ORBITAL TRANSFER VEHICLE STUDIES OVERVIEW

PRESENTATION TO THE CRYOGENIC FLUID MANAGEMENT TECHNOLOGY WORKSHOP

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APRIL 28,1987
NASA/MSFC

ORBITAL TRANSFER VEHICLE CONCEPT DEFINITION AND SYSTEM ANALYSIS STUDIES

OBJECTIVES:

- INVESTIGATE ALTERNATIVE OTV CONCEPTS AND CONDUCT PROGRAM LEVEL STUDIES AND ASSESSMENTS WHICH WILL ALLOW FOCUSING THE OTV PROGRAM TOWARD FUTURE DEVELOPMENT.
- DEFINE POTENTIAL SPACE STATION ACCOMMODATIONS HARDWARE ELEMENTS, RESOURCES, AND INTERFACES NECESSARY TO SUPPORT A SPACE-BASED OTV FLEET.

CONTRACTOR DATA:

- TWO PARALLEL STUDIES UNDER COMPETITIVELY AWARDED CONTRACTS

  - BOEING AEROSPACE COMPANY (SEATTLE, WA)
  - MARTIN MARIETTA AEROSPACE (DENVER, CO)

- ONE PARALLEL STUDY CONDUCTED UNDER COMPANY FUNDS DURING PHASES I & II

  -GENERAL DYNAMICS SPACE SYSTEMS DIVISION (SAN DIEGO, CA)

- $1.6 M EACH CONTRACTED STUDY

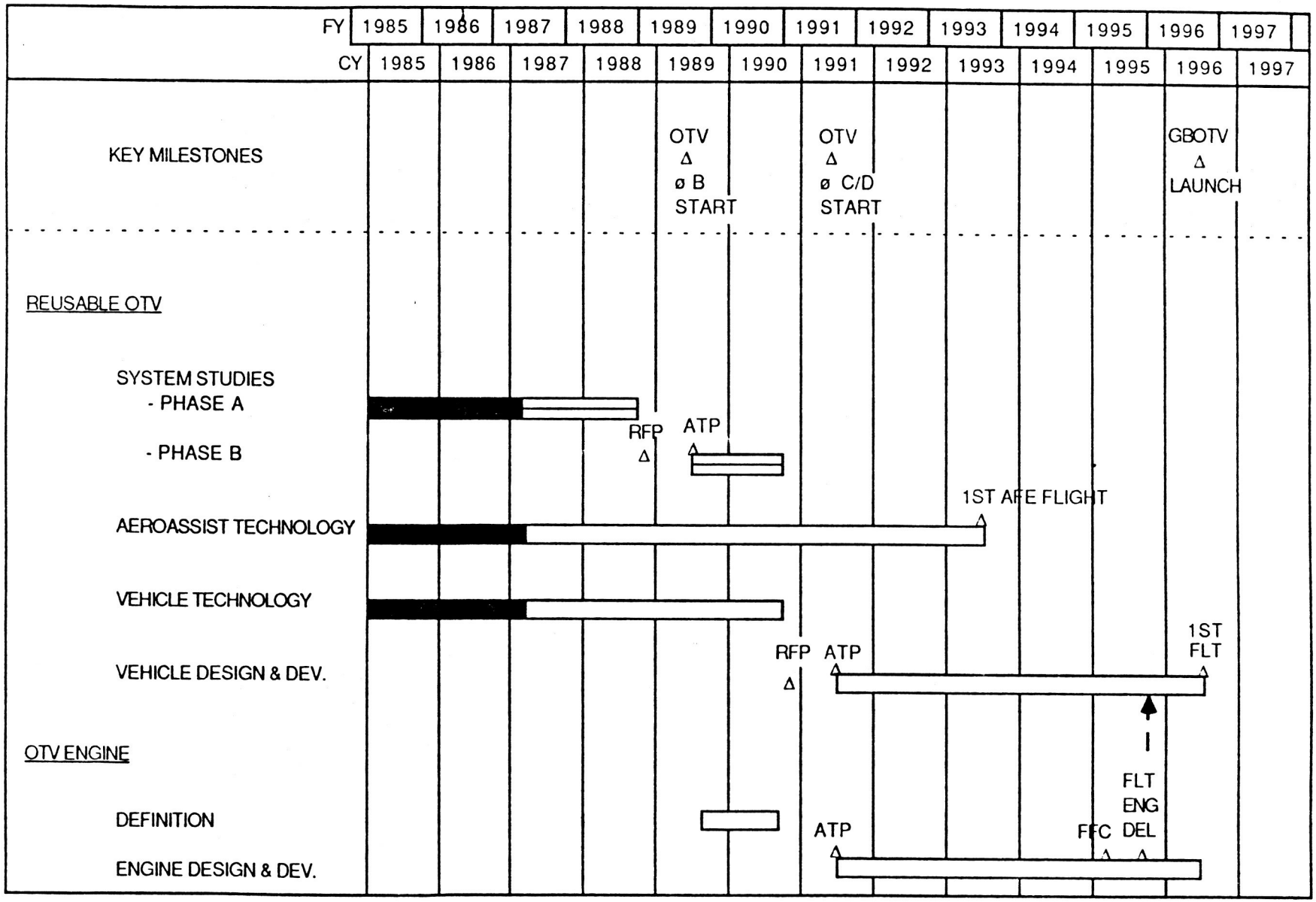
DURATION: 43 MONTHS, INITIATED JULY 1984 (CONTRACTS), PHASE III EXTENDS TO FEBRUARY 1988

