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Space Transportation Nodes Assumptions and Requirements

LBSS

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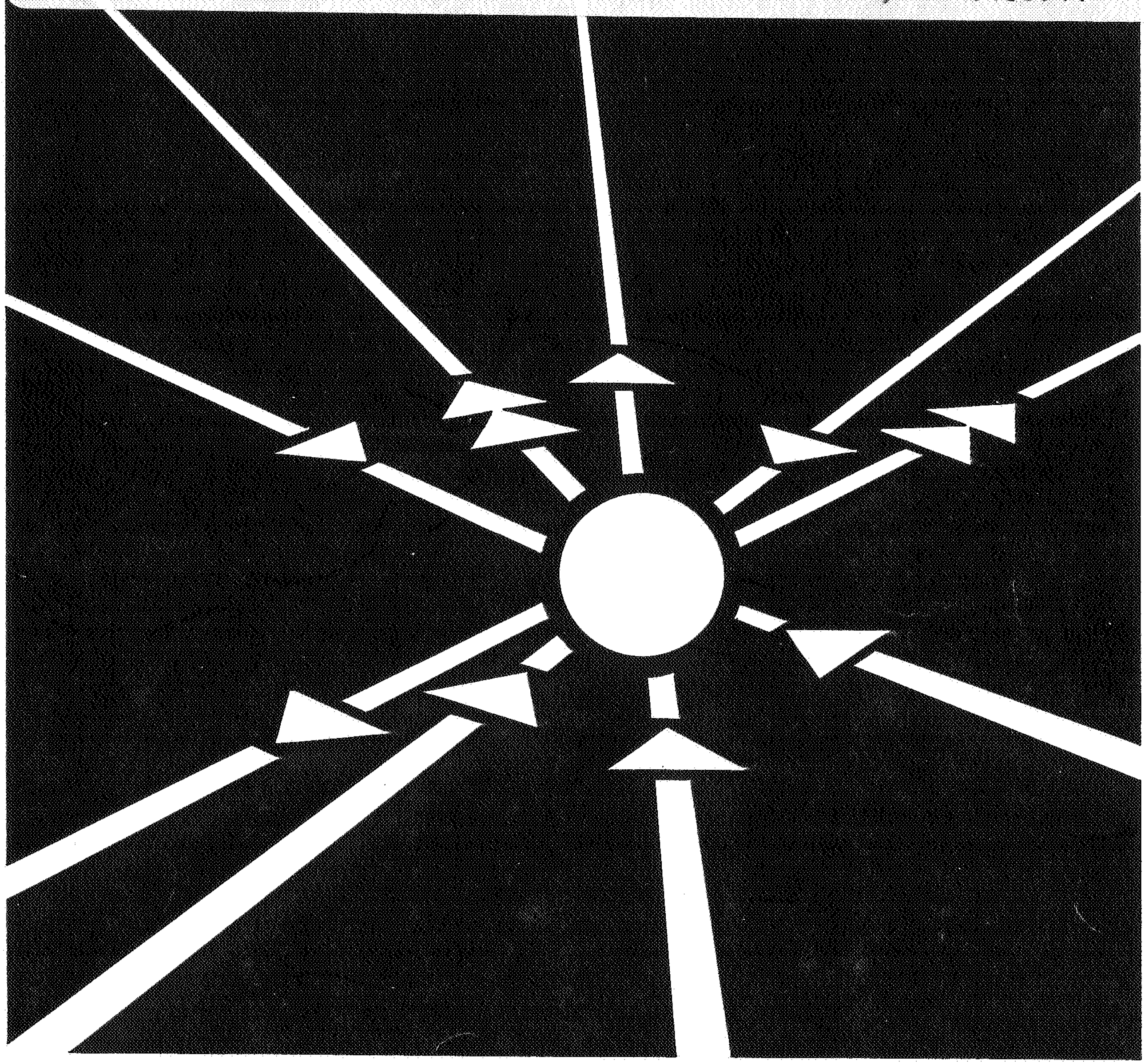

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Space Transportation Nodes Assumptions and Requirements
Lunar Base Systems Study Task 2.1

Prepared under NASA Contract NAS9-17878 for the
Advanced Programs Office
NASA Johnson Space Center

By
Eagle Engineering, Inc.
Houston, Texas
EEI Contract TO-87-57

Task 2.1 Report
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Foreword

The Space Transportation Nodes Assumptions and Requirements Task was performed as part of the Advanced Space Transportation Support Contract which is a NASA Johnson Space Center (JSC) study intended to provide planning for a Lunar Base near the year 2000. The task personnel estimated and documented the assumptions and requirements which define the functions and upper level system performance specifications. These assumptions and requirements are necessary to initiate conceptual design of the Space Transportation Nodes.

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List of Abbreviations

CM	Cubic Meters
CNDB	NASA Headquarters Civil Needs Data Base
CPM	Critical Path Method (of Project Management Review)
CREW-E	STN Crew Members currently performing EVA tasks
CREW-N	STN Crew Members currently performing tasks inside the Node
E-Ascent	Expendable Lunar Ascent Stage
EA	Expendable Lunar Ascent Stage
E-Lander	Expendable Lunar Lander Stage
EL	Expendable Lunar Lander Stage
EVA	Extravehicular Activity
HLLV	Heavy Lift Launch Vehicle
IVA	Intravehicular Activity
LaRC	NASA Langley Research Center
LEO	Low Earth Orbit
LH2	Liquid Hydrogen
LLO	Low Lunar Orbit
LO2	Liquid Oxygen
M	Meters
MT	Metric Tons
OMV	Orbit Maneuvering Vehicle
OTV	Orbit Transfer Vehicle
OTV-A	Orbit Transfer Vehicle Flight with No Crew (Automated)
OTV-M	Orbit Transfer Vehicle Flight in Manned Configuration
P/L	Payload (Lunar Surface)
PTM-4	Personnel Transfer Module for Crew of Four
RMS	Remote Manipulator System
STN	Space Transportation Node

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Space Transportation Nodes Assumptions and Requirements

1.0 Introduction

The Advanced Programs Office of the NASA Johnson Space Center (JSC) has conducted a six-week (one equivalent person) effort to document Space Transportation Node (STN) assumptions and requirements.

1.1 Task Statement

The original task statement has been revised to specify the study scope as follows:

> "Based on previous Eagle reports and the space station accommodation studies performed by LaRC, document the upper level assumptions and requirements for a transportation node in low Earth orbit. In particular, consider the following:
>
> What vehicles are processed at the transportation node ?
>
> What is the flow of activities involved in a vehicle passing through the node ?
>
> What node support resources are necessary to support a lunar scenario traffic model composed of a mix of vehicles in an active flight schedule ?
>
> "The Lunar Base Systems Study (LBSS) is concentrating on the initial years of the Phase II Lunar Base Scenario. The study will develop the first five years of that phase in order to define the transportation and surface systems (including mass, volumes, power requirements, and designs)."

1.2 Assumptions and Requirements Definition

Assumptions are one category of design guidance provided to an engineering design team. They are those guidelines that are conceived through supposition and legislated by policy because insufficient information or time is available for explicit verification. Requirements are the other design guidance category. They are derived by analysis of the functional task of interest or known by prior experience. The assumptions and requirements of interest to this task are the upper level specifications which bound the architectural concepts and state the functional performance demands on the systems. While numerous conceptual configurations for space transportation nodes can be found in the literature, the intent of this task is to develop and document STN assumptions and requirements without any preconceived model of a design configuration. A later, related study is tasked to develop transportation design concepts which satisfy the upper level assumptions and requirements of this study task.

1.3 Task Organization

The task activities have been planned to produce results which are relatable to space station development, responsive to the synthesized models for the initial years of the lunar base, and organized to accommodate continued development.

In the Space Station Program, the requirements documentation tree begins with JSC 30000, JSC 31000 and the Architectural Control Documents (ACD's). Therefore, the STN requirements documentation is patterned after the JSC 31000, Space Station Projects Requirements Document. Documents with detail such as the Space Station Interface Control Documents and Contract End Item Specifications are not appropriate at this phase of program planning. The STN requirements structure and relation to the Space Station program structure is developed in Section 2.0.

The assumptions and requirements are obtained from discussions with appropriate personnel and by analysis of a space transportation reference baseline. Essentially, the requirements analyst is performing the earliest stage of system engineering design. The task is to determine, thinking as a designer, what data must be known to perform specific engineering designs at this level of detail. The assumptions and requirements are identified in the thought process of considering what activities the STN must perform for each particular mission and vehicle passing through the node. The requirements assessment of the space transportation nodes is developed in Section 4.0.

In support of the JSC Advanced Programs Office, Eagle Engineering, Inc. has interpreted the Civil Needs Data Base Option 3, Phase 2 initial years to have the lunar missions scenario defined in Source Reference 9. Due to the fluid nature of a space program definition at this early planning stage and the probable change in detail data, the requirements have been formulated based on generalized missions and flight schedules synthesized from three representative years of our lunar missions scenario. This reference baseline for space transportation activities used in this study is provided in Section 3.0.

The documentation of results is organized into the three sections of Source References, Assumptions and Groundrules, and STN Requirements. Data base methods were chosen as the medium for recording the results. The use of data bases allows the identification of links between references, assumptions, and requirements. The data bases also enable flexibility and ease in reviewing and analyzing the results. Sections 4.0, 5.0, and 6.0 identify the primary results.

Closing comments are provided in section 7.0. Comments are provided on the additional results potential in the data depth, the sensitivity of results to changes in the generic reference baseline input, and the iteration process involved in requirements planning.

1.4 Space Transportation Nodes Location

Due to the near term emphasis of this study and other factors, discussed below, requirements and assumptions are generated for the LEO STN only.

1.4.1 Low Earth Orbit Space Transportation Node Baseline

A space transportation node (STN) in low earth orbit (LEO) is the baseline STN location. It has been assumed that the frequent traffic noise, center of gravity changes, intensive servicing operations, visiting traveler commotion, extensive storage allotments, precise launch scheduling commitments, contamination problems, and unavoidable mechanical movements are unacceptably incompatible with users in a Space Station primarily supporting microgravity commercial and science applications.

The orbit ephemeris of the LEO STN is an especially important design factor due to the lunar transportation orbital mechanics. Reference 20 discusses this aspect in more detail. The STN conceptual design task must meet the LEO STN orbit ephemeris requirements implied by the following Earth-Moon transportation constraints:

1) The inclination of the Moon's orbit plane to the equatorial plane of the Earth varies from 18 to 28 degrees over an 18.5 year period. The LEO STN orbit plane must therefore have an inclination of at least 28 degrees to always be able to launch to the Moon in plane. For this reason, 28 degrees is the

optimum inclination for a LEO STN and can be attained from any launch site with a latitude of 28 degrees or less.

2) The stack must depart approximately when the Moon resides in the LEO STN orbit plane. Specifically, the vehicle must "lead" the Moon somewhat. These departure dates occur at roughly 9 day intervals. The plane of the LEO STN orbit contains the Moon every 9 days. This interval is controlled by the Moon's orbital motion and the precession of the LEO STN orbit around the Earth. The LEO STN precession rate is a function of altitude and inclination and it may be advantageous to adjust the LEO STN altitude so as to have exactly three 9.1-day intervals for every 27.3-day lunar rotation. That would allow optimum arrival to, and departure from, high inclination lunar orbits once a lunar month. The high inclination lunar orbit planes must contain the Earth for arrival and departure which occurs twice per 27.3-day lunar rotation. This can be synchronized with the 9.1-day interval such that both occur together once per month.

3) Once in the vicinity of the Moon, the stack must insert into an orbit with an inclination greater than the landing site (base). Initial work indicates the stack coming from Earth can insert into any inclination lunar orbit at_ little or no propellant cost. At worst, the crew may have to wait some time in lunar orbit for the landing site to move into the orbit plane, though even this wait can probably be avoided by an additional burn before lunar orbit insertion. This lunar orbit can be chosen to minimize waits, propellant usage, and return opportunities for a given stay time.

4) When departure from the lunar surface is desired, the ascent stage must wait for the orbit of the OTV to pass overhead for an optimum opportunity. For low inclination parking orbits, launch can occur at almost any time and plane changes can be used to get in the OTV orbit at low cost. As parking orbit inclinations rise, this becomes more difficult. For a polar parking orbit and a low latitude base, minimum plane change launches occur every 14 days and become very expensive in terms of propellant as the plane change required approaches 90 degrees. For one lander studied, as plane change is varied from 0 degrees to 15 degrees, lander size increases 10 percent.

5) Once the ascent stage and the OTV have docked, the OTV must wait until the plane of the LEO STN orbit contains the Moon to depart. Specifically, the plane of the LEO STN must be properly oriented when the vehicle actually arrives at LEO. This occurs roughly every 9 days as discussed above. Ideally, the plane of the OTV orbit around the Moon should contain the Earth at this time also. However, plane changes up to some point are permissible. This is less of a problem for low inclination lunar orbits than for high inclination orbits. As discussed previously, this optimum condition can occur once a month given proper selection of the STN orbit altitude.

1.4.2 Lunar Libration Point and Lunar Orbit Locations Elimination

Space Transportation Node locations at the Earth-Moon libration points and in lunar orbit have not been addressed in this report because initial studies indicate they only benefit lunar scenarios with extensive infrastructure on the surface and in orbit. The scenario of interest in this study task occurs prior to the implementation of lunar orbit or libration point facilities. The LEO STN exists primarily to assemble the departure stack and maintain reusable OTVs. A firm requirement for a libration point or lunar orbit STN has not been identified at this time. In a later time, a LLO STN could serve as a propellant loading facility for hydrogen from Earth for reusable lunar landers. On the other hand, the hydrogen can be brought to the lunar surface and transferred in a gravity field with only a small performance loss. A lunar orbit STN could serve as a storage and transfer facility for lunar produced oxygen for OTVs and for oxygen to be shipped to other more distant points. Lunar produced oxygen will initially be used for needs on the lunar surface. The second use will probably be for a reusable lunar lander. A reusable lunar lander has been studied in Reference 21 and does indicate it will benefit when operating from a lunar orbit STN. Profitable use of lunar produced oxygen beyond lunar orbit requires large infrastructures, launch rates, and markets.

STN's at the libration points have been shown to be of value in scenarios involving low thrust propulsion to Mars and other points in the solar system. The vehicles do not have to descend into the gravity well of Earth or the Moon, and these points are, therefore, convenient staging points between low and high thrust propulsion systems.

If a LLO STN is required, lunar equatorial orbit has certain advantages. This is the only orbit that can be attained at any time with no plane change from a lunar equatorial base. Since the lunar equatorial plane is inclined at only 6.5 degrees relative to the lunar orbit plane, departures to Earth can also occur anytime with only small penalties for off-nominal times. The LEO STN orbit must be oriented properly however, which occurs every 9 days.

A non-equatorial lunar orbiting station also adds additional constraints to the orbital mechanics of Earth-Moon transportation that is undesirable without some other redeeming benefit. These constraints include:

1) The stack arriving from Earth must enter the lunar STN orbit. Inclination will not be a problem, but unless the orbit is synchronized to a LEO STN orbit, the line of nodes may not be in the proper position. In the event it is synchronized, optimum opportunities will occur once a month. This problem exists for high inclination and polar orbits and decreases as the inclination is lowered. There is no orbital mechanics window problem for a lunar orbit with zero or near-zero inclination.

2) The departure situation is basically the same as the case in which the ascent stage must launch into the OTV's orbit or one within reasonable plane change delta V to the OTV orbit. "Reasonable" plane changes will probably not exceed 15 degrees which will increase the mass of a single-stage lunar lander operating from low lunar orbit by 10 percent. With the lunar STN, the ascent vehicle must make all the plane change. Without the lunar STN, the OTV can make some of the plane change to rendezvous with the ascent stage.

The problem is not simple and a trade study comparing delta V for a variety of lunar STN orbits with delta V for optimum round trips without the lunar STN would be required to determine how much the additional constraints actually cost.

2.0 Requirements Structure

2.1 Project Integration

The Space Station and Shuttle will be well established systems by the time of the STN of this study, calendar year 2000. A large base of technology, hardware, software, documentation, training, and operations experience will exist. Integration of the STN project to optimize application of the existing base of resources should be an important goal in the STN development. Therefore, it is appropriate that the documentation of the Space Transportation Node requirements be influenced by the Space Station documentation. JSC 31000, Source Reference 10, contains more detail than possible for the STN but the STN requirements documentation follows the JSC 31000 format where appropriate.

2.2 Work Breakdown Structure

From the beginning, the STN planning for the STN systems, elements, and configuration need a specific and constant system of reference. The Work Breakdown Structure (WBS) is well suited to provide a logical and constant reference system. In addition, a WBS is required for formal program cost planning and accounting. A WBS outline consistent with the Space Station Work Package 2 WBS has been developed. The Space Station WBS is recommended for use in the STN planning since there is the potential that many common components and systems will be utilized in the STN. Use of the same generic WBS will facilitate exchange of information between the projects. The WBS is presented in Table 2.2-1. This outline is used in this study to functionally group the STN requirements.

2.3 Requirements Origin Traceability

It is important to capture the origin and interrelations of information sources, assumptions, groundrules, and requirements. As a STN configuration evolves, the effect of a changed requirement can be traced into an element design or the variance in a design can be reviewed against the criticality of the originating requirement. A data base system has been used to record the pertinent data in developing the STN assumptions and requirements, providing the beginnings of a mechanism for requirements traceability. Three relational files have been used. Table 2.3-1 defines the structure of the three data base files.

Table 2.2-1 **Recommended Space Transportation Node Work Breakdown Structure (WBS)**

Digit	First	Second	Third
WBS Assignment	Node Location	Element or End Item	System

WBS Outline

1.00 Low Earth Orbit (LEO) STN
1.01 Management and Integration
1.01.1 Management
1.01.2 Systems Engineering & Integration
1.01.2.01 Automation and Robotics
1.01.2.04 Materials, Processes, and Fracture Control
1.01.2.05 Interface Development
1.01.2.06 Maintainability
1.01.2.07 Commonality
1.01.2.08 Requirements and Specification Development
1.01.2.09 Flight Crew Integration
1.02 Integrated Truss Element
1.03 Remote Manipulators
1.04 Propulsion Systems
1.05 Airlocks
1.06 Attached Systems
1.07 Reserved... (Distributed Systems in Space Station)
1.08 Reserved... (IV&T Facility Outfitting in Space Station)
1.09 Resource Node
1.10 - 1.18 Reserved...
1.19 Logistics and Warehouse Elements
1.20 - 1.21 Reserved...
1.22 Habitation Elements
1.23 EVA Systems
1.24 Transportation Operations Center
1.25 Propellant Depot
1.26 Hanger Element
2.00 Low Lunar Orbit (LLO) STN
3.00 Lunar Libration Point (LLP) STN

Table 2.3-1 Assumptions and Requirements Data Base Structure

File Title:	SOURCE REFERENCE		
		Fields:	Source Reference ID Number
			Reference Description (Four Lines)
File Title:	ASSUMPTIONS		
		Fields:	Assumption ID Number (Organized by program factors of: ProgramDefinition, Vehicles, Operations, Schedule)
			Assumption SubID Number
			Assumption Statement (Five Lines)
			Followup Analysis Needed (Trade or Sensitivity)
			Source Reference ID Number
File Title:	REQUIREMENTS		
		Fields:	WBS Number
			Requirement ID Number
			Requirement SubID Number
			Requirement Statement (Four Lines)
			Assumption ID Number
			Source Reference ID Number

3.0 Reference Baseline for Transportation Activities

3.1 Baseline Modeling Approach with ARTEMIS

The STN requirements analysis includes synthesizing the servicing activities on individual transportation missions and, also, developing the facilities loading impact when individual missions are combined into a full schedule of activities. A computer tool, ARTEMIS Project, has been used to record activity resource and schedule aspects in this higher level requirements definition study. ARTEMIS Project (Reference 16) is produced by Metier Management Systems for use as a project management system. The systems provides all of the usual features of a critical path method (CPM) project analysis tool. The reference baseline for the requirements study includes the transportation related vehicles, the individual transportation missions, and a representative annual schedule of transportation missions. The reference baseline is developed and recorded in ARTEMIS format in the following sections.

3.2 Vehicles Baseline

The space transportation vehicles passing through the STN are assumed to be the systems described in references 1, 7, and 8. The Langley Research Center (LaRC) study is the most recent and is based on the NASA Headquarters CNDB. Therefore, the LaRC study vehicles are used as the first choice. The Eagle study is used to clarify details and to support resolution of inconsistencies between sources. Pictorial representations of the reference baseline vehicles are shown in Figures 3.2-1 through 3.2-5. The physical attributes of these vehicles are summarized in Table 3.2-1.

3.3 Lunar Missions Scenario

The CNDB provides the fundamental reference for the NASA advanced program missions and transportation descriptions. This STN requirements study is limited in scope to only the initial years of the Phase II Lunar Base Scenario in the CNDB Option III. In support of the JSC Advanced Programs Office, Eagle Engineering developed the scenario data with adjustments which emphasize the objectives of this Advanced Space Transportation Support Contract. The alternate missions scenario is documented in Reference 9. The alternate missions scenario includes a total of 47 missions in the years of 1999 through

2005 of which 41 pass through the LEO STN. The alternate scenario is outlined at a high level in Table 3.3-1.

3.4 Missions Baseline

For purposes of this study, a representative but generic scenario was desired to reduce the sensitivity of the results to fluctuations in detail definition as the program changes and evolves. The lunar missions scenario was reviewed and typical flight schedules were assumed for the missions in each calendar year. The assumed flight schedules for the years 2000, 2002, and 2005 were found to be representative of three different types of mission sequencing. Calendar year 2002 has been selected as the source of mission requirements for a baseline requirements analysis.

The schedule of year 2000 is relatively slow paced with three manned (14-day) and two automated missions. The schedule of year 2002 is the busiest of the seven years with four manned (30-day) and four automated missions. In addition, a good variety of automated payloads are delivered to the lunar surface as is evident by referring to Table 3.3-1. Schedule year 2005 is primarily characterized by the long duration of the manned missions. In year 2005 there are four manned (186-day) and three automated missions. Therefore, the year 2002 is used as the baseline for the requirements analysis based on having the most active schedule.

From the viewpoint of this task concerning the analysis of higher level requirements, there are only two different support categories of missions in the year 2002, Manned or Automated. All of the 14-day manned missions use the same transportation vehicles, fly the same mission profile, and require the same STN service operations. It is assumed that the automated mission lunar surface cargos are all delivered to the LEO STN stacked with the expendable lunar lander and checked out for translunar injection. Therefore, all of the automated missions use the same transportation vehicles, fly the same mission profiles, and require the same STN service operations.

The ARTEMIS tool is used to record the characteristics of the missions baseline and to analyze the schedule interactions of the LEO STN and transportation vehicle resources. The LEO STN and vehicle resources that are to be monitored are listed in Figure 3.4-1.

These are the basic elements for which sufficient quantities and accommodations must be provided.

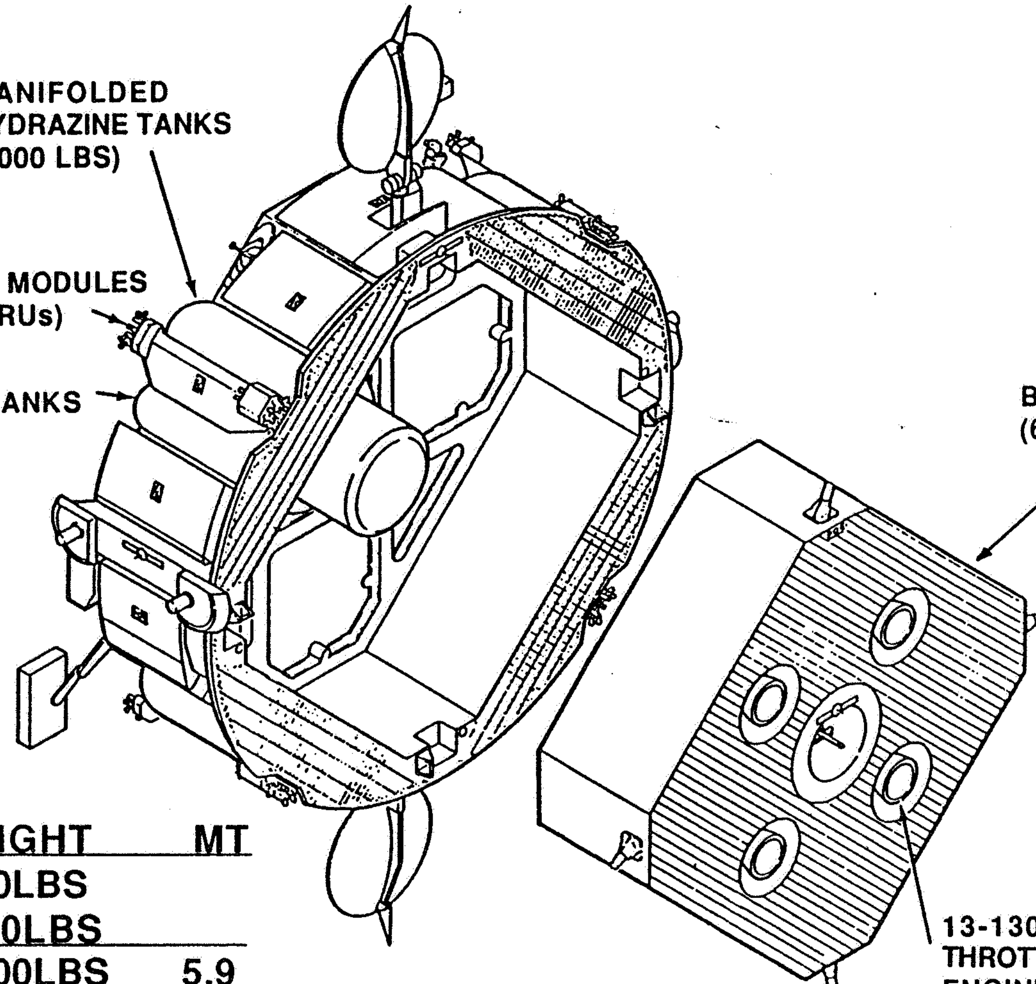
In planning for the flight of a spacecraft, the standard procedure is to layout a timeline of the operational activities to be accomplished from prelaunch checkout to mission completion. For purposes of this study, the operational activities of interest are those requiring service support from the LEO STN. These service activities have been identified based on review of prior space missions and aerospace studies. The flow of events begins with the OTV's, OMV's and other LEO STN facilities already in a state of mission readiness. The assumed service activities for the automated lunar flight, Mission 015, are organized in a logic network in Figure 3.4-2. More information is provided in Figure 3.4-3, including the assumed resource involved in each activity , the quantity of each resource required, and the number of days the resource is required in the activity. Figure 3.4-4 and Figure 3.4-5 provide the same information for the manned lunar flight, Mission 016.

