following recommendations are made:

a. Additional flight testing with performance and stability and control instrumentation should be accomplished on the OV-1D under various conditions of gross weight, density altitude, and external stores configurations.

b. The operator's manual should be changed to reflect the following indicated airspeeds as the minimum airspeeds to be used in accomplishing minimum run takeoffs:

At gross weights up to 15,000 pounds 85 KIAS

At gross weights between 15,000 and 16,500 pounds - 90 KIAS

APPENDIX A. REFERENCES

1. Technical Manual, TM 55-1510-204-104, *Operator's Manual, OV-1C Aircraft,* February 1970, with Changes 1 through 14.

2. Letter, AVRADCOM, DRDAV-EQI, 3 April 1978, subject: OV-1C Takeoff Performance Airworthiness and Flight Characteristics Test.

3. Letter, USAAEFA, DAVTE-TA, 12 April 1978, subject: Abbreviated Test Plan, OV-1 Takeoff Performance Tests, USAAEFA Project No. 78-07.

4. Technical Report No. 6273, Air Force Flight Test Center, *Flight Test Engineering Handbook,* May 1951, corrected and revised June 1964 and January 1966.

5. Model Specification, *T-53-L-7 Turboprop Engine (Lycoming Model LTCIP-2), Specification Number 104.21-B,* 20 January 1961.

6. Report, Grumman Aircraft Engineering Corporation, *Justification of Aerodynamic Data for the Standard Aircraft Characteristics Chart,* August 1962.

APPENDIX B. DATA ANALYSIS METHODS

GENERAL

1. The equations and the analysis methods used to reduce the takeoff performance data are briefly described in this appendix. A detailed discussion of the analysis methods can be found in reference 4, appendix A. Flight test performance data were manually recorded from calibrated test cockpit instruments and from ground based space positioning equipment.

AMBIENT ATMOSPHERIC TEST PARAMETERS

2. Pressure altitudes were obtained by correcting indicated pressure altitudes (HP_i) for instrument error (ΔHP_{ic}).

$$H_P = H_{P_i} + \Delta H_{P_{ic}} \qquad (1)$$

3. Ambient test temperatures (T_a) were obtained by correcting the indicated test temperature (T_i) for instrument error (ΔT_{ic}).

$$T_a = T_i + \Delta T_{ic} \qquad (2)$$

4. The test density ratio (σ_t) was determined from the following relationship:

$$\sigma_t = (T_o/T_a)\ (P_a/P_o) \qquad (3)$$

Where:

T_O = Standard-day, sea-level absolute temperature (°K)

P_O = Standard-day, sea-level absolute pressure (in. of mercury)

5. The density altitude was determined from the test ratio (σ_t) and the US Standard Atmosphere, 1962 tables.

AIRSPEED DETERMINATION

6. The ground speed at takeoff (V_{TO_w}) and at an altitude of 50 feet (V_{50_w}) was determined from true airspeed (V_T) and corrected for wind effects. The ground speed at takeoff is related to true airspeed by the following relationship:

$$V_{TO_w} = V_{TO} - V_w \qquad (4)$$

Where:

V_W = Headwind component of wind velocity

7. True airspeed (V_T) was calculated from the calibrated airspeed and density ratio.

$$V_T = \frac{V_{cal}}{\sigma} \quad \text{(ft/sec)} \tag{5}$$

Where:

σ = Density ratio (ρ/ρ_o)

Where:

ρ_o = Density at sea level on a standard day

8. Calibrated airspeed (V_{cal}) was obtained by correcting indicated airspeed (V_i) from the aircraft pitot-static system for instrument error (ΔV_{ic}) and position error (Δpc).

$$V_{cal} = V_i + \Delta V_{ic} + \Delta Vpc \tag{6}$$

Where:

ΔV_{pc} = Static position error obtained from operator's manual

GROSS WEIGHT DETERMINATION

9. The test gross weight (W_t) was computed by adding the fuel quantity remaining (W_{FR}) obtained from a calibrated indicator to the aircraft operating weight (W_o).

$$W_t = W_o + W_{FR} \tag{7}$$

Where:

W_o = Operating gross weight (lb) (aircraft gross weight minus fuel)

W_{FR} = Fuel quantity remaining (lb)

POWER REQUIRED DETERMINATION

10. The engine output shaft horsepower (shp) was determined from the engine torque pressure (Q) and power turbine (Np) speed. Torque pressure as a function of the power output of the engine was obtained from the engine manufacturer's model specification (ref 5, app A). The shaft horsepower was determined by the following equation:

$$SHP = \frac{2\pi \times K \times N_P \times Q}{33{,}000} \quad (8)$$

Where:

SHP = Shaft horsepower

K = 36.5, conversion factor to change measured engine torque pressure (psi) to torque (ft-lb)

Np = Power turbine speed (rpm)

Q = Engine torque pressure (psi)

33,000 = Conversion factor (ft-lb/min/shp)

11. Thrust horsepower (THP) was computed from engine shaft horsepower and propeller efficiency (ηP) according to the equation:

$$THP = \eta_P \times SHP \quad (9)$$

The propeller efficiency was obtained from the propeller chart supplied by Grumman Aerospace Corporation (ref 6, app A), and is a function of propeller advance ratio (J) and coefficient of power (Cp), which was obtained by the following equations:

$$J = 101.28\ V_T/N_P\ D \quad (10)$$

Where:

Np = Propeller speed (rpm)

D = Propeller diameter (ft)

and

$$C_P = \frac{SHP}{2\sigma (N_P/100)^3\ (D/10)^5} \quad (11)$$

12. Propeller thrust at .7 lift-off true airspeed ($.7V_T$) was computed from thrust horsepower (THP) according to the following relationship:

$$T_t = \frac{550 \text{ X THP}}{.7V_T} \qquad (12)$$

TAKEOFF PERFORMANCE

13. The total horizontal distance required to clear a 50-foot obstacle (S_T) is composed of the ground roll distance (S_g) and the airborne horizontal distance (S_a).

$$S_T = S_g + S_a \qquad (13)$$

14. Values of ground roll distance (S_{g_W}) and airborne horizontal distance (S_{a_W}) were obtained using ground based space positioning equipment and were connected to standard day, no wind conditions. Runway slope corrections were not applied. Ground roll distance was corrected for wind using the equation:

$$S_g = S_{g_W} \left(1 + \frac{V_W}{V_{TO_W}}\right)^{1.85} \qquad (14)$$

Where:

S_g = Ground roll (ft)

S_{g_W} = Observed ground roll (ft)

V_W = Wind velocity (ft/sec)

V_{TO_W} = Takeoff ground speed (ft/sec)

Air distance was corrected for wind using the equation:

$$S_a = S_{a_W} + V_W t \text{ (ft)} \qquad (15)$$

Where:

S_a = Horizontal air distance to 50-foot obstacle (ft)

S_{a_W} = Observed horizontal air distance to 50-foot obstacle (ft)

V_w = Wind velocity (ft/sec)

t = Time from lift-off to 50 feet above ground (sec)