MSFC TECHNICAL MANAGER: DONALD R. SAXTON, PF20

HEADQUARTERS MANAGERS: TED SIMPSON, MD

ORBITAL TRANSFER VEHICLE (OTV)

PF20/ SAXTON
PP02/ TURNER
APRIL 10, 1987



GBOTV = GROUND-BASED OTV

FFC = FINAL FLIGHT CERTIFICATION

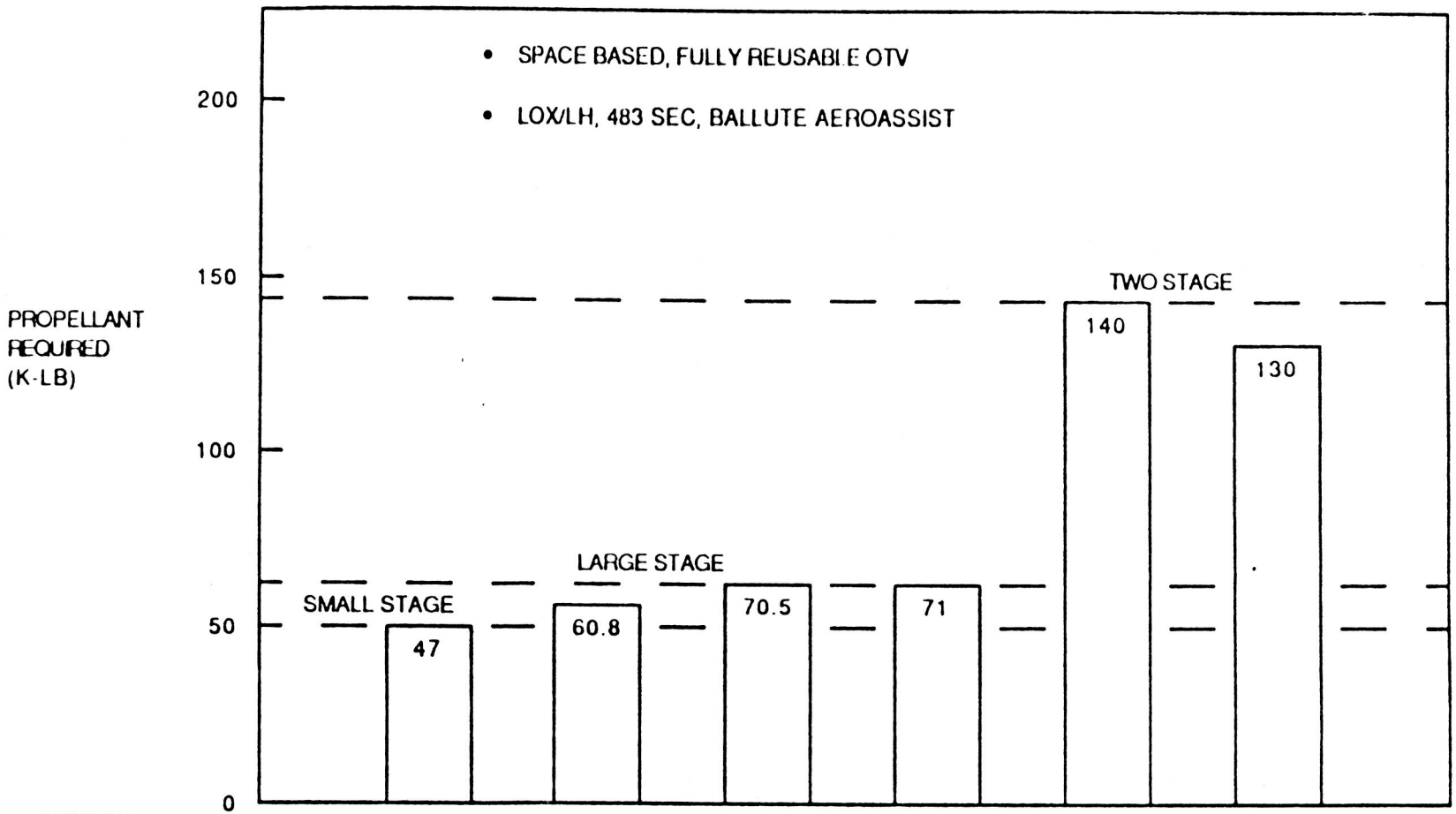
MISSION MODEL: SCENARIO 2
DATE: 4-17-86

OTV MISSION MODEL SUMMARY

REVISION NUMBER: 9 (STAS)

MISSIONS	OTV PLD NO.	STAS PLD NO.	MISSIONS/FY															
			95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	TOT
GEO PLATFORM	13006	2333				1													1
PLANETARY	17xxx		1		1	3	2	3		1		1			2				14
MULT. PLD. DEL.	18912		4	7	9	10	9	11	6	3	1	3	2	3	3	5	4	4	84
IND. GEO SAT.	18xxx		1	2		2	4		1										10
UNMANNED SERV.	13xxx																		0
SAT. RETRIEVAL	18750	1020				1			1										2
MANNED GEO SORT.	15010	5005,5200								1	1	2	2	2	2	2	2	2	16
GEO SHACK	1500x	5006				1						1							2
GEO SHACK LOG.	15011	5010,5011					1	1	2	1	2	4	4	4	4	4	4	6	37
UNMAN. LUN. ORB.	1720x	5013,5015	5017				2				1						3	1	3
UNMAN. LUN. SURF..	17203	5018																	5
LUNAR ORBIT STA..	1720x	5019																	0
LUN. SURF. SORT.	1720x	5020																	0
DOD	190xx		15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	240
SUBTOTAL			21	24	25	33	33	30	25	21	20	26	23	24	26	26	28	29	414
REFLIGHTS					1	1		1		1		1		1		1		1	8
TOTALS			21	24	26	34	33	31	25	22	20	27	23	25	26	27	28	30	422

