UNCLASSIFIED

AD NUMBER
AD147927
CLASSIFICATION CHANGES
TO: **UNCLASSIFIED**
FROM: **CONFIDENTIAL**
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; JUL 1956. Other requests shall be referred to Office of Naval Research, 875 North Randolph Street, Arlington, VA 22203-1995.**
AUTHORITY
31 Jul 1968, DoDD 5200.10; ONR ltr, 28 Jul 1977

THIS PAGE IS UNCLASSIFIED

THIS REPORT HAS BEEN DELIMITED
AND CLEARED FOR PUBLIC RELEASE
UNDER DOD DIRECTIVE 5200.20 AND
NO RESTRICTIONS ARE IMPOSED UPON
ITS USE AND DISCLOSURE.

DISTRIBUTION STATEMENT A

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED.

UNCLASSIFIED

AD 147927

DEFENSE DOCUMENTATION CENTER

FOR

SCIENTIFIC AND TECHNICAL INFORMATION

CAMERON STATION ALEXANDRIA VIRGINIA

CLASSIFICATION CHANGED
TO UNCLASSIFIED
FROM CONFIDENTIAL
PER AUTHORITY LISTED IN
DDC TAB NO. U64-8 FBDO. 148
DATE 15 APR. 64

UNCLASSIFIED

AD No. 147927
ASTIA FILE COPY

ERF

This document is the property of the United States Government. It is furnished for the duration of the contract and shall be returned when no longer required, or upon recall by ASTIA to the following address:
Armed Services Technical Information Agency, Arlington Hall Station
Arlington 12, Virginia

NOTICE: THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 and 794. THE TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

Sup

W. Z

Copy N

CONFIDENTIAL

Comparative Study of Various Types of VTOL Transport Aircraft

PERFORMANCE AND WEIGHT ESTIMATES FOR SIX VTOL AIRCRAFT REPORT R-83

Vertol Aircraft Corporation Morton, Pennsylvania

ONR ARMY

A Combined Research and Development Program

Contract NONR 1681(00)

This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18, U.S.C., Sections 793 and 794. The transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

Reproduction in whole or in part is permitted for any purpose of the United States Government.

PREPARED BY
E. M. IRVIN AND R. H. SWAN

Supervised by W. Z. Stepniewski
W. Z. STEPNIEWSKI Chief - R&D

Approved by L. L. Douglas
L. L. DOUGLAS Vice Pres.- Engineeing

57AA 41119

Copy No. 4

CONFIDENTIAL

JULY 13, 1956

TABLE OF CONTENTS

		Page
I.	Summary	1
II.	Introduction	3
III.	Characteristics Charts	
	Tilt Wing Propeller	9
	Tilting Ducted Propeller	17
	Vectored Lift	25
	Special Hovering Turbojet	33
	Vertodyne	41
	Vectodyne	49
IV.	References	61

I. SUMMARY

This report includes the final performance and weight estimates for the six VTOL aircraft found most promising in the general configuration studies of reference (a) and previously reported in reference (b). The following six configurations were determined to be most suitable for fulfilling the transport mission requirements at speeds of 300 mph or greater:

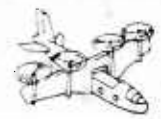
1. Tilt Wing Propeller
2. Tilting Ducted Propeller
3. Vectored Lift
4. Special Hovering Turbojet
5. Vertodyne
6. Vectodyne

The summary of weights and performance on the following page indicate the first three configurations have approximately equal capability at the specified cruising speed of 300 mph with the vectored lift design resulting in a higher gross weight because of its relative inefficiency for VTOL operation. The latter three configurations, considered most promising for high speed, give an indication of the gross weight growth accompanied with the combination of VTOL capabilities and increased forward speed potential. With regard to speed it can be seen that the Special Hovering Turbojet does have relatively low forward flight performance as a result of the minimum number of engines installed for forward thrust. It was felt that the maximum forward speed requirement of 375 mph should be sacrificed for this concept since all other mission requirements were met with the chosen power plants. The 375 mph speed could be met simply by installing a forward flight power package capable of greater thrust with a corresponding increase in the normal gross weight.

The Vertodyne, from a gross weight point of view, appears more promising than the Vectodyne for this particular mission with the former being penalized considerably for cruising at 10,000 feet. Because of its large wing area the Vertodyne is, of course, more suitable to cruising at altitudes higher than the mission requirement as can be easily seen in reference (c).

The summary of weights and performance is shown on the following page for the basic transport mission. A more complete picture of the performance capability of each configuration can be found in the Characteristics Charts presented in the body of the report.

SUMMARY OF PERFORMANCE AND WEIGHTS

	Units	TILT-WING PROPELLER	TILTING DUCTED PROPELLERS	VECTORED LIFT	SPECIAL HOVERING TURBOJET	VERTODYNE	VECTODYNE
							
WEIGHTS:							
GROSS WEIGHT	Lbs.	88899	93270	111313	107286	113958	121790
WEIGHT EMPTY	Lbs.	60037	62860	78863	51506	66910	72380
USEFUL LOAD	Lbs.	28862	30410	32450	55780	47048	47410
CREW	Lbs.	600	600	600	600	600	600
PAYLOAD	Lbs.	8000	8000	8000	8000	8000	8000
FUEL	Lbs.	18120	19690	21320	44750	37510	37950
HOVERING & WARM UP	Lbs.	1850	1850	2480	12500	3725	2785
CRUISE, CLIMB & RESERVE	Lbs.	16270	17840	18840	32250	33785	35165
ENGINE OIL	Lbs.	300	300	400	1360	300	450
XMSN OIL	Lbs.	460	460	300	--	300	360
TRAPPED LIQUIDS	Lbs.	432	390	580	1020	288	650
WATER (FOR INJECTION)	Lbs.	900	920	1200	0	0	1350
MISCELLANEOUS	Lbs.	50	50	50	50	50	50
POWER PLANT:		Allison 550-B1	Allison 550-B1	Allison 550-B1	General Electric J-85	General Electric J-79	Allison 550-B1
NUMBER		6	6	8	68 (60-hover 8-fwd.)	4	9
TYPE		Turboprop	Turboprop	Turboprop	Turbojet	Turbojet	Turboprop
TAKE-OFF PER ENGINE (DRY)		5168 SHP	5168 SHP	5168 SHP			5168 SHP
MILITARY PER ENGINE (DRY)		5168 SHP	5168 SHP	5168 SHP	2450 Lbs.	10000 Lbs.	5168 SHP
NORMAL PER ENGINE (DRY)		4590 SHP	4590 SHP	4590 SHP	2000 Lbs.	9700 Lbs.	4590 SHP
PERFORMANCE:							
MAXIMUM FORWARD SPEED							
S.L. ALTITUDE	mph	436	424	450	364	506	450
10000' ALTITUDE	mph	440	424	455	347	500	460
CRUISE SPEED							
S.L.	mph	300	300	300	300	400	345
10000'	mph	300	300	300	300	400	405
MAXIMUM R/C AT SEA LEVEL	NRP Ft/Min	7100	6660	7600	800	3660	5850
MAXIMUM R/C AT 10000'	Ft/Min	5900	5600	6400	320	2550	3650
TIME S.L. TO 10000'	Min.	1.54	1.63	1.43	17.7	3.40	2.11
SERVICE CEILING (100 fpm)	Ft.	43000	42200	39800	13600	37000	24000
HOVERING CEILING @ 95°F	Ft.	6000(1)	6000(1)	6000(1)	6000	6000	6000(1)
RADIUS OF ACTION(2)	S. Miles	425	425	425	425	425	425

NOTES: (1) With water injection
(2) Mfg's SFC increased 5% - 2 Mins W/U @ NRP - 5 Mins Hovering @ Radius Midpoint - 10% Reserve

CONFIDENTIAL
CONFIDENTIAL

II. INTRODUCTION

The performance analysis used in the preparation of the data presented throughout this report follow the accepted methods as outlined, for instance, in reference (c). The only exception is the method of analysis used for the Vectodyne which employs the Aerodyne principles and is discussed further in that particular section.

The mission requirements which dictated the normal gross weight for the configurations considered are as follows:

a.	Payload	8,000 lb. out - 4,000 lb. return
b.	Take-off	Vertical 6,000 ft. at 95°F
c.	Cabin Size	8' x 9' x length required for 35 troops
d.	Cargo	35 Infantry Troops or equivalent vehicles
e.	Cruise Speed	300 mph
f.	Flight Profile	20% of radius adjacent to target at S.L.
g.	Landing	Vertical
h.	Radius of Action	425 Statute Miles

Pertinent dimensional data for the six VTOL configurations fulfilling the above mission requirements are shown on Table 1. Table 2 is a consolidated group weight statement indicating the difference between configurations of component weight items. The drag summary on Table 3 similarily gives a minimum breakdown of the component drag items. It should be noted that in the case of the Special Hovering Turbojet and the Vertodyne where a thick section is

required, the wing drag coefficient reflects the high speed - low drag airfoil as given in the Table of Dimensions.

Standard Aircraft Characteristics Charts have been prepared for each configu ation and are shown in the following sections. These charts present a composite picture of each aircraft and as such, provide an easy means for an overall appraisal of the six configurations considered most promising for the military transport mission.

TABLE 1

DIMENSIONAL DATA

	TILT WING	TILTING DUCTED PROPELLERS	VECTORED LIFT	SPECIAL HOVERING TURBOJET	VERTODYNE	VECTODYNE
General						
Length (Overall)	84 ft 9 in	84 ft 9 in	84 ft 6 in	92 ft 0 in	91 ft 0 in	85 ft 0 in
Fuselage Width (Max)	13 ft 6 in	13 ft 6 in	13 ft 6 in	13 ft 6 in	13 ft 6 in	13 ft 6 in
Height (to Top of Vertical Fin)	37 ft 0 in	37 ft 0 in	32 ft 0 in	35 ft 0 in	35 ft 0 in	33 ft 8 in
Wing						
Span	85 ft 6 in	109 ft*	98 ft 6 in	90 ft	106 ft	
Area	1170 sq.ft	1426 sq.ft**	1430 sq.ft	1400 sq.ft	2284 sq.ft	
Aspect Ratio	6.25	8.35	6.79	5.78	4.91	
Taper Ratio	.498	.776	1.0	.250	.335	
Airfoil	2415	2415	2415	63_3-018	63_3-018	
M.A.C.	14 ft 4 in	14 ft 6 in	18 ft	15 ft	24 ft 6 in	
Tail						
Vertical Tail Area	260 sq.ft	260 sq.ft	240 sq.ft	300 sq.ft	240 sq.ft	280 sq.ft
Horizontal Tail Area	320 sq.ft	320 sq.ft	300 sq.ft	300 sq.ft	300 sq.ft	400 sq.ft
Landing Gear						
Tread	13 ft 6 in	14 ft	13 ft 6 in	63 ft 0 in	13 ft 6 in	15 ft 8 in
Wheel Base	24 ft 6 in	27 ft 9 in	32 ft 6 in	35 ft 6 in	26 ft 9 in	24 ft 6 in
Propellers						
Diameter	21 ft 0 in	17 ft 6 in 12 ft 0 in	25 ft 0 in	--	16 ft 8.4 in	18 ft 0 in
Tip Speed	850 fps	850 fps	850 fps	--	900 fps	900 fps
Disc Loading	64.1	131.5	57.6	--	259	

*Over Ducts
**Includes 50% Ducts

CONFIDENTIAL

TABLE 2

GROUP WEIGHT SUMMARY

	TILT-WING PROPELLER	TILTING DUCTED PROPELLER	VECTORED LIFT	SPECIAL HOVERING TURBOJET	VERTODYNE	VECTODYNE
ROTOR GROUP	8736	11155	11328	—	4580	6990
WING GROUP	7275	6940	11650	7060	10600	9100
TAIL GROUP	3150	3150	3780	3750	3960	4200
BODY GROUP	6746	7480	7890	8030	8130	8640
ALIGHTING GEAR GROUP	4500	4050	5940	4820	5080	5400
ENGINE SECTION	2710	4530	6030	1620	4730	4750
POWER PLANT	16270	20435	27800	20936	24305	27420
ENGINE	12060	12060	6080	15246	12600	6190
ENGINE ACCESSORIES	910	910	880	820	800	1270
POWER PLANT CONTROLS	120	120	160	510	160	180
STARTING SYSTEM	680	680	900	1350	400	900
COOLING SYSTEM	150	150	200	—	1400	600
LUBRICATION SYSTEM	1340	1340	1780	1320	800	2010
FUEL SYSTEM	1010	1050	1290	1690	1340	1700
TRANSMISSIONS	3470	3040	4640	—	1705	3720
SHAFTING	2210	1085	1870	—	1180	870
FIXED EQUIPMENT	4970	5160	4445	5290	5525	5880
INSTRUMENTS	270	270	360	890	240	300
FLIGHT CONTROLS	2200	2250	1425	1575	2650	2580
HYDRAULIC SYSTEM	350	370	390	430	435	480
ELECTRICAL SYSTEM	850	850	850	1050	850	850
COMMUNICATION SYSTEM	300	300	300	300	300	300
FURNISHINGS	800	800	800	800	800	800
MISCELLANEOUS	200	320	220	245	250	270
WEIGHT EMPTY	60037	62860	78863	51506	66910	72380
USEFUL LOAD	28862	30410	32450	55780	47048	49410
CREW	600	600	600	600	600	600
TRAPPED LIQUIDS	432	390	580	1020	288	650
ENGINE OIL	300	300	400	1360	300	450
TRANSMISSION OIL	460	460	300	—	300	360
FUEL	18120	19690	21320	44750	37510	7950
CARGO	8000	8000	8000	8000	8000	8000
MISCELLANEOUS	50	50	50	50	50	50
WATER	900	920	1200	—	—	1350
GROSS WEIGHT	88899	93270	111313	107286	113958	121790

TABLE 3

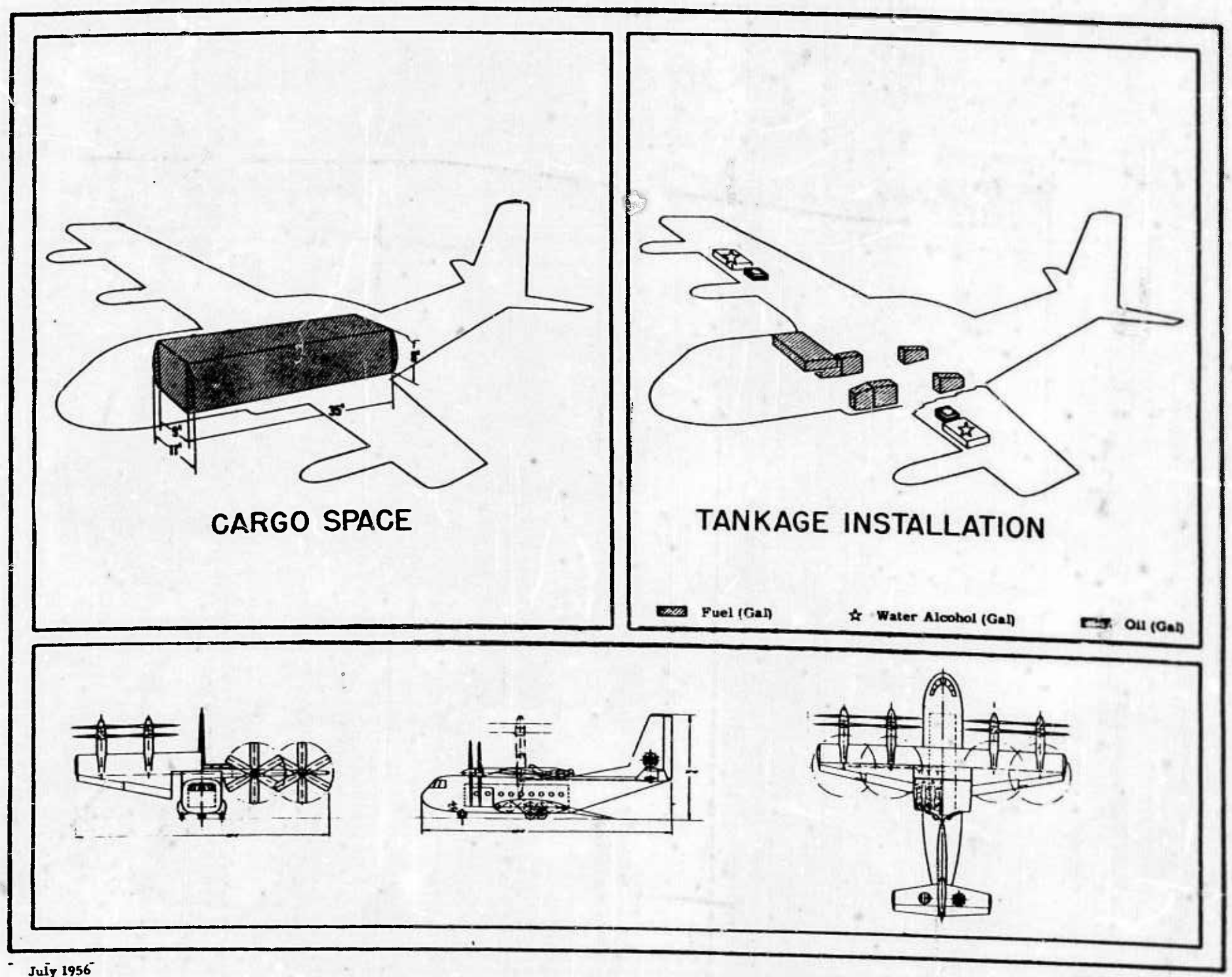
DRAG SUMMARY

	TILT WING	TILTING DUCTED PROPELLERS	VECTORED LIFT	SPECIAL HOVERING TURBOJET	VERTODYNE	VECTODYNE
Wing Area, SW	1170 sq.ft	1426 sq.ft	1430 sq.ft	1400 sq.ft	2284 sq.ft	—
Total Propeller Disc Area						508 sq.ft
	$C_{D_{S_W}}$	$C_{D_{S_W}}$	$C_{D_{S_W}}$	$C_{D_{S_W}}$	$C_{D_{S_W}}$	C_{D_A}
Wing (@ $C_{L_W} = 0$)	.00770	.00770	.00770	.00540	.00540	
Fuselage	.01075	.00883	.00827	.00899	.0055	.0266
Nacelles	.00128	.00133	.00273	.00116	.00192	.0175
Gear Bumps	.000615	.000505	.000502	.000214	.000315	.00204
Horizontal Tail	.00274	.00225	.0021	.00214	.00131	.00789
Vertical Tail	.00222	.00183	.00168	.00214	.00105	.00551
Engine Inlets	.00141	.00116	.00315	.000428	.000656	.00393
Shrouds		.00328				.0120
Booms			.000369			.00709
Σ $C_{D_{S_W}}$	.02672	.02689	.02650	.02047	.01615	
Σ C_{D_A}						.08256
Miscellaneous and Interference 15%	.00401	.00403	.00397	.00307	.00242	.01240
Total $C_{D_{S_W}}$	.03073	.03092	.03047	.02354	.01857	
Total C_{D_A}						.09496