3.5 Flight Schedule Baseline

The following translunar injection launch dates have been assumed for this ARTEMIS project support analysis:

FLIGHT	TRANSLUNAR INJECTION LAUNCH DATE
015AL	January 03, 2002
016ML	February 08, 2002
017AL	April 03, 2002
018ML	May 09, 2002
019AL	July 04, 2002
020ML	August 08, 2002
021AL	October 04, 2002
022ML	November 08, 2002

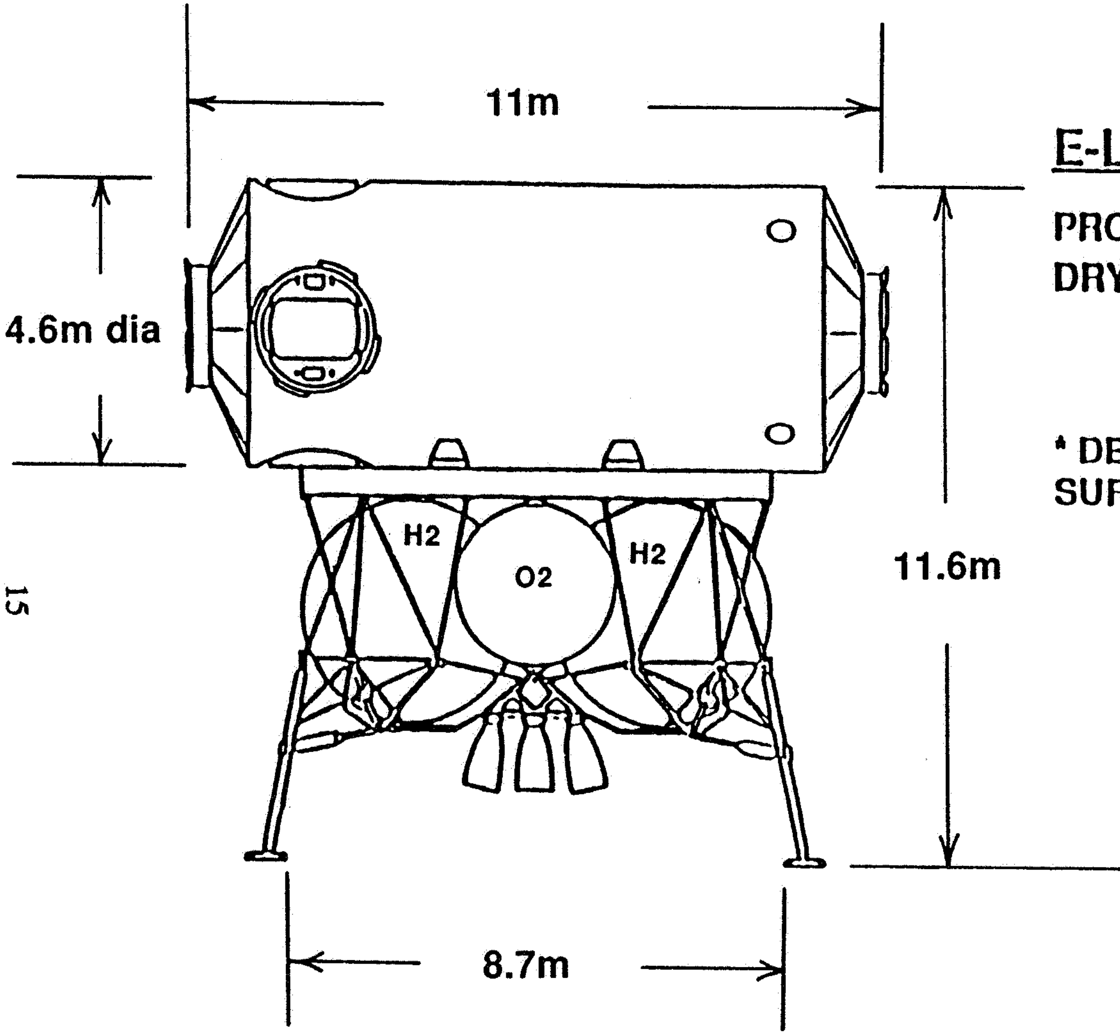
Using the above dates and the missions baseline, the ARTEMIS tool was used to process the flight schedule baseline and produced the integrated STN activity schedule for year 2002 shown in Figure 3.5-1. The required sequence of services (e.g., Figure 3.4-2) for each of the above eight flights were combined and the total list of all service activities which the STN must support in 2002 are listed in chronological order by date.



DIMENSIONS	WEIGHT	MT
SRV: 44"x176" DIA	4700LBS	
PM: 42"x140" DIA	8200LBS	
	12900LBS	5.9
DRY MASS	5135LBS	2.3

Figure 3.2-1 OMV Representation

EXPENDABLE LANDER WITH CARGO (E-LANDER)



E-LANDER*

	LBM	MT
PROPELLANT WEIGHT	29,920 LBS.	13.5
DRY WEIGHT	8,360 LBS.	3.8
TOTAL	38,280 LBS.	17.3

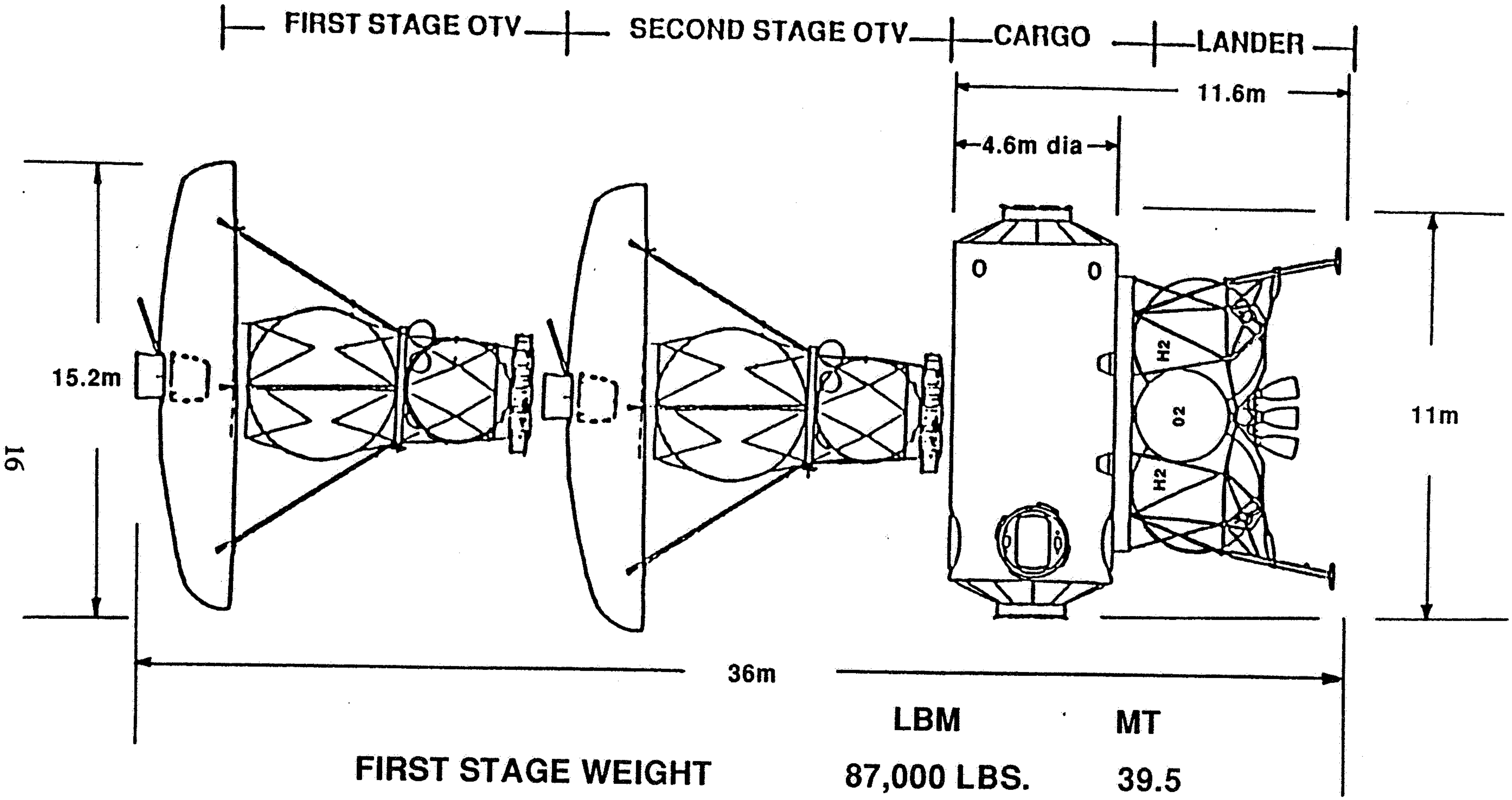
* DELIVERS 38,500 LBS. TO LUNAR SURFACE

CARGO	LBM	MT
	38500	17.5
TOTAL	76,780	34.8

Figure 3.2-2 Representation of Expendable Lander With Cargo

Lunar Base Accommodation Study

UNMANNED LAUNCH STACK

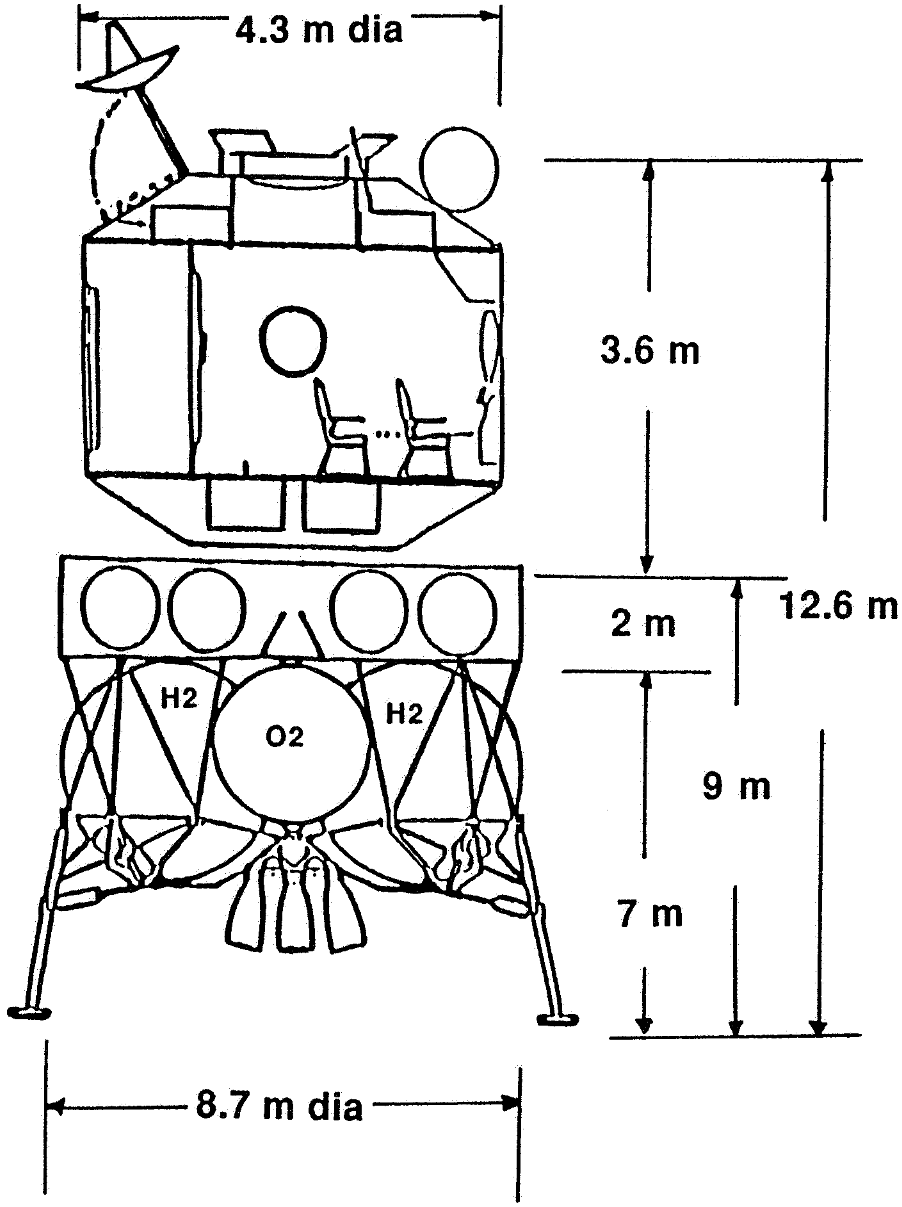


	LBM	MT
FIRST STAGE WEIGHT	87,000 LBS.	39.5
SECOND STAGE WEIGHT	87,000 LBS.	39.5
E-LANDER WEIGHT	38,280 LBS.	17.3
CARGO WEIGHT	38,500 LBS.	17.5
TOTAL WEIGHT	250,780 LBS.	113.8

Figure 3.2-3 Representation of Automated Lunar Transport Departure Stack

Lunar Base Accommodation Study

EXPENDABLE LUNAR EXCURSION MODULE (E-LEM)



MLM

TOTAL WEIGHT	13,200 LBS.	6MT

E-LAUNCHER

PROPELLANT WEIGHT	11,000 LBS.	
DRY WEIGHT	5,720 LBS.	
TOTAL WEIGHT	16,720 LBS.	7.6 MT

E-LANDER*

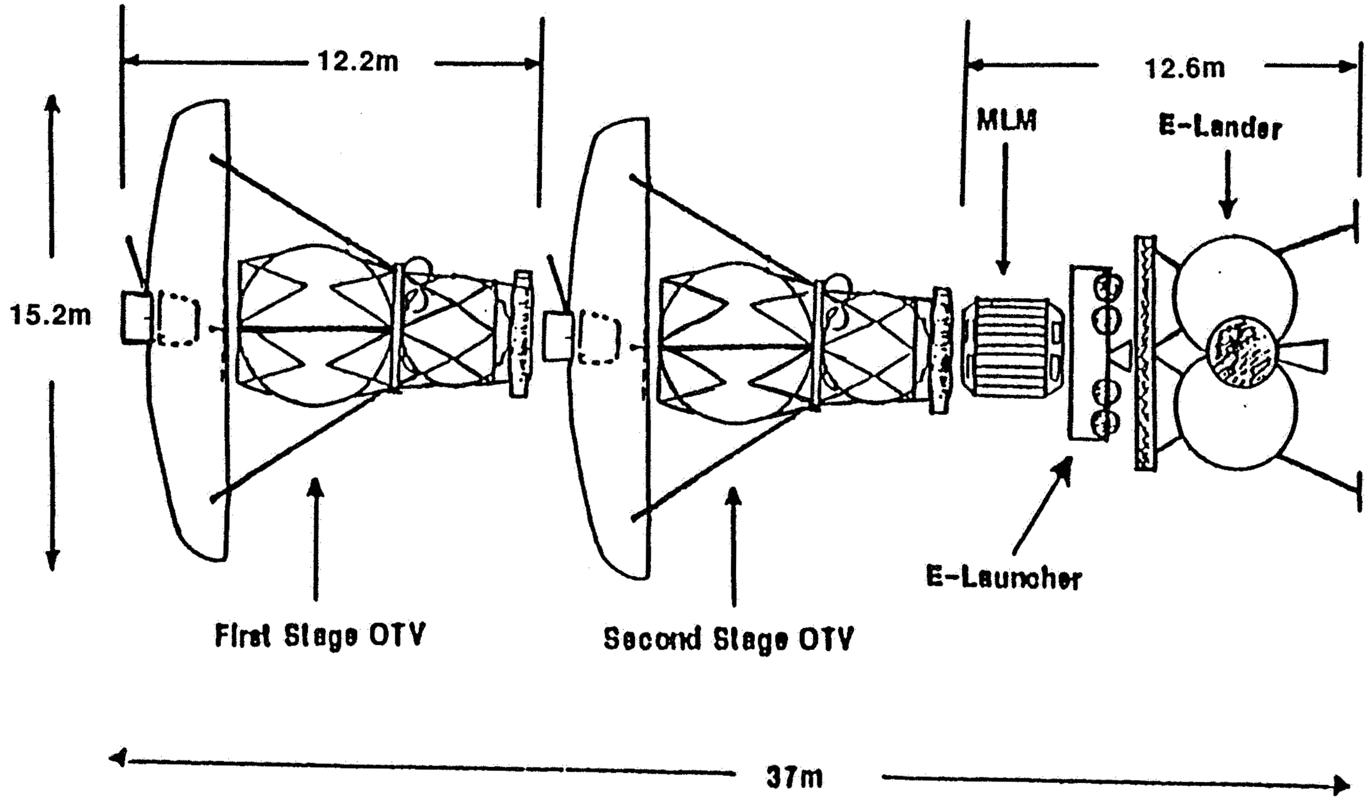
PROPELLANT WEIGHT	29,920 LBS.	13.5 MT
DRY WEIGHT	8,360 LBS.	3.8 MT
TOTAL WEIGHT	38,280 LBS.	17.3 MT
TOTAL	68,200 LBS. 30.9 MT	

*DELIVERS 38,500 LBS. TO LUNAR SURFACE

Figure 3.2-4 Representation of Expendable Lander With Personnel Transfer Module

Lunar Base Initiative

PERSONNEL TRANSPORT VEHICLE STACK



LUNAR VEHICLE STACK WEIGHT (LBS.)

		LBS.	MT
FIRST STAGE	=	87,000	39.5
SECOND STAGE	=	87,000	39.5
MLM	=	13,200	6.0
EXPENDABLE LANDER	=	38,200	17.3
EXPENDABLE LAUNCHER	=	16,720	7.6
TOTAL VEHICLE WEIGHT	=	242,200	109.9

OTV

	LBM	MT
PROPELLANT WEIGHT	75,400	34.2
DRY MASS	11,600	5.3
TOTAL MASS	87,000	39.5

Figure 3.2-5 Representation of Lunar Personnel Transport Departure Stack

Table 3.2-1 Reference Baseline Vehicle Size Definition Matrix

VEHICLE CONFIGURATION	LEN. (M)	DIA. (M)	VOL. (CM)	LO2 (MT)	LH2 (MT)	CRYO. PROP. (MT)	DRY MASS (MT)	TOTAL MASS (MT)
OMV	1.2	4.6	19.9				2.3	5.9
PTM-4	3.6	4.3	52.3				6.0	6.0
OTV	12.2	15.2	2213.8	29.9	4.3	34.2	5.3	39.5
2 OTV's	24.4	15.2	4427.6	0	0	0	10.5	
E-LANDER	7.0	8.7	416.1	11.8	1.7	13.5	3.8	17.3
CARGO (LUNAR HAB MOD)	11.0	4.6						17.5
CARGO/E-LANDER	11.6	11.0	1102.4	11.8	1.7	13.5		34.8
2 OTV's/ CARGO/E-LANDER	36.0	15.2	6532.5	71.7	10.2	82.1	31.7	113.8
E-ASCENT/LANDER	9.0	8.7	535.0	11.8	1.7	13.5		24.9
PTM-4/ E-ASCENT/LANDER	12.6	8.7	749.0	11.8	1.7	13.5	17.4	30.9
2 OTV's/ PTM-4/ E-ASCENT/LANDER	37.0	15.2	6714.0	71.7	10.2	81.9	27.9	109.9
OTV/PTM-4	15.8	15.2	2867.0	0	0	0	11.2	

Table 3.3-1 Summary of Alternate CNDB Lunar Missions Scenario (Reference 9)

	NUMBER OF MISSIONS IN CALENDAR YEAR							
BRIEF MISSION DESCRIPTION	1999	2000	2001	2002	2003	2004	2005	TOTAL
14-Day Manned Lunar Surface	1	2	1					4
Automated: Const. Equipment		1						1
Automated: Comm,Power,Haven		1						1
Automated: Emerg. L-Ascent		1						1
Automated: A/L,Power,Node			1	1				2
Automated: Habitat			1					1
30-Day Manned Lunar Surface			2	4	4	4		14
Automated: Geo Chem Lab			1					1
Automated: LO2 Pilot Plant				1				1
Automated: Lf Sci Res Fac				1			1	2
Automated: Rover,Garage				1				1
Automated: Lf Sci Res Node					1			1
Automated: Farside Payload					2			2
Automated: Advanced Power						1		1
Automated: O2 Mining Equip						1		1
Automated: LO2 Prod. Plant						1		1
Automated: Mod I/F Node,Comm							1	1
186-Day Manned Lunar Surface							4	4
Automated: Surface LO2 Depot							1	1
TOTALS	1	5	6	8	7	7	7	41

Figure 3.4-1 ARTEMIS Listing of Available LEO STN and Vehicle Resources

Resource Name	Quantity Available	Date From	Date Until
OTV	4 *	Jan-01-99	Dec-31-2005
OMV	3 *	Jan-01-99	Dec-31-2005
Crew-EVA	4 *	Jan-01-99	Dec-31-2005
Crew-Lunar	8 *	Jan-01-99	Dec-31-2005
Crew-Nod	6 *	Jan-01-99	Dec-31-2005
E-Lander	2 *	Jan-01-99	Dec-31-2005
PTM-4	2 *	Jan-01-99	Dec-31-2005
RMS	2 *	Jan-01-99	Dec-31-2005
Hanger	20000 **	Jan-01-99	Dec-31-2005

* Items

* Cubic Meters

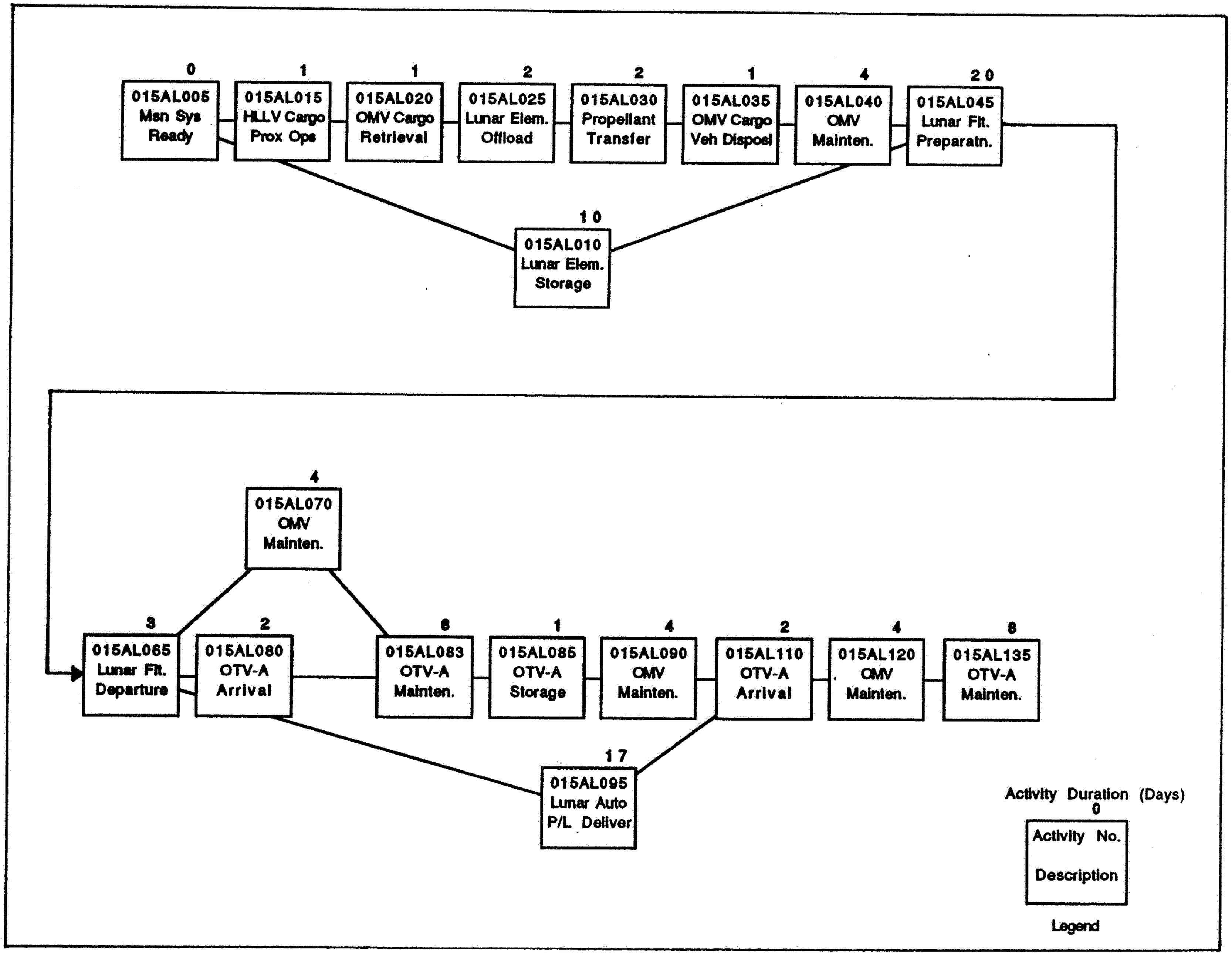


Figure 3.4-2 Logic Network for Assumed Sequence of STN Service Activities Supporting the Automated Lunar Mission Baseline

