N91-28253

PRESENTATION 4.3.1

GENERAL DYNAMICS
Space Systems Division

OPERATIONAL EFFICIENCY PANEL

SPACE-BASING TECHNOLOGY REQUIREMENTS

LUIS R. PEÑA

THE SPACE EXPLORATION INITIATIVE

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SPACE-BASING TECHNOLOGY REQUIREMENTS SOURCES

SPACE STATION	- OTV CONCEPT DEFINITION AND SYSTEMS ANALYSIS	MSFC
	- TURNAROUND OPERATIONS ANALYSIS FOR OTV *	MSFC
	- CENTAUR OPERATIONS AT THE SPACE STATION	LeRC
	- LONG TERM CRYOGENIC STORAGE FACILITY	MSFC
LUNAR / MARS / NODES	- INFRASTRUCTURE STUDY *	MSFC
	- CENTAUR DERIVED LUNAR TRANSFER VEHICLE	LeRC
	- UP-GRADED CENTAUR	LeRC

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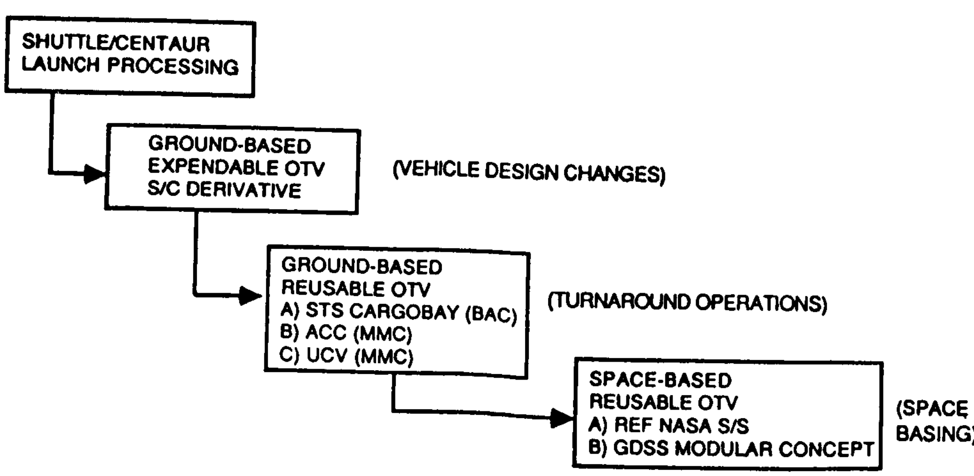
OTV PROCESSING HERITAGE



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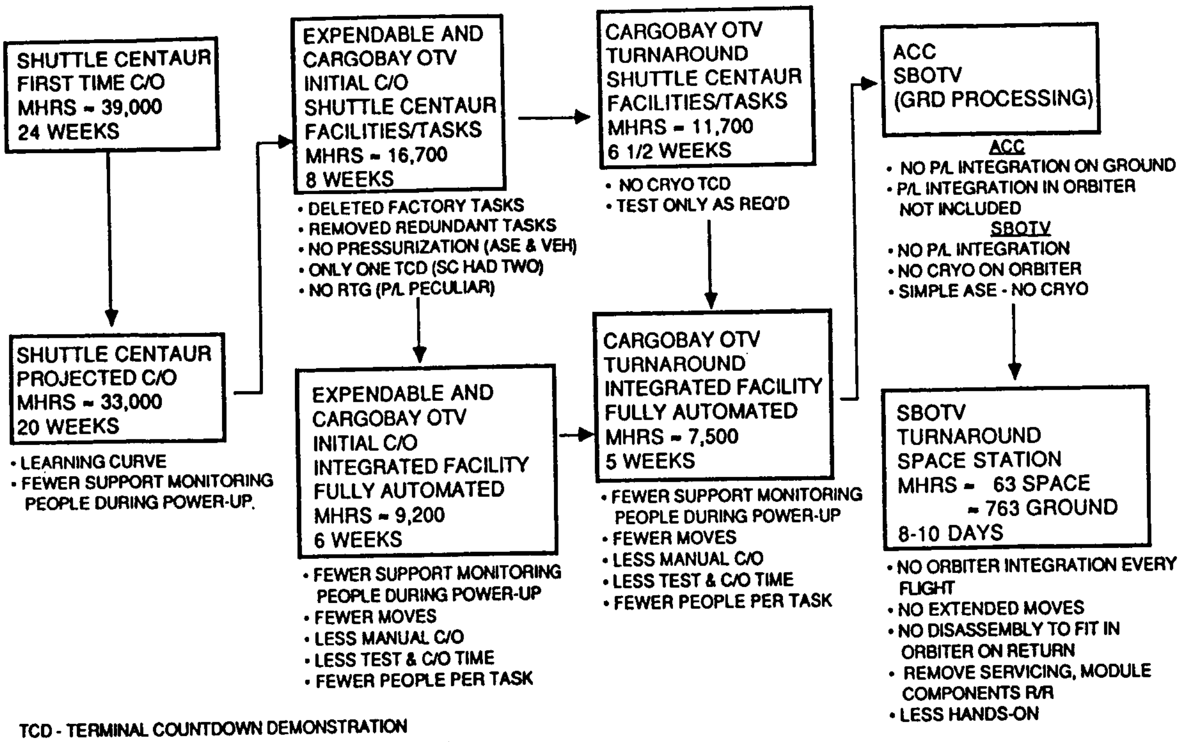
GROUND PROCESSING PROGRESSION TO SPACE PROCESSING



