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LOCKHEED MARTIN

August 2000

To: Future Athena Customers

I am pleased to provide you with this release of the *Athena Mission Planner's Guide*. This guide provides essential technical and programmatic information to perform a first-order assessment of the compatibility of your payload with the Athena launch system. The Athena launch system, and our modular family of launch vehicles have been designed to accommodate a wide range of small to medium class payloads and to accurately, reliably, and at low cost deliver your payload successfully to orbit. With these features, I am confident that we can offer you, our customer, outstanding value and service to meet both your near-term and future launch service needs.

The release of this guide followed the first successful launch of an Athena. Since that time, we have flown several successful Athena I and II configurations from both our Eastern and Western launch sites. Although the West Coast launches are addressed in the *Athena Mission Planner's Guide*, the Athena no longer will launch from the West Coast. Athena's new launch site for high inclination orbits is Kodiak Launch Complex in Kodiak, Alaska. The description of our new launch site is supplied in a separate appendix to the User's Guide. Also, the environments referenced in the *Athena Mission Planner's Guide* are very preliminary, as the guide does not incorporate data from subsequent Athena flights. Updated environment data can be supplied upon request.

Following the merger of the Lockheed and Martin Marietta corporations in early 1995, the Athena program was transitioned to Lockheed Martin Astronautics in Denver, CO. This brought together, in one organization, the teams that design, produce, integrate and launch the Titan, Atlas, Athena and MSLS launch systems and integrate and launch the ILS/Proton. The Athena is an integral part of these launch systems and offers the resources, capabilities and experiences of this unparalleled organization. The Athena program and our customers benefit from Lockheed Martin's 40 years of launch vehicle and satellite integration experience.

Many improvements have been made to the vehicle following the transition of the Athena program to Denver which culminated in a very successful first launch on August 22, 1997. With our history of mission success, the members of the Athena team are eager to assist you in the definition and development of your mission and while pursuing our corporate goal of 100% mission success look forward to many continued successes.

Please call me at (303) 977-4850 for any further information you may require.

Sincerely,

R. L. Malone
Director
Small Launch Vehicle Programs

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September 1997

LMLV MISSION PLANNER'S GUIDE

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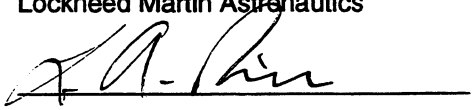

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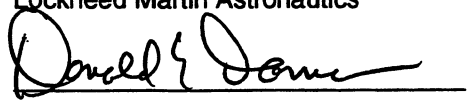

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FOREWORD

This *LMLV Mission Planner's Guide* presents information regarding the Lockheed Martin Launch Vehicle (LMLV) and related launch services. A range of vehicle configurations and performance capabilities are offered to allow an optimum match to customer requirements at low cost. Information is presented in sufficient detail for preliminary assessment of the LMLV family for your missions.

This guide includes essential technical and programmatic information for preliminary mission planning and preliminary spacecraft design. LMLV Performance capability, environments and interfaces are described in sufficient detail to assess a first-order compatibility. A description of the spacecraft processing and launch facilities at our eastern and western launch sites is also included. This guide also describes the operations and hardware flow for the spacecraft and launch vehicle leading to encapsulation, spacecraft mating and launch.

This guide is subject to change and will be revised periodically.

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GLOSSARY

A

ACS	Attitude Control System
AFR	Air Force Regulation
ARIA	Advanced Range Instrumentation Aircraft
ASO	Astrotech Space Operations

B

BC	Bolt Circle
BSI	British Standards Institute

C

CAD	Computer-Aided Design
cc	Carbon-Carbon
CCAM	Collision and Contamination Avoidance Maneuver
CCAS	Cape Canaveral Air Station
CCSI	California Commercial Spaceport, Inc.
CCTV	Closed-Circuit Television
CDR	Critical Design Review
CFE	Customer-Furnished Equipment
cg	Center of Gravity
CLS	Commercial Launch Services
CSD	Chemical Systems Division (Pratt & Whitney)
CSO	Complex Safety Officer

D

DAT	Digital Audio Tape
DEC	Digital Equipment Corporation
DLV	Demonstration Launch Vehicle
DOF	Degree of Freedom

E

EED	Electro-Explosive Device
EGSE	Electrical Ground Support Equipment
EIA	Electrical Industry Association
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPA	Environmental Protection Agency
ER	Eastern Range
ERB	Engineering Review Board
ERR	Eastern Range Regulation
ESMCR	Eastern Space and Missile Center Regulation
EWR	Eastern/Western Range

F

FAMS	Flight Analysis Motion Simulator
FMH	Free Molecular Heating
FOTS	Fiber-Optics Transmission System
FPA	Flight Plan Approval
FS	First Stage
FSPO	Flight Safety Project Officer
FTP	File Transfer Protocol
FTS	Flight Termination System
FTSO	Flight Termination System Observer

G

GHe	Gaseous Helium
GN_2	Gaseous Nitrogen
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GSO	Guidance System Observer
GTO	Geosynchronous Transfer Orbit

H

HEPA	High-Efficiency Particulate Air
HP	Hewlett Packard
HPF	Hazardous Processing Facility
HVAC	Heating, Ventilating and Air Conditioning
HWIL	Hardware-in-the-Loop

I

ICD	Interface Control Document
I/F	Interface
ILC	Initial Launch Capability
IGES	Initial Graphics Exchange Specification
IMU	Inertial Measurement Unit
IPF	Integrated Processing Facility
IRD	Interface Requirements Document
ISO	International Organization of Standardization
ITA	Integrated Thermal Analysis
IUS	Inertial Upper Stage
IV&V	Independent Verification and Validation

J

K

KSC	Kennedy Space Center

L

L-	Launch Minus
LC-46	Launch Complex-46
LEO	Low-Earth Orbit
LM	Launch Mount
LMLV	Lockheed Martin Launch Vehicle
LOCC	Launch Operations Control Center
LVCV	Launch Vehicle Checkout Van
LVMP	Launch Vehicle Mission-Peculiar

M

MAS	Mobile Access Structure
MDR	Mission Dress Rehearsal
MFCO	Mission Flight Control Officer
MGSE	Mechanical Ground Support Equipment
MIL-STD	Military Standard
MIWG	Mission Integration Working Group
MPDR	Mission-Peculiar Design Review
MRR	Mission Readiness Review
ms	Millisecond
MSLS	Multi-Service Launch System
MSPSP	Missile System Prelaunch Safety Package
MST	Mobile Service Tower
MWG	Management Working Group

N

NASA	National Aeronautics and Space Administration
NIOSH	National Institute for Occupational Safety and Health
NRO	National Reconnaissance Organization

O

OAM	Orbit Adjust Module
OCP	Operator Communication Panels
OD	Operations Directive
ORD	Operations Requirements Document
OSB	Operations Support Building
OSHA	Occupational Safety and Health Administration
OTM	Output Transformation Matrix

P

P/A	Payload Adapter
PCM	Pulse Code Modulated
PDR	Preliminary Design Review

PDSM	Product Delivery System Manual
PI	Program Introduction
PIN	Personal Identification Number
PLF	Payload Fairing
PPF	Payload Processing Facility
PRD	Program Requirements Document
PSF	Propellant Servicing Facility
PSP	Program Support Plan
PTA	Payload Technical Advisor
PTD	Payload Technical Director

Q

QIC	Quarter-Inch Cartridge

R

RF	Radio Frequency
ROC	Range Operations Controller
ROCC	Range Operations Control Center
RPO	Radiation Protection Officer

S

SAB	Shuttle Assembly Building
SC	Statement of Capability
S/C	Spacecraft
SCS	Signal Conditioning Set
SDRC	Structural Dynamics Research Corporation
SEB	Support Equipment Building
SFA	Spaceport Florida Authority
SFCO	Senior Mission Flight Control Officer
S&G	Sargent and Greenleaf
SimLab	Simulation Laboratory
SLC-6	Space Launch Complex-6
SRB	Solid Rocket Booster
SRM	Solid Rocket Motor
SS	Second Stage
SSI	Spaceport Systems International
SSPP	System Safety Program Plan

T

TIM	Technical Interchange Meeting
TML	Total Mass Loss
TOPS	Transistorized Operational Phone System
TOS	Transfer Orbit Stage

TRS	Test Requirements Specification
TSO	Telemetry Systems Observer
TVCS	Thrust Vector Control System
TWG	Technical Working Group

U

UDS	Universal Documentation System
UPS	Uninterruptable Power System

V

VAFB	Vandenberg Air Force Base
VCM	Volatile Condensable Materials
VeGA	Velocity Guidance Algorithm
VSWR	Voltage Standing-Wave Ratio

W

WFF	Wallops Flight Facility
WR	Western Range
WRR	Western Range Regulation
WSMCR	Western Space and Missile Center Regulation

X

Y

Z

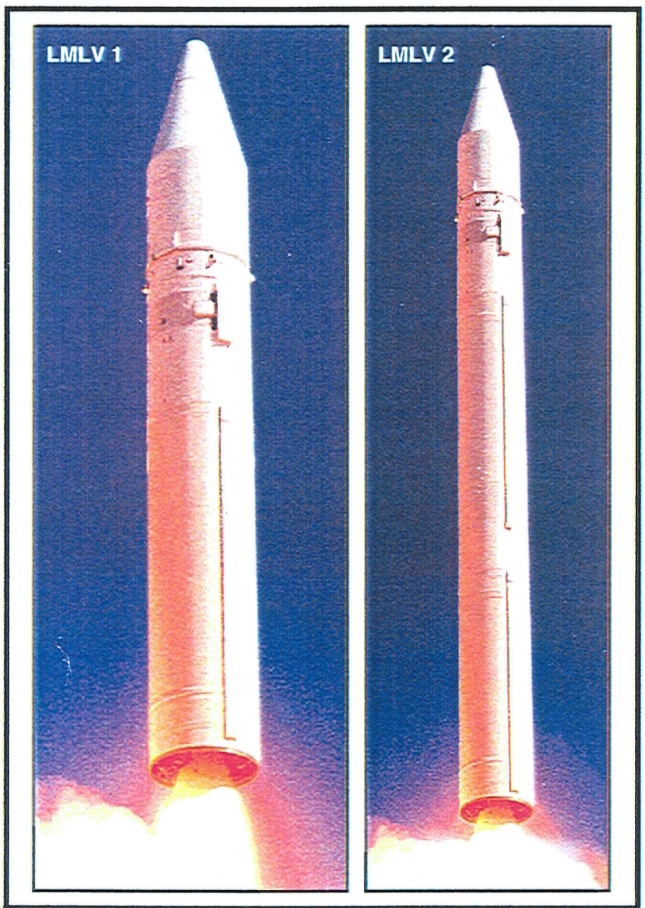
1.0 INTRODUCTION

1.1 SUMMARY

The *LMLV Mission Planner's Guide* is designed to provide current and potential LMLV launch services' customers with information about the operational LMLV family, shown in Figure 1.1-1, and related spacecraft services. A full range of technical planning data is included in this guide to allow the user to assess the compatibility of the user's payload with the various interfaces of the LMLV system.

1.2 LAUNCH SERVICES

The LMLV is offered to commercial and government launch services users through the Commercial Launch Services (CLS) organization of Lockheed Martin. Through CLS, the launch services customer has access to a dedicated team of technical and management specialists to readily define the complete and most cost-effective LMLV launch services solution.



Development Launch Vehicle	Aug 95
LMLV1 Initial Launch Capability	Aug 97
LMLV2 Initial Launch Capability	Oct 97

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Figure 1.1-1 The LMLV1 and LMLV2 provide highly reliable, low-cost access to space.

The LMLV/CLS organization offers a full launch service, from spacecraft integration, processing and encapsulation, through launch operations and verification of orbit. The typical launch service includes:

1) Launch of the LMLV;
2) Launch operations services;
3) Mission-peculiar hardware and software design, test, and production;
4) Technical launch vehicle/spacecraft integration and interface design;
5) Launch facilities and support provisions;
6) Payload processing facilities;
7) Spacecraft support at the launch site;
8) Range safety and support interface;
9) Mission management;
10) Validation of spacecraft separation sequence and orbit.

With authority to proceed on a launch services contract, the LMLV program immediately assigns a single point-of-contact, the Mission Manager, to be responsible for program development and management. The Mission Manager acts as the customer's advocate to the various organizations within Lockheed Martin, its subcontractors, and suppliers. The Mission Manager's primary duty is to arrange the resources necessary for the successful completion of the launch services contract and to ensure complete customer satisfaction.

In cases that involve the national security interests of the United States, such as with the National Reconnaissance Organization (NRO), separate integration management resources of the Lockheed Martin Astronautics organization are called on to handle the unique requirements typically associated with the integration and launch of these types of payloads.

As part of our LMLV launch services contract support, administrative guidance and assistance can be provided, when needed, in meeting

government regulations, including import and export licenses, permits, and clearances from government and political entities.

The LMLV/CLS organization procures all commercial and government agreements required to launch the LMLV and supports the customer in procuring all agreements required to launch the spacecraft. The LMLV/CLS organization also procures all agreements covering payload and LMLV processing facilities, services, and range support at Cape Canaveral Air Station (CCAS) in Florida and Vandenberg Air Force Base (VAFB) in California.

1.3 ADVANTAGES OF SELECTING LMLV

Our launch vehicles and services provide the following key advantages:

1) Backed by Lockheed Martin, the world's largest aerospace company, with stable, long-term capability in space products and services;
2) More than 40 years of launch vehicle development and spacecraft integration experience enables us to have, in-place, the right personnel, procedures, test facilities, and analysis tools to provide a successful launch;
3) A dedicated Mission Manager supported by the resources and capabilities of Lockheed Martin;
4) A conservative design with flight-proven components that provides highly reliable, low-cost, access to space;
5) Proven non-segmented solid rocket motors with demonstrated high reliability;
6) A large payload fairing that accommodates large spacecraft volume and volume growth;
7) Moderate payload launch environments (e.g., loads, shock, vibration, acoustic, thermal and electromagnetic) that are generally lower than those of other launch vehicles in this class;
8) Lockheed Martin's unique Simulation Laboratory (SimLab) is configured to "fly" the integrated LMLV mission-specific software and avionics hardware in-the-loop before launch;
9) East Coast launch facilities for launch of low-inclination spacecraft missions;
10) Dedicated West Coast launch facilities for launch of high-inclination spacecraft missions;
11) An established mission success organization dedicated and committed to the success of each and every mission;
12) The combined resources and experience of the Titan, Atlas and LMLV teams to meet the challenging commercial launch services needs of the future.

1.4 LAUNCH SYSTEM CAPABILITIES AND INTERFACES

The LMLV launch system is comprised of a number of hardware and software-based subsystems and engineering, manufacturing, and operations processes that are designed to properly integrate the spacecraft with the launch vehicle. The remainder of this section summarizes the major interface and process components of the LMLV system. More detailed information can be found in the related sections of this guide.

1.4.1 LMLV Launch System

The LMLV has been designed to provide highly reliable, low-cost access to space, primarily by utilizing non-segmented solid rocket motors. The LMLV solid fueled propulsion systems provide advantages over liquid fueled propulsion systems by providing handling convenience and significantly reducing on-pad time by simplifying prelaunch and launch operations.

The LMLV family consists of two basic configurations; designated LMLV1 and LMLV2, and two enhanced configurations; designated LMLV1B and LMLV2B. The family has application for a range of spacecrafts according to mission and program requirements. The basic LMLV1 is capable of delivering up to 1,548 lb (702 kg) to low-Earth orbit (LEO) and the basic LMLV2 is capable of delivering up to 4,219 lb (1,914 kg) to LEO. The enhanced LMLV1B is capable of delivering up to 1,905 lb (865 kg) to LEO and the enhanced LMLV2B is capable of delivering up to 4,355 lb (1,976 kg) to LEO. LEO is defined as a 100 nmi circular orbit inclined at 28.5 deg.

The LMLV1 and 1B and the LMLV2 and 2B all use common components and systems, as shown in Figure 1.4.1-1 to achieve mission requirements for performance, reliability, and cost. The modular architecture allows for common hardware, build processes, testing, launch site facilities, assembly and checkout, ground support equipment, and launch operations procedures.

LMLV1 Description—The LMLV1 is a three-stage vehicle. It has an overall height of 61.9 ft (18.9 m), a maximum diameter of 93 in. (236 cm), and a lift-off weight of 146,100 lb (66,300 kg). The major components of the LMLV1 include: The Castor 120® first-stage motor; the interstage structure; the Orbus® 21D second-stage motor; the Orbit Adjust Module (OAM), which includes the equipment section structure, attitude control system (ACS) and avionics; the Model 92 payload fairing; and the payload adapter.

LMLV2 Description—The LMLV2 is a four-stage vehicle. It has an overall height of 93.2 ft (28.4 m), a maximum diameter of 93 in. (236 cm), and a lift-off weight of 266,100 lb (120,700 kg). The LMLV2 has a large number of components common to the LMLV1. Major components unique to the LMLV2 include: The Thiokol Castor 120® second-stage motor; a structurally augmented lower interstage section between the first- and second-stage motors; and an additional flight termination destruct package and ordnance for the second-stage motor.

LMLV1B Description—The LMLV1B is a variation of the LMLV1 that replaces the monopropellant propulsion system in the OAM with a bipropellant propulsion system. The bipropellant system operates in a dual-mode utilizing hydrazine and nitrogen tetroxide, for orbit insertion and/or trim burns, and hydrazine for attitude control burns. The bipropellant system increases the performance of the LMLV1 by 357 lb (162 kg) to LEO.

LMLV2B Description—The LMLV2B is a variation of the LMLV2 that uses the same bipropellant propulsion system as the LMLV1B. The bipropellant system increases the performance of the LMLV2 by 136 lb (62 kg) to LEO.

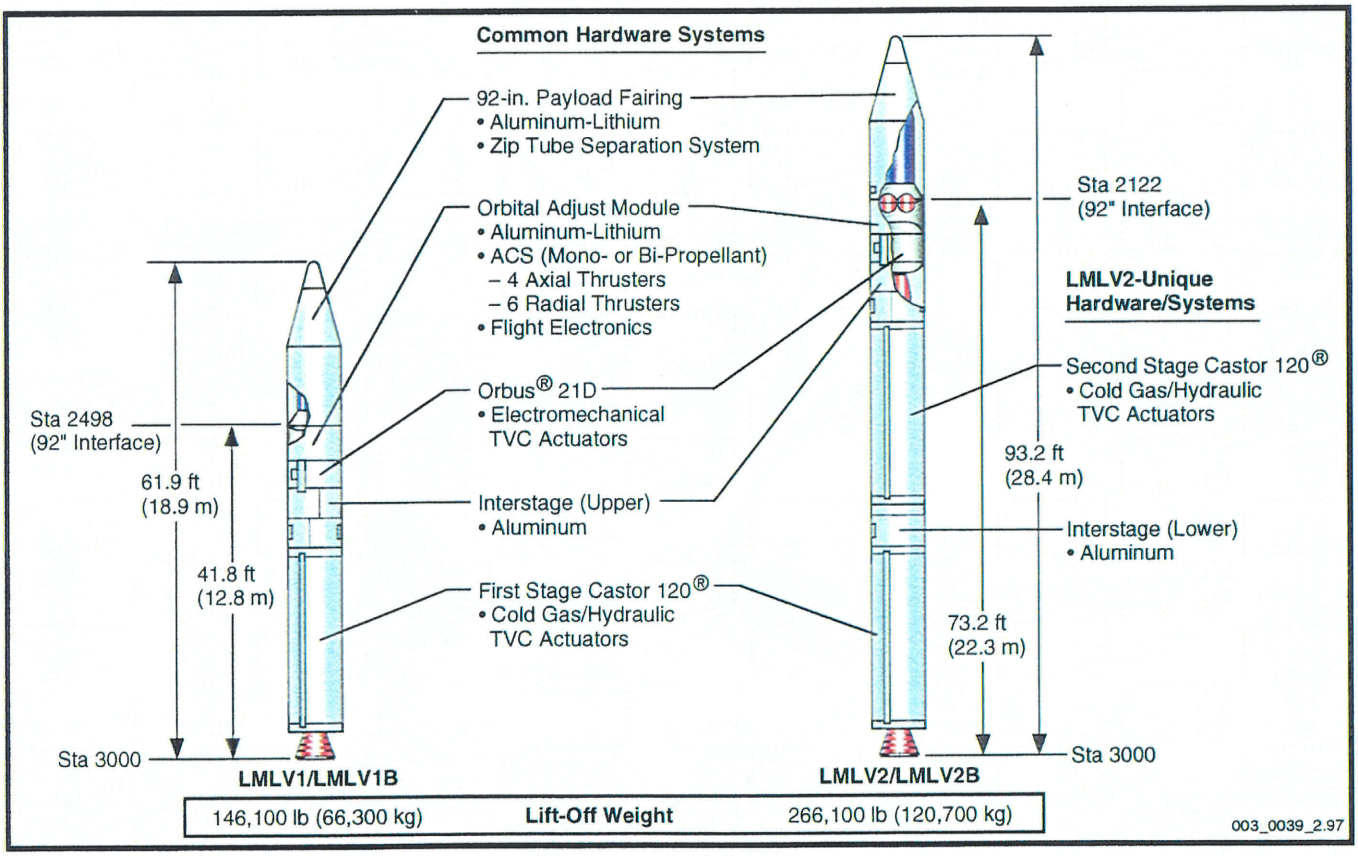


Figure 1.4.1-1 Our use of common components and systems meets mission requirements reliably and at low cost.

1.4.2 Mission Design and Performance

The LMLV has been designed to provide the small spacecraft community with low-cost, highly reliable access to space. The LMLV has the capability of accurately delivering payloads weighing up to 4,355 lb (1,976 kg) to orbit. Achievable orbits range from circular to highly elliptical and cover a broad range of inclinations, from low, using our Eastern Range (ER) launch facilities, to polar and sun-synchronous, using our Western Range (WR) launch facilities. Section 2.0 discusses the full range of mission designs and performance capabilities available to the customer.

1.4.3 Environments

All environments specified for the LMLV (e.g., loads, shock, vibration, acoustic, thermal and electromagnetic) are based on engineering analyses and have been thoroughly validated by test and flight telemetry data. LMLV instrumentation enables the telemetering of high-frequency measurements concerning the spacecraft interface and environments. These measurements allow verification of the interface control document (ICD) flight environments for each LMLV mission. Section 3.0 discusses the environments to which the spacecraft is exposed.

1.4.4 Spacecraft Interfaces

Lockheed Martin has developed simple, reliable mechanical and electrical interfaces that allow the spacecraft to be integrated to the launch vehicle quickly and with minimal risk. Our standard Model 92 payload fairing and five standard payload adapters, available for LMLV missions, are shown in Figure 1.4.4-1.

Payload Fairing—Lockheed Martin provides a large 92-in. diameter payload fairing (PLF). The PLF provides a thermal and acoustic enclosure that protects the payload from prelaunch operations through atmospheric ascent. Portions of the external surfaces of the PLF are insulated with cork to limit temperatures to acceptable values. Noncontaminating thermal control coatings are used on internal surfaces to reduce incident heat fluxes to the spacecraft. Low out-gassing parts and materials are used inside the PLF to reduce spacecraft contamination.

Payload Adapters—Lockheed Martin provides five standard payload adapters (P/A); the Model 24, 37, 38, 47 and 66. The P/A supports and mechanically connects the spacecraft to the launch vehicle. Each P/A is designed to assure that the proper clearances are maintained for an unobstructed separation. Standard separation systems and connectors are available for the Model 24, 37, 38 and 47 payload adapters. Other payload adapters and separation systems may be specified or provided by the customer. Positive spacecraft separation is detected through continuity loops, installed in the electrical separation connectors, and telemetered to the ground. This system provides near real-time, positive confirmation of the spacecraft separation event.

Mission-Peculiar Items—In addition to the P/A and separation system, Lockheed Martin provides launch vehicle mission–peculiar (LVMP) items to support the spacecraft during the launch vehicle mission. LVMP items include payload fairing access doors, acoustic blankets, and other hardware that the payload may require as mission–unique standard or nonstandard services.

Section 4.0 describes our launch vehicle and ground system interfaces with the spacecraft.

1.4.5 Spacecraft and Launch Facilities

Upon arrival to the launch site, most spacecraft require the use of payload and/or hazardous processing facilities for final checkout and processing of on-board systems before launch. Section 5.0 summarizes the payload processing facilities as well as the operational capabilities and interfaces of the launch facilities used by LMLV in operations at CCAS in Florida. Section 6.0 summarizes the payload processing and launch facilities used by LMLV in operations at VAFB in California.

1.4.6 Launch Campaign

The LMLV launch campaign processes require the involvement of the launch services customer and the spacecraft contractor. Section 7.0 provides a first-order overview of our operations processes and discusses issues that the potential

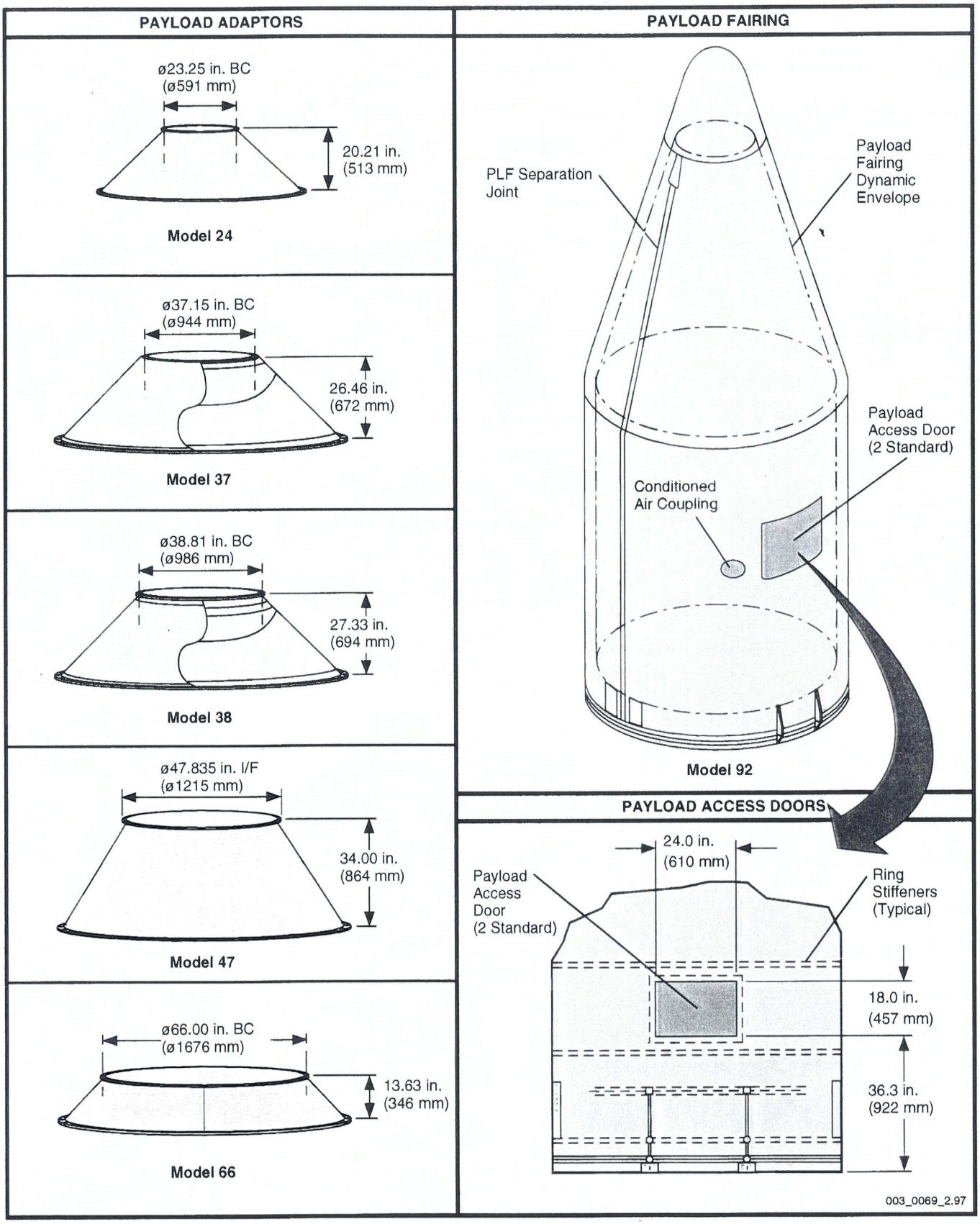


Figure 1.4.4-1 Standard payload fairing and payload adapters available for LMLV missions.

launch services user may wish to consider early in the mission integration process.

1.4.7 Mission Integration and Management

The mission integration and management process is designed to effectively use the engineering and production talents of Lockheed Martin Astronautics as well as those of the spacecraft contractors organizations to integrate the spacecraft with the LMLV. Section 8.0 provides an overview of the mission integration process and launch services management functions in place for both commercial and government missions. Our 24-month integration schedule, typical for most spacecraft missions, is discussed. Our management approach and a summary of integration analyses tasks are provided to enable the customer to have full confidence in the mission integration process.

1.4.8 System Enhancements

Section 9.0 provides insight into Lockheed Martin's plans for enhancing the LMLV to meet the high end launch services needs of the small launch vehicle community. Some of the enhancements include:

1) Orbus® 21G;
2) Orbus® 21HP;
3) 120 in. Payload Fairing;
4) Alternate Launch Sites.

1.4.9 Supplemental Information

The following three appendices are provided to address various issues in more detail:

1) Appendix A discusses the heritage of the LMLV and provides a more detailed description of its stages, components and subsystems;
2) Appendix B provides details of our mission success philosophy and quality assurance process firmly in place at our facilities and at our subcontractors and suppliers;
3) Appendix C defines the desired exchange of technical data requirements to support the initial mission development process. In addition, a discussion of the type and format of technical data needed is summarized to provide insight into the exchange of information between the spacecraft contractor, launch services customer, and launch vehicle contractor that occurs during the typical mission integration process.

1.5 CONCLUSION

The members of the LMLV team are eager to assist in the definition and development of future LMLV missions. The Foreword of this document contains information to allow the potential launch services customer to contact the appropriate CLS representative.

2.0 MISSION DESIGN AND PERFORMANCE

This section describes the performance capabilities of the LMLV family of configurations. Together these configurations have the capability to accurately deliver payloads weighing up to 4,355 lb (1,976 kg) to orbit. Achievable orbits range from circular to highly elliptical, and cover a broad range of orbital inclinations, from low, using launch azimuths available from our launch site at the Eastern Range (ER), to polar and sunsynchronous, using launch azimuths available from our launch site at the Western Range (WR), all with a high degree of accuracy for spacecraft position and attitude at spacecraft separation. Performance to geosynchronous transfer orbits (GTO) and planetary missions are also described in this section.

2.1 MISSION DESCRIPTIONS

Data for five representative inclinations is provided: Two ER mission profiles, low-Earth orbit (LEO) launches at 28.5 degrees and 50 degrees; and three WR mission profiles, LEO launches at 70 degrees, 90 degrees and 99 degrees. These cases were selected because they bracket the range of launch azimuths and orbit inclinations most commonly used from each location. These cases well represent our performance capabilities and provide the basis for interpolation to meet the initial needs of most users. Please contact Lockheed Martin for specific mission data that is not covered here.

2.1.1 Launch Sites

The launch sites that presently accommodate launches of the LMLV family are: Launch Complex-46 (LC-46) located at the ER at Cape Canaveral Air Station (CCAS) on the Atlantic Coast of Florida, and Space Launch Complex-6 (SLC-6) at the WR at Vandenberg Air Force Base (VAFB) on the Pacific Coast of California. Figure 2.1.1-1 shows the range of azimuths and inclinations available from both of these sites. Lower inclinations than those in the range shown can be achieved by using "dog-leg" trajectory maneuvers, although these maneuvers may result in significantly less payload weight-to-orbit. Also, there are some azimuth and trajectory restrictions that are launch-site peculiar as related to stage impact, debris fallout, safety and security reasons. Trajectory maneuvers can be used to compensate for these restrictions although these too may result in significantly less payload weight-to-orbit. Please contact Lockheed Martin for range safety related details concerning a specific mission inclination. Both ranges are readily accessible by rail, air, and road transport, and are well-equipped to support the full range of spacecraft customer needs.

2.1.2 Mission Profiles

The mission profiles provided illustrate how the vehicle will fly to obtain the required orbit from lift-off through orbit insertion. Figure 2.1.2-1 illustrates a typical LMLV1 profile and its key events. Figure 2.1.2-2 illustrates a typical LMLV2 mission profile and its key events. For most missions, the ascending LMLV injects into a transfer orbit with apogee at the target altitude. The LMLV adjusts the trajectory loft and coast period to achieve the required velocity for transfer orbit insertion using the Orbit Adjust Module (OAM) for vernier control. For the LMLV1, the OAM provides additional energy to achieve orbit and trims the final velocity for the required orbit. For the LMLV2, orbital velocity is provided by the Orbus® 21D (Stage 3) and the OAM trims the final velocity for the required orbit. In both configurations, the OAM is used to raise perigee and circularize the orbit. Orbits achievable using the LMLV family range from circular at altitudes to 700 nmi or more, to those that are extremely elliptical, depending on the mass properties of the spacecraft. Payload weight-to-orbit capability varies as a function of the amount of energy needed to attain the orbit and altitude required.

2.1.3 Launch Trajectories and Sequences of Events

Typically, the launch commences upon certification of launch readiness given by the range control authority. Commensurate with that authority, the LMLV family can be launched at any time of day, any day of the year, to accommodate even the most restricted launch window. The events that fol-

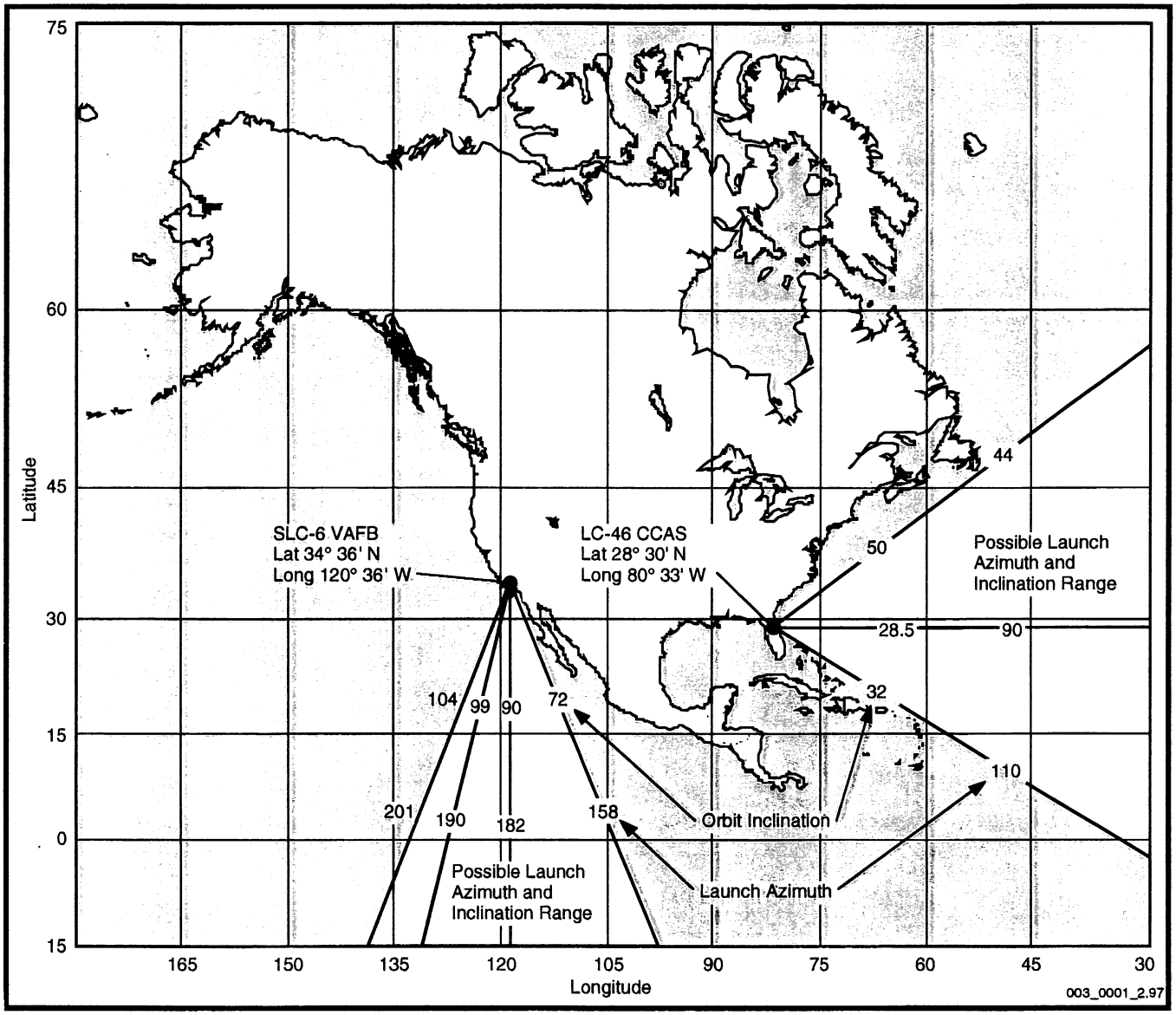


Figure 2.1.1-1 Possible Launch Azimuths and Orbit Inclinations from the Eastern and Western Ranges

low first-stage ignition are sequenced to implement the mission-unique trajectory designed for the spacecraft.

Figure 2.1.3-1 illustrates a representative LMLV1 trajectory. Shown are the elapsed time from launch, velocity, altitude, and range for significant launch events typical of a 100-nmi (185-km), 28.5-degree inclined orbit launched from the ER. For an LMLV1, the Castor 120® first-stage motor burns for approximately 90 seconds. During this phase of flight, attitude control is provided by the first-stage thrust vector control system. Following first-stage burnout the vehicle coasts under the control of the attitude control system (ACS). The duration of this ascent coast period is determined by the desired orbital parameters. The payload fairing is jettisoned during the ascent coast at nominally five seconds before second-stage ignition. Second-stage ignition and separation from the first-stage motor occur simultaneously. The Orbus® 21D second-stage motor burns for approximately 148 seconds. During this phase of flight, attitude control is provided by the second-stage thrust vector control system. After second-stage burnout, the OAM and payload separate from the Orbus® 21D and coast for a duration determined by the desired orbital parameters. The OAM then burns to achieve the final orbital velocity. The spacecraft can be separated or allowed to coast,

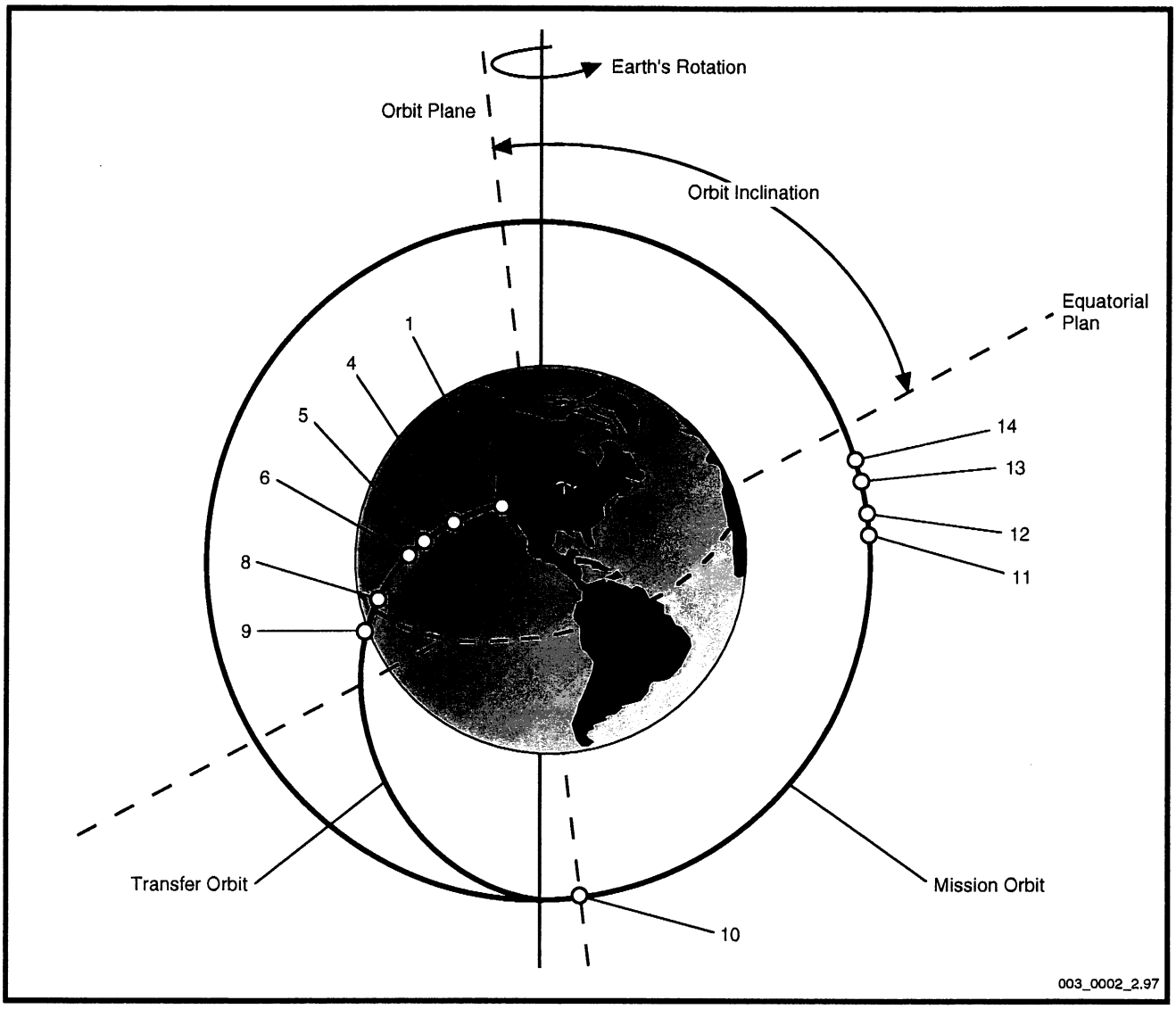


Figure 2.1.2-1 Typical LMLV1 Mission Profile

attached to the OAM, until within view of a ground telemetry station.

Figure 2.1.3-2 illustrates a representative LMLV2 trajectory. Shown are the elapsed time from launch, velocity, altitude, and range for significant launch events typical of a 100-nmi (185-km), 28.5-degree inclined orbit launched from the ER. For an LMLV2, the Castor 120® first-stage motor burns for approximately 90 seconds. The Castor 120® second-stage motor ignites immediately following burnout of the first-stage motor. During first-and second-stage burns attitude control is provided by the respective stage's thrust vector control system. Following second-stage burnout, the vehicle coasts under the control of the ACS. The duration of this ascent coast is determined by the desired orbital parameters. The payload fairing is jettisoned during the ascent coast at nominally five seconds before third-stage ignition. Third-stage ignition and separation from the second-stage motor occur simultaneously. The Orbus® 21D third stage burns for approximately 148 seconds and achieves the required transfer orbit velocity. A short ACS burn is performed, if required, to trim the apogee of the transfer orbit. After the transfer coast, a second ACS burn is performed to raise perigee to the target altitude. The spacecraft can be separated or allowed to coast, attached to the OAM, until within view of a ground telemetry station.

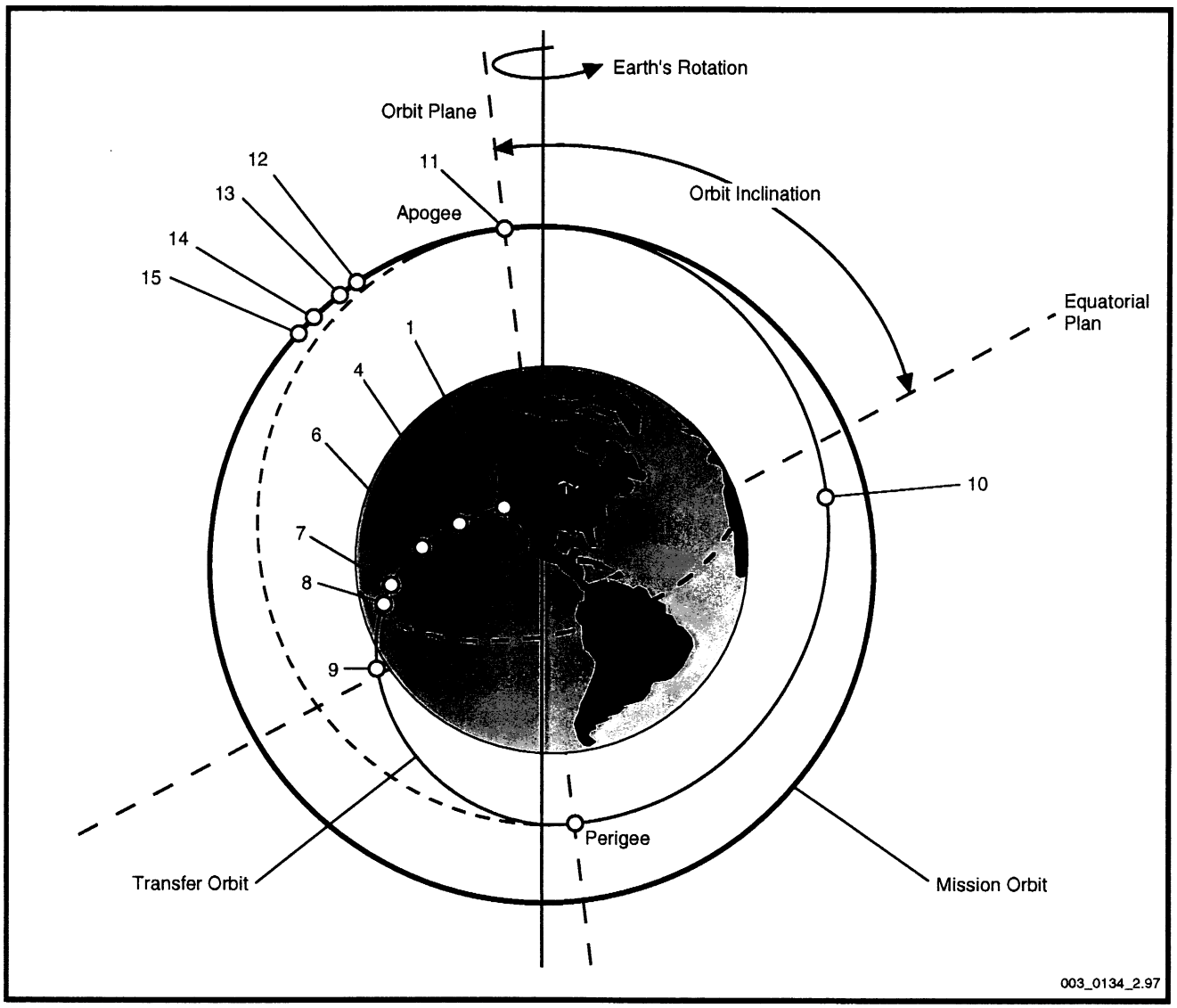


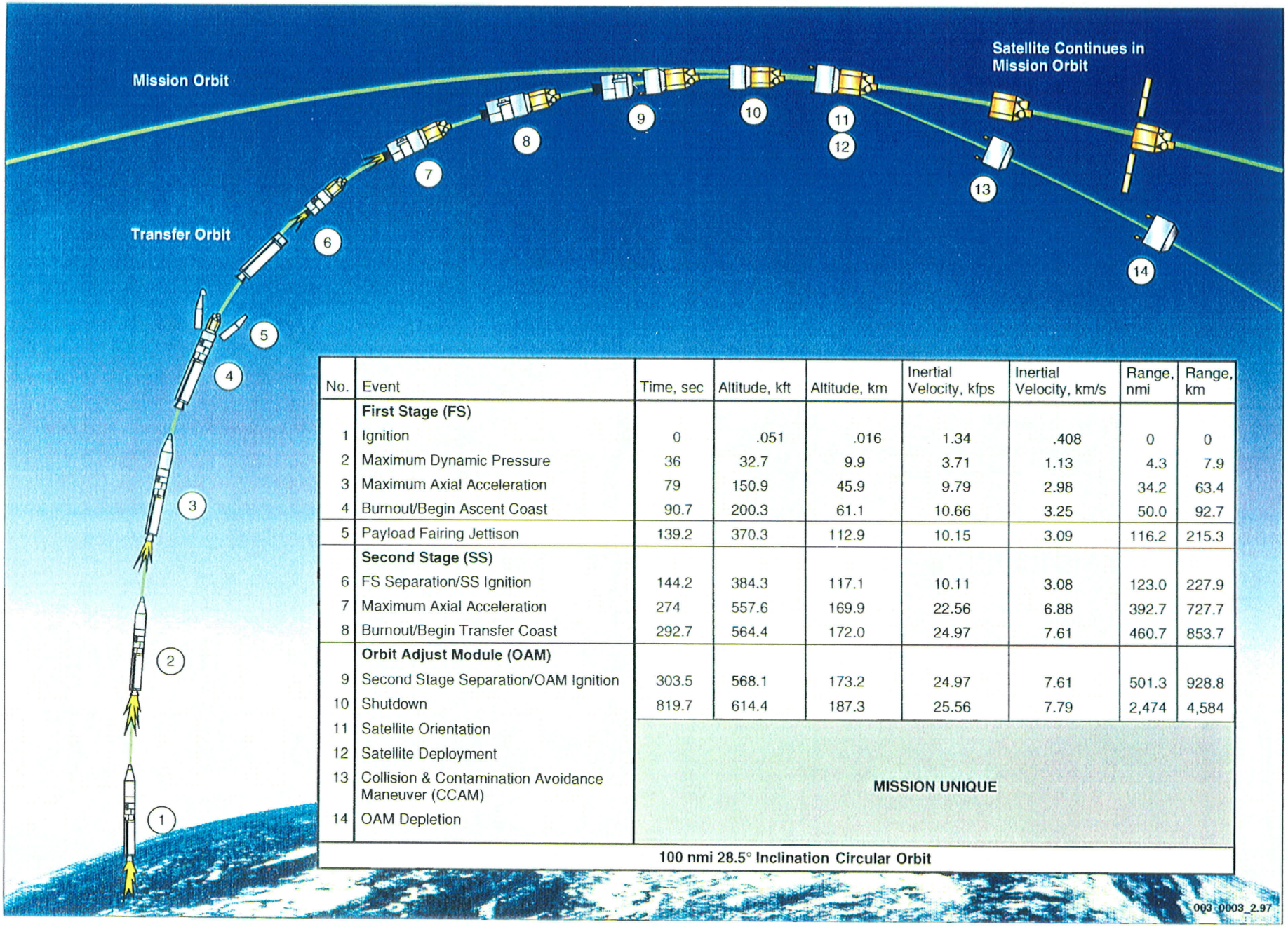
Figure 2.1.2-2 Typical LMLV2 Mission Profile

When spacecraft-provided propulsion is used to augment the launch ascent, an alternate mission profile is created in which the ACS propellant load is optimized for insertion of the spacecraft into an elliptical transfer orbit, or maximized to reach a higher target apogee. In both cases, sufficient propellant is provided to maintain attitude control during deployment of the spacecraft and to perform a contamination and collision avoidance maneuver (CCAM) following separation of the spacecraft. When using this approach, the spacecraft propulsion system typically performs a circularization burn following separation. The benefits of this approach are a higher final mission orbit or more payload weight-to-orbit, or both. Planetary missions are typically accomplished using a similar sequence of events. In these cases the spacecraft propulsion system typically provides the required escape velocity while in the circular or elliptical low-Earth orbit.

2.2 PERFORMANCE CAPABILITY

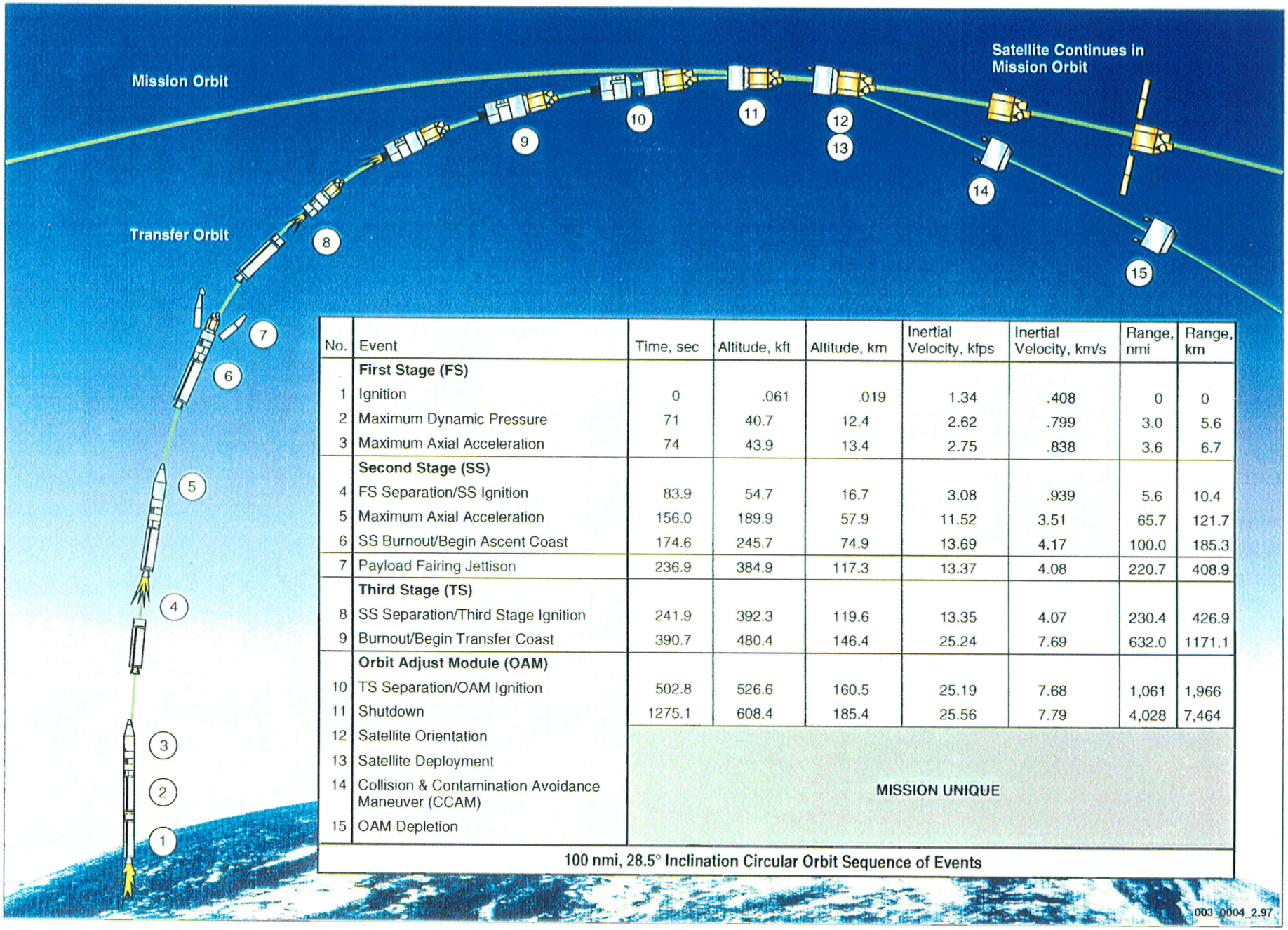
The LMLV family has been cost optimized to deliver small-to-medium sized payloads, up to 4,355 lb (1,976 kg), to orbit. Variables that effect performance capability, such as, orbital parameters, LMLV configurations, payload dimensions, and trajectory constraints are discussed in this section.

Performance margins reflecting the maturity of the current vehicle design have been applied to



No.	Event	Time, sec	Altitude, kft	Altitude, km	Inertial Velocity, kfps	Inertial Velocity, km/s	Range, nmi	Range, km
	First Stage (FS)							
1	Ignition	0	.051	.016	1.34	.408	0	0
2	Maximum Dynamic Pressure	36	32.7	9.9	3.71	1.13	4.3	7.9
3	Maximum Axial Acceleration	79	150.9	45.9	9.79	2.98	34.2	63.4
4	Burnout/Begin Ascent Coast	90.7	200.3	61.1	10.66	3.25	50.0	92.7
5	Payload Fairing Jettison	139.2	370.3	112.9	10.15	3.09	116.2	215.3
	Second Stage (SS)							
6	FS Separation/SS Ignition	144.2	384.3	117.1	10.11	3.08	123.0	227.9
7	Maximum Axial Acceleration	274	557.6	169.9	22.56	6.88	392.7	727.7
8	Burnout/Begin Transfer Coast	292.7	564.4	172.0	24.97	7.61	460.7	853.7
	Orbit Adjust Module (OAM)							
9	Second Stage Separation/OAM Ignition	303.5	568.1	173.2	24.97	7.61	501.3	928.8
10	Shutdown	819.7	614.4	187.3	25.56	7.79	2,474	4,584
11	Satellite Orientation	**MISSION UNIQUE**						
12	Satellite Deployment							
13	Collision & Contamination Avoidance Maneuver (CCAM)							
14	OAM Depletion							
	100 nmi 28.5° Inclination Circular Orbit							

Figure 2.1.3-1 Typical LMLV1 Launch Trajectory and Sequence of Events



No.	Event	Time, sec	Altitude, kft	Altitude, km	Inertial Velocity, kfps	Inertial Velocity, km/s	Range, nmi	Range, km
	First Stage (FS)							
1	Ignition	0	.061	.019	1.34	.408	0	0
2	Maximum Dynamic Pressure	71	40.7	12.4	2.62	.799	3.0	5.6
3	Maximum Axial Acceleration	74	43.9	13.4	2.75	.838	3.6	6.7
	Second Stage (SS)							
4	FS Separation/SS Ignition	83.9	54.7	16.7	3.08	.939	5.6	10.4
5	Maximum Axial Acceleration	156.0	189.9	57.9	11.52	3.51	65.7	121.7
6	SS Burnout/Begin Ascent Coast	174.6	245.7	74.9	13.69	4.17	100.0	185.3
7	Payload Fairing Jettison	236.9	384.9	117.3	13.37	4.08	220.7	408.9
	Third Stage (TS)							
8	SS Separation/Third Stage Ignition	241.9	392.3	119.6	13.35	4.07	230.4	426.9
9	Burnout/Begin Transfer Coast	390.7	480.4	146.4	25.24	7.69	632.0	1171.1
	Orbit Adjust Module (OAM)							
10	TS Separation/OAM Ignition	502.8	526.6	160.5	25.19	7.68	1,061	1,966
11	Shutdown	1275.1	608.4	185.4	25.56	7.79	4,028	7,464
12	Satellite Orientation	MISSION UNIQUE						
13	Satellite Deployment							
14	Collision & Contamination Avoidance Maneuver (CCAM)							
15	OAM Depletion							

100 nmi, 28.5° Inclination Circular Orbit Sequence of Events

Figure 2.1.3-2 Typical LMLV2 Launch Trajectory and Sequence of Events

all data. The special cases of GTO and planetary mission performance are lightly covered here with additional data obtainable upon request. The LMLV Mission Planner's Guide will be updated as further design and flight performance data becomes available.

2.2.1 Performance Factors

The principal factors that affect the performance capability of the LMLV include final orbit altitude and inclination, payload fairing selected, payload adapter selected, payload mass properties, launch site latitude, range safety considerations, and trajectory shaping.

All performance data provided in this section reflect LMLV configurations using the Model 92 payload fairing. Performance capabilities using the planned Model 120 payload fairing, discussed in Section 9.2, will be less. All performance data shown are to the 92-in. (234-cm) interface, i.e., exclude the payload adapter, separation system, and any mission-unique cabling or components. The weight of these items must be added to the payload mass when assessing performance capability using the enclosed curves. This simplifies determining performance capability when either a LMLV-provided or a spacecraft-provided payload adapter/separation system is used. LMLV standard payload adapter weights, are shown in Table 4.1.2.1-1. LMLV standard separation system weights are shown in Table 4.1.2.3-1.

Performance data for LMLV configurations are for typical trajectories flown from the ER, for inclinations between 28.5 degrees and 50 degrees, and from the WR, for inclinations greater than 72 degrees. Flight from the ER to inclinations between 50 and 57 degrees is possible although performance may be reduced due to the required implementation of either a "dog-leg," lofted trajectories, to avoid the impact of expended stages on land masses, or the addition of range-safety destruct hardware. Additional analysis is required for ER launches to inclinations beyond 50 degrees. The same considerations apply to WR launches to inclinations below 72 degrees.

Launching spacecraft from other launch sites is possible, but LMLV performance curves from alternative launch sites are not provided here. Site-specific data will be provided upon further request. The use of alternate launch sites is discussed in Section 9.3. Launches to inclinations lower than the latitude of the launch site normally requires use of an augmenting upper propulsion stage.

2.2.2 Trajectory Design Optimization

A mission-unique trajectory analysis must be performed once the spacecraft weight and orbit parameters have been defined. This analysis validates that the orbit parameters are achievable from the site selected within the performance envelope of the LMLV configuration selected. Details of this analysis are described in Section 8.0.

Conservative performance margins reflecting the current vehicle design maturity have been applied to all data. As design and flight performance data becomes available, prediction tools and margins will be updated.

2.2.3 LMLV1 and LMVL2 LEO Performance

Predicted performance capability for the LMLV1 and LMLV2 configurations using the Model 92 payload fairing are shown in Figures 2.2.3-1 through 2.2.3-6. These figures provide the predicted payload system weight-to-orbit for both circular and elliptical orbits at five selected inclinations. The selected inclinations are those commonly of interest for launches from ER and WR. For circular orbits, payload system weight-to-orbit is shown as a function of circular orbit altitude. For elliptical orbits, payload system weight-to-orbit is shown as a function of apogee altitude with a fixed perigee altitude of 100 nmi (185 km). Figures are provided in both *English* and *Metric* (SI) units. The data shown in these figures were developed per ANSI Standard S-60-1992, *Standard Earth to Orbit Mission Profiles* using the World Geodetic System-84 Earth Model and the 1963 Partick AFB reference atmosphere for ER and the 1971 Vandenberg Air Force Base reference atmosphere for WR.

2.2.4 LMVL1B and LMLV2B LEO Performance

The LMLV program is currently developing a bi-propellant version of the OAM that provides an increase in specific impulse, and therefore, an increase in performance. The bi-propellant OAM will be a pressure-regulated system, not a blow-down system, thereby providing a further increase in performance, particularly at low-propellant levels.

Performance capability estimates for both the LMLV1 and LMLV2 vehicles with the bi-propellant OAM, designated LMLV1B and LMLV2B, respectively, are provided in Figures 2.2.4-1 through 2.2.4-4. Because of the development status of the bi-propellant system, these performance capability figures represent preliminary predictions only. Please contact Lockheed Martin for the latest LMLV1B and LML2B performance predictions.

2.2.5 GTO and Planetary Performance

The LMLV can be used to launch GTO missions from the ER using an additional customer-provided upper stage such as a Star series solid rocket motor. The design of an LMLV configuration for GTO missions requires the integration of a suitable customer-provided upper stage with the LMLV. LMLV2 performance estimates to GTO are shown in Table 2.2.5-1.These estimates include a Star 37 upper stage, upper-stage adapter and upper-stage separation system. They do not include a payload adapter, payload separation system, and any mission-unique cabling or components.

Transfer orbits inclined at 28.5 degrees are obtainable by direct injection. Lower inclination transfer orbits typically require an initial 100 nmi (185 km) circular parking orbit, inclined at 28.5 degrees. At the first equatorial crossing, the vehicle is yawed and then propelled again to inject the spacecraft into a transfer orbit at the lower inclination. Missions to lower inclinations are very spacecraft and upper-stage dependent. Please contact Lockheed Martin to assist in developing an optimum orbit injection solution.

Table 2.2.5-1 LMLV2 Performance to GTO

ORBIT	INCLINATION	SPIN STABLIZED	3-AXIS STABLIZED
200 x 19,323 nmi	28.5 deg	1030 lb (467 kg)	675 lb (306 kg)
110 x 27,000 nmi	28.5 deg	940 lb (426 kg)	585 lb (265 kg)

Notes:
- 6-Tank Monopropellant Blowdown OAM
- Star 37FM Upper Stage
- LMLV to Star Motor Adapter
- Model 92 Payload Fairing (PLF)
- PLF Separation Q-Bar <0.005 psf (2.4 N/m2)
- 3 Sigma Confidence Level
- Perigee Altitudes Greater Than 100 nmi Are Driven by Range Safety Constraints

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The LMLV1 and LMLV2 can also be used to launch planetary missions from the ER using an additional customer-provided upper stage such as a Star series solid rocket motor. Performance estimates at multiple vis-viva energy levels for a 4-tank LMLV1 and a 6-tank LMLV2 are provided in Figures 2.2.5-1 through 2.2.5-4. The 4-tank LMLV1 generally provides greater performance capability than the 6-tank LMLV1. The 6-tank LMLV2 provides greater performance capability than the 4-tank LMLV2. Please contact Lockheed Martin for specific planetary mission performance capability.

Planetary missions are similar to GTO missions in that once the vehicle is placed into a low-Earth orbit, the upper stage will be fired according to the required departure asymptote.

2.3 ORBIT INJECTION ACCURACY

To assure that errors are correctly accounted for during flight, the avionics processor package continually updates the trajectory based on data from the Inertial Measurement Unit (IMU). Motor vectoring commands and coast periods are adjusted to drive the measured deviation from the updated trajectory to zero. Pitch, roll and azimuth errors are corrected via commands to the thrust vector control systems during the burn of each

motor. A finer correction capability is provided by the ACS. Calculated orbit injection accuracy is limited during the time of flight primarily by the IMU accuracy and gyro drift rates. A calculation within the IMU of the cumulative effect of the various error sources is required to determine the error for a specific orbit. The errors applicable to a specific orbit can be supplied upon request.

2.4 SEPARATION CONTROL

The separation approaches used on LMLV are based on more than 35 years of spacecraft and payload separation system design implementation experience. Data has been developed for control of separation sequences for single and multiple spacecraft injections. The services available for conducting these analyses are described in Section 8.0

2.4.1 Attitude Rates and Stabilization

Rates of rotation (tip-off rates) of the spacecraft at separation are effected by bending modes, products of inertia, center of gravity offset, ACS thruster behavior, and separation force asymmetry. These factors will be unique for most missions. Therefore, an analysis and simulation will be performed as described in Section 8.0 on a mission-specific basis. Taking into account these factors, spacecraft stabilization may require as much as 90 seconds for 3-axis stabilized payloads to allow for correction, compensation, and oscillation damping. Spin-stabilized payloads may require more time, depending on their spin-up rates. The OAM can provide a rate of approximately 3 rpm to assist in thermal control (barbecue mode) and preseparation stabilization.

2.4.2 Attitude Orientation and Pointing Accuracy

Orientation and pointing accuracy before spacecraft separation is a function of the capabilities of the avionics and attitude control systems. For 3-axis stabilized payloads, the pointing accuracy that can be maintained, assuming spacecraft mass property misalignments are negligible, is 1 degree or less. For spin-stabilized payloads, pointing errors can combine with tip-off effects as well as spacecraft-to-OAM axis misalignment to produce post-separation pointing and nutation errors. While specific errors are ultimately determined by spacecraft mass properties, the OAM can maintain separation conditions such that the spacecraft maximum pointing errors are typically less than 1 degree, and maximum attitude rates are less than 2.4 degrees per second.

2.4.3 Separation Velocity

Separation acceleration and velocity must take into consideration any impulse sensitivity and extremity recontact potential of the spacecraft. Separation acceleration is characterized by the mission-unique spring design and the minimum relative velocity between the spacecraft and the OAM. Vector considerations can be accommodated via use of the ACS. Services available for separation dynamics' analysis are described in Section 8.0.

2.5 COLLISION AND CONTAMINATION AVOIDANCE MANEUVER

The collision and contamination avoidance maneuver (CCAM) requirement is established by the obvious need to avoid recontact between the separated bodies and by the need to avoid exposure of sensitive spacecraft components to potential contaminants.

Recontact potential is determined by analysis of the mechanics of separation for each separation event as well as by an assessment of any postseparation maneuvering of the separated bodies. The effects of contamination on the spacecraft are minimized by designing the spacecraft to be resistant to contamination unavoidable in the local environment, and by determining the maneuvers that avoid contamination on the spacecraft. Analytical services available for establishing the requirements for the CCAM are described in Section 8.0.

Once the spacecraft separation requirements are established, the separation springs can be tuned, and the separation sequence and the subsequent CCAM defined to assure that all requirements can be met. The ACS propellant load is sized for 3σ worst case conditions to assure that sufficient propellant remains following the injection sequence to allow for a simulation-validated

CCAM. In most cases, following spacecraft deployment, the avionics system commands the ACS to carefully maneuver the OAM out of the spacecraft orbit. When well clear, approximately 100 ft (30m), the thrusters are fired until the residual propellant is depleted. This maneuver increases the separation between the OAM and the spacecraft, and relieves residual pressure in the ACS tanks, which minimizes the potential for orbital debris.