OTV SIZING MISSIONS

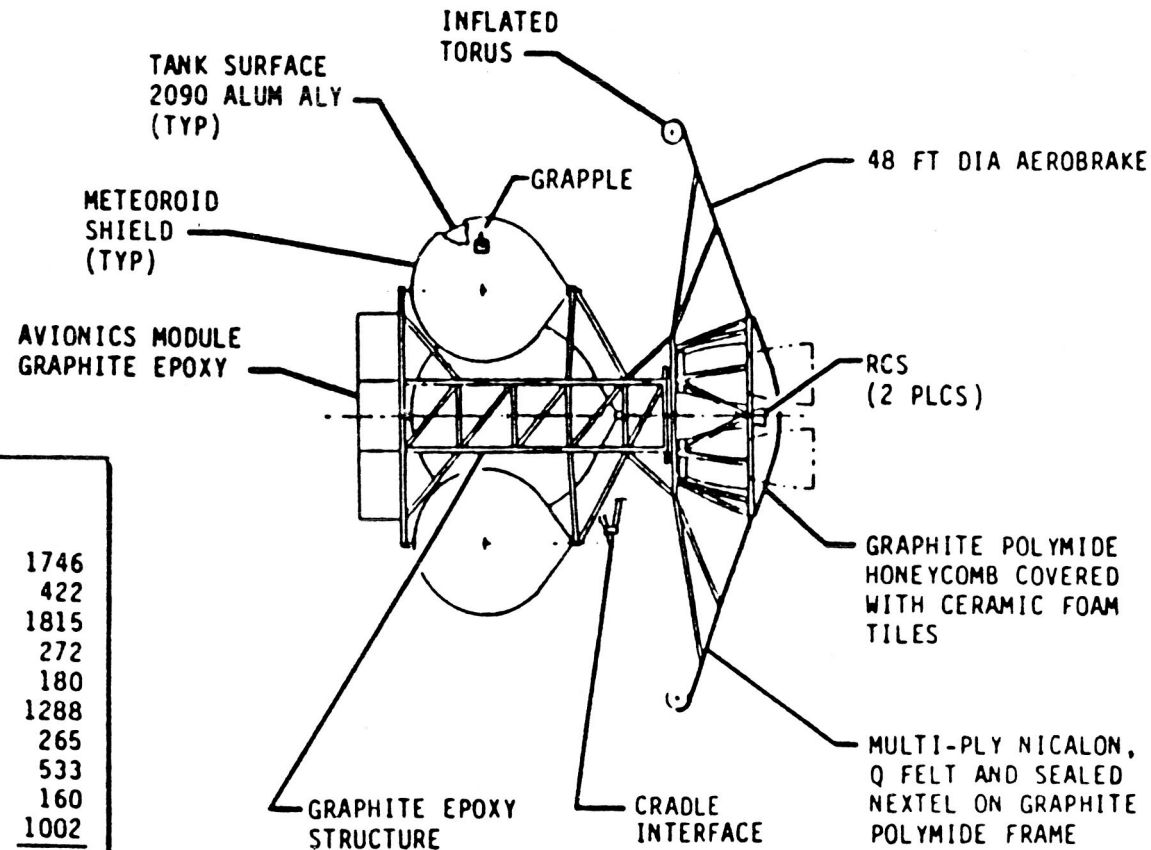


MISSION	CIVIL & DOD S/C (MULTIPLE P/L)	VOA/SETI	GEO LOGISTICS & MAN SORTIE	LUNAR SURF. DELIVERY	LUNAR SURF. DELIVERY	PLUTO ORBITER
MASS (K-LB)	14.6 (12/2)	21.8	12/10	33 (L.O.)	73 (L.O.)	32.3 (C3=49)
FIRST FLIGHT	1995	1996	1999	2000	2009	2007
QUANTITY	342	2	54	1	4	1