CONFIDENTIAL

CONFIDENTIAL

Standard Aircraft Characteristics
VTOL COMPARATIVE STUDY
"TILTING WING PROPELLER"
REPORT R-83
VERTOL AIRCRAFT CORP.
CONTRACT NONR 1681 (00)


CARGO SPACE
TANKAGE INSTALLATION
Fuel (Gal)
Water Alcohol (Gal)
Oil (Gal)

CONFIDENTIAL

POWER PLANT

No. and Model	(6) 550 B-1
Manufacturer	Allison
Eng. Spec No.	394-B

ENGINE RATINGS

	SHP	RPM	ALT.
T.O.	5168	9900	S.L.
MIL.	5168	9900	S.L.
NOR.	4590	9900	S.L.

Mission and Description

The basic mission given in detail in the notes is to provide air transportation for troops and cargo with specific requirements for VTOL operation and a radius capability of 425 statute mil .

This aircraft employs a wing-propeller combination which can be tilted to a vertical attitude through approximately eighty degrees to utilize the propeller thrust in hovering. The propellers are interconnected with the power plants mounted horizontally on top of the fuselage.

Pitch and yaw control in hovering and slow speed flight is provided through the use of submerged fans in the tail connected to the propeller drive system while roll control is obtained through differential thrust of the propellers.

WEIGHTS

Normal Gross Wt. VTOL - 6000' @ 95°F	88,899 lb.
Weight Empty	60,037 lb.

FUEL

Normal Internal

2790 Gal. 6.5 lbs./gal.

DIMENSIONS

Length	84 ft. 9 in.
Height	37 ft. 0 in.
Wing Span	85 ft. 6 in.
Wing Area	1170 sq. ft.
Wing Aspect Ratio	6.25
Wheel Tread	13 ft. 6 in.

MISCELLANEOUS

ELECTRONICS

UHF plus Homing Adapter	ARC-27 and ARA-25
VHF plus Homing Adapter	ARC Type 12 and ARA 8A

Liaison - Range 1000 Miles

Interphone

CONFIDENTIAL

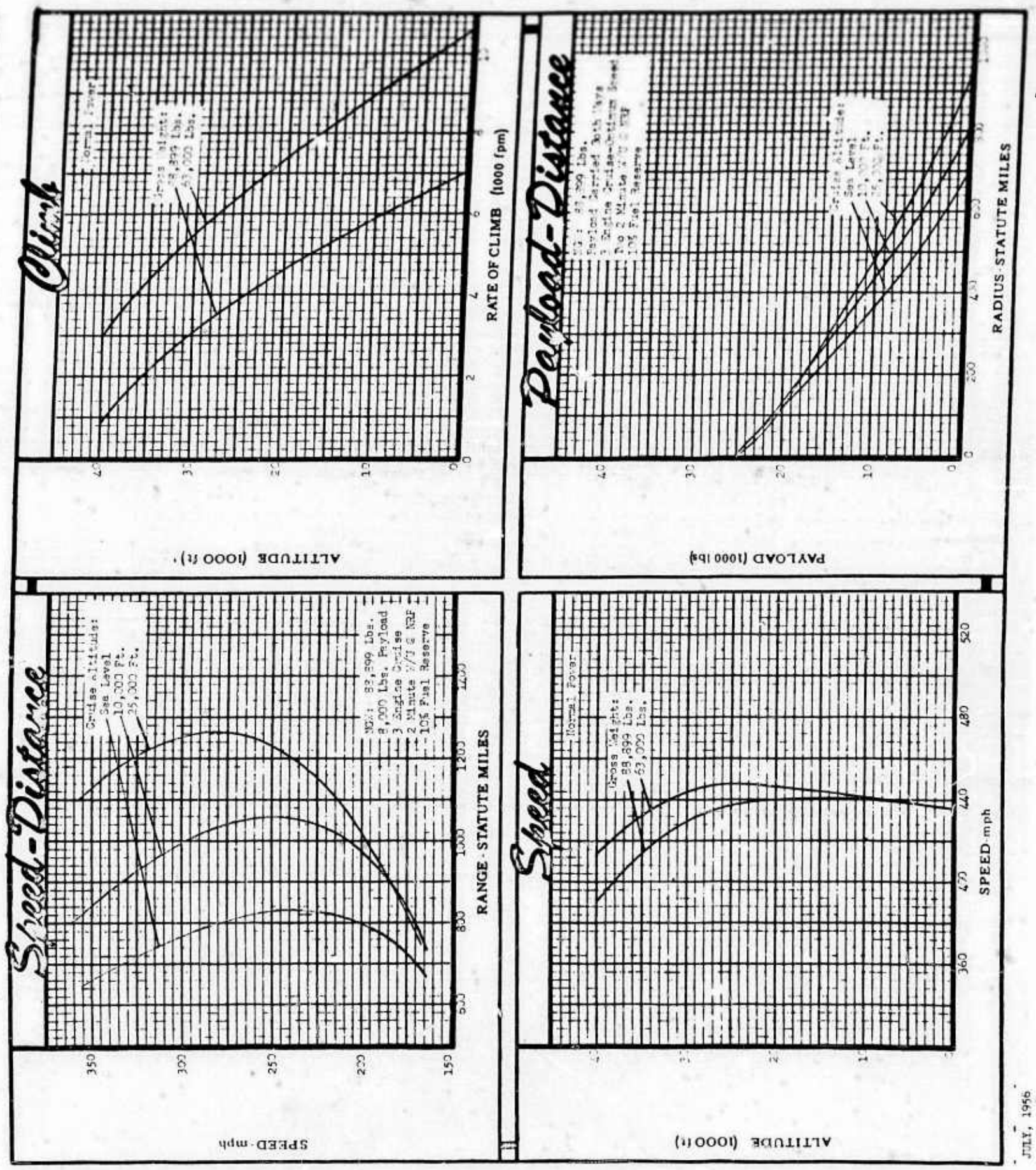
Loading and Performance — Typical Mission

CONDITIONS			BASIC	FERRY RANGE
TAKE-OFF WEIGHT		(lb)	88,899	106,500
Fuel at 6.5 lb/gal		(lb)	18,120	41,160
Payload (outbound)		(lb)	8,000	0
Payload (inbound)		(lb)	4,000	0
Take-off power loading		(lb/Shp)	2.86	3.44
Disc loading		(lb/sq ft)	64.1	77.0
Wing loading		(lb/sq ft)	75.9	91.0
Take-off ground run at 6000 ft. and 95° F/clear 50 ft.	1	(ft)	0/0	
Maximum Speed at S. L.	2	(mph)	436	436
Maximum Speed at 10000 ft.	2	(mph)	440	440
Max. rate of climb at S. L.	2	(fpm)	7,100	5,750
Time: SL to 10000 ft.	2	(min)	1.54	1.9
Time: SL to 25000 ft.	2	(min)	4.60	5.8
Service ceiling (100 fpm)	2	(ft)	43,000	41,500
COMBAT RADIUS OR RANGE	3	(s. mi)	425	2,830
Average Cruising Speed		(mph)	300	300
Cruising altitude (20% @ S. L.)		(ft)	10,000	25,000
FIRST LANDING WEIGHT		(lb)	81,020	
Ground roll at 6000 ft. and 95 F	1	(ft)	0	
COMBAT WEIGHT	4	(lb)	75,700	69,455
Cruise altitude		(ft)	10,000	
Cruise speed		(mph)	300	
Service ceiling (100 fpm)	2	(ft)	46,000	48,000
Take-off ground run at 6000 ft and 95° F/clear 50 ft	1	(ft)	0/0	
Max. rate of climb at S. L.	2	(fpm)	8,750	9,700
Time: SL to 10000 ft	2	(min)	1.98	1.12
Time: SL to 25000 ft	2	(min)	4.38	3.34
Max. speed at S. L.	2	(mph)	436	436
Max. speed at 10000 ft.	2	(mph)	440	440
LANDING WEIGHT		(lb)	68,680	69,455
Ground roll at 6000 ft. and 95 F	1	(ft)	0	0

NOTES
1. Military power
2. Normal power
3. Detailed description of missions are given on Page 5
4. With 4000# return payload - no fuel added.

PERFORMANCE BASIS:
(a) Data source: Estimated.
(b) Performance is based on powers shown on Page 3
(c) Data do not include ground effect.

CONFIDENTIAL


Climb
Normal Power
Gross Weights
88,899 Lbs.
63,000 Lbs.
RATE OF CLIMB (1000 fpm)
ALTITUDE (1000 ft)
Payload-Distance
Cruise Altitude:
Sea Level
10,000 Ft.
25,000 Ft.
RADIUS-STATUTE MILES
PAYLOAD (1000 lbs)
Speed-Distance
Cruise Altitude:
Sea Level
10,000 Ft.
25,000 Ft.
MGW: 88,899 Lbs.
8,000 Lbs. Payload
3 Engine Cruise
2 Minute W/O @ MRP
10% Fuel Reserve
RANGE-STATUTE MILES
SPEED-mph
Speed
Normal Power
Gross Weights
88,899 Lbs.
63,000 Lbs.
SPEED-mph
ALTITUDE (1000 ft)

N O T E S

I. The design or basic mission of the aircraft is essentially that of a military transport suitable for transporting either troops or associated equipment with the additional requirement for a vertical take-off capability to increase its mobility in the absence of unprepared landing surfaces.

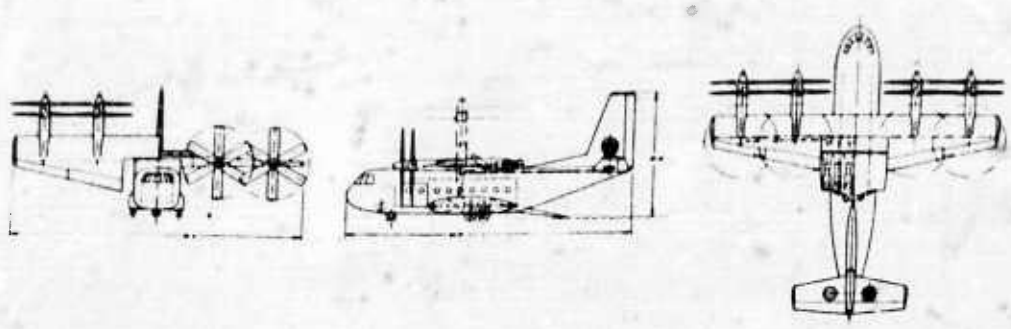
II. The basic mission requirements in addition to the capability of hovering @ 6,000' and 95°F with military power consist of the following:

1. Two minute warm-up @ normal power prior to take-off.
2. Take-off vertically with 8,000# payload and climb on course to 10,000' with normal power.
3. Cruise at 10,000', 80 per cent of the required radius (425 statute miles), descend to sea and cruise the remaining 20% to the destination.
4. Hover allowance of 5 minutes @ sea level for vertical take-off and landing operation.
5. Return cruise with 4000# payload is initially @ sea level again for 20% of the required radius followed by a normal power climb to 10,000'. Remaining cruise at 10,000' completes the 425 statute mile radius requirement.
6. Fuel allowances include 10% for reserve with a 5% increase in manufacturer's SFC values.

III. An additional ferry mission applicable to this aircraft consists of the following:

1. Two minute warm-up @ normal power prior to take-off.
2. With a 20% increase in normal gross weight take-off and climb on course with normal power to 25,000'.
3. At 25,000' cruise out a maximum distance prior to landing with a 10% fuel reserve.
4. Manufacturer's SFC values increased 5%.

Characteristics Summary



AVAILABILITY			PROCUREMENT			
Number available			Number to be delivered in fiscal years			
ACTIVE	RESERVE	TOTAL				

STATUS

POWER PLANT

(6) Allison 550 B-1 Turboprops

Engine Ratings

	SHP	RPM	ALT
TO:	5168	9900	S.L.
MIL:	5168	9900	S.L.
NOR:	4590	9900	S.L.

FEATURES

Rear aperature loading ramp.

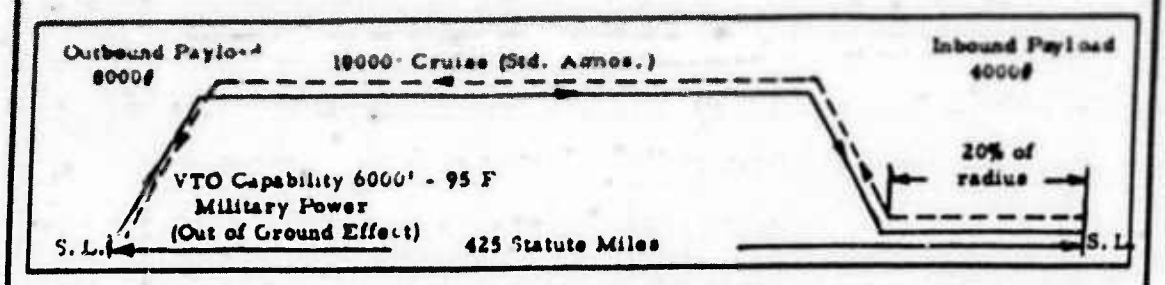
Cargo floor at truck bed loading height.

GENERAL

Crew	3
Troops	35
Cabin Floor Area	315 sq.ft.
Cabin Volume	2,520 cu.ft.