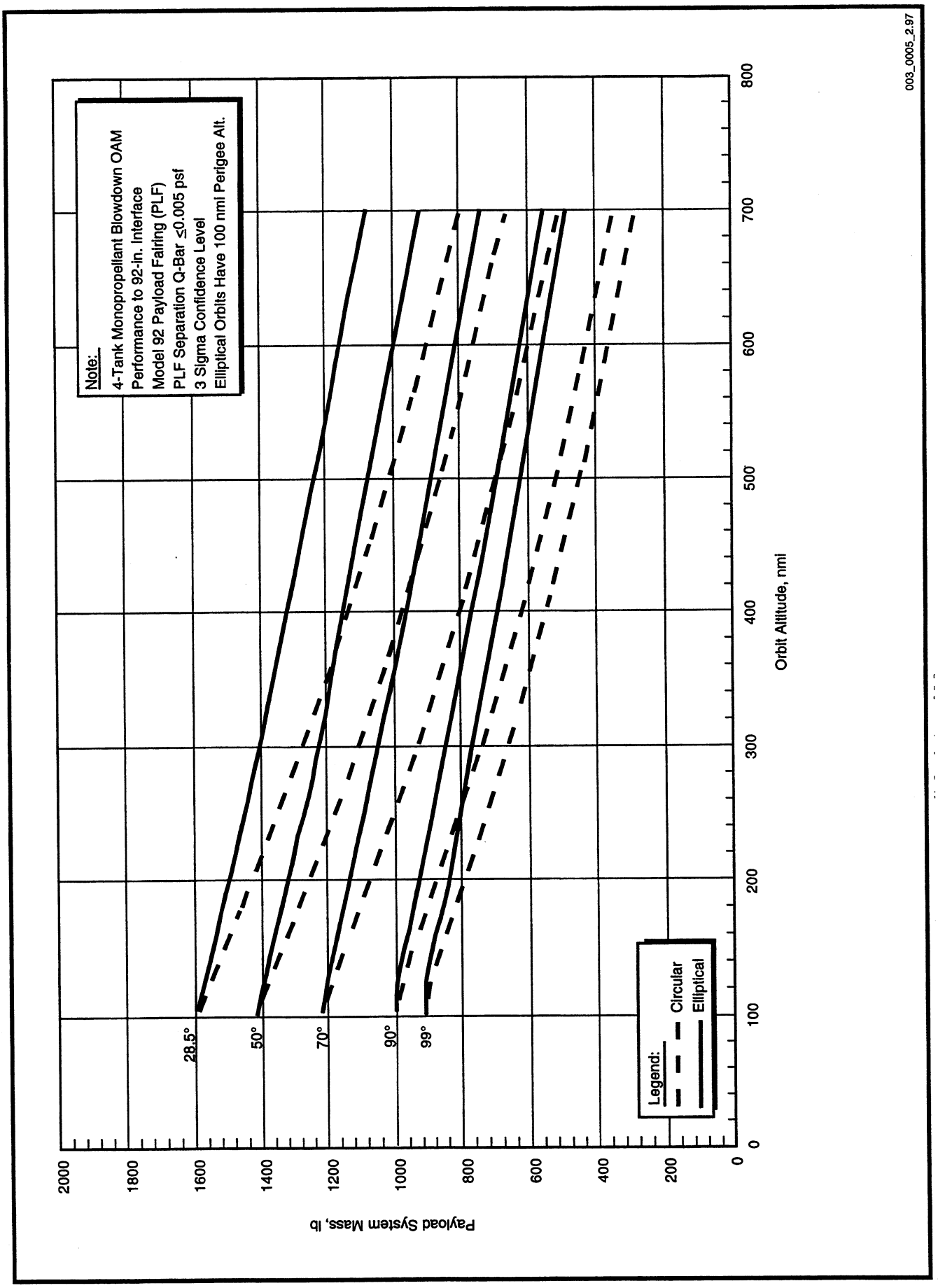

Figure 2.2.3-1 LMLV1 4-Tank LEO Performance, English Units of Measure

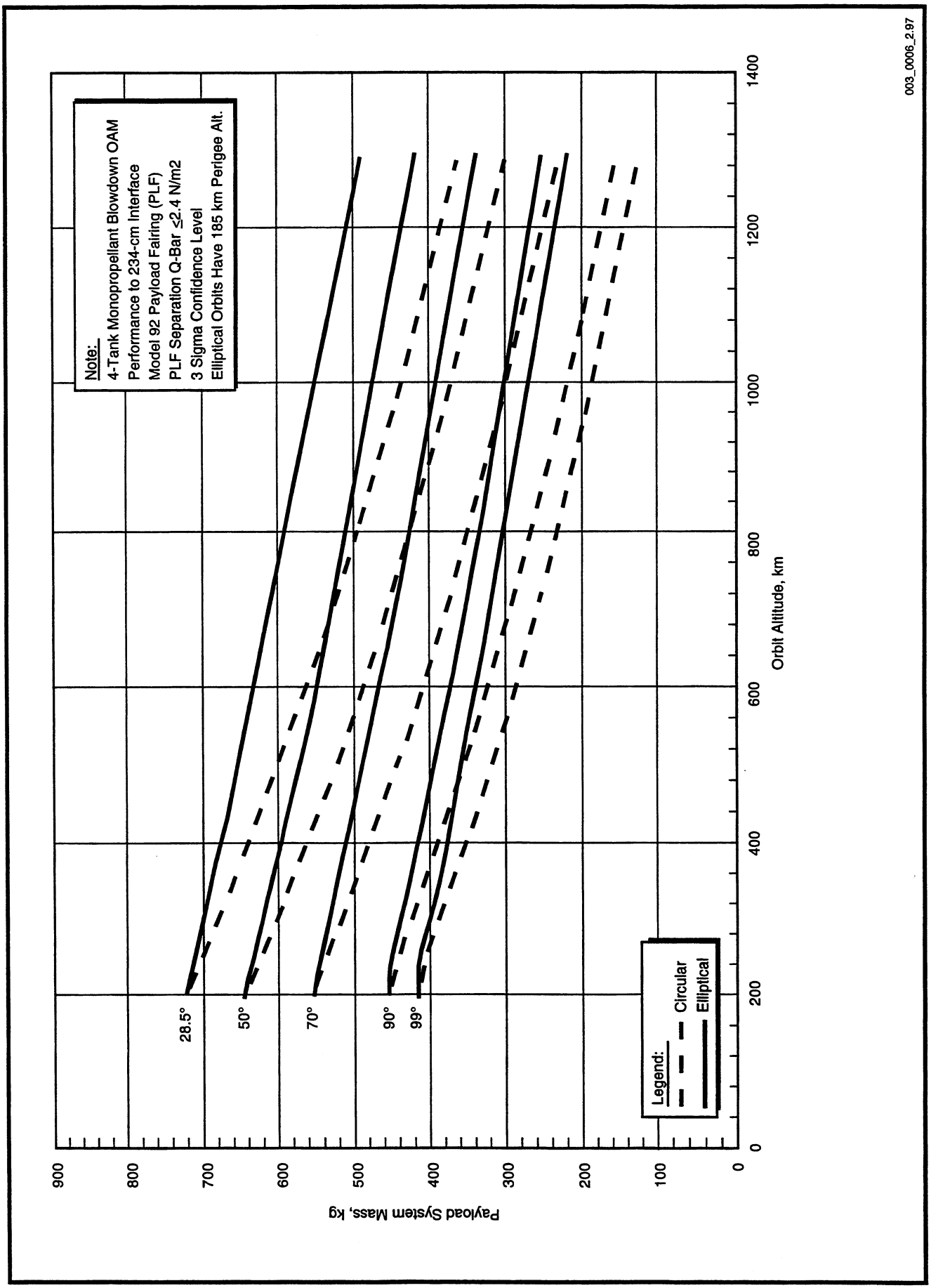

Figure 2.2.3-2 LMLV1 4-Tank LEO Performance, Metric Units of Measure

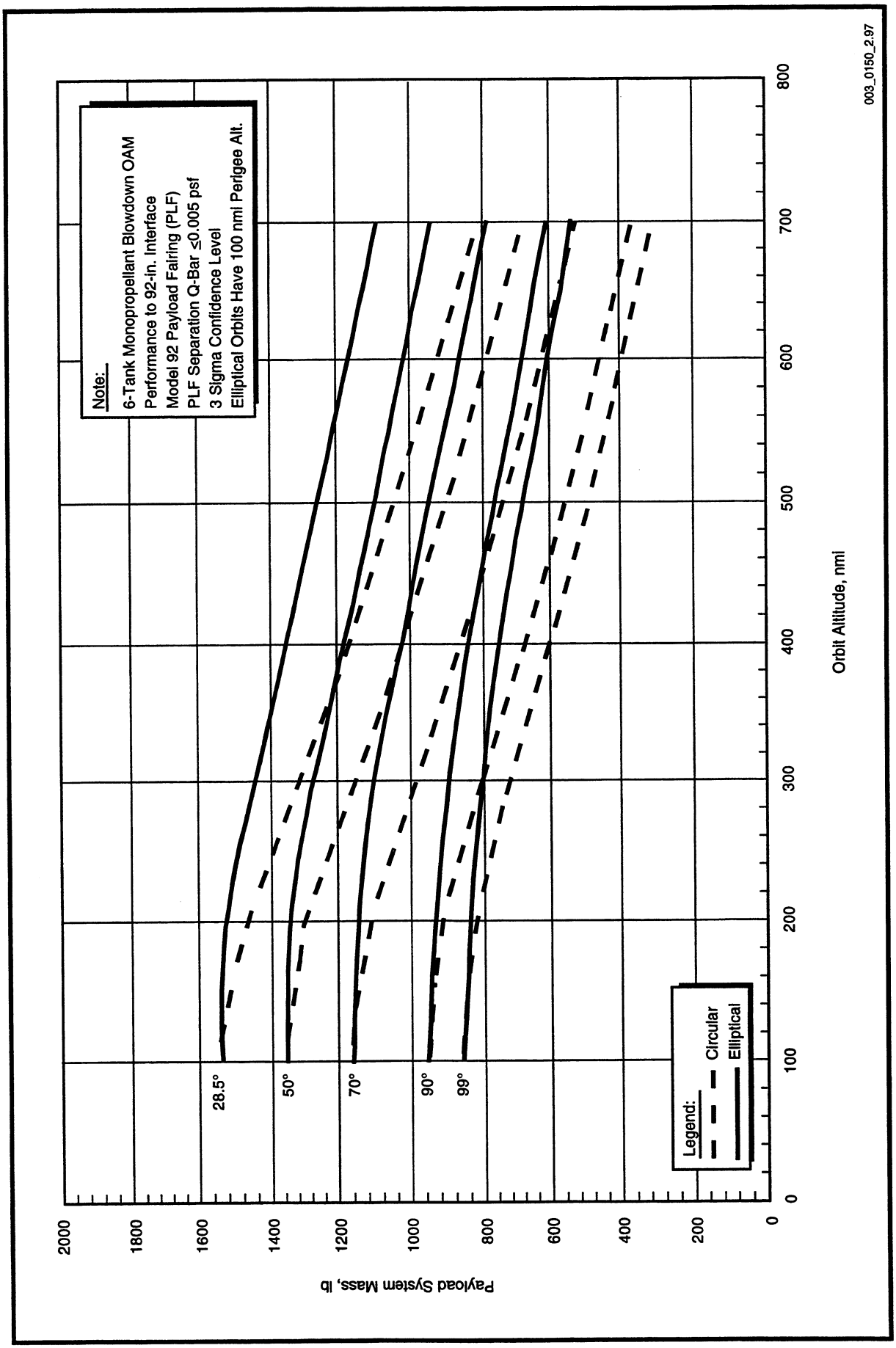

Figure 2.2.3-3 LMLV1 6-Tank LEO Performance, English Units of Measure

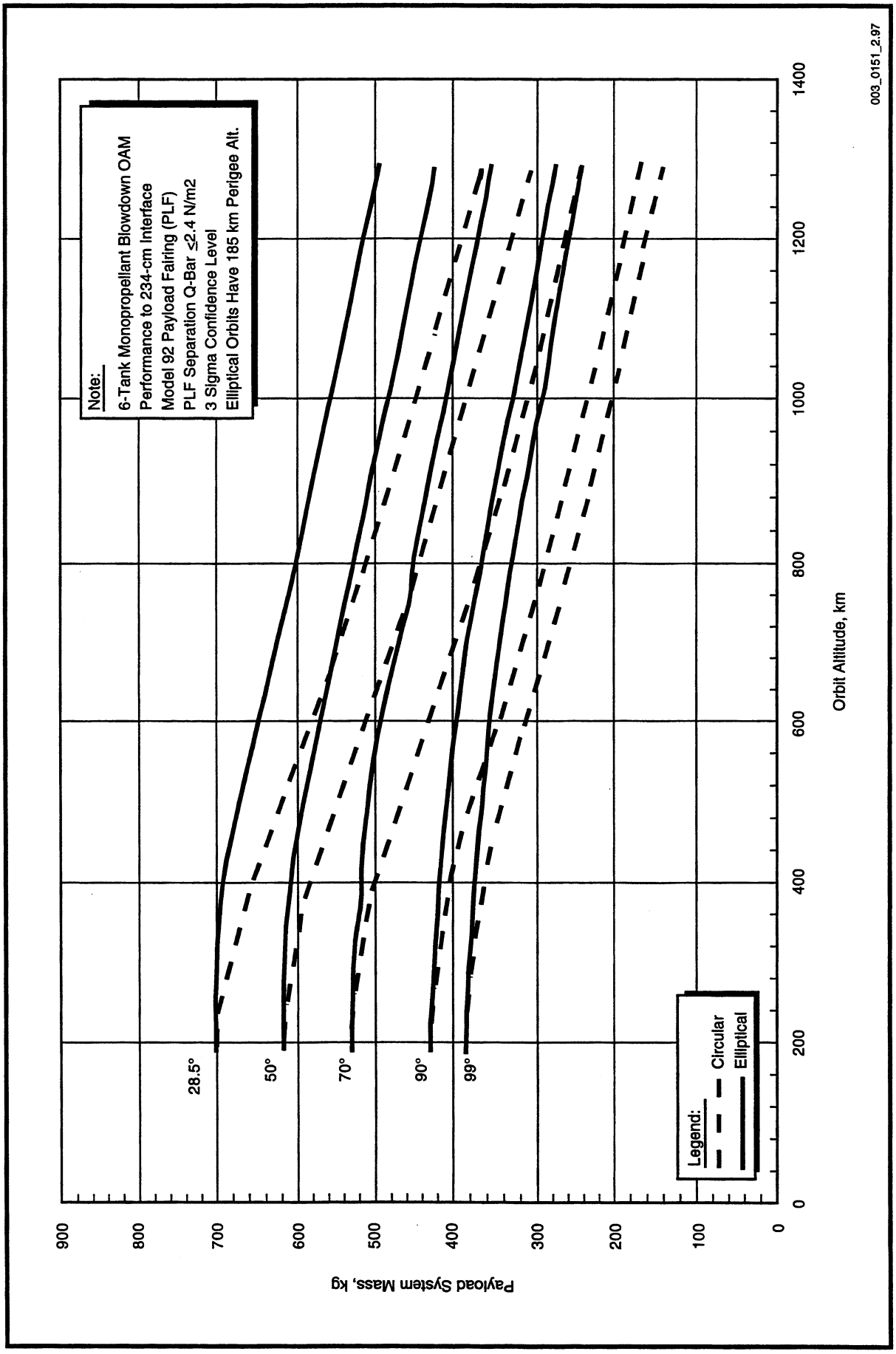

Figure 2.2.3-4 LMLV1 6-Tank LEO Performance, Metric Units of Measure

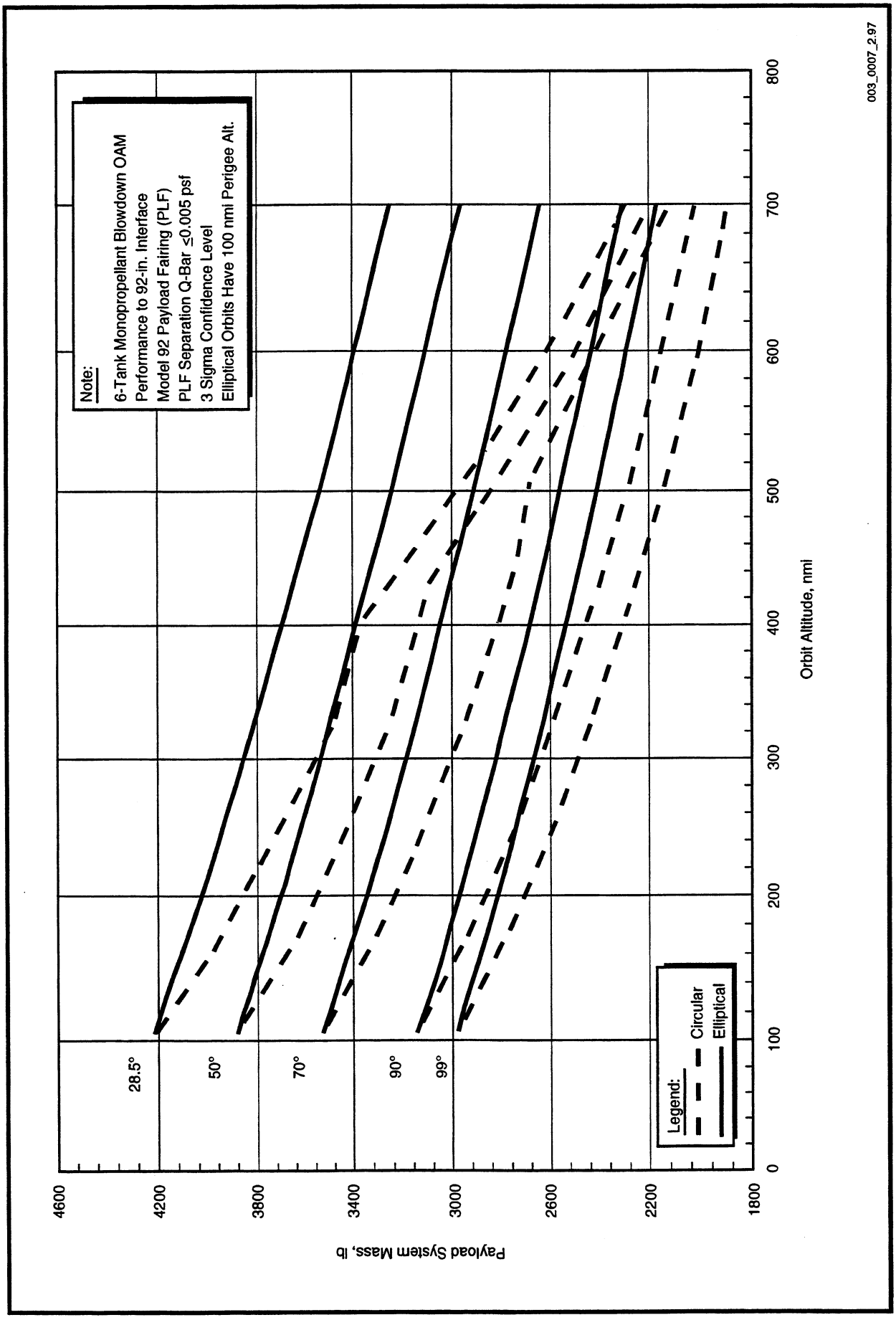

Figure 2.2.3-5 LMLV2 6-Tank LEO Performance, English Units of Measure

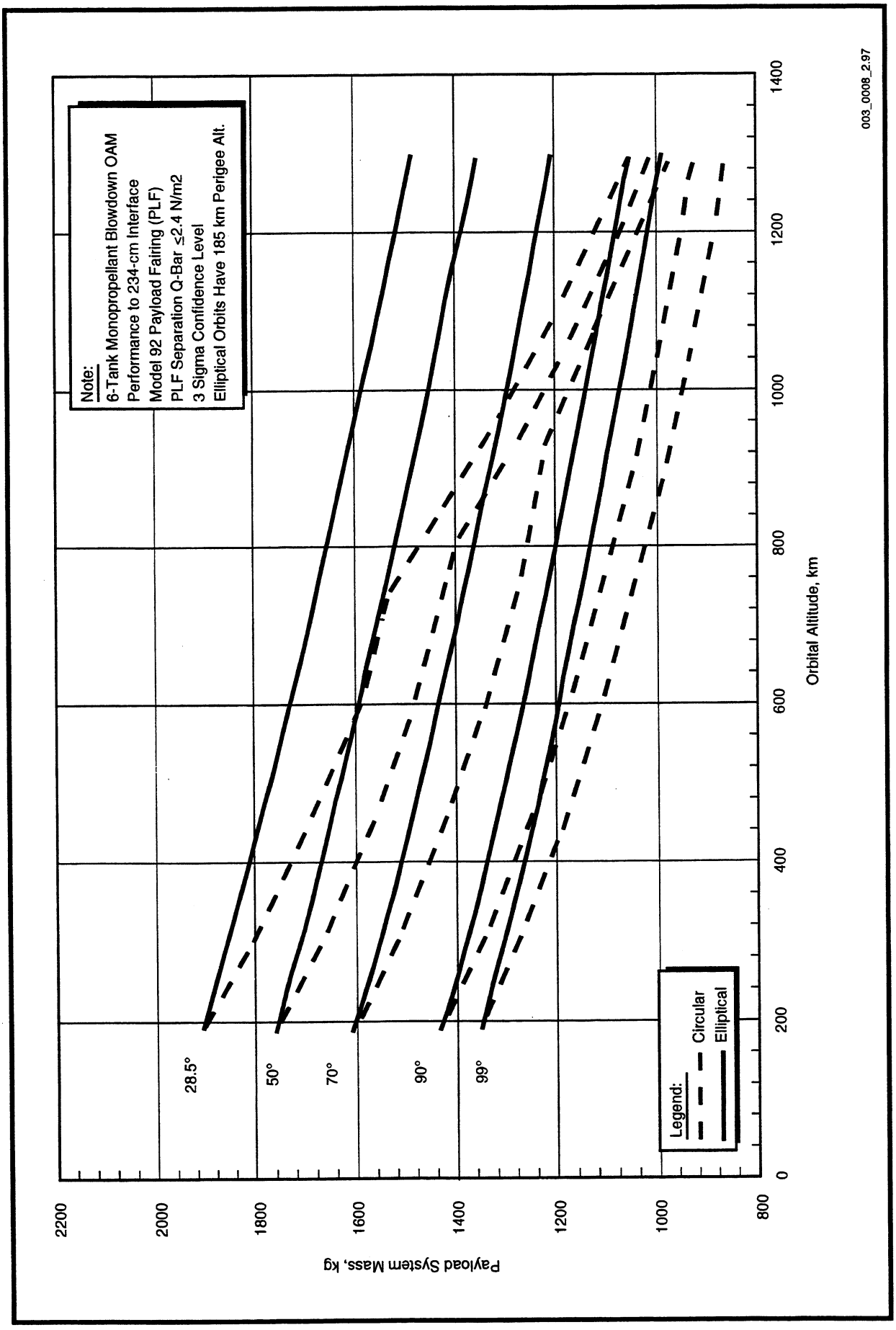

Figure 2.2.3-6 LMLV2 6-Tank LEO Performance, Metric Units of Measure

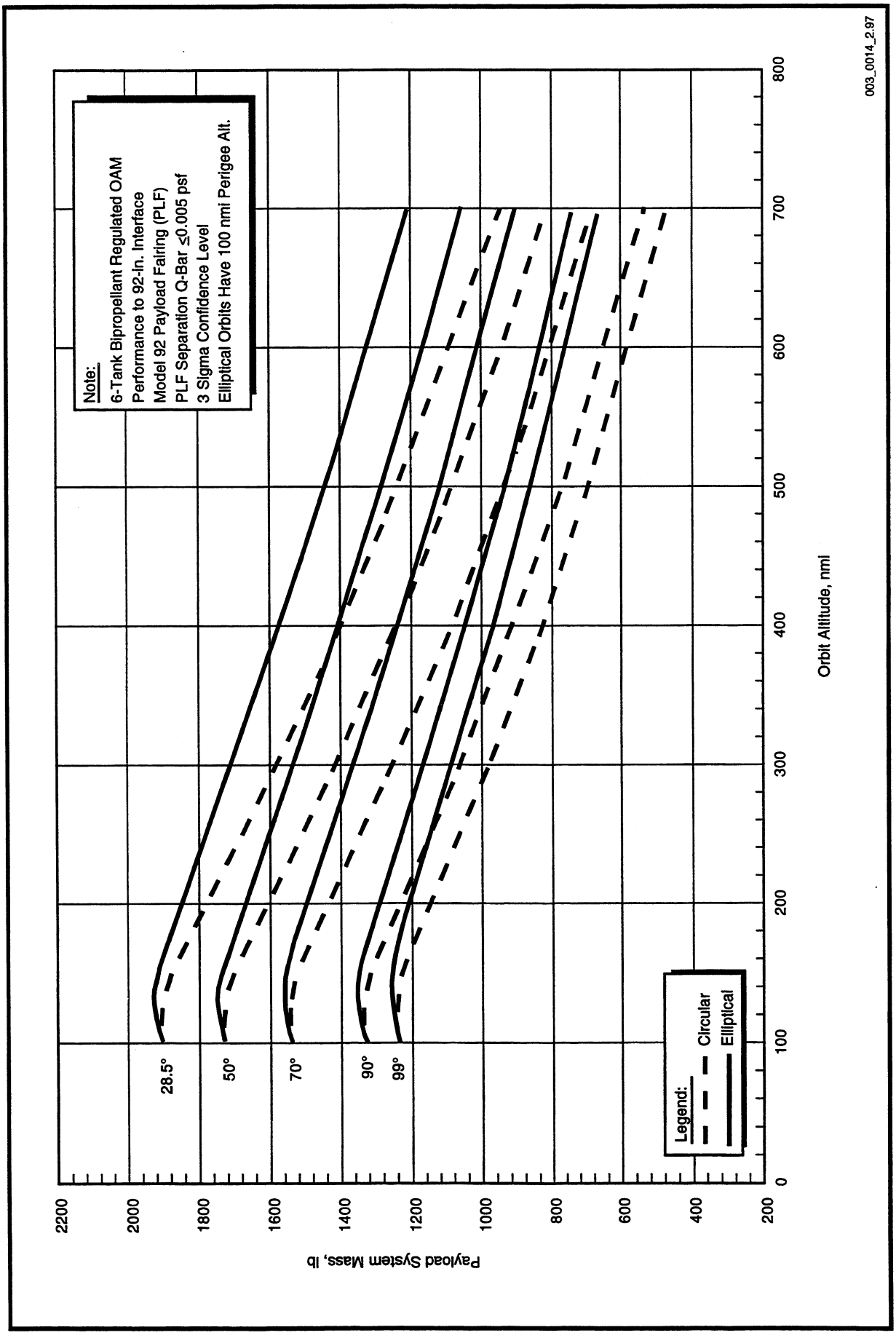

Figure 2.2.4-1 LMLV1B 6-Tank LEO Performance, English Units of Measure

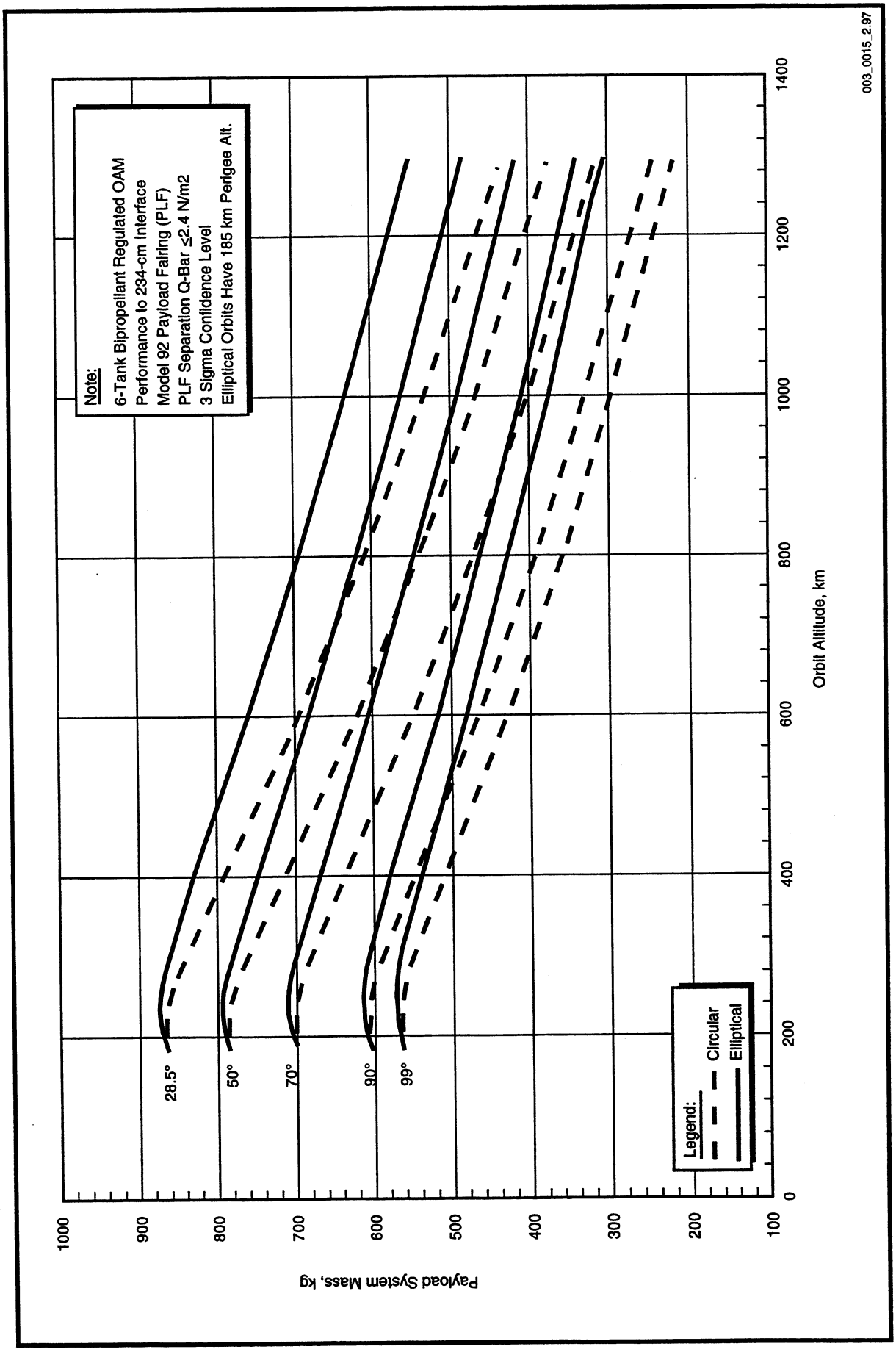

Figure 2.2.4-2 LMLV1B 6-Tank LEO Performance, Metric Units of Measure

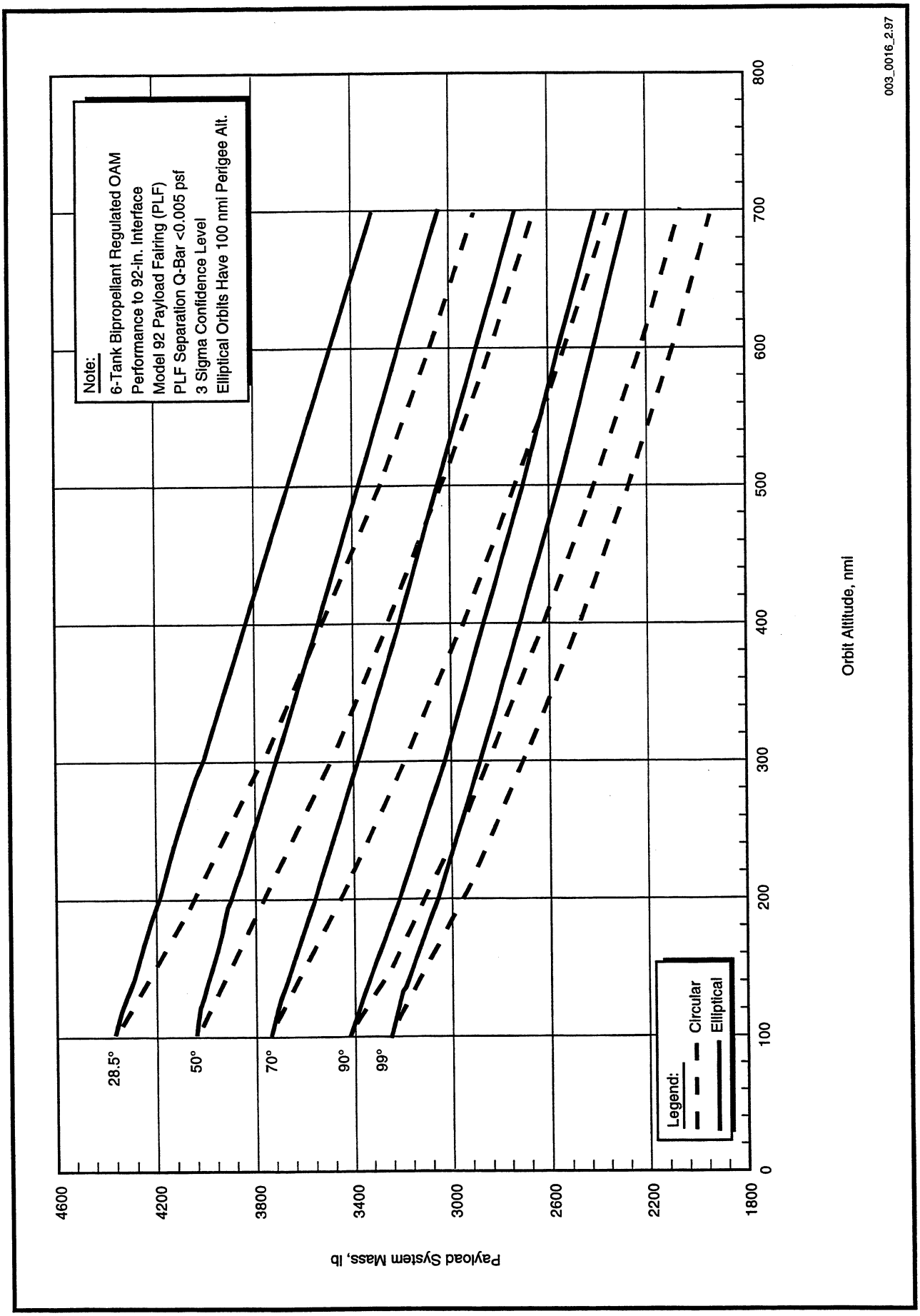

Figure 2.2.4-3 LMLV2B 6-Tank LEO Performance, English Units of Measure

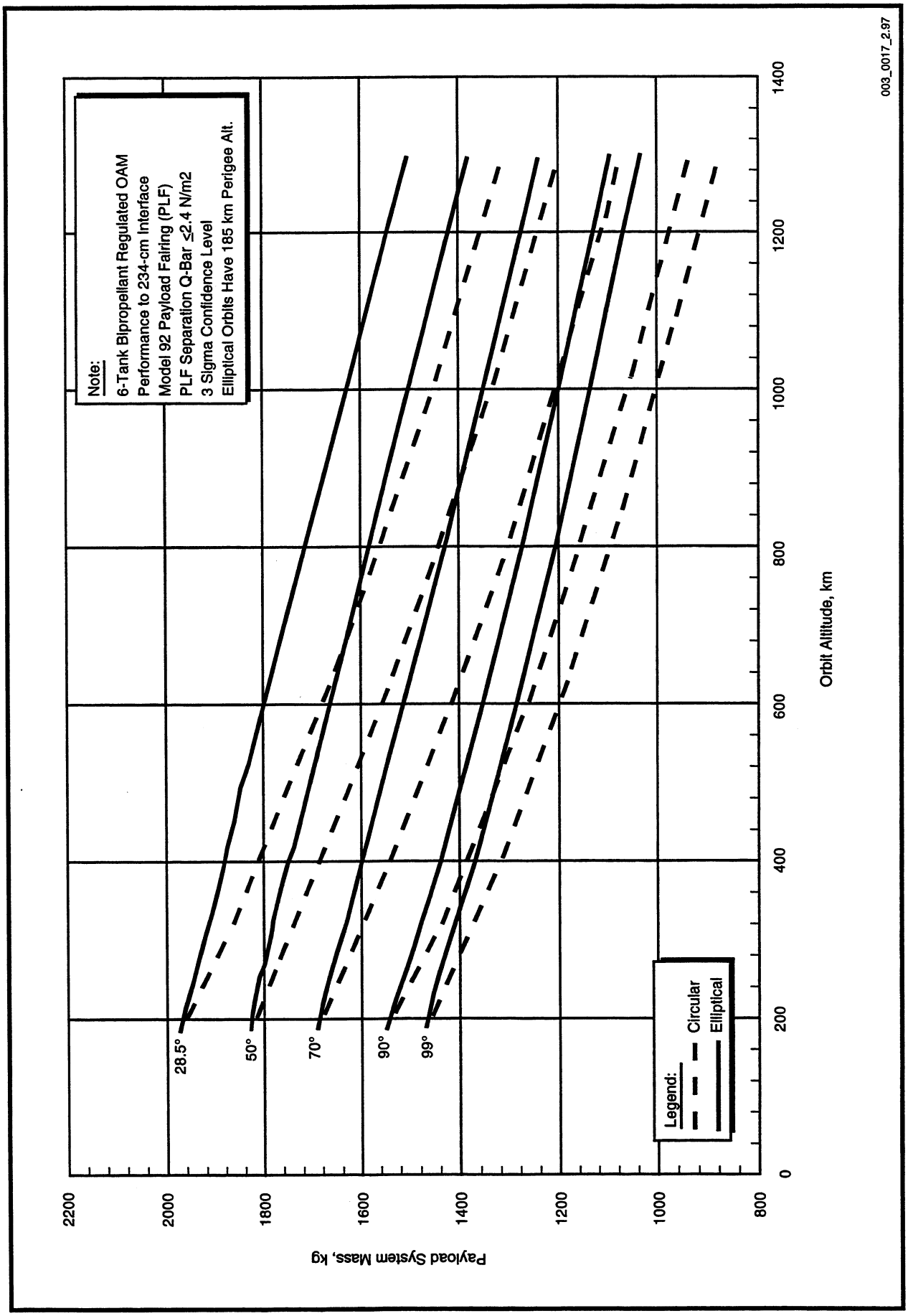

Figure 2.2.4-4 LMLV2B 6-Tank LEO Performance, Metric Units of Measure

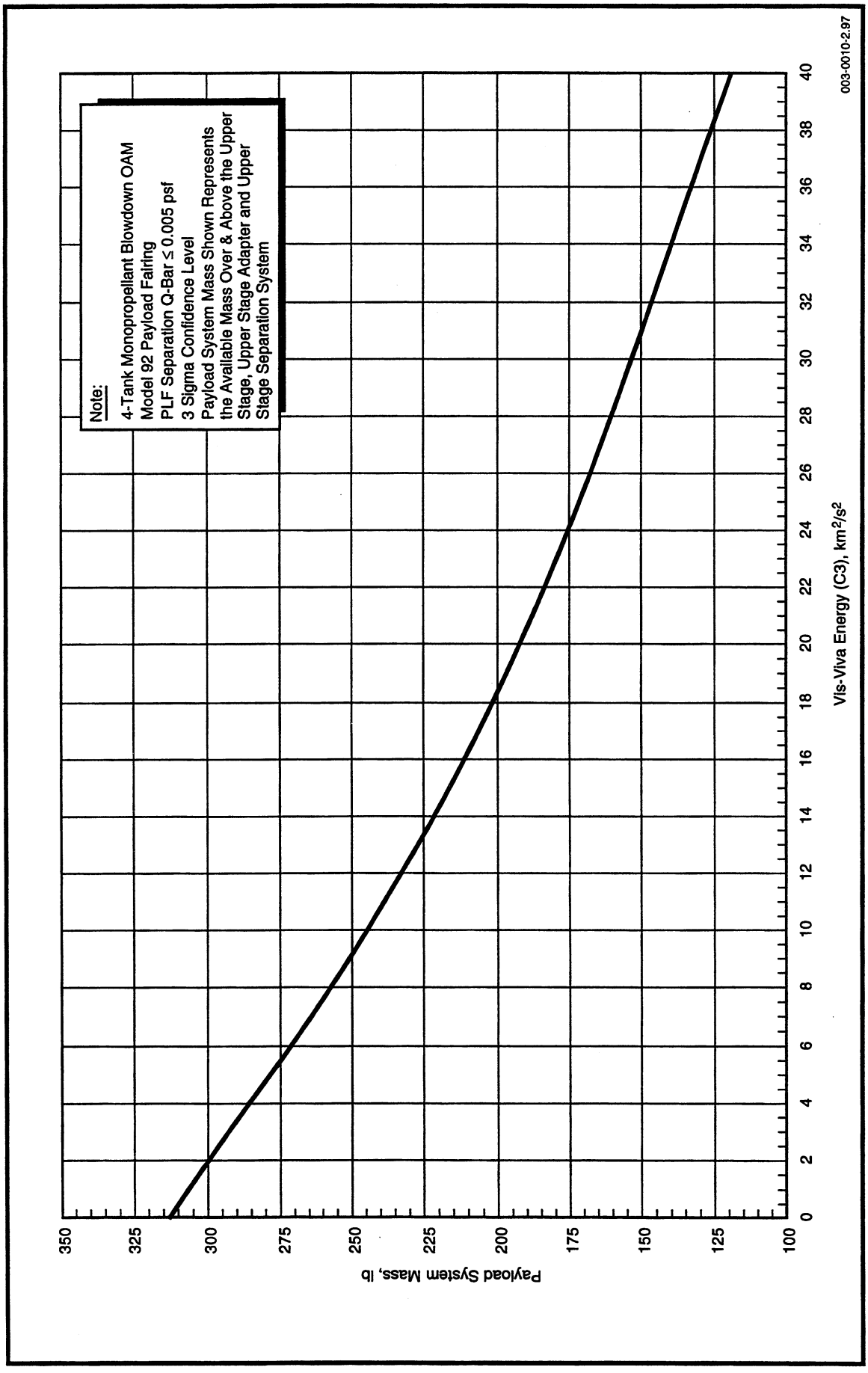

Figure 2.2.5-1 LMLV1/STAR 27 Escape Velocity Performance, English Units of Measure

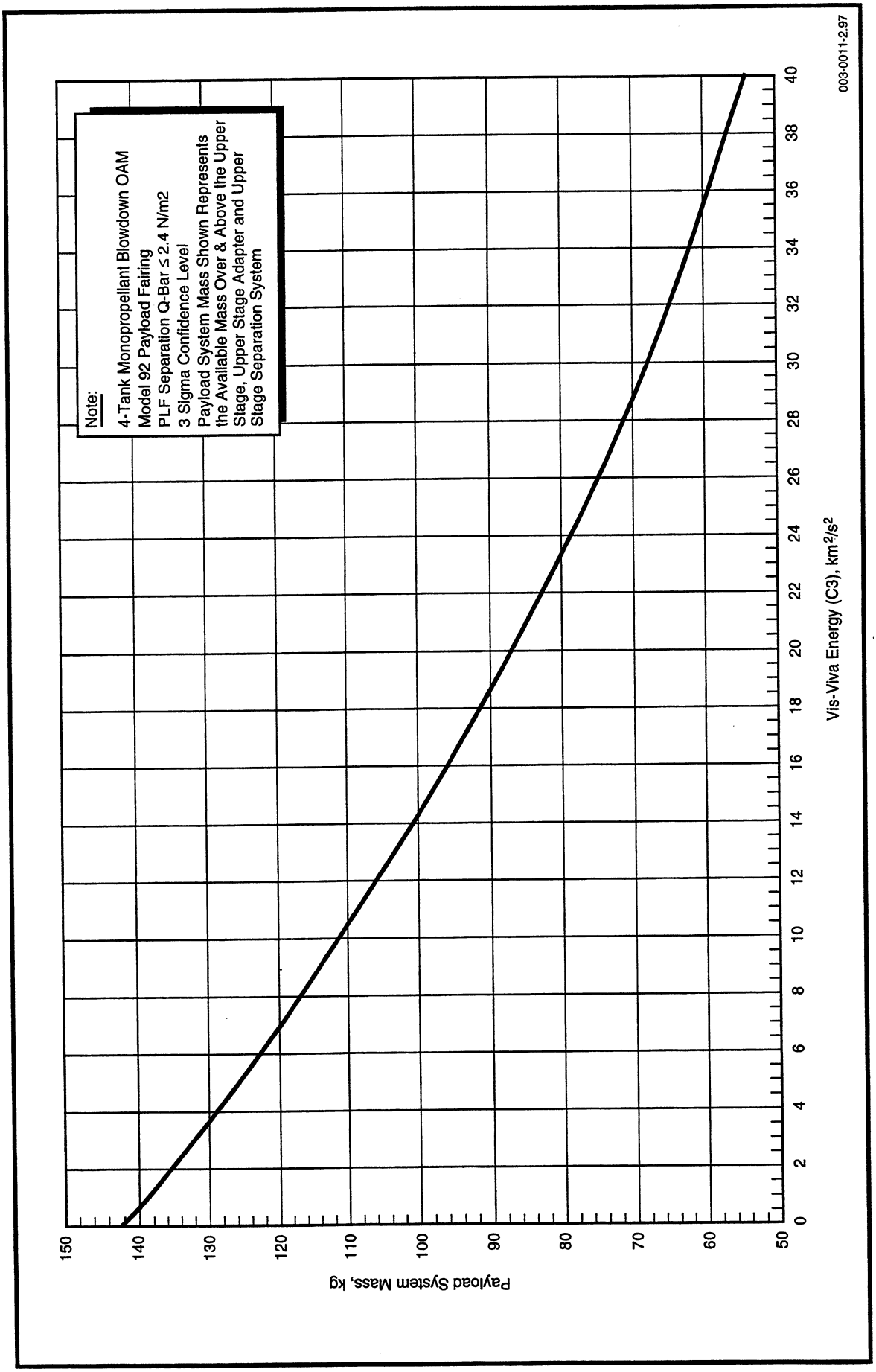

Figure 2.2.5-2 LMLV1/STAR 27 Escape Velocity Performance, Metric Units of Measure

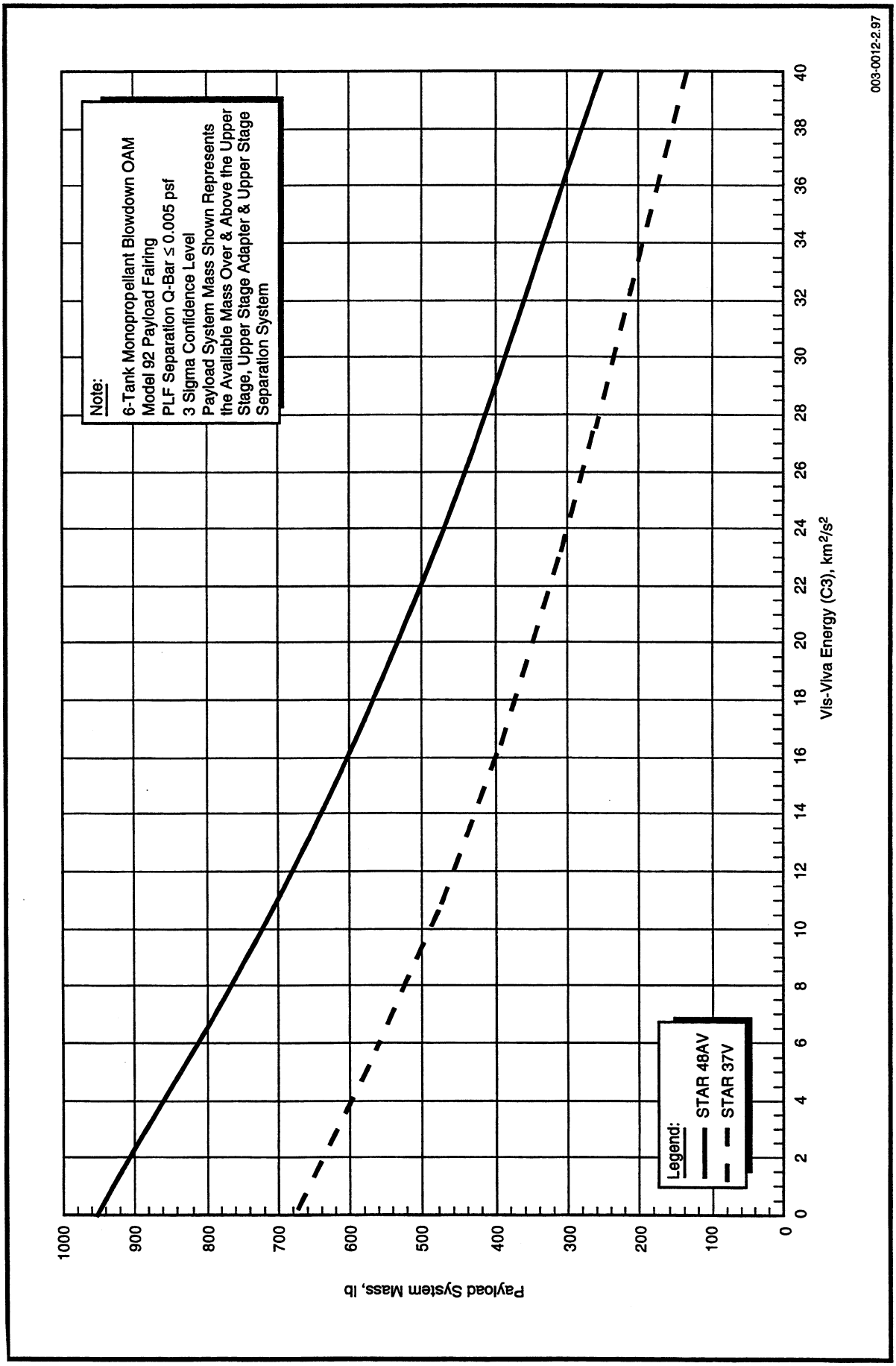

Figure 2.2.5-3 LMLV2 Escape Velocity Performance, English Units of Measure

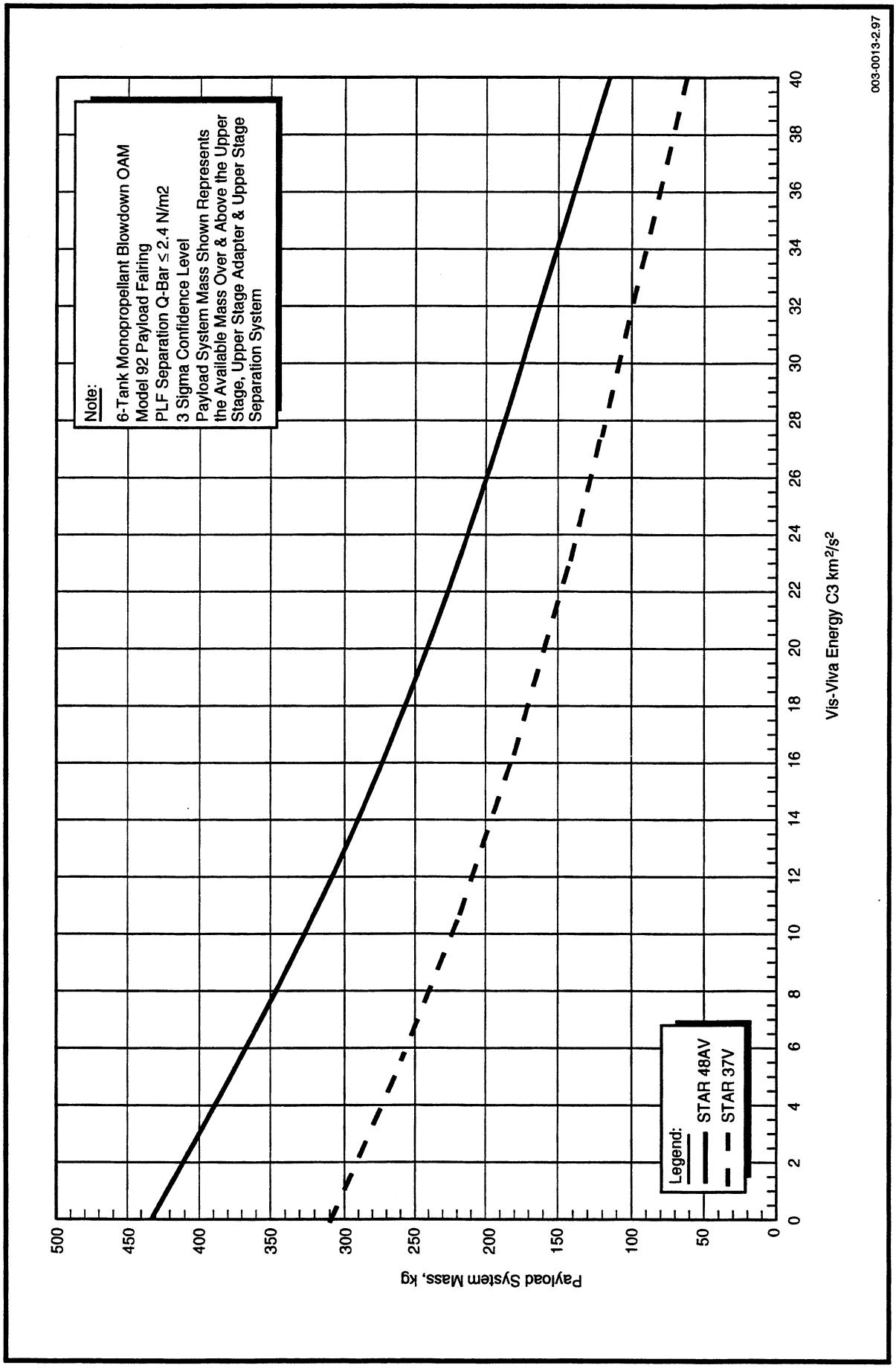

Figure 2.2.5-4 LMLV2 Escape Velocity Performance, Metric Units of Measure

3.0 ENVIRONMENTS

This section describes the environments that the spacecraft is exposed to during LMLV processing and launch. Prelaunch environments are provided in Section 3.1 and launch and flight environments are provided in Section 3.2. The environments data, together with LMLV performance data, provided in Section 2, define many of the dynamics to which the spacecraft will be exposed, both on the ground and during ascent. The environments described in this section include margins that reflect the current design maturity, confidence level, and sample size.

3.1 PRELAUNCH ENVIRONMENTS

Prelaunch environments encompass everything that the spacecraft is exposed to from arrival at the processing facility through first-stage ignition. This includes diurnal thermal and light cycling, RF through gamma radiation exposure, mechanical and chemical reactions.

3.1.1 Loads and Load Factors

Mechanical shock and vibration resulting from transportation by aircraft, railcar, or motor transporter, and during processing from the installation of ground support equipment, moving, rolling, erecting, encapsulating, etc, are largely mission-peculiar. However, the transportation and processing procedures and equipment used by LMLV in support of launch services are state-of-the-art and designed to minimize the potential for damage. The unparalleled experience of Lockheed Martin in processing and handling of spacecraft provides additional assurance to mitigate risk.

3.1.2 Temperature, Humidity, Contamination Control, and Cleanliness

The environments surrounding the spacecraft during prelaunch operations are carefully controlled at both the Eastern Range (ER) and Western Range (WR) subsequent to removal of the spacecraft from the customer-provided shipping container. The clean rooms at both the ER and WR, used for payload processing, are maintained to at least Class 100,000 per FED-STD-209 as shown in Table 3.1.2-1.

This environment is controlled by meeting the requirements and using the processes and equipment specified in the mission-peculiar contamination control plan. These controls are initiated at the payload processing facility and maintained during transport of the spacecraft to the launch pad, and while mated to the launch vehicle. While Class 100,000 clean conditions are standard, Class 10,000 clean conditions can be provided.

At the ER, LMLV payload processing is conducted at the Astrotech Space Operations, L.P. facilities in Titusville, Florida. The Astrotech facilities are located adjacent to the Space Center Executive Airport, 16.8 miles (27 km) from Launch Complex 46 (LC-46). Astrotech Buildings 1 and 1A provide processing for nonhazardous operations.These buildings have two Class 100,000 clean airlocks and four Class 100,000 clean high bays. The high bays are maintained to within the

Table 3.1.2-1 Summary of LMLV Payload Facility Environments at the Eastern and Western Ranges

RANGE	LOCATION		TEMPERATURE RANGE	RELATIVE HUMDITY	FILTRATION
	FACILITY	CLEANROOM			
Eastern Range	Astrotech	Bldgs 1/1a & 2 High Bays	72° ±5°F (22.2° ±2.8°C)	55 ±5%	Class 100,000
		Bldg 3 Storage Bays	70° to 78°F (21.1° to 25.6°C)	55% Max	
Western Range	Integrated Processing Facility	Checkout Cells	65° ±10°F (18.3° ±5.6°C)	40 ±10%	Class 100,000 15-17 Air Changes/hr
		Airlocks	70° ±5°F (21.1° ±2.8°C)	40 ±10%	Class 100,000 10-12 Air changes/hr
	Astrotech	Bldg 1032 Rooms 106, 107, 108, 109, 117, 118	70° ±2°F (21.1° ±1.1°C)	45 ±10%	Class 100,000

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temperature and relative humidity ranges and cleanliness levels listed. Astrotech Building 2 provides processing for hazardous operations and is located approximately 650 ft (198 m) and 350 ft (107 m) from the airlock doors of Building 1 and 1A, respectively. This building has three high bays maintained at Class 100,000 cleanliness level while providing an explosion-proof environment for performing liquid propellant fueling, solid propellant motor operations, and ordnance installation. Portable air-conditioning units maintain the temperature and relative humidity as indicated in Table 3.1.2-1.

Following final spacecraft/payload assembly and checkout in Buildings 1 or 1A, the spacecraft/payload is moved to Building 2 for solid motor installation and fueling as applicable. The spacecraft/payload is mated to the payload adapter and encapsulated in the North high bay of Building 2. The encapsulated assembly is transferred to the pad on a "low-boy" trailer at night to minimize temperature extremes. A gaseous nitrogen purge maintains a positive pressure within the payload fairing (PLF) to prevent the intrusion of moisture or contaminates. The nitrogen purge is maintained until the encapsulated assembly is mated to the launch vehicle and conditioned air is supplied to the PLF. The cleanliness, flowrate, temperature, and humidity levels of the conditioned air supplied to the PLF are shown in Table 3.1.2-2. Internal ducting within the PLF prevents the conditioned air from directly impinging, in excess of the velocity shown, on any part of the encapsulated spacecraft. The conditioned air is vented to the OAM through five one-way vent valves in the payload adapter.

At the WR, LMLV payload processing is conducted at the Spaceport Systems International (SSI) Integrated Processing Facility (IPF) or at Astrotech Space Operations, L.P., facilities, both at Vandenberg Air Force Base (VAFB), California. The IPF is located at Space Launch Complex-6 (SLC-6) on South VAFB approximately 500 ft (152 m) from the launch mount. The IPF includes one Class 100,000 clean airlock, one Class 100,000 clean high bay for hazardous operations, and three Class 100,000 payload checkout cells.

Table 3.1.2-2 Properties of Conditioned Air Supplied to the Payload Fairing

Cleanliness	Class 5,000
Flow	200-750 SCFM
Temperature	50-75°F (10-23.9°C)
Max Dew Point	40°F (4.4°C)
Payload Impingement Velocity	<15/s

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The Astrotech facilities are located on North VAFB at Building 1032. Building 1032 contains five clean rooms for payload preparations, liquid propellant transfer, solid rocket motor and ordnance installations, spcacecraft/upper stage mating, and payload fairing encapsulations. All high bays are maintained within the temperature and relative humidity limits shown in Table 3.1.2-1.

Following final spacecraft/payload assembly and checkout at the IPF or at Astrotech, the spacecraft/payload is readied for solid motor installation and fueling as applicable. The spacecraft/payload is mated to the payload adapter and encapsulated. The encapsulated assembly is transferred to a flatbed trailer and transported to the launch pad as described for ER above.

3.1.3 Radiation and Electromagnetic Environments

Radiation and electromagnetic environments must be controlled at the launch site for reasons of range safety and for the protection of sensitive mission components. Signal levels emanating from, or impinging on, the Range, the LMLV, or the spacecraft must be known for all ground and flight modes of operation. Range Safety at each launch complex identifies, measures, and maps all fixed radiation sources that impinge on the ground and flight envelopes. Emission characteristics of the LMLV and spacecraft must be integrated with local characteristics to assure that safe margin-limited levels are not exceeded for any part of the spectrum. Radiation from the LMLV or spacecraft must be coordinated with the Range at all times subsequent to arrival at the launch site. The spacecraft contractor must therefore, provide the data necessary to support an EMI/EMC compatibility evaluation to preclude adversely affecting launch

processing or range-wide operations. Similarly, Lockheed Martin will provide the necessary data to support the design of sensitive payload components. For these reasons an Electromagnetic Compatibility Control Plan is prepared and implemented for each mission as described in Section 8.

The LMLV transmits at several frequencies to provide telemetry data for range tracking of the launch vehicle. The radiation characteristics of the launch vehicle are provided in Figure 3.1.3-1. These systems are switched on before launch and remain active until after spacecraft separation, CCAM, and propellant depletion.

The electromagnetic environment generated by the LMLV at the spacecraft location within the PLF does not exceed the limits shown in Figure 3.1.3-2.

The maximum induced electromagnetic environment resulting from all sources operating at the ER and impinging on LC-46 is 5 v/m from 14-kHz to 40 GHz. The maximum induced electromagnetic environment resulting from all sources

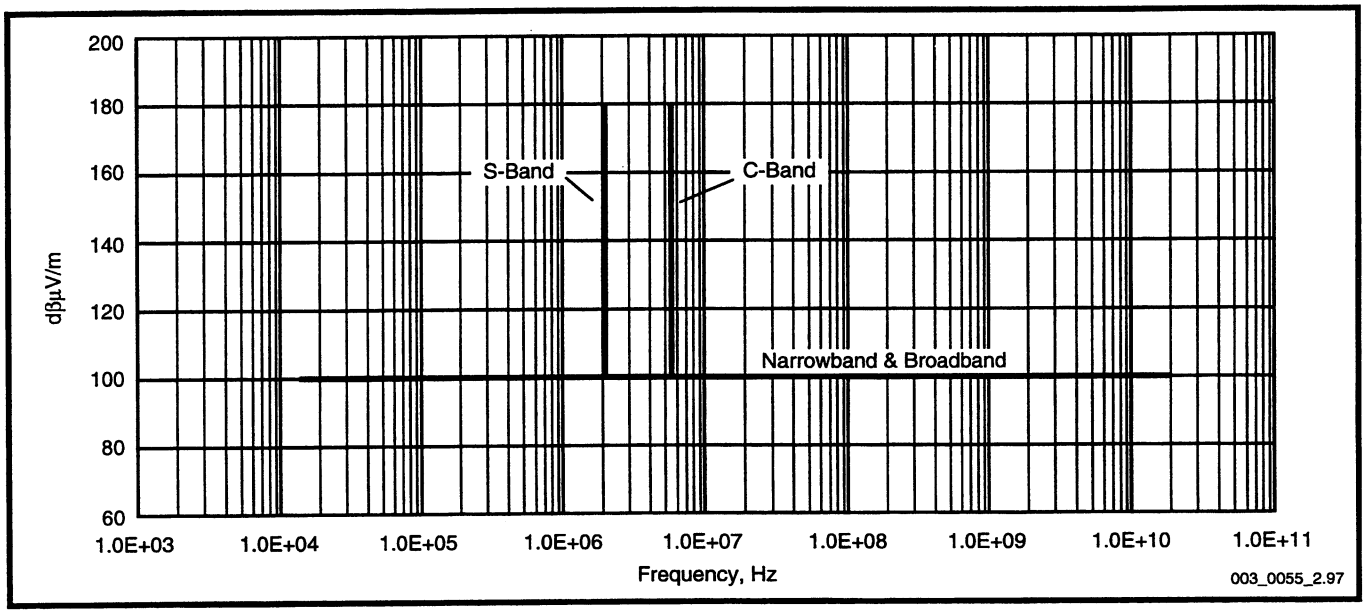

Figure 3.1.3-1 Launch Vehicle Electric Field Radiation from Antennas

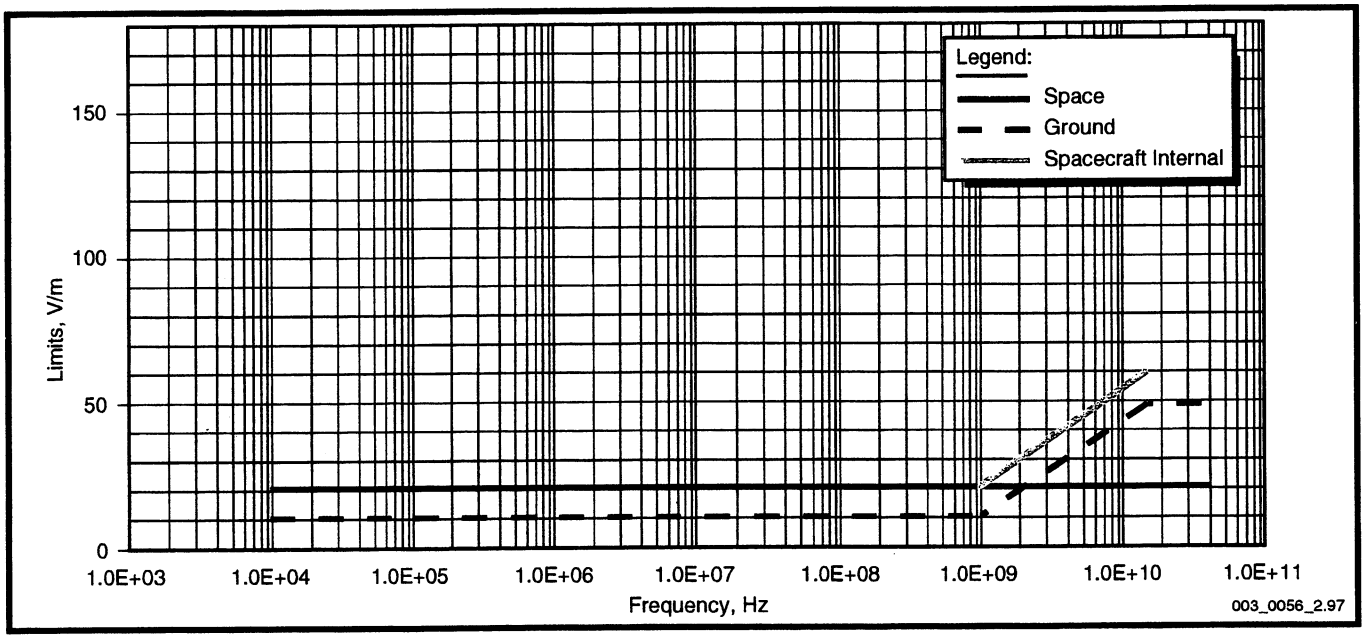

Figure 3.1.3-2 LMLV Emission Limits

operating at the WR and impinging on SLC-6 is 636 v/m from 5.4 GHz to 5.9 GHz.

During ground operations and during flight through spacecraft separation, spacecraft EMI radiated emissions from internal and external equipment or subsystems, except antennas, must not exceed the limits shown in Figure 3.1.3-3.

3.1.4 Electrostatic Potential and Grounding

The buildup of high-electrostatic discharge potential is present in prelaunch operations. The nature of the materials, size of surface areas, presence of electrical current sources, and weather conditions all contribute to the potential danger. To keep personnel, equipment, pyrotechnic devices, and sensitive electronics out of the discharge path, proper electrical bonding between surfaces are established and proper electrical ground paths are provided and maintained between the spacecraft and ground throughout the preflight phase.

Also, electronic and electrical circuits require a common ground reference to operate together or communicate as they are designed. Consequently, the spacecraft must be equipped with ground attachment points to which properly designed ground straps can be attached during prelaunch processing. These attach points provide the path for grounding the spacecraft to a ground potential equal to that of the checkout equipment and the launch vehicle. To avoid potential damage or erroneous signal levels, the electrical resistance across the spacecraft to payload adapter interface must be verified to be less than 2.5 milliohm when installation is complete (MIL-B 5087B, Class R). Point-to-point requirements for detailed electrical measurement values, including shielding, are developed and included with each spacecraft-to-launch vehicle ICD.