SPACE BASED OTV

MARTIN MARIETTA

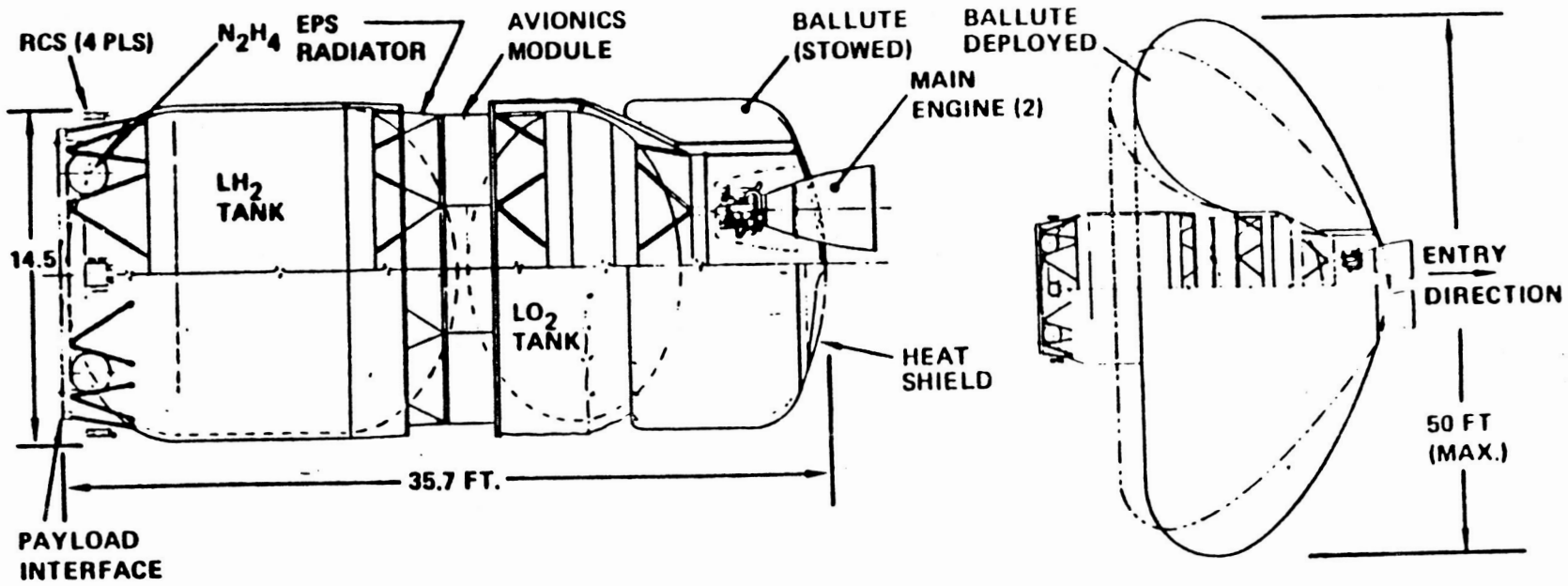
PAYLOAD 12,000 UP/10,000 DN



WEIGHTS	
AEROBRAKE	1746
TANKS	422
STRUCTURE	1815
SUPPORT (ASE)	272
ENVIRONMENTAL CONTROL	180
MAIN PROPULSION	1288
ORIENTATION CONTROL	265
ELECTRIC SYSTEMS	533
G, N&C	160
CONTINGENCY (15%)	1002
DRY WEIGHT	7683
PROPELLANTS, ETC	74015
LOADED WEIGHT	81698

BOEING SPACE BASED OTV

BALLUTE BRAKED



UNIQUE FEATURES

- BALLUTE
  - NEXTEL/CS 105
  - 1500°F BACKWALL
  - TURNDOWN RATIO = 1.5
  - 1 USE
- HEAT SHIELD–RSI
  - 20 USES
- NO INITIAL ON-ORBIT ASSEMBLY