TCD - TERMINAL COUNTDOWN DEMONSTRATION

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TECHNOLOGY REQUIREMENTS
SPACE-BASED OTV SERVICING AND MAINTENANCE

1. CRYOGENIC PROPELLANT TRANSFER, STORAGE AND RELIQUEFACTION
2. AUTOMATED FAULT DETECTION / ISOLATION AND SYSTEM CHECKOUT
3. OTV DOCKING AND BERTHING
4. OTV MAINTENANCE / SERVICING OPERATIONS AND FACILITIES / SUPPORT EQUIPMENT
   - TELEOPERATORS / ROBOTICS
   - CREW TRANSLATION EQUIPMENT
   - OTV TRANSLATING & BERTHING ROTATION EQUIPMENT
   - CONTROLS AND DISPLAYS
   - EVA OPERATIONS
5. OTV / PAYLOAD MATING AND INTERFACES

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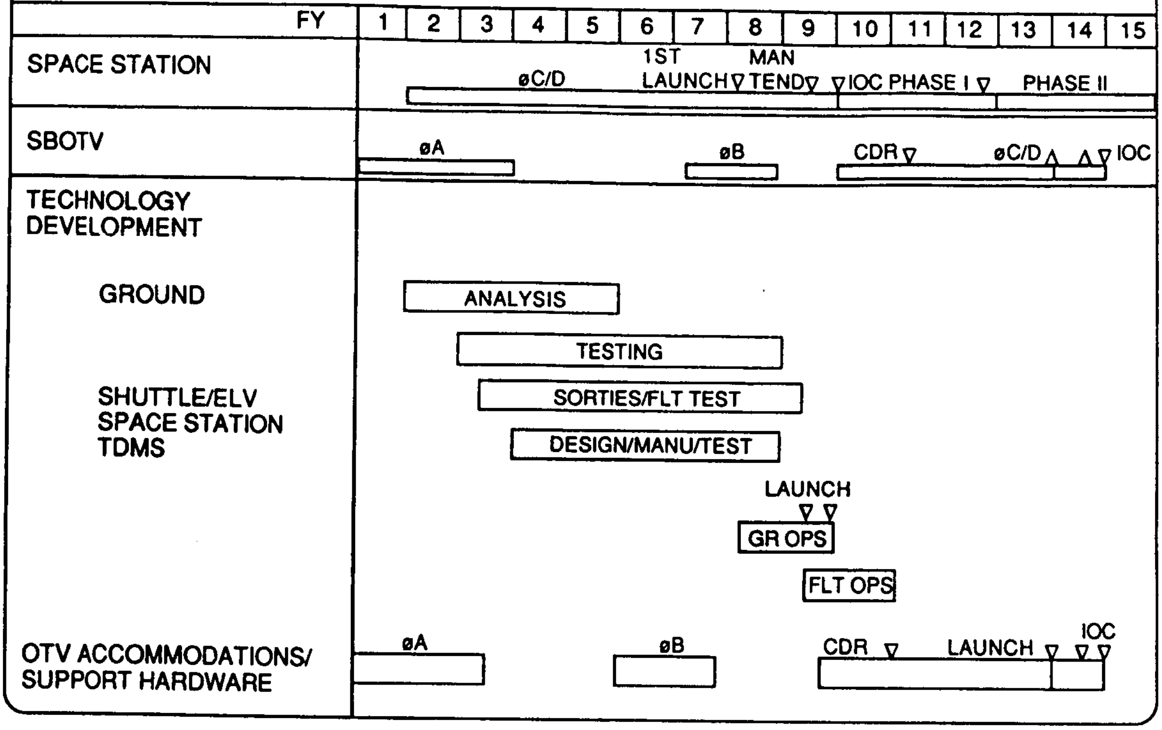
DESIGN AND DEVELOPMENT SCHEDULE FOR OTV'S AND OTV ACCOMMODATIONS/SUPPORT HARDWARE