3.2 LAUNCH AND FLIGHT ENVIRONMENTS

Launch and flight environments encompass everything that the spacecraft is exposed to from first-stage ignition through onorbit separation. The predominant environments, from a spacecraft design perspective, are the quasi-steady state and oscillatory dynamic structural loads, shock, vibration, and pressure experienced as the spacecraft is boosted through the atmosphere. The radiant effects of atmospheric heating of the PLF and the potential for payload contamination by LMLV debris are comparatively less severe environmental concerns and are usually more amenable to design accommodation. Meteorological conditions, trajectory lofting, PLF jettison timing, and ACS maneuvering are examples of variables that affect

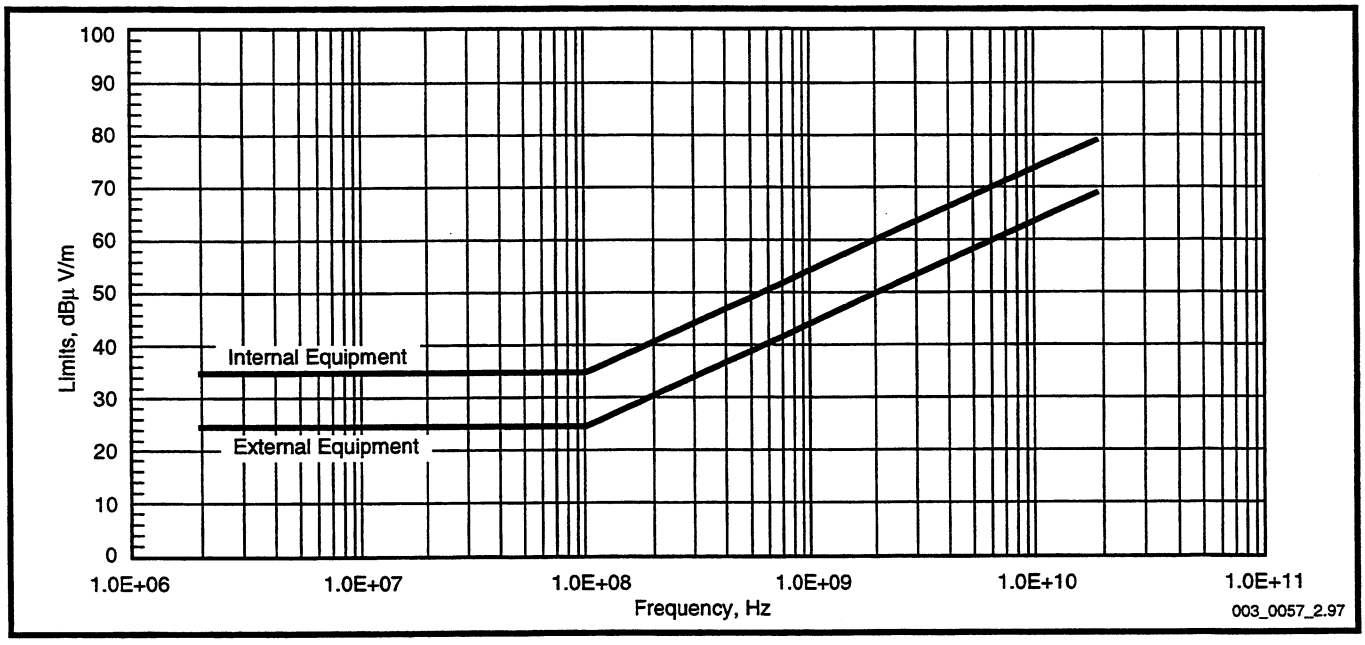

Figure 3.1.3-3 Spacecraft Not-To-Exceed EMI Radiated Emissions

the environmental conditions that must be considered in each mission's environmental analyses.

3.2.1 Loads and Load Factors

Preliminary design load factors at the launch vehicle-to-spacecraft interface that envelope the maximum spacecraft response during critical flight events for the LMLV1 and LMLV2 are shown in Tables 3.2.1-1 and 3.2.1-2 respectively. The values, in g's, include an average spacecraft response because loads are partly dependent on the specific spacecraft configuration. These values are provided for preliminary spacecraft primary structure sizing only. To avoid undesirable coupling between the launch vehicle and the spacecraft, the stiffness of the spacecraft structure should be such that fundamental fixed base frequencies comply with the values shown in Table 3.2.1-3. For spacecraft not meeting this modal frequency criteria, structural dynamic spacecraft response may exceed the preliminary design load factors shown in Tables 3.2.1-1 and 3.2.1-2. In such cases, detailed coupled load analysis must be performed to quantify mission load factors on a mission-unique basis for potential mitigation through cg adjustment, payload adapter structural modification, or other means. The leveraged effects of small changes in spacecraft configuration merit close budgeting of their cg and mass properties, plus stringent acceptance criteria, as a result of the potentially large cost and schedule impact of late accommodation.

Table 3.2.1-1 LMLV1 Spacecraft Center of Gravity (cg) Load Factors

FLIGHT EVENT	AXIAL LOAD, g's	LATERAL LOAD, g's
Launch/First Stage (Castor 120®) Ignition	-8.7 to +9.2	0.0 ± 2.4
First Stage Motor Resonance	3.6 ± 2.7	0.0 ± 2.9
First Stage Maximum Acceleration	8.1	0.0 ± 2.0
Wind Gust	3.5	0.0 ± 2.5
Second Stage (Orbus®21D) Ignition	-2.0 to +5.0	0.0 ± 2.0
Second Stage Maximum Acceleration	7.0	0.0 ± 1.0
Envelope	-8.7 to +9.2	0.0 ± 2.9

Note:
1) All Loads have a 99th percentile probability of nonexceedance;
2) Positive axial load factors act in the aftward direction at the spacecraft center of gravity (cg);
3) Axial load factors envelope spacecraft cg responses to motor ignition transients and steady-state boost accelerations;
4) Lateral load factors are peak spacecraft cg responses to maximum nozzle deflections during all stages of boost flight;
5) Coupled loads analysis provides specific spacecraft dynamic response;
6) Axial and lateral load factors should be applied simultaneously.

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Table 3.2.1-2 LMLV2 Spacecraft Center of Gravity (cg) Load Factors

FLIGHT EVENT	AXIAL LOAD, g's	LATERAL LOAD, g's
Launch/First Stage (Castor 120®) Ignition	-1.0/+3.0	±1.5
First Stage Motor Resonance	2.0 ± 1.0	± 1.5
Wind Gust	2.0	±2.5
First Stage Maximum Acceleration	2.0	± 2.0
Second Stage (Castor 120®) Ignition	-1.0/+6.0	± 1.5
Second Stage Motor Resonance	4.0 ± 3.0	± 2.5
Second Stage Maximum Acceleration	8.0	±2.0
Third Stage (Orbus® 21D) Ignition	-2.0/+5.0	±2.0
Third Stage Maximum Acceleration	7.0	±1.0
Envelope	-2.0 to +8.0	±2.5

Note:
1) All loads have a 99th percentile probability of nonexceedance;
2) Positive axial load factors act in the aftward direction at the spacecraft cg;
3) Axial load factors envelope spacecraft cg responses to motor ignition transients and steady-state boost accelerations;
4) Lateral load factors are peak spacecraft cg responses to maximum nozzle deflections during all stages of boost flight;
5) Coupled loads analysis provides specific spacecraft dynamic response;
6) Axial and lateral load factors should be applied simultaneously.

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3.2.2 Low-Frequency Vibration

For the LMLV family, low-frequency quasi-sinusoidal vibration is generated mainly by first- and second-stage solid rocket motor chamber resonances. For the Castor 120® SRM, the first chamber resonant mode ranges from 45 Hz to 70 Hz. Based on previous flight experience and test firings, oscillation amplitudes for the LMLV family peak at the spacecraft at 55 Hz as a result of this chamber resonance phenomenon. This has been incorporated into the LMLV1 and LMLV2 preliminary design load factors shown in Tables 3.2.1-1 and 3.2.1-2, respectively. Predicted sinusoidal

Table 3.2.1-3 Spacecraft Preliminary Dynamic Mode Frequency Recommendations

MODE	LMLV1	LMLV2
Axial, Hz[1]	>30	>30
Axial, Hz[2]	≠ 45 to 70	≠ 45 to 70
Lateral, Hz[3]	>15	>12

Note:
1) Axial mode frequency requirements avoid dynamic coupling between spacecraft and booster ignition-forcing functions.
2) Minimizing spacecraft structure resonances in this range will reduce dynamic coupling with launch vehicle solid motor resonances.
3) Lateral mode requirements avoid dynamic coupling between spacecraft and first bending mode of the launch vehicle.

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vibration response of a specific. Spacecraft caused by motor chamber resonance is determined through coupled loads analysis for each mission. By designing spacecraft structure fundamental frequencies to remain out of the frequencies shown in Table 3.2.1-3 quasi-sinusoidal effects are greatly diminished.

3.2.3 Random Vibration

High-frequency broadband random vibration from transient sources at the launch vehicle-to-spacecraft interface for the LMLV family is shown in Figure 3.2.3-1 and Table 3.2.3-1. In general, launch and transonic acoustics drive the mechanically transmitted random environment.

3.2.4 Acoustics

Spacecrafts are exposed to an acoustic environment during launch and throughout flight. The acoustic pressure levels for frequencies present inside the PLF will vary according to the dimensions of the PLF; the shape and size of the unfilled interior space; the pressure density of the

Table 3.2.3-1 Random Vibration Environment at the LV/SV Interface

FREQUENCY, H_Z	POWER SPECTRAL DENSITY, g^2/H_Z
LMLV1	
20	0.001
500	0.015
2000	0.015
LMLV2	
20	0.001
500	0.005
2000	0.005

Note:
1) 3-db Margin Per MIL-STD-1540B
2) 5% Probability of Exceedance (1 in 20) at the LV/SV Interface
3) Acoustically Induced
4) Transonic Flight Dominated
5) Ducted Launch Pad
6) Omni-Directional

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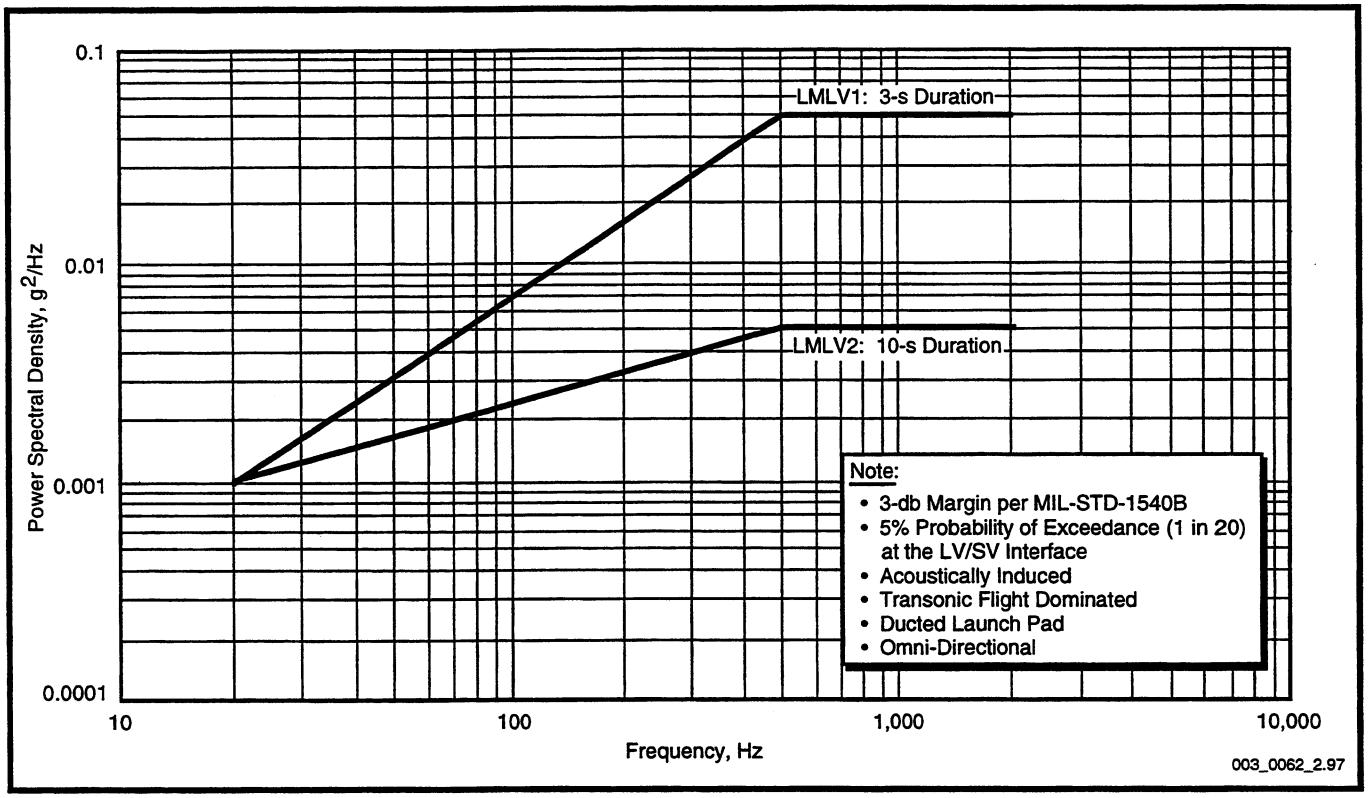

Figure 3.2.3-1 Random Vibration Environment at the LV/SV Interface

environment; the venting design; and the size, shape, and surface material properties of the spacecraft components. The concern of the spacecraft designer is to limit exposure of those components to acoustic pressures within an acceptable range. The greatest acoustic sound pressure levels inside the PLF occur during the first 10 seconds after launch and during transonic flight. Figure 3.2.4-1 and Table 3.2.4-1 provide the envelope of the launch and transonic acoustic levels. The acoustic sound pressure-frequency data are provided for the LMLV1 and LMLV2 with an aluminum Model 92 PLF. These acoustic levels are for an empty PLF without acoustic blankets. On a mission-unique basis, the acoustic levels can be reduced by adding acoustic blankets. During the spacecraft integration process, the empty PLF acoustic data are revised to include a "fill-factor" based on the volume within the PLF occupied by the spacecraft. The effects of the fill factor tend to increase the acoustic environment. The acoustic environment will also increase if an aluminum-lithium PLF is used in lieu of the aluminum PLF. These factors must be considered early in the design of the spacecraft.

3.2.5 Shock

During flight, the spacecraft is exposed to several shock events, some of which are highly attenuated by the LMLV structure. These events include first-stage ignition, first-stage separation, second-stage ignition, second-stage separation, third stage ignition (LMLV2 only), third stage separation (LMLV2 only), PLF separation, and payload separation. Shown in Figure 3.2.5-1 and Table 3.2.5-1 is the upper limit of the envelope of the maximum predicted shock environments at the launch vehicle-to-spacecraft. interface. This figure applies to both the LMLV1 and LMLV2 configurations.

3.2.6 Thermal

During ascent, aerodynamic heating of the PLF results in a time-dependent radiant-heating environment around the spacecraft. This heating is the dominant thermal energy source to which the spacecraft is exposed during its flight. After the PLF is jettisoned, the remaining thermal environment involves a much lower level of free molecular

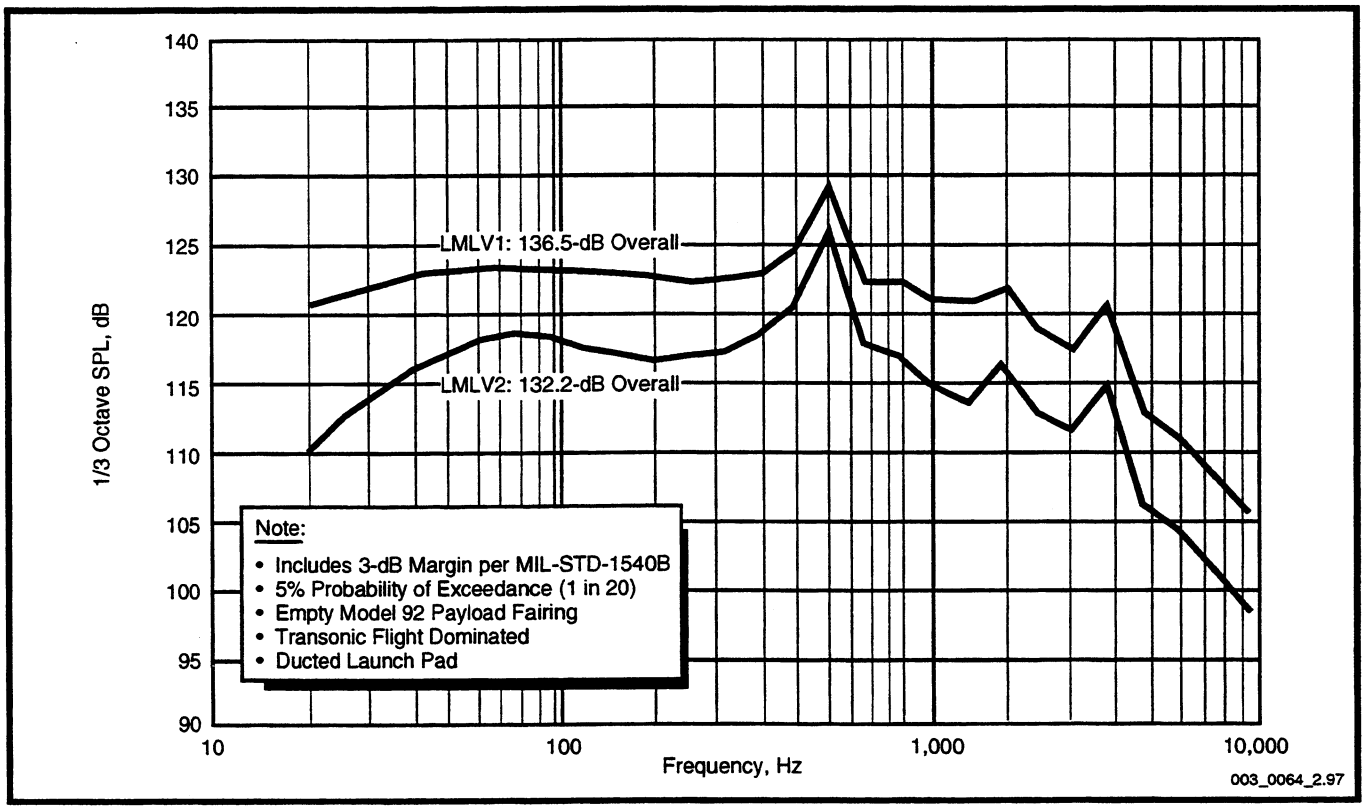

Figure 3.2.4-1 LMLV Empty Payload Fairing Acoustic Levels

Table 3.2.4-1 LMLV Empty Payload Fairing Acoustic Levels

LMLV1 INTERNAL ACOUSTICS LEVELS			LMLV2 INTERNAL ACOUSTICS LEVELS		
	1/3 OCTAVE SPL, dB			1/3 OCTAVE SPL, dB	
FREQUENCY, Hz	LAUNCH	FLIGHT	FREQUENCY, Hz	LAUNCH	FLIGHT
20	106.0	122.0	20	106	110
25	107.5	122.1	25	108.9	112.5
32	109.0	122.3	32	111.2	114.3
40	111.4	122.5	40	113.3	116.0
50	112.8	122.7	50	114.9	117.2
63	114.4	122.9	63	116.0	118.1
80	116.4	122.8	80	116.8	118.7
100	117.9	122.7	100	116.8	118.3
125	118.9	122.6	125	116.7	117.7
160	119.8	122.3	160	116.4	117.1
200	120.2	122.0	200	115.8	116.7
250	119.8	121.8	250	115.4	116.9
315	117.8	121.9	315	113.4	117.3
400	116.4	122.5	400	112.0	118.5
500	115.7	124.1	500	111.3	120.5
630	115.8	129.6	630	111.4	126.3
800	116.0	121.8	800	111.6	117.8
1000	115.2	121.8	1000	110.8	117.0
1250	113.2	120.4	1250	108.8	114.9
1600	111.0	120.2	1600	106.6	113.6
2000	120.6	121.1	2000	116.2	115.0
2500	112.9	117.8	2500	108.5	112.6
3150	109.0	116.6	3150	104.6	111.4
4000	106.0	119.9	4000	101.6	114.7
5000	102.7	111.1	5000	98.3	105.9
6300	101.2	109.3	6300	96.8	104.0
8000	98.9	106.2	8000	94.5	100.9
10000	96.8	103.3	10000	92.4	98.0
OASPL	130.0	136.5	OASPL	127.3	131.7

Note:
1) Includes 3-db margin per MIL-STD-1540B
2) 5% Probability of Exceedance (1 in 20)
3) Empty Model 92 Payload Fairing
4) Transonic Flight Dominated
5) Ducted Launch Pad

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Table 3.2.5-1 Shock Environment at the LV/SV Interface

FREQUENCY, Hz	ACCELERATION RESPONSE, g
20	15
100	60
400	1000
2000	3000
10000	3000

1) Includes 4.5-dB margin per MIL-STD-1540B
2) 5% Probability of Exceedance (1 in 20)
3) Envelopes All Launch Vehicle Produced Shock Events
4) Shock Produced by LV/SV Separation System May Exceed These Values
5) Omni-Directional
6) Q = 10

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heating (FMH), plus solar heating, Earth thermal and albedo heating, Orbus® 21D solid rocket motor plume heating, and heating through conductive structural coupling. Mitigation methods available on a mission-unique basis include PLF separation delay; slow-roll during coast; and the addition of thermal blankets, reflectors, shades, or shields.

Because the major contributor to the spacecraft's thermal environment is the heat absorbed by the PLF, its effect depends largely on its configuration. For the standard Model 92 PLF, the skin temperature is determined by the mission trajec-

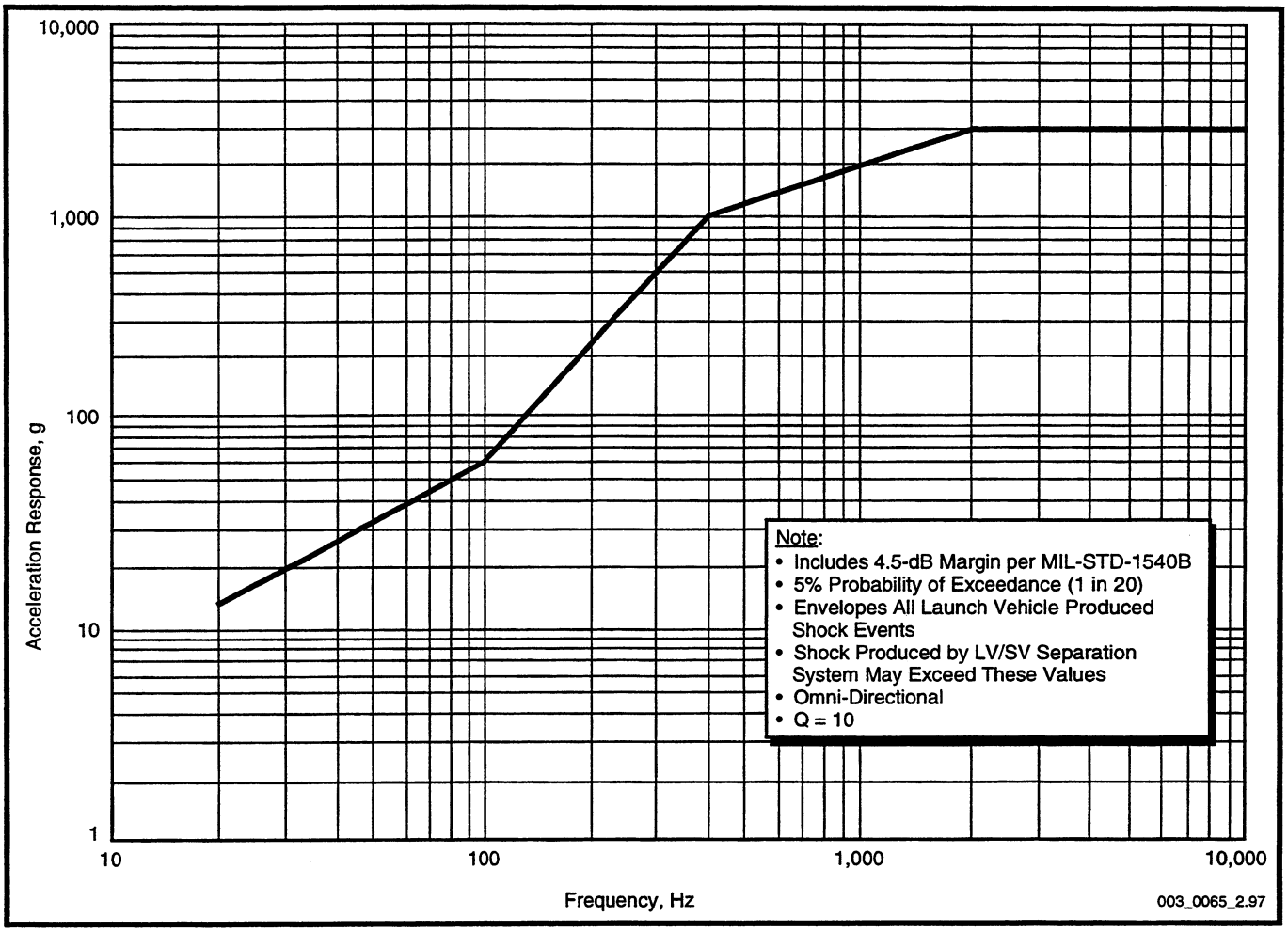

Figure 3.2.5-1 Shock Environment at the LV/SV Interface

tory, and insulation configuration. Maximum temperature histories of the Model 92 PLF internal surface for the LMLV1 and LMLV2 are shown in Figures 3.2.6-1 and 3.2.6-2.

PLF separation is planned at a time and altitude in the flight trajectory such that the FMH rate is less than 0.1 Btu/ft^2-sec. To meet mission-specific spacecraft thermal requirements, PLF separation can be delayed to provide lower FMH rates.

During the transfer coast, a slow roll (typically 1 to 3 deg/sec) to moderate solar-generated heating and cooling, can be provided.

Generally, plume heating of the spacecraft from the Orbus® 21D and the attitude control system is negligible. However, in rare cases where the spacecraft has aft facing components that are in view of the Orbus® 21D plume, some radiation heat transfer to the spacecraft may occur. At worst, this heating rate would be 0.20 Btu/ft^2-sec for the 154-second duration of the Orbus® 21D burn.

3.2.7 Atmospheric Pressure Venting

The pressure on the spacecraft diminishes from first-stage ignition as a function of the trajectory profile through PLF jettison. After PLF jettison, the pressure on the spacecraft diminishes as a function of altitude.

As the LMLV ascends through the atmosphere, pressure within the payload fairing is relieved through five one-way vent valves in the payload adapter. PLF internal pressure time histories are shown in Figure 3.2.7-1 for typical LMLV1 and LMLV2 flight trajectories. The maximum steady state venting rate prediction is typically 0.5 psi/sec during ascent. However, a transient event occurs as the vehicle crosses into the transonic regime where the pressure decay rate increases to 1.0 psi/sec for approximately 3 seconds.

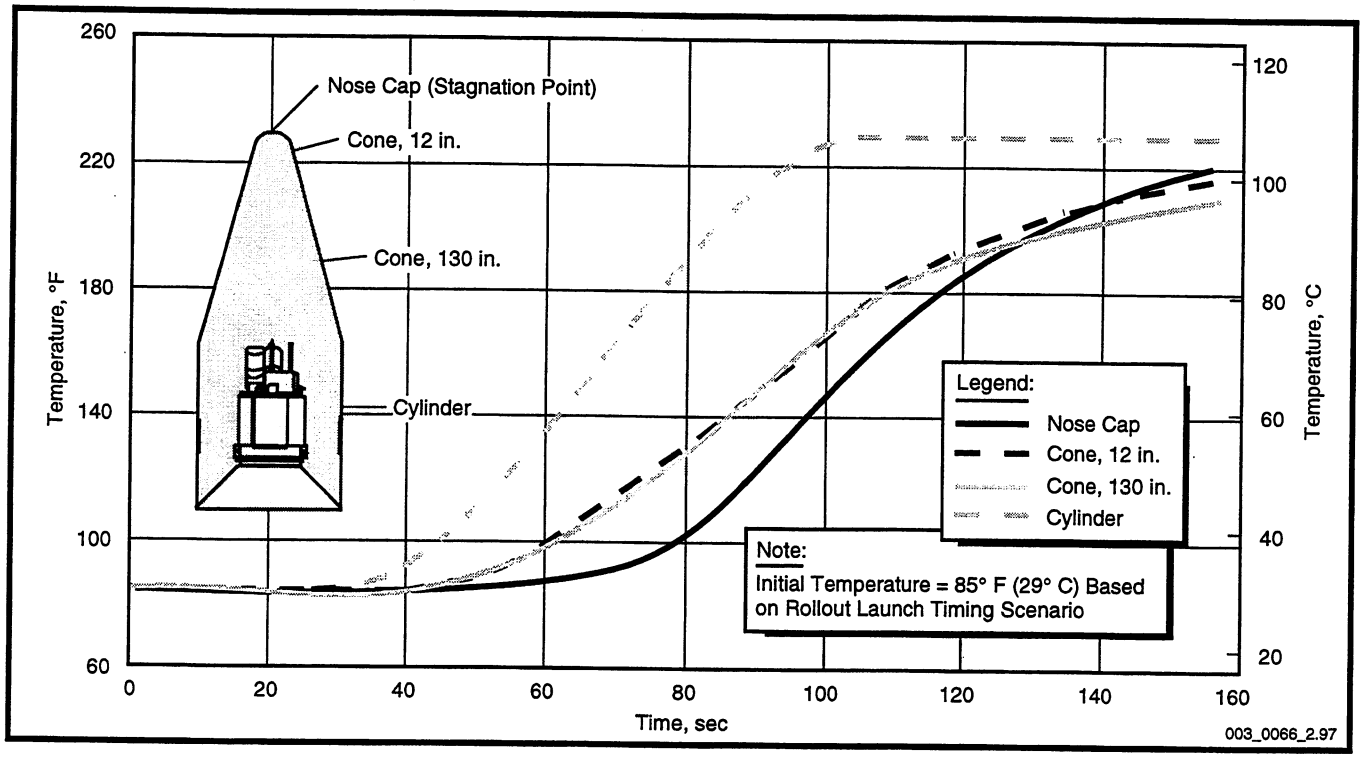

Figure 3.2.6-1 LMLV1 Payload Fairing Inner Surface Temperature

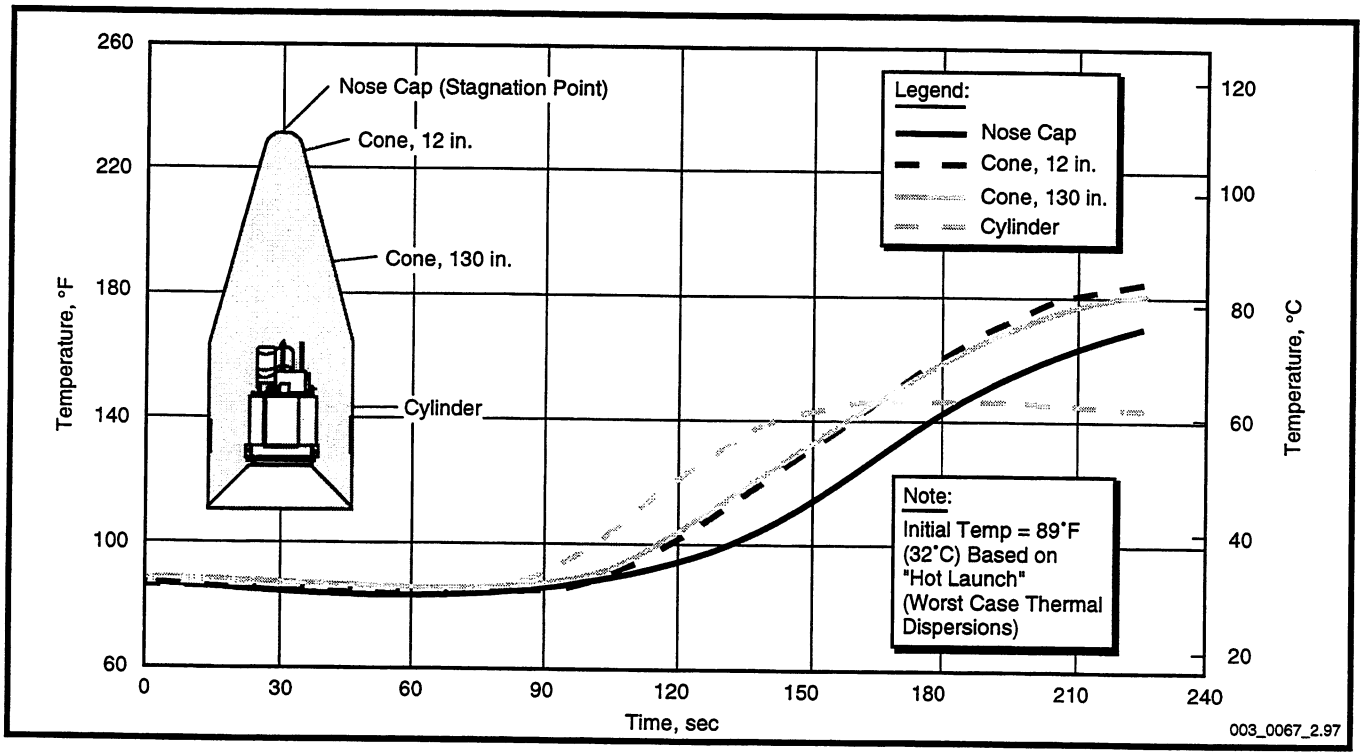

Figure 3.2.6-2 LMLV2 Payload Fairing Inner Surface Temperature

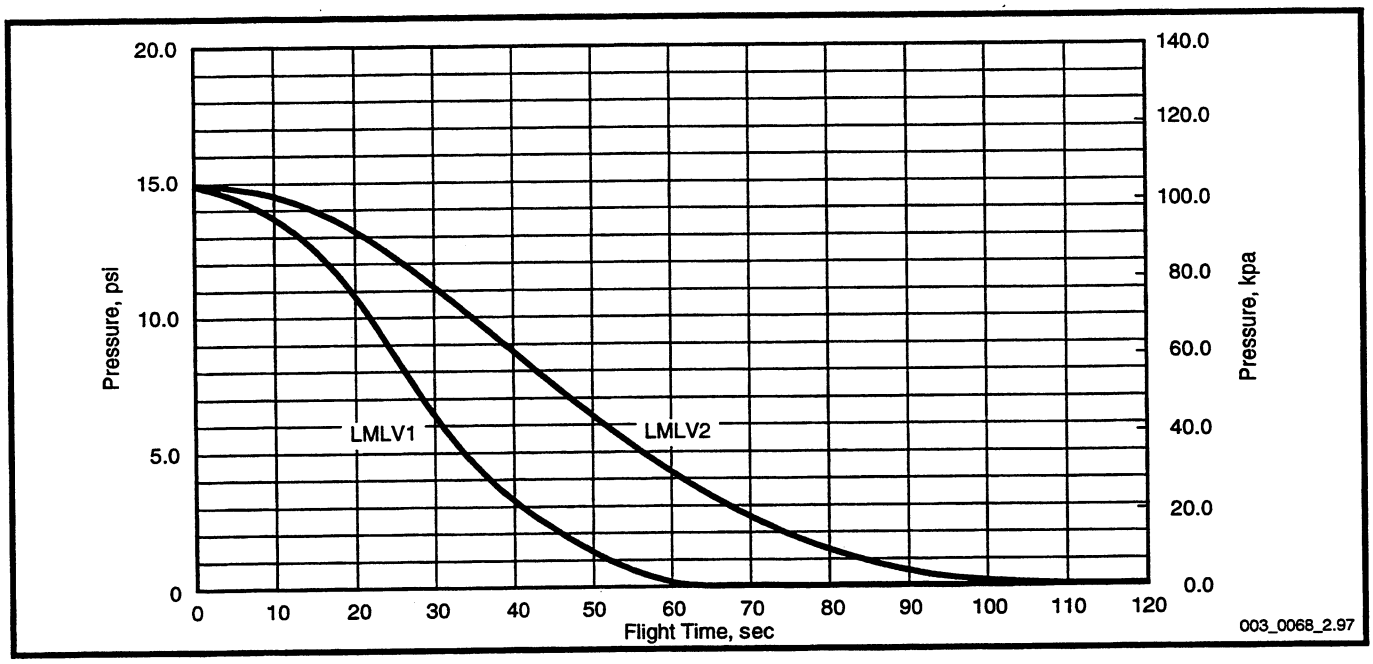

Figure 3.2.7-1 Payload Fairing Internal Pressure History

3.2.8 Contamination Control and Cleanliness

The PLF protects the spacecraft from all sources of contamination by maintaining the clean environment that was established under ground launch conditions discussed in Section 3.1.2. To prevent contaminating the spacecraft following PLF jettison through spacecraft separation, the LMLV has been designed with features that either eliminate contamination or reduce it to acceptable levels. The PLF employs Zip, a patented clean separation system, along the base and separation joints of the two halves of the PLF. All contamination from detonable items are contained within the Zip Tube to allow a clean separation of the PLF. During orbit injection and spacecraft orientation, contamination by the ACS thruster plumes is minimized because the thrusters are oriented away from the spacecraft.

During spacecraft deployment, the ACS does not begin the CCAM maneuver until the deployed spacecraft is nominally 100 ft (30 m) away. This reduces potential contamination from the ACS thruster plumes.

Contamination avoidance and mitigation techniques readily available include containment, maneuvering, materials selection, and the addition of shielding, coatings, coverings, and sealants. In addition to particulate contamination, low molecular outgassing materials have been considered in the LMLV design.The PLF, (including acoustic blankets if required), and payload adapter internal and forward facing surfaces, and all launch vehicle equipment within this volume, have been carefully chosen to not produce greater han 0.1 percent volatile condensable materials (VCM) (by weight), nor total mass loss (TML) of 1.0 percent or more after spacecraft encapsulation through spacecraft separation.

4.0 SPACECRAFT INTERFACES

4.1 SPACECRAFT-TO-LAUNCH-VEHICLE INTERFACES

This section presents the mechanical and electrical interfaces of the LMLV family with detailed descriptions of the payload fairing and its envelope, five standard payload adapters, two representative separation systems and a wiring diagram of the LMLV umbilical with available circuits. All vehicle interface information contained in this section should be used as a guide. Ultimate control of interface information for a given mission is governed through the interface control document (ICD), which is developed and maintained during the mission integration process.

LMLV Coordinate System—The LMLV coordinate system, for all LMLV configurations, is provided to assist the user in the preliminary orientation of the spacecraft. Details of the spacecraft coordinate system and launch vehicle coordinate system are required to determine spacecraft accessibility (through the payload fairing access doors) and to evaluate mission performance as related to spacecraft cg offset. The LMLV orthogonal coordinate system is shown in Figure 4.1-1. The X axis is longitudinal along the vehicle centerline with the Y and Z axes as shown in the figure.

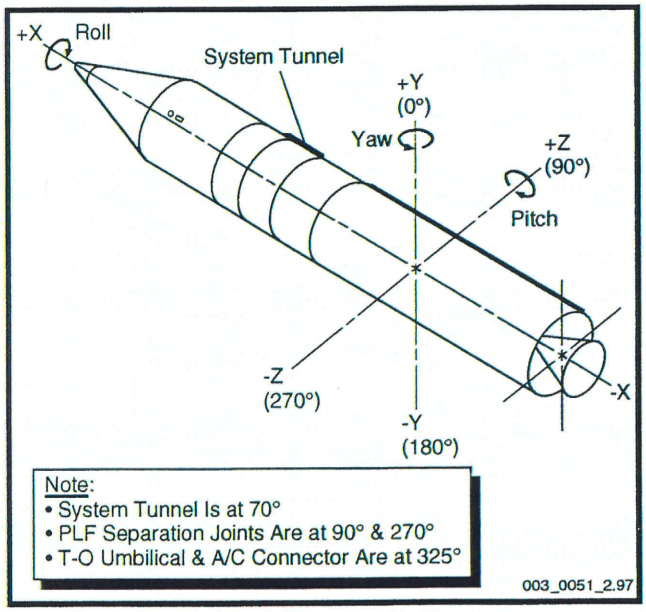

Figure 4.1-1 LMLV Coordinate System

4.1.1 Mechanical Interfaces—Payload Fairing

The Model 92 payload fairing provides the LMLV with a large payload volume for this class of vehicle. This large volume eases packaging restrictions on the spacecraft designer which reduces cost and risk. The payload fairing protects the spacecraft from encapsulation through payload fairing jettison. Figure 4.1.1-1 shows the large Model 92 payload fairing during the encapsulation process.

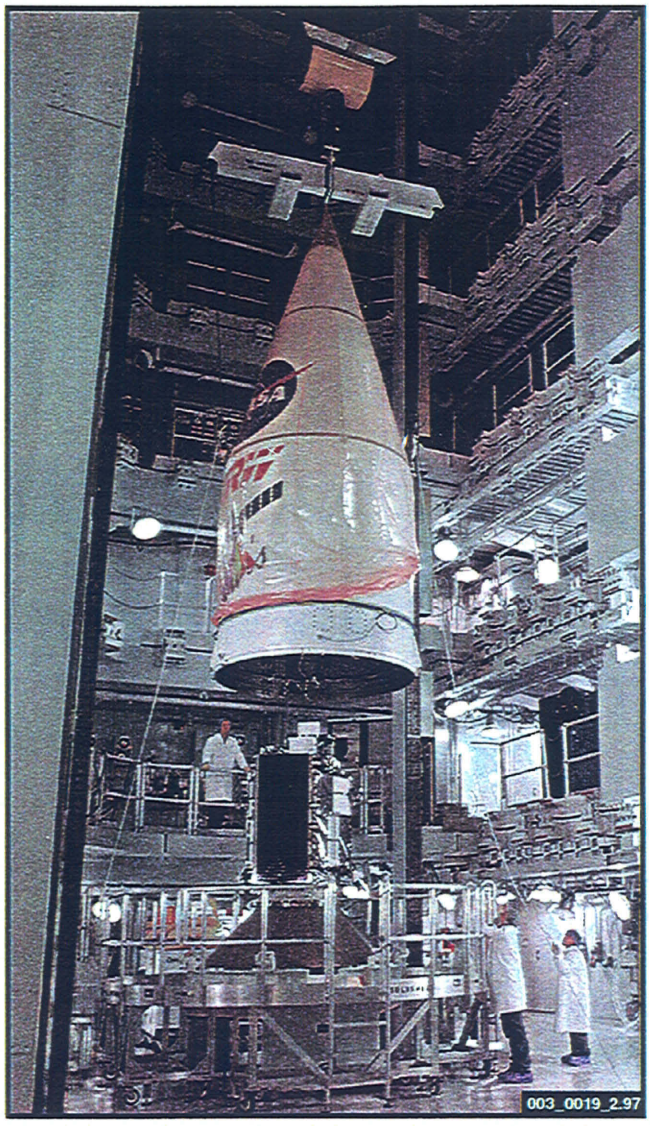

Figure 4.1.1-1 The Model 92 Payload Fairing easily accommodates LMLV class payloads.

The Model 92 payload fairing, is a 92-in. (2337-mm) diameter contoured shell that attaches to the payload adapter and to the Orbit Adjust Module (OAM) at a common field joint. Lift points

on the payload fairing allow the encapsulated assembly, which includes the payload fairing, the payload adapter, and the payload, to be mated to the OAM.

The Model 92 payload fairing consists of an aluminum-lithium, ring-stiffened, monocoque structure and ordnance components. The conical section is tapered 15 degrees to reduce aerodynamic drag and is lined externally with cork thermal protection to maintain payload temperature within specified limits. The payload fairing separates into two halves when jettisoned. Figure 4.1.1-2 shows the Model 92 payload fairing successfully completing a separation test. Zip Tube®, a Lockheed Martin-patented clean pyrotechnic separation system, severs the payload fairing along a circumferential joint at the base and along two longitudinal joints. Thruster springs located along the base joint and helper springs located along the upper half of the longitudinal joint provide the required energy to separate the payload fairing from the launch vehicle. Each payload fairing half rotates on two hinges located at its base. The hinges release the payload fairing halves when they have rotated past 45 degrees. This design reduces payload fairing radial deflection and increases the dynamic envelope. The Model 92 payload fairing is shown in Figure 4.1.1-3.

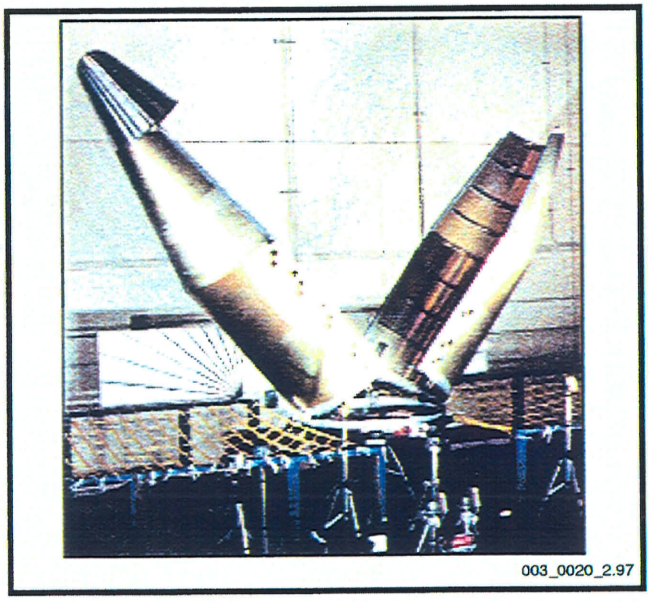

Figure 4.1.1-2 Model 92 Payload Fairing Successfully Completing a Separation Test

4.1.1.1 Payload Fairing Usable Volume—The payload fairing's dynamic envelope accounts for structural tolerances as well as static and dynamic deflections. The aft portion of the envelope around the payload adapter varies for each user, depending on which payload adapter is used. Figures 4.1.1.1-1 through 4.1.1.1-5 show the payload fairing's dynamic envelope with each of the five standard payload adapters, Models 24, 37, 38, 47, and 66, respectively. A conditioned-air coupling is located on the payload fairing barrel section that provides the inlet for prelaunch encapsulated assembly climate controlled air (temperature, humidity and cleanliness). Air exits the payload fairing envelope through one-way air valve assemblies, located on the payload adapter, and enters the OAM during prelaunch operations. During ascent through payload fairing jettison, the conditioned air inlet is sealed and air in the payload fairing envelope is vented through the one-way air valve assemblies, into the OAM.

Coupled loads and clearance analyses are performed for all flight events to verify the payload fairing dynamic envelope for each mission. Slight protrusions into the standard envelope may be accommodated on a case-by-case basis. Such requests must be accompanied by documentation that meets stringent drawing and specification standards. All requests are subjected to analyses that may include worst-case payload attachment tolerances, spring and retractor tolerances, wind gusts, bending, and asymmetrical loads effects, effects of flexing of the separating bodies, and thermal distortion assessments.

4.1.1.2 Payload Accessibility—The Model 92 payload fairing includes six access doors. Four doors are located at the payload fairing base to provide access for arming the payload fairing separation ordnance. Two standard 18-in. (457-mm) high by 24-in. (610-mm) wide doors are available to the customer to provide access to the spacecraft during prelaunch operations. These doors can be located axially between ring stiffeners and radially between the longitudinal separation joints as shown in Figure 4.1.1.2-1.

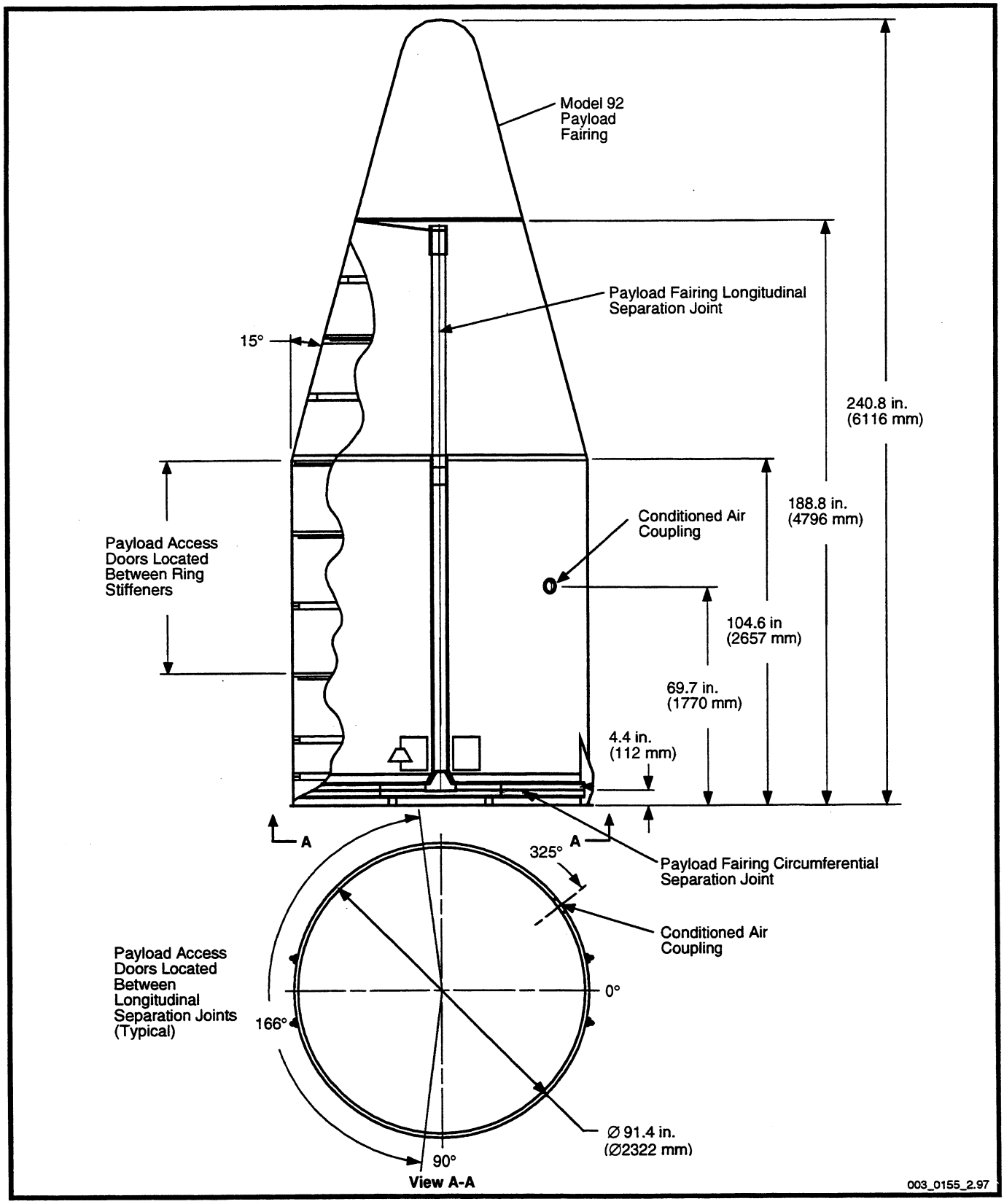

Figure 4.1.1-3 Model 92 Payload Fairing

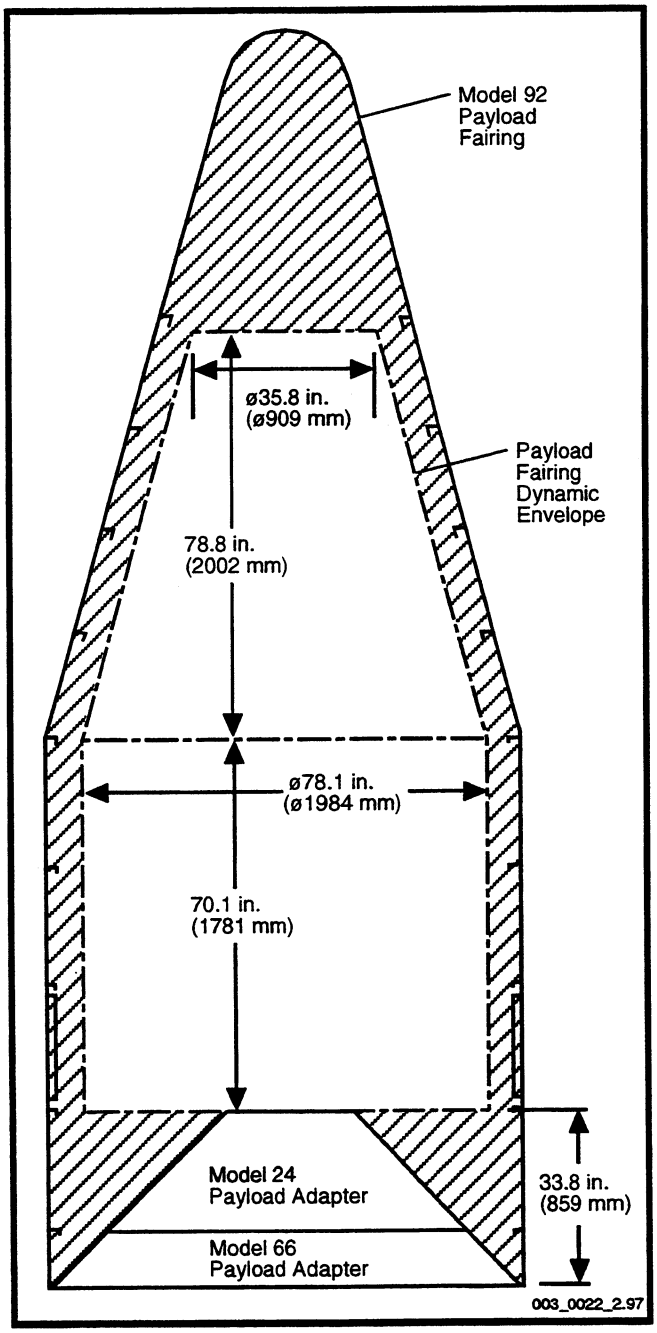

Figure 4.1.1.1-1 Model 92 Payload Fairing Dynamic Envelope with Model 24 Payload Adapter

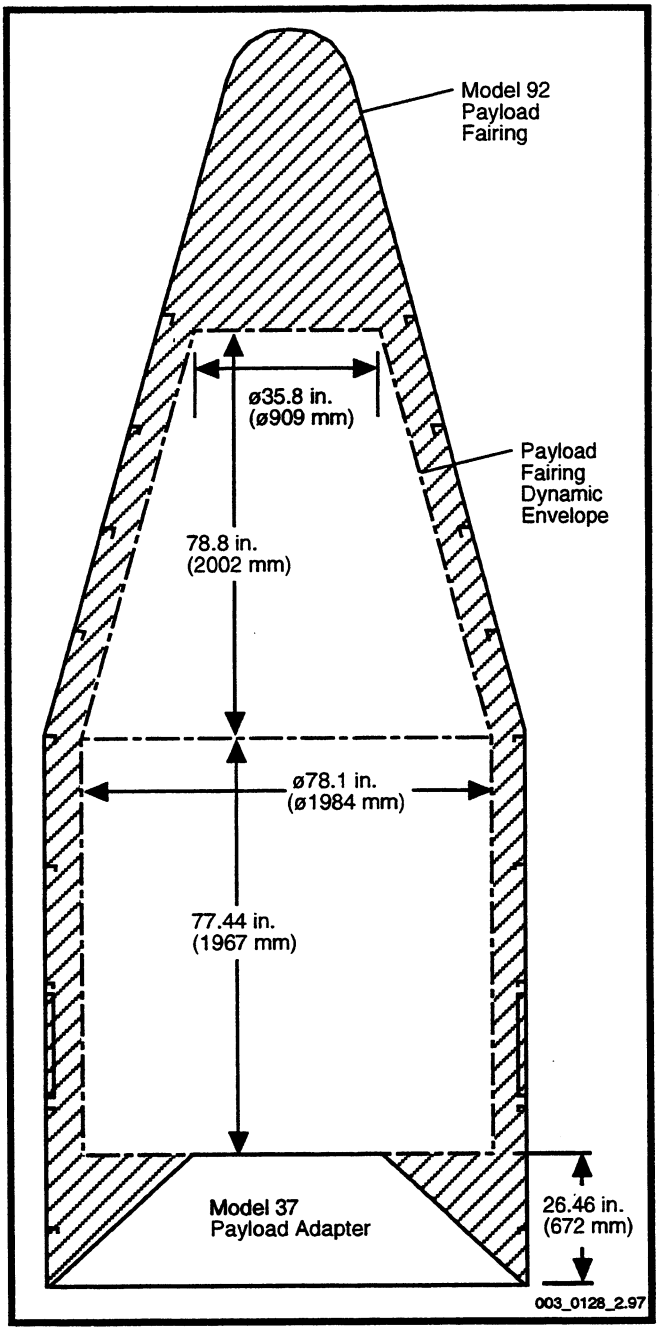

Figure 4.1.1.1-2 Model 92 Payload Fairing Dynamic Envelope with Model 37 Payload Adapter

4.1.1.3 Payload Fairing Enhancements—Enhancements to the Model 92 payload fairing include additional nonstandard payload access doors, acoustic blankets, and RF transparent windows. RF transparent windows can be incorporated into the payload fairing to provide spacecraft telemetry through the payload fairing. The location and size of additional access doors and RF windows must be coordinated with Lockheed Martin.

As an alternative to RF windows, LMLV offers the transmission of payload telemetry data though the launch vehicle telemetry system as described in Section 4.1.3.3.

Lockheed Martin also has the capability of providing a larger payload fairing as customers require. The details of our planned Model 120 payload fairing with a diameter of 120 in. (3048 mm) are shown in Section 9.2.

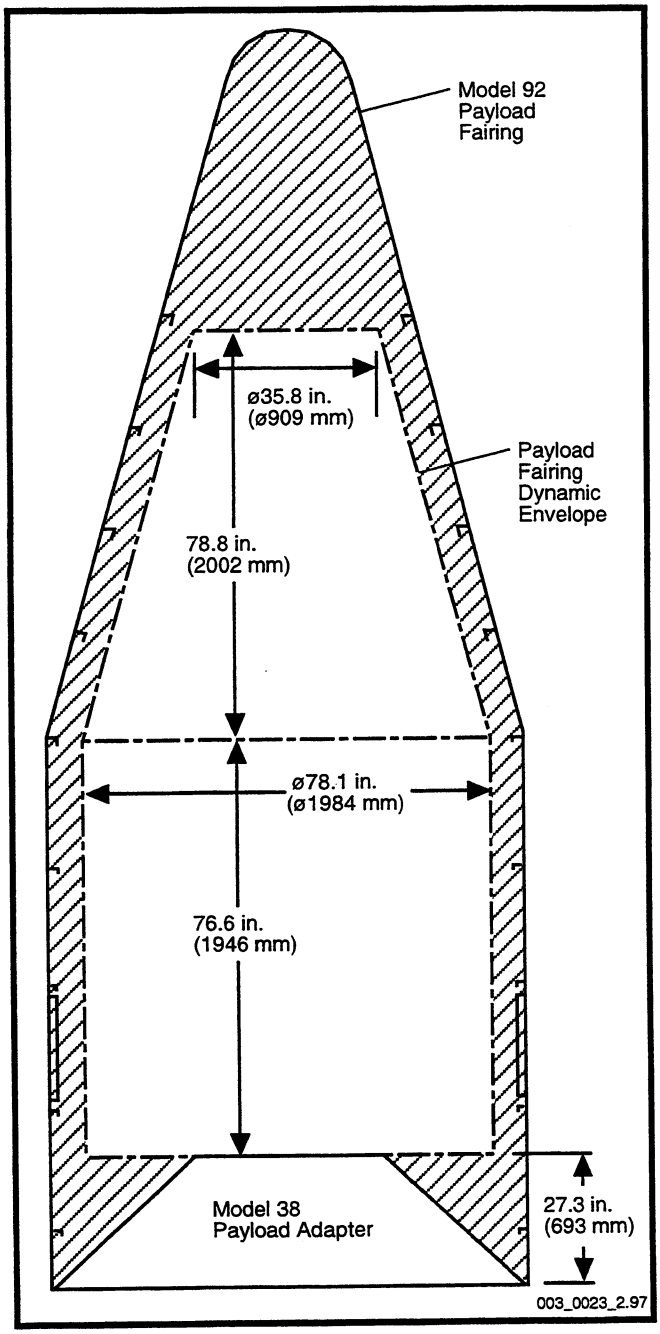

Figure 4.1.1.1-3 Model 92 Payload Fairing Dynamic Envelope with Model 38 Payload Adapter

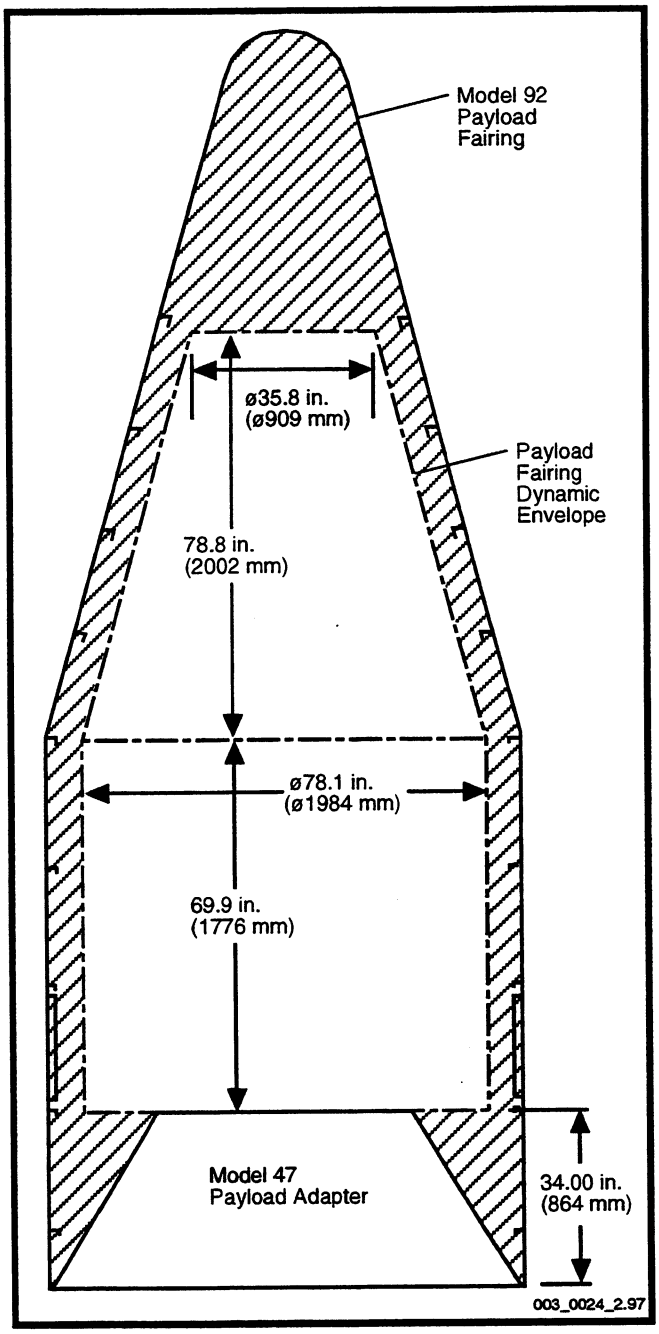

Figure 4.1.1.1-4 Model 92 Payload Fairing Dynamic Envelope with Model 47 Payload Adapter

4.1.2 Mechanical Interfaces—Payload Adapters and Separation Systems

Lockheed Martin offers five standard payload adapters that provide customers with a wide range of industry standard launch vehicle interfaces. The payload adapter provides the mechanical interface between the payload, separation system, and the launch vehicle.

4.1.2.1 Payload Adapters—The five standard payload adapters offered for the LMLV are listed in Table 4.1.2.1-1. Models 24, 37, 38 and 66 are constructed from high-strength, low-weight Al-Li. The Model 47 payload adapter is constructed from Al. Models 37, 38, 47, and 66 provide the interface from the 92-in. (2337-mm) launch vehicle diameter to each payload adapter's interface diameter. The Model 24 payload adapter

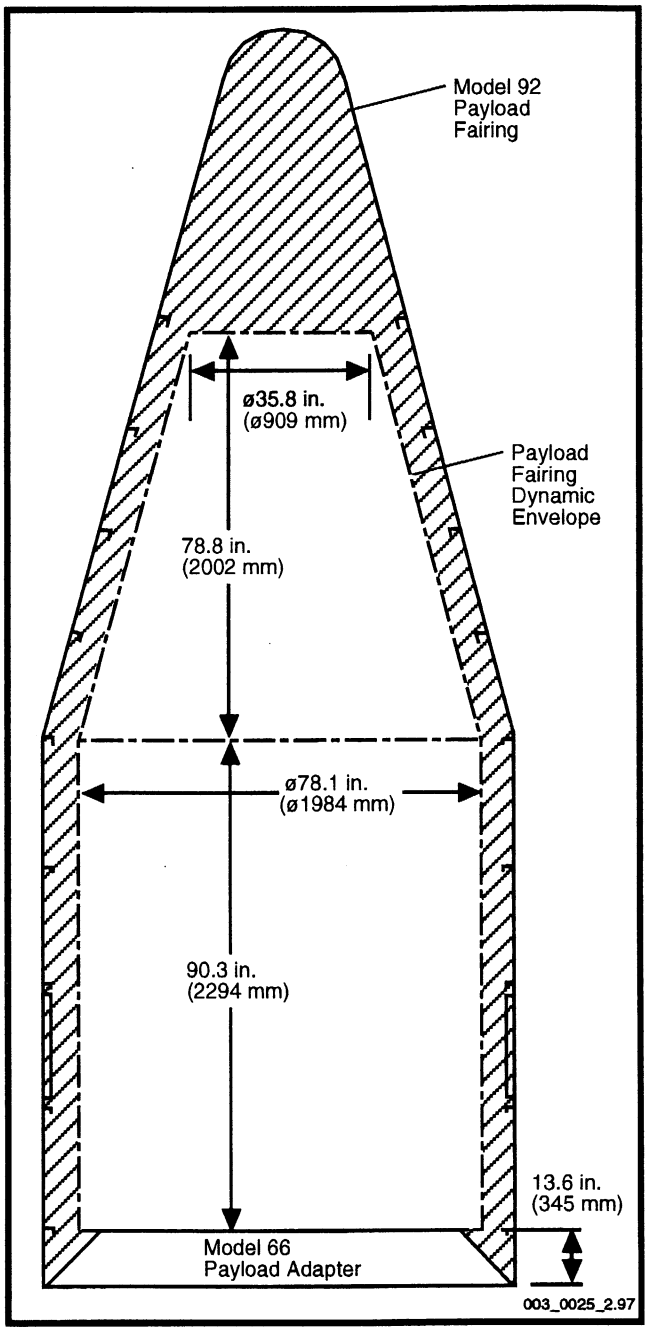

Figure 4.1.1.1-5 Model 92 Payload Fairing Dynamic Envelope with Model 66 Payload Adapter

transitions from the Model 66 bolted interface to the Model 24's—23.25-in. (591-mm) diameter interface. The five standard payload adapters are shown in Figure 4.1.2.1-1.

Each payload adapter has five one-way air valve assemblies to allow conditioned air to enter the OAM from the payload faring during prelaunch operations. During ascent through payload fairing jettison, air in the payload fairing envelope is

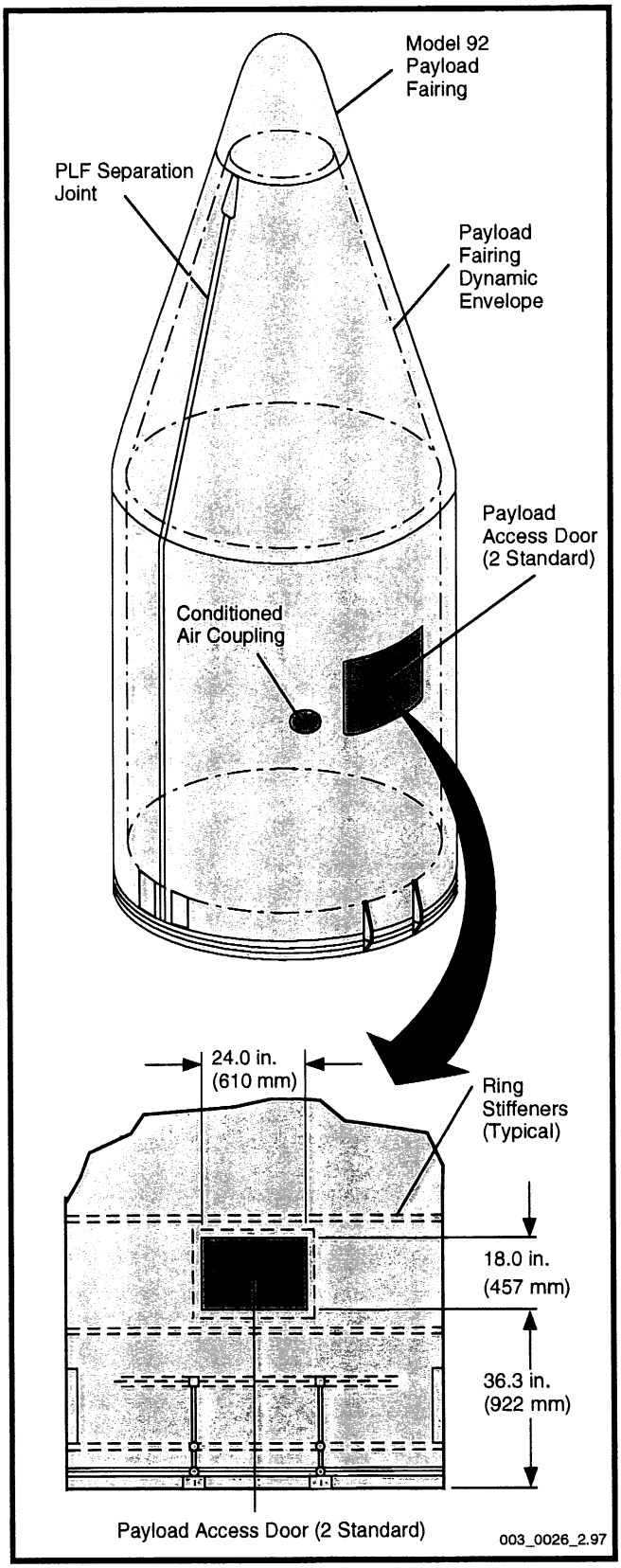

Figure 4.1.1.2-1 Model 92 Payload Fairing Access Door Placements

vented through the one-way air valve assemblies into the OAM.