CONFIDENTIAL

Characteristics Summary Basic Mission



PERFORMANCE

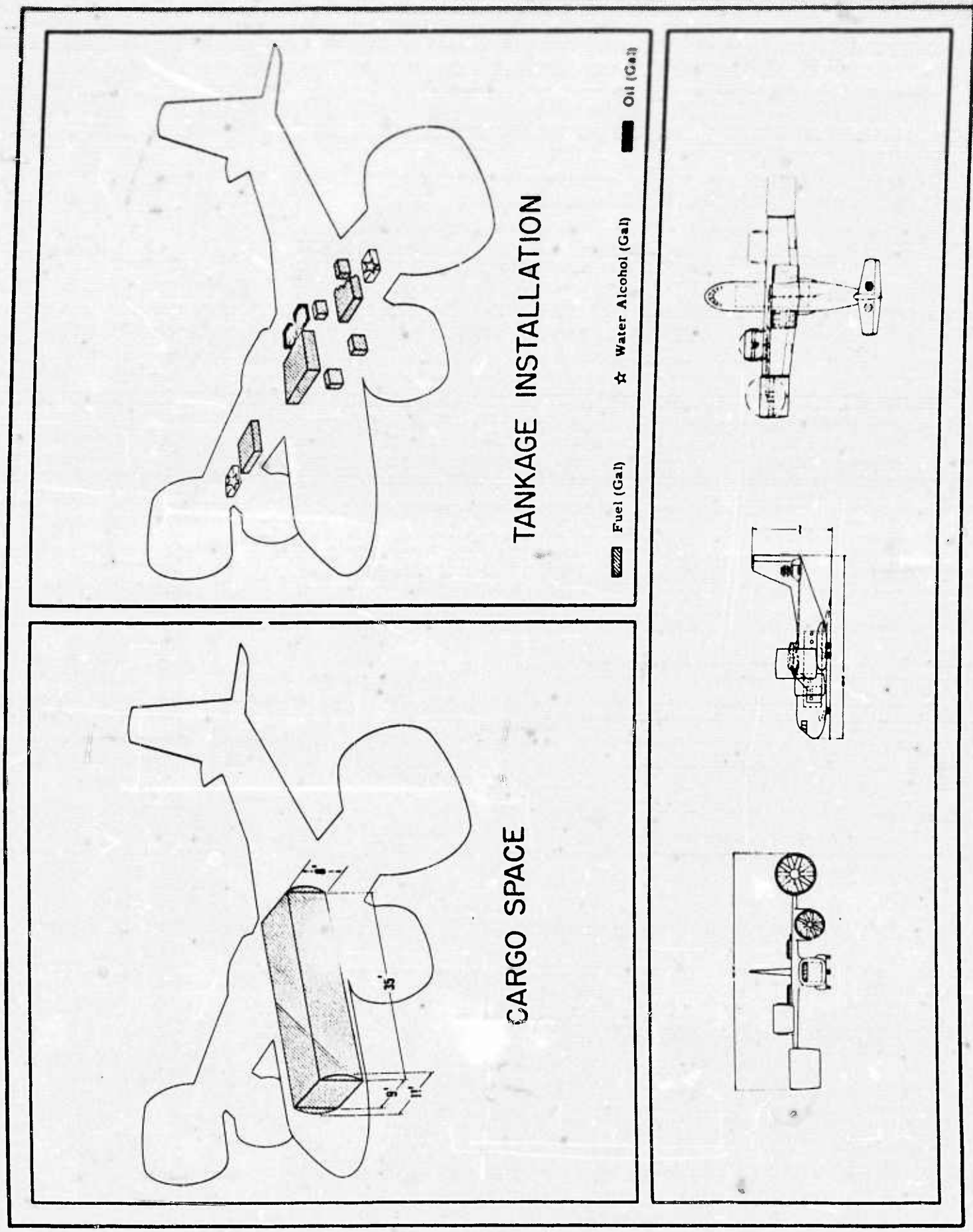
COMBAT RADIUS	FERRY RANGE	S P E E D
425 Stat. Mi. with 8000 lb payload at 300 mph avg.	1265 Stat. Mi. with 2790 gal. fuel at 280 mph avg. at 88,899 lb T.O. wt. and 8000 lbs payload	MAX 436 mph at Sea Level ft alt, N.R.P. MAX 440 mph at 10,000 ft alt, N.R.P.
C L I M B	**C E I L I N G**	**TAKE-OFF**
7100 fpm sea level, take-off weight normal power	43000 ft 100 fpm, take-off weight normal power	Vertical Take-Off
5900 fpm 10000 ft take-off weight normal power		
L O A D	**W E I G H T S**	**HOVERING CEIL.**
Crew 600 lbs Payload 8000 lbs Fuel 18120 lbs Oil 300 lbs	Useful 28862 lb Empty 60037 lb Take-Off 88,899 lb	6000 ft., take-off Military Power 98°F Ambient Temperature

N O T E S

1. Performance Basis:
   (a) Data Source: Estimated
   (b) Performance is Based on Powers Shown on Page 3
   (c) Data do not include Ground Effect

CONFIDENTIAL

Standard Aircraft Characteristics
VTOL COMPARATIVE STUDY
"TILTING DUCTED PROPELLER"
REPORT R-83
VERTOL AIRCRAFT CORP.
CONTRACT NONR 1681(00)



CONFIDENTIAL

POWER PLANT

No. and Model	(6) 550 B-1
Manufacturer	Allison
Eng. Spec No.	394-B

ENGINE RATINGS

	SHP	RPM	ALT.
T.O.	5168	9900	S.L.
MIL.	5168	9900	S.L.
NOR.	4590	9900	S.L.

DIMENSIONS

Length	84 ft. 9 in.
Height	37 ft. 0 in.
Wing Span	109 ft. 0 in.
Wing Area	1426 ft.^{2} (includes 50% ducts)
Wing Aspect Ratio	8.35
Wheel Tread	14 ft. 0 in.

Mission and Description

The basic mission given in detail in the notes is to provide air transportation for troops and cargo with specific requirements for VTOL operation and a radius capability of 425 statute miles.

This aircraft employs four ducted fans mounted on the wing which can be rotated through ninety degrees to provide thrust in both the hovering and forward flight condition. The fans are interconnected with the power plants located on the inboard section of the wing.

Pitch and yaw control obtained from submerged fans in the tail surfaces driven by shafting from the interconnected propeller system. Roll control is obtained through differential propeller thrust.

MISCELLANEOUS

WEIGHTS

Normal Gross Wt. VTOL - 6000' @ 95°F	93,270 lb.
Weight Empty	62,860 lb.

FUEL

Normal Internal

3030 Gal. 6.5 lbs./gal.

ELECTRONICS

UHF plus Homing Adapter	ARC-27 and ARA-25
VHF plus Homing Adapter	ARC Type 12 and ARA 8A
Liaison - Range 1000 Miles	
Interphone	

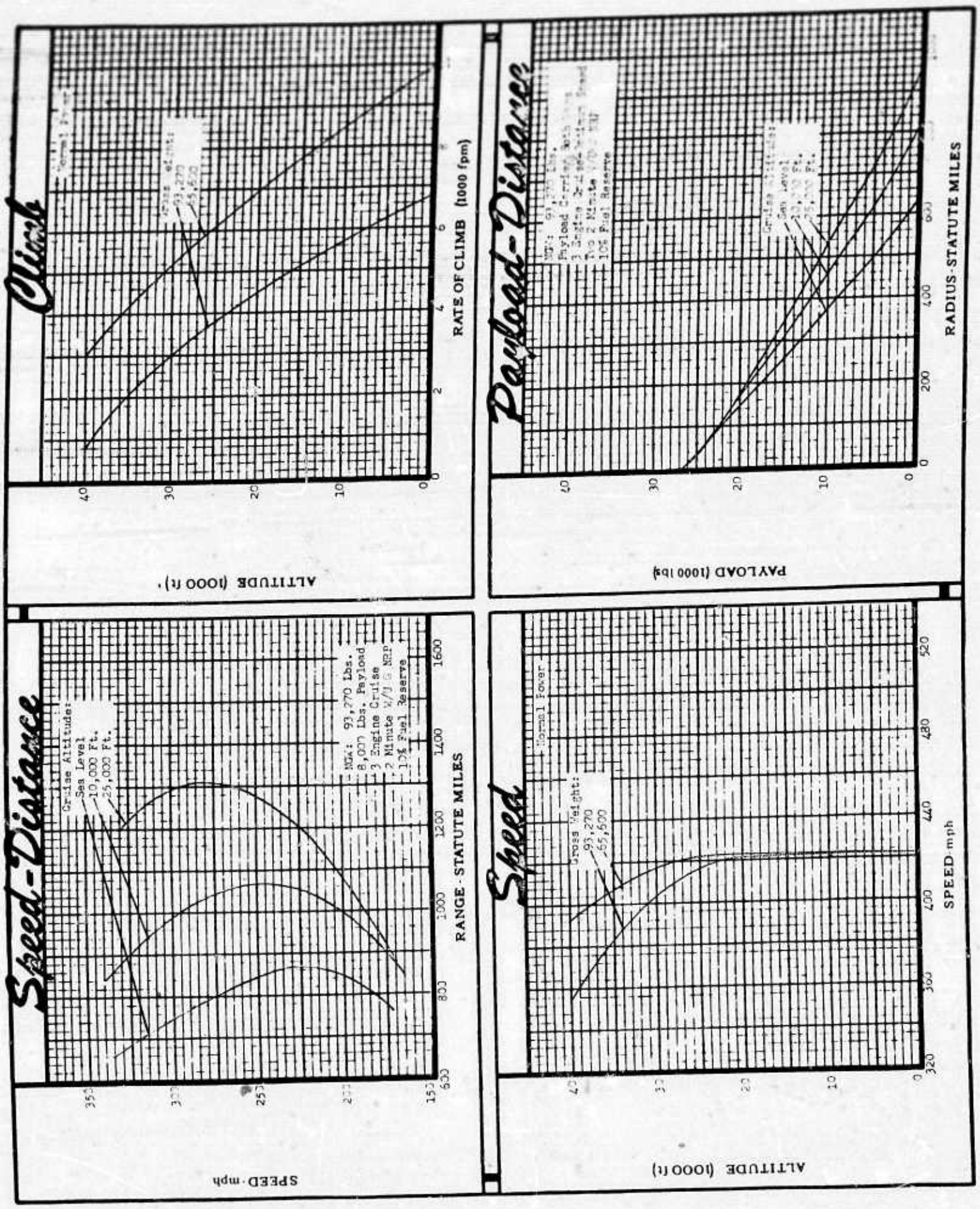
Loading and Performance—Typical Mission

CONDITIONS			BASIC	FERRY RANGE
TAKE-OFF WEIGHT		(lb)	93,270	111,924
Fuel at 6.5 lb/gal		(lb)	19,690	44,479
Payload (outbound)		(lb)	8,000	0
Payload (inbound)		(lb)	4,000	0
Take-off power loading		(lb/Shp)	3.01	3.61
Disc loading		(lb/sq ft)	131.5	158
Wing loading		(lb/sq ft)	65.5	78.5
Take-off ground run at 6000 ft. and 95° F/clear 50 ft.	1	(ft)	0/0	
Maximum Speed at S. L.	2	(mph)	424	424
Maximum Speed at 10000 ft.	2	(mph)	424	424
Max. rate of climb at S. L.	2	(fpm)	6,660	5,200
Time: SL to 10000 ft.	2	(min)	1.63	2.12
Time: SL to 25000 ft.	2	(min)	4.86	6.64
Service ceiling (100 fpm)	2	(ft)	42,200	36,800
COMBAT RADIUS OR RANGE	3	(s. mi)	425	2,857
Average Cruising Speed		(mph)	300	300
Cruising altitude (20% @ S. L.)		(ft)	10,000	25,000
FIRST LANDING WEIGHT		(lb)	85,060	
Ground roll at 6000 ft. and 95 F	1	(ft)	0	
COMBAT WEIGHT	4	(lb)	79,740	71,893
Cruise altitude		(ft)	10,000	
Cruise speed		(mph)	300	
Service ceiling (100 fpm)	2	(ft)	46,000	51,000
Take-off ground run at 6000 ft and 95° F/clear 50 ft	1	(ft)	0/0	
Max. rate of climb at S. L.	2	(fpm)	8,100	9,100
Time: SL to 10000 ft	2	(min)	1.33	1.18
Time: SL to 25000 ft	2	(min)	3.89	3.48
Max. speed at S. L.	2	(mph)	424	424
Max. speed at 10000 ft.	2	(mph)	424	424
LANDING WEIGHT		(lb)	71,900	71,893
Ground roll at 6000 ft. and 95 F	1	(ft)	0	0

NOTES
1. Military power
2. Normal power
3. Detailed description of missions are given on Page 6
4. With 4000# return payload - no fuel added.

PERFORMANCE BASIS:
(a) Data source: Estimated
(b) Performance is based on powers shown on Page 3
(c) Data do not include ground affect.

CONFIDENTIAL


Climb
RATE OF CLIMB (1000 fpm)
ALTITUDE (1000 ft)
Payload-Distance
RADIUS-STATUTE MILES
PAYLOAD (1000 lbs)
Speed-Distance
Cruise Altitude:
Sea Level
10,000 Ft.
25,000 Ft.
GWt: 93,270 lbs.
8,000 Lbs. Payload
3 Engine Cruise
2 Minute W/U @ MRP
10% Fuel Reserve
RANGE-STATUTE MILES
SPEED-mph
Speed
Normal Power
Gross Weight:
93,270
65,600
SPEED-mph
ALTITUDE (1000 ft)

JULY, 1956

N O T E S

I. The design or basic mission of the aircraft is essentially that of a military transport suitable for transporting either troops or associated equipment with the additional requirement for a vertical take-off capability to increase its mobility in the absence of unprepared landing surfaces.

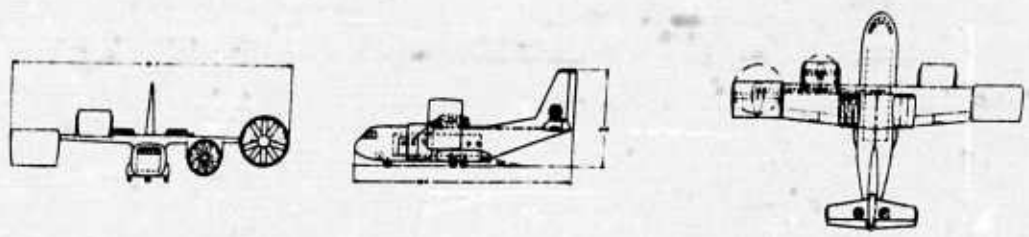
II. The basic mission requirements in addition to the capability of hovering @ 6,000' and 95°F with military power consist of the following:

1. Two minute warm-up @ normal power prior to take-off.
2. Take-off vertically with 8,000# payload and climb on course to 10,000' with normal power.
3. Cruise at 10,000', 80 per cent of the required radius (425 statute miles), descend to sea and cruise the remaining 20% to the destination.
4. Hover allowance of 5 minutes @ sea level for vertical take-off and landing operation.
5. Return cruise with 4000# payload is initially @ sea level again for 20% of the required radius followed by a normal power climb to 10,000'. Remaining cruise at 10,000' completes the 425 statute mile radius requirement.
6. Fuel allowances include 10% for reserve with a 5% increase in manufacturer's SFC values.

III. An additional ferry mission applicable to this aircraft consists of the following:

1. Two minute warm-up @ normal power prior to take-off.
2. With a 20% increase in normal gross weight take-off and climb on course with normal power to 25,000'.
3. At 25,000' cruise out a maximum distance prior to landing with a 10% fuel reserve.
4. Manufacturer's SFC values increased 5%.

Characteristics Summary



AVAILABILITY			PROCUREMENT			
Number available			Number to be delivered in fiscal years			
ACTIVE	RESERVE	TOTAL				

STATUS

POWER PLANT

(6) Allison 550 B-1 Turboprops

Engine Ratings

	SHP	RPM	ALT
TO:	5168	9900	S.L.
MIL:	5168	9900	S.L.
NOR:	4590	9900	S.L.

FEATURES

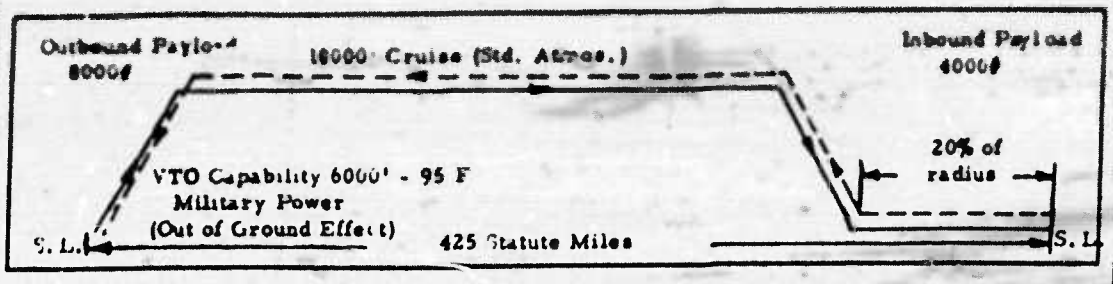
Rear aperature loading ramp.

Cargo floor at truck bed loading height.

