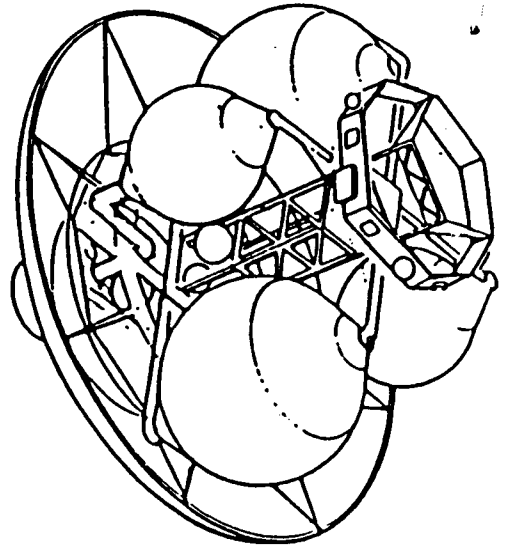
MCR-86-2601
NAS8-36108

Appendix A toVolume IV

Space Station Accommodations

Orbital Transfer Vehicle Concept Definition And System Analysis Study



MARTIN MARIETTA

MCR-86-2601
NAS8-36108

ORBITAL TRANSFER VEHICLE
CONCEPT DEFINITION AND SYSTEM ANALYSIS STUDY

APPENDIX A TO VOLUME IV
SPACE STATION ACCOMMODATIONS

August 1985
Rev 1 - July 1987

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INTRODUCTION

Martin Marietta conducted an Orbital Transfer Vehicle Concept Definition and System Analyisis Study for NASA/MSFC under Contract No. NAS8-36108. A portion of that study, Task 5, addressed Space Station Accommodations Concept Definition relative to the Orbital Transfer Vehicle. The results of the Task 5 studies and investigations are reported in Volume IV of the Final Report.

In the performance of Task 5, a large number of detailed functional flow analyses and resultant requirements definitions were generated to allow specific definiton of the OTV accommodations at Space Station. ROBSIM (a robotic simulation developed under contract from NASA/LaRC) provided the basic building blocks for determining task times for Space Station processing operations. The ROBSIM software system, running on a VAX 11/750 minicomputer and an Evans & Southerland Graphics workstation, is used to develop engineering data on robotic arm design as well as logistics timelines and operational procedures using actual OTV hardware descriptions. Finite simulations of transport motion and remove & replace tasks were run to establish baseline time data from which functional task times were developed and subsequently grouped into operations required to support processing, servicing, and maintenance. This Appendix A to Volume IV of the Final Study Report is a compendium of those analyses and defintions.

Within this Appendix A, functional flow analyses and requirements definitions are provided for the Space Based OTV, with further delineation for both cryogenic and storable OTVs, and for the Ground Based OTV operating in conjunction with Space Station.

INTRODUCTION

- ORBITAL TRANSFER VEHICLE CONCEPT DEFINITION AND SYSTEM ANALYSIS STUDY
  - *NASA / MSFC CONTRACT NAS8-36108 (PHASE A)*
- TASK 5: SPACE STATION ACCOMMODATIONS CONCEPT DEFINITION
  - *VOLUME IV OF FINAL STUDY REPORT*
- APPENDIX A TO VOLUME IV
  - FUNCTIONAL FLOWS & REQUIREMENTS DEFINITIONS
    - *CRYOGENIC SPACE-BASED OTV*
    - *STORABLE SPACE-BASED OTV*
    - *GROUND-BASED OTV*

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SPACE-BASED OTV

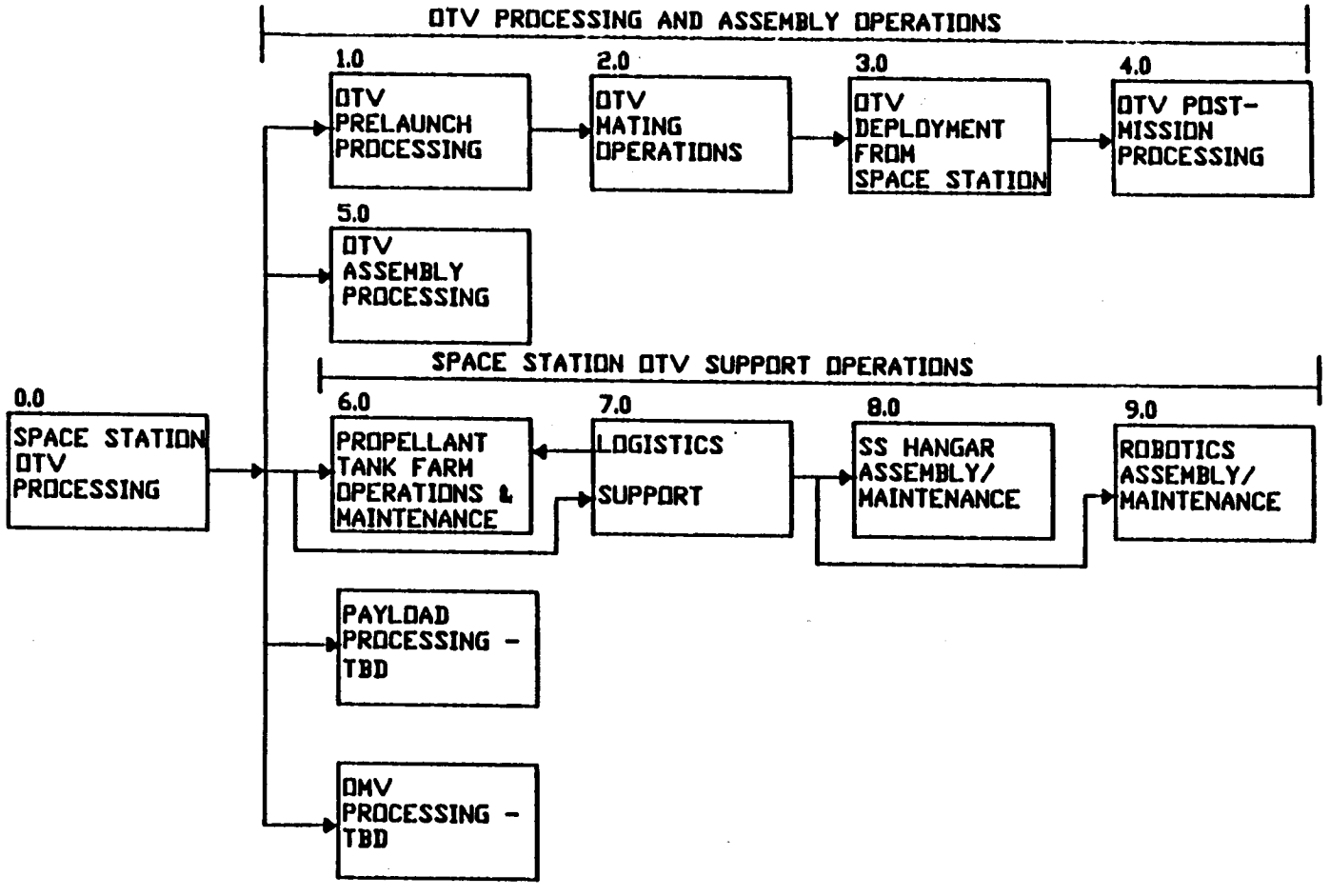
SPACE-BASED OTV FUNCTIONAL FLOW OVERVIEW

OTV processing at Space Station was divided into two major categories: OTV processing and assembly operations; and support operations. These categories were further subdivided into major functional areas to allow development of detailed OTV processing procedures and timelines. These procedures and timelines were used to derive the specific Space Station accommodations necessary to support OTV activities.

Our overall objective was to limit impact of OTV processing requirements on Space Station operations, involvement of crew, and associated crew training and skill requirements. Our operational concept maximizes use of automated and robotic systems to perform all required OTV servicing and maintenance tasks. Only potentially critical activities would require direct crew involvement or supervision. EVA operations are considered to be strictly contingency back-up to failure of the automated and robotic systems, with the exception of the initial assembly of Space-Based OTV accommodations at Space Station, which will require manned involvement.

Each of the numbered major functional areas shown on the facing page chart is further defined in the following charts, first, for the Cryogenic SBOTV, and then for the Storable SBOTV. Behind each major functional area definition are the corresponding requirements definition sheets identifying tasks, facilities, tools, and timelines.

SBOTV FUNCTIONAL FLOW - OVERVIEW



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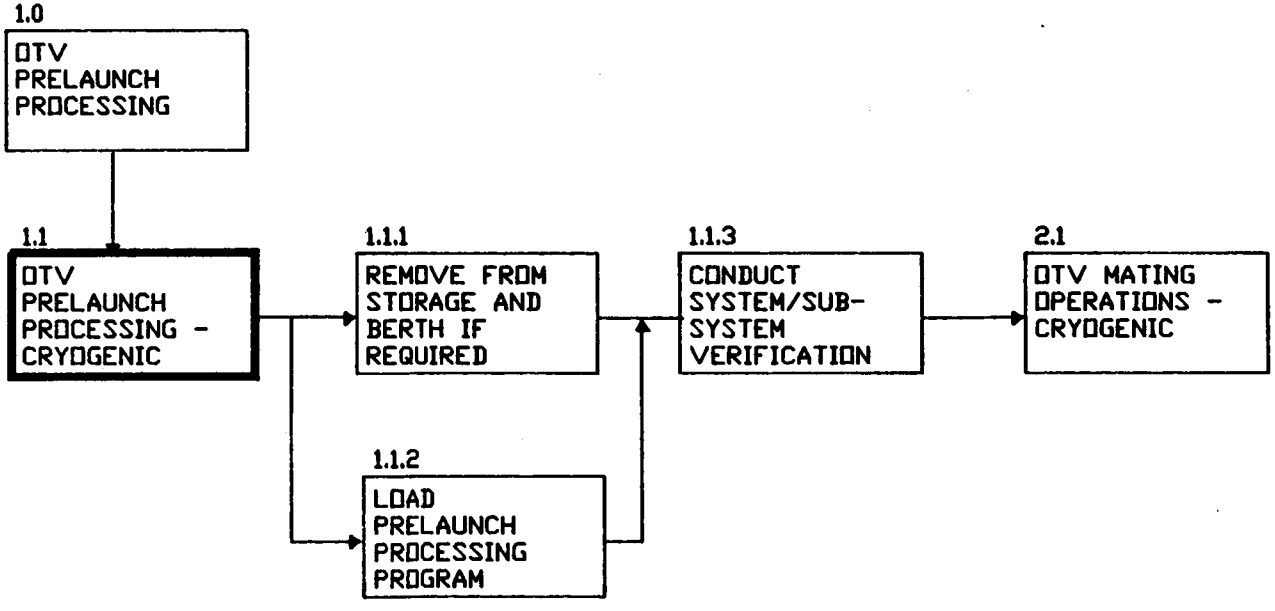
CRYOGENIC SPACE-BASED OTV

CRYOGENIC SPACE-BASED OTV PRELAUNCH PROCESSING

This functional flow and corresponding requirements definitions addresses the operations necessary to prepare the Cryogenic SBOTV for payload mating prior to mission launch.

SBOTV PRELAUNCH PROCESSING – CRYOGENIC



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OTV PRELAUNCH PROCESSING - CRYOGENIC

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
1.1	OTV PreLaunch Processing - Cryogenic	SS hangar, ligting power, signal, propellant umbilicals	Control console, SS computer, software, robotics, MRMS, tools/effectors	-	4:35-5:35	0:45-1:30			0:45-1:30	
1.1.1	Remove From Storage and Berth (if required)			-	1:00	0:45			0:45	OTV fleet size would dictate OTV storage hangar requirements. The following sequence would apply if a storage hangar is required
1.1.1.1	Disconnect power and signal umbilical		Control console, SS computer	1	0:05					
1.1.1.2	Open storage hangar door		Control console, SS computer	1	0:05					
1.1.1.3	Translate OTV to processing hangar		Control console, SS computer	2	0:45	0:45			0:45	May use MRMS or storage hangar berthing cradle
1.1.1.4	Attach power and signal umbilicals		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
1.1.2	Load Prelaunch Processing Program		Control console, SS computer, software	-	0:40	0:20			0:20	
1.1.2.1	Verify program matchs OTV configuration		Control console, SS computer	1	0:15	0:15			0:15	
1.1.2.2	Conduct program self-test		Control console, SS computer	1	0:20					
1.1.2.3	Verify program self-test		Control console, SS computer	1	0:05	0:05			0:05	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
1.1.3	Conduct System/Subsystem Verification - Self Test		Control console, SS computer, software	-	3:55	0:25			0:25	
1.1.3.1	Load program and conduct auto test of the following subsystems		Control console, SS computer	1	0:10	0:10			0:10	
1.1.3.2	Avionics		Control console, SS computer	1	1:00					
1.1.3.3	GN&C		Control console, SS computer	1	0:30					
1.1.3.4	Data management		Control console, SS computer	1	0:30					
1.1.3.5	Communications and tracking (less RF antenna systems)		Control console, SS computer	1	0:30					
1.1.3.6	Power (less fuel cells)		Control console, SS computer	1	0:30					Fuel cells checked following RCS propellant transfer
1.1.3.7	Payload interface system		Control console, SS computer	1	0:30					
1.1.3.8	Verify self test			2	0:15	0:15			0:15	

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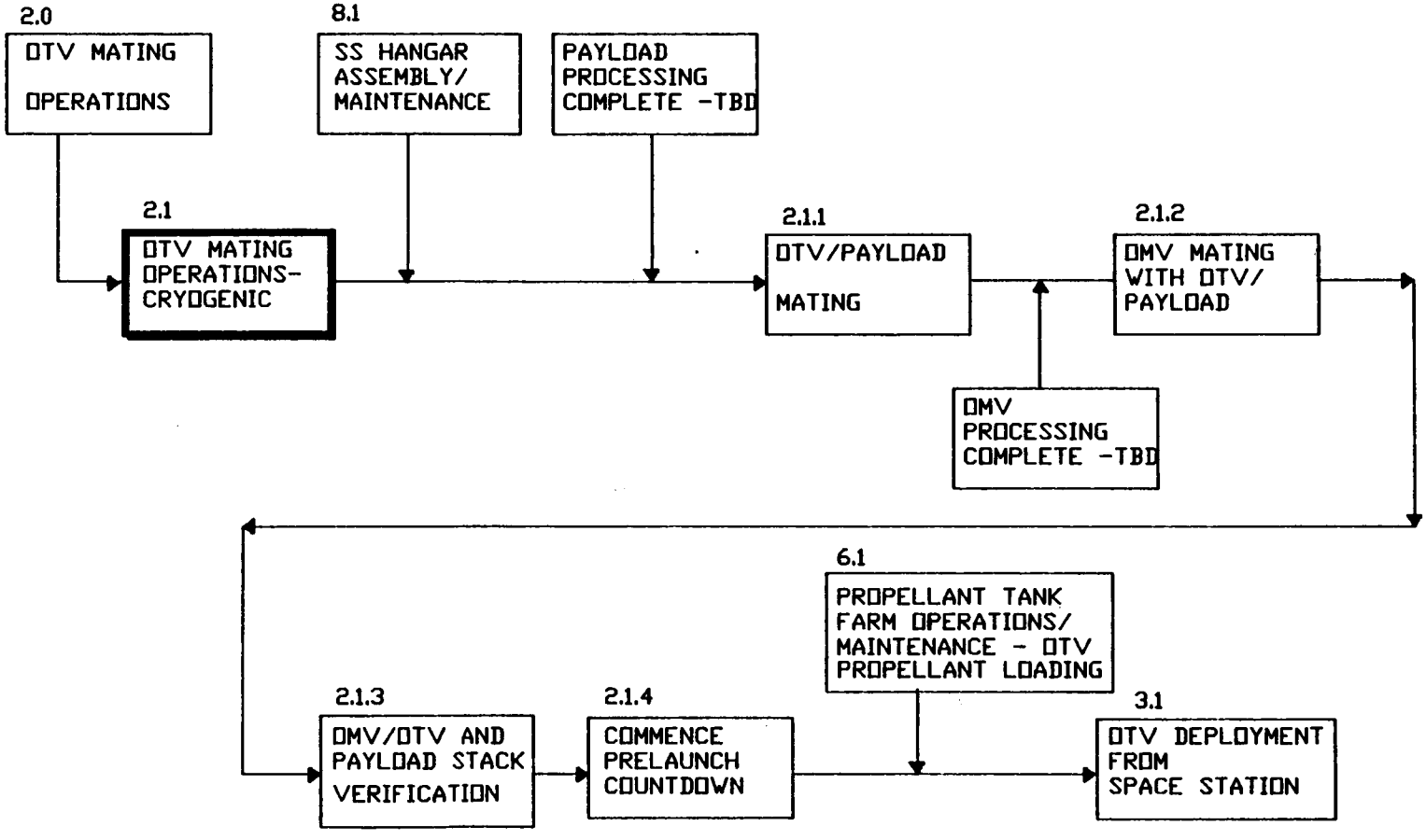
CRYOGENIC SPACE-BASED OTV MATING OPERATIONS

This functional flow and set of requirements definitions addresses the operations associated with payload and OMV mating and the attendant operations required to checkout and verify the OMV/OTV/Payload stack.

SBOTV MATING OPERATIONS – CRYOGENIC



OTV MATING OPERATIONS-CRYOGENIC

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.1	OTV Mating Operations - Cryogenic	SS hangar, ligting, power, signal, propellant umbilicals	Control console, SS computer RMS, robotics, CCTV software	--	15:30	10:25			10:25	
2.1.1	OTV/Payload Mating				1:45	1:45			1:45	
	Logistic support available to support mating operations			—	—	—			—	See 7.0 Logistics Support
	Verify hangar contamination level			--	--	—			--	See 8.0 SS Hangar Assembly/ Maintenance
2.1.1.1	Translate payload to OTV processing area		Control console, SS computer, RMS, CCTV	2	0:15	0:15			0:15	Assumed to be in hangar
2.1.1.2	Secure payload to mating cradle		Control console, SS computer, RMS, CCTV	2	0:15	0:15			0:15	
2.1.1.3	Verify OTV/payload alignment		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
2.1.1.4	Mate OTV/payload - verify proper electrical/mechanical interfaces		Control console, SS computer,	2	1:00	1:00			1:00	Correct anomalies

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.1.2	OMV Mating with OTV/Payload				1:20	1:15			1:15	
2.1.2.1	Translate OMV to OTV processing area		Control console, SS computer, RMS, CCTV	2	0:30	0:30			0:30	
2.1.2.2	Secure OMV to mating cradle		Control console, SS computer, RMS, CCTV	2	0:15	0:15			0:15	
2.1.2.3	Verify OMV/OTV alignment		Control console, SS computer, RMS, CCTV	2	0:15	0:15			0:15	
2.1.2.4	Mate OMV/OTV - verify proper mechanical-interfaces		Control console, SS computer, CCTV,	2	0:15	0:15			0:15	Correct anomalies
2.1.2.5	Connect power, signal, umbilicals to OMV		Control console, SS computer,	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.1.3	OMV/OTV/Payload Stack Verification			--	0:30	0:30			0:30	
2.1.3.1	Verify mechanical/electrical connections		Control console, SS computer, CCTV	1	0:20	0:20			0:20	
2.1.3.2	Verify stack is ready to commence prelaunch countdown		Control console, SS computer	1	0:10	0:10			0:10	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.1.4	Commence Prelaunch Countdown			--	11:55	6:55			6:55	
2.1.4.1	Propellant Transfer		Control console, SS computer, leak detection equipment	--	4:25	4:05			4:05	See 6.0 Propellant Tank Farm Operations/Maintenance
2.1.4.1.1	Attach propellant umbilicals		Control console, SS computer	1	0:20					
2.1.4.1.2	Verify detection equipment operational		Control console, SS computer	1	0:05	0:05			0:05	
2.1.4.1.3	Complete propellant transfer		Control console, SS computer, leak detection equipment	2	4:00	4:00			4:00	Monitor for leaks

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.1.4.2	Conduct Avionics Module Testings			--	1:00	0:30			0:30	
2.1.4.2.1	Verify OTV configuration		Control console, SS computer	1	0:15	0:15			0:15	
2.1.4.2.2	Select, verify and load diagnostic checkout program		Control console, SS computer	1	0:15	0:15			0:15	
2.1.4.2.3	Conduct diagnostic testing of avionics systems (less RF antennas)		Control console, SS computer	1	0:30					Correct anomalies - See 4.0 for maintenance activities

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.1.4.3	Conduct Power Checks			--	0:35	0:05			0:05	
2.1.4.3.1	Verify fuel cell propellant loaded		Control console, SS computer	1	0:15					
2.1.4.3.2	Verify fuel cell operation		Control console, SS computer	1	0:15					
2.1.4.3.3	Verify self-test			1	0:05	0:05			0:05	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.1.4.4	Load Mission Program			--	1:30	0:30			0:30	
2.1.4.4.1	Verify mission program prior to loading		Control console, SS computer	1	0:20	0:20			0:20	
2.1.4.4.2	Load program, conduct program verification		Control console, SS computer	1	1:00					
2.1.4.4.3	Verify program test			1	0:10	0:10			0:10	Correct anomalies

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.1.4.5	Main Engine Check			--	1:30	0:25			0:25	
2.1.4.5.1	Load self-test program			1	0:10	0:10			0:10	
2.1.4.5.2	Engine valve operation check		Control console, SS computer	2	0:15					
2.1.4.5.3	Ignition system check		Control console, SS computer	2	0:15					
2.1.4.5.4	Instrumentation checkout		Control console, SS computer	2	0:20					
2.1.4.5.5	Solenoid checkout		Control console, SS computer	2	0:15					
2.1.4.5.6	Verify self-test			2	0:15	0:15			0:15	Correct anomalies - See 4.0 for maintenance activites

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.1.4.6	Propellant System Check				0:20	0:20			0:20	
2.1.4.6.1	Verify leak check equipment operational		Control console, SS computer leak detection equipment	1	0:05	0:05			0:05	Correct anomalies
2.1.4.6.2	Verify propellant subsystems operating within limits		Control console, SS computer	2	0:15	0:15			0:15	Correct anomalies - See 4.0 for maintenance activities

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.1.4.7	OTV RCS Check				0:30	0:30			0:30	
2.1.4.7.1	Conduct RCS system check		Control console, SS computer	2	0:15	0:15			0:15	Correct anomalies - See 4.0 for maintenance activities
2.1.4.7.2	Verify RCS propellant loaded within limits		Control console, SS computer	2	0:15	0:15			0:15	Correct anomalies - See 4.0 for maintenance activities

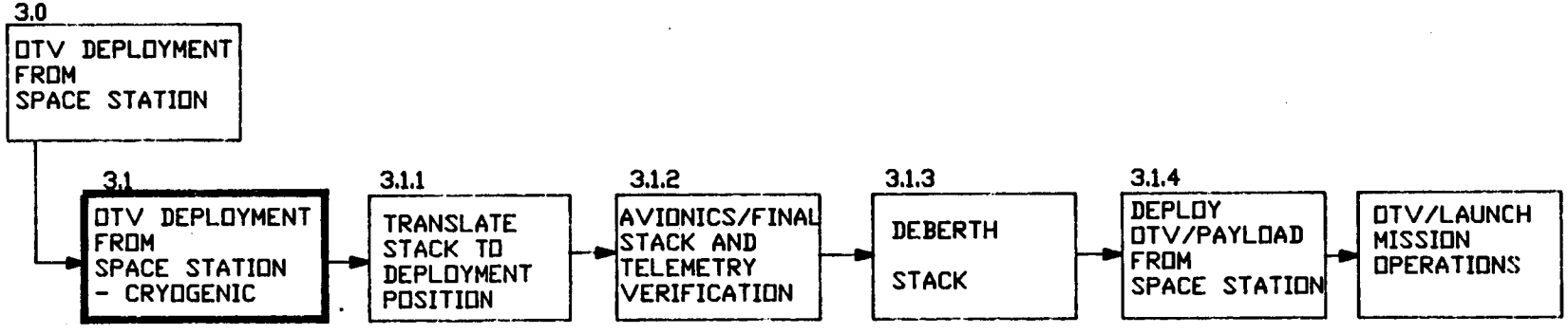
SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.1.4.8	Verify Health and Status of Payload			--	1:05	0:15			0:15	
2.1.4.8.1	Reverify electrical/ mechanical OTV payload interface		Control console, SS computer, CCTV	2	0:15					
2.1.4.8.2	Verify proper power levels and telemetry data		Control console, SS computer	2	0:20					
2.1.4.8.3	Verify payload ACS operation /propellant load		Control console, SS computer	2	0:15					
2.1.4.8.4	Verify self-test			2	0:15	0:15			0:15	Correct anomalies - See payload maintenance activities - TBD

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.1.4.9	Verify Health and Status of OMV			--	1:00	0:15			0:15	
2.1.4.9.1	Reverify mechanical OMV/OIV interface		Control console, SS computer	2	0:10					
2.1.4.9.2	Verify proper power levels and telemetry data		Control console, SS computer	2	0:20					
2.1.4.9.3	Verify propellant load		Control console, SS computer	2	0:15					
2.1.4.9.4	Verify self-test			2	0:15	0:15			0:15	Correct anomalies - See OMV maintenance activites - TBD

CRYOGENIC SPACE-BASED OTV DEPLOYMENT

A functional flow and requirements definition set relative to deployment of the Cryogenic SBOTV, mated with a payload and the OMV, from Space Station is provided.

SBOTV DEPLOYMENT FROM SPACE STATION – CRYOGENIC



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OTV DEPLOYMENT FROM SPACE STATION - CRYOGENIC

SHEET 1 of 4

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
3.1	OTV Deployment From Space Station - Cryogenic	SS hangar, lighting, power signal, propellant umbilicals	Control console, SS computer, CCTV, RMS		2:40	1:25			1:25	
3.1.1	Translate Stack to Deployment Position				1:15	0:30			0:30	
3.1.1.1	Verify mating/checkout complete		Control console, SS computer	2	0:20					
3.1.1.2	Release propellant umbilicals		Control console, SS computer CCTV	1	0:20					
3.1.1.3	Open hangar doors		Control console, SS computer CCTV	1	0:05					
3.1.1.4	Translate stack to hangar porch		Control console, SS computer CCTV	2	0:30	0:30			0:30	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
3.1.2	Avionics/Final Stack and Telemetry Verification				0:20	0:20			0:20	
3.1.2.1	Conduct S-Band check		Control console, SS computer, antenna systems	1	0:10	0:10			0:10	Correct anomolies - See 4.0 for maintenance activities
3.1.2.2	Conduct GPS check		Control console, SS computer, antenna systems	1	0:10	0:10			0:10	Correct anomolies - See 4.0 for maintenance activities

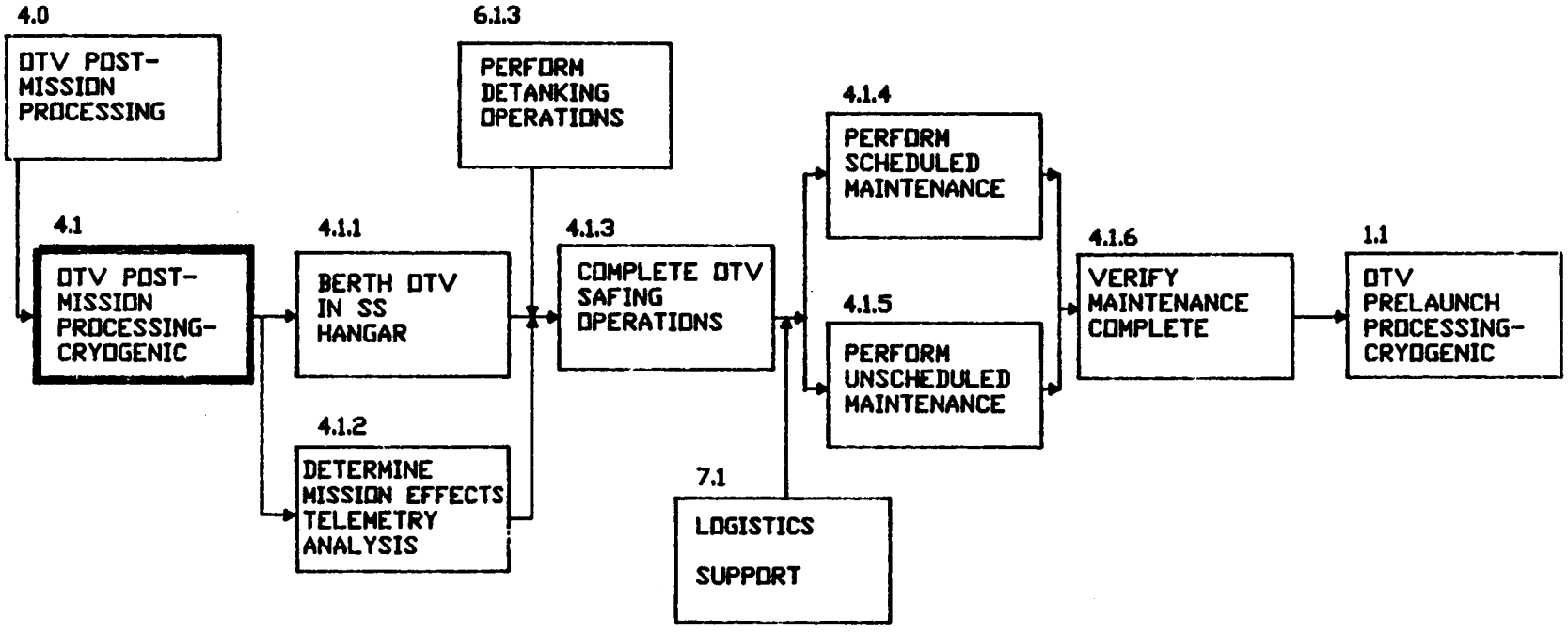
SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
3.1.3	Release Deberth Stack				0:35	0:05			0.05	
3.1.3.1	Release latches on OMV		Control console, SS computer, CCTV	1	0:05				0:05	
3.1.3.2	Collapse OMV mating cradle		Control console, SS computer, CCTV	1	0:05				0:05	
3.1.3.3	Release latches on payload		Control console, SS computer, CCTV	1	0:05				0:05	
3.1.3.4	Collapse payload mating cradle		Control console, SS computer, CCTV	1	0:05				0:05	
3.1.3.5	Attach space crane; release latches on OTV and collapse berthing cradle		Control console, SS computer, CCTV	2	0:05				0:05	
3.1.3.6	Release power and signal umbilicals		Control console, SS computer, CCTV	1	0:05				0:05	
3.1.3.7	Verify sequence complete			2	0:05	0:05			0:05	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
3.1.4	Deploy OMV/OTV/Payload from Space Station				0:30	0:30			0:30	
3.1.4.1	Translate OTV and space crane to deployment position		Control console, SS computer, CCTV	2	0:30	0:30			0:30	
3.1.4.2	Deploy stack		Control console, SS computer, CCTV	2	--	--			--	
3.1.4.3	Transfer conrol of stack to Space Station			2	--	--			--	

CRYOGENIC SPACE-BASED OTV POSTMISSION PROCESSING

The operations associated with retrieval of the Cryogenic SBOTV and OMV, with or without a return payload, and the safing, demating, detanking, and maintenance operations necessary after the return from a mission are provided in the following charts.

SBOTV POSTMISSION PROCESSING – CRYOGENIC



Assumptions:

1. All major components will be removed as a unit i.e., Fuel Tanks, Regulators, Avionics Modules, Engine(s).
2. Only items that cannot be replaced on orbit will be located within the core structure.
3. Tool Kits, special tools and robotic effectors will be provided for each major task.
4. GPS antenna system is not permanently bonded to LO_2 propellant tanks.
5. RF cabling can be disconnected from the octagonal avionics assembly as a unit, to support GPS antenna system replacement.
6. Octagonal avionics assembly will not be removed from the core structure.
7. Core structure and octagonal avionics assembly will be delivered to the Space Station as a single assembled unit.
8. Removal of the main propulsion engine(s) will not require removal of the aerobrake.
9. Robotics will be capable of reaching all connect/disconnect points on the vehicle.
10. Robotics will be used to the maximum extent possible to preclude EVA operations except in contingencies.

Common Actions Associated With All Functions

1. Verify OTV berthing and latching prior to any activities.
2. Verify OTV propellant levels and safing.
3. Verify operations of remote manipulator systems and robotics.
4. Verify current maintenance procedures and robotic programs are available and loaded.
5. Verify that tools/effectors are available and serviceable.
6. Verify that all required test equipment is on hand and operational. Computer programs are available.
7. SS hangar will be clear of all packaging debris after every maintenance activity - Disposal bags will be required during all maintenance activities.