15. The ground roll distance was next corrected to standard values of weight, density, and thrust by the relationship:

For the ground phase:

$$S_{gs} = S_{gt} \frac{\frac{W_s}{W_t}\frac{\sigma_t}{\sigma_s}}{\frac{2gS_{gt}}{W_t V_{TO_t}{}^2}\left(\frac{W_t}{W_s} \times T_s - T_t\right) + 1} \qquad (16)$$

Where:

S_{gs} = Standard-day ground roll distance (ft)

S_{gt} = Test-day ground roll distance measured from start of ground roll to point of left-off (ft)

W_s = Standard gross weight (lb)

W_t = Test gross weight (lb)

V_{TO_t} = Test takeoff true airspeed (ft/sec)

T_s = Standard propeller thrust (lb)

T_t = Test propeller thrust (lb)

σ_s = Standard-day density ratio

σ_t = Test-day density ratio

g = Acceleration due to gravity (ft/sec²)

For the air phase:

$$S_{a_s} = S_{a_t} \frac{\left(\frac{W_s}{W_t}\frac{\sigma_t}{\sigma_s}\right)\left(\frac{V_{50}{}^2 - V_{TO}{}^2}{2g}\right) + 50}{\left(\frac{V_{50}{}^2 - V_{TO}{}^2}{2g}\right) + 50 + \frac{S_{a_t} T_s}{W_s} - \frac{S_{a_t} T_t}{W_t}} \qquad (17)$$

Where:

S_{a_s} = Standard-day takeoff air distance (ft)

S_{a_t} = Test-day takeoff air distance measured from point of lift-off to 50 feet above the ground (ft)

V_{50} = True airspeed at 50 feet above ground level (ft/sec)

The total horizontal distance to clear a 50-foot obstacle is $S_{g_s} + S_{a_s}$.

16. In analyzing takeoff performance data and comparing aircraft with different combinations of takeoff weights, altitudes and airspeeds, it is more convenient to deal in total aircraft energy. At any instant the total energy (E) is the sum of the potential (PE) and kinetic (KE) energies.

$$E = PE + KE \tag{18}$$

or

$$E = W_s h + \frac{W_s V_{T_s}^{\ 2}}{2g} \tag{19}$$

Where:

h = Height above lift-off elevation (ft)

V_{T_s} = Standard true airspeed (ft/sec)

The standard true airspeed was calculated from the following relationship:

$$V_{T_s} = \left(\frac{W_s}{W_t} \frac{\sigma_t}{\sigma_s}\right)^{1/2} V_{T_t} \tag{20}$$

Where:

V_{T_s} = Standard true airspeed (ft/sec)

V_{T_t} = Test true airspeed (ft/sec)

This empirical relationship between total energy and takeoff distance is determined by calculating values of total energy (E) and fitting a zero intercept linear least squares curve through the data plotted as a function of takeoff distance. This curve is determined for each test altitude for both ground and total distance. The effects of weight are assumed to be accounted for in the calculation of total energy and power corrections were unnecessary as the engine limit gearbox torque was used at all conditions tested. A typical curve is presented in figure A. The curve is then used to calculate the fairing of the standardized takeoff data. The indicated airspeed is computed from the functional relationship of total aircraft energy to takeoff distance by the following equation:

$$V_i = 2g\sqrt{\left(\frac{E - W_s h}{W_s}\right) \sigma_s} - \Delta pc \qquad (21)$$

Where:

V_i = Aircraft indicated airspeed (instrument corrected) (kt)

E = Total aircraft energy

W_s = Standard aircraft test weight (lb)

h = Height above ground level (ft)

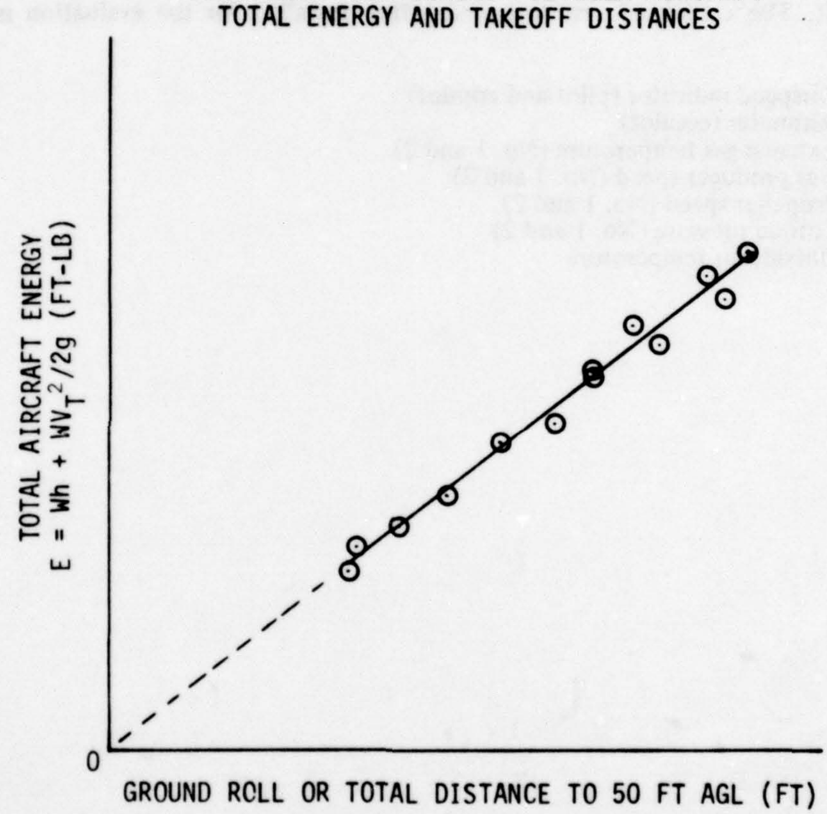
σ_s = Standard density ratio

ΔV_{pc} = Pitot-static position error (kt)

WEIGHT AND BALANCE

17. The aircraft weight and longitudinal and lateral centers of gravity were determined prior to start ot testing. A fuel cell calibration was also accomplished in conjunction with the weight and balance determination. The aircraft was weighed in a level condition seven times with incremental amounts of fuel on board from zero fuel to full fuel. The longitudinal center of gravity for the empty test aircraft with flight test instrumentation installed was at fuselage station (FS) 159.2.

FIGURE A.
FUNCTIONAL RELATIONSHIP BETWEEN AIRCRAFT
TOTAL ENERGY AND TAKEOFF DISTANCES



APPENDIX C. INSTRUMENTATION

1. Instrumentation was calibrated, installed an maintained in the test aircraft by USAAEFA personnel. Hand-recorded cockpit data were the primary means of obtaining engineering flight data. A 16mm high-speed motion picture camera was installed on the center console between the pilots for recording the instrument readings for each data point.

2. During the takeoff performance tests a recording observation instrument (ROI) was used. This system recorded on tape the azimuth and altitude bearings to the test aircraft. The calibrated test instrumentation installed for the evaluation is listed below.

