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DESIGN AND ANALYSIS OF A FUEL-EFFICIENT SINGLE-ENGINE, TURBOPROP-POWERED, BUSINESS AIRPLANE

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SUMMARY

A study was conducted to determine whether a general aviation airplane powered by one turboprop engine could be configured to have a speed, range, and payload comparable to current twin-engine turboprop aircraft and also achieve a significant increase in fuel efficiency. An airplane configuration was developed which can carry six people for a no-reserve range of 2 408 km (1 300 n.mi.) at a cruise speed above 154 m/s (300 kt) and a cruise altitude above 9 144 m (30 000 ft). This cruise speed is comparable to that of the fastest of the current twin turboprop-powered airplanes. The airplane has a cruise specific range greater than all twin turboprop-engine airplanes flying in its speed range and most twin piston-engine airplanes flying at considerably slower cruise airspeeds. The high thrust-weight ratio and maximum use of high-lift devices produce takeoff and landing distances of less than 762 m (2 500 ft) at maximum gross weight for airport pressure altitudes up to 1 830 m (6 000 ft).

INTRODUCTION

A large segment of the business community depends upon the use of twin-engine turboprop general aviation aircraft to satisfy their transportation requirements. These aircraft have been developed to the point where they now provide reliable, all-weather capability and block times comparable to turbojet aircraft for short and medium ranges. This, combined with the ability to operate out of smaller airports, provides the business community with a very versatile air transportation system.

A continuing effort is being made by the NASA and industry toward improving the fuel efficiency of aircraft. This study was conducted to determine whether a single-engine turboprop business aircraft could be configured to have a speed, range, and payload comparable to current twin-turboprop business aircraft and also have a substantial increase in fuel efficiency. Such a configuration would provide a considerable savings in initial cost, maintenance costs, and fuel costs over current twin-engine business aircraft.

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In order to evaluate the performance characteristics of a single-engine turboprop-powered airplane and the fuel conservation improvements which could be gained, a six place configuration was developed which would have a design cruise speed of 154 m/s (300 kt) and cruise at altitudes above 9 144 m (30 000 ft). The design range is 2 408 km (1 300 n.mi.) without reserves. The structure is of conventional aluminum construction with cabin pressurization such that a cabin altitude of 2 438 m (8 000 ft) could be maintained to the service ceiling. A relatively small wing of 11.15 m^2 (120 ft^2) and an aspect ratio of 8 was specified in order to achieve better cruise performance. The higher wing loading, resulting from the use of a small wing, required extensive use of high-lift devices in order to provide acceptable low-speed characteristics.

SYMBOLS

Values are given in this report in both International System Units (SI) and U.S. Customary Units. All calculations were made in U.S. Customary Units.

A	aspect ratio
C_D	drag coefficient, D/qS
C_{D_i}	induced drag coefficient
C_{D_p}	parasite drag coefficient
$C_{D_{trim}}$	trim drag coefficient
C_L	lift coefficient, L/qS
C_{L_i}	propeller integrated lift coefficient
C_P	power coefficient
D	drag, N (lbf)
J	propeller advance ratio

L	lift, N (lbf)
q	dynamic pressure, Pa (lbf/ft^2)
S	reference area, m^2 (ft^2)
V_{cruise}	cruise speed, m/s (kt)
V_{stall}	stall speed, m/s (kt)
ΔC_{D_p}	lift-dependent parasite drag coefficient
$\Delta C_{D_{power}}$	power-dependent drag coefficient
δ_f	trailing-edge flap deflection angle, degrees
δ_s	leading-edge slat deflection angle, degrees
η	propeller efficiency

Subscripts:

min	minimum

Abbreviations:

AF	propeller activity factor
FAR	Federal Aviation Regulation
MAC	mean aerodynamic chord, m (ft)

CONFIGURATION DESCRIPTION

The airplane is of conventional design with a low wing, a front mounted engine, and an aft located horizontal tail. This configuration was selected instead of a more unconventional configuration, such as those with pusher propellers or canards, in order to provide a more accurate comparison of the relative merits of using one engine or two engines.

The wing selected has an area of 11.15 m^2 (120 ft^2), a span of 9.39 m (30.8 ft), an aspect ratio of 8 and a taper ratio of 0.33. A high wing loading, 1.9 Pa (39.6 lb/ft^2), was desired in order to provide a better match for the wing at the cruise condition. A 15 percent thick airfoil section, the NACA 65_2-415, was selected for use on the unswept wing to reduce the wing structural weight. In order to simplify the leading-edge slat and trailing-edge flap mechanism, straight leading and trailing edges were used on the wing. The taper ratio of .33 produces a nearly elliptical spanwise load distribution for a straight-tapered wing, and also results in a lighter wing structure.

The high-lift devices used on the wing consist of a single-slotted 30 percent chord trailing-edge fowler flap and a 15-percent chord leading-edge slat. The flaps have a 20-percent chord extension, 40 degrees of deflection and extend from the fuselage to 90 percent of the semispan. The remaining 10 percent of the trailing edge is used for the aileron. Roll control is provided primarily by spoilers located ahead of the flaps on the upper surface of the wing. The small ailerons are used to provide linearity in the roll control system. Full span leading-edge slats, with a deflection of 26 degrees, are used on this configuration to increase the obtainable lift. The extensive use of high-lift devices are required on this configuration in order to provide a stall speed which meets the requirement of FAR 23.49 (ref. 1).

The wing design is of conventional riveted aluminum, skin-stringer construction with spars located at 15 and 65 percent of the chord. These spars pass through the fuselage under the cabin floor. Integral fuel tanks in the wings have sufficient capacity to contain the fuel required for the design mission.

The fuselage cabin was designed to seat six 97.5-percentile men, including the pilot. The length of the cabin is 3.70 m (12.125 ft), the height is 1.42 m (56 in) at the center, and the width is 1.28 m (51 in) at elbow level. The second and third rows of seats have pitches of .86 m (34 in) and 1.12 m (44 in) respectively and are separated by a .23 m (9 in) wide aisle. Entrance to the cabin is through a door located at the left rear. An escape hatch is provided on the right side of the cabin. The baggage compartment is located aft of the pressure bulkhead. The layout and dimensions of the cabin are presented in figures 1 and 2. This cabin has more room than most of the current six-place twin-engine aircraft.

The fuselage is designed for a pressure differential of 56.9 kPa (8.25 psi) which allows a 2 438 m (8 000 ft) cabin pressure altitude to be maintained to a cruise altitude of 12 190 m (40 000 ft). The cabin pressurization system is conventional, utilizing engine bleed air to maintain the required level of pressurization.

The configuration is equipped with a tricycle landing gear arrangement. The nose gear rotates and retracts aft into a compartment under the cabin floor. The wing-mounted main gear retracts inward into the wing root and fuselage.

A conventional empennage arrangement is used on the study aircraft. The vertical tail has an area of 1.79 m^2 (19.25 ft^2) with a 30 percent full span rudder. The horizontal tail has an area of 2.69 m^2 (29 ft^2) and a 30 percent chord elevator. The horizontal tail is mounted so that the elevator is aft of the fuselage and extends the full span of the horizontal tail.

A general arrangement drawing of the configuration is presented as figure 3. A summary of the geometric characteristics is contained in table I.

PROPULSION ANALYSIS

The engine used for this study was the Pratt and Whitney Aircraft of Canada PT6A-45A which is a lightweight, free-power turbine, turboprop engine. Installed performance for this engine was generated with the aid of an engine performance computer program provided by Pratt and Whitney Aircraft of Canada. The engine performance thus generated is based on the following installation effects and constraints at all altitudes, airspeeds, and throttle settings:

Inlet ram pressure recovery	.98
Service airbleed	.113 kg/s (.25 lbm/s)
Accessory power extraction	7.46 kN (10 HP)
Propeller speed	1700 rpm
Convergent nozzle exhaust area	.058 m^2 (90 in^2)
Nozzle discharge angle	0° (parallel to engine centerline)

As a result of constraints and limits built into the PT6A-45A computer program, it was not possible to generate performance data above an altitude of

9 144 m (30 000 ft). In order to provide performance data adequate to encompass the desired airplane flight envelope, it was necessary to extrapolate engine performance data to an altitude of 10 668 m (35 000 ft).

Propeller selection and performance estimation were based on the Hamilton Standard methods presented in reference 2. These methods are based on a series of performance maps which provide systematic variations of the basic propeller shape and aerodynamic parameters. The performance of a given propeller is accurately defined by the map over the complete range of potential operating conditions.

Preliminary design considerations resulted in the definition of a four-bladed propeller with a 2.13 m (7 ft) diameter. A parametric analysis was then performed to determine the optimum (i.e., highest efficiency) combination of activity factor and integrated lift coefficient for several combinations of cruise power and speed at altitudes of 9 144 m (30 000 ft) and 10 668 m (35 000 ft). Based on this analysis, a final propeller was selected which was best matched to the required cruise conditions and which also provided acceptable performance throughout the flight envelope. Table II summarizes the propeller design point and characteristics.

Figures 4 and 5 summarize the estimated propeller performance for altitudes from sea level to 10 668 m (35 000 ft). The engine power setting is that for maximum climb/cruise power for each altitude. This performance summary indicates increasing efficiencies and decreasing thrusts with speed for a given altitude. Propeller efficiencies near 0.85 are indicated for the cruise conditions.

Additional thrust is produced by the engine exhausts and varies according to both power setting and airspeed. This thrust ranges from 533.8 N (120 lbf) at takeoff power and sea level static conditions to 13.3 N (3 lbf) at cruise conditions at 10 669 m (35 000 ft). At low power settings and high airspeed, such as may be experienced in descents, the thrust produced by the exhausts becomes slightly negative.

WEIGHTS ANALYSIS

The empty weight was estimated to be 11.20 kN (2 520 lbf) at a take-off gross weight of 21.1 kN (4 750 lbf). This gross weight includes 4.58 kN (1 030 lbf) for the fuel required to meet the no reserve range of 2 408 km (1 300 n.mi.) and 5.34 kN (1 200 lbf) for the passengers and baggage which comprise the payload. The avionics included in the weight analysis are comparable to those currently in use on general aviation aircraft operating in the high-altitude IFR environment. The design ultimate load factor used for this study was 6.66, which places the study aircraft in the utility category. A detailed weight breakdown is presented in table III. For the purpose of maintaining conventional weights engineering terminology, .89 kN (200 lbf) of the payload (pilot) is included in the operating weight empty of table III.

The requirement of maintaining a 2 438 m (8 000 ft) cabin pressure altitude to the service ceiling resulted in a cabin pressurization differential of 56.88 kPa (8.25 psi). Additional structural and systems weight penalities for pressurization to this level were estimated to be .89 kN (200 lbf).

The weight data for the engine and its accessories were obtained from reference 3. Avionics and propeller weights were obtained from manufacturer's data.

The center of gravity travel for this airplane ranges from 3 percent MAC at the operating weight empty condition to 30 percent MAC at the maximum gross weight condition.

AERODYNAMIC ANALYSIS

The airplane was designed primarily for high-speed cruise conditions and, therefore, has a wing loading much higher than other single-engine general aviation aircraft. Because of the high wing loading, an extensive use of high-lift devices was required to produce sufficient lift to allow the configuration to meet the FAR 23.49 (ref. 1) stall speed limit of 31.4 m/s (61 kt). The system designed to meet this requirement incorporates the maximum practical application of high-lift devices with full-span leading-edge slats and 90 percent span single-slotted fowler flaps. Some additional lift could be obtained by using multiple-slotted flaps, but the complexity of such a mechanism does not lend itself to use on a general aviation aircraft.