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1	OTV Postmission Processing Cryogenic	SS hanger, lighting, power signal, propellant umbilicals berthing cradle, MRMS	Control console, SS computer, CCTV, robotics, tools/ effectors,	-	-	-	-	-	-	
4.1.1	Berth OTV in Space Station Hangar			-	2:10	2:00			2:00	
4.1.1.1	Open hangar doors		Control console, SS computer	1	0:05					
4.1.1.2	Translate OTV berthing structure onto hangar porch		Control console, SS computer	1	0:15					
4.1.1.3	Position MRMS for OTV retrieval		Control console, SS computer	2	0:15	0:15			0:15	
4.1.1.4	Secure MRMS to OTV grappeling fixtures		Control console, SS computer, CCTV, MRMS	2	0:20	0:20			0:20	
4.1.1.5	Translate OTV to berthing cradle		Control console, SS computer, CCTV, MRMS	2	0:30	0:30			0:30	
4.1.1.6	Position OTV in berthing cradle		Control console, SS computer,	2	0:05	0:05			0:05	
4.1.1.7	Release MRMS grapples - secure MRMS		Control console, SS computer	2	0:20	0:20			0:20	
4.1.1.8	Demate OMV for OTV		Control console, SS computer	2	0:05	0:05			0:05	
4.1.1.9	Translate OTV into hangar - secure hangar doors		Control console, SS computer	2	0:30	0:25			0.25	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.2	Determine Mission Effects - Telemetry Analysis		Control console, SS computer, CCTV, leak detection equipment	-	5:45-6:30	3:15-4:00			3:15-4:00	
4.1.2.1	Conduct visual inspection of OTV - hazardous conditions		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
4.1.2.2	Conduct leak check		Control console, SS computer, leak detection equipment	1	0:15	0:15			0:15	
4.1.2.3	Demate/secure payload		Control console, SS computer	2	0:45	0:45			0:45	As required
4.1.2.4	Load diagnostic program and verify as-flown condition		Control console, SS computer	2	0:15	0:15			0:15	
4.1.2.5	Commence detanking of residual propellants		Control console, SS computer, CCTV	2	2:15	2:15			2:15	See 6.1.3 OTV detanking
4.1.2.6	Run diagnostic program on as-flown configuration		Control console, SS computer	1	2:30					
4.1.2.7	Prepare maintenance plan		Control console, SS computer	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.3	Complete OTV Safing Operations			-	0:40	0:35			0:35	
4.1.3.1	Verify propellant valves closed		Control console, SS computer	2	—	—			—	
4.1.3.2	Conduct leak check		Control console, SS computer, leak check equipment	1	0:10	0:10			0:10	
4.1.3.3	Verify tank pressure stabilized		Control console, SS computer pressure gauges	2	0:10	0:10			0:10	
4.1.3.4	Disconnect propellant umbilical		Control console, SS computer	2	0:10					
4.1.3.5	Verify critical electrical and avionics components safed		Control console, SS computer	1	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.4	Perform Scheduled Maintenance			-	-	-	-	-	-	
4.1.4.1	Propellant Tank Scheduled Maintenance	SS hangar lighting, power, signal, propellant umbilicals	SS computer, control console, test equipment, robotics, CCTV, tools/effectors	-	2:15	1:55			1:55	Computer interfaces with onboard diagnostic equipment/systems o Includes an external visual inspection (CCTV) o PU and TVS system
4.1.4.1.1	Translate robotics to tool area and secure tools/ effectors		Control console, SS computer, CCTV	1	0:05					
4.1.4.1.2	Translate robotics to propellant tank work area		Control console, SS computer	1	0:05					
4.1.4.1.3	Visually inspect propellant tank and valve system		Control console, CCTV, robotics	2	1:40	1:40			1:40	
4.1.4.1.4	Conduct diagnostic testing		Control console, SS computer	1	0:15	0:15			0:15	Non-destructive test equipment
4.1.4.1.5	Translate robotics to tool area store tools/effectors		Control console, SS computer, CCTV	1	0:05					
4.1.4.1.6	Translate robotics to storage		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.4.2	Avionics Scheduled Maint.									
4.1.4.2.1	Module Test	SS Hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, test equipment		2:05	0:30			0:30	
4.1.4.2.1.1	Verify signal and power umbilicals connected		Control console, SS computer	1	0:10					
4.1.4.2.1.2	Verify required test software is loaded into SS computer		SS computer, control console	2	0:15	0:15			0:15	
4.1.4.2.1.3	Conduct test		SS computer, control console	1	1:25					Replace defective modules.
4.1.4.2.1.4	Verify self-test complete		SS computer, control console	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS		TRNG	FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS		TIME	IVA	EVA	EVA	TOTAL	
4.1.4.2.2	Scheduled Module Replacement	SS hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, CCTV, robotics, test equipment, tools/effectors, LRU's		1:50	1:00			1:00	
4.1.4.2.2.1	Translate robotics to tool area and secure tools/ effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.2.2.2	Translate robotics to spare parts storage area - secure replacement module and store		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.2.2.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.1.4.2.2.4	Remove avionics module and store		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:15	0:15			0:15	
4.1.4.2.2.5	Visually inspect module mounting interface for defects		Control console, SS computer, CCTV, robotics,	2	0:05	0:05			0:05	
4.1.4.2.2.6	Install replacement module and secure		Control console, SS computer, CCTV, robotics, tools/ effectors	2	0:15	0:15			0:15	
4.1.4.2.2.7	Conduct module test/ checkout		Control console, SS computer	1	0:30	0:05			0:05	
4.1.4.2.2.8	Translate robotics to parts storage area-package module for shipment		Control console, SS computer, robotics, CCTV	1	0:20	0:20			0:20	Return to earth
4.1.4.2.2.9	Translate robotics to tool storage and secure tools		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.2.2.10	Translate robotics to storage and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.4.2.3	ACS Update	SS Hangar, lighting, signal, power, propellant umbilicals	Control console, SS computer, software		0:45	0:10			0:10	
4.1.4.2.3.1	Verify power and signal umbilicals are connected		Control console, SS computer	1	0:05					
4.1.4.2.3.2	Verify ACS update loaded		Control console, SS computer, software	1	0:05	0:05			0:05	
4.1.4.2.3.3	Update ACS		Control console, SS computer, software	2	0:30					
4.1.4.2.3.4	Verify update complete		Control console, SS computer	2	0:05	0:05			0:05	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.4.2.4	Avionic - Mission Peculiar									
4.1.4.2.4.1	Module Replacement	SS hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, robotics, CCTV, tools/effector checkout equipment, software	1+2	1:50	1:00			1:00	
	See 4.1.4.2.2									
4.1.4.2.4.2	Reconfiguration	SS hangar lighting power, signal, propellant umbilicals	Control console, SS computer, robotics, CCTV, tools/ effectors, checkout equipment, software	1+2	1:50	1:00			1:00	
	See 4.1.4.2.2									

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	REQUIREMENTS TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.1.4.3	RCS Scheduled Maintenance									
4.1.4.3.1	Leak Check	SS hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, CCTV, test equipment, RMS	-	0:50	0:35			0:35	
4.1.4.3.1.1	Condition propellant umbilical		Control console, SS computer	2	0:10					
4.1.4.3.1.2	Connect umbilical and verify connection		Control console, SS computer	1	0:05	0:05			0:05	
4.1.4.3.1.3	Conduct leak check and verify		Control console, SS computer	1	0:30	0:30			0:30	Correct anomalies
4.1.4.3.1.4	Disconnect propellant umbilical		Control console, SS computer	2	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.4.3.2	Transducer Check	SS hanger, lighting, power, signal, propellant umbilicals	Control console, SS computer, software, CCTV	-	0:55	0:20			0:20	
4.1.4.3.2.1	Verify power, signal and propellant umbilicals connected		Control console, SS computer CCTV	1	0:05					
4.1.4.3.2.2	Load transducer check software		Control console, SS computer, software	1	0:15	0:15			0:15	
4.1.4.3.2.3	Conduct transducer check		SS computer, software	1	0:30					
4.1.4.3.2.4	Verify check complete		SS computer, control console	2	0:05	0:05			0:05	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.4.3.3	RCS - Resupply	SS hanger, lighting, power, signal, propellant umbilicals	Control Console, SS computer, RCS software		1:50	1:35			1:35	
4.1.4.3.3.1	Condition propellant umbilical		Control console, SS computer	2	0:10					
4.1.4.3.3.2	Connect propellant umbilical and verify connection		Control console, SS computer, RMS	1	0:05	0:05			0:05	
4.1.4.3.3.3	Transfer RCS propellant		Control console, SS computer, leak detection equipment	2	1:15	1:15			1:15	Monitor for leaks
4.1.4.3.3.4	Blow back propellant umbilical when transfer complete		Control console, SS computer	2	0:15	0:15			0:15	
4.1.4.3.3.5	Disconnect propellant umbilical		Control console, SS computer, RMS	2	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.4.3.4	RCS - Health Maintenance									
4.1.4.3.4.1	Scheduled Transducer Replacement	SS hanger, lighting, power, signal, propellant umbilicals	Control console, SS computer, robotics, CCTV, tools/ effectors	-	2:20	1:30			1:30	
4.1.4.3.4.1.1	Translate robotics to tool storage area and secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.3.4.1.2	Translate robotics to parts storage area select LRU and store		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.3.4.1.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.1.4.3.4.1.4	Remove transducer and store		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:30	0:30			0:30	
4.1.4.3.4.1.5	Conduct visual inspection		Control console, SS computer, CCTV	2	0:05	0:05			0:05	
4.1.4.3.4.1.6	Install and secure replacement transducer		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:30	0:30			0:30	
4.1.4.3.4.1.7	Conduct transducer check and verify		SS computer, software	1	0:30	0:05			0:05	
4.1.4.3.4.1.8	Translate robotics to parts storage area - package for shipment		Control console, SS computer, robotics, CCTV	1	0:20	0:20			0:20	Return to earth
4.1.4.3.4.1.9	Translate robotics to tools storage area, secure tools		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.3.4.1.10	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.4.3.4.2	Scheduled Thruster Replacement	SS hanger, lighting, power, signal, propellant umbilicals	Control console, SS computer, LRU's, robotics, CCTV, tools/ effectors	-	2:55	2:20			2:20	
4.1.4.3.4.2.1	Translate robotics to tool storage area and secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.3.4.2.2	Translate robotics to spare parts storage area - secure spare thrusters and store		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.3.4.2.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.1.4.3.4.2.4	Disconnect thruster propellant lines and electrical interfaces		Control console, SS computer, robotics, CCTV, tool/ effectors	2	0:15	0:15			0:15	
4.1.4.3.4.2.5	Remove and store thruster		Control console, SS computer, robotics, CCTV	2	0:20	0:20			0:20	
4.1.4.3.4.2.6	Install new thruster		Control console, SS computer, robotics, CCTV	2	0:30	0:30			0:30	
4.1.4.3.4.2.7	Connect thruster propellant lines and electrical interfaces		Control console, SS computer, robotics, CCTV	2	0:15	0:15			0:15	
4.1.4.3.4.2.8	Connect propellant umbilical		Control console, SS computer, CCTV	1	0:05					
4.1.4.3.4.2.9	Conduct leak check		Control console, SS computer leak detection equipment	1	0:30	0:30			0:30	
4.1.4.3.4.2.10	Blow back propellant lines and disconnect		Control console, SS computer	2	0:15	0:10			0:10	
4.1.4.3.4.2.11	Translate robotics to parts area - package thrusters for shipment		Control console, SS computer, robotics, CCTV	1	0:20	0:20			0:20	Return to earth
4.1.4.3.4.2.12	Translate robotics to tool area, secure tools		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.3.4.2.13	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.4.4	Scheduled Engine Maintenance	SS hanger, lighting, Ground computer, power, signal, propellant umbilicals	Control console, SS computer, robotics, CCTV		4:15	0:40			0:40	
4.1.4.4.1	Post Flight Maintenance									
4.1.4.4.1.1	Analysis of flight data		SS computer, ground computer	1	--	--			--	
4.1.4.4.1.2	Load self-test program		Control console, SS computer	1	0:10	0:10			0:10	
4.1.4.4.1.3	Lock up pressure decay		SS computer, engine software	1	0:30					
4.1.4.4.1.4	Engine valve operation check		SS computer, engine software	1	0:30					
4.1.4.4.1.5	Nozzle inspection		SS computer, CCTV robotics	2	0:35					
4.1.4.4.1.6	Nozzle extension check		SS computer, software, CCTV	1	0:10					
4.1.4.4.1.7	Gimbal actuator check		SS computer, software, CCTV	1	0:10					
4.1.4.4.1.8	Connect umbilicals		Control console, SS computer, CCTV	1	0:10					
4.1.4.4.1.9	Turbopump torque check		SS computer, software	2	0:10					Flight data analysis
4.1.4.4.1.10	Ignition system check		SS computer, software	1	0:20					
4.1.4.4.1.11	Instrumentation checkout		SS computer, software	1	0:30					
4.1.4.4.1.12	Solenoid checkout		SS computer, software	1	0:20					
4.1.4.4.1.13	Disconnect umbilicals		Control console, SS computer	1	0:10					
4.1.4.4.1.14	Verify self-test complete			2	0:30	0:30			0:30	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.4.4.2	Engine - Periodic Maint	SS hanger, lighting, power, signal, propellant umbilicals	Control console, SS computer boroscope, robotics, LRU, tools/effectors		2:00	1:30			1:30	
4.1.4.4.2.1	Translate robotics to tool storage area - secure tools/effectors		Control console, SS computer, RMS, robotics, CCTV	1	0:05					
4.1.4.4.2.2	Translate robotics to parts storage area - secure and store LRU's		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.4.2.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.1.4.4.2.4	Conduct engine boroscope inspection.		Control console, SS computer, robotics, CCTV, boroscope	2	0:30	0:30			0:30	
4.1.4.4.2.5	Conduct thrust chamber inspection		Control console, SS computer, CCTV, RMS	2	1:00	1:00			1:00	
4.1.4.4.2.6	Translate robotics to parts storage area. Secure unused parts		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.4.2.7	Translate robotics to tool storage area - secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.4.2.8	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.1.4.4.3	Engine Remove and Replace	SS hanger, lighting, power, signal, propellant umbilicals	Control console, SS computer, robotics, RMS, CCTV, tools/ effectors, special tools, protective covers	1	5.30	3:35			3:35	
4.1.4.4.3.1	Translate robotics to tool storage area - secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.4.3.2	Translate robotics to parts storage - secure and store parts		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.4.3.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.1.4.4.3.4	With engine removal tool disconnect engine from interface plate		Control console, SS computer, robotics, CCTV, special tool	2	0:40	0:40			0:40	
4.1.4.4.3.5	Inflate engine removal tool		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.1.4.4.3.6	Remove engine with robotics		Control console, SS computer, CCTV, robotics, special tool	2	0:05	0:05			0:05	
4.1.4.4.3.7	Translate RMS to work site; Attach grapple; disengage removal tool		Control console, SS computer, robotics, RMS, CCTV,	2	0:10	0:10			0:10	
4.1.4.4.3.8	Translate RMS to parts storage area and secure unserviceable engine		Control console, SS computer, RMS, CCTV,	2	0:15	0:15			0:15	
					"	"			"	
4.1.4.4.3.9	Translate robotics to parts storage area; unpackage replacement engine		Control console, SS computer, robotics, CCTV,	2	0:15	0:15			0:15	
4.1.4.4.3.10	Conduct visual inspection		CCTV, robotics	2	0:05	0:05			0:05	
4.1.4.4.3.11	Attach RMS to engine grapple; translate RMS to work site		Control console, SS computer, CCTV, robotics	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.4.4.3.12	Translate robotics to work site; secure removal tool		Control console, SS computer	1	0:05					
4.1.4.4.3.13	Install engine removal tool; inflate support mechanism		Control console, SS computer, robotics, CCTV, special tool	2	0:10	0:10			0:10	
4.1.4.4.3.14	Position robotics for installation		Control console, SS computer	2	0:05					
4.1.4.4.3.15	Release RMS from engine grapple		Control console, SS computer,	2	-	-			-	
4.1.4.4.3.16	Verify engine alignment with interface		Control console, SS computer, robotics, CCTV, special tool	2	0:05	0:05			0:05	
4.1.4.4.3.17	Complete installation verify locking mechanisms are secured		Control console, SS computer, robotics, CCTV, special tool	2	0:40	0:40			0:40	
4.1.4.4.3.18	Disengage engine removal tool		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.1.4.4.3.19	Engine check and verify		Control console, SS computer, CCTV	2	1:30	0:20			0:20	
4.1.4.4.3.20	Translate RMS to parts storage area and secure unserviceable engine at grapple fixture		Control console, SS computer, RMS, CCTV	2	0:05	0:05			0:05	
4.1.4.4.3.21	Translate robotics to tool storage area and secure engine removal tool		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.4.3.22	Translate robotics to parts storage area. Install protective covers on unserviceable engine; prepare for shipment		Control console, SS computer, robotics, CCTV	1	0:20	0:20			0:20	Return to earth
4.1.4.4.3.23	Store and secure engine with RMS following protective cover installation		Control console, SS computer, robotics, CCTV, protective covers	2	0:05	0:05			0:05	
4.1.4.4.3.24	Store and secure RMS		Control console, SS computer	1	0:05					Accomplished in conjunction with 4.1.4.4.3.25

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.4.4.3.25	Store and secure additional replacement parts carried by robotics		Control console, SS computer, robotics, CCTV	1	0:10					
4.1.4.4.3.26	Translate robotics to tool storage area and secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.4.3.27	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.4.5	Aerobrake Scheduled Maintenance									
4.1.4.5.1	Aerobrake Inspection	SS hanger, lighting, power, signal, propellant umbilicals	Control console, SS computer, robotics, CCTV, special equipment	-	1:10	0:30			0:30	
4.1.4.5.1.1	Analyze post mission telemetry data		SS computer, software	2	0:20	0:20			0:20	
4.1.4.5.1.2	Translate robotics to tool storage area; secure tools/ effectors		SS computer, software, robotics, CCTV	1	0:05					
4.1.4.5.1.3	Translate robotics to aerobrake work site		SS computer, software	1	0:05					
4.1.4.5.1.4	Conduct aerobrake inspection		Control console, SS computer, inspection equipment, CCTV, robotics	1	0:20					
4.1.4.5.1.5	Verify inspection data		Control console, SS computer	2	0:10	0:10			0:10	Correct anomalies
4.1.4.5.1.6	Translate robotics to tool area-secure tools		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.5.1.7	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.4.5.2	Remove and Replace Aerobrake and Support	SS hanger, lighting, power, signal, propellant umbilicals	Control console, SS computer, robotics, RMS, CCTV, tools/ effectors, special tools LRU's, leak detection equipment	-	4:25	3:50			3:50	
4.1.4.5.2.1	Translate RMS to aerobrake work site and attach to grapple fixture		Control console, SS computer	1	0:05	0:05			0:05	
4.1.4.5.2.2	Translate robotics to tool area; secure and store required tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.5.2.3	Translate robotics to parts storage area; secure and store replacement hardware		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.5.2.4	Translate robotics to aerobrake work site		Control console, SS computer	1	0:05					
4.1.4.5.2.5	Disconnect RCS propellant/ electrical interfaces		Control console, SS computer, robotics, CCTV	2	0:20	0:20			0:20	
4.1.4.5.2.6	Disconnect aerobrake and support from support ring		Control console, SS computer, robotics, CCTV	2	0:15	0:15			0:15	
4.1.4.5.2.7	Translate RMS and robotics from work site to storage area; secure unserviceable aerobrake and support		Control console, SS computer, RMS, CCTV	2	0:20	0:20			0:20	
4.1.4.5.2.8	Assemble aerobrake and support with RMS and robotics		Control console, SS computer, RMS, robotics, CCTV	2	0:30	0:30			0:30	
4.1.4.5.2.9	Translate RMS and robotics to work site with replacement aerobrake and support		Control console, SS computer	2	0:20	0:20			0:20	
4.1.4.5.2.10	Inspect aerobrake support ring and RCS propellant/ interfaces		Control console, SS computer, robotics, CCTV	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.4.5.2.11	Align aerobrake and support with attachments		Control console, SS computer, robotics, RMS, CCTV	2	0:10	0:10			0:10	
4.1.4.5.2.12	Attach aerobrake and support to support ring, verify mechanical attachments are secure		Control console, SS computer, RMS, robotics, CCTV	2	0:10	0:10			0:10	
4.1.4.5.2.13	Verify RCS propellant/ electrical interfaces are seated		Control console, SS computer, robotics, CCTV	2	0:10	0:10			0:10	
4.1.4.5.2.14	Attach RCS test equipment		Control console, SS computer, robotics, CCTV, test equipment	2	0:15	0:15			0:15	
4.1.4.5.2.15	Pressurize RCS propellant spheres		Control console, SS computer	2	0:05					
4.1.4.5.2.16	Conduct RCS propellant leak check		Control console, SS computer, leak detector equipment	2	0:15	0:15			0:15	
4.1.4.5.2.17	Disconnect test equipment		Control console, SS computer, robotics, CCTV	2	0:15	0:15			0:15	
4.1.4.5.2.18	Depressurize RCS propellant spheres		Control console, SS computer	2	0:05					
4.1.4.5.2.19	Translate RMS to storage area and secure		Control console, SS computer	1	0:05					
4.1.4.5.2.20	Translate robotics to parts storage area and secure parts		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.5.2.21	Disassemble unserviceable aerobrake; package for shipment		Control console, SS computer, robotics, CCTV, tools/ effectors	1	0:30	0:30			0:30	Return to earth
4.1.4.5.2.22	Translate robotics to tool storage area and secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.4.5.2.23	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5	Perform unscheduled Maintenance									
4.1.5.1	Propellant Tank Unscheduled Maintenance									
4.1.5.1.1	Remove and Replace Propellant Tank	SS hanger, lighting power, signal, propellant umbilicals	Control console, SS computer, test equipment, robotics, tools/effectors	-	3:00	2:20			2:20	
4.1.5.1.1.1	Translate robotics to tool area; secure & store tools/effectors		Control console, SS computer, CCTV	1	0:05					
4.1.5.1.1.2	Translate robotics to work site		Control console, SS computer	1	0:05					
4.1.5.1.1.3	Translate RMS to work site and attach propellant tank grapple fixture		Control console, SS computer, RMS, CCTV	2	0:10	0:10			0:10	
4.1.5.1.1.4	Release tank at attaching Point 1		Control console, SS computer, robotics, CCTV	2	0:15	0:15			0:15	
4.1.5.1.1.5	Release tank at attaching Point 2		Control console, SS computer, robotics, CCTV	2	0:10	0:10			0:10	
4.1.5.1.1.6	Translate robotics from work site		Control console, SS computer	1	—	—			—	This creates a clear path for the propellant tank when removed by RMS'
4.1.5.1.1.7	Remove tank with RMS		Control console, SS computer,	2	0:05	0:05			0:05	
4.1.5.1.1.8	Translate RMS to parts storage area and secure unserviceable tank		Control console, SS computer, CCTV, RMS	2	0:20	0:20			0:20	
4.1.5.1.1.9	Inspect tank interfaces with robotics; replace or repair any damaged components prior to tank installation		Control console, SS computer, CCTV, parts kit (as required)	2	0:20 ||	0:20 ||			0:20 ||	
4.1.5.1.1.10	Translate RMS with serviceable tank to work site		Control console, SS computer, CCTV, RMS	2	0:20	0:20			0:20	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.1.1.11	Verify sufficient clearance between robotics and RMS with tank		Control console, SS computer	1	—	—			—	This is a precaution to ensure tank is not damaged during the initial alignment process
4.1.5.1.1.12	Position/align tank with OTV attaching and interface points		CCTV, SS computer, control console, RMS, robotics	2	0:10	0:10			0:10	
4.1.5.1.1.13	Secure tank at attaching Point 2		Robotics, control console, SS computer, CCTV	2	0:10	0:10			0:10	
4.1.5.1.1.14	Secure tank at attaching Point 1		Robotics, control console, SS computer, CCTV	2	0:10	0:10			0:10	
4.1.5.1.1.15	Release RMS from grapple fixture		Control console, SS computer, RMS	2	—	—			—	
4.1.5.1.1.16	Install/checkout & calibrate leak check equipment		Control console, SS computer, test equipment, CCTV	2	0:15	0:15			0:15	
4.1.5.1.1.17	Pressurize tank		Control console, SS computer, test equipment	2	0:15					
4.1.5.1.1.18	Depressurize tank if no anomalies are detected; disconnect test equipment		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.1.5.1.1.19	Translate RMS to storage location and secure		Control console, SS computer	1	0:05					
4.1.5.1.1.20	Translate robotics to parts parts area		Control console, SS computer, CCTV	1	0:05					
4.1.5.1.1.21	Prepare tank for shipment		Control console, SS computer,	1	0:10	0:10			0:10	Return to earth
4.1.5.1.1.22	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.1.2	Propellant Tank Insulation Repair	SS hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, tools/effectors, robotics, repair unit, special tools	-	2:00	1:35			1:35	
4.1.5.1.2.1	Translate robotics to tool area; secure insulation repair kit and tools/ effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.1.2.2	Translate robotics to work site		Control console, SS computer	1	0:05					
4.1.5.1.2.3	Verify that insulation damage is within established tolerances		Control console, SS computer, measuring equipment, robotics, CCTV	2	0:15	0:15			0:15	
4.1.5.1.2.4	Fill or remove damaged area IAW prescribed procedures		Control console, SS computer, robotics, CCTV, repair kit	2	0:40	0:40			0:40	
4.1.5.1.2.5	Place removed section in waste disposal container		Control console, SS computer, CCTV, robotics	2	--	--			--	
4.1.5.1.2.6	Replace section IAW prescribed procedures		Control console, SS computer, CCTV, robotics, repair kit	2	0:40	0:40			0:40	
4.1.5.1.2.7	Verify proper set up and curing is taking place		CCTV, SS computer robotics, control console,	2	0:05					
4.1.5.1.2.8	Translate robotics to tool area, store tools/effectors		CCTV, control console, robotics, SS computer	1	0:05					
4.1.5.1.2.9	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.1.3	Transducer Replacement	SS hangar, lighting, power, signal propellant umbilicals	Control console, SS computer, CCTV, robotics, LRU, tools/effectors, test equipment	-	2:05	1:15			1:15	
4.1.5.1.3.1	Translate robotics to tool area - secure tools/ effectors and test equipment		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.1.3.2	Translate robotics to parts storage area and secure replacement transducer		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.1.3.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.1.5.1.3.4	Remove unserviceable transducer and store		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
4.1.5.1.3.5	Install serviceable transducer		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
4.1.5.1.3.6	Install/checkout & calibrate transducer test equipment		Control console, SS computer, CCTV, robotics, test equipment	2	0:15	0:15			0:15	
4.1.5.1.3.7	Conduct transducer checkout		Control console, SS computer, CCTV, robotics,	1	0:15					Correct anomolies
4.1.5.1.3.8	Disconnect & store test equipment		Control console, SS computer, CCTV, robotics,	2	0:15	0:15			0:15	
4.1.5.1.3.9	Translate robotics to parts area; package unserviceable transducer		Control console, SS computer, CCTV, robotics,	1	0:15	0:15			0:15	Return to earth
4.1.5.1.3.10	Translate robotics to tool area - secure tools and test equipment		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.1.3.11	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.1.4	Remove and Replace PU or TVS	SS hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, robotics, CCTV, tools/ effectors, PU or TVS LRUs, test equipment	1	2:10	1:30			1:30	
4.1.5.1.4.1	Translate robotics to tool area - secure tools/effectors and test equipment		Control console, SS computer, robotics, CCTV, tools/ effectors	1	0:05					
4.1.5.1.4.2	Translate robotics to parts storage area secure PU or TVS LRUs		Control console, SS computer, robotics, CCTV, PU or TVS LRU effectors	1	0:05					
4.1.5.1.4.3	Translate robotics to work site		Control console, SS computer		0:05					
4.1.5.1.4.4	Remove PU or TVS		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
4.1.5.1.4.5	Install new PU or TVS		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
4.1.5.1.4.6	Install/checkout/calibrate PU or TVS test equipment		Control console, SS computer, robotics, CCTV, test equipment	2	0:15	0:15			0:15	
4.1.5.1.4.7	Conduct PU or TVS checkout		Control console, SS computer	1	0:15					Correct anomalies
4.1.5.1.4.8	Disconnect and store test equipment in robotics		Control console, SS computer, robotics, CCTV	2	0:15	0:15			0:15	
4.1.5.1.4.9	Translate robotics to parts area, package unserviceable PU or TVS		Control console, SS computer, robotics, CCTV	1	0:20	0:20			0:20	Return to earth
4.1.5.1.4.10	Translate robotics to tool area - secure tools/ effectors and test equipment		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.1.4.11	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.1.5	Tank Reconfiguration NOTE: LO_2 tank remove and replace will follow LH_2 procedures once antennas are removed (see 4.1.5.1.1)	SS hangar, lighting, power, signal, propellant umbilical	Control console, SS computer, robotics, RMS, CCTV, tools/ effectors, propellant tank(s), test equipment		3:00	2:20			2:20	3:00 hrs/tank

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.2	Avionics Unscheduled Maintenance									
4.1.5.2.1	Module Replacement	SS hangar, lighting, signal, power, propellant umbilicals	Control console, SS computer, CCTV, robotics, tools/ effectors, test equipment	-	1:50	0:55			0:55	
4.1.5.2.1.1	Translate robotics to tool area; secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.2.1.2	Translate robotics to parts storage; secure replacement module		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.2.1.3	Translate robotics to work site		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.2.1.4	Remove and store avionics module		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:15	0:15			0:15	
4.1.5.2.1.5	Inspect module mounting interface for defects		Control console, CCTV, robotics	2	0:05	0:05			0:05	
4.1.5.2.1.6	Install replacement module		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:15	0:15			0:15	
4.1.5.2.1.7	Conduct module test/checkout		Control console, SS computer	1	0:30					Correct anomalies
4.1.5.2.1.8	Translate robotics to parts storage; package unservice-able module		Control console, SS computer, robotics, CCTV	1	0:20	0:20			0:20	Return to earth
4.1.5.2.1.9	Translate robotics to tool storage area; secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.2.1.10	Translate robotics to storage and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.1.5.2.2	Remove and replace GPS Antenna System	SS hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, tools/effectors, robotics, CCTV, LRU's	-	2:35	1:40			1:40	S-Band antenna is mounted on octagonal avionics assembly
4.1.5.2.2.1	Translate robotics to tool area; secure tools/effectors and test equipment		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.2.2.2	Translate robotics to parts storage area - secure and store replacement parts		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.2.2.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.1.5.2.2.4	Disconnect GPS antenna cabling		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:10	0:10			0:10	
4.1.5.2.2.5	Disconnect GPS cable retaining devices if attach to tank		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:15	0:15			0:15	
4.1.5.2.2.6	Disconnect, remove and store GPS antenna system		Control console, SS computer, robotics, CCTV, tools/ effectors		0:20	0:20			0:20	
4.1.5.2.2.7	Install GPS antenna system		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
4.1.5.2.2.8	Reattach RF cabling		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:15	0:15			0:15	
4.1.5.2.2.9	Conduct test on GPS antenna system		Control console, SS computer, test equipment	1	0:30					Correct anomalies
4.1.5.2.2.10	Translate robotics to parts storage area; package GPS antenna system		Control console, SS computer, robotics, CCTV	1	0:20	0:20			0:20	Return to earth

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.2.2.11	Translate robotics to tool storage area and secure tools		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.2.2.12	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.3	Unscheduled RCS Maintenance - TBD									
4.1.5.4	Unscheduled Engine Maintenance-TBD									

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.1.5.5	Remove and Replace Turbopump	SS hanger, signal, power, propellant		-	4:40	3:30			3:30	4:40/Turbopump
4.1.5.5.1	Translate robotics to tool area - secure and stow tools/effectors and special removal tools	umbilical lighting	Control console, SS computer, CCTV	1	0:05					
4.1.5.5.2	Translate robotics to parts area - secure and stow replacement turbopump		Control console, SS computer, CCTV	1	0:05					
4.1.5.5.3	Translate robotics to work site		Control console, SS computer, CCTV	1	0:05					
4.1.5.5.4	Install turbopump installation tools		Control console, SS computer, CCTV, tools/effectors, special tools	2	0:50	0:50			0:50	
4.1.5.5.5	Disconnect turbopump		Control console, SS computer, CCTV, tools/effectors,	2	0:10	0:10			0:10	
4.1.5.5.6	Remove turbopump		Control console, SS computer, CCTV, tools/effectors,	2	0:30	0:30			0:30	
4.1.5.5.7	Install turbopump installation tools		Control console, SS computer, CCTV, tools/effectors,	2	0:45	0:45			0:45	
4.1.5.5.8	Position turbopump and connect		Control console, SS computer, CCTV, tools/effectors,	2	0:10	0:10			0:10	
4.1.5.5.9	Remove installation tools		Control console, SS computer, CCTV, tools/effectors,	2	0:20	0:20			0:20	
4.1.5.5.10	Connect checkout equipment		Control console, SS computer, CCTV, tools/effectors, special tools	2	0:15	0:15			0:15	
4.1.5.5.11	Conduct leak check and electrical check		Control console, SS computer, test equipment	1	0:40					Correct anomalies
4.1.5.5.12	Remove checkout equipment		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
4.1.5.5.13	Translate robotics to parts area		Control console, SS computer, CCTV	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.5.14	Package turbopump for shipment		Control console, SS computer, CCTV, tools/effectors,	1	0:15	0:15			0:15	Return to earth
4.1.5.5.15	Translate robotics to tool area - secure tools		Control console, SS computer	1	0:05					
4.1.5.5.16	Secure robotics		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.6	Aerobrake Unscheduled Repair	SS Hangar, lighting, power, signal, umbilicals	Control console, SS computer, robotics, CCTV, repair kit, special tools	-	3:05	2:30			2:30	
4.1.5.6.1	Translate robotics to tool storage area; secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.6.2	Translate robotics to parts storage area; secure repair kit		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.6.3	Translate robotics to aerobrake work site		Control console, SS computer	1	0:05					
4.1.5.6.4	Verify damaged area is within prescribed repairable tolerance		Control console, SS computer, robotics, CCTV, measuring tool	2	0:10	0:10			0:10	
4.1.5.6.5	Prepare area for repair		Control console, SS computer, robotics, CCTV, tools	2	0:30	0:30			0:30	
4.1.5.6.6	Complete repairs		Control console, SS computer, robotics, CCTV, tools	2	1:20	1:20			1:20	
4.1.5.6.7	Verify curing/setup requirements		SS computer	1	0:05					
4.1.5.6.8	Conduct required repair test		Control console, SS computer, CCTV, robotics	2	0:30	0:30			0:30	Visual, pull, etc.
4.1.5.6.9	Translate robotics to parts storage area		Control console, SS computer, robotics, CCTV,	1	0:05					
4.1.5.6.10	Translate robotics to tool storage area, secure tools/effector		Control console, SS computer, robotics, CCTV,	1	0:05					
4.1.5.6.11	Translate robotics to storage area and secure		Control console, SS computer,	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.7	Remove and Replace GHe, GO_2 or GH_2 Regulator Control Package	SS hangar, lighting, signal, power, propellant umbilicals	Control console, SS computer, robotics, CCTV, special tools/effectors, LRU's, test equipment	-	2:30	1:45			1:45	
4.1.5.7.1	Translate robotics to tool storage area, secure and store tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.7.2	Translate robotics to parts storage area, secure and store required LRU's		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.7.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.1.5.7.4	Release and remove unserviceable regulator/ control package and store		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:30	0:30			0:30	
4.1.5.7.5	Inspect regulator/control package interface; repair as required		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.1.5.7.6	Align and install regulator control package		Control console, SS computer, robotics, CCTV	2	0:30	0:30			0:30	
4.1.5.7.7	Verify mechanical interfaces are secure		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.1.5.7.8	Install leak detection equipment		Control console, SS computer, robotics, CCTV	2	0:10	0:10			0:10	
4.1.5.7.9	Pressurize appropriate system		Control console, SS computer	2	0:15					Correct anomolies
4.1.5.7.10	Depressurize system		Control console, SS computer	2	0:05					
4.1.5.7.11	Remove leak detection equipment		Control console, SS computer, robotics, CCTV	2	0:10	0:10			0:10	
4.1.5.7.12	Translate robotics to parts storage area; package unserviceable components		Control console, SS computer, robotics, CCTV	1	0:15	0:15			0:15	Return to earth