Figure 3.4-3 (1 of 2) **Assumed Sequence of Service Activities for the Automated Lunar Mission Baseline**

Activity Codes	Activity Description	Resource Name	Quantity per unit	Resource Duration
015AL005	Mission Systems Ready	OTV	2	
015AL010	Lunar Elements Storage	Hanger	4428	10 DAYS
		OTV	2	10 DAYS
015AL015	HLLV Cargo/Tanker Prox O	Crew-Nod	2	1 DAYS
		E-Lander	1	1 DAYS
		OMV	1	1 DAYS
015AL020	OMV Cargo/Tanker Retriev	Crew-Nod	2	1 DAYS
		E-Lander	1	1 DAYS
		OMV	1	1 DAYS
		RMS	1	1 DAYS
015AL025	Lunar Element Offload	Crew-Nod	2	2 DAYS
		E-Lander	1	2 DAYS
		Hanger	1102	2 DAYS
		OMV	1	2 DAYS
		RMS	1	2 DAYS
015AL030	Propellant Transfer	Crew-Nod	2	2 DAYS
		E-Lander	1	2 DAYS
		Hanger	1102	2 DAYS
		OMV	1	2 DAYS
		RMS	1	2 DAYS
015AL035	OMV HLLV C/T Disposal	Crew-Nod	2	1 DAYS
		E-Lander	1	1 DAYS
		Hanger	1102	1 DAYS
		OMV	1	1 DAYS
015AL040	OMV Maintenance	Crew-Nod	2	4 DAYS
		E-Lander	1	4 DAYS
		Hanger	1122	4 DAYS
		OMV	1	4 DAYS
		RMS	1	4 DAYS
015AL045	Lunar Flight Preparation	Crew-EVA	2	3 DAYS
		Crew-Nod	2	20 DAYS
		E-Lander	1	20 DAYS
		Hanger	6553	20 DAYS
		OTV	2	20 DAYS
		RMS	1	20 DAYS
015AL065	Lunar Flight Departure	Crew-Nod	2	3 DAYS
		E-Lander	1	3 DAYS
		Hanger	6553	3 DAYS
		OMV	1	3 DAYS
		OTV	2	3 DAYS
		RMS	1	1 DAYS
015AL070	OMV Maintenance	Crew-Nod	2	4 DAYS
		Hanger	20	4 DAYS
		OMV	1	4 DAYS
		RMS	1	4 DAYS
015AL080	OTV-A Arrival	Crew-Nod	2	2 DAYS
		OMV	1	2 DAYS
		OTV	1	2 DAYS
		RMS	1	1 DAYS
015AL083	OTV-A Maintenance	Crew-EVA	2	3 DAYS
		Crew-Nod	2	8 DAYS
		Hanger	2234	8 DAYS
		OTV	1	8 DAYS
		RMS	1	8 DAYS
015AL085	OTV-A Storage	Crew-Nod	1	1 DAYS

Order: AN RES Where: AN<"016ML005"

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Figure 3.4-3 (2 of 2) **Assumed Sequence of Service Activities for the Automated Lunar Mission Baseline**

Activity Codes	Activity Description	Resource Name	Quantity per unit	Resource Duration
015AL085	OTV-A Storage	Hanger	2234	1 DAYS
		OMV	1	1 DAYS
		OTV	1	1 DAYS
015AL090	OMV Maintenance	Crew-Nod	2	4 DAYS
		Hanger	2234	4 DAYS
		OMV	1	4 DAYS
		RMS	1	4 DAYS
015AL095	Lunar Auto P/L Delivery	E-Lander	1	17 DAYS
		OTV	1	17 DAYS
015AL110	OTV-A Arrival	Crew-Nod	2	2 DAYS
		Hanger	2214	2 DAYS
		OMV	1	2 DAYS
		OTV	1	2 DAYS
		RMS	1	1 DAYS
015AL120	OMV Maintenance	Crew-Nod	2	4 DAYS
		Hanger	4448	4 DAYS
		OMV	1	4 DAYS
		RMS	1	4 DAYS
015AL135	OTV-A Maintenance	Crew-EVA	2	3 DAYS
		Crew-Nod	2	8 DAYS
		Hanger	4448	8 DAYS
		OTV	1	8 DAYS
		RMS	1	8 DAYS

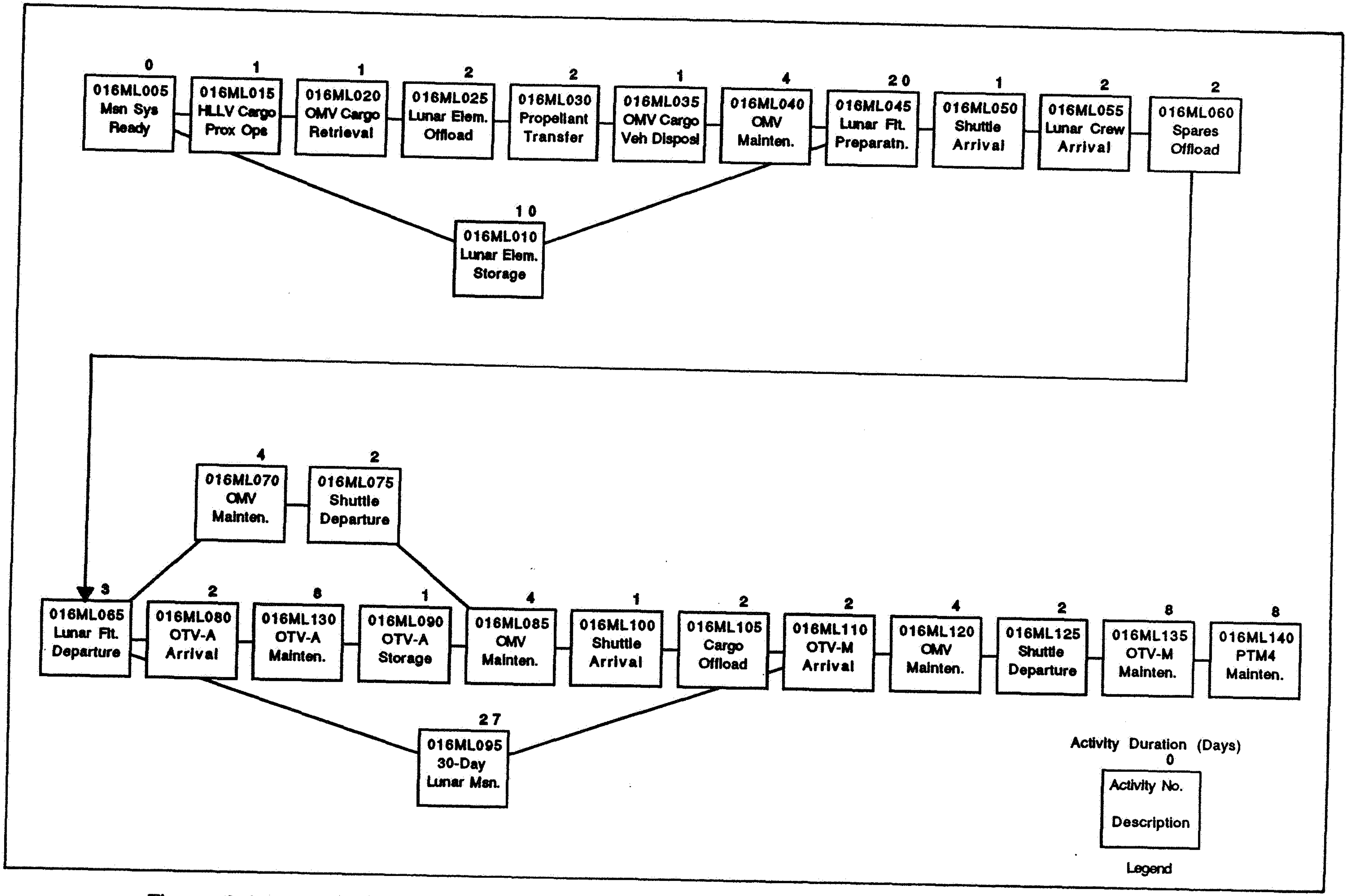

Figure 3.4-4 Logic Network for Assumed Sequence of STN Service Activities Supporting the Manned Lunar Mission Baseline

Figure 3.4-5 (1 of 3) Assumed Sequence of Service Activities for the Manned Lunar Mission Baseline

Activity Codes	Activity Description	Resource Name	Quantity per unit	Resource Duration
016ML005	Mission Systems Ready	OTV	2	
		PTM-4	1	
016ML010	Lunar Elements Storage	Hanger	4480	10 DAYS
		OTV	2	10 DAYS
		PTM-4	1	10 DAYS
016ML015	HLLV Cargo/Tanker Prox O	Crew-Nod	2	1 DAYS
		E-Lander	1	1 DAYS
		OMV	1	1 DAYS
016ML020	OMV Cargo/Tanker Retriev	Crew-Nod	2	1 DAYS
		E-Lander	1	1 DAYS
		OMV	1	1 DAYS
		RMS	1	1 DAYS
016ML025	Lunar Element Offload	Crew-Nod	2	2 DAYS
		E-Lander	1	2 DAYS
		Hanger	535	2 DAYS
		OMV	1	2 DAYS
		RMS	1	2 DAYS
016ML030	Propellant Transfer	Crew-Nod	2	2 DAYS
		E-Lander	1	2 DAYS
		Hanger	535	2 DAYS
		OMV	1	2 DAYS
		RMS	1	2 DAYS
016ML035	OMV HLLV C/T Disposal	Crew-Nod	2	1 DAYS
		E-Lander	1	1 DAYS
		hanger	535	1 DAYS
		OMV	1	1 DAYS
016ML040	OMV Maintenance	Crew-Nod	2	4 DAYS
		E-Lander	1	4 DAYS
		Hanger	555	4 DAYS
		OMV	1	4 DAYS
		RMS	1	4 DAYS
016ML045	Lunar Flight Preparation	Crew-EVA	2	3 DAYS
		Crew-Nod	2	20 DAYS
		E-Lander	1	20 DAYS
		Hanger	6734	20 DAYS
		OTV	2	20 DAYS
		PTM-4	1	20 DAYS
		RMS	1	20 DAYS
016ML050	Shuttle Arrival	Crew-Nod	2	1 DAYS
		E-Lander	1	1 DAYS
		Hanger	6734	1 DAYS
		OTV	2	1 DAYS
		PTM-4	1	1 DAYS
016ML055	Lunar Crew Arrival	E-Lander	1	2 DAYS
		Hanger	6734	2 DAYS
		OTV	2	2 DAYS
		PTM-4	1	2 DAYS
016ML060	Spares Offload	Crew-Nod	2	2 DAYS
		E-Lander	1	2 DAYS
		Hanger	6734	2 DAYS
		OTV	2	2 DAYS
		PTM-4	1	2 DAYS
		RMS	1	2 DAYS
016ML065	Lunar Flight Departure	Crew-Nod	2	3 DAYS
		E-Lander	1	3 DAYS

Order: AN RES Where: AN>"015AL135" AND AN<"017AL005"

Figure 3.4-5 (2 of 3) Assumed Sequence of Service Activities for the Manned Lunar Mission Baseline

Activity Codes	Activity Description	Resource Name	Quantity per unit	Resource Duration
016ML065	Lunar Flight Departure	Hanger	6734	3 DAYS
		OMV	1	3 DAYS
		OTV	2	3 DAYS
		PTM-4	1	3 DAYS
		RMS	1	1 DAYS
016ML070	OMV Maintenance	Crew-Nod	2	4 DAYS
		Hanger	20	4 DAYS
		OMV	1	4 DAYS
		RMS	1	4 DAYS
016ML075	Shuttle Departure	Crew-Nod	1	2 DAYS
		Hanger	20	2 DAYS
016ML080	OTV-A Arrival	Crew-Nod	2	2 DAYS
		OMV	1	2 DAYS
		OTV	1	2 DAYS
		RMS	1	1 DAYS
016ML085	OMV Maintenance	Crew-Nod	2	4 DAYS
		Hanger	2234	4 DAYS
		OMV	1	4 DAYS
		RMS	1	4 DAYS
016ML090	OTV-A Storage	Crew-Nod	1	1 DAYS
		Hanger	2234	1 DAYS
		OMV	1	1 DAYS
		OTV	1	1 DAYS
016ML095	Lunar 30-Day Mission	E-Lander	1	27 DAYS
		OTV	1	27 DAYS
		PTM-4	1	27 DAYS
016ML100	Shuttle Arrival	Crew-Nod	2	1 DAYS
		Hanger	2234	1 DAYS
016ML105	Cargo Offload	Crew-Nod	2	2 DAYS
		Hanger	2234	2 DAYS
		RMS	1	2 DAYS
016ML110	OTV-M Arrival	Crew-Nod	2	2 DAYS
		Hanger	2214	2 DAYS
		OMV	1	2 DAYS
		OTV	1	2 DAYS
		PTM-4	1	2 DAYS
		RMS	1	1 DAYS
016ML120	OMV Maintenance	Crew-Nod	2	4 DAYS
		Hanger	4500	4 DAYS
		OMV	1	4 DAYS
		RMS	1	4 DAYS
016ML125	Shuttle Departure	Crew-Nod	1	2 DAYS
		Hanger	4500	2 DAYS
016ML130	OTV-A Maintenance	Crew-EVA	2	3 DAYS
		Crew-Nod	2	8 DAYS
		Hanger	4500	8 DAYS
		OTV	1	8 DAYS
		RMS	1	8 DAYS
016ML135	OTV-M Maintenance	Crew-EVA	2	3 DAYS
		Crew-Nod	2	8 DAYS
		Hanger	4500	8 DAYS
		OTV	1	8 DAYS
		RMS	1	8 DAYS
016ML140	PTM4 Maintenance	Crew-Nod	2	8 DAYS
		Hanger	4500	8 DAYS

Order: AN RES   Where: AN>"015AL135" AND AN<"017AL005"

Figure 3.4-5 (3 of 3) **Assumed Sequence of Service Activities for the Manned Lunar Mission Baseline**

Activity Codes	Activity Description	Resource Name	Quantity per unit	Resource Duration
016ML140	PTM4 Maintenance	PTM-4	1	8 DAYS
		RMS	1	8 DAYS

Figure 3.5-1 (1 of 4) Integrated STN Activity Support of the Flight Schedule Baseline

Activity Codes	Activity Description	Early Start	Duration (units)	Early Finish
015AL005	Mission Systems Ready	Dec-01-2001	0 DAYS	Nov-30-2001
015AL015	HLLV Cargo/Tanker Prox O	Dec-01-2001	1 DAYS	Dec-01-2001
015AL010	Lunar Elements Storage	Dec-01-2001	10 DAYS	Dec-10-2001
015AL020	OMV Cargo/Tanker Retriev	Dec-02-2001	1 DAYS	Dec-02-2001
015AL025	Lunar Element Offload	Dec-03-2001	2 DAYS	Dec-04-2001
015AL030	Propellant Transfer	Dec-05-2001	2 DAYS	Dec-06-2001
015AL035	OMV HLLV C/T Disposal	Dec-07-2001	1 DAYS	Dec-07-2001
015AL040	OMV Maintenance	Dec-08-2001	4 DAYS	Dec-11-2001
015AL045	Lunar Flight Preparation	Dec-12-2001	20 DAYS	Dec-31-2001
016ML005	Mission Systems Ready	Jan-01-2002	0 DAYS	Dec-31-2001
016ML015	HLLV Cargo/Tanker Prox O	Jan-01-2002	1 DAYS	Jan-01-2002
015AL065	Lunar Flight Departure	Jan-01-2002	3 DAYS	Jan-03-2002
016ML010	Lunar Elements Storage	Jan-01-2002	10 DAYS	Jan-10-2002
016ML020	OMV Cargo/Tanker Retriev	Jan-02-2002	1 DAYS	Jan-02-2002
016ML025	Lunar Element Offload	Jan-03-2002	2 DAYS	Jan-04-2002
015AL070	OMV Maintenance	Jan-04-2002	4 DAYS	Jan-07-2002
015AL095	Lunar Auto P/L Delivery	Jan-04-2002	17 DAYS	Jan-20-2002
016ML030	Propellant Transfer	Jan-05-2002	2 DAYS	Jan-06-2002
016ML035	OMV HLLV C/T Disposal	Jan-07-2002	1 DAYS	Jan-07-2002
015AL080	OTV-A Arrival	Jan-07-2002	2 DAYS	Jan-08-2002
016ML040	OMV Maintenance	Jan-08-2002	4 DAYS	Jan-11-2002
015AL083	OTV-A Maintenance	Jan-09-2002	8 DAYS	Jan-16-2002
016ML045	Lunar Flight Preparation	Jan-12-2002	20 DAYS	Jan-31-2002
015AL085	OTV-A Storage	Jan-17-2002	1 DAYS	Jan-17-2002
015AL090	OMV Maintenance	Jan-18-2002	4 DAYS	Jan-21-2002
015AL110	OTV-A Arrival	Jan-22-2002	2 DAYS	Jan-23-2002
015AL120	OMV Maintenance	Jan-24-2002	4 DAYS	Jan-27-2002
015AL135	OTV-A Maintenance	Jan-28-2002	8 DAYS	Feb-04-2002
016ML050	Shuttle Arrival	Feb-01-2002	1 DAYS	Feb-01-2002
016ML055	Lunar Crew Arrival	Feb-02-2002	2 DAYS	Feb-03-2002
016ML060	Spares Offload	Feb-04-2002	2 DAYS	Feb-05-2002
016ML065	Lunar Flight Departure	Feb-06-2002	3 DAYS	Feb-08-2002
016ML070	OMV Maintenance	Feb-09-2002	4 DAYS	Feb-12-2002
016ML095	Lunar 30-Day Mission	Feb-09-2002	27 DAYS	Mar-07-2002
016ML080	OTV-A Arrival	Feb-12-2002	2 DAYS	Feb-13-2002
016ML075	Shuttle Departure	Feb-13-2002	2 DAYS	Feb-14-2002
016ML130	OTV-A Maintenance	Feb-14-2002	8 DAYS	Feb-21-2002
016ML090	OTV-A Storage	Feb-22-2002	1 DAYS	Feb-22-2002
016ML085	OMV Maintenance	Feb-23-2002	4 DAYS	Feb-26-2002
016ML100	Shuttle Arrival	Feb-27-2002	1 DAYS	Feb-27-2002
016ML105	Cargo Offload	Feb-28-2002	2 DAYS	Mar-01-2002
017AL005	Mission Systems Ready	Mar-01-2002	0 DAYS	Feb-28-2002
017AL015	HLLV Cargo/Tanker Prox O	Mar-01-2002	1 DAYS	Mar-01-2002
017AL010	Lunar Elements Storage	Mar-01-2002	10 DAYS	Mar-10-2002
017AL020	OMV Cargo/Tanker Retriev	Mar-02-2002	1 DAYS	Mar-02-2002
017AL025	Lunar Element Offload	Mar-03-2002	2 DAYS	Mar-04-2002
017AL030	Propellant Transfer	Mar-05-2002	2 DAYS	Mar-06-2002
017AL035	OMV HLLV C/T Disposal	Mar-07-2002	1 DAYS	Mar-07-2002
016ML110	OTV-M Arrival	Mar-08-2002	2 DAYS	Mar-09-2002
017AL040	OMV Maintenance	Mar-08-2002	4 DAYS	Mar-11-2002
016ML115	Lunar Crew Return	Mar-10-2002	2 DAYS	Mar-11-2002
016ML120	OMV Maintenance	Mar-12-2002	4 DAYS	Mar-15-2002
017AL045	Lunar Flight Preparation	Mar-12-2002	20 DAYS	Mar-31-2002
016ML125	Shuttle Departure	Mar-16-2002	2 DAYS	Mar-17-2002
016ML135	OTV-M Maintenance	Mar-18-2002	8 DAYS	Mar-25-2002

Order: ES EF Where: AN PRESENT

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Figure 3.5-1 (2 of 4) Integrated STN Activity Support of the Flight Schedule Baseline

Activity Codes	Activity Description	Early Start	Duration (units)	Early Finish
016ML140	PTM4 Maintenance	Mar-26-2002	8 DAYS	Apr-02-2002
018ML005	Mission Systems Ready	Apr-01-2002	0 DAYS	Mar-31-2002
018ML015	HLLV Cargo/Tanker Prox O	Apr-01-2002	1 DAYS	Apr-01-2002
017AL065	Lunar Flight Departure	Apr-01-2002	3 DAYS	Apr-03-2002
018ML010	Lunar Elements Storage	Apr-01-2002	10 DAYS	Apr-10-2002
018ML020	OMV Cargo/Tanker Retriev	Apr-02-2002	1 DAYS	Apr-02-2002
018ML025	Lunar Element Offload	Apr-03-2002	2 DAYS	Apr-04-2002
017AL070	OMV Maintenance	Apr-04-2002	4 DAYS	Apr-07-2002
017AL095	Lunar Auto P/L Delivery	Apr-04-2002	17 DAYS	Apr-20-2002
018ML030	Propellant Transfer	Apr-05-2002	2 DAYS	Apr-06-2002
018ML035	OMV HLLV C/T Disposal	Apr-07-2002	1 DAYS	Apr-07-2002
017AL080	OTV-A Arrival	Apr-07-2002	2 DAYS	Apr-08-2002
018ML040	OMV Maintenance	Apr-08-2002	4 DAYS	Apr-11-2002
017AL083	OTV-A Maintenance	Apr-09-2002	8 DAYS	Apr-16-2002
018ML045	Lunar Flight Preparation	Apr-12-2002	20 DAYS	May-01-2002
017AL085	OTV-A Storage	Apr-17-2002	1 DAYS	Apr-17-2002
017AL090	OMV Maintenance	Apr-18-2002	4 DAYS	Apr-21-2002
017AL110	OTV-A Arrival	Apr-22-2002	2 DAYS	Apr-23-2002
017AL120	OMV Maintenance	Apr-24-2002	4 DAYS	Apr-27-2002
017AL135	OTV-A Maintenance	Apr-28-2002	8 DAYS	May-05-2002
018ML050	Shuttle Arrival	May-02-2002	1 DAYS	May-02-2002
018ML055	Lunar Crew Arrival	May-03-2002	2 DAYS	May-04-2002
018ML060	Spares Offload	May-05-2002	2 DAYS	May-06-2002
018ML065	Lunar Flight Departure	May-07-2002	3 DAYS	May-09-2002
018ML070	OMV Maintenance	May-10-2002	4 DAYS	May-13-2002
018ML095	Lunar 30-Day Mission	May-10-2002	27 DAYS	Jun-05-2002
018ML080	OTV-A Arrival	May-13-2002	2 DAYS	May-14-2002
018ML075	Shuttle Departure	May-14-2002	2 DAYS	May-15-2002
018ML130	OTV-A Maintenance	May-15-2002	8 DAYS	May-22-2002
018ML090	OTV-A Storage	May-23-2002	1 DAYS	May-23-2002
018ML085	OMV Maintenance	May-24-2002	4 DAYS	May-27-2002
018ML100	Shuttle Arrival	May-28-2002	1 DAYS	May-28-2002
018ML105	Cargo Offload	May-29-2002	2 DAYS	May-30-2002
019AL005	Mission Systems Ready	Jun-01-2002	0 DAYS	May-31-2002
019AL015	HLLV Cargo/Tanker Prox O	Jun-01-2002	1 DAYS	Jun-01-2002
019AL010	Lunar Elements Storage	Jun-01-2002	10 DAYS	Jun-10-2002
019AL020	OMV Cargo/Tanker Retriev	Jun-02-2002	1 DAYS	Jun-02-2002
019AL025	Lunar Element Offload	Jun-03-2002	2 DAYS	Jun-04-2002
019AL030	Propellant Transfer	Jun-05-2002	2 DAYS	Jun-06-2002
018ML110	OTV-M Arrival	Jun-06-2002	2 DAYS	Jun-07-2002
019AL035	OMV HLLV C/T Disposal	Jun-07-2002	1 DAYS	Jun-07-2002
018ML115	Lunar Crew Return	Jun-08-2002	2 DAYS	Jun-09-2002
019AL040	OMV Maintenance	Jun-08-2002	4 DAYS	Jun-11-2002
018ML120	OMV Maintenance	Jun-10-2002	4 DAYS	Jun-13-2002
019AL045	Lunar Flight Preparation	Jun-12-2002	20 DAYS	Jul-01-2002
018ML125	Shuttle Departure	Jun-14-2002	2 DAYS	Jun-15-2002
018ML135	OTV-M Maintenance	Jun-16-2002	8 DAYS	Jun-23-2002
018ML140	PTM4 Maintenance	Jun-24-2002	8 DAYS	Jul-01-2002
020ML005	Mission Systems Ready	Jul-01-2002	0 DAYS	Jun-30-2002
020ML015	HLLV Cargo/Tanker Prox O	Jul-01-2002	1 DAYS	Jul-01-2002
020ML010	Lunar Elements Storage	Jul-01-2002	10 DAYS	Jul-10-2002
020ML020	OMV Cargo/Tanker Retriev	Jul-02-2002	1 DAYS	Jul-02-2002
019AL065	Lunar Flight Departure	Jul-02-2002	3 DAYS	Jul-04-2002
020ML025	Lunar Element Offload	Jul-03-2002	2 DAYS	Jul-04-2002
020ML030	Propellant Transfer	Jul-05-2002	2 DAYS	Jul-06-2002