The lift characteristics were determined using the methods presented in reference 4. This method assumes that all slots in the flap system have been optimized. The lift curves are presented in figure 6 for flap deflections of 0 degrees, 5 degrees, and 40 degrees. These flap settings are used for cruise, takeoff, and landing, respectively. Using the maximum trimmed lift coefficient of 2.97, a minimum stall speed of 32.26 m/s (62.7 kts) can be obtained, which is .9 m/s (1.7 kt) above the FAR 23 requirement. A slight increase in wing area would allow the configuration to meet the requirement; however, no resizing was done in this study.

Drag polars were constructed for the takeoff, cruise, and landing modes of flight. The drag was defined as:

$$C_D = C_{D_{p_{min}}} + \Delta C_{D_p} + C_{D_i} + C_{D_{trim}} + \Delta C_{D_{power}}$$

The minimum value of parasite drag ($C_{D_{p_{min}}}$) consists of skin friction, profile, interference, roughness, and excrescence drag. The first three were determined by using the method presented in reference 5. Even though the airfoil section being used has the potential for a laminar boundary layer, the presence of the leading-edge slat and the normal operational accumulation of debris would probably preclude any extensive laminar boundary layer. Therefore, the skin-friction coefficients were calculated for a fully turbulent boundary layer on all parts of the airplane. Excrescence drag was calculated using the data of reference 6. Parasite drag was increased 5 percent to account for roughness effects.

The variation of parasite drag with lift (ΔC_{D_p}), which includes angle-of-attack dependent friction drag, pressure drag, and the effects of a non-elliptical load distribution on the wing, was determined from a method based on correlations with transport flight data.

The induced drag, C_{D_i}, was assumed to be $C_L^2/\pi A$, which is the induced-drag coefficient of a wing assuming an elliptical loading. The effects of deviations from elliptical loading are included in the method from which ΔC_{D_p} was determined.

Trim drag was calculated for an average center of gravity position and applied as an increment to the cruise drag polar. Trim drag was considered negligible for the takeoff and landing modes of flight and, therefore, was not included in the polars.

Power effects on lift and drag were calculated using the methods of reference 4. While power effects on lift and drag are small for cruise conditions, they are large during takeoff where the components of the airplane immersed in the propeller slipstream experience a much higher velocity than those in the freestream. The increment in drag at the cruise condition was added to the polar. Due to the large variation with airspeed of the incremental lift and drag due to power, they are not included in the takeoff polar. Since approaches are usually made at low power settings, no power effects on lift or drag were included in the landing analysis.

The cruise, takeoff, and landing polars are presented as figures 7, 8, and 9, respectively. The cruise polar is presented only for a typical cruise condition of 9 144 m (30 000 ft) and a Mach number of 0.5. A plot of the lift-drag ratio as a function of lift coefficient for this cruise condition is presented as figure 10.

PERFORMANCE ANLAYSIS

Takeoff and Climb

The takeoff distance was required to be 762 m (2 500 ft) or less at sea level and standard-day conditions. Although the configuration has a relatively high wing loading and, therefore, high rotation and liftoff speeds, its high thrust-weight ratio and resulting high acceleration allow it to exceed this requirement. Figure 11 presents the takeoff distance over a 15.2 m (50 ft) obstacle as a function of pressure altitude. As shown in figure 11, the configuration is capable of taking off from a 762 m (2 500 ft) runway at maximum gross weight at density altitudes as high as to 1 830 m (6 000 ft). This capability would allow the airplane to operate out of almost all of the airports in the United States at maximum gross weight and with temperatures above standard day conditions.

The rate of climb, time to climb, and distance for climb are presented in figures 12, 13, and 14 for standard day conditions and various weights. A high thrust-weight ratio provides the airplane with a rate of climb of 21.2 m/s (4 175 ft/min) at sea level and 2.8 m/s (550 ft/min) at an altitude of 10 668 m (35 000 ft). The speeds for these rates of climb vary from 92.1 m/s (179 kt) to 97.2 m/s (189 kt), respectively. The time to climb to 10 668 m (35 000 ft) is 17 minutes and the distance travelled is 98.2 km (53 n.mi.) These figures are for a gross weight of 21.1 kN (4 750 lb). This climb performance is sufficient to allow the airplane to be compatible with other high speed aircraft in the high density controlled flight environment around major airports.

Cruise

The performance specification required a payload of 5.34 kN (1 200 lb) including the pilot, a range of 2 408 km (1 300 n.mi.) without reserves, and a cruise speed of 154 m/s (300 kt). Cruise altitudes were to be between 9 144 m (30 000 ft) and 12 192 m (40 000 ft). The level of performance specified is comparable to that of current twin-engine turboprop business aircraft.

The mission performance was calculated for cruise altitudes of 7 620 m (25 000 ft), 9 144 m (30 000 ft), and 10 668 m (35 000 ft). Limitations on the range of engine data available prevented any investigation of the airplane's performance at higher cruise altitudes. The climb to cruise altitude was at the best rate of climb airspeed. Allowances for both fuel consumed and distance traveled during the climb and descent phases were included in the mission performance calculations.

Figure 15 presents the range of the airplane for variations in cruise speed and altitude. From this figure, it can be seen that the maximum cruise speed for which the design range can be met is 161 m/s (312 kt) at an altitude of 10 668 m (35 000 ft). The maximum range speed of 121 m/s (236 kt) can also be determined from this figure. The maximum cruise speed is 170 m/s (331 kt) at an altitude of 6 096 m (20 000 ft). In general, increases in altitude result in better range with only small changes in maximum speed; however, performance above 10 668 m (35 000 ft) will probably become marginal rapidly due to the degradation of the propeller and engine performance.

Figure 16 presents the cruise specific range as a function of cruise speed and altitude. Points corresponding to the conditions discussed in the preceding paragraph are shown. These points are also plotted in figure 17 from reference 7. Figure 17 illustrates the performance and fuel conservation advantages of the present configuration. The specific range of this configuration is comparable to many of the single-engine airplanes with retractable landing gear, and it is better than both the twin-piston engine and twin-turboprop engine airplanes. The airplane has a higher cruise speed than any of the single or twin piston-engine aircraft and the majority of the twin turboprop-powered airplanes.

Landing

The landing performance of the study airplane is presented in figure 18 for a combination of landing weights and density altitudes. These landing distances are approximately the same as the takeoff distances presented in figure 11 for sea level conditions but are considerably less at higher altitudes. The landing analysis was conducted assuming the use of spoilers to decrease lift and increase drag during the landing roll, but no use of the reversible pitch propeller for reverse thrust. The use of reverser thrust braking would result in a further decrease in landing distances.

CONCLUDING REMARKS

A study was conducted to configure and evaluate a single-engine turboprop-powered general aviation airplane and determine its relative advantages as compared to current general aviation airplanes. The six-place configuration which resulted from this study has a range, cruise speed, and cruise altitude which is equal to or better than the cruise performance of most current twin-engine general aviation business airplanes. This cruise performance coupled with the ability to operate out of very small airports, could provide the business community with a very versatile means of air transportation. The fuel efficiency of the aircraft has been shown to be significantly better than all other aircraft in its performance class and equal to many much slower aircraft. Thus, a substantial increase in fuel conservation is possible without any degradation in performance by using one turboprop engine instead of two smaller engines to power a general aviation business aircraft.

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6. Hoerner, S. F.: Fluid Dynamic Drag. Hoerner Fluid Dynamics, Brick Town, New Jersey, 1965.

7. Holmes, B. J.: Aerodynamic Design Optimization of a Fuel Efficient High Performance, Single-Engine, Business Airplane. AIAA Paper No. 80-1846, August 1980.

TABLE I. - GEOMETRIC CHARACTERISTICS

Overall Dimensions	
Overall length	10.44 m (34.25 ft)
Overall span	9.39 m (30.80 ft)
Overall height	3.98 m (10.35 ft)
Wing	
Reference area	11.15 m^2 (120 ft^2)
Exposed area	9.29 m^2 (100 ft^2)
Span	9.39 m (30.80 ft)
Mean aerodynamic chord	1.28 m (4.20 ft)
Aspect ratio	8
Dihedral	3°
Incidence	0°
Quarter chord sweep	0°
Leading edge sweep	3.6°
Thickness/chord ratio	15%
Taper ratio	.33
Airfoil section	65_2-415
Wing High Lift and Control Devices	
Total flap area	1.54 m (16.6 ft)
Flap chord percentage	30%
Flap extension	20% chord
Flap span percentage	90%
Maximum flap deflection	40°
Total aileron area	.17 m^2 (1.8 ft^2)
Total slat area	.87 m^2 (9.4 ft^2)
Slat span percentage	100%
Spoiler hinge line	70% chord
Vertical Tail	
Area	1.79 m^2 (19.25 ft^2)
Span	1.52 m (5 ft)
Aspect ratio	1.3
Leading edge sweep	40°
Taper ratio	0.5
Rudder chord percentage	30%

TABLE I. - Continued

Horizontal Tail	
Area	2.69 m^2 (29 ft^2)
Span	3.48 m (11.42 ft)
Aspect ratio	4.5
Leading edge sweep	6°
Taper ratio	0.7
Elevator to chord percentage	30%
Elevator root chord percentage	31%
Fuselage	
Maximum width (exterior)	1.42 m (56 in)
Maximum height (exterior)	1.65 m (65 in)
Length	9.79 m (32.0 ft)
Cabin width	1.30 m (51.0 in)
Cabin height	1.42 m (56.0 in)
Cabin length	3.70 m (12.125 ft)
Propeller	
Propeller diameter	2.13 m (7 ft)

TABLE II. - PROEPELLER SElECTION SUMMARY

° DESIGN POINT

Altitude	10 668 m (35 000 ft)	
Speed	154 m/s (300 kt)	
Engine	261 kw (350 bhp)	80% cruise power

° SELECTED PROPELLER

4 Blades

Diameter = 2.13 m (7 ft)

AF = 1.80

C_{L_i} = 0.5

C_p = 0.684

J = 2.556

η = .85 @ Design Point

TABLE III. - WEIGHT SUMMARY

	kN	lbf
Structure - excluding wing	4.40	990
- wing	1.82	410
Propulsion	2.80	630
Systems	2.18	490
Weight Empty	11.20	2520
Operating Items	.89	200
Operating Weight Empty	12.09	2720
Passengers	4.45	1000
Zero Fuel Weight	16.54	3720
Mission Fuel	4.58	1030
Take-Off Gross Weight	21.12	4750
Warm-Up and Taxi-Out Fuel	.19	42
Start Engine Weight	21.31	4792