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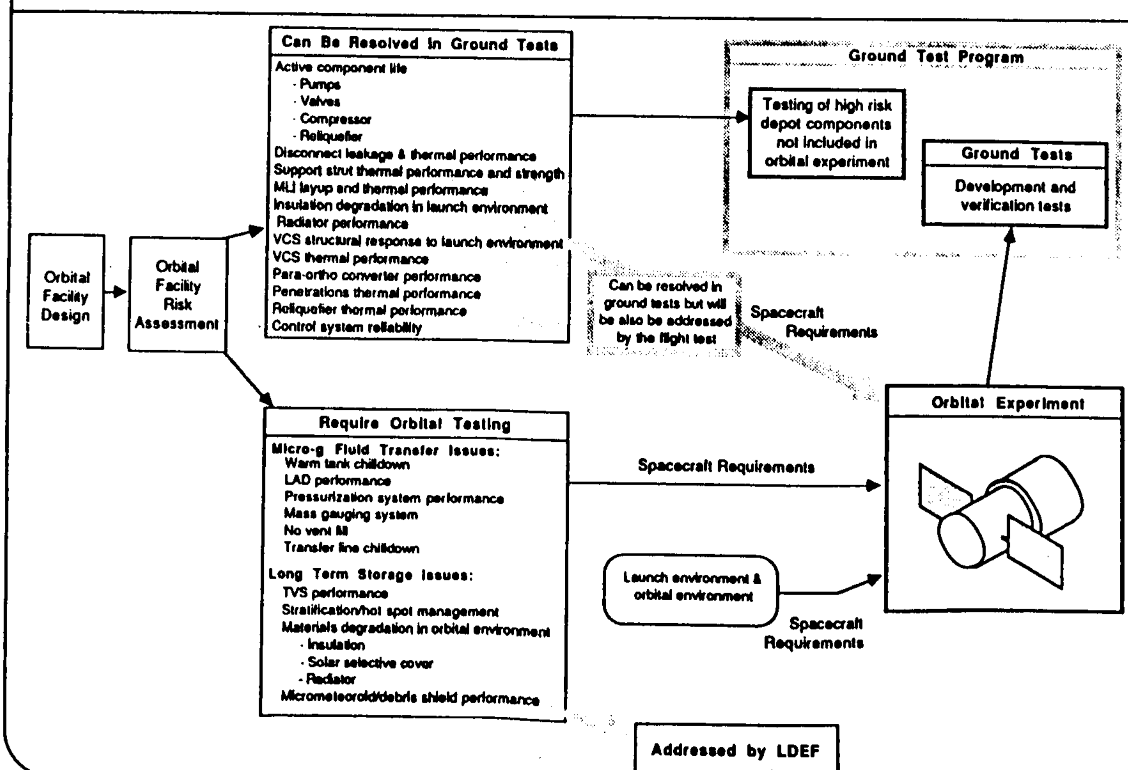
CRYOGENIC TECHNOLOGY TEST PROGRAM DEVELOPMENT



CRYOGENIC PROPELLANT TRANSFER, STORAGE AND RELIQUEFACTION MANAGEMENT SUMMARY

MANY OTV PROPELLANT STORAGE, TRANSFER, AND RELIQUEFACTION TECHNOLOGY PERFORMANCE ISSUES CAN BE RESOLVED THROUGH ANALYSIS AND GROUND TESTING

- o ACTIVE COMPONENTS (RELIQUEFIER, PUMPS, VALVES, COMPRESSORS, RADIATOR)
- o PASSIVE COMPONENTS (MLI, VCS, P-O CONVERTER)

CERTAIN TECHNOLOGY DEVELOPMENTS REQUIRE ORBITAL, LOW-G TESTING

- o TRANSFER
  - LIQUID ACQUISITION DEVICE
  - PRESSURIZATION SYSTEMS
  - MASS GAGING SYSTEMS
  - NO-VENT FILL/REFILL
  - TRANSFER LINE CHILLDOWN
- o LONG-TERM STORAGE ISSUES
  - THERMODYNAMIC VENT SYSTEM
  - STRATIFICATION AND "HOT SPOT" MANAGEMENT
  - MATERIALS DEGRADATION (MLI, SOLAR SELECTIVE COVER, RADIATOR)
- o MICROMETEOROID/DEBRIS SHIELD PERFORMANCE

PROPELLANT TRANSFER TECHNOLOGY ANALYSIS & GROUND TESTING

DESCRIPTION OF TECHNOLOGY:

- o AUTOMATIC, LEAK-FREE OPERATION OF CRYOGENIC TRANSFER LINES AND DISCONNECTS
- o CHILLDOWN BEHAVIOR OF TRANSFER LINES
- o PRECHILL ACCUMULATOR & COMPRESSOR SYSTEM TEST
- o VALVE & TRANSFER PUMP TESTING

RATIONALE & ANALYSIS:

- o SYSTEM REQUIRES FULLY AUTOMATED TRANSFER SYSTEM
- o RELIABILE, LEAK-FREE OPERATION OF DISCONNECTS, PUMPS, VALVES, AND COMPRESSORS

TECHNOLOGY OPTIONS:

- o TRANSFER LINE CONFIGURATIONS; ELV-SS DEPOT TANK, DEPOT-OTV, ET SCAVENGING
- o TRANSFER PRESSURANT SYSTEM; AUTOGENOUS, GHe, GH2, PUMP-FED
- o TRANSFER LINE INSULATION TYPES/INTERNALLY COATED VS. UNCOATED

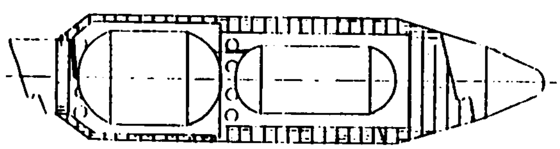
OTV PROPELLANT STORAGE DEPOT DEVELOPMENT CRITICAL SCALING RELATIONSHIPS

EXPERIMENT	SIGNIFICANT PARAMETERS
Thermodynamic venting, passive & active	TVS flowrate/direct venting flowrate, tank pressure/vapor pressure, Weber no., jet Reynolds no., mixing parameter (time), Bond no., mixer heat input / total heat input
Tank prechill	Tank pressure, volume/tank mass, temperature, Nusselt no., spray Reynolds no., mixing parameter
No-vent fill	Nusselt no., spray / jet Reynolds no., mixing parameter, peak pressure / vapor pressure, Weber no., Jacob no.
Liquid acquisition device fill / refill	Bond no., liquid volume / total volume, bulk density / liquid density, average bubble volume / total ullage volume
Slosh dynamics & control	Bond no., jet Weber no., acceleration ratios, dimensionless slosh frequency, damping factor, expulsion efficiency