Table 4.1.2.1-1 LMLV Standard Payload Adapters

PAYLOAD ADAPTER TYPE	PAYLOAD ADAPTER INTERFACE	PAYLOAD ADAPTER WEIGHT
Model 24*	23.25 in. (591 mm) Diameter Bolt Circle	40 lb (18.1 kg)
Model 37	37.15 in. (944 mm) Diameter Bolt Circle	106 lb (48.1 kg)
Model 38	38.81 in. (986 mm) Diameter Bolt Circle	103 lb (46.7 kg)
Model 47	45.709 in. (1161 mm) Diameter Interface	110 lb (49.9 kg)
Model 66	66.00 in. (1676 mm) Diameter Bolt Circle	120 lb (54.4 kg)

Note:
*Model 24 payload adapter weight must be added to the Model 66 payload adapter weight for total payload adapter weight.

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Model 24 Payload Adapter—The Model 24 payload adapter, shown in Figure 4.1.2.1-2 is attached to the Model 66 payload adapter, and reduces its 66-in. (1676-mm) diameter to a 23.25-in. (591-mm) diameter bolt circle. The 23.25-in. (591-mm) diameter bolt circle has 32 equally spaced holes for 0.250-in. (6.35-mm) bolts. The height of the Model 24 payload adapter above the Model 66 payload adapter is 13.63-in. (346-mm). A contamination shield is attached to the 66.00-in. (1676-mm) diameter face of the Model 66 payload adapter to seal the encapsulated assembly and to minimize contamination of the controlled environment within the payload fairing after leaving the clean room. One 19-in. (483-mm) diameter access door is provided in the contamination shield to service areas inside the payload adapter forward of the contamination shield. The Model 24 and Model 66 payload adapter structure weigh approximately 179 lb (81 kg) together. The maximum spacecraft radial cg offset is limited to TBS in. (TBS mm) from the launch vehicle centerline. The maximum spacecraft axial cg location is limited to TBS in. (TBS mm) forward of the 23.25-in. (591-mm) payload adapter interface.

Model 37 Payload Adapter—The Model 37 payload adapter, shown in Figure 4.1.2.1-3 is attached to the aft end of the payload fairing and reduces the 92-in. (2337-mm) diameter of the OAM to a 37.15-in. (944-mm) diameter bolt circle. The 37.15-in. (944-mm) diameter bolt circle has 60 equally spaced holes for 0.1875-in. (4.75-mm)

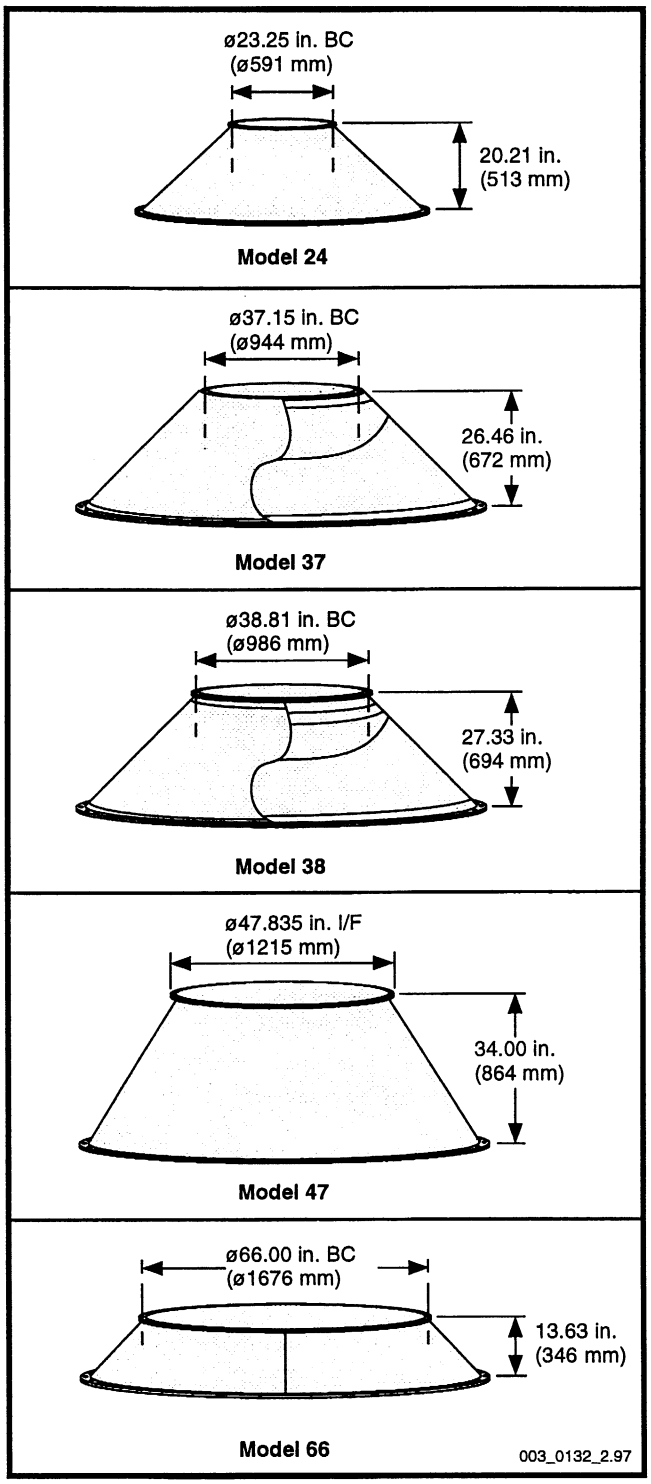


Figure 4.1.2.1-1 Standard Payload Adapters Available for LMLV Missions

bolts. The height of the Model 37 payload adapter above the OAM is 26.46 in. (672 mm). A contamination shield is attached to the 37.15-in. (944-mm) diameter face of the payload adapter to seal the encapsulated assembly and to minimize contamination of the controlled environment within the payload fairing after leaving the clean room. One

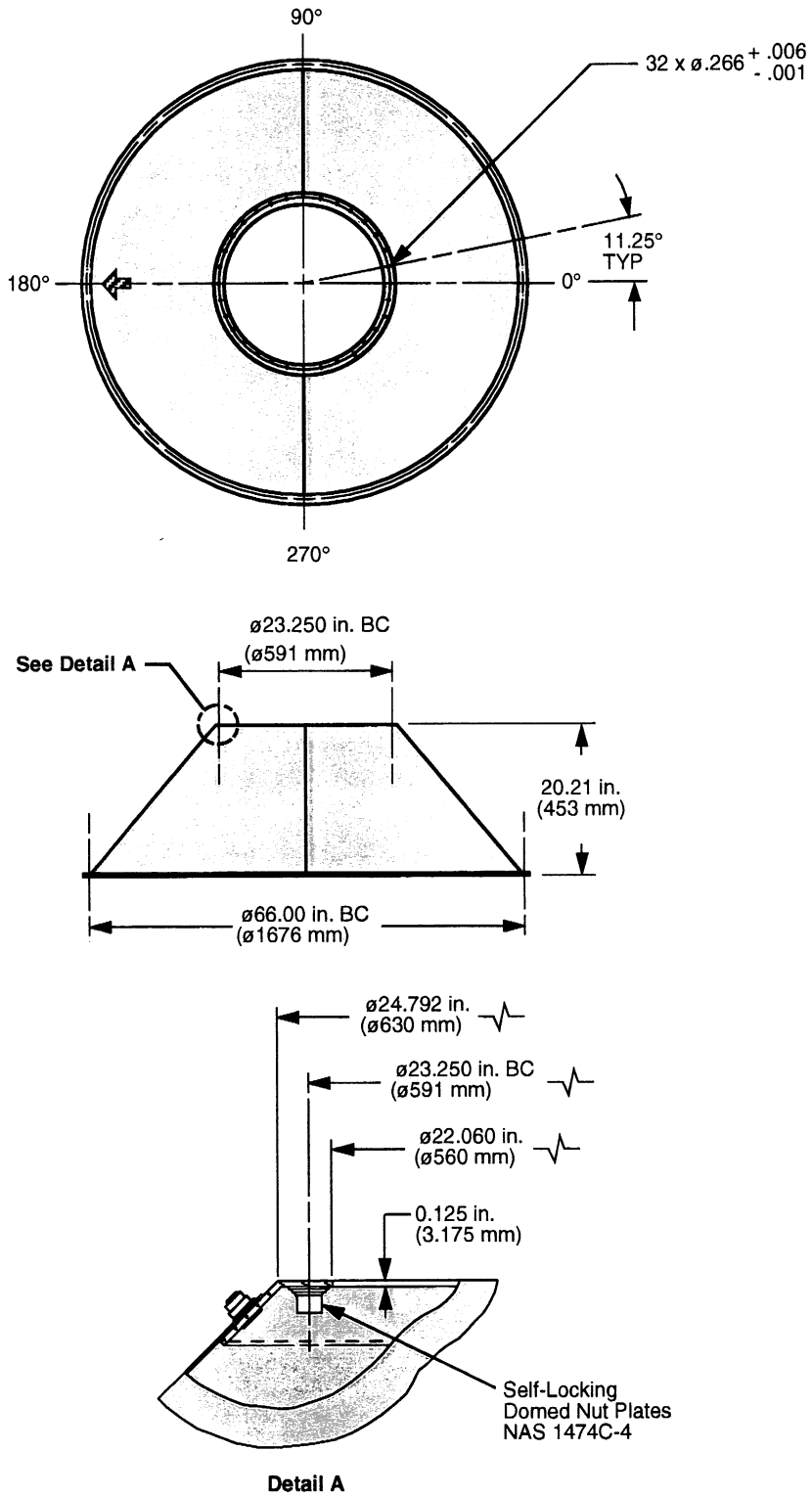
19-in. (483-mm) diameter access door is provided in the contamination shield to service areas inside the payload adapter forward of the contamination shield. The Model 37 payload adapter structure weighs approximately 115 lb (52 kg). The maximum spacecraft radial cg offset is limited to 2 in. (51 mm) from the launch vehicle centerline. The maximum spacecraft axial cg location is limited to 44 in. (1118 mm) forward of the 37.15-in. (944-mm) adapter interface.

Model 38 Payload Adapter—The Model 38 payload adapter, shown in Figure 4.1.2.1-4, is attached to the aft end of the payload fairing and reduces the 92-in. (2337-mm) diameter of the OAM to a 38.81-in. (986-mm) diameter bolt circle. The 38.81-in. (986-mm) diameter bolt circle has 60 equally spaced holes for 0.190-in. (4.83-mm) bolts. The height of the Model 38 payload adapter above the OAM is 27.33 in. (694 mm). A contamination shield is attached to the 38.81-in. (986-mm) diameter face of the payload adapter to seal the encapsulated assembly and to minimize contamination of the controlled environment within the payload fairing after leaving the clean room. One 19-in. (483-mm) diameter access door is provided in the contamination shield to service areas inside the payload adapter forward of the contamination shield. The Model 38 payload adapter structure weighs approximately 103 lb (47 kg). The maximum spacecraft radial cg offset is limited to 2 in. (51 mm) from the launch vehicle centerline. The maximum spacecraft axial cg location is limited to 44 in. (1118-mm) forward of the 38.81-in. (986-mm) payload adapter interface.

Model 47 Payload Adapter—The Model 47 payload adapter, shown in Figure 4.1.2.1-5, is attached to the aft end of the payload fairing, and reduces the 92-in. (2337-mm) diameter of the OAM to a 47.835-in. (1215-mm) interface ring diameter. The 47.835-in. (1215-mm) interface ring is designed to support an industry standard 47.835 in. (1215-mm) clamp band separation system. The height of the Model 47 payload adapter above the OAM is 34.00 in. (864 mm). The additional height of the Model 47 payload adapter can accommodate a typical kick motor nozzle assembly. A contamination shield is attached to the 47.835-in. (1215-mm) diameter face of the payload adapters to seal the encapsulated assembly and to minimize contamination of the controlled environment within the payload fairing after leaving the clean room. One 19-in. (483-mm) diameter access door is provided in the contamination shield to service areas inside the payload adapter forward of the contamination shield. The Model 47 payload adapter structure weighs approximately 113 lb (51 kg). The maximum spacecraft radial cg offset is limited to TBS in. (TBS mm) from the launch vehicle centerline. The maximum spacecraft axial cg location is limited to TBS in. (TBS mm) forward of the 47.835-in. (1215-mm) adapter interface.

Model 66 Payload Adapter—The Model 66 payload adapter, shown in Figure 4.1.2.1-6, is attached to the aft end of the payload fairing, and reduces the 92-in. (2337-mm) diameter of the OAM to a 66.00-in. (1676-mm) diameter bolt circle. The 66.00-in (1676-mm) diameter bolt circle has 120 equally spaced holes for 0.250-in. (6.35-mm) bolts. The height of the Model 66 payload adapter above the OAM is 13.63 in. (346-mm). A contamination shield is attached to the 66-in. (1676-mm) diameter face of the payload adapters to seal the encapsulated assembly and to minimize contamination of the controlled environment within the payload fairing after leaving the clean room. One 19-in. (483-mm) diameter access door is provided in the contamination shield to service areas inside the payload adapter forward of the contamination shield. The Model 66 payload adapter structure weighs approximately 129 lb (63 kg). The maximum spacecraft radial cg offset is limited to TBS in. (TBS mm) from the launch vehicle centerline. The maximum spacecraft axial cg location is limited to TBS in. (TBS mm) forward of the 66.00-in. (1676-mm) adapter interface.

4.1.2.2 Payload-Unique Adapters—Additional payload adapters can be designed to provide users with a variety of mounting options. These options include different diameters and multiple payload configurations to fully employ the launch vehicle's capabilities.



Note: The Model 24 Payload Adapter Bolts to the Model 66 Payload Adapter

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Figure 4.1.2.1-2 Model 24 Payload Adapter

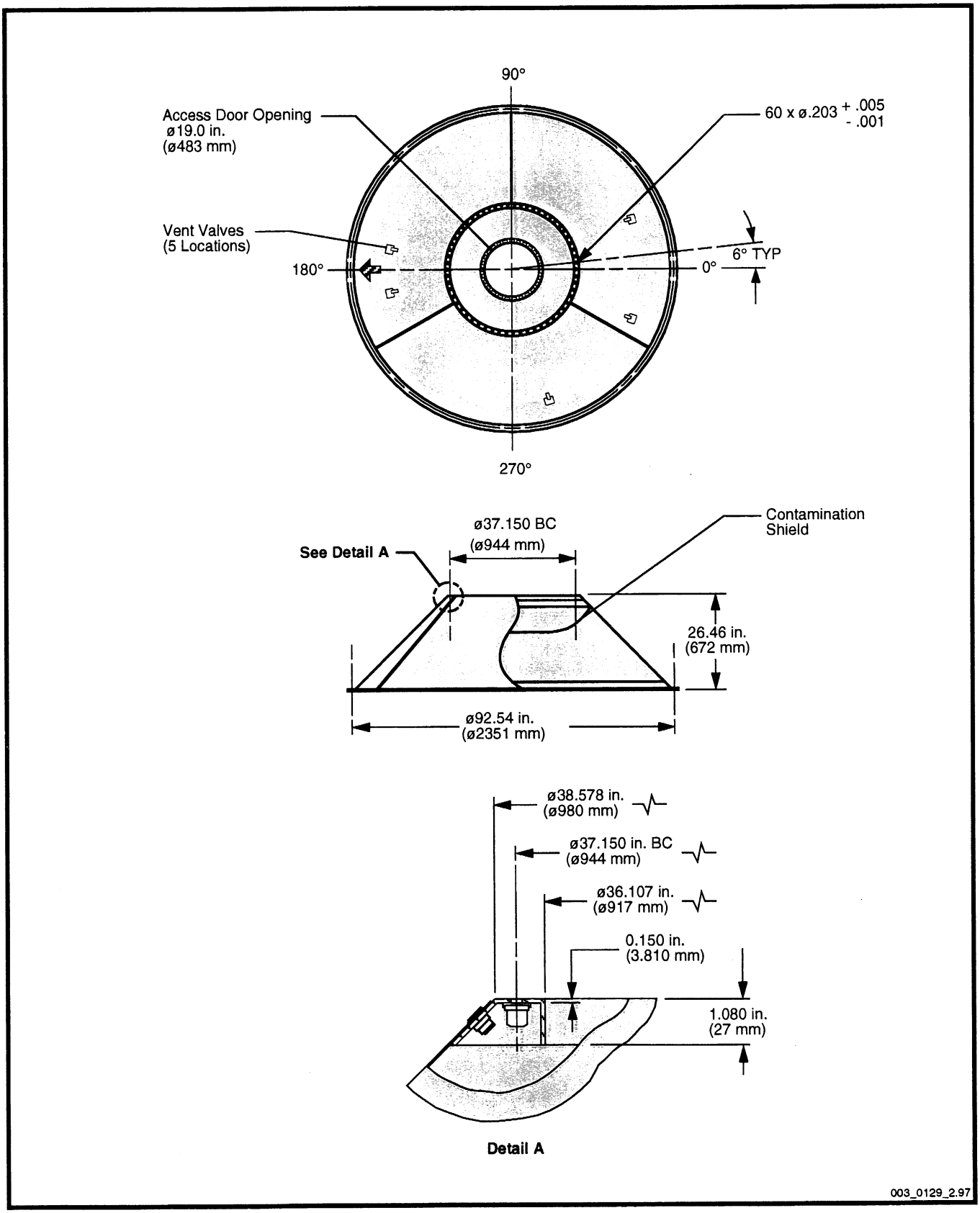

Figure 4.1.2.1-3 Model 37 Payload Adapter

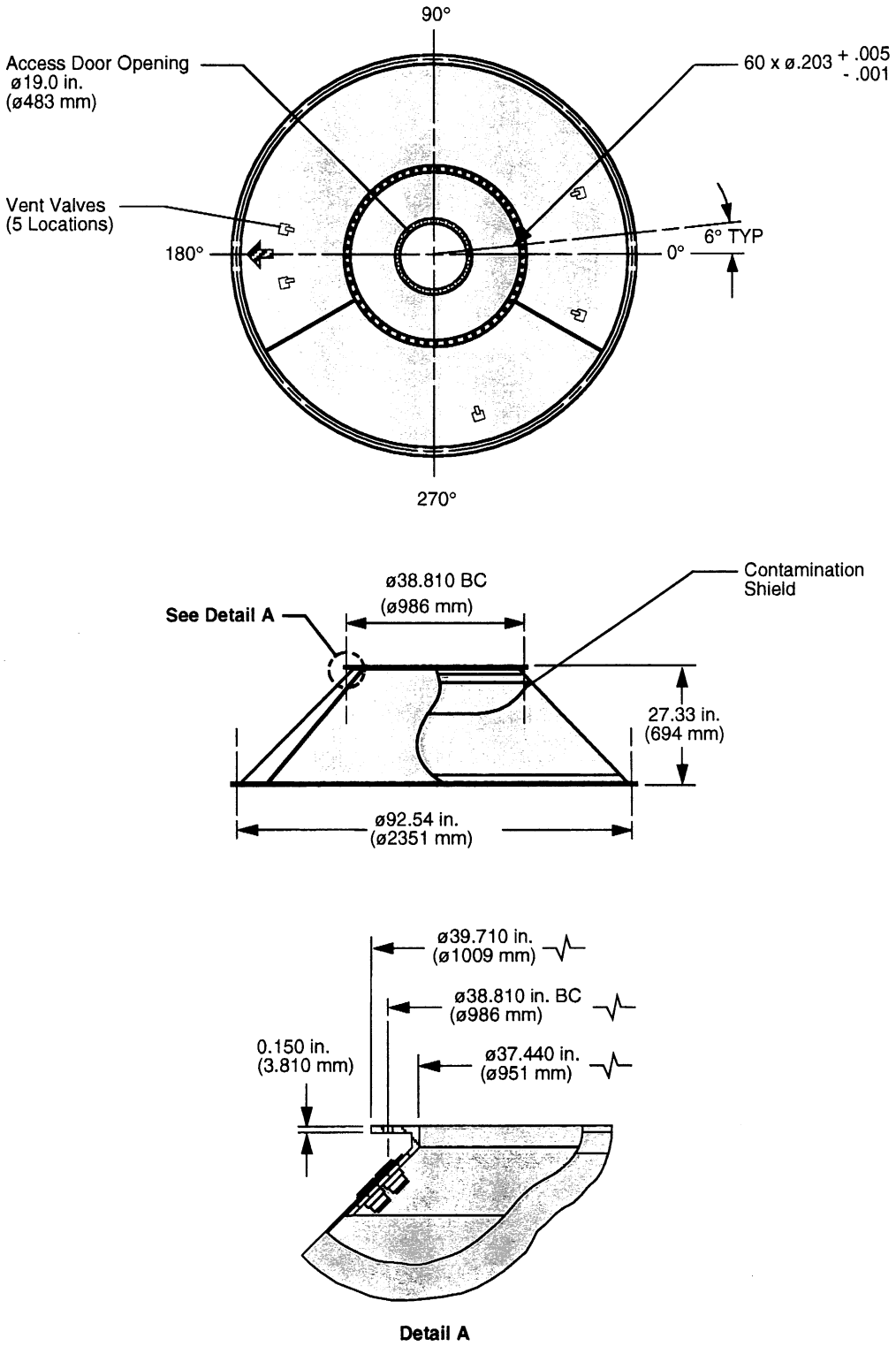

Figure 4.1.2.1-4 Model 38 Payload Adapter

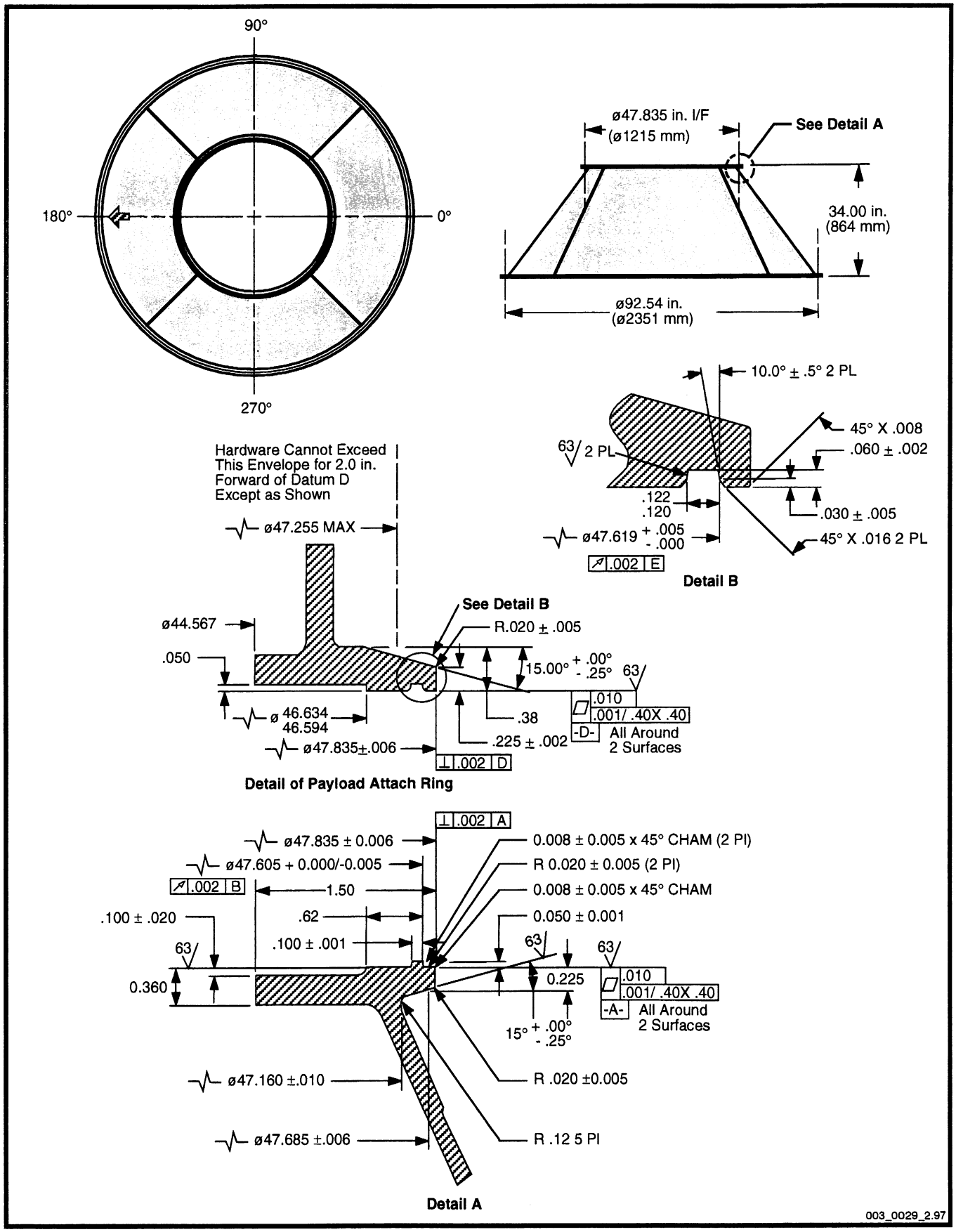

Figure 4.1.2.1-5 Model 47 Payload Adapter

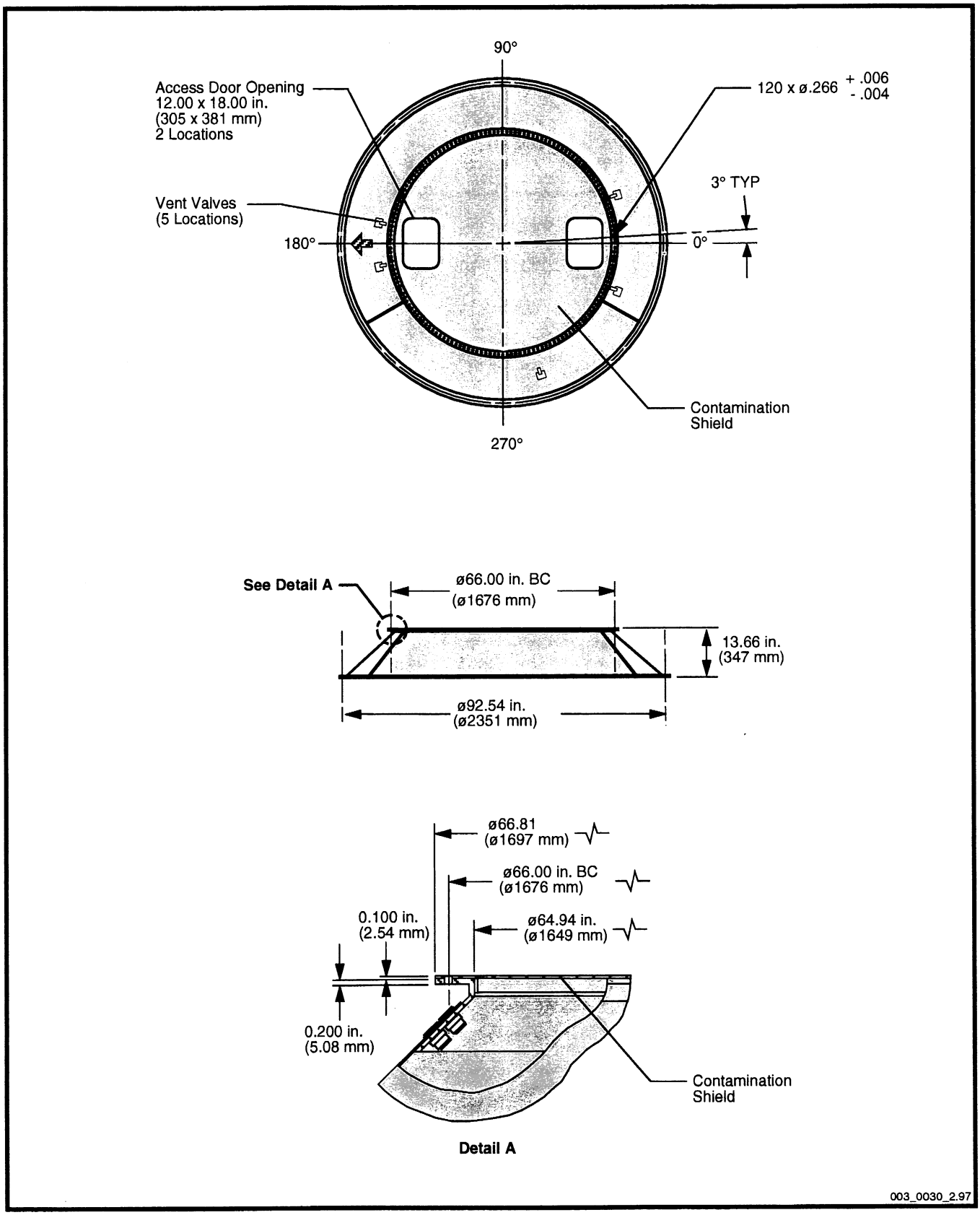

Figure 4.1.2.1-6 Model 66 Payload Adapter

4.1.2.3 Payload Separation Systems—Lockheed Martin offers proven industry standard clampband separation systems for the Model 24, 37, 38, 47 and 66 payload adapters as listed in Table 4.1.2.3-1. The weights of these systems are also shown in the Table although they may vary for a specific mission. The weights shown are for the total separation system and for the portion that remains with the spacecraft.

Lockheed Martin's standard clampband separation systems use flight-proven designs as shown in Figure 4.1.2.3-1. The Model 24 payload adapter and separation system were flown on the Demonstration Launch Vehicle (DLV) on August 15, 1995 and the Model 37 payload adapter and separation system were flown on the LMLV-1 on August 22, 1997. Models 38, 47, and 66 are slated for flight on currently manifested launches.

The clampband separation system consists of upper and lower interface rings and a clampband ring. Figures 4.1.2.3-2 and 4.1.2.3-3 show two examples of LMLV standard clampband separation systems. Each separation system has two rise-up separation connectors and four separation springs. The four separation springs impart a relative separation velocity and tipoff rates. These springs can be tuned to meet specific spacecraft requirements. The upper interface ring is attached to the spacecraft and remains with the spacecraft after separation. The bolt pattern for the upper interface ring, which attaches to the spacecraft, is identical to the bolt pattern of the corresponding payload adapter.

Table 4.1.2.3-1 LMLV Standard Separation Systems

PAYLOAD ADAPTER TYPE	SEPARATION SYSTEM TOTAL WEIGHT	SEPARATION SYSTEM FLY-AWAY WEIGHT*
Model 24	22.4 lb (10.2 kg)	6.9 lb (3.1 kg)
Model 37	21.6 lb (9.80 kg)	5.2 lb (2.4 kg)
Model 38	21.6 lb (9.80 kg)	5.2 lb (2.4 kg)
Model 47	40.8 lb (18.5 kg)	0.0 lb (0.0 kg)
Model 66	40.0 lb (18.1 kg)	15.0 lb (6.80 kg)

Note:
*Portion of Separation System That Stays with the Spacecraft After Separation

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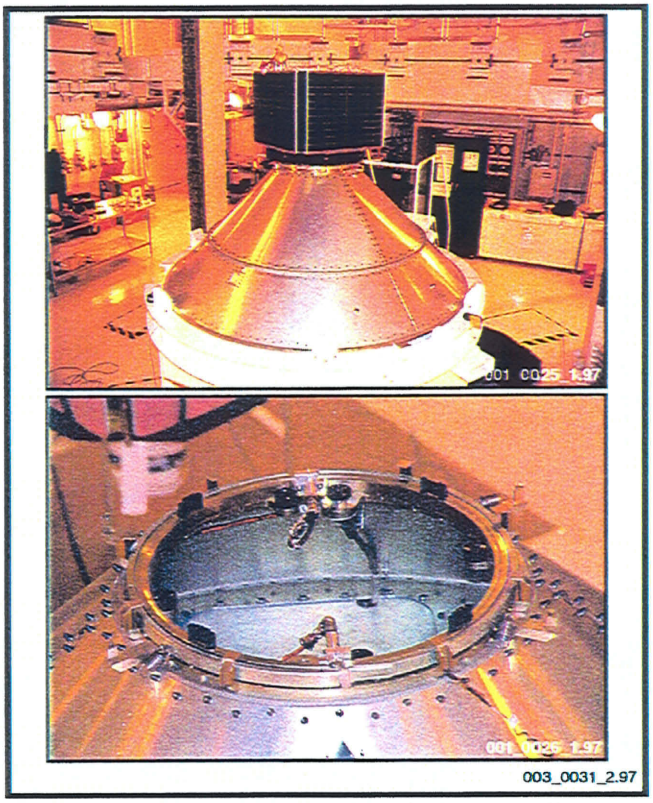

Figure 4.1.2.3-1 Model 24 Payload Adapter and Separation System

Spacecraft customers can choose to use either an LMLV standard separation system or provide their own separation system. Customer provided separation systems must be coordinated with Lockheed Martin during the mission integration process.

4.1.2.4 Payload Adapter and Separation System Structural Capabilities—Figure 4.1.2.4-1 shows the standard structural capabilities of each LMLV standard payload adapter and separation system (if applicable). If the customer requirements exceed the standard capabilities, Lockheed Martin can strengthen the payload adapters or separation systems to meet mission-specific requirements.

Spacecraft mass and center of gravity (cg) capabilities should be used only as a guideline in preliminary design. They are determined using generic spacecraft interface-ring geometry and quasi-static load factors. Actual spacecraft designs allowables may vary depending on interface ring stiffness and results of spacecraft mission-peculiar

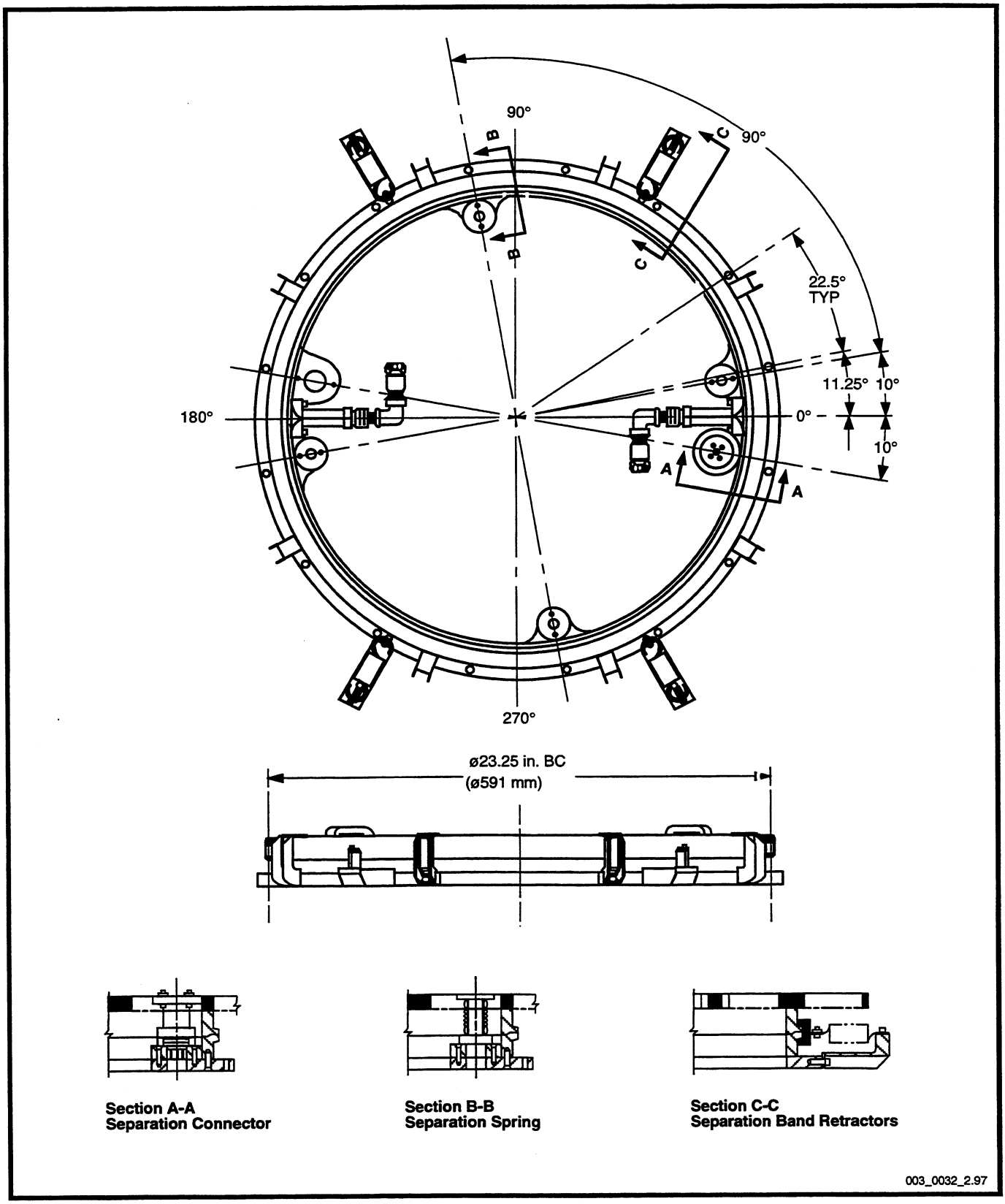

Figure 4.1.2.3-2 Model 24 Separation System

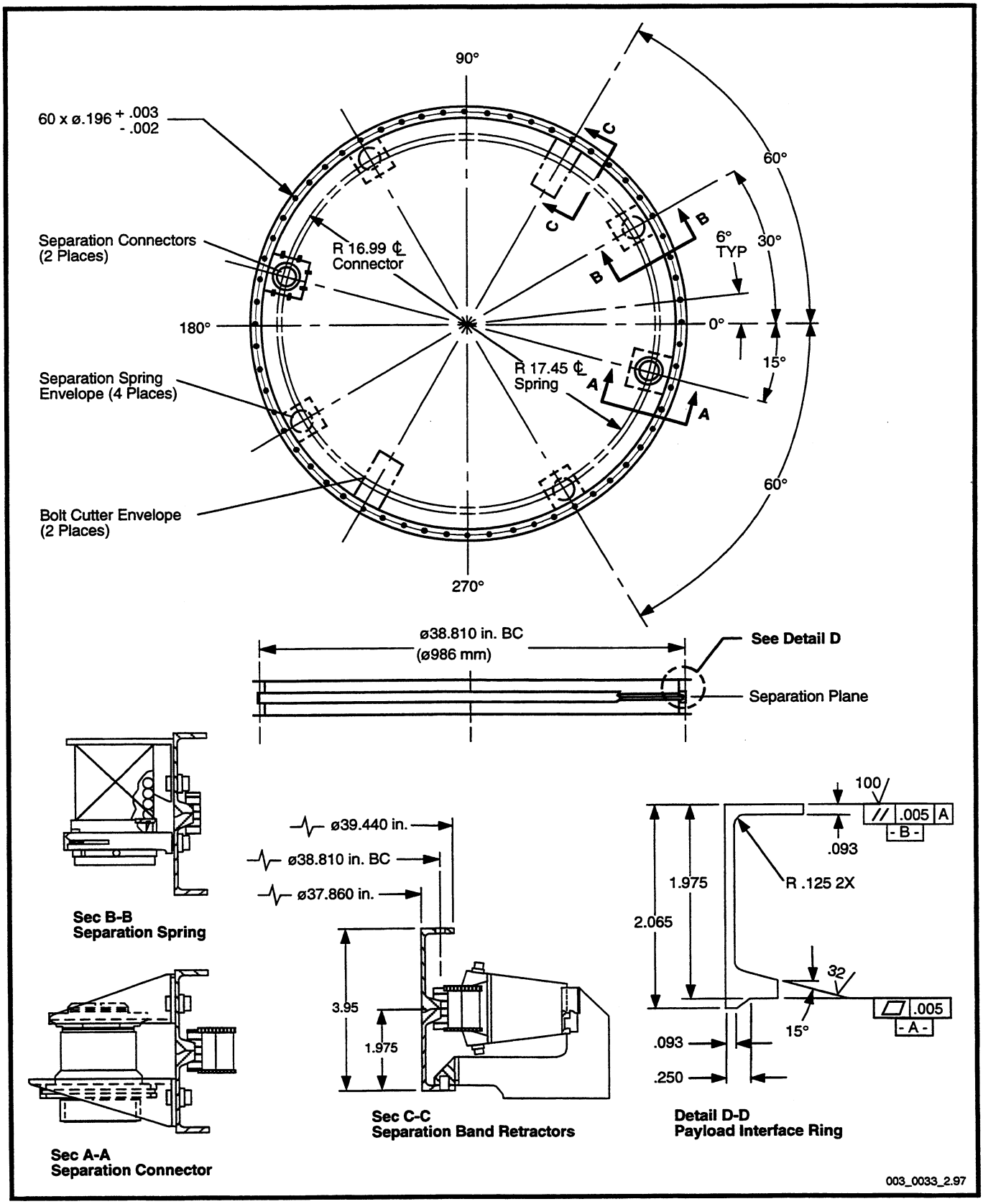

Figure 4.1.2.3-3 Model 38 Separation System

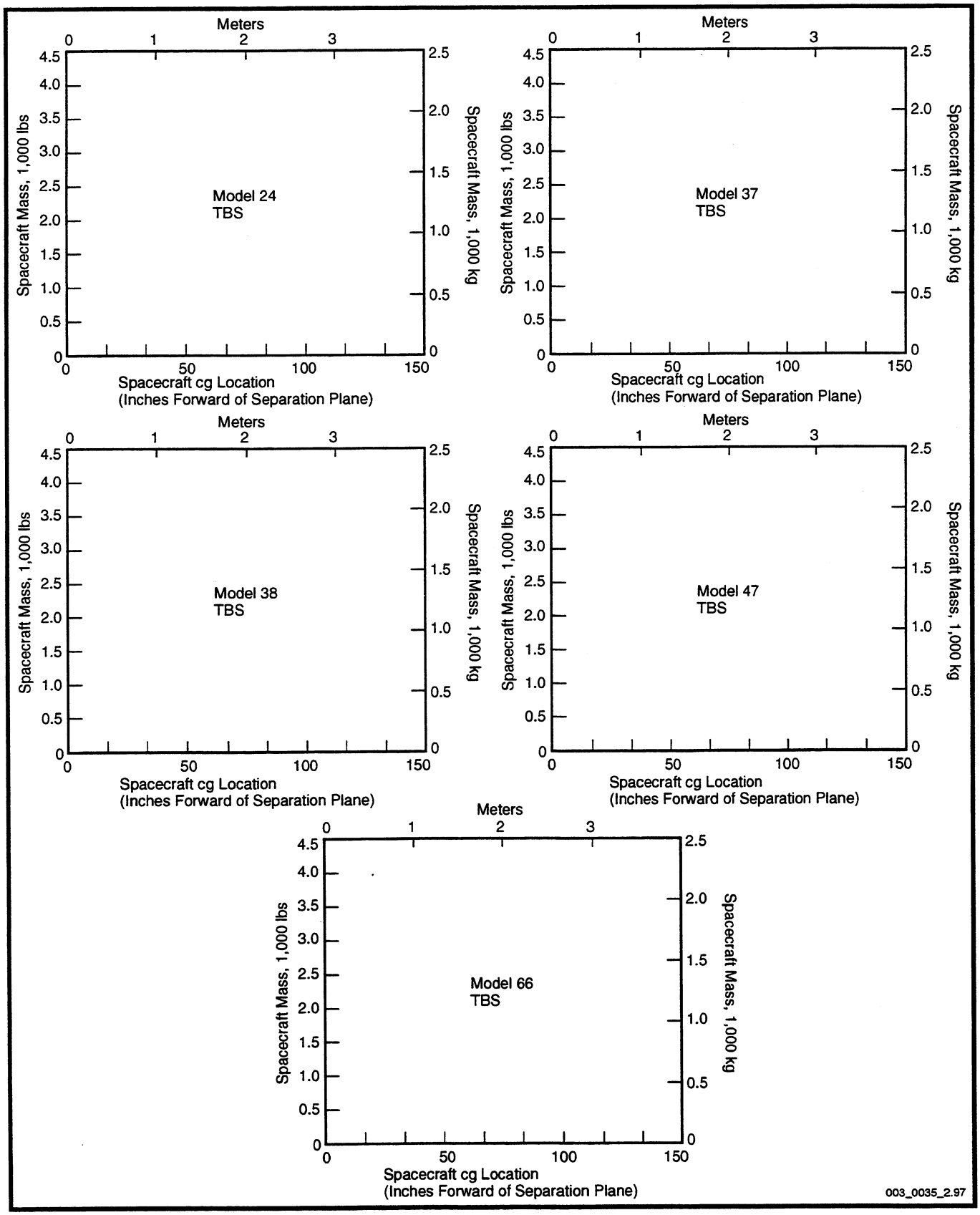

Figure 4.1.2.4-1 Payload Adapter/Separation System Structural Capabilities

coupled loads analyses. Please contact Lockheed Martin for further discussion regarding spacecraft designs that exceed these generic allowables.

4.1.3 ELECTRICAL INTERFACES

Lockheed Martin provides the LMLV customer with a flexible electrical interface structure. Figure 4.1.3-1 shows the LMLV standard electrical interfaces between the spacecraft and the launch vehicle. Mission-unique cables that connect the spacecraft to the launch vehicle are provided by Lockheed Martin. The data link between the spacecraft and the launch vehicle umbilical is used for prelaunch spacecraft test; checkout, command, and monitoring; and spacecraft health and status. The data link between the spacecraft and the interlocks package is used for prelaunch and in-flight spacecraft discrete commands and monitors and separation indication. The data link between the spacecraft and the telemetry system is also used for prelaunch and in-flight spacecraft health and status (analog originated data).

4.1.3.1 Umbilical Interfaces—The launch vehicle umbilical connector, a rise-off disconnect, is released from the ground umbilical at ignition by a lanyard and separates via launch forces during lift-off. Before ignition, it is the single hardline conduit that provides the electrical interface between the spacecraft and the Launch Vehicle Checkout Van (LVCV). Descriptions of the umbilical-to-LVCV landline configurations are provided in Section 4.2. Payload-related wiring is routed in three cables on the payload side of the umbilical; one cable carries payload-related wiring to the interlocks package, one carries payload-related wiring to the telemetry unit, and one is routed directly to the payload separation connectors.

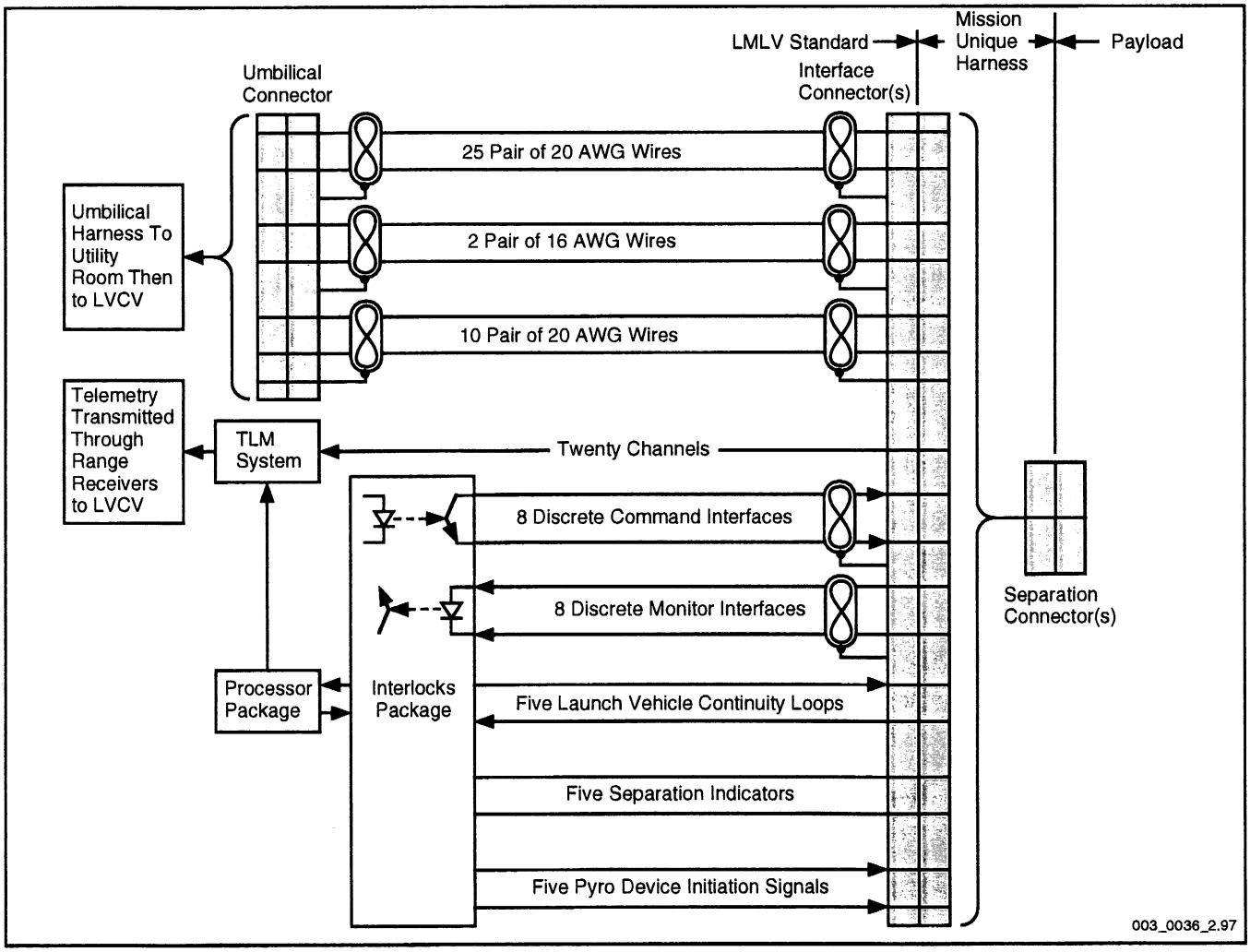

Figure 4.1.3-1 LMLV Standard Electrical Interfaces

For prelaunch power and battery charging, there are two pairs of 16 AWG wires that connect the spacecraft to the spacecraft electrical ground support equipment (EGSE) located in the utility room. Use of both pairs of 16 AWG wires provides minimal power loss in supplying external power to support pre-launch checkout, battery maintenance and charging, or other high current load needs. These wires meet a 2-ohm maximum resistance specification.

For prelaunch command and telemetry, there are 25 twisted pairs of 20 AWG wire and 10 shielded twisted pairs of 20 AWG wire that provide the data link between the spacecraft and the spacecraft EGSE. These wires meet a 10-ohm maximum resistance specification.

4.1.3.2 Command and Control Interfaces—The LMLV interlocks package provides the capability to issue in-flight commands to the payload and monitor signals generated in the spacecraft. The spacecraft designer is invited to use this capability by arranging to program time- or event-related commands to be transferred to the spacecraft and to condition spacecraft signals to feed time- or event-related information into the interlocks over the span of the spacecraft's flight into orbit, within the limits listed here. All interlocks package interfaces are monitored at 4-millisecond (ms) intervals and the status is available from the pre- and postlaunch vehicle telemetry signals. The following is a listing of the interlock package capabilities:

1) Eight discrete command interfaces are made available via optically coupled isolators serially controlled at 12-ms intervals and programmable for a 2- to 510-ms duration with a maximum current of 20 milliamps at a voltage of 24 to 34 Vdc;
2) Eight discrete monitor interfaces are made available via optically isolated circuits polled at 4-ms intervals;
3) Five continuity loops are available to monitor binary events such as on-off switches on board the spacecraft;
4) Breakwire loops are available to run through up to five separation connectors to provide near-realtime indication of spacecraft separation. Each loop provides a positive and return. The electrical bonding resistance between the spacecraft structure and the LMLV equipment section is less than 2.5 milliohms.

4.1.3.3 Telemetry Interfaces—Twenty telemetry channels are available for spacecraft use through a remote encoder. Sample rates are programmable with the launch vehicle capable of providing a maximum of 20 channels of spacecraft data, with a maximum 2048 sample/second data rate for any one channel up to a total maximum of 3076 samples/second for the telemetry system. The S-band multiplexed telemetry capability provides both analog and digital spacecraft signal transmission. Telemetry bandwidth allocations are established on a mission-by-mission basis. The spacecraft designer is invited to arrange for use of this capability within the sampling and bandwidth constraints specified.

4.1.3.4 Spacecraft Separation Signals—The LMLV is capable of providing up to five pairs of electro-explosive device (EED) initiation signals for spacecraft events. Each signal has a duration of 2 to 510 ms and a maximum current of 5 to 10 amps at a voltage of 24 to 34 Vdc for one or a pair of 1-ohm EED bridgewires connected in parallel.

4.1.3.5 Spacecraft Separation Connectors—Each of the standard separation systems provided by Lockheed Martin contain two separation connectors. Three standard connectors are available to choose from as shown in Table 4.1.3.5-1. Selected for their high reliability, these connectors separate cleanly at the separation plane. Alternative connectors can also be specified, however stringent qualification is required. The spacecraft contractor may elect to supply any such qualified separation connector for incorporation into the launch vehicle. Services available to coordinate connector selection and interface design are described in Section 8.0. The pin-out for the connector is established in the mission-peculiar ICD.

Table 4.1.3.5-1 LMLV Standard Electrical Connectors

PART NUMBER	INSERT ARRANGEMENT	TYPE OF CONTACT
GM 104615-0	25-4, 8 ea AWG 16, 48 ea AWG 20	Pins
GM 104614-1	25-35, 128 ea AWG 22D	Pins
GM 104615-2	25-61, 61 ea AWG 20	Pins
GM 104615-5	25-61, 61 ea AWG 20	Sockets
GM 105615-6	25-4, 8 ea AWG 16, 48 ea AWG 20	Sockets
GM 104615-1	25-35, 128 ea AWG 22D	Sockets

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4.1.3.6 Spacecraft Destruct Option—A flight termination signal, if required, can be supplied to the spacecraft from the Flight Termination System. Flight termination conditions are discussed in Section 8.0.

4.2 SPACECRAFT-TO-GROUND INTERFACES

4.2.1 Ground Support Equipment Interfaces

Lockheed Martin provides all ground support equipment (GSE), both mechanical (MGSE) and electrical (EGSE), required to support launch vehicle processing and launch. The spacecraft contractor is responsible for providing all GSE required to support spacecraft processing and integration.

4.2.2 Utility Room Interfaces

The utility room, shown in Figure 4.2.2-1, is the interface between the LMLV, the LVCV, and the Launch Operation Control Center (LOCC) at the Western Range or to Hangar AE and the Range Operations Control Center (ROCC) at the Eastern Range. The utility room is located underneath the launch mount and houses the Signal Conditioning Set (SCS) and the fiber-optic electronics to interface with the LVCV. The SCS is a two-bay rack containing equipment designed to condition the signals received from the LMLV via the umbilical for transmission to the LVCV and display on the consoles. The SCS contains a computer that performs preprogrammed sequences of operations when instructed by the van console operator. This implements a "distributed processing" system that allows some autonomous control for emergency shutdown of launch or checkout operations in the event of failure of communications with the LVCV. The SCS also houses the electronics for the payload interfaces to the LVCV

Space and facility power are provided in the utility room for customer-furnished equipment (CFE) which may interface with the payload using the umbilical hardwire links. The location of the utility room provides convenience for other attended activities up to T-4 hours. Spacecraft batteries may be charged remotely via hardwire interfaces from the utility room rather than having to use drag-on cables connected through an access panel. Utility room payload CFE can be locally controlled during nonhazardous prelaunch operations. Remote control from the LVCV payload station is also possible via the SCS using the fiber-optic fibers and connections.

The utility room has the following launch site dependent physical characteristics:

WR

- Mechanical:
  - — Door size
    5 feet x 6.5 feet high (1.5 m x 2.0 m)
  - — Usable floor space for SV GSE
    35 square feet (3.3 square meters)
- Electrical:
  - — Three circuits 120 V, 20 amp, single phase
  - — Two circuits 208 V, 30 amp, three-phase, backed up by UPS rated for 30 minutes

ER

- LC-46 Utility Room (below grade)
- LC-46 Utility Room (below grade)
  - — Door size
    3 feet x 7 feet high (0.9 m x 2.1 m)
  - — Usable floor space for SV GSE35 square feet (3.3 square meters)
- Electrical:
  - — TBD

4.2.3 Launch Vehicle Checkout Van Interfaces

The mobile LVCV is the control center for launch operations, including prelaunch testing and launch countdown. Figure 4.2.3-1 shows the layout of the LVCV. The LVCV has four operating

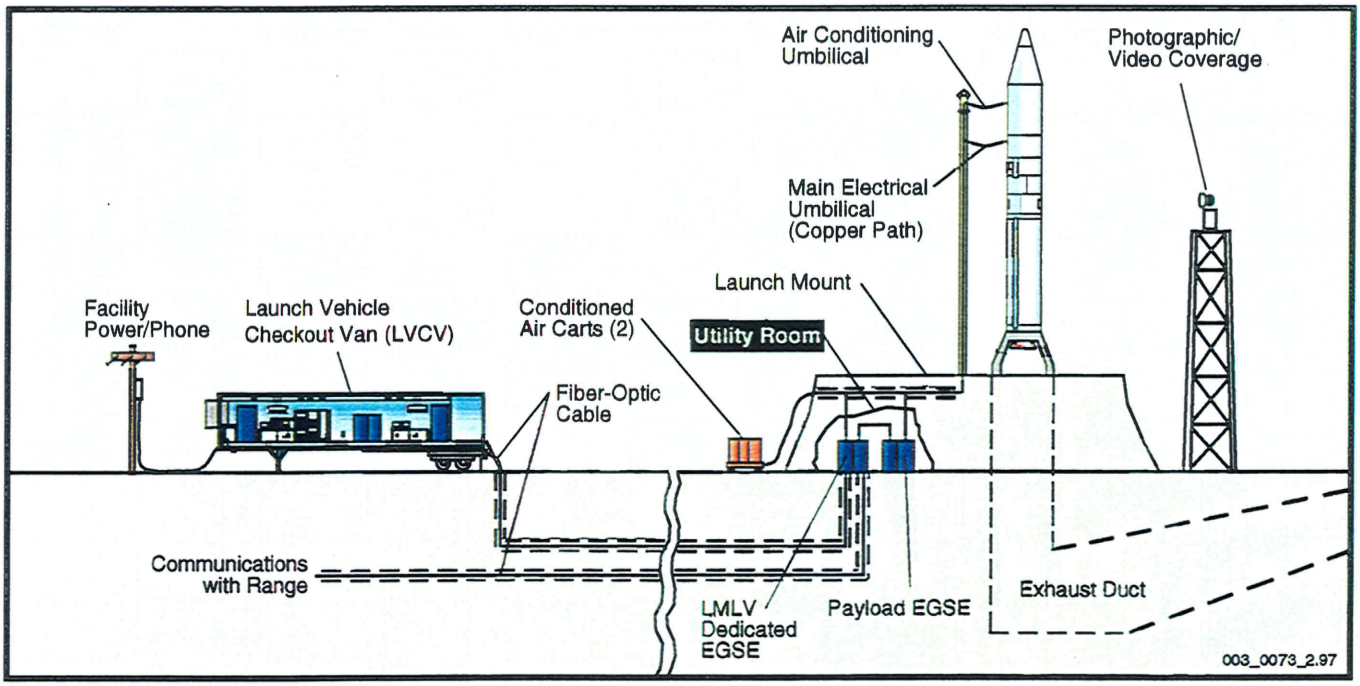


Figure 4.2.2-1 LMLV Launch Site Utility Room Interfaces

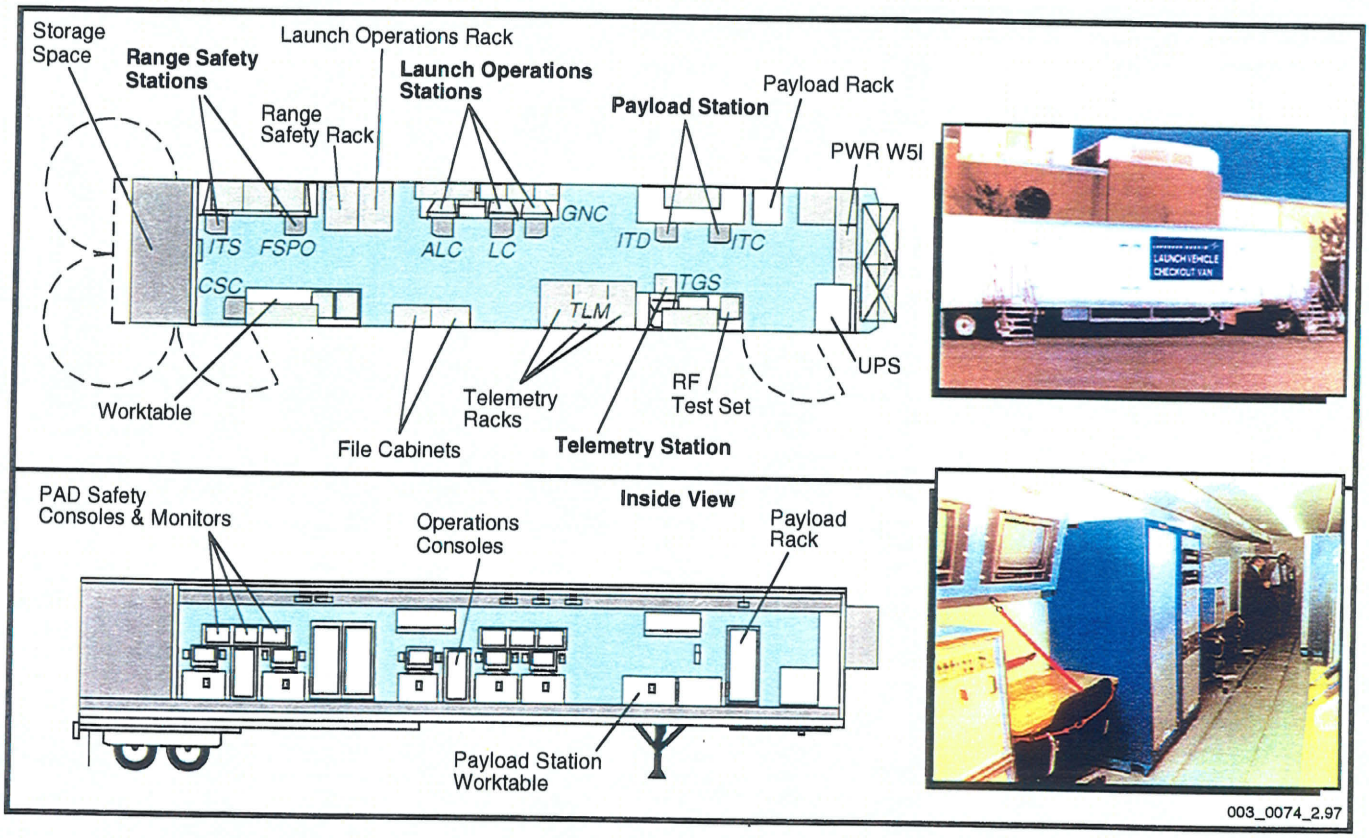


Figure 4.2.3-1 The Launch Vehicle Checkout Van (LVCV) serves as the center of the LMLV launch operations.

stations: payload, telemetry, launch operations, and range safety. Each operating station contains an equipment rack, console, and monitors. For prelaunch test and checkout and launch, the LVCV is positioned near Building 596 at the Western Range and near Hangar K at the Eastern Range. A fiber-optic network links the LVCV to the utility room, and to the LOCC at the Western Range or to Hangar AE and the ROCC at the Eastern Range.

4.2.3.1 Payload Station—The payload station, manned by the payload technical director (PTD) and the payload technical advisor (PTA), monitor and control the spacecraft. The payload station has space for one equipment rack for customer-supplied EGSE.

The payload station work area is equipped with power, shelving, and a desktop area for customer use. It is located next to the signal entry panel and is conveniently close to one of the two equipment loading doors. Rack-mounted hardware brought in by the payload customer can be loaded into a 61-in. (1550-mm) high x 19-in. (480-mm) wide industry standard Electrical Industry Association (EIA) rack equipped with its own uninterruptable 120-volt AC, 60-Hz, 15-ampere power source. This rack may be removed if the customer prefers to put other equipment in this space, in which case the customer's equipment can be mounted to the payload rack slide mounting plate. Also provided is a 30-in. (760-mm) deep by 80-in. (2030-mm) long worktable that is designed to accommodate two seated payload operators.

All landline links to the pad are via fiber optic link between the CFE in the utility room and CFE in the LVCV operations station. The CFE interfaces in the LVCV are made available through the fiber-optics equipment and Ethernet bridge located in the operations station console. CFE and discrete payload fiber-optic channels out of these fiber-optics modules are available at BNC-type connectors to be linked using BNC-type coaxial cables. Payload-related links are then cabled to the payload station, as appropriate.

4.2.3.2 Telemetry Station—The telemetry stations, manned by the telemetry systems observer (TSO) and guidance system observer (GSO), receive raw telemetry data from the launch vehicle and spacecraft through the umbilical or from range receivers, and archive the data to 8-mm tape. This system is used to monitor prelaunch data to determine a go/no-go status and to report that status to the launch operations stations for display and recording. The TSO can play back the archived data and distribute the data to other consoles for analysis or simulation.

Telemetry data from the payload is routed to the payload station from the telemetry ground station, which receives raw LMLV telemetry Pulse Code Modulated (PCM) data via the LLV umbilical and range receivers before launch and from the receivers thereafter. There are two streams of telemetry data—a "digital link" and an "analog link." After processing at the telemetry ground station, the data is distributed as needed to the other consoles and also is archived in digital format on 8-mm tapes. The maximum recording time provided by this service is 1.5 hours (at a standard 1.4 mega bits/second over two channels). To complement the 8-mm tapes, the telemetry ground station has one analog tape recorder to record the raw PCM telemetry data streams and IRIG time codes. This recorder has a maximum available recording time of 15 minutes (at the same bit rate). Bit-synchronized data are available via both analog and digital links for decommutation and use by the payload customer.

The PC architecture of the telemetry ground station controller allows access to telemetry data not routinely displayed on the van consoles. This decom system can be used to monitor the data, determine the go/no-go status, and report the status to the operations console for display and recording.

4.2.3.3 Launch Operations Station—The LMLV launch director controls the testing and launching of the LMLV from the operations station two-person console. The interface CFE for fiber optic connection of the LVCV to the utility room is located at this station. Signals are converted as required and distributed via cabling to the other stations. Go/no-go status is displayed on the CRT

screen while running test events from here. LMLV systems data are recorded on a (capacity) hard disk for retrieval upon completion of a test. The data may be reviewed on the console monitors and/or printed. The data handled at this station can be made available for use at the payload station.

4.2.3.4 Range Safety Station—The Pad Safety Station, manned by the flight safety project officer (FSPO), the flight termination system observer (FTSO), and the complex safety officer (CSO), provides vehicle and launch equipment status during checkout and launch operations. The flight safety officer is stationed here and has the means to manually inhibit a launch. During flight the status of the flight termination system is continuously displayed, before flight the console can also display any safety-critical information that is processed by the checkout equipment. LMLV safety information is derived from telemetry data and from discrete umbilical monitor signals via the signal conditioning set. The CRT screen can display up to 90 functions and is updated every second.

Area surveillance monitors are used by pad safety personnel in the LVCV to observe the pad area during hazardous operations and launch. Several remote-controlled color video cameras are strategically located at the pad to provide a view of the launch area. Each camera can be independently controlled from the pad safety console for pan, tilt, and zoom.

4.2.3.5 LVCV Equipment—Other LVCV-supplied equipment of potential use and interest to payload station personnel includes:

1) Status and alert panels;
2) Area warning system;
3) Public address system;
4) Range-synchronized IRIG-B time base generator;
5) Range interface to the van countdown clock;
6) Surge protectors for all hardwire signals;
7) Two 4-ton air conditioning units and 15-kW heating units and humidity control;
8) 120/208 volts AC, 60-Hz electrical system rates at 100 amperes, and uninterruptable (capacity) AC power supply;
9) Dual smoke alarms;
10) Erectable 3-in. (762-mm) diameter, 21-ft (6.4-m) long antenna mast locatable in any of six locations;
11) Overhead 42-in. (1070-mm) wide storage cabinets, a 64-in. (1630-mm) high by 30-in. (760-mm) wide by 18-in. (460-mm) deep bookcase, two 5-drawer file cabinets, storage drawers, and a tape storage cabinet;
12) Two side access doors, 41 in. (1040 mm) wide by 78 in. (1980 mm) high;
13) Two undervan 8x9x6-ft (2.4x2.7x1.80-m) storage compartments;
14) Erectable 25-ft (7.6-meters) high air terminal to provide cone of protection;
15) Standard semitrailer spring and shock absorber suspension at the rear axle with solid-post jacks supporting the tractor end of the trailer (directly under the payload station).