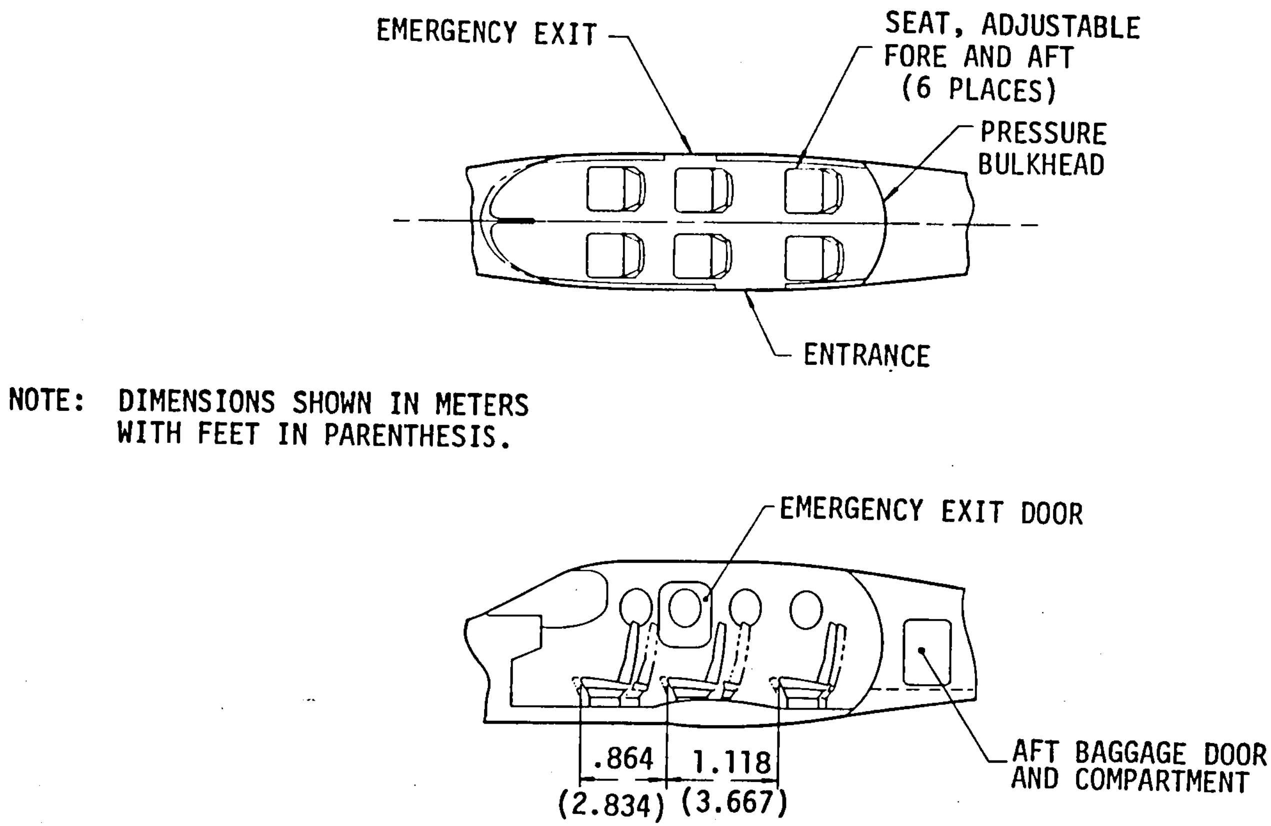

Figure 1. - Cabin interior arrangement of a fuel-efficient single-engine turboprop powered business airplane.

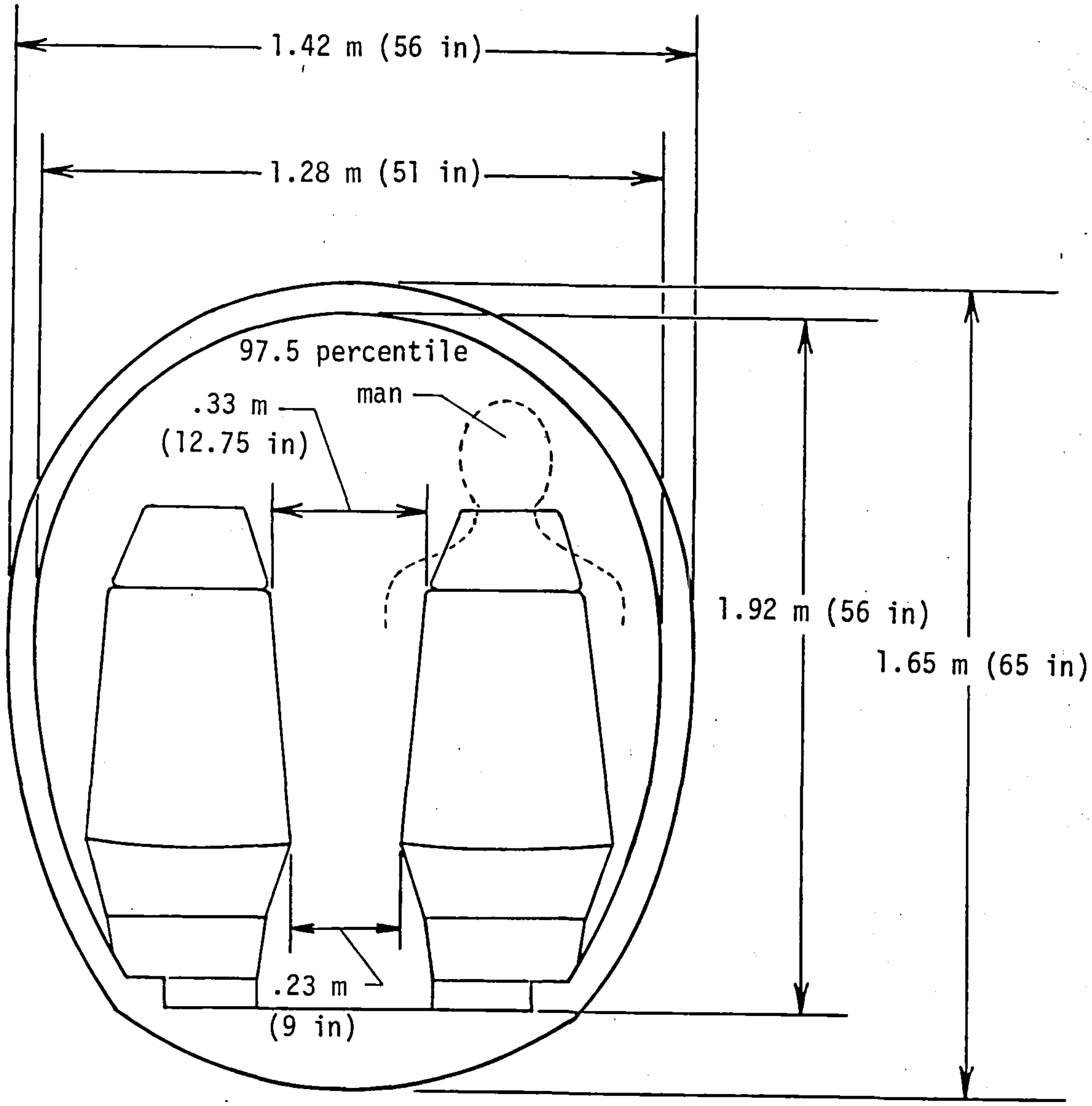

Figure 2. - Fuselage cross section

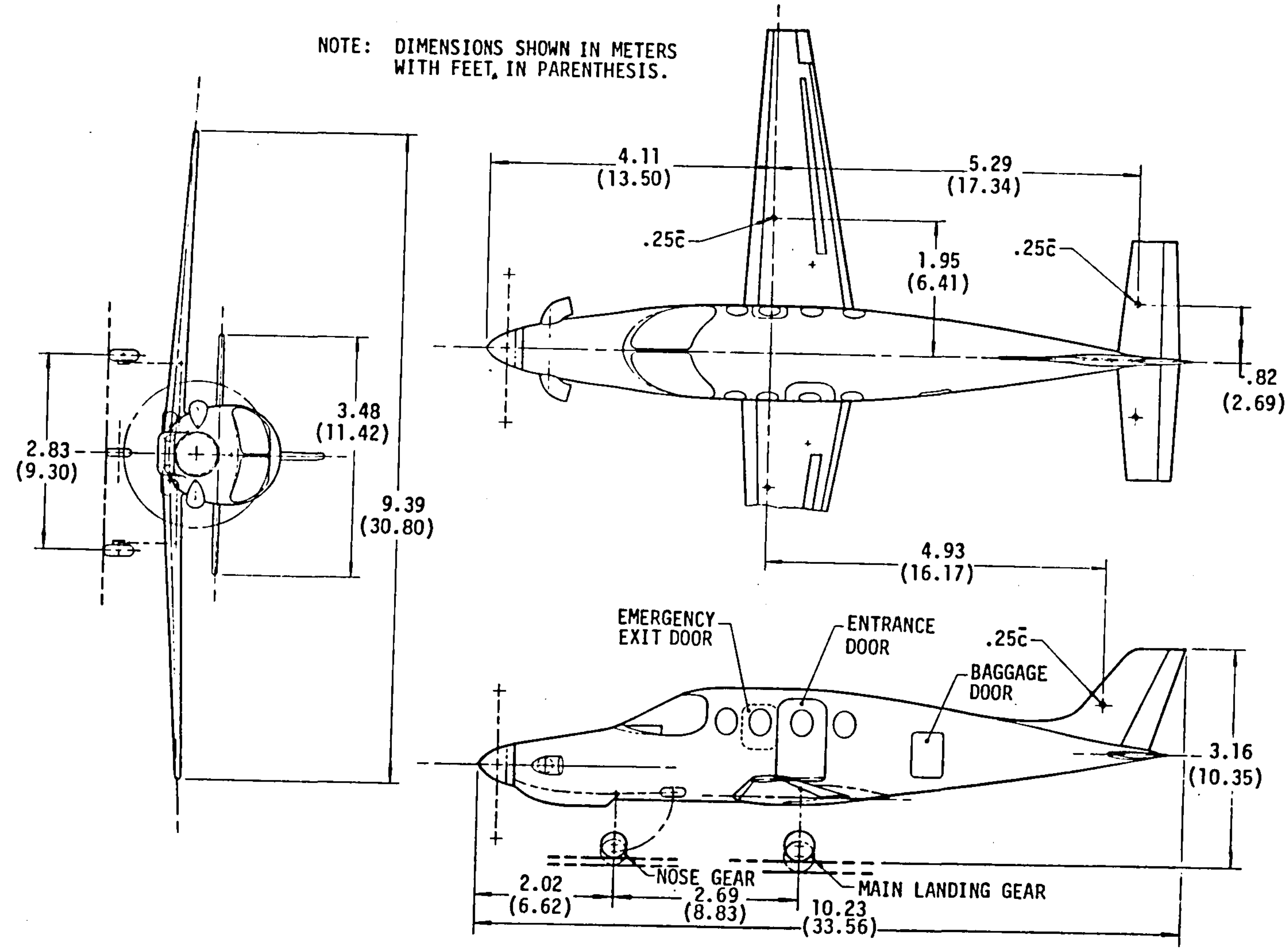

Figure 3. - General arrangement of a fuel-efficient single-engine turboprop powered business airplane.