FLIGHT EXPERIMENT OPTIONS

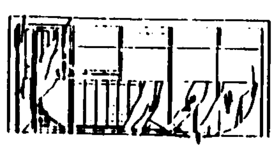
SMALL SCALE (~1/10) ORBITAL FLIGHT EXPERIMENT

Launch Vehicle: Atlas/Centaur
Experiment Size: 10.5 ft. dia. max., 24 ft. long
LH2 Capacity: 230 cu. ft., 998 lbs. (Receiver Tank)
Total Weight: ~9800 lbs. wet



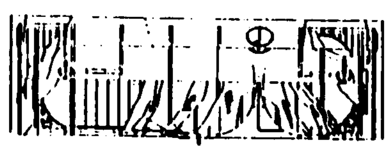
LARGE SCALE (~4/10) ORBITAL FLIGHT EXPERIMENT

Launch Vehicle: TITAN IV SS I &II
Experiment Size: 15 ft. dia. max., 47 ft. long
LH2 Capacity: 1320 cu. ft., 5728 lbs. (Receiver Tank)
Total Weight: ~25000 lbs. wet



FULL SPACE STATION LH2 TDM

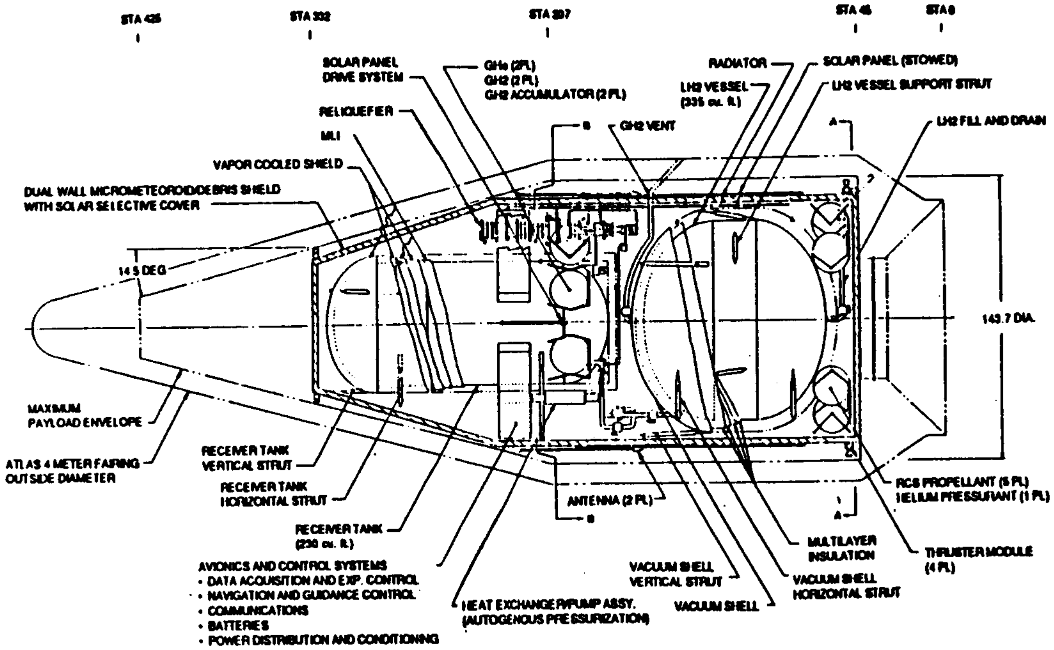
Launch Vehicle: Space Shuttle (dry), or SDV
Experiment Size: 14.5 ft. dia. x 34.5 ft. long
LH2 Capacity: 3292 cu. ft., 14286 lbs.
Total Weight: ~18000 lbs. dry



FULL SCALE LONG TERM CRYOGENIC STORAGE DEPOT

Launch Vehicle: Space Shuttle (dry), SDV or ALS
Size: 14.5 ft. dia. x 50 ft. long
Capacities: 3292 cu. ft. LH2, 1203 cu. ft. LO2
14286 lbs. LH2, 85714 lbs. LO2
Total Weight: ~30200 lbs. dry

