N72-33017

NASA CR-112155

ROTOR SYSTEMS RESEARCH AIRCRAFT
PREDESIGN STUDY

FINAL REPORT
VOLUME IV
PRELIMINARY DRAFT DETAIL SPECIFICATION

by Alfred N. Miller, Arthur W. Linden, et al.

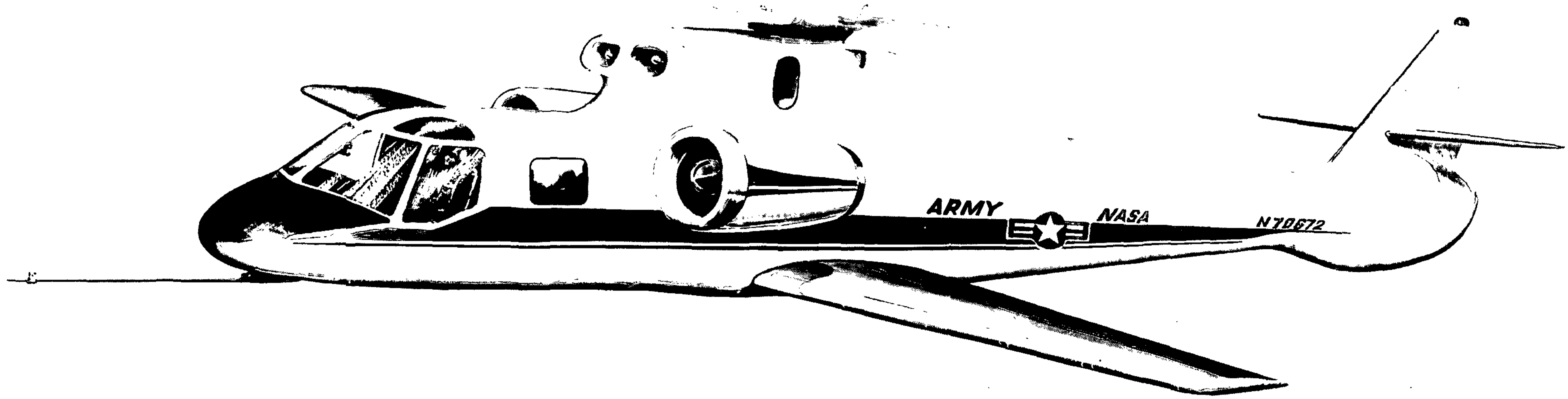
SIKORSKY REPORT NO. SER-50775

October 6, 1972

Prepared Under Contract No. NAS1-11228 by
Sikorsky Aircraft Division of United Aircraft Corporation
Stratford, Connecticut

for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AND
UNITED STATES ARMY


ARMY
NASA
N70672

Sikorsky Aircraft DIVISION OF UNITED AIRCRAFT CORPORATION

DRAFT

TITLE: PRELIMINARY DETAIL SPECIFICATION FOR ROTOR SYSTEM RESEARCH AIRCRAFT *

REPORT NUMBER: SES-501001

PREPARED UNDER: Contract NAS1-11228 (including Modification No. 1 dated 28 March 1972)

REPORT DATE:

REPORT PERIOD:

This report is applicable to the following aircraft model(s) and contract(s):

MODEL	CONTRACT
	NAS1-11228

* The contract research effort which has led to the results in this report was financially supported by USAAMRDL (Langley Directorate)

Prepared by A. N. Miller Checked by A. Linden

Approved by R. F. Donovan

REV.	CHANGED BY	REVISED PAGE(S)	ADDED PAGE(S)	DELETED PAGE(S)	DESCRIPTION	DATE	APPROVAL

REVISIONS CONTINUED ON NEXT PAGE

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1. SCOPE

1.1 MODEL DESIGNATION. This preliminary specification draft is a part of the predesign study under Contract NAS1-11228 and is intended to define the preliminary configuration and capabilities of a single rotor compound, rotor system research aircraft.

Service model designationn	None assigned
Designer's name	Sikorsky Aircraft Division of United Aircraft
Designer's model designation	None assigned
Number and places for crew	Two: Pilot and copilot (also provisions for instrumentation engineer)
Number and kinds of engines	For rotor propulsion: Two T58-GE-16 Turboshaft (General Electric Company) For auxiliary propulsion: Two TF34-GE-100 Turbofan (General Electric Company)
Number of rotors (location and type)	One main
Number of blades per rotor	Five

1.1.1 MISSION. The mission of this aircraft shall be the research to be conducted by the government to gather engineering data on the performance, loads, noise, stability, and control characteristics of various new and different rotor concepts.

1.1.2 GENERAL REQUIREMENTS. The rotor system research aircraft shall have the capability to operate a rotor, in flight, under controlled or specified flight operating conditions with provisions to measure the rotor characteristics in maneuvers as well as level flight. In addition, the system shall incorporate as much flexibility as is technically and economically feasible in order to provide a wide range of available test conditions.

1.1.3 DETAIL SPECIFICATION FORMAT AND CONTENT. The format and content followed in this specification is in general accordance with MIL-STD-832, Format B, Rotary Wing Aircraft, dated 3 June, 1963.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the exact issue shown, form a part of this specification to the extent specified herein. In the event of conflict between documents referenced here and this specification, this specification shall be considered the superseding document. The applicable revision, amendment or change to a document shall be as cited here; only the basic document number is stated in other sections of this specification.

SPECIFICATIONS

Military

MIL-W-5013H(1)	Wheel and Brake Assemblies, Aircraft
MIL-T-5041F(1)	Tires, Pneumatic, Aircraft
MIL-W-5088C	Wiring, Aircraft, Installation of
MIL-I-5417D	Indicator, Indicated Airspeed, Pitot Static, 40-400 Knots
MIL-H-5440F	Hydraulic System, Aircraft Types I and II, Design, Installation, and Data Requirements
MIL-H-5606C	Hydraulic Fluid, Petroleum Base, Aircraft and Ordnance
MIL-T-5955C	Transmission System, VTOL-STOL, General Specification for
MIL-G-6162(2)	Generators, 30-Volt, Direct Current, Aircraft Engine Driven, General Specification for
MIL-T-6396C	Tanks, Fuel, Oil, Water-Alcohol, Coolant Fluid, Aircraft, Non-Self-Sealing, Removable, Internal
MIL-L-6503G(1)	Lighting Equipment, Aircraft, General Specification for Installation
MIL-E-7080B(3)	Electrical Equipment, Aircraft, Selection and Installation of

2.1 (Cont'd)

SPECIFICATIONS (Cont'd)

Military (Cont'd)

MIL-H-8501A(1)	Helicopter Flying and Ground Handling Qualities, Requirement for
MIL-L-8552C(2)	Landing Gear, Aircraft Shock Absorber (Air-Oil Type)
MIL-B-8584C	Brake Systems, Wheel, Aircraft, Design of
MIL-S-8698(1)	Structural Design Requirements, Helicopters
MIL-F-8785B	Flying Qualities of Piloted Airplanes
MIL-A-8860	Airplane Strength and Rigidity, General Specification for
MIL-A-8870	Airplane Strength and Rigidity, Vibration, Flutter, and Divergence
MIL-F-9490C(1)	Flight Control Systems - Design, Installation and Test of, Piloted Aircraft, General Specification for
MIL-L-18276C(1)	Lighting, Aircraft Interior, Installation of
MIL-F-18372	Flight Control Systems: Design, Installation and Test of, Aircraft (General Specification for)
MIL-P-19692A	Pumps, Hydraulic, Variable Delivery, (General Specification for)
MIL-G-26988B	Gage, Liquid Quantity, Capacitor Type Transistorized, General Specification for

2.1 (Cont'd)

SPECIFICATIONS (Cont'd)

Military (Cont'd)

MIL-C-27298A(1)	Clock, Aircraft, Mechanical ABU-9/A
MIL-I-58067(2)	Indicator, Vertical Velocity, Rapid Response, Acceleration Sensitive

STANDARDS

Military

MIL-STD-250C	Cockpit Controls, Location and Actuation for Helicopter
MIL-STD-451 Part I	Summary Weight Statement - Rotorcraft Only
MIL-STD-704A-2	Electric Power, Aircraft, Characteristics and Utilization of
MIL-STD-805	Tow Fittings, and Provisions for Fixed Wing
MIL-STD-809	Adapter, Aircraft, Jacking Point, Design and Installation of
MIL-STD-832-1	Preparation of Detail Specifications, Format B, Rotary Wing Aircraft
MS17983	Compass, Magnetic, Standby
MS25454-4	Indicator, Vertical Velocity, Rapid Response, Acceleration Sensitive
MS28028C	Thermometer, Self-Sealing, Bimettalic
MS28046	Indicator, Indicated Airspeed, Pitot Static, 40-400 Knots

2.1 (Cont'd)

STANDARDS (Cont'd)

Military (Cont'd)

MS90362	Receptacle, External Electric Power, Aircraft, 115/200 Volt, 400 CPS
AN2552-3A	Receptacle, External Power, 28 Volt DC

OTHER GOVERNMENT DOCUMENTS

NASA CR-114	Charts for Estimating Rotary Wing Performance in Hover and at High Forward Speeds (Watson H. Tanner)

2.2 OTHER PUBLICATIONS. The following documents, of the exact issue shown, form a part of this specification to the extent specified herein. In the event of conflict between documents referenced here and this specification, this specification shall be considered the superseding document. The applicable revision, amendment or change to a document shall be as cited here; only the basic document number is stated in other sections of this specification.

GENERAL ELECTRIC COMPANY

Spec. No. E1105-A dated 29 April 1968	Model Specification, Engine, Aircraft, Turboshaft, T58-GE-16
Spec. No. CP45E0002 (no date)	Model Specification, Engine, Aircraft, Turbofan, TF34-GE-100

2.3 DATA. No data are required by this specification or by applicable documents referenced herein, unless specified in the contract.

3. REQUIREMENTS

3.1 AIRCRAFT CHARACTERISTICS

3.1.1 DRAWINGS

3.1.1.1 THREE-VIEW DRAWING. A three-view drawing of the aircraft is provided herein (see Figure 1).

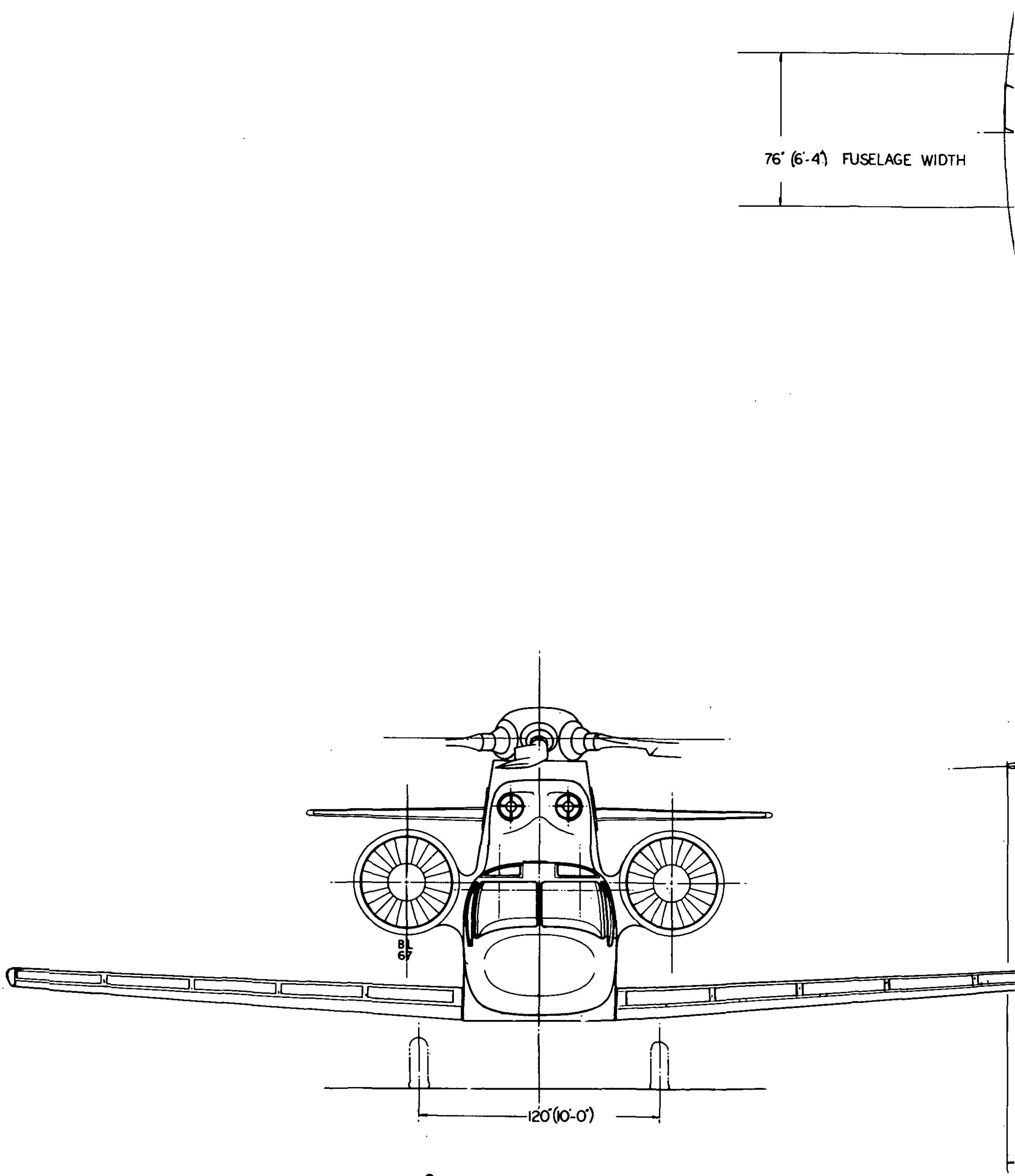
3.1.1.2 INBOARD PROFILE DRAWING. An inboard profile drawing of the aircraft is provided herein (see Figure 2).