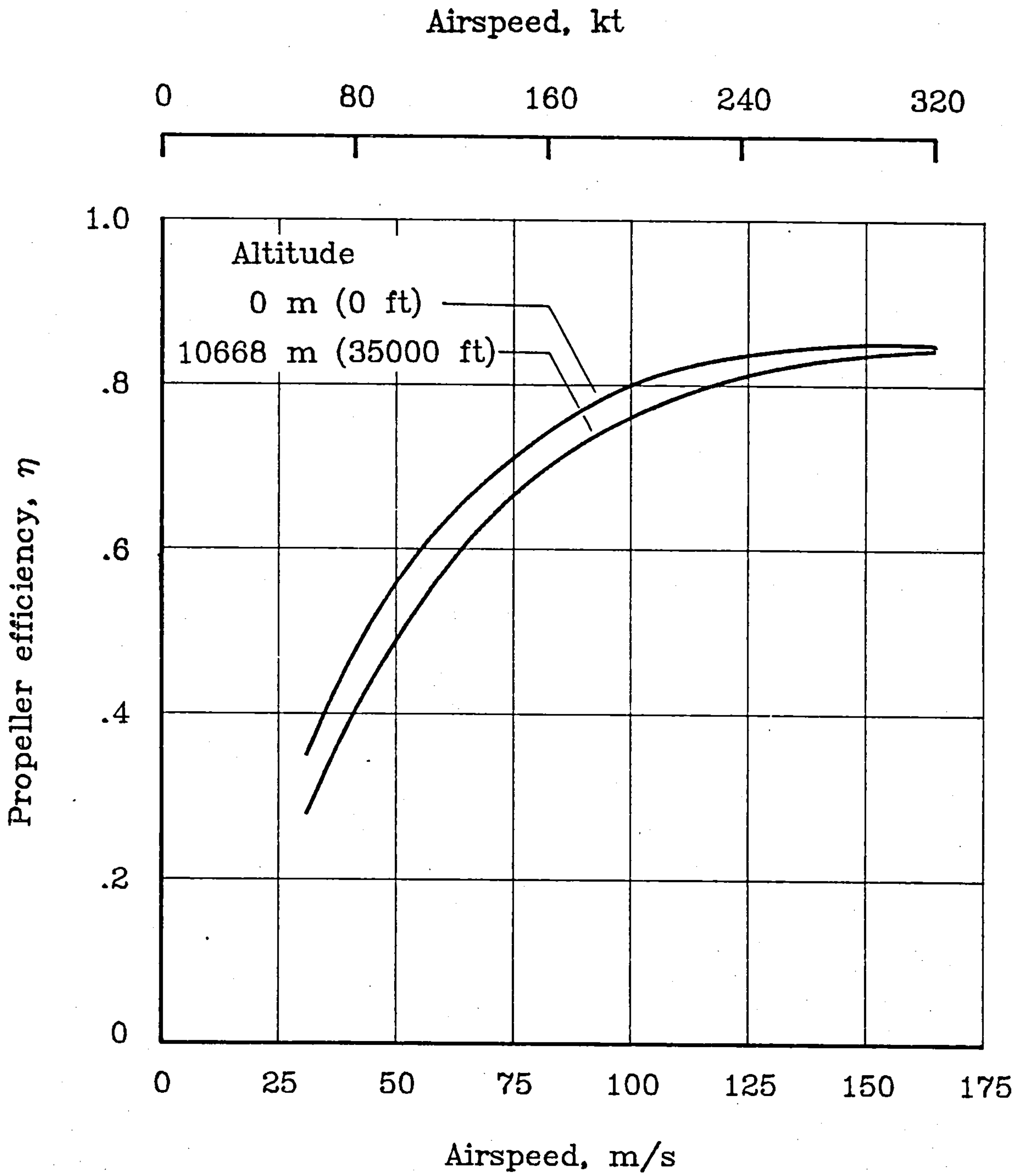

Figure 4. - Estimated propeller efficiency for maximum climb and maximum cruise power, standard day atmospheric conditions.

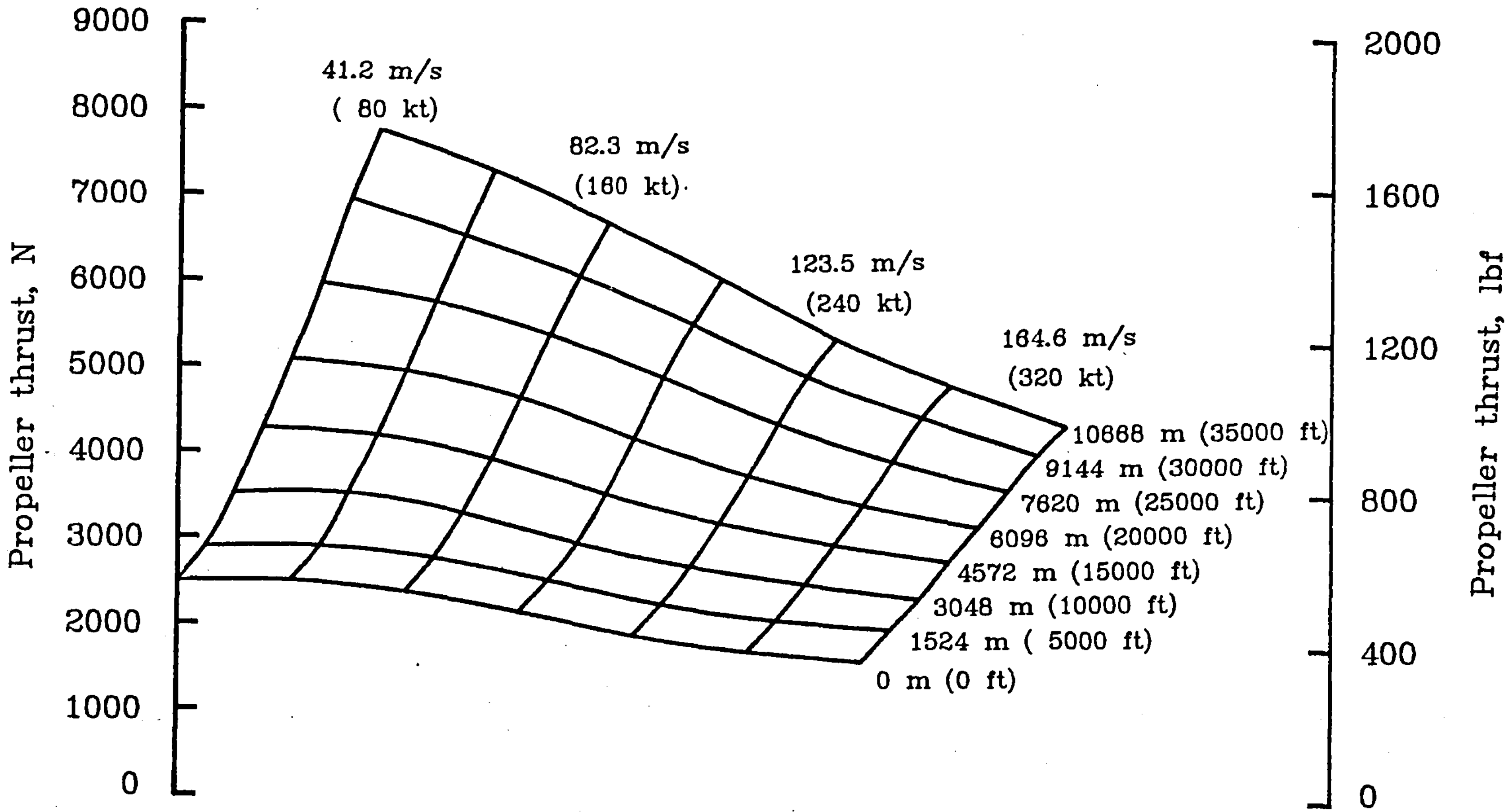

Figure 5. - Estimates installed propeller thrust for maximum climb and maximum cruise power, standard day atmospheric conditions.

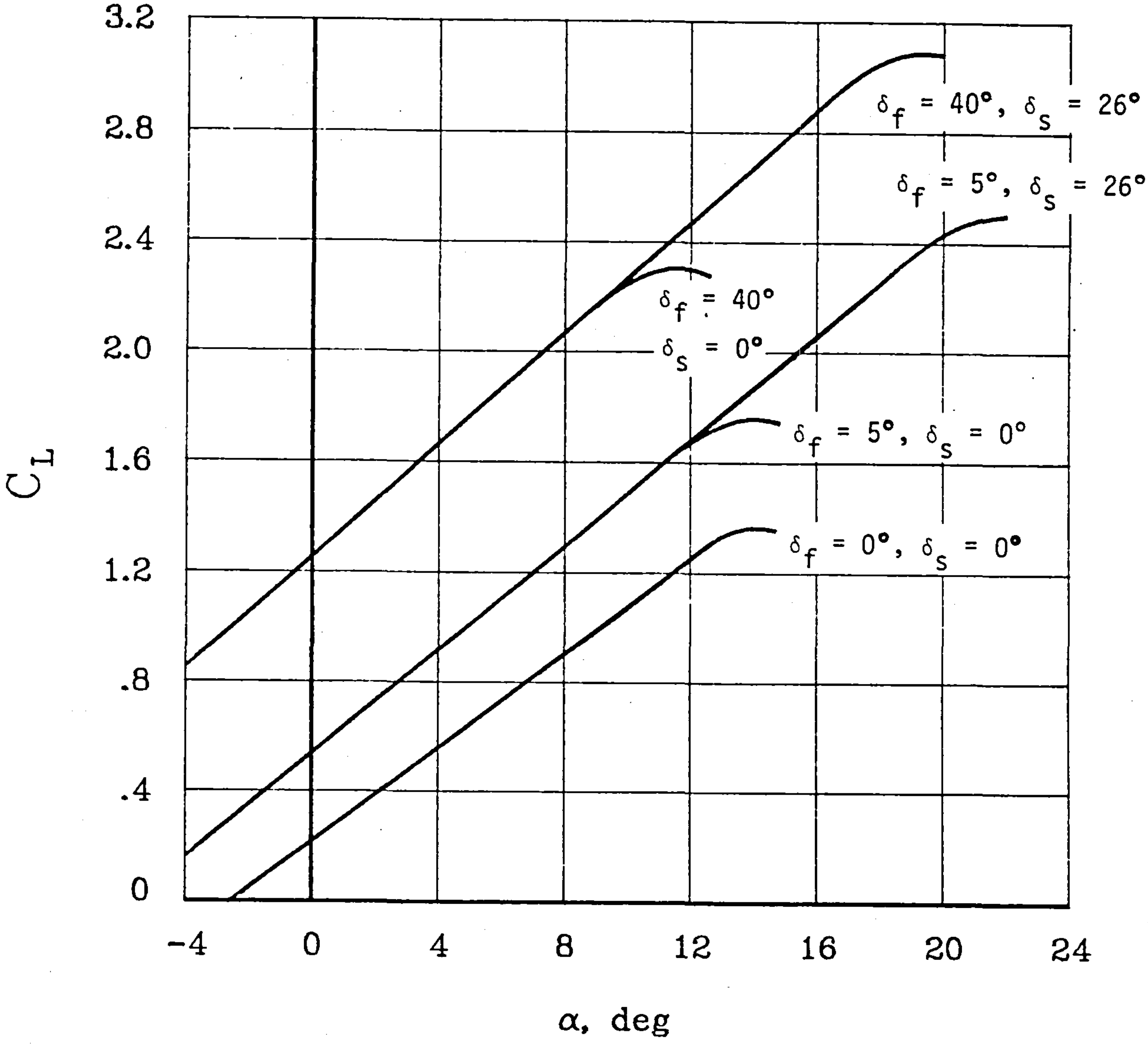

Figure 6. - Estimated lift curves for various deflections of the high lift system, untrimmed.