Airspeed indicator (pilot and copilot)
Altimeter (copilot)
Exhaust gas temperature (No. 1 and 2)
Gas producer speed (No. 1 and 2)
Propeller speed (No. 1 and 2)
Torque pressure (No. 1 and 2)
Outside air temperature

APPENDIX D. TEST DATA

Index

Figure	Figure Number
Takeoff Performance Summary	1 through 3
Takeoff Performance	4 through 8

FIGURE 1
TAKEOFF PERFORMANCE SUMMARY
OV-1C USA S/N 67-18918

NOTES:
1. NORMAL TAKEOFF TECHNIQUE - 5 DEG TAKEOFF ATTITUDE
2. ENGINE MODEL T53-L-15
3. DRY PAVED RUNWAY
4. FORWARD CENTER OF GRAVITY (FS 159.5)
5. STANDARD DAY CONDITIONS
6. CURVES DERIVED FROM FIGS 4 THROUGH 7
7. FLAP SETTING 15 DEGREES
8. PERFORMANCE BASED ON AIRSPEED PROFILE RECOMMENDED IN OPERATOR'S MANUAL
9. LONG DASHED CURVES FROM OPERATOR'S MANUAL
10. 15000 POUND DATA POINT FOR 2000 FOOT ALTITUDE ONLY.

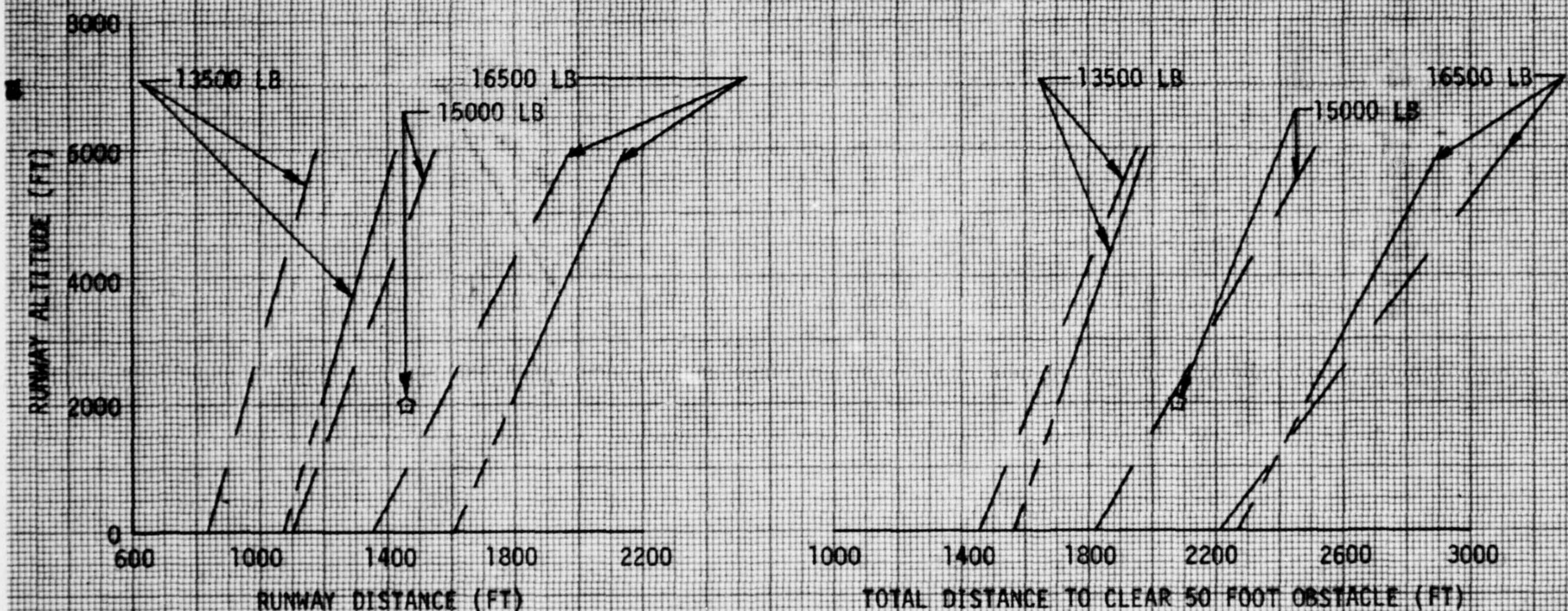


FIGURE 2
TAKEOFF PERFORMANCE SUMMARY
OV-1C USA S/N 67-18918

NOTES:
1. NORMAL TAKEOFF TECHNIQUE - 10 DEG TAKEOFF ATTITUDE
2. ENGINE MODEL T53-L-15
3. DRY PAVED RUNWAY
4. FORWARD CENTER OF GRAVITY (FS 159.5)
5. STANDARD DAY CONDITIONS
6. CURVES DERIVED FROM FIGS 4 THROUGH 7
7. FLAP SETTING 15 DEGREES
8. PERFORMANCE BASED ON AIRSPEED PROFILE RECOMMENDED IN OPERATOR'S MANUAL
9. LONG DASHED CURVES FROM OPERATOR'S MANUAL
10. 15000 POUND DATA POINT FOR 2000 FOOT ALTITUDE ONLY.