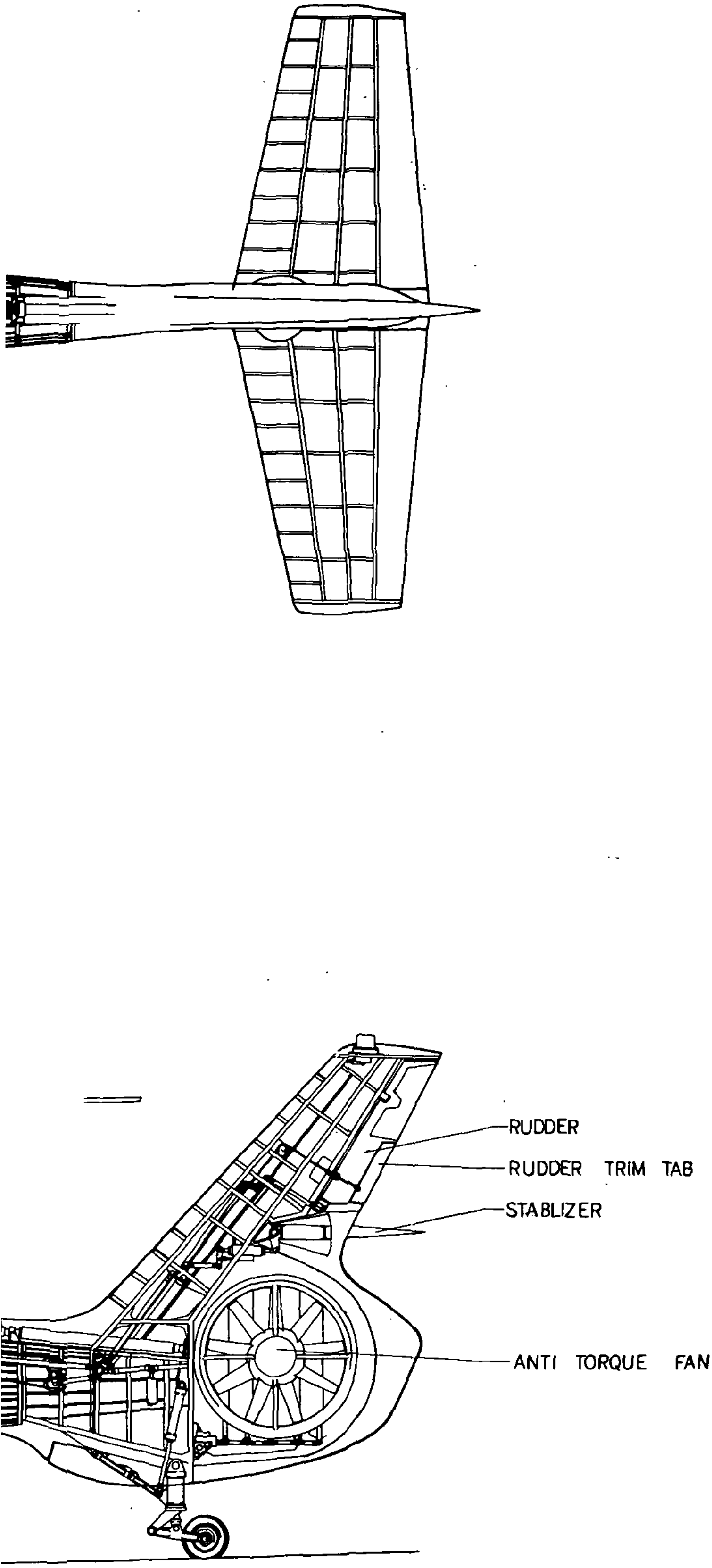
3.1.2 AIRCRAFT PERFORMANCE

3.1.2.1 HELICOPTER MODE FLIGHT CONDITIONS. Estimated performance shall be as follows:

Sea Level, Standard Day, OGE	
Maximum Hovering Gross Weight, Military Power (LBS)	23,900
Mission Hovering Gross Weight (LBS)	20,276
Sea Level, 95 degrees F, OGE	
Maximum Hovering Gross Weight, Military Power (LBS)	20,950
Mission Hovering Gross weight (LBS)	20,276

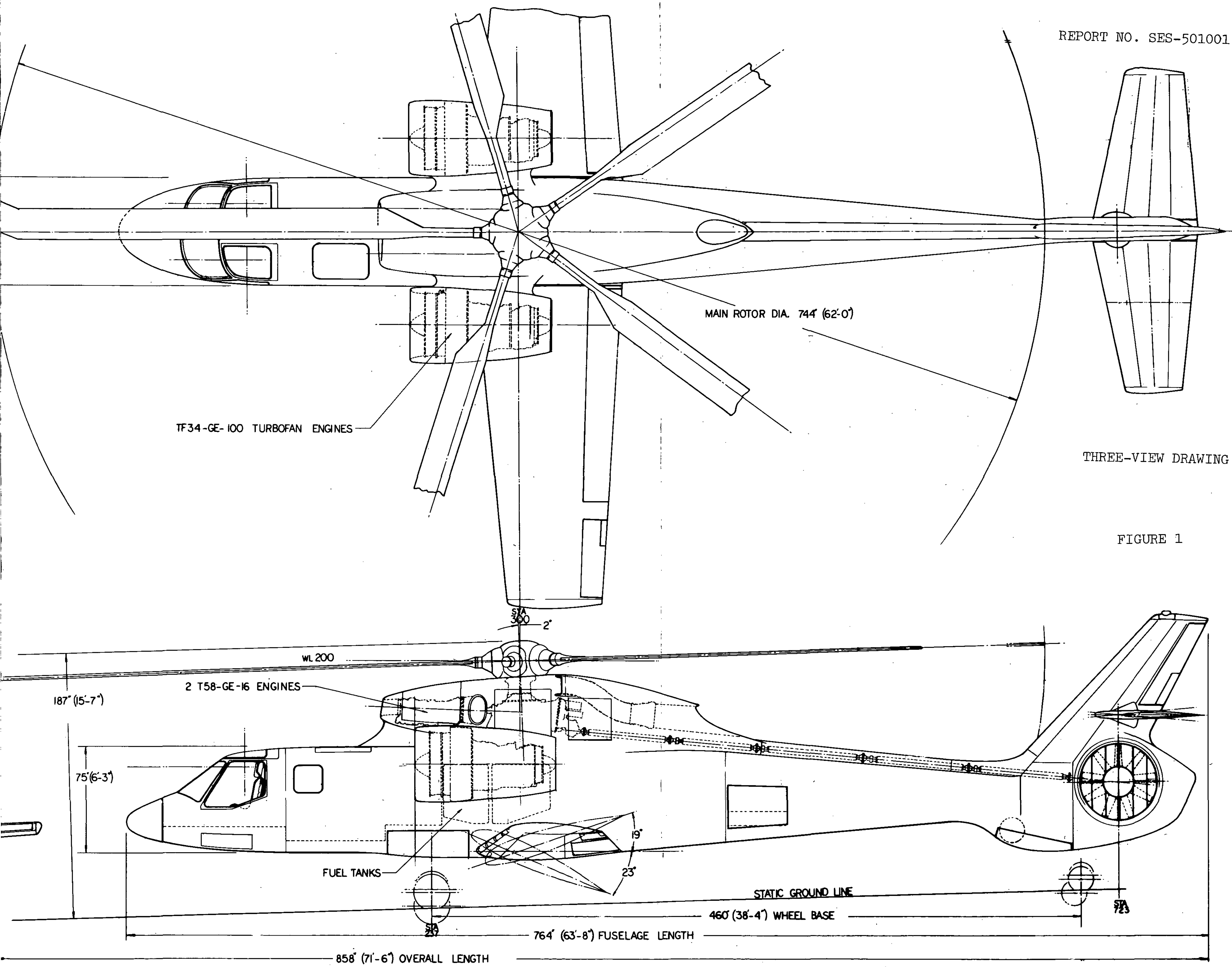
NOTE: Mission gross weights include fuel for two minutes of warm-up at normal rated power, 32 minutes hovering OGE, 10 nautical miles of cruise, and 20 minutes fuel reserve at speed for maximum range. The fuel is calculated for sea level standard and sea level 95 degrees F conditions, respectively. A payload of 2,000 pounds is included. The auxiliary propulsion engines and the wing are removed.


76" (6'-4") FUSELAGE WIDTH
BL 67
120"(10'-0")



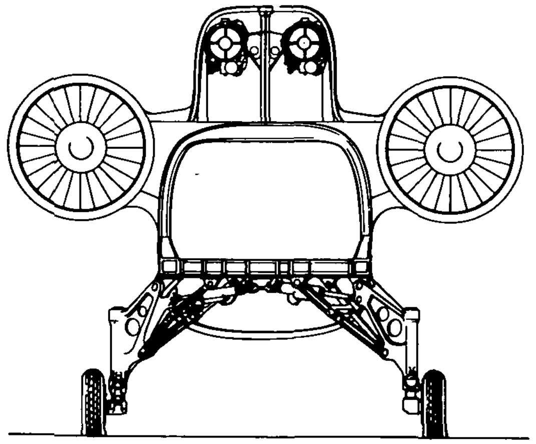
INBOARD PROFILE DRAWING

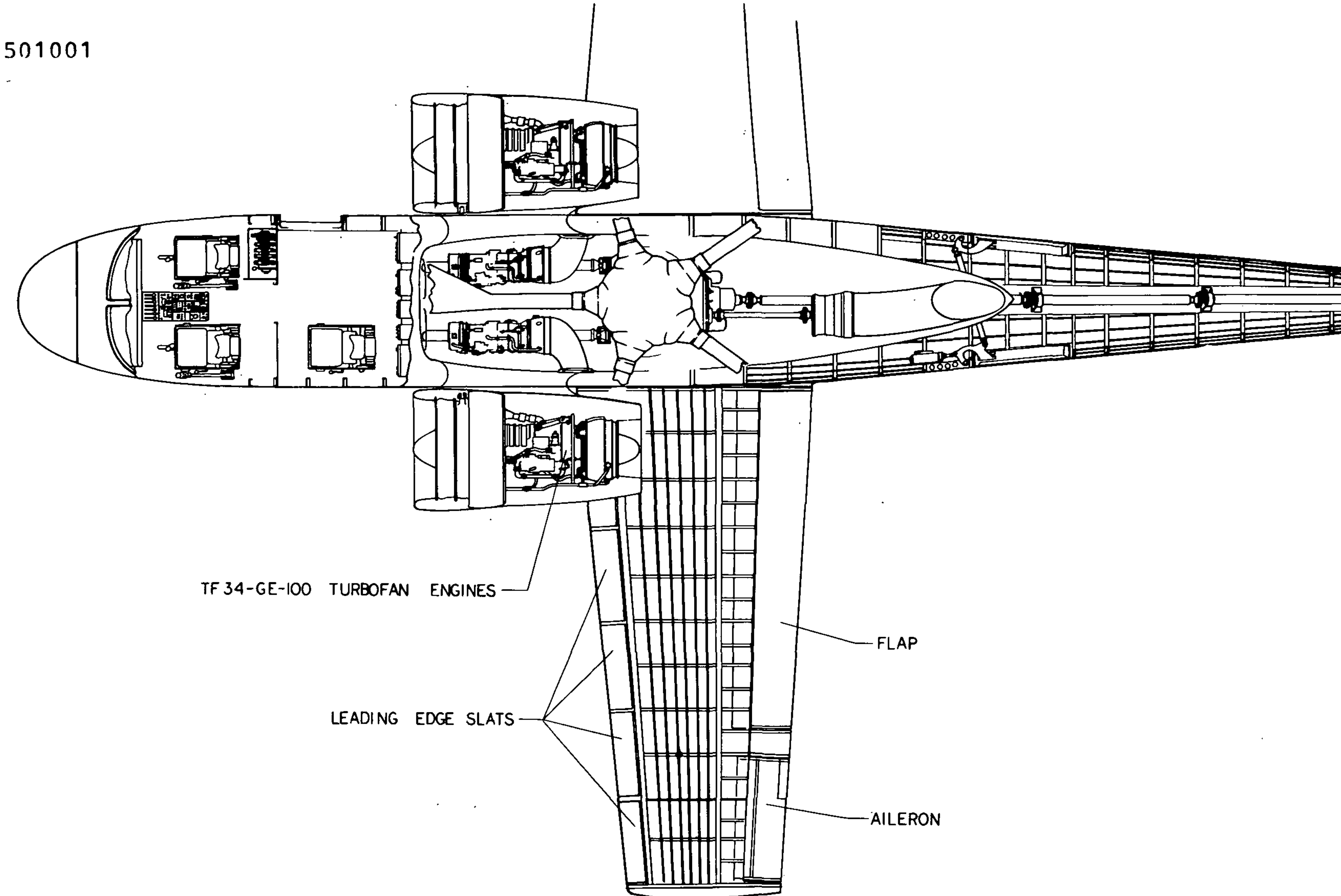
FIGURE 2



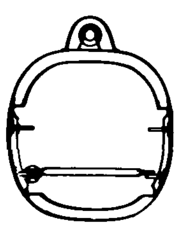
THREE-VIEW DRAWING

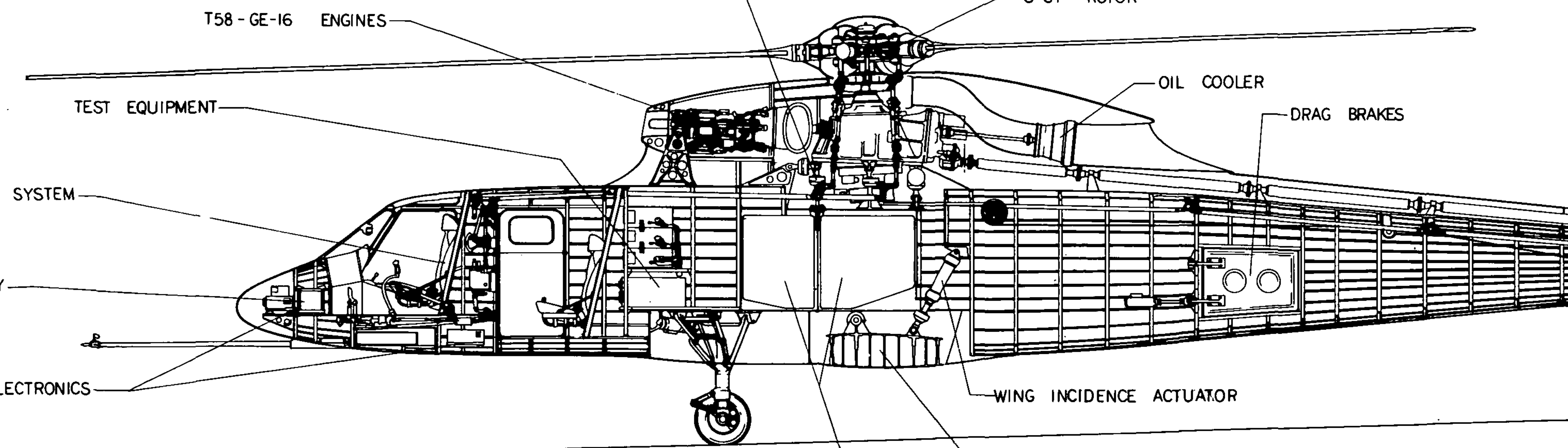
FIGURE 1





TF 34-GE-100 TURBOFAN ENGINES
FLAP
LEADING EDGE SLATS
AILERON





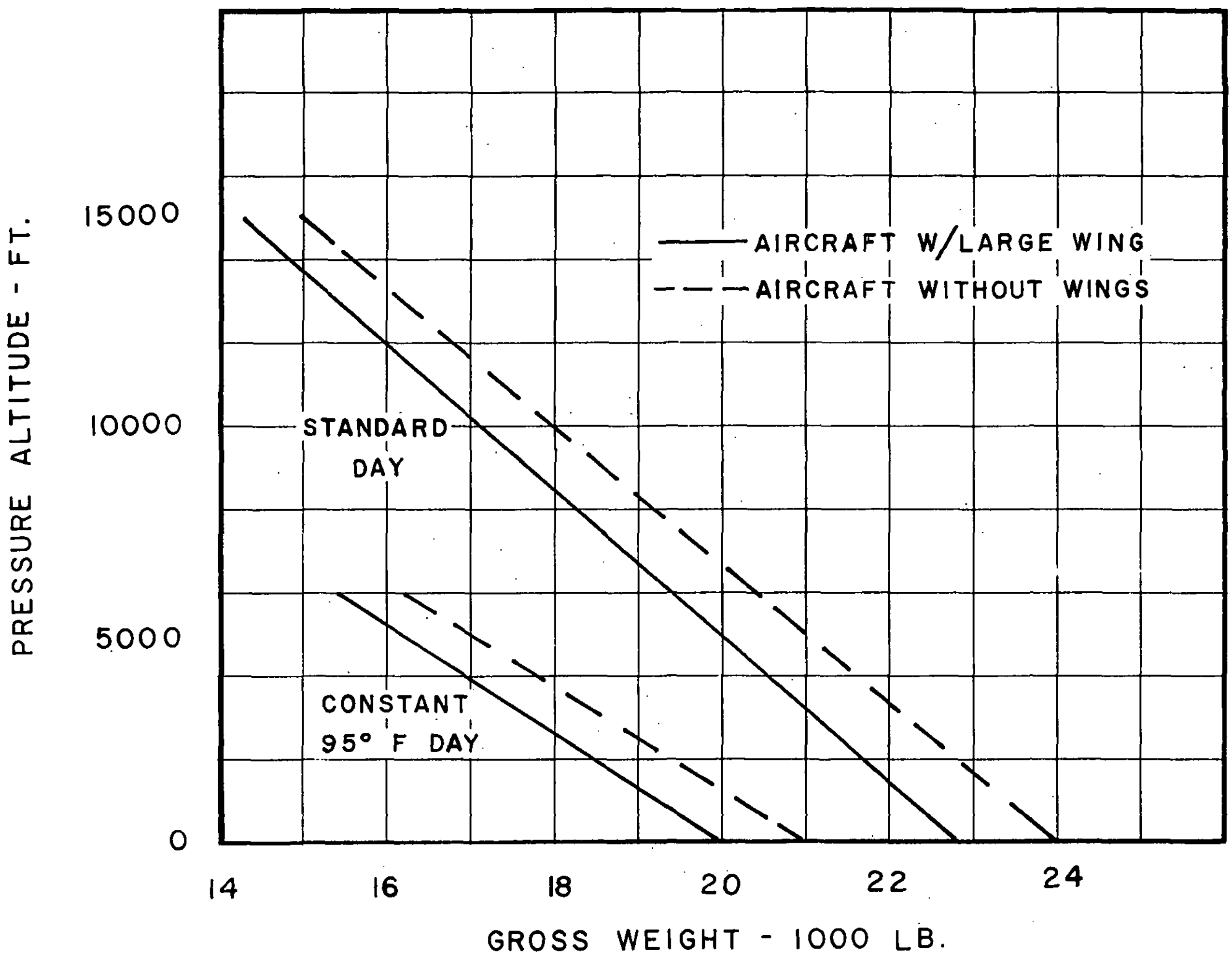
LOAD CELL MOUNTING SYSTEM
S-67 ROTOR
T58-GE-16 ENGINES
OIL COOLER
DRAG BRAKES
TEST EQUIPMENT
EJECTION SYSTEM
BATTERY
ELECTRONICS
WING INCIDENCE ACTUATOR
WING
FUEL TANKS