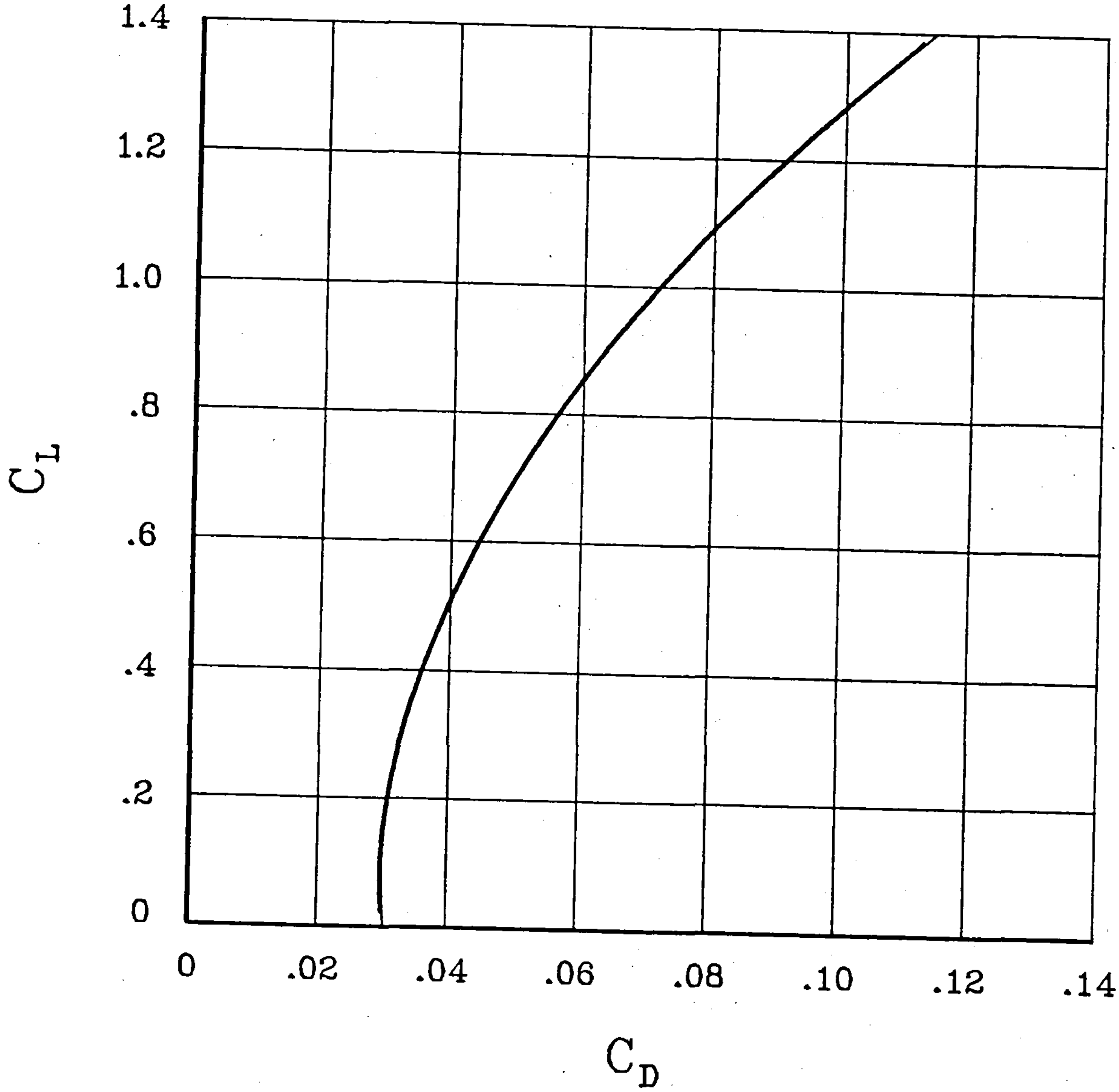

Figure 7. - Estimated drag polar for the takeoff configuration, δ_f = 5°, untrimmed.

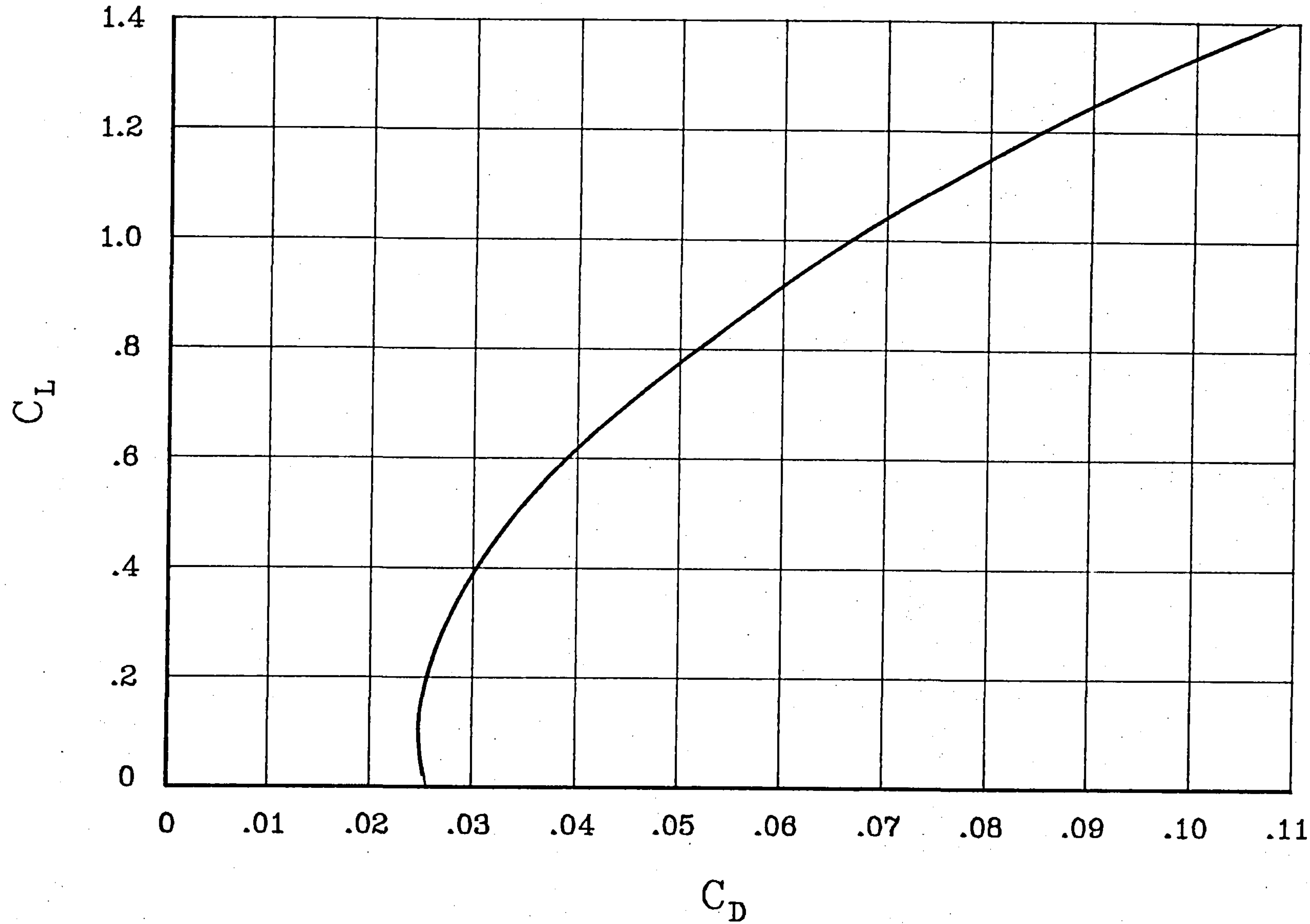

Figure 8. Estimated drag polar for an average cruise condition, altitude = 9144 m (30 000 ft), Mach number = 0.5, trimmed.

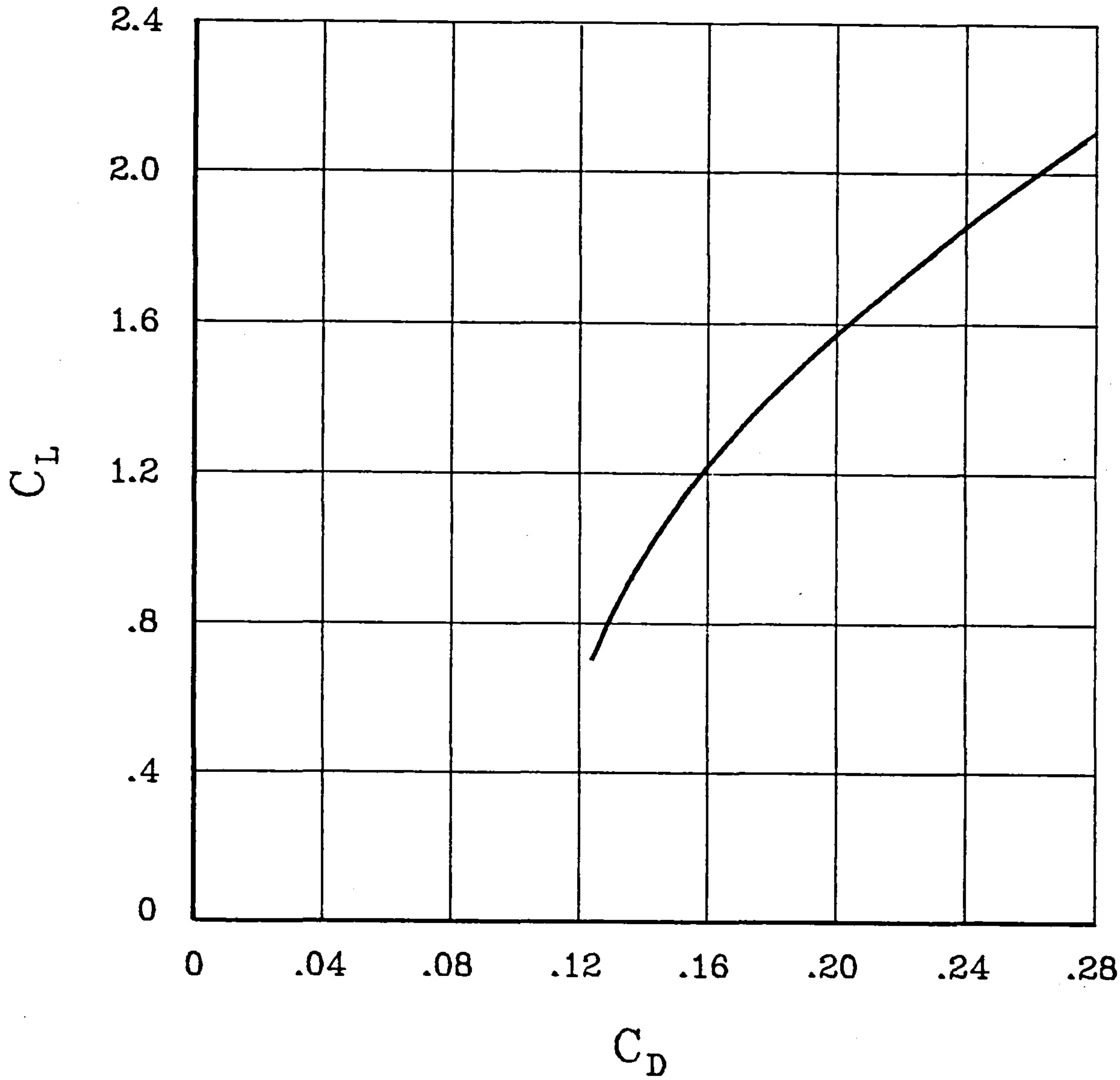

Figure 9. - Estimated drag polar for the landing configuration, δ_f = 40°, untrimmed.