GENERAL

Crew	3
Troops	35
Cabin Floor Area	315 sq.ft
Cabin Volume	2,520 cu.ft

Characteristics Summary Basic Mission



PERFORMANCE

COMBAT RADIUS	FERRY RANGE	SPEED
425 Stat. Mi. with 8000 lb payload at 300 mph avg.	1310 Stat. Mi. with 3030 gal. fuel at 280 mph avg. at 93270 lb T.O. wt. and 8000 lbs. payload	MAX 424 mph at Sea Level ft alt, N.R.P. MAX 424 mph at 10,000 ft alt, N.R.P.
CLIMB	**CEILING**	**TAKE-OFF**
6660 fpm sea level, take-off weight normal power	42,200 ft 100 fpm, take-off weight normal power	Vertical Take-Off
5600 fpm 10000 ft take-off weight normal power		

LOAD		WEIGHTS			HOVERING CEIL.
Crew	600 lbs	Useful	30410	lb	6000 ft., take-off Military Power 95°F Ambient Temperature
Payload	8000 lbs	Empty	62860	lb	
Fuel	19690 lbs	Take-Off	93270	lb	
Oil	300 lbs				

NOTES

1. Performance Basis:
   (a) Data Source: Estimated
   (b) Performance is Based on Powers Shown on Page 3
   (c) Data do not include Ground Effect

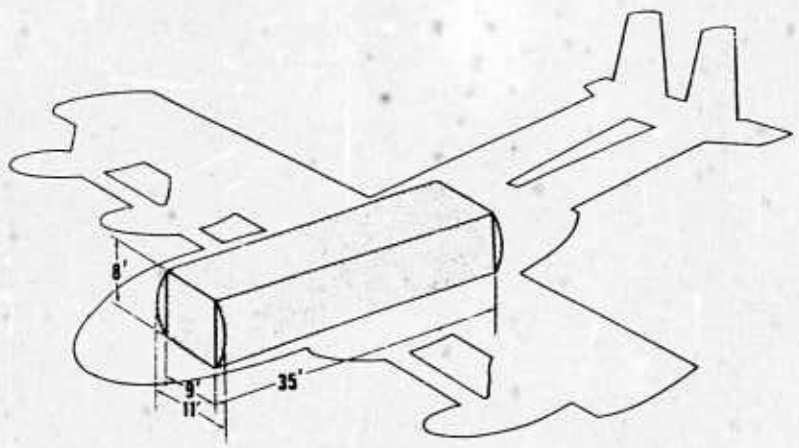
Standard Aircraft Characteristics

VTOL COMPARATIVE STUDY

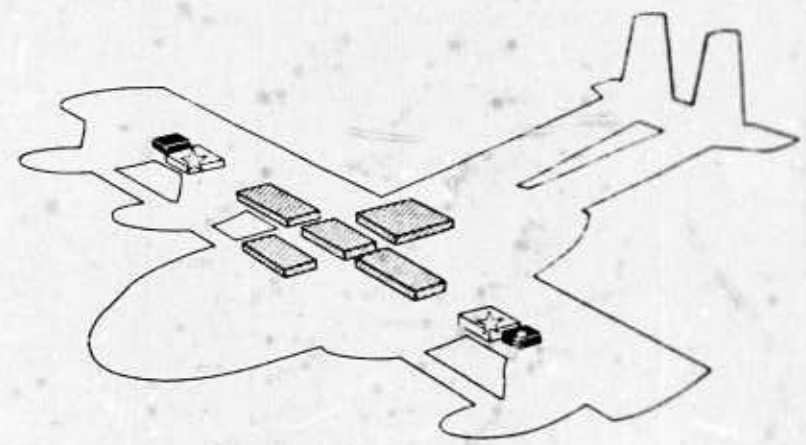
"VECTORED LIFT"

VERTOL AIRCRAFT CORP. CONTRACT Nonr 1681(00)

REPORT R-83

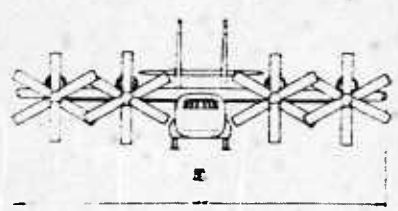


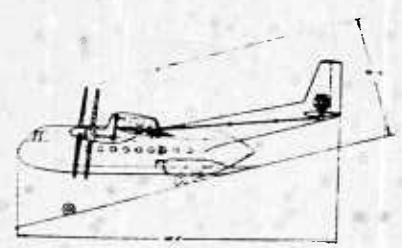
CARGO SPACE

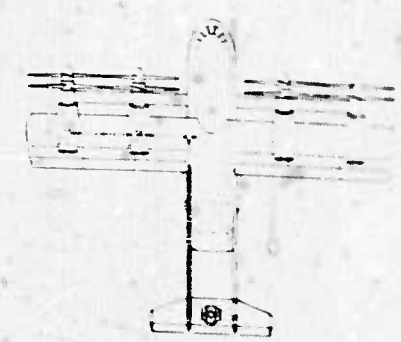


TANKAGE INSTALLATION

Fuel (Gal) ☆ Water Alcohol (Gal) Oil (Gal)







POWER PLANT

No. and Model	(8) 550 B-1
Manufacturer	Allison
Eng. Spec No.	394-B

ENGINE RATINGS

	SHP	RPM	ALT.
T.O.	5168	9900	S.L.
MIL.	5168	9900	S.L.
NOR.	4590	9900	S.L.

Mission and Description

The basic mission given in detail in the notes is to provide air transportation for troops and cargo with specific requirements for VTOL operation and a radius capability of 425 statute miles.

The vectored lift configuration derives its VTOL capabilities by deflecting the propeller slipstream through large angles by means of a full-span double-flap arrangement. The propellers are interconnected with two power plants located in each of the four nacelles.

The use of a controllable forward located stabilizer immersed in the propeller slipstream alleviates hovering pitching moments. Additional pitch control as well as yaw control are obtained through submerged fans in the tail surfaces and driven by the central propeller drive system.

WEIGHTS

Normal Gross Wt.
VTOL - 6000' @ 95°F = 111,313 lb.

Weight Empty = 78,663 lb.

FUEL

Normal Internal

3280 Gal. 6.5 lbs./gal.

DIMENSIONS

Length	84 ft. 6 in.
Height	32 ft. 0 in.
Wing Span	98 ft. 6 in.
Wing Area	1430
Wing Aspect Ratio	6.79
Wheel Tread	13 ft. 6 in.

MISCELLANEOUS

ELECTRONICS

UHF plus Homing Adapter	ARC-27 and ARA-25
VHF plus Homing Adapter	ARC Type 12 and ARA 8A

Liaison - Range 1000 Miles

Interphone

Loading and Performance—Typical Mission

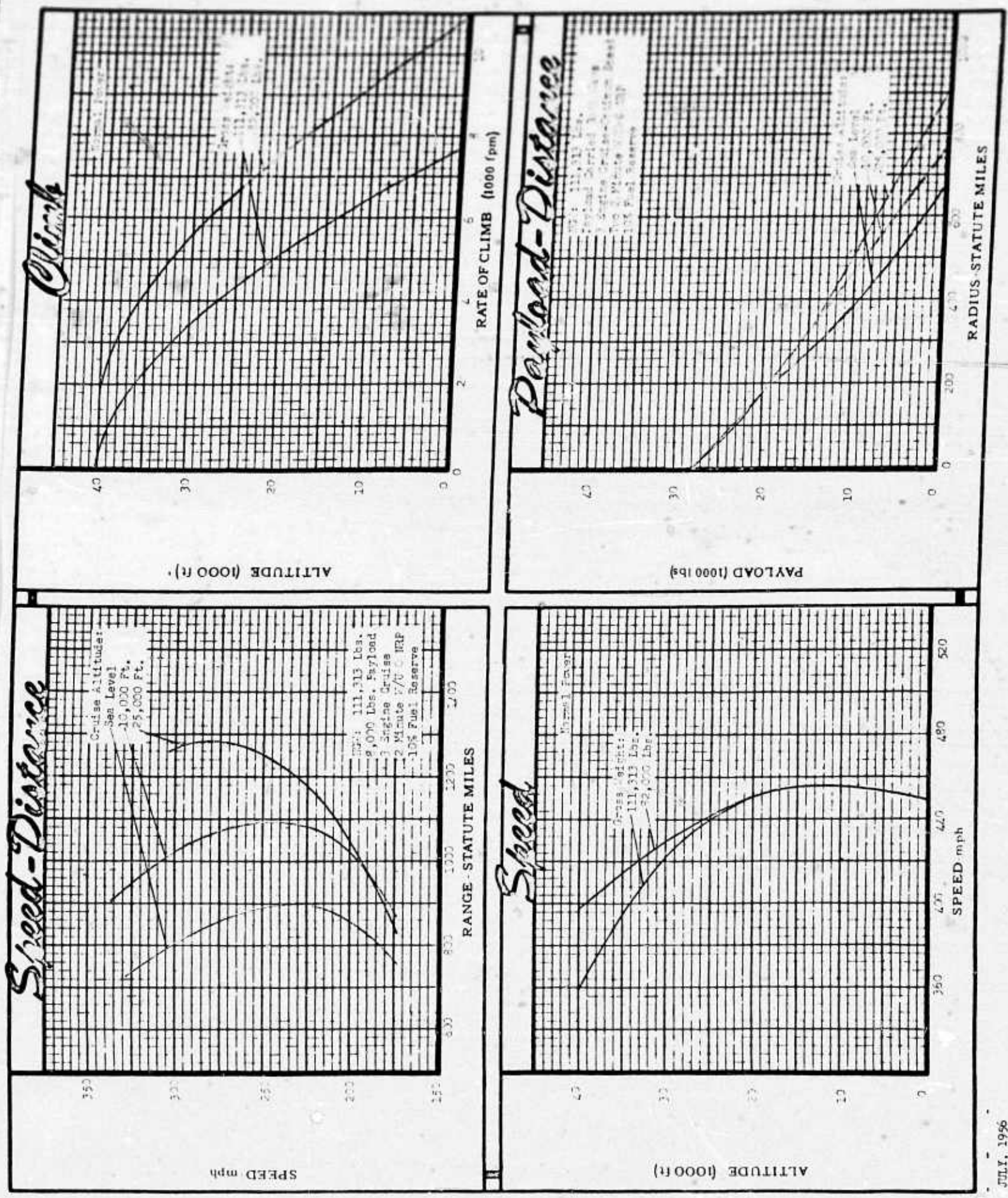
CONDITIONS			BASIC	FERRY RANGE
TAKE-OFF WEIGHT		(lb)	111,313	133,500
Fuel at 6.5 lb/gal		(lb)	21,320	48,487
Payload (outbound)		(lb)	8,000	0
Payload (inbound)		(lb)	4,000	0
Take-off power loading		(lb/Shp)	2.69	3.23
Disc loading		(lb/sq ft)	57.6	69.2
Wing loading		(lb/sq ft)	78.0	93.4
Take-off ground run at 6000 ft. and 95°F/clear 50 ft.	1	(ft)	0/0	
Maximum Speed at S. L.	2	(mph)	450	450
Maximum Speed at 10000 ft.	2	(mph)	455	455
Max. rate of climb at S. L.	2	(fpm)	7,600	6,100
Time: SL to 10000 ft.	2	(min)	1.43	1.8
Time: SL to 25000 ft.	2	(min)	4.21	5.64
Service ceiling (100 fpm)	2	(ft)	39,800	37,200
COMBAT RADIUS OR RANGE	3	(s. mi)	425	2,800
Average Cruising Speed		(mph)	300	318
Cruising altitude (20% @ S. L.)		(ft)	10,000	25,000
FIRST LANDING WEIGHT		(lb)	101,928	
Ground roll at 6000 ft. and 95 F	1	(ft)	0	
COMBAT WEIGHT	4	(lb)	100,158	89,863
Cruise altitude		(ft)	30,000	
Cruise speed		(mph)	300	
Service ceiling (100 fpm)	2	(ft)	41,000	42,400
Take-off ground run at 6000 ft and 95°F/clear 50 ft	1	(ft)	0/0	
Max. rate of climb at S. L.	2	(fpm)	8,700	10,000
Time: SL to 10000 ft	2	(min)	1.22	1.075
Time: SL to 25000 ft	2	(min)	3.62	3.21
Max. speed at S. L.	2	(mph)	450	450
Max. speed at 10000 ft.	2	(mph)	455	455
LANDING WEIGHT		(lb)	87,933	89,863
Ground roll at 6000 ft. and 95 F	1	(ft)	0	0

NOTES

1. Military power
2. Normal power
3. Detailed description of missions are given on Page 6
4. With 4000# return payload - no fuel added.

PERFORMANCE BASIS:

(a) Data source: Estimated
(b) Performance is based on powers shown on Page 3
(c) Data do not include ground effect.


Climb
RATE OF CLIMB (1000 fpm)
ALTITUDE (1000 ft)
Payload-Distance
RADIUS-STATUTE MILES
PAYLOAD (1000 lbs)
Speed-Distance
Cruise Altitude:
Sea Level
10,000 Ft.
25,000 Ft.
111,313 Lbs.
8,000 Lbs. Payload
3 Engine Cruise
2 Minute F/O @ MRP
10% Fuel Reserve
RANGE-STATUTE MILES
SPEED mph
Speed
Wheel Power
Gross Weight:
111,313 Lbs.
SPEED mph
ALTITUDE (1000 ft)

CONFIDENTIAL

N O T E S

I. The design or basic mission of the aircraft is essentially that of a military transport suitable for transporting either troops or associated equipment with the additional requirement for a vertical take-off capability to increase its mobility in the absence of unprepared landing surfaces.

II. The basic mission requirements in addition to the capability of hovering @ 6,000' and 95°F with military power consist of the following:

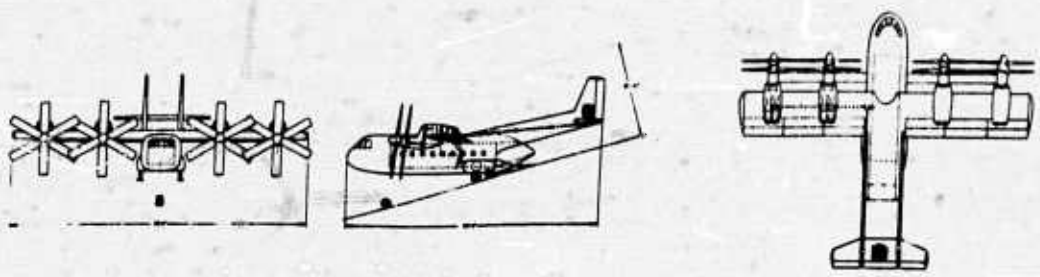
1. Two minute warm-up @ normal power prior to take-off.
2. Take-off vertically with 8,000# payload and climb on course to 10,000' with normal power.
3. Cruise at 10,000', 80 per cent of the required radius (425 statute miles), descend to sea and cruise the remaining 20% to the destination.
4. Hover allowance of 5 minutes @ sea level for vertical take-off and landing operation.
5. Return cruise with 4000# payload is initially @ sea level again for 20% of the required radius followed by a normal power climb to 10,000'. Remaining cruise at 10,000' completes the 425 statute mile radius requirement.
6. Fuel allowances include 10% for reserve with a 5% increase in manufacturer's SFC values.

III. An additional ferry mission applicable to this aircraft consists of the following:

1. Two minute warm-up @ normal power prior to take-off.
2. With a 20% increase in normal gross weight take-off and climb on course with normal power to 25,000'.
3. At 25,000' cruise out a maximum distance prior to landing with a 10% fuel reserve.
4. Manufacturer's SFC values increased 5%.

CONFIDENTIAL

Characteristics Summary



AVAILABILITY			PROCUREMENT			
Number available			Number to be delivered in fiscal years			
ACTIVE	RESERVE	TOTAL				

STATUS

POWER PLANT

(8) Allison 550 B-1 Turboprops

Engine Ratings

	SHP	RPM	ALT
TO:	5168	9900	S.L.
MIL:	5168	9900	S.L.
MCR:	4590	9900	S.L.

FEATURES

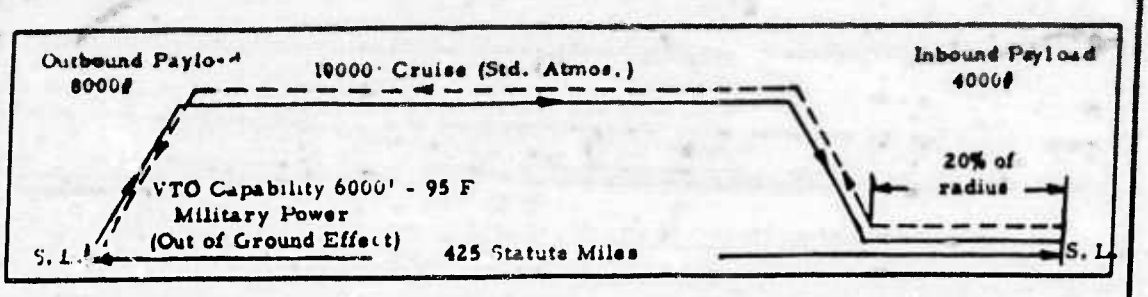
Rear aperature loading ramp.

Cargo floor at truck bed loading height.

GENERAL

Crew	3
Troops	35
Cabin Floor Area	315 sq.ft.
Cabin Volume	2,520 cu.ft.