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.1.5.7.13	Translate robotics to tool storage area; secure tools/effector		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.7.14	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.8	Remove and Replace GHe, CO_2 or GH_2 Spheres	SS hangar lighting, signal, power, propellant umbilicals	Control console, SS computer, CCTV, robotics, special tools, test equipment	-	2:10	1:25			1:25	
4.1.5.8.1	Translate robotics to tool storage area, secure and store tools/effectors		Control console, SS computer, CCTV, robotics	1	0:05					
4.1.5.8.2	Translate robotics to part storage area, secure and store required IRUs		Control console, SS computer, CCTV, robotics	1	0:05					
4.1.5.8.3	Translate robotics to the designated work site		Control console, SS computer	1	0:05					
4.1.5.8.4	Release, remove and store unserviceable sphere		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
4.1.5.8.5	Inspect interface area for damage, repair as necessary		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.1.5.8.6	Align and install replacement sphere		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
4.1.5.8.7	Verify mechanical interfaces are seated		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.1.5.8.8	Attach leak detection equipment		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:10	0:10			0:10	
4.1.5.8.9	Pressurize sphere		Control console, SS computer	2	0:15					Correct anomolies
4.1.5.8.10	Depressurize sphere		Control console, SS computer	2	0:05					
4.1.5.8.11	Remove leak detection equipment		Control console, SS computer, robotics, CCTV	2	0:10	0:10			0:10	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.8.12	Translate robotics to parts storage area; package unserviceable components		Control console, SS computer, robotics, CCTV	1	0:15	0:15			0:15	Return to earth
4.1.5.8.13	Translate robotics to tool storage area; secure tools/effector		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.8.14	Translate robotics to storage area and secure		Control console, SS computer,	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.9	Remove and Replace Payload Interface System	SS hangar, lighting, power, signal, umbilicals	Control console, SS computer, robotics, RMS, CCTV, Tools/ effectors, test equip, LRU's	-	4:00	2:40			2:40	
4.1.5.9.1	Translate robotics to tool storage area; secure and store tools/effector		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.9.2	Translate robotics to parts storage area, secure and store required parts		Control console, SS computer robotics, CCTV	1	0:05					
4.1.5.9.3	Translate robotics to work site		Control console, SS computer,	1	0:05					
4.1.5.9.4	Translate RMS to work site and attach to payload interface system grapple fixture		Control console, SS computer, CCTV	2	0:10	0:10			0:10	
4.1.5.9.5	Release payload interface system		Control console, SS computer, CCTV, robotics, tools/ effectors	2	0:30	0:30			0:30	
4.1.5.9.6	Remove and translate unserviceable payload interface system to parts area and secure		Control console, SS computer, CCTV, RMS	2	0:20	0:20			0:20	
4.1.5.9.7	Secure serviceable payload interface system with RMS		Control console, SS computer, CCTV, RMS	2	0:05					
4.1.5.9.8	Translate payload interface system to work site		Control console, SS computer	2	0:20	0:20			0:20	
4.1.5.9.9	Inspect payload interface mounting area; repair as necessary		Control console, SS computer, CCTV, robotics	2	0:10	0:10			0:10	
4.1.5.9.10	Align payload interface system with RMS		Control console, SS computer, RMS, CCTV, robotics	2	0:10	0:10			0:10	
4.1.5.9.11	Install and secure payload interface system		Control console, SS computer, CCTV, robotics	2	0:10	0:10			0:10	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.9.12	Install test equipment		Control console, SS computer, CCTV, robotics	2	0:15	0:15			0:15	
4.1.5.9.13	Conduct system test		Control console, SS computer	2	0:45					Correct anomolies
4.1.5.9.14	Remove test equipment and store		Control console, SS computer, CCTV, robotics,	2	0:15	0:15			0:15	
4.1.5.9.15	Translate RMS to storage area and secure		Control console, SS computer	1	0:05					
4.1.5.9.16	Translate robotics to parts area, package unserviceable payload interface system		Control console, SS computer, CCTV, robotics,	1	0:20	0:20			0:20	Return to earth
4.1.5.9.17	Translate robotics to tool storage area; store tools/ effectors		Control console, SS computer, CCTV, robotics,	1	0:05					
4.1.5.9.18	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.10	Remove and Replace LO_2 or LH_2 Tank Pressure System	SS hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, tools/effectors, LRU's robotics, test equipment CCTV	-	2:35	1:45			1:45	
4.1.5.10.1	Translate robotics to tool storage area; secure and store tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.10.2	Translate robotics to parts storage area; secure and store LRU's		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.10.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.1.5.10.4	Detach, remove and store unserviceable tank press system		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:30	0:30			0:30	
4.1.5.10.5	Inspect tank press system interfaces		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.1.5.10.6	Align, install and secure serviceable tank press system		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:30	0:30			0:30	
4.1.5.10.7	Install leak check equipment		Control console, SS computer, robotics, CCTV,	2	0:15	0:15			0:15	
4.1.5.10.8	Pressurize system		Control console, SS computer	2	0:05					
4.1.5.10.9	Conduct leak check		Control console, SS computer	1	0:15					Correct anomolies
4.1.5.10.10	Depressurize tank press system		Control console, SS computer	2	0:05					
4.1.5.10.11	Disconnect and remove test equipment		Control console, SS computer, robotics, CCTV	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.10.12	Translate robotics to part storage area; package unserviceable system		Control console, SS computer, robotics, CCTV	1	0:10	0:10			0:10	Return to earth
4.1.5.10.13	Translate robotics to tool storage area; store tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.10.14	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.11	Core Structure Replacement	Hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, robotics, RMS, CCTV, tools/ effectors, test equipment, LRU's, special tools	-	81:55	50:10			50:10	
4.1.5.11.1	Translate robotics to tool storage area, secure and store required tools/ effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.11.2	Translate robotics to parts storage area, secure and store required LRU's		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.11.3	Translate robotics to designated work site		Control console, SS computer,	1	0:05					
4.1.5.11.4	Translate RMS to designated work site		Control console, SS computer,	1	0:05					
4.1.5.11.5	Remove payload interface system (see 4.1.5.9)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	0:55	0:55			0:55	
4.1.5.11.6	Remove GPS antenna system (See 4.1.5.2.2)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	0:30	0:30			0:30	
4.1.5.11.7	Remove octagonal avionics assembly modules (See 4.1.4.2.2)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	7:00	7:00			7:00	21 Total modules - 20 minutes per module
4.1.5.11.8	Remove propellant tanks - 4 ea (See 4.1.5.1.1) (1 hr/tnk)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	4:00	4:00			4:00	1 hour per tank
4.1.5.11.9	Remove aerobrake and support (See 4.1.4.5.2)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:00	1:00			1:00	
4.1.5.11.10	Remove engines (See 4.1.4.4.3)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors, special tool	2	2:50	2:50			2:50	1:25 hrs per engine

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.1.5.11.11	Remove GH_e, GO_2, and GH_2 spheres. (See 4.1.5.8)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:15	1:15			1:15	25 minutes per sphere
4.1.5.11.12	Remove GH_e, GO_2, and GH_2 regulators/control packages (See 4.1.5.7)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:45	1:45			1:45	35 minutes per package
4.1.5.11.13	Remove LO_2, LH_2 tank pressure system (See 4.1.5.10)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:10	1:10			1:10	55 minutes per system
4.1.5.11.14	Attach RMS to core structure avionics ring		Control console, SS computer, RMS, CCTV	2	0:10	0:10			0:10	
4.1.5.11.15	Translate RMS to parts area and secure unserviceable core structure		Control console, SS computer, RMS, CCTV	2	0:30	0:30			0:30	
4.1.5.11.16	Translate RMS to OTV berthing area, with serviceable core octagonal avionics assembly and secure to berthing cradle		Control console, SS computer, RMS, CCTV,	2	0:30	0:30			0:30	
4.1.5.11.17	Install LO_2/LH_2 tank pressure system (See 4.1.5.10)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:10	1:10			1:10	
4.1.5.11.18	Install GH_e, GO_2, and GH_2 spheres. (See 4.1.5.8)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:15	1:15			1:15	
4.1.5.11.19	Install GH_e, GO_2, and GH_2 regulators/control packages (See 4.1.5.7)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:45	1:45			1:45	
4.1.5.11.20	Install main engines (See 4.1.4.4.3)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors, special tool	2	2:50	2:50			2:50	
4.1.5.11.21	Install aerobrake and support (See 4.1.4.5.2)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:00	1:00			1:00	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.5.11.22	Install propellant tanks - 4 ea (See 4.1.5.1.1) (1 hr/tank)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	4:00	4:00			4:00	
4.1.5.11.23	Install octagonal avionics assembly modules (See 4.1.4.2.2)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	7:00	7:00			7:00	
4.1.5.11.24	Install GPS antenna system (See 4.1.5.2.2)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	0:30	0:30			0:30	
4.1.5.11.25	Install payload interface system (see 4.1.5.9)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	0:55	0:55			0:55	
4.1.5.11.26	Attach power, signal and propellant umbilicals		Control console, SS computer, robotics, CCTV,	1	0:20	0:20			0:20	
4.1.5.11.27	Install and checkout test equipment		Control console, SS computer, robotics, CCTV,	2	2:00	2:00			2:00	
4.1.5.11.28	Conduct subsystem and system checkout; correct anomalies		Control console, SS computer	1+2	32:00	1:00			1:00	Correct anomolies
4.1.5.11.29	Disconnect and store test equipment		Control console, SS computer, CCTV, robotics	2	2:00	2:00			2:00	
4.1.5.11.30	Translate RMS to storage area and secure		Control console, SS computer	1	0:05					
4.1.5.11.31	Translate robotics to parts storage area; store serviceable parts; package unserviceable parts		Control console, SS computer, robotics, CCTV	1	3:00	3:00			3:00	Return to earth
4.1.5.11.32	Translate robotics to tool storage area; store tools/ effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.1.5.11.33	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.1.6	Verify Maintenance Complete				1:15	1:15			1:15	
4.1.6.1	Verify all maintenance completed per maintenance plan		Control console, SS computer	1	0:15	0:15			0:15	
4.1.6.2	Verify all anomalies corrected and diagnostic tests completed		Control console, SS computer	1	0:20	0:20			0:20	
4.1.6.3	Verify OTV safed		Control console, SS computer	1	0:40	0:40			0:40	

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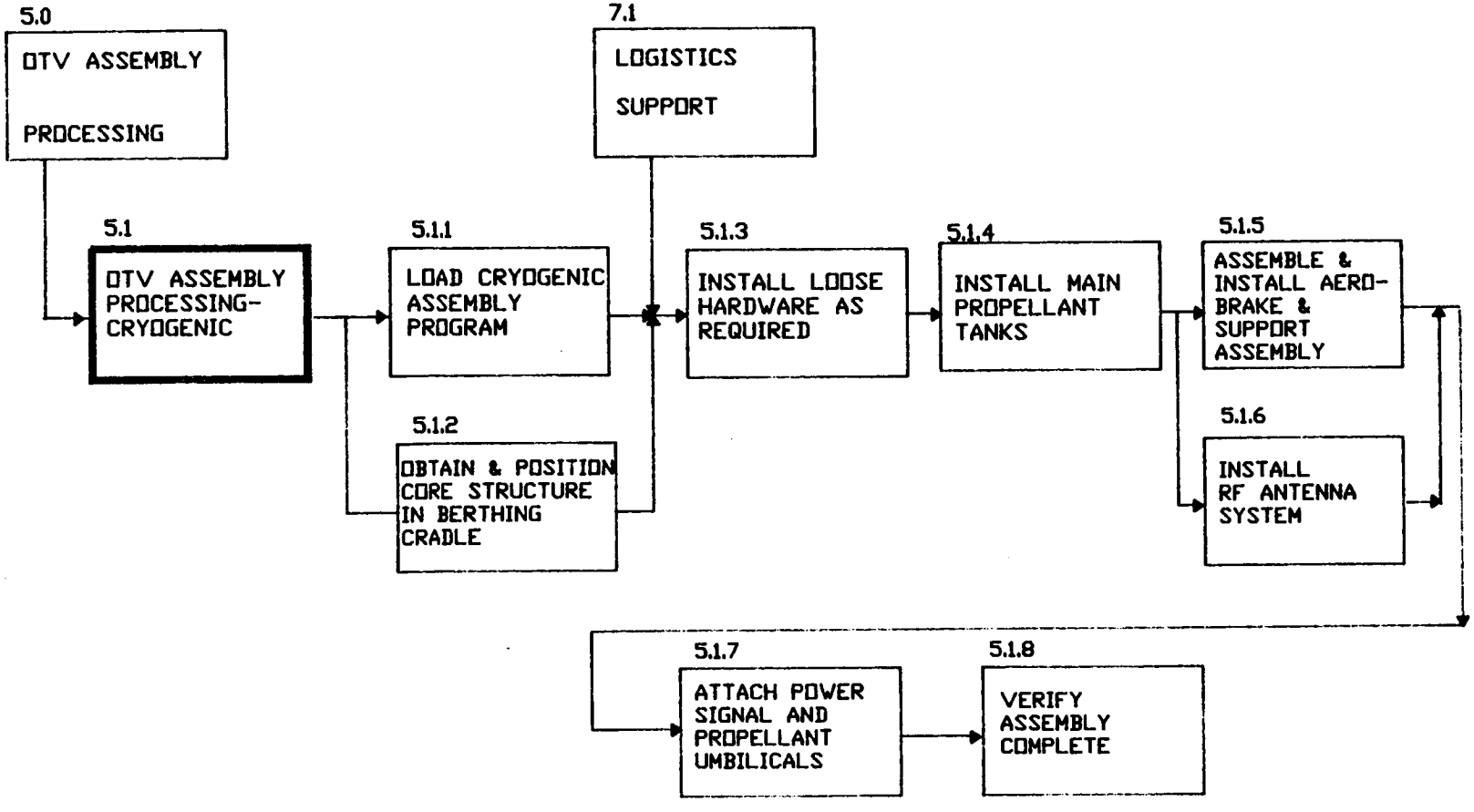
CRYOGENIC SPACE-BASED OTV ASSEMBLY PROCESSING

The Cryogenic SBOTV is initially delivered to Space Station unassembled, requiring the equivalent of two Shuttle flights for the delivery. This functional flow and requirements definition set identifies the operations associated with initial assembly of the Cryogenic SBOTV.

SBOTV ASSEMBLY PROCESSING – CRYOGENIC



MARTIN MARIETTA

OTV ASSEMBLY PROCESSING - CRYOGENIC

SHEET 1 OF 8

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
5.1	OTV Assembly Processing - Cryogenic	SS hanger, lighting, signal, power, propellant umbilicals		22:40	11:15				11:15	Components/parts will be unpacked and visually inspected prior to transfer to the processing area
5.1.1	Load Cryogenic Assembly Program		SS computer, control console	--	0:30	0:30			0:30	Task accomplished concurrently with core structure berthing
5.1.1.1	Verify correct program		Control console, SS computer	1	0:05	0:05			0:05	
5.1.1.2	Verify all applicable OTV modifications are incorporated in assembly program		Control console, Ss computer	1	0:15	0:15			0:15	
5.1.1.3	Load and verify proper assembly operations			1	0:10	0:10			0:10	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
5.1.2	Obtain and Position Core Structure in Berthing Cradle		SS computer, control console, RMS, CCTV, robotics	1	1:00	1:00			1:00	Task accomplished concurrently with assembly program loading.
5.1.2.1	Translate OTV from storage area		SS computer, control console, RMS, CCTV	2	0:20	0:20			0:20	
5.1.2.2	Extend cradle interfaces and lock in place		SS computer, control console, robotics, CCTV	2	0:30	0:30			0:30	OTV cradle interfaces will be folded to meet cargo bay limitations
5.1.2.3	Position core structure in berthing cradle and secure		SS computer, control console, RMS, CCTV, robotics	2	0:10	0:10			0:10	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
5.1.3	Install Loose Hardware	SS hangar, lighting, signal, power, umbilical	SS computer, control console, RMS, CCTV, robotics, tools/ effectors, test equipment	--	2:45	2:30			2:30	
5.1.3.1	Translate robotics to tool storage area, secure and stow required tools/effectors		SS computer, control console, robotics, CCTV	1	0:05					
5.1.3.2	Translate robotics to storage area, secure and stow required hardware		SS computer, control console, robotics, CCTV	1	0:05					
5.1.3.3	Translate robotics to OTV processing area		SS computer, control console	1	0:05					
5.1.3.4	Install hardware as required		SS computer, control console, robotics, CCTV, tools/ effectors	2	1:00	1:00			1:00	
5.1.3.5	Extend propellant tank supports and lock in place		SS computer, control console, robotics, CCTV	2	1:00	1:00			1:00	Support will be folded to meet shuttle cargo bay limitations.
5.1.3.6	Verify all packaging material is removed from OTV interfaces		SS computer, control console, CCTV	2	0:20	0:20			0:20	
5.1.3.7	Verify all loose hardware is installed		SS computer, control console, CCTV	2	0:10	0:10			0:10	Conduct inventory of parts/ hardware kit.

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
5.1.4	Install Main Propellant Tanks		SS computer, control console, CCTV, RMS, robotics, tools/ effectors	1	4:10	4:10			4:10	Four (4) tanks require intallation. 1 Hr/Tank
5.1.4.1	Translate RMS to parts storage area.Secure tank and translate to work site		SS computer, control console, CCTV, RMS	2	0:20	0:20			0:20	
5.1.4.2	Inspect tank interfaces with robotics prior to tank installation		SS computer, control console, CCTV, robotics	2	0:10	0:10			0:10	
5.1.4.3	Verify sufficient clearance between robotics and RMS with tank		SS computer, control console	1	--	--			--	
5.1.4.4	Position/align tank with OTV attaching points and insert onto tank interface		SS computer, control console, CCTV, robotics, RMS	2	0:10	0:10			0:10	
5.1.4.5	Secure tank at attaching point 2 with robotics		SS computer, control console, CCTV, robotics, RMS	2	0:10	0:10			0:10	
5.1.4.6	Secure tank at attaching point 1 with robotics		SS computer, control console, CCTV, robotics, RMS	2	0:10	0:10			0:10	
5.1.4.7	Release RMS from tank		SS computer, control console,	2	--	--			--	
5.1.4.8	Complete steps 5.1.4.1 thru 5.1.4.7 for remaining tanks		SS computer, control console, CCTV, robotics, RMS	--	--	--			--	
5.1.4.9	Install, checkout and calibrate leak detection equipment		SS computer, control console, CCTV, robotics	2	0:10	0:10			0:10	Following last tank installation

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
5.1.5	Assemble and Install Aerobrake and Support Assembly	SS hangar, lighting, signal, power, umbilicals	SS computer, control console, CCTV, robotics, RMS, tools and effectors	--	2:35	2:00			2:00	
5.1.5.1	Translate RMS to aerobrake storage area		SS computer, control console	1	0:05					
5.1.5.2	Translate robotics to aerobrake storage area		SS computer, control console	1	0:05					
5.1.5.3	Secure aerobrake for assembly		SS computer, control console, RMS, CCTV	2	0:10	0:10			0:10	
5.1.5.4	Unfold aerobrake and support structure with robotics		SS computer, control console, RMS, CCTV, robotics, tools/ effectors	2	0:30	0:30			0:30	
5.1.5.5	Secure aerobrake support latches		SS computer, control console, RMS, CCTV, robotics, tools/ effectors	2	0:10	0:10			0:10	
5.1.5.6	Inject aerobrake outer ring with rigidizing compound		SS computer, control console, RMS, CCTV, robotics, tools/ effectors	2	0:20	0:20			0:20	
5.1.5.7	Conduct inspection of aerobrake, prior to installation on OTV		SS computer, control console, CCTV, robotics, test equipment	2	0:10					
5.1.5.8	Translate RMS with assembled aerobrake to OTV processing area		SS computer, control console, CCTV, RMS	2	0:20	0:20			0:20	
5.1.5.9	Translate robotics to OTV processing area		SS computer, control console	1	0:05					
5.1.5.10	Align and attach aerobrake and support to core structure		SS computer, control console, RMS, robotics, CCTV, tools/ effectors	2	0:10	0:10			0:10	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
5.1.5.11	Connect RCS propellant lines		SS computer, control console, robotics, CCTV, tools/ effectors	2	0:10	0:10			0:10	
5.1.5.12	Connect RCS power and signal lines		SS computer, control console, robotics, CCTV, tools/ effectors	2	0:05	0:05			0:05	
5.1.5.13	Install, checkout and calibrate test equipment		SS computer, control console, Robotics, CCTV, tools/ effectors, test equipment	2	0:05	0:05			0:05	

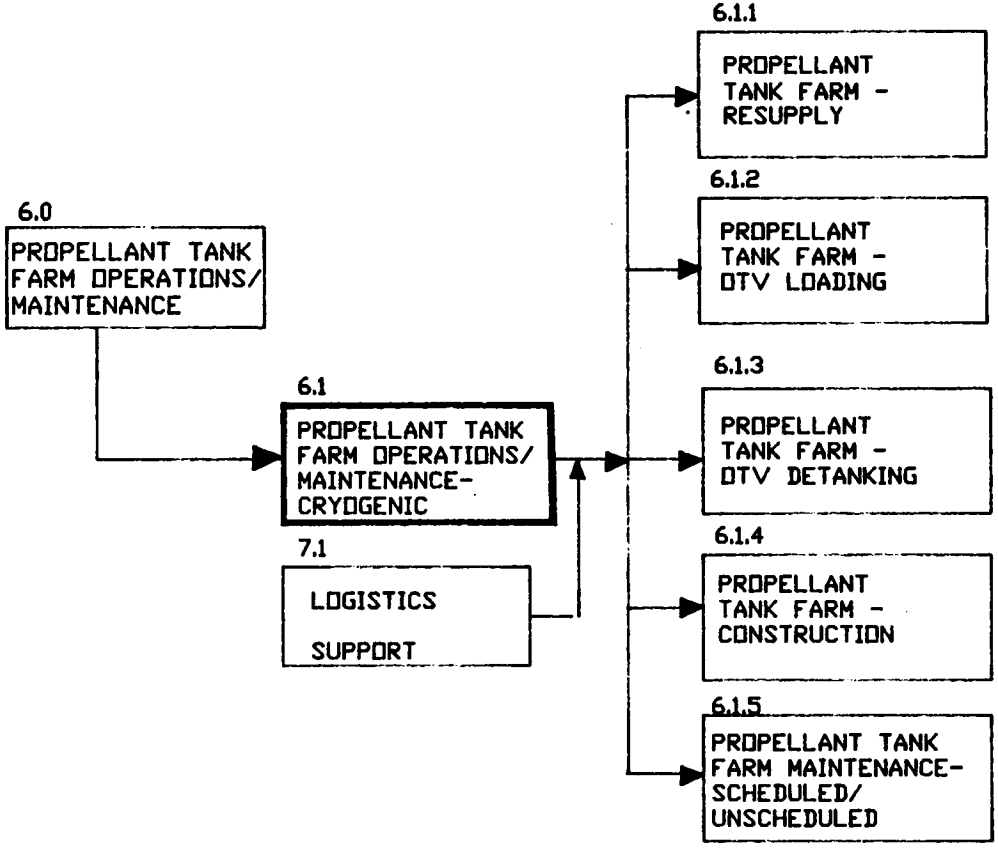
SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
5.1.6	Install GPS Antenna Assembly		SS computer, control console, robotics, CCTV, tools/ effectors, test equipment	—	0:45	0:35			0:35	
5.1.6.1	Translate robotics to storage area and secure required GPS antenna assembly		SS computer, control console, CCTV	1	0:05					
5.1.6.2	Translate robotics to processing area		SS computer, control console	1	0:05					
5.1.6.3	Install GPS antenna assembly		SS computer, control console, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
5.1.6.4	Attach RF cabling as necessary		SS computer, control console, robotics, CCTV, tools/ effectors	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
5.1.7	Attach Power, Signal and Propellant Umbilicals		SS computer, control console, RMS, CCTV, robotics	--	11:05	0:30			0:30	
5.1.7.1	Attach power, signal and propellant umbilicals to OTV		SS computer, control console, RMS, CCTV, robotics	1	0:05					
5.1.7.2	Verify power levels		SS computer, control console	1	0:10					
5.1.7.3	Verify signal transmission		SS computer, control console	1	0:20					
5.1.7.4	Conduct OTV system checks		SS computer, control console	1	10:00					Correct anomolies - See Section 4.0 maintenance activities
5.1.7.5	Verify OTV Safe		SS computer, control console	2	0:30	0:30			0:30	

CRYOGENIC PROPELLANT TANK FARM OPERATIONS AND MAINTENANCE

The various aspects of assembling, operating, and maintaining the Cryogenic propellant tank farm at Space Station are identified.

PROPELLANT TANK FARM OPERATIONS/MAINTENANCE – CRYOGENIC



PROPELLANT TANK FARM OPERATIONS/MAINTENANCE - CRYOGENIC

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1	Propellant Tank Farm Operations/Maintenance - Cryogenic	Tank farm pumps, lighting, propellant lines	RMS, CCTV, measuring equipment, leak detection equipment							
6.1.1	Propellant Tank Farm - Resupply			-	8:25	5:15			5:15	
6.1.1.1	Chill Down LH_2 and LO_2 Lines			-	2:20	0:15			0:15	
6.1.1.1.1	Open GH_2 and GO_2 valves		Control console, SS computer	2	0:05	0:05			0:05	Correct anomolies
6.1.1.1.2	Pressurize lines		Control console, SS computer	2	0:05					
6.1.1.1.3	Monitor line temperature		Control console, SS computer, temperature sensors	1	2:00					Continue recycling until required temperature is reached and stabilized
6.1.1.1.4	Install and check out leak detection equipment		Control console, SS computer	2	0:10	0:10			0:10	Correct anomolies

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
6.1.1.2	Connect LH_2 and LO_2 Transfer LInes to Tanker			-	0:25					
6.1.1.2.1	Verify mechanical/electrical interface between tanker and propellant transfer lines		Control console, SS computer	2	0:20					Correct anomolies
6.1.1.2.1	Verify leak detection equipment operational		Control console, SS computer	1	0:05					Correct anomolies

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.1.3	Open Tank Farm LH_2 and LO_2 Propellant Valves			-	0:15	0:15			0:15	
6.1.1.3.1	Extract GH_2 and GO_2 boiloff and chill gas to high pressure tanks		Control console, SS computer	2	0:15	0:15			0:15	Correct anomolies
6.1.1.3.2	Conduct leak detection monitoring		Control console, SS computer, leak detection equipment	1	-	-			-	Correct anomolies if leak is detected.

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.1.4	Propellant Transfer			-	4:10	4:10			4:10	
6.1.1.4.1	Open tanker LH_2 & LO_2 valves		Tanker control	2	0:05	0:05			0:05	
6.1.1.4.2	Monitor propellant transfer		Control console, SS computer, flow meters	2	4:00	4:00			4:00	
6.1.1.4.3	Conduct leak detection monitoring		Control console, SS computer, leak detection equipment	1	-	-			-	Correct anomolies if leak is detected
6.1.1.4.4	Close tanker LH_2 & LO_2 valves when transfer complete		Control console, SS computer, flow meters, tanker controls	2	0:05	0:05			0:05	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.1.5	Complete Transfer			-	1:00	0:30			0:30	
6.1.1.5.1	Blow back LH_2 and LO_2 lines - tanker to Tank Farm		Control console, SS computer, flow meters	2	0:15	0:15			0:15	
6.1.1.5.2	Blow back complete - close tank farm LH_2 and LO_2 valves		Control console, SS computer	2	0:05	0:05			0:05	
6.1.1.5.3	Evacuate excess GH_2 and GO_2 from propellant lines to high pressure storage		Control console, SS computer	2	0:10	0:10			0:10	
6.1.1.5.4	Verify Propellant Tank Farm VCS system operational		Control console, SS computer	1	0:10					Correct anomolies
6.1.1.5.5	Disconnect LH_2 and LO_2 propellant lines from tanker		Control console, SS computer	1	0:20					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.1.6	Secure Tanker from Propellant Transfer Operations - TBD			-	-	-			-	
6.1.1.7	Place Tank Farm in Standby Mode - Continue leak detection monitoring		Control consolé, SS computer	1	0:15	0:05			0:05	
6.1.1.8	Secure Space Station from propellant transfer operations - TBD		Control console, SS computer	-	-	-			-	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.2	Propellant Tank Farm - OTV Loading	Tank farm, SS hangar, lighting, power signal, propellant umbilicals	Control console, SS computer, CCTV, leak detection equipment, flow meters	-	9:55	9:55			9:55	
6.1.2.1	Chill Down LH_2 AND LO_2 Lines and Umbilicals		Control console, SS computer	-	2:20	0:40			0:40	
6.1.2.1.1	Open GH_2 and GO_2 valves		Control console, SS computer	2	0:05					Correct Anomolies
6.1.2.1.2	Pressurize lines		Control console, SS computer	2	0:05					
6.1.2.1.3	Monitor line and umbilical temperature		Control console, SS computer, temperature sensors	1	2:00	0:30			0:30	Continue recycling until required temperature is reached and stabilized.
6.1.2.1.4	Install and checkout leak detection equipment		Control console, SS computer	2	0:10	0:10			0:10	Correct Anomolies

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.2.2	Chill Down OTV LH_2 and LO_2 Propellant Tanks			-	1:50	0:10			0:10	
6.1.2.2.1	Connect LH_2 and LO_2 umbilicals to OTV		Control console, SS computer	1	0:20					Correct Anomolies
6.1.2.2.2	Pressurize LH_2 and LO_2 tanks with GH_2 and GO_2		Control console, SS computer	2	0:05					Correct Anomolies
6.1.2.2.3	Monitor tank temperature		Control console, SS computer, temperature sensors	1	1:00	0:05			0:05	Continue recycling, until required temperature is reached and stabilized.
6.1.2.2.4	Depressurize LH_2 and LO_2 tanks		Control consol SS computer	2	0:20	0:05			0:05	
6.1.2.2.5	Close OTV LH_2 and LO_2 valves		Control console, SS computer	2	0.05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.2.3	Main Propellant Transfer			-	4:10	4:10			4:10	
6.1.2.3.1	Open tank farm LH_2 and LO_2 valve		Control console, SS computer	2	0:05	0:05			0:05	
6.1.2.3.2	Extract GH_2 and GO_2 boiloff and chill down gas to high pressure tanks		Control console, SS computer	2	0:05	0:05			0:05	Correct anomolies
6.1.2.3.3	Conduct leak detection Monitoring		Control console, SS computer, leak detection equipment	1						Correct anomolies
6.1.2.3.4	Open OTV LH_2 and LO_2 valves - commence propellant transfer		Control console, SS computer, leak detection equipment	2	4:00	4:00			4:00	Correct anomolies

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.2.4	Main Propellant Transfer Complete			-	0:05	0:05			0:05	
6.1.2.4.1	Close OTV LH_2 and LO_2 Valves		Control console, SS computer	2	0:05	0:05			0:05	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.2.5	Prepare GH_2, GO_2 and GH_2 RCS Propellant Spheres				0:30	0:05			0:05	
6.1.2.5.1	Open OTV GH_2, GO_2 and GHe RCS valves		Control console, SS computer	2	0:05					
6.1.2.5.2	Pressurize GH_2, GO_2 and GHe spheres		Control console, SS computer	2	0:20	0:05			0:05	Pressurize to required level.
6.1.2.5.3	Conduct leak detection monitoring		Control console, SS computer, leak detection equipment	1						Correct anomolies
6.1.2.5.4	Close OTV GH_2, GO_2 and GHe RCS valves		Control console, SS computer	2	0:05					Correct anomolies

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
6.1.2.6	OTV Main and RCS Propellant Transfer Complete			-	0:45	0:25			0:25	
6.1.2.6.1	Disconnect propellant umbilicals		Control console, SS computer	1	0:20					
6.1.2.6.2	Verify OTV safed		Control console, SS computer	1	0:05	0:05			0:05	Correct anomolies
6.1.2.6.3	Blowdown LH_2 and LO_2 lines and umbilicals		Control console, SS computer	2	0:15	0:15			0:15	Accomplished after OMV/OTV/ Payload stack is deployed from space station
6.1.2.6.4	Close Propellant Tank Farm LH_2 and LO_2 valves		Control console, SS computer	1	0:05	0:05			0:05	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.2.7	Tank Farm Placed in Standby Mode		Control console, SS computer	1+2	0:15	0:15			0:15	Accomplished after OMV/OTV/ Payload stack is deployed
6.1.2.8	Space Station Secured From Propellant Transfer Operations - TBD		Control console, SS computer	1+2						

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
6.1.3	Propellant Tank Farm - OTV Detanking			-	5:10	5:10			5:10	
6.1.3.1	Chill Down LH_2 and LO_2 Lines and Umbilicals		Control console, SS computer	-	2:35	0:15			0:15	Complete only if steps 6.1.2.6.3 and 6.1.2.6.4 were not completed.
6.1.3.1.1	Open GH_2 and GO_2 valves		Control console, SS computer	2	0:05					
6.1.3.1.2	Pressurize lines		Control console, SS computer, temperature sensors	2	0:05					Continue recycling until required temperature is reached or stabilized.
6.1.3.1.3	Monitor line and umbilical		Control console, SS computer,	1	2:00					
6.1.3.1.4	Install and check out leak detection equipment		Control console, SS computer, robotics	2	0:10	0:10			0:10	
6.1.3.1.5	Open LH_2 and LO_2 tank farm valves		Control console, SS computer	2	0:05					
6.1.3.1.6	Extract GH_2 and GO_2 from lines and umbilicals		Control console, SS computer	2	0:05	0:05			0:05	
6.1.3.1.7	Close GH_2 and GO_2 Valves		Control console, SS computer	2	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.3.2	OTV Detanking			1	1:45	1:00			1:00	
6.1.3.2.1	Connect umbilicals to OTV		Control console, SS computer	1	0:20					
6.1.3.2.2	Verify electrical/mechanical connections		Control console, SS computer	1	0:20					
6.1.3.2.3	Pressurize OTV LH_2 and LO_2 Tanks		Control console, SS computer	2	0:05					Accomplished through use of RCS GH_2 and GO_2 residual gas.
6.1.3.2.4	Open OTV LH_2 LO_2 valves		Control console, SS computer	2	1:00	1:00			1:00	
6.1.3.2.5	Leak detection monitoring			1	-					Correct anomolies

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.3.3	OTV Detanking Complete			-	0:30	0:20			0:20	
6.1.3.3.1	Close OTV LH_2 and LO_2 valves		Control console, SS computer	2	0:05					Correct anomolies
6.1.3.3.2	Blowback LH_2 and LO_2 lines and umbilicals		Control console, SS computer	2	0:15	0:15			0:15	
6.1.3.3.3	Close tank farm LH_2 and LO_2 valves		Control console, SS computer	2	0:05					Correct anomolies
6.1.3.3.4	Evacuate GH_2 and GO_2 from LH_2 and LO_2 lines		Control console, SS computer	2	0:05	0:05			0:05	Correct anomolies

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.3.4	Place Tank Farm in Standby Mode		Control console, SS computer	1+2	0:15	0:15			0:15	
6.1.3.5	Secure Space Station from OTV Detanking Operations - TBD		Control console, SS computer	-						

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.4	Tank Farm Construction	SS hangar, MRMS, lighting, power,	SS computer, control console, CCTV, robotics, tools/ effectors, test equipment, leak detection equipment, software	-	34:05	34:05	7:20	14:40	29:15	Switch EVA and total times
6.1.4.1	Install Propellant Transfer Lines			-	8:50	8:50	4:40	9:20	17:55	
6.1.4.1.1	Translate MRMS to shuttle docking area		SS computer, control console	2	0:15	0:15			0:15	
6.1.4.1.2	Translate MRMS to hangar with LO_2 control valve and manifold		SS computer, control console	-	0:20	0:20			0:20	18' section
6.1.4.1.3	Attach LO_2 control valve and manifold to outer structure		SS computer, tools, CCTV	3	0:20	0:20	0:20	0:40	1:00	
6.1.4.1.4	Translate MRMS to shuttle docking area		SS computer, control console	2	0:15	0:15			0:15	
6.1.4.1.5	Translate MRMS to hangar with LH_2 control valve and manifold		SS computer, control console	2	0:20	0:20			0:20	
6.1.4.1.6	Attach LH_2 control valve and manifold to out structure		SS computer, tools, CCTV	3	0:20	0:20	0:20	0:40	1:00	10' section
6.1.4.7	Translate MRMS to shuttle docking area		SS computer, control console	2	1:00	1:00			1:00	Secure remaining 3 sections each 54' - 20 min/section
6.1.4.1.8	Translate MRMS to install-ation site		SS computer, control console	2	1:00	1:00			1:00	
6.1.4.1.9	Attach 3 sections to outer structure		SS computer, tools, CCTV	3	1:00	1:00	1:00	2:00	3:00	
6.1.4.1.10	Secure remaining LH_2 sections and translate to installation site		SS computer, control console	2	1:00	1:00			1:00	Remaining 3 sections each 54'. Section 3 contains shuttle LH_2 control valve.
6.1.4.1.11	Attach 3 sections to outer structure		SS computer, tools, CCTV	3	1:00	1:00	1:00	2:00	3:00	
6.1.4.1.12	Secure and attach LO2 boom to LO_2 line		SS computer, tools, CCTV	3	1:00	1:00	1:00	2:00	3:00	
6.1.4.1.13	Secure and attach LH_2 boom to LH_2 line		SS computer, tools CCTV	3	1:00	1:00	1:00	2:00	3:00	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.4.2	Propellant Control Console			-	7:50	1:20			1:20	
6.1.4.2.1	Translate propellant control console through space station airlock		SS computer, control console	2	0:20	0:20			0:20	
6.1.4.2.2	Install and secure propellant control console		SS computer, control console tools	2	1:00	1:00			1.00	
6.1.4.2.3	Conduct system test of propellant control console		SS computer, software, control console	2	6:30					Self test

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.4.3	Install Propellant Module No. 1				8:50	2:20	1:20	2:40	5:00	
6.1.4.3.1	Translate MRMS to shuttle docking area		SS computer, control console	2	0:15	0:15			0:15	
6.1.4.3.2	Translate MRMS to propellant module No. 1 attaching point		SS computer, control console tools	2	0:45	0:45			0:45	Approximately 5,000 lbm
6.1.4.3	Attach propellant module to attachning points		SS computer, tools	3	0:20	0:20	0:20	0:40	1:00	
6.1.4.3.4	Connect propellant module to LO_2 and LH_2 manifolds		SS computer, tools	3	1:00	1:00	1:00	2:00	3:00	
6.1.4.3.4	Pressurize system and conduct pressure and system test		SS computer, gauges, leak detection equipment	2	6:30					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.4.4	Install propellant module No. 2		See 6.1.4.3 above for tool tool requirements	2+3	8:50	2:20	1:20	2:40	5:00	See 6.1.4.3

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.5	Propellant Tank Farm Scheduled Maintenance	Space station power, lighting	Control console, SS computer test equipment, CCTV							
6.1.5.1	Visual Inspection		SS computer, control console, CCTV	2	6:00	6:00			6:00	Conducted periodically on modules and propellant transfer lines
6.1.5.2	Leak Check		SS computer, control console, halographic equipment, pressure gauges, leak detection equipment	2	---	---			---	Continuious when tank farm is in standby mode, transfer operations and detanking
6.4.5.3	Diagnostic Testing		SS computer, control console pressure drop gauges, test equipment	2	3:00	3:00			3:00	Conducted periodically on all major components i.e. compressons, safety valves, etc.