4.3 RANGE AND SYSTEM SAFETY INTERFACES

4.3.1 Requirements

To launch from either Cape Canaveral Air Station (CCAS) or Vandenberg Air Force Base (VAFB), launch vehicle design, spacecraft design and ground operations must be according to applicable launch site Range Safety requirements and U.S. Air Force regulations concerning explosives safety and occupational safety and health.

In addition, when using spacecraft processing facilities operated by Astrotech International Corporation, the National Aeronautics and Space Administration (NASA), or the U.S. Air Force, compliance with their respective facility safety policies is also required.

Over the years, the CCAS and VAFB Range Safety organizations have regularly modified their safety requirements documents. A single safety document for both CCAS and VAFB (Eastern/Western Range Regulation [EWR] 127-1) was released 31 March 1995. Earlier versions of this Range Safety document could still apply to a given

spacecraft or mission depending on when the spacecraft was designed and built and which range is used. These earlier versions include the following:

1) Eastern Range;
   a) Eastern Range Regulation (ERR) 127-1, June 1993;
   b) Eastern Space and Missile Center Regulation (ESMCR) 127-1, July 1984.
2) Western Range;
   a) Western Range Regulation (WRR) 127-1, June 1993;
   b) Western Space and Missile Center Regulation (WSMCR) 127-1, 15 December 1989;
   c) WSMCR 127-1, 15 May 1985.

Other compliance documents are agreed upon with the Range, Lockheed Martin, and the spacecraft contractor at the outset of the mission integration process. Other documents that can apply to the launch site safety interface are as follows:

1) ESMCR 160-1, Radiation Protection Program;
2) Air Force Regulation (AFR) 127-100, Explosives Safety Standard;
3) AFR 127-12, Air Force Occupational Safety, Fire Prevention, and Health Program;
4) MIL-STD 1522A, Standard General Requirements for Safe Design and Operation of Pressurized Missile and Space Systems;
5) MIL-STD 1576, Electroexplosive Subsystem Safety Requirements and Test Methods for Space Systems;
6) LMLV Launch Site Safety Manual.

At the start of mission integration (or soon after), the applicable range safety documents will be tailored with the range to the spacecraft. Tailoring defines the safety criteria specifically interpreted for application to the spacecraft.

4.3.2 Applicability

A major component of the launch site range safety regulations (e.g., EWR 127-1) concerns spacecraft design and operational requirements that must be met to obtain range safety approval. For all spacecraft and missions, compliance with the EWR 127-1 regulations will be specifically reviewed in safety submittals.

Lockheed Martin System Safety engineers will evaluate, analyze, and provide guidance for spacecraft design to support range safety approval. Lockheed Martin will develop a specific set of design and operational requirements that define spacecraft-peculiar range safety and spacecraft processing requirements. Should areas of noncompliance be determined, Lockheed Martin can evaluate the situation and provide advice on resolving the specific noncompliance while still meeting the intent of the safety requirement. For commercial programs, Lockheed Martin will act as the spacecraft agent for all interface activities with the launch site range safety office.

4.3.3 Safety

The typical process used by the LMLV program to safety certify spacecraft at the range is illustrated in Figure 4.3.3-1. The figure illustrates the documents or tasks required of the spacecraft contractor. For all mission integration efforts, Lockheed Martin will provide a qualified system safety engineer to help the spacecraft contractor through the range approval process. All requests for range approval will be submitted by the LMLV program regardless of whether they are based on spacecraft or launch vehicle data. Approval to fly on the range is based on documentation of the spacecraft design that proves the design meets the intent of the applied range safety requirements document. The safety interface and approval process is summarized in the following paragraphs describing the various safety submittals or tasks.

Mission Orientation—Lockheed Martin and the spacecraft contractor will introduce a new system or mission to the range in a mission orientation meeting sometimes also known as a Program Introduction, at the range soon after contract award. The mission orientation meeting identifies any peculiar design or operational issues so they can be resolved early in the integration phase of the mission. The mission orientation also provides the opportunity to determine which Range Safety requirements

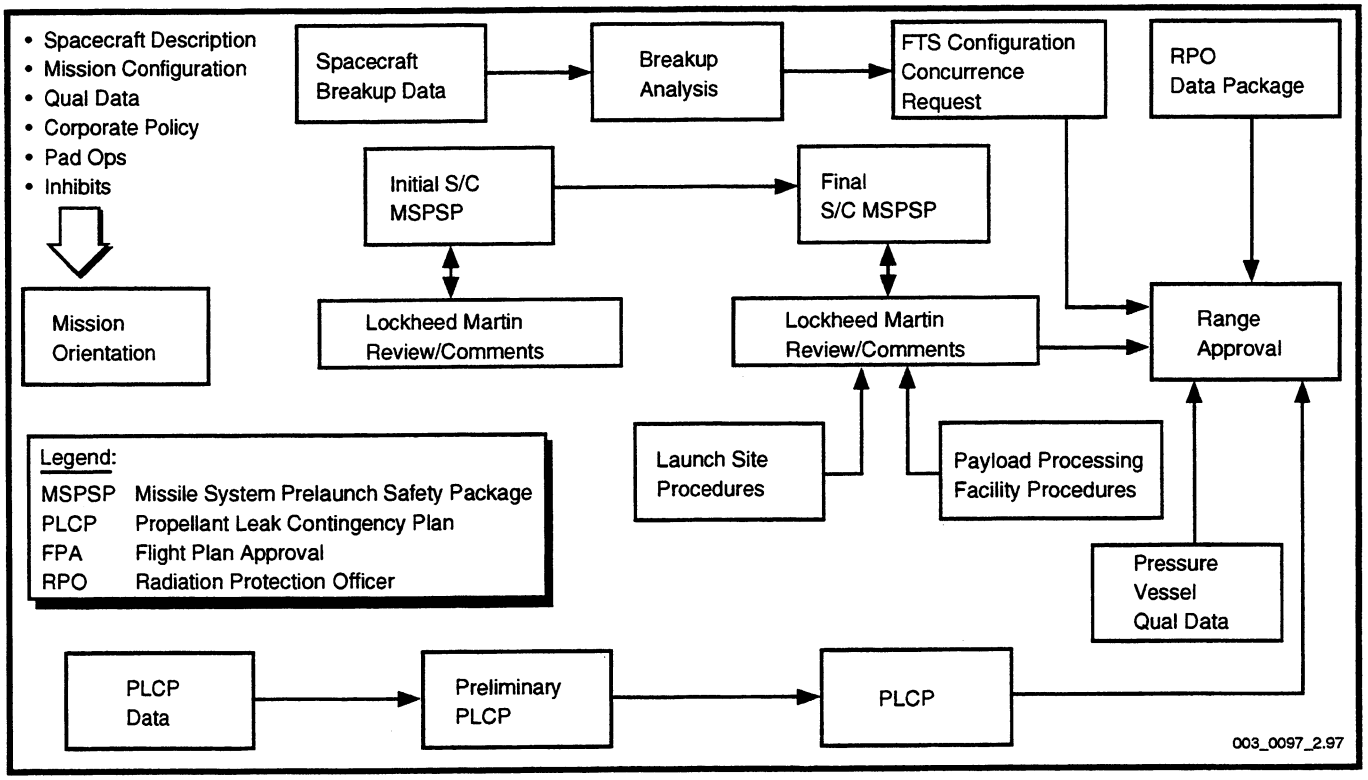


Figure 4.3.3-1 System and Range Safety Interfaces and Requirements

will be imposed on spacecraft design and operations.

LMLV and spacecraft personnel jointly develop a contingency, emergency fuel offload procedure for Range Safety approval. LMLV technicians perform the offload if it becomes necessary.

Spacecraft Missile System Prelaunch Safety Package—The spacecraft contractor develops the initial spacecraft Missile System Prelaunch Safety Package (MSPSP) to describe the spacecraft; the hazards associated with the spacecraft (e.g., pressure systems, ordnance control systems, toxic hazards, access requirements, processing hazards, etc); and the means by which each hazard is eliminated or controlled to an acceptable level. Range Safety regulations (EWR 127-1) provide details on the format and contents of the MSPSP.

The initial MSPSP is typically submitted to Lockheed Martin about 14 months before initial launch capability (ILC). The LMLV program will review the document and forward it with comments to the range for review and comment. The LMLV program will pass along comments to the spacecraft contractor for incorporation into the final spacecraft MSPSP to be submitted to the LMLV program approximately 5 months before ILC.

Mission-Unique MSPSP—Lockheed Martin will combine the data in the spacecraft MSPSP with data from the LMLV booster MSPSP and the ICD to perform and document a safety analysis and assessment across the booster-spacecraft interface. Results will be delivered to the range as the formal mission-specific MSPSP, both in preliminary and final documents.

Range Safety Data Package—Lockheed Martin will develop a preliminary range safety data package that provides the basic spacecraft configuration, the preliminary flight profile, and the time of launch. Lockheed Martin will forward this package to the range for comment, together with a preliminary flight plan approval request about 12 months before launch. About 60 days before ILC, the LMLV program will provide the final range safety data package to the range with a request for a final flight plan approval (FPA). Final FPA is usually received from the range about 30 days before ILC.

Spacecraft Breakup Data—The spacecraft contractor will provide spacecraft breakup data to Lockheed Martin for the range safety data package. Lockheed Martin will use this breakup data to perform a breakup analysis of the spacecraft in expected mission conditions.

Flight Termination System Configuration Concurrence—Based on the breakup analysis, the LMLV program will submit a flight termination system (FTS) configuration concurrence request to the Range. The purpose of this concurrence request is to obtain an agreement with the Range as to the requirement for a spacecraft destruct capability. With most spacecrafts, Lockheed Martin usually pursues FTS concurrence without a spacecraft FTS destruct system, as there is no appreciable additional public safety hazard.

Pressure Vessel Qualification Data—The spacecraft contractor will provide pressure vessel qualification data to the Range, through the LMLV program, to the Range for review and acceptance.

Radiation Protection Officer Data—The spacecraft contractor will submit data on the type and intensity of RF radiation that the spacecraft will transmit during ground tests, processing, and launch at the range. Lockheed Martin will forward these data to the radiation protection officer (RPO) for review and approval of the RF-related operations to be performed at the launch site.

Spacecraft Processing Procedures—The spacecraft contractor will provide all onsite processing procedures to the operator of the payload processing facility (e.g., Astrotech) through the LMLV program for review and approval. The procedures must comply with the processing facility safety policy. the spacecraft contractor will also provide all other launch site operating procedures through the LMLV program to the Range for review and approval.

5.0 SPACECRAFT AND LAUNCH FACILITIES—EASTERN RANGE

LMLV launch services at the Eastern Range (ER) are conducted from Launch Complex-46 (LC-46). Spaceport Florida Authority (SFA), a nonprofit organization established by the State of Florida to enhance commercial launch business, offers LC-46 for launch activities under an agreement with the U.S. Navy. LMLV has worked closely with SFA to adapt LC-46 for the LMLV. The complete range of ancillary facilities required for a launch campaign are also available on the adjacent Cape Canaveral Air Station (CCAS) Industrial Area or elsewhere nearby, and are described in this section. Figure 5-1 shows the locations of the ER, LC-46, and the principal facilities used by LMLV for payload and launch vehicle processing.

LC-46 is located at 28 degrees 28 minutes North, 80 degrees 32 minutes West near the tip of Cape Canaveral, making it well suited for low- to medium-inclination missions.

5.1 EASTERN RANGE PAYLOAD PROCESSING FACILITIES

The commercial payload processing facility, owned and operated by Astrotech Space Operations, Inc., is the primary facility used for processing LMLV-class civil, government, and commercial spacecraft at ER. An aerial view of Astrotech's payload processing facility is shown in Figure 5.1-1. This facility contains separate nonhazardous and hazardous processing buildings, storage buildings, and offices that are described in the following sections. Astrotech complies fully with all applicable federal, state, regional, and local statutes, ordinances, rules, and regulations relating to safety and environmental requirements.

5.1.1 Astrotech Payload Processing Facility

Astrotech's building 1/1a is the Payload Processing Facility (PPF) and the usual location for spacecraft test and check-out before launch. Building 1 has overall dimensions of approximately 200 ft (61.0 m) by 125 ft (38.1 m) with a height of 49 ft (14.9 m). Building 1a has overall dimensions of 170 ft (51.8 m) by 95 ft (29.0 m) with a height of 60 ft (18.3 m). Detailed floor plans of buildings 1 and 1a are shown in Figures 5.1.1-1 and 5.1.1-2, respectively. Details such as cleanliness levels, environments, room dimensions and crane capabilities for building 1/1a are shown in Table 5.1.1-1.

The major features of building 1/1a are:

1) Two airlocks;
2) Four high bays (three identical in size and one larger);
3) Eight control rooms (two per high bay);
4) Office complex, administrative area, central communications, conference rooms, and support areas.

5.1.2 Astrotech Hazardous Processing Facility

Astrotech's building 2 is the Hazardous Processing Facility (HPF) and the usual location for spacecraft fueling. Building 2 has overall dimensions of approximately 159 ft (48.5 m) by 112 ft (34.1 m) with a height of 49 ft (14.9 m). A detailed floor plan of building 2 is shown in Figure 5.1.2-1. Details such as cleanliness levels, environments, room dimensions and crane capabilities for building 2 are shown in Table 5.1.2-1.

The major features of building 2 are:

1) One airlock;
2) Two spacecraft processing high bays and operations rooms;
3) Two encapsulation high bays;
4) One spin balance bay.

Each high bay is built to explosion-proof or equivalent standards to support operations involving liquid propellant transfer, solid propellant motor preparations, and ordnance installation. The spin balance machine, a Schenk-Trebel Model E7S, can turn in either direction from 30 to 300 rpm and can accommodate large payloads.

5.1.3 Astrotech Spacecraft Support Facilities

Building 3 at Astrotech is an explosive-safe facility designed for short- and long-term storage of payloads, solid propellant motors, and other environmentally sensitive items (liquid propellants are not allowed). It has six separate storage bays with independent environmental controls, though

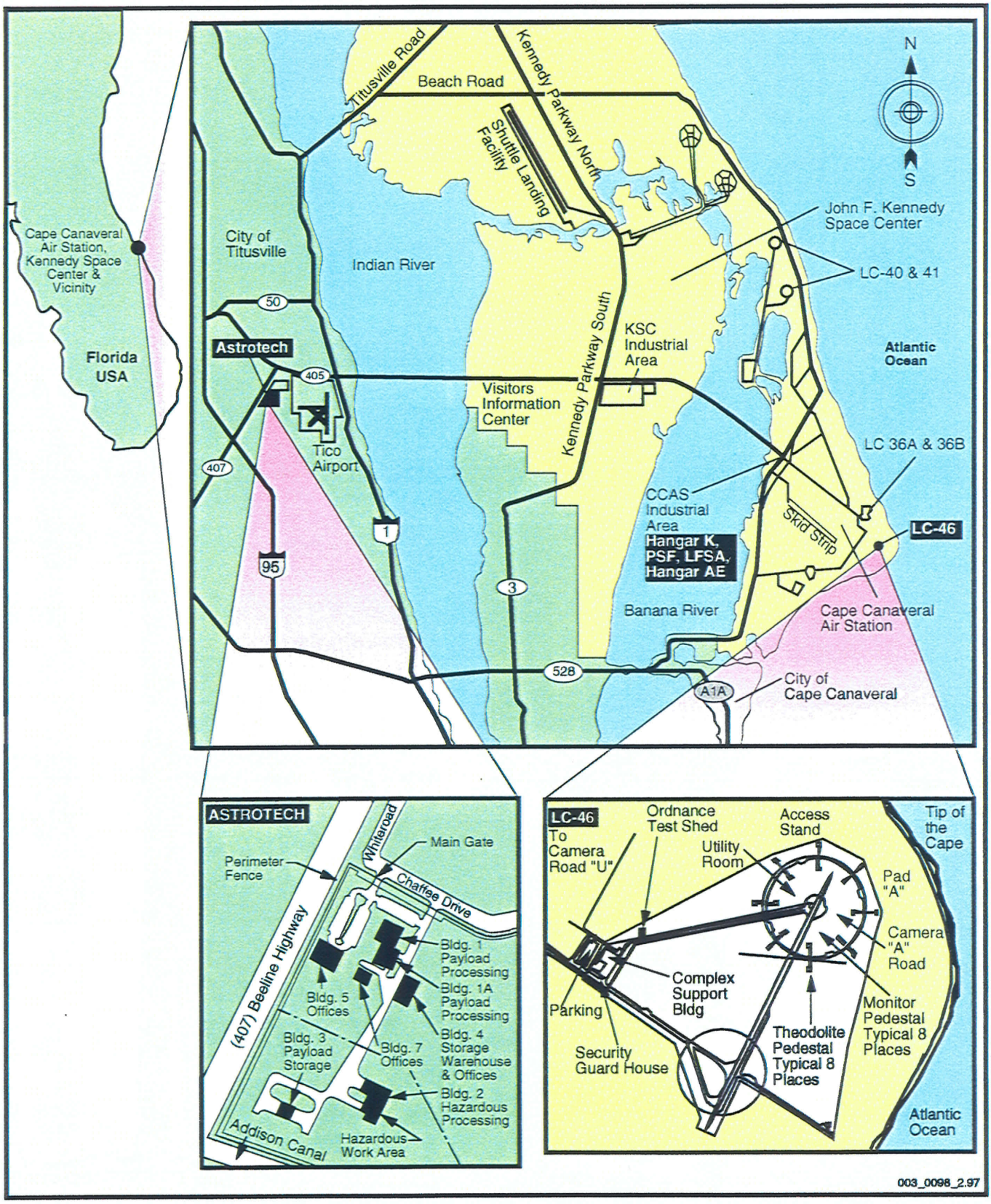


Figure 5-1 Eastern Range Facilities

Figure 5.1-1 Aerial View of Astrotech's Payload Processing Facility

they are not clean rooms and payloads will require suitable containers. There is no overhead crane in building 3. Environments and room dimensions for building 3 are shown in Table 5.1.3-1.

Astrotech's building 4 is a warehouse storage area featuring a single large bay without environmental controls and is suitable for storage of shipping containers and mechanical ground support equipment (MGSE). There is no overhead crane in building 4. Table 5.1.3-2 shows the dimensions of building 4.

Astrotech's building 5 provides 3,600 ft^2 (334.4 m^2) of customer office space divided into 17 individual offices. A reception area provides sufficient space to accommodate up to three secretaries.

Building 6 at Astrotech provides storage primarily for Lockheed Martin's payload fairing (PLF) support equipment. However, if additional nonenvironmentally controlled storage is required by customer users, this space can be made available.

5.1.4 Astrotech Spacecraft Services

Full services for payload processing and integration can be provided at Astrotech.

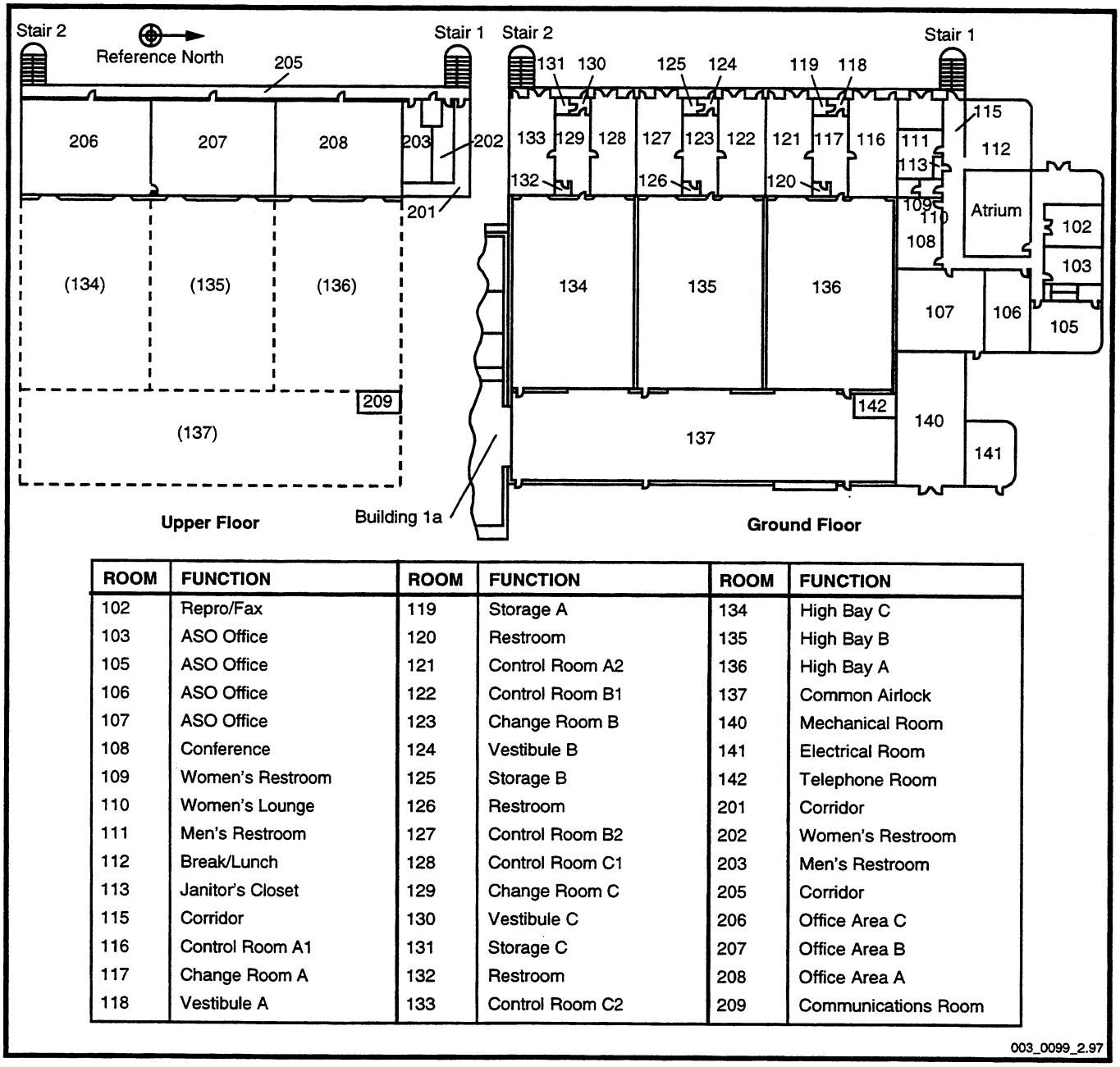
Electrical Power and Lighting—The Astrotech facility is served by 480-Vac/three-phase commercial 60- and 50-Hz electrical power that can be redistributed as 480-Vac/three-phase/30-A, 120/208-Vac/three-phase/60-A, or 120-Vac/single phase/20-A power to any location in buildings 1/1a and 2. Commercial power is backed up by a diesel generator during critical testing and launch periods. Astrotech can provide 35 kW of 230/380-Vac/three-phase 50-Hz power, which is also backed up by a diesel generator.

The high bays and airlocks in buildings 1 and 2 are lighted by 400-W metal halide lamps to maintain 50 ft candles of illumination. Control rooms, offices, and conference areas have 35-W fluorescent lamps to maintain 50 ft candles of illumination.

Telephone and Facsimile—Astrotech provides all telephone equipment, local telephone service, and long-distance access. A Group 3 facsimile machine is available.

Intercommunication Systems—Astrotech provides a minimum of three channels of voice communications among all work areas. The facility is connected to the NASA/USAF Operational Intercommunications System and Transistorized Operational Phone System (TOPS) to provide multiple-channel voice communications between the Astrotech facility and selected locations at CCAS.

Closed-Circuit Television (CCTV)—CCTV cameras are located in the high bays of Building 2 to permit remote viewing operations in those areas. CCTV can be distributed within the Astrotech facility to any location desired. In addition, Astrotech has the capability to transmit and receive a single channel of video to and from Kennedy Space



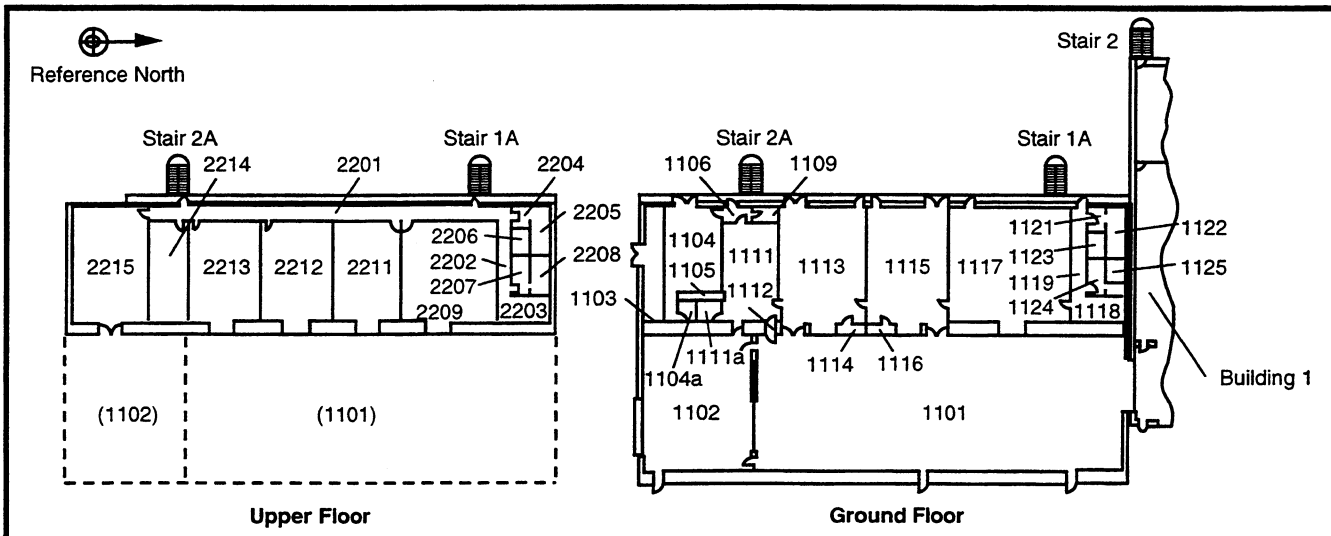
ROOM	FUNCTION	ROOM	FUNCTION	ROOM	FUNCTION
102	Repro/Fax	119	Storage A	134	High Bay C
103	ASO Office	120	Restroom	135	High Bay B
105	ASO Office	121	Control Room A2	136	High Bay A
106	ASO Office	122	Control Room B1	137	Common Airlock
107	ASO Office	123	Change Room B	140	Mechanical Room
108	Conference	124	Vestibule B	141	Electrical Room
109	Women's Restroom	125	Storage B	142	Telephone Room
110	Women's Lounge	126	Restroom	201	Corridor
111	Men's Restroom	127	Control Room B2	202	Women's Restroom
112	Break/Lunch	128	Control Room C1	203	Men's Restroom
113	Janitor's Closet	129	Change Room C	205	Corridor
115	Corridor	130	Vestibule C	206	Office Area C
116	Control Room A1	131	Storage C	207	Office Area B
117	Change Room A	132	Restroom	208	Office Area A
118	Vestibule A	133	Control Room C2	209	Communications Room

Figure 5.1.1-1 Astrotech's Building 1 Detailed Floor Plan

Center (KSC)/CCAS via a dedicated microwave link.

Command and Data Links—Astrotech provides both wideband and narrowband data transmission capability via a dedicated microwave link and the KSC/CCAS cable transmission system to all locations served by the KSC/CCAS network. If a spacecraft requires a hardline transmission capability, the spacecraft customer is responsible for providing correct signal characteristics for interfacing to the KSC/CCAS cable transmission system.

Astrotech provides antennas for direct S-band, C-band, and Ku-band air links from the Astrotech facility to LC-46, and antennas for S-band, C-band, and Ku-band air links between Astrotech Buildings 1/1a and 2. There is also a ground connection between the PPF and HPF for hardline radio frequency (RF) transmissions up to Ku-band.



ROOM	FUNCTION	ROOM	FUNCTION	ROOM	FUNCTION
1101	Large High Bay D	1115	Control Room D1	2204	Men's Washroom
1102	Large Airlock	1116	Closet	2205	Men's Restroom
1103	Elec/Mech Room	1117	Office Area D1	2206	Storage Closet
1104	Conference D1	1118	Break Room	2207	Women's Washroom
1104a	Restroom	1119	Corridor	2208	Women's Restroom
1105	Closet	1121	Men's Washroom	2209	Office Area D2
1106	Vestibule	1122	Men's Restroom	2211	Office Area D3
1109	Janitor's Closet	1123	Storage Closet	2212	Office Area D4
1111	Change Room D	1124	Women's Washroom	2213	Office Area D5
1111a	Restroom	1125	Women's Restroom	2214	Conference D2
1112	Air Shower	2201	Corridor	2215	ASO Storage
1113	Control Room D2	2202	Corridor		
1114	Closet	2203	Break Room		

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Figure 5.1.1-2 Astrotech's Building 1a Large Bay Detailed Floor Plan

Remote Spacecraft Control Center—Astrotech has capability to link remote ground stations (voice and data) between Astrotech and CCAS resources.

Temperature and Humidity Control—The environments of all Astrotech high bays and airlocks are maintained at a temperature of 75 ±5°F (24±2.8°C) and a relative humidity of 50±5%. The environments of all other areas are maintained by conditioned air at a temperature between 70 to 78°F (21 to 26°C) and a comfortable humidity.

Compressed Air—Regulated compressed air at 125 psi is available in Buildings 1 and 2.

Security and Emergency Support—Perimeter security is provided 24 hours a day. Access to the Astrotech facility is via the main gate, where a guard is posted during working hours to control access. There are frequent patrols throughout the facility during nonworking hours. Internal security is provided by cipher locks on all doors leading to payload processing areas. Brevard County provides emergency medical support, and the City of Titusville provides emergency fire support. In case of an accident, personnel will be transported to Jess Parish Hospital in Titusville. Both medical and fire personnel have been trained by NASA.

Foreign Trade Zone—Astrotech has been designated as a foreign trade zone. Astrotech will coordinate all licensing requirements to meet governmental regulations for importing and exporting support hardware for the duration of mission support.

Table 5.1.1-1 Astrotech's Building 1/1a features four high-bay areas.

BUILDING 1 HIGH-BAYS (ROOMS 134, 135, 136)			BUILDING 1a HIGH-BAY (ROOM 1101)		
Cleanliness	Class 100,000		Cleanliness	Class 100,000	
Temperature	75 ±5°F	23.9 ±2.8°C	Temperature	75 ±5°F	23.9 ±2.8°C
Relative Humidity	50 ±5%		Relative Humidity	50 ±5%	
Floor Space	60x40 ft	18.3x12.2 m	Floor Space	125x51 ft	38.1x15.5 m
Clear Height	43 ft	13.1 m	Clear Height	60 ft	18.3 m
Door to Airlock (wxh)	20x23 ft	6.1x7.0 m	Door to Airlock (wxh)	20x50 ft	6.1x15.2 m
Door to Cntrl Rooms (wxh)	8x8 ft	2.4x2.4 m	Door to Cntrl Rooms (wxh)	8x8 ft	2.4x2.4 m
Crane Type (Each Bay)	Bridge		Crane Type	Bridge	
Crane Capacity	10 ton	9.1 tonne	Crane Capacity	30 ton	27.2 tonne
Crane Hook Height	37 ft	11.3 m	Crane Hook Height	50 ft	15.2 m
BUILDING 1 HIGH-BAY CONTROL ROOMS (2/BAY)			**BUILDING 1a CONTROL ROOMS (ROOMS 1113, 1115)**		
Temperature	75 ±5°F	23.9 ±2.8°C	Temperature	75 ±5°F	23.9 ±2.8°C
Relative Humidity	50 ±5%		Relative Humidity	50 ±5%	
Floor Space	30x14 ft	9.1x4.3 m	Floor Space	34x30 ft	10.4x9.1 m
Ceiling Height	8.75 ft	2.67 m	Ceiling Height	8.75 ft	2.67 m
Door to High Bay (wxh)	8x8 ft	2.4x2.4 m	Door to High Bay (wxh)	8x8 ft	2.4x2.4 m
Bay Window (wxh)	8x4 ft	2.4x1.2 m	Bay Window (wxh)	7x4 ft	2.1x1.2 m
BUILDING 1 AIRLOCK (ROOM 137)			**BUILDING 1a LARGE-BAY AIRLOCK (ROOM 1102)**		
Cleanliness	Class 100,000		Cleanliness	Class 100,000	
Temperature	75 ±5°F	23.9 ±2.8°C	Temperature	75 ±5°F	23.9 ±2.8°C
Relative Humidity	50 ±5%		Relative Humidity	50 ±5%	
Floor Space	120x30 ft	36.6x9.1 m	Floor Space	40x50 ft	12.2x15.2 m
Clear Height	24 ft	7.3 m	Clear Ceiling Height	60 ft	18.3 m
Door to High Bay (wxh)	20x23 ft	6.1x7.0 m	Door to High Bay (wxh)	20x50 ft	6.1x15.2 m
Door to Outside (wxh)	20x23 ft	6.1x7.0 m	Door to Outside (wxh)	20x50 ft	6.1x15.2 m
Crane	None		Crane	Common to High Bay	
BUILDING 1 OFFICES (ROOMS 206, 207, 208)			**BUILDING 1a OFFICES (ROOMS 1117, 2209, 2211, 2212, 2213)**		
Temperature	75 ±5°F	23.9 ±2.8°C	Temperature	75 ±5°F	23.9 ±2.8°C
Floor Space	41x24 ft	12.5x7.3 m	Floor Space		
Ceiling Height	8 ft	2.4 m	Room 1117	34x50 ft	10.4x15.2 m
Door to Corridor (wxh)	3x6.67 ft	0.9x2.03 m	Room 2209	30x33 ft	9.1x10.0 m
Bay Window (wxh)	4x6 ft	1.2x1.8 m	Room 2211, 12 & 13	30x25 ft	9.1x7.6 m
			Ceiling Height	8.75 ft	2.67 m
			Door to Corridor (wxh)	3x6.67 ft	0.9x2.03 m
			Bay Window (wxh)		
			Room 1117	8x4 ft	2.4x1.2 m

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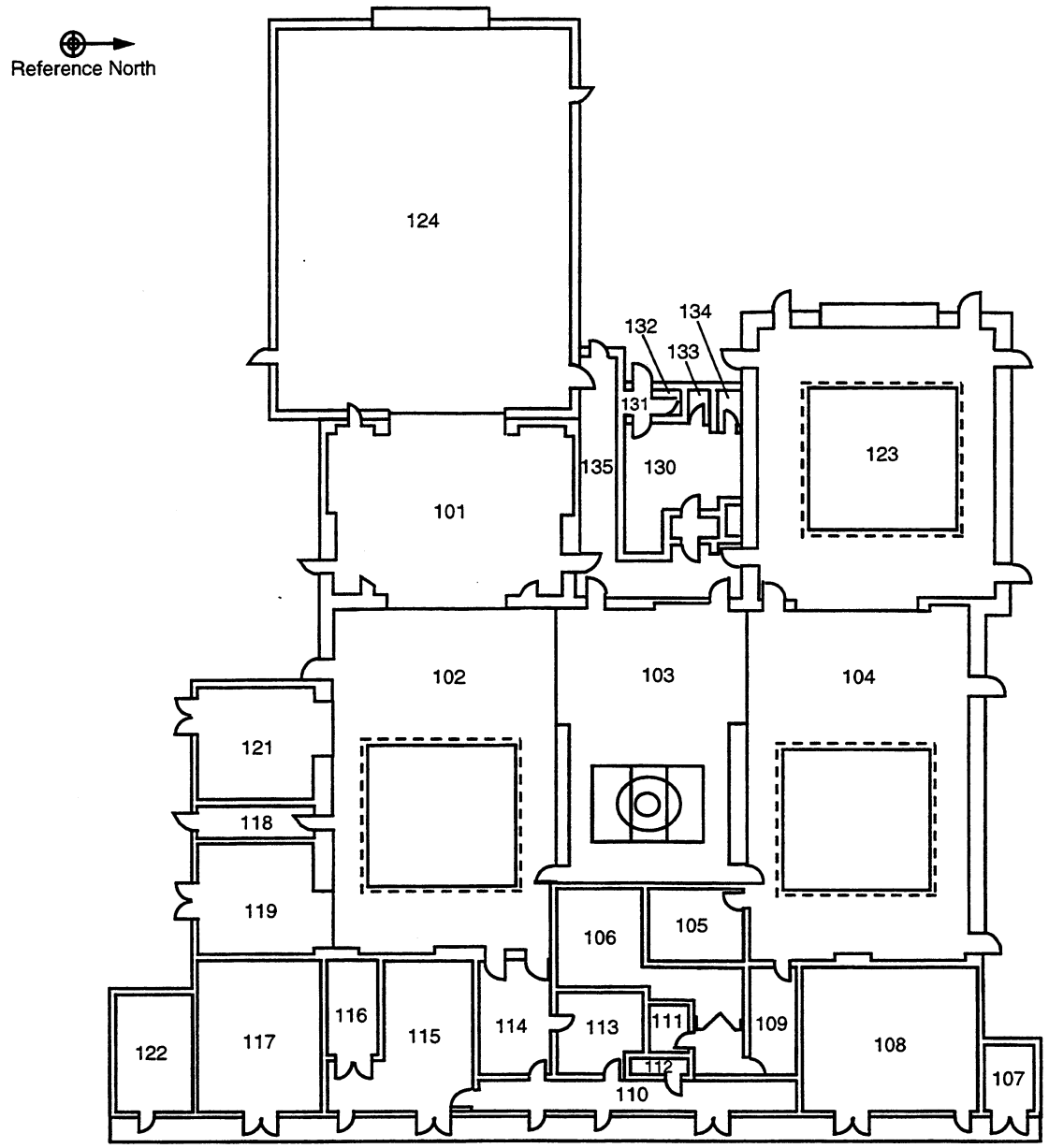
5.2 LAUNCH COMPLEX 46

An aerial view of LC-46 is shown in Figure 5.2-1. The SFA conversion of LC-46 for commercial launch use has included the addition of the Mobile Access Structure (MAS), a new launch pedestal, a flame trench, and a utility room.

The MAS is a large, moveable, open-frame structure that rolls up to and back from the launch mount. It provides access for vehicle buildup and checkout, as well as access to the satellite within the launch vehicle fairing. Shown in Figures 5.2-2 and 5.2-3 are the elevations of seven U-shaped platforms in the MAS, which girdle the launch mount on three sides and can be used for viewing the launch vehicle, but are not close enough to provide direct access.

Access (360°) is provided instead by up to four adjustable platforms (not shown in Figures



ROOM	FUNCTION	ROOM	FUNCTION	ROOM	FUNCTION
101	Airlock	111	Women's Restroom	122	Mechanical Room
102	South High Bay	112	Janitor	123	North Encapsulation Bay
103	Spin Balance High Bay	113	Men's Restroom	124	South Encapsulation Bay
104	North High Bay	114	South Change Room	130	Garment Change Room
105	Equipment Storage	115	South Control Room	131	Vestibule
106	Mechanical Room	116	Balance Control Room	132	Janitor
107	Mechanical Room	117	Mechanical Room	133	Women's Restroom
108	North Control Room	118	Corridor	134	Men's Restroom
109	North Change Room	119	Prop. Cart Room	135	Corridor
110	Corridor	121	Prop. Cart Room		

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Figure 5.1.2-1 Astrotech's Building 2 provides excellent hazardous operations facilities for liquid- and solid-propellant-based spacecraft.

Table 5.1.2-1 Astrotech's Building 2 features three blast-proof processing rooms.

SOUTH AND NORTH HIGH BAYS (ROOMS 102, 104)		
Cleanliness	Class 100,000	
Temperature	75 ±5°F	23.9 ±2.8°C
Relative Humidity	50 ±5%	
Floor Space	60x37ft	18.3x11.3 m
Fuel Island	25x25 ft	7.6x7.6 m
Clear Height	43 ft	13.1 m
Doors to Room 101 & 123 (wxh)	20x40 ft	6.1x12.2 m
Door to Room 103 (wxh)	20x40 ft	6.1x12.2 m
Crane Type (Each Bay)	Bridge	
Crane Capacity	10 ton	9.1 tonne
Crane Hook Height	37 ft	11.3 m
NORTH HIGH-BAY CONTROL ROOM (ROOM 108)		
Temperature	70 to 75°F	21.1 to 23.9°C
Floor Space	25x30 ft	7.6x9.1 m
Ceiling Height	9.33 ft	2.84 m
Door to Outside (wxh)	8x8 ft	2.4x2.4 m
Bay Window (wxh)	4x4 ft	1.2x1.2 m
SOUTH HIGH-BAY CONTROL ROOM (ROOM 115)		
Temperature	70 to 75°F	21.1 to 23.9°C
Floor Space	25x15 ft	7.6x4.6 m
Ceiling Height	9.33 ft	2.84 m
Door to Outside (wxh)	8x8 ft	2.4x2.4 m
Bay Window (wxh)	2.67x2.50 ft	0.81x0.76 m
SPIN BALANCE HIGH-BAY (ROOM 103)		
Cleanliness	Class 100,000	
Temperature	75 ±5°F	23.9 ±2.8°C
Relative Humidity	50 ±5%	
Floor Space	48x27 ft	14.6x8.2 m
Clear Height	43 ft	13.1 m
Doors to Room 102 & 104, (wxh)	20x40 ft	6.1x12.2 m
Crane Type	Bridge	
Crane Capacity	10 ton	9.1 tonne
Crane Hook Height	37.0 ft	11.3 m
SPIN BALANCE HIGH-BAY CONTROL ROOM (ROOM 116)		
Temperature	75 ±5°F	23.9 ±2.8°C
Floor Space	10x15 ft	3x4.6 m
Clear Height	9.33 ft	2.84 m
Door to Room 115 (wxh)	6x6.67 ft	1.8x2.03 m

AIRLOCK (ROOM 101)		
Cleanliness	Class 100,000	
Temperature	75 ±5°F	23.9 ±2.8°C
Relative Humidity	50 ±5%	
Floor Space	38x29 ft	11.6x8.8 m
Clear Height	43 ft	13.1 m
Door to Room 124 (wxh)	20x40 ft	6.1x12.2 m
Door to Room 102 (wxh)	20x40 ft	6.1x12.2 m
Crane	Monorail	
Crane Capacity	2 ton	1.8 tonne
Crane Hook Height	37 ft	11.3 m
PROP CART ROOMS (ROOMS 119, 121)		
Floor Space	20x20 ft	6.1x6.1 m
Clear Height	9.33 ft	2.84 m
Door to Room 102 (wxh)	10x8 ft	3.1x2.4 m
Door to Outside (wxh))	6x6.67 ft	1.8x2.03 m
NORTH ENCAPSULATION HIGH-BAY (ROOM 123)		
Cleanliness	Class 100,000	
Temperature	75 ±5°F	23.9 ±2.8°C
Relative Humidity	50 ±5%	
Floor Space	50x40 ft	15.2x12.2 m
Fuel Island	25x25 ft	7.6x7.6 m
Clear Height	65 ft	19.8 m
Door to Outside (wxh)	20x50 ft	6.1x15.2 m
Door to Room 104 (wxh)	20x40 ft	6.1x12.2 m
Crane Type	Bridge	
Crane Capacity	30 ton	27.2 tonne
Crane Hook Height	55 ft	16.8 m
SOUTH ENCAPSULATION HIGH-BAY (ROOM 124)		
Cleanliness	Class 100,000	
Temperature	75 ±5°F	23.9 ±2.8°C
Relative Humidity	50 ±5%	
Floor Space	45x70 ft	13.7x21.3 m
Clear Height	65 ft	19.8 m
Door to Outside (wxh)	23x55 ft	7.0x16.8 m
Door to Room 101 (wxh)	20x40 ft	6.1x12.2 m
Crane Type	Bridge	
Crane Capacity	30 ton	27.2 tonne
Crane Hook Height	55 ft	16.8 m

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Table 5.1.3-1 Astrotech's Payload Storage Building is used for short-term hardware storage.

BUILDING 3: THERMALLY CONTROLLED STORAGE FACILITY		
Temperature Control	70 to 78°F	21.1 to 25.6°C
Relative Humidity	50 ±10%	
Floor Space		
Bays A, C, D & F	25x22 ft	7.6x6.7 m
Bays B & E	25x24 ft	7.6x7.3 m
Clear Height (All Bays)	28 ft	8.5 m
Door Size (wxh)		
Bays A, C, D & F	20x25 ft	6.1x7.6 m
Bays B & E	18x25 ft	5.5x7.6 m
Crane	None	

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Table 5.1.3-2 Astrotech's Warehouse Storage Building is suitable for storage of items not requiring climate controls.

BUILDING 4: STORAGE WITHOUT ENVIRONMENTAL CONTROL		
Floor Space	50x125 ft	15.2x38.1 m
Clear Height	28 ft	8.5 m
Door Size	20x27 ft	6.1x8.2 m
Crane	None	

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Figure 5.2-1 Aerial View of Launch Complex 46

5.2-2 and 5.2-3), which can be pinned to the fixed structure at any 1-ft increment between elevations 28 feet and 120 feet. One of these platforms will typically be positioned at the optimum elevation for conducting satellite operations through the fairing access door(s). Inserts are used to tailor the platform through-hole to the size of the fairing being used, such that there is always a consistent 9-inch gap between the fairing and the platform. Figure 5.2-4 shows a top view of the access area around the LMLV fairing.

The tower encloses the launch vehicle to provide protection from wind and rain. An LMLV GSE clean tent is also available to enclose the specific satellite working area around the fairing access door. Satellite access typically ceases at T-10 hours, just before building rollback.

The MAS does not incorporate a crane or an elevator. A mobile crane is used for vehicle stacking operations and, if required, for hoisting GSE to upper platforms by means of the "diving board" platform extensions at the 47-foot and 67-foot platforms (Figs. 5.2-2 and 5.2-3).

LMLV installs its own umbilical mast near the launch mount to provide air conditioning, power, and telemetry connections to the vehicle and the encapsulated satellite. The electrical umbilical connects the vehicle via the mast to a bunkered utility room nearby. The utility room provides a protected location for certain electrical ground support equipment (EGSE), such as battery chargers,

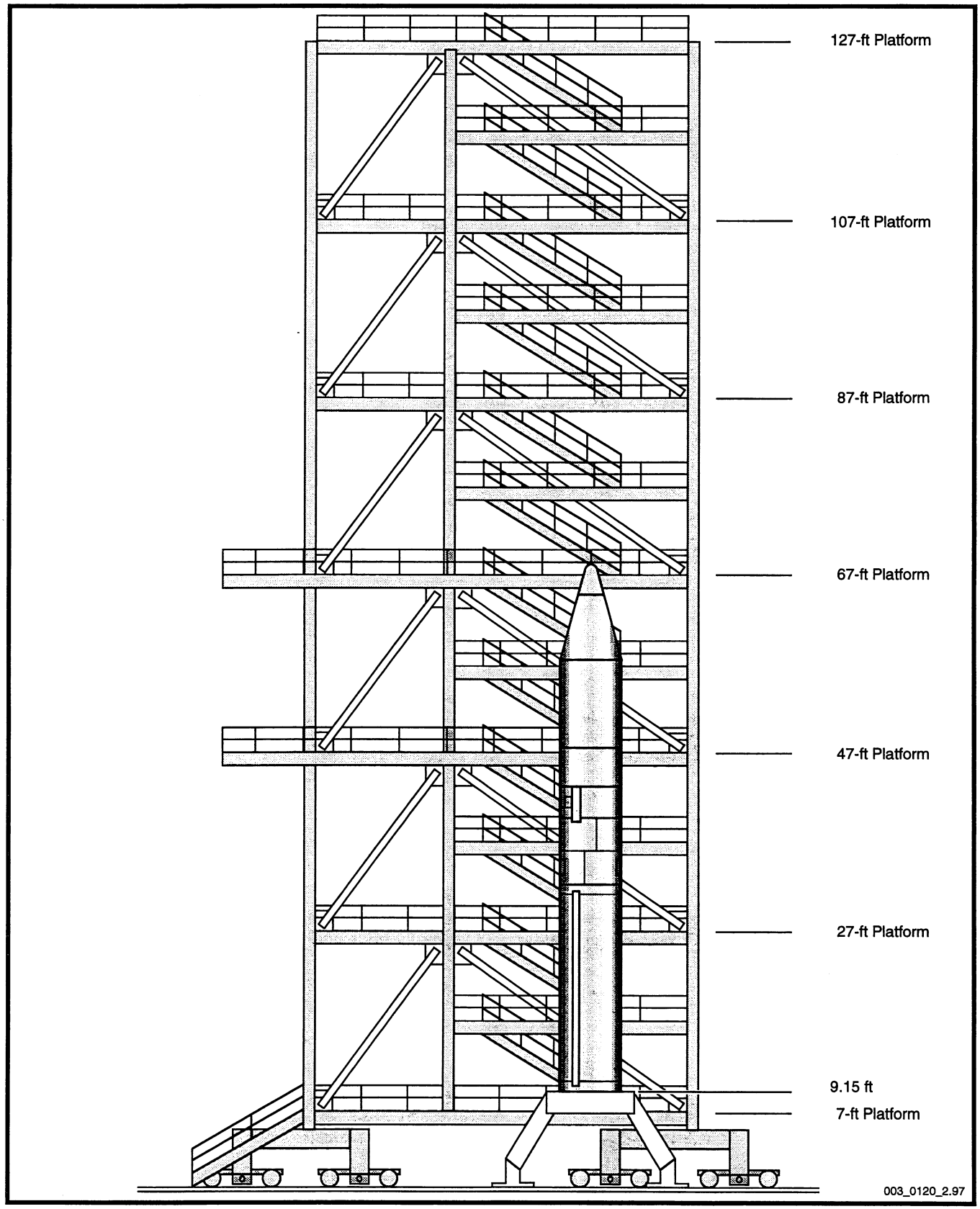

Figure 5.2-2 LMLV1 and MAS Platforms

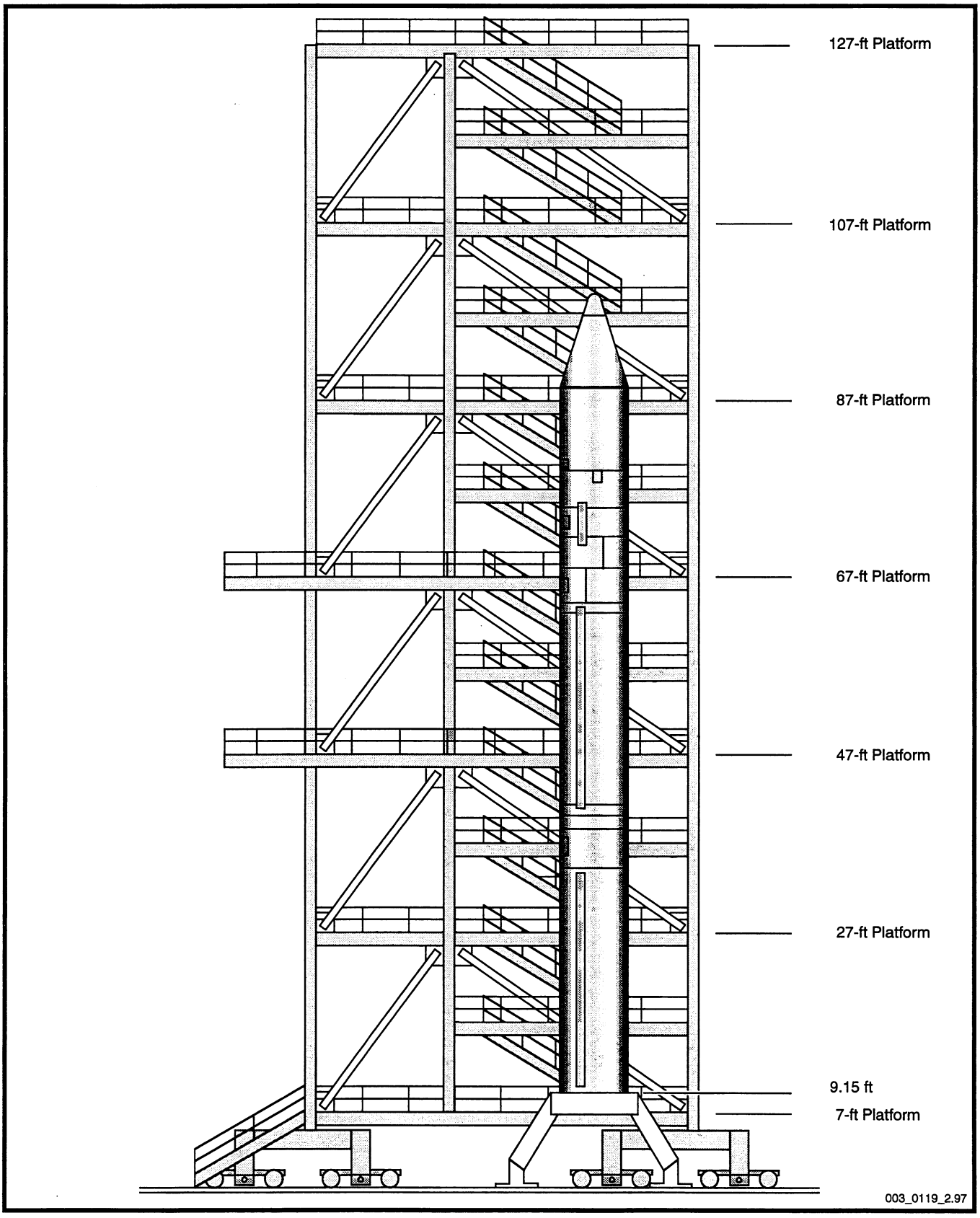

Figure 5.2-3 LMLV2 and MAS Platforms

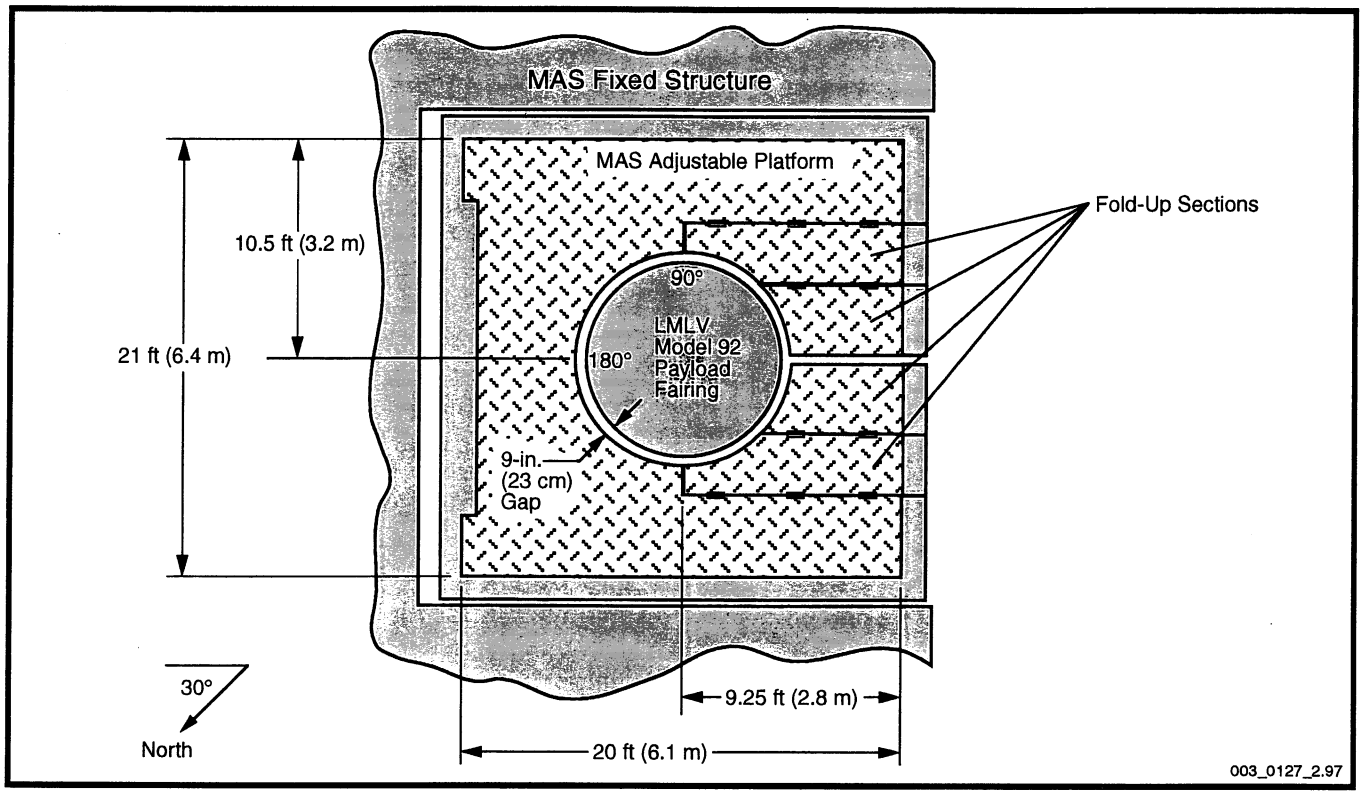

Figure 5.2-4 Top View of LMLV Payload Access from MAS Adjustable Platforms

which is close to the launch mount and to the encapsulated payload. See Section 4.2.2 for a description of customer accommodations within the utility room.

Other support systems available at the LC-46 launch mount include:

1) Power, light, and protection against static discharge and lightning;
2) A continuously monitored and redundant clean air supply to the fairing that is Class 5,000 clean, high-efficiency particulate air (HEPA) filtered, with a maximum dew point of 40°F (4.4°C), and between 50-75°F (10-23.9°C);
3) Public address network;
4) Area warning system;
5) Access control;
6) Remote controlled color video surveillance monitors;
7) Compressed gaseous nitrogen;

5.3 SUPPORT FACILITIES

Described below are additional facilities used by LMLV for launch vehicle processing at ER.

5.3.1 Hangar K

Located at CCAS, Hangar K is shared by LMLV with the Atlas program and provides a workshop, office space, GSE storage space, and an enclosed work area for the staging of certain flight hardware. The LMLV interstage(s) and the orbital adjust module (OAM) are given receiving and inspection at Hangar K, have ordnance installed, and are prepared for transportation to the Propellant Servicing Facility (in the case of the OAM) or directly to the launch site for stacking (in the case of the interstage[s]). Hangar K is also the location where the Launch Vehicle Checkout Van (LVCV) will be positioned during launch and will provide personal amenities for those stationed in the LVCV.

5.3.2 Propellant Servicing Facility

The Propellant Servicing Facility (PSF) is used by LMLV for hazardous processing. This is where the OAM is fueled. It is located on CCAS, has all the necessary features to support safe fueling operations, and is approved by Range Safety for this purpose. The use of this facility is obtained from the Air Force by including it in the program requirements document. Note that satellites are typically fueled in Astrotech Building 2 (see Sect. 5.1.2).

5.3.3 Liquid Fuels Storage Areas No. 1 and No. 2

The Liquid Fuels Storage Area No. 1 is used by LMLV for storage of hydrazine fuel. The Liquid Fuels Storage Area No. 2 is used by LMLV for the storage of ordnance and pyrotechnic devices. Both are located on CCAS. The use of these two facilities is also obtained by means of the program requirements document.

5.4 LAUNCH CONTROL

Launch control during ER operations is conducted jointly from the LVCV located at Hangar K, from Hangar AE, and from the Range Operations Control Center (ROCC). The LVCV and its functions are described in Section 4.2.3. Hangar AE and the ROCC are described below. All three locations are interconnected fiber-optically during launch operations for data and communication transmittal.

5.4.1 Hangar AE

Hangar AE is a NASA facility located on CCAS that will be used by LMLV as its Mission Control Center, while Range functions will be controlled from the ROCC.

A seating chart of the Mission Director's Center in Hangar AE is shown in Figure 5.4.1-1. Consoles for up to two customer personnel will normally be available in the Mission Director's Center, though additional consoles in the adjoining Launch Vehicle Data Center may also be available on an exceptional basis. The consoles are equipped with operational voice circuits, administrative telephones, and closed circuit television displays, which allows personnel to monitor or participate in launch operations. Six dial-in circuits are also available in Hangar AE, which the customer may use for remote (offsite) monitoring of the countdown and payload voice nets.

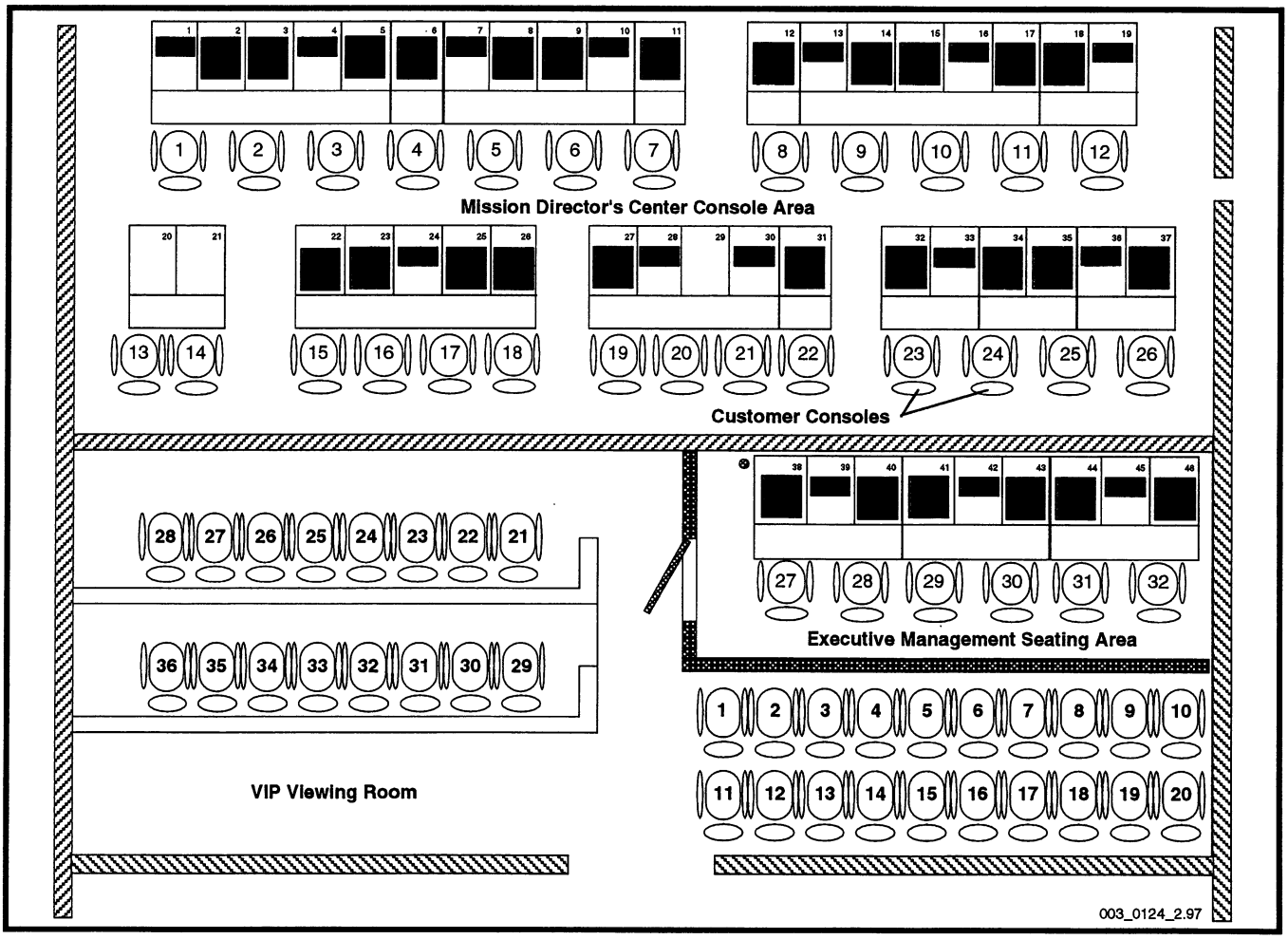

Figure 5.4.1-1 Hanger AE—Mission Director's Center Seating Plan

Seating for additional key customer personnel and dignitaries is provided in the VIP viewing area of the Mission Director's Center. The VIP viewing area has bay windows overlooking the console area, two speakers connecting it to the public affairs net, and video capability during launch and ascent.

5.4.2 Range Operations Control Center

The ROCC is located on CCAS and is the hub of range operations. Command destruct is controlled by Range Safety personnel from the ROCC, while all other vehicle events and parameters are monitored only. The range operations controller (ROC), senior mission flight control officer (SFCO) and the mission flight control observer (MFCO) are the other primary range personnel in the ROCC during launch operations.

6.0 Launch Site Facilities

Lockheed Martin's extensive experience and familiarity with launch site processing provides the customer with seamless on-time operations at the launch site. The launch site services and support provided to the customer will enhance the probability of mission success during the launch campaign.

6.1 Launch Site – Kodiak Launch Complex

The Athena program proposes to conduct high inclination missions, i.e., typically polar and sun-synchronous orbits, from the Kodiak Launch Complex (KLC) on Kodiak Island, Alaska. KLC is a project of the Alaska Aerospace Development Corporation (AADC), which was formed by the Alaska State government in 1992 to develop and promote aerospace industries in Alaska. The U.S. Air Force began suborbital launches from KLC in September 1998 and it will be operational for orbital launches by late 1999. The first Athena launch from KLC is planned for Aug 2000.

6.1.1 Site Activation

The Athena program has a proven record of launch site activation. Space Launch Complex 6 (SLC-6) at Vandenberg Air Force Base (VAFB), used to launch the Lewis and IKONOS missions as well as Launch Complex 46 (LC-46) at Cape Canaveral Air Station (CCAS) used to launch the Lunar Prospector and ROCSAT missions were converted for Athena use within two years. At LC-46 these conversions entailed the design and construction of an entirely new access structure and launch pedestal as is the case at KLC. The KLC launch pad is being baselined for the Athena family of launch vehicles.

Athena is currently working closely with AADC in the development of the facilities necessary for Athena payload processing and launches. With the first Athena launch from KLC planned for August 2000, the Athena program is fully committed to ensuring the activation of KLC proceeds as planned. All launch site facilities and support services necessary to support the launch campaign (payload processing, mate and encapsulation, launch vehicle processing and control, meteorology, range safety, etc.) will be in place and validated well in time to support the August 2000 launch as well as all future launches.

6.1.2 Accommodations, Transportation and Weather

There are more than 250 hotel rooms in Kodiak and five car rental agencies. AADC is negotiating special airfare, car rental and hotel rates for personnel supporting operations at the launch site.

Transportation links are well established and fully capable of supporting the needs of both the launch vehicle and payload processing teams. The Kodiak airport has three runways and supports 10 daily flights to Anchorage. It is capable of accepting planes as large as a heavy transport C-5.

Warm ocean currents moderate the weather in Kodak. Average daily temperatures are approximately 60 °F (16 °C) in the summer months of June, July and August with record highs in the middle 80s °F (high 20s °C). Average daily temperatures in the fall months of September and October range from 40° to 50 °F (4° to 10 °C) and from the mid 30°s to 40 °F (1° to 4 °C) in the spring months of April and May. Average daily temperatures are approximately 30 °F (-1 °C) in the winter months of November through March. There is less fog than at VAFB and virtually no lightning, lessening the probability of weather delays.

6.1.3 Site Location

KLC is located on the Narrow Cape peninsula on the south shore of Kodiak Island, about 25 miles southwest of Kodiak borough (population 14,100) and 250 miles south of the city of Anchorage

(population 100,000). At 57° 36' 16" north latitude and with a clear flight path to the south, as shown in Figure 6.1.3-1, KLC is an excellent location for high inclination missions, i.e., typically polar and sun-synchronous orbits.