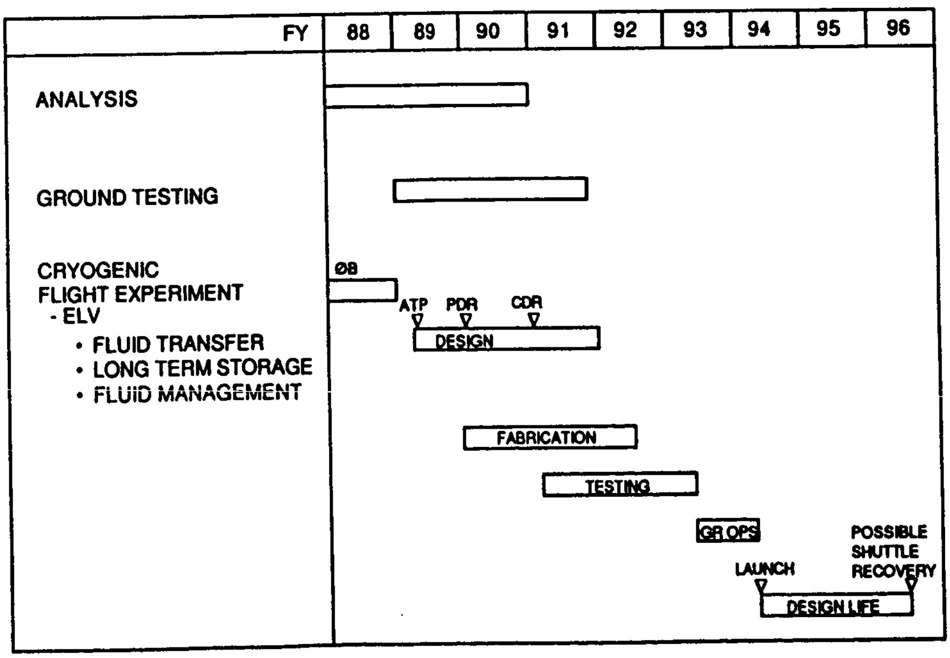
SMALL SCALE (~1/10) LTCSF FLIGHT EXPERIMENT (CONFIGURED FOR ATLAS/CENTAUR LAUNCH VEHICLE)



SIDE VIEW

ALL DIMENSIONS IN INCHES

OTV ACCOMMODATIONS/SUPPORT HARDWARE *TECHNOLOGY DEVELOPMENT - CRYOGENIC PROPELLANT ELV EXPERIMENT



*MAY REQUIRE SPACE STATION TDM

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OTV MAINTENANCE PHILOSOPHY

THREE-LEVEL MAINTENANCE

- LEVEL ONE - OTV LOCAL MAINTENANCE
- LEVEL TWO - SPACE STATION REPAIR OF REPLACEABLE UNITS
- LEVEL THREE - RETURN TO EARTH MAINTENANCE

STOCK SPARE PARTS BASED ON RELIABILITY, CRITICALITY & COST

- SPACE STATION STORAGE VS SHUTTLE DELIVERY

STRESS MODULAR CONSTRUCTION FOR ASSEMBLY & REPLACEMENT CAPABILITY

- MINIMIZE INTERFACES
- SIMPLIFY INTERFACES

PROVIDE OPERATIONAL FLIGHT INSTRUMENTATION & BUILT-IN TEST

- FAULT ISOLATE TO REPLACEABLE UNIT

MINIMIZE EVA VEHICLE MAINTENANCE OPERATIONS

- CONSIDER SAFETY IN HAZARDOUS SITUATIONS
- TRADE-OFF EVA VERSUS SUPPORT EQUIPMENT
  - TV INSPECTION
  - TELEOPERATIONS / ROBOTICS FOR COMPONENT REPLACEMENT

AUTOMATED FAULT DETECTION/ISOLATION AND SYSTEM CHECKOUT SUMMARY

THE AUTOMATED FAULT DETECTION/ISOLATION AND SYSTEM CHECKOUT REQUIRED TECHNOLOGY DEVELOPMENT FOR GROUND PROCESSING CAN BE RESOLVED THROUGH ANALYSES, SIMULATION AND GROUND TESTING.

THE REQUIRED TECHNOLOGY DEVELOPMENTS FOR SPACE PROCESSING (SAME AS ONES FOR THE GROUND) CAN FOR THE MOST PART BE RESOLVED THROUGH ANALYSES, SIMULATION AND GROUND TESTING.

- NO TESTING ON A SHUTTLE SORTIE OR ELV
- MAY WANT TO INCLUDE SOME PROTOTYPE EQUIPMENT ON MAINTENANCE/SERVICING/SUPPORT EQUIPMENT SPACE STATION TDM

MAINTENANCE/SERVICING OPERATIONS AND SUPPORT EQUIPMENT TECHNOLOGY SUMMARY

MANY MAINTENANCE/SERVICING/SUPPORT EQUIPMENT REQUIRED TECHNOLOGY DEVELOPMENTS CAN BE RESOLVED THROUGH ANALYSIS, SIMULATION AND GROUND TESTING.

- TELEOPERATIONS/ROBOTICS/TOOLS
- CREWMAN SUPPORT/WORKSTATION/TRANSLATION EQUIPMENT
- OTV TRANSLATING AND BERTHING ROTATION EQUIPMENT
- CONTROLS/DISPLAYS/COMMUNICATIONS

CERTAIN TECHNOLOGIES REQUIRE ORBITAL, LOW-G TESTING

- EVA MAINTENANCE/SERVICING OPERATIONS/CONTROLS/TOOLS
- TELEOPERATIONS/ROBOTICS/CONTROLS/TOOLS (VERIFICATION)