Order: ES EF   Where: AN PRESENT

Figure 3.5-1 (3 of 4) Integrated STN Activity Support of the Flight Schedule Baseline

Activity Codes	Activity Description	Early Start	Duration (units)	Early Finish
019AL070	OMV Maintenance	Jul-05-2002	4 DAYS	Jul-08-2002
019AL095	Lunar Auto P/L Delivery	Jul-05-2002	17 DAYS	Jul-21-2002
020ML035	OMV HLLV C/T Disposal	Jul-07-2002	1 DAYS	Jul-07-2002
019AL080	OTV-A Arrival	Jul-08-2002	2 DAYS	Jul-09-2002
020ML040	OMV Maintenance	Jul-08-2002	4 DAYS	Jul-11-2002
019AL083	OTV-A Maintenance	Jul-10-2002	8 DAYS	Jul-17-2002
020ML045	Lunar Flight Preparation	Jul-12-2002	20 DAYS	Jul-31-2002
019AL085	OTV-A Storage	Jul-18-2002	1 DAYS	Jul-18-2002
019AL090	OMV Maintenance	Jul-19-2002	4 DAYS	Jul-22-2002
019AL110	OTV-A Arrival	Jul-23-2002	2 DAYS	Jul-24-2002
019AL120	OMV Maintenance	Jul-25-2002	4 DAYS	Jul-28-2002
019AL135	OTV-A Maintenance	Jul-29-2002	8 DAYS	Aug-05-2002
020ML050	Shuttle Arrival	Aug-01-2002	1 DAYS	Aug-01-2002
020ML055	Lunar Crew Arrival	Aug-02-2002	2 DAYS	Aug-03-2002
020ML060	Spares Offload	Aug-04-2002	2 DAYS	Aug-05-2002
020ML065	Lunar Flight Departure	Aug-06-2002	3 DAYS	Aug-08-2002
020ML070	OMV Maintenance	Aug-09-2002	4 DAYS	Aug-12-2002
020ML095	Lunar 30-Day Mission	Aug-09-2002	27 DAYS	Sep-04-2002
020ML080	OTV-A Arrival	Aug-12-2002	2 DAYS	Aug-13-2002
020ML075	Shuttle Departure	Aug-13-2002	2 DAYS	Aug-14-2002
020ML130	OTV-A Maintenance	Aug-14-2002	8 DAYS	Aug-21-2002
020ML090	OTV-A Storage	Aug-22-2002	1 DAYS	Aug-22-2002
020ML085	OMV Maintenance	Aug-23-2002	4 DAYS	Aug-26-2002
020ML100	Shuttle Arrival	Aug-27-2002	1 DAYS	Aug-27-2002
020ML105	Cargo Offload	Aug-28-2002	2 DAYS	Aug-29-2002
021AL005	Mission Systems Ready	Sep-01-2002	0 DAYS	Aug-31-2002
021AL015	HLLV Cargo/Tanker Prox O	Sep-01-2002	1 DAYS	Sep-01-2002
021AL010	Lunar Elements Storage	Sep-01-2002	10 DAYS	Sep-10-2002
021AL020	OMV Cargo/Tanker Retriev	Sep-02-2002	1 DAYS	Sep-02-2002
021AL025	Lunar Element Offload	Sep-03-2002	2 DAYS	Sep-04-2002
020ML110	OTV-M Arrival	Sep-05-2002	2 DAYS	Sep-06-2002
021AL030	Propellant Transfer	Sep-05-2002	2 DAYS	Sep-06-2002
021AL035	OMV HLLV C/T Disposal	Sep-07-2002	1 DAYS	Sep-07-2002
020ML115	Lunar Crew Return	Sep-07-2002	2 DAYS	Sep-08-2002
021AL040	OMV Maintenance	Sep-08-2002	4 DAYS	Sep-11-2002
020ML120	OMV Maintenance	Sep-09-2002	4 DAYS	Sep-12-2002
021AL045	Lunar Flight Preparation	Sep-12-2002	20 DAYS	Oct-01-2002
020ML125	Shuttle Departure	Sep-13-2002	2 DAYS	Sep-14-2002
020ML135	OTV-M Maintenance	Sep-15-2002	8 DAYS	Sep-22-2002
020ML140	PTM4 Maintenance	Sep-23-2002	8 DAYS	Sep-30-2002
022ML005	Mission Systems Ready	Oct-01-2002	0 DAYS	Sep-30-2002
022ML015	HLLV Cargo/Tanker Prox O	Oct-01-2002	1 DAYS	Oct-01-2002
022ML010	Lunar Elements Storage	Oct-01-2002	10 DAYS	Oct-10-2002
022ML020	OMV Cargo/Tanker Retriev	Oct-02-2002	1 DAYS	Oct-02-2002
021AL065	Lunar Flight Departure	Oct-02-2002	3 DAYS	Oct-04-2002
022ML025	Lunar Element Offload	Oct-03-2002	2 DAYS	Oct-04-2002
022ML030	Propellant Transfer	Oct-05-2002	2 DAYS	Oct-06-2002
021AL070	OMV Maintenance	Oct-05-2002	4 DAYS	Oct-08-2002
021AL095	Lunar Auto P/L Delivery	Oct-05-2002	17 DAYS	Oct-21-2002
022ML035	OMV HLLV C/T Disposal	Oct-07-2002	1 DAYS	Oct-07-2002
021AL080	OTV-A Arrival	Oct-08-2002	2 DAYS	Oct-09-2002
022ML040	OMV Maintenance	Oct-08-2002	4 DAYS	Oct-11-2002
021AL083	OTV-A Maintenance	Oct-10-2002	8 DAYS	Oct-17-2002
022ML045	Lunar Flight Preparation	Oct-12-2002	20 DAYS	Oct-31-2002
021AL085	OTV-A Storage	Oct-18-2002	1 DAYS	Oct-18-2002

Order: ES EF   Where: AN PRESENT

Figure 3.5-1 (4 of 4) Integrated STN Activity Support of the Flight Schedule Baseline

Activity Codes	Activity Description	Early Start	Duration (units)	Early Finish
021AL090	OMV Maintenance	Oct-19-2002	4 DAYS	Oct-22-2002
021AL110	OTV-A Arrival	Oct-23-2002	2 DAYS	Oct-24-2002
021AL120	OMV Maintenance	Oct-25-2002	4 DAYS	Oct-28-2002
021AL135	OTV-A Maintenance	Oct-29-2002	8 DAYS	Nov-05-2002
022ML050	Shuttle Arrival	Nov-01-2002	1 DAYS	Nov-01-2002
022ML055	Lunar Crew Arrival	Nov-02-2002	2 DAYS	Nov-03-2002
022ML060	Spares Offload	Nov-04-2002	2 DAYS	Nov-05-2002
022ML065	Lunar Flight Departure	Nov-06-2002	3 DAYS	Nov-08-2002
022ML070	OMV Maintenance	Nov-09-2002	4 DAYS	Nov-12-2002
022ML095	Lunar 30-Day Mission	Nov-09-2002	27 DAYS	Dec-05-2002
022ML080	OTV-A Arrival	Nov-12-2002	2 DAYS	Nov-13-2002
022ML075	Shuttle Departure	Nov-13-2002	2 DAYS	Nov-14-2002
022ML130	OTV-A Maintenance	Nov-14-2002	8 DAYS	Nov-21-2002
022ML090	OTV-A Storage	Nov-22-2002	1 DAYS	Nov-22-2002
022ML085	OMV Maintenance	Nov-23-2002	4 DAYS	Nov-26-2002
022ML100	Shuttle Arrival	Nov-27-2002	1 DAYS	Nov-27-2002
022ML105	Cargo Offload	Nov-28-2002	2 DAYS	Nov-29-2002
022ML110	OTV-M Arrival	Dec-06-2002	2 DAYS	Dec-07-2002
022ML115	Lunar Crew Return	Dec-08-2002	2 DAYS	Dec-09-2002
022ML120	OMV Maintenance	Dec-10-2002	4 DAYS	Dec-13-2002
022ML125	Shuttle Departure	Dec-14-2002	2 DAYS	Dec-15-2002
022ML135	OTV-M Maintenance	Dec-16-2002	8 DAYS	Dec-23-2002
022ML140	PTM4 Maintenance	Dec-24-2002	8 DAYS	Dec-31-2002

4.0 Source References

Figure 4.0-1 provides the list of sources and references for information and guidance required in the performance of this study.

Figure 4.0-1 (1 of 2) LEO Space Transportation Node List of References

1. National Space Transportation and Support Study, Civil Needs Database Version 3.0, Draft. Planning and Analysis of Advanced Programs, NASA Contract NASW-3921, General Research Corporation, July 16, 1987.

2. Alred, John W., Lunar Base Activities: An Overview. Advanced Programs Office, NASA Johnson Space Center, September 21, 1987.

3. Davidson, William. Eagle Engineering, Inc., Houston Division, (713) 338-2682.

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5. Turnaround Operations Analysis for OTV. Mid-term Progress Review Meeting at NASA-MSFC, NASA Contract NAS 8-36924, Report No. DR-3, General Dynamics, Space Systems Division, March 18, 1987.

6. Turnaround Operations Analysis for OTV. Progress Review Meeting at NASA-MSFC, NASA Contract NAS 8-36924, Report No. DR-3, General Dynamics, Space Systems Division, July 21, 1987.

7. Lunar Base Accommodation Study, Final Report. NASA-LaRC, June 18, 1987.

8. Impact of Lunar and Planetary Mission on the Space Station, Final Report. NASA Contract NAS9-17176, by Eagle Engineering, Inc., Houston Division, November 21, 1984.

9. Lunar Surface Operations, Table 4-6. Task 4.1 of the Lunar Systems Study, NASA Contract NAS9-17878, Report No. 87-172, Eagle Engineering, Inc., Houston Division, December 1, 1987.

10. JSC 31000 REV C, Space Station Projects Requirements Document. NASA Johnson Space Center, Space Station Projects Office, March 6, 1987.

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12. Simonds, Charles. Eagle Engineering, Inc., Houston Division, (713) 338-2682.

13. Orbital Transfer Vehicle Concept Definition and Systems Analysis Study, Final Report-Phase1, Volume 1 (Rev. A), Executive Summary. NASA Contract NAS8-36107, Report No: D180-29108-1, Boeing Aerospace Company, December 1986.

14. Stecklein, Jonette. Advanced Programs Office, NASA Johnson Space Center.

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Figure 4.0-1 (2 of 2) LEO Space Transportation Node List of References

16. Artemis Project Software Package. Metier Management Systems, Ltd., 1987.

17. User's Guide For Orbital Maneuvering Vehicle. NASA Marshall Space Flight Center, December 1986.

18. dBase III Plus Database Software Package. Ashton-Tate Company, 1986.

19. Maloney, John W. General Dynamics, Space Systems Division, (619) 547-7167.

20. Woodcock, Gordon R., Mission and Operations Modes for Lunar Basing. Boeing Aerospace Co., Huntsville, AL. Paper in Lunar Bases and Space Activities of the 21st Century. W.W. Mendell, Editor. Lunar and Planetary Institute, Houston, TX. 1985.

21. Lunar Lander Conceptual Design. NASA Contract NAS9-17878. Eagle Engineering, Inc. Report No. 88-181. March 31, 1988.

5.0 Assumptions and Groundrules

Figure 5.0-1 provides the list of assumptions as compiled during the performance of this study. Basically, the assumptions are information necessary to develop a LEO STN conceptual design, but which cannot be technically derived at this time. Therefore, in some cases it may be difficult to distinguish between an assumption and a requirement. Since the LEO STN conceptual design must satisfy both the assumptions and the requirements, a fine distinction between assumptions and requirements is not required or important. For documentation purposes the assumptions have been grouped under the categories of:

1.0 Program Definition
2.0 Vehicles
3.0 Operations
4.0 Schedule

Figure 5.0-1 (1 of 8) LEO Space Transportation Node List of Assumptions

1.01a Assembly of lunar space transportation vehicle components in low Earth orbit requires human presence and participation. That is, the assembly cannot be totally automated.
Prog Factor: Prog Def Ref: 3,2
Rationale: Current state of the art does not indicate feasibility.

1.01b The LEO space transportation node (STN) will be manned and it will operate independent of the Space Station.
Prog Factor: Prog Def Ref: 15
Rationale: Space Station environment requirements incompatible with STN.

1.02 The Lunar Orbit STN does not appear to be advantageous for the early lunar surface based program.
Prog Factor: Prog Def Ref: 1,15
Rationale: The Lunar Orbit STN will have advantages when lunar oxygen or lunar hydrogen can be produced. It would also be advantageous for a lunar orbit based program. Neither of these conditions apply for the studied timeframe.

1.03 There will not be an STN at any lunar libration point in the time period considered for the study.
Prog Factor: Prog Def Ref: 1,15
Rationale: There is no requirement for a STN at a lunar libration point in the time period considered.

1.04 All the transportation vehicles that will be used during this phase have been flight tested and operationally proven. Therefore, no flight test activities or support are included in this analysis.
Prog Factor: Prog Def Ref: 3
Rationale: The development of a flight test and verification program is beyond the scope of this study.

1.05 There are four lunar mission types to be supported by the LEO STN. They are:
Rationale: A representative but generic set of missions was desired to enable the study to be accomplished in the time allotted and to reduce the sensitivity of results to fluctuations in detail as project descriptions evolve.

1.05a A = Automated flight to moon and one way delivery to lunar surface. The LEO STN departure configuration is OTV-OTV-P/L-EL. Both the OTV's will return to the LEO STN.
Ref: 1,9

1.05b M14 = A 14-day Manned mission from LEO to lunar surface and return. The LEO STN departure configuration is OTV-OTV-PTM-EA-EL. Both the OTV's and the PTM will return to the LEO STN.
Ref: 1,9

Figure 5.0-1 (2 of 8) LEO Space Transportation Node List of Assumptions

1.05c M30 = A 30-day Manned mission from LEO to lunar surface and return. The LEO STN departure configuration is OTV-OTV-PTM-EA-EL. Both the OTV's and the PTM will return to the LEO STN.

Ref: 1,9

1.05d M186 = A 186-day Manned mission from LEO to lunar surface and return. The LEO STN departure configuration is OTV-OTV-PTM-EA-EL. Both the OTV's will return to the LEO STN. The second OTV will return to the LEO STN 30-days after deploying the PTM. This PTM will return to the LEO STN on the OTV of a future delivery mission.

Ref: 1,3,9

1.06 A provision will be implemented to insure that a lunar crew always has the capability to be retrieved, to return to Earth, or to return to a safe LEO facility. This study assumes that an OTV will be maintained in a status ready to return lunar crew to the LEO STN.

Prog Factor: Prog Def — Ref: 14

Rationale: Crew safety is first priority.

1.07 The space-based transportation vehicles require protection from solar radiation, space debris, and micrometeoroids while stored in the space environment.

Prog Factor: Prof Def — Ref: 5

Rationale: The vehicles are reusable and it is not economically sound to expose the equipment to degrading factors when not in use if cost effective protection can be provided.

1.08 Three annual flight schedule models are supported by the LEO STN.

Month:	1	2	3	4	5	6	7	8	9	10	11	12
14-Day:	A		M			A		M			A	
30-Day:	A	M		A	M		A	M		A	M	
186-Day:	A	M		A	M		A	M		A	M	

Prog Factor: Prof Def — Ref: 9,3

Rationale: Summarized from available information.

1.09 A steady state program is being supported where all necessary vehicles are placed in space by 1999.

Prog Factor: Prog Def — Ref: 3

Rationale: The development of the program infrastructure implementation and buildup is beyond the scope of this study.

1.10 Plans and requirements are based on nominal missions. Abort issues and plans have not been considered.

Prog Factor: Prog Def — Ref: 3

Rationale: The analysis and synthesis of failure modes and risks are beyond the scope of this study.

1.11a 90 metric tons of propellant (78 LO2 & 12 LH2) are delivered from Earth in a dedicated tanker by a Heavy Lift Launch Vehicle (HLLV). The HLLV configuration could be any one of the numerous designs currently under study in the industry. The propellant is transferred from the tanker to the LEO STN propellant depot. The propellant is subsequently transferred to space-based vehicles.
Prog Factor: Prog Def Ref: 7
Rationale: It has been assumed that propellant transfer will be more cost effective than tankage exchange for a continuing, extensive program of reusable vehicles.

1.11b The E-Lander, E-Ascent, and Lunar Payload are delivered to the LEO STN by a HLLV in combination with the propellant delivery.
Prog Factor: Prog Def Ref: 4,14,3
Rationale: The capacity is available and a single rendezvous and retrieval is preferred over multiple retrievals.

1.11c The HLLV delivers 55 metric tons of propellant (48 LO2 & 7 LH2) when combined with delivery of a 35 MT lunar landing package.
Prog Factor: Prog Def Ref: 15
Rationale: 55 metric tons is the approximate capacity remaining in the HLLV payload after including the lunar landing package.

1.12 LEO STN crew rotation is assumed to occur on the Shuttle lunar crew transport flights. When the lunar crew is delivered from Earth, STN crew personnel will ride on the Shuttle return to Earth. When the Shuttle arrives to meet the lunar crew returning from the Moon, STN crew personnel will come from Earth with the Shuttle.
Prog Factor: Prog Def Ref: 3
Rationale: This busing approach makes effective use of the Shuttle and relieves the requirement for an unproductive Shuttle wait in orbit. On the 1st flight, the departing lunar crew rides up and the rotating STN crew rides down. On the 2nd flight, the rotating STN crew rides up and the returning lunar crew rides down.

1.13 The Shuttle is operated by a crew of three when transporting the lunar crew of four personnel.
Prog Factor: Prog Def Ref: 3
Rationale: It is assumed that a commander, pilot, and cargo master (RMS operator) are required.

2.01 The overall baseline scenario lunar vehicles are outlined in the CNDB Option III. Additional details or exceptions are noted in other assumptions.
Prog Factor: Vehicles Ref: 1
Rationale: Specified by study directive.

2.02 The LEO STN will have a tank-to-tank propellant transfer system.
Prog Factor: Vehicles Ref: 4
Rationale: It has been assumed that propellant transfer will be more cost effective than tankage exchange for a continuing, extensive program of reusable vehicles.

Figure 5.0-1 (4 of 8) LEO Space Transportation Node List of Assumptions

2.03 The Orbital Transfer Vehicle (OTV) is reused on Earth-moon flights up to 40 times.

Prog Factor: Vehicles Ref: 5

Rationale: 40 reuses of a space vehicle maintained in space is a large number. The number of practical reuses incorporated in the planning for program funding requires careful OTV vehicle analysis and a prudent consideration of the Space Shuttle program experience. The derivation of the number of vehicle reuses is beyond the scope of this study. In this initial STN requirements study, the number of reuses has not been a direct factor.

2.04 The 4-crew Personnel Transfer Module (PTM) will transfer from the OTV to the E-Lander for the landing phase of the mission and from the E-Ascent Vehicle to the OTV for the Earth return phase.

Prog Factor: Vehicles Ref: 1

Rationale: Using the PTM4 for the cislunar transportation crew module as well as the lunar lander crew module reduces the number of modules required and results in a more productive payload in terms of the percent of the OTV capacity which is used on the lunar surface.

2.05 The 4-crew PTM is reused on Earth-moon flights up to 40 times.

Prog Factor: Vehicles Ref: 3

Rationale: 40 reuses of a space vehicle maintained in space is a large number. The number of practical reuses incorporated in the planning for program funding requires careful PTM4 vehicle analysis and a prudent consideration of the Space Shuttle program experience. The derivation of the number of vehicle reuses is beyond the scope of this study. In this initial STN requirements study, the number of reuses has not been a direct factor.

2.06 The OTV has an in-mission standby time of 180 days during missions in lunar orbit.

Prog Factor: Vehicles Ref: 3

Rationale: The OTV could be required to wait in lunar orbit up to 180 days for the return of the lunar crew to lunar orbit for transfer to the Earth.

2.07 The LEO STN will be implemented using Space Station technology and systems.

Prog Factor: Vehicles Ref: 3

Rationale: The Space Station technology will be available, demonstrated, and capable. The same systems should be used for reasons of economy, commonality, and maintainability.

2.08 The OTV is designed according to the following criteria:

Prog Factor: Vehicles Ref: 5

2.08a Flight systems designed with built-in test equipment and automated checkout operation.

Prog Factor: Vehicles Ref: 5

Rationale: Automation use enables a smaller, in-orbit crew size.

Figure 5.0-1 (5 of 8) LEO Space Transportation Node List of Assumptions

2.08b Flight hardware to be under continuous self-check.
Prog Factor: Vehicles Ref: 5
Rationale: Automation use enables a smaller, in-orbit crew size.

2.08c Automated fault detection/fault isolation to ORU level.
Prog Factor: Vehicles Ref: 5
Rationale: Automation use enables a smaller, in-orbit crew size.

2.08d Standard interfaces between vehicles.
Prog Factor: Vehicles Ref: 5
Rationale: Standard vehicle interfaces reduce training requirements, spares provisioning, and data systems complexity.

2.08e Provide enough access to remove and replace ORU's.
Prog Factor: Vehicles Ref: 5
Rationale: ORU's are not feasible or productive if inadequate room to work is not provided.

2.08f No ORU's need to be removed to replace a fault except the debris protection and aerobrake.
Prog Factor: Vehicles Ref: 5
Rationale: For safety and productivity reasons, maintenance items must be accessible without removing other equipment. This approach is not practical with the major structural items designed to degrade in use such as the aerobrake and debris shield.

2.09 The OMV can handle the retrieval of the mass of a returning OTV/PTM-4/Payload (11.2 MT) and a propellant delivery vehicle (91 MT).
Prog Factor: Vehicles Ref: 7
Rationale: This capability is required, appears to be feasible, and study resources are not available to provide a technical derivation.

2.10 The OMV will be used as a space tug for nominal retrieval of arriving vehicles and for contingency handling of non-functioning deployed vehicles.
Prog Factor: Vehicles Ref: 7
Rationale: This is the function for which the OMV is designed.

2.11a The E-Lander, E-Ascent, and lunar payload arrive at the LEO STN stacked, checked out, and ready to fly except for propellant top-off and total lunar spacecraft integrated test and verification.
Prog Factor: Vehicles Ref: 3
Rationale: The prepackaged and tested approach is feasible and reduces crew size and expensive checkout activity in space.

2.11b The E-Lander and Lunar Cargo arrive at the LEO STN stacked, checked out, and ready to fly except for propellant top-off and total lunar spacecraft integrated test and verification.
Prog Factor: Vehicles Ref: 3
Rationale: The prepackaged and tested approach is feasible and reduces crew size and expensive checkout activity in space.

2.12 The Extravehicular Excursion Unit shall provide support for free-flying proximity operations around the STN out to at least a 300-meter (984-foot) distance.
Prog Factor: Vehicles Ref: 10
Rationale: 300 meters is a sufficient distance to maneuver around the largest vehicle considered and is a feasible free-flying distance.