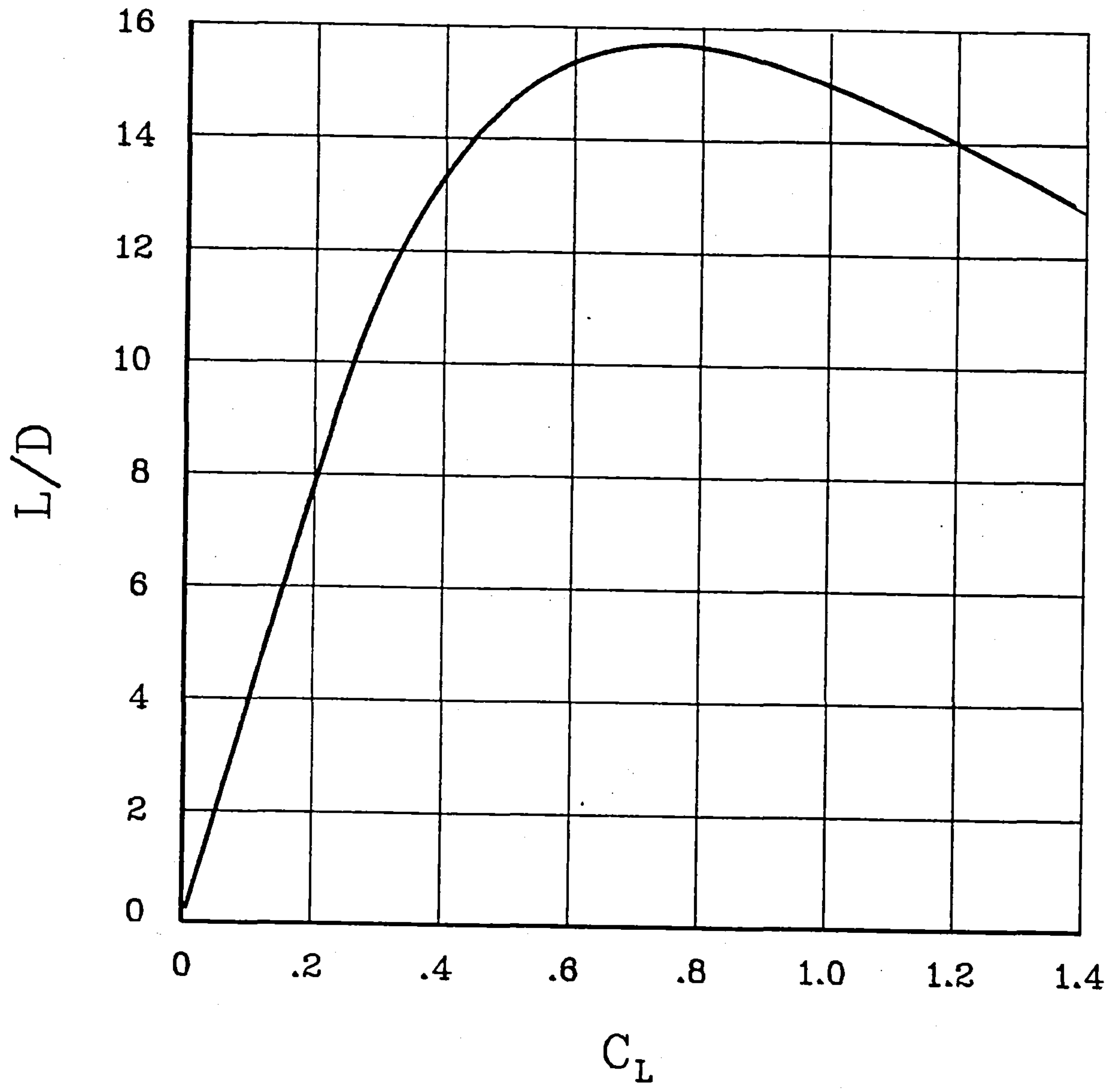

Figure 10. - Estimated lift-drag ratio for an average cruise condition, altitude = 9144 m (30 000 ft), Mach number = 0.5, trimmed.

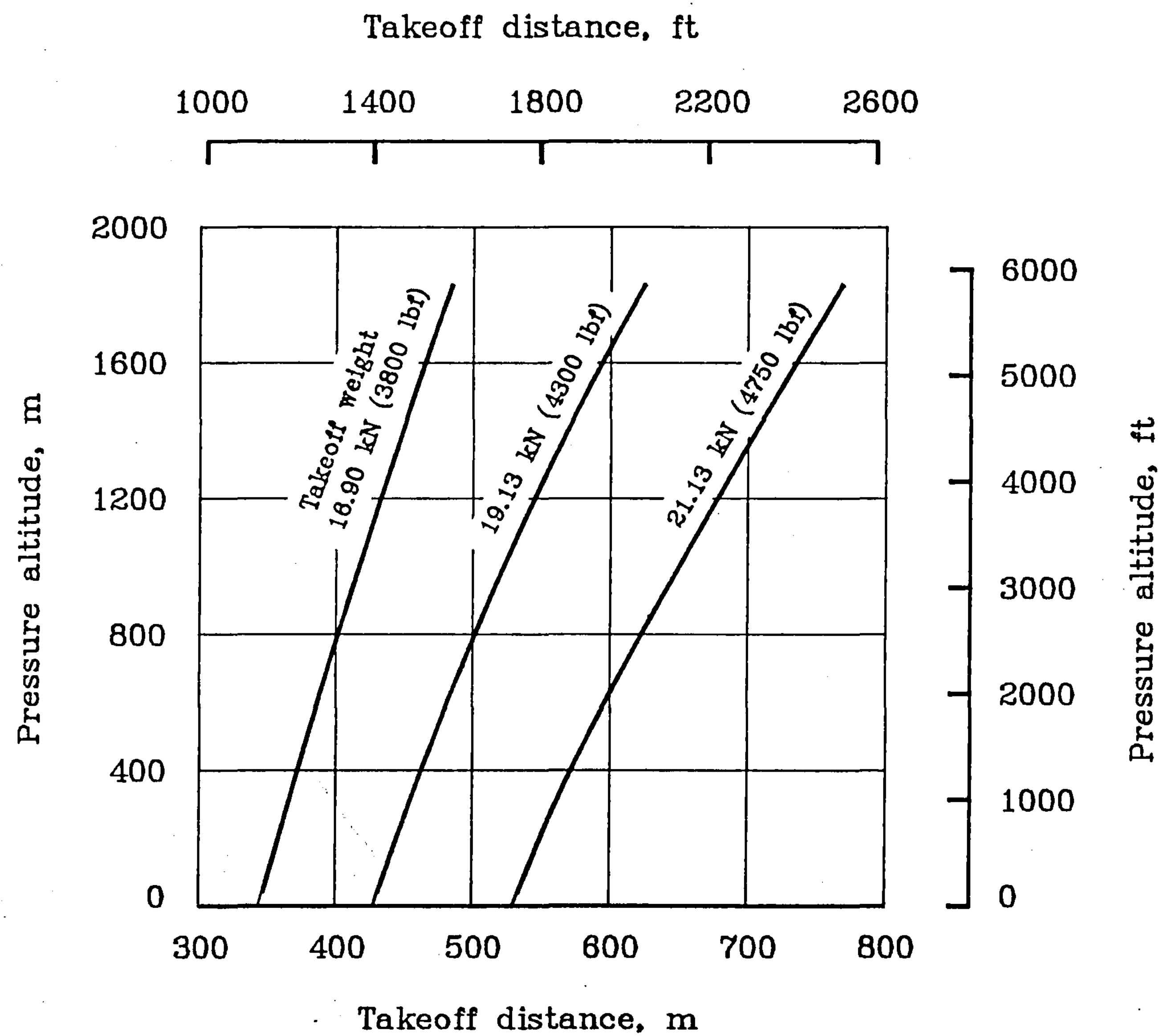

Figure 11. - Estimated takeoff distance over a 15.2 m (50 ft) obstacle for various takeoff weights.

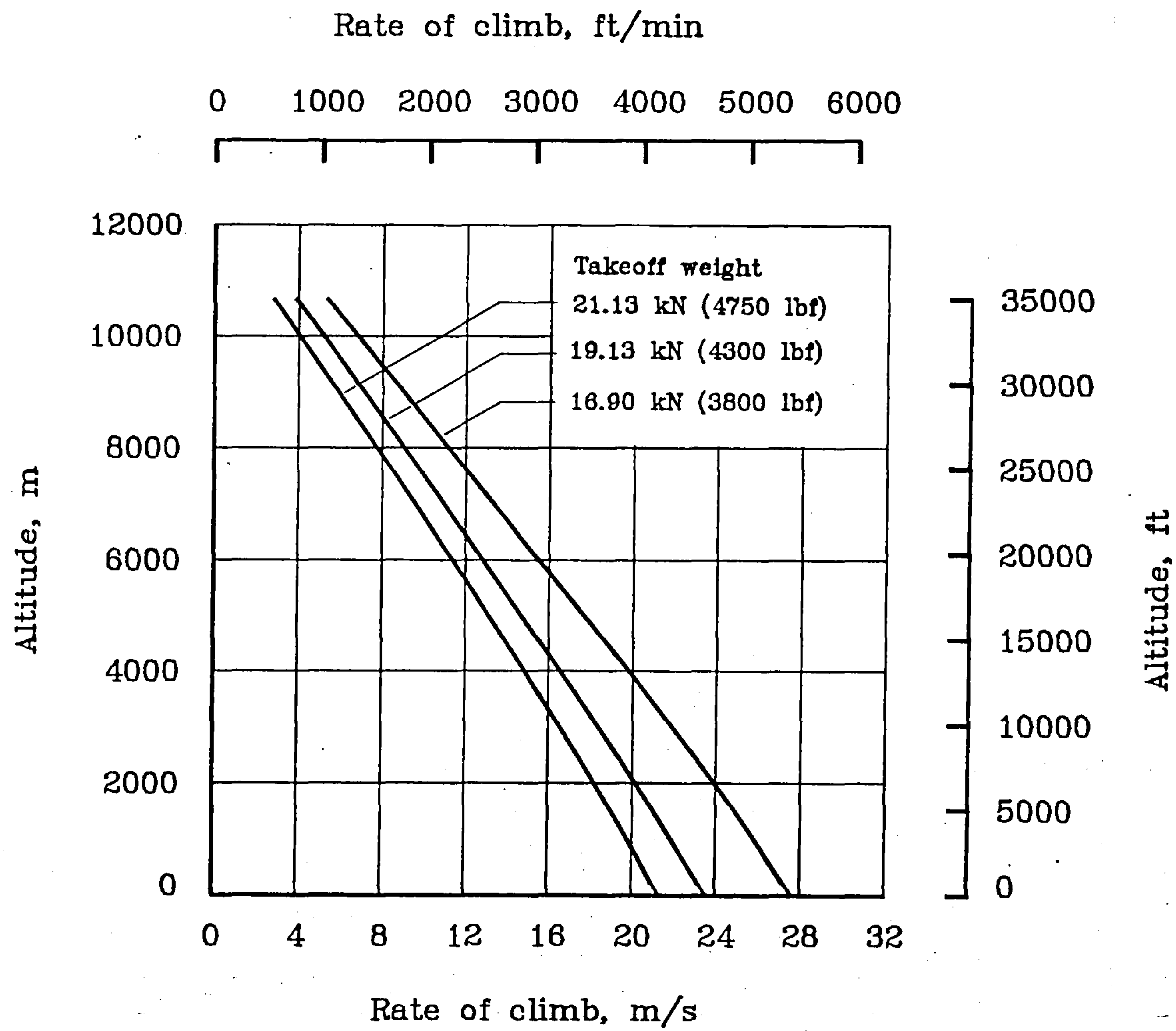

Figure 12. - Estimated rate of climb for various takeoff weights, standard day atmospheric conditions.