Characteristics Summary Basic Mission

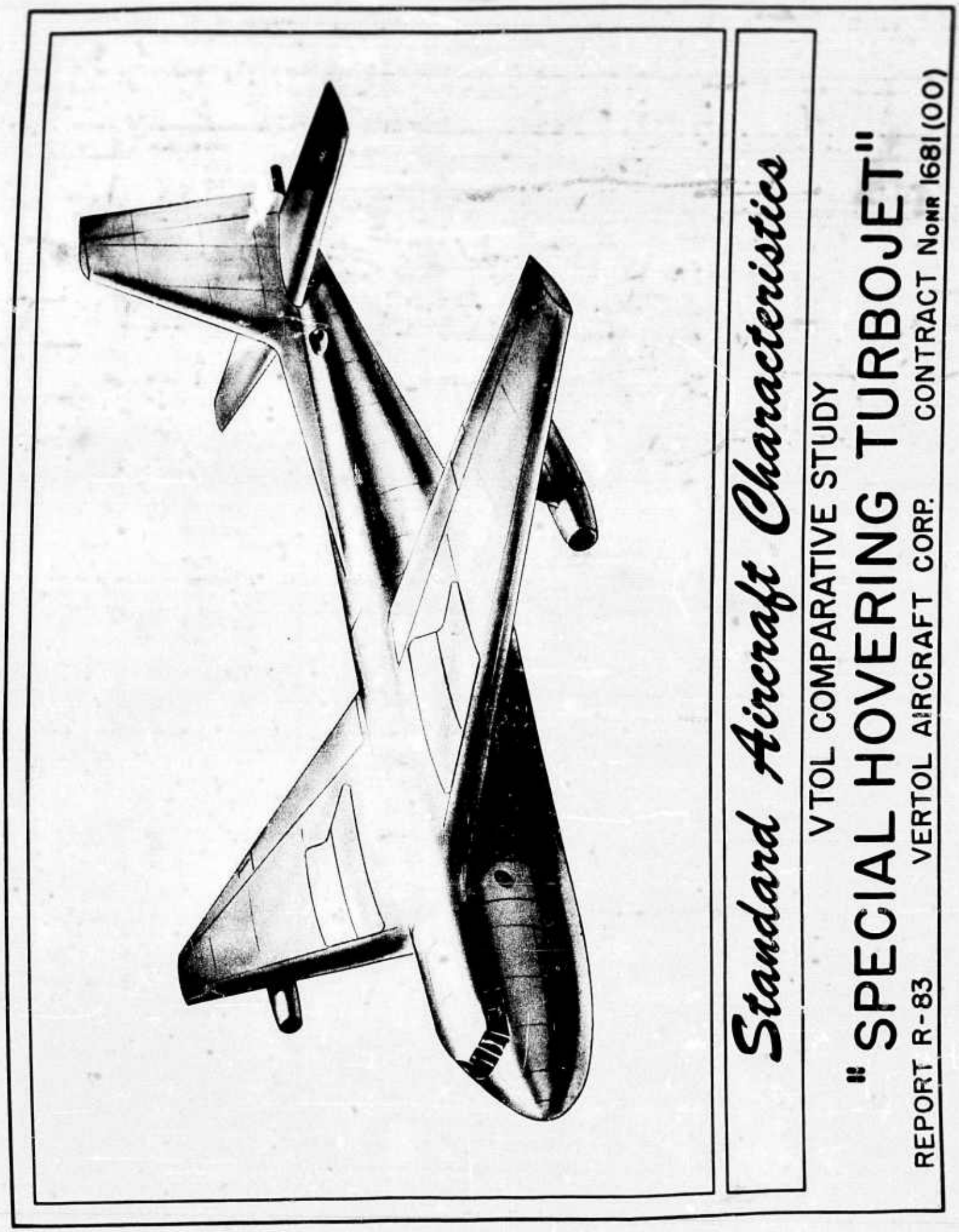


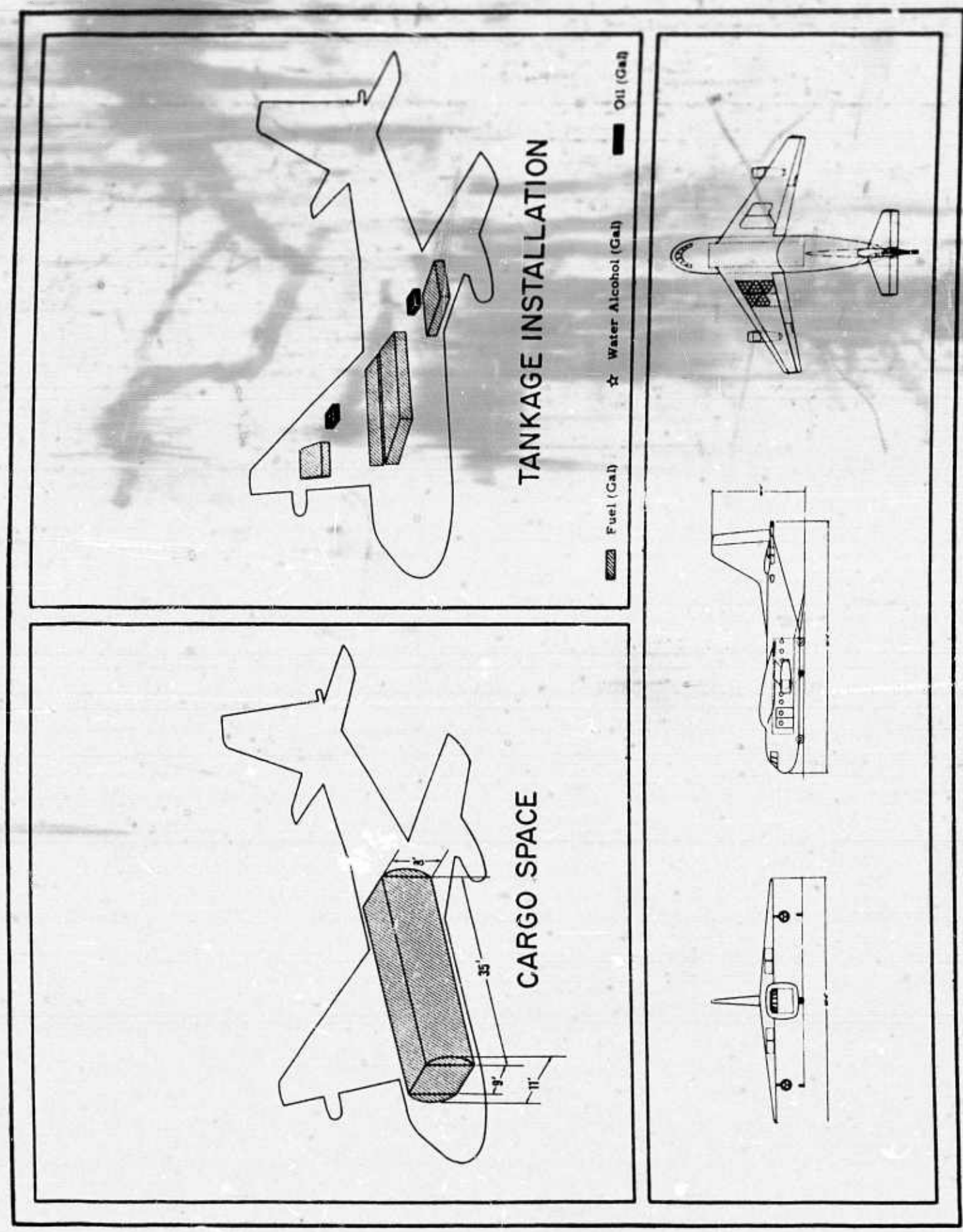
PERFORMANCE

COMBAT RADIUS	FERRY RANGE	SPEED
425 Stat. Mi. with 8000 lb payload at 300 mph avg.	1280 Stat. Mi. with 3280 gal. fuel at 280 mph avg. at 111,313 lb T.O. wt. and 8000 lbs payload	MAX 450 mph at Sea Level ft alt, N.R.P. MAX 455 mph at 10,000 ft alt, N.R.P.
CLIMB	**CEILING**	**TAKE-OFF**
7600 fpm sea level, take-off weight normal power	39800 ft 100 fpm, take-off weight normal power	Vertical Take-Off
6400 fpm 10000 ft take-off weight normal power		
LOAD	**WEIGHTS**	**HOVERING CEIL.**
Crew 600 lbs Payload 8000 lbs Fuel 21320 lbs Oil 400 lbs	Useful 32450 lb Empty 78863 lb Take-Off 111,313 lb	6000 ft., take-off Military Power 95°F Ambient Temperature

NOTES

1. Performance Basis:
   (a) Data Source: Estimated
   (b) Performance is Based on Powers Shown on Page 3
   (c) Data do not include Ground Effect


Standard Aircraft Characteristics
VTOL COMPARATIVE STUDY
"SPECIAL HOVERING TURBOJET"
REPORT R-83
VERTOL AIRCRAFT CORP.
CONTRACT NONR 1681(00)



Special Hovering Turbojet

July 1956

POWER PLANT

No. and Model	(68) J-85
Manufacturer	General Electric
Eng. Spec No.	R55SE5

ENGINE RATINGS

	STATIC THRUST	ALT.
MIL.	2450 lbs.	S. L.
NOR.	2000 lbs.	S. L.

DIMENSIONS

Length	92 ft. 0 in.
Height	35 ft. 0 in.
Wing Span	90 ft. 0 in.
Wing Area	1400 sq. ft.
Wing Aspect Ratio	5.78
Wheel Tread	63 ft. 0 in.

Mission and Description

The basic mission given in detail in the notes is to provide air transportation for troops and cargo with specific requirements for VTOL operation and a radius capability of 425 statute miles.

The special hovering turbojet derives its vertical capabilities from 10 clusters of six modified J-85 turbojets mounted vertically in the inboard wing area. For forward thrust three J-85 engines are installed in pods suspended on each wing. In addition two J-85's are located in the tail for pitch and yaw control and in addition may be used for forward propulsion. Roll control is obtained by bleeding air from the six engines located in the wing pods.

MISCELLANEOUS

WEIGHTS

Normal Gross Wt.
VTOL - 6000' @ 95°F = 107,286 lb.

Weight Empty = 51,506 lb.

FUEL

Normal Internal

6900 Gal. 6.5 lbs./gal.

ELECTRONICS

UHF plus Homing Adapter	ARC-27 and ARA-25
VHF plus Homing Adapter	ARC Type 12 and ARA 3A

Liaison - Range 1000 Miles

Interphone

CONFIDENTIAL

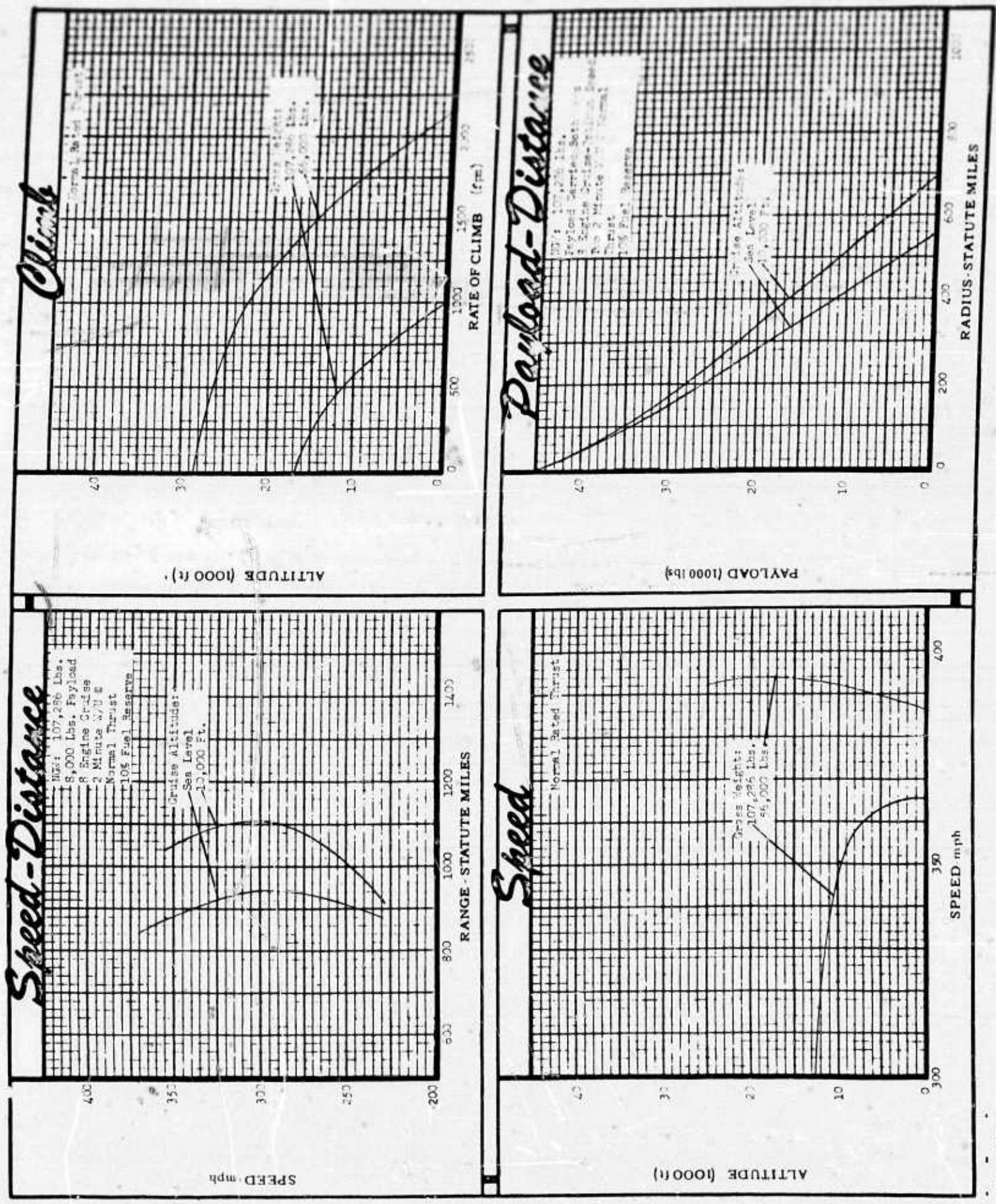
Loading and Performance—Typical Mission

CONDITIONS			BASIC	FERRY RANGE
TAKE-OFF WEIGHT		(lb)	107,285	129,000
Fuel at 6.5 lb/gal		(lb)	44,750	71,594
Payload (outbound)		(lb)	8,000	0
Payload (inbound)		(lb)	4,000	0
Take-off thrust loading		(lb/lb)	5.48	6.59#/#
Disc loading		(lb/sq ft)		
Wing loading		(lb/sq ft)	76.6	92.2
Take-off ground run at 6000 ft. and 95°F/clear 50 ft.	1	(ft)	0/0	
Maximum Speed at S. L.	2	(mph)	364	350
Maximum Speed at 10000 ft.	2	(mph)	347	315
Max. rate of climb at S. L.	2	(fpm)	800	360
Time: SL to 10000 ft.	2	(min)	17.7	
Time: SL to 25000 ft.	2	(min)		
Service ceiling (100 fpm)	2	(ft)	13,600	6,500
COMBAT RADIUS OR RANGE	3	(s. mi)	425	1,570
Average Cruising Speed		(mph)	300	318
Cruising altitude (20% @ S. L.)		(ft)	10,000	S. L.
FIRST LANDING WEIGHT		(lb)	88,336	
Ground roll at 6000 ft. and 95 F	1	(ft)	0	
COMBAT WEIGHT	4	(lb)	75,736	64,566
Cruise altitude		(ft)	10,000	
Cruise speed		(mph)	300	
Service ceiling (100 fpm)	2	(ft)	25,000	29,750
Take-off ground run at 6000 ft and 95°F/clear 50 ft	1	(ft)	0/0	
Max. rate of climb at S. L.	2	(fpm)	1,540	1,850
Time: SL to 10000 ft	2	(min)	7.55	6.1
Time: SL to 25000 ft	2	(min)	32.4	22.3
Max. speed at S. L.	2	(mph)	377	383
Max. speed at 10000 ft.	2	(mph)	382	387
LANDING WEIGHT		(lb)	62,606	64,566
Ground roll at 6000 ft. and 95 F	1	(ft)	0	0

NOTES
1. Military power
2. Normal power
3. Detailed description of missions are given on Page 6
4. With 4000# return payload - no fuel added.

PERFORMANCE BASIS:
(a) Data source: Estimated
(b) Performance is based on powers shown on Page 3
(c) Data do not include ground effect.

CONFIDENTIAL


Speed-Distance
Max: 107,286 Lbs.
8,000 Lbs. Payload
8 Engine Cruise
2 Minute W/U E
Normal Thrust
10% Fuel Reserve
Cruise Altitude:
Sea Level
10,000 Ft.
RANGE - STATUTE MILES
SPEED-mph
Speed
Normal Rated Thrust
Gross Weights:
107,286 Lbs.
86,000 Lbs.
SPEED-mph
ALTITUDE (1000 ft)
Payload-Distance
Cruise Altitude:
Sea Level
10,000 Ft.
RADIUS-STATUTE MILES
PAYLOAD (1000 lbs)
Climb
RATE OF CLIMB (fpm)
ALTITUDE (1000 ft)

JULY, 1956

CONFIDENTIAL

I. The design or basic mission of the aircraft is essentially that of a military transport suitable for transporting either troops or associated equipment with the additional requirement for a vertical take-off capability to increase its mobility in the absence of unprepared landing surfaces.

II. The basic mission requirements in addition to the capability of hovering @ 6,000' and 95°F with military power consist of the following:

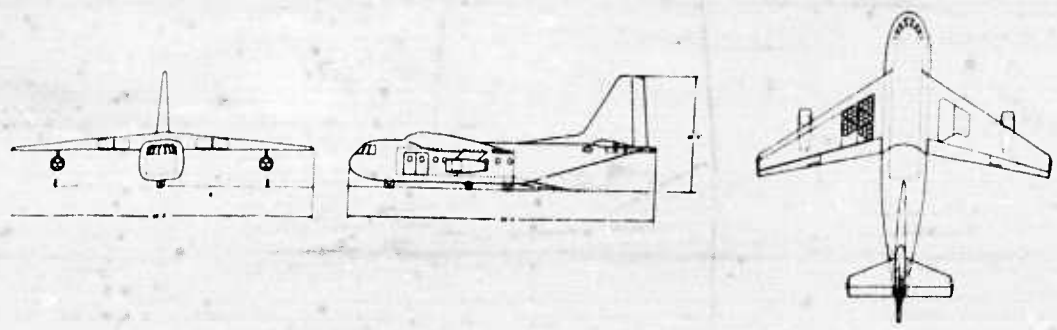
1. Two minute warm-up @ normal power prior to take-off.
2. Take-off vertically with 8,000# payload and climb on course to 10,000' with normal power.
3. Cruise at 10,000', 80 per cent of the required radius (425 statute miles), descend to sea and cruise the remaining 20% to the destination.
4. Hover allowance of 5 minutes @ sea level for vertical take-off and landing operation.
5. Return cruise with 4000# payload is initially @ sea level again for 20% of the required radius followed by a normal power climb to 10,000'. Remaining cruise at 10,000' completes the 425 statute mile radius requirement.
6. Fuel allowances include 10% for reserve with a 5% increase in manufacturer's SFC values.