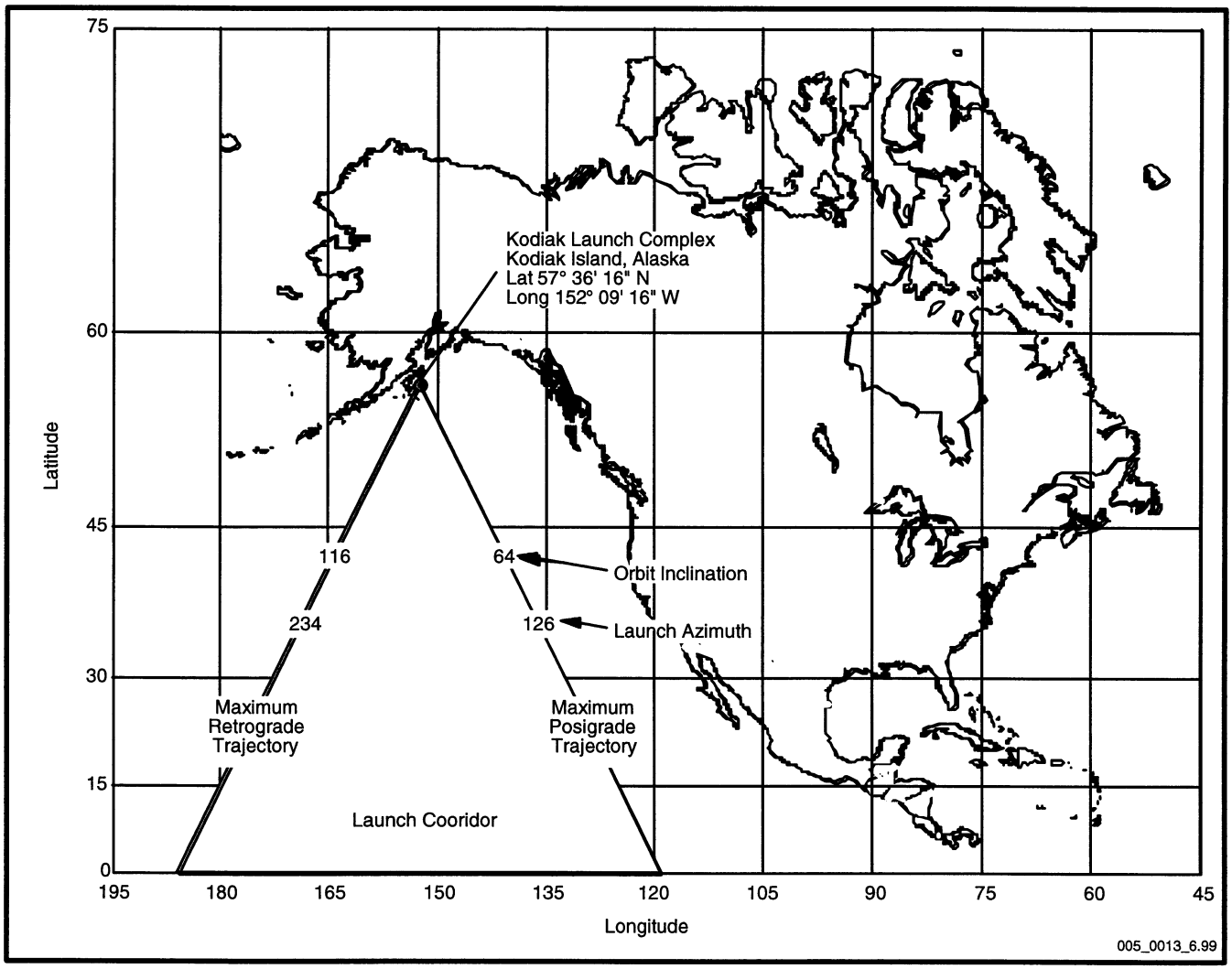

Figure 6.1.3-1 KLC is an excellent location for launching high inclination missions, i.e., typically polar and sun-synchronous orbits.

6.1.4 Site Facilities and Services

KLC will provide spacious facilities endowed with the latest, state-of-the-art amenities to support both launch vehicle and satellite processing operations. The primary facilities at KLC, and those that will be used by the customer, are the Payload Processing Facility (PPF), the Launch Service Structure (LSS) and the Launch Control Center (LCC). The LCC is located less than a mile (1.6 km) from the PPF and approximately two miles (3.2 km) from the LSS making access to all facilities quick and easy. Each of these facilities is described in detail below and shown in Figure 6.1.4-1.

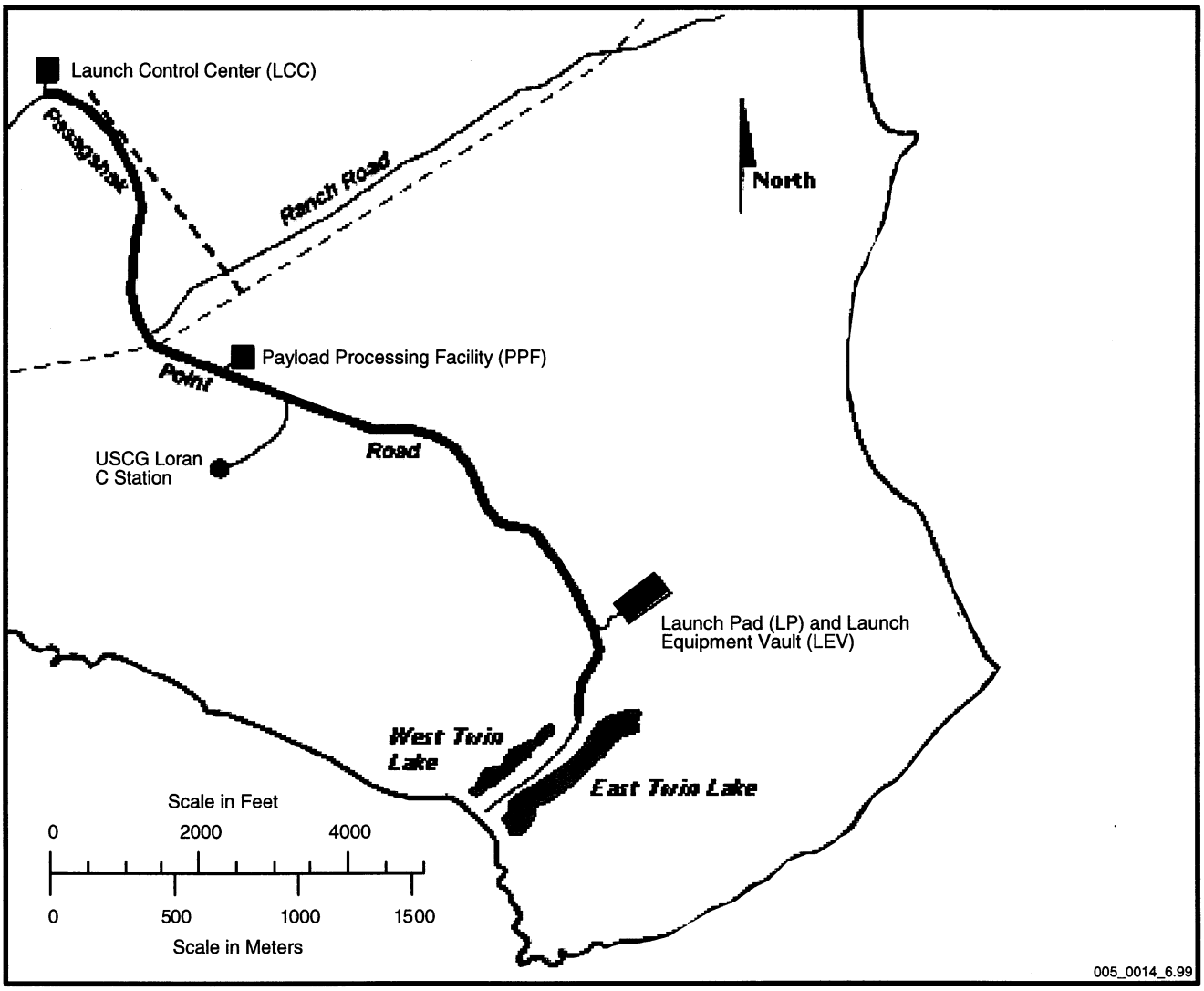

Figure 6.1.4-1 KLC provides spacious facilities endowed with the latest, state-of-the-art amenities located to facilitate quick and easy access.

In addition to the facilities and support services provided at KLC, Lockheed Martin will have some launch vehicle ground support equipment (GSE) available for use by the customer during payload processing. This GSE includes: two JLG 2-man bucket lifts, one 5 ton (minimum) Hydraset, four 8 ft web slings, four 12 ft web slings, and an assortment of Crosby shackles. Cleaning items will be provided by KLC.

6.2 Payload Processing Facility

All payload processing will be conducted in the KLC Payload Processing Facility (PPF), shown in Figure 6.2-1. The PPF will be used to support both hazardous and non-hazardous operations eliminating the need to relocate the satellite and its support equipment during payload processing operations.

The PPF has two high bays, one dedicated for payload processing and the other for an airlock. Both bays are equal in size and are controlled to class 100,000 cleanliness levels (standard). Floors in the high bays are sealed with an electrostatic dissipating, conductive epoxy coating. The floor in each contains a

safety approved trench system for containment of fuel in the event of a spill. Walls are constructed of sound insulating gypsum. Exits from the hazardous work areas are clearly marked and an emergency eyewash/shower is located in an exit corridor. A concrete wall with an observation window and operable fire damper separates the processing bay from the control room. A change room adjacent to the control room provides lockers and clean work area garment storage. An airlock with air shower permits controlled entry of hands-on personnel. An equipment airlock permits controlled entry of ground support equipment (GSE) and fuel carts into the processing bay. An emergency eyewash and shower is located in the hallway outside the processing bay. Portable eyewashes can also be located at the customer's request.

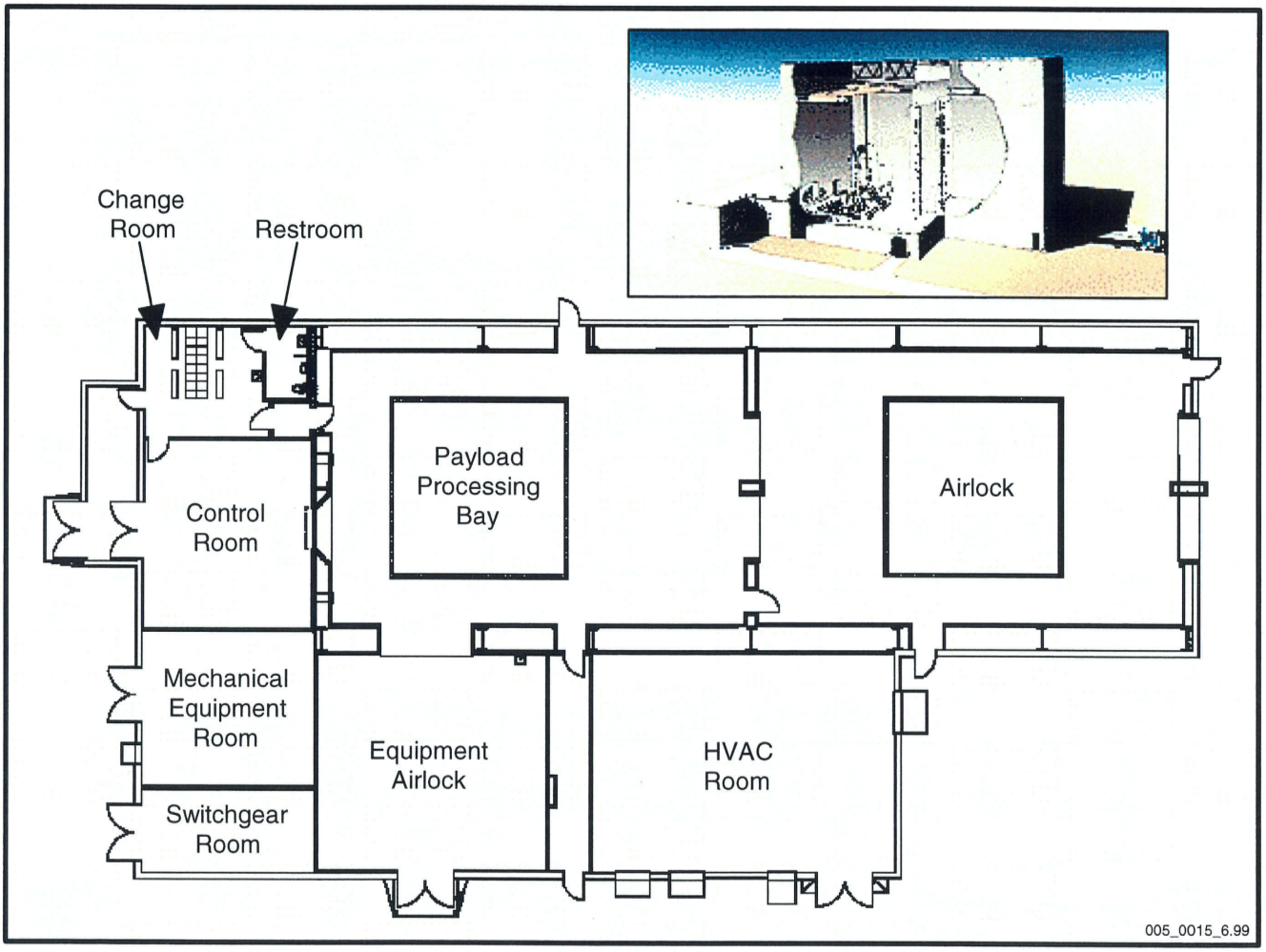

Figure 6.2-1 The KLC Payload Processing Facility features the latest, state-of-the-art amenities that will easily accommodate launch site payload processing requirements.

6.2.1 Room Dimensions

The PPF measures approximately 9,000 ft^2 (836 m^2) and features a 40 ft (12.2 m) wide by 60 ft (18.3 m) long by 40 ft (12.2m) processing bay and an adjacent airlock with the same dimensions. In addition, a 992 ft^2 (92 m^2) airlock allows access for fuel carts or other support equipment. The 676 ft^2 (63 m^2) control room provides adequate space for satellite test equipment and has a viewing window

with line-of-sight to both the processing bay and airlock. The 375 ft^2 (35 m^2) change room includes a restroom and personnel lockers. Lockheed Martin provides clean garments, for day-to-day payload processing operations, as well as SCAPE suits, for fueling operations.

6.2.2 Door Dimensions

All personnel access doors are a minimum of 3 ft (0.9 m) wide by 7 ft (2.1 m) high. All equipment access doors are double wide. Doors to critical rooms are fire rated. Equipment access to the processing bay is through a manually operated roll-up door measuring 13 ft (4.0 m) wide by 10 ft (3.1 m) high. Satellite and transporter access is through a pair of back to back 20 ft (6.1 m) wide by 40 ft (12.2 m) high roll-up doors at the exterior of the airlock. A single 20 ft (6.1 m) wide by 58 ft (17.7 m) high roll-up door separates the airlock from the processing bay. All high bay doors are motorized for ease of use.

6.2.3 Environments

The PPF has two independent heating, ventilation and air conditioning (HVAC) systems for the protection of personnel and payloads. Both HVAC systems utilize direct digital control for complete and programmable temperature and humidity control. One system environmentally controls the vestibule, the change room, the control room, and the equipment room. The high bay system utilizes pre-filters, carbon filters, and 95% High Efficiency Particle Air (HEPA) filters to produce a class 100,000 clean room. By minimizing and controlling the number of personnel entering and exiting the high bay, the room can be operated at cleanliness levels as low as class 10,000. These rooms are maintained from 60 °F (15.6 °C) to 85 °F (29.4 °C) ± 2-1/2 °F (1.4 °C) with 40% minimum relative humidity. The processing bay and airlock are kept at a positive pressure of 0.05 in. (1.3 mm) water.

The PPF has a solid state Hazardous Vapor Detection System (HVDS) for sensing hydrazine and hydrogen. The system has adjustable calibration settings and contains its own battery backup. The 8 zone HVDS has four permanently mounted sensors in the high bay ceiling and four portable units that may be positioned at the customers discretion. Upon activation, the system sounds an audible alarm, energizes a red strobe light, and sends a signal back to the site manager in the LCC. A Portable battery operated sniffer is also available.

6.2.4 Electrical Power and UPS

US standard 120 volt, 60 Hz, single phase power is supplied to all of the rooms and high bays. Special power (208 volt, 60 amp, 3 phase and 480 volt, 30 amp, 3 phase) is available in the change room, equipment room, and high bays. All electrical enclosures in hazardous working environments are either explosion proof or purged. Surge protection (200 joules, 650 amp and 8x20 μsec) is provided for all circuits with sensitive electronics. Seven Technical Power Cutoff (TPC) switches are strategically located throughout the PPF for emergency cutoff. Activation of the TPC switches shuts off all power to the receptacles in the equipment room and high bays and concurrently activates the Caution and Area Warning (C/AW) red strobe lights.

Though the loss of power is not likely, the PPF has its own backup generator. The diesel generator is rated at 500 kW and is fed by a 2,500 gal (9,475 liter) fuel tank. The generator is sized to account for the electrical demands of the PPF, including the two HVAC systems, and the launch pad. No UPS is provided for the facility.

6.2.5 Grounding

The PPF is surrounded by an underground grid network of #4/0 copper ground cable. Ten ground bus bars are located throughout the PPF providing the customer with ample grounding. The all metal construction of the PPF provides for excellent stray voltage protection for any sensitive electronics within the facility. All conduits, cable trays, and metallic water pipes entering the facility are grounded to this grid.

6.2.6 Data and Communications

The PPF is fully integrated in to the Operational Intercom System (OIS) and Paging and Area Warning (P/AW) systems. All hazardous operations in the PPF are monitored on the OIS. The P/AW serves as the PPF paging system. All PPF communications may be accessed in the control room. The PPF has a Caution and Area Warning Display System (C/AW). As in the LCC, it utilizes a three color (green, yellow and red) approach for visual indication of hazardous operations. A green light represents non-hazardous operations; an amber light represents active hazardous operations and area controls are in effect; and a red light represents an emergency condition and area clears are in effect. This system is manually controlled via the control room C/AW control panel and is tied into the fire alarm control panel, the HVDS controller, and the Technical Power Cut-off switches.

Four pan and tilt color closed circuit television (CCTV) cameras in explosion proof housings are strategically located in the PPF high bays. Control of these cameras is through the PPF control room CCTV panel. All PPF television channels are fed to the LCC over the fiber optic backbone. During hazardous operations, visual contact is maintained by the site manager or satellite test director.

6.2.7 Security and Fire Protection

Security for the PPF is provided through 16 doorway magnetic switches and 4 sirens. It is controlled by a keypad in the PPF vestibule and may be monitored from the LCC site manager's console or from a remote location. Fire protection is provided through 6 smoke detectors, 8 flame detectors, 13 heat sensors, and 12 pull stations. Activation triggers 11 area strobes and horns, an alarm on the LCC site manager console, and the water deluge pre-action control valve. This system shuts down the air handlers for both the high bays and personnel areas. Both the security and fire alarm systems have their own surge protection and backup power.

6.2.8 Crane Specifications

A 15-ton (13.6 tonne) bridge crane with a 50 ft (15.2 m) hook height serves both the processing bay and the airlock. A swing-up section of the door track permits the bridge crane to pass between the two bays. The crane is operated from either a hanging pendant or remote infrared control system.

6.2.9 Commodities

The PPF has a 2 stage, oil-free, rotary compressor capable of providing compressed air at 110 ACFM (3.1 m^3/minute) at 125 psig (862 Kpa). This compressor provides both compressed and breathing air. Compressed air is passed through a refrigerated air dryer, then a 99.99% one micron filter before it is stored in a 120 gallon (455 liter) tank. A compressed air regulating panel and breathing air purifier provides the final cleaning before the supply quick disconnects. There are no dry nitrogen sources hardlined in the PPF but K bottles may be stored in the equipment airlock with flex lines to the required work area.

The PPF has its own vacuum system. This system is designed for the cleaning of hardware and support equipment brought into the high bay areas. Two vacuum sources are located in each of the high bays and hoses are provided.

6.3 Launch Pad and Service Structure

The launch pad area, shown in Figure 6.3-1, consists of the pad and apron, flame duct, and Launch Service Structure (LSS). The LSS has four main substructures, the Fixed Service Structure (FSS), the Rotating Service Structure (RSS), the Rotating Service Door (RSD), and the Launch Equipment Vault (LEV). The RSS and the RSD rotate about the FSS to form a fully enclosed and environmentally controlled area. The RSS has two stairways and a service elevator.

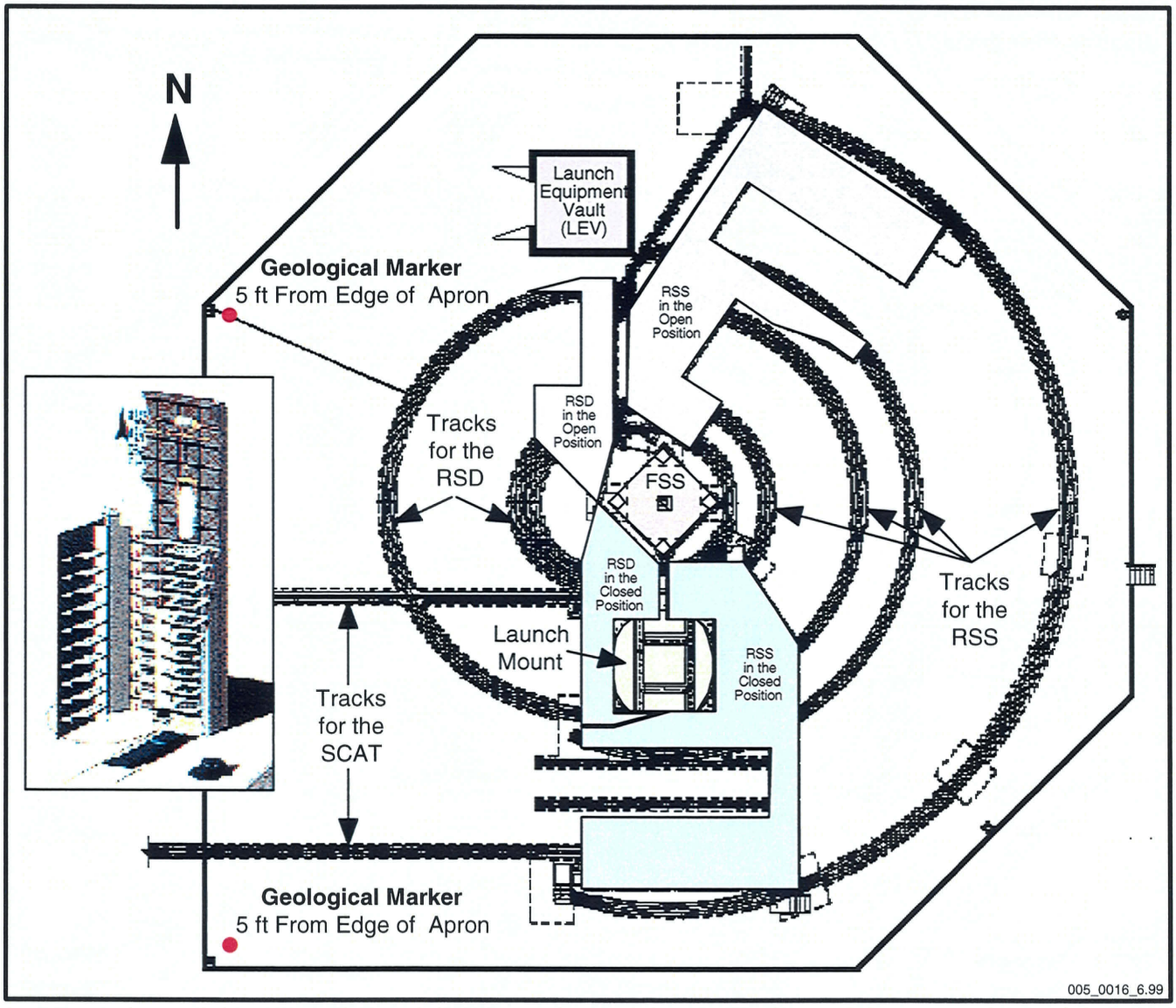

Figure 6.3-1 The KLC Launch Service Structure provides a fully enclosed and environmentally controlled area for launch vehicle and final satellite processing.

The pad apron is 175 ft (53.3 m) wide by 175 ft (53.3 m) long and easily accommodates large transporters and other equipment required to support launch vehicle and satellite operations. The round flame duct is 20 ft (6.1 m) in diameter and directs the launch vehicle exhaust away from the vehicle to minimize acoustic energy. The LSS is designed to withstand winds of up to 110 mph (177 km/hr) in the closed configuration.

The LEV houses the electronic and communications equipment and has adequate space for launch vehicle and satellite interface ground support equipment. The LEV has six 4 in. (10 cm) diameter ducts leading to the FSS and to the base of the launch mount. Athena will use one of these ducts for its ground umbilical, including circuits dedicated for satellite telemetry. In addition, there are four 4 in. (10 cm) diameter ducts leading to the pad apron. Athena will use one of these ducts for its fiber optic cable connecting the LEV to the Launch Vehicle Control Van.

6.3.1 Work Platforms and Elevator

The LSS is approximately 170 ft (51.8 m) in height with fixed work platforms located at 10 ft (3.1 m) intervals. Adjustable work platforms may be located at 12 in. (30.5 cm) intervals providing 360 degrees of access over the full height of the vehicle. Articulating stairs on the fixed platforms provide access to the adjustable platforms. A personnel and equipment elevator stops on every fixed platform. The maximum capacity of the elevator is 2,700 lb (1,225 kg) and its door is 5 ft 3-1/2 in. (1.6 m) wide by 8 ft (2.4 m) high.

6.3.2 Door Dimensions

The RSD is approximately 26 ft (7.9 m) wide by 118 ft (36.0 m) high and easily accommodates the Athena encapsulated assembly on its transport trailer. This roll-up door is electrically operated. There are three personnel access doors measuring 3 ft (0.9 m) wide by 7 ft (2.1 m) high.

6.3.3 Environments

The RSS with the RSD closed provides and environmentally conditioned area maintained at 60 °F (15.6 °C) for personnel comfort and solid rocket motor thermal conditioning requirements. Conditioned air is provided to the PLF as described in Section 2.2.1.2.

The LSS has an 8 zone solid state Hazardous Vapor Detection System (HVDS) for sensing hydrazine. The HVDS has two permanently mounted sensors in the RSS and four portable units that may be positioned at the customers discretion. The system has adjustable calibration settings and contains a battery backup. Upon activation, the system sounds an audible alarm, energizes a red strobe light, and sends a signal back to the site manager and vehicle test conductor in the LCC. Portable sniffers are also available.

6.3.4 Electrical Power and UPS

US standard 120 volt, 60 Hz, single phase power is supplied to all of the fixed work platforms. Special power (208 volt, 60 amp, 3 phase and 480 volt, 30 amp, 3 phase) is available on selected levels. Technical power cut-off switches are located on every fixed level. Activation disconnects all 120 volt sources and activates the C/AW red strobes. Backup power is provided by the 500 kW diesel generator. No UPS is provided for the LSS, however, the LEV does have UPS.

6.3.5 Grounding

The LSS is an all metal building that offers excellent stray voltage protection. The structure is tied to a building perimeter counterpoise grounding system made of a network of #4/0 copper ground cable and the support rails. A grounding bar is located on each fixed work platform in the RSS. In addition, all conduits, cable trays, and metallic pipes entering the LSS are grounded to this network.

6.3.6 Data and Communications

The LSS is fully integrated into the KLC Operational Intercom System (OIS) and Paging and Area Warning (P/AW) systems. The OIS serves as the point-to-point voice network between the Launch Pad and other KLC facilities. Hazardous operations are monitored on the OIS. This system is used to warn of inclement weather such as high winds or lightning. The LSS has a Caution and Area Warning Display System (C/AW). This system is manually controlled via the LEV C/AW control panel and is tied to the fire alarm control panel, the HVDS controller, and the Technical Power Cut-off switches.

There are thirteen CCTV interface outlet stations within the RSS. Four pan and tilt color cameras in explosion proof housings may be strategically located in accordance with the customers requirements. Control of these cameras is through the LCC CCTV panel. In addition, there are four pad surface camera outlet stations for use during launch and hazardous operations. All PPF television channels are fed to the LCC over the fiber optic backbone. Visual contact is maintained by the site manager or satellite test director.

The LEV receives IRIG-B time of year and countdown signal from the LCC. The signal is integrated into the CCTV system. The LSS has its own 10 Base-T network. The copper between work station phone jacks (RJ45) and the LEV equipment rack is data level 5, unshielded 8-strand, 24 awg plenum rated. Data RJ45 patch cords connect between patch boards and between work stations and wall mounted phone jacks. Wall jacks are available on every fixed level work platform and extender boxes can be located on the adjustable platforms.

6.3.7 Security and Fire Protection

Security for the LEV is provided through two doorway magnetic switches and two sirens. A control access keypad in the LEV is monitored from the LCC site managers console or from another remote location. Fire protection is provided through seven flame detectors, two heat sensors, and twenty-three pull stations. Activation triggers twenty-three area strobes and horns and an alarm on the LCC site manager console. The security and fire alarm systems have separate surge protection and backup power.

6.3.8 Crane Specifications

The RSS has a 75 ton (68 tonne) bridge crane with a 157 ft (47.9 m) hook height. The hoist motor can control the lift speed to a minimum of 1 in. (2.54 cm) per minute. The crane is operated from a plug-in pendant that may be relocated to every fixed work platform except the 110 ft and 120 ft levels. This crane is used to position the adjustable work platforms (well before arrival of any launch vehicle or satellite equipment), stack the solid rocket motors, stack the OAM and stack the encapsulated assembly.

6.3.9 Commodities

The LSS has a small capacity oil less reciprocating compressor capable of providing compressed air at 21.4 ACFM (0.6 m^3/min) at 125 psig (862 Kpa). Compressed air is passed through a dual-stage, desiccant air dryer. This system is not meant for breathing air. Connecting points are located on each of

the fixed work platforms. The RSS is hardlined for dry nitrogen, and supply ports are located on each fixed work platform. The compressed air and dry nitrogen ports are physically separated and have identifying safety placards for operational distinction.

6.4 Launch Control Center

The Launch Control Center (LCC), shown in Figure 6.4-1, is the heart of KLC. It contains the Launch Operations Control Center (LOCC), a VIP viewing area of the LOCC and an administrative area. Overall launch vehicle, satellite and Range direction and management will be conducted from the LOCC. LMA and customer personnel supporting launch vehicle and payload processing operations will have office space in the administrative area of the LCC.

To ensure personnel safety, the PPF will be evacuated approximately 4 to 12 hours before launch. Satellite monitoring of critical parameters can continue from the LOCC. Power, communications and telemetry drops can be made to any console within the LOCC. The facility is fully grounded and provides stray voltage protection for sensitive electronics. To ensure personnel safety, all VIPs and visiting personnel will be located in a safer area further away from the launch site.

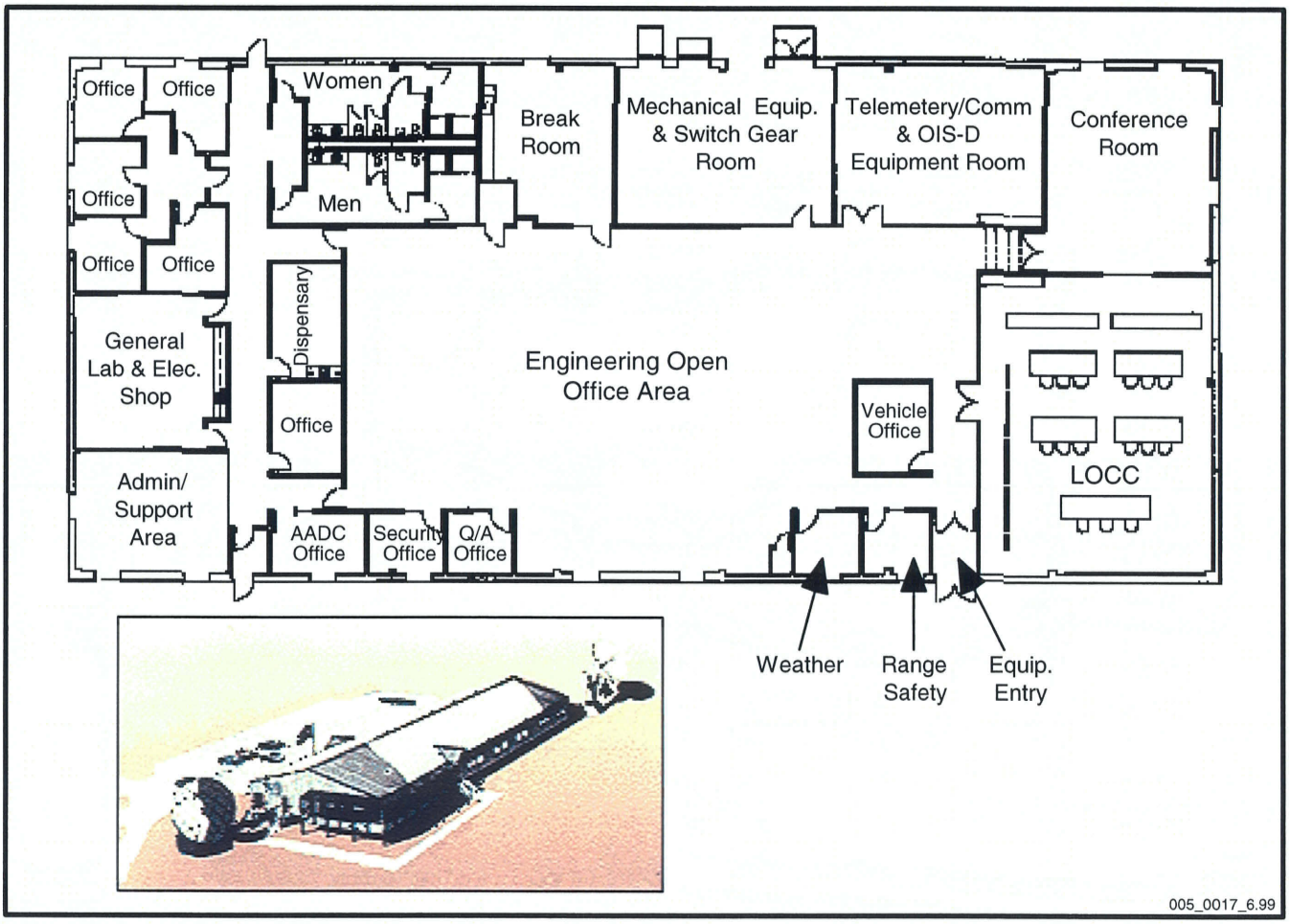

Figure 6.4-1 The KLC Launch Control Center is the heart of launch and satellite processing operations as well as overall launch vehicle, satellite and Range direction and management.

6.4.1 Room Dimensions

The LCC is approximately 14,000 sq ft (1,300 sq m) in an 80 feet (24.4 m) wide by 175 ft (53.3 m) long building. The LOCC is approximately 35 ft (10.7 m) wide by 46 ft (14.0 m) long and has 12 consoles for up to 24 personnel. Customer personnel will have two of these positions at one console. The VIP viewing area is approximately 25 ft (7.6 m) wide by 32 ft (9.8 m) long and has seating for approximately 40 personnel. It can also be used as a conference room except on day of launch. The administrative area is approximately 8,310 sq ft (772 sq m) and provides private and open office space for both Athena and customer personnel. Seven offices will be dedicated for up to 15 customer personnel, including desks, 7 telephones (one per office), one dedicated copier and one dedicated fax machine. The offices vary in size from approximately 100 sq ft (9.3 sq m) to approximately 168 sq ft (15.6 sq m). Shared areas include a 380 sq ft (35 sq m) break room and men's and women's restrooms with showers.

6.4.2 Door Dimensions

All doors in the LCC are a minimum of 3 ft (0.9 m) wide by 7 ft (2.1 m) high. Entrance ways and access to equipment rooms have double doors. Doors to critical rooms are fire rated.

6.4.3 Environments

The LCC is maintained at a comfortable temperature between 68 °F (20.0 °C) and 76 °F (24.4 °C). Humidity is adjustable and typically controlled to between 40% and 80% RH. Digital controllers automatically adjust the temperature in each zone and may be adjusted to meet specific requirements. Extra temperature control margin is designed into the T&C room, the conference room, and the LOCC for cooling of sensitive electronics.

6.4.4 Electrical Power and UPS

US standard power is supplied to all of the offices and equipment rooms. Though the loss of power is not likely, the LCC has its own backup generator and an uninterruptible power supply. The diesel generator is rated at 250 kW and is fed by a 2,500 gal (9,475 liter) fuel tank. The UPS is rated at 15 kvA for 15 minutes under normal power demands. Surge protection (200 joules, 650 amp and 8x20 μsec) is provided to the T&C room equipment racks and the LOCC consoles.

6.4.5 Grounding

The LCC is a completely metal covered building and provides excellent stray voltage protection for all interior spaces. The building, the static ground bars, and all entry conduits are grounded to a common network tied to a below grade ground loop that surrounds the facility.

6.4.6 Data and Communications

The KLC facilities are linked together using fiber optic and copper paths. The Telecommunications and Control (T&C) room patch panel, located in the Launch Control Center (LCC), serves as the central routing point and will be configured to support payload telemetry requirements. The T&C room is across the hall from the LOCC and streamlines the communications networks enhancing their effectiveness and reliability.

The LCC is also fully integrated in to the Operational Intercom System (OIS) and Paging and Area Warning (P/AW) systems. Closed Circuit Television (CCTV) from the PPF and launch pad can be displayed in the LCC. During hazardous operations, visual contact is maintained by the site manager or

test director (launch vehicle or satellite). The CCTV system has its own dedicated fiber transmission network.

The LCC is equipped with a GPS signal receiver for developing IRIG-B time of year (TOY). The signal is fed to a time code generator that delivers a one pulse per second signal to the countdown generator. The countdown clock and TOY clock are located in the LOCC. Time of year code is integrated into the CCTV. The IRIG-B signal is routed to the other KLC facilities through the fiber network. In addition to these systems, the LCC has its own 10 Base-T network. The copper between work station phone jacks (RJ45) and the equipment rack is Data Level 5, unshielded 8-strand, 24 awg plenum rated. Data RJ45 patch cords connect between patch boards and between work stations and wall mounted phone jacks.

6.4.7 Security and Fire Protection

Security for the LCC is provided through 6 doorway magnetic switches, 8 motion detectors, and 7 sirens. It is controlled via three hallway keypads (computer programmable) and can be monitored from the LOCC site manager's console or from a remote location. Fire protection is provided through 23 smoke detectors, 5 heat sensors, and 7 pull stations. Four of the smoke alarms reside in the crawl space below the LOCC raised floor. Activation triggers 15 area strobes and horns and sends an alarm to the LOCC site manager's console. Both the security and fire alarm systems each have surge protection and backup power.

6.5 Launch Vehicle Control Van

The mobile Launch Vehicle Control Van (LVCV), shown in Figure 6.5-1, is the heart of Athena launch operations, including prelaunch test and check-out. The LVCV has four primary operating stations: payload, telemetry, launch operations, and pad safety. Each operating station contains an equipment rack and one or more consoles. In addition to these primary operating stations, the LVCV contains status and alert panels; an area warning system; a public address system; a range-synchronized IRIG-B time base generator; a range interface to the LVCV countdown clock; an uninterruptible AC power supply; and surge protectors for all hardwire signals.

6.5.1 Payload Station

This needs to be updated for generic payload stations.

LMA proposes to conduct integrated launch vehicle and payload processing operations similarly to ROCSAT-1. The ROCSAT-2 EGSE will remain in the PPF and final satellite testing and health and status monitoring will be conducted from the PPF from the time the encapsulated assembly is mated to the launch vehicle until the PPF is evacuated shortly before launch. Therefore, the Payload Station in the LVCV will not be needed for customer personnel or satellite GSE.

6.5.2 Telemetry Ground Station

The Telemetry Ground Station (TGS) is manned by up to two personnel (the TLM and the TGS) to receive raw Pulse Code Modulated (PCM) telemetry data from the launch vehicle and satellite through the umbilical, or from range receivers, and to archive the data. This system is used to monitor pre-launch data and to provide that data to the launch operations stations for display and recording. The TGS can play back the archived data and distribute the data to other consoles for analysis or simulation.

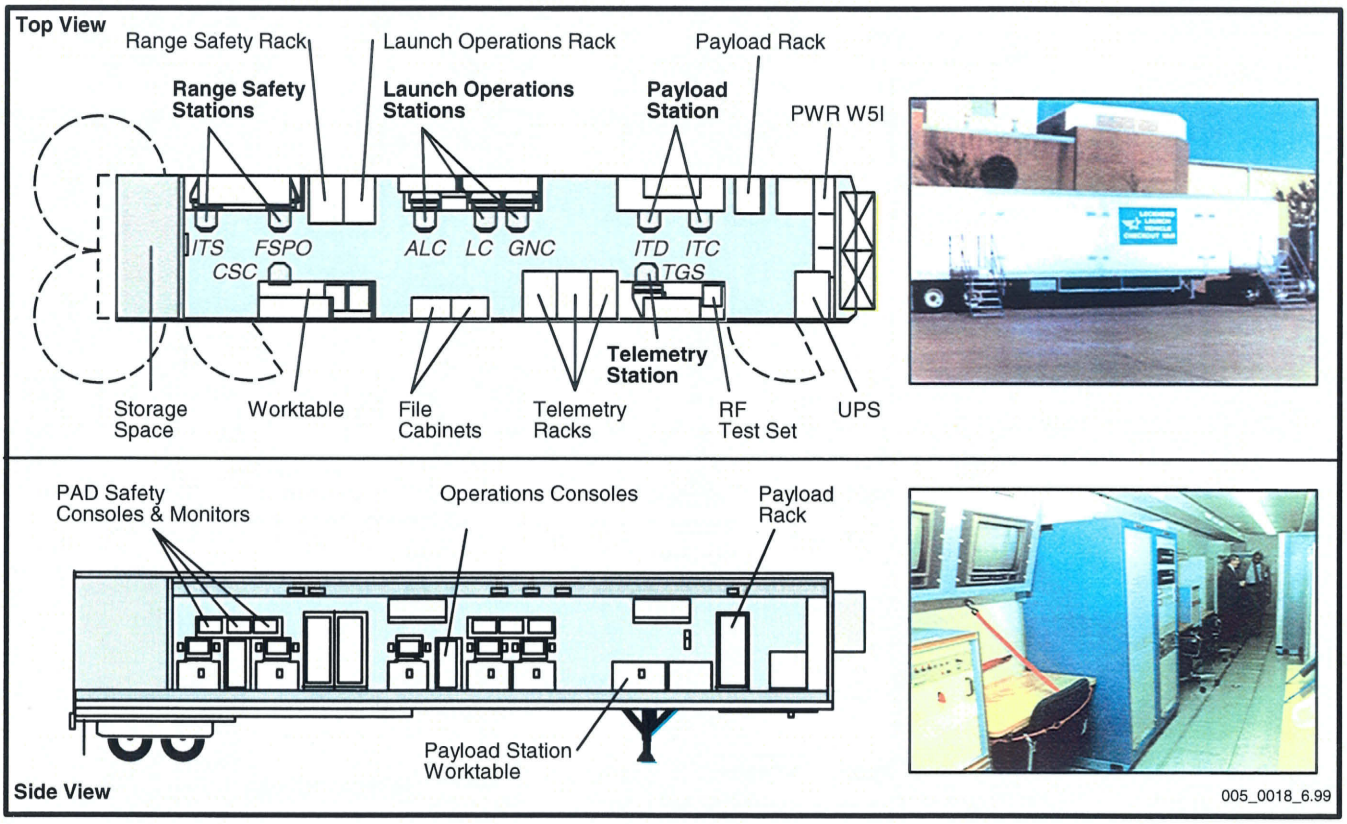

Figure 6.5-1 The Athena Launch Vehicle Control Van is the heart of launch operations including prelaunch test and check-out.

6.5.3 Launch Operations Station

The Launch Operations Station is manned by the Launch Conductor (LC), Assistant Launch Conductor (ALC), the Guidance, Navigation and Control monitor (GNC) and Ground Software Operator (GSO) who control the testing and launching of the vehicle. All launch vehicle tests and launch are conducted by the LC or the ALC, at the discretion of the LC, from this station. All launch vehicle state-of-health data are displayed at this station and recorded for retrieval as necessary.

6.5.4 Pad Safety Station

The Pad Safety Station is manned by the Flight Safety Project Officer (FSPO), the Flight Termination System observer (FTS), and the Operations Safety Manager (OSM), to provide vehicle and launch equipment status during checkout and launch operations. The FSPO has the means to manually inhibit the launch from this station. During launch countdown and flight, the status of the flight termination system is continuously displayed. Several remote-controlled color video cameras are strategically located at the pad. Each camera can be independently controlled from the pad safety console for pan, tilt, and zoom. Hazardous pad operations and launch are displayed and monitored by pad safety personnel.

7.0 LAUNCH CAMPAIGN

7.1 VEHICLE INTEGRATION AND SITE PREPARATION

Lockheed Martin provides complete vehicle integration and launch services for its customers. A system of facilities, equipment, and personnel trained in launch vehicle/spacecraft integration and launch operations is in place. The following subsections summarize the types of support and services available.

7.1.1 Spacecraft-to-Launch Vehicle Integration

Lockheed Martin performs spacecraft-to-launch vehicle integration and interface verification testing. This testing includes:

1) Matchmate testing of interface hardware;
   a) Prototype items:
      i) Early verification of design,
      ii) Accessibility to install equipment,
      iii) Development of handling/installation procedures,
   b) Flight items:
      i) Verification of critical mechanical and electrical mating interfaces before hardware delivery to the launch site,
      ii) Separation system installation,
      iii) Bolt hole pattern alignments and indexing,
2) Electrical system interfaces;
   a) Telemetry, command, and monitor interfaces,
   b) Pyrotechnic signal interfaces,
3) Launch site testing;
   a) End-to-end test,
   b) Spacecraft data flow,

7.1.2 Launch Services

In addition to our basic responsibilities for LMLV program management, component manufacture, vehicle integration, checkout, and launch, Lockheed Martin offers the following prelaunch and launch operations, integration, and documentation services:

1) Launch site operations support;
   a) Prelaunch preparation of the Lockheed Martin-supplied payload adapter, payload fairing, and other spacecraft support hardware,
   b) Transport of the encapsulated spacecraft to the launch pad and mating of the encapsulated assembly to the launch vehicle,
   c) Support of launch vehicle and spacecraft interface tests,
   d) Support of spacecraft onstand launch readiness tests (if requested),
   e) Prepare for and conduct joint launch countdown,
2) Basic facility services and assistance in the installation of spacecraft ground support equipment at the launch site;
   a) Installation of spacecraft power, instrumentation, and control equipment in the utility room and LVCV.
   b) Provision of electrical power, water, gaseous helium (GHe), and gaseous nitrogen (GN2) cable circuits, and onpad communications,
   c) Supply of onpad payload air conditioning,
3) Coordination, preparation, and maintenance of the required range support documents in accordance with the Universal Documentation System (UDS).
   a) Documents prepared in accordance with the UDS are required to gain the consent of the Eastern or Western Range authorities. In addition, these documents are required to obtain essential range assets and services required to support the launch operations associated with each mission. Lockheed Martin, with inputs from the customer, is responsible for preparing the Program Introduction (PI) document, the Program Requirements Document (PRD), and the Operations Requirements (OR) document. In response to the PI, PRD and OR, the

range prepares the Statement of Capability (SC) document, the Program Support Plan (PSP), and the Operations Directive (OD) document, respectively. Figure 7.1.2-1 illustrates this range interchange process.

Note:

Requests for downrange tracking support are included in the UDS documentation when this support is provided by USAF assets. Alternate documentation is required in cases where downgrade support is provided by NASA or foreign assets.

b) Range ground safety and flight safety documentation as required by the launch site range safety regulation,

   i) Missile system prelaunch safety package (MSPSP), which provides detailed technical data on all launch vehicle and spacecraft hazardous items, forming the basis for launch site approval of hazardous ground operations at the launch site,

   ii) Flight data safety package, which compiles detailed trajectory and vehicle performance data (nominal and dispersed trajectories, instantaneous impact data, 3-sigma maximum turn rate data, etc), forming the basis for launch site approval of mission-unique targeted trajectory,

4) Flight status reporting during launch ascent of flight telemetry data;

   a) Mark event voice callouts of major flight events throughout launch ascent,

   b) Orbital parameters (from LV guidance data),

   c) Confirmation of spacecraft separation, time of separation, and separation state vector (if separation within site of a tracking station),

5) Transmission of spacecraft data, by interleaving a limited amount of spacecraft data into the launch vehicle data and downlinking it as part of the flight telemetry;

6) Postflight processing of launch vehicle flight data, which provides quick-look and final flight evaluation reports of selected flight data on a timeline and quantitative basis, as negotiated with the customer.

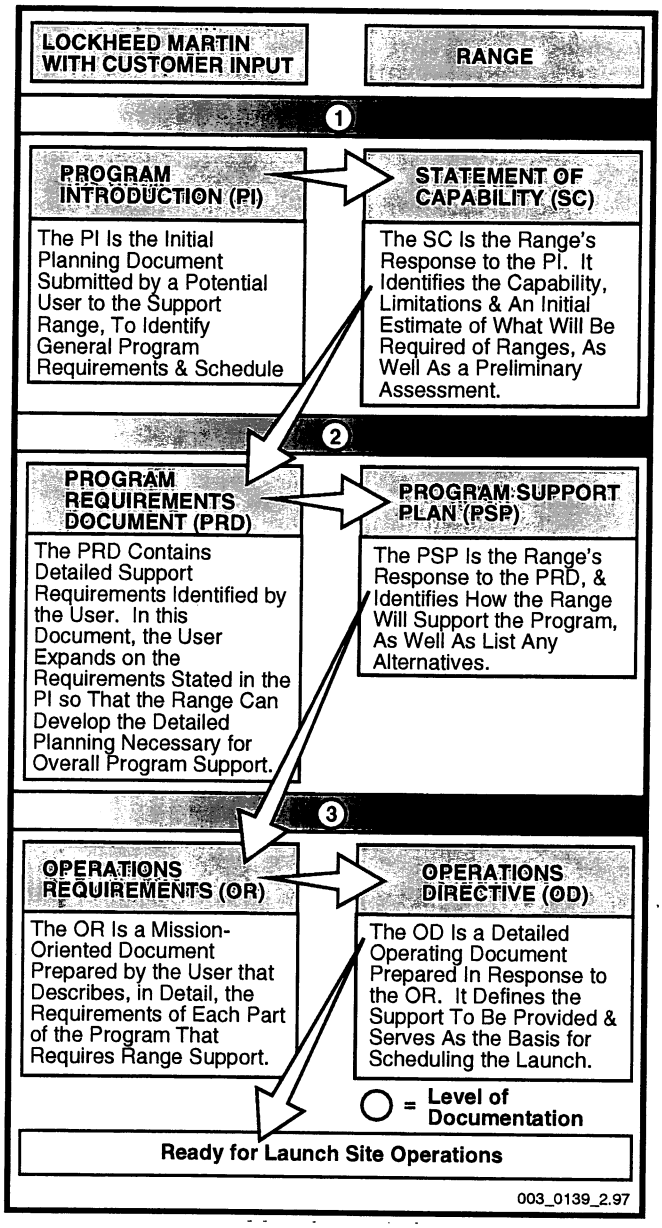

Figure 7.1.2-1 Lockheed Martin/Range Documentation Interchange Process Using the UDS

7.1.3 Propellants, Gases, and Ordnance

All chemicals used will be in compliance with all Federal, State, and local regulations. As part of LMLV's standard service, up to 100 lb (45 kg) of hydrazine is available to the spacecraft. Additionally, limited quantities of GN2, GHe, isopropyl

alcohol, and deionized water can be provided before propellant loading. A hazardous materials disposal service is also provided. All propellants required by the spacecraft must comply and be handled in compliance with U.S. national aerospace standards and U.S. military specifications (MIL-STD P26536).

1) Sampling and Analysis—Analysis of fluid and gas samples is provided as specified in the interface control document (ICD);
2) Propellant Handling and Storage—Short-term storage and delivery to the Hazardous Processing Facility (HPF) of spacecraft propellants;
3) Ordnance and Solid Motor Storage—Spacecraft ordnance and solid motors may be stored for approximately 3 months and spares may be stored for up to 6 months. Other long-term storage is provided on a space-available basis and must be arranged in advance. In addition, there is a safe facility for test and checkout (receiving, inspection, lot verification testing) of ordnance devices.

7.2 VEHICLE TEST REQUIREMENTS

All testing performed during LMLV design, development, manufacture, launch site checkout, and launch operations is planned and controlled through the test requirements specification (TRS) for the LMLV. This encompasses all launch vehicle testing, including the spacecraft mission-peculiar equipment and spacecraft-to-launch vehicle integrated tests.

The TRS documents all phases of testing in an organized, structured format. It provides the visibility necessary to formulate an integrated test program that satisfies overall technical requirements and provides a management tool to control test program implementation.

The TRS consists of six sections that define test concepts, philosophy, and management policies shown in Figure 7.2-1. Subsections consist of the individual test plans for each LMLV component, system, and integrated system and provide

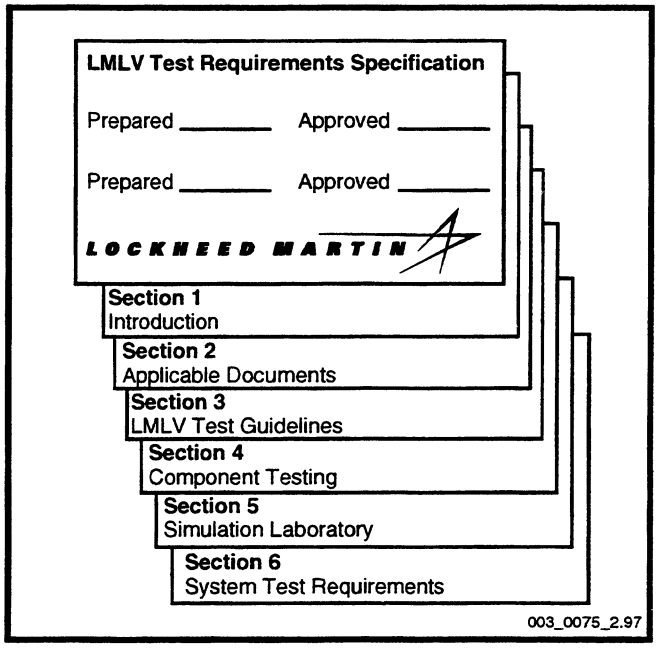

Figure 7.2-1 Test Requirements Specifications

detailed test requirements and parameters necessary to achieve desired test objectives.

Test and Checkout Responsibilities—Lockheed Martin operations personnel are responsible for launch vehicle standalone operations and for the overall conduct of integrated spacecraft/launch vehicle tests and operations. The spacecraft contractor is responsible for the conduct of spacecraft standalone tests and operations.

Specifically, the Lockheed Martin launch site function performs the following major tasks in the test conduct arena:

1) Launch vehicle integration with the spacecraft contractor activities associated with the launch vehicle and the launch complex;
2) Provide overall launch pad operation integration and conduct the final countdown and launch;
3) Organize and chair Mission Integration Working Groups (MIWG) between contractors, as necessary, to provide an integrated spacecraft launch vehicle operation;
4) Represent the launch vehicle operations at the spacecraft, launch vehicle, and launch-base-related working group meetings, joint procedure critiques, and readiness reviews;
5) Prepare and control all launch vehicle-prepared integrated spacecraft/launch vehicle

test procedures and launch vehicle-unique test procedures;

6) Provide integrated safety documentation and monitoring for compliance with the applicable range safety requirements;
7) Provide integrated launch complex schedule;
8) Support spacecraft prelaunch activities;
9) Provide launch complex security;
10) Provide launch complex safety;
11) Conduct readiness reviews at key points during launch vehicle processing.

The spacecraft contractor is responsible for providing all spacecraft-associated test equipment and the logistical and technical support required to support spacecraft launch operations at the launch site. The spacecraft contractor is responsible for the following major tasks in the test conduct arena:

1) Prepare and control spacecraft standalone procedures;
2) Prepare, input, and approve spacecraft and launch vehicle integrated procedures;
3) Attend all launch-base-related working group meetings, integrated procedure critiques, and readiness reviews;
4) Provide safety documentation (e.g., procedures, plans) and monitor compliance with applicable range safety requirements;
5) Plan and, if necessary, implement spacecraft abort activities.

7.3 VEHICLE TEST PROCEDURES

All test operations are performed according to documented test procedures prepared by test operations personnel using the approved TRS subsections together with engineering drawings and specifications. The procedures for testing of LMLV flight hardware are formally reviewed, approved, and released before testing. The procedures are verified as properly performed by inspection and made a part of each vehicle's permanent history file for use in determining acceptance for flight and final launch readiness.

Test procedures are also documented for spacecraft mission-peculiar hardware and joint launch vehicle/spacecraft integrated tests and operations. Customers are urged to discuss their launch operations needs with Lockheed Martin early in the mission planning phase so that various interface and hardware tests can be identified and planned. Customer personnel review and approve mission-peculiar test procedures that involve the spacecraft and participate as required in launch vehicle and spacecraft integrated tests.

7.4 VEHICLE VERIFICATION

The following paragraphs provide an overview of the typical sequence of tests and activities performed during manufacture, prelaunch checkout, major launch readiness operations, and launch countdown of the LMLV launch vehicle. The purpose is to provide customers with an overview of the general flow and overall scope of activities typically performed.

7.4.1 Launch Vehicle Tests

Flight vehicle acceptance tests are performed after final assembly is complete. Functional testing is typically performed at the system level. Lockheed Martin performs a wide range of tests on the OAM, which houses all of the avionics, at Lockheed Martin's Denver facility before shipment to the launch site. These tests include a full integrated systems test with additional LMLV components simulated for completeness. A functional test is also performed at the system level. All testing that is completed on the OAM is controlled through the TRS.

SimLab Mission Software Validation—Lockheed Martin performs rigorous mission software validation in our Simulation Laboratory "SimLab" with the processor package and Litton Inertial Measurement Unit (IMU) hardware. The mission software is loaded into the processor package to run the "end-to-end" flight simulation. Our real-time trajectory simulation commands the 4-axis flight analysis motion simulator (FAMS) at each point along the flight profile. The IMU, mounted on the FAMS, sends position and rate data to the processor package via a 1553 bus. The processor package sends commands to the thrust vector control system (TVCS) of the Castor 120® during first/second-stage flight. During second/third-stage flight, the processor package sends

commands to the TVCS of the Orbus® 21D. The simulation includes all of the attitude control system (ACS) thruster flight phase. The processor package also sends telemetry downlink data for flight communication checkout. Finally, the TVCS feedback real-time nozzle angular positions are sent to the 6-DOF trajectory simulation in the simulation computer to allow calculation of vehicle acceleration. The simulation computer integrates acceleration to predict vehicle motion and to drive the FAMS so that the IMU "thinks" it is flying the mission. Payload fairing separation, OAM maneuvers, and spacecraft separation events are faithfully implemented. This end-to-end, real-time, closed-loop simulation fully checks out mission software and ascent performance before launch. Our LMLV independent verification and validation (IV&V) team reports the results of the end-to-end flight simulation to the LMLV Program Office for review and assessment.

By using the above process, we validate the planned flight trajectory and mission-unique spacecraft separation sequence before each mission. For example, after the mission software is programmed into the flight-qualified processor package the mission software is verified through a bit-by-bit comparison with the master software disk. Embedding mission software in the vehicle's processor package allows us to quickly turn around mission software changes when required.

The "SimLab's" computers perform all-digital as well as real-time hardware tie-in simulations. Real-time simulations allow late changes to the mission software to be incorporated without impacting the launch schedule. Changes in mission parameters, such as orbit inclination and separation altitude, can be implemented in the mission software data tables and then reverified and revalidated in the "SimLab" before launch.

Thiokol and Pratt and Whitney conduct their own testing of the Castor 120® and Orbus® 21D motors, at their respective facilities before shipment to the launch site. Lockheed Martin works with the motor manufacturers to ensure each motor meets its design specifications. These motors are accepted by Lockheed Martin at each manufacturers respective factory.

7.4.2 Launch Site Prelaunch Operations

Figure 7.4.2-1 shows a typical LMLV checkout and launch operations sequence. After arrival at the launch site, all launch vehicle items are inspected before stacking on the launch pad. The Castor 120® and Orbus® 21D are shipped directly to the launch site by Thiokol and Pratt and Whitney, respectively. Each motor undergoes a receiving inspection to confirm that the motors were not damaged during transport. The payload fairing, with nose cap, and payload adapters are also shipped directly from Harlingen to the launch site where a receiving inspection is performed.

Before shipment to the launch site, we subject the OAM, which houses all the avionics, to subsystem testing, hardware-in-the-loop mission software verification and validation in the Lockheed Martin SimLab, and multiple end-to-end system checks at our Denver facility. At the launch site, after stacking the vehicle, we perform vehicle tests, concluding with a complete end-to-end system test and launch rehearsal. We perform the tests, listed in Table 7.4.2-1 as often as required to ensure proper operation of the subsystems. Customer and spacecraft contractor personnel participate in the end-to-end system test and launch rehearsal as well as other spacecraft-specific tests.

RF Tests—Lockheed Martin performs RF tests on the telemetry, C-band transponder, and command destruct subsystems. We run these tests closed-loop to verify LMLV equipment operation and conduct open-loop tests in which the range receivers are brought up to verify the Range interface. RF testing of the spacecraft can be accommodated as a nonstandard item.

Subsystem Tests—All subsystems are subjected to individual tests that verify postshipping operation. We bench-test the C-band transponder and the command destruct subsystems in compliance to Range requirements.

Integrated System Tests—An integrated system test is run on the launch vehicle to determine that all subsystems operate together as in flight. We perform this test sequence several times before the launch rehearsal.

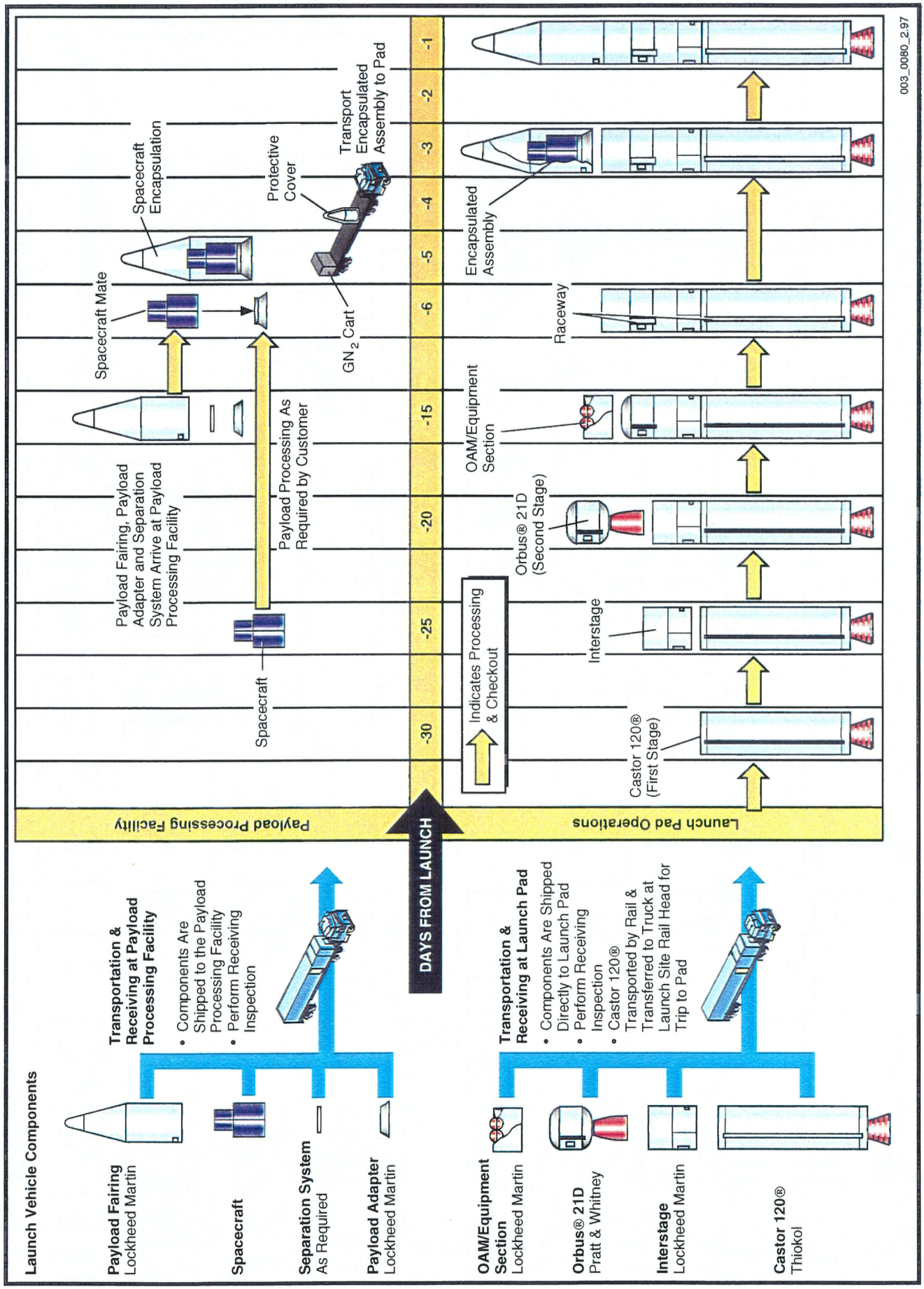

Figure 7.4.2-1 Typical Checkout and Launch Operations Sequence

Table 7.4.2-1 Complete "end-to-end" launch site testing verifies all systems including spacecraft interfaces.

LAUNCHSITE TESTS	OBJECTIVES
Checkout Equipment Verification	Determine That the Launch Control Van & the Utility Room Equipment Are Ready To Perform Launch Vehicle Checkout
Power Distribution Test	Determine That Launch Vehicle Power Is Correctly Applied Through Launch Vehicle Cabling
Grounding, Bonding, & Shielding Test	Determine That Launch Vehicle Packages & Cables & Components Are Correctly Grounded Through Launch Vehicle Cabling & Structure
Telemetry RF Subsystem Test	Verify the Operation of the Telemetry RF Subsystem
C-Band Transponder Subsystem Test	Verify the Operation of the Transponder Subsystem
Command Destruct RF Subsystem	Verify the Operation of the RF Portion of the Destruct Subsystem
Destruct System Test	Determine That the Launch Destruct System Will Operate Properly During Normal Staging, Abnormal Staging, & Command Destruct Scenarios
TVC System Test	Determine That the Launch Vehicle TVC System Will Properly Respond to Steering Commands from the Avionics Package & Activate the Correct Actuator with the Proper Polarity
ACS System Test	Determine That the Launch Vehicle ACS System Will Properly Respond to Steering Commands from the Avionics Package & Activate the Correct Valve with the Proper Polarity
IMU Gyro Compass Test	Determine That the Launch Vehicle IMU Will Gyro Compass & Track Earth Rotation
Instrumentation System Sense Test	Determine That All Instrumentation Is Properly Connected & Data Processed Through the Correct Telemetry Channelization
Integrated System Test	Determine That the Launch Vehicle Will Fly a Mission with All Subsystems Operating As In Flight, with Real Flight Timing & Events Controlling the Sequence
Launch Countdown	Determine That the Launch Vehicle Is Ready for Launch & Perform Launch Sequence 003_0078_2.97

Mission Dress Rehearsal—A mission dress rehearsal (MDR) is conducted to verify the readiness of all ground and flight hardware, all support functions, the launch countdown procedure, and all LMLV and spacecraft system launch operations personnel that have assigned launch countdown responsibilities. Pad operations and selected system responses are simulated. The MDR demonstrates that the integrated LMLV ground, flight, and associated launch support functions, including range operations, are ready to support launch operations

The customer supports the launch vehicle simulated flight and MDR operations. Spacecraft and launch vehicle activities are simulated and participation in the MDR enhances efficiency of personnel and procedures in subsequent integrated tests and the launch operation.

7.4.3 Integrated Operations

Integrated operations begin by preparing the launch vehicle and launch pad for arrival of the spacecraft. Major prelaunch integrated test and operations are discussed in the following paragraphs.

Spacecraft Encapsulation—Spacecraft encapsulation occurs in the Payload Processing Facility (PPF) under the required cleanliness conditions. After the spacecraft has been mated to the payload adapter, it is encapsulated. Final preparation of the payload fairing is completed and the payload fairing is lowered into place over the spacecraft. The payload fairing is mated to the payload adapter at a common field joint.

Transport to the Launch Mount—The encapsulated assembly is placed on an LMLV-provided transport trailer in the airlock of the PPF, and a nitrogen purge is connected through the bag enclosing the encapsulated assembly to prevent the intrusion of moisture or contaminants. Temperature and humidity are monitored until the trailer arrives at the launch mount. The necessary permits and arrangements are made with the relevant authorities in advance of transporting the encapsulated assembly from the PPF to the launch mount. The trailer leaves the PPF and proceeds at a prudent speed to the launch mount. At ER, this typically occurs at night to minimize solar heat load during the 25-mile journey from Astrotech to LC-46. At WR there is usually no such constraint, as the distance from the Integrated Processing Facility (IPF) to the enclosed launch mount at SLC-6 is less than 0.5 miles. A nighttime journey at WR may be necessary at certain times of the year if the Astrotech PPF facility on North VAFB is used rather than the IPF at SLC-6.

Mating to the LMLV—Upon arrival of the encapsulated assembly at the launch pad, we install the hoist adapters and lifting sling, release the assembly from the trailer and lift it to the tower where it is mated to the OAM, as shown in Figure 7.4.3-1. A continuous nitrogen purge into the assembly preserves the clean, dry environment during transport and mating operations. Tag lines are used to stabilize the assembly during the lift and to guide the assembly into position. Once mating is complete, the umbilical is connected and Class 5000 conditioned air is supplied. We supply conditioned air at 200-750 SCFM at 50-75°F (10-24°C). Spacecraft access is provided through two access doors in the payload fairing after the encapsulated assembly has been mated to the OAM.

Spacecraft Testing—After mating of the encapsulated assembly to the LMLV, spacecraft personnel can perform required spacecraft onstack testing and activation checks. All activities will be coordinated with Lockheed Martin to ensure that ongoing launch vehicle activities and spacecraft activities will not conflict. Spacecraft personnel will have access to the spacecraft until T-X hours.