2.13 A LO2/LH2 mixture ratio of 7 is assumed.
Prog Factor: Vehicles Ref: 8
Rationale: A mixture ratio between 6 and 7 is commonly used and 7 was used in the quoted reference.

3.01 The Lunar Mission transfer window is a significant factor which must be considered in future tasks. However, windows have not been determined and included in the STN requirements task.
Prog Factor: Ops Ref: 15,4
Rationale: The planning and analysis of mission profiles and trajectories is beyond the scope of this study.

3.02a LEO prelaunch operations, launch control, and STN rendezvous are managed by Earth-based mission control with STN acting as on-site action operators.
Prog Factor: Ops Ref: 6
Rationale: Work should be allocated to the site where the best ability resides and which is most cost effective. Large numbers of personnel and facilities can be afforded on Earth. Manipulation of some sensitive or difficult to instrument activities are best accomplished at the physical site of the action.

3.02b The LEO STN will provide operations control of all approach and proximity operations.
Prog Factor: Ops Ref: 3
Rationale: Final vehicle approach and closure is best observed at the STN and control can be more direct. In addition, results of improper action will most immediately impact the STN.

3.03 OTV turnaround tasks will be accomplished using teleoperations except when servicing the Aerobrake Thermal Protection System where EVA activities will be prime.
Prog Factor: Ops Ref: 5
Rationale: EVA activity is more hazardous and expensive than IVA activity. Teleoperation and robotics are to be used where human's unique abilities are not required or cost effective.

3.04 Extravehicular Activities (EVA) will adhere to the following constraints:
Prog Factor: Ops Ref:

3.04a Productive EVA operations (where productive EVA is defined as the time between completion of hatch egress to beginning of hatch ingress) will not exceed 8 hours per day per crewmember.
Prog Factor: Ops Ref: 10
Rationale: Same as Space Station requirement.

3.04b Scheduled EVA operations shall not exceed 8 hours per week per crewmember.
Prog Factor: Ops Ref: 10
Rationale: Same as Space Station requirement.

3.04c The STN will provide the capability for the simultaneous EVA of four crewmembers.
Prog Factor: Ops Ref: 10
Rationale: An EVA activity must always have at least two crew involved to provide a buddy system for safety. The STN is a EVA-intensive facility and must be prepared to provide emergency support to an ongoing EVA activity. Therefore, a four-EVA capability is the minimum capacity acceptable.

3.04d An Extravehicular operation will require a minimum of 2 crewmembers involved in EVA and a intravehicular crewmember dedicated to EVA support.
Prog Factor: Ops Ref: 3,5,11
Rationale: Any EVA activity requires constant monitoring from inside the STN for purposes of safety and work assistance.

3.05 A Shuttle will deliver the lunar crew to the LEO STN after the lunar transportation vehicle has successfully completed IT&V. The Shuttle will remain at the LEO STN until the lunar crew has successful translunar injection.
Prog Factor: Ops Ref: 3
Rationale: The STN must be prepared for the occasion of a non-functioning OTV stack. In this event, the lunar crew needs a ride back to Earth. Holding the Shuttle for several days is cost effective.

3.06 A lunar crew recovery Shuttle will launch for the LEO STN after the lunar crew has successful transearth injection.
Prog Factor: Ops Ref: 3
Rationale: Until it is certain that the lunar crew is in transearth flight, the prepared Shuttle will be held in readiness on Earth. This will prevent an unnecessary long wait in earth orbit or even an wasted flight if the lunar crew is delayed longer than the Shuttle waiting ability in earth orbit.

3.07 EVA of two crewmembers in a service team is required for discrepancy support of lunar vehicle stacking, mating, and IT&V; for OTV aerobrake TPS repairs; and for unscheduled STN maintenance.
Prog Factor: Ops Ref: 3
Rationale: This capability appears to be required, is feasible, and study resources are not available to provide a technical derivation.

3.08 Two STN crew are assumed to participate with Earth mission control in the rendezvous of the Tanker/Cargo with the LEO STN.
Prog Factor: Ops Ref: 3
Rationale: This capability appears to be required, is feasible, and study resources are not available to provide a technical derivation.

3.09 An EVA event is assumed to be one person performing EVA work for eight hours.
Prog Factor: Ops Ref: 3
Rationale: This is a study defined term.

Figure 5.0-1 (of 8) LEO Space Transportation Node List of Assumptions

3.10 The NSTS Shuttle will have the operations support capacity to provide the STN support implied by the STN mission and schedule baseline.

Prog Factor: Ops Ref: 3

Rationale: A NSTS Shuttle flight traffic load analysis will be required to determine the actual Shuttle operations support capacity and availability. The derivation of this potential support capacity is beyond the scope of this study. In this initial STN requirements study, the Shuttle has been assumed to be available and has not been a direct factor.

3.11 There are no crew holidays during a mission tour of duty. Work is accomplished seven days a week.

Prog Factor: Ops Ref: 3

Rationale: STN operations crew time in orbit is too valuable to set aside 14 percent for nonproductive time. The crew would be amply compensated during off time on Earth. This is standard operating procedure in difficult operating environments on Earth.

4.01 The Advanced Space Transportation System (ASTS) study spans the years 1999 through 2005.

Prog Factor: Schedule Ref: 2

Rationale: Specified by study directive.

4.02 The assumed mission servicing activity resource requirements are specified in Figures 3.4-3 and Figure 3.4-5.

Prog Factor: Schedule Ref: 3

Rationale: Generic summary of support activities based on common industry experience and standard practices.

6.0 STN Requirements

The requirements are recorded in the requirements data base as they are identified. As previously discussed, the requirements are organized by the WBS structure.

6.1 Vehicle and Mission Requirements Assessment

The initial requirements were identified by the nature of the environment (orbital mechanics, materials, existing NASA procedural rules, space environment, etc.) in which the LEO STN must exist. Many of these requirements are the same or similar to the Space Station and, therefore, have been taken directly from the Space Station experience. Other requirements have been identified by analysis of the transportation node mission services to be provided. Mission services requirements were identified and recorded in the requirements data base as the vehicles and missions baselines were developed in Section 3.0.

6.2 Schedule Load Requirements Assessment

Finally, the requirements imposed by the impact of supporting the load of a full, busy annual schedule of lunar operations are identified. The schedule load requirements are the result of combining the overlapping transportation servicing activities according to the schedule of Figure 3.5-1. The ARTEMIS tool is used to accomplish the resource load analysis.

6.2.1 EVA

An EVA event is assumed to be one person performing EVA work for eight hours. Figure 6.2.1-1 is an ARTEMIS record of requirements for EVA events on a daily basis for each day and for cumulative events. Although four EVA events occur on only two days (07-12-2002 and 10-02-2002), the requirement is to have the capability to support four simultaneous EVA events. The four-EVA-event requirement is necessary since a two-EVA-event capability would be marginal and the lunar windows will not adjust for potential infrequent lack of EVA capability. In addition, the requirement enhances safety and could enable EVA rescue of a disabled EVA team. More normal two-EVA-event days occur approximately 20 percent of the STN days. The EVA schedule load indicates that a total of 72 two-man EVA's occur in 2002 requiring 1152 EVA hours. The airlocks are required to support nine EVA passages in a 30-day period.

6.2.2 Hanger

Figure 6.2.2-1 is a histogram indicating the daily hanger volume requirements in cubic meters. It should be noted that these requirements do not include unproductive volume. That is, the volume requirement is the simple total of the volume of the individual vehicle stacks to be hangered. It is estimated that the actual volume implemented would be twice the amount of the simple measured vehicle total. The histogram format is primarily useful for observing the peaks and averages in an analog view. The peaks for hanger volume in early April and July are a minor modelling anomaly and can be ignored. The requirements for all of the vehicle and STN resources analyzed are included in Figure 6.2.2-2. A review of the figure indicates that the Hanger is required to have the capacity to accommodate two (2) OMV's, four (4) OTV's, one (1) PTM-4, two (2) E-Landers, one (1) E-Ascent, and one (1) Lunar Surface Cargo. The volume appears different since the space taken by the vehicles varies depending on whether they are separate or stacked.

6.2.3 Habitation Capacity

The crew resource data in Figure 6.2.2-2 has been analyzed to determine the habitation capacity required in the LEO STN. The results indicate that support for a regular STN crew of six is required for 15 percent of the year. For another 40 percent of the annual days an STN crew of four operate in the facility. When the Shuttle with a three-man crew transports the four-man lunar crew, the total residents on the LEO STN increase to nine for 14 days with several days of 13 personnel including the lunar crew.

6.2.4 Propellant Storage Requirement

A HLLV is assumed to deliver 55 metric tons of propellant (48 MT of LO2 and 7 MT of LH2) when combined with delivery of a 35 metric ton lunar landing package. The E-Lander is delivered fully fueled. Therefore, 384 MT of LO2 and 56 MT of LH2 are delivered and pumped into the LEO STN propellant depot by the HLLV/E-Lander transport flights Not including boiloff, 480 MT of LO2 and 70 MT of LH2 must be pumped into OTV's at the LEO STN for lunar flights in 2002. Based on the above, additional propellant must be delivered to the LEO STN. It is assumed that a dedicated HLLV tanker can deliver 78 MT of LO2 and 12 MT of LH2. The use of one dedicated HLLV tanker and one additional HLLV/Cargo Tanker provides a total propellant delivery to the LEO STN of 510 MT of LO2 and 75 MT of LH2 in 2002.

The LEO STN propellant depot requirements are to store sufficient propellant to fuel two lunar departure stacks plus one additional OTV plus approximately 10 percent for losses. This requirement results in storage facilities for 160 MT of LO2 and 24 MT of LH2. This storage capacity is compatible with the delivery capability of two full HLLV tankers (156 MT of LO2 and 24 MT of LH2.)

6.2.5 STN Crew Rotation

LEO STN crew rotation is assumed to occur on the Shuttle lunar crew transport flights. When the lunar crew is delivered from Earth, STN crew ride on the Shuttle back to Earth. When the Shuttle arrives to meet the lunar crew returning from the Moon, STN crew personnel come from Earth with the Shuttle.

6.2.6 OTV Maintenance

The basis for OTV maintenance is the work of General Dynamics Space Systems Division (references 5 and 6) in the 1987 study "Turnaround Analysis for OTV." The work was reviewed in some detail and appears to be well founded. Telephone contact was established with Mr. John Maloney of General Dynamics (Reference 19) and additional detail obtained on turnaround activities. Based on this investigation and due to the constraints of time, no additional OTV maintenance detail was developed by Eagle Engineering. As the task study was ending, a 1986 Boeing Aerospace Company titled "OTV Concept Definition and Systems Analysis Study" (reference 13) was obtained. The Boeing study appears to be very useful also but was obtained too late for application in this effort.

6.3 LEO STN List of Requirements

The LEO STN requirements which were been developed and stored in the requirements data base have been printed from the dBASE THREE PLUS program (reference 18) and are included as Figure 6.3-1.

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Figure 6.2.1-1 (1 of 8) **Schedule Load Requirements for EVA Events**

Period	<----------	This Period	---------->		<---------	Cumulative	---------	
Start	Req'd	Avail.	Over	Under	Req'd	Avail.	Over	Under
Resource: CREW-EVA								
Dec-01-2001	0	4		4	0	4	0	4
Dec-02-2001	0	4		4	0	8	0	8
Dec-03-2001	0	4		4	0	12	0	12
Dec-04-2001	0	4		4	0	16	0	16
Dec-05-2001	0	4		4	0	20	0	20
Dec-06-2001	0	4		4	0	24	0	24
Dec-07-2001	0	4		4	0	28	0	28
Dec-08-2001	0	4		4	0	32	0	32
Dec-09-2001	0	4		4	0	36	0	36
Dec-10-2001	0	4		4	0	40	0	40
Dec-11-2001	0	4		4	0	44	0	44
Dec-12-2001	2	4		2	2	48	0	46
Dec-13-2001	2	4		2	4	52	0	48
Dec-14-2001	2	4		2	6	56	0	50
Dec-15-2001	0	4		4	6	60	0	54
Dec-16-2001	0	4		4	6	64	0	58
Dec-17-2001	0	4		4	6	68	0	62
Dec-18-2001	0	4		4	6	72	0	66
Dec-19-2001	0	4		4	6	76	0	70
Dec-20-2001	0	4		4	6	80	0	74
Dec-21-2001	0	4		4	6	84	0	78
Dec-22-2001	0	4		4	6	88	0	82
Dec-23-2001	0	4		4	6	92	0	86
Dec-24-2001	0	4		4	6	96	0	90
Dec-25-2001	0	4		4	6	100	0	94
Dec-26-2001	0	4		4	6	104	0	98
Dec-27-2001	0	4		4	6	108	0	102
Dec-28-2001	0	4		4	6	112	0	106
Dec-29-2001	0	4		4	6	116	0	110
Dec-30-2001	0	4		4	6	120	0	114
Dec-31-2001	0	4		4	6	124	0	118
Jan-01-2002	0	4		4	6	128	0	122
Jan-02-2002	0	4		4	6	132	0	126
Jan-03-2002	0	4		4	6	136	0	130
Jan-04-2002	0	4		4	6	140	0	134
Jan-05-2002	0	4		4	6	144	0	138
Jan-06-2002	0	4		4	6	148	0	142
Jan-07-2002	0	4		4	6	152	0	146
Jan-08-2002	0	4		4	6	156	0	150
Jan-09-2002	2	4		2	8	160	0	152
Jan-10-2002	2	4		2	10	164	0	154
Jan-11-2002	2	4		2	12	168	0	156
Jan-12-2002	2	4		2	14	172	0	158
Jan-13-2002	2	4		2	16	176	0	160
Jan-14-2002	2	4		2	18	180	0	162
Jan-15-2002	0	4		4	18	184	0	166
Jan-16-2002	0	4		4	18	188	0	170
Jan-17-2002	0	4		4	18	192	0	174
Jan-18-2002	0	4		4	18	196	0	178
Jan-19-2002	0	4		4	18	200	0	182
Jan-20-2002	0	4		4	18	204	0	186
Jan-21-2002	0	4		4	18	208	0	190
Jan-22-2002	0	4		4	18	212	0	194

Order: RES NP Where: RES="CREW-EVA"

Figure 6.2.1-1 (2 of 8) Schedule Load Requirements for EVA Events

Period	<---------- This Period			---------->	<---------- Cumulative			----------
Start	Req'd	Avail.	Over	Under	Req'd	Avail.	Over	Under
Resource: CREW-EVA								
Jan-23-2002	0	4		4	18	216	0	198
Jan-24-2002	0	4		4	18	220	0	202
Jan-25-2002	0	4		4	18	224	0	206
Jan-26-2002	0	4		4	18	228	0	210
Jan-27-2002	0	4		4	18	232	0	214
Jan-28-2002	2	4		2	20	236	0	216
Jan-29-2002	2	4		2	22	240	0	218
Jan-30-2002	2	4		2	24	244	0	220
Jan-31-2002	0	4		4	24	248	0	224
Feb-01-2002	0	4		4	24	252	0	228
Feb-02-2002	0	4		4	24	256	0	232
Feb-03-2002	0	4		4	24	260	0	236
Feb-04-2002	0	4		4	24	264	0	240
Feb-05-2002	0	4		4	24	268	0	244
Feb-06-2002	0	4		4	24	272	0	248
Feb-07-2002	0	4		4	24	276	0	252
Feb-08-2002	0	4		4	24	280	0	256
Feb-09-2002	0	4		4	24	284	0	260
Feb-10-2002	0	4		4	24	288	0	264
Feb-11-2002	0	4		4	24	292	0	268
Feb-12-2002	0	4		4	24	296	0	272
Feb-13-2002	0	4		4	24	300	0	276
Feb-14-2002	2	4		2	26	304	0	278
Feb-15-2002	2	4		2	28	308	0	280
Feb-16-2002	2	4		2	30	312	0	282
Feb-17-2002	0	4		4	30	316	0	286
Feb-18-2002	0	4		4	30	320	0	290
Feb-19-2002	0	4		4	30	324	0	294
Feb-20-2002	0	4		4	30	328	0	298
Feb-21-2002	0	4		4	30	332	0	302
Feb-22-2002	0	4		4	30	336	0	306
Feb-23-2002	0	4		4	30	340	0	310
Feb-24-2002	0	4		4	30	344	0	314
Feb-25-2002	0	4		4	30	348	0	318
Feb-26-2002	0	4		4	30	352	0	322
Feb-27-2002	0	4		4	30	356	0	326
Feb-28-2002	0	4		4	30	360	0	330
Mar-01-2002	0	4		4	30	364	0	334
Mar-02-2002	0	4		4	30	368	0	338
Mar-03-2002	0	4		4	30	372	0	342
Mar-04-2002	0	4		4	30	376	0	346
Mar-05-2002	0	4		4	30	380	0	350
Mar-06-2002	0	4		4	30	384	0	354
Mar-07-2002	0	4		4	30	388	0	358
Mar-08-2002	0	4		4	30	392	0	362
Mar-09-2002	0	4		4	30	396	0	366
Mar-10-2002	0	4		4	30	400	0	370
Mar-11-2002	0	4		4	30	404	0	374
Mar-12-2002	2	4		2	32	408	0	376
Mar-13-2002	2	4		2	34	412	0	378
Mar-14-2002	2	4		2	36	416	0	380
Mar-15-2002	0	4		4	36	420	0	384
Mar-16-2002	0	4		4	36	424	0	388

Order: RES NP Where: RES="CREW-EVA"

Figure 6.2.1-1 (3 of 8) Schedule Load Requirements for EVA Events

Period Start	This Period Req'd	This Period Avail.	This Period Over	This Period Under	Cumulative Req'd	Cumulative Avail.	Cumulative Over	Cumulative Under
Resource: CREW-EVA								
Mar-17-2002	0	4		4	36	428	0	392
Mar-18-2002	2	4		2	38	432	0	394
Mar-19-2002	2	4		2	40	436	0	396
Mar-20-2002	2	4		2	42	440	0	398
Mar-21-2002	0	4		4	42	444	0	402
Mar-22-2002	0	4		4	42	448	0	406
Mar-23-2002	0	4		4	42	452	0	410
Mar-24-2002	0	4		4	42	456	0	414
Mar-25-2002	0	4		4	42	460	0	418
Mar-26-2002	0	4		4	42	464	0	422
Mar-27-2002	0	4		4	42	468	0	426
Mar-28-2002	0	4		4	42	472	0	430
Mar-29-2002	0	4		4	42	476	0	434
Mar-30-2002	0	4		4	42	480	0	438
Mar-31-2002	0	4		4	42	484	0	442
Apr-01-2002	0	4		4	42	488	0	446
Apr-02-2002	0	4		4	42	492	0	450
Apr-03-2002	0	4		4	42	496	0	454
Apr-04-2002	0	4		4	42	500	0	458
Apr-05-2002	0	4		4	42	504	0	462
Apr-06-2002	0	4		4	42	508	0	466
Apr-07-2002	0	4		4	42	512	0	470
Apr-08-2002	0	4		4	42	516	0	474
Apr-09-2002	2	4		2	44	520	0	476
Apr-10-2002	2	4		2	46	524	0	478
Apr-11-2002	2	4		2	48	528	0	480
Apr-12-2002	2	4		2	50	532	0	482
Apr-13-2002	2	4		2	52	536	0	484
Apr-14-2002	2	4		2	54	540	0	486
Apr-15-2002	0	4		4	54	544	0	490
Apr-16-2002	0	4		4	54	548	0	494
Apr-17-2002	0	4		4	54	552	0	498
Apr-18-2002	0	4		4	54	556	0	502
Apr-19-2002	0	4		4	54	560	0	506
Apr-20-2002	0	4		4	54	564	0	510
Apr-21-2002	0	4		4	54	568	0	514
Apr-22-2002	0	4		4	54	572	0	518
Apr-23-2002	0	4		4	54	576	0	522
Apr-24-2002	0	4		4	54	580	0	526
Apr-25-2002	0	4		4	54	584	0	530
Apr-26-2002	0	4		4	54	588	0	534
Apr-27-2002	0	4		4	54	592	0	538
Apr-28-2002	2	4		2	56	596	0	540
Apr-29-2002	2	4		2	58	600	0	542
Apr-30-2002	2	4		2	60	604	0	544
May-01-2002	0	4		4	60	608	0	548
May-02-2002	0	4		4	60	612	0	552
May-03-2002	0	4		4	60	616	0	556
May-04-2002	0	4		4	60	620	0	560
May-05-2002	0	4		4	60	624	0	564
May-06-2002	0	4		4	60	628	0	568
May-07-2002	0	4		4	60	632	0	572
May-08-2002	0	4		4	60	636	0	576

Order: RES NP   Where: RES="CREW-EVA"

Figure 6.2.1-1 (4 of 8) Schedule Load Requirements for EVA Events

Period	<---------- This Period			----------><----------	Cumulative			----------
Start	Req'd	Avail.	Over	Under	Req'd	Avail.	Over	Under
Resource: CREW-EVA								
May-09-2002	0	4		4	60	640	0	580
May-10-2002	0	4		4	60	644	0	584
May-11-2002	0	4		4	60	648	0	588
May-12-2002	0	4		4	60	652	0	592
May-13-2002	0	4		4	60	656	0	596
May-14-2002	0	4		4	60	660	0	600
May-15-2002	2	4		2	62	664	0	602
May-16-2002	2	4		2	64	668	0	604
May-17-2002	2	4		2	66	672	0	606
May-18-2002	0	4		4	66	676	0	610
May-19-2002	0	4		4	66	680	0	614
May-20-2002	0	4		4	66	684	0	618
May-21-2002	0	4		4	66	688	0	622
May-22-2002	0	4		4	66	692	0	626
May-23-2002	0	4		4	66	696	0	630
May-24-2002	0	4		4	66	700	0	634
May-25-2002	0	4		4	66	704	0	638
May-26-2002	0	4		4	66	708	0	642
May-27-2002	0	4		4	66	712	0	646
May-28-2002	0	4		4	66	716	0	650
May-29-2002	0	4		4	66	720	0	654
May-30-2002	0	4		4	66	724	0	658
May-31-2002	0	4		4	66	728	0	662
Jun-01-2002	0	4		4	66	732	0	666
Jun-02-2002	0	4		4	66	736	0	670
Jun-03-2002	0	4		4	66	740	0	674
Jun-04-2002	0	4		4	66	744	0	678
Jun-05-2002	0	4		4	66	748	0	682
Jun-06-2002	0	4		4	66	752	0	686
Jun-07-2002	0	4		4	66	756	0	690
Jun-08-2002	0	4		4	66	760	0	694
Jun-09-2002	0	4		4	66	764	0	698
Jun-10-2002	0	4		4	66	768	0	702
Jun-11-2002	0	4		4	66	772	0	706
Jun-12-2002	2	4		2	68	776	0	708
Jun-13-2002	2	4		2	70	780	0	710
Jun-14-2002	2	4		2	72	784	0	712
Jun-15-2002	0	4		4	72	788	0	716
Jun-16-2002	2	4		2	74	792	0	718
Jun-17-2002	2	4		2	76	796	0	720
Jun-18-2002	2	4		2	78	800	0	722
Jun-19-2002	0	4		4	78	804	0	726
Jun-20-2002	0	4		4	78	808	0	730
Jun-21-2002	0	4		4	78	812	0	734
Jun-22-2002	0	4		4	78	816	0	738
Jun-23-2002	0	4		4	78	820	0	742
Jun-24-2002	0	4		4	78	824	0	746
Jun-25-2002	0	4		4	78	828	0	750
Jun-26-2002	0	4		4	78	832	0	754
Jun-27-2002	0	4		4	78	836	0	758
Jun-28-2002	0	4		4	78	840	0	762
Jun-29-2002	0	4		4	78	844	0	766
Jun-30-2002	0	4		4	78	848	0	770

Order: RES NF   Where: RES="CREW-EVA"