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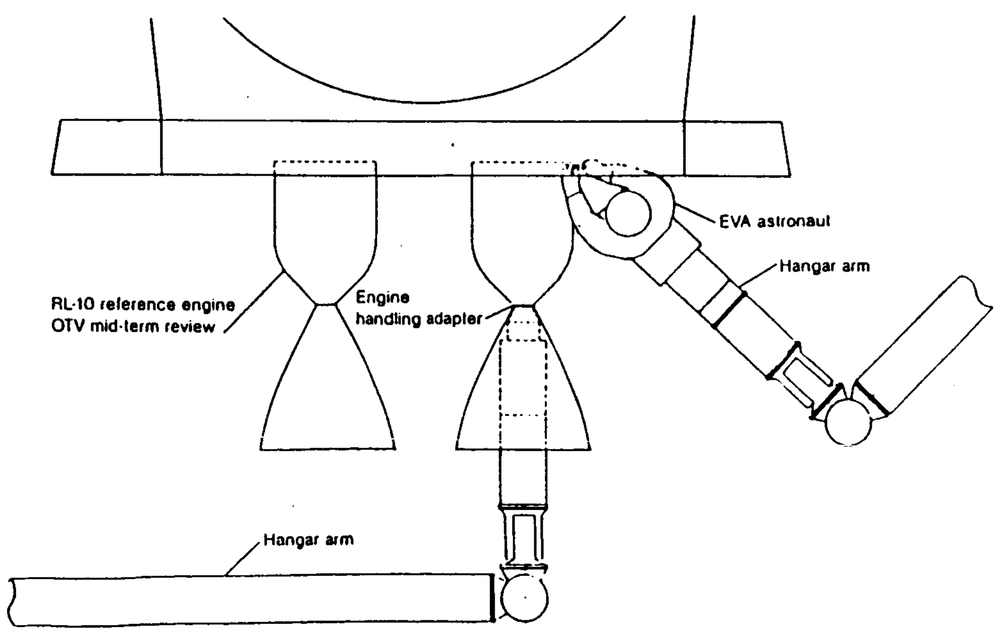
ENGINE REPLACEMENT OPERATIONS