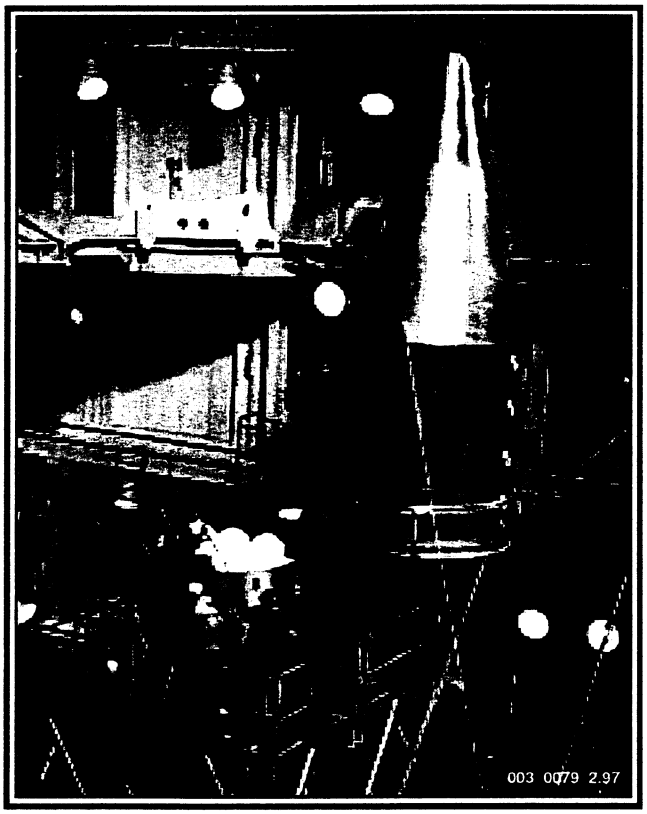

Figure 7.4.3-1 LMLV Mating Operation

Launch Vehicle Activities—After mating the encapsulated assembly to the LMLV, Lockheed Martin continues activities to test and prepare the vehicle for flight. These activities and test include:

1) Installing vehicle destruct units;
2) Test vehicle flight termination system;
3) Installation of flight batteries;
4) Power-on no-voltage test.

Launch Countdown Rehearsal—A joint spacecraft/launch vehicle countdown rehearsal is typically performed on L-2 day. This procedure uses key elements from the respective countdowns arranged on an abbreviated timeline. The objective of this integrated test is to acquaint launch team operations personnel with communications systems, reporting, and status procedures used in the launch countdown. Simulated "holds" are included to rehearse hold and recycle procedures. The operation is critiqued, and recommendations are incorporated as required to improve overall communications procedures. Spacecraft personnel participating in this rehearsal use the actual operating stations they will be assigned for the countdown operation.

7.4.4 Launch Countdown Operations

Lockheed Martin conducts the final launch countdown operations in two phases. Phase I carries the count from approximately T-26 hours to T-2 hours and Phase II carries the count from T-2 hours to launch. The spacecraft contractor supports both phases of the launch countdown. A third launch countdown phase, Phase III, is entered if contingency operations are required as a result of a countdown anomaly or a launch scrub.

Phase I—Table 7.4.4-1 shows a listing of the five task groups that are completed during Phase I. During each task group, several different operations are completed.

Table 7.4.4-1 Phase I Countdown Tasks

TASK	EVENT
Task 1	Verify Launch Support Readiness • Call to Stations • Countdown Clock Initiation
Task 2	Prepare & Commit to Vehicle Arming • Telemetry Systems Test • FTS End-to-End Checks • FTS Open-Loop Checks • S&C Band RF Checks • Missile Liftoff Test Tone • RF Coupler Removal • Weather Briefing
Task 3	Direct Arming of Launch Vehicle & Spacecraft Vehicle • LV Power-Off No-Voltage Tests • Complex Clearing • LV Arming • Continuity Checks • Pad Reopen
Task 4	Prepare Final Facility Closeouts Before Phase II Initiation • LV Closeout • SV Config for Flight & Closeout • Umbilical Release & Retract Cable Rigging • MST Roll & Securing • Camera Bore Sighting • LST Readiness Verification • Utility Room Arming • Final Pad Evacuation
Task 5	Verify Launch Vehicle RF Systems on External Power with Buildings Away • S-Band RF Checks • C-Band RF Checks 003_0072_2.97

Phase II—This phase of the countdown carries the vehicle to launch. Phase II consists of eight modes that prepare the launch vehicle and spacecraft for launch. Table 7.4.4-2 (WR) and Table 7.4.4-3 (ER) show these eight modes and their respective tasks. The spacecraft contractor is required to give a go/no-go for launch Mode-1 at T-4 minutes. The launch vehicle transitions for automatic sequence in Mode-0 at T-60 seconds. The inertial measurement unit (IMU) "Go Inertial" is commanded, followed by a nozzle slew check and ignition arm and fire at T-0.9 seconds.

7.5 LAUNCH CAPABILITY

LMLV was designed to be capable of launching at any time of the day, any day of the year. Launch window restrictions are typically determined by spacecraft mission requirements.

7.6 WEATHER LAUNCH CONSTRAINTS

Weather launch constraints include cloud conditions, lightning, thunderstorms, and ground and upper atmospheric winds. Excessive winds during launch may cause overloading of the vehicle structure and control system. Limiting conditions have been well defined and operational approaches developed to ensure launch within safe limits.

The decision to launch may be constrained if significant weather and/or thunderstorm conditions exist in the proximity of the launch site or the planned vehicle flight path at the time of liftoff. A go/no-go decision to launch is made by the Lockheed Martin launch director based on various environmental factors such as lightning and winds.

Table 7.4.4-2 Phase II Countdown Sequence (WR)

NOMINAL TIME	TIME DURATION	MAJOR EVENTS
-120 min	50 min	RTS Status Checked with OAS/DET 2
-110 min	11 min	Mode -7 Countdown Begins with Manually Enabled Mode Changes; Call to Stations; Prelaunch Checklist Complete; Verify Resistance Measurements of Vehicle Status Through Umbilical Status & Alert Checks
-99 min	5 min	Mode -6 Turn on External Power Supplies; Verify Voltages
-94 min	54 min	Mode -5 Apply External Power; Apply Power, Warm Up & Begin Aligning the IMU
-40 min	10 min	Mode -4 S&C Band Range Checks on External Power; FTS Open-Loop Test on External Power; Final Weather Briefing; MFCO Confirms; Range Clear; Ships, Trains, Personnel; Helicopter Sweep Complete; Radars Are Functional
-30 min	16 min	Mode -3 IMU Reset/Restart
-14 min	10 min	Mode -2 Check Battery Voltage; Apply Internal Power & Remove Tlm Avionics External Power; S&C Band Checks on Internal Power; FTS Open-Loop Test on Internal Power
-4 min	3 min	Mode -1 Check Battery Voltage; FTS Arming; Range Launch Countdown Switch Enable; VTC Launch Countdown Switch Enable; Remove External Destruct Power
-60 sec	1 sec	Mode -0 Go Inertial {PP, IMU); Verify Navigation Performance (IMU); Auto Sequence Begins
-30 sec	15 sec	Ignition Arm Relay
-15 sec	10 sec	TVC-1 Arm & Fire
-8 sec	8 sec	TVC-1 Hydraulic & Helium Pressure Verify
-0.9 sec	0.9 sec	Ignition 1 Arm & Fire/Reset Nav State
T_0		Liftoff
Note: Nominal Time Is from Launch T_0		003_0084_2.97

Table 7.4.4-3 Phase II Countdown Sequence (ER)

NOMINAL TIME	TIME DURATION	MAJOR EVENTS
-130 min	5 min	Mode -7 Countdown Begins with Manually Enable Mode Changes; Call To Status; Prelaunch Checklist Complete: Verify Resistance Measurements of Vehicle Status Through Umbilical; Status & Alert Checks
-125 min	10 min	Mode -6 Turn On External Power Supplies; Verify Voltages; Apply External Power
-115 min	15 min	Mode -5 S&C Band Range Checks on External Power, FTS Open-Loop Test on External Power
-100 min	30 min	Mode -4 Load Mission Software; Bit-by-Bit Check; Check Sum Verification
-170 min	60 min	Mode -3 IMU Alignment; Gyro Compass Verify; Final Weather Brief; MFCO Confirms; Range Clear; Sweep Complete: Radar Functional
-10 min	5 min	Mode -2 Check Battery Voltage; Verify Relative Value of External Power Supply Transfer to Internal Power; S&C Band Checks on Internal Power; FTS Open-Loop Test on Internal Power; Range FTS Switch Enable; Range Launch Countdown Switch Enable
-5 min	4.5 min	Mode -1 FTS Arming; LMLV Launch Countdown Switch Enable
-30 min	0.5 min	Mode -0 Auto Sequence Begins
-29.5 min	19.5 sec	Ignition Arm Play
-10 min	5 sec	TVC-1 Arm & Fire; IMU Switches to Inertial
-5 min	4.1 sec	TVC-1 Hydraulic & Helium Pressure Verify
-0.9 min	0.9 sec	Ignition 1 Arm & Fire
T_0		Liftoff
Note: Nominal Time is from Launch T_0		003_0123_2.97

7.6.1 Avoidance of Lightning

The launch vehicle will not be launched if lightning is detected within 10 nautical miles of the launch site or flight path within 30 minutes of flight. In addition, lightning may delay the launch countdown if it delays movement of the launch access structure.

7.6.2 Ground Winds Monitoring

The launch vehicle will not be launched if sustained ground winds exceed 45 knots, omnidirectional, as measured approximately 200 feet above the pad surface. In addition, ground winds may delay the launch countdown if they are of sufficient strength to delay movement of launch access structure.

7.6.3 Flight Wind Restrictions

The LMLV was designed to maximize launch availability, including the ability to fly through high velocity and upper atmospheric winds. Winds are monitored during launch countdown and evaluated against criteria specified in the launch commit criteria. If upper atmospheric winds exceed these criteria, the launch will be held.

7.7 LAUNCH POSTPONEMENTS

Phase III of the launch countdown is entered if a launch countdown anomaly arises or the launch is scrubbed forcing the vehicle into recycle mode. The vehicle can be recycled for launch within 24 to 72 hours depending on the cause of the scrub. Access to the spacecraft can be accommodated, if required, during scrub timelines. Times of access will be coordinated with the spacecraft contractor during the course of normal integration activities.

8.0 MISSION INTEGRATION AND MANAGEMENT

8.1 INTEGRATION MANAGEMENT

Clear communication between spacecraft and launch vehicle contractors is vital to mission success. Procedures and interfaces have been established to delineate areas of responsibility and authority.

The mission integration and management process defined in this section has been successfully used on many missions, both commercial and government. These identified processes and interfaces have enabled mission integration in as little as 6 months, with 24 months being a more typical schedule.

As an additional information resource, Appendix C of this document details the preferred approach and format for the exchange of data required for mission integration. When necessary, deviations from these specified practices can be accommodated.

8.1.1 Launch Vehicle Responsibilities

Lockheed Martin is responsible for LMLV design, integration, checkout, and launch. This work is performed primarily at the Lockheed Martin South Lincoln Facility in Denver, Colorado. Additional facilities in Harlingen, Texas, support hardware manufacture and structural assembly. Teammates with Lockheed Martin on the LMLV program are Pratt & Whitney (Orbus® 21D Motor), Primex Technologies (OAM Propulsion System), and Thiokol (Castor 120®). As the spacecraft-to-launch vehicle integrating contractor, Lockheed Martin is responsible for payload integration (e.g., electrical, mechanical, environmental, and electromagnetic compatibilities; guidance system integration; mission analysis; software design; range safety documentation and support; launch site processing and coordination). Lockheed Martin produces all launch vehicle-related software for LMLV launches and is responsible for the launch vehicle ascent trajectory, data acquisition, performance analysis, targeting, guidance analysis, and range safety analysis.

8.1.2 Spacecraft Responsibilities

Each spacecraft mission has unique requirements. Interested LMLV users are encouraged to discuss their particular needs with Lockheed Martin. Appendix C, Spacecraft Data Requirements, can be used as a guide to initiating dialogue. Shaded items in Appendix C should be used as the basis for the first face-to-face meeting between Lockheed Martin and the potential user to assist in determining spacecraft/launch vehicle compatibility.

Customers are encouraged to contact Lockheed Martin to verify the latest launch information, including the following:

1) Hardware status and plans;
2) Launch and launch complex schedules;
3) Hardware production schedule and costs.

8.1.3 Integration Organization

For all missions, Lockheed Martin management assigns a mission manager. The mission manager is responsible for overall management of the particular customer activities at Lockheed Martin facilities and at the launch site. This person is the principal interface with the customer for all technical and launch vehicle and spacecraft interface and integration matters.

The Lockheed Martin Mission Manager continues to manage the mission-peculiar engineering aspects of the program by performing the following major tasks during the launch campaign:

1) Provide technical management overview of the launch vehicle/spacecraft launch campaign to ensure compliance to the mission requirements and resolution of requirements issues;
2) Ensure that launch vehicle/spacecraft interface requirements to be verified during launch operations are flowed down to appropriate site checkout and test procedures and parameter/redline documents;
3) Act as engineering focal point, responsible for timely and thorough communication of all issues and decisions within Lockheed Martin engineering and the spacecraft community

and initiate engineering review board (ERB) activity as required;

4) Integrate ICD waiver/deviation requests and disposition with spacecraft community and integrate ICD change activity as appropriate;
5) Manage mission integration schedule to ensure timely completion of Lockheed Martin engineering milestones for the launch campaign and review and approve mission-peculiar technical documentation;
6) Ensure closeout of all mission-peculiar action items.

LMLV responds to a customer order by arranging services from several organizations. LMLV has contracts with the U.S. government for use of launch complexes and payload integration facilities, and with the U.S. Air Force for range and launch site services. Astrotech spacecraft payload integration facilities are contracted for most LMLV launches, with additional support from other government facilities when required.

Lockheed Martin's approach to integration management is through establishment of a formal interface control document (ICD) agreement and formal configuration control after ICD signature. Existing ICDs may be adapted to reduce development time. Coordination of the tasks required to develop and maintain the ICD is accomplished through management and technical working groups.

8.1.4 Working Groups and Responsibilities

In all phases of the mission, from go-ahead to launch, interface activities between the spacecraft and launch vehicle contractors are coordinated by specialized working groups. These groups, which include the spacecraft contractor as an active participant, develop schedules, monitor progress, and ensure that the technical and management tasks are accomplished properly and on time. Figure 8.1.4-1 shows the typical working groups and their responsibilities.

The technical working groups can be tailored to support unique payload integration requirements. It should be noted that technical personnel frequently participate in multiple working groups, where qualifications allow, to minimize the personnel requirements of the participating contractor.

The contractor and the working groups exchange information through minutes and action items developed during the meetings and through control drawings and other documentation.

8.1.4.1 Management Working Group—The technical and program managers comprise the Management Working Group (MWG). This group is responsible for coordinating and managing the work of all mission participants throughout all phases of the mission. This group establishes policy and provides integration guidelines. Where interface incompatibilities are not resolved within the working group structure, the MWG provides

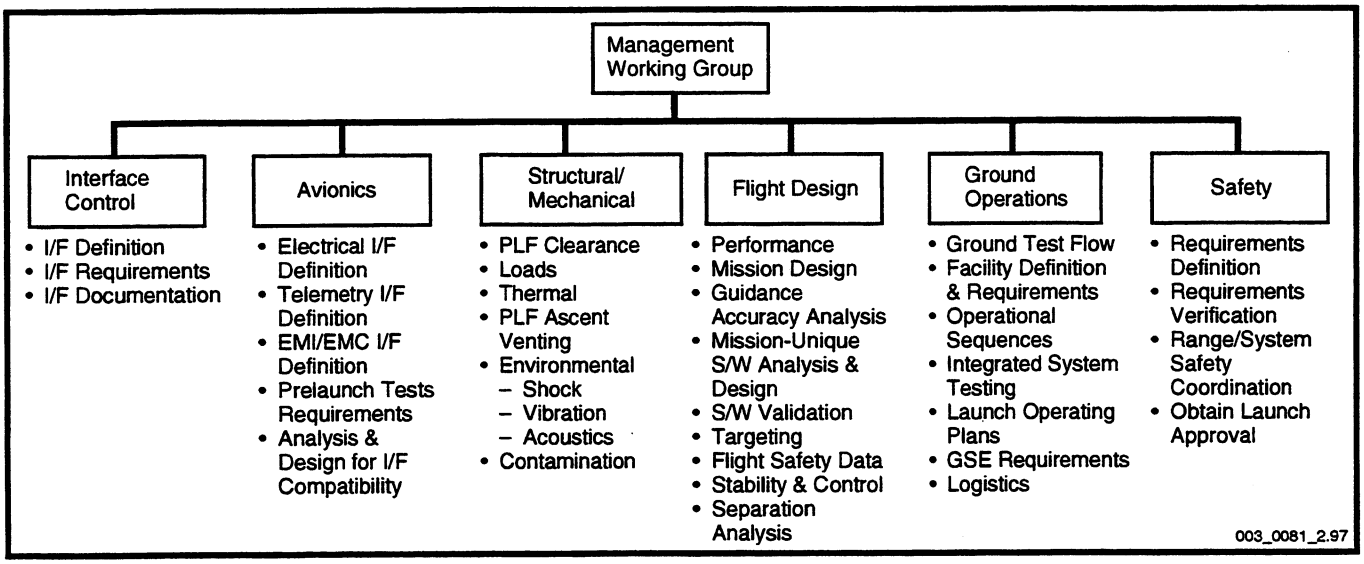

Figure 8.1.4-1 Typical Working Groups and Responsibilities

the direction required to achieve spacecraft and launch vehicle system interface compatibility. The group also manages the mission integration schedule, which monitors integration status including interface documentation, analyses documentation, hardware interchange, and systems and launch operations integrated tests.

8.1.4.2 Technical Working Groups—Technical Working Groups (TWG) are organized by function. TWGs operate under MWG authority. For items that require specialized attention for resolution, technical interchange meetings (TIM) can be called by either the MWG or a working group.

In general, the TWGs convene as required to coordinate integration tasks and schedules. Working group meetings are attended by technical representatives from each organization. Meeting objectives include development of data exchange lists, a review of outstanding action items, a status of scheduled activities, and a discussion of outstanding issues or concerns.

8.1.5 Management Working Group Meetings

The MWG convenes approximately quarterly and is attended by representatives from Lockheed Martin, the spacecraft contractor, and the launch services customer. The Lockheed Martin MWG senior member is the mission manager, who is supported by members of the Lockheed Martin staff as required. The MWG meeting provides an overall program review, including review of the master schedule, approval of program documentation, and review of all outstanding action items and action item closures since the previous MWG.

8.1.6 Integration Program Reviews

During the integration process, reviews focus management attention on significant milestones during the launch system design and launch preparation process. As with the working group meetings, these reviews can be tailored to user requirements; however, for a first-of-a-kind launch, they may include a preliminary and critical mission-peculiar design review and a mission readiness review. For typical spacecraft launches, only one design review is required.

8.1.6.1 Mission-Peculiar Design Reviews—As Lockheed Martin has significant experience with most spacecraft contractors, we have found that one Mission-Peculiar Design Review (MPDR) can successfully meet the goals and requirements that were, in the past, met by both the Preliminary Design Review (PDR) and Critical Design Review (CDR). Approximately midway through the mission integration process, the MPDR is conducted to ensure that customer requirements have been correctly and completely identified and that integration analyses and designs meet these requirements. Lockheed Martin prepares and presents the reviews with participation from the spacecraft contractor, launch services customer, and launch vehicle management.

For missions in which the spacecraft requires unique interfaces with the launch vehicle or the launch vehicle mission is unlike other previously flown missions, two design reviews may be proposed by Lockheed Martin after discussions with the launch services customer and spacecraft contractor.

8.1.6.2 Mission Readiness Review—The Mission Readiness Review (MRR), conducted approximately 2 days before launch, provides a final prelaunch assessment of the integrated spacecraft and launch vehicle system and launch facility readiness. The MRR provides the forum for final assessment of all launch system preparations and the contractors' individual certifications of launch readiness.

8.1.7 Integration Control Documentation

8.1.7.1 Program Master Schedule—This top-level schedule is prepared by Lockheed Martin and monitored by the MWG. It maintains visibility and control of all major program milestone requirements, including working group meetings, major integrated reviews, design and analysis requirements, and major launch operations tests. It is developed from the tasks and schedule requirements identified during the initial integration meetings and is used by all participating organizations and working groups to develop and update subtier schedules.

8.1.7.2 Interface Control Document—This document defines spacecraft-to-launch vehicle and launch complex interfaces. All mission-peculiar requirements are documented in the ICD. The ICD is prepared by Lockheed Martin and is under configuration control after formal signoff. The document contains the appropriate technical and functional requirements necessary to ensure a successful launch.

8.2 MISSION INTEGRATION ANALYSIS

In support of a given mission, Lockheed Martin will perform the analyses summarized in Table 8.2-1.

This table indicates the specific output of the analyses to be performed, required spacecraft data, the timing during the integration cycle that the analysis is completed, and the application of the analyses to first-of-a-kind and follow-on missions. In this context a follow-on mission is an exact copy of a previous mission, with no change to the functional requirements or physical interfaces. Table 8.2-1 represents the standard integration analyses. For many missions, Lockheed Martin uses generic versions of these analyses and may not be required to perform a mission-peculiar version.

Figure 8.2-1 is our preliminary schedule for a typical LMLV mission. The full-scale integration process begins at approximately launch minus 24 (L-24) months.

The following paragraphs describe the integration analyses.

8.2.1 Coupled Loads Analysis

Lockheed Martin will perform mission-peculiar coupled loads analyses where launch vehicle and payload parameters may be affected. Included are:

1) Spacecraft loading and loss of clearance evaluation for the critical flight events of all motor ignition and resonance events;
2) Flight wind launch availability assessment;
3) Payload fairing (PLF) jettison evaluation applicable to a mission spacecraft.

Analysis of all events uses state-of-the-art finite element models of the booster coupled with a customer-supplied dynamic math model of the spacecraft. Appendix C of this document provides a description of the type and format of the dynamic model.

8.2.2 Integrated Thermal Analysis—Preflight and Flight

Lockheed Martin performs an integrated launch vehicle and spacecraft analysis of the thermal environments imposed on the spacecraft under prelaunch conditions and for flight mission phases up to spacecraft separation. The integrated thermal analysis (ITA) is performed with customer-supplied spacecraft geometric and thermal math models and a detailed spacecraft power dissipation timeline. The results are provided to the customer for evaluation and can be used to design thermal interfaces and mission operations to maintain predicted spacecraft temperatures within allowable limits.

In addition to the ITA, Lockheed Martin performs PLF aeroheating analyses and free molecular heating analyses to verify compliance with customer ICD thermal requirements and thermal requirements derived from the ITA.

Thermal analyses ensure that vehicle design is compatible with and has adequate margins over proposed spacecraft thermal constraints. Analyses include assessment of vehicle aeroheating, PLF surface temperature ranges, maximum and minimum prelaunch air conditioning temperatures and velocities, and spacecraft-to-launch vehicle interface temperature ranges.

PLF internal surface temperature ranges are predicted by analyzing flight aerodynamic heating using our thermal analyzer computer program.

PLF jettison time is selected to meet the spacecraft free molecular heating constraint. LMLV missions ensure a benign spacecraft thermal environment by selecting jettison time based on a flight program calculation of three-sigma maximum qV during flight.

8.2.3 Payload Fairing Venting Analysis (Ascent Phase)

A venting analysis is performed on the PLF to determine the mission-peculiar pressure profiles in the payload compartment during launch vehicle ascent. Existing models that have been validated

Table 8.2-1 Summary of Mission Integration Tasks (Part 1 of 2)

ANALYSIS	S/C DATA	ANALYSIS PRODUCTS	NO. OF CYCLES	SCHEDULE	FIRST-OF-A-KIND	FOLLOW-ON
1. Coupled Loads	S/C Dynamic Math Model	• S/C Loads • Dynamic Loss of Clearance	2	Model Delivery + 4 mo	X	
2) Integrated Thermal	S/C Geometric & Thermal Math Models & Power Dissipation Profile	• S/C Compnt Temp • Prelaunch Gas Cond & Set Points	1	Model Delivery + 6 mo	X	
3) PLF Venting	S/C Venting Volume	• Press Profiles • Depressurization Rate	1	S/C Data + 2 mo	X	
4) Critical Clearance	S/C Geometric Model; S/C Dynamic Model	• S/C-to-PLF Loss of Clearance (Dynamic + Static)	2	S/C Model Delivery + 4 mo	X	
5) PLF Jettison Clearance	S/C Geometric Model	• P/L Clearance Margin During PLF Jettison Event	1	Design Review	X	
6) S/C Separation & Clearance	S/C Mass Properties	• S/C Sep Clearance • S/C Sep Att & Rate & Spin-Up Verification	1	Design Review	X	
7) Postseparation Clearance		• LV-S/CSep History	1	Design Review	X	
8) Pyro Shock	S/C Interface Definition	• S/C Shock Environment	1	Design Review	X	
9) Acoustics	S/C Geometry Fill Factors	• S/C Acoustics Environment	1	Design Review	X	
10) EMI/EMC	• S/C Radiated Emissions Curve • S/C Radiated Susceptibility Curve • S/C Rec Op & Demise Thresholds • S/C Diplexer Rejection	• Confirmation of Margins • Integrated EMI/EMC Analysis	1	Design Review	X	
11) Contamination	S/C Contamination Limits for Sensitive, Critical Vertical & Horizontal Surfaces	• Contamination Analysis • Contamination Assessment	1	Design Review	X	
12) RF Link Compatibility & Telemetry Cov (Airborne)	S/C Transmitter & Receiver Characteristics	• Link Margins • ARIA Positioning Requirements	1	Design Review	X	
13) RF Link Compatibility & Telemetry Cov (Ground)	S/C Transmitter & Receiver Characteristics	• Link Margins • Identify Required Hardware	1	Design Review	X	
14) Performance	S/C Mass & Mission Requirements Definition	• Trajectory Analysis Report	3	ATP + 3 mo Design Review Final Targeting		X
15) Stability		• Control System Margins • ACS Use	1	L-2 mo		
16) Mass Properties		• Mass Properties of LV	1	Coincident with Perf Reports		X
17) Trajectory Analysis	S/C Mass & Mission Requirements Definition	• LV Ref Trajectory • Performance Margin	1	Design Review	X	X
18) Guidance Analysis	Mission Requirements	• VeGA Guidance Algorithms • Mission Targeting Cap & Accuracies	1	Design Review	X	
19) Injection Accuracy	Mission Requirements	• LV System Orbit Injection Accuracy	1	Design Review	X	
20) Launch Window	Window Definition	• Window Durations	1	Design Review	X	X
21) Wind Placard	S/C Mass Properties	• LV Ground & Flight Winds Restrictions	1	Design Review	X	
22) Range Safety	S/C Breakup Data & Propulsion Characteristics	• Trajectory Data & Tapes for Range Approval	2	L-1 yr, Prelim L-7 wk, Final		

Table 8.2-1 Summary of Mission Integration Tasks (Part 2 of 2)

ANALYSIS	S/C DATA	ANALYSIS PRODUCTS	NO. OF CYCLES	SCHEDULE	FIRST-OF-A-KIND	FOLLOW-ON
23) Electrical Compatibility	Electrical Interface Requirements	• End-to-End Circuit Analysis	1	Design Review	X	X
24) Postflight		• Flight Eval of Mission Data, LV Perf & Environ	1	L + 60/days		
25) Destruct System		• Confirmation of Meeting Range Safety Rqmts	1	Design Review	X	
26) Mission Targeting	Orbit Requirements	• VeGA I-Loads • Discrete Command Events	1	L-1 mo		X
27) Flight Software	Mission Requirements	• Flight Software	1	L-3 weeks		X

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with flight data are used for this analysis. The analysis incorporates the customer-provided spacecraft venting configuration and any mission-specific PLF requirements (e.g., thermal shields). Analysis outputs provided to the customer can include PLF pressure profiles and depressurization rates as a function of flight time.

8.2.4 Critical Clearance Analysis (Loss of Clearance)

A spacecraft-to-launch vehicle loss of clearance analysis is performed with the coupled dynamic loads analysis (Sect. 8.2.1). The clearance loss as a result of the dynamic response of the spacecraft and launch vehicle during major events is combined with static deflections, manufacturing stackup tolerances, and misalignments. These values are compared against the allowable payload envelope.

8.2.5 Payload Fairing Jettison and Loss of Clearance Analyses

Verification of payload clearance during PLF jettison is performed using the effects of thermal preload, disconnect forces, shear pin forces, actuator forces, and dynamic response in a fully 3-D nonlinear analysis.

8.2.6 Spacecraft Separation Analysis

Extensive Monte Carlo analysis of the preseparation dynamics, using a 3-degree-of-freedom (DOF) simulation of the vehicle demonstrates compliance with all spacecraft attitude pointing and angular rate and spin rate requirements under nominal and three-sigma dispersions.

A two-body 6-DOF Monte Carlo simulation of the launch vehicle and spacecraft separation event is performed using finalized spacecraft mass properties to verify that OAM will not recontact the spacecraft after separation system release. This analysis demonstrates the minimum relative separation velocity, ensuring that adequate separation distance is achieved before initiating any postseparation OAM maneuvers.

8.2.7 Spacecraft Postseparation Clearance Analysis

After the spacecraft has separated from the launch vehicle, the LMLV OAM performs a collision and contamination avoidance maneuver (CCAM). The OAM attitude control system uses hydrazine thrusters to perform this maneuver.

The CCAM is designed to positively preclude physical recontact with the spacecraft and eliminate the possibility of significant impingement of OAM effluents on the spacecraft. The typical CCAM maneuver involves turning the OAM normal to the spacecraft flight plane and firing the hydrazine thruster to depletion in an attempt to de-orbit the OAM as much as possible and to preclude rupture of the hydrazine tanks.

8.2.8 Pyroshock Analysis

The spacecraft pyroshock environment is maximum for the spacecraft separation event. PLF separation and launch vehicle staging are also significant events, but the distances of the shock sources from the spacecraft and launch vehicle interface make them less severe for the spacecraft than activation of the payload separation system.

8.2.9 Acoustic Analysis

Analysis of the acoustic environment of the payload compartment includes effects of noise reduction of the PLF and payload fill factors. Verification includes flight measurements taken from

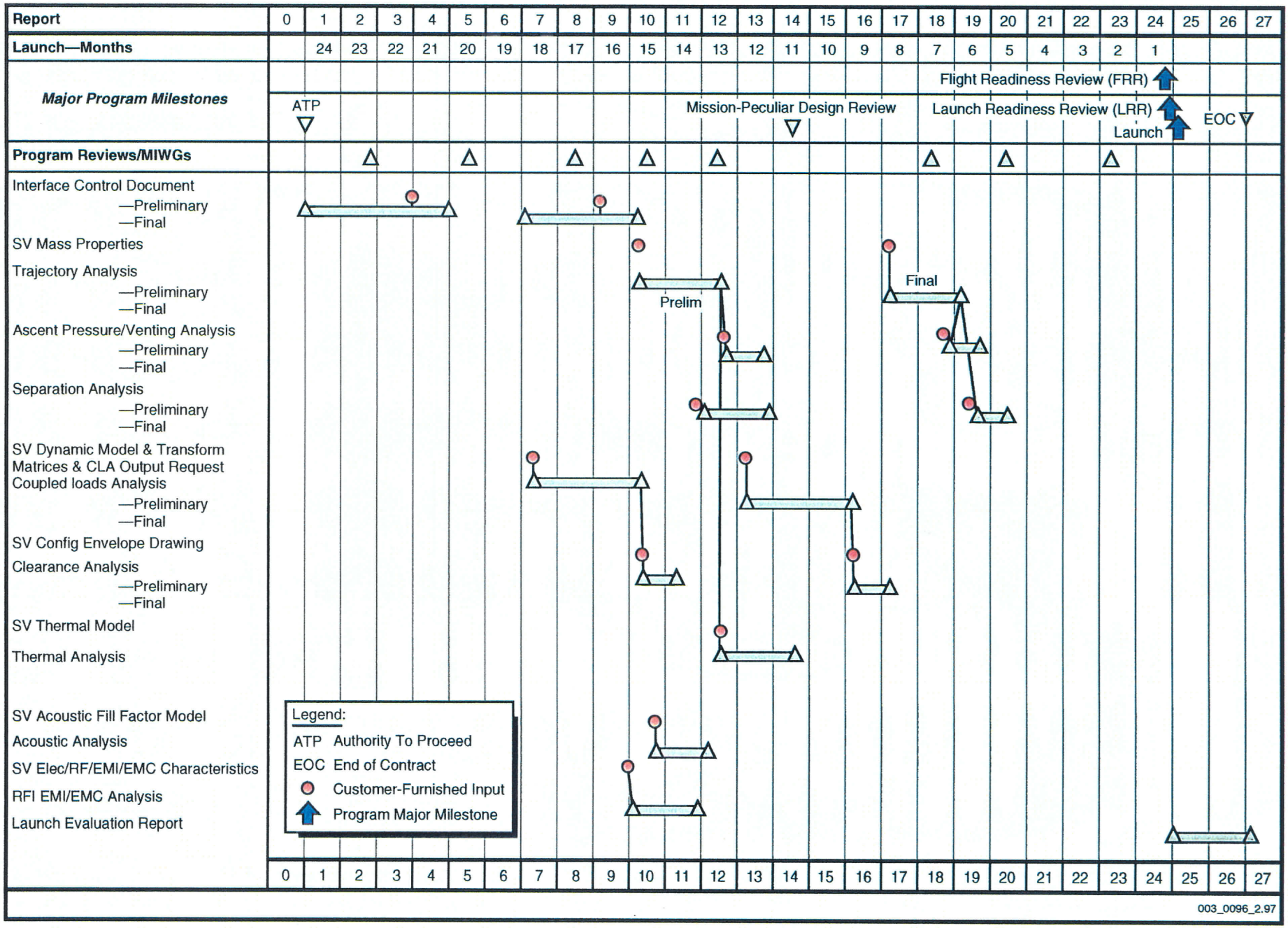

Figure 8.2-1 Typical Mission Integration Schedule

flight and ground acoustic tests of representative PLF/payload configurations.

8.2.10 Electromagnetic Interference/ Electromagnetic Compatibility Analysis

Lockheed Martin maintains an electromagnetic interference/electromagnetic compatibility (EMI/EMC) plan to ensure compatibility between all avionics equipment. This plan covers requirements for bonding, lightning protection, wire routing and shielding, and procedures. Lockheed Martin analyzes both intentional and unintentional RF sources to confirm 6-dB margins with respect to all general EMI/EMC requirements. In addition, an electro-explosive device (EED) RF susceptibility analysis is performed to the requirements of the range. This analysis is intended to confirm 20-dB margin with respect to the EED no-fire power.

8.2.11 Contamination Analysis

Lockheed Martin provides new spacecraft with an assessment of contamination contributions from launch vehicle sources, as required. Starting from PLF encapsulation of the spacecraft through separation, contamination sources are identified and analyzed. This assessment provides a first-order contamination analysis to allow the spacecraft user to determine final onorbit contamination budgets. A more detailed mission-peculiar analysis can be provided to the spacecraft after identification in the ICD.

Lockheed Martin also implements a contamination control plan that ensures hardware cleanliness from the manufacturing phase through launch operations. Material control, ground support hardware cleanliness, and contamination monitoring are specified and implemented through the contamination control plan. A mission-unique appendix can supplement the contamination control plan if the mission-specific requirements identified in the ICD are more stringent than those baselined in the control plan.

8.2.12 RF Link Compatibility and Telemetry Coverage Analysis (Airborne)

Lockheed Martin conducts an airborne link analysis on all RF links between ground stations and the LMLV. The systems analyzed are the S-band telemetry system, the active C-band vehicle tracking system, and the flight termination system. Lockheed Martin uses a program that takes into account airborne and ground station equipment characteristics and vehicle position and attitude. When advanced range instrumentation aircraft (ARIA) are required, Lockheed Martin analyzes the mission support positions of the aircraft to maximize link capabilities.

Lockheed Martin conducts an RF compatibility analysis between all airborne RF transmitters and receivers to ensure proper function of the integrated system. The transmit frequencies and their harmonics are analyzed for potential interference to each active receiver. In addition, strong site sources such as C-band radar are also analyzed. The spacecraft contractor provides details of the active transmitters and receivers for this analysis.

8.2.13 RF Link Compatibility and Telemetry Coverage Analysis (Ground)

Lockheed Martin conducts a ground link analysis on the spacecraft RF systems to ensure that a positive link exists between the spacecraft and the spacecraft checkout equipment to check out the spacecraft telemetry and command system. Information concerning spacecraft requirements is contained in the ICD.

8.2.14 Performance Analysis

The capability of LMLV to place the spacecraft into the required orbit(s) is evaluated through our trajectory simulation program, POST. Vehicle performance capability is provided through our configuration, performance, and weight status report. This report is tailored to accommodate the needs of specific missions.

The status report provides a comprehensive listing of the vehicle configuration, mission-peculiar groundrules and inputs, and vehicle masses for performance analysis. The detailed trajectory simulation used for the performance assessment is provided as an appendix to the report.

8.2.15 Stability and Control Analysis

Linear stability analysis, primarily frequency response and nonlinear time-varying 6-DOF simulation is performed to determine the LMLV

autopilot configurations; establish gain and filter requirements for satisfactory rigid body, slosh, and elastic mode stability margins; verify vehicle/ launch stand clearances; and demonstrate OAM ACS maneuver and attitude hold capabilities. Uncertainties affecting control system stability and performance are evaluated through a rigorous stability dispersion analysis. Tolerances are applied to vehicle and environmental parameters and analyzed using frequency response methods, ensuring that the LMLV autopilot maintains robust stability throughout the defined mission.

8.2.16 Mass Properties Analysis

Lockheed Martin performs mass properties analysis, reporting, and verification to support performance evaluation, structural loads analysis, control system software configuration development, ground operations planning, airborne shipping requirements, and customer reporting requirements.

8.2.17 Trajectory Analysis and Design

The Lockheed Martin trajectory design process ensures that all spacecraft, launch vehicle, and range-imposed environmental and operational constraints are met during flight, while simultaneously providing performance-efficient flight designs.

The trajectory design and simulation process provides the vehicle performance capability for the mission. It provides the basis, by the simulation of non-nominal vehicle and environmental parameters, for the analyses of FPR and injection accuracy. Telemetry coverage assessment, RF link margins, PLF venting, and in-flight thermal analyses also rely on the reference mission design. The trajectory design is documented in the status report (Sect. 8.2.14). Detailed insight into the tradeoffs used for the trajectory design is provided in the trajectory design report.

8.2.18 Guidance Analysis

Analyses are performed to demonstrate that spacecraft guidance and navigation requirements are satisfied. Analyses include targeting, standard vehicle dispersions, extreme vehicle dispersions, and guidance accuracy. The targeting analysis verifies that the guidance program achieves all mission requirements across launch windows throughout the launch opportunity. Standard vehicle dispersion analysis demonstrates that guidance algorithms are insensitive to 3-sigma vehicle dispersions by showing that the guidance program compensates for these dispersions while minimizing orbit insertion errors. Extreme vehicle dispersions and failure modes are selected to stress the guidance program and demonstrate that the guidance software capabilities far exceed the vehicle capabilities.

8.2.19 Injection Accuracy Analysis

The guidance accuracy analysis combines vehicle dispersions and guidance hardware and software error models to evaluate total guidance system injection accuracy. Hardware errors model the off-nominal effects of the guidance system gyros and accelerometers. Software errors include Inertial Measurement Unit (IMU) computation errors and vehicle dispersion effects. Positive and negative dispersions of more than 30 independent vehicle and atmospheric parameters that perturb vehicle performance are simulated.

8.2.20 Launch Window Analysis

Launch window analyses are performed to ensure the proper launch vehicle and spacecraft launch constraints are understood. Customers are requested to provide the opening and closing times for the maximum launch window the spacecraft is capable of supporting.

Some missions may have more complicated window constraints requiring analysis by Lockheed Martin. For example, launch system performance capability constrains the windows for missions that require precise control of the right ascension of the ascending node. That control is achieved by varying the trajectory as a function of launch time.

8.2.21 Wind Placard Analysis (Prelaunch, Flight)

Stress analyses of the LMLV configurations have been performed to determine loading for both ground and flight wind conditions. This information, combined with launch site wind statistics, is

used to determine the wind placards and subsequent launch availability for any given launch date.

8.2.22 Range Safety Analyses

Lockheed Martin performs the flight analyses required to comply with Eastern/Western Range Regulations for both the request for preliminary flight plan approval and the more detailed submittal for final flight plan approval. These submittals occur approximately 1 year before launch for the initial request and approximately 45 days before for the second. Reports and magnetic tapes of the required information are provided to the range agency in the required formats, and include nominal and non-nominal trajectories and the impact locations of jettisoned hardware. During spacecraft integration, a range support plan is prepared documenting our planned coverage.

8.2.23 End-to-End Electrical Compatibility Analysis

Lockheed Martin conducts an end-to-end electrical circuit analysis to verify proper voltage/current parameters as well as any required timing/sequencing interfaces between all the spacecraft and launch vehicle airborne interfaces (through to the end function). This analysis requires data from the spacecraft, such as pin assignments, wiring interfaces, and circuit detail of avionics (first level) to verify end-to-end (spacecraft-to-launch vehicle) compatibility. All "in-between" wiring/circuits are analyzed to verify proper routing, connections, and functionality of the entire system interface. This analysis is documented as part of the ICD verification process and used to generate inputs for all necessary launch site interface testing.

8.2.24 Postflight Data Analysis

For LMLV missions, Lockheed Martin uses an effective analysis technique to obtain the individual stage payload performance capabilities derived from available flight test data. The main outputs of the analysis are (1) launch vehicle stage performance with respect to the predicted nominal and (2) the average thrust and specific impulse of the stages. In addition to these outputs, the postflight performance report presents historical data for past flights of similar family and the statistics of the outputs of principal interest.

A principal input into the postflight analysis is flight telemetry data of the actual variables as function of time from the onboard flight computer. Times of key vehicle mark events are also required. The actual vector states of radius and velocity at stage shutdown, compared to the predicted nominal values, provide sufficient knowledge to obtain the stage performance.

In addition to the performance evaluation of the launch vehicle, the postflight report provides an assessment of the injection conditions in terms of orbital parameters and deviations from the target values, and spacecraft separation attitude and rates.

Finally, the report documents the payload environments to the extent that the launch vehicle instrumentation permits. These environments include interface loads, acoustics, vibration, and shock.

8.2.25 Destruct System Analysis

Lockheed Martin updates the airborne segment of the detailed description of the LMLV range safety system, including a full analysis of system safety and reliability for each mission as required. The analysis includes the qualification status of each component and a summary of component and system-level testing. The analysis also includes worst-case component, battery, cordage, connectors, firing, squib parameters, and timing. It is designed to evaluate the tolerance to single-point failure, RF pattern capability, critical resistance, RF sensitivity, voltage standing-wave ratio (VSWR), and insertion loss. Our range safety system is evaluated with respect to meeting the requirements of EWR 127-1.

8.2.26 Mission Targeting

Mission targeting is conducted to define the target orbit parameters that will be used to guide the launch vehicle into the desired orbit. This process requires a target specification from the spacecraft agency and results in the publication of the Velocity Guidance Algorithm (VeGA) I-loads integrated into the mission-peculiar flight software

used to load the flight processor package and the mission-peculiar discrete command events.

8.2.27 Mission-Peculiar Flight Software

Our mission-peculiar software activity for mission integration is a controlled process that ensures the generation and release of the flight software to support the launch schedule. Our modular software design minimizes the impact of changes resulting from mission-peculiar requirements. The mature system of development and controls at Lockheed Martin, in place and operational for all missions, is used to customize a reliable, tested product specifically designed to satisfy new mission requirements.

The flight software baseline encompasses all the functionality needed to fly most typical LMLV missions.

A complete software validation test program is run using the specific mission trajectory to validate the flight software for nominal, 3-sigma dispersed, severe stress, and failure mode environments before flight. Testing and validation is completed in our Hardware-in-the-Loop Laboratory (HWIL), which includes flight-like avionics components.

8.3 POLICIES

This section is intended to provide potential and current launch services customers with information concerning some management, integration, and production policies to ensure efficient integration and launch of the customer's payload.

8.3.1 Launch Vehicle Logos

As part of our standard launch service, the LMLV program offers customers the option of placing a mission or company logo on portions of that mission's PLF hardware. The logo can be placed almost anywhere on the PLF cylindrical section. Delivery of the customer PLF logo design is a schedule milestone required to support nominal assembly spans for PLF fabrication. Logo changes or modifications proposed by customers after this milestone may be accommodated in the following manner:

1) Area of application is confined to the PLF;
2) All art and material for the design will be supplied by the requester;
3) Art should be designed to account for parallax distortions caused by the slope of the PLF;
4) Requester-supplied materials (art, adhesives, etc) shall comply with LMLV program;
5) Changes will be supplied at a time that supports the scheduled PLF completion date at our Harlingen facility.

8.3.2 Launch Scheduling

Missions are contracted and scheduled into available launch opportunities, typically 24 months in advance. The earlier a desired schedule position is contracted for, the more likely it will be available.

Scheduling and rescheduling launches in the manifest requires the equitable treatment of all customers. Sequential scheduling of launches in the queue, the customer's position in the queue, and vehicle processing flow time will dictate earliest launch date(s). Lockheed Martin endeavors to fill each position in the queue. Consequently, once in queue, close coordination is required should the customer desire rescheduling. Rescheduling requires mutual agreement on the selection of available launch opportunities offered by Lockheed Martin.

8.3.3 Spacecraft Launch Window Options

LMLV can be launched at any time of the day year round. However, seasonal weather patterns should be considered in setting launch windows when possible.

8.3.3.1 Spacecraft Launch Window Duration—Any launch window duration can be accommodated. However, a window of between 45 minutes and 120 minutes is recommended. Shorter windows increase the risk of a launch delay if exceeded due to weather or technical problem resolution. Windows longer than 2 hours may be limited by crew rest limits.

9.0 SYSTEM ENHANCEMENTS

LMLV system enhancements discussed in this section are available to the customer to support specific mission requirements. Cost savings or additions associated with these enhancements will be passed on to the customer.

9.1 ORBUS 21D

Attractive performance upgrades to the Orbus® 21D motor can reduce weight and increase motor specific impulse, resulting in a significant increase in LMLV payload capability. Four motor upgrades have been identified as shown in Figure 9.1-1. These upgrades are primarily the incorporation of a graphite epoxy case, designated the Orbus 21G, and incorporation of a carbon-carbon (C-C) exit cone, designated the Orbus 21HP.

9.1.1 Orbus 21G Description

The Orbus 21G primarily incorporates a graphite epoxy case as well as reduced instrumentation and more efficient use of insulation materials on the aft dome of the motor. The graphite epoxy case (total graphite epoxy pressure vessel and skirts) reduces the weight of the motor by approximately 180 lb (82 kg) and provides stronger skirts capable of supporting higher loads, i.e., heavier payloads. The reduced instrumentation and insulation upgrades further reduce the weight of the motor by approximately 30 lb (13 kg) for a total weight reduction of approximately 210 lb (95 kg). This weight reduction corresponds to an increase in payload weight-to-orbit of approximately 160 lb (70 kg), which is both vehicle configuration and orbit dependent. Please contact Lockheed Martin for increases in payload weight-to-orbit for specific vehicle configurations and orbits.

The graphite epoxy case design will incorporate Pratt & Whitney's Chemical Systems Division (CSD) proven design heritage, test, and operational experience with graphite epoxy motor cases. Included in this experience is the transition by CSD from Kevlar to graphite epoxy on a similar motor used as a vehicle's third stage. This third stage motor case was originally designed and manufactured using the same Kevlar epoxy system as the Orbus 21/21D. It was subsequently redesigned with graphite epoxy during development to provide increased performance capability through a significant reduction in case inert weight. This case transition was accomplished with complete success, starting with the first graphite case that was built and tested.

The proposed graphite epoxy case qualification program will take advantage of CSD's

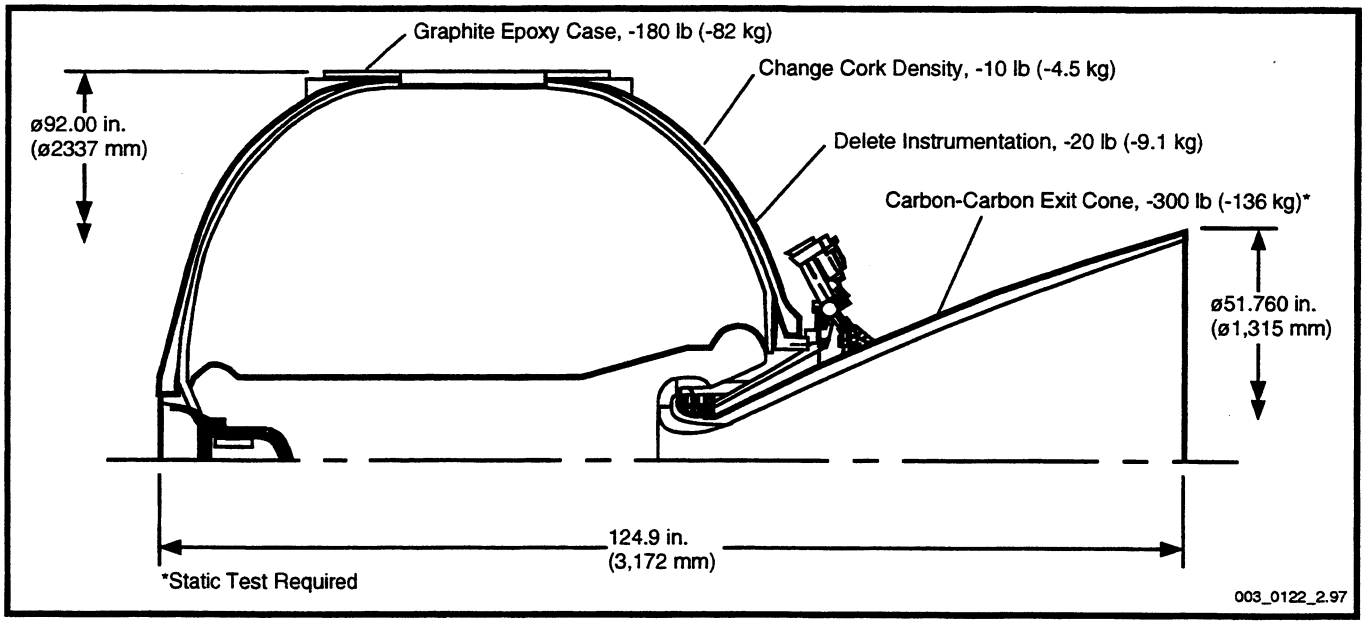

Figure 9.1-1 Orbus® 21D Weight Reduction Initiatives—Weight Deltas

extensive graphite epoxy case design, manufacturing, and test experience. The program will consist of hydroproof, structural, and burst testing of a graphite epoxy case. This test series, along with conservative design factors, will verify the integrity of the design/analysis and provide the rationale for using the graphite epoxy case on LMLV. Development of the Orbus 21G through initial launch capability is approximately 24 months.

9.1.2 Orbus 21HP Description

The Orbus 21HP incorporates all of the upgrades of the Orbus 21G as well as a C-C exit cone. The C-C exit cone reduces the weight of the motor by approximately 325 lb (147 kg) and provides a higher specific impulse (Isp) of as much as 2 seconds. This weight reduction corresponds to an increase in payload weight-to-orbit of approximately 240 lb (110 kg), which is vehicle configuration and orbit dependent. The higher Isp corresponds to an increase in payload weight-to-orbit of approximately 50 lb (20 kg), which is more vehicle configuration and orbit dependent. Please contact Lockheed Martin for increases in payload weight-to-orbit for specific vehicle configurations and orbits.

The Orbus 21HP development program maximizes the design heritage of the existing Orbus 21D motor configuration, thus minimizing program risk, schedule, and cost. The basic nozzle design will be virtually identical to the Orbus 21/21D heritage, incorporating the same movable joint design conservatism of the Orbus 21D along with the exit cone/nozzle throat attachment qualified on the Orbus 21. CSD will use existing technology and methods to produce the C-C exit cone. The thrust vector control (TVC) electromechanical actuation system (EMA) will be unchanged from the Orbus 21D. All interface characteristics will remain unchanged, making the Orbus 21 HP interchangeable with the Orbus 21D on LMLV.

To meet LMLV requirements, the Orbus 21D nozzle went from a preexisting C-C exit cone to a more robust and lower cost carbon phenolic exit cone. The exit cone also included other enhancements to improve design margins. The new Orbus 21HP nozzle will retain these enhancements as well as all other design improvements currently used on the Orbus 21D.

The C-C exit cone was flight qualified on the inertial upper stage (IUS) (Orbus 21), the transfer orbit stage (TOS) perigee kick stage (Orbus 21), and the perigee kick stage of the Intelsat Vl (Orbus 21S). The proposed C-C exit cone qualification program will consist of an altitude motor test firing to qualify the nozzle. This test, along with conservative design factors, will verify the integrity of the design and analysis and provide the rationale for using the C-C exit cone on LMLV. Development of the Orbus 21HP through initial launch capability (ILC) is approximately 24 months.

9.2 MODEL 120 PAYLOAD FAIRING

Lockheed Martin has investigated the use of a 120-in. (3048-mm) diameter payload fairing, designated the Model 120. The Model 120 payload fairing, shown in Figure 9.2-1, has been designed for use on the LMLV2 to accommodate larger and heavier payloads. The Model 120 payload fairing can be made to support specific mission requirements in approximately 18 months.

9.2.1 Payload Fairing Usable Volume

The payload fairing's dynamic envelope accounts for structural tolerances as well as static and dynamic deflections. Clearance at the aft end of the envelope is necessary to accommodate the "boat tail" during payload fairing jettison. Figure 9.2.1-1 shows the dynamic envelope of the Model 120 payload fairing with the Model 66 payload adapter. Any of the five standard payload adapters, Models 24, 37, 38, 47 or 66, can be used with the Model 120 payload fairing.

9.3 ALTERNATE LAUNCH SITES

Lockheed Martin is investigating the use of alternate launch sites to achieve additional inclinations using launch azimuths not available from our launch sites at the Eastern Range (ER) and at the Western Range (WR) and to enhance launch site flexibility. Wallops Flight Facility (WFF) among others is being considered.

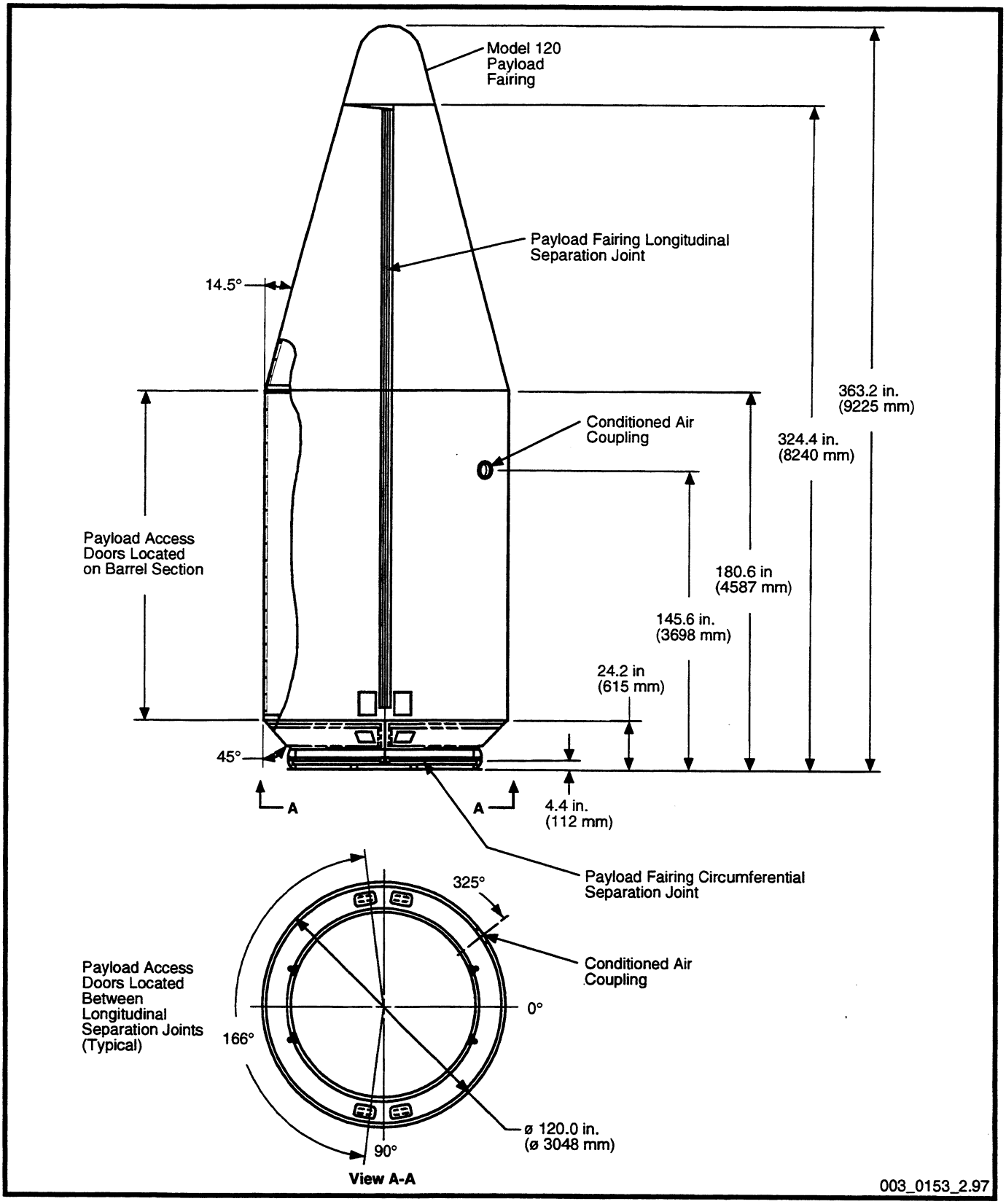

Figure 9.2-1 LMLV Planned Model 120 Payload Fairing

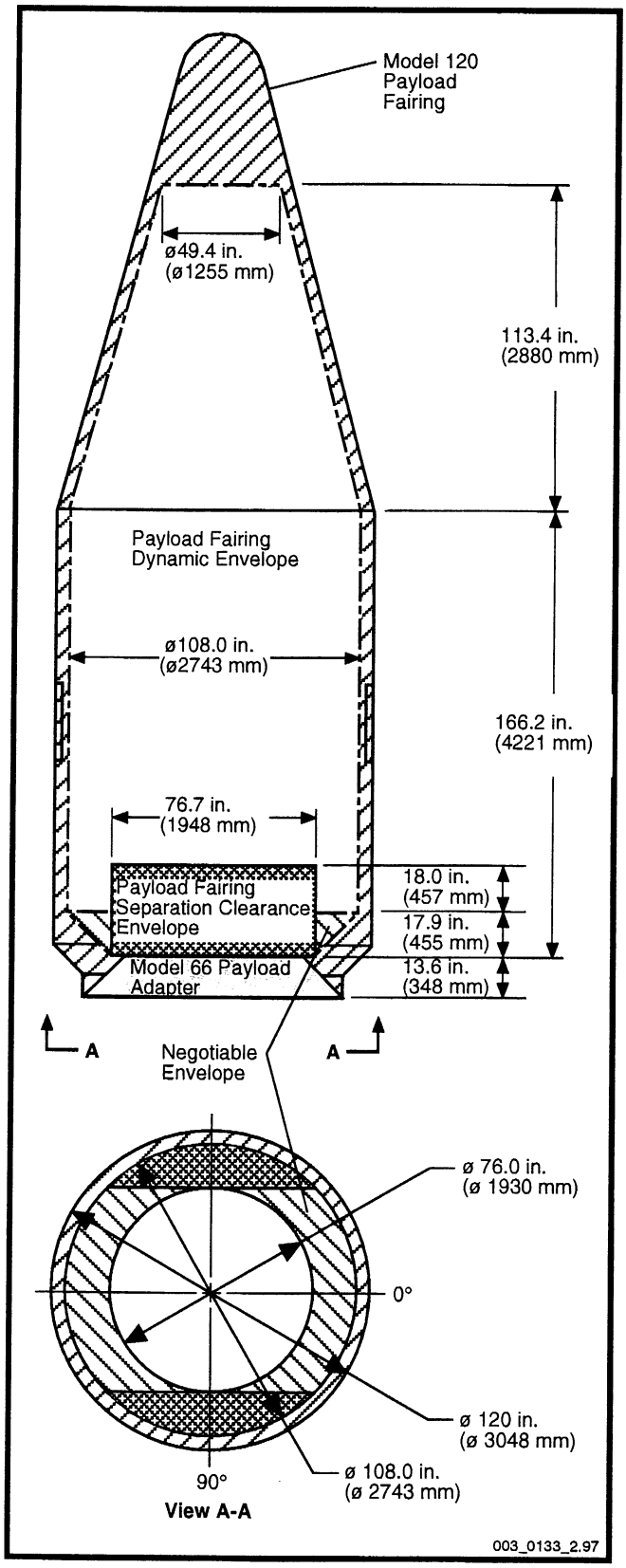

Figure 9.2.1-1 LMLV Planned Model 120 Payload Fairing Dynamic Envelope with Model 66 Payload Adapter

9.3.1 Wallops Launch Site

The WFF main base is located on Virginia's eastern shore 5 miles west of Chincoteague, Virginia, at geographical coordinate 37 degrees 51 minutes north latitude, and 75 degrees 28 minutes west longitude. It is approximately 90 miles north of Norfolk, Virginia, and 40 miles southeast of Salisbury, Maryland. WFF consists of three separate areas:

1) Main base;
2) Mainland site;
3) Wallops Island launch site.

The mainland site and the Wallops Island launch site are approximately 7 miles southeast of the main base. Figures 9.3.1-1 and 9.3.1-2 show WFF and the relationship between the main base, mainland, and Wallops Island launch site.

9.3.2 Wallops Test Range

The Wallops Test Range is a part of the WFF and is managed by the Goddard Space Flight Center (GSFC). The range consists of a launch range; an aeronautical research airport; and associated tracking, data acquisition, and control instrumentation systems. Included in the range are authorized operating space, primarily over the Atlantic Ocean, and authorized radio frequency spectrum.

Wallops users represent NASA, other United States Government agencies, and foreign and commercial organizations.

9.3.3 Wallops Launch Trajectories

Launches from the Wallops Test Range make possible additional inclinations using launch azimuths not available from our launch sites at ER or WR. The Wallops Test Range is located such that launch azimuths between approximately 90° and 139° are possible depending on impact zones. For most orbital vehicles, this translates into orbital inclinations between approximately 38° and 58°.

Figure 9.3.3-1 shows the possible range of launch azimuths and inclinations available from this site. Please contact Lockheed Martin for range safety-related details concerning a specific mission inclination.