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
6.1.6	Propellant Tank Farm - Unscheduled Maintenance	space station power lighting MRMS, RMS	Control console, SS computer robotocs. CCTV, tools, effectors, test equipment							
6.1.6.1	Repair Propellant Module Insulation				2:05	0:55			0:55	
6.1.6.1.1	Translate robotics to tool area-secure and stow tools/ effectors		Control console, SS computer, robotics, tools/effectors, CCTV	1	0:05	0:05			0:05	
6.1.6.1.2	Translate robotics to parts area-secure and stow insulation repair kit		Control console, SS computer, robotics, tools/effectors, CCTV	1	0:05					
6.4.6.1.3	Translate robotics to SS hangar porch - transfer repair kit, tools/effectors to external robotics		Control console, SS computer, robotics, tools/effectors, CCTV	1	0:15					
6.1.6.1.4	Translate external robotics to work site		Control console, SS computer, CCTV	1	0:15					
6.1.6.1.5	Remove Damaged Insulation section-stow		Control console, SS computer, CCTV, tools/effectors robotics	2	0:30	0:30			0:30	
6.1.6.1.6	Install new insulation section-verify seal		Control console, SS computer, CCTV, tools/effectors robotics	2	0:20	0:20			0:20	
6.1.6.1.7	Translate robotics to hangar porch-transfer repair kit		Control console, SS computer CCTV, tools/effectors, robotics	1	0:15					
6.1.6.1.8	Translate robotics to parts area-stow repair kit		Control console, SS computer, CCTV	1	0:05	0:05			0:05	Package damaged insulation
6.1.6.1.9	Secure external robotic		Control console, SS computer	1	0:05					
6.1.6.1.10	Translate robotics to tool area-secure tools/effectors		Control console, SS computer, CCTV	1	0:05					
6.1.6.1.11	Secure robotics		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
6.1.6.2	Motor/Compressor Unit Replacement (Low Pressure)	space station power, lighting, MRMS, RMS	Control console, SS computer, CCTV, tools/effectors, robotics, test equipment		4:40	3:30			3:30	LH_2 or LO_2 units within propellant transfer unit.
6.1.6.2.2	Translate robotics to tool area-secure and stow tools and effectors		Control console, SS computer, CCTV	1	0:05					
6.1.6.2.2	Translate robotics to parts area-secure replacement motor/compressor unit		Control console, SS computer, CCTV, tools/effectors	1	0:05					
6.1.6.2.3	Translate robotics to hangar porch-transfer tools/ effectors to external robotics		Control console, SS computer, CCTV, tools/effectors	1	0:15					
6.1.6.2.4	Translate external robotic to work site-open and secure access panel		Control console, SS computer, CCTV, tools/effectors	2	0:15	0:15			0:15	
6.1.6.2.5	Disconnect and remove motor/ compressor unit		Control console, SS computer, CCTV, tools/effectors	2	1:00	1:00			1:00	
6.1.6.2.6	Translate external robotic to hangar porch w/motor compressor unit		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
6.1.6.2.7	Secure replacement motor/ compressor unit-translate to work site		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
6.1.6.2.8	Install replacement motor compressor to work site		Control console, SS computer, CCTV, robotics, tools/ effectors	2	1:00	1:00			1:00	
6.1.6.2.9	Pressurize system - conduct leak check/functional test		Control console, SS conputer, CCTV, test equipment, leak detection equipment	2	0:30					
6.1.6.2.10	Secure access panel-translate external robotic to hangar porch			2	0:15	0:15			0:15	
6.1.6.2.11	Transfer tools/effectors to internal robotics-translate internal robotics to part area w/motor/compressor unit		Control console, SS computer, CCTV, robotics	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.6.2.12	Secure external robotic			1	0:05					
6.1.6.2.13	Package unserviceable motor/ compressor unit		Control console, SS computer, CCTV, robotics, tools/ effectors	1	0:15	0:15			0:15	Return to earth
6.1.6.2.14	Translate robotics to tool area-secure tools/effectors		Control console, SS computer, CCTV	1	0:05					
6.1.6.2.15	Secure robotics		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
6.1.6.3	Propellant Transfer unit Replacement	space station power, lighting, MRMS	Control console, SS computer, CCTV, tools/effectors, robotics, test equipment		5:15	4:15			4:15	Less motor compressor unit LH_2 or LO_2
6.1.6.3.1	Translate robotics to tool area-secure and stow tools/ effectors		Control console, SS computer, CCTV	1	0:05					
6.1.6.3.2	Translate robotics to hangar proch-transfer tools/ effectors to external robotics		Control console, SS computer, CCTV	1	0:15					
6.1.6.3.3	Translate RMS to parts area-secure and translate propellant transfer unit to hangar porch		Control console, SS computer, CCTV	2	0:15					
6.1.6.3.4	Translate external robotics to propellant module-open access panel		Control console, SS computer, CCTV, tools/effectors	2	0:15	0:15			0:15	
6.1.6.3.5	Translate MRMS to hangar porch-secure propellant transfer unit-translate to work site		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
6.1.6.3.6	Disconnect and remove propellant transfer unit		Control console, SS computer, CCTV, tools/effectors, robotics	2	1:00	1:00			1:00	
6.16.3.7	Secure serviceable propellant transfer unit from MRMS and install		Control console, SS computer, CCTV, tools/effectors, robotics	2	1:00	1:00			1:00	
6.1.6.3.8	Secure unserviceable propellant transfer unit w/MRMS-translate to hangar porch		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
6.1.6.3.9	Secure unserviceable propellant transfer unit W/RMS translate to parts area		Control console, SS computer CCTV	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.6.3.10	Secure MRMS and RMS		Control console, SS computer	1	0:10					
6.1.6.3.11	Pressurize System-conduct leak check.		Control console, SS computer, CCTV, leak detection equipment	2	0:30	0:30			0:30	
6.1.6.3.12	Secure access panel-translate external robotics to hangar porch		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
6.1.6.3.13	Transfer tools/effectors to internal robotics-translate to parts area		Control console, SS computer, CCTV	1	0:15	0:15			0:15	
6.1.6.3.14	Secure external robotics		Control console, SS computer	1	0:05					
6.1.6.3.15	Package propellant transfer unit for shipment		Control console, SS computer, CCTV, tools/effectors	1	0:15	0:15			0:15	Return to earth
6.1.6.3.16	Translate robotics to tool area-secure tools/effectors		Control console, SS computer, CCTV	1	0:05					
6.1.6.3.17	Secure robotics		Control console, SS computer		0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
6.1.6.4	Remove and Replace Motor/ Compressor (High Pressure)	space station power, lighting, MRMS	Control console, SS computer, CCTV, tools/effectors, robotics, test equipment		4:10	2:50			2:50	Hydrogen storage accumulators
6.1.6.4.1	Translate robotics to tool area-secure and stow tools/ effectors		Control console, SS computer, CCTV	1	0:05					
6.1.6.4.2	Translate robotics to parts area-secure ans stow replacement motor/compressor		Control console, SS computer, CCTV	1	0:05					
6.1.6.4.3	Translate robotics to hangar proch-transfer tools/ effectors and motor/ compressor to external robotics		Control console, SS computer, CCTV	1	0:15					
6.1.6.4.4	Translate external robotics to propellant module-open access door		Control console, SS computer CCTV, tools/effectors, robotics	2	0:15	0:15			0:15	
6.1.6.4.5	Verify high pressure is bled off		Control console, SS computer, CCTV, tools/effectors, robotics	2	0:05	0:05			0:05	
6.1.6.4.6	Disconnect, remove, and stow unserviceable motor/ compressor		Control console, SS computer CCTV, tools/effectors, robotics	2	1:00	1:00			1:00	
6.1.6.4.7	Install and connect service-able motor/compressor		Control console, SS computer, CCTV, tools/effectprs, robotics	2	1:00	1:00			1:00	
6.1.6.4.8	Pressurize system-conduct leak and functional test		Control console, SS computer CCTV, leak detection eqipment, pressure gauges.	2	0:30					
6.1.6.4.9	Secure access panel-translate external robotics to hangar porch		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
6.1.6.4.10	Transfer motor compressor, tools/effectors to internal robotics-translate to pants area		Control console, SS computer, CCTV	2	0:15					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.6.4.11	Package unserviceable motor/ compressor		Control console, SS computer CCTV, tools/effectors	1	0:15	0:15			0:15	Return to earth
6.1.6.4.12	Translate robotics to tool area-secure tools/effectors		Control console, SS computer CCTV	1	0:05					
6.1.6.4.13	Secure robotics		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.6.5	Remove and Replace Hydrogen Accumulator	Space station power, lighting, MRMS	Control console, SS computer, CCTV, tools/effectors, robotics, test equipment		5:10	3:35			3:35	
6.1.6.5.1	Translate robotics to tool area-secure and stow tools/ effectors		Control console, SS computer, CCTV	1	0:05					
6.1.6.5.2	Translate robotics to hangar porch-transfer tools/ effectors to external robotics		Control console, SS computer, CCTV	1	0:15					
6.1.6.5.3	Translate RMS to parts area-secure hydrogen accumulator-translate to hangar porch		Control console, SS computer, CCTV	1	0:15					
6.1.6.5.4	Translate robotics to propellant module-open access panel		Control console, SS computer, CCTV, tools/effectors	2	0:15	0:15			0:15	
6.1.6.5.5	Transfer hydrogen accumulator to MRMS-translate MRMS to work site		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
6.1.6.5.6	Verify high pressure is bled off		Control console, SS computer, pressure gauges	2	0:05	0:05			0:05	
6.1.6.5.7	Disconnect and remove hydrogen accumulator		Control console, SS computer, CCTV, tools/effectors	2	1:00	1:00			1:00	
6.1.6.5.8	Secure replacement hydrogen accumulator from MRMS and install		Control console, SS computer, CCTV, tools/effectors	2	1:00	1:00			1:00	
6.1.6.5.9	Secure unserviceable hydrogen accumulator W/MRMS - translate to hangar porch		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
6.1.6.5.10	Transfer hydrogen accumulator to RMS-translate RMS to parts area		Control console, SS computer, CCTV	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.6.5.11	Secure MRMS and RMS		Control console, SS computer	1	0:05					
6.1.6.5.12	Pressurize hydrogen accumulator-conduct leak check		Control console, SS computer, CCTV, leak detection equipment, pressure gauges	2	0:30					
6.1.6.5.13	Secure access panel and translate external robotics to hangar porch		Control console, SS computer, CCTV, tools/effectors	2	0:15	0:15			0:15	
6.1.6.5.14	Transfer tools/effectors to internal robotics-translate to parts area		Control console, SS computer CCTV	2	0:15					
6.1.6.5.15	Package, unserviceable hydrogen accumulator		Control console, SS computer, CCTV	1	0:15	0:15			0:15	
6.1.6.5.16	Translate robotics to tool area-secure tools/effectors		Control console, SS computer	1	0:05					
6.1.6.5.17	Secure Internal/external robotics		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
6.1.6.6	Remove and Replace Hydrogen Accumulator Valve Module	space station power, lighting, MRMS	Control console, SS computer, CCTV, tools/effectors, robotics, test equipment		3:45	2:25			2:25	
6.1.6.6.1	Translate robotics to tool area-secure and stow tools/ effectors		Control console, SS computer, CCTV	1	0:05					
6.1.6.6.2	Translate robotics to parts area-secure and stow valve module		Control console, SS computer, CCTV	1	0:05					
6.1.6.6.3	Translate robotics to hangar porch-transfer tools/ effectors valve module to external robotics		Control console, SS computer, CCTV	1	0:15					
6.1.6.6.4	Translate robotics to work site-open access panel		Control console, SS computer, CCTV, tools/effectors	2	0:15	0:15			0:15	
6.1.6.6.5	Verify pressure is bled from system		Control console, SS computer, pressure gauges	2	0:05	0:05			0:05	High pressure
6.1.6.6.6	Remove unserviceable valve system & stow		Control console, SS computer, CCTV, tools/effectors, robotics	2	0:45	0:45			0:45	
6.1.6.6.7	Install serviceable valve system		Control console, SS computer, CCTV, tools/effectors	2	0:45	0:45			0:45	
6.1.6.6.8	Pressurize system-conduct leak check		Control console, SS computer, leak detection equipment, CCTV	2	0:30					
6.1.6.6.9	Close access panel-translate robotics to hangar porch		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
6.1.6.6.10	Transfer unservicable valve module, tools/effectors to internal robotics-translate to parts area		Control console, SS computer, CCTV	2	0:15					
6.1.6.6.11	Package unserviceable valve module		Control console, SS computer, CCTV, tools/effectors	1	0:20	0:20			0:20	Return to earth
6.1.6.6.12	Translate robotics to to area-secure tools/effectors		Control cosole, SS computer	1	0:05					
6.1.6.6.13	Secure robotics		Control console, SS computer	1	0:05					

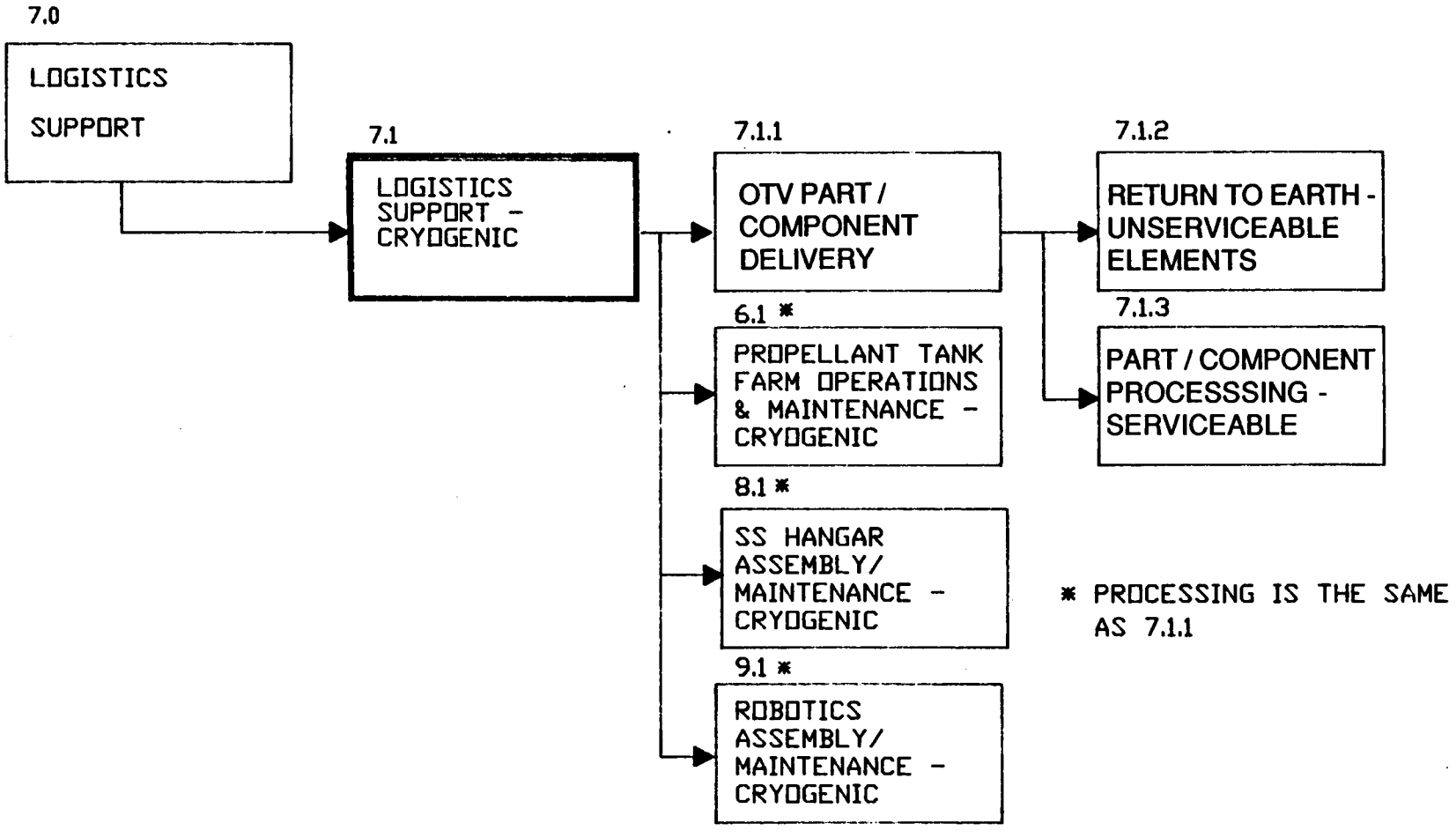
SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
6.1.6.7	Remove and Replace Propellant Line	Space station power, lighting, MRMS	Control console, SS computer, CCTV, tools/effectors, robotics, test equipment		5:45	4:10			4:10	
6.1.6.7.1	Translate robotics to tool area-secure and stow tools/ effectors, test equipment		Control console, SS computer CCTV	1	0:05					
6.1.6.7.2	Translate robotics to parts area-secure and stow propellant line repair kits		Control console, SS computer CCTV	1	0:05	:50		:50		
6.1.6.7.3	Translate hangar RMs to parts area-secure serviceable propellant line sections		Control console, SS computer CCTV	1	0:05					
6.1.6.7.4	Translate robotics & RMS to hangar prorch		Control console, SS computer CCTV	1+2	0:15	0:15			0:15	
6.1.6.7.5	Transfer tools/effectors, repair units to external robotics		Control console, SS computer CCTV	1	0:10					
6.1.6.7.6	Transfer serviceable propellant line to MRMS		Control console, SS computer CCTV	2	0:05	0:05			0:05	
6.1.6.7.7	Translate robotics to work site		Control console, SS computer CCTV	2	0:15					Assumed max distance from hangar
6.1.6.7.8	Release first propellant line connection/joint		Control console, SS computer CCTV, tool/effectors	2	0:20	0:20			0:20	
6.1.6.7.9	Translate robotics to second connection/joint and release		Control console, SS computer CCTV, tool/effectors	2	0:25	0:25			0:25	
6.1.6.7.10	Release propellant line retaining straps and remove propellant line		Control console, SS computer CCTV, tool/effectors	2	0:20	0:20			0:20	
6.1.6.7.11	Translate MRMS to work site		Control console, SS computer tool/effectors	2	0:15	0:15			0:15	
6.1.6.7.12	Exchange propellant lines		Control console, SS computer CCTV	2	0:10	0:10			0:10	
6.1.6.7.13	Translate MRMS to hangar porch - transfer unserviceable propellant line to hanger RMS		Control console, SS computer CCTV	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
6.1.6.7.14	Install serviceable propellant line - secure first connection/joint		Control console, SS computer CCTV, tool/effectors, repair kit	2	0:30	0:30			0:30	
6.1.6.7.15	Translate RMS to parts area		Control console, SS computer CCTV	2	0:20	0:20			0:20	
6.1.6.7.16	Translate robotics to second connection/joint and secure		Control console, SS computer CCTV, tools/effectors, repair kit	2	0:35	0:35			0:35	
6.1.6.7.17	Secure propellant line retaining strips		Control console, SS computer CCTV, tools/effectors,	2	0:20	0:20			0:20	
6.1.6.7.18	Pressurization line - Conduct leak check		Control console, SS computer CCTV, pressure gauges	2	0:30					
6.1.6.7.19	Translate robotics to hangar porch; transfer tools/ effectors and repair kit to interval robotics		Control console, SS computer CCTV	1	0:10					
6.1.6.7.20	Translate robotics to parts area		Control console, SS computer CCTV	1	0:15					
6.1.6.7.21	Prepare propellant line and repair kit for shipment		Control console, SS computer CCTV, tolls/effectors	1	0:20	0:20			0:20	Return to earth
6.1.6.7.22	Translate robotics to tools area - secure tools/ effectors		Control console, SS computer CCTV	1	0:05					
6.1.6.7.23	Secure robotics		Control console, SS computer CCTV	1	0:05					

CRYOGENIC SPACE-BASED OTV LOGISTICS SUPPORT

Provided are the logistics support operations associated with the Cryogenics SBOTV and its attendant accommodations.

LOGISTICS SUPPORT – CRYOGENIC



MARTIN MARIETTA

LOGISTICS SUPPORT-CRYOGENIC

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
7.1	Logistics Support - Cryogenic	SS hangar, lighting, power	Control console, SS computer, RMS, robotics, CCTV, test equipment	-	6:00 - 17:00	6:00- 17:00			6:00 - 17:00	
7.1.1	OTV Part or Component Delivery			-	3:00- 10:00	3:00- 10:00			3:00- 10:00	
7.1.1.1	Translate parts/components to storage area		Control console, SS computer, RMS, robotics, CCTV	2	1:00- 4:00	1:00- 4:00			1:00- 4:00	
7.1.1.2	Conduct visual inspection		Control console, SS computer, CCTV	2	1:00- 4:00	1:00- 4:00			1:00- 4:00	Damaged units are segregated for diagnostic testing or for immediate return to earth
7.1.1.3	Conduct diagnostic testing		Control console, SS computer, test equipment, robotics	1	1:00- 2:00	1:00- 2:00			1:00- 2:00	Damaged units - return to earth

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
7.1.2	Return to Earth - Unserviceable			-	2:00-6:00	2:00-6:00			2:00-6:00	
7.1.2.1	Determine shuttle cargo bay capabilities	Ground computer		-						
7.1.2.2	Package damaged parts/ components for shipment		Control console, SS computer, CCTV, robotics	1	1:00-4:00	1:00-4:00			1:00-4:00	
7.1.2.3	Translate parts / components to Shuttle for stowage		Control console, SS computer, CCTV, robotics, RMS	1	1:00-2:00	1:00-2:00			1:00-2:00	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
7.1.3	Part or Component Processing -Serviceable									
7.1.3.1	Immediate Use				0:40	0:40			0.40	
7.1.3.1.1	Translate components to OTV processing or buildup area		Control console, SS computer, CCTV, robotics, RMS	2	0:20	0:20			0:20	20 minutes/component
7.1.3.1.2	Translate unserviceable OTV parts/components to storage area for processing.		Control console, SS computer, CCTV, robotics, RMS	2	0:20	0:20			0:20	
7.1.3.2	Store for Future Missions				-	-			-	
7.1.3.2.1	Translate parts/components to designated storage area		Control console, SS computer, CCTV, robotics, RMS	2	0:20	0:20			0:20	20 minutes/component
7.1.3.2.2	Upon removal follow Sequence 7.1.3.1			-						

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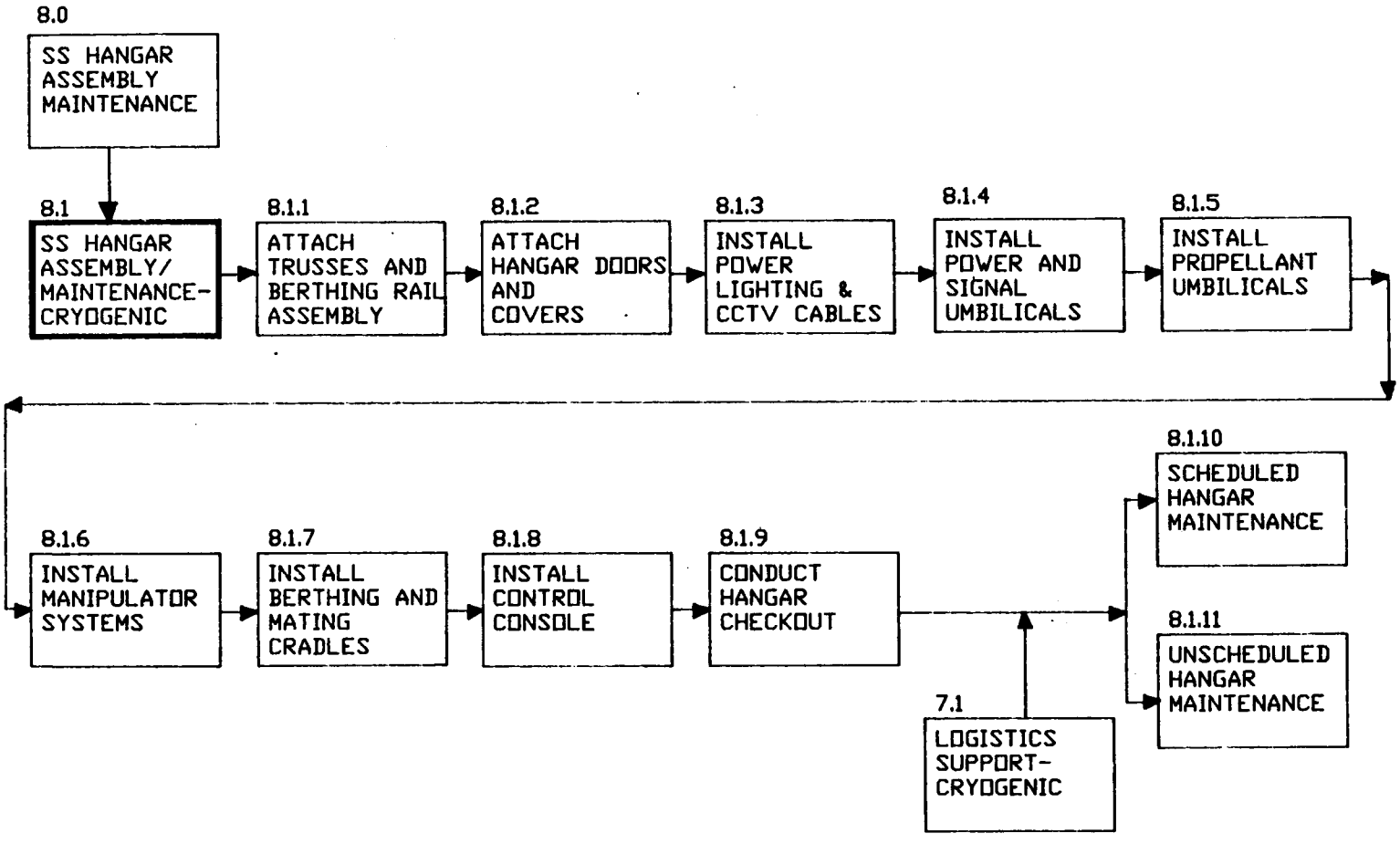
CRYOGENIC SPACE-BASED OTV HANGAR ASSEMBLY & MAINTENANCE

All of the operations associated with initial assembly of the hangar, including trusses and rails, outer shell, manipulator systems, berthing/mating cradles, and umbilicals as well as long term maintenance operations, are identified. Most of the initial hangar assembly must be accomplished by EVA until the robotic arms are installed and operational.

SS HANGAR ASSEMBLY/MAINTENANCE – CRYOGENIC



MARTIN MARIETTA

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
8.1	Space Station Hangar Assembly and Maintenance	Space station power, lighting. MRMS	SS computer, control console, MRMS, CCTV, special assembly tools, MMU's, software, test equipment	-	87:15	87:15	67:35	135:10	222:25	
8.1.1	Attach Trusses and Berthing Rail Assembly	Space station power, lighting, MRMS		-	19:00	19:00	14:40	29:20	48:20	
8.1.1.1	Load space station hangar assembly program		SS computer, software	2	0:15	0:15			0:15	
8.1.1.2	Translate MRMS to shuttle docking area - obtain truss assembly module		SS computer, MRMS, CCTV, control console	2	1:45	1:45			1:45	Truss is removed from shuttle by shuttle RMS. 7 trusses - 15 min/truss
8.1.1.3	Translate MRMS to hangar assembly area		SS computer, control console, MRMS, CCTV	2	2:20	2:20			2:20	7 trusses - 20 min/truss
8.1.1.4	Open truss module - assemble first truss - attach to space station interface and latch in place		SS computer, control console, MRMS, CCTV	3	12:15	12:15	12:15	24:30	36:45	Repeat until 7 trusses are installed 1:45/truss
8.1.1.5	Assemble berthing rail assembly - attach to space station and hangar truss assembly		Control console, SS computer, MRMS, CCTV	3	2:25	2:25	2:25	4:50	7:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
8.1.2	Install Hangar Cover	Space station power, lighting MRMS		-	15:25	15:25	12:30	25:00	40:25	
8.1.2.1	Translate MRMS to shuttle docking area - obtain hangar section modules		SS computer, control console, MRMS, CCTV	2	1:15	1:15			1:15	Hanger sections are shipped to space station in 27'x 235' sections, 5 sections req'd, 15 min/section
8.1.2.2	Translate MRMS to hangar assembly area		SS computer, control console, CCTV, MRMS	2	1:40	1:40			1:40	20 min/section
8.1.2.3	Unpack hanger sections and attach to truss assemblies		SS computer, control console, CCTV	3	10:00	10:00	10.00	20:00	30.00	2.0 hrs per section
8.1.2.4	Inject foam into hanger sections			3	2:30	2:30	2:30	5:00	7:30	30 minutes per section

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
8.1.3	Attach Hanger Doors and Covers	Space station power, lighting, MRMS		-	13:10	13:10	12:00	24:00	37:10	
8.1.3.1	Translate MRMS to shuttle docking area - obtain door assemblies and covers		SS computer, MRMS, CCTV, control console	2	0:30	0:30			0.30	Module is removed from shuttle cargo bay by the shuttle RMS
8.1.3.2	Translate MRMS to hangar assembly area		SS computer, MRMS, CCTV, control console		0:40	0:40			0:40	Module is removed from shuttle cargo bay by the shuttle RMS
8.1.3.3	Assemble door frame and attach to hangar mounting points		SS computer, MRMS, CCTV, control console	3	7:00	7:00	7:00	14:00	21:00	3:30/complete door assembly
8.1.3.4	Attach door operating mechanism - opener		SS computer, MRMS, CCTV, control console	3	2:00	2:00	2:00	4:00	6:00	1 hr/complete door assembly
8.1.3.5	Attach door cover and inject foam		SS computer, MRMS, CCTV, control console	3	2:00	2:00	2:00	4:00	6:00	
8.1.3.6	Verify doors opens and close properly.		SS computer, MRMS, CCTV control console	3	1.00	1:00	1:00	2:00	3:00	Correct anomolies

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
8.1.4	Install Power, Lighting, Signal and CCTV Cables	Space station power, lighting, MRMS		-	17:50	17:50	15:30	31:00	48:50	
8.1.4.1	Translate MRMS to shutle docking area - obtain power, lighting and CCTV cable modules		SS computer, MRMS, CCTV, control console	2	1:00	1:00			1:00	Modules are removed from shuttle cargo bay by the shuttle RMS 15 min/module - 4 each
8.1.4.2	Translate MRMS to hanger		SS computer, control console	2	1:20	1:20			1:20	20 min/module - 4 each
8.1.4.3	Unpackage power cables - install and secure as designated		SS computer, MRMS, CCTV, control console	3	3:00	3:00	3:00	6:00	9:00	Conduct continuity checks - correct anomolies - secure at power distribution point
8.1.4.4	Unpackage lighting cables - install and secure as designated		SS computer, MRMS, CCTV, control console, test equipment	3	3:00	3:00	3:00	6:00	9:00	Conduct continuity checks - correct anomolies - secure at power distribution point
8.1.4.5	Install and secure lighting fixtures		SS computer, MRMS, CCTV, control console	3	1:30	1:30	1:30	3:00	4:30	
8.1.4.6	Unpackage CCTV cables - install and secure as designated		SS computer, MRMS, CCTV, control console, test equipment	3	3:00	3:00	3:00	6:00	9:00	Conduct continuity checks - correct anomolies - secure at power distribution point
8.1.4.7	Install and secure CCTV cameras/monitors		SS computer, MRMS, CCTV, control console	3	1:30	1:30	1:30	3:00	4:30	
8.1.4.8	Unpackage signal cables - install and secure as designated		SS computer, MRMS, CCTV control console	3	3:00	3:00	3:00	6:00	9:00	Conduct continuity checks, correct anomolies, secure to S.S. signal distribution panel
8.1.4.9	Connect power cables to designated main power distribution points		SS computer, MRMS, CCTV control console	3	0:30	0:30	0:30	1:00	1:30	Verify power levels where possible

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
8.1.5	Install Power and Signal Umbilicals	Space station power, lighting, MRMS		-	6:15	6:15	5:05	10:10	16:25	
8.1.5.1	Translate MRMS to shuttle docking area - obtain power and signal umbilicals and reels		SS computer, MRMS, CCTV, control console.	2	0:30	0:30			0:30	Modules are removed from shuttle bay with shuttle RMS 2 modules - 15 min/module
8.1.5.2	Translate MRMS to Hangar assembly area		SS computer, MRMS, CCTV, control console	2	0:40	0:40			0:40	2 modules - 20 min/module
8.1.5.3	Disconnect power to power and signal cables		SS computer, MRMS, CCTV, control console.	3	0:15	0:15	0:15	0:30	0:45	
8.1.5.4	Unpackage power umbilical and reel assembly		SS computer, MRMS, CCTV, control Console	3	0:15	0:15	0:15	0:30	0:45	Reel assembly used for umbilical management
8.1.5.5	Install and secure power umbilical and reel assembly		SS computer, MRMS, CCTV, control console, Test equipment	3	2:00	2:00	2:00	4:00	6:00	operation checks.
8.1.5.6	Unpackage signal umbilical and reel assembly.		SS computer, MRMS, CCTV, control console	3	0:15	0:15	0:15	0:30	0:45	Reel assembly used for umbilical management.
8.1.5.7	Install and secure signal umbilical and reel assembly		SS computer, MRMS, CCTV, control console, Test equipment	3	2:00	2:00	2:00	4:00	6:00	
8.1.5.8	Connect power and signal umbilicals at respective distribution points		SS computer, MRMS, CCTV, control console.	3	0:20	0:20		0:40	1:00	Conduct continuity and reel operation checks

SEQUENCE NUMBER	TASK	REQUIREMENTS		TRNG	FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS		TIME	IVA	EVA	EVA	TOTAL	
8.1.6	Install Propellant Umbilicals	Space station power, lighting MRMS		-	3:00	3:00	2:25	4:50	7:50	
8.1.6.1	Translatre MRMS to shuttle docking area - obtain propellant umbilical		SS computer, MRMS, CCTV, control console.	2	0:15	0:15			0:15	Module removed from shuttle bay with shuttle RMS
8.1.6.2	Translate MRMS to hangar assembly area		SS computer, MRMS, CCTV, control console.	2	0:20	0:20			0:20	
8.1.6.3	Unpackage propellant umbilical - Install and secure at designated location		SS computer, MRMS, CCTV control console	3	2:15	2:15	2:15	4:30	6:45	
8.1.6.4	Verify umbilical connection properly seated			3	0:10	0:10	0:10	0:20	0:30	Leak check conducted during initial propellant line chill down - correct anomolies.