ENGINE REPLACEMENT TRADE COMPARISON

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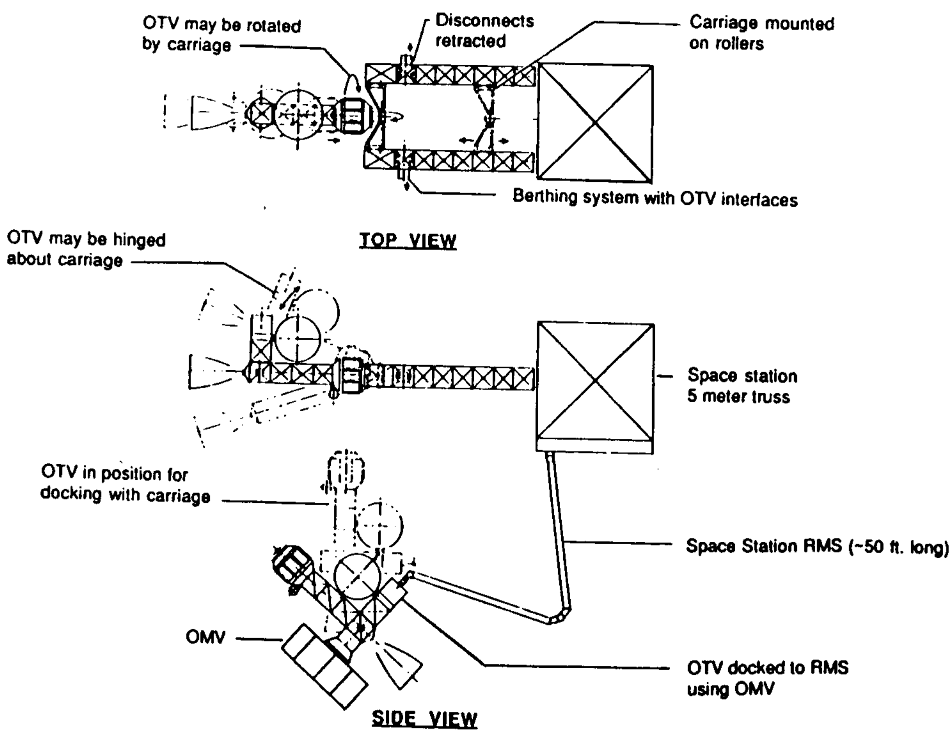
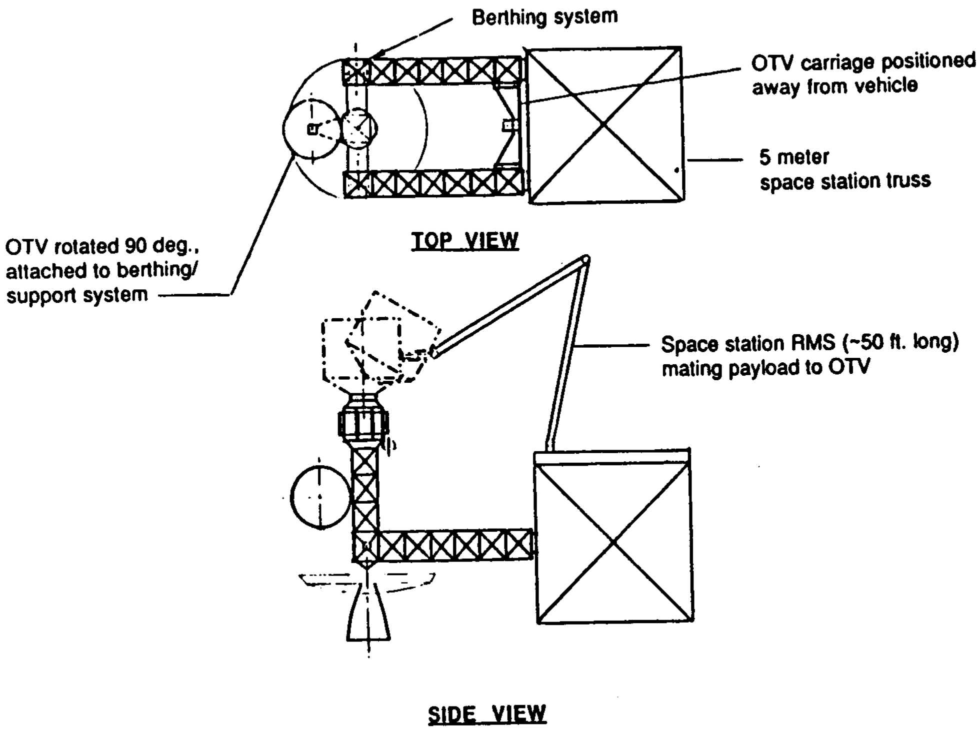
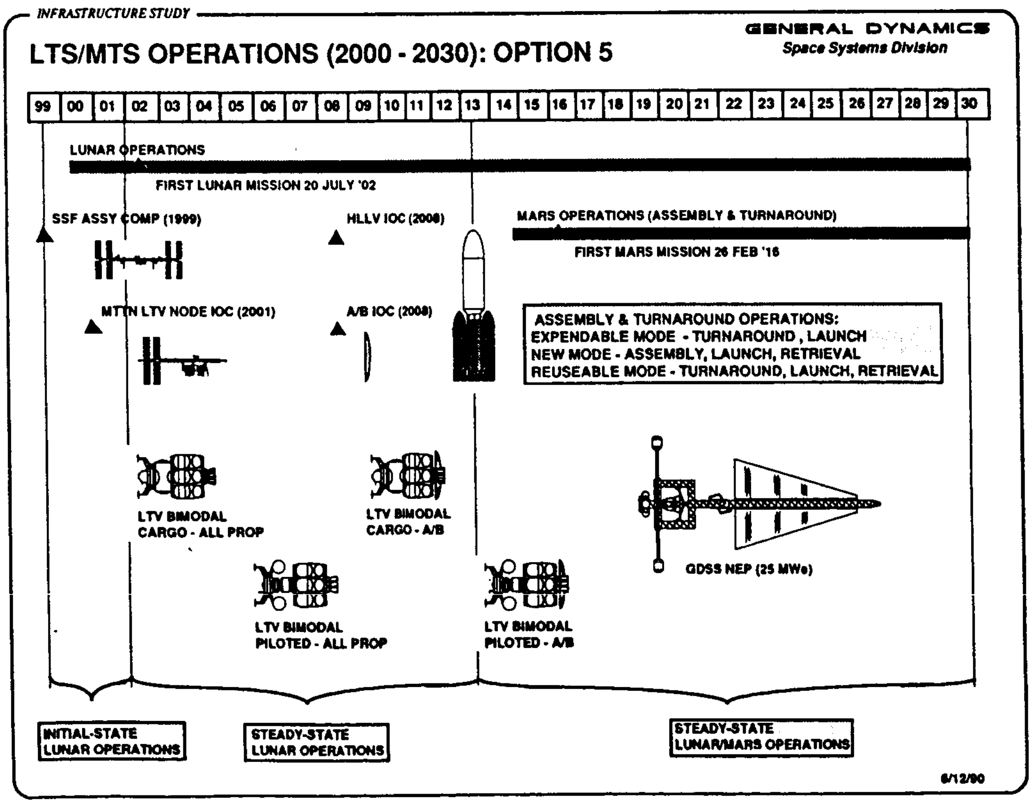
CRITERIA \ OPTION	TELEOPERATION WITH EVA	TELEOPERATION ONLY	TELEOPERATION WITH AUTOMATED LATCHES
SUPPORT EQUIPMENT REQUIREMENTS	2 RMS - 1 crew support adapter - 1 grasping adapter EVA support equipment	2 RMS - 1 servicing tool adapter - 1 grasping adapter	1 RMS - 1 grasping adapter
VEHICLE DESIGN REQUIREMENTS	OTV modular design EVA compatible disconnect	OTV modular design EVA/teleoperator compatible disconnect	OTV modular design Automated disconnect
TASK DURATION	18:10	12:50	7:15
MANHOURS EVA	24:50	---	---
MANHOURS TOTAL	53:30	20:20	13:45
MANHOUR COST(NMM)	49.5M	7.5M	2.7M
△ VEHICLE WEIGHT PER MISSION	Baseline	Same	+100lb/engine
REQUIRE TECHNICAL DEVELOPMENT	No	Minimal	Yes
ACCESSIBILITY REQUIREMENT	Aerobrake: remove Crew: 4 ft x 5 ft x 6.5 ft RMS : nossle area	Aerobrake: remove Crew: none RMS : 28 in. dia for RMS & tool, nozzle area	Aerobrake: not removed Crew: none RMS : nozzle area
VEHICLE COMPLEXITY	Baseline	Same	Increased - Hardware - Software
VEHICLE RELIABILITY	Baseline	Same	Decrease
COST (REV 8 NMM)	130M	53M	556M