III. An additional ferry mission applicable to this aircraft consists of the following:

1. Two minute warm-up @ normal power prior to take-off.
2. With a 20% increase in normal gross weight take-off and climb on course with normal power to 1000'.
3. At 1000' cruise out a maximum distance prior to landing with a 10% fuel reserve.
4. Manufacturer's SFC values increased 5%.

CONFIDENTIAL

Characteristics Summary



AVAILABILITY			PROCUREMENT			
Number available			Number to be delivered in fiscal years			
ACTIVE	RESERVE	TOTAL				

STATUS

POWER PLANT

(68) General Electric J-85 Turbojets (60-Hover 8-Fwd)

Engine Ratings

	Static Thrust	Alt
MIL:	2,450 lbs.	S.L.
NOR:	2,000 lbs.	S.L.

FEATURES

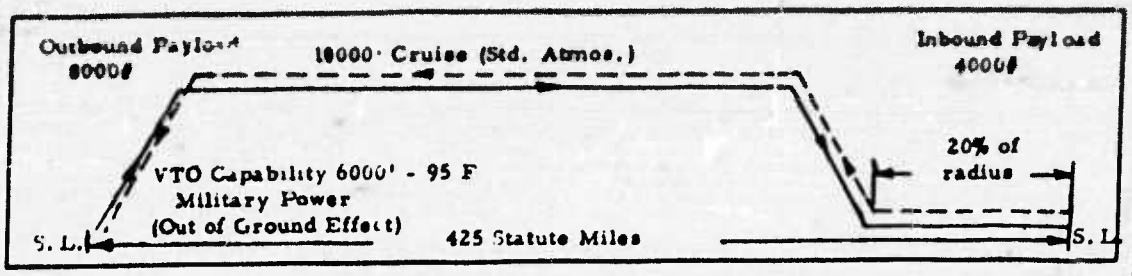
Rear aperature loading ramp.

Cargo floor at truck bed loading height.

GENERAL

Crew	3
Troops	35
Cabin Floor Area	315 sq.ft
Cabin Volume	2,520 cu.ft

Characteristics Summary Basic Mission



PERFORMANCE

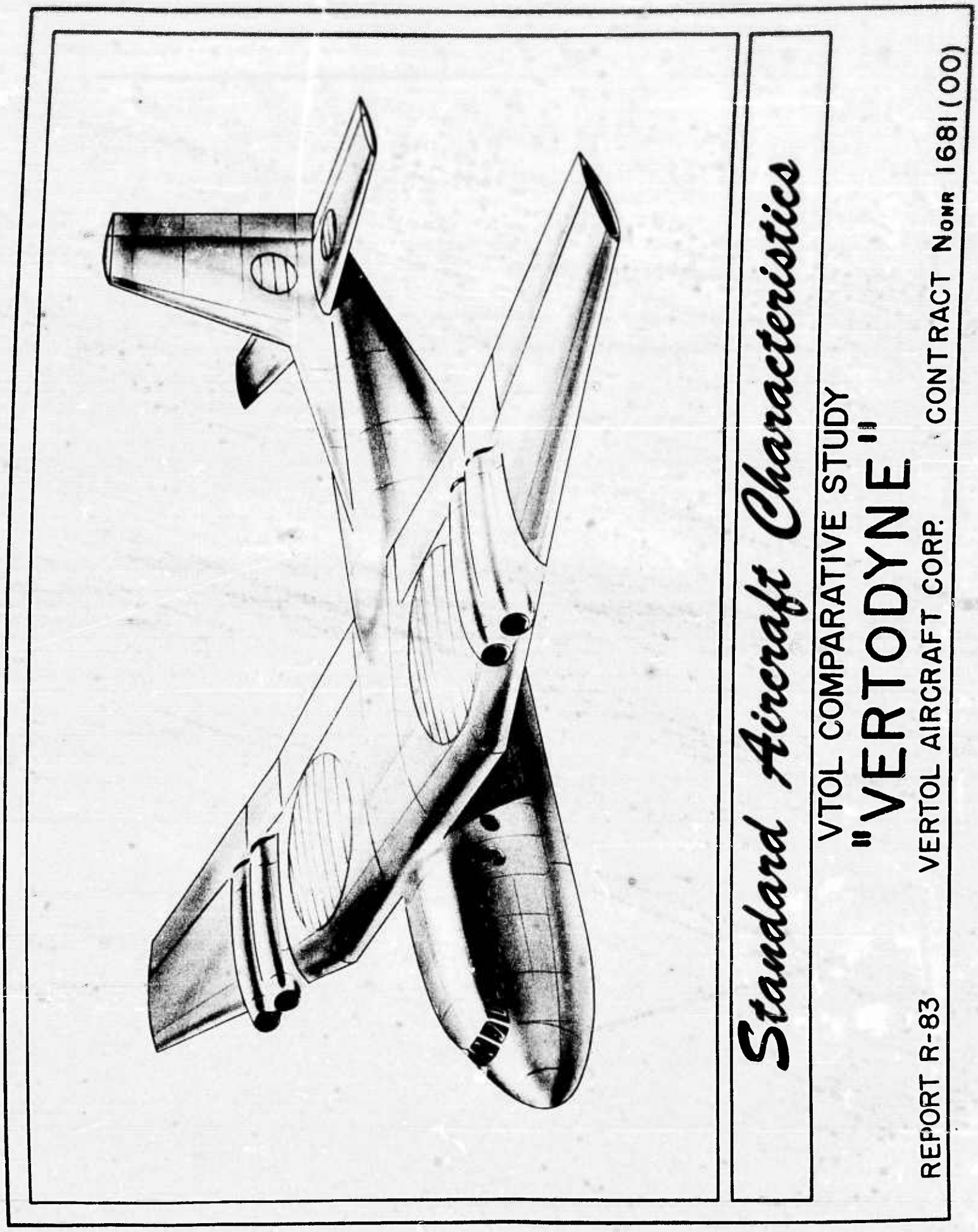
COMBAT RADIUS	FERRY RANGE	SPEED
425 Stat. Mi. with 8000 lb payload at 300 mph avg.	1110 Stat. Mi. with 6900 gal. fuel at 300 mph avg. at 107,286 lb T.O. wt.	MAX 364 mph at Sea Level ft alt, N.R.P. MAX 347 mph at 10,000 ft alt, N.R.P.

CLIMB	CEILING	TAKE-OFF
800 fpm sea level, take-off weight normal power	13600 ft 100 fpm, take-off weight normal power	Vertical Take-Off
330 fpm 10000 ft take-off weight normal power		

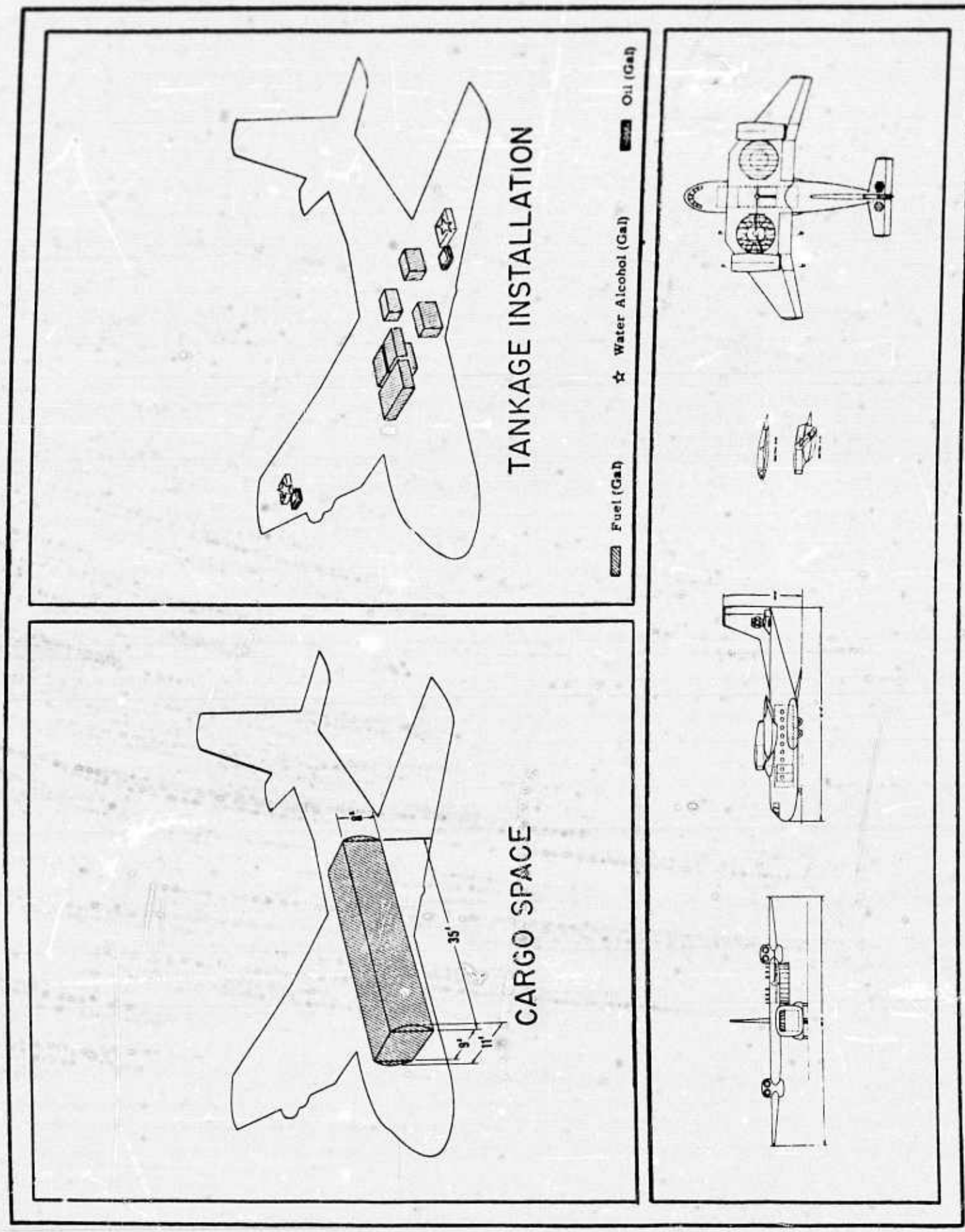
LOAD		WEIGHTS		HOVERING CEIL.
Crew	600 lbs	Useful	55,780 lb	6000 ft., take-off Military Power 95°F Ambient Temperature
Payload	8000 lbs	Empty	51,506 lb	
Fuel	44750 lbs	Take-Off	107,286 lb	
Oil	1360 lbs			

NOTES

1. Performance Basis:
   (a) Data Source: Estimated
   (b) Performance is Based on Powers Shown on Page 3
   (c) Data do not include Ground Effect


Standard Aircraft Characteristics
VTOL COMPARATIVE STUDY
"VERTODYNE"
VERTOL AIRCRAFT CORP.
CONTRACT NONR 1681(00)
REPORT R-83

CONFIDENTIAL



CONFIDENTIAL

POWER PLANT

No. and Model	(4) J-79
Manufacturer	General Electric
Eng. Spec No.	R55AGT400

ENGINE RATINGS

	STATIC THRUST	ALT.
MIL.	10,000 lbs.	S. L.
NOR.	9,700 lbs.	S. L.

Mission and Description

The basic mission given in detail in the notes is to provide air transportation for troops and cargo with specific requirements for VTOL operation and a radius capability of 425 statute miles.

The Vertodyne derives its VTOL capabilities by means of interconnected ducted fans located in the inboard section of the wing. The ducted fans are mechanically driven by a power turbine separated by means of ducting from the gas generator of four modified J-79 turbojets. The engines are mounted horizontally on the wing outboard of the ducted fans so that they operate as conventional turbojets in forward flight and as turboprops in the hovering condition.

Pitch and yaw control is obtained from shaft driven tail fans while control in roll is obtained by differential thrust of the main lifting fans.

WEIGHTS

Normal Gross Wt. VTOL 6000' @ 95°F =	113,958 lb.
Weight Empty =	66,910 lb.

FUEL

Normal Internal

5760 Gal. 6.5 lbs./gal

DIMENSIONS

Length	91 ft. 0 in.
Height	34 ft. 9 in.
Wing Span	106 ft. 0 in.
Wing Area	2284
Wing Aspect Ratio	4.91
Wheel Tread	13 ft. 6 in.

MISCELLANEOUS

ELECTRONICS

UHF plus Homing Adapter	ARC-27 and ARA-25
VHF plus Homing Adapter	ARC Type 12 and ARA 8A
Liaison - Range 1000 Miles	
Interphone	

CONFIDENTIAL

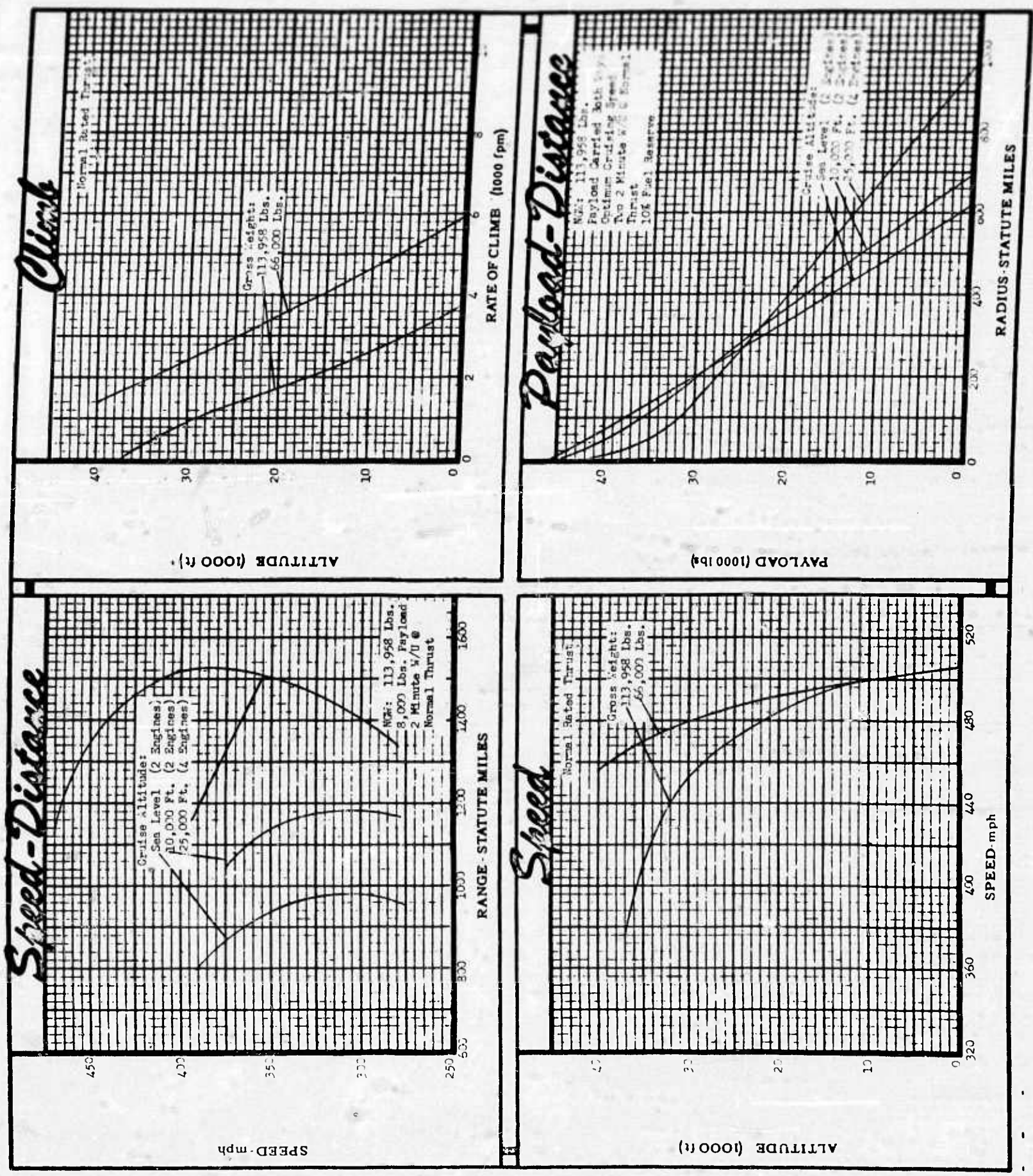
Loading and Performance—Typical Mission

CONDITIONS			BASIC	FERRY RANGE
TAKE-OFF WEIGHT		(lb)	113,958	136,900
Fuel at 6.5 lb/gal		(lb)	37,510	65,358
Payload (outbound)		(lb)	8,000	0
Payload (inbound)		(lb)	4,000	0
Take-off power loading		(lb/Shp)	2.1	2.52
Disc loading		(lb/sq ft)	259	311
Wing loading		(lb/sq ft)	49.8	60.0
Take-off ground run at 6000 ft. and 95°F/clear 50 ft.	1	(ft)	0/0	
Maximum Speed at S. L.	2	(mph)	506	506
Maximum Speed at 10000 ft.	2	(mph)	500	500
Max. rate of climb at S. L.	2	(fpm)	3,660	3,200
Time: SL to 10000 ft.	2	(min)	3.40	3.7
Time: SL to 25000 ft.	2	(min)	10.59	11.9
Service ceiling (100 fpm)	2	(ft)	37,000	33,500
COMBAT RADIUS OR RANGE	3	(s. mi)	425	2,480
Average Cruising Speed		(mph)	400	420
Cruising altitude (20% @ S. L.)		(ft)	10,000	25,000
FIRST LANDING WEIGHT		(lb)	97,433	
Ground roll at 6000 ft. and 95 F	1	(ft)	0	
COMBAT WEIGHT	4	(lb)	90,773	78,438
Cruise altitude		(ft)	10,000	
Cruise speed		(mph)	400	
Service ceiling (100 fpm)	2	(ft)	42,500	44,500
Take-off ground run at 6000 ft and 95°F/clear 50 ft	1	(ft)	0/0	
Max. rate of climb at S. L.	2	(fpm)	4,450	5,100
Time: SL to 10000 ft	2	(min)	2.7	2.20
Time: SL to 25000 ft	2	(min)	8.82	6.95
Max. speed at S. L.	2	(mph)	506	506
Max. speed at 10000 ft.	2	(mph)	500	500
LANDING WEIGHT		(lb)	76,198	78,438
Ground roll at 6000 ft. and 95 F	1	(ft)	0	0

NOTES
1. Military power
2. Normal power
3. Detailed description of missions are given on Page 6
4. With 4000# return payload - no fuel added.