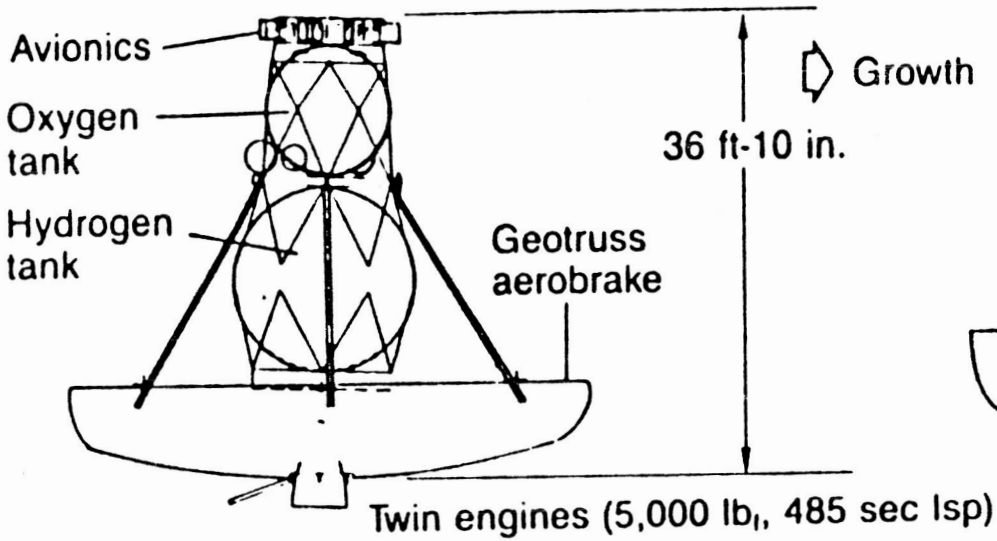
STAGE WEIGHT SUMMARY (LBS)

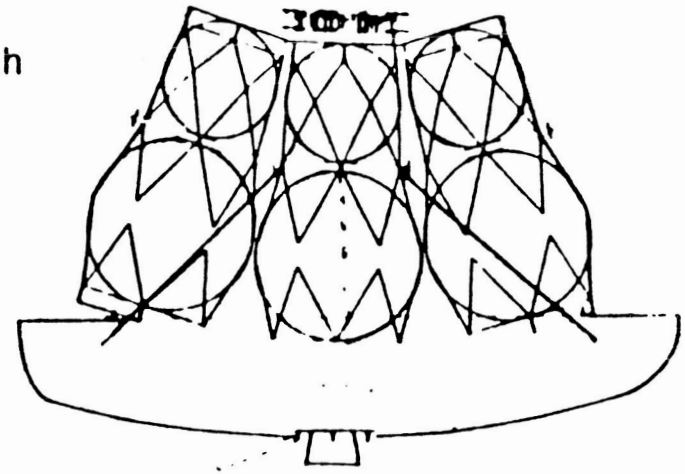
● DRY	9189	
● MAIN PROP.	63,890	1
● OTHER FLUIDS	1,061	
● STARTBURN	74,140	

1 FOR MANNED GEO SORTIE (7.5K R.T.) OR 20K GEO DELIV

GENERAL DYNAMICS

MODULAR SPACE-BASED OTV





Tanksets	1	3	4	5	7
Vehicle ignition	48,300 lb	134,900	177,500	220,500	306,000
Usable propellant	40,800 lb	122,500	163,500	204,200	285,900
Payload to GEO	13,500 lb	59,100	83,000	106,800	154,200
Payload roundtrip	6,450 lb	31,450	42,840	55,400	80,490

OTV TECHNOLOGY REQUIREMENTS

- ZERO G PROPELLANT TRANSFER
  - PROPELLANT PUMP/PRESSURIZATION
  - CHILL DOWN & VENT SYSTEM
  - PROPELLANT ACQUISITION (TANKER/STORAGE)
  - ABORT DUMP/TRANSFER (OTV)
  - QUICK CONNECT/DISCONNECTS
- PROPELLANT MASS GAUGING
  - ZERO G MEASUREMENT
  - PROPELLANT MASS TRANSFERRED
  - PROPELLANT REMAINING DURING BURN
- INSULATION
  - MLI ONLY FOR SPACE BASED OTV
  - MLI/FOAM/INERT GAS FOR GROUND BASED OTV

PROPELLANT PUMP/PRESSURIZATION

- DEMONSTRATE PROPELLANT TRANSFER BETWEEN TANKS BY CRYOGENIC COMPATIBLE PUMPS AND/OR TANK PRESSURIZATION
- MEASURE HEAT ADDED TO CRYOGEN BY PUMP
- DETERMINE EFFECTS OF ZERO G ON PUMP OPERATION, BUBBLE FORMATION, SUCTION LINE FLUID FLOW,ETC
- DETERMINE EFFECTS OF ZERO G ON PRESSURANT GAS/FLUID SEPARATION
- MEASURE G NECESSARY TO SETTLE FLUID, FLUID SLOSH IN LOW G, ETC
- BUBBLE UP/AUTOGENOUS PRESSURIZATION