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
8.1.7	Install Berthing and Mating Cradles	Space station power, lighting, MRMS		-	6:35	6:35	5:25	10:50	17:25	
8.1.7.1	Translate MRMS to shuttle docking area - obtain berthing structure		SS computer, MRMS, CCTV, control console	2	0:30	0:30			0:30	2 modules - 15 min/module
8.1.7.2	Translate MRMS to hangar assembly area		SS computer, MRMS, CCTV, control console	2	0:40	0:40			0:40	20 min/module
8.1.7.3	Unpackage berthing cradle		SS computer, MRMS, CCTV, control console	3	0:20	0:20	0:20	0:40	1:00	
8.1.7.4	Install and secure berthing cradle to rail assembly		SS computer, MRMS, CCTV, control console	3	1:30	1:30	1:30	3:00	4:30	
8.1.7.5	Translate MRMS to shuttle docking area secure mating cradles		SS computer, MRMS, CCTV, control console	2	0:45	0:45	0:45	1:30	2:15	3 modules - 15 min/module 2 payload, 10 OMV
8.1.7.6	Translate MRMS to hangar assembly area		SS computer, MRMS, CCTV, control console	2	1:00	1:00	1:00	2:00	3:00	20 min/module
8.1.7.7	Unpackage mating cradles		Control console, SS computer, CCTV	3	0:20	0:20	0:20	0:40	1:00	
8.1.7.8	Install and secure mating cradles to rail assembly		SS computer, MRMS, CCTV control console	3	1:30	1:30	1:30	3:00	4:30	

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
8.1.8	Hangar Control Console Installation	Space station power, lighting, MRMS		-	3:00	3:00			4:00	
8.1.8.1	Translate MRMS to shuttle docking area - obtain hangar control console		SS computer, MRMS, CCTV, control console	2	0:15	0:15			0:15	
8.1.8.2	Translate MRMS to space station airlock		SS computer, MRMS, CCTV, control console	2	0:15	0:15			0:15	
8.1.8.3	Translate hangar control console through airlock.			2	0:30	0:30		1:00	1:30	
8.1.8.4	Install and secure hangar control console			2	2:00	2:00			2:00	

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
8.1.9.1	Conduct Hangar Checkout	Space station power, lighting		-	3:00	3:00			3:00	
8.1.9.1	Verify operations of hangar doors		SS computer, hangar control console	2	0:15	0:15			0:15	Correct anomolies
8.1.9.2	Verify power levels throughout hangar		SS computer, hangar control console	2	0:15	0:15			0:15	Correct anomolies
8.1.9.3	Verify operation of hangar lighting console		SS computer, hangar control console	2	0:15	0:15			0:15	Correct anomolies
8.1.9.4	Verify operation of CCTV system		CC computer, hangar control console	2	0:15	0:15			0:15	Correct anomolies
8.1.9.5	Verify operations of power umbilical		SS computer, hangar control console	2	0:15	0:15			0:15	Correct anomolies
8.1.9.6	Verify operation of signal umbilical		SS computer, hangar control console	2	0:15	0:15			0:15	Correct anomolies
8.1.9.7	Verify operation of propellant umbilical		SS computer, hangar control console.	2	0:30	0:30			0:30	Correct anomolies
8.1.9.8	Verify operation of hangar robotic system		SS computer, hangar control console	2	0:30	0:30			0:30	See 9.1 Robotics Assembly and maintenance
8.1.9.9	Verify operation of berthing and mating cradles		SS computer, hangar control console	2	0:30	0:30			0:30	Correct anomolies
8.1.9.10	Verify control console operations		SS computer	2	-	-			-	Verified through above steps.

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
8.1.10	Schedule Hangar Maintenance									
8.1.10.1	Inspect Berthing Rail Assembly	Space station power, Lighting	SS computer, control console, robotics, CCTV, test equipment,	-	1:00	1:00			1:00	
8:1.10.1.1	Turn power off		Control console	1						
8.1.10.1.2	Clean berthing rail assembly		SS computer, control console	2	0:30	0:30			0:30	
8.1.10.1.3	Inspect berthing rail assembly		SS computer, control console, robotics, CCTV, test equipment.	2	0:30	0:30			0:30	Visual and electronic inspection for excessive wear, cracks, warps, etc.
8.1.10.1.4	Turn power on		Control console	1	-	-			-	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
8.1.10.2	Inspect and Lubricate Berthing Structures	Space station power, Lighting	SS computer, control console, robotics, CCTV	-	1:55	1:55		2:00	3:55	
8.1.10.2.1	Turn power off		Control console	1	-	-			-	
8.1.10.2.2	Cleaning berthing cradles		SS computer, control console robotics, CCTV	2	0:30	0:30		1:00	1:30	
8.1.10.2.3	Inspect berthing cradles		SS computer, control console, robotics, CCTV, test equipment.	2	0:30	0:30			0:30	Visual and electronics inspection for excessive wear, cracks, etc.
8.1.10.2.4	Lubricate berthing cradle joints, and rail mounting points		SS computer, control console, robotics, CCTV	2	0:30	0:30		1:00	1:30	
8.1.10.2.5	Turn power on			1	-	-			-	
8.1.10.2.6	Translate berthing cradle along rails		S computer, control console	2	0:10	0:10			0:10	
8.1.10.2.7	Collapse and extend berthing cradle		SS computer, control console test equipment.	2	0:10	0:10			0:10	Check for binding in joints
8.1.10.2.8	Verify OTV, OMV and payload locking mechanisms operational		SS computer, control console	2	0:05	0:05			0:05	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
8.1.10.3	Inspect and Lubricate Hangar Door Mechanism		SS computer, control console, CCTV, robotics, test equipment	-	1:55	1:55		2:30	4:25	
8.1.10.3.1	Clean hangar door mechanism		SS computer, control console, CCTV, robotics	2	0:45	0:45		1:30	2:15	
8.1.10.3.2	Inspect hangar door mechanism		SS computer, control console, CCTV, robotics, test equipment	2	0:30	0:30			0:30	
8.1.10.3.3	Lubricate hangar door mechanism		SS computer, control console, CCTV, robotics	2	0:30	0:30		1:00	1:30	
8.1.10.3.4	Exercise hangar door mechanism through full operational range		SS computer, control console	1	0:10	0:10			0:10	Correct anomolies

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
8.1.10.4	Inspect and Lubricate Umbilicals and Umbilical Management reels	Space station power, lighting	SS computer, control console, CCTV, robotics, test equipment	-	1:20	1:20		0:50	2:10	
8.1.10.4.1	Clean umbilical management reels		SS computer, control console, CCTV, robotics	2	0:15	0:15		:30	0:45	
8.1.10.4.2	Inspect umbilicals and umbilical management reels		SS computer, control console, CCTV, robotics, test equipment	2	0.30	0:30			0:30	
8.1.10.4.3	Lubricate umbilical management reels		SS computer, control console, CCTV, robotics	2	0:10	0:10		:20	0:30	
8.1.10.4.4	Verify umbilical interfaces mate properly		SS computer, control console, CCTV	2	0.10	0:10			0:10	Correct anomolies
8.1.10.4.5	Operate umbilical management reels through full range		SS computer, control console	1	0:15	0:15			0:15	Correct anomolies

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	EVA	MANHOURS EVA	TOTAL	REMARKS
8.1.10.5	Inspect and Lubricate CCTV	Space station power, lighting, signal	SS computer, control console, CCTV, robotics	-	0:55	0:55		0:50	1:45	
8.1.10.5.1	Clean CCTV lenses and mounting brackets		SS computer, control console, CCTV, robotics	2	0:15	0:15		:30	0:45	
8.1.10.5.2	Inspect lenses and mounting brackets		SS computer, control console, CCTV, robotics	2	0.20	0:20			0:20	
8.1.10.5.3	Lubricate mounting brackets		SS computer, control console, CCTV robotics	2	0.10	0:10		:20	0:30	
8.1.10.5.4	Operate CCTV through full range		SS computer, control console	1	0:10	0:10			0.10	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
8.1.10.6	Contamination Monitoring System	Space station power, lighting, signal	SS computer, control console, calibration equipment, test equipment	-	0:45	0:45			0:45	
8.1.10.6.1	Calibrate hangar contamination monitoring equipment		SS computer, control console, calibration equipment	2	0:15	0:15			0:15	
8.1.10.6.2	Conduct contamination survey		SS computer, control console, test equipment	2	0:30	0:30			0:30	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
8.1.11	Unscheduled Hangar Maintenance		SS computer, control console, CCTV, robotics, tools/ effectors, repair kits, test equipment							
8.1.11.1	Repair Hangar Walls and Doors	Space station power, lighting, signal		1	0:40	0:15			0:15	
8.1.11.1.1	Translate robotics to tool storage area - obtain and stow tools / effectors		Control console, SS computer	1	0:50					
8.1.11.1.2	Translate robotics to parts storage - obtain and stow repair kits		Control console, SS computer	1	0:05					
8.1.11.1.3	Translate robotics to work site - prepare damaged area for patching - apply patch		Control console, SS computer robotics, CCTV, tools/ effectors.	1	0:15	0:15			0:15	
8.1.11.1.4	Translate robotics to parts storage - secure repair kit		Control console, SS computer	1	0:05					
8.1.11.1.5	Translate robotics to tool area - secure tools and effectors		Control console, SS computer	1	0:05					
8.1.11.1.6	Secure robotics.		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
8.1.11.2	Remove and Replace Berthing Rails	Space station power, lighting	Control console, SS computer, CTV, robotics, tools/ effectors	-	3:30	2:40			2:40	
8.1.11.2.1	Move berthing cradles away from work site location		Control console, SS computer	1	0:20					
8.1.11.2.2	Translate robotics to tool area - secure and stow tools and effectors.		Control control, SS computer	1	0:05					
8.1.11.2.3	Translate robotics to work site		Control control, SS computer	1	0:05					
8.1.11.2.4	Remove damaged section of berthing rails		Control control, SS computer, CCTV, robotics, Tools/ effectors	1	1:00	1:00			1:00	
8.1.11.2.5	Translate robotics to parts storage - secure damaged rail		Control control, SS computer, robotics, CCTV	1	0:15	0:15			0:15	
8.1.11.2.6	Secure serviceable berthing rail		Control control, SS computer, robotics, CCTV	1	0:05	0:05			0:05	
8.1.11.2.7	Translate robotics and berthing rail to work site		Control control, SS computer	2	0:15	0:15			0:15	
8.1.11.2.8	Install serviceable berthing rail		Control control, SS computer, CCTV, robotics, tools/ effectors	2	1:00	1:00			1:00	
8.1.11.2.9	Translate robotics to parts area - dissassemble unserviceable berthing rail and package for shipment		Control control, SS computer, CCTV, robotics, tools/ effectors	1	0:15	0:15			0:15	Return to earth
8.1.11.2.10	Translate robotics to tool area - secure and store tools/effectors		Control control, SS computer	1	0:05					
8.1.11.2.11	Secure robotics		Control control, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
8.1.11.3	Remove and Replace Hangar Door Mechanism	Space station power, lighting, signal	Control console, SS computer, robotics, tools/effectors	-	1:55	1:25			1:25	
8.1.11.3.1	Translate robotics to tool area - secure and stow tools/effectors		Control control, SS computer	1	0:05					
8.1.11.3.2	Translate robotics to parts area - secure and stow replacement components		Control control, SS computer, CCTV, robotics	1	0:10					
8.1.11.3.3	Translate robotics to work site		Control control, SS computer	1	0:05					
8.1.11.3.4	Remove and stow door mechanism		Control control, SS computer, CCTV, robotics, tools/ effectors.	2	0:30	0:30			0:30	
8.1.11.3.5	Install new door mechanism		Control control, SS computer, CCTV, robotics, Tools/ effectors.	2	0:30	0:30			0:30	
8.1.11.3.6	Conduct operational check of door mechanism		Control control, SS computer	1	0:10	0:10			0:10	
8.1.11.3.7	Translate robotics to parts storage - secure unservice-able components and package		Control console, SS computer, CCTV, robotics	1	0:15	0:15			0:15	Return to earth
8.1.11.3.8	Translate robotics to tool area - secure and stow tools/effectors		Control control, SS computer	1	0:05					
8.1.11.3.9	Secure robotics		Control control, SS computer	1						

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
8.1.11.4	Remove and Replace CCTV Camera and Brackets	Space station power, lighting, signal	Control console, Ss computer, CCTV, robotics, tools/ effectors	-	1:25	0:55			0:55	
8.1.11.4.1	Translate robotics to tool area - secure and stow tools/effectors		Control control, SS computer	1	0:05					
8.1.11.4.2	Translate robotics to parts area - secure and stow replacement component		Control control, SS computer	1	0:10					
8.1.11.4.3	Translate robotics to work site		Control Console, SS computer	1	0:05					
8.1.11.4.4	Remove unserviceable component		Control control, SS computer CCTV, robotics, tools/ effectors	2	0:15	0:15			0:15	
8.1.11.4.5	Install replacement component		Control control, SS computer, CCTV, robotics, tools/ effectors	2	0:15	0:15			0:15	
8.1.11.4.6	Conduct system test of CCTV		Control control, SS computer	1	0:10	0:10			0:10	
8.1.11.4.7	Translate robotics to parts area - package unserviceable component		Control control, SS computer, CCTV, robotics, tools/ effectors	1	0:15	0:15			0:15	Return to earth
8.1.11.4.8	Translate robotics to tool area - secure and stow tools/effectors		Control control, SS computer	1	0:05					
8.1.11.4.9	Secure robotics		Control control, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
8.1.11.5	Remove and Replace Umbilicals	Space station power, lighting, signal	Control console, SS computer, CCTV, robotics, tools/ effectors, test equipment	1	2:30	2:05			2:05	
8.1.11.5.1	Translate robotics to tool area - secure and stow tools/effectors		Control control, SS computer	1	0:05					
8.1.11.5.2	Translate robotics to work site		Control control, SS computer	1	0:05					
8.1.11.5.3	Translate RMS to work site - attach to unserviceable umbilical		Control control, SS computer	2	0:05	0:05			0:05	Power off/propellant purged
8.1.11.5.4	Verify umbilical is safe for removal		Control control, SS computer.	2	0:05	0:05			0:05	
8.1.11.5.5	Remove unserviceable umbilical		Control control, SS computer, CCTV, robotics, RMS, tools/ effectors.	2	0:30	0:30			0:30	
8.1.11.5.6	Translate RMS and unservice-able umbilical to parts area and secure		Control control, SS computer CCTV, RMS.	2	0:15	0:15			0:15	
8.1.11.5.7	Secure replacement umbilical and translate to work site		Control control, SS computer, RMS.	2	0:15	0:15			0:15	
8.1.11.5.8	Install replacement umbilical		Control control, SS computer, CCTV, robotics, RMS, Tools/ effectors.	2	0:30	0:30			0:30	
8.1.11.5.9	Disengage RMS and secure		Control control, SS computer	1	0:05					
8.1.11.5.10	Verify umbilical operation		Control control, SS computer robotics, test equipment.	2	0:10	0:10			0:10	Propellant umbilical will be checked prior to next scheduled propellant transfer

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
8.1.11.5.11	Translate robotics to parts area - package unserviceable umbilical		Control control, SS computer robotics, CCTV. robotics, CCTV.	1	0:15	0:15			0:15	Return to earth
8.1.11.5.12	Translate robotics to tool area - secure and stow tools/effectors		Control control, SS computer	1	0:05					
8.1.11.5.13	Secure robotics		Control control, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
8.1.11.6	Remove and Replace Umbilical Reels	Space station power, lighting, signal	Control console, SS computer, CCTV, robotics, tools/ effectors	1	2:25	1:55			1:55	
8.1.11.6.1	Translate Robitics to tool area - secure and stow tools/effectors		Control control, SS computer	1	0:05					
8.1.11.6.2	Translate robotics to work site		Control control, SS computer	1	0:05					
8.1.11.6.3	Translate RMS to work site - attach to reel assembly		Control control, SS computer	1	0:05	0:05			0:05	
8.1.11.6.4	Verify umbilical reel is safe for removal		Control Console, SS computer	1	0:05					Power off
8.1.11.6.5	Disconnect umbilical reel assembly		Control control, SS computer, CCTV, robotics, tools/ effectors	2	0:30	0:30			0:30	
8.1.11.6.6	Translate RMS and reel assembly to parts are and secure		Control control, SS computer, CCTV, RMS	2	0:10	0:10			0:10	
8.1.11.6.7	Secure replacement reel assembly and translate to work site		Control control, SS computer CCTV, RMS	2	0:15	0:15			0:15	
8.1.11.6.8	Install and secure reel assembly		Control control, SS computer, CCTV, robotics, RMS, tools/ effectors	2	0:30	0:30			0:30	
8.1.11.6.9	Disengage RMS and secure		Control control, SS computer	1	0:05					
8.1.11.6.10	Verify umbilical/reel operational		Control control, SS computer, robotics	2	0:10	0:10			0:10	
8.1.11.6.11	Translate robotics to parts area - package reel assembly		Control control, SS computer, CCTV, RMS, robotics, tools/ effectors.	1	0:15	0:15			0:15	Return to earth
8.1.11.6.12	Translate robotics to tool area - secure and stow tools		Control control, SS computer	1	0:05					
8.1.11.6.13	Secure robotics		Control control, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
8.1.11.7	Remove and Replace Lighting System	Space station power, lighting		-	0:55	0:30			0:30	
8.1.11.7.1	Translate robotics to tool area - secure and stow tools/effectors		Control control, SS computer	1	0:05					
8.1.11.7.2	Translate robotics to parts area - secure and stow replacement components		Control control, SS computer	1	0:05					
8.1.11.7.3	Translate robotics to work site		Control Console, SS computer	1	0:05					
8.1.11.7.4	Remove and replace defective component		Control control, SS computer CCTV, robotics, tools/ effectors.	2	0:15	0:15			0:15	
8.1.11.7.5	Translate robotics to parts area - package unservice-able components		Control control, SS computer, CCTV, robotics.		0:15	0:15			0:15	Return to earth
8.1.11.7.6	Translate robotics to tool area - secure and stow tools/effectors		Control control, SS computer		0:05					
8.1.11.7.7	Secure robotics		Control control, SS computer		0:05					

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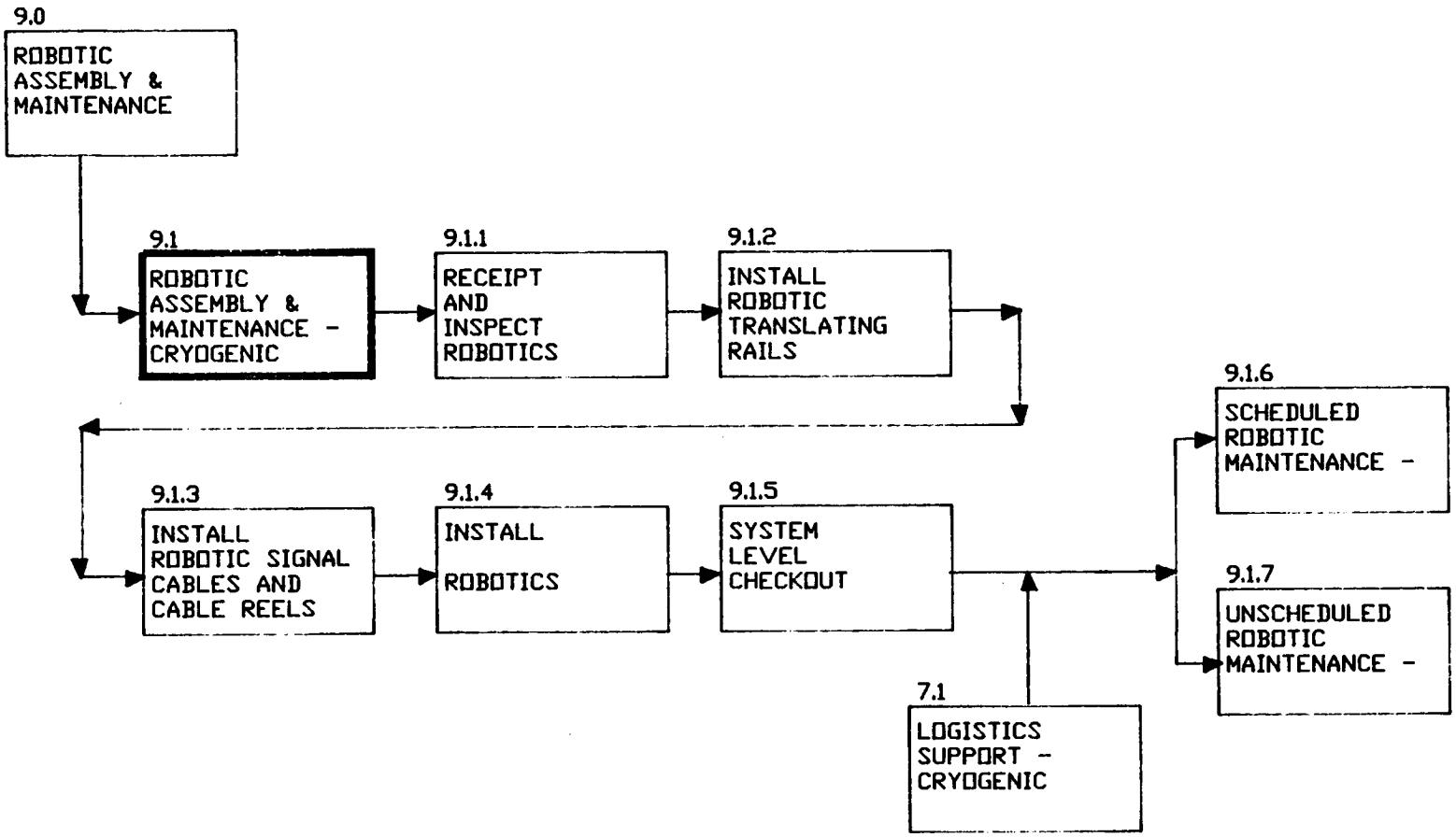
CRYOGENIC SPACE-BASED OTV ROBOTIC ASSEMBLY & MAINTENANCE

Installation of the robotics system, performed primarily by EVA, and maintenance of the system, performed robotically, is identified on the facing page functional flow and following requirements definition set.

ROBOTIC ASSEMBLY & MAINTENANCE –CRYOGENIC



MARTIN MARIETTA

ROBOTIC ASSEMBLY AND MAINTENANCE - CRYOGENIC

SHEET 1 of 7

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
9.1	Robotic Assembly and Maintenance - Cryogenic	Space station power, lighting, signal, MRMS	Control console, SS computer, CCTV, tools/effectors, test equipment		24:20	24:20	21:00	42:00	66:20	
9.1.1	Receipt and Inspect Robotics	Space station power, lighting, MRMS		-	3:20	3:20	1:00	2:00	5:20	
9.1.1.1	Translate MRMS to shuttle docking area - secure robotics module		MRMS, control console, SS computer, CCTV	2	1:00	1:00	-	-	1:00	Robotic modules removed from shuttle by shuttle RMS. 15 mins/robotics module - 4 each.
9.1.1.2	Translate MRMS to SS hangar		MRMS, control console, SS computer, CCTV	2	1:20	1:20	-	-	1:20	20 min/robotics module - 4 each.
9.1.1.3	Unpackage robotics module, store components			1	1:00	1:00	1:00	2:00	3:00	Visual inspection (15 min/module) accomplished. Repeat steps 9.1.1.1 - 9.1.1.3 until all modules are delivered to Hangar.

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
9.1.2	Install Robotic Translating Rails	Space station power, lighting		-	8:00	8:00	7:00	14:00	22:00	
9.1.2.1	Translate MRMS to shuttle docking area - obtain translating rails		SS computer, control console, CCTV, tools	2	1:00	1:00			1:00	
9.1.2.3	Assemble, and attach robotic translating rails at designated locations		SS computer, control console, CCTV, tools	3	6:00	6:00	6:00	12:00	18:00	Attached parallel and perpendicular to hangar trusses.
9.1.2.2	Verify attachments are secure.		SS computer, control console, test equipment	3	1:00	1:00	1:00	2:00	3:00	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
9.1.3	Install Robotic Signal/Power Cables and Cable Management Reels	Space station power, lighting	Control console, SS computer, CCTV, tools, test equipment	-	6:00	6:00	6:00	12:00	18:00	
9.1.3.1	Install cable and cable reels		Control console, SS computer	3	4:00	4:00	4:00	8:00	12:00	1 hr/module - 4 each
9.1.3.2	Verify proper cable reel operation		SS Computer, CCTV	3	1:00	1:00	1:00	2:00	3:00	Cable management - 15 min/ module
9.1.3.3	Verify continuity and signal transmission		Control console, SS computer, test equipment	3	1:00	1:00	1:00	2:00	3:00	15 min/module

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
9.1.4	Install Robotics	Space station power, lighting	Control console, SS computer, CCTV	-	7:00	7:00	7:00	14:00	21:00	
9.1.4.1	Attach robotics to translating rails		Control console, SS computer, CCTV	3	5:00	5:00	5:00	10:00	15:00	1:15/module - 4 each
9.1.4.2	Attach signal/power cables to robotics		Control console, SS computer, CCTV	3	1:00	1:00	1:00	2:00	3:00	
9.1.4.3	Verify interfaces at all attaching points		Control console, SS computer, CCTV	3	1:00	1:00	1:00	2:00	3:00	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
9.1.5	System Level Checkout	Space station power, lighting, signal	Control console, SS computer	2	1:00	1:00			1:00	Correct anomolies

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
9.1.6	Inspect and Lubricate RMS and Robotic Arms	Space station power, lighting signal		-	1:45	1:45		1:00	2:45	
9.1.6.1	Power-off			1	-	-	-	-	-	
9.1.6.2	Clean RMS and robotic arms		SS computer, control console robotics, CCTV, test equipment.	2	0:15	0:15		0:30	0:45	Sequentially - operations 1 robotic system.
9.1.6.3	Inspect RMS or robotic arms		SS computer, control console robotics, CCTV, test equipment.	2	0:30	0:30			0:30	
9.1.6.4	Lubricate RMS and robotic arms		SS computer, control console	2	0:15	0:15		0:30	0:45	
9.1.6.5	Power - On			1	-	-	-		-	
9.1.6.6	Verify full operational range of RMS and robotics		SS computer, control console	2	0:15	0:15			0:15	
9.1.6.7	Inspect tools and effectors		SS computer, control console, CCTV, robotics.	2	0:30	0:30			0:13	

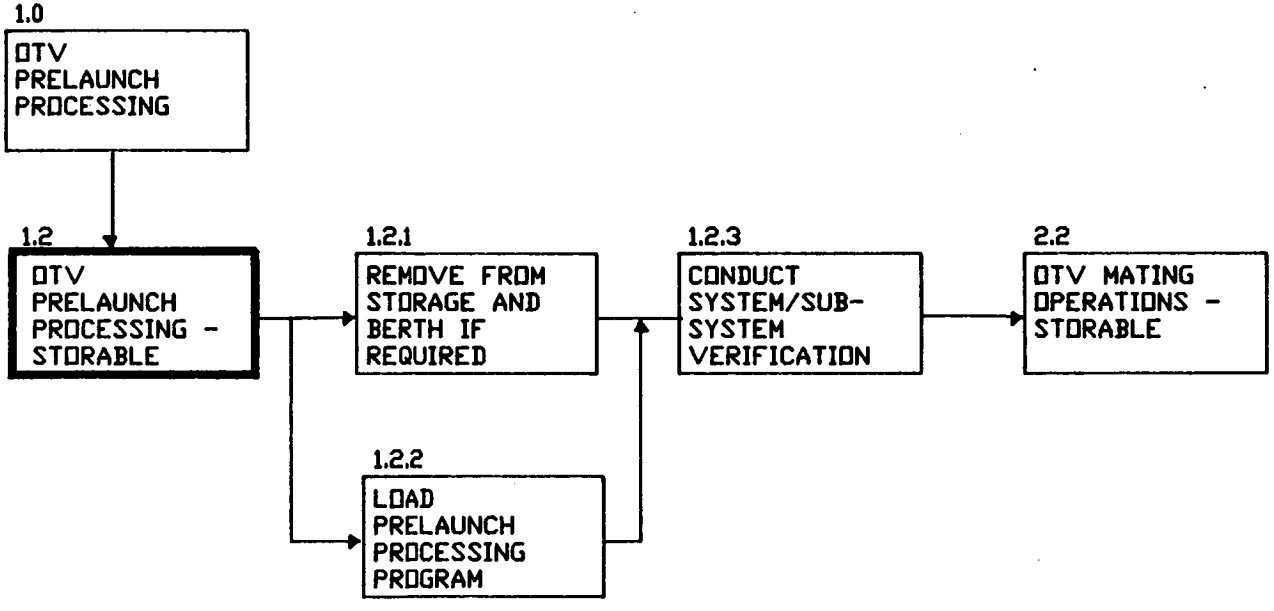
SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
9.1.7	Remove and Replace RMS or Robotics	Space station power, lighting, signal		-	2:15-3:15	1:55-2:55			1:55-2:55	
9.1.7.1	Translate robotics to tool area - secure and stow tools/effectors		Control console, SS computer	1	0:05					
9.1.7.2	Translate robotics to the location of the unserviceable robotic		Control console, SS computer	1	0:05					
9.1.7.3	remove unserviceable component		Control console, SS computer CCTV, robotics, tools/ effectors	2	0:30-1:00	0:30-1:00			0:30-1:00	
9.1.7.4	Translate unserviceable component to parts storage and secure		Control console, SS computer	2	0:10	0:10			0:10	
9.1.7.5	Secure serviceable component - translate to work site		Control console, SS computer	1	0:15	0:15			0:15	
9.1.7.6	Install serviceable component		Control console, SS computer, CCTV, robotics, tools/ effectors	2	0:30-1:00	0:30-1:00			0:30-1:00	
9.1.7.7	Conduct system check of repaired robotic		Control console, SS computer	1	0:15	0:15			0:15	
9.1.7.8	Translate robotics to parts storage - package unservice-able component		Control console, SS computer	1	0:15	0:15			0:15	Return to earth
9.1.7.9	Translate robotics to tool area - secure and store tools/effectors		Control console, SS computer	1	0:05					
9.1.7.10	Secure robotics		Control console, SS computer	1	0:05					

STORABLE SPACE-BASED OTV

STORABLE SPACE-BASED OTV PRELAUNCH PROCESSING

This functional flow and corresponding requirements definitions addresses the operations necessary to prepare the Storable SBOTV for payload mating prior to mission launch.

SBOTV PRELAUNCH PROCESSING – STORABLE



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OTV PRELAUNCH PROCESSING - STORABLE

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
1.2	OTV PreLaunch Processing - Storable	SS hangar, ligting power, signal, propellant umbilicals	Control console, SS computer, software, robotics, MRMS, tools/effectors	-	4:35-5:35	0:45-1:30			0:45-1:30	
1.2.1	Remove From Storage and Berth (if required)			-	1:00	0:45			0:45	OTV fleet size would dictate OTV storage hangar requirements. The following sequence would apply if a storage hangar is required
1.2.1.1	Disconnect power and signal umbilical		Control console, SS computer	1	0:05					
1.2.1.2	Open storage hangar door		Control console, SS computer	1	0:05					
1.2.1.3	Translate OTV to processing hangar		Control console, SS computer	2	0:45	0:45			0:45	
1.2.1.4	Attach power and signal umbilicals		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
1.2.2	Load Prelaunch Processing Program		Control console, SS computer, software	-	0:40	0:20			0:20	
1.2.2.1	Verify program matchs OTV configuration		Control console, SS computer	1	0:15	0:15			0:15	
1.2.2.2	Conduct program self-test		Control console, SS computer	1	0:20					
1.2.2.3	Verify program self-test		Control console, SS computer	1	0:05	0:05			0:05	

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
1.2.3	Conduct System/Subsystem Verification - Self Test		Control console, SS computer, software	-	3:55	0:25			0:25	
1.2.3.1	Load program and conduct automatic test of the following subsys		Control console, SS computer	1	0:10	0:10			0:10	
1.2.3.2	Avionics		Control console, SS computer	1	1:00					
1.2.3.3	GN&C		Control console, SS computer	1	0:30					
1.2.3.4	Data management		Control console, SS computer	1	0:30					
1.2.3.5	Communications and tracking (less RF antenna systems)		Control console, SS computer	1	0:30					
1.2.3.6	Power (less fuel cells)		Control console, SS computer	1	0:30					Fuel cells checked following RCS propellant transfer
1.2.3.7	Payload interface system		Control console, SS computer	1	0:30					
1.2.3.8	Verify self test			2	0:15	0:15			0:15	

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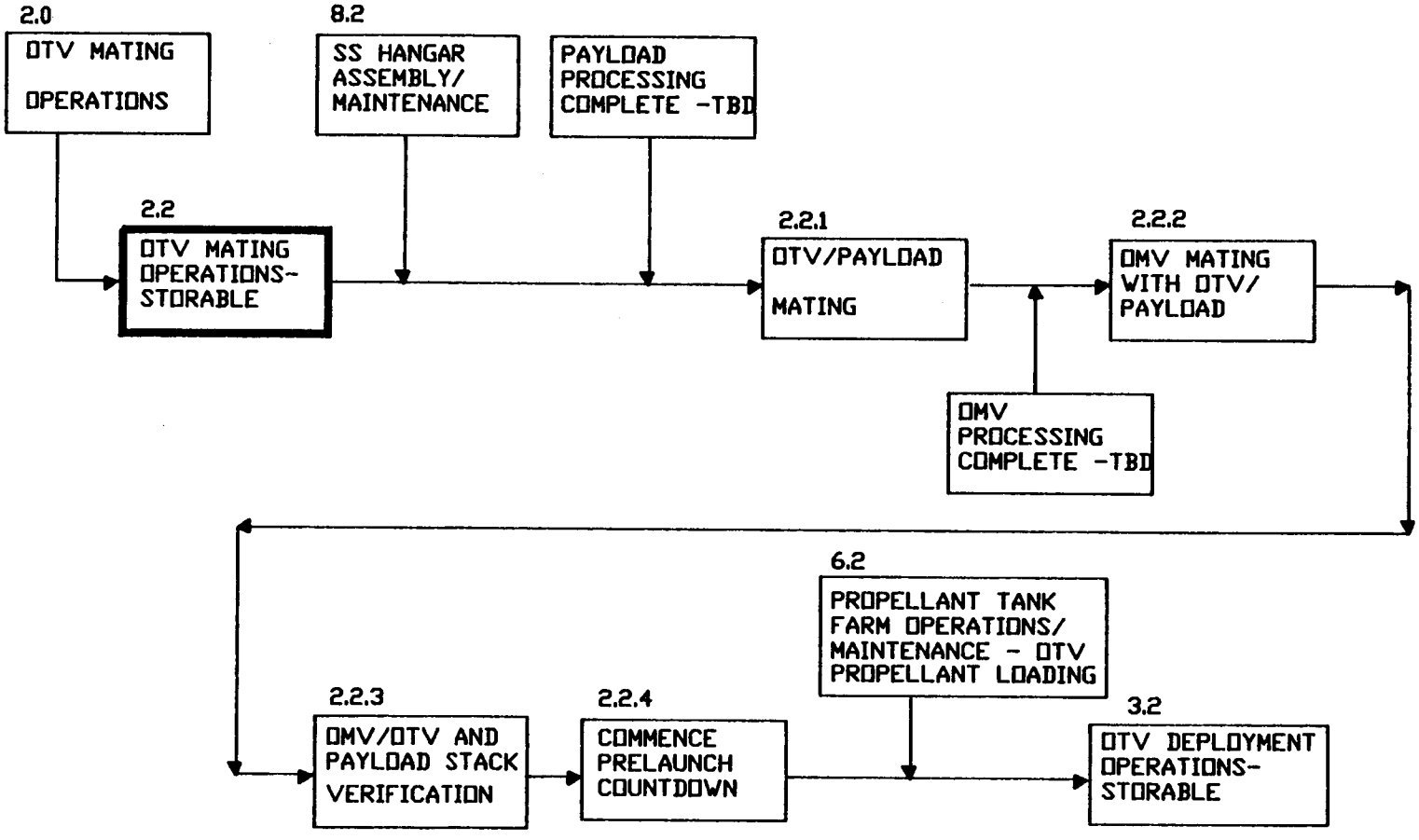
STORABLE SPACE-BASED OTV MATING OPERATIONS

This functional flow and set of requirements definitions addresses the operations associated with payload and OMV mating and the attendant operations required to checkout and verify the OMV/OTV/payload stack.