3.1.2.2 HIGH-SPEED MODE FLIGHT CONDITIONS. Estimated performance shall be as follows:

Take-off (Design) Gross Weight (LBS)	26,392
Maximum Speed, Sea Level, Standard Day (KTS)	309
Maximum Speed, 9,500 Feet, Standard Day (KTS)	319

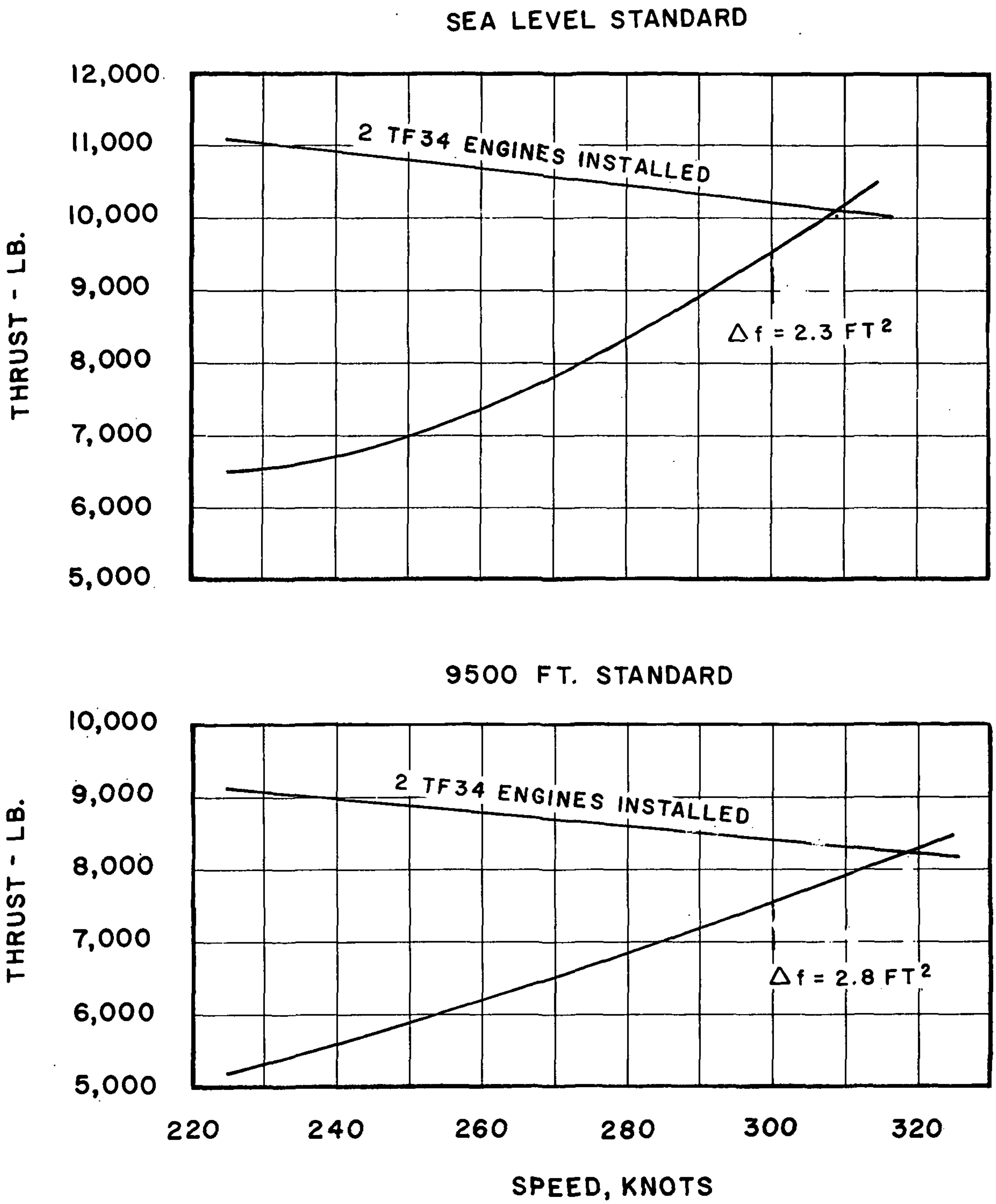
NOTE: The maximum speeds quoted are estimated for the basic aircraft with an appropriate high-speed rotor system. The maximum-speed capabilities of the initially-installed compound rotor have not been estimated, but are presumed to be less than 300 knots.

3.1.2.3 AIRCRAFT PERFORMANCE CURVES. Performance curves, delineating the estimated performance for the aircraft in the hovering and high-speed modes, are provided herein (see Figures 3 and 4).



RSRA HOVER CAPABILITY
TWO T58-GE-16 ENGINES @ MIL POWER
TURBOFANS REMOVED OGE

Figure 3



RSRA HIGH SPEED THRUST SMALL WING INSTALLED
THRUST AVAILABLE & THRUST REQUIRED VS. SPEED

Figure 4

3.1.2.4 ENGINE PERFORMANCE DATA. The engines for rotor propulsion shall be two T58-GE-16 turboshaft engines with performance in accordance with General Electric Company Specification No. E1105-A dated 29 April 1968. The engines for auxiliary propulsion shall be two TF34-GE-100 turbofan engines with performance in accordance with General Electric Company Specification No. CP45E0002 (no date). The engines shall be furnished by the government and installed by the contractor. The manufacturer's engine performance ratings at standard day, sea level, static conditions, are as follows:

T58-GE-16 Turboshaft Engine

Rating	Min. SHP	Max. SFC (lb/shp/hr)	Rated Power-Turbine Speed (rpm)	Max. Gas-Generator Speed (rpm)	Max. Measured Power-Turbine Inlet Temp (T_5) (Degrees C)	(Degrees F)
Military	1870	.530	20,280	26,800	805	1481
Normal	1770	.540	20,280	------	785	1445
90% Normal	1593	.555	20,280	------	---	----
75% Normal	1328	.590	20,280	------	---	----
Ground Idle	----	180 lb/hr	0	15,400	---	----

TF34-GE-100 Turbofan Engine

Ratings	Net Thrust (Min.) (lb)	Gas Generator Rotor Speed (Max.) (rpm)	Fan Rotor Speed (Max.) (rpm)	Specific Fuel Consumption (Max.) (lb/hr/lb)	Measured Gas Generator Discharge Temp. (Max.) (Degrees F)	(Degrees C)
Maximum	8985	17,600	7,110	.373	1495	813
Intermediate	7915	17,180	6,720	.362	1405	763
Max. Continuous	7260	16,910	6,490	.358	1350	733
90% Max. Continuous	6534	------	-----	.353	----	---
75% Max. Continuous	5445	------	-----	.350	----	---
Ground Idle	550 (Max)	------	-----	390 (Max. fuel flow lb/hr)	----	---

3.1.2.5 DESIGN MISSION. The basic aircraft shall be capable of performing the following mission at design gross weight, at sea level standard and 9,500 feet standard conditions, with the engine fuel-flow specifications increased by five percent:

1. Two minutes of normal rated power (all engines).
2. Two minutes hover OGE (or at minimum airspeed attainable if HOGE cannot be accomplished).
3. Accelerate and cruise at 300 knots for 15 minutes with 2,000 lbs payload (assuming an appropriate high-speed rotor system is installed).
4. Decelerate and hover 2 minutes OGE.
5. Land with fuel reserve of 20 minutes at airspeed for maximum range.

3.1.2.6 HELICOPTER SIMULATION. The aircraft shall be capable of steady flight at airspeeds from 100 to 200 knots which shall include rotor operation from autorotation to the "upper stall limit" as defined in NASA CR-114. Zero rotor lift shall be obtainable above 120 knots, at sea level standard conditions.

3.1.3 WEIGHTS. A MIL-STD-451 (Part I) Estimated Summary Weight Statement is provided on the following pages.

NAME

DATE

MODEL

REPORT SES-501001

SUMMARY WEIGHT STATEMENT
ROTORCRAFT ONLY
ESTIMATED - ~~CALCULATED~~ - ~~ACTUAL~~
(Cross out those not applicable)

CONTRACT NAS1-11228

ROTORCRAFT, GOVERNMENT NUMBER

ROTORCRAFT, CONTRACTOR NUMBER

MANUFACTURED BY

		MAIN	AUXILIARY
ENGINE	MANUFACTURED BY	General Electric	General Electric
	MODEL	T58-GE-16	TF34-GE-100
	NUMBER	2	2
PROPELLER	MANUFACTURED BY		
	MODEL		
	NUMBER		

NAME

DATE

MODEL

REPORT SES-501001

ROTORCRAFT
SUMMARY WEIGHT STATEMENT
WEIGHT EMPTY

1							
2	ROTOR GROUP						2104
3	BLADE ASSEMBLY					1098	
4	HUB					321	
5	HINGE AND BLADE RETENTION					685	
6		FLAPPING					
7		LEAD LAG					
8		PITCH					
9		FOLDING					
10	WING GROUP, Small Wing						1125*
11	WING PANELS-BASIC STRUCTURE						
12	CENTER SECTION-BASIC STRUCTURE						
13	INTERMEDIATE PANEL-BASIC STRUCTURE						
14	OUTER PANEL-BASIC STRUCTURE-INCL TIPS			LBS			
15	SECONDARY STRUCT-INCL FOLD MECH			LBS			
16	AILERONS-INCL BALANCE WTS			LBS			
17	FLAPS						
18	-TRAILING EDGE						
19	-LEADING EDGE						
20	SLATS						
21	SPOILERS						
22							
23	TAIL GROUP						863
24	TAIL ~~ROTOR~~ FAN					360	
25	-BLADES						
26	-HUB						
27	~~STABILIZER-BASIC STRUCTURE~~ STABILATOR					349	
28	FINS-BASIC STRUCTURE-INCL DORSAL - TOTAL			LBS		154	
29	SECONDARY STRUCTURE -STABILIZER AND FINS						
30	ELEVATOR - INCL BALANCE WEIGHT			LBS			
31	RUDDER - INCL BALANCE WEIGHT			LBS			
32							
33	BODY GROUP						3518
34	FUSELAGE OR HULL - BASIC STRUCTURE						
35	BOOMS - BASIC STRUCTURE						
36	SECONDARY STRUCTURE - FUSELAGE OR HULL						
37	- BOOMS						
38	- DOORS, PANELS & MISC						
39							
40							
41	ALIGHTING GEAR - LAND TYPE						1098
42	LOCATION	*ROLLING	STRUCT	CONTROLS			
43		ASSEMBLY					
44		460	458	180			
45							
46							
47							
48							
49							
50	ALIGHTING GEAR GROUP - WATER TYPE						
51	LOCATION	FLOATS	STRUTS	CONTROLS			
52							
53							
54							
55							
56							
57	* Large wing weight - 2411 lbs						

*WHEELS, BRAKES, TIRES, TUBES AND AIR

ROTORCRAFT
SUMMARY WEIGHT STATEMENT
WEIGHT EMPTY

1								
2	FLIGHT CONTROLS GROUP							1627
3	COCKPIT CONTROLS						88	
4	AUTOMATIC STABILIZATION						89	
5	SYSTEM CONTROLS - ROTOR	NON ROTATING					515	
6		ROTATING					91	
7	- FIXED WING						483 *	
8	HYDRAULIC BOOST						130	
9	SPECIAL INCL. WING TILT						231	
10	ENGINE SECTION OR NACELLE GROUP							989
11	INBOARD						216	
12	CENTER							
13	OUTBOARD						773	
14	DOORS, PANELS AND MISC							
15								
16	PROPULSION GROUP							6902
17			X AUXILIARY X		X MAIN X			
18	ENGINE INSTALLATION			2890			886	
19	ENGINE							
20	TIP BURNERS							
21	LOAD COMPRESSOR							
22	REDUCTION GEAR BOX, ETC							
23	ACCESSORY GEAR BOXES AND DRIVES							
24	SUPERCHARGER-FOR TURBOS							
25	AIR INDUCTION SYSTEM						20	
26	EXHAUST SYSTEM			34			8	
27	COOLING SYSTEM							
28	LUBRICATING SYSTEM			16			42	
29	TANKS							
30	BACKING BD, TANK SUP & PADDING							
31	COOLING INSTALLATION							
32	PLUMBING, ETC							
33	FUEL SYSTEM						304	
34	TANKS - UNPROTECTED							
35	- PROTECTED							
36	BACKING BD, TANK SUP & PADDING							
37	PLUMBING, ETC							
38	WATER INJECTION SYSTEM							
39	ENGINE CONTROLS			54			35	
40	STARTING SYSTEM			79			58	
41	PROPELLER INSTALLATION							
42	DRIVE SYSTEM						2476	
43	GEAR BOXES INCL. SHAFT					2200		
44	LUBE SYSTEM					98		
45	CLUTCH AND MISC					43		
46	TRANSMISSION DRIVE					135		
47	ROTOR SHAFT							
48	JET DRIVE							
49								
50								
51								
52	AUXILIARY POWER PLANT GROUP							
53								
54	* Includes 50 lbs of wing controls which are removable with the small wing.							
55	The large wing includes 130 lbs of control which must be added when the large							
56	wing is included. Therefore wing control weight with the large wing is 563 lb.							
57								