Figure 6.2.1-1 (5 of 8) Schedule Load Requirements for EVA Events

Period Start	This Period Req'd	This Period Avail.	This Period Over	This Period Under	Cumulative Req'd	Cumulative Avail.	Cumulative Over	Cumulative Under
Resource: CREW-EVA								
Jul-01-2002	0	4		4	78	852	0	774
Jul-02-2002	0	4		4	78	856	0	778
Jul-03-2002	0	4		4	78	860	0	782
Jul-04-2002	0	4		4	78	864	0	786
Jul-05-2002	0	4		4	78	868	0	790
Jul-06-2002	0	4		4	78	872	0	794
Jul-07-2002	0	4		4	78	876	0	798
Jul-08-2002	0	4		4	78	880	0	802
Jul-09-2002	0	4		4	78	884	0	806
Jul-10-2002	2	4		2	80	888	0	808
Jul-11-2002	2	4		2	82	892	0	810
Jul-12-2002	4	4			86	896	0	810
Jul-13-2002	2	4		2	88	900	0	812
Jul-14-2002	2	4		2	90	904	0	814
Jul-15-2002	0	4		4	90	908	0	818
Jul-16-2002	0	4		4	90	912	0	822
Jul-17-2002	0	4		4	90	916	0	826
Jul-18-2002	0	4		4	90	920	0	830
Jul-19-2002	0	4		4	90	924	0	834
Jul-20-2002	0	4		4	90	928	0	838
Jul-21-2002	0	4		4	90	932	0	842
Jul-22-2002	0	4		4	90	936	0	846
Jul-23-2002	0	4		4	90	940	0	850
Jul-24-2002	0	4		4	90	944	0	854
Jul-25-2002	0	4		4	90	948	0	858
Jul-26-2002	0	4		4	90	952	0	862
Jul-27-2002	0	4		4	90	956	0	866
Jul-28-2002	0	4		4	90	960	0	870
Jul-29-2002	2	4		2	92	964	0	872
Jul-30-2002	2	4		2	94	968	0	874
Jul-31-2002	2	4		2	96	972	0	876
Aug-01-2002	0	4		4	96	976	0	880
Aug-02-2002	0	4		4	96	980	0	884
Aug-03-2002	0	4		4	96	984	0	888
Aug-04-2002	0	4		4	96	988	0	892
Aug-05-2002	0	4		4	96	992	0	896
Aug-06-2002	0	4		4	96	996	0	900
Aug-07-2002	0	4		4	96	1000	0	904
Aug-08-2002	0	4		4	96	1004	0	908
Aug-09-2002	0	4		4	96	1008	0	912
Aug-10-2002	0	4		4	96	1012	0	916
Aug-11-2002	0	4		4	96	1016	0	920
Aug-12-2002	0	4		4	96	1020	0	924
Aug-13-2002	0	4		4	96	1024	0	928
Aug-14-2002	2	4		2	98	1028	0	930
Aug-15-2002	2	4		2	100	1032	0	932
Aug-16-2002	2	4		2	102	1036	0	934
Aug-17-2002	0	4		4	102	1040	0	938
Aug-18-2002	0	4		4	102	1044	0	942
Aug-19-2002	0	4		4	102	1048	0	946
Aug-20-2002	0	4		4	102	1052	0	950
Aug-21-2002	0	4		4	102	1056	0	954
Aug-22-2002	0	4		4	102	1060	0	958

Order: RES NP Where: RES="CREW-EVA"

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Figure 6.2.1-1 (6 of 8) Schedule Load Requirements for EVA Events

Period Start	<---------- This Period Req'd	Avail.	Over	Under ---------->	<--------- Cumulative Req'd	Avail.	Over	Under --------->
Resource: CREW-EVA								
Aug-23-2002	0	4		4	102	1064	0	962
Aug-24-2002	0	4		4	102	1068	0	966
Aug-25-2002	0	4		4	102	1072	0	970
Aug-26-2002	0	4		4	102	1076	0	974
Aug-27-2002	0	4		4	102	1080	0	978
Aug-28-2002	0	4		4	102	1084	0	982
Aug-29-2002	0	4		4	102	1088	0	986
Aug-30-2002	0	4		4	102	1092	0	990
Aug-31-2002	0	4		4	102	1096	0	994
Sep-01-2002	0	4		4	102	1100	0	998
Sep-02-2002	0	4		4	102	1104	0	1002
Sep-03-2002	0	4		4	102	1108	0	1006
Sep-04-2002	0	4		4	102	1112	0	1010
Sep-05-2002	0	4		4	102	1116	0	1014
Sep-06-2002	0	4		4	102	1120	0	1018
Sep-07-2002	0	4		4	102	1124	0	1022
Sep-08-2002	0	4		4	102	1128	0	1026
Sep-09-2002	0	4		4	102	1132	0	1030
Sep-10-2002	0	4		4	102	1136	0	1034
Sep-11-2002	0	4		4	102	1140	0	1038
Sep-12-2002	2	4		2	104	1144	0	1040
Sep-13-2002	2	4		2	106	1148	0	1042
Sep-14-2002	2	4		2	108	1152	0	1044
Sep-15-2002	2	4		2	110	1156	0	1046
Sep-16-2002	2	4		2	112	1160	0	1048
Sep-17-2002	2	4		2	114	1164	0	1050
Sep-18-2002	0	4		4	114	1168	0	1054
Sep-19-2002	0	4		4	114	1172	0	1058
Sep-20-2002	0	4		4	114	1176	0	1062
Sep-21-2002	0	4		4	114	1180	0	1066
Sep-22-2002	0	4		4	114	1184	0	1070
Sep-23-2002	0	4		4	114	1188	0	1074
Sep-24-2002	0	4		4	114	1192	0	1078
Sep-25-2002	0	4		4	114	1196	0	1082
Sep-26-2002	0	4		4	114	1200	0	1086
Sep-27-2002	0	4		4	114	1204	0	1090
Sep-28-2002	0	4		4	114	1208	0	1094
Sep-29-2002	0	4		4	114	1212	0	1098
Sep-30-2002	0	4		4	114	1216	0	1102
Oct-01-2002	0	4		4	114	1220	0	1106
Oct-02-2002	0	4		4	114	1224	0	1110
Oct-03-2002	0	4		4	114	1228	0	1114
Oct-04-2002	0	4		4	114	1232	0	1118
Oct-05-2002	0	4		4	114	1236	0	1122
Oct-06-2002	0	4		4	114	1240	0	1126
Oct-07-2002	0	4		4	114	1244	0	1130
Oct-08-2002	0	4		4	114	1248	0	1134
Oct-09-2002	0	4		4	114	1252	0	1138
Oct-10-2002	2	4		2	116	1256	0	1140
Oct-11-2002	2	4		2	118	1260	0	1142
Oct-12-2002	4	4			122	1264	0	1142
Oct-13-2002	2	4		2	124	1268	0	1144
Oct-14-2002	2	4		2	126	1272	0	1146

Order: RES NP   Where: RES="CREW-EVA"

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Figure 6.2.1-1 (7 of 8) Schedule Load Requirements for EVA Events

Period Start	This Period Req'd	Avail.	Over	Under	Cumulative Req'd	Avail.	Over	Under
Resource: CREW-EVA								
Oct-15-2002	0	4		4	126	1276	0	1150
Oct-16-2002	0	4		4	126	1280	0	1154
Oct-17-2002	0	4		4	126	1284	0	1158
Oct-18-2002	0	4		4	126	1288	0	1162
Oct-19-2002	0	4		4	126	1292	0	1166
Oct-20-2002	0	4		4	126	1296	0	1170
Oct-21-2002	0	4		4	126	1300	0	1174
Oct-22-2002	0	4		4	126	1304	0	1178
Oct-23-2002	0	4		4	126	1308	0	1182
Oct-24-2002	0	4		4	126	1312	0	1186
Oct-25-2002	0	4		4	126	1316	0	1190
Oct-26-2002	0	4		4	126	1320	0	1194
Oct-27-2002	0	4		4	126	1324	0	1198
Oct-28-2002	0	4		4	126	1328	0	1202
Oct-29-2002	2	4		2	128	1332	0	1204
Oct-30-2002	2	4		2	130	1336	0	1206
Oct-31-2002	2	4		2	132	1340	0	1208
Nov-01-2002	0	4		4	132	1344	0	1212
Nov-02-2002	0	4		4	132	1348	0	1216
Nov-03-2002	0	4		4	132	1352	0	1220
Nov-04-2002	0	4		4	132	1356	0	1224
Nov-05-2002	0	4		4	132	1360	0	1228
Nov-06-2002	0	4		4	132	1364	0	1232
Nov-07-2002	0	4		4	132	1368	0	1236
Nov-08-2002	0	4		4	132	1372	0	1240
Nov-09-2002	0	4		4	132	1376	0	1244
Nov-10-2002	0	4		4	132	1380	0	1248
Nov-11-2002	0	4		4	132	1384	0	1252
Nov-12-2002	0	4		4	132	1388	0	1256
Nov-13-2002	0	4		4	132	1392	0	1260
Nov-14-2002	2	4		2	134	1396	0	1262
Nov-15-2002	2	4		2	136	1400	0	1264
Nov-16-2002	2	4		2	138	1404	0	1266
Nov-17-2002	0	4		4	138	1408	0	1270
Nov-18-2002	0	4		4	138	1412	0	1274
Nov-19-2002	0	4		4	138	1416	0	1278
Nov-20-2002	0	4		4	138	1420	0	1282
Nov-21-2002	0	4		4	138	1424	0	1286
Nov-22-2002	0	4		4	138	1428	0	1290
Nov-23-2002	0	4		4	138	1432	0	1294
Nov-24-2002	0	4		4	138	1436	0	1298
Nov-25-2002	0	4		4	138	1440	0	1302
Nov-26-2002	0	4		4	138	1444	0	1306
Nov-27-2002	0	4		4	138	1448	0	1310
Nov-28-2002	0	4		4	138	1452	0	1314
Nov-29-2002	0	4		4	138	1456	0	1318
Nov-30-2002	0	4		4	138	1460	0	1322
Dec-01-2002	0	4		4	138	1464	0	1326
Dec-02-2002	0	4		4	138	1468	0	1330
Dec-03-2002	0	4		4	138	1472	0	1334
Dec-04-2002	0	4		4	138	1476	0	1338
Dec-05-2002	0	4		4	138	1480	0	1342
Dec-06-2002	0	4		4	138	1484	0	1346

Order: RES NP Where: RES="CREW-EVA"

Figure 6.2.1-1 (8 of 8) Schedule Load Requirements for EVA Events

Period	<----------	This Period	---------->	<----------	Cumulative	----------		
Start	Req'd	Avail.	Over	Under	Req'd	Avail.	Over	Under
Resource: CREW-EVA								
Dec-07-2002	0	4		4	138	1488	0	1350
Dec-08-2002	0	4		4	138	1492	0	1354
Dec-09-2002	0	4		4	138	1496	0	1358
Dec-10-2002	0	4		4	138	1500	0	1362
Dec-11-2002	0	4		4	138	1504	0	1366
Dec-12-2002	0	4		4	138	1508	0	1370
Dec-13-2002	0	4		4	138	1512	0	1374
Dec-14-2002	0	4		4	138	1516	0	1378
Dec-15-2002	0	4		4	138	1520	0	1382
Dec-16-2002	2	4		2	140	1524	0	1384
Dec-17-2002	2	4		2	142	1528	0	1386
Dec-18-2002	2	4		2	144	1532	0	1388
Dec-19-2002	0	4		4	144	1536	0	1392
Dec-20-2002	0	4		4	144	1540	0	1396
Dec-21-2002	0	4		4	144	1544	0	1400
Dec-22-2002	0	4		4	144	1548	0	1404
Dec-23-2002	0	4		4	144	1552	0	1408
Dec-24-2002	0	4		4	144	1556	0	1412
Dec-25-2002	0	4		4	144	1560	0	1416
Dec-26-2002	0	4		4	144	1564	0	1420
Dec-27-2002	0	4		4	144	1568	0	1424
Dec-28-2002	0	4		4	144	1572	0	1428
Dec-29-2002	0	4		4	144	1576	0	1432
Dec-30-2002	0	4		4	144	1580	0	1436
Dec-31-2002	0	4		4	144	1584	0	1440

Order: RES NP Where: RES="CREW-EVA"

Figure 6.2.2-1 (1 of 8) **Schedule Load Requirements Histogram for Daily Hanger Volume in Cubic Meters**

```
           Date       0         4002      8004      12006     16008     20010
Resource   From       I---------I---------I---------I---------I---------I----

HANGER    Dec-01-2001 ************        I         I         I        !I
          Dec-02-2001 ************        I         I         I        !I
          Dec-03-2001 **************      I         I         I        !I
          Dec-04-2001 **************      I         I         I        !I
          Dec-05-2001 **************      I         I         I        !I
          Dec-06-2001 **************      I         I         I        !I
          Dec-07-2001 **************      I         I         I        !I
          Dec-08-2001 **************      I         I         I        !I
          Dec-09-2001 **************      I         I         I        !I
          Dec-10-2001 **************      I         I         I        !I
          Dec-11-2001 ***       I         I         I         I        !I
          Dec-12-2001 *****************   I         I         I        !I
          Dec-13-2001 *****************   I         I         I        !I
          Dec-14-2001 *****************   I         I         I        !I
          Dec-15-2001 *****************   I         I         I        !I
          Dec-16-2001 *****************   I         I         I        !I
          Dec-17-2001 *****************   I         I         I        !I
          Dec-18-2001 *****************   I         I         I        !I
          Dec-19-2001 *****************   I         I         I        !I
          Dec-20-2001 *****************   I         I         I        !I
          Dec-21-2001 *****************   I         I         I        !I
          Dec-22-2001 *****************   I         I         I        !I
          Dec-23-2001 *****************   I         I         I        !I
          Dec-24-2001 *****************   I         I         I        !I
          Dec-25-2001 *****************   I         I         I        !I
          Dec-26-2001 *****************   I         I         I        !I
          Dec-27-2001 *****************   I         I         I        !I
          Dec-28-2001 *****************   I         I         I        !I
          Dec-29-2001 *****************   I         I         I        !I
          Dec-30-2001 *****************   I         I         I        !I
          Dec-31-2001 *****************   I         I         I        !I
          Jan-01-2002 ****************************  I         I        !I
          Jan-02-2002 ****************************  I         I        !I
          Jan-03-2002 ***************************** I         I        !I
          Jan-04-2002 *************       I         I         I        !I
          Jan-05-2002 *************       I         I         I        !I
          Jan-06-2002 *************       I         I         I        !I
          Jan-07-2002 *************       I         I         I        !I
          Jan-08-2002 *************       I         I         I        !I
          Jan-09-2002 ******************* I         I         I        !I
          Jan-10-2002 ******************* I         I         I        !I
          Jan-11-2002 *******   I         I         I         I        !I
          Jan-12-2002 ***********************       I         I        !I
          Jan-13-2002 ***********************       I         I        !I
          Jan-14-2002 ***********************       I         I        !I
          Jan-15-2002 ***********************       I         I        !I
          Jan-16-2002 ***********************       I         I        !I
          Jan-17-2002 ***********************       I         I        !I
          Jan-18-2002 ***********************       I         I        !I
          Jan-19-2002 ***********************       I         I        !I
          Jan-20-2002 ***********************       I         I        !I
          Jan-21-2002 ***********************       I         I        !I
          Jan-22-2002 ***********************       I         I        !I
          Jan-23-2002 ***********************       I         I        !I
--------------------------------------------------------------------------------
* - Resources Required      ! - Resources Available      # - Resource Overload
Order: RES NP               Where: RES="HANGER"
```

Figure 6.2.2-1 (2 of 8) Schedule Load Requirements Histogram for Daily Hanger Volume in Cubic Meters

```
           Date    0         4002      8004     12006     16008     20010
Resource   From    I---------I---------I---------I---------I---------I----
HANGER   Jan-24-2002 ****************************  I         I        !I
         Jan-25-2002 ****************************  I         I        !I
         Jan-26-2002 ****************************  I         I        !I
         Jan-27-2002 ****************************  I         I        !I
         Jan-28-2002 ****************************  I         I        !I
         Jan-29-2002 ****************************  I         I        !I
         Jan-30-2002 ****************************  I         I        !I
         Jan-31-2002 ****************************  I         I        !I
         Feb-01-2002 ****************************  I         I        !I
         Feb-02-2002 ****************************  I         I        !I
         Feb-03-2002 ****************************  I         I        !I
         Feb-04-2002 ****************************  I         I        !I
         Feb-05-2002 *****************   I         I         I        !I
         Feb-06-2002 *****************   I         I         I        !I
         Feb-07-2002 *****************   I         I         I        !I
         Feb-08-2002 *****************   I         I         I        !I
         Feb-09-2002 *         I         I         I         I        !I
         Feb-10-2002 *         I         I         I         I        !I
         Feb-11-2002 *         I         I         I         I        !I
         Feb-12-2002 *         I         I         I         I        !I
         Feb-13-2002 *         I         I         I         I        !I
         Feb-14-2002 ************        I         I         I        !I
         Feb-15-2002 ************        I         I         I        !I
         Feb-16-2002 ************        I         I         I        !I
         Feb-17-2002 ************        I         I         I        !I
         Feb-18-2002 ************        I         I         I        !I
         Feb-19-2002 ************        I         I         I        !I
         Feb-20-2002 ************        I         I         I        !I
         Feb-21-2002 ************        I         I         I        !I
         Feb-22-2002 ******    I         I         I         I        !I
         Feb-23-2002 ******    I         I         I         I        !I
         Feb-24-2002 ******    I         I         I         I        !I
         Feb-25-2002 ******    I         I         I         I        !I
         Feb-26-2002 ******    I         I         I         I        !I
         Feb-27-2002 ******    I         I         I         I        !I
         Feb-28-2002 ******    I         I         I         I        !I
         Mar-01-2002 *****************   I         I         I        !I
         Mar-02-2002 ************        I         I         I        !I
         Mar-03-2002 **************      I         I         I        !I
         Mar-04-2002 **************      I         I         I        !I
         Mar-05-2002 **************      I         I         I        !I
         Mar-06-2002 **************      I         I         I        !I
         Mar-07-2002 **************      I         I         I        !I
         Mar-08-2002 ********************I         I         I        !I
         Mar-09-2002 ********************I         I         I        !I
         Mar-10-2002 **************      I         I         I        !I
         Mar-11-2002 ***       I         I         I         I        !I
         Mar-12-2002 ****************************  I         I        !I
         Mar-13-2002 ****************************  I         I        !I
         Mar-14-2002 ****************************  I         I        !I
         Mar-15-2002 ****************************  I         I        !I
         Mar-16-2002 ****************************  I         I        !I
         Mar-17-2002 ****************************  I         I        !I
         Mar-18-2002 ****************************  I         I        !I
         Mar-19-2002 ****************************  I         I        !I
----------------------------------------------------------------------------
* - Resources Required    ! - Resources Available    # - Resource Overload
Order: RES NP                 Where: RES="HANGER"
```

Figure 6.2.2-1 (3 of 8) **Schedule Load Requirements Histogram for Daily Hanger Volume in Cubic Meters**

```
               Date  0         4002      8004      12006     16008     20010
Resource       From  I---------I---------I---------I---------I---------I-----
HANGER     Mar-20-2002 ***************************  I         I        !I
           Mar-21-2002 ***************************  I         I        !I
           Mar-22-2002 ***************************  I         I        !I
           Mar-23-2002 ***************************  I         I        !I
           Mar-24-2002 ***************************  I         I        !I
           Mar-25-2002 ***************************  I         I        !I
           Mar-26-2002 ***************************  I         I        !I
           Mar-27-2002 ***************************  I         I        !I
           Mar-28-2002 ***************************  I         I        !I
           Mar-29-2002 ***************************  I         I        !I
           Mar-30-2002 ***************************  I         I        !I
           Mar-31-2002 ***************************  I         I        !I
           Apr-01-2002 ************************************** I        !I
           Apr-02-2002 ************************************** I        !I
           Apr-03-2002 **************************** I         I        !I
           Apr-04-2002 *************      I         I         I        !I
           Apr-05-2002 *************      I         I         I        !I
           Apr-06-2002 *************      I         I         I        !I
           Apr-07-2002 *************      I         I         I        !I
           Apr-08-2002 *************      I         I         I        !I
           Apr-09-2002 ****************** I         I         I        !I
           Apr-10-2002 ****************** I         I         I        !I
           Apr-11-2002 *******  I         I         I         I        !I
           Apr-12-2002 **********************       I         I        !I
           Apr-13-2002 **********************       I         I        !I
           Apr-14-2002 **********************       I         I        !I
           Apr-15-2002 **********************       I         I        !I
           Apr-16-2002 **********************       I         I        !I
           Apr-17-2002 **********************       I         I        !I
           Apr-18-2002 **********************       I         I        !I
           Apr-19-2002 **********************       I         I        !I
           Apr-20-2002 **********************       I         I        !I
           Apr-21-2002 **********************       I         I        !I
           Apr-22-2002 **********************       I         I        !I
           Apr-23-2002 **********************       I         I        !I
           Apr-24-2002 ***************************  I         I        !I
           Apr-25-2002 ***************************  I         I        !I
           Apr-26-2002 ***************************  I         I        !I
           Apr-27-2002 ***************************  I         I        !I
           Apr-28-2002 ***************************  I         I        !I
           Apr-29-2002 ***************************  I         I        !I
           Apr-30-2002 ***************************  I         I        !I
           May-01-2002 ***************************  I         I        !I
           May-02-2002 ***************************  I         I        !I
           May-03-2002 ***************************  I         I        !I
           May-04-2002 ***************************  I         I        !I
           May-05-2002 ***************************  I         I        !I
           May-06-2002 *****************  I         I         I        !I
           May-07-2002 *****************  I         I         I        !I
           May-08-2002 *****************  I         I         I        !I
           May-09-2002 *****************  I         I         I        !I
           May-10-2002 *        I         I         I         I        !I
           May-11-2002 *        I         I         I         I        !I
           May-12-2002 *        I         I         I         I        !I
           May-13-2002 *        I         I         I         I        !I
--------------------------------------------------------------------------------
* - Resources Required      ! - Resources Available     # - Resource Overload
Order: RES NF               Where: RES="HANGER"
```

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Figure 6.2.2-1 (4 of 8) Schedule Load Requirements Histogram for Daily Hanger Volume in Cubic Meters

```
           Date    0         4002      8004      12006     16008     20010
Resource   From    I---------I---------I---------I---------I---------I----
HANGER   May-14-2002 *         I         I         I         I         !I
         May-15-2002 ************        I         I         I         !I
         May-16-2002 ************        I         I         I         !I
         May-17-2002 ************        I         I         I         !I
         May-18-2002 ************        I         I         I         !I
         May-19-2002 ************        I         I         I         !I
         May-20-2002 ************        I         I         I         !I
         May-21-2002 ************        I         I         I         !I
         May-22-2002 ************        I         I         I         !I
         May-23-2002 ******    I         I         I         I         !I
         May-24-2002 ******    I         I         I         I         !I
         May-25-2002 ******    I         I         I         I         !I
         May-26-2002 ******    I         I         I         I         !I
         May-27-2002 ******    I         I         I         I         !I
         May-28-2002 ******    I         I         I         I         !I
         May-29-2002 ******    I         I         I         I         !I
         May-30-2002 ******    I         I         I         I         !I
         May-31-2002 *         I         I         I         I         !I
         Jun-01-2002 ************        I         I         I         !I
         Jun-02-2002 ************        I         I         I         !I
         Jun-03-2002 **************      I         I         I         !I
         Jun-04-2002 **************      I         I         I         !I
         Jun-05-2002 **************      I         I         I         !I
         Jun-06-2002 ********************I         I         I         !I
         Jun-07-2002 ********************I         I         I         !I
         Jun-08-2002 **************      I         I         I         !I
         Jun-09-2002 **************      I         I         I         !I
         Jun-10-2002 **************************    I         I         !I
         Jun-11-2002 ***************     I         I         I         !I
         Jun-12-2002 ****************************  I         I         !I
         Jun-13-2002 ****************************  I         I         !I
         Jun-14-2002 ****************************  I         I         !I
         Jun-15-2002 ****************************  I         I         !I
         Jun-16-2002 ****************************  I         I         !I
         Jun-17-2002 ****************************  I         I         !I
         Jun-18-2002 ****************************  I         I         !I
         Jun-19-2002 ****************************  I         I         !I
         Jun-20-2002 ****************************  I         I         !I
         Jun-21-2002 ****************************  I         I         !I
         Jun-22-2002 ****************************  I         I         !I
         Jun-23-2002 ****************************  I         I         !I
         Jun-24-2002 ****************************  I         I         !I
         Jun-25-2002 ****************************  I         I         !I
         Jun-26-2002 ****************************  I         I         !I
         Jun-27-2002 ****************************  I         I         !I
         Jun-28-2002 ****************************  I         I         !I
         Jun-29-2002 ****************************  I         I         !I
         Jun-30-2002 ****************************  I         I         !I
         Jul-01-2002 *************************************** I         !I
         Jul-02-2002 ****************************  I         I         !I
         Jul-03-2002 ***************************** I         I         !I
         Jul-04-2002 ***************************** I         I         !I
         Jul-05-2002 *************       I         I         I         !I
         Jul-06-2002 *************       I         I         I         !I
         Jul-07-2002 *************       I         I         I         !I
---------------------------------------------------------------------------
* - Resources Required     ! - Resources Available     # - Resource Overload
Order: RES NP                  Where: RES="HANGER"
```