SBOTV MATING OPERATIONS – STORABLE



OTV MATING OPERATIONS-STORABLE

SEQUENCE NUMBER	TASK	REQUIREMENTS		TRNG	FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS		TIME	IVA	EVA	EVA	TOTAL	
2.2	OTV and Payload Mating Operations- Storable	SS hangar, ligting, power, signal, propellant umbilicals	Control console, SS computer RMS, robotics, CCTV software	--	15:30	10:25			10:25	
2.2.1	OTV/Payload Mating				1:45	1:45			1:45	
	Logistic support available to support mating operations			--	--	--			--	See 7.0 Logistics Support
	Verify hangar contamination level			--	--	--			--	See 8.0 SS Hangar Assembly/ Maintenance
2.2.1.1	Translate payload to OTV processing area		Control console, SS computer, RMS, CCTV	2	0:15	0:15			0:15	Assumed to be in hangar
2.2.1.2	Secure payload to mating cradle		Control console, SS computer, RMS, CCTV	2	0:15	0:15			0:15	
2.2.1.3	Verify OTV/payload alignment		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
2.2.1.4	Mate OTV/payload - verify proper electrical/mechanical interfaces		Control console, SS computer,	2	1:00	1:00			1:00	Correct anomalies

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.2.2	OMV Mating with OTV/Payload				1:20	1:15			1:15	
2.2.2.1	Translate OMV to OTV processing area		Control console, SS computer, RMS, CCTV	2	0:30	0:30			0:30	
2.2.2.2	Secure OMV to mating cradle		Control console, SS computer, RMS, CCTV	2	0:15	0:15			0:15	
2.2.2.3	Verify OMV/OTV alignment		Control console, SS computer, RMS, CCTV	2	0:15	0:15			0:15	
2.2.2.4	Mate OMV/OTV - verify proper mechanical interfaces		Control console, SS computer, CCTV,	2	0:15	0:15			0:15	Correct anomalies
2.2.2.5	Connect power, signal, umbilicals to OMV		Control console, SS computer,	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.2.3	OMV/OTV/Payload Stack Verification			—	0:30	0:30			0:30	
2.2.3.1	Verify mechanical/electrical connections		Control console, SS computer, CCTV	1	0:20	0:20			0:20	
2.2.3.2	Verify stack is ready to commence prelaunch countdown		Control console, SS computer	1	0:10	0:10			0:10	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.2.4	Prelaunch Countdown			--	11:40	6:55			6:55	
2.2.4.1	Propellant Transfer		Control console, SS computer, leak detection equipment	--	4:25	4:05			4:05	See 6.0 Propellant Tank Farm Operations/Maintenance
2.2.4.1.1	Attach propellant umbilicals		Control console, SS computer	1	0:20					
2.2.4.1.2	Verify detection equipment operational		Control console, SS computer	1	0:05	0:05			0:05	
2.2.4.1.3	Complete propellant transfer		Control console, SS computer leak detection equipment	2	4:00	4:00			4:00	Monitor for leaks

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.2.4.2	Conduct Avionics Module Testings			—	1:00	0:30			0:30	
2.2.4.2.1	Verify OTV configuration		Control console, SS computer	1	0:15	0:15			0:15	
2.2.4.2.2	Select, verify and load diagnostic checkout program		Control console, SS computer	1	0:15	0:15			0:15	
2.2.4.2.3	Conduct diagnostic testing of avionics systems (less RF antennas)		Control console, SS computer	1	0:30					Correct anomalies - See 4.0 for maintenance activities

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.2.4.3	Conduct Power Checks			--	0:35	0:05			0:05	
2.2.4.3.1	Verify fuel cell propellant loaded		Control console, SS computer	1	0:15					
2.2.4.3.2	Verify fuel cell operation		Control console, SS computer	1	0:15					
2.2.4.3.3	Verify self-test			1	0:05	0:05			0:05	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.2.4.4	Load Mission Program			--	1:30	0:30			0:30	
2.2.4.4.1	Verify mission program prior to loading		Control console, SS computer	1	0:20	0:20			0:20	
2.2.4.4.2	Load program, conduct program verification		Control console, SS computer	1	1:00					
2.2.4.4.3	Verify program test			1	0:10	0:10			0:10	Correct anomalies

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.2.4.5	Main Engine Check			--	1:15	0:25			0:25	
2.2.4.5.1	Load self-test program			1	0:10	0:10			0:10	
2.2.4.5.2	Engine valve operation check		Control console, SS computer	2	0:15					
2.2.4.5.3	Instrumentation checkout		Control console, SS computer	2	0:20					
2.2.4.5.4	Solenoid checkout		Control console, SS computer	2	0:15					
2.2.4.5.5	Verify self-test			2	0:15	0:15			0:15	Correct anomalies - See 4.0 for maintenance activites

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.2.4.6	Propellant System Check				0:20	0:20			0:20	
2.2.4.6.1	Verify leak check equipment operational		Control console, SS computer leak detection equipment	1	0:05	0:05			0:05	Correct anomalies
2.2.4.6.2	Verify propellant subsystems operating within limits		Control console, SS computer	2	0:15	0:15			0:15	Correct anomalies - See 4.0 for maintenance activities

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.2.4.7	OTV RCS Check				0:30	0:30			0:30	
2.2.4.7.1	Conduct RCS system check		Control console, SS computer	2	0:15	0:15			0:15	Correct anomalies - See 4.0 for maintenance activities
2.2.4.7.2	Verify RCS propellant loaded within limits		Control console, SS computer	2	0:15	0:15			0:15	Correct anomalies - See 4.0 for maintenance activities

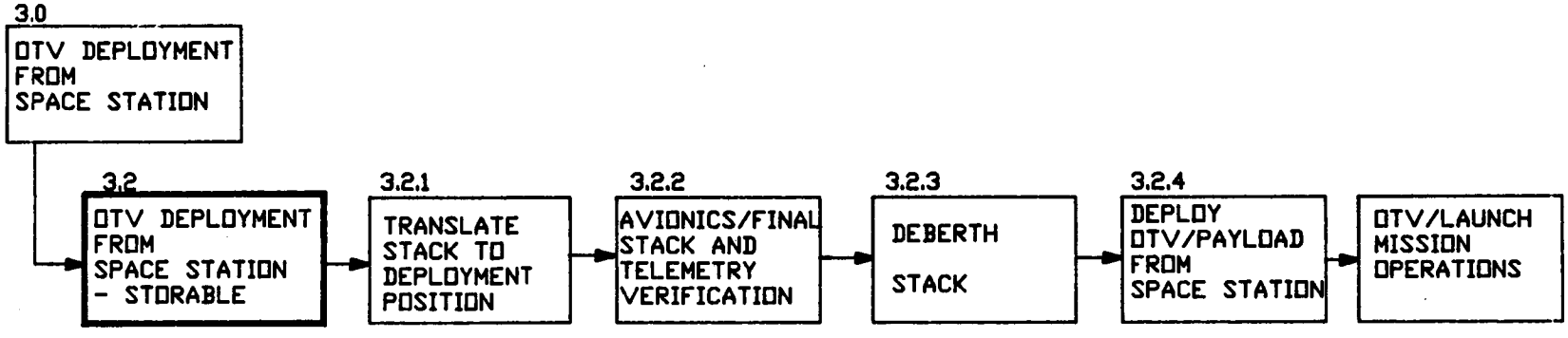
SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.2.4.8	Verify Health and Status of Payload			--	1:05	0:15			0:15	
2.2.4.8.1	Reverify electrical/ mechanical OTV payload interface		Control console, SS computer, CCTV	2	0:15					
2.2.4.8.2	Verify proper power levels and telemetry data		Control console, SS computer	2	0:20					
2.2.4.8.3	Verify payload ACS operation /propellant load		Control console, SS computer	2	0:15					
2.2.4.8.4	Verify self-test			2	0:15	0:15			0:15	Correct anomalies - See payload maintenance activities - TBD

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
2.2.4.9	Verify Health and Status of OMV			--	1:00	0:15			0:15	
2.2.4.9.1	Reverify mechanical OMV/OTV interface		Control console, SS computer	2	0:10					
2.2.4.9.2	Verify proper power levels and telemetry data		Control console, SS computer	2	0:20					
2.2.4.9.3	Verify propellant load		Control console, SS computer	2	0:15					
2.2.4.9.4	Verify self-test			2	0:15	0:15			0:15	Correct anomalies - See OMV maintenance activites - TBD

STORABLE SPACE-BASED OTV DEPLOYMENT

A functional flow and requirements definition set relative to deployment of the Storable SBOTV, mated with a payload and the OMV, from Space Station is provided.

SBOTV DEPLOYMENT FROM SPACE STATION – STORABLE



MARTIN MARIETTA

OTV DEPLOYMENT - STORABLE

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
3.2	OTV Deployment From Space Station - Storable	SS hangar, lighting, power signal, propellant umbilicals	Control console, SS computer, CCTV, RMS		2:40	1:25			1:25	
3.2.1	Translate Stack to Deployment Position				1:15	0:30			0:30	
3.2.1.1	Verify mating/checkout complete		Control console, SS computer	2	0:20					
3.2.1.2	Release propellant umbilicals		Control console, SS computer CCTV	1	0:20					
3.2.1.3	Open hangar doors		Control console, SS computer CCTV	1	0:05					
3.2.1.4	Translate stack to hangar porch		Control console, SS computer CCTV	2	0:30	0:30			0:30	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
3.2.2	Avionics/Final Stack and Telemetry Verification				0:20	0:20			0:20	
3.2.2.1	Conduct S-Band check		Control console, SS computer, antenna systems	1	0:10	0:10			0:10	Correct anomolies - See 4.0 for maintenance activities
3.2.2.2	Conduct GPS check		Control console, SS computer, antenna systems	1	0:10	0:10			0:10	Correct anomolies - See 4.0 for maintenance activities

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
3.2.3	Release Deberth Stack				0:35	0:05			0.05	
3.2.3.1	Release latches on OMV		Control console, SS computer, CCTV	1	0:05				0:05	
3.2.3.2	Collapse OMV mating cradle		Control console, SS computer, CCTV	1	0:05				0:05	
3.2.3.3	Release latches on payload		Control console, SS computer, CCTV	1	0:05				0:05	
3.2.3.4	Collapse payload mating cradle		Control console, SS computer, CCTV	1	0:05				0:05	
3.2.3.5	Attach space crane; release latches on OTV and collapse berthing cradle		Control console, SS computer, CCTV	2	0:05				0:05	
3.2.3.6	Release power and signal umbilicals		Control console, SS computer, CCTV	1	0:05				0:05	
3.2.3.7	Verify sequence complete			2	0:05	0:05			0:05	

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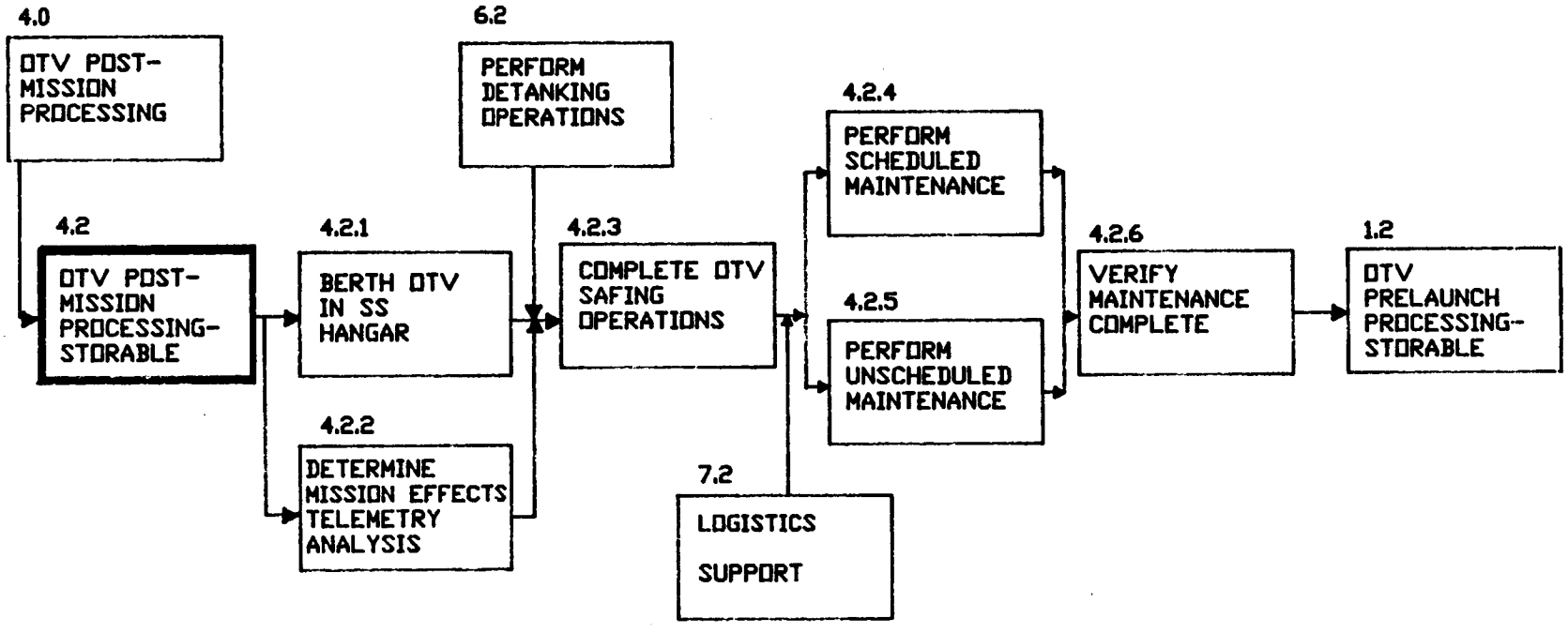
SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
3.2.4	Deploy OMV/OTV/Payload from Space Station				0:30	0:30			0:30	
3.2.4.1	Translate OTV and space crane to deployment position		Control console, SS computer, CCTV	2	0:30	0:30			0:30	
3.2.4.2	Deploy stack		Control console, SS computer, CCTV	2	--	--			--	
3.2.4.3	Control of stack transferred to space station			2	--	--			--	

STORABLE SPACE-BASED OTV POSTMISSION PROCESSING

The operations associated with retrieval of the Storable SBOTV and OMV, with or without a return payload, and the safing, demating, detanking, and maintenance operations necessary after the return from a mission are provided in the following charts.

SBOTV POSTMISSION PROCESSING – STORABLE



MARTIN MARIETTA

Assumptions:

1. All major components will be removed as a unit i.e., Fuel Tanks, Regulators, Avionics Modules, Engine(s).
2. Only items that cannot be replaced on orbit will be located within the Main Structure.
3. Tool Kits, special tools and robotic effectors will be provided for each major task.
4. Removal of the main propulsion engine(s) will not require removal of the aerobrake.
5. Robotics will be capable of reaching all connect/disconnect points on the vehicle.
6. Robotics will be used to the maximum extent possible to preclude EVA operations except in contingencies.

Common Actions Associated With All Functions

1. Verify OTV berthing and latching prior to any activities.
2. Verify OTV propellant levels and safing.
3. Verify operation of remote manipulator systems and robotics.
4. Verify current maintenance procedures and robotic programs are available and loaded.
5. Verify that tools/effectors are available and serviceable.
6. Verify that all required test equipment is on hand and operational. Computer programs are available.
7. SS hangar will be clear of all packaging debris after every maintenance activity - Disposal bags will be required during all maintenance activities.

SEQUENCE NUMBER	TASK	REQUIREMENTS		TRNG	FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS		TIME	IVA	EVA	EVA	TOTAL	
4.2	OTV Postmission Processing Storable	SS hanger, lighting, power signal, propellant umbilicals berthing cradle, MRMS	Control console, SS computer, CCTV, robotics, tools/ effectors,	-	-	-	-	-	-	
4.2.1	Berth OTV in Space Station Hangar			-	2:10	2:00			2:00	
4.2.1.1	Open hangar doors		Control console, SS computer	1	0:05					
4.2.1.2	Translate OTV berthing structure onto hangar porch		Control console, SS computer	1	0:15 ||					
4.2.1.3	Position MRMS for OTV retrieval		Control console, SS computer	2	0:15	0:15			0:15	
4.2.1.4	Secure MRMS to OTV grappeling fixtures		Control console, SS computer, CCTV, MRMS	2	0:20	0:20			0:20	
4.2.1.5	Translate OTV to berthing cradle		Control console, SS computer, CCTV, MRMS	2	0:30	0:30			0:30	
4.2.1.6	Position OTV in berthing cradle		Control console, SS computer,	2	0:05	0:05			0:05	
4.2.1.7	Release MRMS grapples - secure MRMS		Control console, SS computer	2	0:20	0:20			0:20	
4.2.1.8	Demate OMV for OTV		Control console, SS computer	2	0:05	0:05			0:05	
4.2.1.9	Translate OTV into hangar - secure hangar doors		Control console, SS computer	2	0:30	0:25			0.25	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.2	Determine Mission Effects - Telemetry Analysis		Control console, SS computer, CCTV, leak detection equipment	-	5:45-6:30	3:15-4:00			3:15-4:00	
4.2.2.1	Conduct visual inspection of OTV - hazardous conditions		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
4.2.2.2	Conduct leak check		Control console, SS computer, leak detection equipment	1	0:15	0:15			0:15	
4.2.2.3	Demate/secure payload		Control console, SS computer	2	0:45	0:45			0:45	As required
4.2.2.4	Load diagnostic program and verify as-flown condition		Control console, SS computer	2	0:15	0:15			0:15	
4.2.2.5	Commence detanking of residual propellants		Control console, SS computer, CCTV	2	2:15	2:15			2:15	See 6.1.3 OTV detanking
4.2.2.6	Run diagnostic program on as-flown configuration		Control console, SS computer	1	2:30					
4.2.2.7	Prepare maintenance plan		Control console, SS computer	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.3	Complete OTV Safing Operations			-	0:40	0:35			0:35	
4.2.3.1	Verify propellant valves closed		Control console, SS computer	2	--	--			--	
4.2.3.2	Conduct leak check		Control console, SS computer, leak check equipment	1	0:10	0:10			0:10	
4.2.3.3	Verify tank pressure stabilized		Control console, SS computer pressure gauges	2	0:10	0:10			0:10	
4.2.3.4	Disconnect propellant umbilical		Control console, SS computer	2	0:10					
4.2.3.5	Verify critical electrical and avionics components safed		Control console, SS computer	1	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.4	Perform Scheduled Maintenance			-	-	-	-	-	-	
4.2.4.1	Propellant Tank Scheduled Maintenance	SS hangar lighting, power, signal, propellant umbilicals	SS computer, control console, test equipment, robotics, CCTV, tools/effectors	-	2:15	1:55			1:55	Computer interfaces with onboard diagnostic equipment/systems o Includes an external visual inspection (CCTV) o PU and TVS system
4.2.4.1.1	Translate robotics to tool area and secure tools/ effectors		Control console, SS computer, CCTV	1	0:05					
4.2.4.1.2	Translate robotics to propellant tank work area		Control console, SS computer	1	0:05					
4.2.4.1.3	Visually inspect propellant tank and valve system		Control console, CCTV, robotics	2	1:40	1:40			1:40	
4.2.4.1.4	Conduct diagnostic testing		Control console, SS computer	1	0:15	0:15			0:15	Non-destructive test equipment
4.2.4.1.5	Translate robotics to tool area store tools/effectors		Control console, SS computer, CCTV	1	0:05					
4.2.4.1.6	Translate robotics to storage		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.4.2	Avionics Scheduled Maint.									
4.2.4.2.1	Module Test	SS Hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, test equipment		2:05	0:30			0:30	
4.2.4.2.1.1	Verify signal and power umbilicals connected		Control console, SS computer	1	0:10					
4.2.4.2.1.2	Verify required test software is loaded into SS computer		SS computer, control console	2	0:15	0:15			0:15	
4.2.4.2.1.3	Conduct test		SS computer, control console	1	1:25					Replace defective modules.
4.2.4.2.1.4	Verify self-test complete		SS computer, control console	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.4.2.2	Scheduled Module Replacement	SS hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, CCTV, robotics, test equipment, tools/effectors, LRU's		1:50	1:00			1:00	
4.2.4.2.2.1	Translate robotics to tool area and secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.2.2.2	Translate robotics to spare parts storage area - secure replacement module and store		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.2.2.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.2.4.2.2.4	Remove avionics module and store		Control console, SS computer, robotics, CCTV, tools/effectors	2	0:15	0:15			0:15	
4.2.4.2.2.5	Visually inspect module mounting interface for defects		Control console, SS computer, CCTV, robotics,	2	0:05	0:05			0:05	
4.2.4.2.2.6	Install replacement module and secure		Control console, SS computer, CCTV, robotics, tools/effectors	2	0:15	0:15			0:15	
4.2.4.2.2.7	Conduct module test/checkout		Control console, SS computer	1	0:30	0:05			0:05	
4.2.4.2.2.8	Translate robotics to parts storage area-package module for shipment		Control console, SS computer, robotics, CCTV	1	0:20	0:20			0:20	Return to earth
4.2.4.2.2.9	Translate robotics to tool storage and secure tools		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.2.2.10	Translate robotics to storage and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.4.2.3	ACS Update	SS Hangar, lighting, signal, power, propellant umbilicals	Control console, SS computer, software		0:45	0:10			0:10	
4.2.4.2.3.1	Verify power and signal umbilicals are connected		Control console, SS computer	1	0:05					
4.2.4.2.3.2	Verify ACS update loaded		Control console, SS computer, software	1	0:05	0:05			0:05	
4.2.4.2.3.3	Update ACS		Control console, SS computer, software	2	0:30					
4.2.4.2.3.4	Verify update complete		Control console, SS computer	2	0:05	0:05			0:05	

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.4.2.4	Avionic - Mission Peculiar									
4.2.4.2.4.1	Module Replacement See 4.2.4.2.2	SS hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, robotics, CCTV, tools/effector checkout equipment, software	1+2	1:50	1:00			1:00	
4.2.4.2.4.2	Reconfiguration See 4.2.4.2.2	SS hangar lighting power, signal, propellant umbilicals	Control console, SS computer, robotics, CCTV, tools/ effectors, checkout equipment, software	1+2	1:50	1:00			1:00	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.4.3	RCS Scheduled Maintenance									
4.2.4.3.1	Leak Check	SS hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, CCTV, test equipment, RMS	-	0:50	0:35			0:35	
4.2.4.3.1.1	Condition propellant umbilical		Control console, SS computer	2	0:10					
4.2.4.3.1.2	Connect umbilical and verify connection		Control console, SS computer	1	0:05	0:05			0:05	
4.2.4.3.1.3	Conduct leak check and verify		Control console, SS computer	1	0:30	0:30			0:30	Correct anomalies
4.2.4.3.1.4	Disconnect propellant umbilical		Control console, SS computer	2	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.4.3.2	Transducer Check	SS hanger, lighting, power, signal, propellant umbilicals	Control console, SS computer, software, CCTV	-	0:55	0:20			0:20	
4.2.4.3.2.1	Verify power, signal and propellant umbilicals connected		Control console, SS computer CCTV	1	0:05					
4.2.4.3.2.2	Load transducer check software		Control console, SS computer, software	1	0:15	0:15			0:15	
4.2.4.3.2.3	Conduct transducer check		SS computer, software	1	0:30					
4.2.4.3.2.4	Verify check complete		SS computer, control console	2	0:05	0:05			0:05	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.4.3.3	RCS - Resupply	SS hanger, lighting, power, signal, propellant umbilicals	Control Console, SS computer, RCS software		1:50	1:35			1:35	
4.2.4.3.3.1	Condition propellant umbilical		Control console, SS computer	2	0:10					
4.2.4.3.3.2	Connect propellant umbilical and verify connection		Control console, SS computer, RMS	1	0:05	0:05			0:05	
4.2.4.3.3.3	Transfer RCS propellant		Control console, SS computer, leak detection equipment	2	1:15	1:15			1:15	Monitor for leaks
4.2.4.3.3.4	Blow back propellant umbilical when transfer complete		Control console, SS computer	2	0:15	0:15			0:15	
4.2.4.3.3.5	Disconnect propellant umbilical		Control console, SS computer, RMS	2	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.4.3.4	RCS - Health Maintenance									
4.2.4.3.4.1	Scheduled Transducer Replacement	SS hanger, lighting, power, signal, propellant umbilicals	Control console, SS computer, robotics, CCTV, tools/ effectors	-	2:20	1:30			1:30	
4.2.4.3.4.1.1	Translate robotics to tool storage area and secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.3.4.1.2	Translate robotics to parts storage area select LRU and store		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.3.4.1.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.2.4.3.4.1.4	Remove transducer and store		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:30	0:30			0:30	
4.2.4.3.4.1.5	Conduct visual inspection		Control console, SS computer, CCTV	2	0:05	0:05			0:05	
4.2.4.3.4.1.6	Install and secure replacement transducer		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:30	0:30			0:30	
4.2.4.3.4.1.7	Conduct transducer check and verify		SS computer, software	1	0:30	0:05			0:05	
4.2.4.3.4.1.8	Translate robotics to parts storage area - package for shipment		Control console, SS computer, robotics, CCTV	1	0:20	0:20			0:20	Return to earth
4.2.4.3.4.1.9	Translate robotics to tools storage area, secure tools		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.3.4.1.10	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	EVA	MANHOURS EVA	TOTAL	REMARKS
4.2.4.3.4.2	Scheduled Thruster Replacement	SS hanger, lighting, power, signal, propellant umbilicals	Control console, SS computer, LRU's, robotics, CCTV, tools/ effectors	-	2:55	2:20			2:20	
4.2.4.3.4.2.1	Translate robotics to tool storage area and secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.3.4.2.2	Translate robotics to spare parts storage area - secure spare thrusters and store		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.3.4.2.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.2.4.3.4.2.4	Disconnect thruster propellant lines and electrical interfaces		Control console, SS computer, robotics, CCTV, tool/ effectors	2	0:15	0:15			0:15	
4.2.4.3.4.2.5	Remove and store thruster		Control console, SS computer, robotics, CCTV	2	0:20	0:20			0:20	
4.2.4.3.4.2.6	Install new thruster		Control console, SS computer, robotics, CCTV	2	0:30	0:30			0:30	
4.2.4.3.4.2.7	Connect thruster propellant lines and electrical interfaces		Control console, SS computer, robotics, CCTV	2	0:15	0:15			0:15	
4.2.4.3.4.2.8	Connect propellant umbilical		Control console, SS computer, CCTV	1	0:05					
4.2.4.3.4.2.9	Conduct leak check		Control console, SS computer leak detection equipment	1	0:30	0:30			0:30	
4.2.4.3.4.2.10	Blow back propellant lines and disconnect		Control console, SS computer	2	0:15	0:10			0:10	
4.2.4.3.4.2.11	Translate robotics to parts area - package thrusters for shipment		Control console, SS computer, robotics, CCTV	1	0:20	0:20			0:20	Return to earth
4.2.4.3.4.2.12	Translate robotics to tool area, secure tools		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.3.4.2.13	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.4.4	Scheduled Engine Maintenance	SS hanger, lighting, Ground computer, power, signal, propellant umbilicals	Control console, SS computer, robotics, CCTV		3:55	0:40			0:40	
4.2.4.4.1	Post Flight Maintenance									
4.2.4.4.1.1	Analysis of flight data		SS computer, ground computer	1	--	--			--	
4.2.4.4.1.2	Load self-test program		Control console, SS computer	1	0:10	0:10			0:10	
4.2.4.4.1.3	Lock up pressure decay		SS computer, engine software	1	0:30					
4.2.4.4.1.4	Engine valve operation check		SS computer, engine software	1	0:30					
4.2.4.4.1.5	Nozzle inspection		SS computer, CCTV robotics	2	0:35					
4.2.4.4.1.6	Nozzle extension check		SS computer, software, CCTV	1	0:10					
4.2.4.4.1.7	Gimbal actuator check		SS computer, software, CCTV	1	0:10					
4.2.4.4.1.8	Connect umbilicals		Control console, SS computer, CCTV	1	0:10					
4.2.4.4.1.9	Turbopump torque check		SS computer, software	2	0:10					Flight data analysis
4.2.4.4.1.10	Instrumentation checkout		SS computer, software	1	0:30					
4.2.4.4.1.11	Solenoid checkout		SS computer, software	1	0:20					
4.2.4.4.1.12	Disconnect umbilicals		Control console, SS computer	1	0:10					
4.2.4.4.1.13	Verify self-test complete			2	0:30	0:30			0:30	

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.4.4.2	Engine - Periodic Maint	SS hanger, lighting, power, signal, propellant umbilicals	Control console, SS computer boroscope, robotics, LRU, tools/effectors		2:00	1:30			1:30	
4.2.4.4.2.1	Translate robotics to tool storage area - secure tools/effectors		Control console, SS computer, RMS, robotics, CCTV	1	0:05					
4.2.4.4.2.2	Translate robotics to parts storage area - secure and store LRU's		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.4.2.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.2.4.4.2.4	Conduct engine boroscope inspection.		Control console, SS computer, robotics, CCTV, boroscope	2	0:30	0:30			0:30	
4.2.4.4.2.5	Conduct thrust chamber inspection		Control console, SS computer, CCTV, RMS	2	1:00	1:00			1:00	
4.2.4.4.2.6	Translate robotics to parts storage area. Secure unused parts		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.4.2.7	Translate robotics to tool storage area - secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.4.2.8	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.4.4.3	Engine Remove and Replace	SS hanger, lighting, power, signal, propellant umbilicals	Control console, SS computer, robotics, RMS, CCTV, tools/effectors, special tools, protective covers	1	5.30	3:35			3:35	
4.2.4.4.3.1	Translate robotics to tool storage area - secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.4.3.2	Translate robotics to parts storage - secure and store parts		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.4.3.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.2.4.4.3.4	Using the engine removal tool, disconnect engine from interface plate		Control gonsole, SS computer, robotics, CCTV, special tool	2	0:40	0:40			0:40	
4.2.4.4.3.5	Inflate engine removal tool		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.2.4.4.3.6	Remove engine with robotics		Control console, SS computer, CCTV, robotics, special tool	2	0:05	0:05			0:05	
4.2.4.4.3.7	Translate RMS to work site; Attach grapple; disengage removal tool		Control console, SS computer, robotics, RMS, CCTV,	2	0:10	0:10			0:10	
4.2.4.4.3.8	Translate RMS to parts storage area and secure unserviceable engine		Control console, SS computer, RMS, CCTV,	2	0:15	0:15			0:15	
					"	"			"	
4.2.4.4.3.9	Translate robotics to parts storage area; unpackage replacement engine		Control console, SS computer, robotics, CCTV,	2	0:15	0:15			0:15	
4.2.4.4.3.10	Conduct visual inspection		CCTV, robotics	2	0:05	0:05			0:05	
4.2.4.4.3.11	Attach RMS to engine grapple; translate RMS to work site		Control console, SS computer, CCTV, robotics	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.4.4.3.12	Translate robotics to work site; secure removal tool		Control console, SS computer	1	0:05					
4.2.4.4.3.13	Install engine removal tool; inflate support mechanism		Control console, SS computer, robotics, CCTV, special tool	2	0:10	0:10			0:10	
4.2.4.4.3.14	Position robotics for installation		Control console, SS computer	2	0:05					
4.2.4.4.3.15	Release RMS from engine grapple		Control console, SS computer,	2	-	-			-	
4.2.4.4.3.16	Verify engine alignment with interface		Control console, SS computer, robotics, CCTV, special tool	2	0:05	0:05			0:05	
4.2.4.4.3.17	Complete installation verify locking mechanisms are secured		Control console, SS computer, robotics, CCTV, special tool	2	0:40	0:40			0:40	
4.2.4.4.3.18	Disengage engine removal tool		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.2.4.4.3.19	Engine check and verify		Control console, SS computer, CCTV	2	1:30	0:20			0:20	
4.2.4.4.3.20	Translate RMS to parts storage area and secure unserviceable engine at grapple fixture		Control console, SS computer, RMS, CCTV	2	0:05	0:05			0:05	
4.2.4.4.3.21	Translate robotics to tool storage area and secure engine removal tool		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.4.3.22	Translate robotics to parts storage area. Install protective covers on unserviceable engine; prepare for shipment		Control console, SS computer, robotics, CCTV	1	0:20	0:20			0:20	Return to earth
4.2.4.4.3.23	Store and secure engine with RMS following protective cover installation		Control console, SS computer, robotics, CCTV, protective covers	2	0:05	0:05			0:05	
4.2.4.4.3.24	Store and secure RMS		Control console, SS computer	1	0:05					Accomplished in conjunction with 4.1.4.4.3.25