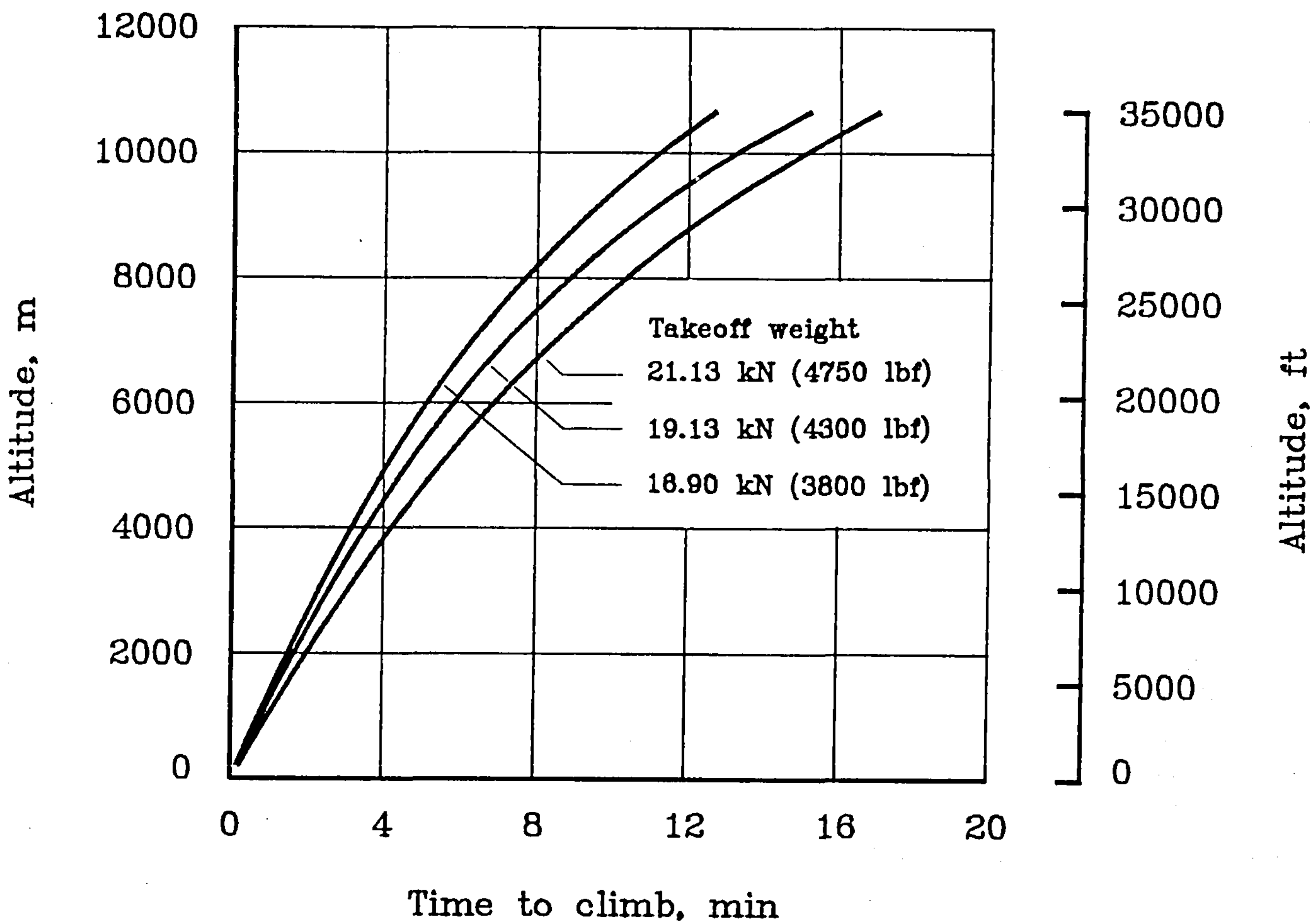

Figure 13. - Estimated time to climb for various takeoff weights, standard day atmospheric conditions.

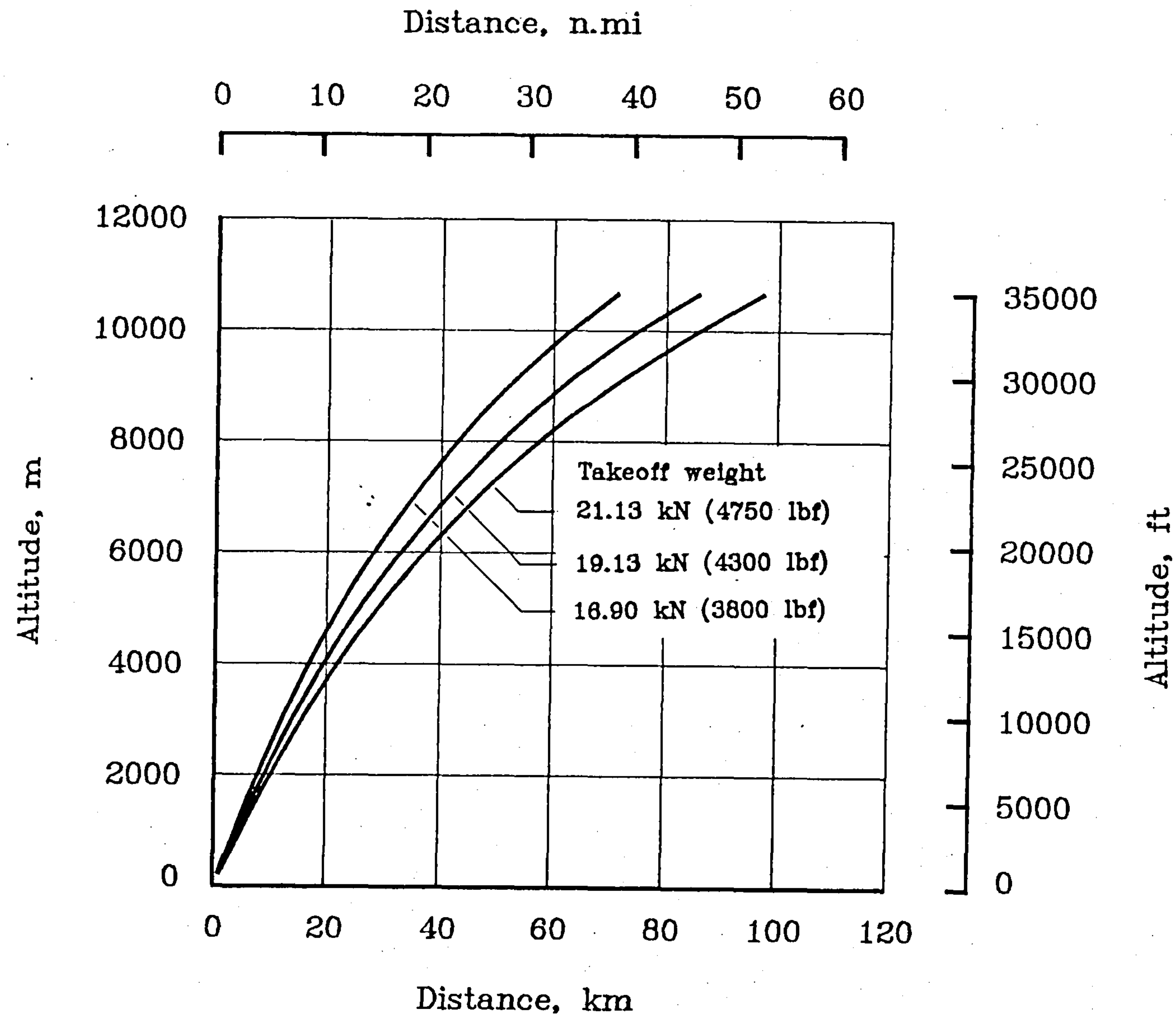

Figure 14. - Estimated distance to climb for various takeoff weights, standard day atmospheric conditions.

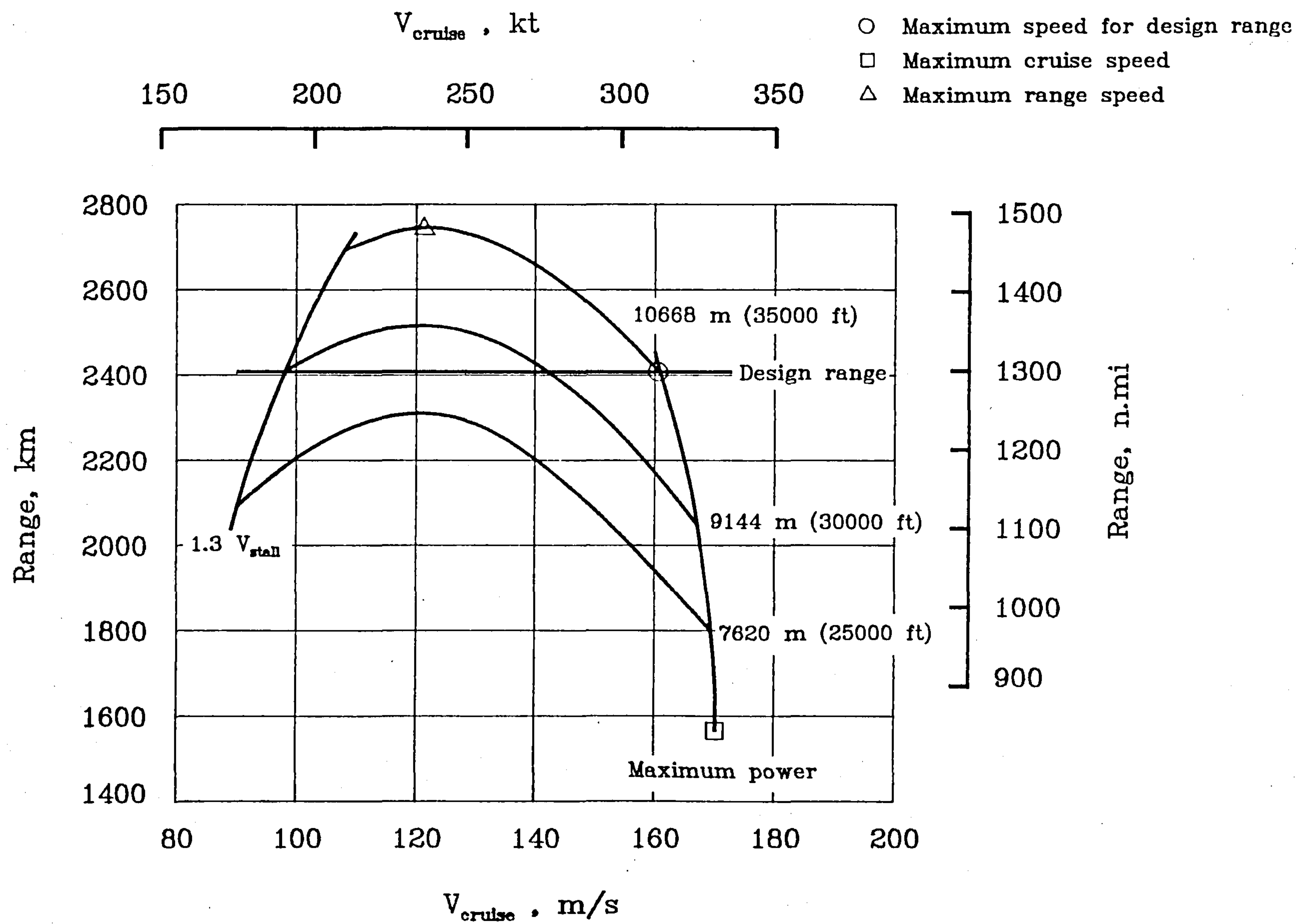

Figure 15. - Estimated range for various cruise speeds and altitudes, standard day atmospheric conditions.