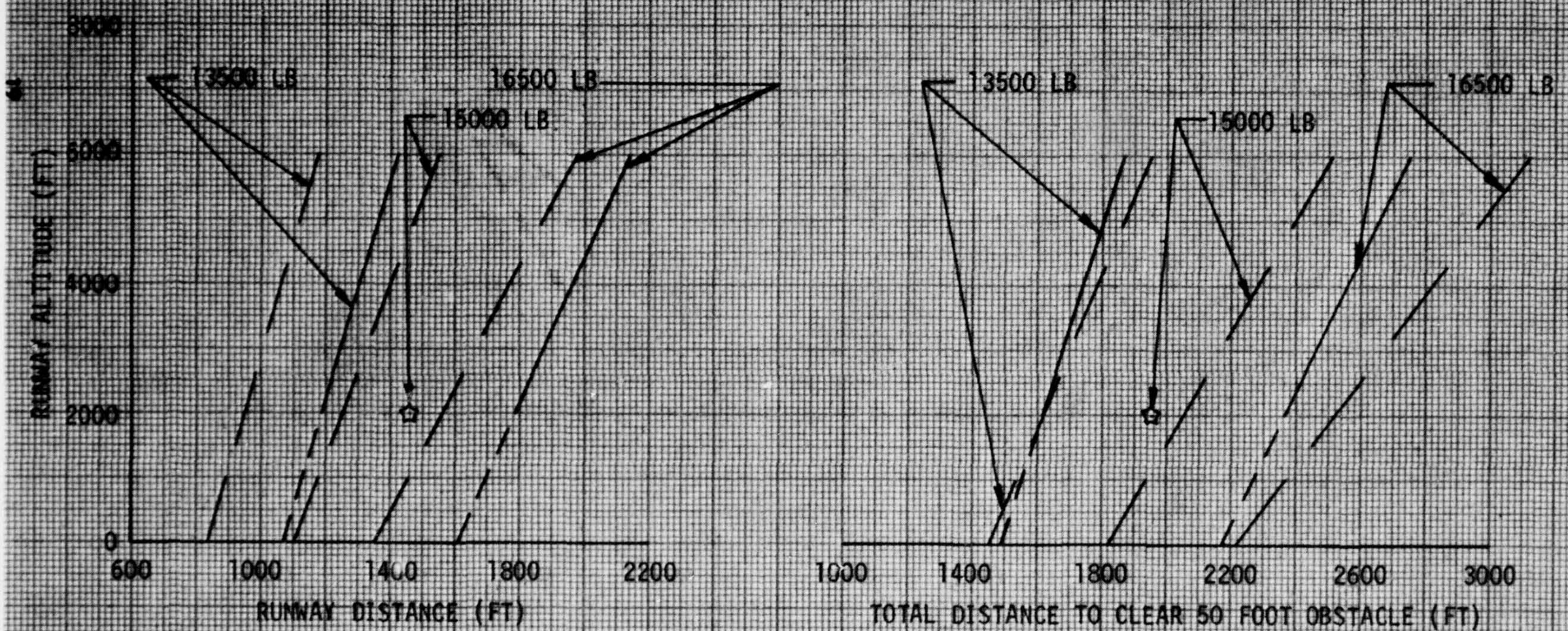


FIGURE 3
TAKEOFF PERFORMANCE SUMMARY
OV-1C USA S/N 67-18918

NOTES:
1. MINIMUM RUN TAKEOFF TECHNIQUE
2. ENGINE MODEL T53-L-15
3. DRY PAVED RUNWAY
4. FORWARD CENTER OF GRAVITY (FS 159.5)
5. STANDARD DAY CONDITIONS
6. CURVES DERIVED FROM FIGS 4 THROUGH 7
7. FLAP SETTING 15 DEGREES
8. PERFORMANCE BASED ON LOWEST AIRSPEED TESTED
9. LONG DASHED CURVES FROM OPERATOR'S MANUAL
10. 15000 POUND DATA POINT FOR 2000 FOOT ALTITUDE ONLY.

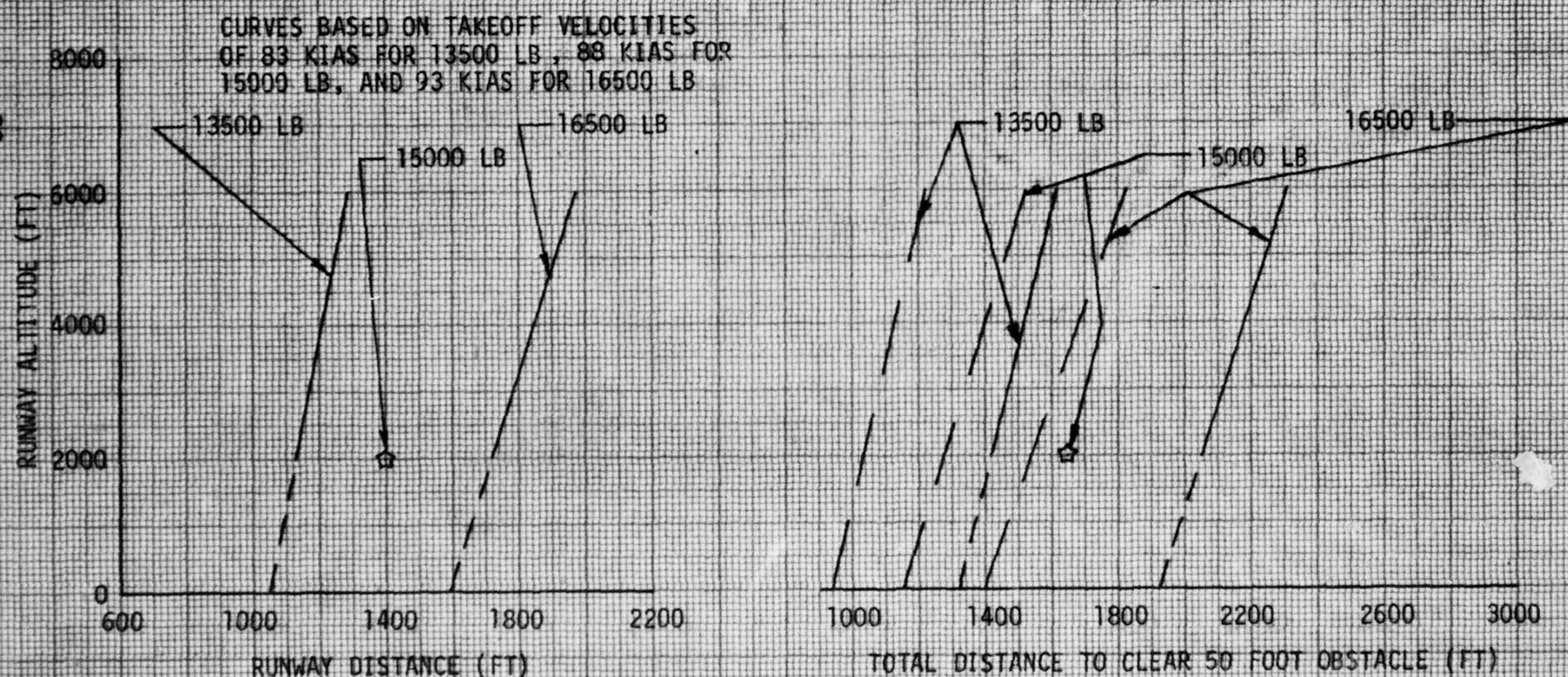


FIGURE 4
TAKEOFF PERFORMANCE
OV-1C USA S/N 67-18918

GROSS WEIGHT (LB)	LONG C.G. (FS)	DENSITY ALTITUDE (FT)	ROTOR SPEED (RPM)	CONFIGURATION
13500	159.5(FWD)	2000	1720	TAKEOFF, 2-150 GAL DROP TANKS

NOTES:
1. STANDARD DAY.
2. POWER AVAILABLE FOR MODEL T53-L-15 ENGINES OBTAINED FROM OPERATOR'S MANUAL.
3. CURVE FAIRINGS OBTAINED BY ENERGY METHOD.

□—OPERATOR'S MANUAL, NORMAL TAKEOFF TECHNIQUE.
△—OPERATOR'S MANUAL, MINIMUM RUN TAKEOFF TECHNIQUE
○—TEST DATA.