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.4.4.3.25	Store and secure additional replacement parts carried by robotics		Control console, SS computer, robotics, CCTV	1	0:10					
4.2.4.4.3.26	Translate robotics to tool storage area and secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.4.3.27	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.4.5	Aerobrake Scheduled Maintenance									
4.2.4.5.1	Aerobrake Inspection	SS hanger, lighting, power, signal, propellant umbilicals	Control console, SS computer, robotics, CCTV, special equipment	-	1:10	0:30			0:30	
4.2.4.5.1.1	Analyze post mission telemetry data		SS computer, software	2	0:20	0:20			0:20	
4.2.4.5.1.2	Translate robotics to tool storage area; secure tools/ effectors		SS computer, software, robotics, CCTV	1	0:05					
4.2.4.5.1.3	Translate robotics to aerobrake work site		SS computer, software	1	0:05					
4.2.4.5.1.4	Conduct aerobrake inspection		Control console, SS computer, inspection equipment, CCTV, robotics	1	0:20					
4.2.4.5.1.5	Verify inspection data		Control console, SS computer	2	0:10	0:10			0:10	Correct anomalies
4.2.4.5.1.6	Translate robotics to tool area-secure tools		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.5.1.7	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.4.5.2	Remove and Replace Aerobrake and Support	SS hanger, lighting, power, signal, propellant umbilicals	Control console, SS computer, robotics, RMS, CCTV, tools/ effectors, special tools LRU's, leak detection equipment	-	4:25	3:50			3:50	
4.2.4.5.2.1	Translate RMS to aerobrake work site and attach to grapple fixture		Control console, SS computer	1	0:05 ||	0:05			0:05	
4.2.4.5.2.2	Translate robotics to tool area; secure and store required tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.5.2.3	Translate robotics to parts storage area; secure and store replacement hardware		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.5.2.4	Translate robotics to aerobrake work site		Control console, SS computer	1	0:05					
4.2.4.5.2.5	Disconnect RCS propellant/ electrical interfaces		Control console, SS computer, robotics, CCTV	2	0:20	0:20			0:20	
4.2.4.5.2.6	Disconnect aerobrake and support from support ring		Control console, SS computer, robotics, CCTV	2	0:15	0:15			0:15	
4.2.4.5.2.7	Translate RMS and robotics from work site to storage area; secure unserviceable aerobrake and support		Control console, SS computer, RMS, CCTV	2	0:20	0:20			0:20	
4.2.4.5.2.8	Assemble aerobrake and support with RMS and robotics		Control console, SS computer, RMS, robotics, CCTV	2	0:30	0:30			0:30	
4.2.4.5.2.9	Translate RMS and robotics to work site with replacement aerobrake and support		Control console, SS computer	2	0:20	0:20			0:20	
4.2.4.5.2.10	Inspect aerobrake support ring and RCS propellant/ interfaces		Control console, SS computer, robotics, CCTV	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.4.5.2.11	Align aerobrake and support with attachments		Control console, SS computer, robotics, RMS, CCTV	2	0:10	0:10			0:10	
4.2.4.5.2.12	Attach aerobrake and support to support ring, verify mechanical attachments are secure		Control console, SS computer, RMS, robotics, CCTV	2	0:10	0:10			0:10	
4.2.4.5.2.13	Verify RCS propellant/ electrical interfaces are seated		Control console, SS computer, robotics, CCTV	2	0:10	0:10			0:10	
4.2.4.5.2.14	Attach RCS test equipment		Control console, SS computer, robotics, CCTV, test equipment	2	0:15	0:15			0:15	
4.2.4.5.2.15	Pressurize RCS propellant spheres		Control console, SS computer	2	0:05					
4.2.4.5.2.16	Conduct RCS propellant leak check		Control console, SS computer, leak detector equipment	2	0:15	0:15			0:15	
4.2.4.5.2.17	Disconnect test equipment		Control console, SS computer, robotics, CCTV	2	0:15	0:15			0:15	
4.2.4.5.2.18	Depressurize RCS propellant spheres		Control console, SS computer	2	0:05					
4.2.4.5.2.19	Translate RMS to storage area and secure		Control console, SS computer	1	0:05					
4.2.4.5.2.20	Translate robotics to parts storage area and secure parts		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.5.2.21	Disassemble unserviceable aerobrake; package for shipment		Control console, SS computer, robotics, CCTV, tools/ effectors	1	0:30	0:30			0:30	Return to earth
4.2.4.5.2.22	Translate robotics to tool storage area and secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.4.5.2.23	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.5	Perform unscheduled Maintenance									
4.2.5.1	Propellant Tank Unscheduled Maintenance									
4.2.5.1.1	Remove and Replace Propellant Tank	SS hanger, lighting power, signal, propellant umbilicals	Control console, SS computer, test equipment, robotics, tools/effectors	-	3:00	2:20			2:20	
4.2.5.1.1.1	Translate robotics to tool area; secure & store tools/effectors		Control console, SS computer, CCTV	1	0:05					
4.2.5.1.1.2	Translate robotics to work site		Control console, SS computer	1	0:05					
4.2.5.1.1.3	Translate RMS to work site and attach propellant tank grapple fixture		Control console, SS computer, RMS, CCTV	2	0:10	0:10			0:10	
4.2.5.1.1.4	Release tank at attaching Point 1		Control console, SS computer, robotics, CCTV	2	0:15	0:15			0:15	
4.2.5.1.1.5	Release tank at attaching Point 2		Control console, SS computer, robotics, CCTV	2	0:10	0:10			0:10	
4.2.5.1.1.6	Translate robotics from work site		Control console, SS computer	1	--	--			--	This creates a clear path for the propellant tank when removed by RMS'
4.2.5.1.1.7	Remove tank with RMS		Control console, SS computer,	2	0:05	0:05			0:05	
4.2.5.1.1.8	Translate RMS to parts storage area and secure unserviceable tank		Control console, SS computer, CCTV, RMS	2	0:20	0:20			0:20	
4.2.5.1.1.9	Inspect tank interfaces with robotics; replace or repair any damaged components prior to tank installation		Control console, SS computer, CCTV, parts kit (as required)	2	0:20 ||	0:20 ||			0:20 ||	
4.2.5.1.1.10	Translate RMS with serviceable tank to work site		Control console, SS computer, CCTV, RMS	2	0:20	0:20			0:20	

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.5.1.1.11	Verify sufficient clearance between robotics and RMS with tank		Control console, SS computer	1	--	--			--	This is a precaution to ensure tank is not damaged during the initial alignment process
4.2.5.1.1.12	Position/align tank with OTV attaching and interface points		CCTV, SS computer, control console, RMS, robotics	2	0:10	0:10			0:10	
4.2.5.1.1.13	Secure tank at attaching Point 2		Robotics, control console, SS computer, CCTV	2	0:10	0:10			0:10	
4.2.5.1.1.14	Secure tank at attaching Point 1		Robotics, control console, SS computer, CCTV	2	0:10	0:10			0:10	
4.2.5.1.1.15	Release RMS from grapple fixture		Control console, SS computer, RMS	2	--	--			--	
4.2.5.1.1.16	Install/checkout & calibrate leak check equipment		Control console, SS computer, test equipment, CCTV	2	0:15	0:15			0:15	
4.2.5.1.1.17	Pressurize tank		Control console, SS computer, test equipment	2	0:15					
4.2.5.1.1.18	Depressurize tank if no anomalies are detected; disconnect test equipment		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.2.5.1.1.19	Translate RMS to storage location and secure		Control console, SS computer	1	0:05					
4.2.5.1.1.20	Translate robotics to parts parts area		Control console, SS computer, CCTV	1	0:05					
4.2.5.1.1.21	Prepare tank for shipment		Control console, SS computer,	1	0:10	0:10			0:10	Return to earth
4.2.5.1.1.22	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.5.1.2	Propellant Tank Insulation Repair	SS hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, tools/effectors, robotics, repair unit, special tools	-	2:00	1:35			1:35	
4.2.5.1.2.1	Translate robotics to tool area; secure insulation repair kit and tools/ effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.1.2.2	Translate robotics to work site		Control console, SS computer	1	0:05					
4.2.5.1.2.3	Verify that insulation damage is within established tolerances		Control console, SS computer, measuring equipment, robotics, CCTV	2	0:15	0:15			0:15	
4.2.5.1.2.4	Fill or remove damaged area IAW prescribed procedures		Control console, SS computer, robotics, CCTV, repair kit	2	0:40	0:40			0:40	
4.2.5.1.2.5	Place removed section in waste disposal container		Control console, SS computer, CCTV, robotics	2	--	--			--	
4.2.5.1.2.6	Replace section IAW prescribed procedures		Control console, SS computer, CCTV, robotics, repair kit	2	0:40	0:40			0:40	
4.2.5.1.2.7	Verify proper set up and curing is taking place		CCTV, SS computer robotics, control console,	2	0:05					
4.2.5.1.2.8	Translate robotics to tool area, store tools/effectors		CCTV, control console, robotics, SS computer	1	0:05					
4.2.5.1.2.9	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.5.1.3	Transducer Replacement	SS hangar, lighting, power, signal propellant umbilicals	Control console, SS computer, CCTV, robotics, LRU, tools/effectors, test equipment	-	2:05	1:15			1:15	
4.2.5.1.3.1	Translate robotics to tool area - secure tools/ effectors and test equipment		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.1.3.2	Translate robotics to parts storage area and secure replacement transducer		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.1.3.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.2.5.1.3.4	Remove unserviceable transducer and store		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
4.2.5.1.3.5	Install serviceable transducer		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
4.2.5.1.3.6	Install/checkout & calibrate transducer test equipment		Control console, SS computer, CCTV, robotics, test equipment	2	0:15	0:15			0:15	
4.2.5.1.3.7	Conduct transducer checkout		Control console, SS computer, CCTV, robotics,	1	0:15					Correct anomolies
4.2.5.1.3.8	Disconnect & store test equipment		Control console, SS computer, CCTV, robotics,	2	0:15	0:15			0:15	
4.2.5.1.3.9	Translate robotics to parts area; package unserviceable transducer		Control console, SS computer, CCTV, robotics,	1	0:15	0:15			0:15	Return to earth
4.2.5.1.3.10	Translate robotics to tool area - secure tools and test equipment		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.1.3.11	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.5.1.4	Remove and Replace PU or TVS	SS hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, robotics, CCTV, tools/ effectors, PU or TVS LRUs, test equipment	1	2:10	1:30			1:30	
4.2.5.1.4.1	Translate robotics to tool area - secure tools/effectors and test equipment		Control console, SS computer, robotics, CCTV, tools/ effectors	1	0:05					
4.2.5.1.4.2	Translate robotics to parts storage area secure PU or TVS LRUs		Control console, SS computer, robotics, CCTV, PU or TVS LRU effectors	1	0:05					
4.2.5.1.4.3	Translate robotics to work site		Control console, SS computer		0:05					
4.2.5.1.4.4	Remove PU or TVS		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
4.2.5.1.4.5	Install new PU or TVS		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
4.2.5.1.4.6	Install/checkout/calibrate PU or TVS test equipment		Control console, SS computer, robotics, CCTV, test equipment	2	0:15	0:15			0:15	
4.2.5.1.4.7	Conduct PU or TVS checkout		Control console, SS computer	1	0:15					Correct anomalies
4.2.5.1.4.8	Disconnect and store test equipment in robotics		Control console, SS computer, robotics, CCTV	2	0:15	0:15			0:15	
4.2.5.1.4.9	Translate robotics to parts area, package unserviceable PU or TVS		Control console, SS computer, robotics, CCTV	1	0:20	0:20			0:20	Return to earth
4.2.5.1.4.10	Translate robotics to tool area - secure tools/ effectors and test equipment		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.1.4.11	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.5.1.5	Tank Reconfiguration see 4.2.5.1.1	SS hangar, lighting, power, signal, propellant umbilical	Control console, SS computer, robotics, RMS, CCTV, tools/ effectors, propellant tank(s), test equipment		3:00	2:20			2:20	3:00 hrs/tank

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	TOOLS	TRNG	FUNC TIME	CREW SUPPT MANHOURS IVA	EVA	EVA	TOTAL	REMARKS
4.2.5.2	Avionics Unscheduled Maintenance									
4.2.5.2.1	Module Replacement	SS hangar, lighting, signal, power, propellant umbilicals	Control console, SS computer, CCTV, robotics, tools/ effectors, test equipment	-	1:50	0:55			0:55	
4.2.5.2.1.1	Translate robotics to tool area; secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.2.1.2	Translate robotics to parts storage; secure replacement module		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.2.1.3	Translate robotics to work site		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.2.1.4	Remove and store avionics module		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:15	0:15			0:15	
4.2.5.2.1.5	Inspect module mounting interface for defects		Control console, CCTV, robotics	2	0:05	0:05			0:05	
4.2.5.2.1.6	Install replacement module		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:15	0:15			0:15	
4.2.5.2.1.7	Conduct module test/checkout		Control console, SS computer	1	0:30					Correct anomalies
4.2.5.2.1.8	Translate robotics to parts storage; package unserviceable module		Control console, SS computer, robotics, CCTV	1	0:20	0:20			0:20	Return to earth
4.2.5.2.1.9	Translate robotics to tool storage area; secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.2.1.10	Translate robotics to storage and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.5.2.2	Remove and Replace Antenna System	SS hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, tools/effectors, robotics, CCTV, LRU's	-	2:20	1:25			1:25	
4.2.5.2.2.1	Translate robotics to tool area; secure tools/effectors and test equipment		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.2.2.2	Translate robotics to parts storage area - secure and store replacement parts		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.2.2.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.2.5.2.2.4	Disconnect antenna cabling		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:10	0:10			0:10	
4.2.5.2.2.5	Disconnect, remove and store antenna system		Control console, SS computer, robotics, CCTV, tools/ effectors		0:20	0:20			0:20	
4.2.5.2.2.6	Install serviceable antenna system		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
4.2.5.2.2.7	Reattach RF cabling		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:15	0:15			0:15	
4.2.5.2.2.8	Conduct test on antenna system		Control console, SS computer, test equipment	1	0:30					Correct anomalies
4.2.5.2.2.9	Translate robotics to parts storage area; package antenna system		Control console, SS computer, robotics, CCTV	1	0:20	0:20			0:20	Return to earth
4.2.5.2.2.10	Translate robotics to tool storage area and secure tools		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.2.2.11	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.5.3	Unscheduled RCS Maintenance - TBD									
4.2.5.4	Unscheduled Engine Maintenance-TBD									

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.5.5	Remove and Replace Turbopump	SS hanger, signal, power, propellant		-	4:40	3:30			3:30	4:40/Turbopump
4.2.5.5.1	Translate robotics to tool area - secure and stow tools/effectors and special removal tools	umbilical lighting	Control console, SS computer, CCTV	1	0:05					
4.2.5.5.2	Translate robotics to parts area - secure and stow replacement turbopump		Control console, SS computer, CCTV	1	0:05					
4.2.5.5.3	Translate robotics to work site		Control console, SS computer, CCTV	1	0:05					
4.2.5.5.4	Install turbopump installation tools		Control console, SS computer, CCTV, tools/effectors, special tools	2	0:50	0:50			0:50	
4.2.5.5.5	Disconnect turbopump		Control console, SS computer, CCTV, tools/effectors,	2	0:10	0:10			0:10	
4.2.5.5.6	Remove turbopump		Control console, SS computer, CCTV, tools/effectors,	2	0:30	0:30			0:30	
4.2.5.5.7	Install turbopump installation tools		Control console, SS computer, CCTV, tools/effectors,	2	0:45	0:45			0:45	
4.2.5.5.8	Position turbopump and connect		Control console, SS computer, CCTV, tools/effectors,	2	0:10	0:10			0:10	
4.2.5.5.9	Remove installation tools		Control console, SS computer, CCTV, tools/effectors,	2	0:20	0:20			0:20	
4.2.5.5.10	Connect checkout equipment		Control console, SS computer, CCTV, tools/effectors, special tools	2	0:15	0:15			0:15	
4.2.5.5.11	Conduct leak check and electrical check		Control console, SS computer, test equipment	1	0:40					Correct anomalies
4.2.5.5.12	Remove checkout equipment		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
4.2.5.5.13	Translate robotics to parts area		Control console, SS computer, CCTV	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.5.5.14	Package turbopump for shipment		Control console, SS computer, CCTV, tools/effectors,	1	0:15	0:15			0:15	Return to earth
4.2.5.5.15	Translate robotics to tool area - secure tools		Control console, SS computer	1	0:05					
4.2.5.5.16	Secure robotics		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.5.6	Aerobrake Unscheduled Repair	SS Hangar, lighting, power, signal, umbilicals	Control console, SS computer, robotics, CCTV, repair kit, special tools	-	3:05	2:30			2:30	
4.2.5.6.1	Translate robotics to tool storage area; secure tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.6.2	Translate robotics to parts storage area; secure repair kit		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.6.3	Translate robotics to aerobrake work site		Control console, SS computer	1	0:05					
4.2.5.6.4	Verify whether damaged area is within prescribed repairable tolerance		Control console, SS computer, robotics, CCTV, measuring tool	2	0:10	0:10			0:10	
4.2.5.6.5	Prepare area for repair		Control console, SS computer, robotics, CCTV, tools	2	0:30	0:30			0:30	
4.2.5.6.6	Complete repairs		Control console, SS computer, robotics, CCTV, tools	2	1:20	1:20			1:20	
4.2.5.6.7	Verify curing/setup requirements		SS computer	1	0:05					
4.2.5.6.8	Conduct required repair test		Control console, SS computer, CCTV, robotics	2	0:30	0:30			0:30	Visual, pull, etc.
4.2.5.6.9	Translate robotics to parts storage area		Control console, SS computer, robotics, CCTV,	1	0:05					
4.2.5.6.10	Translate robotics to tool storage area, secure tools/effector		Control console, SS computer, robotics, CCTV,	1	0:05					
4.2.5.6.11	Translate robotics to storage area and secure		Control console, SS computer,	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.5.7	Remove and Replace Regulator Control Package(s)	SS hangar, lighting, signal, power, propellant umbilicals	Control console, SS computer, robotics, CCTV, special tools/effectors, LRU's, test equipment	-	2:30	1:45			1:45	
4.2.5.7.1	Translate robotics to tool storage area, secure and store tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.7.2	Translate robotics to parts storage area, secure and store required LRU's		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.7.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.2.5.7.4	Release and remove unserviceable regulator/ control package and store		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:30	0:30			0:30	
4.2.5.7.5	Inspect regulator/control package interface; repair as required		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.2.5.7.6	Align and install regulator control package		Control console, SS computer, robotics, CCTV	2	0:30	0:30			0:30	
4.2.5.7.7	Verify mechanical interfaces are secure		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.2.5.7.8	Install leak detection equipment		Control console, SS computer, robotics, CCTV	2	0:10	0:10			0:10	
4.2.5.7.9	Pressurize appropriate system		Control console, SS computer	2	0:15					Correct anomolies
4.2.5.7.10	Depressurize system		Control console, SS computer	2	0:05					
4.2.5.7.11	Remove leak check detection equipment		Control console, SS computer, robotics, CCTV	2	0:10	0:10			0:10	
4.2.5.7.12	Translate robotics to parts storage area; package unserviceable components		Control console, SS computer, robotics, CCTV	1	0:15	0:15			0:15	Return to earth

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.5.7.13	Translate robotics to tool storage area; secure tools/effector		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.7.14	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW IVA	SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.5.8	Remove and Replace MMH, LH_2, LO_2, NTO, H_2O, He, Tanks	SS hangar lighting, signal, power, propellant umbilicals	Control console, SS computer, CCTV, robotics, special tools, test equipment	-	2:10	1:25			1:25	
4.2.5.8.1	Translate robotics to tool storage area, secure and store tools/effectors		Control console, SS computer, CCTV, robotics	1	0:05					
4.2.5.8.2	Translate robotics to part storage area, secure and store required LRUs		Control console, SS computer, CCTV, robotics	1	0:05					
4.2.5.8.3	Translate robotics to the designated work site		Control console, SS computer	1	0:05					
4.2.5.8.4	Release, remove and store unserviceable sphere		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
4.2.5.8.5	Inspect interface area for damage, repair as necessary		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.2.5.8.6	Align and install replacement sphere		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
4.2.5.8.7	Verify mechanical interfaces are seated		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.2.5.8.8	Attach leak detection equipment		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:10	0:10			0:10	
4.2.5.8.9	Pressurize sphere		Control console, SS computer	2	0:15					Correct anomolies
4.2.5.8.10	Depressurize sphere		Control console, SS computer	2	0:05					
4.2.5.8.11	Remove leak detection equipment		Control console, SS computer, robotics, CCTV	2	0:10	0:10			0:10	

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.5.8.12	Translate robotics to parts storage area; package unserviceable components		Control console, SS computer, robotics, CCTV	1	0:15	0:15			0:15	Return to earth
4.2.5.8.13	Translate robotics to tool storage area; secure tools/effector		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.8.14	Translate robotics to storage area and secure		Control console, SS computer,	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	EVA	MANHOURS EVA	TOTAL	REMARKS
4.2.5.9	Remove and Replace Payload Interface System	SS hangar, lighting, power, signal, umbilicals	Control console, SS computer, robotics, RMS, CCTV, Tools/ effectors, test equip, LRU's	-	4:00	2:40			2:40	
4.2.5.9.1	Translate robotics to tool storage area; secure and store tools/effector		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.9.2	Translate robotics to parts storage area, secure and store required parts		Control console, SS computer robotics, CCTV	1	0:05					
4.2.5.9.3	Translate robotics to work site		Control console, SS computer,	1	0:05					
4.2.5.9.4	Translate RMS to work site and attach to payload interface system grapple fixture		Control console, SS computer, CCTV	2	0:10	0:10			0:10	
4.2.5.9.5	Release payload interface system		Control console, SS computer, CCTV, robotics, tools/ effectors	2	0:30	0:30			0:30	
4.2.5.9.6	Remove and translate unserviceable payload interface system to parts area and secure		Control console, SS computer, CCTV, RMS	2	0:20	0:20			0:20	
4.2.5.9.7	Secure serviceable payload interface system with RMS		Control console, SS computer, CCTV, RMS	2	0:05					
4.2.5.9.8	Translate payload interface system to work site		Control console, SS computer	2	0:20	0:20			0:20	
4.2.5.9.9	Inspect payload interface mounting area; repair as necessary		Control console, SS computer, CCTV, robotics	2	0:10	0:10			0:10	
4.2.5.9.10	Align payload interface system with RMS		Control console, SS computer, RMS, CCTV, robotics	2	0:10	0:10			0:10	
4.2.5.9.11	Install and secure payload interface system		Control console, SS computer, CCTV, robotics	2	0:10	0:10			0:10	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.5.9.12	Install test equipment		Control console, SS computer, CCTV, robotics	2	0:15	0:15			0:15	
4.2.5.9.13	Conduct system test		Control console, SS computer	2	0:45					Correct anomolies
4.2.5.9.14	Remove test equipment and store		Control console, SS computer, CCTV, robotics,	2	0:15	0:15			0:15	
4.2.5.9.15	Translate RMS to storage area and secure		Control console, SS computer	1	0:05					
4.2.5.9.16	Translate robotics to parts area, package unserviceable payload interface system		Control console, SS computer, CCTV, robotics,	1	0:20	0:20			0:20	Return to earth
4.2.5.9.17	Translate robotics to tool storage area; store tools/ effectors		Control console, SS computer, CCTV, robotics,	1	0:05					
4.2.5.9.18	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS		TRNG	FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS		TIME	IVA	EVA	EVA	TOTAL	
4.2.5.10	Remove and Replace Main Propellent Tank Pressure System	SS hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, tools/effectors, LRU's robotics, test equipment CCTV	-	2:35	1:45			1:45	
4.2.5.10.1	Translate robotics to tool storage area; secure and store tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.10.2	Translate robotics to parts storage area; secure and store LRU's		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.10.3	Translate robotics to work site		Control console, SS computer	1	0:05					
4.2.5.10.4	Detach, remove and store unserviceable tank press system		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:30	0:30			0:30	
4.2.5.10.5	Inspect tank press system interfaces		Control console, SS computer, robotics, CCTV	2	0:05	0:05			0:05	
4.2.5.10.6	Align, install and secure serviceable tank press system		Control console, SS computer, robotics, CCTV, tools/ effectors	2	0:30	0:30			0:30	
4.2.5.10.7	Install leak check equipment		Control console, SS computer, robotics, CCTV,	2	0:15	0:15			0:15	
4.2.5.10.8	Pressurize system		Control console, SS computer	2	0:05					
4.2.5.10.9	Conduct leak check		Control console, SS computer	1	0:15					Correct anomolies
4.2.5.10.10	Depressurize tank press system		Control console, SS computer	2	0:05					
4.2.5.10.11	Disconnect and remove test equipment		Control console, SS computer, robotics, CCTV	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.5.10.12	Translate robotics to part storage area; package unserviceable system		Control console, SS computer, robotics, CCTV	1	0:10	0:10			0:10	Return to earth
4.2.5.10.13	Translate robotics to tool storage area; store tools/effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.10.14	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	EVA	MANHOURS EVA	TOTAL	REMARKS
4.2.5.11	Main Structure Replacement	Hangar, lighting, power, signal, propellant umbilicals	Control console, SS computer, robotics, RMS, CCTV, tools/ effectors, test equipment, LRU's, special tools	-	81:55	50:10			50:10	
4.2.5.11.1	Translate robotics to tool storage area, secure and store required tools/ effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.11.2	Translate robotics to parts storage area, secure and store required LRU's		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.11.3	Translate robotics to designated work site		Control console, SS computer,	1	0:05					
4.2.5.11.4	Translate RMS to designated work site		Control console, SS computer,	1	0:05					
4.2.5.11.5	Remove payload interface system (see 4.2.5.9)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	0:55	0:55			0:55	
4.2.5.11.6	Remove antenna system (See 4.2.5.2.2)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	0:30	0:30			0:30	
4.2.5.11.7	Remove avionics modules (See 4.2.4.2.2)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	7:00	7:00			7:00	21 Total modules - 20 minutes per module
4.2.5.11.8	Remove propellant tanks - 4 ea (See 4.2.5.1.1) (1 hr/tnk)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	4:00	4:00			4:00	1 hour per tank
4.2.5.11.9	Remove aerobrake and support (See 4.2.4.5.2)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:00	1:00			1:00	
4.2.5.11.10	Remove engines (See 4.2.4.4.3)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors, special tool	2	2:50	2:50			2:50	1:25 hrs per engine

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.5.11.11	Remove MMH, LH_2, NTO, H_2O, He tanks (See 4.2.5.8)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:15	1:15			1:15	25 minutes per sphere
4.2.5.11.12	Remove regulator/control packages (See 4.2.5.7)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:45	1:45			1:45	35 minutes per package
4.2.5.11.13	Remove main propellant tank pressure system (See 4.2.5.10)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:10	1:10			1:10	55 minutes per system
4.2.5.11.14	Attach RMS to main structure		Control console, SS computer, RMS, CCTV	2	0:10	0:10			0:10	
4.2.5.11.15	Translate RMS to parts area and secure unserviceable main structure		Control console, SS computer, RMS, CCTV	2	0:30	0:30			0:30	
4.2.5.11.16	Translate RMS to OTV berthing area, with serviceable main structure and secure to berthing cradle		Control console, SS computer, RMS, CCTV,	2	0:30	0:30			0:30	
4.2.5.11.17	Install main propellant tank pressure system (See 4.2.5.10)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:10	1:10			1:10	
4.2.5.11.18	Install MMH, LH_2, H_2O, He tanks (See 4.2.5.8)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:15	1:15			1:15	
4.2.5.11.19	Install regulator/control packages (See 4.2.5.7)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:45	1:45			1:45	
4.2.5.11.20	Install main engines (See 4.2.4.4.3)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors, special tool	2	2:50	2:50			2:50	
4.2.5.11.21	Install aerobrake and support (See 4.2.4.5.2)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	1:00	1:00			1:00	

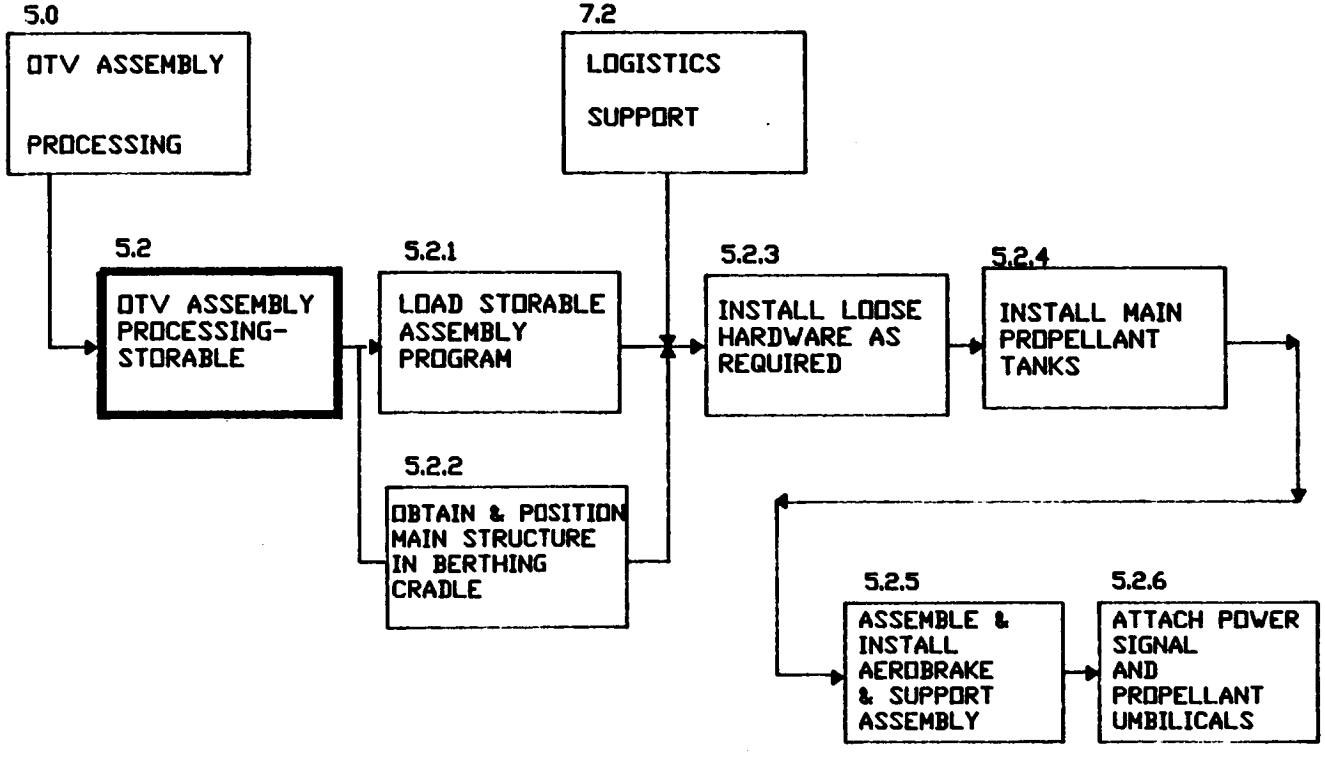
SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.2.5.11.22	Install propellant tanks - 4 ea (See 4.2.5.1.1) (1 hr/tank)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	4:00	4:00			4:00	
4.2.5.11.23	Install avionics modules (See 4.2.4.2.2)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	7:00	7:00			7:00	
4.2.5.11.24	Install antenna system (See 4.2.5.2.2)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	0:30	0:30			0:30	
4.2.5.11.25	Install payload interface system (see 4.2.5.9)		Control console, SS computer, RMS, robotics, CCTV, tools/ effectors	2	0:55	0:55			0:55	
4.2.5.11.26	Attach power, signal and propellant umbilicals		Control console, SS computer, robotics, CCTV,	1	0:20	0:20			0:20	
4.2.5.11.27	Install and checkout test equipment		Control console, SS computer, robotics, CCTV,	2	2:00	2:00			2:00	
4.2.5.11.28	Conduct subsystem and system checkout; correct anomalies		Control console, SS computer	1+2	32:00	1:00			1:00	Correct anomolies
4.2.5.11.29	Disconnect and store test equipment		Control console, SS computer, CCTV, robotics	2	2:00	2:00			2:00	
4.2.5.11.30	Translate RMS to storage area and secure		Control console, SS computer	1	0:05					
4.2.5.11.31	Translate robotics to parts storage area; store serviceable parts; package unserviceable parts		Control console, SS computer, robotics, CCTV	1	3:00	3:00			3:00	Return to earth
4.2.5.11.32	Translate robotics to tool storage area; store tools/ effectors		Control console, SS computer, robotics, CCTV	1	0:05					
4.2.5.11.33	Translate robotics to storage area and secure		Control console, SS computer	1	0:05					

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
4.2.6	Verify Maintenance Complete				1:15	1:15			1:15	
4.2.6.1	Verify all maintenance completed per maintenance plan		Control console, SS computer	1	0:15	0:15			0:15	
4.2.6.2	Verify all anomalies corrected and diagnostic tests completed		Control console, SS computer	1	0:20	0:20			0:20	
4.2.6.3	Verify OTV safed		Control console, SS computer	1	0:40	0:40			0:40	

STORABLE SPACE-BASED OTV ASSEMBLY PROCESSING

The Storable SBOTV is also initially delivered to Space Station unassembled, and this functional flow and requirements definition set identifies the operations associated with initial assembly of the Storable SBOTV.

SBOTV ASSEMBLY PROCESSING – STORABLE



MARTIN MARIETTA

OTV ASSEMBLY PROCESSING - STORABLE

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
5.2	OTV Assembly Processing - Storable	SS hanger lighting, signal, power, propellant umbilicals	SS computer, control console, robotics, RMS, CCTV, tools/ effectors, test equipemnt	--	22:40	11:15			11:15	Components/parts will be unpackaged and visually inspected prior to transfer to the processing area
5.2.1	Load Storable Assembly Program		SS computer, control console	--	0:30	0:30			0:30	Task accomplished concurrently with core structure berthing
5.2.1.1	Verify correct program		Control console, SS computer	1	0:05	0:05			0:05	
5.2.1.2	Verify all applicable OTV modifications are incorporated in assembly program		Control console, Ss computer	1	0:15	0:15			0:15	
5.2.1.3	Load and verify proper assembly operations			1	0:10	0:10			0:10	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
5.2.2	Obtain and Position Main Structure in Berthing Cradle		SS computer, control console, RMS, CCTV, robotics	1	1:00	1:00			1:00	Task accomplished concurrently with assembly program loading.
5.2.2.1	Translate OTV from storage area		SS computer, control console, RMS, CCTV	2	0:20	0:20			0:20	
5.2.2.2	Extend cradle interfaces and lock in place		SS computer, control console, robotics, CCTV	2	0:30	0:30			0:30	OTV cradle interfaces will be folded to meet cargo bay limitations
5.2.2.3	Position main structure in berthing cradle and secure		SS computer, control console, RMS, CCTV, robotics	2	0:10	0:10			0:10	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
5.2.3	Install Loose Hardware	SS hangar, lighting, signal, power, umbilical	SS computer, control console, RMS, CCTV, robotics, tools/ effectors, test equipment	--	2:45	2:30			2:30	
5.2.3.1	Translate robotics to tool storage area, secure and stow required tools/effectors		SS computer, control console, robotics, CCTV	1	0:05					
5.2.3.2	Translate robotics to storage area, secure and stow required hardware		SS computer, control console, robotics, CCTV	1	0:05					
5.2.3.3	Translate robotics to OTV processing area		SS computer, control console	1	0:05					
5.2.3.4	Install hardware as required		SS computer, control console, robotics, CCTV, tools/ effectors	2	1:00	1:00			1:00	
5.2.3.5	Extend propellant tank supports and lock in place		SS computer, control console, robotics, CCTV	2	1:00	1:00			1:00	Support will be folded to meet shuttle cargo bay limitations.
5.2.3.6	Verify all packaging material is removed from OTV interfaces		SS computer, control console, CCTV	2	0:20	0:20			0:20	
5.2.3.7	Verify all loose hardware is installed		SS computer, control console, CCTV	2	0:10	0:10			0:10	Conduct inventory of parts/ hardware kit.