ROTORCRAFT
SUMMARY WEIGHT STATEMENT
WEIGHT EMPTY

1							
2							
3							
4	INSTRUMENT AND NAVIGATIONAL EQUIPMENT GROUP						567
5	INSTRUMENTS					216	
6	NAVIGATIONAL EQUIPMENT					19	
7	INSTRUMENTATION					332	
8							
9	HYDRAULIC AND PNEUMATIC GROUP						54
10	HYDRAULIC					54	
11	PNEUMATIC						
12							
13							
14	ELECTRICAL GROUP						403
15	A C SYSTEM						
16	D C SYSTEM						
17							
18							
19	ELECTRONICS GROUP						260
20	EQUIPMENT INCL. ANT.					183	
21	INSTALLATION					77	
22							
23							
24	ARMAMENT GROUP - INCL GUNFIRE PROTECTION				LBS		
25							
26	FURNISHINGS AND EQUIPMENT GROUP						284
27	ACCOMMODATIONS FOR PERSONNEL INCL. EJECTION					145	
28	MISCELLANEOUS EQUIPMENT	X INCL		LBS	BALLASTX		
29	FURNISHINGS					46	
30	EMERGENCY EQUIPMENT					93	
31							
32							
33							
34	AIR CONDITIONING AND ANTI-ICING EQUIPMENT						136
35	AIR CONDITIONING					136	
36	ANTI-ICING						
37							
38							
39	PHOTOGRAPHIC GROUP						
40	EQUIPMENT						
41	INSTALLATION						
42							
43	AUXILIARY GEAR GROUP						30
44	AIRCRAFT HANDLING GEAR					30	
45	LOAD HANDLING GEAR						
46	ATO GEAR						
47							
48							
49							
50							
51							
52							
53							
54	MANUFACTURING VARIATION (CONTINGENCY)						599
55							
56							
57	TOTAL-WEIGHT EMPTY - PAGES 2, 3 AND 4						20559

SUMMARY WEIGHT STATEMENT

1	LOAD CONDITION				HIGH-SPEED		HELO
2							
3	CREW - NO. (2)				400		400
4	~~PASSENGERS - NO.~~ RESEARCH PAYLOAD				2000		2000
5	FUEL LOCATION	TYPE	GALS				
6	UNUSABLE	JP-4			30		30
7	INTERNAL	JP-4			3313		2202
8							
9							
10							
11	EXTERNAL						
12							
13							
14							
15	BOMB BAY						
16							
17							
18							
19	OIL						
20	UNUSABLE				10		5
21	ENGINE				80		40
22							
23							
24							
25	BAGGAGE						
26	CARGO						
27							
28	ARMAMENT						
29	GUNS - LOCATION TYPE**	QUANTITY	CALIBER				
30							
31							
32							
33							
34	AMM						
35							
36							
37							
38	BOMB INSTL*						
39	BOMBS						
40							
41	TORPEDO INSTL*						
42	TORPEDOES						
43							
44	ROCKET INSTL*						
45	ROCKETS						
46							
47	EQUIPMENT - PYROTECHNICS						
48	-PHOTOGRAPHIC						
49							
50	-*OXYGEN						
51							
52	-MISCELLANEOUS						
53							
54							
55	USEFUL LOAD				5833		4677
56	WEIGHT EMPTY CHANGE - REMOVAL OF WING & OUTBOARD ENGINES						-4960
57	GROSS WEIGHTS - PAGES 2-5				26392		20276

*IF NOT SPECIFIED AS WEIGHT EMPTY **FIXED. FLEXIBLE. ETC.

MIL-STD-451 PART I
NAME
DATE

SUMMARY WEIGHT STATEMENT
DIMENSIONAL STRUCTURAL DATA
ROTORCRAFT

PAGE 21
MODEL
REPORT SES-501001

1	LENGTH - OVERALL	71.8 ft.		X BLADES	~~FOLDED~~ REMOVED 63.9		
2	GENERAL DATS			BOOM	FUS	NAC	CABIN
3	LENGTH - MAXIMUM FEET						
4	DEPTH - MAXIMUM FEET						
5	WIDTH - MAXIMUM FEET						
6	WETTED AREA TOTAL - ft^2				1110		
7	WETTED AREA GLASS						
8	WING TAIL & FLOOR DATA			WING	H TAIL	V TAIL	FLOOR
9	GROSS AREA - SQUARE FEET			184.6	90	50	
10	WEIGHT/GROSS AREA - POUNDS	PER SQUARE	FEET	6.09	3.88	3.08	
11	SPAN - FEET			33.3			
12	FOLDED SPAN - FEET						
13	*THEORETICAL ROOT CHORD -	INCHES		77			
14	MAXIMUM THICKNESS - INCHES			12.5			
15	CHORD AT PLANFORM BREAK	INCHES					
16	MAXIMUM THICKNESS - INCHES						
17	THEORETICAL TIP CHORD -	INCHES		46			
18	MAXIMUM THICKNESS - INCHES			7.5			
19	DORSAL AREA INCLUDED IN FUSELAGE			SQ FT	TAIL		SQ FT
20	TAIL LENGTH 25% MAC WING TO 25% MAC HORIZONTAL TAIL					FEET	
21	AREA - SQ FT PER ROTORCRAFT	FLAPS	40	AILERONS	5.56	SPOILERS	
22		SLATS		WING LE		WING TE	
23	**ROTOR DATA - TYPE - ARTICULATING	FLAPPING - TEETERING				RIGID	
24		X	MAIN ROTOR	XX	TAIL ROTOR		X
25	FROM CL ROTATION - INCHES		ROOT	TIP	ROOT		TIP
26	CHORD - INCHES		18.25	18.25			
27	THICKNESS - INCHES		2.19	2.19			
28					MAIN - FWD	MAIN - AFT	TAIL
29	BLADE RADIUS - FEET				31.0		
30	NUMBER BLADES				5		
31	BLADE AREA - TOTAL - OUTBOARD		INCHES RADIUS		185 ft^2		
32	DISC AREA - TOTAL SWEPT	3020	SQUARE FEET -	OVERLAP			SQUARE FEET
33	TIP SPEED AT DESIGN LIMIT	ROTOR-SPEED-POWER-FT/SEC*****			769		
34	DESIGN FACTOR USED BY CONTRACTOR				1.1		
35	LOCATION FROM HORIZONTAL	REF DATUM	INCHES		300		
36	PRESSURE JET % BLADE SECTION	AREA	FOR DUCT				
37	TIP JET THRUST						GEAR***
38	POWER TRANSMISSION DATA				HP	RPM	RATIO
39	MAX POWER - TAKE-OFF				3700	19700	.0107
40	ALIGHT GEAR TYPE**BICYCLE -	TRICYCLE	QUADRICYCLE-SKID		OUTRGR	MAIN - AFT	AUX-FWD
41	GEAR LENGTH - OLEO EXTND CL	AXLE TO	CL TRUNNION				
42	OLEO TRAVEL - FULL EXTENDED	TO COMPRESSED		INCHES			
43	WHEEL SIZE AND NUMBER REQUIRED						
44	FUEL AND OIL SYSTEM		LOCATION	NO. TANKS	****GALS	NO. TANKS	****GALS
45					UNPRTCTD		PROTECTD
46	FUEL - BUILT IN				769		
47	FUEL - EXTERNAL						
48	LUBRICATING SYSTEM						
49	HYDRAULIC SYSTEM						
50	STRUCTURAL DATA - CONDITION			FUEL IN	DESIGN	STRESS	
51				WINGS - LB	GROSS WT	GROSS WT	ULT LF
52	FLIGHT					26392	6.0
53	LANDING						
54	% DESIGN LOAD	WING	%	FWD RTR	%	AFT RTR	%
55							
56	**TYPE OF POWER TRANSMISSION	- GEARED	- PRESSURE JET		- RAM	JET	
57							

*PARALLEL TO CL • CL ROTORCRAFT
**CROSS OUT NON-APPLICABLE TYPE
***GEAR RATIO-ENG TO ROTOR
****TOTAL USEABLE CAPACITY
*****REFER TO PARA. 5.1.1.3 - ITEMS 6-33 & 6-34

3.1.4 CENTER OF GRAVITY LOCATION. Center of gravity location is estimated to be as follows:

		Helicopter Mode		High-Speed Mode	
a.	Design gross weight,	20,276	lbs	26,392	lbs
	cg location, wheel up	297.7		294.8	
b.	Design gross weight,	20,276	lbs	26,392	lbs
	cg location, wheels down	298.1		295.0	
c.	Extreme forward position cg possible in flight, regardless of loading at take-off (wheels up,	291.3	(up)	290.3	(up)
	wheels down)	291.5	(down)	290.5	(down)
	(1) Gross weight for this condition	23,074	lbs	28,079	lbs
d.	Extreme rearward position cg possible in flight, regardless of loading at take-off (wheels up,	311.0	(up)	305.0	(up)
	wheels down)	311.3	(down)	305.2	(down)
	(1) Gross weight for this condition	20,276	lbs	26,392	lbs

3.1.4.1 VARIATIONS IN CENTER OF GRAVITY. Provisions shall be made to allow ground-adjustable variations in the aircraft center of gravity by the installation or movement of high-density ballast (see 3.7.1.6 herein). The structure for, and access to, the ballast weights shall be considered a part of the design gross weight. The removable ballast weight shall be considered a part of the unspecified payload.

3.1.5 AREAS. The principal areas are estimated to be as follows: (Not to be used for inspection purposes.)

Small wing area, total, including ailerons, flaps, and 41.2 square feet of fuselage	184 sq.ft.
Small wing flap area, aft of hinge line, total	40 sq.ft.
Small wing aileron area, aft of hinge line but including overhanging external balance forward of hinge, total including 1.44 square feet of tab area	5.56 sq.ft.
Large wing area, total, including ailerons, flaps, and 64.8 square feet of fuselage	348 sq.ft.
Large wing flap area, aft of hinge line, total	42.8 sq.ft.
Large wing aileron area, aft of hinge line but including overhanging external balance forward of hinge, total including 1.88 square feet of tab area	10.46 sq.ft.
Horizontal tail area (stabilator)	90 sq.ft.
Vertical tail area, total	50 sq.ft.
Vertical stabilizer (to rudder hinge)	43.6 sq.ft.
Rudder (aft of hinge)	6.4 sq.ft.
A_b = Main rotor blade area (one blade)	47 sq.ft.
A_g = Main rotor geometric disc area (total)	3020 sq.ft.
σ_g = Main rotor blade geometric solidity ratio	0.078
Fan-in-fin blade activity factor	950
Fan-in-fin geometric disc area (total)	71.1 sq.ft.

3.1.6 DIMENSIONS AND GENERAL DATA. The principal dimensions and general data are estimated to be as follows: (Not to be used for inspection purposes.)

Small wing	
Span	33 ft. 3 in.
Chord	
Root	6 ft. 5 in.
Tip	3 ft. 10 in.
Airfoil section designation	NACA23015
Root thickness	15 percent
Tip thickness	15 percent
Incidence (variable)	-19 thru +23 degrees
Dihedral	3 degrees
Aspect ratio	6
Ailerons	
Span	3 ft. 4 in.
Chord (average percent wing chord)	20 percent
High lift devices	
Plain flaps	
Span, exclusive of cutouts (percent of wing span)	59 percent
Chord (percent of wing chord)	36.5 percent
Large wing	
Span	45 ft. 8 in.
Chord	
Root	9 ft. 3 in.
Tip	5 ft. 6 in.
Airfoil section designation	NACA23015
Root thickness	1 ft. 2 in.
Tip thickness	8.25 in.
Incidence (variable)	-19 thru +23 degrees
Dihedral	3 degrees
Aspect ratio	6
Ailerons	
Span	9 ft. 2 in.
Chord (average percent wing chord)	19 percent
High lift devices	
Double slotted flaps	
Span, exclusive of cutouts (percent of wing span)	57.5 percent
Chord (percent of wing chord)	25.8 percent
Leading edge slats	
Span, exclusive of cutouts (percent of wing span)	84 percent
Chord (percent of wing chord)	11 percent

3.1.6 (Cont'd)

Tail	
Horizontal	
Span	19 ft. 4 in.
Aspect ratio	4.1
Chord	
Root	6 ft. 4 in.
Tip	3 ft. 5 in.
Airfoil section designation	NACA0012, NACA0009
Root thickness	12 percent
Tip thickness	9 percent
Vertical	
Span	10 ft.
Aspect ratio	2
Chord	
Root	6 ft. 11 in.
Tip	3 ft. 4 in.
Height over highest fixed part of aircraft (rotor head)	15 ft. 7 in.
Fuselage length, maximum	63 ft. 8 in.
Distance from centerline of main rotor to horizontal tail MAC quarter chord point	35 ft.10 in.
Ground angle	1 degree,45 minutes
Wheel size	
Main wheels	16 in. dia.
Auxiliary wheel (tail)	11.6 in. dia.
Tire size	
Main wheels	25.5 X 6.85
Auxiliary wheel (tail)	17.9 X 4.45
Tread of main wheels	10 ft.
Wheel base	38 ft. 4 in.
Vertical travel of axle from extended to fully compressed position	
Main wheels	12 in.
Tail wheel	12 in.

3.1.6 (Cont'd)

Angle between lines joining center of gravity with point of ground contact of main wheel tires, static deflection at DGW (front elevation)	31.7 degrees
Angle of line through center of gravity and ground contact point of main wheel tire to vertical line, reference line level, static deflection at DGW (side elevation)	29.4 degrees
Critical turnover angle at DGW	28.8 degrees
D = diameter of main rotor	62 ft.
Number of blades for main rotor	5
Airfoil section designation and thickness	0012, 12 percent
Length	
Maximum-main rotor blades turning	71 ft. 6 in.
Width	
Maximum-main rotor blades turning	62 ft.
Height	
Over main rotor blades at rest	15 ft. 7 in.
In hoisting attitude from top of fitting to bottom of wheels (no load on wheels)	17 ft. 10 in.
Main rotor clearance (ground to tip, rotor static)	12 ft.
Main rotor clearance (ground to tip, rotor turning)	14 ft. 2 in.
Main rotor clearance (tailcone structure to tip, rotor static)	3 ft. 8 in.
Main rotor clearance (tailcone structure to tip, rotor turning)	5 ft. 10in.
Diameter fan-in-fin	4 ft. 8 in.

3.1.7 CONTROL SURFACE AND CORRESPONDING CONTROL MOVEMENTS

3.1.7.1 CONTROL SURFACE MOVEMENTS. Control surface movements are estimated to be as follows: (Not to be used for inspection purposes.)

Rudder	25 degrees trailing edge right
	25 degrees trailing edge left
Stabilator	17 degrees trailing edge up
	9 degrees trailing edge down
Ailerons	25 degrees trailing edge up
	25 degrees trailing edge down
Small wing flaps maximum movement	60 degrees
Large wing flaps maximum movement	60 degrees
Large wing leading edge slats	25 degrees deflection
	14 percent of chord

3.1.7.2 ROTOR BLADE MOVEMENTS. Rotor blade movements are estimated to be as follows: (Not to be used for inspection purposes.)

Range of blade angles using collective pitch (root)	+ 2.5 degrees (low pitch)
	+16.5 degrees (high pitch)
Maximum range of blade angles with cyclic pitch (collective pitch, low position)	+14.5 degrees fwd
	-11 degrees aft
	+ 8 degrees right
	- 8 degrees left
Fan-in-fin	
Range of blade angles (root)	-20 degrees (low pitch)
	+38 degrees (high pitch)

3.1.7.3 CORRESPONDING CONTROL MOVEMENTS. Corresponding control movements are estimated to be as follows: (Not to be used for inspection purposes.)

Pedals	3.45 inches right 3.45 inches left
Collective pitch control lever	7.46 inches up 0 inches down
Azimuth control stick	
Longitudinal	7 inches fwd 7 inches aft
Lateral	7 inches right 7 inches left

3.2 GENERAL FEATURES OF DESIGN AND CONSTRUCTION

3.2.1 GENERAL INTERIOR ARRANGEMENT. The interior arrangement of the helicopter shall be as described herein.

3.2.1.1 COCKPIT. The cockpit shall be located in the forward section of the aircraft. Side-by-side seating shall be provided for the pilot and copilot. The pilot's seat shall be on the right.