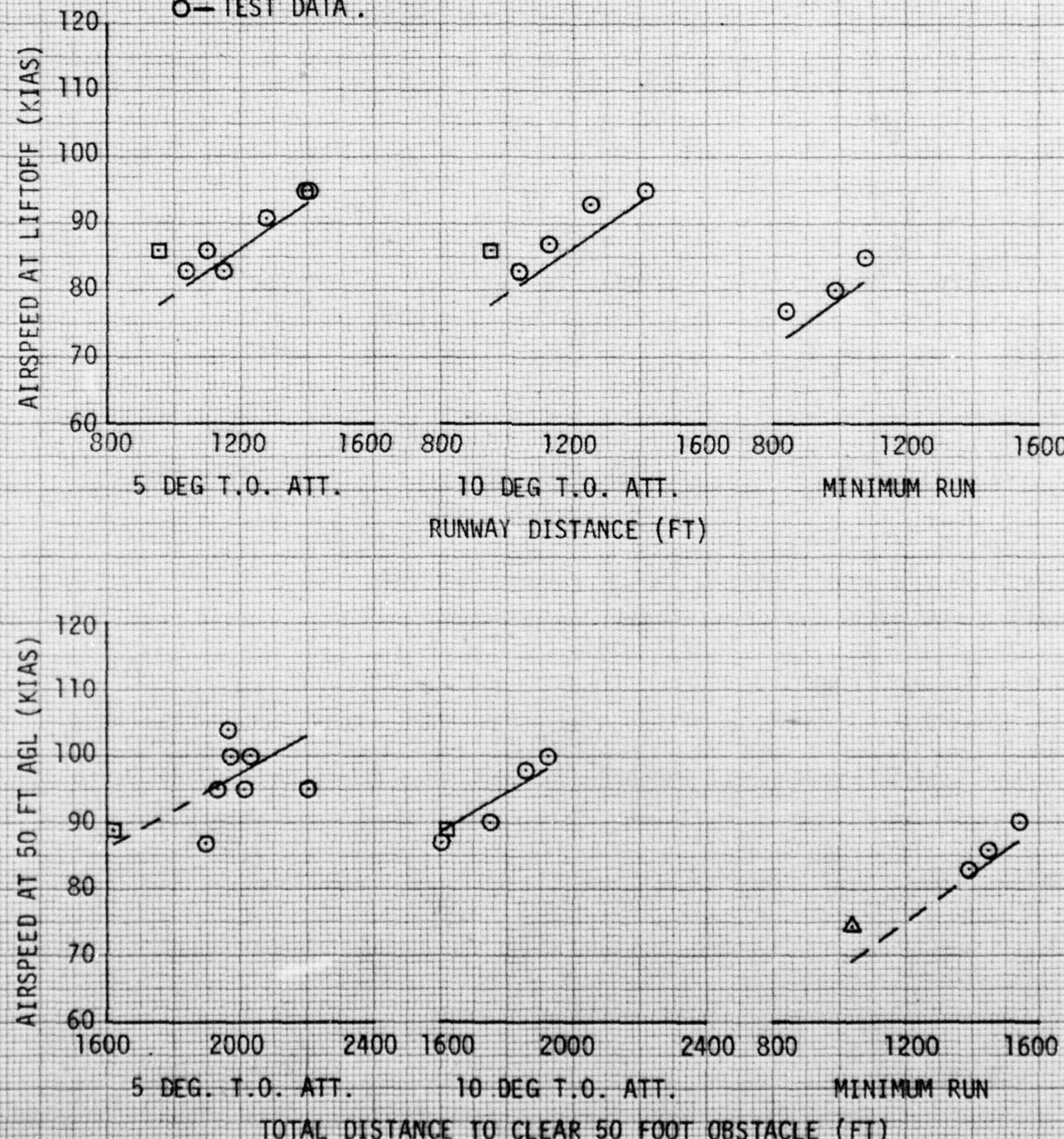
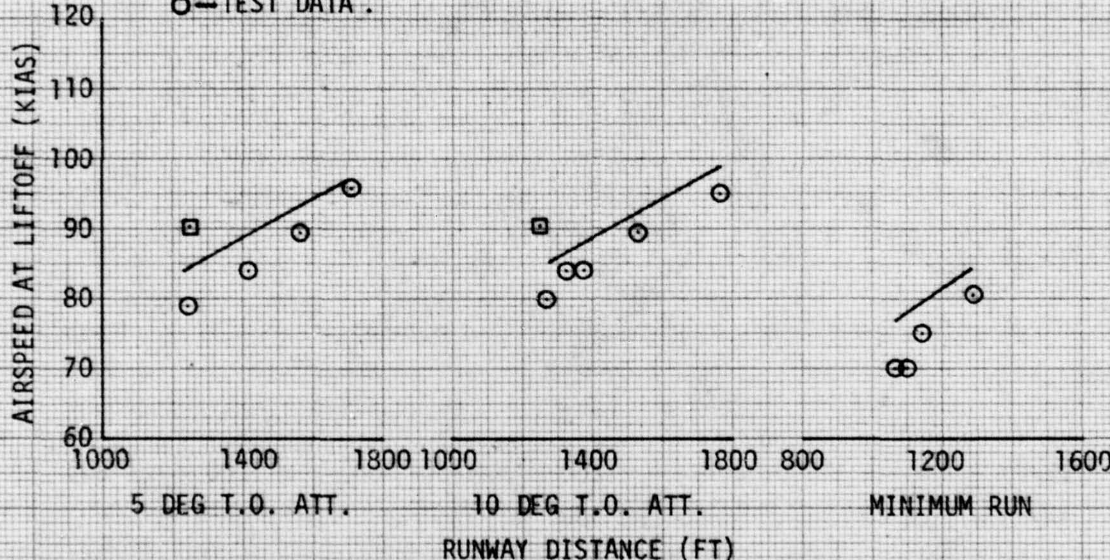


FIGURE 5
TAKEOFF PERFORMANCE
OV-1C USA S/N 67-18918

GROSS WEIGHT (LB)	LONG C.G. (FS)	DENSITY ALTITUDE (FT)	ROTOR SPEED (RPM)	CONFIGURATION
15000	159.5(FWD)	2000	1720	TAKEOFF, 2-150 GAL DROP TANKS

NOTES:
1. STANDARD DAY.
2. POWER AVAILABLE FOR MODEL T53-L-15 ENGINES OBTAINED FROM OPERATOR'S MANUAL.
3. CURVE FAIRINGS OBTAINED BY ENERGY METHOD.

□— OPERATOR'S MANUAL, NORMAL TAKEOFF TECHNIQUE.
△— OPERATOR'S MANUAL, MINIMUM RUN TAKEOFF TECHNIQUE.
○— TEST DATA.