ALTERNATIVE DOCKING OPERATION



CONCEPT FOR OTV/PAYLOAD INTEGRATION





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TECHNOLOGY CRITICALITY & CAPABILITY ASSESSMENT

Technology	Criticality Assessment	Mission Element Lunar	Mission Element Mars	Capability	Need Date
Cryogenic Fluid Management	1	X	X	Refuel/Store	1998
Nuclear Electric Power System	1		X	25 MWe	2005
Ion Thrusters	1		X	F=410n, ISP=9ks	2005
Heat Pipe Radiation	1		X		2005
Cryogenic Ascent/Descent Propulsion	2	X	X	Man-rated, Reuse, High ISP, Throttle	1998
Aerobrake (rigid or flexible)	1	Low Engy	High Engy	Flex Preferred	1998/05
Gaseous Oxygen/Hydrogen RCS	3	X	X	50-100# thrust	1998
Automated Health Monitoring	2	X	X	All systems	1998
Regenerative Fuel Cells	1	X	X	4-6kW	1998
In-Space Rendezvous & Docking	1	X	X	Lunar/Mars Orb	1998
EVA Systems Technology	2	X	X	8 psi suit	1998
In-Space Assembly, Ckout, Processing	1	X	X	Ground control	1998
Closed Loop Life Support Systems	2	X	X		1998
Radiation Protection	1	X	X	Crew Mod	1998
Artificial Gravity	2		X	Reqm't pending	2005
Upgraded OMV	1	X	X	80 Klbs P/L	1998

TRANSFER VEHICLE TECHNOLOGY DEVELOPMENT PLAN

TECHNOLOGY DEVELOPMENT

TECH PLANS GDSS	TECH PLANS NASA	TECHNOLOGY DEVELOPMENT
STV	√	**HUMAN FACTORS**
		• MAN RATING/SAFING, PROXIMITY OPS
		• LIFE SUPPORT SYSTEMS AND REQ'MTS
		• ARTIFICIAL GRAVITY, ECLSS
STV	√	**SPACE MISSION PLANNING AND SUPPORT**
		• INTEGRATED MISSION DEVELOPMENT
		• MISSION PERFORMANCE SCENARIOS
		• EMERGENCY SCENARIO/ALTERNATIVES
STV, NASP, CDLTV	√	**AEROBRAKE / AEROSYSTEMS**
		• HYPERSONIC AERO THERMODYNAMICS
		• MATERIALS
		• AUTONOMOUS OPERATIONS
STV, NASP, ALS	√	**EXPERT SYSTEMS**
		• ON-BOARD INTELLIGENT SYSTEMS
		• DECISION-AID
		• GROUND AND MISSION OPS INTEGRATION
STV, NASP, ATLAS, ALS	√	**SIMULATION MODELS - INTEGRATED**
		• MISSION PARAMETERS
		• AVIONICS & STRUCTURES DEVELOPMENT
		• LAUNCH AND GROUND SYSTEMS
STV	√	**IN-SPACE OPERATIONS**
		• RENDEZVOUS, DOCKING, MATING & ASSY
		• SPACE BASING, MAINTENANCE, ROBOTICS
		• AUTONOMOUS OPERATIONS
STV, AUS, NASP, ATLAS, ALS, SPS	√	**CRYOGENIC MANAGEMENT - ADVANCED**
		• "0" G CRYO XFER, LIQUID ACQ DEV (LAD)
		• FLOW & MASS MEASUREMENT
		• RELIQUEFACTION, INSULATION SYSTEMS

TECHNOLOGY APPLICATIONS

TECH PLANS GDSS	TECH PLANS NASA	TECHNOLOGY APPLICATIONS
STV, AUS, ATLAS, T/C, ALS	√	**AVIONICS, MPRAS, REDUNDANCY**
		• ADAPTIVE / EXTENDED GN & C
		• SOFTWARE UPDATE SYSTEMS
		• SPACE COMM'S HI RATE - DATA / VOICE
STV, AUS, NASP, ATLAS, T/C, ALS & SPS	√	**MATERIALS / STRUCTURES AND TANKS**
		• COMPOSITES - STRUCTURAL SHIELDING
		• METAL MATRIX COMPOSITES, AL-LI
		• CRYO-TANK COMPOSITES / INSULATION
STV, AUS, NASP, ATLAS, T/C, ALS	√	**FLUID / MECHANICAL SYSTEMS - ADVANCED**
		• ELECTRO / PNEU VALVES
		• ELECTROMECHANICAL ACTUATORS
		• AUTOGENOUS PRESSURIZATION / TVS
STV, AUS, T/C	√	**PROPULSION SYSTEMS - ADVANCED**
		• ALTERNATE RCS METHODS
		• MULTI- MISSION & MULTI-CYCLE PROP
		• NUCLEAR PROPULSION SYSTEMS
STV, SPS	√	**ELECTRICAL POWER SYSTEMS**
		• BATTERIES, SOLAR CELLS, FUEL CELLS
		• RTG AND NUCLEAR SYSTEMS, He3
		• SUPERCONDUCTIVITY, COLD FUSION
STV, AUS, ATLAS, T/C, ALS	√	**MANUFACTURING TECHNOLOGY**
		• CONCURRENT ENGR, COST REDUCTION
		• SIMPLIFIED METHODS / HIGH RELIABILITY
		• ROBOTIC APPLICATIONS
STV, AUS, ATLAS, T/C, ALS	√	**LAUNCH RESPONSIVENESS**
		• AUTO CH'KOUT, IHM, REDUNDANCY MGT
		• AUTO PROPELLANT LOADING
		• AUTOMATED / INTEGRATED TEST & GSE