3.2.1.2 CABIN. The cabin shall be located in the fuselage forward section immediately aft of the cockpit. Flight control rods and components shall be routed through an enclosure in the cabin. Complete provisions shall be made in the cabin for a third seat, special test instrumentation, and emergency escape system (see 3.7.1.3.7.1 herein) for an instrumentation engineer. Removable items such as seat, belt, shoulder harness, inertia reel, emergency escape system components, instrumentation control panel and instruments shall not be included in Weight Empty.

3.2.1.3 ENGINES AND TRANSMISSION. The main transmission shall be located above the fuselage center section. The T58-GE-16 turboshaft engines shall be located forward of the main transmission. The two auxiliary propulsion TF34-GE-100 turbofan engines shall be mounted in nacelles and installed high on the left and right side of the fuselage.

3.2.2 SELECTION OF MATERIALS AND PARTS. The materials, parts, processes and equipment selected shall be in accordance with a government recognized or other approved specification, to the extent practicable for a research aircraft.

3.2.3 WORKMANSHIP. Work shall be accomplished and finished in a thoroughly workmanlike manner and in accordance with standard aircraft practices.

3.2.4 PRODUCTION, MAINTENANCE, AND REPAIR. The aircraft shall be designed to facilitate installation and removal of equipment and components such as power plants, wing, rotor, and blades. Quick disconnects shall be incorporated where practicable. Accessibility shall be provided for inspection, maintenance, and repair. Requirements for special tools shall be held to a minimum.

3.2.5 INTERCHANGEABILITY AND REPLACEABILITY. Not applicable.

3.2.6 FINISH. The finish for the aircraft and its parts shall be in accordance with requirements set forth by the contractor during detail design.

3.2.6.1 EXTERIOR AND INTERIOR COLOR AND MARKINGS. Exterior and interior color and markings for the aircraft shall be determined during detail design.

3.2.7 IDENTIFICATION AND MARKING. Identification and marking shall be as required for a research aircraft.

3.2.8 EXTREME TEMPERATURE OPERATION. Not applicable.

3.2.9 CLIMATIC REQUIREMENTS. Not applicable.

3.2.10 LUBRICATION. Provision shall be made for lubrication of all parts subject to wear in accordance with requirements established by the contractor.

3.2.11 EQUIPMENT AND FURNISHING INSTALLATION

3.2.11.1 GOVERNMENT-FURNISHED EQUIPMENT. Government-furnished equipment listed in Appendices I-A and I-B hereto shall be installed under the applicable conditions set forth in this specification.

3.2.11.2 CONTRACTOR FURNISHED EQUIPMENT. The contractor shall provide and install necessary equipment and furnishings not specified herein as government furnished, except for personal issue items.

3.2.12 CREW. The crew shall consist of one pilot and one copilot. Complete provisions shall be made for a third crewman (see 3.2.1.2).

3.2.13 RELIABILITY. Reliability values will be determined during preliminary design and updated during detail design and test.

3.2.14 MAINTAINABILITY. Maintainability values will be determined during preliminary design and updated during detail design and test.

3.2.15 NOISE LEVEL. A total noise level of 95 EPNdb at 500 feet side line, shall not be exceeded in take-off and landings with the basic compound-helicopter rotor.

3.3 AERODYNAMICS

3.3.1 AERODYNAMIC DESIGN. Aerodynamic design shall be in general accordance with the flying and handling quality requirements of MIL-H-8501 and the applicable requirements of MIL-F-8785. Specific deviations shall be submitted at the time of contract consistent with deviations taken for contemporary helicopters including: yaw response at altitude, time delay for corrective action following full autorotative entry, time delay for corrective action following full AFCS hardover, and autorotative touchdown speed greater than 15 knots.

These deviations are considered necessary to effect a useful design. The intent of MIL-H-8501 shall be met in the above areas and the aircraft shall be designed with major considerations for safety.

3.3.2 STABILITY AND CONTROL. The stability and control characteristics of the research aircraft shall be designed to meet the requirements of 3.3.1.

3.4 STRUCTURAL DESIGN CRITERIA

3.4.1 STRENGTH REQUIREMENTS. The following are for information only:

	Helicopter Mode	High-Speed Mode
Design gross weight (lb)	26,392	26,392
Maximum positive limit load factor (flight) at design gross weight	2.5	4.0
Maximum negative limit load factor (flight) at design gross weight	0.5	1.5
Design sink speed (fps)	8	8

3.4.1.1 DETAIL STRENGTH REQUIREMENTS. Strength and rigidity shall be designed in general accordance with the applicable requirements of MIL-A-8860 (Series) and MIL-S-8698(ASG). The aircraft structure, with the exception of the main rotor system and the rotor control system, shall be designed to 240 knots limit dive speed in the helicopter mode and 360 knots limit dive speed in the high-speed mode. The aircraft limit load factor shall be +4.0, -1.5 at design gross weight. The aircraft shall be designed for a limit sink speed of 8 feet-per-second from hover at 2/3 hovering thrust at design gross weight. The maximum landing speed at design gross weight, shall be 120 knots forward speed at 8 feet-per-second sink speed with lift equal to weight.

3.4.1.2 FLUTTER CHARACTERISTICS. The aircraft shall be designed to be free from divergence, flutter, buzz, or other aeroelastic instability throughout its range of design speeds, altitudes, maneuvers, and loading and weight conditions. MIL-A-8870 shall be used as a guide.

3.4.1.3 DESIGN SERVICE LIFE. The design service life of the aircraft shall be a minimum of 600 hours. To the maximum extent feasible, the design of primary aircraft structure shall utilize fail-safe design concepts.

3.5 MAIN ROTOR AND WING GROUP

3.5.1 MAIN ROTOR GROUP

3.5.1.1 DESCRIPTION AND COMPONENTS. The main rotor group includes five main rotor blades, blade retention, main rotor head, aerodynamic fairing, and controls at the head.

3.5.1.2 BLADE CONSTRUCTION. The main rotor blades shall be of all-metal construction utilizing adhesive bonding and mechanical fasteners. The leading-edge spar shall be extruded aluminum alloy, and the root fitting of alloy steel. Blade twist shall be three degrees. Seven percent of the blade, at the tip end, shall be swept aft 20 degrees relative to the span axis in order to obtain low vibratory control loads, low blade stresses at high forward-flight speeds, and improved hovering efficiency through aerodynamic compressibility relief. Rotor blade tip caps shall be removable for field replacement. A crack detection and indicating system shall be incorporated to provide for monitoring the structural integrity of the spar during ground inspection. Rotor blades shall be interchangeable individually without balancing.

3.5.1.3 BLADE RETENTION. The blade shall be attached to the rotor head sleeve outer flange by means of circular bolt retention.

3.5.1.4 ROTOR HEAD. A fully articulated rotor head shall be provided. It shall include a steel upper plate with integral hub, which is splined to the rotor shaft, and a titanium lower plate, which is bolted to the hub. Needle bearings shall be used with the lower plate for centrifugal loads and tapered roller bearings with the upper plate for centrifugal and lifting loads. The main rotor head also shall include hydraulic dampers, vertical hinges, horizontal hinge pins, and sleeve and spindle assemblies, one for each of the five blades. Each sleeve shall rotate on its feathering axis by means of angular contact ball bearings. Each blade shall have a flanged root end that is bolted to the sleeve in a manner to permit blade removal. Rotor head bearings shall be oil lubricated or self-lubricating. The major bearings shall be lubricated by oil, and individual reservoirs shall be provided. A fairing shall be provided for the main rotor head to reduce aerodynamic drag.

3.5.1.5 BLADE FOLDING. Blade folding shall not be provided.

3.5.1.6 BLADE SECURING. Blade tie-down equipment shall be included as part of ground support equipment.

3.5.1.7 BLADE RESTRAINERS AND STOPS. A blade droop-stop restrainer shall be provided for each rotor blade.

3.5.1.8 BLADE TRACKING. Pre-tracked blades shall be provided.

3.5.1.9 ROTOR TACHOMETER. A rotor tachometer generator shall be provided to permit rotor RPM measurement. It shall be driven by the main rotor transmission.

3.5.1.10 BLADE SEVERANCE. See 3.7.1.3.7.1 herein.

3.5.2 WING GROUP

3.5.2.1 DESCRIPTION. The wing group shall include a center section, wing panels, wing tips, ailerons, flaps, slats, wing-tilt mechanism, and wing-load instrumentation devices. Two wings shall be provided: a small wing to unload the rotor during high-speed operation and an alternate large wing to unload the rotor during lower speed helicopter simulation.

3.5.2.2 CONSTRUCTION. Each wing shall be cambered and shall be of aluminum alloy, two-spar, multiple-stringer, rib, and redundant fail-safe design and construction. Each wing shall be designed for maximum energy absorption in event of a crash. All ribs shall have shear ties to the top and bottom of shear panels, providing a rigid torsional bending box.

3.5.2.2.1 INTEGRAL WING FUEL TANKS. Not applicable.

3.5.2.3 DETACHABLE WINGS. The small or large wing shall be capable of being installed interchangeably within a notch in the lower fuselage. Each wing shall be removable as a unit. A fairing shall be provided over the lower fuselage notch for wingless helicopter-mode flight.

3.5.2.3.1 WING TILT/INSTRUMENTATION. Variable wing incidence and wing-load instrumentation shall be provided and shall include fittings, hydraulic actuators, and load cells. The wing incidence shall be adjustable in flight within a range of +23 degrees to -19 degrees. Load-cell mounting shall provide for measuring wing lift, chordforce, rolling moment, and pitching moment.

3.5.2.3.2 WING TIPS. Detachable wing tips shall be provided to facilitate repair of the wings. Wing tips shall be capable of absorbing the shock of minor ground collisions by yielding under load and still meet flight strength requirements. Wing tips shall be replaceable without disassembly of wing structure.

3.5.2.4 AILERONS. Ailerons shall be provided for both small and large wings. They shall consist of panels with attached fittings, trimming tabs, control horns, and fastenings. Aileron movement on either side of the neutral position shall be such that satisfactory control will result for all normal operations and specified maneuvers of the aircraft. Additional movement of the ailerons shall be provided so that the limit of movement may be controlled by stops rather than by jamming the hinges or the control surfaces proper.

3.5.2.5 LIFT AND DRAG DEVICES. Plain flaps shall be provided for the small wing. Leading-edge slats and double-slotted flaps shall be provided for the large wing. Drag brakes, controllable within a range of zero to 60 degrees, shall be mounted on the forward end of the tailcone (see 3.7.1.5 herein).

3.6 ANTI-TORQUE SYSTEM AND TAIL GROUP

3.6.1 ANTI-TORQUE SYSTEM

3.6.1.1 DESCRIPTION AND COMPONENTS. The anti-torque system shall consist of a variable-pitch yaw fan incorporated in the vertical fin. The fan-in-fin shall include an integrated variable-pitch rotor; duct; single-stage, spiral-bevel-gear gearbox; and a blade pitch-change system. The fan support struts shall be attached to the airframe through a load-cell mounting system to permit accurate thrust measurements and to determine precisely the thrust-vector center location. A hydraulic actuator shall be connected directly to the blade-pitch yoke to provide the shortest possible load path between the servos and the fan rotor blades. Controllable three-position (OPEN, MID, CLOSED) fan shutters shall be provided. Anti-torque fan operation shall not be required during high-speed aircraft performance.

3.6.2 TAIL GROUP

3.6.2.1 DESCRIPTION AND COMPONENTS. The tail group shall consist of a controllable horizontal stabilator, vertical fin, rudder, and rudder trim tab.

3.6.2.2 STABILATOR. A controllable-pitch horizontal stabilator with trim tabs shall be provided. It shall be of 2-spar construction, fabricated with ribs, stringers, and aluminum-alloy sheet metal. The stabilator shall be movable as a unit.

3.6.2.3 ELEVATORS. Elevators shall not be required.

3.6.2.4 VERTICAL FIN. The vertical fin shall be of 2-spar construction with ribs, stringers, and aluminum-alloy skins.

3.6.2.5 RUDDER. A controllable-pitch rudder with trim tabs, shall be provided. Hinge brackets shall be provided on the fin rear spars. The rudders shall facilitate directional control in forward flight.

3.6.2.6 STABILATOR AND RUDDER STOPS. Stabilator and rudder stops shall be provided to limit control surface movement.

3.7 BODY GROUP

3.7.1 FUSELAGE

3.7.1.1 DESCRIPTION. The fuselage shall consist of a cockpit, center section, tail cone, and tail section; it shall include crew stations, cabin, and equipment compartments.

3.7.1.2 CONSTRUCTION. The fuselage primary structure shall be of aluminum-alloy semi-monocoque construction. Stainless steel or titanium shall be used for fire isolation where necessary.

3.7.1.3 CREW STATION SUBSYSTEMS

3.7.1.3.1 OXYGEN. Not applicable.

3.7.1.3.2 COCKPIT. The cockpit shall be arranged for side-by-side seating of pilot and copilot. Cockpit arrangement shall permit unrestricted movement of control levers through their specified ranges. Design of the cockpit canopy shall be compatible with the cockpit-canopy-jettisoning provisions of the emergency escape system (see 3.7.1.3.7.1 herein).

3.7.1.3.3 PERSONNEL FURNISHINGS, ACCOMMODATIONS, AND CONVENIENCES

3.7.1.3.3.1 SEATS. The pilot's seat shall be installed on the right side of the cockpit and the copilot's seat on the left side. Seats shall be comfortable and provide a rigid support. The back and sides shall be smooth and faired. The seat strength requirements shall be 20g fwd, 20g down, and 10g lateral. A shoulder-harness inertia-reel take-up mechanism shall be provided. The inertia reel and manual lock control shall be operable throughout the range of seat adjustment. Tie points for the lap belt shall be located to provide capability for adjustment and retention. Provisions shall be made for a third crewman's seat (see 3.2.1.2 herein). The design of the three seats shall be compatible with the aircrew-extraction provisions of the emergency escape system (see 3.7.1.3.7.1 herein).

3.7.1.3.3.2 CHECK-OFF LISTS. Take-off and landing check-off lists shall be provided.

3.7.1.3.3.3 FLOORING. A floor shall be provided in the cabin.

3.7.1.3.3.4 FIRE DETECTION SYSTEM. A fire-detection system shall be provided for the engines.

3.7.1.3.3.5 FIRE EXTINGUISHING SYSTEM. A high-rate-discharge type fixed fire-extinguishing system shall be provided for each engine compartment; it shall include charged containers of bromotrifluoromethane ($C F_3 B_r$), lines, nozzles and controls.

3.7.1.3.3.6 HAND FIRE EXTINGUISHER. Two portable fire extinguishers shall be provided: one in the cockpit accessible to the pilot and copilot, and one in the cabin accessible to the third crewman.

3.7.1.3.4 INSTRUMENT PANEL. A hard-mounted instrument panel shall be provided.

3.7.1.3.5 LIGHTING AND VISIBILITY

3.7.1.3.5.1 WINDSHIELD. A two-panel windshield shall be provided. It shall be of nonflammable transparent plastic material and shall be designed to withstand the airloads imposed by the flight requirements specified for the aircraft.

3.7.1.3.5.2 WINDOWS. Nonflammable transparent plastic material shall be used.

3.7.1.3.5.2.1 COCKPIT. Windows shall be provided: one above the pilot and one above the copilot in the cockpit canopy, and one each left and right side.

3.7.1.3.5.2.2 CABIN. Windows shall be provided, one in the cabin door on the right side and one on the left side opposite.

3.7.1.3.5.3 INSTRUMENT PANEL. Lighting shall be provided for the instrument panel.

3.7.1.3.6 SURVIVAL AND CRASH RESTRAINING PROVISIONS

3.7.1.3.6.1 FIRST AID KIT. A first aid kit shall be provided.

3.7.1.3.7 ESCAPE PROVISIONS. The left and right cockpit windows and the cabin door shall be jettisonable.

3.7.1.3.7.1 EMERGENCY ESCAPE SYSTEM. An aircrew emergency escape system shall be provided for pilot and copilot and complete provisions shall be made for the third crewman. The system shall operate independently of aircraft power and shall provide for severance of the five main rotor blades, jettisoning of the cockpit canopy, and aircrew extraction.