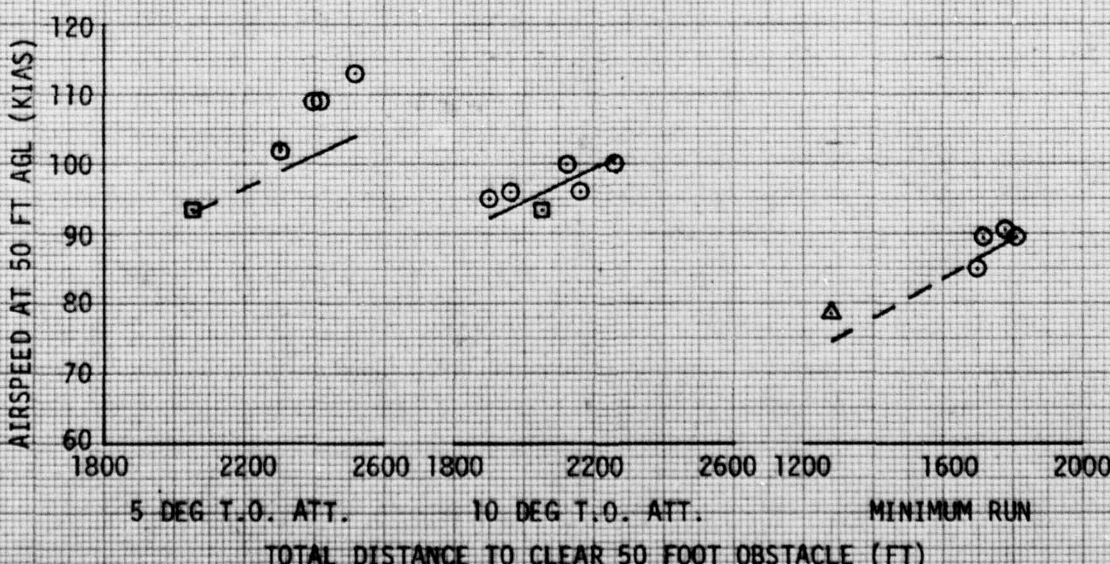
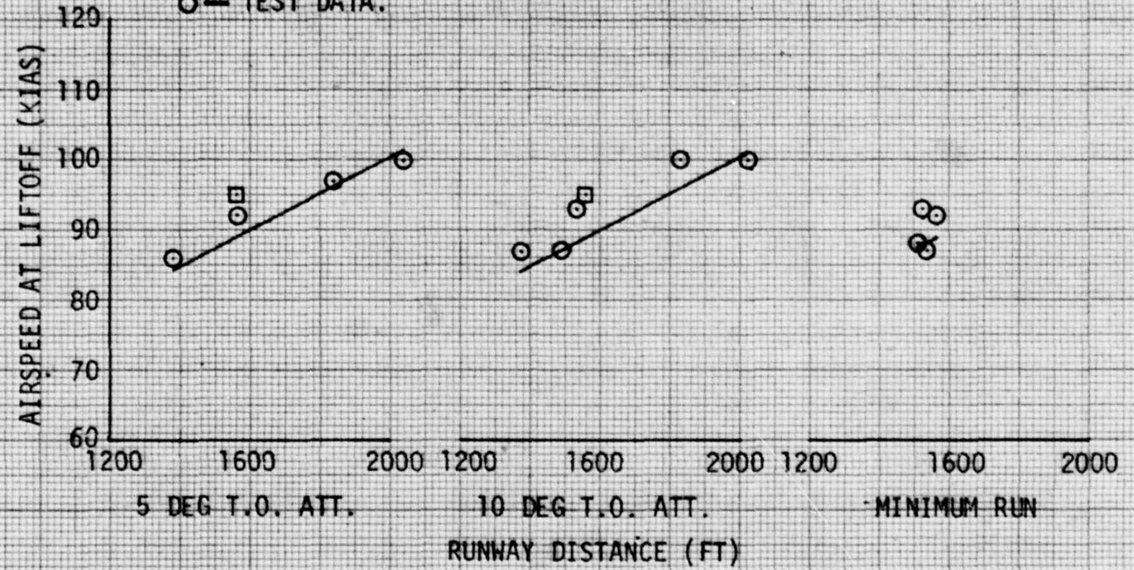


FIGURE 6
TAKEOFF PERFORMANCE
OV-1C USA S/N 67-18918

GROSS WEIGHT (LB)	LONG C.G. (FS)	DENSITY ALTITUDE (FT)	ROTOR SPEED (RPM)	CONFIGURATION
16500	159.5(FWD)	2000	1720	TAKEOFF, 2-150 GAL DROP TANKS

NOTES:
1. STANDARD DAY.
2. POWER AVAILABLE FOR MODEL T53-L-15 ENGINES OBTAINED FROM OPERATOR'S MANUAL.
3. CURVE FAIRINGS OBTAINED BY ENERGY METHOD.

□ — OPERATOR'S MANUAL, NORMAL TAKEOFF TECHNIQUE.
△ — OPERATOR'S MANUAL, MINIMUM RUN TAKEOFF TECHNIQUE.
○ — TEST DATA.



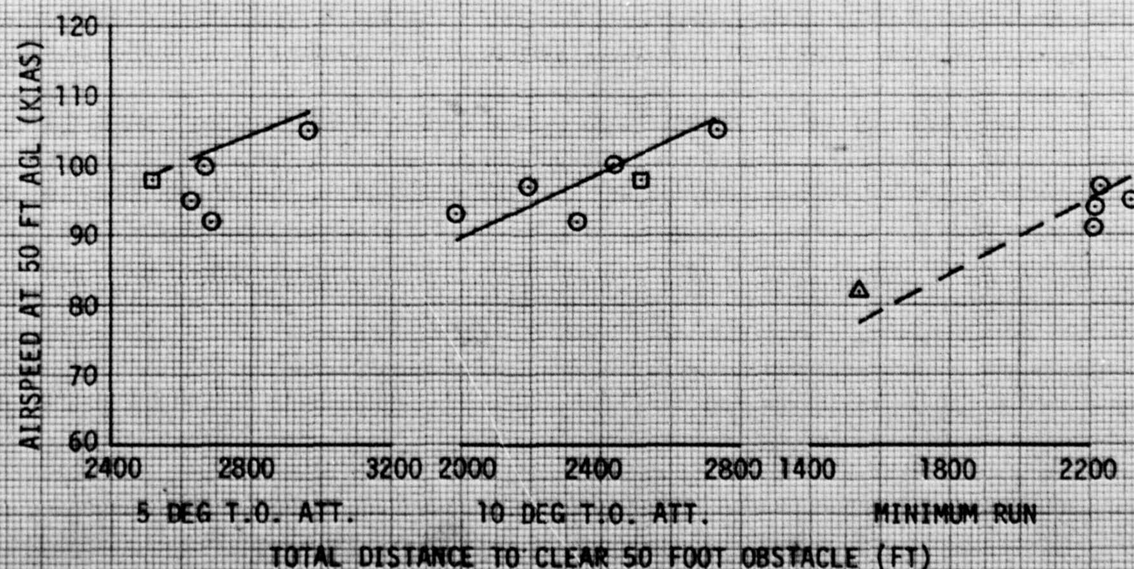


FIGURE 7
TAKEOFF PERFORMANCE
OV-1C USA S/N 67-18918

GROSS WEIGHT (LB)	LONG C.G. (FS)	DENSITY ALTITUDE (FT)	ROTOR SPEED (RPM)	CONFIGURATION
13500	159.5(FWD)	6000	1720	TAKEOFF, 2-150 GAL DROP TANKS

NOTES:
1. STANDARD DAY.
2. POWER AVAILABLE FOR MODEL T53-L-15 ENGINES OBTAINED FROM OPERATOR'S MANUAL.
3. CURVE FAIRINGS OBTAINED BY ENERGY METHOD.