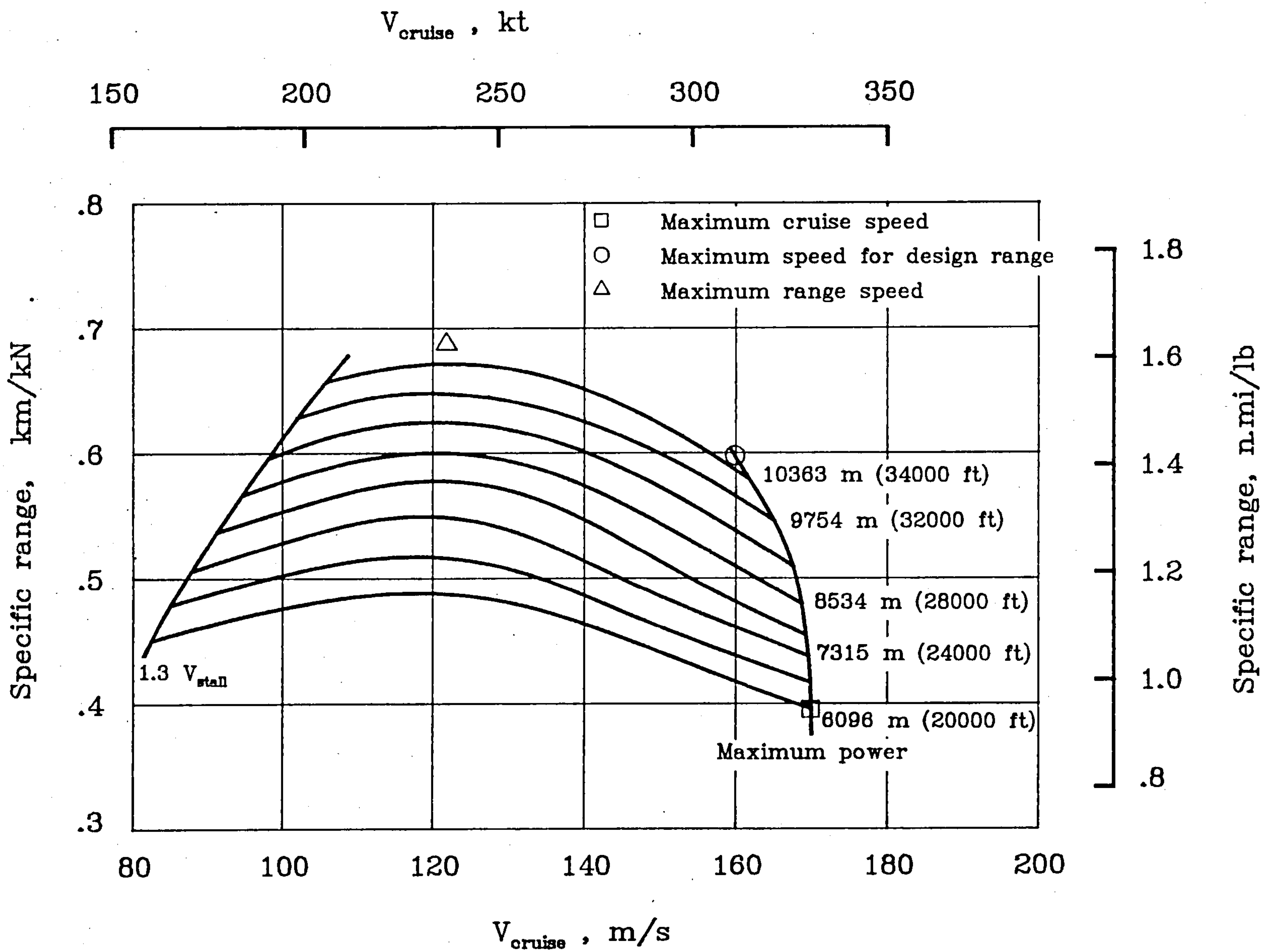

Figure 16. - Estimated cruise specific range for various cruise speeds and altitudes, standard day atmospheric conditions, average weight of 18.67 kN (4200 lbs).

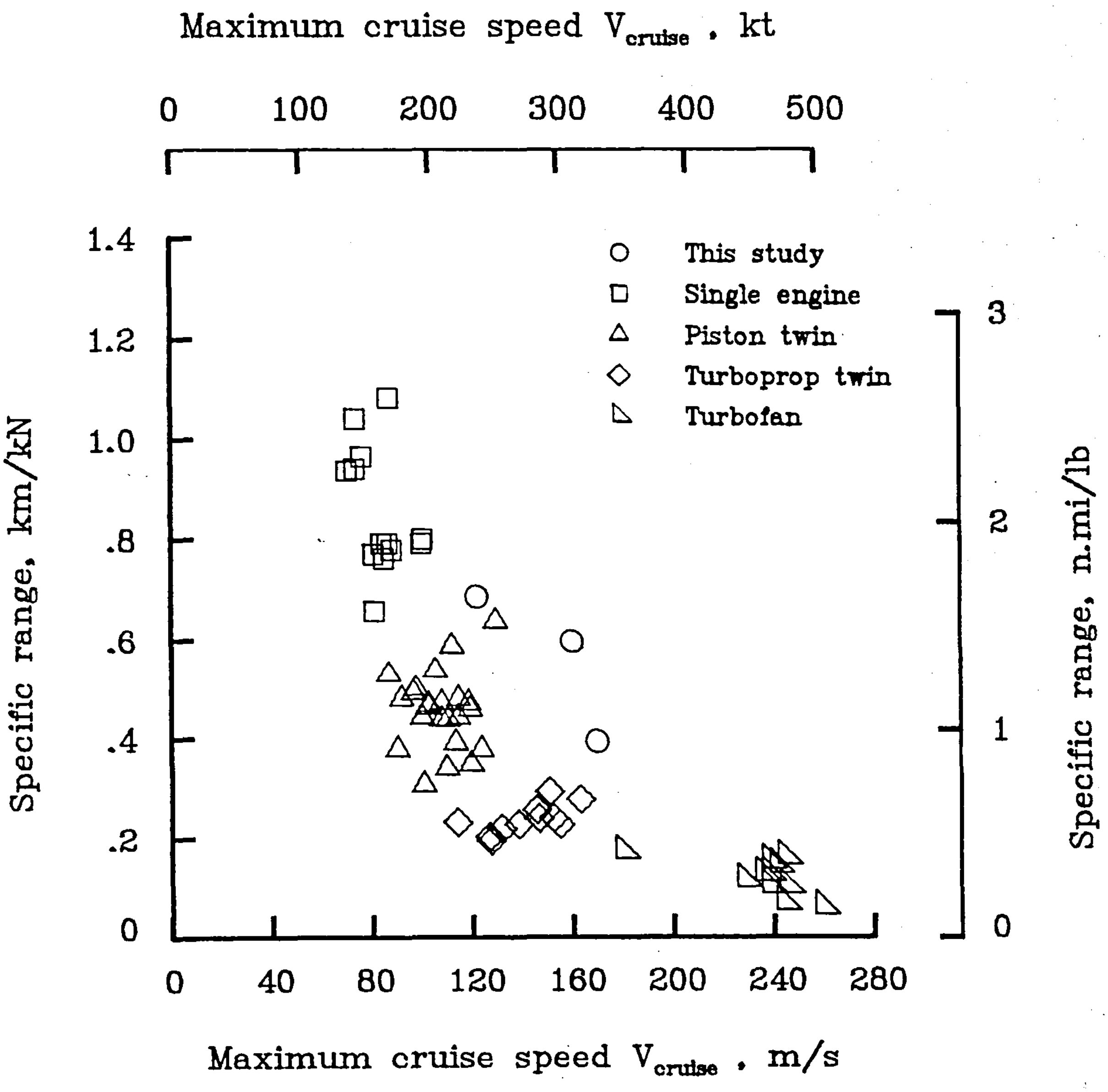

Figure 17. - Comparison of study airplane cruise efficiency with that of current general aviation airplanes.

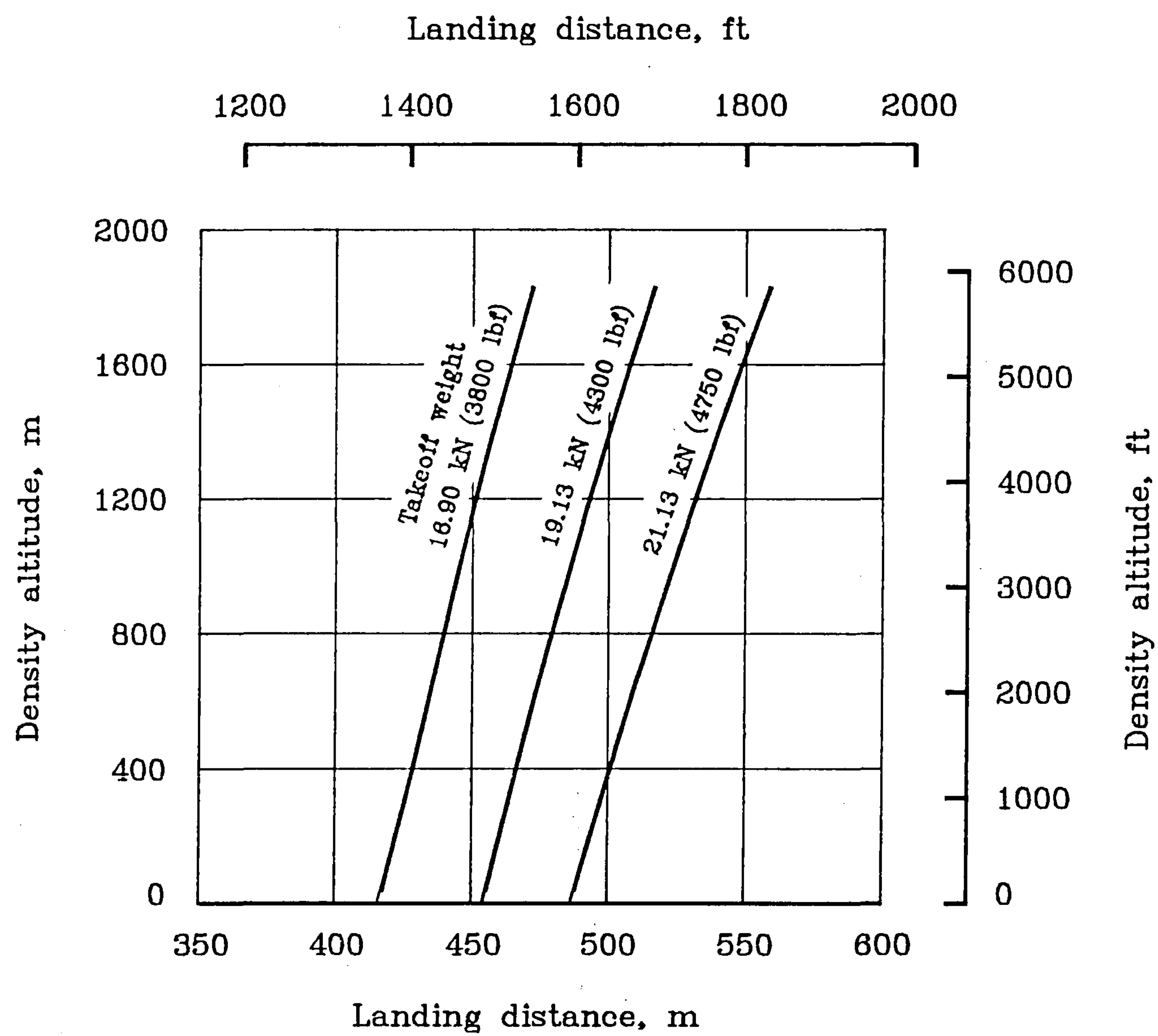

Figure 18. - Estimated landing distance over a 15.2 m (50 ft) obstacle.

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15. Supplementary Notes

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16. Abstract

A study was conducted to determine whether a general aviation airplane powered by one turboprop engine could be configured to have a speed, range, and payload comparable to current twin-engine turboprop aircraft and also achieve a significant increase in fuel efficiency. An airplane configuration was developed which can carry six people for a no-reserve range of 2 408 km (1 300 n.mi.) at a cruise speed above 154 m/s (300 kt) and a cruise altitude about 9 144 m (30 000 ft). This cruise speed is comparable to that of the fastest of the current twin turboprop-powered airplanes. The airplane has a cruise specific range greater than all twin turboprop-engine airplanes flying in its speed range and most twin piston-engine airplanes flying at considerably slower cruise airspeeds. The high thrust-weight ratio and maximum use of high-lift devices produce takeoff and landing distances of less than 760 m (2 500 ft) at maximum gross weight for airport pressure altitudes up to 1830 m (6000 ft).

17. Key Words (Suggested by Author(s))	18. Distribution Statement
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