3.7.1.3.7.1.1 DESCRIPTION. The emergency escape system shall include: mechanical/percussion-type initiators, a rotary transfer unit at the main rotor shaft, a flexible linear-shaped charge for each blade, cockpit-canopy jettisoning provisions, and an extraction system for each crewman.

3.7.1.3.7.1.2 INITIATOR SYSTEM. The initiator shall be a pull-type device with two firing pin/primer elements. The initiator system shall be inert to any form of electrical strays, short circuits, electromagnetically-induced currents, or static electricity including lightning. The initiator handle shall be designed to prevent accidental actuation of the initiator.

3.7.1.3.7.1.2.1 CONTROL. Escape-system initiator control shall be provided for pilot and copilot. The single action of pulling the initiator handle shall activate the system and result in an automatic sequence of operation. Time delays shall be incorporated to control sequential intervals for blade severance, canopy jettisoning, and aircrew extraction.

3.7.1.3.8 DOORS AND HATCHES. A forward-hinged door shall be provided on the right side of the cabin aft of the cockpit. An opening shall be provided for access between cockpit and cabin.

3.7.1.4 EQUIPMENT COMPARTMENTS. Equipment compartments shall be provided in the nose section, under the cockpit floor, and in the center fuselage for communications, navigation, and test equipment. These equipment compartments shall include external access doors or covers for routine servicing, checkout, and maintenance. Space provisions shall be made in the cabin for additional research aircraft test equipment.

3.7.1.5 DRAG BRAKES. Two 7.5-square-foot drag brakes shall be provided, one on each side of the tailcone at the forward end. The drag brakes shall be designed to hinge forward and shall be controllable within a range of 0 to 60 degrees. The drag brakes shall be installed in such a manner that deployment shall not result in any abrupt or uncontrollable trim change.

3.7.1.6 BALLAST. Two ballast compartments, each capable of supporting 1000 pounds maximum ballast weight, shall be provided. One ballast compartment shall be located in the fuselage cockpit section and the other in the tailcone.

3.8 ALIGHTING GEAR

3.8.1 GENERAL DESCRIPTION AND COMPONENTS. A wheel-type alighting gear shall be provided and shall include retractable single-wheel main and tail landing gears, a retraction and extension system, and a wheel brake system.

3.8.2 MAIN LANDING GEAR

3.8.2.1 DESCRIPTION. The main landing gear shall include axle and oleo assemblies; wheels; tires; and a retracting, extending, and locking system, as described herein.

3.8.2.2 WHEELS, BRAKES, AND BRAKE CONTROL SYTEM

3.8.2.2.1 WHEELS AND BRAKES. Main wheels and brakes shall be in general accordance with MIL-W-5013, Method II, Analysis. Single wheels, 25X6.75 Type VII, and disc brakes shall be provided.

3.8.2.2.2 BRAKE CONTROL SYSTEM. The main wheel disc brakes shall be operated by a power boost Type IV hydraulic system in general accordance with MIL-B-8584. Hydraulic boost shall be provided by the No. 3 hydraulic system (see 3.13.2.2.2 herein). Master brake cylinders shall be provided. Taxi brakes, controlled by differential toe pedals, shall be provided for the pilot. The brake system shall incorporate a pilot-operated hydraulic parking brake. The brakes shall be designed for parking on a 10-degree slope, holding on a 20-degree slope, and decelerating the helicopter at eight ft/sec^2 from 120 knots forward speed.

3.8.2.3 CASINGS. Tubeless casings, 25X6.75 Type VII, shall be provided for the main wheels. The casings shall be in general accordance with MIL-T-5041.

3.8.2.4 SHOCK ABSORBERS. Shock-absorber air-oil struts, designed in general accordance with MIL-L-8552, shall be provided. The strut assemblies shall be replaceable as a complete unit. The air valve shall be accessible for inflating the strut.

3.8.2.5 RETRACTING, EXTENDING, AND LOCKING SYSTEMS. Power shall be provided by the No. 3 hydraulic system (see 3.13.2.2.2 herein). Positive-type devices shall be provided for retraction, extension, and locking of the main and tail landing gears. The main and tail landing gear wells shall be provided with mechanically-linked doors which are actuated by landing gear motion during retraction and extension. Retraction shall be hydraulic by means of cylinders with internal down-locks. Uplocks, engaged automatically by spring load, shall be disengaged hydraulically for extension. A landing gear position-indicating system shall be provided in the cockpit. Emergency extension pressure shall be provided by an electrically-actuated air or nitrogen cylinder. Main gear retraction shall be inward; tail gear retraction shall be forward.

3.8.3 AUXILIARY LANDING GEAR (TAIL WHEEL)

3.8.3.1 DESCRIPTION. The tail wheel assembly shall include an axle and oleo assembly; wheel; tire; and a retracting, extending, and locking system, as described herein. It shall be designed to permit swiveling of the tail wheel through 360 degrees. Provisions shall be made for locking the tail wheel in the trailing position by means of a lock controlled from the cockpit. Tow bar fittings shall be provided in the axle in general accordance with MIL-STD-805.

3.8.3.2 WHEEL. A single wheel, 18X4.4 Type VII, shall be provided and shall be in general accordance with MIL-W-5013.

3.8.3.3 CASING. A tubeless casing, 18X4.4 Type VII, shall be provided and shall be in general accordance with MIL-T-5041.

3.8.3.4 SHOCK ABSORBERS. See 3.8.2.4.

3.8.3.5 RETRACTING, EXTENDING, AND LOCKING SYSTEMS. See 3.8.2.5.

3.8.4 AUXILIARY LANDING GEAR (NOSE WHEEL). Not applicable.

3.9 ALIGHTING GEAR (WATER TYPE). Not applicable.

3.10 FLIGHT CONTROL SYSTEM. The flight control system shall be designed in general accordance with MIL-F-18372 and MIL-F-9490. The power control system shall be capable of continuous operation under positive and negative "g" conditions within the design envelope of the aircraft.

3.10.1 PRIMARY FLIGHT CONTROL SYSTEM. The primary flight control system shall control the main rotor, the tail fan, the stabilator, the ailerons, the flaps, and the rudder. The system shall provide fundamental control inputs and superimposed trim and automatic stabilization inputs. The system shall be capable of accepting computer inputs to the main rotor, the stabilator, the ailerons, and the flaps. The system shall include dual cockpit controls, auxiliary servos, control-integration units, mixing unit, main rotor primary servos, control-surface actuators, mechanical linkages, and control rods. The system shall also include a Force Augmentation System (FAS), a Stability Augmentation System (SAS), and a digital computer interface unit.

3.10.1.1 *COCKPIT FLIGHT CONTROLS. The arrangement,* location, and actuation of controls and related items of equipment shall be in general accordance with MIL-STD-250. Cyclic and collective sticks and rudder pedals shall be provided at both pilot stations. The collective stick shall be located to the left at each pilot's station. The copilot's controls shall be mechanically connected to the aircraft control system. The pilot's cyclic and collective controls shall not be mechanically interconnected with the copilot's controls. Electrical transducers shall be incorporated on the pilot's cyclic and collective controls. These transducers shall send control-position information to the copilot's FAS either directly or via the digital computer. The copilot's FAS shall position the copilot's cyclic and collective controls thus affecting aircraft control. The pilot's rudder pedals shall be mechanically interconnected with the copilot's rudder pedals. Positive stops shall be provided in the control system to prevent movement of controls beyond established limits.

3.10.1.2 AUXILIARY SERVOS. The copilot's controls shall be mechanically connected to the auxiliary servo. The auxiliary servo shall provide a full-time power boost to the controls. It shall react main rotor flight loads in the event of main rotor primary servo malfunction. The auxiliary servo shall provide capability for introducing electrically-commanded control motions into the control system. The control motions shall be limited in authority and in series with the copilot's control inputs so as not to be reflected at the copilot's controls. The electrical signals shall be sent from the SAS and/or the digital computer.

3.10.1.3 CONTROL INTEGRATION UNITS. The pitch, roll, and yaw outputs of the auxiliary servo shall be mechanically connected to control-integration units. These units shall apportion the copilot's control inputs between the helicopter controls and the fixed-wing controls. The helicopter/fixed-wing control ratio shall be varied by the pilot through integration-control levers and electric motors. Provision shall be made to allow the integration to be commanded by the digital computer or a secondary electrical source.

3.10.1.4 MIXING UNIT. The mixing unit shall be mechanically interconnected with the rotor-control outputs of the control integration units and the yaw output of the auxiliary servo. The mixing unit shall convert the mechanical control inputs from the pilot/copilot co-ordinate system to the swashplate co-ordinates. It shall further provide the control inputs to essentially decouple the controls for improved handling qualities.

3.10.1.5 MAIN ROTOR PRIMARY SERVOS. The three main rotor primary servos shall be single-stage hydraulic servos. They shall receive their inputs mechanically from the mixing unit.

3.10.1.6 CONTROL SURFACE ACTUATORS. Control-surface actuators shall be mechanically connected to the stabilator and ailerons. They shall receive their inputs mechanically from the fixed-wing control outputs of the control integration units. The flap actuators shall receive their inputs electrically from the pilot/copilot flap-control lever and the computer. Control-surface actuators shall consist of a boost servo; a limited-authority, electrical-input-series servo; and dual, electrical-input, full-authority trim servos. The trim servos shall receive electrical signals from the pilot/copilot trim controls and shall have provisions for receiving inputs from the digital computer. The series servo shall have provisions to receive electrical signals from the computer.

3.10.1.7 TAIL FAN SERVO. The tail-fan servo shall receive mechanical inputs from the directional control integration unit. It shall be capable of reacting tail-fan-control loads.

3.10.1.8 RUDDER SERVO. The rudder servo shall receive mechanical inputs from the directional control integration unit and shall be capable of reacting flight loads.

3.10.2 SECONDARY FLIGHT CONTROL SYSTEMS. The research aircraft shall have separate control for wing-tilt angle, drag-brake deployment, and auxiliary-engine thrust.

3.10.2.1 WING TILT SYSTEM. The angle of incidence of the wing shall be controllable by the pilot and copilot. The actuators shall be electro-hydraulic, receiving electrical signals from the pilot/copilot control lever.

3.10.2.2 DRAG BRAKES. Deployment of the drag brakes shall be controlled electrically by movement of the pilot/copilot control lever. The actuator shall be electro-hydraulic.

3.10.3 TRIM CONTROL SYSTEM. Trim-control systems shall be provided for the pilot and copilot's controls.

3.10.3.1 PILOT'S TRIM SYSTEM. The pilot's controls shall be trimmed by the FAS. Trim wheels located on the cyclic and collective sticks shall provide for trimming controls.

3.10.3.2 COPILOT'S TRIM SYSTEM. During normal operation, the copilot's controls shall be trimmed by the FAS. Trim wheels located on the cyclic and collective sticks shall provide for the trimming commands. With the FAS disengaged, trim-centering springs in the auxiliary servo shall be used for trimming.

3.10.4 AUTOMATIC FLIGHT CONTROL SYSTEM (AFCS). The AFCS for the research aircraft shall consist of a Force Augmentation System (FAS), a Stability Augmentation System (SAS), and a digital-computer interface unit.

3.10.4.1 FORCE AUGMENTATION SYSTEM (FAS). The FAS shall be configured to provide the following control/trim functions: electrical interconnect between the pilot and copilot controls, trim control for the pilot and copilot controls, maneuvering-control feel, and a computer-control input device.

3.10.4.1.1 ELECTRICAL CONTROL INTERCONNECT. In the normal flight mode, the FAS shall sense the motions of the pilot/copilot controls and exert a force on the controls so as to cause the pilot and copilot controls to move synchronously.

3.10.4.1.2 TRIM CONTROL. Thumb wheels shall be mounted on the pilot/copilot control sticks. A pitch and roll trim wheel shall be provided on each cyclic stick and a collective trim wheel shall be provided on the collective stick. Movement of any wheel shall cause a force proportional to the amount of wheel motion to be exerted on the associated control. Movement of the control in the direction of the force shall cause the force to be relieved by an amount proportional to the movement. This force/displacement relationship shall constitute a trim force gradient analagous to a conventional trim spring.

3.10.4.1.3 MANEUVERING CONTROL FEEL. The FAS shall provide forces on the pilot/copilot controls proportional to the maneuvering condition of the aircraft to give the pilot/copilot desirable control cues for high-speed flight. Force proportional to load factor shall be implemented on the longitudinal cyclic control. Stick damping shall be implemented on the lateral cyclic to provide control harmony during maneuvers. Force proportional to control load shall be implemented on the collective control to provide a cue as to maneuver severity. A collective stick shaker shall be provided to induce a vibratory input to the collective control to warn the pilot of excessive control loads.

3.10.4.1.4 COMPUTER INPUTS. Digital rotor-trim control and autopilot inputs to the flight controls shall be made through the FAS trim system. Electrical commands from the computer shall cause the control to displace an amount proportional to the command.

3.10.4.2 STABILITY AUGMENTATION SYSTEM (SAS). A SAS shall be provided to improve the handling qualities of the research aircraft. The SAS shall use rate gyros as sensors in pitch, roll, and yaw. The rate signals shall be shaped appropriately and sent to the limited-authority-series input of the pitch, roll, and yaw auxiliary servos. The authority limits shall be set to prevent excessive transients in the event of a SAS malfunction.

3.10.4.3 COMPUTER INTERFACE UNIT. Command signals from the digital computer shall be conditioned in the computer interface unit prior to being sent to the various actuators. This unit shall also provide the differential summing between pilot/copilot commands and computer commands.

3.11 ENGINE SECTION OR NACELLE GROUP

3.11.1 DESCRIPTION. The engine section shall be as described herein.

3.11.2 ENGINE MOUNTS. The rotor propulsion turboshaft engines shall be mounted on support structure by a three-point suspension consisting of an aft gimbal and two front supports. The auxiliary propulsion engines shall be mounted in Fairchild A-10A TF34-GE-100 nacelles and shall be attached by fittings to aircraft structure. The nacelles shall be furnished by the government. Load-cell mounting shall be provided to measure auxiliary-propulsion thrust.

3.11.3 FIREWALLS. The deck beneath the rotor propulsion engines shall be covered with titanium skin. A titanium firewall shall be provided between the engines. Canted titanium firewalls shall be provided aft to isolate the engines from the main transmission. Stainless steel shall also be used, as required, in the formation of the firewall installations. Firewalls for the auxiliary propulsion engines shall be as incorporated in the Fairchild A-10A TF34-GE-100 nacelles.

3.11.4 INSPECTION AND MAINTENANCE. Access shall be provided for normal inspection and maintenance without requiring disassembly of major structural components or removal of engines.

3.12 PROPULSION SUBSYSTEM

3.12.1 GENERAL DESCRIPTION AND COMPONENTS. The propulsion subsystem shall include the T58-GE-16 rotor propulsion engines, TF34-GE-100 auxiliary propulsion engines, engine-driven accessories, air induction systems, exhaust systems, cooling systems, lubrication systems, fuel systems, propulsion system controls, starting systems, and transmission system.

3.12.2 ROTOR PROPULSION ENGINES. The rotor propulsion engines shall be furnished by the government and installed by the contractor. They shall be two T58-GE-16 turboshaft engines. Each engine shall consist of a gas-generator rotor comprising a ten-stage axial compressor driven by a two-stage turbine, an annular combustion chamber, a two-stage free power turbine, and a single-port exhaust duct. Sufficient power shall be provided by each engine to allow recovery to level forward flight from a single-engine malfunction in any level flight condition above 40 KTAS without losing in excess of 40 feet of altitude. Engine controls shall be modified to permit low-power operation at reduced RPM's as low as 40 percent.