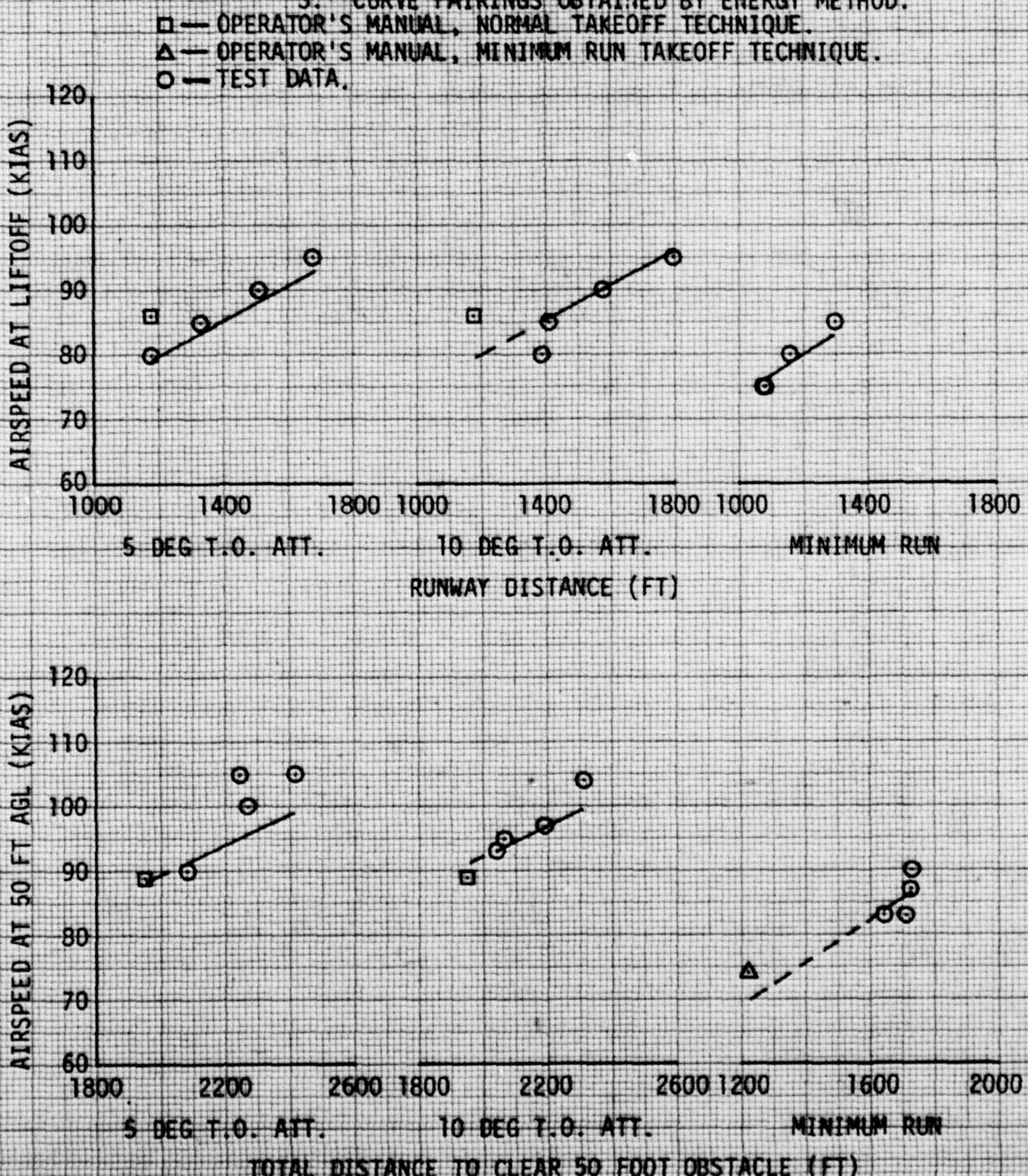
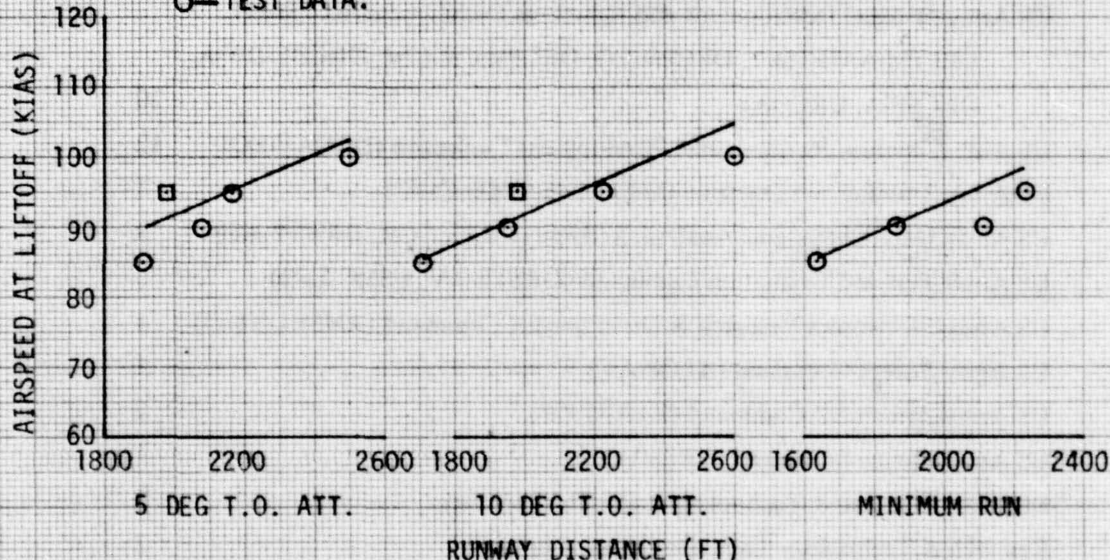


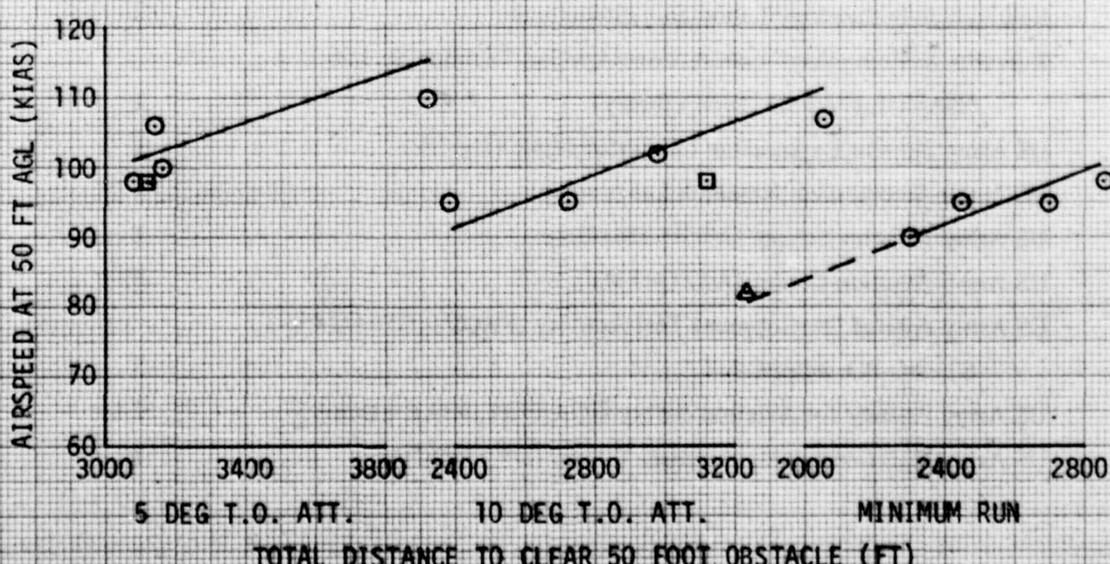
FIGURE 8
TAKEOFF PERFORMANCE
OV-1C USA S/N 67-18918