PERFORMANCE BASIS:
(a) Data source: Estimated
(b) Performance s based on powers shown on Page 3
(c) Data do not include ground effect.

CONFIDENTIAL


Climb
Normal Rated Thrust
Gross Weights:
113,958 Lbs.
66,000 Lbs.
RATE OF CLIMB (1000 fpm)
ALTITUDE (1000 ft)
Payload-Distance
NGW: 113,958 Lbs.
Payload Carried Both Ways
Optimum Cruising Speed
Two 2 Minute W/U @ Normal
Thrust
10% Fuel Reserve
Cruise Altitude:
Sea Level (2 Engines)
10,000 Ft. (2 Engines)
25,000 Ft. (4 Engines)
RADIUS-STATUTE MILES
PAYLOAD (1000 lbs)
Speed-Distance
Cruise Altitude:
Sea Level (2 Engines)
10,000 Ft. (2 Engines)
25,000 Ft. (4 Engines)
NGW: 113,958 Lbs.
8,000 Lbs. Payload
2 Minute W/U @
Normal Thrust
RANGE-STATUTE MILES
SPEED-mph
Speed
Normal Rated Thrust
Gross Weights:
113,958 Lbs.
66,000 Lbs.
SPEED-mph
ALTITUDE (1000 ft)

JULY, 1956

CONFIDENTIAL

N O T E S

I. The design or basic mission of the aircraft is essentially that of a military transport suitable for transporting either troops or associated equipment with the additional requirement for a vertical take-off capability to increase its mobility in the absence of unprepared landing surfaces.

II. The basic mission requirements in addition to the capability of hovering @ 6,000' and 95°F with military power consist of the following:

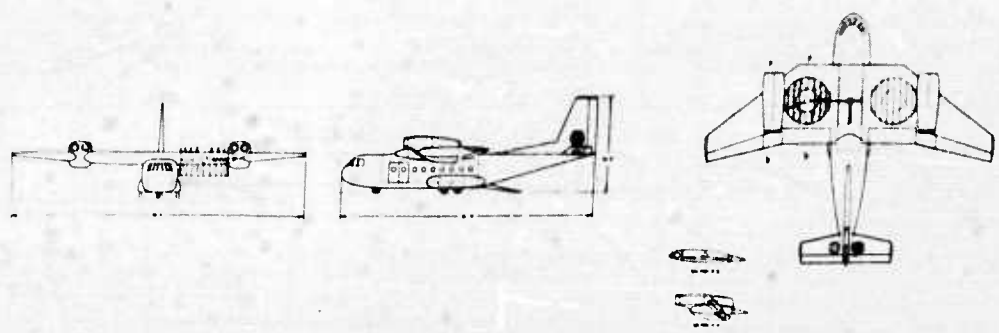
1. Two minute warm-up @ normal power prior to take-off.
2. Take-off vertically with 8,000# payload and climb on course to 10,000' with normal power.
3. Cruise at 10,000', 80 per cent of the required radius (425 statute miles), descend to sea and cruise the remaining 20% to the destination.
4. Hover allowance of 5 minutes @ sea level for vertical take-off and landing operation.
5. Return cruise with 4000# payload is initially @ sea level again for 20% of the required radius followed by a normal power climb to 10,000'. Remaining cruise at 10,000' completes the 425 statute mile radius requirement.
6. Fuel allowances include 10% for reserve with a 5% increase in manufacturer's SFC values.

III. An additional ferry mission applicable to this aircraft consists of the following:

1. Two minute warm-up @ normal power prior to take-off.
2. With a 20% increase in normal gross weight take-off and climb on course with normal power to 25,000'.
3. At 25,000' cruise out a maximum distance prior to landing with a 10% fuel reserve.
4. Manufacturer's SFC values increased 5%.

CONFIDENTIAL

Characteristics Summary



AVAILABILITY			PROCUREMENT			
Number available			Number to be delivered in fiscal years			
ACTIVE	RESERVE	TOTAL				

STATUS

POWER PLANT

(4) General Electric J-79 Turbojets

Engine Ratings

	Static Thrust	Alt
MIL:	10,000 lbs.	S.L.
MCR:	9,700 lbs.	S.L.

FEATURES

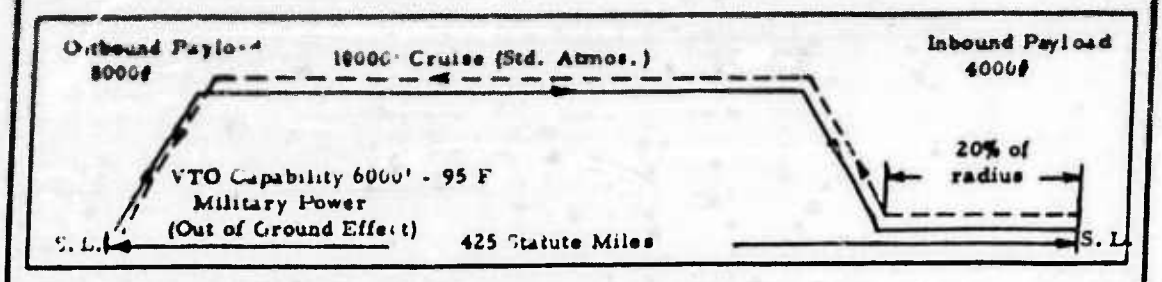
Rear aperature loading ramp.

Cargo floor at truck bed loading height.

GENERAL

Crew	3
Troops	35
Cabin Floor Area	315 sq.ft.
Cabin Volume	2,520 cu.ft.

Characteristics Summary Basic Mission



PERFORMANCE

COMBAT RADIUS	FERRY RANGE	SPEED
425 Stat. Mi. with 8000 lb payload at 400 mph avg.	1530 Stat. Mi. with 5770 gal. fuel at 385 mph avg. at 113,958 lb T.O. wt. and 8000 lbs payload	MAX 506 mph at Sea Level ft alt, N.R.P. MAX 500 mph at 10,000 ft alt, N.R.P.
CLIMB	**CEILING**	**TAKE-OFF**
3650 fpm sea level, take-off weight normal power	37000 ft 100 fpm, take-off weight normal power	Vertical Take-Off
2550 fpm 10000 ft take-off weight normal power		
LOAD	**WEIGHTS**	**HOVERING CEIL.**
Crew 600 lbs Payload 8000 lbs Fuel 37510 lbs Oil 300 lbs	Useful 47048 lb Empty 66910 lb Take-Off 113,958 lb	6000 ft., take-off Military Power 95°F Ambient Temperature

NOTES

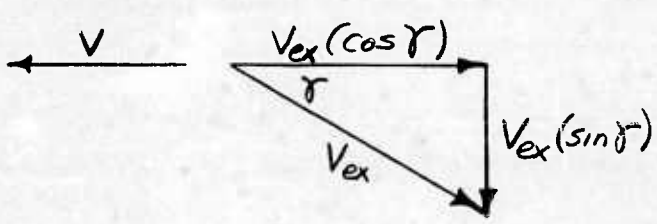
1. Performance Basis:
   (a) Data Source. Estimated
   (b) Performance is Based on Powers Shown on Page 3
   (c) Data do not include Ground Effect

VECTODYNE - FORWARD FLIGHT PERFORMANCE

In the broad parametric analysis (Reference (a)) performance evaluation for the "Vectodyne" concept was estimated from equations which were arrived at following a series of discussions with Dr. Lippisch of Collins Radio Corporation and considered adequate for the study at the time.

However, the methods used have been altered to better reflect the thrust and power requirements for the Vectodyne and are based on the momentun and energy principles.

If a mass of air is directed through a duct which is moving at some velocity (V) and deflected through an angle (γ) so that its exit velocity (V_{ex}) is greater than (V), a velocity diagram for this condition would be as follows:



V = forward speed (f.p.s.)

V_{ex} = velocity of air at exit of duct (f.p.s.)

γ = angle of deflection of air mass

ρ = density of air (slugs/ft.^{3})

f = equivalent flat plate of aircraft (ft.^{2})

A_{ex} = exit area of duct (ft.^{2})

The mass flow of air at the duct's exit multiplied by the net horizontal velocity would give the force available in the horizontal direction. Now if V_{ex} > than V so that the net horizontal velocity

is ($V_{ex} \times \cos\gamma - V$), then the horizontal force (T_H) will be:

$$T_H = (\rho A_{ex} V_{ex})(V_{ex} \cos\gamma - V) \qquad (1)$$

Since $V_{ex} > V$, the horizontal force (T_H) can be utilized to overcome the drag (D_p) of an aircraft traveling at a velocity (V), and since $D_p = \frac{1}{2}\rho V^2 f$ then:

$$D_p = T_H \qquad (1a)$$

or $$\frac{1}{2}\rho V^2 f = \rho A_{ex} V_{ex} (V_{ex} \cos\gamma - V)$$

Similarly, the net velocity in the vertical direction ($V_{ex} \sin\gamma$)multiplied by the mass flow of air at the duct's exit would give the force available in the vertical direction:

$$T_V = (\rho A_{ex} V_{ex})(V_{ex} \sin\gamma) \qquad (2)$$

This force (T_V) must be equal to the weight (W) of the aircraft traveling at velocity (V) in level forward flight.

or $$W = T_V = (\rho A_{ex} V_{ex})(V_{ex} \sin\gamma) \qquad (2a)$$

The horsepower required (P) to move the aircraft traveling at velocity (V) in level forward flight must equal the change in Kinetic energy per second:

$$P = \frac{\left(\frac{\rho A_{ex} V_{ex}}{2}\right) V_{ex}^2 - \left(\frac{\rho A_{ex} V_{ex}}{2}\right) V^2}{550} \qquad (3)$$

or, $$P = \frac{\rho A_{ex} V_{ex}}{1100}(V_{ex}^2 - V^2) \qquad (3a)$$

In order to incorporate the effect of compressibility and drag at higher forward speeds, equation (1a) should be altered as follows:

$$\frac{1}{2}\rho V^2 f\left(\frac{C_{d_o}}{C_{d_{inc}}}\right) = \rho A_{ex} V_{ex}\left(V_{ex}\cos\gamma - V\right) \qquad (1b)$$

Now, solving equation (1b) for V_{ex} the following expression is obtained:

$$V_{ex} = V\left[\frac{2A_{ex} \pm \sqrt{4A_{ex}^2 + 8A_{ex}(\cos\gamma) f\left(\frac{C_{d_o}}{C_{d_{inc}}}\right)}}{4A_{ex}(\cos\gamma)}\right]$$

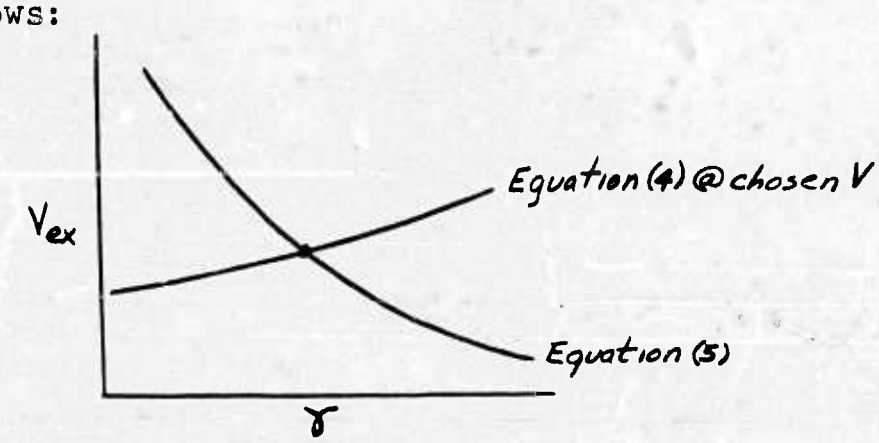
$$\text{let } \beta = \left[\frac{2A_{ex} \pm \sqrt{4A_{ex} + 8A_{ex}(\cos\gamma) f\left(\frac{C_{d_o}}{C_{d_{inc}}}\right)}}{4A_{ex}(\cos\gamma)}\right]$$

$$\therefore \quad V_{ex} = V(\beta) \qquad (4)$$

Solving equation (2a) for V_{ex}, the following expression is obtained:

$$V_{ex} = \sqrt{\frac{W}{A_{ex}(\sin\gamma)\rho}} \qquad (5)$$

Equation (4) expresses V_{ex} as a function of forward speed (V) and deflection angle (γ), and equation (5) expresses V_{ex} as a function of (γ) and air density, (ρ), or altitude. For a given set of conditions, i.e., forward speed, altitude, and gross weight, two solutions for V_{ex} can be obtained as a function of γ and plotted as follows:



CONFIDENTIAL

AD 147927

Armed Services Technical Information Agency

ARLINGTON HALL STATION
ARLINGTON 12 VIRGINIA

FOR
MICRO-CARD
CONTROL ONLY

2 OF 2

NOTICE: WHEN GOVERNMENT OR OTHER DRAWINGS, SPECIFICATIONS OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE U. S. GOVERNMENT THEREBY INCURS NO RESPONSIBILITY, NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

CONFIDENTIAL

The intersection of these two functions yields the required deflection setting (γ) and corresponding exit velocity (V_{ex}) necessary to maintain level forward flight at the chosen forward speed (V) and given set of conditions.