Figure 6.2.2-1 (5 of 8) Schedule Load Requirements Histogram for Daily Hanger Volume in Cubic Meters

```
            Date     0        4002      8004      12006     16008     20010
Resource    From     I---------I---------I---------I---------I---------I----
HANGER   Jul-08-2002 *************       I         I         I        !I
         Jul-09-2002 *************       I         I         I        !I
         Jul-10-2002 ******************* I         I         I        !I
         Jul-11-2002 *******   I         I         I         I        !I
         Jul-12-2002 ***********************       I         I        !I
         Jul-13-2002 ***********************       I         I        !I
         Jul-14-2002 ***********************       I         I        !I
         Jul-15-2002 ***********************       I         I        !I
         Jul-16-2002 ***********************       I         I        !I
         Jul-17-2002 ***********************       I         I        !I
         Jul-18-2002 ***********************       I         I        !I
         Jul-19-2002 ***********************       I         I        !I
         Jul-20-2002 ***********************       I         I        !I
         Jul-21-2002 ***********************       I         I        !I
         Jul-22-2002 ***********************       I         I        !I
         Jul-23-2002 ***********************       I         I        !I
         Jul-24-2002 ***********************       I         I        !I
         Jul-25-2002 ****************************  I         I        !I
         Jul-26-2002 ****************************  I         I        !I
         Jul-27-2002 ****************************  I         I        !I
         Jul-28-2002 ****************************  I         I        !I
         Jul-29-2002 ****************************  I         I        !I
         Jul-30-2002 ****************************  I         I        !I
         Jul-31-2002 ****************************  I         I        !I
         Aug-01-2002 ****************************  I         I        !I
         Aug-02-2002 ****************************  I         I        !I
         Aug-03-2002 ****************************  I         I        !I
         Aug-04-2002 ****************************  I         I        !I
         Aug-05-2002 ****************************  I         I        !I
         Aug-06-2002 *****************   I         I         I        !I
         Aug-07-2002 *****************   I         I         I        !I
         Aug-08-2002 *****************   I         I         I        !I
         Aug-09-2002 *         I         I         I         I        !I
         Aug-10-2002 *         I         I         I         I        !I
         Aug-11-2002 *         I         I         I         I        !I
         Aug-12-2002 *         I         I         I         I        !I
         Aug-13-2002 *         I         I         I         I        !I
         Aug-14-2002 ************        I         I         I        !I
         Aug-15-2002 ************        I         I         I        !I
         Aug-16-2002 ************        I         I         I        !I
         Aug-17-2002 ************        I         I         I        !I
         Aug-18-2002 ************        I         I         I        !I
         Aug-19-2002 ************        I         I         I        !I
         Aug-20-2002 ************        I         I         I        !I
         Aug-21-2002 ************        I         I         I        !I
         Aug-22-2002 ******    I         I         I         I        !I
         Aug-23-2002 ******    I         I         I         I        !I
         Aug-24-2002 ******    I         I         I         I        !I
         Aug-25-2002 ******    I         I         I         I        !I
         Aug-26-2002 ******    I         I         I         I        !I
         Aug-27-2002 ******    I         I         I         I        !I
         Aug-28-2002 ******    I         I         I         I        !I
         Aug-29-2002 ******    I         I         I         I        !I
         Aug-30-2002 *         I         I         I         I        !I
         Aug-31-2002 *         I         I         I         I        !I
---------------------------------------------------------------------------
*  - Resources Required     !  - Resources Available     #  - Resource Overload
Order: RES NF                  Where: RES="HANGER"
```

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Figure 6.2.2-1 (6 of 8) Schedule Load Requirements Histogram for Daily Hanger Volume in Cubic Meters

```
           Date    0        4002      8004      12006     16008     20010
Resource   From    I---------I---------I---------I---------I---------I----
HANGER   Sep-01-2002 ************        I         I         I        !I
         Sep-02-2002 ************        I         I         I        !I
         Sep-03-2002 **************      I         I         I        !I
         Sep-04-2002 **************      I         I         I        !I
         Sep-05-2002 ********************I         I         I        !I
         Sep-06-2002 ********************I         I         I        !I
         Sep-07-2002 **************      I         I         I        !I
         Sep-08-2002 **************      I         I         I        !I
         Sep-09-2002 **************************    I         I        !I
         Sep-10-2002 **************************    I         I        !I
         Sep-11-2002 ***************     I         I         I        !I
         Sep-12-2002 ****************************  I         I        !I
         Sep-13-2002 ****************************  I         I        !I
         Sep-14-2002 ****************************  I         I        !I
         Sep-15-2002 ****************************  I         I        !I
         Sep-16-2002 ****************************  I         I        !I
         Sep-17-2002 ****************************  I         I        !I
         Sep-18-2002 ****************************  I         I        !I
         Sep-19-2002 ****************************  I         I        !I
         Sep-20-2002 ****************************  I         I        !I
         Sep-21-2002 ****************************  I         I        !I
         Sep-22-2002 ****************************  I         I        !I
         Sep-23-2002 ****************************  I         I        !I
         Sep-24-2002 ****************************  I         I        !I
         Sep-25-2002 ****************************  I         I        !I
         Sep-26-2002 ****************************  I         I        !I
         Sep-27-2002 ****************************  I         I        !I
         Sep-28-2002 ****************************  I         I        !I
         Sep-29-2002 ****************************  I         I        !I
         Sep-30-2002 ****************************  I         I        !I
         Oct-01-2002 ****************************  I         I        !I
         Oct-02-2002 ****************************  I         I        !I
         Oct-03-2002 ***************************** I         I        !I
         Oct-04-2002 ***************************** I         I        !I
         Oct-05-2002 *************       I         I         I        !I
         Oct-06-2002 *************       I         I         I        !I
         Oct-07-2002 *************       I         I         I        !I
         Oct-08-2002 *************       I         I         I        !I
         Oct-09-2002 *************       I         I         I        !I
         Oct-10-2002 ******************* I         I         I        !I
         Oct-11-2002 *******   I         I         I         I        !I
         Oct-12-2002 ***********************       I         I        !I
         Oct-13-2002 ***********************       I         I        !I
         Oct-14-2002 ***********************       I         I        !I
         Oct-15-2002 ***********************       I         I        !I
         Oct-16-2002 ***********************       I         I        !I
         Oct-17-2002 ***********************       I         I        !I
         Oct-18-2002 ***********************       I         I        !I
         Oct-19-2002 ***********************       I         I        !I
         Oct-20-2002 ***********************       I         I        !I
         Oct-21-2002 ***********************       I         I        !I
         Oct-22-2002 ***********************       I         I        !I
         Oct-23-2002 ***********************       I         I        !I
         Oct-24-2002 ***********************       I         I        !I
         Oct-25-2002 ****************************  I         I        !I
--------------------------------------------------------------------------------
* - Resources Required     ! - Resources Available     # - Resource Overload
Order: RES NF              Where: RES="HANGER"
```

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Figure 6.2.2-1 (7 of 8) Schedule Load Requirements Histogram for Daily Hanger Volume in Cubic Meters

```
            Date      0          4002       8004       12006      16008      20010
Resource    From      I----------I----------I----------I----------I----------I----
HANGER    Oct-26-2002 ****************************     I          I         !I
          Oct-27-2002 ****************************     I          I         !I
          Oct-28-2002 ****************************     I          I         !I
          Oct-29-2002 ****************************     I          I         !I
          Oct-30-2002 ****************************     I          I         !I
          Oct-31-2002 ****************************     I          I         !I
          Nov-01-2002 ****************************     I          I         !I
          Nov-02-2002 ****************************     I          I         !I
          Nov-03-2002 ****************************     I          I         !I
          Nov-04-2002 ****************************     I          I         !I
          Nov-05-2002 ****************************     I          I         !I
          Nov-06-2002 *****************     I          I          I         !I
          Nov-07-2002 *****************     I          I          I         !I
          Nov-08-2002 *****************     I          I          I         !I
          Nov-09-2002 *          I          I          I          I         !I
          Nov-10-2002 *          I          I          I          I         !I
          Nov-11-2002 *          I          I          I          I         !I
          Nov-12-2002 *          I          I          I          I         !I
          Nov-13-2002 *          I          I          I          I         !I
          Nov-14-2002 ************          I          I          I         !I
          Nov-15-2002 ************          I          I          I         !I
          Nov-16-2002 ************          I          I          I         !I
          Nov-17-2002 ************          I          I          I         !I
          Nov-18-2002 ************          I          I          I         !I
          Nov-19-2002 ************          I          I          I         !I
          Nov-20-2002 ************          I          I          I         !I
          Nov-21-2002 ************          I          I          I         !I
          Nov-22-2002 ******     I          I          I          I         !I
          Nov-23-2002 ******     I          I          I          I         !I
          Nov-24-2002 ******     I          I          I          I         !I
          Nov-25-2002 ******     I          I          I          I         !I
          Nov-26-2002 ******     I          I          I          I         !I
          Nov-27-2002 ******     I          I          I          I         !I
          Nov-28-2002 ******     I          I          I          I         !I
          Nov-29-2002 ******     I          I          I          I         !I
          Nov-30-2002 *          I          I          I          I         !I
          Dec-01-2002 *          I          I          I          I         !I
          Dec-02-2002 *          I          I          I          I         !I
          Dec-03-2002 *          I          I          I          I         !I
          Dec-04-2002 *          I          I          I          I         !I
          Dec-05-2002 *          I          I          I          I         !I
          Dec-06-2002 ******     I          I          I          I         !I
          Dec-07-2002 ******     I          I          I          I         !I
          Dec-08-2002 *          I          I          I          I         !I
          Dec-09-2002 *          I          I          I          I         !I
          Dec-10-2002 ************          I          I          I         !I
          Dec-11-2002 ************          I          I          I         !I
          Dec-12-2002 ************          I          I          I         !I
          Dec-13-2002 ************          I          I          I         !I
          Dec-14-2002 ************          I          I          I         !I
          Dec-15-2002 ************          I          I          I         !I
          Dec-16-2002 ************          I          I          I         !I
          Dec-17-2002 ************          I          I          I         !I
          Dec-18-2002 ************          I          I          I         !I
          Dec-19-2002 ************          I          I          I         !I
---------------------------------------------------------------------------------------
* - Resources Required      ! - Resources Available      # - Resource Overload
Order: RES NP               Where: RES=="HANGER"
```

Figure 6.2.2-1 (8 of 8) **Schedule Load Requirements Histogram for Daily Hanger Volume in Cubic Meters**

```
          Date      0          4002        8004        12006       16008       20010
Resource  From      I----------I-----------I-----------I-----------I-----------I-----
HANGER   Dec-20-2002 ************          I           I           I          ! I
         Dec-21-2002 ************          I           I           I          ! I
         Dec-22-2002 ************          I           I           I          ! I
         Dec-23-2002 ************          I           I           I          ! I
         Dec-24-2002 ************          I           I           I          ! I
         Dec-25-2002 ************          I           I           I          ! I
         Dec-26-2002 ************          I           I           I          ! I
         Dec-27-2002 ************          I           I           I          ! I
         Dec-28-2002 ************          I           I           I          ! I
         Dec-29-2002 ************          I           I           I          ! I
         Dec-30-2002 ************          I           I           I          ! I
         Dec-31-2002 ************          I           I           I          ! I
```