CHILL DOWN & VENT SYSTEM

- CHILL DOWN OF A WARM TANK
- ULLAGE VENTING AND FILL OF A PARTIALLY FILLED TANK
- A THERMODYNAMIC VENT SYSTEM HAS BEEN DESIGNED FOR THE CENTAUR AND DEMONSTRATED ON THE GROUND
- DEMONSTRATE THERMODYNAMIC VENT SYSTEM IN ZERO G
- DEVELOP AND DEMONSTRATE A ZERO G HELIUM VENT SYSTEM (?)

PROPELLANT ACQUISITION/MANAGEMENT (TANKER/STORAGE FACILITY)

- DEMONSTRATE LIQUID ACQUISITION AND VAPOR FREE OUTFLOW
- DETERMINE SPACECRAFT DYNAMICS DURING PROPELLANT TRANSFER
- COMPARE STORAGE TANK/TANKER REQUIREMENTS TO OTV DETANK REQUIREMENTS
- CONTROL FLUID DYNAMICS (SLOSH, SETTLING)

ABORT DUMP/TRANSFER (OTV)

- PROPELLANT RECOVERY AFTER MISSION ABORT NEAR THE SPACE STATION
- PROPELLANT DUMP
- RETURN OF RESIDUAL PROPELLANT TO STORAGE FACILITY

QUICK CONNECT/DISCONNECT FLUID INTERFACES

- "ZERO LEAKAGE" CONNECTIONS
- MINIMIZE ALIGNMENT REQUIREMENTS
- PROVIDE SEAL VENTING FOR PRESSURIZED SYSTEMS
- CONSIDER LEAK DETECTION, SEAL REPLACEMENT, INSPECTION, ETC
- MINIMIZE PRESSURE DROP ACROSS INTERFACE

ZERO G MASS GAUGING

- NO PROVEN METHOD FOR LARGE TANKS IN ZERO G
- NEED METHOD PROVIDING 1% OR BETTER ACCURACY
- ADDRESS SENSITIVITY TO PRESSURE OR TEMPERATURE

PROPELLANT MASS TRANSFERRED

- MEASURE PROPELLANT TRANSFER RATE AND TOTAL TRANSFERRED
- CORRECT FOR TEMPERATURE EFFECTS
- DETERMINE AND CORRECT FOR PRESENCE OF BUBBLES IN FLUID
- PROPELLANT UTILIZATION/MANAGEMENT IN MULTI-TANK OTV CONFIGURATIONS

PROPELLANT REMAINING DURING BURN

- MEASURE PROPELLANT DURING 0.01 TO 1.0 G ACCELERATION
- PROVIDE RAPID MEASUREMENT UPDATE

INSULATION

- SPACE BASED OTV
  - THICK MLI WITH LONG LIFE IN VACUUM
  - INSULATE LH2 TANK FROM LOX TANK TO PROVIDE LOITER CAPABILITY AND TO MINIMIZE IMPACT OF SLOW FILL/DRAIN
  - MINIMIZE MICROMETEOROID/DEBRIS DAMAGE
- GROUND BASED OTV
  - MLI ON LOX TANK
  - MLI/FOAM/INERT GAS ON LH2 TANK TO PREVENT CRYOPUMPING
  - INSULATE LH2 TANK FROM LOX TANK TO PROVIDE LOITER CAPABILITY

OTV SUPPORT TECHNOLOGY (SPACE BASED)

- LONG TERM CRYOGENIC STORAGE
- VAPOR COOLED SHIELDS
- PARA/ORTHO CONVERSION
- REFRIGERATION
- RELIQUEFACTION
- PROPELLANT DELIVERY