The power required for this set of conditions can now be easily obtained from equation (3a) rearranged as follows:

$$SHP_{REQ} = \frac{1}{\eta_t}\left(\frac{\rho A_{ex}}{1100}\right) V\beta\left[(V\beta)^2 - V^2\right] \tag{6}$$

or

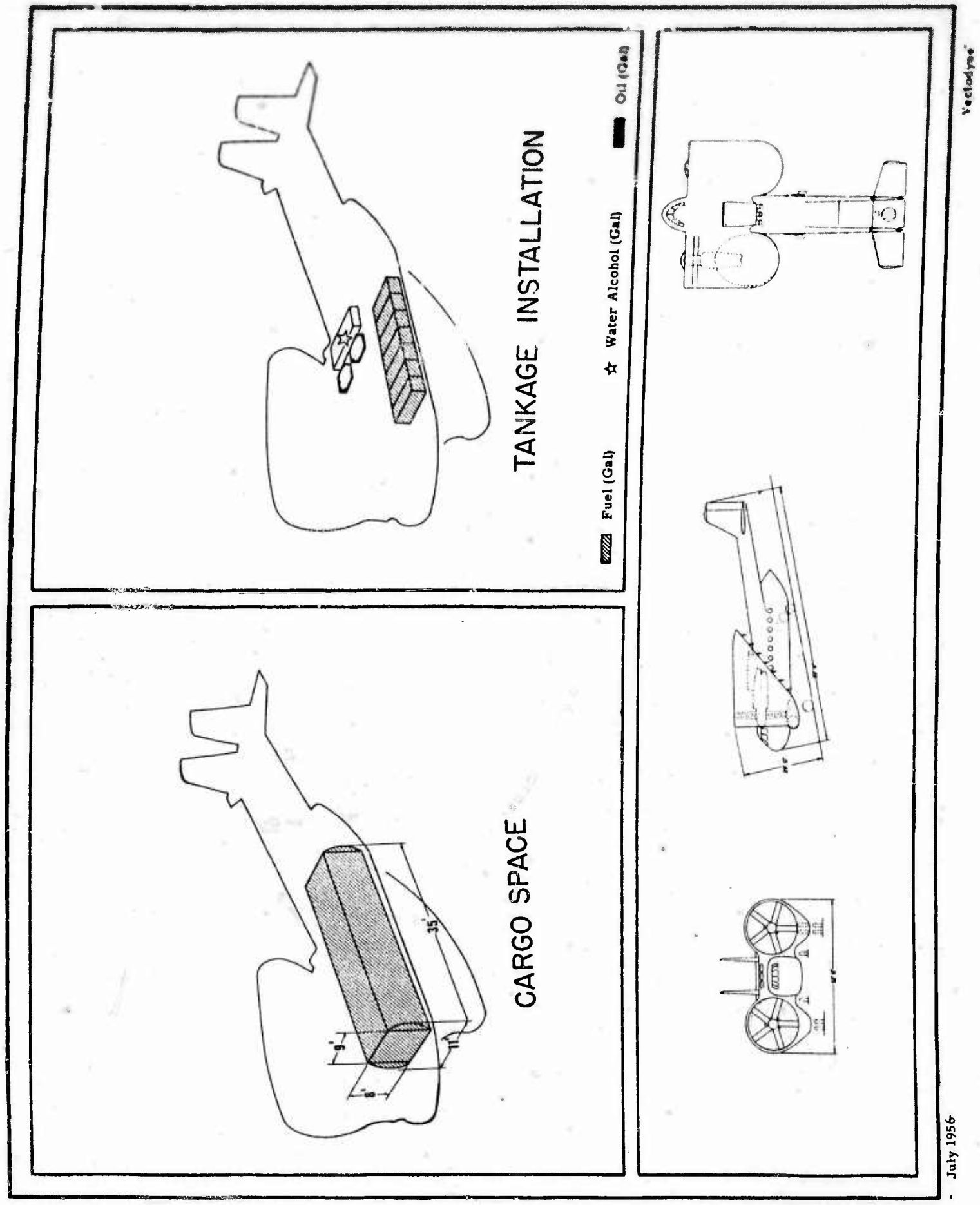
$$SHP_{REQ} = \frac{\rho A_{ex}}{\eta_t (1100)} V^3 \beta(\beta+1)(\beta-1)$$

where, η_t accounts for transmission and duct losses and propeller efficiency.

Standard Aircraft Characteristics

VTOL COMPARATIVE STUDY
"VECTODYNE"
(AERODYNE PRINCIPLE)
VERTOL AIRCRAFT CORP.

REPORT R-83 CONTRACT NONR 1681(00)


TANKAGE INSTALLATION
Fuel (Gal)
Water Alcohol (Gal)
Oil (Gal)
CARGO SPACE
35'
9'
8'
11'
Vectodyne
July 1956

POWER PLANT

No. and Model	(9) 550 B-1
Manufacturer	Allison
Eng. Spec No.	394-B

ENGINE RATINGS

	SHP	RPM	ALT.
T.O.	5168	9900	S.L.
MIL.	5168	9900	S.L.
NOR.	4590	9900	S.L.

DIMENSIONS

Length	87 ft. 9 in.
Height	29 ft. 0 in.
Width	52 ft. 0 in.
Prop. Dia.	18 ft. 0 in.
Wheel Tread	32 ft. 6 in.

Mission and Description

The basic mission given in detail in the notes is to provide air transportation for troops and cargo with specific requirements for VTOL operation and a radius capability of 425 statute miles.

This aircraft employs two outboard mounted counter-rotating ducted propellers which supply airflow to controllable deflector vanes mounted horizontally at the exit of the ducts. The position of these vanes controls the direction of thrust for both the hovering and forward flight condition. The propellers are interconnected with the power plants, three of which are located in each of two outboard nacelles and the remaining three atop the fuselage.

Both yaw and roll control are obtained through adjustment of the propeller pitch and deflector vanes working in combination. Pitch control is obtained from a single ducted tail fan centrally located within the horizontal tail surface and interconnected with the main power source.

MISCELLANEOUS

WEIGHTS

Normal Gross Wt. VTOL - 6000' @ 95°F =	121,790 lb.
Weight Empty	72,380 lb.

FUEL

Normal Internal

5840 Gal. 6.5 lbs./gal.

ELECTRONICS

UHF plus Homing Adapter	ARC-27 and ARA-25
VHF plus Homing Adapter	ARC Type 12 and APA 8A
Liaison - Range 1000 Miles	
Interphone	

CONFIDENTIAL

CONFIDENTIAL

Loading and Performance—Typical Mission

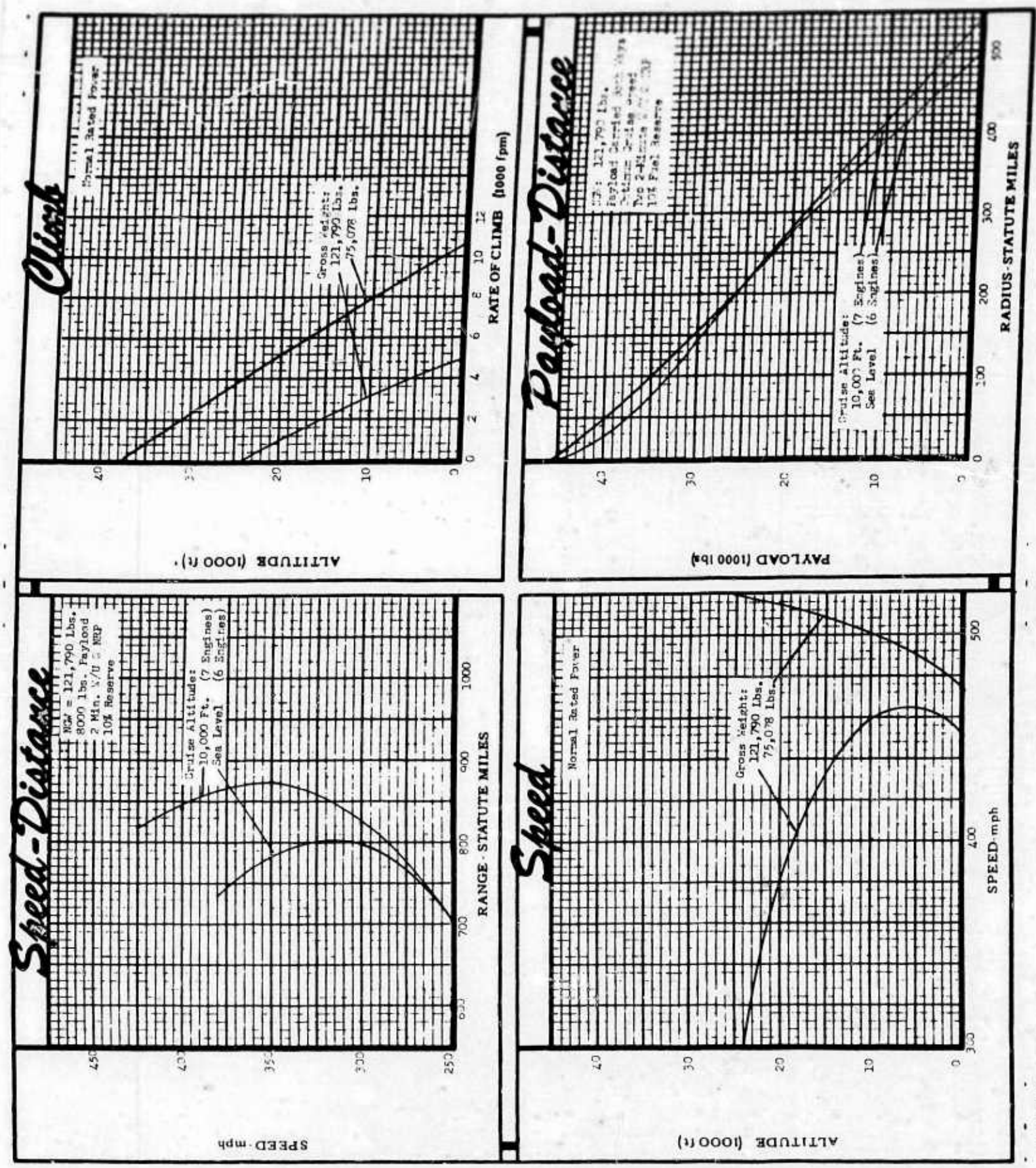
CONDITIONS			BASIC	FERRY RANGE
TAKE-OFF WEIGHT		(lb)	121,790	145,000
Fuel at 6.5 lb/gal		(lb)	37,950	66,720
Payload (outbound)		(lb)	8,000	0
Payload (inbound)		(lb)	4,000	0
Take-off power loading		(lb/Shp)	2.60	3.12
Disc loading		(lb/sq ft)	237	284
Wing loading		(lb/sq ft)		
Take-off ground run at 6000 ft. and 95°F/clear 50 ft.	1	(ft)	0/0	
Maximum Speed at S. L.	2	(mph)	450	425
Maximum Speed at 10000 ft.	2	(mph)	450	400
Max. rate of climb at S. L.	2	(fpm)	5,850	3,300
Time: SL to 10000 ft.	2	(min)	2.11	4.55
Time: SL to 25000 ft.	2	(min)		
Service ceiling (100 fpm)	2	(ft)	24,000	15,000
COMBAT RADIUS OR RANGE	3	(s. mi)	425	1,185
Average Cruising Speed		(mph)	375	320
Cruising altitude (20% @ S. L.)		(ft)	10,000	S. L.
FIRST LANDING WEIGHT		(lb)	103,040	
Ground roll at 6000 ft. and 95 F	1	(ft)	0	
COMBAT WEIGHT	4	(lb)	97,050	84,950
Cruise altitude		(ft)	10,000	
Cruise speed		(mph)	350	
Service ceiling (100 fpm)	2	(ft)	32,400	35,000
Take-off ground run at 6000 ft and 95°F/clear 50 ft	1	(ft)	0/0	
Max. rate of climb at S. L.	2	(fpm)	9,100	11,500
Time: SL to 10000 ft	2	(min)	1.15	.95
Time: SL to 25000 ft	2	(min)	4.54	3.25
Max. speed at S. L.	2	(mph)	462	470
Max. speed at 10000 ft.	2	(mph)	483	494
LANDING WEIGHT		(lb)	82,730	84,950
Ground roll at 6000 ft. and 95 F	1	(ft)	0	0

NOTES
1. Military power
2. Normal power
3. Detailed description of missions are given on Page 6
4. With 4000# return payload - no fuel added.

PERFORMANCE BASIS:
(a) Data source: Estimated
(b) Performance is based on powers shown on Page 3
(c) Data do not include ground effect.

Teledyne

CONFIDENTIAL


Climb
Normal Rated Power
Gross Weight:
121,790 Lbs.
75,078 Lbs.
RATE OF CLIMB (1000 fpm)
ALTITUDE (1000 ft)
Payload-Distance
Cruise Altitude:
10,000 Ft. (7 Engines)
Sea Level (6 Engines)
RADIUS-STATUTE MILES
PAYLOAD (1000 lbs)
Speed-Distance
NGW = 121,790 Lbs.
8000 Lbs. Payload
2 Min. W/U = MRP
10% Reserve
Cruise Altitude:
10,000 Ft. (7 Engines)
Sea Level (6 Engines)
RANGE-STATUTE MILES
SPEED-mph
Speed
Normal Rated Power
Gross Weight:
121,790 Lbs.
75,078 Lbs.
SPEED-mph
ALTITUDE (1000 ft)

CONFIDENTIAL

N O T E S

I. The design or basic mission of the aircraft is essentially that of a military transport suitable for transporting either troops or associated equipment with the additional requirement for a vertical take-off capability to increase its mobility in the absence of unprepared landing surfaces.

II. The basic mission requirements in addition to the capability of hovering @ 6,000' and 95°F with military power consist of the following:

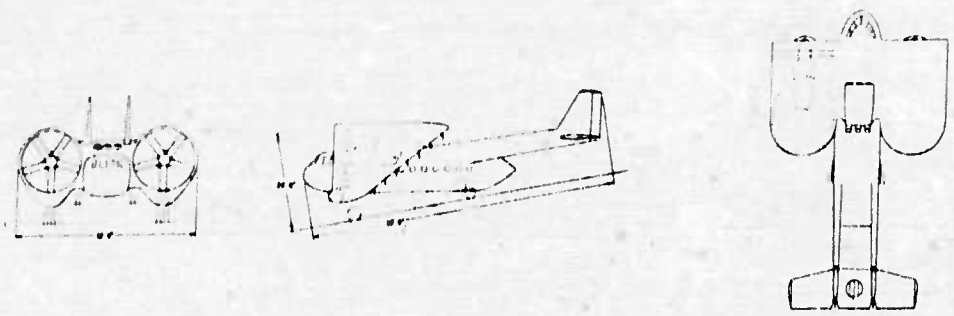
1. Two minute warm-up @ normal power prior to take-off.
2. Take-off vertically with 8,000# payload and climb on course to 10,000' with normal power.
3. Cruise at 10,000', 80 per cent of the required radius (425 statute miles), descend to sea and cruise the remaining 20% to the destination.
4. Hover allowance of 5 minutes @ sea level for vertical take-off and landing operation.
5. Return cruise with 4000# payload is initially @ sea level again for 20% of the required radius followed by a normal power climb to 10,000'. Remaining cruise at 10,000' completes the 425 statute mile radius requirement.
6. Fuel allowances include 10% for reserve with a 5% increase in manufacturer's SFC values.

III. An additional ferry mission applicable to this aircraft consists of the following:

1. Two minute warm-up @ normal power prior to take-off.
2. With a 20% increase in normal gross weight take-off and climb on course with normal power to 10000'.
3. At 10000' cruise out a maximum distance prior to landing with a 10% fuel reserve.
4. Manufacturer's SFC values increased 5%.

CONFIDENTIAL

Characteristics Summary



AVAILABILITY			PROCUREMENT			
Number available			Number to be delivered in fiscal years			
ACTIVE	RESERVE	TOTAL				

STATUS

POWER PLANT

(9) Allison 550 B-1 Turboprops

Engine Ratings

	SHP	RPM	ALT
TO:	5168	9900	S.L.
MIL:	5168	9900	S.L.
NOR:	4590	9900	S.L.

FEATURES

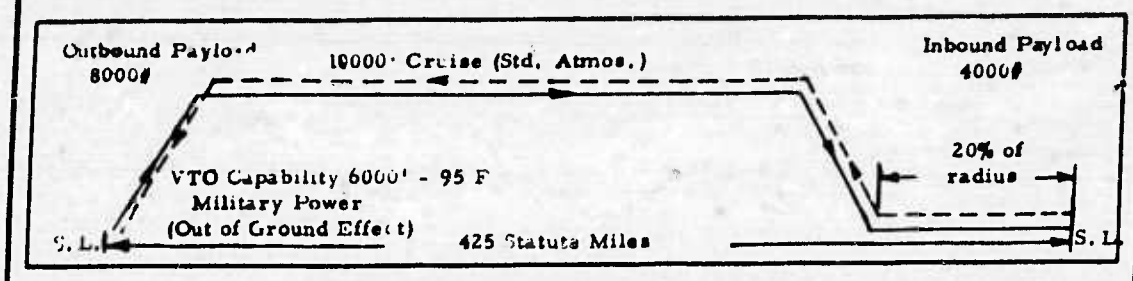
Rear aperature loading ramp.

Cargo floor at truck bed loading height.

GENERAL

Crew	3
Troops	35
Cabin Floor Area	315 sq.ft.
Cabin Volume	2,520 cu.ft.

Characteristics Summary Basic Mission



PERFORMANCE

COMBAT RADIUS	FERRY RANGE	SPEED
425 Stat. Mi. with 8000 lb payload at 360 mph avg.	360 Stat. Mi. with 5840 gal. fuel at 350 mph avg. at 121790 lb T.O. wt. and 8000 lbs. Payload	MAX 450 mph at Sea Level ft alt, N.R.P. MAX 460 mph at 10,000 ft alt, N.R.P.
CLIMB	**CEILING**	**TAKE-OFF**
5850 fpm sea level, take-off weight normal power	24000 ft 100 fpm, take-off weight normal power	Vertical Take-Off
3650 fpm 10000 ft take-off weight normal power		
LOAD	**WEIGHTS**	**HOVERING CEIL.**
Crew 600 lbs Payload 8000 lbs Fuel 37950 lbs Oil 450 lbs	Useful 49410 lb Empty 72380 lb Take-Off 121,790 lb	6000 ft., take-off Military Power 95°F Ambient Temperature

NOTES

1. Performance Basis:
   (a) Data Source: Estimated
   (b) Performance is Based on Powers Shown on Page 3
   (c) Data do not include Ground Effect

July 1956

Vectodyne

IV. REFERENCES

(a) Vertol Aircraft Corporation Report R-75 - "Comparative Study of Various Types of VTOL Aircraft - Interim Summary Report."

(b) Vertol Aircraft Corporation Report R-76 - "Comparative Study of Various Types of VTOL Transport Aircraft - Configuration Studies Report."

(c) Perkins and Hage - "Airplane Performance, Stability and Control."

UNCLASSIFIED

UNCLASSIFIED