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```
* -- Resources Required    ! - Resources Available    # - Resource Overload
Order: RES NP              Where: RES="HANGER"
```

Figure 6.2.2-2 (1 of 8) **Schedule Load Requirements for All Vehicle and STN Resources**

Period Start	CREW-E	CREW-N	E-LAND	HANGER	OMV	OTV	PTM-4	RMS
Dec-01-2001	0	2	1	4428	1	2	0	0
Dec-02-2001	0	2	1	4428	1	2	0	1
Dec-03-2001	0	2	1	5530	1	2	0	1
Dec-04-2001	0	2	1	5530	1	2	0	1
Dec-05-2001	0	2	1	5530	1	2	0	1
Dec-06-2001	0	2	1	5530	1	2	0	1
Dec-07-2001	0	2	1	5530	1	2	0	0
Dec-08-2001	0	2	1	5550	1	2	0	1
Dec-09-2001	0	2	1	5550	1	2	0	1
Dec-10-2001	0	2	1	5550	1	2	0	1
Dec-11-2001	0	2	1	1122	1	0	0	1
Dec-12-2001	2	2	1	6553	0	2	0	1
Dec-13-2001	2	2	1	6553	0	2	0	1
Dec-14-2001	2	2	1	6553	0	2	0	1
Dec-15-2001	0	2	1	6553	0	2	0	1
Dec-16-2001	0	2	1	6553	0	2	0	1
Dec-17-2001	0	2	1	6553	0	2	0	1
Dec-18-2001	0	2	1	6553	0	2	0	1
Dec-19-2001	0	2	1	6553	0	2	0	1
Dec-20-2001	0	2	1	6553	0	2	0	1
Dec-21-2001	0	2	1	6553	0	2	0	1
Dec-22-2001	0	2	1	6553	0	2	0	1
Dec-23-2001	0	2	1	6553	0	2	0	1
Dec-24-2001	0	2	1	6553	0	2	0	1
Dec-25-2001	0	2	1	6553	0	2	0	1
Dec-26-2001	0	2	1	6553	0	2	0	1
Dec-27-2001	0	2	1	6553	0	2	0	1
Dec-28-2001	0	2	1	6553	0	2	0	1
Dec-29-2001	0	2	1	6553	0	2	0	1
Dec-30-2001	0	2	1	6553	0	2	0	1
Dec-31-2001	0	2	1	6553	0	2	0	1
Jan-01-2002	0	4	2	11033	2	4	1	1
Jan-02-2002	0	4	2	11033	2	4	1	1
Jan-03-2002	0	4	2	11568	2	4	1	1
Jan-04-2002	0	4	2	5035	2	3	1	2
Jan-05-2002	0	4	2	5035	2	3	1	2
Jan-06-2002	0	4	2	5035	2	3	1	2
Jan-07-2002	0	6	2	5035	3	4	1	1
Jan-08-2002	0	4	2	5035	2	4	1	2
Jan-09-2002	2	4	2	7269	1	4	1	2
Jan-10-2002	2	4	2	7269	1	4	1	2
Jan-11-2002	2	4	2	2789	1	2	0	2
Jan-12-2002	2	4	2	8968	0	4	1	2
Jan-13-2002	2	4	2	8968	0	4	1	2
Jan-14-2002	2	4	2	8968	0	4	1	2
Jan-15-2002	0	4	2	8968	0	4	1	2
Jan-16-2002	0	4	2	8968	0	4	1	2
Jan-17-2002	0	3	2	8968	1	4	1	1
Jan-18-2002	0	4	2	8968	1	3	1	2
Jan-19-2002	0	4	2	8968	1	3	1	2
Jan-20-2002	0	4	2	8968	1	3	1	2
Jan-21-2002	0	4	1	8968	1	2	1	2
Jan-22-2002	0	4	1	8948	1	3	1	1
Jan-23-2002	0	4	1	8948	1	3	1	2
Jan-24-2002	0	4	1	11182	1	2	1	2

Order: NP Where: RES PRESENT

Figure 6.2.2-2 (2 of 8) Schedule Load Requirements for All Vehicle and STN Resources

Period Start	CREW-E	CREW-N	E-LAND	HANGER	OMV	OTV	PTM-4	RMS
Jan-25-2002	0	4	1	11182	1	2	1	2
Jan-26-2002	0	4	1	11182	1	2	1	2
Jan-27-2002	0	4	1	11182	1	2	1	2
Jan-28-2002	2	4	1	11182	0	3	1	2
Jan-29-2002	2	4	1	11182	0	3	1	2
Jan-30-2002	2	4	1	11182	0	3	1	2
Jan-31-2002	0	4	1	11182	0	3	1	2
Feb-01-2002	0	4	1	11182	0	3	1	1
Feb-02-2002	0	2	1	11182	0	3	1	1
Feb-03-2002	0	2	1	11182	0	3	1	1
Feb-04-2002	0	4	1	11182	0	3	1	2
Feb-05-2002	0	2	1	6734	0	2	1	1
Feb-06-2002	0	2	1	6734	1	2	1	1
Feb-07-2002	0	2	1	6734	1	2	1	0
Feb-08-2002	0	2	1	6734	1	2	1	0
Feb-09-2002	0	2	1	20	1	1	1	1
Feb-10-2002	0	2	1	20	1	1	1	1
Feb-11-2002	0	2	1	20	1	1	1	1
Feb-12-2002	0	4	1	20	2	2	1	1
Feb-13-2002	0	3	1	20	1	2	1	1
Feb-14-2002	2	3	1	4520	0	2	1	1
Feb-15-2002	2	2	1	4500	0	2	1	1
Feb-16-2002	2	2	1	4500	0	2	1	1
Feb-17-2002	0	2	1	4500	0	2	1	1
Feb-18-2002	0	2	1	4500	0	2	1	1
Feb-19-2002	0	2	1	4500	0	2	1	1
Feb-20-2002	0	2	1	4500	0	2	1	1
Feb-21-2002	0	2	1	4500	0	2	1	1
Feb-22-2002	0	1	1	2234	1	2	1	0
Feb-23-2002	0	2	1	2234	1	1	1	1
Feb-24-2002	0	2	1	2234	1	1	1	1
Feb-25-2002	0	2	1	2234	1	1	1	1
Feb-26-2002	0	2	1	2234	1	1	1	1
Feb-27-2002	0	2	1	2234	0	1	1	0
Feb-28-2002	0	2	1	2234	0	1	1	1
Mar-01-2002	0	4	2	6662	1	3	1	1
Mar-02-2002	0	2	2	4428	1	3	1	1
Mar-03-2002	0	2	2	5530	1	3	1	1
Mar-04-2002	0	2	2	5530	1	3	1	1
Mar-05-2002	0	2	2	5530	1	3	1	1
Mar-06-2002	0	2	2	5530	1	3	1	1
Mar-07-2002	0	2	2	5530	1	3	1	0
Mar-08-2002	0	4	1	7764	2	3	1	1
Mar-09-2002	0	4	1	7764	2	3	1	2
Mar-10-2002	0	2	1	5550	1	2	0	1
Mar-11-2002	0	2	1	1122	1	0	0	1
Mar-12-2002	2	4	1	11053	1	2	0	2
Mar-13-2002	2	4	1	11053	1	2	0	2
Mar-14-2002	2	4	1	11053	1	2	0	2
Mar-15-2002	0	4	1	11053	1	2	0	2
Mar-16-2002	0	3	1	11053	0	2	0	1
Mar-17-2002	0	3	1	11053	0	2	0	1
Mar-18-2002	2	4	1	11053	0	3	0	2
Mar-19-2002	2	4	1	11053	0	3	0	2
Mar-20-2002	2	4	1	11053	0	3	0	2

Order: NP Where: RES PRESENT

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Figure 6.2.2-2 (3 of 8) Schedule Load Requirements for All Vehicle and STN Resources

Period Start	CREW-E	CREW-N	E-LAND	HANGER	OMV	OTV	PTM-4	RMS
Mar-21-2002	0	4	1	11053	0	3	0	2
Mar-22-2002	0	4	1	11053	0	3	0	2
Mar-23-2002	0	4	1	11053	0	3	0	2
Mar-24-2002	0	4	1	11053	0	3	0	2
Mar-25-2002	0	4	1	11053	0	3	0	2
Mar-26-2002	0	4	1	11053	0	2	1	2
Mar-27-2002	0	4	1	11053	0	2	1	2
Mar-28-2002	0	4	1	11053	0	2	1	2
Mar-29-2002	0	4	1	11053	0	2	1	2
Mar-30-2002	0	4	1	11053	0	2	1	2
Mar-31-2002	0	4	1	11053	0	2	1	2
Apr-01-2002	0	6	2	15533	2	4	2	2
Apr-02-2002	0	6	2	15533	2	4	2	2
Apr-03-2002	0	4	2	11568	2	4	1	1
Apr-04-2002	0	4	2	5035	2	3	1	2
Apr-05-2002	0	4	2	5035	2	3	1	2
Apr-06-2002	0	4	2	5035	2	3	1	2
Apr-07-2002	0	6	2	5035	3	4	1	1
Apr-08-2002	0	4	2	5035	2	4	1	2
Apr-09-2002	2	4	2	7269	1	4	1	2
Apr-10-2002	2	4	2	7269	1	4	1	2
Apr-11-2002	2	4	2	2789	1	2	0	2
Apr-12-2002	2	4	2	8968	0	4	1	2
Apr-13-2002	2	4	2	8968	0	4	1	2
Apr-14-2002	2	4	2	8968	0	4	1	2
Apr-15-2002	0	4	2	8968	0	4	1	2
Apr-16-2002	0	4	2	8968	0	4	1	2
Apr-17-2002	0	3	2	8968	1	4	1	1
Apr-18-2002	0	4	2	8968	1	3	1	2
Apr-19-2002	0	4	2	8968	1	3	1	2
Apr-20-2002	0	4	2	8968	1	3	1	2
Apr-21-2002	0	4	1	8968	1	2	1	2
Apr-22-2002	0	4	1	8948	1	3	1	1
Apr-23-2002	0	4	1	8948	1	3	1	2
Apr-24-2002	0	4	1	11182	1	2	1	2
Apr-25-2002	0	4	1	11182	1	2	1	2
Apr-26-2002	0	4	1	11182	1	2	1	2
Apr-27-2002	0	4	1	11182	1	2	1	2
Apr-28-2002	2	4	1	11182	0	3	1	2
Apr-29-2002	2	4	1	11182	0	3	1	2
Apr-30-2002	2	4	1	11182	0	3	1	2
May-01-2002	0	4	1	11182	0	3	1	2
May-02-2002	0	4	1	11182	0	3	1	1
May-03-2002	0	2	1	11182	0	3	1	1
May-04-2002	0	2	1	11182	0	3	1	1
May-05-2002	0	4	1	11182	0	3	1	2
May-06-2002	0	2	1	6734	0	2	1	1
May-07-2002	0	2	1	6734	1	2	1	1
May-08-2002	0	2	1	6734	1	2	1	0
May-09-2002	0	2	1	6734	1	2	1	0
May-10-2002	0	2	1	20	1	1	1	1
May-11-2002	0	2	1	20	1	1	1	1
May-12-2002	0	2	1	20	1	1	1	1
May-13-2002	0	4	1	20	2	2	1	1
May-14-2002	0	3	1	20	1	2	1	1

Order: NP Where: RES PRESENT

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Figure 6.2.2-2 (4 of 8) Schedule Load Requirements for All Vehicle and STN Resources

Period Start	CREW-E	CREW-N	E-LAND	HANGER	OMV	OTV	PTM-4	RMS
May-15-2002	2	3	1	4520	0	2	1	1
May-16-2002	2	2	1	4500	0	2	1	1
May-17-2002	2	2	1	4500	0	2	1	1
May-18-2002	0	2	1	4500	0	2	1	1
May-19-2002	0	2	1	4500	0	2	1	1
May-20-2002	0	2	1	4500	0	2	1	1
May-21-2002	0	2	1	4500	0	2	1	1
May-22-2002	0	2	1	4500	0	2	1	1
May-23-2002	0	1	1	2234	1	2	1	0
May-24-2002	0	2	1	2234	1	1	1	1
May-25-2002	0	2	1	2234	1	1	1	1
May-26-2002	0	2	1	2234	1	1	1	1
May-27-2002	0	2	1	2234	1	1	1	1
May-28-2002	0	2	1	2234	0	1	1	0
May-29-2002	0	2	1	2234	0	1	1	1
May-30-2002	0	2	1	2234	0	1	1	1
May-31-2002	0	0	1	0	0	1	1	0
Jun-01-2002	0	2	2	4428	1	3	1	0
Jun-02-2002	0	2	2	4428	1	3	1	1
Jun-03-2002	0	2	2	5530	1	3	1	1
Jun-04-2002	0	2	2	5530	1	3	1	1
Jun-05-2002	0	2	2	5530	1	3	1	1
Jun-06-2002	0	4	1	7744	2	3	1	1
Jun-07-2002	0	4	1	7744	2	3	1	1
Jun-08-2002	0	2	1	5550	1	2	0	1
Jun-09-2002	0	2	1	5550	1	2	0	1
Jun-10-2002	0	4	1	10050	2	2	0	2
Jun-11-2002	0	4	1	5622	2	0	0	2
Jun-12-2002	2	4	1	11053	1	2	0	2
Jun-13-2002	2	4	1	11053	1	2	0	2
Jun-14-2002	2	3	1	11053	0	2	0	1
Jun-15-2002	0	3	1	11053	0	2	0	1
Jun-16-2002	2	4	1	11053	0	3	0	2
Jun-17-2002	2	4	1	11053	0	3	0	2
Jun-18-2002	2	4	1	11053	0	3	0	2
Jun-19-2002	0	4	1	11053	0	3	0	2
Jun-20-2002	0	4	1	11053	0	3	0	2
Jun-21-2002	0	4	1	11053	0	3	0	2
Jun-22-2002	0	4	1	11053	0	3	0	2
Jun-23-2002	0	4	1	11053	0	3	0	2
Jun-24-2002	0	4	1	11053	0	2	1	2
Jun-25-2002	0	4	1	11053	0	2	1	2
Jun-26-2002	0	4	1	11053	0	2	1	2
Jun-27-2002	0	4	1	11053	0	2	1	2
Jun-28-2002	0	4	1	11053	0	2	1	2
Jun-29-2002	0	4	1	11053	0	2	1	2
Jun-30-2002	0	4	1	11053	0	2	1	2
Jul-01-2002	0	6	2	15533	1	4	2	2
Jul-02-2002	0	4	2	11033	2	4	1	2
Jul-03-2002	0	4	2	11568	2	4	1	1
Jul-04-2002	0	4	2	11568	2	4	1	1
Jul-05-2002	0	4	2	5035	2	3	1	2
Jul-06-2002	0	4	2	5035	2	3	1	2
Jul-07-2002	0	4	2	5035	2	3	1	1
Jul-08-2002	0	6	2	5055	3	4	1	2

Order: NP Where: RES PRESENT

Figure 6.2.2-2 (5 of 8) Schedule Load Requirements for All Vehicle and STN Resources

Period Start	CREW-E	CREW-N	E-LAND	HANGER	OMV	OTV	PTM-4	RMS
Jul-09-2002	0	4	2	5035	2	4	1	2
Jul-10-2002	2	4	2	7269	1	4	1	2
Jul-11-2002	2	4	2	2789	1	2	0	2
Jul-12-2002	4	4	2	8968	0	4	1	2
Jul-13-2002	2	4	2	8968	0	4	1	2
Jul-14-2002	2	4	2	8968	0	4	1	2
Jul-15-2002	0	4	2	8968	0	4	1	2
Jul-16-2002	0	4	2	8968	0	4	1	2
Jul-17-2002	0	4	2	8968	0	4	1	2
Jul-18-2002	0	3	2	8968	1	4	1	1
Jul-19-2002	0	4	2	8968	1	3	1	2
Jul-20-2002	0	4	2	8968	1	3	1	2
Jul-21-2002	0	4	2	8968	1	3	1	2
Jul-22-2002	0	4	1	8968	1	2	1	2
Jul-23-2002	0	4	1	8948	1	3	1	1
Jul-24-2002	0	4	1	8948	1	3	1	2
Jul-25-2002	0	4	1	11182	1	2	1	2
Jul-26-2002	0	4	1	11182	1	2	1	2
Jul-27-2002	0	4	1	11182	1	2	1	2
Jul-28-2002	0	4	1	11182	1	2	1	2
Jul-29-2002	2	4	1	11182	0	3	1	2
Jul-30-2002	2	4	1	11182	0	3	1	2
Jul-31-2002	2	4	1	11182	0	3	1	2
Aug-01-2002	0	4	1	11182	0	3	1	1
Aug-02-2002	0	2	1	11182	0	3	1	1
Aug-03-2002	0	2	1	11182	0	3	1	1
Aug-04-2002	0	4	1	11182	0	3	1	2
Aug-05-2002	0	4	1	11182	0	3	1	2
Aug-06-2002	0	2	1	6734	1	2	1	1
Aug-07-2002	0	2	1	6734	1	2	1	0
Aug-08-2002	0	2	1	6734	1	2	1	0
Aug-09-2002	0	2	1	20	1	1	1	1
Aug-10-2002	0	2	1	20	1	1	1	1
Aug-11-2002	0	2	1	20	1	1	1	1
Aug-12-2002	0	4	1	20	2	2	1	1
Aug-13-2002	0	3	1	20	1	2	1	1
Aug-14-2002	2	3	1	4520	0	2	1	1
Aug-15-2002	2	2	1	4500	0	2	1	1
Aug-16-2002	2	2	1	4500	0	2	1	1
Aug-17-2002	0	2	1	4500	0	2	1	1
Aug-18-2002	0	2	1	4500	0	2	1	1
Aug-19-2002	0	2	1	4500	0	2	1	1
Aug-20-2002	0	2	1	4500	0	2	1	1
Aug-21-2002	0	2	1	4500	0	2	1	1
Aug-22-2002	0	1	1	2234	1	2	1	0
Aug-23-2002	0	2	1	2234	1	1	1	1
Aug-24-2002	0	2	1	2234	1	1	1	1
Aug-25-2002	0	2	1	2234	1	1	1	1
Aug-26-2002	0	2	1	2234	1	1	1	1
Aug-27-2002	0	2	1	2234	0	1	1	0
Aug-28-2002	0	2	1	2234	0	1	1	1
Aug-29-2002	0	2	1	2234	0	1	1	1
Aug-30-2002	0	0	1	0	0	1	1	0
Aug-31-2002	0	0	1	0	0	1	1	0
Sep-01-2002	0	2	2	4428	1	3	1	0

Order: NP Where: RES PRESENT

Figure 6.2.2-2 (6 of 8) Schedule Load Requirements for All Vehicle and STN Resources

Period Start	CREW-E	CREW-N	E-LAND	HANGER	OMV	OTV	PTM-4	RMS
Sep-02-2002	0	2	2	4428	1	3	1	1
Sep-03-2002	0	2	2	5530	1	3	1	1
Sep-04-2002	0	2	2	5530	1	3	1	1
Sep-05-2002	0	4	1	7744	2	3	1	1
Sep-06-2002	0	4	1	7744	2	3	1	2
Sep-07-2002	0	2	1	5530	1	2	0	0
Sep-08-2002	0	2	1	5550	1	2	0	1
Sep-09-2002	0	4	1	10050	2	2	0	2
Sep-10-2002	0	4	1	10050	2	2	0	2
Sep-11-2002	0	4	1	5622	2	0	0	2
Sep-12-2002	2	4	1	11053	1	2	0	2
Sep-13-2002	2	3	1	11053	0	2	0	1
Sep-14-2002	2	3	1	11053	0	2	0	1
Sep-15-2002	2	4	1	11053	0	3	0	2
Sep-16-2002	2	4	1	11053	0	3	0	2
Sep-17-2002	2	4	1	11053	0	3	0	2
Sep-18-2002	0	4	1	11053	0	3	0	2
Sep-19-2002	0	4	1	11053	0	3	0	2
Sep-20-2002	0	4	1	11053	0	3	0	2
Sep-21-2002	0	4	1	11053	0	3	0	2
Sep-22-2002	0	4	1	11053	0	3	0	2
Sep-23-2002	0	4	1	11053	0	2	1	2
Sep-24-2002	0	4	1	11053	0	2	1	2
Sep-25-2002	0	4	1	11053	0	2	1	2
Sep-26-2002	0	4	1	11053	0	2	1	2
Sep-27-2002	0	4	1	11053	0	2	1	2
Sep-28-2002	0	4	1	11053	0	2	1	2
Sep-29-2002	0	4	1	11053	0	2	1	2
Sep-30-2002	0	4	1	11053	0	2	1	2
Oct-01-2002	0	4	2	11033	1	4	1	1
Oct-02-2002	0	4	2	11033	2	4	1	2
Oct-03-2002	0	4	2	11568	2	4	1	1
Oct-04-2002	0	4	2	11568	2	4	1	1
Oct-05-2002	0	4	2	5035	2	3	1	2
Oct-06-2002	0	4	2	5035	2	3	1	2
Oct-07-2002	0	4	2	5035	2	3	1	1
Oct-08-2002	0	6	2	5055	3	4	1	2
Oct-09-2002	0	4	2	5035	2	4	1	2
Oct-10-2002	2	4	2	7269	1	4	1	2
Oct-11-2002	2	4	2	2789	1	2	0	2
Oct-12-2002	4	4	2	8968	0	4	1	2
Oct-13-2002	2	4	2	8968	0	4	1	2
Oct-14-2002	2	4	2	8968	0	4	1	2
Oct-15-2002	0	4	2	8968	0	4	1	2
Oct-16-2002	0	4	2	8968	0	4	1	2
Oct-17-2002	0	4	2	8968	0	4	1	2
Oct-18-2002	0	3	2	8968	1	4	1	1
Oct-19-2002	0	4	2	8968	1	3	1	2
Oct-20-2002	0	4	2	8968	1	3	1	2
Oct-21-2002	0	4	2	8968	1	3	1	2
Oct-22-2002	0	4	1	8968	1	2	1	2
Oct-23-2002	0	4	1	8948	1	3	1	1
Oct-24-2002	0	4	1	8948	1	3	1	2
Oct-25-2002	0	4	1	11182	1	2	1	2
Oct-26-2002	0	4	1	11182	1	2	1	2

Order: NP Where: RES PRESENT

Figure 6.2.2-2 (7 of 8) Schedule Load Requirements for All Vehicle and STN Resources

Period Start	CREW-E	CREW-N	E-LAND	HANGER	OMV	OTV	PTM-4	RMS
Oct-27-2002	0	4	1	11182	1	2	1	2
Oct-28-2002	0	4	1	11182	1	2	1	2
Oct-29-2002	2	4	1	11182	0	3	1	2
Oct-30-2002	2	4	1	11182	0	3	1	2
Oct-31-2002	2	4	1	11182	0	3	1	2
Nov-01-2002	0	4	1	11182	0	3	1	1
Nov-02-2002	0	2	1	11182	0	3	1	1
Nov-03-2002	0	2	1	11182	0	3	1	1
Nov-04-2002	0	4	1	11182	0	3	1	2
Nov-05-2002	0	4	1	11182	0	3	1	2
Nov-06-2002	0	2	1	6734	1	2	1	1
Nov-07-2002	0	2	1	6734	1	2	1	0
Nov-08-2002	0	2	1	6734	1	2	1	0
Nov-09-2002	0	2	1	20	1	1	1	1
Nov-10-2002	0	2	1	20	1	1	1	1
Nov-11-2002	0	2	1	20	1	1	1	1
Nov-12-2002	0	4	1	20	2	2	1	1
Nov-13-2002	0	3	1	20	1	2	1	1
Nov-14-2002	2	3	1	4520	0	2	1	1
Nov-15-2002	2	2	1	4500	0	2	1	1
Nov-16-2002	2	2	1	4500	0	2	1	1
Nov-17-2002	0	2	1	4500	0	2	1	1
Nov-18-2002	0	2	1	4500	0	2	1	1
Nov-19-2002	0	2	1	4500	0	2	1	1
Nov-20-2002	0	2	1	4500	0	2	1	1
Nov-21-2002	0	2	1	4500	0	2	1	1
Nov-22-2002	0	1	1	2234	1	2	1	0
Nov-23-2002	0	2	1	2234	1	1	1	1
Nov-24-2002	0	2	1	2234	1	1	1	1
Nov-25-2002	0	2	1	2234	1	1	1	1
Nov-26-2002	0	2	1	2234	1	1	1	1
Nov-27-2002	0	2	1	2234	0	1	1	0
Nov-28-2002	0	2	1	2234	0	1	1	1
Nov-29-2002	0	2	1	2234	0	1	1	1
Nov-30-2002	0	0	1	0	0	1	1	0
Dec-01-2002	0	0	1	0	0	1	1	0
Dec-02-2002	0	0	1	0	0	1	1	0
Dec-03-2002	0	0	1	0	0	1	1	0
Dec-04-2002	0	0	1	0	0	1	1	0
Dec-05-2002	0	0	1	0	0	1	1	0
Dec-06-2002	0	2	0	2214	1	1	1	0
Dec-07-2002	0	2	0	2214	1	1	1	1
Dec-08-2002	0	0	0	0	0	0	0	0
Dec-09-2002	0	0	0	0	0	0	0	0
Dec-10-2002	0	2	0	4500	1	0	0	1
Dec-11-2002	0	2	0	4500	1	0	0	1
Dec-12-2002	0	2	0	4500	1	0	0	1
Dec-13-2002	0	2	0	4500	1	0	0	1
Dec-14-2002	0	1	0	4500	0	0	0	0
Dec-15-2002	0	1	0	4500	0	0	0	0
Dec-16-2002	2	2	0	4500	0	1	0	1
Dec-17-2002	2	2	0	4500	0	1	0	1
Dec-18-2002	2	2	0	4500	0	1	0	1
Dec-19-2002	0	2	0	4500	0	1	0	1
Dec-20-2002	0	2	0	4500	0	1	0	1

Order: NP Where: RES PRESENT

Figure 6.2.2-2 (8 of 8) Schedule Load Requirements for All Vehicle and STN Resources

Period Start	CREW-E	CREW-N	E-LAND	HANGER	OMV	OTV	PTM-4	RMS
Dec-21-2002	0	2	0	4500	0	1	0	1
Dec-22-2002	0	2	0	4500	0	1	0	1
Dec-23-2002	0	2	0	4500	0	1	0	1
Dec-24-2002	0	2	0	4500	0	0	1	1
Dec-25-2002	0	2	0	4500	0	0	1	1
Dec-26-2002	0	2	0	4500	0	0	1	1
Dec-27-2002	0	2	0	4500	0	0	1	1
Dec-28-2002	0	2	0	4500	0	0	1	1
Dec-29-2002	0	2	0	4500	0	0	1	1
Dec-30-2002	0	2	0	4500	0	0	1	1
Dec-31-2002	0	2	0	4500	0	0	1	1

Order: NP Where: RES PRESENT

Figure 6.3-1 (1 of 6) LEO Space Transportation Node List of Requirements

WBS No.: 1.01 Requirement ID: 1
STN Element: Mgt/Integr Assumptions: Ref:

The General Requirements in Section 2.1 of JSC 31000 also apply to the LEO STN; except for the induced environment restrictions due to user accommodation.

Rationale: The JSC 31000 general Space Station requirements appear to be appropriate for the STN and represent more planning and analysis effort than is available for derivation of similar requirements in this study. The limitations of induced environment due to accommodating applications users are not appropriate for the STN and are one reason for the need of an STN separate from the Space Station.

WBS No.: 1.01 Requirement ID: 2
STN Element: Mgt/Integr Assumptions: Ref: 3

The LEO STN orbit parameters must enable efficient payload delivery from earth, allow transfer to lunar trajectories, insure no collision with the space station, and minimize space station viewing interference.

Rationale: By definition, the transportation node should be located in the optimum position in the transportation path. However, the transportation facility must not interfere with the important objectives of the earth orbit base, the Space Station.

WBS No.: 1.01 Requirement ID: 3
STN Element: Mgt/Integr Assumptions: 3.05,3.06 Ref: 3

The STN shall have the capability to accommodate one docked space shuttle while supporting a lunar flight departure or arrival.

Rationale: The lunar crews do not arrive until the lunar flight vehicle is substantially ready for departure and the Shuttle must remain until the lunar flight has departed so the lunar crew could be returned to Earth in the event of a failure to launch.

WBS No.: 1.01 Requirement ID: 4
STN Element: Mgt/Integr Assumptions: 1.0lb Ref: 3

The LEO STN orbital orientation is to be optimized for spacecraft systems design. There are no mission pointing or orientation requirements.

Rationale: The STN is not subject to design compromises related to diverse earth orbit applications interests. The STN orientation is to be designed to facilitate the best possible support to transportation activities transitioning from earth orbit to transplanetary trajectories.

Figure 6.3-1 (2 of 6) LEO Space Transportation Node List of Requirements

WBS No.: 1.01 Requirement ID: 5
STN Element: Mgt/Integr Assumptions: 2.07 Ref: 16

Implementation of LEO STN is to maximize commonality of systems, hardware, software, procedures, and operations with the Space Station.

Rationale: The STN objective is not to extend technology in earth orbit human sustenance. The STN must be safe and economical to be an element in an active transportation network. Use of existing technology and experience from the Space Station supports these STN goals.

WBS No.: 1.01 Requirement ID: 6
STN Element: Mgt/Integr Assumptions: Ref: 5

As many space exposed maintenance activities as is practical should be designed for replacement by automatic equipment.

Rationale: EVA will be more commonly used, but it will remain more hazardous and expensive than IVA. Automation technology appears sufficiently developed to accommodate space exposed maintenance cost effectively for many routine requirements.

WBS No.: 1.03 Requirement ID: 1
STN Element: RMS Assumptions: Ref: 3

A minimum of two Remote Manipulator Systems (RMS's) are required. Each must be able to move the 113.8 metric ton lunar departure spacecraft from the servicing fixture to a safe deployment release point.

Rationale: An RMS is required for servicing activities of vehicles in the STN Hanger. In addition, an RMS is used in berthing and support in translating vehicles into and out of the hanger. These RMS support functions can not be constrained not to occur simultaneously.

WBS No.: 1.03 Requirement ID: 2
STN Element: RMS Assumptions: 3.04 Ref: 3

Robotic end effectors shall be available for connection to the RMS. The robot shall have manipulative and reach capabilities comparable to or better than an EVA astronaut.

Rationale: EVA will be more commonly used, but it will remain more hazardous and expensive than IVA. Automation technology appears sufficiently developed to accommodate space exposed maintenance cost effectively for many routine requirements. The automation equipment must have capabilities adequate to perform work tasks also performed by EVA astronauts.

Figure 6.3-1 (3 of 6) LEO Space Transportation Node List of Requirements

WBS No.: 1.05 Requirement ID: 1
STN Element: Airlocks Assumptions: Ref: 15-6.2.1

The airlocks are required to support 9 EVA passages and two Shuttle berthings in 30 days. The maximum number of EVA events per 24-hour period is four (4) -- Two shifts of 2-crewmember team making two EVA events in one day.
Rationale: Derived from evaluation of Figure 6.2.1-1.

WBS No.: 1.19 Requirement ID: 1
STN Element: Warehouse Assumptions: Ref: 3

TBD cubic feet of pressurized logistics and warehouse storage space and TBD cubic feet of unpressurized volume are required to store vehicle spares and parts in a timeframe facilitating successful lunar flight departure.
Rationale: The derivation of storage volume needed for spares requires more information on vehicles and spares planning than currently exists. This storage volume is an important parameter and a "place-holder" requirement here serves as a reminder.

WBS No.: 1.22 Requirement ID: 1
STN Element: Hab Element Assumptions: Ref: 15-6.2.3

Permanent accommodations for a crew of six (6) are required.
Rationale: Derived from evaluation of Figure 6.2.2-2.

WBS No.: 1.22 Requirement ID: 2
STN Element: Hab Element Assumptions: Ref: 15-6.2.3

In addition to the permanent crew, the STN shall provide habitation facilities for seven visitors (3 shuttle and 4 lunar) for 14 days.
Rationale: The purpose of the STN is to provide for personnel involved in transportation from earth orbit to transplanetary trajectories.

WBS No.: 1.23 Requirement ID: 1
STN Element: EVA Systems Assumptions: Ref: 5,10

Components of all vehicles and service facilities (propellant depot, etc.) must be free of sharp corners and objects. In addition, the components must have appropriate EVA handholds and foot restraints.
Rationale: This is a generic statement of standards historically required by NASA EVA-responsible management.

WBS No.: 1.23 Requirement ID: 2
STN Element: EVA Systems Assumptions: Ref: 5

When remotely controlled arms and cranes are being operated, the EVA crewmembers will be stationed at an area which is safe from accidental contact with the systems.
Rationale: This is a generic statement based on common industry health and safety practices for working in the area of robotic manipulators and other dangerous mobile equipment.

WBS No.: 1.24 Requirement ID: 1
STN Element: Ops Center Assumptions: 3.02b Ref: 3

A Transportation Operations Center is required in the STN with operations command and control facilities capable of 24 hours per day operation to control all activities in the hanger, propellant depot, RMS, warehouse, airlock, and space within five km of the STN.
Rationale: Local, central control and monitoring of all STN operations is necessary to enhance productivity and to ensure operations safety.

WBS No.: 1.24 Requirement ID: 2
STN Element: Ops Center Assumptions: Ref: 3

The STN Operations Center is required to monitor status of vehicles stored in the hanger and actively verify health at sufficiently frequent intervals to prevent degradation.
Rationale: The STN crew will be onboard the STN essentially continuously. More effective crew time utilization is achieved by detecting and correcting systems malfunctions early rather than incurring peaks in manpower required for problems during a concentrated checkout. In addition, some degradations in vehicles could escalate into general STN safety hazards.

WBS No.: 1.25 Requirement ID: 1
STN Element: Prop Depot Assumptions: Ref: 15-6.2.4

A propellant storage depot is required to store 160 metric tons of liquid oxygen, 24 metric tons of liquid hydrogen, and sufficient OMV propellant for 8 STN prox ops flights.
Rationale: This requirement is based on supporting two (2) loaded lunar departure spacecraft plus an additional OTV and 10 percent contingency.

WBS No.: 1.25 Requirement ID: 2
STN Element: Prop Depot Assumptions: Ref: 3

Nominal propellant transfer at the propellant depot is required to be accomplished without EVA.
Rationale: Propellant transfer could be hazardous for the health of any EVA astronauts.

Figure 6.3-1 (of 6) LEO Space Transportation Node List of Requirements

WBS No.: 1.25 Requirement ID: 3
STN Element: Prop Depot Assumptions: Ref: 19

The propellant depot gas boiloff rates shall be less than the following rates:
Liquid Oxygen = 0.1% per month
Liquid Hydrogen = 0.3% per month

Rationale: Guidelines are required for planning purposes and these values obtained from General Dynamics were said to be potentially obtainable.

WBS No.: 1.25 Requirement ID: 4
STN Element: Prop Depot Assumptions: Ref: 3,12,5

The LEO STN shall have external explosion control systems where appropriate (e.g. propellant depot and hanger). As an example, liquid hydrogen tanks and oxygen tanks should be separated as far as practicable.

Rationale: Explosive hazard monitoring and control systems are common industry practice for explosive storage facilities and petrochemical plants.

WBS No.: 1.25 Requirement ID: 5
STN Element: Prop Depot Assumptions: Ref: 5

When LOX is being transferred from one container to another, the receiving vessel should be filled at a rate of TBD to minimize the thermal shocks.

Rationale: The analysis of thermal shock in STN cryogenic systems requires more information than is currently available and more time than allotted for this study. However, thermal shock and the resulting impact on time required for propellant transfer is an important parameter. A "place-holder" requirement here serves as a reminder.

WBS No.: 1.26 Requirement ID: 1
STN Element: Hanger Assumptions: 1.08 Ref: 15

A hanger is required to provide protection, maintenance facilities, and storage of space-based transportation equipment. A volume sufficient to contain 2 RMS's, 4 OTV's, 2 OMV's, 1 PTM-4, 1 E-Lander/E-Ascent/Lunar Payload, 1 E-Lander/Lunar Surface Cargo, and 4 EVA astronauts. More specific information is available in the baseline model schedule analysis.

Rationale: Derived from evaluation of Figure 6.2.2-1 and Figure 6.2.2-2.

WBS No.: 1.26 Requirement ID: 2
STN Element: Hanger Assumptions: Ref: 15

The hanger shall contain aids and facilities for stacking, mating, and unstacking a lunar mission spacecraft.

Rationale: The purpose of the hanger is to provide protection and a facilities for providing servicing support to space based transportation vehicles.

Figure 6.3-1 (6 of 6) LEO Space Transportation Node List of Requirements

WBS No.: 1.26 Requirement ID: 3
STN Element: Hanger Assumptions: Ref: 15

The hanger shall contain aids and facilities to deactivate and store OMV's, OTV's and PTM-4's.
Rationale: The purpose of the hanger is to provide protection and a facilities for storing and monitoring space based transportation vehicles.

WBS No.: 1.26 Requirement ID: 4
STN Element: Hanger Assumptions: Ref: 6

Each of the two hanger servicing fixtures must be able to rotate the docked vehicle around the vehicle longitudinal axis to allow a fixed servicing position to access 360 degrees of the vehicle exterior.
Rationale: The referenced Langley Research Center study indicates that it more productive to fix the work station position and rotate the vehicle being serviced.

WBS No.: 1.26 Requirement ID: 5
STN Element: Hanger Assumptions: Ref: 15

The hanger shall have aids and facilities to provide maintenance for OMV's, OTV's PTM-4's, E-Lander's, E-Ascent's, EMU's, and STN elements.
Rationale: The purpose of the hanger is to provide protection and a facilities for providing maintenance support to space based transportation vehicles.

WBS No.: 1.26 Requirement ID: 6
STN Element: Hanger Assumptions: Ref: 12

IVA crew transfer is required to the PTM-4 while in the hanger.
Rationale: The PTM-4 requires internal cabin servicing and maintenance not common to most other vehicles in the transportation inventory. In addition, more frequent access may be required to load/unload mission related items. EVA service is not compatible with internal cabin servicing and airlock transfer is not desirable.

WBS No.: 1.26 Requirement ID: 7
STN Element: Hanger Assumptions: Ref: 6

The hanger access opening shall have provisions to eliminate entry of micrometeors and solar radiation (e.g. doors or orientation to Earth).
Rationale: In order to provide a complete envelope of protection to vehicles in the hanger, the entrance/exit must be designed to allow blocking of radiation and micrometeors.

7.0 Closing Comments

This study task to document the upper level assumptions and requirements for transportation nodes has initiated a document and procedural methods which are designed for continued growth and use. The assumptions and requirements recorded in the data base are the more visible and important ones identified in the thought process of developing the transportation mission service and the schedule load demands. Additional comments are provided in the following sections.

7.1 Data Depth

In the time allotted for this effort, many assumptions and requirements have been recorded. However, with further analysis, the depth of the schedule data will allow more assumptions and requirements to be recognized.

7.2 Sensitivities

The LEO STN assumptions and requirements have been recorded for the baseline systems defined in section 3.0. The intention of establishing generic baselines which are representative of a class of scenarios rather than analyzing a specific scenario is to reduce the sensitivity of results to normal program planning fluctuations. However, it could be useful to vary parameters for specific factors in the generic baseline to determine the degree of results sensitivity. Such a sensitivity analysis was not accomplished in this task effort.

7.3 Iteration Process

The formulation of project assumptions and requirements is an iterative process. Based on the statement of requirements in this document, conceptual engineering design will be performed. In the LEO STN design analysis and related programmatic interaction, additional assumptions and requirements will be identified. The new information learned as a result of conceptual designing should be reviewed and incorporated into the baselines and requirements analysis of this document. Any new assumptions and requirements flowing from the new requirements review will now effect the existing conceptual design and so the iteration continues.