3.12.3 AUXILIARY PROPULSION ENGINES. The auxiliary propulsion engines shall be furnished by the government and installed by the contractor. They shall be two TF34-GE-100 turbofan engines. Each engine shall consist of a single-stage fan, a fourteen-stage axial compressor, a two-stage compressor turbine, a four-stage fan turbine, and a fan nozzle. The auxiliary propulsion shall be sufficient to overcome the drag of the main rotor in autorotation (main rotor shaft power requirements of zero) for the compound helicopter configuration in the speed range from 200 KEAS to 300 KEAS. The auxiliary propulsion engines and nacelles shall be removable for hovering flight tests. Fuselage fairings shall be provided for installation when auxiliary propulsion engines and nacelles are removed. Quick-disconnects shall be incorporated to the extent practicable.

3.12.4 ENGINE-DRIVEN ACCESSORIES. The following accessories shall be driven by the rotor-propulsion engines: compressor-turbine tachometer generators and power-turbine tachometer generators.

3.12.5 AIR INDUCTION SYSTEM. The T58-GE-16 engines air-induction system shall consist of a forward-facing inlet. The air inlet shall be designed to prevent erratic or adverse air-flow distribution which would cause the engine compressor to stall or otherwise malfunction. The TF34-GE-100 engines air induction system shall be that incorporated in the Fairchild A-10A nacelle.

3.12.6 EXHAUST SYSTEM. The T58-GE-16 engines exhaust system shall be designed to meet engine-performance requirements, to prevent damage to airframe from high temperature exhaust gas, and to function as a low-energy ejector which will draw cooling air from an opening under the engine inlet through the hot section and out the exhaust. The engine-exhaust ducts shall be corrosion-resistant steel and shall be mounted to the engine rather than to the airframe. The TF34-GE-100 engines exhaust system shall be that incorporated in the Fairchild A-10A nacelle.

3.12.7 COOLING SYSTEM. Engine oil cooling is furnished integrally with the T58-GE-16 and TF34-GE-100 engines.

3.12.7.1 TEMPERATURE MEASURING SYSTEM. An interturbine temperature-measuring system (T_5) shall be provided for each T58-GE-16 and TF34-GE-100 engine.

3.12.8 LUBRICATION SYSTEM. An integral lubrication system shall be furnished with each T58-GE-16 and TF34-GE-100 engine. An oil tank and sight gage shall be provided for the T58-GE-16 engines. Venting shall be provided for the oil tanks. Oil pressure and temperature gages shall be provided for each engine.

3.12.8.1 DRAINAGE PROVISIONS. Drains shall be provided at the low point in the system to permit drainage of trapped oil when the aircraft is in normal attitude on the ground. Separate drainage shall be provided for each engine oil tank. Drains shall discharge clear of the aircraft structure and shall be clearly identified.

3.12.8.2 MAGNETIC CHIP DETECTION. A magnetic chip-detection system shall be provided for each TF34-GE-100 engine. The system shall include word-warning light display on the cockpit caution/advisory panel.

3.12.9 FUEL SYSTEM. Two separate fuel tanks and engine-feed systems shall be provided. One system shall provide fuel to the No. 1 rotor propulsion engine and the No. 1 auxiliary propulsion engine and the other system shall provide fuel to the No. 2 rotor propulsion engine and the No. 2 auxiliary propulsion engine. Pressurized feed for each system and a cross-feed system shall be provided. Fuel filters and pumps are furnished with each engine. Two tank-mounted boost pumps shall be provided for each engine-feed system. An electrically-actuated fuel shut-off valve shall be provided in the cross-feed system and at the firewall for each engine. The fuel system shall be designed for use of type JP-4 and JP-5 fuels.

3.12.9.1 FUEL TANKS (FIXED). Non-self-sealing bladder-type cells shall be provided in general accordance with MIL-T-6396. The fuel tanks shall be located in the fuselage center section below the main transmission. The forward tank shall connect with the No. 1 rotor propulsion engine and the No. 1 auxiliary propulsion engine and the aft tank shall connect with the No. 2 rotor propulsion engine and the No. 2 auxiliary propulsion engine. Total usable fuel capacity shall be 769 gallons ±2%. A minimum of three percent expansion space shall be provided in the fuel tanks.

3.12.9.2 VENT SYSTEM. An open-type vent system shall be provided.

3.12.9.3 PIPING AND FITTINGS. Corrosion-and heat-resistant tubing shall be used where possible. Flexible hose assemblies shall be used in the engine compartments.

3.12.9.4 VALVES. Drain valves shall be provided in the sump.

3.12.9.5 FUEL QUANTITY GAGING SYSTEM. A two-unit capacitance-type fuel-quantity-gaging system in general accordance with MIL-G-26988 shall be provided, one for each fuel tank. Continuous fuel-quantity display shall be provided on the pilot's instrument panel.

3.12.9.6 REFUELING AND DEFUELING. A pressure refueling and suction defueling system shall be provided.

3.12.10 WATER INJECTION SYSTEM. Not applicable.

3.12.11 PROPULSION SYSTEM CONTROLS

3.12.11.1 ENGINE CONTROL SYSTEMS

3.12.11.1.1 ROTOR PROPULSION ENGINES. The control system for the T58-GE-16 turboshaft engines shall include quadrant-mounted speed-control levers for each engine and a power-turbine-speed-selector electrical switch on each pilot's collective stick. A load-bias control shall be incorporated to anticipate load changes and reduce power-turbine-speed droop.

3.12.11.1.2 AUXILIARY PROPULSION ENGINES. Dual twist grips shall be provided on pilot and copilot collective sticks for throttle control of the TF34-GE-100 turbofan auxiliary propulsion engines.

3.12.12 STARTING SYSTEM

3.12.12.1 ROTOR PROPULSION ENGINES. The engine-starting system shall supply DC power to each engine-mounted starter for cranking each engine during engine start. Each DC starter shall provide sufficient torque to accelerate each engine past the minimum self-sustaining speed to avoid hot or hung starts. An automatic cut-out feature shall be provided.

3.12.12.2 AUXILIARY PROPULSION ENGINES. Pneumatic ground-support equipment shall be used to supply pneumatic power to each TF34-GE-100 auxiliary propulsion engine pneumatic starter for cranking each engine during engine start.

3.12.13 PROPELLER. Not applicable.

3.12.14 ROCKET PROPULSION SYSTEM. Not applicable.

3.12.15 TRANSMISSION SYSTEM

3.12.15.1 MAIN ROTOR TRANSMISSION SYSTEM. The main rotor transmission system shall be designed in accordance with the applicable provisions of MIL-T-5955. The main gearbox shall consist of three reduction stages: an input bevel-gear reduction mesh, a combining spur-gear reduction mesh, and a roller-gear reduction unit. Disc-type couplings shall be installed between the main gearbox input drive shafts and the engine power turbine flanges, between the main gearbox tail take-off flange and the tail drive shaft, and between the tail drive shaft and fan-in-fin-gearbox input flange. The overall gearbox reduction ratio from the turboshaft engines to the main rotor shaft shall be 93.4:1. Load-cell mounting shall be provided for the main gearbox to measure rotor thrust, drag, sideforce, rolling moment, and pitching moment. Seven load cells, mounted on self-aligning bearings, shall be attached to base plates under the main gearbox. Four load cells shall react vertical loads and moments, two load cells shall react side loads and rotor torque, and one load cell shall react fore and aft loads. Provisions shall be made for on-the-ground positioning of the main rotor shaft at 0 degrees, +2 degrees, and +4 degrees. Spacer fittings provided at the engine supports and load-cell mounting provided for the main gearbox shall accommodate positioning of the main rotor shaft.

3.12.15.1.1 ENGINE TORQUE MONITORING SYSTEM. An engine torque monitoring system shall be provided. It shall include an electric-impulse system incorporated in the input drive shafts of the main gearbox to measure the output torque of each turboshaft engine.

3.12.15.1.2 ROTOR TACHOMETER DRIVE PAD. A rotor tachometer generator drive pad shall be provided on the main gearbox accessory drive. (See 3.5.1.9 herein.)

3.12.15.1.3 FREE WHEELING UNITS. Overrunning, cam-roller type free wheeling units shall be provided in each main gearbox input section.

3.12.15.1.4 MAGNETIC CHIP DETECTION. A magnetic chip detection system shall be provided and shall include word-warning light display on the caution/advisory panel in the cockpit.

3.12.15.2 ANTI-TORQUE TRANSMISSION SYSTEM. The tail drive shaft shall be connected to the gearbox furnished with the fan-in-fin (see 3.6.1.1 herein).

3.12.15.3 TRANSMISSION SYSTEM COOLING AND LUBRICATING SYSTEMS. A cooling system shall be provided for the main gearbox lubricant. Provisions shall be made for gaging oil-out temperatures. A lubricating system shall be provided for the main gearbox; it shall be separate from that of the engines. It shall incorporate two oil pumps, one driven by the main rotor shaft and the other by the tail take-off accessory drive. The lubrication lines shall be external and shall merge to a single line from the filter to the gearbox. Each oil pump shall be capable of providing complete lubrication for the gearbox. Provisions shall be made for measuring main gearbox oil pressure. An oil-pressure indicator and a low-oil-pressure word-warning light shall be provided in the cockpit. A filter with pressure by-pass valve shall be provided between the gearbox and the oil cooler.

3.12.15.4 ROTOR BRAKE. A hydraulically-powered rotor brake shall be provided. It shall be capable of stopping the main rotor from 203 RPM in 20 seconds, with both engines in ground idle throttle position, that interval consisting of a natural rotor RPM decay of 5 seconds, and a 15-second brake application, thereby bringing the rotor to a complete stop. Rotor brake ON and low-pressure word-warning lights shall be provided on the caution/advisory panel.

3.12.15.5 ROTOR ENGAGEMENT. The free wheeling units shall permit rotor and fan-in-fin disengagement from the engines in autorotation and permit re-engagement in flight.

3.12.15.6 AUTOROTATION. The aircraft shall be capable of autorotation during aircraft high-speed operation and also in event of multiple-engine malfunction.

3.13 SECONDARY POWER AND DISTRIBUTION SUBSYSTEM

3.13.1 ELECTRICAL POWER GENERATION AND DISTRIBUTION SUBSYSTEM

3.13.1.1 DESCRIPTION. The electrical system shall include components required for generation, storage, conversion, distribution and control of electric power, and lighting.

3.13.1.2 PRIME POWER. The prime source of electrical power shall be DC and shall supply power to utilization and conversion equipment. The system shall be designed to meet the applicable requirements of MIL-STD-704.

3.13.1.3 BUS SYSTEM

3.13.1.3.1 DC BUS SYSTEM. DC electric power shall be supplied to utilization and conversion equipment by an essential bus and two DC primary busses.

3.13.1.3.1.1. ESSENTIAL BUS. Electrical equipment essential for flight shall be connected to the DC essential bus. The bus shall be powered by the DC primary bus, by a DC external power source, or by the battery.

3.13.1.3.1.2 DC PRIMARY BUSSES. The DC primary busses shall supply power to general load equipment.

3.13.1.3.1.3 POWER SOURCE. Two 300-ampere DC generators, in general accordance with MIL-G-6162, shall be provided and shall be the prime source of electrical power.

3.13.1.3.2 AC BUS SYSTEM. AC electrical power shall be supplied to utilization equipment by an AC primary bus and an AC monitor bus.

3.13.1.3.2.1 AC PRIMARY BUS. AC load equipment essential to flight shall be connected to the AC primary bus.

3.13.1.3.2.2 AC MONITOR BUS. Non-essential AC load equipment shall be connected to the AC monitor bus.

3.13.1.3.2.3 AC POWER SOURCE. Two 750-VA, 400-Hz, 115-volt, three-phase static inverters shall be provided to supply power to AC loads on the primary and monitor busses.

3.13.1.4 RESEARCH INSTRUMENTATION POWER. A 5-KVA, 115-volt, 400-Hz, three-phase AC generator, driven by a constant-speed hydraulic motor, shall be provided to power the research instrumentation and digital computer.

3.13.1.5 POWER SYSTEM WARNING. Caution lights shall be provided for the pilot to indicate loss of any one power source.

3.13.1.6 BATTERY. A 22-ampere-hour nickel-cadmium battery and a battery charger shall be provided.

3.13.1.7 EXTERNAL POWER RECEPTACLES. One MS90362 AC receptacle and one AN2552-3A DC receptacle shall be provided for external power connection to the aircraft.

3.13.1.8 EQUIPMENT INSTALLATION. Installation of electrical equipment shall be in general accordance with MIL-E-7080.

3.13.1.9 WIRING. Electrical wiring shall be in general accordance with MIL-W-5088.

3.13.1.10 LIGHTING

3.13.1.10.1 EXTERIOR LIGHTING. Exterior lighting shall be in general accordance with MIL-L-6503. The following shall be provided:

a. <u>Position Lights</u>:
   One - Port
   One - Starboard
   One - Tail

b. Two - Anti-collision lights

c. One - Controllable landing light (450 watts)

3.13.1.10.2 INTERIOR LIGHTING. Interior lighting shall be in general accordance with MIL-L-18276. The following shall be provided:

a. Instruments and consoles primary lighting (with dimming controls)

b. Cockpit red and white floodlighting

c. Emergency lighting

d. Cabin red and white dome lights

3.13.1.11 IGNITION AND STARTING CONTROL SYSTEM

3.13.1.11.1 ROTOR PROPULSION ENGINES. Starter controls for the T58-GE-16 engines shall be provided on a centrally-located power quadrant. Start control shall be accomplished by energizing the starter switch and moving the engine-speed-control lever to the IDLE position.

3.13.1.11.2 AUXILIARY PROPULSION ENGINES. Starter controls for the TF34-GE-100 turbofan engines shall be provided by the collective-stick twist grips, one for each engine. Start control shall be accomplished by energizing the starter switch and rotating the twist-grip throttle control to the IDLE position.

3.13.2 HYDRAULIC POWER GENERATION AND DISTRIBUTION SUBSYSTEM

3.13.2.1 DESCRIPTION. Five independent hydraulic power systems shall be provided: No. 1, No. 2, No. 3, No. 4, and rotor brake. The five systems shall be designed to operate with MIL-H-5606 fluid and shall be in general accordance with MIL-H-5440. The No. 1 and No. 2 systems shall operate at 1500 psi, the No. 3 and No. 4 systems shall operate at 3000 psi, and the rotor brake system shall operate at 750 psi. Test connections shall be provided independently on the No. 1, No. 2, No. 3, and No. 4 systems to permit ground checking from an external power source. Word-warning lights shall be provided on the caution/advisory panel to warn of a low-pressure condition in each of the five hydraulic systems. Separate pressure gauges shall be provided for the No. 1, No. 2, No. 3, and No. 4 hydraulic systems to indicate system pressure.

3.13.2.2 HYDRAULIC SYSTEMS

3.13.2.2.1 NO. 1 AND NO. 2 HYDRAULIC SYSTEMS. The No. 1 and No. 2 hydraulic systems shall supply power to the flight-control servos only. The No. 1 system shall supply power to the primary rotor-head-control servos only. The No. 2 system shall supply power to the auxiliary servo, the FAS servos, and the first stage of the tail-fan servo. A malfunction in any one hydraulic control system shall not cause loss of control power. Electrical interlock circuitry shall be provided to prevent pressure shut-off to one system if the other control system is depressurized, and shall also automatically reactivate a de-activated system if the pressure becomes low in the opposite system.