GROSS WEIGHT (LB)	LONG C.G. (FS)	DENSITY ALTITUDE (FT)	ROTOR SPEED (RPM)	CONFIGURATION
16500	159.5(FWD)	6000	1720	TAKEOFF, 2-150 GAL DROP TANKS

NOTES:
1. STANDARD DAY.
2. POWER AVAILABLE FOR MODEL T53-L-15 ENGINES OBTAINED FROM OPERATOR'S MANUAL.
3. CURVE FAIRINGS OBTAINED BY ENERGY METHOD.

□— OPERATOR'S MANUAL, NORMAL TAKEOFF TECHNIQUE.
△— OPERATOR'S MANUAL, MINIMUM RUN TAKEOFF TECHNIQUE.
○— TEST DATA.





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INFORMATION

AD-A069827

ERRATA

USAAEFA Project No. 78-07

Final Report

Airworthiness and Flight Characteristics Test
OV-1C Takeoff Performance

United States Army Aviation Engineering Flight Activity
Edwards Air Force Base, California 93523

Remove pages 9/10 and 11/12 and replace with new 9/10 and 11/12.

Where:

V_W = Headwind component of wind velocity

7. True airspeed (V_T) was calculated from the calibrated airspeed and density ratio.

$$V_T = \frac{V_{cal}}{\sqrt{\sigma}} \quad \text{(ft/sec)} \tag{5}$$

Where:

σ = Density ratio (ρ/ρ_o)

Where:

ρ_o = Density at sea level on a standard day

8. Calibrated airspeed (V_{cal}) was obtained by correcting indicated airspeed (V_i) from the aircraft pitot-static system for instrument error (ΔV_{ic}) and position error (Δpc).

$$V_{cal} = V_i + \Delta V_{ic} + \Delta V_{pc} \tag{6}$$

Where:

ΔV_{pc} = Static position error obtained from operator's manual

GROSS WEIGHT DETERMINATION

9. The test gross weight (W_t) was computed by adding the fuel quantity remaining (W_{FR}) obtained from a calibrated indicator to the aircraft operating weight (W_o).

$$W_t = W_o + W_{FR} \tag{7}$$

Where:

W_o = Operating gross weight (lb) (aircraft gross weight minus fuel)

W_{FR} = Fuel quantity remaining (lb)

POWER REQUIRED DETERMINATION

10. The engine output shaft horsepower (shp) was determined from the engine torque pressure (Q) and power turbine (Np) speed. Torque pressure as a function of the power output of the engine was obtained from the engine manufacturer's model specification (ref 5, app A). The shaft horsepower was determined by the following equation:

$$SHP = \frac{2\pi \times K \times Np \times Q}{33{,}000} \qquad (8)$$

Where:

SHP = Shaft horsepower

K = 36.5, conversion factor to change measured engine torque pressure (psi) to torque (ft-lb)

Np = Power turbine speed (rpm)

Q = Engine torque pressure (psi)

33,000 = Conversion factor (ft-lb/min/shp)

11. Thrust horsepower (THP) was computed from engine shaft horsepower and propeller efficiency (ηP) according to the equation:

$$THP = \eta_p \times SHP \qquad (9)$$

The propeller efficiency was obtained from the propeller chart supplied by Grumman Aerospace Corporation (ref 6, app A), and is a function of propeller advance ratio (J) and coefficient of power (Cp), which was obtained by the following equations:

$$J = 60\ V_T/N_p D \qquad (10)$$

Where:

Np = Propeller speed (rpm)

D = Propeller diameter (ft)

and

$$C_P = \frac{SHP}{2\sigma (Np/100)^3\ (D/10)^5} \qquad (11)$$

12. Propeller thrust at .7 lift-off true airspeed (.7V_T) was computed from thrust horsepower (THP) according to the following relationship:

$$T_t = \frac{550 \times THP}{.7V_T} \qquad (12)$$

TAKEOFF PERFORMANCE

13. The total horizontal distance required to clear a 50-foot obstacle (S_T) is composed of the ground roll distance (S_g) and the airborne horizontal distance (S_a).

$$S_T = S_g + S_a \qquad (13)$$

14. Values of ground roll distance (S_{g_w}) and airborne horizontal distance (S_{a_w}) were obtained using ground based space positioning equipment and were corrected to standard day, no wind conditions. Runway slope corrections were not applied. Ground roll distance was corrected for wind using the equation:

$$S_g = S_{g_w} \left(1 + \frac{V_w}{V_{TO_w}}\right)^{1.85} \qquad (14)$$

Where:

S_g = Ground roll (ft)

S_{g_w} = Observed ground roll (ft)

V_w = Wind velocity (ft/sec)

V_{TO_w} = Takeoff ground speed (ft/sec)

Air distance was corrected for wind using the equation:

$$S_a = S_{a_w} + V_w t \text{ (ft)} \qquad (15)$$

Where:

S_a = Horizontal air distance to 50-foot obstacle (ft)

S_{a_w} = Observed horizontal air distance to 50-foot obstacle (ft)

V_W = Wind velocity (ft/sec)

t = Time from lift-off to 50 feet above ground (sec)

15. The ground roll distance was next corrected to standard values of weight, density, and thrust by the relationship:

For the ground phase:

$$S_{g_s} = S_{g_t} \frac{\frac{W_s}{W_t} \frac{\sigma_t}{\sigma_s}}{\frac{2gS_{g_t}}{W_t V_{TO_t}^{\ 2}} \left(\frac{W_t}{W_s} X\, T_s - T_t\right) + 1} \qquad (16)$$

Where:

S_{g_s} = Standard-day ground roll distance (ft)

S_{g_t} = Test-day ground roll distance measured from start of ground roll to point of lift-off (ft)

W_s = Standard gross weight (lb)

W_t = Test gross weight (lb)

V_{TO_t} = Test takeoff true airspeed (ft/sec)

T_s = Standard propeller thrust (lb)

T_t = Test propeller thrust (lb)

σ_s = Standard-day density ratio

σ_t = Test-day density ratio

g = Acceleration due to gravity (ft/sec^2)

For the air phase:

$$S_{a_s} = S_{a_t} \frac{\left(\frac{W_s}{W_t} \frac{\sigma_t}{\sigma_s}\right) \left(\frac{V_{50}^{\ 2} - V_{TO}^{\ 2}}{2g}\right) + 50}{\left(\frac{V_{50}^{\ 2} - V_{TO}^{\ 2}}{2g}\right) + 50 + \frac{S_{a_t} T_s}{W_s} - \frac{S_{a_t} T_t}{W_t}} \qquad (17)$$