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
5.2.4	Install Main Propellant Tanks		SS computer, control console, CCTV, RMS, robotics, tools/ effectors	1	4:10	4:10			4:10	Four (4) tanks require intallation. 1 Hr/Tank
5.2.4.1	Translate RMS to parts storage area.Secure tank and translate to work site		SS computer, control console, CCTV, RMS	2	0:20	0:20			0:20	
5.2.4.2	Inspect tank interfaces with robotics prior to tank installation		SS computer, control console, CCTV, robotics	2	0:10	0:10			0:10	
5.2.4.3	Verify sufficient clearance between robotics and RMS with tank		SS computer, control console	1	--	--			--	
5.2.4.4	Position/align tank with OTV attaching points and insert onto tank interface		SS computer, control console, CCTV, robotics, RMS	2	0:10	0:10			0:10	
5.2.4.5	Secure tank at attaching point 2 with robotics		SS computer, control console, CCTV, robotics, RMS	2	0:10	0:10			0:10	
5.2.4.6	Secure tank at attaching point 1 with robotics		SS computer, control console, CCTV, robotics, RMS	2	0:10	0:10			0:10	
5.2.4.7	Release RMS from tank		SS computer, control console,	2	--	--			--	
5.2.4.8	Complete steps 5.1.4.1 thru 5.2.4.7 for remaining tanks		SS computer, control console, CCTV, robotics, RMS	--	--	--			--	
5.2.4.9	Install, checkout and calibrate leak detection equipment		SS computer, control console, CCTV, robotics	2	0:10	0:10			0:10	Following last tank installation

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
5.2.5	Assemble and Install Aerobrake and Support Assembly	SS hangar, lighting, signal, power, umbilicals	SS computer, control console, CCTV, robotics, RMS, tools and effectors	--	2:35	2:00			2:00	
5.2.5.1	Translate RMS to aerobrake storage area		SS computer, control console	1	0:05					
5.2.5.2	Translate robotics to aerobrake storage area		SS computer, control console	1	0:05					
5.2.5.3	Secure aerobrake for assembly		SS computer, control console, RMS, CCTV	2	0:10	0:10			0:10	
5.2.5.4	Unfold aerobrake and support structure with robotics		SS computer, control console, RMS, CCTV, robotics, tools/ effectors	2	0:30	0:30			0:30	
5.2.5.5	Secure aerobrake support latches		SS computer, control console, RMS, CCTV, robotics, tools/ effectors	2	0:10	0:10			0:10	
5.2.5.6	Inject aerobrake outer ring with rigidizing compound		SS computer, control console, RMS, CCTV, robotics, tools/ effectors	2	0:20	0:20			0:20	
5.2.5.7	Conduct inspection of aerobrake, prior to installation on OTV		SS computer, control console, CCTV, robotics, test equipment	2	0:10					
5.2.5.8	Translate RMS with assembled aerobrake to OTV processing area		SS computer, control console, CCTV, RMS	2	0:20	0:20			0:20	
5.2.5.9	Translate robotics to OTV processing area		SS computer, control console	1	0:05					
5.2.5.10	Align and attach aerobrake and support to core structure		SS computer, control console, RMS, robotics, CCTV, tools/ effectors	2	0:10	0:10			0:10	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
5.2.5.11	Connect RCS propellant lines		SS computer, control console, robotics, CCTV, tools/ effectors	2	0:10	0:10			0:10	
5.2.5.12	Connect RCS power and signal lines		SS computer, control console, robotics, CCTV, tools/ effectors	2	0:05	0:05			0:05	
5.2.5.13	Install, checkout and calibrate test equipment		SS computer, control console, Robotics, CCTV, tools/ effectors, test equipment	2	0:05	0:05			0:05	

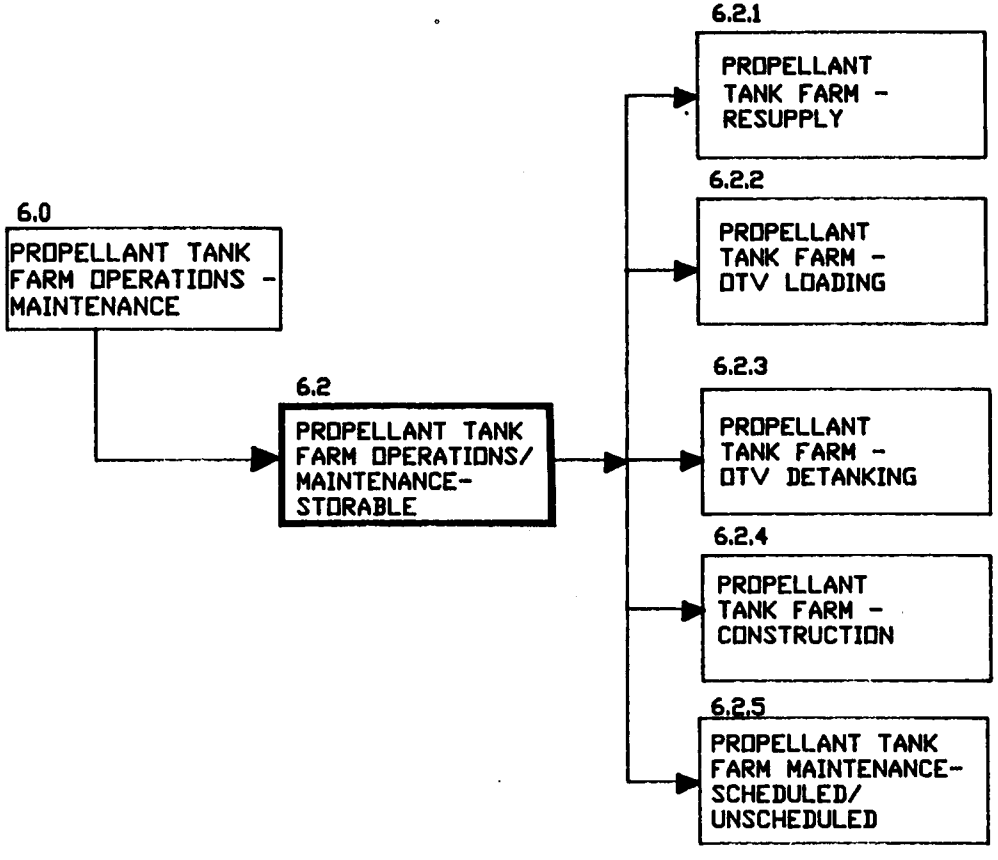
SEQUENCE NUMBER	TASK	REQUIREMENTS		TRNG	FUNC TIME	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS			IVA	EVA	EVA	TOTAL	
5.2.6	Install RF Antenna System		SS computer, control console, robotics, CCTV, tools/ effectors, test equipment	--	0:45	0:35			0:35	
5.2.6.1	Translate robotics to storage area and secure required RF antenna assemblies		SS computer, control console, CCTV	1	0:05					
5.2.6.2	Translate robotics to processing area		SS computer, control console	1	0:05					
5.2.6.3	Install antenna system		SS computer, control console, robotics, CCTV, tools/ effectors	2	0:20	0:20			0:20	
5.2.6.4	Attach RF cabling as necessary		SS computer, control console, robotics, CCTV, tools/ effectors	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
5.2.7	Attach Power, Signal and Propellant Umbilicals		SS computer, control console, RMS, CCTV, robotics	--	11:05	0:30			0:30	
5.2.7.1	Attach power, signal and propellant umbilicals to OTV		SS computer, control console, RMS, CCTV, robotics	1	0:05					
5.2.7.2	Verify power levels		SS computer, control console	1	0:10					
5.2.7.3	Verify signal transmission		SS computer, control console	1	0:20					
5.2.7.4	Conduct OTV system checks		SS computer, control console	1	10:00					Correct anomolies - See Section 4.0 maintenance activities
5.2.7.5	Verify OTV Safe		SS computer, control console	2	0:30	0:30			0:30	

STORABLE PROPELLANT TANK FARM OPERATIONS & MAINTENANCE

The various aspects of assembling, operating, and maintaining the Storable propellant tank farm at Space Station are shown on the facing page functional flow. Requirements definition sheets were being initiated when, upon receipt of the Revision 8 Mission Model, it was determined that the Storable OTV was no longer a viable candidate. Consequently, the requirements definition set for this flow was not completed.

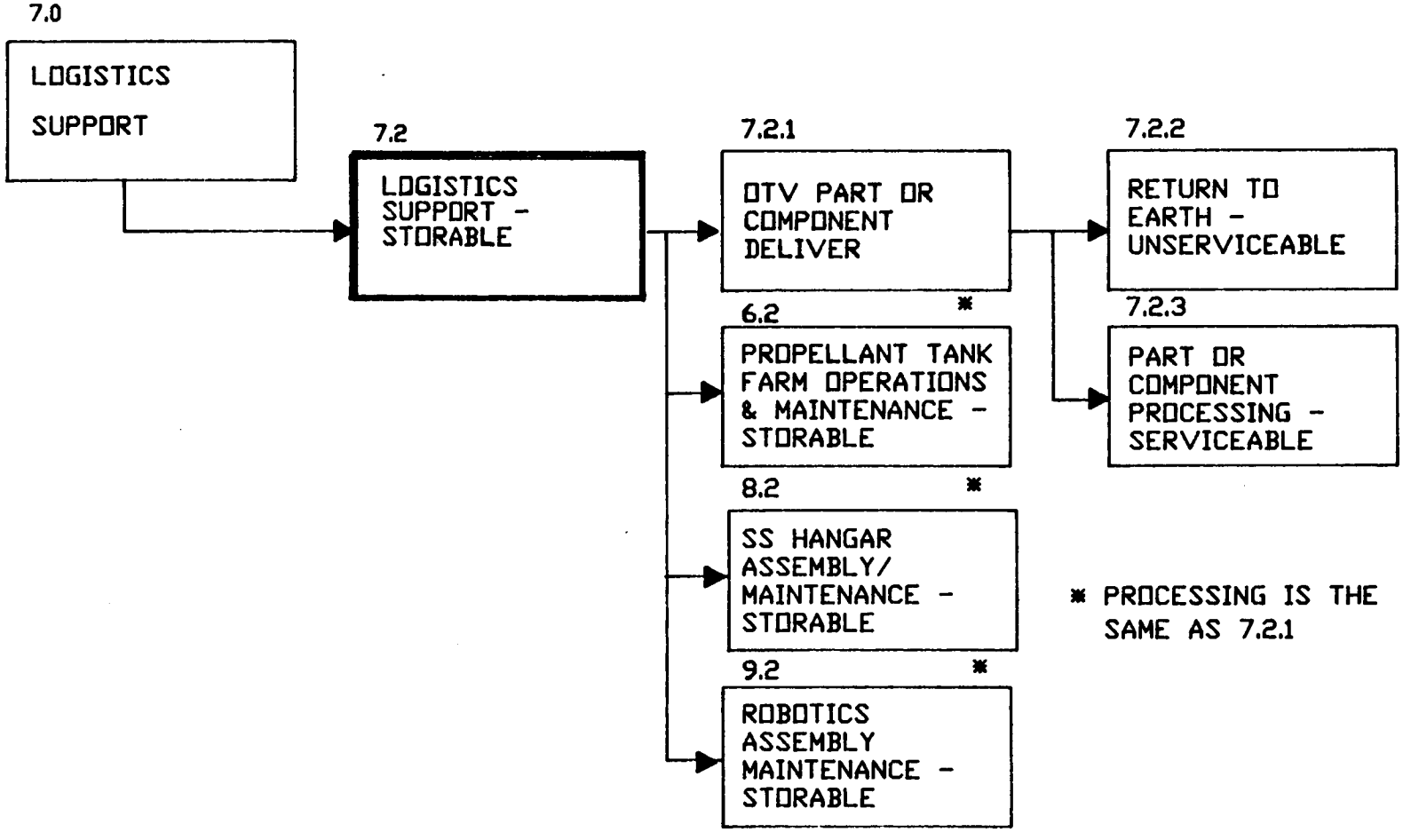
PROPELLANT TANK FARM OPERATIONS/MAINTENANCE – STORABLE



STORABLE SPACE-BASED OTV LOGISTICS SUPPORT

The logistics support operations associated with the Storable SBOTV and its attendant accommodations is shown on the facing page functional flow. Requirements definitions were not completed as a consequence of the deletion of the Storable OTV as a viable candidate.

LOGISTICS SUPPORT – STORABLE



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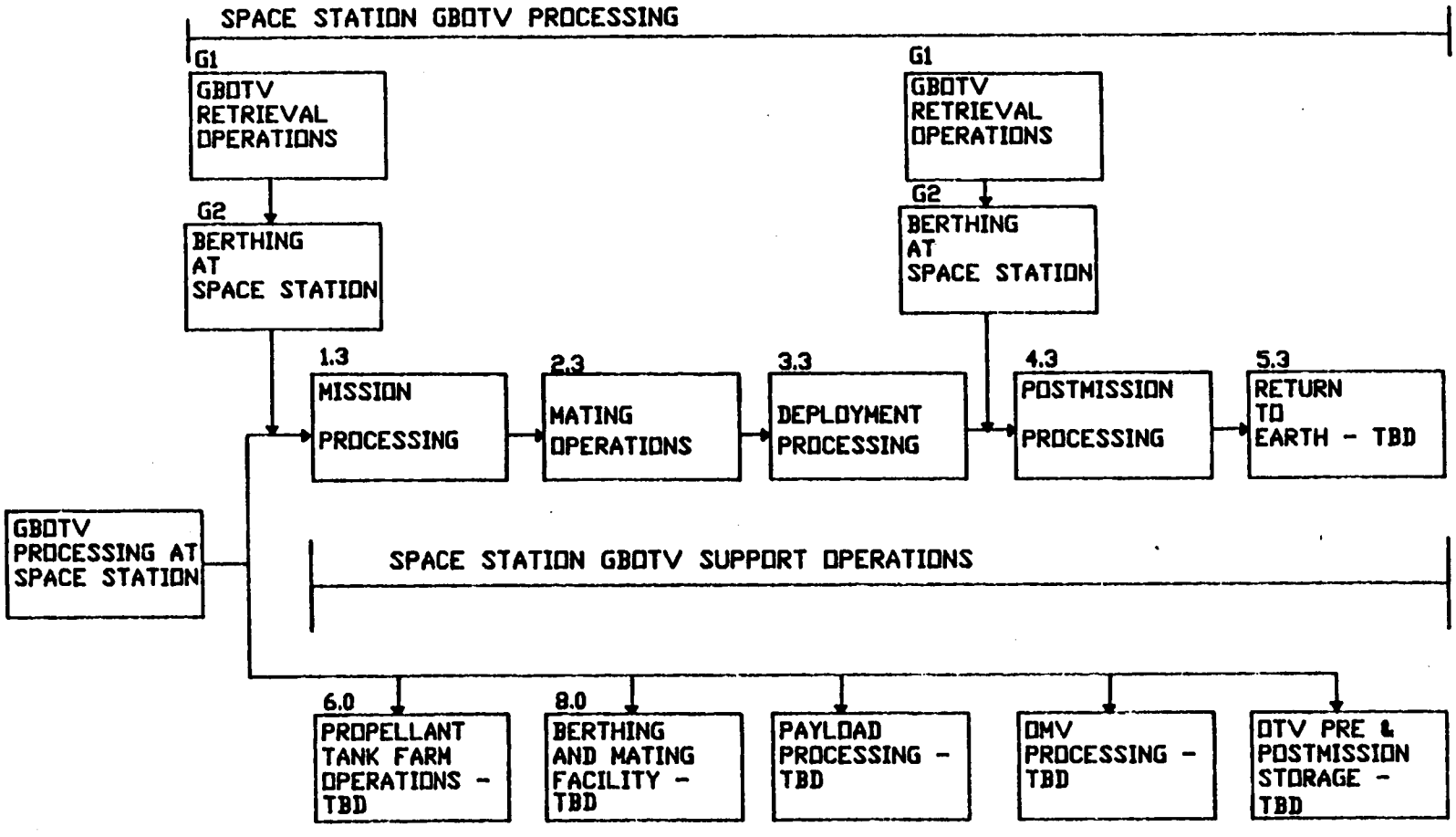
GROUND-BASED OTV

GROUND-BASED OTV FUNCTIONAL FLOW OVERVIEW

Unlike the Space-Based OTV, the Ground-Based OTV is delivered to Space Station fully assembled by the OMV. Also unlike the SBOTV, there are no provisions for service and maintenance of the GBOTV. Once its single mission has been completed, the GBOTV is partially disassembled, allowing Earth return in the Shuttle Cargo Bay. The equivalent of two Shuttle return flights are required to return a single Ground-Based OTV.

The following charts address the numbered operational blocks on the facing page chart.

GBOTV FUNCTIONAL FLOW — OVERVIEW



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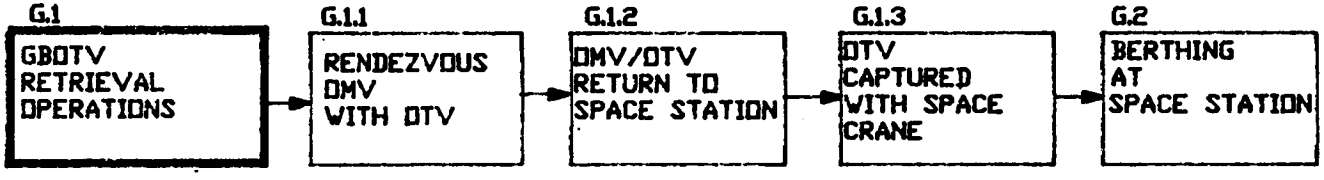
GROUND-BASED OTV RETRIEVAL OPERATIONS

Top level Ground-Based OTV retrieval operations, either for initial delivery to Space Station or upon return from a mission, are identified on the facing page functional flow and accompanying requirements definition.

GBOTV RETRIEVAL OPERATIONS



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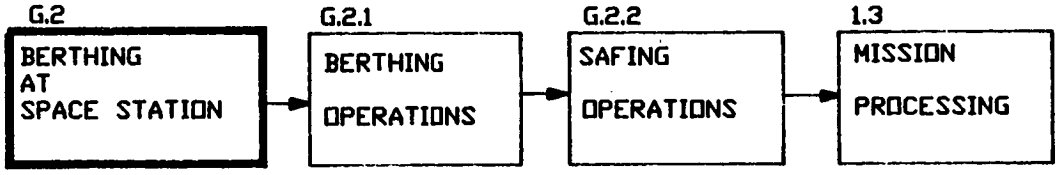
GBOTV RETRIEVAL OPERATIONS

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
G.1	GBOTV RETREIVAL OPERATIONS	Space station berthing area, communi-cations, space crane	Control console, SS computer		3:00	3:00			3:00	Ground control until OMV/OTV return to vicinity of the space station
G.1.1	Rendevous OMV with OTV		Ground computer	-	-	-			-	Ground control
G.1.2	OMV/OTV return to vicinity of the space station		Control console, SS computer	2	2:25	2:25			2:25	Control of OMV transferred to space station
G.1.3	Capture OTV with space crane		Control console, space crane, CCTV	2	0:15	0:15			0:10	
G.1.3.1	Demate OMV - Translate to berthing area		Control console, SS computer, CCTV	2	0:20	0:20			0:20	

GROUND-BASED OTV BERTHING

Ground-Based OTV berthing at Space Station, either upon initial delivery or upon return from a mission, are shown on the functional flow and following requirements definition.

GBOTV BERTHING AT SPACE STATION



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GBOTV BERTHING AT SPACE

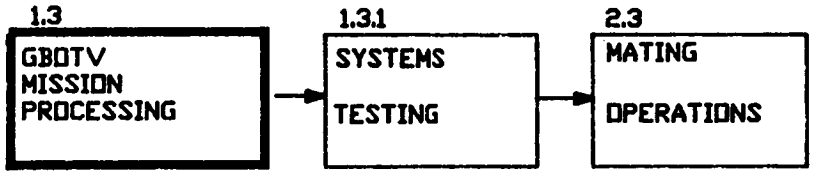
SHEET 1 of 1

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
G.2	BERTHING AT SPACE STATION	Space station berthing area, signal, power, propel-ant umbilicals lighting	Control console, SS computer, space crane, CCTV, robotics, test equipment	-	2:35	2:35			2:35	
G.2.1	BERTHING OPERATIONS									
G.2.1.1	Inspect berthing cradle		Control console, CCTV, robotics	1	0:10	0:10			0:10	
G.2.2	Translate OTV to berthing cradle		Control console, SS computer, space crane, CCTV	2	0:40	0:40			0:40	
G.2.3	Inspect OTV for damage		Control console, SS computer, robotics, CCTV	2	0:30	0:30			0:30	
G.2.4	Position and latch OTV in berthing cradle		Control console, SS computer, space crane, CCTV	2	0:20	0:20			0:20	
G.2.5	Connect umbilicals to OTV		Control console, SS computer, robotics, CCTV	2	0:20	0:20			0:20	
G.2.6	Verify mechanical and electrical umbilical connections		Control console, SS computer	2	0:15	0:15			0:15	
G.2.7	Install leak detection equipment		Control console, SS computer CCTV, robotics	2	0:10	0:10			0:10	
G.2.8	Safing operations		Control console, SS computer	1	0:10	0:10			0:10	

GROUND-BASED OTV PRELAUNCH MISSION PROCESSING

Operations related to prelaunch mission processing of the Ground-Based OTV are provided.

GBOTV MISSION PROCESSING



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GBOTV POSTMISSION PROCESSING

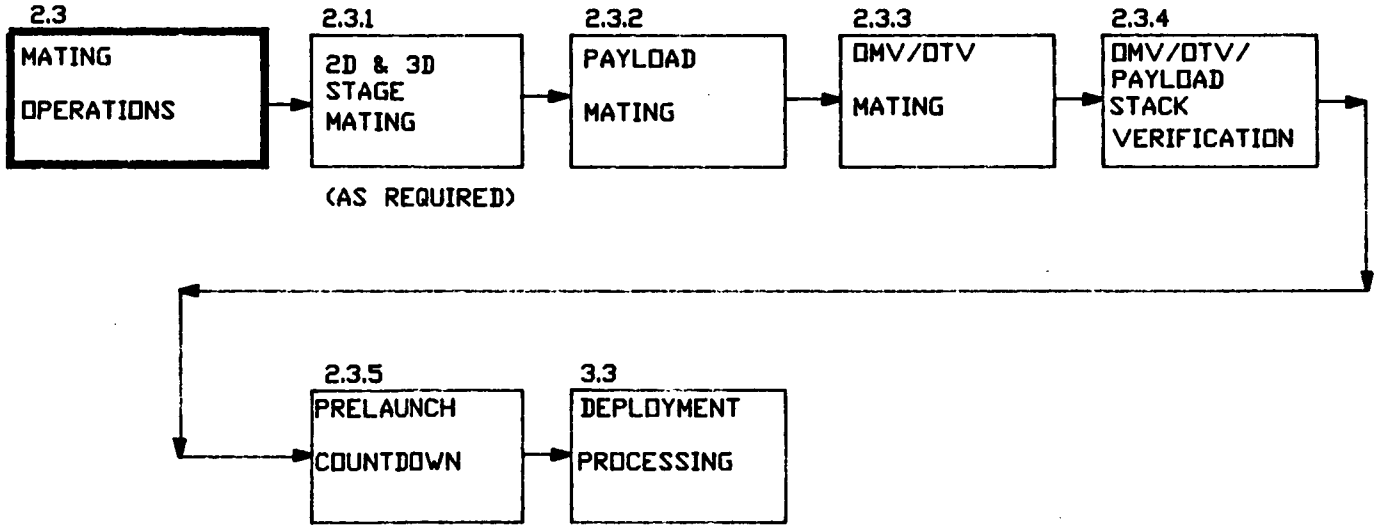
SHEET 1 of 1

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
1.3	MISSION PROCESSING	SS berthing area, power, signal umbilicals lighting	Control console, SS computer, robotics, CCTV, tools/ effectors, test equipment	-	8:55	8:55			8:55	
1.3.1	Systems Testing				8:55	8:55			8:55	
1.3.1.1	Connect propellant umbilicals		Control console, SS computer	1	0:05	0:05			0:05	
1.3.1.2	Verify power levels		Control console, SS computer	1	0:10	0:10			0:10	
1.3.1.3	Verify signal transmission		Control console, SS computer	1	0:20	0:20			0:20	
1.3.1.4	Verify OTV systems		Control console, SS computer, software	1+2	8:00	8:00			8:00	
1.3.1.5	Verify OTV safed		Control console, SS computer	1	0:10	0:10			0:10	

GROUND-BASED OTV MATING OPERATIONS

Operations addressing the mating of the GBOTV with payloads, OMV, and other GBOTV stages are shown on the functional flow and following requirements definition set.

GBOTV MATING OPERATIONS



SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
2.3	Mating Procedures	SS berthing area, power, signal, propellant umbilicals space crane	Control console, SS computer,	-	15:00	15:00			15:00	
2.3.1	GBOTV 2d & 3d Stage Mating (as required)			-	15:00	15:00			15:00	As required by mission model
2.3.1.1	See G.1, G.2, 1.3 for specific procedures pertaining to 1st stage processing		Control console, SS computer, CCTV, robotics							

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
2.3.2	Payload Mating				2:30	2:30			2:30	
2.3.2.1	Logistics support available to support mating operations			-	-	-				
2.3.2.2	Translate space crane to shuttle docking area		Control console, SS computer, CCTV	2	0:15	0:15			0:15	Payload removed from cargo bay w/shuttle RMS
2.3.2.3	Translate payload to berthing area		Control console, SS computer, CCTV, space crane	2	0:20	0:20			0:20	
2.3.2.4	Position and secure payload in mating cradle		Control console, SS computer, CCTV, space crane	2	0:20	0:20			0:20	
2.3.2.5	Connect power and signal umbilicals to payload		Control console, SS computer, CCTV, robotics	2	0:15	0:15			0:15	
2.3.2.6	Verify mechanical/ electrical interfaces		Control console, SS computer	1	0:05	0:05			0:05	
2.3.2.7	Verify OTV/payload alignment		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
2.3.2.8	Mate OTV/payload - verify proper electrical/mechanical		Control console, SS computer, CCTV	2	1:00	1:00			1:00	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.3.3	OMV/OTV MATING				1:25	1:25			1:25	
2.3.3.1	Translate OMV to OTV berthing area		Control console, SS computer, CCTV, space crane	2	0:30	0:30			0:30	
2.3.3.2	Secure OMV to berthing cradle		Control console, SS computer, CCTV, space crane	2	0:15	0:15			0:15	
2.3.3.3	Verify OMV/OTV alignment		Control console, SS computer, CCTV	2	0:15	0:15			0:15	
2.3.3.4	Mate OMV with OTV - verify mechanical interfaces		Control console, SS computer	2	0:15	0:15			0:15	
2.3.3.5	Connect power and signal umbilicals to OMV		Control console, SS computer	1	0:10	0:10			0:10	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.3.4	OMV/GBOTV/ Payload Stack Verification				0:30	0:30			0:30	
2.3.4.1	Verify all mechanical/ electrical connections		Control console, SS computer, CCTV	1	0:20	0:20			0:20	
2.3.4.2	Verify stack is ready to commence prelaunch count-down		Control console, SS computer	1	0:10	0:10			0:10	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.3.5	Prelaunch Countdown									
2.3.5.1	Propellant Transfer		Control console, SS computer, leak detection equipment	-	4:05	4:05			4:05	
2.3.5.1.1	Verify leak detection equipment operational		Control console, SS computer	2	0:05	0:05			0:05	
2.3.5.1.2	Complete propellant transfer		Control console, SS computer	2	4:00	4:00			4:00	4:00 hrs/stage

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.3.5.2	AVIONICS MODULE TESTING			-	1:20	1:20			1:20	
2.3.5.2.1	Verify OTV configuration		Control console, SS computer	2	0:15	0:15			0:15	
2.3.5.2.2	Load diagnostic checkout program		Control console, SS computer, software	2	0:15	0:15			0:15	
2.3.5.2.3	Conduct diagnostic testing		SS computer	2	0:50	0:50			0:50	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.3.5.3	Power Checks			-	0:30	0:30			0:30	
2.3.5.3.1	Verify fuel cell propellant		Control console, SS computer	2	0:15	0:15			0:15	
2.3.5.3.2	Verify fuel cell propellant operations		Control console, SS computer	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.3.5.4	Verify Mission Program		Control console, SS computer	-	1:10	1:10			1:10	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.3.5.5	Main Engine Checks			-	1:05	1:05			1:05	
2.3.5.5.1	Engine valve operations check		Control console, SS computer	2	0:15	0:15			0:15	
2.3.5.5.2	Ignition system check		Control console, SS computer	2	0:15	0:15			0:15	(Cryogenic only)
2.3.5.5.3	Instrumentation check		Control console, SS computer	2	0:20	0:20			0:20	
2.3.5.5.4	Solenoid check		Control console, SS computer	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.3.5.6	Propellant System Check			-	0:20	0:20			0:20	
2.3.5.6.1	Verify leak check		Control console, SS computer	2	0:05	0:05			0:05	
2.3.5.6.2	Propellant subsystems operational		Control console, SS computer	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.3.5.7	OTV RCS Check				0:30	0:30			0:30	
2.3.5.7.1	RCS system check		Control console, SS computer	2	0:15	0:15			0:15	
2.3.5.7.2	Verify RCS propellant load		Control console, SS computer	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS			FUNC	CREW SUPPT		MANHOURS		REMARKS
		FACILITIES	TOOLS	TRNG	TIME	IVA	EVA	EVA	TOTAL	
2.3.5.8	Verify Health and Status of Payload				0:50	0:50			0:50	
2.3.5.8.1	Verify OTV/payload mechanical/electrical interfaces		Control console, SS computer	2	0:15	0:15			0:15	
2.3.5.8.2	Verify power/telemetry data		Control console, SS computer	2	0:20	0:20			0:20	
2.3.5.8.3	Verify payload ACS operating and propellant load		Control console, SS computer	2	0:15	0:15			0:15	

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	EVA	MANHOURS EVA	TOTAL	REMARKS
2.3.5.9	OMV Health and Status				0:45	0:45			0:45	
2.3.5.9.1	Verify mechanical OMV/OTV interface		Control console, SS computer	2	0:10	0:10			0:10	
2.3.5.9.2	Verify power levels and telemetry data		Control console, SS computer	2	0:20	0:20			0:20	
2.3.5.9.3	Verify propellant loads		Control console, SS computer	2	0:15	0:15			0:15	

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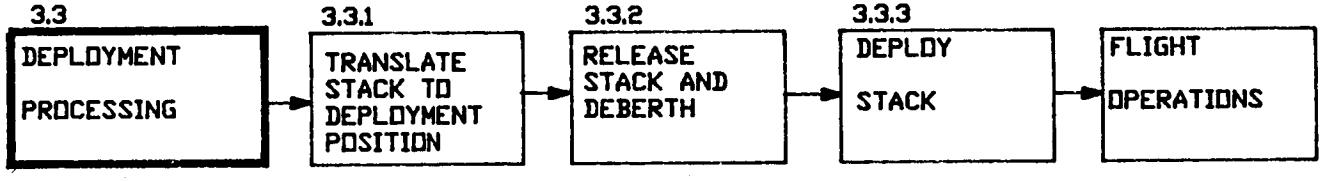
GROUND-BASED OTV DEPLOYMENT

Top level functional flow and requirements definition are provided for deployment of the Ground-Based OTV, mated with a payload and the OMV, from Space Station.

GBOTV DEPLOYMENT FROM SPACE STATION



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DEPLOYMENT PROCESSING

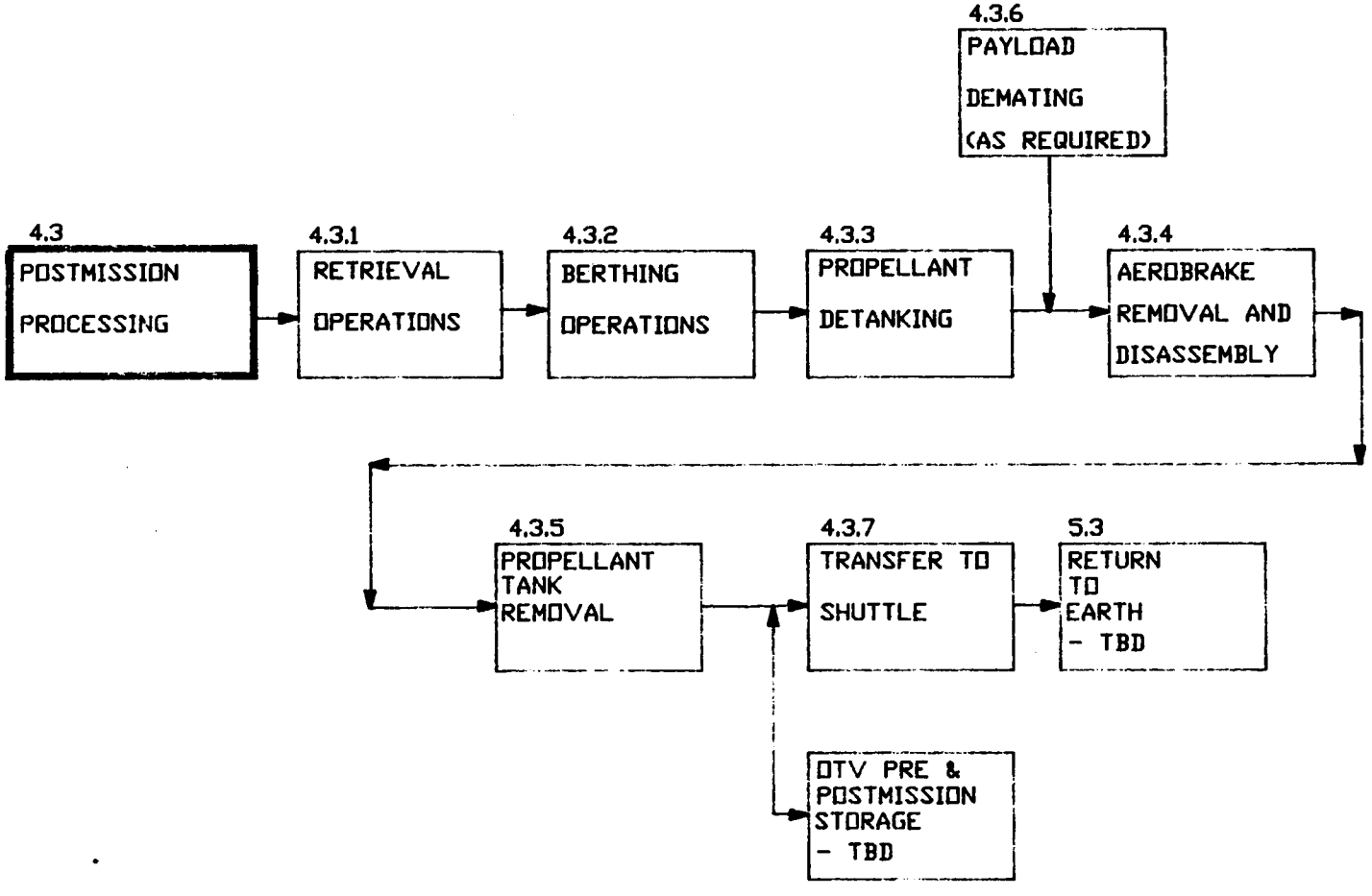
SHEET 1 of 1

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
3.3	Deployment Processing				1:45	1:45			1:45	
3.3.1	Translate stack to deployment position			2	1:10	1:10			1:10	
3.3.2	Release stack and deberth			2	0:30	0:30			0:30	
3.3.3	Deploy stack			2	0:05	0:05			0:05	

GROUND-BASED OTV POSTMISSION PROCESSING

The operations associated with retrieval of the GBOTV and OMV and, at times, a return payload, and the subsequent postmission processing operations are provided.

GBOTV POSTMISSION PROCESSING



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OTV POSTMISSION PROCESSING

SHEET 1 of 1

SEQUENCE NUMBER	TASK	REQUIREMENTS FACILITIES	REQUIREMENTS TOOLS	REQUIREMENTS TRNG	FUNC TIME	CREW SUPPT IVA	CREW SUPPT EVA	MANHOURS EVA	MANHOURS TOTAL	REMARKS
4.3	Postmission Processing	SS berthing structure, signal, power, propellent umbilicals space crane	Control console, SS computer, CCTV, tools/effectors, aero-brake disassembly tool		24:45	24:45			24:45	
4.3.1	Retrieval operations		Control console, SS computer, space crane, CCTV	2	3:00	3:00			3:00	See G.1 for details
4.3.2	Berthing at space station		Control console, SS computer, space crane, CCTV	2	2:35	2:35			2:35	See G.2 for details
4.3.3	Propellant detanking		Control console, SS computer	2	4:00	4:00			4:00	See 2.3.5.1 for details
4.3.4	Aerobrake removal and disassembly		Control console, SS computer, CCTV, tools/effectors, aero-brake disassembly tool	2	5:05	5:05			5:05	
4.3.5	Propellant tank removal		Control console, SS Computer, CCTV, tools/effectors	2	5:00	5:00			5:00	See 4.1 for details - 1:25/tank
4.3.6	Payload demating		Control console; SS computer, CCTV	2 2	1:00	1:00			1:00	
4.3.7	Transfer to shuttle		Control console, SS computer, CCTV, space crane	2	3:35	3:35			3:35	4 ea propellent tanks; 1 ea aerobrake; 1 ea core structure w/engines
4.3.8	Storage awaiting shuttle		Control console, SS computer		-	-			-	Monitor health and status

END DATA

MAY 18, 1988

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