3.13.2.2.2 NO. 3 AND No. 4 HYDRAULIC SYSTEMS. The No. 3 and No. 4 hydraulic systems shall supply power to the wing-tilt, flap, and aileron control actuators; the stabilator control actuators; the rudder control actuators; the second stage of the tail-fan actuators; and the aircraft utility functions. The No. 3 system shall supply power to the first stage of the flap actuators, the first stage of the aileron actuators, the first stage of the rudder actuators, the first stage of the horizontal stabilator actuators, and to the following utility functions: the drag-brake actuator, the wing-tilt actuators, the fan-shutter actuator, the landing gear retraction and extension actuators, the wheel brakes, and the research instrumentation 5-KVA-generator constant-speed drive motor. The No. 4 hydraulic system shall supply power to the second stage of the flap actuators, the second stage of the aileron actuators, the second stage of the rudder actuators, the second stage of the horizontal stabilator actuators, and the second stage of the tail-fan actuators. Malfunction of any one of the two fixed-wing mode hydraulic supply systems shall not cause loss of flight control power. Electrical interlock circuitry shall be provided to prevent pressure shut-off to one system if the other system is depressurized, and shall also automatically activate a de-activated system if the pressure becomes low in the opposite system. A priority valve shall be provided in the No. 3 system to limit the flow to the aircraft utility function to provide for flight control system demands. Velocity fuses shall be provided in the No. 3 system to isolate the flight control portion from the utility portion to prevent system loss due to any utility component malfunction.

3.13.2.3 ROTOR BRAKE HYDRAULIC SYSTEM. The rotor brake hydraulic system shall be completely independent of any other hydraulic system. The system shall consist of an electric-motor-driven pump, a reservoir-accumulator, a relief valve, a shut-off valve, and a brake unit.

3.13.2.4 HYDRAULIC PUMPS. Hydraulic pumps shall be mounted on the main transmission accessory pad and shall be driven by the main rotor independently of engine operation. The pumps for the No. 1, No. 2, No. 3, and No. 4 hydraulic systems shall be the variable-displacement type and in accordance with MIL-P-19692. The rotor brake hydraulic system pump shall be driven by an electric motor.

3.13.2.5 RESERVOIRS. Separate reservoirs shall be provided for the No. 1, No. 2, No. 3, No. 4, and the rotor brake hydraulic systems. The rotor-brake-hydraulic-system reservoir shall be integral with the rotor-brake manifold. The No. 1, No. 2, No. 3, and No. 4 reservoirs shall be of the vented type. A fluid level visual indicator shall be provided on each reservoir. A remote cockpit fluid level indicator shall be provided in accordance with MIL-H-5440.

3.13.2.6 SUMMARY OF ACTUATED ITEMS. The following equipment shall be actuated hydraulically:

Primary and auxiliary flight control servos
FAS servos
Main landing gear retraction and extension actuators
Flap actuators
Aileron actuators
Rudder actuators
Horizontal stabilator actuators
Fan-pitch-control actuators
Drag-brake actuator
Fan-shutter actuator
Wing-tilt actuators
Wheel brakes
Constant-speed hydraulic motor for
 research instrumentation 5-KVA generator

3.13.3 PNEUMATIC POWER GENERATION AND DISTRIBUTION SUBSYSTEM. See 3.12.12.2 herein for auxiliary propulsion engines starting. See 3.8.2.5 herein for alighting gear emergency extension.

3.14 UTILITIES AND EQUIPMENT SUBSYSTEM. See 3.7.1.3.3 herein.

3.15 MISSION AND AIR TRAFFIC CONTROL SUBSYSTEMS. Mission and air traffic control subsystems shall consist of communications, navigation, and identification equipment as described herein.

3.15.1 COMMUNICATIONS. The following communications equipment shall be furnished by the government and installed by the contractor.

One - AN/ARC-115	VHF/AM Radio Set
One - AN/ARC-116	UHF/AM Radio Set
Three-C-6533/AIC	Intercommunication Set (Pilot, Copilot and Provisions for Instrumentation Engineer)

3.15.2 NAVIGATION. The following navigation equipment shall be furnished by the government and installed by the contractor:

One - AN/ASN-43	Gyro Compass
One - AN/ARN-82A	VOR/LOC Navigation
One - R-844/ARN-58	Glide Slope/Marker Beacon
One - AN/ARN-52	TACAN

3.15.3 IDENTIFICATION. The following identification equipment shall be furnished by the government and installed by the contractor.

One - AN/APX-72	IFF Transponder

3.16 RECONNAISSANCE SUBSYSTEMS. Not applicable.

3.17 FIRE-POWER CONTROL SUBSYSTEMS. Not applicable.

3.18 ARMAMENT SUBSYSTEMS. Not applicable.

3.19 DEFENSIVE SUBSYSTEMS. Not applicable.

3.20 GROUND HANDLING AND SERVICING PROVISIONS

3.20.1 TOWING PROVISION. Provision shall be made for towing the aircraft (see 3.8.3.1 herein).

3.20.2 JACKING PROVISION. Provision for jacking the aircraft shall be made in general accordance with MIL-STD-809.

3.20.3 HOISTING PROVISION. Provision shall be made for hoisting the aircraft.

3.20.4 AIR DUCT PLUGS AND COVERS. Air duct plugs or covers shall be provided for engine inlets and exhausts. A cover shall be provided for the pitot tube.

3.20.5 TEST MOUNTING PROVISION. Provision shall be made for mounting the entire airframe within the NASA-Ames full-scale tunnel.

3.21 FLIGHT AND PROPULSION INSTRUMENT SUBSYSTEMS. Flight and propulsion instrument subsystems shall be as described in the following paragraphs.

3.21.1 FLIGHT INSTRUMENTS. The following flight instruments shall be furnished by the government or provided by the contractor, as noted:

- Two - Attitude Gyro Indicator with Integral Turn and Slip (CFE)
- Two - Bearing Distance Heading Indicator, ID-663/ARN (GFAE)
- Two - Indicated Airspeed, Pitot Static, MIL-I-5417, MS28046 (GFAE)
- One - Barometric Altimeter, AAU-24/A (GFAE)
- One - Barometric Altimeter (with Altitude Encoder), AAU-21/A (GFAE)
- Two - Vertical Velocity Indicator, MIL-I-58067, MS25454-4 (GFAE)
- Two - Dual Torquemeter (CFE)
- Two - Triple Tachometer Indicator No. 1 and No. 2 Engine N_f and Rotor RPM (CFE)
- One - Compass, Magnetic, MS17983 (GFAE)
- One - Outside Air Temperature Indicator, MS28028 (GFAE)
- Two - Clock, Elapsed Time, ABU-9/A, MIL-C-27298 (GFAE)
- One - Course Deviation Indicator, ID-387/ARN (GFAE)
- One - Blade Tip Mach Indicator (CFE)

3.21.2 PROPULSION INSTRUMENTS. The following propulsion instruments shall be provided by the contractor:

One - Dual Vertical Scale N_g Tachometer with Integral Digital Readout (Main Engines)
One - Dual Vertical Scale Power Turbine Inlet T_5 Temperature Indicator with Integral Digital Readout (Main Engines)
One - Dual Vertical Scale Fuel Flow Indicator
One - Dual Vertical Scale Engine Oil Pressure Indicator (Main Engines)
One - Dual Vertical Scale Engine Oil Temperature Indicator (Main Engines)
One - Dual Vertical Scale Fuel Quantity Indicator
One - Dual Vertical Scale Oil Pressure Indicator (Transmission and Tail Fan Gearbox)
One - Dual Vertical Scale Oil Temperature Indicator (Transmission and Tail Fan Gearbox)
One - Quadruple Vertical Scale Hydraulic Pressure Indicator
One - Dual Vertical Scale N_g Tachometer with Integral Digital Readout (Auxiliary Engines)
One - Dual Vertical Scale N_f Tachometer with Integral Digital Readout (Auxiliary Engines)
One - Dual Vertical Scale T_5 Temperature Indicator with Integral Digital Readout (Auxiliary Engines)
One - Dual Vertical Scale Engine Oil Pressure Indicator (Auxiliary Engines)
One - Dual Vertical Scale Engine Oil Temperature Indicator (Auxiliary Engines)
One - Hydraulic Quantity Indicator

3.21.3 TEST INSTRUMENTS. The following test instruments shall be provided by the contractor:

One - Lateral Cyclic Position Indicator
One - Longitudinal Cyclic Position Indicator
One - Pedal Position Indicator
One - Rudder Deflection Indicator
One - Stabilator Incidence Angle Indicator
One - Side Slip Angle Indicator
One - Collective Position Indicator
One - Accelerometer (G Meter)
One - Wing Tilt Position Indicator
One - Wing Flap Position Indicator
One - Drag Brake Position Indicator
One - Tail Fan Shutter Position Indicator
One - Tail Fan/Rudder Mixing Indicator
One - Stabilator/Rotor Cyclic Mixing Indicator
One - Aileron/Rotor Cyclic Mixing Indicator

Space provisions shall be made, at one pilot station, to allow for the central installation of research instrumentation with panel dimensions of eight inches by eight inches, and installed depth of two feet, and weighing 50 pounds. The weight of this installation shall be included in instrumentation payload and not in Weight Empty.

Provisions shall be made at the third crewman's station in the cabin for the following (see 3.2.1.2 herein):

One - Instrumentation Control Panel

3.21.4 CAUTION INDICATION. A word-warning type caution/advisory panel shall be provided.

3.21.5 MOUNTING. Instruments shall be removable from the front of the panel.

3.21.6 MARKING. Operating limits shall be indicated on the instruments, as applicable.

3.21.7 PITOT SYSTEM. A pitot-static system shall be provided.

3.21.8 CONSOLES. A center console and an overhead panel shall be provided between pilot and copilot in the cockpit. Console and panel installation shall be compatible with the emergency-escape-system aircrew-extraction requirement (see 3.7.1.3.7.1 herein).

3.22 AIR RESCUE SUBSYSTEMS. Not applicable.

3.23 RANGE EXTENSION SUBSYSTEMS. Not applicable.

3.24 AIR WEATHER SUBSYSTEMS

3.24.1 AIR CONDITIONING AND HEATING. An air conditioning system shall be provided at the crew stations. The system shall have approximately the following capability: 65 degrees F cockpit heating temperature at 0 degrees F outside air temperature to 15,000 feet altitude, and 85 degrees F cockpit cooling temperature at 110 degrees F outside air temperature at sea level. Ventilating provisions shall be made for use in event of air-conditioning-system malfunction.

3.25 PREFLIGHT READINESS CHECKOUT PROVISIONS. Not applicable.

4. QUALITY ASSURANCE PROVISIONS

4.1 SAMPLING, INSPECTION, AND TEST PROCEDURES. Sampling, inspection, and test procedures shall be as specified in the contract.

5. PREPARATION FOR DELIVERY

5.1 Preparation for delivery shall be as specified by the government.

6. NOTES

6.1 INTENDED USE. This document is submitted as a part of the predesign study under contract NAS1-11228 and is intended to define the preliminary configuration and capabilities of a single rotor compound, rotor system research aircraft.

6.2 DEFINITIONS. Where the phrases "Complete provisions for", "Structural provisions for", "Space provisions for", "Power provisions for", and "Weight provisions for" are used, the intent is as defined.

6.2.1 COMPLETE PROVISIONS FOR OR PROVISIONS FOR. "Complete provisions for" or "Provisions for" a specific item of equipment, or assembly or installation shall mean that lines, etc. have been installed and space allocated so that the equipment can be installed without alteration to the specified equipment or the helicopter, and that no additional parts are required for installation, other than the item itself. The weight of the equipment or assembly or installation shall be included in Weight Empty unless specifically stated otherwise.

6.2.2 STRUCTURAL PROVISIONS FOR. "Structural provisions for" a specific installation shall mean that the primary structure will accept the installation, but that brackets, bolt holes, electrical wiring, hydraulic lines, etc. will not be installed. The weight of the specific installation shall not be included in Weight Empty unless specifically stated otherwise.

6.2.3 SPACE PROVISIONS FOR. "Space provisions for" a specific installation shall mean that space shall be allocated for the installation, but that brackets, bolt holes, electrical wiring, hydraulic lines, etc. will not be installed. "Space provisions for" does not imply that attaching structure is provided, unless otherwise stated. The weight of the specific installation shall not be included in Weight Empty unless specifically stated otherwise.

6.2.4 POWER PROVISIONS FOR. "Power provisions for" a specific installation shall mean the primary electric, hydraulic or pneumatic components shall have capability to permit later incorporation without primary power component modification. The weight of the specific installation shall not be included in Weight Empty unless specifically stated otherwise.

6.2.5 WEIGHT PROVISIONS FOR. "Weight provisions for" means that suitable weight allowance to simulate later incorporation of the item or complete installation shall be included in the applicable design gross weights for the aircraft, and in all applicable structural design conditions. The item of equipment, assembly or installation shall be included in Weight Empty unless otherwise indicated or stated in the detail specification.

6.2.6 DESIGN OBJECTIVE OR GOAL. "Design objective" or "design goal" shall mean the description of a program objective but shall not be construed as a representation of absolute achievement.

APPENDIX 1-A

GOVERNMENT-FURNISHED AIRCRAFT EQUIPMENT, CONTRACTOR INSTALLED

POWER PLANT (Weight Empty)

AERNO	QTY	DESCRIPTION	IDENTIFICATION	ESTIMATED UNIT WT(LB)
----	2	Turboshaft Engine	General Electric Company T58-GE-16	445(wet)
----	2	Turbofan Engine	General Electric Company TF34-GE-100	1445(wet)
----	2	Nacelle (L.H. and R.H., one each)	Fairchild A-10A TF34-GE-100	467

INSTRUMENTS (Weight Empty)

AERNO	QTY	DESCRIPTION	IDENTIFICATION	ESTIMATED UNIT WT(LB)
----	2	Bearing Distance Heading Indicator	ID-663/ARN	3.5
----	2	Indicated Air-speed, Pitot Static	MIL-I-5417 MS28046	1.0
----	1	Barometric Altimeter	AAU-24/A	2.5
----	1	Barometric Altimeter (with Altitude Encoder)	AAU-21/A	3.75
----	2	Vertical Velocity Indicator	MIL-I-58067 MS25454-4	1.75
----	1	Compass, Magnetic	MS17983	0.87
----	1	Outside Air Temperature Indicator	MS28028	0.28
----	2	Clock, Elapsed Time	ABU-9/A MIL-C-27298	0.56
----	1	Course Deviation Indicator	ID-387/ARN	3.8

APPENDIX 1-A

GOVERNMENT-FURNISHED AIRCRAFT EQUIPMENT,
CONTRACTOR INSTALLED

AVIONICS (Weight Empty)

AERNO	QTY	DESCRIPTION	IDENTIFICATION	ESTIMATED UNIT WT (LB)
----	1	VHF/AM Radio Set	AN/ARC-115	7.2
----	1	UHF/AM Radio Set	AN/ARC-116	7.5
----	3	Intercommunication Set	C-6533/AIC	1.8
----	1	Gyro Compass	AN/ASN-43	9.9
----	1	VOR/LOC Navigation	AN/ARN-82A	12.1
----	1	Glide Slope/ Marker Beacon	R-844/ARN-58	9.0
----	1	TACAN	AN/ARN-52	52.0
----	1	IFF Transponder	AN/APX-72	23.3
----	1	Flight Control Computer	(Not in Weight Empty; Included in Payload)	----

MISCELLANEOUS (Weight Empty)

AERNO	QTY	DESCRIPTION	IDENTIFICATION	ESTIMATED UNIT WT (LB)
----	1	First Aid Kit	FSN6545-919-6650	1.8
----	2	Portable Fire Extinguisher	MIL-E-52031 FSN4210-555-8837	6.4

APPENDIX 1-B

GOVERNMENT FURNISHED AIRCRAFT EQUIPMENT, GOVERNMENT INSTALLED

NONE