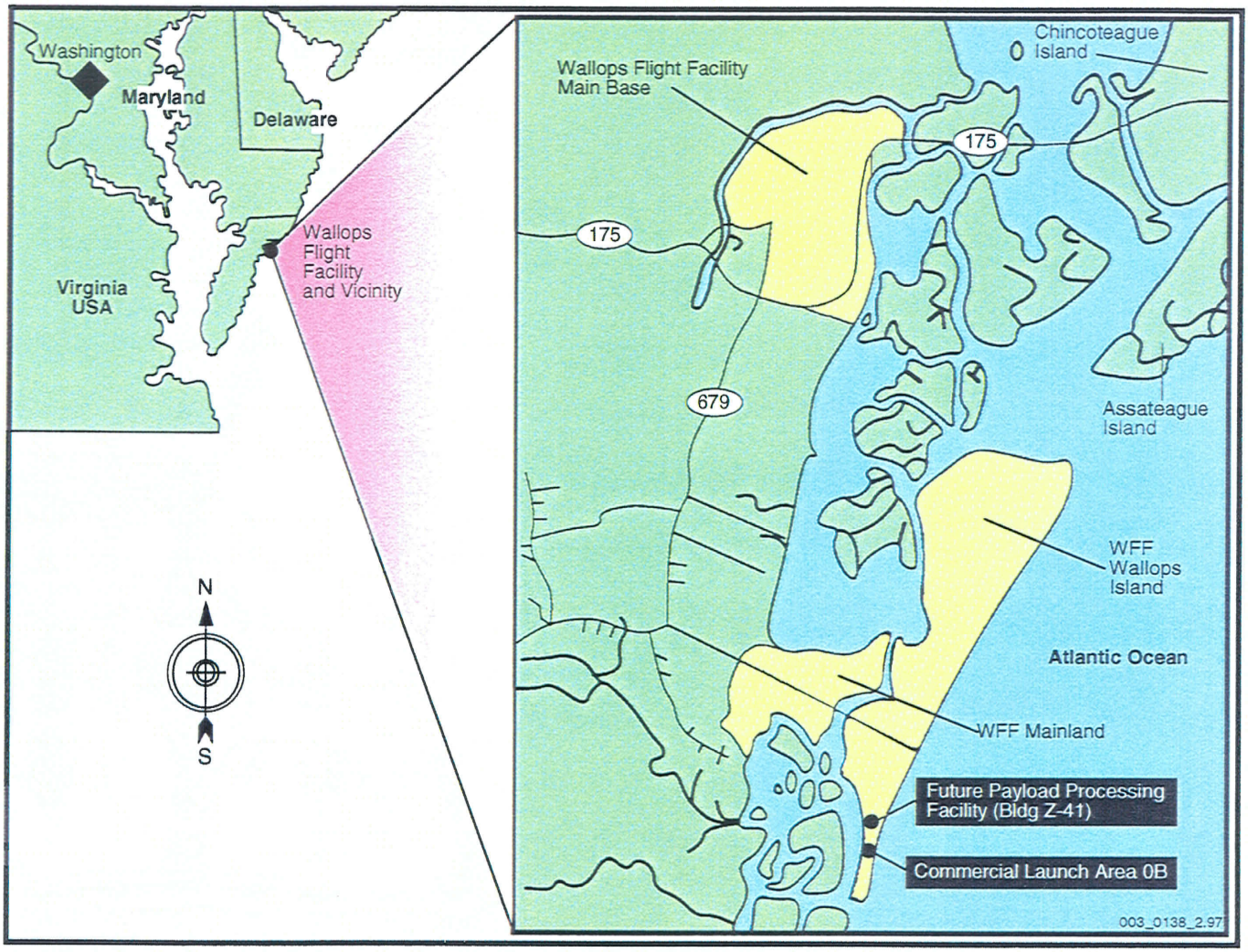

Figure 9.3.1-1 Wallops Range Facilities

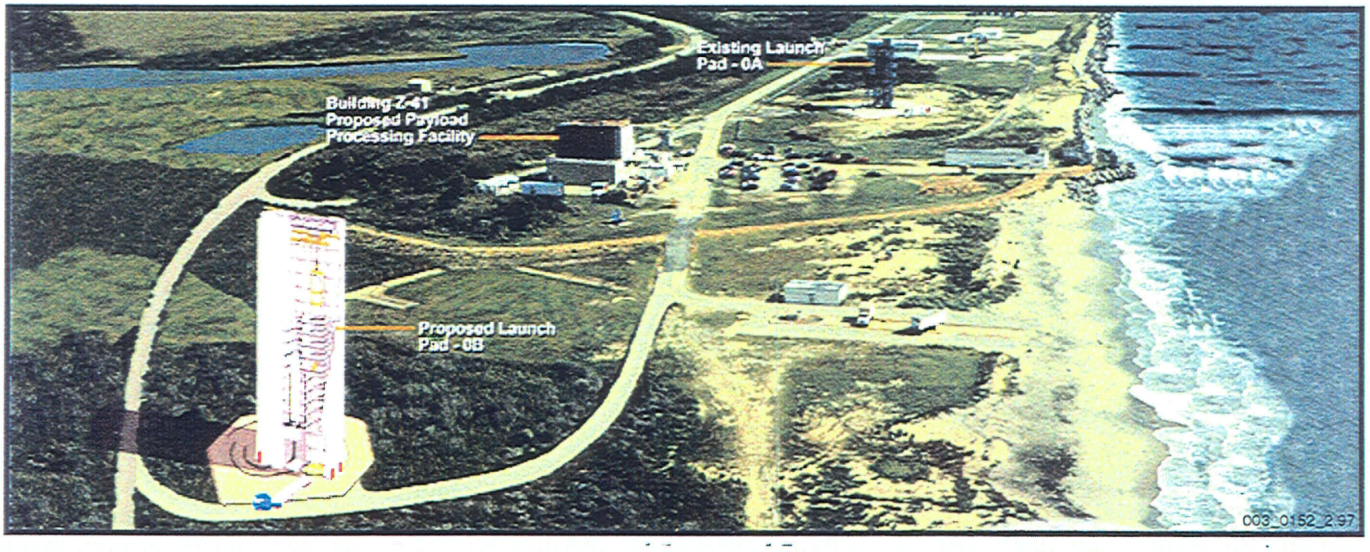

Figure 9.3.1-2 Aerial View of the Wallops Range and Proposed Payload Processing and Launch Facilities

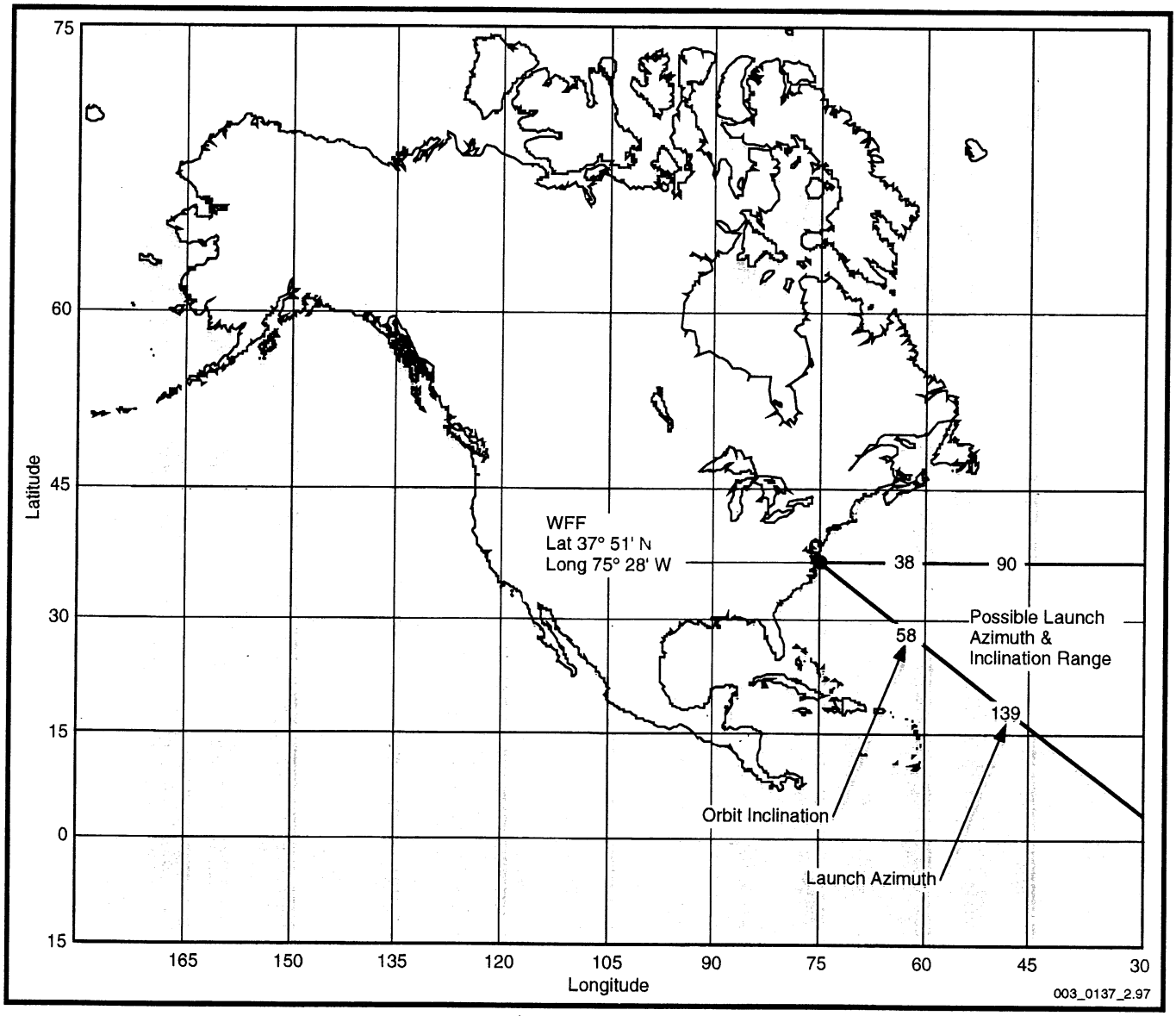

Figure 9.3.3-1 Possible Launch Azimuths and Orbit Inclinations from the Wallops Test Range

APPENDIX A—LMLV HERITAGE, VEHICLE DESIGN, AND PRODUCTION

A.1 LOCKHEED MARTIN SPACE LAUNCH SYSTEMS

Lockheed Martin Astronautics has acquired a variety of space launch systems capable of meeting the needs of current space missions as well as the needs of space missions well into the future. These systems shown in Figure A.1-1 include the Titan family of launch vehicles, the Atlas family of

WORLD'S LARGEST SUPPLIER OF SPACE LAUNCH SYSTEMS

Atlas Space Launch Record
Last 50 Launches (9/25/89 Through 9/4/97) with 94% Success

Launch Vehicle	Timespan	Launches	% Success
Atlas SLV-3, 3A, 3B, 3C, 3D	1964-1983	179	86.6
Atlas D, E, F, G, H	1965-1995	60	88.3
Atlas I	1990-1997	11	73.0
Atlas II	1991-1997	8	100.0
Atlas IIA	1991-1997	12	100.0
Atlas IIAS	1993-1997	10	100.0

Titan Space Launch Record
Last 50 Launches (4/15/83 Through 4/4/97) with 90% Success

Launch Vehicle	Timespan	Launches	% Success
Titan II Gemini	1964-1966	12	100.0
Titan IIIB, IIIC, IIID, IIIE	1966-1982	116	97.4
Titan 34B, 34D	1976-1989	26	88.5
Commercial Titan	1989-1992	4	75.0
Titan II SLV	1988-1997	6	100.0
Titan IV	1989-1997	20	95.0

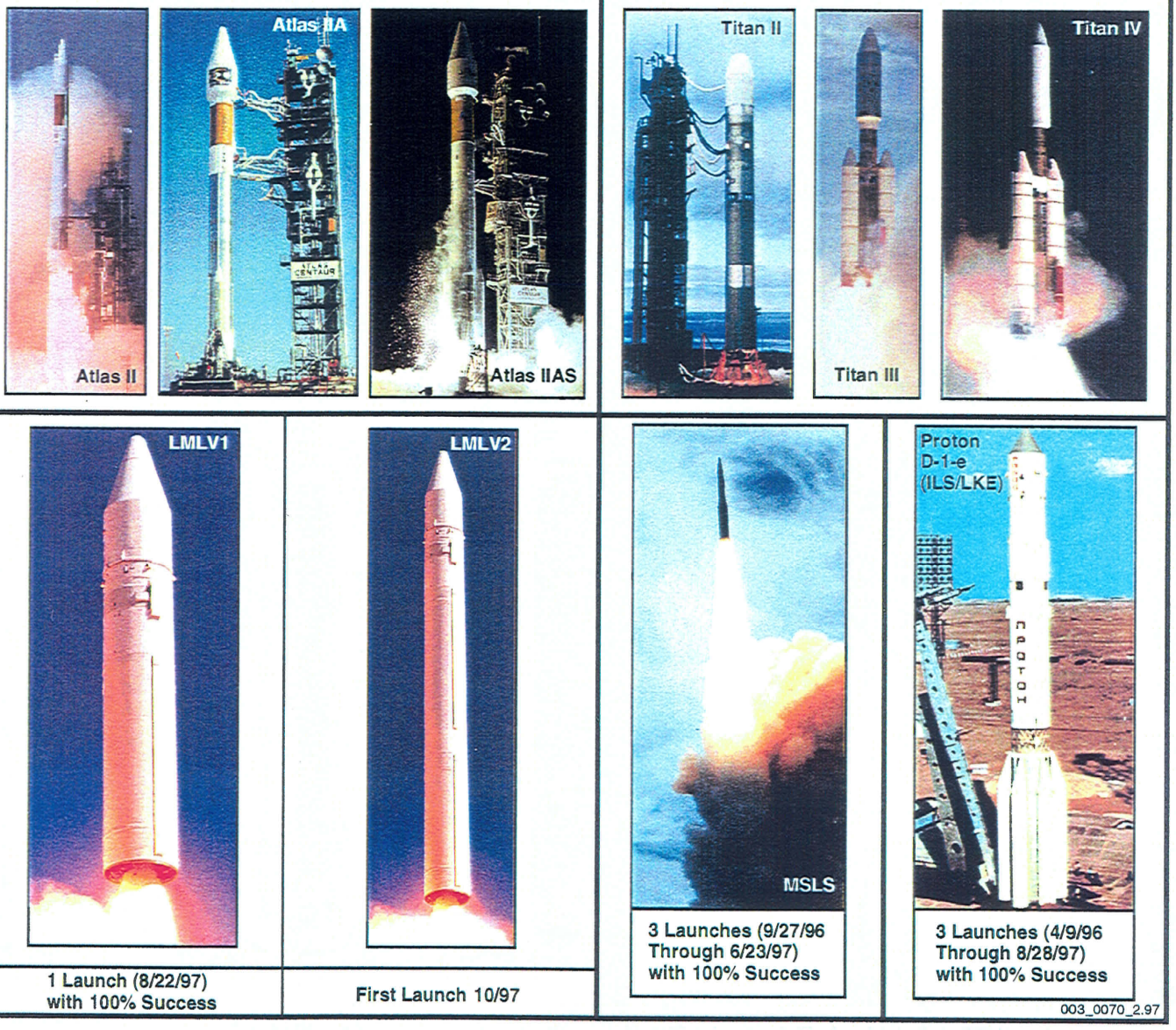

Figure A.1-1 The LMLV is a core component of the Lockheed Martin family of Space Launch Systems.

launch vehicles, the LMLV family, the Proton and the Multi-Service Launch System (MSLS). These space launch systems have been contributing to the success of both government and commercial space programs for over three decades. Their reliability and versatility has been demonstrated by their selection for all types of missions including critical national security programs, manned and unmanned missions, interplanetary missions, scientific research and Earth observation payloads, and communication spacecrafts, just to name a few. The combined resources of these space launch systems provide the expertise and resources necessary to successfully develop the LMLV family, a family of new commercial launch vehicles capable of meeting the challenging launch services needs of the small spacecraft community.

A.2 LMLV MAJOR COMPONENT HERITAGE

LMLV heritage extends from over three decades of space and launch vehicle programs. Cost-effective propulsion, reliability, high structural integrity, accurate guidance, navigation and control, and safe operation are inherent in the systems and components that have been selected. The major systems and components of the LMLV, integral to our modular design, along with their design/performance heritage and predicted reliability are listed in Table A.2-1. The LMLV has a strong technical heritage and our extensive use of flight-proven, off-the-shelf components provides the basis for a highly reliable launch vehicle.

Table A.2-1 LMLV's extensive use of flight-proven, off-the-shelf components provides high system reliability.

COMPONENTS	SUPPLIER	HERITAGE	PREDICTED RELIABILITY
LMLV 1	Lockheed Martin	Based on the Success of Six Generations of Fleet Ballistic Missiles Spanning More Than 3 Decades	0.9863
LMLV 2	Lockheed Martin	Based on the Success of Six Generations of Fleet Ballistic Missiles Spanning More Than 3 Decades	0.9848
PROPULSION			0.9939
• Castor 120® First & Second Stage Motor	Thiokol	Castor 120® Uses Peacekeeper, Space Shuttle SRM & Small ICBM Technology	0.9990
• Orbus® 21D Second & Third Stage Motor	Pratt & Whitney	Derivative of Orbus® 21, Successfully Flown on Space Shuttle, Titan 34D & Titan IV	0.9971
• Attitude Control System	Primex Technologies	Components Qualified & Flown on Atlas II Roll Control Module, Pegasus & Small ICBMs	0.9978
STRUCTURES			0.9999
• Interstage, Equipment Section, Payload Fairing, Payload Adapter	Lockheed Martin-Harlingen Facility	Proven Design Techniques with Well-Characterized Materials & High Factors of Safety (FS = 2.0)	
AVIONICS SYSTEM			0.9838
			0.9955
• Inertial Measurement Unit	Litton	Derivative Successfully Flown on MSLS	0.999867
• Processor	Lockheed Martin	Successfully Flown on Over 200 Flights	0.999087
TELEMETRY & TRACKING SYSTEM*			0.9982
S-Band Antenna, C-Band Antenna	M/A Com	Qualified Since 1990; 24 C-Band & 28 S-Band Antennas Successfully Flown on 7 Atlas II Launches	0.999994
• Transmitter	Loral Conic	Commercial Derivative of CTS-525 Successfully Flown on More Than 200 Flights	0.999720
• Transponder	Herley-Vega	Commercial Derivative of Family of Transponders Successfully Flown on Atlas, Titan/Centaur & Delta Launch Vehicles	0.999903
FLIGHT TERMINATION SYSTEM*			0.9996
• Destruct Antenna	M/A Com	Qualified Since 1990; 24 Destruct Antennas Successfully Flown on 7 Atlas II Launches	0.999999
• Destruct Receiver	Cincinnati Electronics	Successfully Flown on Shuttle, Atlas, Titan & Delta Launch Vehicles	0.9999999
• Destruct Firing Unit	Thiokol	Modified Peacekeeper Units	0.9999999

Note: * Not Included in Overall Launch Vehicle Predicted Reliabilities

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A.3 LMLV MAJOR COMPONENT DESIGN

The LMLV is designed to reliably and cost-effectively deliver spacecraft to orbit through the use of modular systems and components. This modular architecture allows for common hardware, build processes, testing, launch site facilities, assembly and checkout, ground support equipment, and procedures.

Our team members and suppliers, shown in Figure A.3-1, are selected, in part, on the basis of their flight proven performance. Their proven products, in conjunction with our high factor of safety hardware and software systems, provide the user with a reliable, low-cost family of launch vehicles from which an optimum solution can readily be determined for specific mission requirements.

A.3.1 LMLV Characteristics

The LMLV family consists of two basic configurations designated LMLV1 and LMLV2. The family has application for a range of spacecrafts according to mission and program requirements. The basic LMLV1 is capable of delivering up to 1453 lb (659 kg) to low-Earth-orbit (LEO) and the basic LMLV2 is capable of delivering up to 4064 lb (1843 kg) to LEO.

A.3.1.1 LMLV1 Characteristics—The LMLV1 is a three-stage vehicle. It has an overall height of 62 ft (18.9 m), a maximum diameter of 93 in. (236 cm), and a lift-off weight of 146,000 lb (66,200 kg). The major components of the LMLV1, shown in Figure A.3.1.1-1, include the Castor 120® first-stage motor, the interstage structure, the Orbus® 21D second-stage motor, the Orbit Adjust Module, which includes the equipment section structure, the attitude control system, and avionics, the Model 92 payload fairing, and a payload adapter.

A.3.1.2 LMLV2 Characteristics—The LMLV2 is a four-stage vehicle. It has an overall height of 93 ft (28.4 m), a maximum diameter of 93

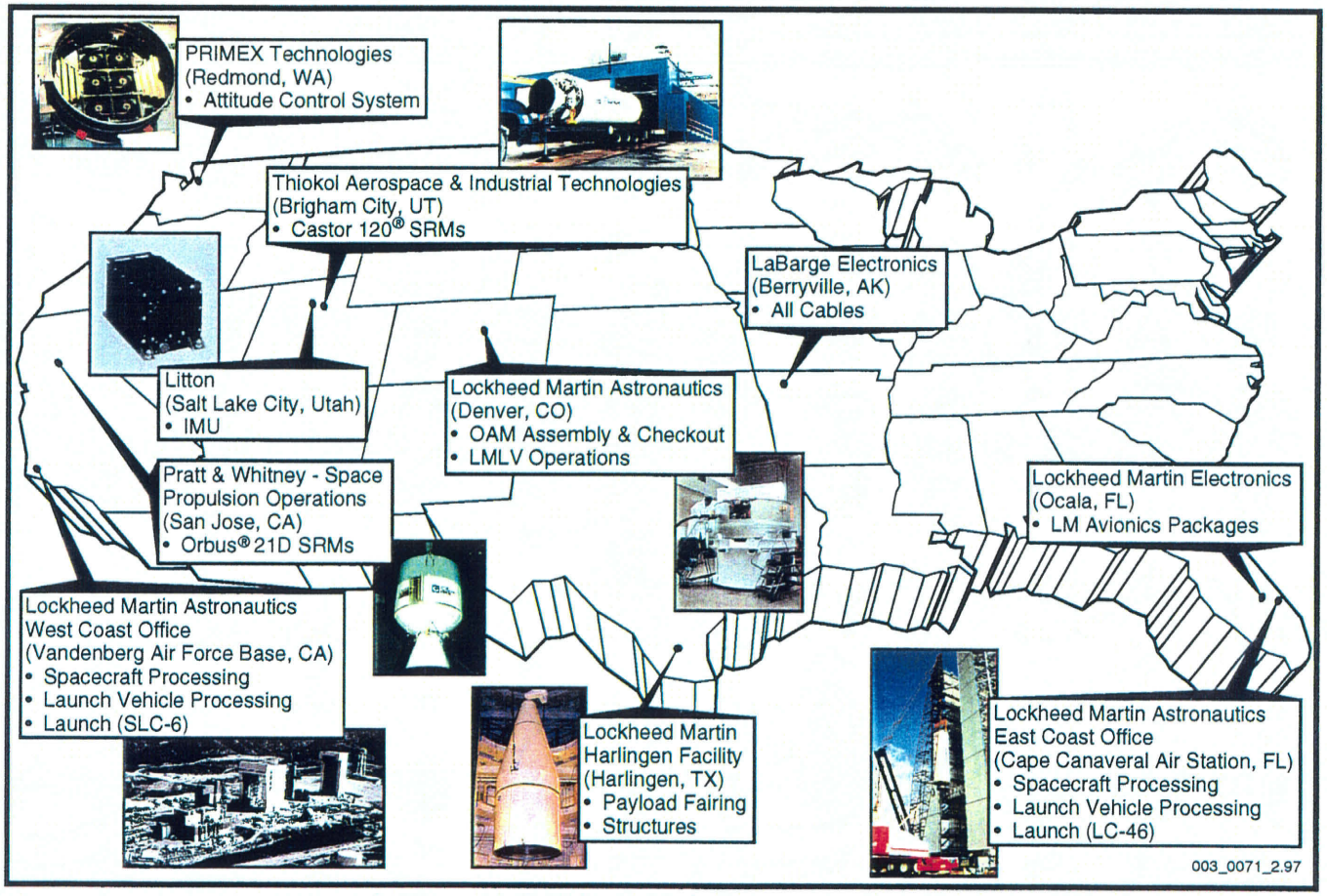


Figure A.3-1 The LMLV team members and suppliers are a proven team of top aerospace performers.

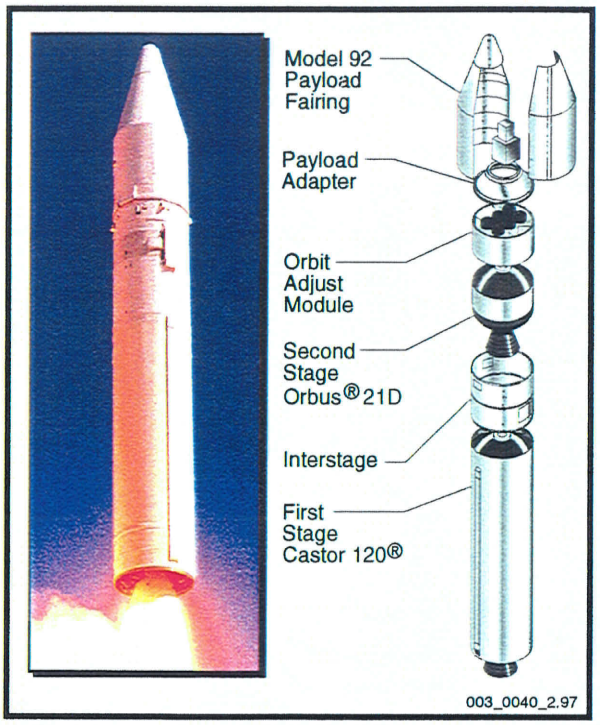


Figure A.3.1.1-1 LMLV1 Major Components

in. (236 cm), and a lift-off weight of 266,000 lb (121,000 kg). Major components unique to the LMLV2, shown in Figure A.3.1.2-1, include the Thiokol Castor 120® second-stage motor, a structurally augmented lower interstage structure between the first- and second-stage motors, and an additional flight termination destruct package and ordnance for the second-stage motor.

A.3.2 Propulsion

The propulsion subsystems consist of the Castor 120® and Orbus® 21D solid rocket motors and the hydrazine attitude control system. A description of each of these subsystems is provided.

A.3.2.1 Castor 120® First and Second Stage Motor—The Castor 120® solid rocket motor (SRM), manufactured by Thiokol, is shown in Figure A.3.2.1-1 during its second successful static firing test. It is the first stage of the LMLV1 and first and second stages of the LMLV2. The assembly includes the motor, thrust vector control system (TVCS), electrical wiring, initiation and destruct ordnance, and an external conduit. The second-stage exhaust nozzle is enlarged to increase the expansion ratio for more efficient performance at higher altitudes.

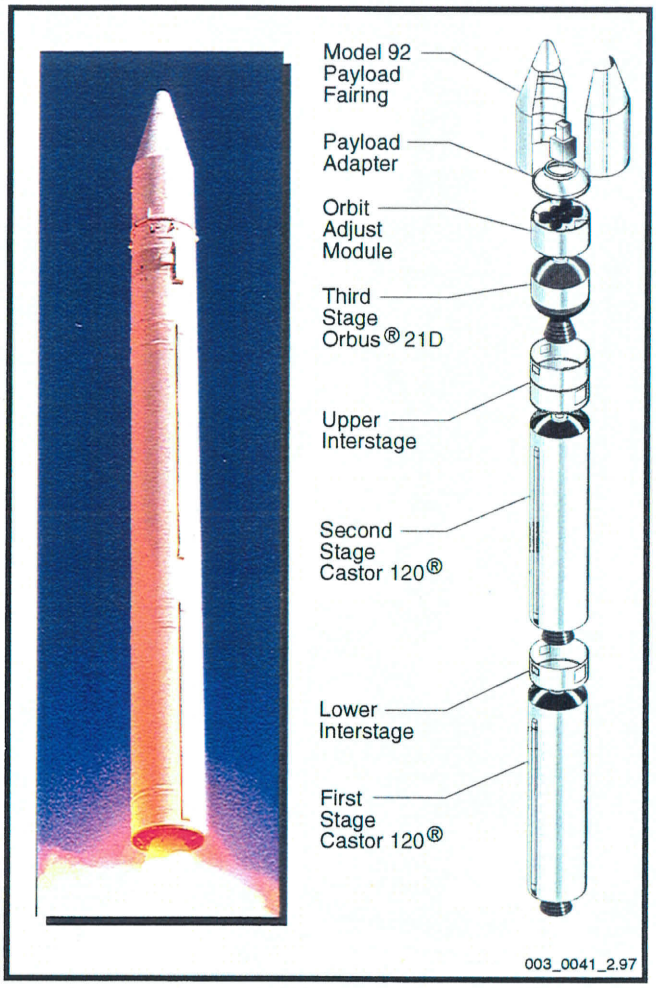


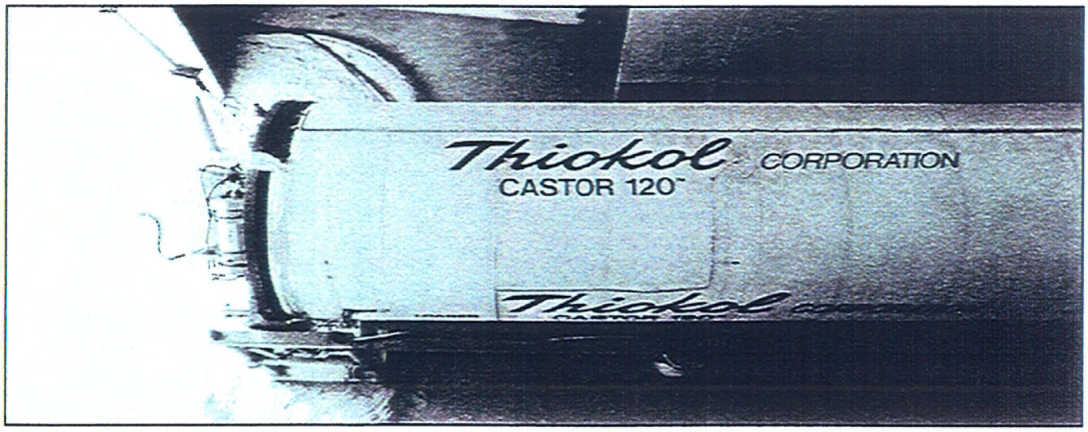
Figure A.3.1.2-1 LMLV2 Major Components

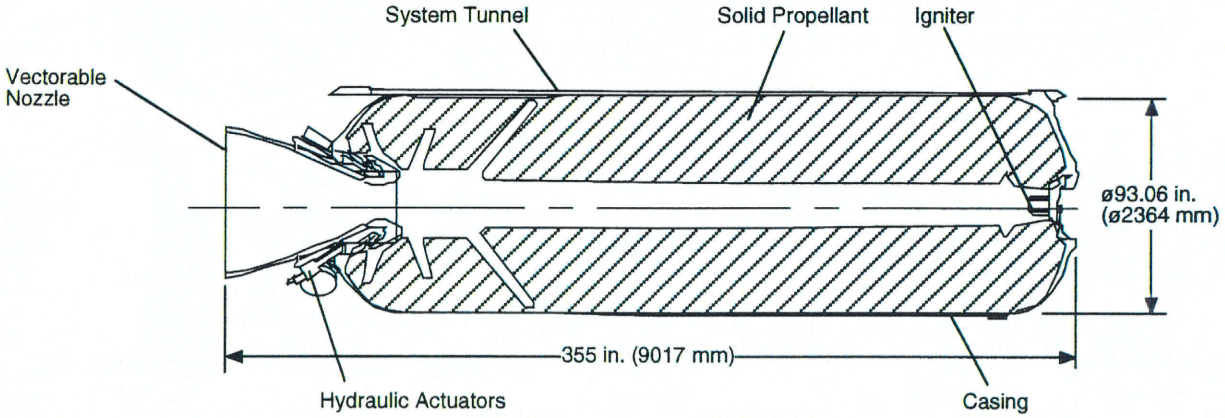
The Castor 120® SRM is a commercially available motor derived from Thiokol's experience with large solid rocket motors developed for military applications. Its robust design and production processes have been specifically engineered to provide maximum reliability and producibility. Thrust vectoring is provided by hydraulically powered pitch and yaw actuators with analog feedback. The use of TVC provides precise guidance and control and efficient use of propellant. Flight termination capability is provided by destruct ordnance.

A.3.2.2 Orbus® 21D Second and Third Stage Motor—The Orbus® 21D solid rocket motor (SRM), manufactured by Pratt & Whitney, is shown in Figure A.3.2.2-1 during a successful static firing test. It is the second stage of the LMLV1 and the third stage of the LMLV2. The assembly includes the motor, the thrust vector

COMPONENT HERITAGE-CASTOR 120® FIRST & SECOND STAGE MOTOR

Castor 120® I Through IVB, USAF Peacekeeper, Minuteman, Small ICBM, U.S. Navy Polaris, Poseidon, Trident





MASS PROPERTIES		
• Total Stage	116,275 lb	57,732 kg
• Total Inerts	8,885 lb	4,030 kg
• Total Propellant	107,390 lb	48,703 kg
• Mass Fraction	0.924	

PERFORMANCE	
• Total Vacuum Impulse (x10^6)	29.9 lbf-s
• Action Time	81 s
• Average Thrust (x10^3)	371 lbf
• Specific Impulse	280 lbf-s/lbm
• Vector Angle	5 deg

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Figure A.3.2.1-1 The Castor 120® SRM, shown successfully completing a static firing test, cost-effectively and reliably meets the first and second stage propulsion requirements of the LMLV.

control system, electrical wiring, initiation and destruct ordnance, and an external conduit.

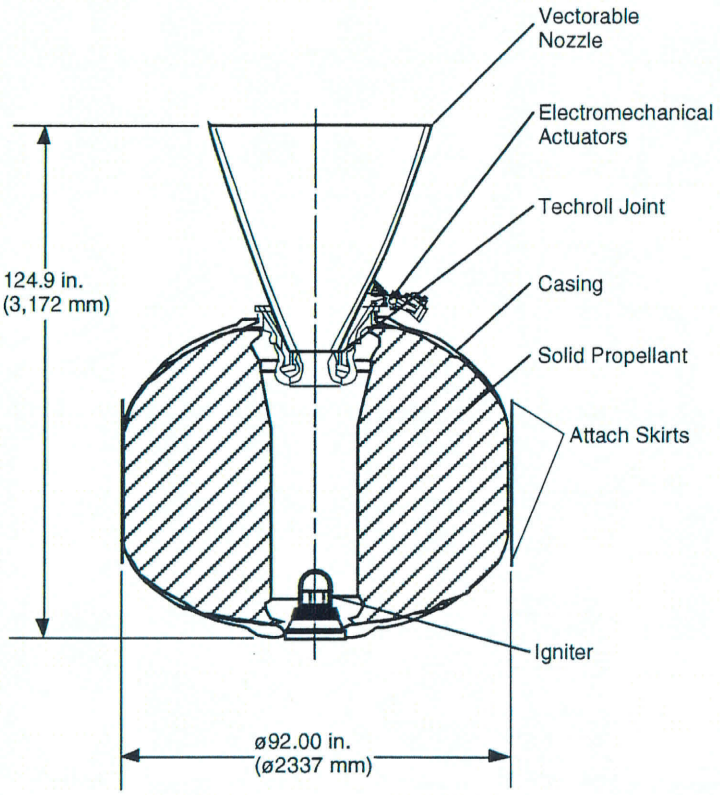
The Orbus® 21D SRM is derived from the flight-proven Orbus® 21. The Orbus® 21 family of motors have completed 12 of 12 successful static firings and 20 of 20 successful flights including the Magellan, Mars Observer, Ulysses and Galileo programs. Thrust vectoring is provided by electro-mechanical pitch and yaw actuators with digital feedback. Flight termination capability is equivalent to that provided for the first-stage motor.

A.3.2.3 Orbit Adjust Module—The orbit adjust module (OAM) contains the attitude control system (ACS), manufactured by PRIMEX Technologies, shown in Figure A.3.2.3-1. The ACS uses off-the-shelf components to provide roll control during stage 1 and 2 thrust phases and 3-axis attitude control during coast phases and orbit insertion, spacecraft deployment and contamination and collision avoidance maneuvers. It also provides additional delta velocity to compensate for solid rocket motor velocity errors following Orbus® 21D SRM burnout, to circularize the orbit or to place the payload into a typical Hohmann transfer orbit, and to perform the final contamination and collision avoidance maneuver (CCAM).

The ACS consists of a monopropellant hydrazine propulsion system with six thrusters which provide pitch, yaw, and roll control, concordantly, and four axial thrusters which simultaneously

COMPONENT HERITAGE—ORBUS 21D® SECOND & THIRD STAGE MOTOR

12 Static Firings at AEDC, 20 Flights (Including Magellan, Mars Observer, Ulysses, Galileo)
With No Failures, Flight Qualified on Space Shuttle, Titan 34D & Titan IV



MASS PROPERTIES		
• Total Stage	23,417 lb	(10,620 kg)
• Total Inerts	1,724 lb	(782 kg)
• Total Propellant	21,560 lb	(9,778 kg)
• Mass Fraction	0.92	

PERFORMANCE	
• Total Vacuum Impulse ($x10^6$)	6.31 lbf-s
• Action Time	158 s
• Average Thrust ($x10^3$)	44.4 lbf
• Delivered Specific Impulse	293.3 lbf-s/lbm
• Vector Angle	4.0 deg

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Figure A.3.2.2-1 The Orbus® 21D SRM, shown successfully completing a static firing test, cost-effectively and reliably meets the second and third stage propulsion requirements of the LMLV.

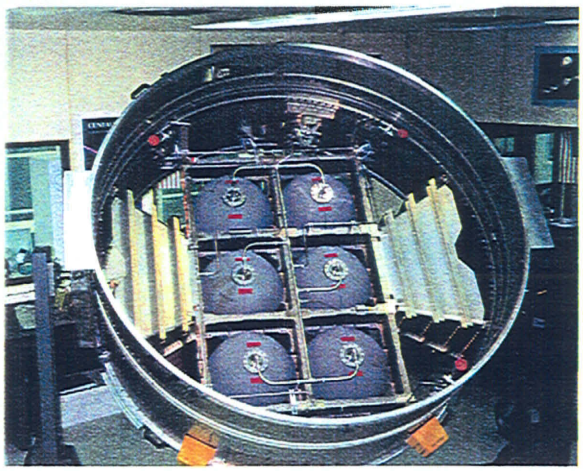
provide delta velocity and pitch and yaw control. The ACS operates in a simple, highly reliable, blowdown mode which provides high thrust, when full, and low thrust, when empty. The initial high thrust provides the delta velocity needed for orbit injection, while the low thrust provides accurate pointing as well as a stable platform for payload separation.

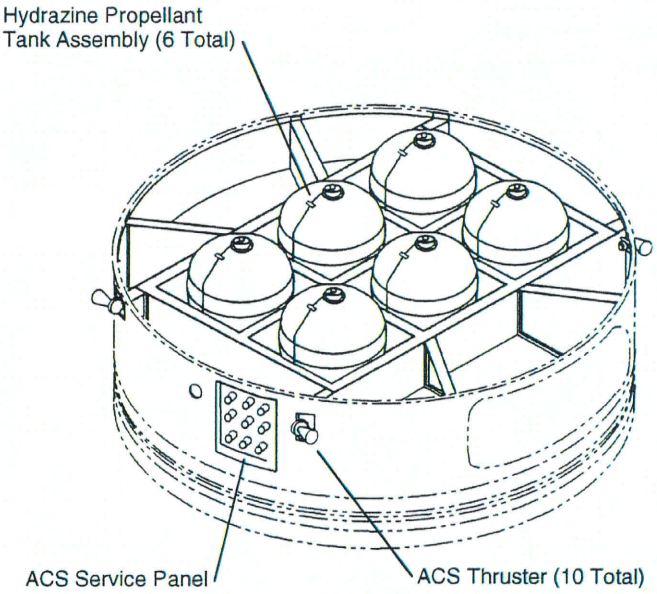
The hydrazine propellant for the ACS is contained in 2, 4, or 6 propellant tanks according to mission requirements. The maximum propellant load for the 6-tank configuration is 780 lb (354 kg). The propellant tanks are spun aluminum with a composite overwrap and an elastomeric bladder. The bladder is pressurized during prelaunch operations and is allowed to blowdown as propellant is consumed during flight. The bladder provides ullage control and assures the delivery of gas free propellant to the thrusters for precise and accurate thruster performance.

The use of monopropellant hydrazine for attitude control minimizes payload contamination

COMPONENT HERITAGE—ATTITUDE CONTROL SYSTEM

ACRM, Titan II, Commercial Titan, MSX, STEP, Small ICBM, Delta Star, PAM/Delta II-NCT, Atlas, CCAS, Atlas I RCM, Trident II, Atlas RCM, DOT/DCA, GPS, TIROS N, SCATHA, Centaur RCS





MASS PROPERTIES		
• Total ACS Weight (Dry)	245 lb	(111 kg)
• Total ACS Propellant		
– 2 Tanks	260 lb	(118 kg)
– 4 Tanks	520 lb	(236 kg)
– 6 Tanks	780 lb	(354 kg)

PERFORMANCE	
• Total Number of Thrusters	10
– Number Used for 3-Axis Attitude Control	6
– Number Used for ΔV	4
• Nominal Thrust (Per Thruster)	50 lbf
• Specific Impulse	228 s

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Figure A.3.2.3-1 All attitude control system components are flight proven.

before and following payload separation, and during the CCAM maneuver.

A.3.3 Structures

The structures subsystems consist of the upper and lower interstages, equipment section, payload fairing and payload adapter. These structures are designed with high factors of safety under worse case loads. They have been qualified by analysis, using industry-standard finite element codes, by separation joint tests, and have a heritage from more than 1000 successful launches. Their robust designs and conservative safety margins provide excellent weight-to-orbit performance with high reliability.

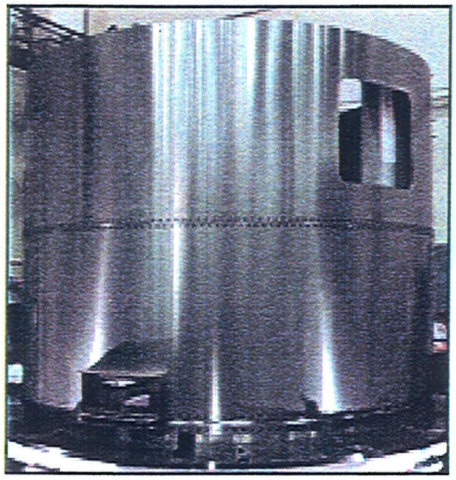
A.3.3.1 Interstage—The LMLV1 has a single interstage, shown in Figure A.3.3.1-1, that provides mounting of the Orbus® 21D second-stage motor to the Castor 120® first-stage motor. The LMLV2 has two interstages that are designated as upper and lower. The upper interstage is common to the LMLV1 and provides mounting of the Orbus® 21D third-stage motor to the Castor 120® second-stage motor. The lower interstage provides mounting of the Castor 120® second-stage motor to the Castor 120® first-stage motor. The lower interstage is similar to the upper interstage, although it is structurally augmented to accommodate higher loads.

The upper interstage consists of an aluminum, ring-stiffened, cylindrical structure, with upper- and lower-field joints, and electrical and ordnance components. Included are access doors, mounting provisions for firing units, and a separation joint with provisions for the mounting of its separation ordnance.

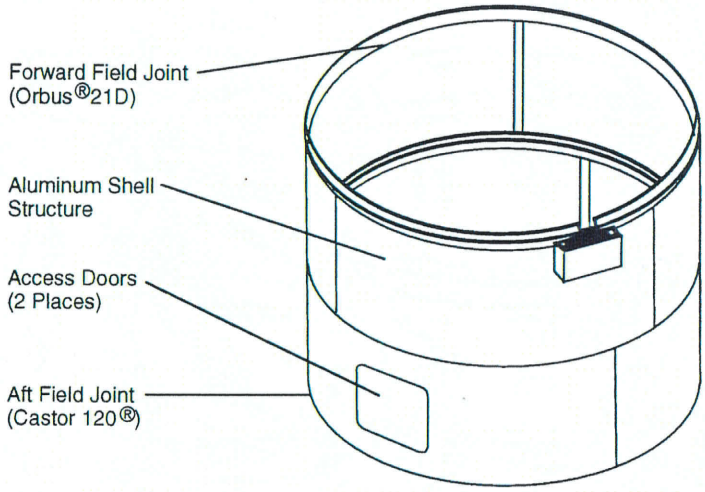
A.3.3.2 Equipment Section—The equipment section, shown in Figure A.3.3.2-1 is common to both the LMLV1 and LMLV2 configurations. The equipment section is mounted above the Orbus® 21D SRM. The encapsulated

COMPONENT HERITAGE—INTERSTAGE: UPPER AND LOWER

Lockheed Martin Structural Test Data from Over 1000 Flights



(Upper Inner Stage Shown)



Mass Properties		Features
• Total Upper Interstage Weight (LMLV1 & 2)	599 lb (272 kg)	• Aluminum Structure with High Factor of Safety
• Total Lower Interstage Weight (LMLV2 Only)	TBD	• Flight-Proven Separation Design

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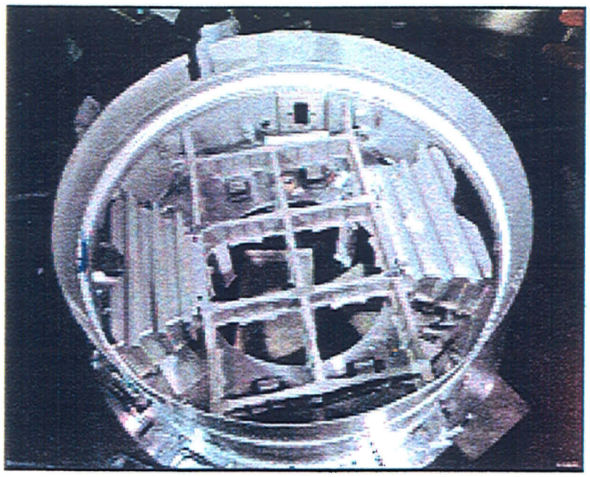
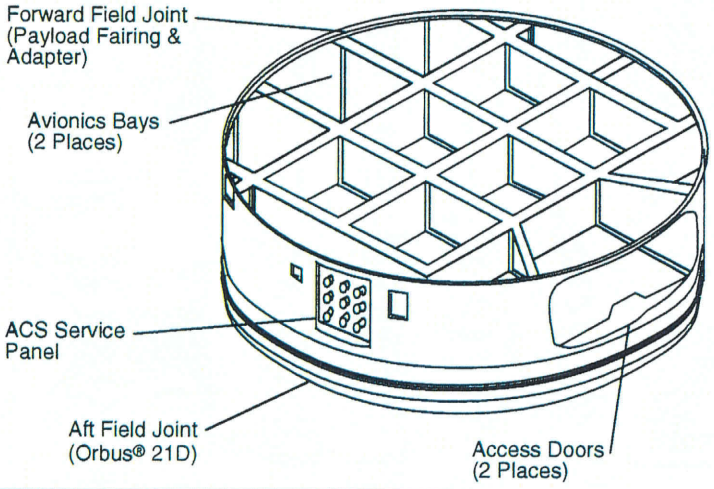
Figure A.3.3.1-1 LMLV interstages are robust, low-risk hardware items manufactured by Lockheed Martin.

COMPONENT HERITAGE—EQUIPMENT SECTION

Lockheed Martin Structural Test Data from Over 1000 Flights





MASS PROPERTIES			FEATURES
• Total Weight	816 lb*	(370 kg)	• Aluminum-Lithium Structure with High Factor of Safety
• Structures	526 lb	(238 kg)	• Flight-Proven Separation System
• Avionics	290 lb	(132 kg)	• Contains All Avionics Packages
*Excludes ACS Components			

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Figure A.3.3.2-1 The LMLV equipment section is a robust, low-risk hardware item manufactured by Lockheed Martin.

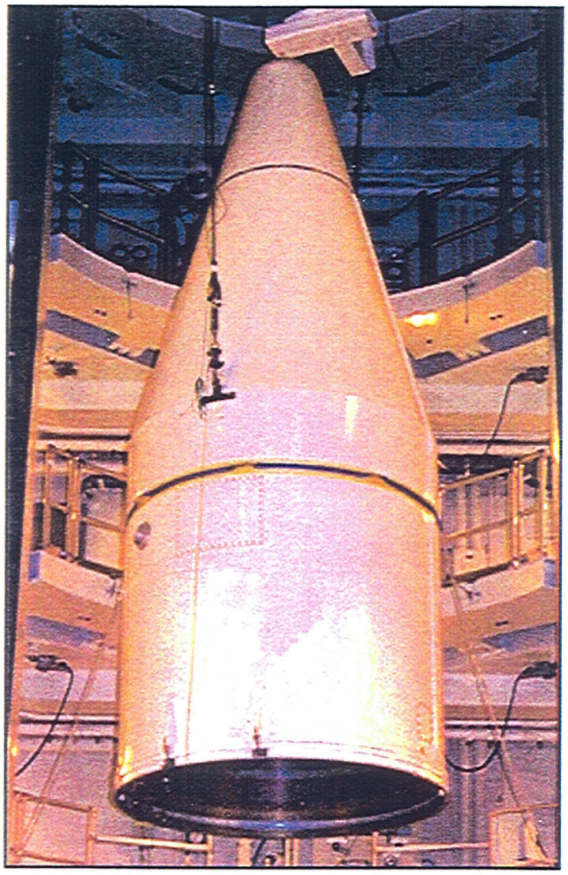
assembly, which includes the payload, payload adapter and payload fairing, are mounted above the equipment section at a common interface completing the vehicle.

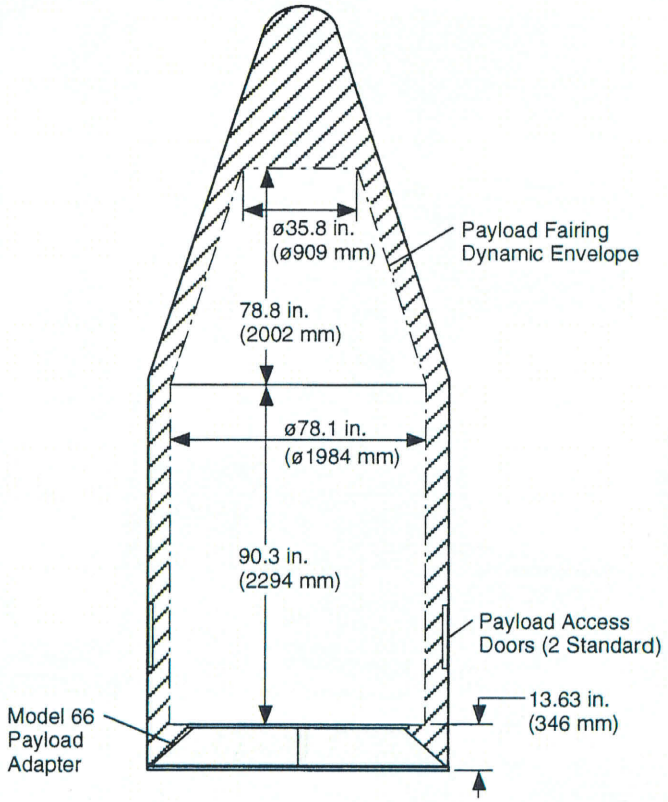
The equipment section consists of an aluminum-lithium, ring-stiffened, cylindrical shell, with upper- and lower-field joints, and structure that supports the ACS propellant tanks and thrusters and houses the flight electronics. As an assembly it is designated the Orbit Adjust Module (OAM). Included are access doors for easy and rapid access to the flight electronics for system test and checkout before launch. The single electrical umbilical is mounted to the side of the equipment section and separates shortly after lift-off as the vehicle leaves the pad.

A.3.3.3 Payload Fairing—Lockheed Martin provides a very large payload fairing (PLF), for this class of launch vehicle that is capable of accommodating very large and/or multiple spacecrafts. The Model 92 PLF has an outside diameter of 92 inches and is common to both the LMLV1 and LMLV2 configurations. The fairing's dynamic envelope, shown in Figure A.3.3.3-1 accounts for structural tolerances as well as static and dynamic deflections. Two standard, 18-in. (45.7-cm) high

COMPONENT HERITAGE—MODEL 92 PAYLOAD FAIRING

Structural Test Data from Hundreds of Flights





MASS PROPERTIES		PERFORMANCE
Total Payload Fairing Weight	1395 lb (633 kg)	• Lightweight Aluminum-Lithium Construction • Large Payload Access Doors (2 Standard) • Large Payload Fairing Envelope – Allows Spacecraft Volume Growth – Makes Initial Design Tasks Easier & Less Costly – Avoids Spacecraft Redesign – Allows Spacecraft Designers To Focus on Performance, Higher Reliability & Lower Cost

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Figure A.3.3.3-1 The Model 92 payload fairing accommodates large spacecraft for this class of launch vehicle.

by 24-in. (61.0- cm) wide, access doors are provided for payload access during prelaunch operations. These doors can be located axially between the ring stiffeners and radially between the longitudinal separation joints. Additional nonstandard access doors can be accommodated.

The Model 92 PLF is an aluminum-lithium, ring-stiffened, monocoque structure lined externally with cork to maintain the payload temperature within specifications. The PLF separates into two halves when jettisoned. Zip Tube®, a patented clean separation system which produces no contamination, severs the fairing along a circumferential joint at the base and along two longitudinal joints. Thruster springs, located along the base joint, and helper springs, located near the top of the longitudinal joints, push the hinged fairing halves away. Payload fairing envelopes and design details are fully described in Section 4.0

Payload Adapters—Lockheed Martin provides a number of payload adapters to accommodate small to large and/or multiple spacecrafts. The payload adapter supports and mechanically connects the spacecraft to the launch vehicle at a common interface at the top of the equipment section. Four standard payload adapters are currently available, as shown in Table A.3.3.4-1.

Each payload adapter includes a contamination shield that protects the payload, only allowing filtered and conditioned air to flow from the encapsulated payload assembly to the equipment section. Each payload adapter accommodates all payload mechanical and electrical interfaces and is designed to assure that the proper clearances are maintained for an unobstructed separation. Figure A.3.3.4-1 shows the four standard payload adapters.

Table A.3.3.4-1 LMLV Standard Payload Adapters

PAYLOAD ADAPTER TYPE	PAYLOAD ADAPTER INTERFACE
Model 24*	23.25 in. (591 mm) Diameter Bolt Circle
Model 37	37.15 in. (944 mm) Diameter Bolt Circle
Model 38	38.81 in. (986 mm) Diameter Bolt Circle
Model 47	45.709 in. (1161 mm) Diameter Interface
Model 66	66.00 in. (1676 mm) Diameter Bolt Circle

Note:
*Model 24 payload adapter is bolted to the Model 66 payload adapter.

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Separation systems and connectors are available for the Model 24 and the Model 38 payload adapters or may be provided by the customer. The payload adapter could be available to the customer for mechanical compatibility and/or integrated system tests. A match-mate tooling template could also be available to the customer to assure mechanical compatibility. Section 4.0 fully describes payload adapter interfaces and design details.

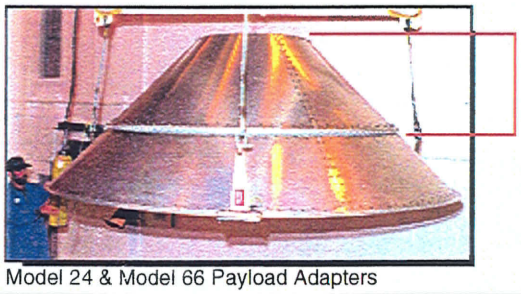
A.3.4 Flight Electronics

The electrical subsystems consist of the avionics, telemetry and tracking, and flight termination systems. More than 75 percent of the components in these systems are flight-proven, off-the-shelf items.

A.3.4.1 Avionics System—The avionics system, shown schematically in Figure A.3.4.1-1 is common to all LMLV configurations. The system provides the navigation, guidance and control of the vehicle, provides vehicle and spacecraft data for telemetry monitoring, and provides the initiation of vehicle and spacecraft separation events. The principal components of the avionics system include the processor package, inertial measurement unit, interlocks package, power distribution package and batteries.

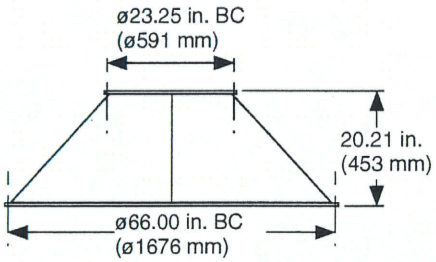
A.3.4.2 Telemetry and Tracking System—The telemetry and tracking system is common to all LMLV configurations. The two-link system provides the vehicle and spacecraft RF telemetry stream to the ground during flight. The system consists of two S-band transmitters, a diplexer and power divider, four S-band antennas, and a distributed suite of data collection and encoding hardware. More than 100 analog and 150 digital measurements provide propulsion performance monitoring, etc. Payload separation events are monitored and combined within the processor telemetry stream operating under flight software control. The telemetry provides spacecraft-related information including payload adapter accelerations, acoustics, temperature, vibration, five continuity loops, separation discretes, (eight command discretes and eight monitor discretes), and 20 channels reserved for payload use.

COMPONENT HERITAGE—PAYLOAD ADAPTERS
Lockheed Martin Structural Test Data from Hundreds of Flights



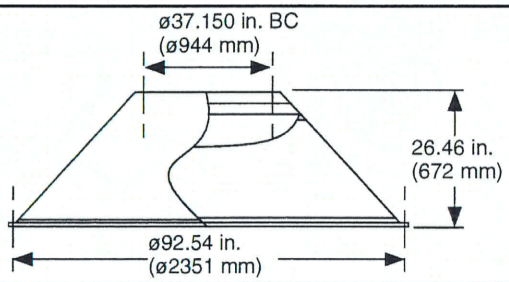
Model 24 & Model 66 Payload Adapters

Model 24



Model 37
Photo
Not Available

Model 37



Model 38 Photo
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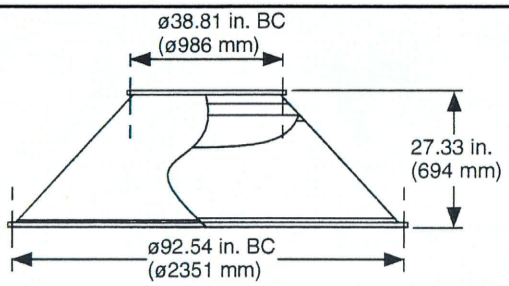
Model 38



Model 47 Photo
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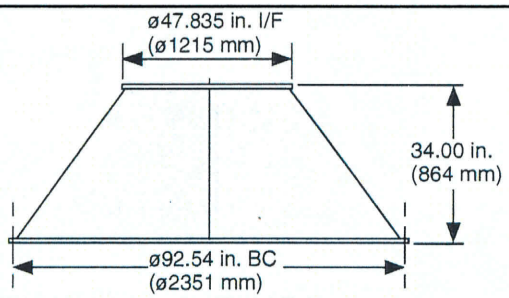
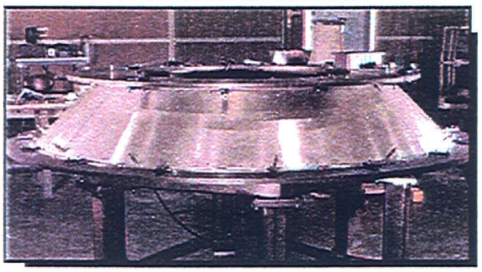
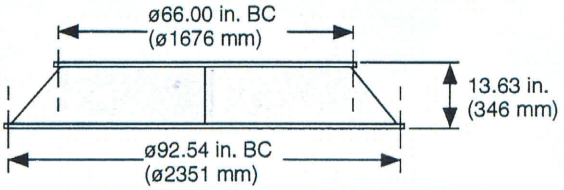
Model 47





Model 66



MASS PROPERTIES			
Total P/A Weight	• Model 24*	40 lb	(18.1 kg)
	• Model 37	106 lb	(48.1 kg)
	• Model 38	103 lb	(46.7 kg)
	• Model 47	110 lb	(49.9 kg)
	• Model 66	120 lb	(54.4 kg)

PERFORMANCE

- Aluminum-Lithium for Strength & Reduced Weight
- Readily Accommodates a Range of Satellites
- Simple, ICD-Controlled Interface

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Note: *Model 24 payload adapter weight must be added to the Model 66 payload adapter weight for total payload adapter weight.

Figure A.3.3.4-1 Five standard payload adapters easily accommodate a variety of spacecraft.

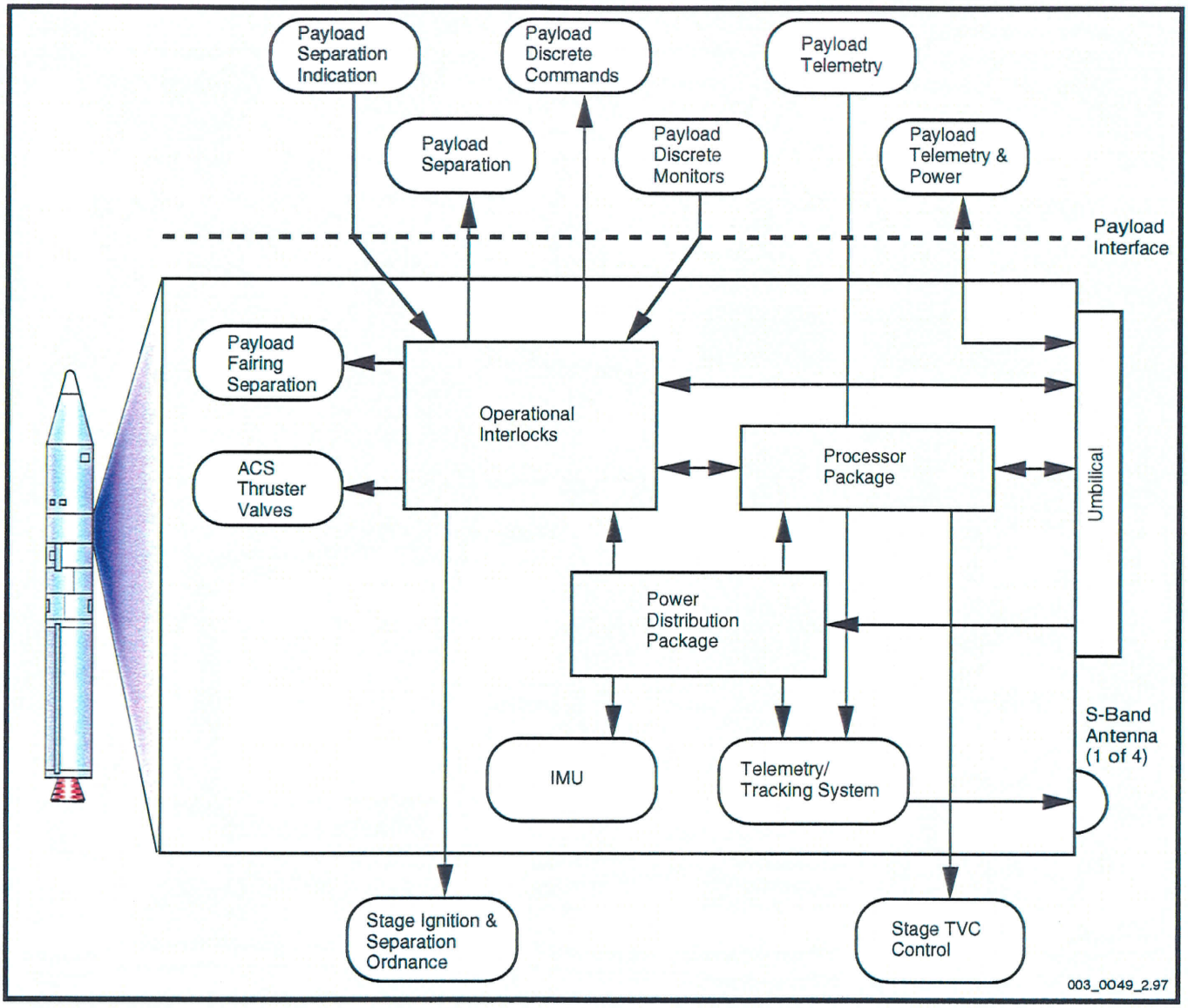

Figure A.3.4.1-1 LMLV Flight Electronics and Payload Interfaces

RF tracking is accomplished by a C-band beacon consisting of a C-band transponder, a bi-directional combiner/splitter and two C-band antennas, all powered by an independent battery. All tracking hardware has been fully qualified on earlier programs including Pegasus and Taurus flights.

A.3.4.3 Flight Termination System—The flight termination system is common to all LMLV configurations. The system is a range required capability that provides controlled flight termination of the LMLV in the event of a vehicle flight anomaly beyond specified flight criteria. Flight termination is initiated by either an RF command from Range Control on the ground or through the autodestruct command initiated onboard via preprogrammed flight avionics. Motor-mounted destruct charges destroy the vehicle such that the debris are contained within the range boundaries. The system consists of redundant batteries, antennas, command receiver decoders, destruct interlocks and multiple firing units. Dual UHF antennas, coupled to provide omnidirectional reception assure a command link regardless of vehicle attitude. Lockheed Martin's flight termination system of fully certified components evolved over several decades of tests. It has proven its effectiveness in flights from both Eastern Range (ER) and Western Range (WR). Range-required elements of telemetry, tracking, and flight termination equipment meet all ER and WR requirements as specified by documents ERR 127-1 and WRR 127-1, respectively.

APPENDIX B—MISSION SUCCESS AND QUALITY ASSURANCE

B.1 QUALITY ASSURANCE

Lockheed Martin Astronautics operates an ISO 9001 (International Organization for Standardization 9001:1994, Quality Systems Model for quality assurance in design, development, production, installation, and servicing) registered quality management system. Astronautics is internationally accredited through the British Standards Institute (BSI) under registration number FM 35743. The registration was conferred on December 13, 1996, and includes Astronautics' Denver, CO; San Diego, CA; and Harlingen, TX, facilities. LMLV's facilities are included as part of the Denver operations. The scope of the registration includes the design, development, test, manufacture, and assembly of advanced technology systems for space and defense, including space systems, launch systems, and ground systems.

Adherence to the ISO 9001 quality standard is revalidated at 6-month intervals by BSI, an independent, third party registrar.

ISO 9001 is executed through Astronautics' internal policies, practices, and procedures that are described in our Product Delivery System Manual (PDSM). ISO 9001 is a quality management system that provides a framework of 20 major elements:

1) Management Responsibility;
2) Quality System;
3) Contract Review;
4) Design Control;
5) Document and Data Control;
6) Purchasing;
7) Control of Customer-Supplied Product;
8) Product Identification and Traceability;
9) Process Control;
10) Inspection and Testing;
11) Control of Inspection, Measuring, and Test Equipment;
12) Inspection and Test Status;
13) Control of Nonconforming Product;
14) Corrective and Preventive Action;
15) Handling, Storage, Packaging, Preservation, and Delivery;
16) Control of Quality Records;
17) Internal Quality Audits;
18) Training;
19) Servicing;
20) Statistical Techniques.

The PDSM examines each element and provides an overview of the element and flowdown references to individual implementation procedures.

B.2 MISSION SUCCESS

In addition to the basic quality system framework provided by ISO 9001, Astronautics has included Mission Success as a 21st element in the Astronautics PDSM. Mission Success drives Astronautics to additional levels of advanced assurance such as Program Reliability Boards for problem resolution, and readiness reviews conducted at critical milestones as illustrated in Figure B.2-1. This ensures complete investigation and resolution of all concerns and constraints that could potentially affect Mission Success.

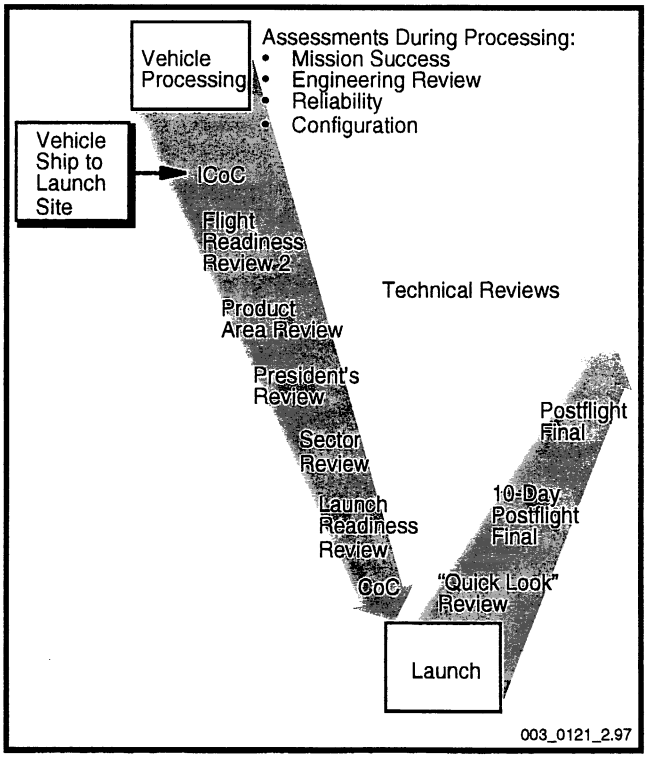

Figure B.2-1 LMLV Assessment and Review Process

B.3 SYSTEMS SAFETY

Astronautics also includes Systems Safety as an essential quality system element. Systems Safety engineering prepares the LMLV Missile System Prelaunch Safety Package (MSPSP) and the System Safety Program Plan (SSPP) in accordance with Eastern and Western Range (EWR) 127-1 requirements. This provides a means of substantiating compliance of the LMLV hardware and related activities with Range safety requirements, ensuring proper design and operational controls are incorporated into the vehicle and its support equipment.

APPENDIX C—SPACECRAFT DATA REQUIREMENTS

The items listed in this appendix are representative of the information required for spacecraft integration and launch activities. Additional information may be required for specific spacecraft.

C.1 INTERFACE CONTROL DOCUMENT INPUTS

Table C.1-1 indicates the spacecraft information required to assess the compatibility of the spacecraft with the LMLV. Data are usually provided by the customer in the form of an interface requirements document (IRD) and are the basis for preparing the interface control document (ICD). Shaded items should be provided for a preliminary compatibility assessment, while all items should be completed for a detailed assessment. The shaded items are typically supplied for the spacecraft before a proposal is offered for LMLV Launch Services. These lists are generalized and apply to any candidate mission. In cases in which Lockheed Martin has previous experience with the spacecraft bus or spacecraft contractor, less information can be initially provided, (assuming the spacecraft contractor is willing to use a "same as mission" designation for purposes of assessing preliminary compatibility. A complete IRD is typically supplied within 30 days of contract signing.

Table C.1-1 Spacecraft Information Worksheet (Part 1 of 3)

Spacecraft Name:	Spacecraft Manufacturer:
Spacecraft Owner:	Spacecraft Model No.:
Name of Principal Contact:	Number of Launches:
Telephone Number:	Date of Launches:
Date:	

SPACECRAFT DESIGN PARAMETER	ENGLISH UNITS	SI UNITS
TRAJECTORY REQUIREMENTS		
• Spacecrafts Mass		
• Minimum Spacecrafts Lifetime	_____ lbm	_____ kg
• Final Orbit Apogee	_____ yrs	_____ yrs
• Final Orbit Perigee	_____ km	_____ km
• Final Orbit Inclination	_____ km	_____ km
• Propulsion—Propellant Type, Orbit Insertion	_____ deg	_____ deg
• Propulsion—Propellant Type, Stationkeeping		
• Propulsion—Multiple Burn Capability (Y/N)		
• Propulsion—Propellant Mass	_____ lbm	_____ kg
• Propulsion—Effective I_{sp}	_____ s	_____ s
• Maximum Apogee Allowable	_____ nmi	_____ km
• Minimum Perigee Allowable	_____ nmi	_____ km
• Argument of Perigee Requirement	_____ deg	_____ deg
• Right Ascension of Ascending Node Requirement	_____ deg	_____ deg
• Apogee Accuracy Requirement	_____ km	_____ km
• Perigee Accuracy Requirement	_____ km	_____ km
• Inclination Accuracy Requirement	_____ deg	_____ deg
• Argument of Perigee Accuracy Requirement	_____ deg	_____ deg
• Right Ascension of Ascending Node Accuracy Requirement	_____ deg	_____ deg
MECHANICAL INTERFACE		
• Spacecraft Mechanical Drawing (Launch Configuration)		
• Spacecraft Effective Diameter	_____ in.	_____ mm
• Spacecraft Height	_____ in.	_____ mm
• Spacecraft/Launch Vehicle Interface Diameter	_____ in.	_____ mm
• Payload Sep System Supplier (Spacecraft or Launch Vehicle)		
• Payload Adapter Supplier (Spacecraft or Launch Vehicle)		
• Maximum Spacecraft Cross-Sectional Area	_____ ft^2	_____ m^2
• Number & Size Payload Fairing Access Doors	_____ in. x in.	_____ mm x mm
• Preseparation RF Transmission Requirement	_____ band	_____ band

Note: For a preliminary compatibility assessment, all shaded items should be completed. For a detailed compatibility assessment, all items should be completed.

Table C.1-1 Spacecraft Information Worksheet (Part 2 of 3)

SPACECRAFT DESIGN PARAMETER	ENGLISH UNITS	SI UNITS
ELECTRICAL INTERFACE		
• Spacecraft Electrical Drawing		
• Number of Launch Vehicle signals Required		
• Number of Separation Discretes Required		
• Number of Umbilicals & Pins/Umbilical		
• Curve of Spacecraft-Induced Electric Field-Radiated Emissions	_____ MHz	_____ dBμ V/m
• Curve of Spacecraft-Radiated Susceptibility	_____ MHz	_____ dBμ V/m
• Number of Instrumentation Analogs Required		
THERMAL ENVIRONMENT		
• Prelaunch Ground Transport Temperature Range	_____ °F	_____ °C
• Prelaunch Launch Pad Temperature Range	_____ °F	_____ °C
• Maximum Prelaunch Gas Impingement Velocity	_____ ft/s	_____ m/s
• Maximum Ascent Heat Flux	_____ Btu/hr ft^2	_____ W/m^2
• Maximum Fee-Molecular Heat Flux	_____ Btu/hr ft^2	_____ W/m^2
• Maximum Fairing Ascent Depressurization Rate	_____ psi/s	_____ mbar/s
• Spacecraft Vented Volume(s)	_____ ft^3	_____ m^3
• Spacecraft Vent Area(s)	_____ in.^{2}	_____ cm^2
• Prelaunch Relative Humidity Range	_____ %	_____ %
• Preseparation Spacecraft Power Dissipation	_____ Btu/hr	_____ W
• Maximum Free-Stream Dynamic Pressure	_____ psi	_____ mbar
DYNAMIC ENVIRONMENT		
• Maximum Allowable Flight Acoustics	_____ dB OA	_____ dB OA
• Allowable Acoustics Curve		
• Maximum Allowable Sine Vibration	_____ G_{RMS}	_____ G_{RMS}
• Allowable Sine Vibration Curve	_____ G_{RMS}	_____ G_{RMS}
• Maximum Allowable Shock	_____ g	_____ g
• Allowable Shock Curve		
• Maximum Acceleration (Static + Dynamic) Lateral	_____ g	_____ g
• Maximum Acceleration (Static + Dynamic) Longitudinal	_____ g	_____ g
• Fundamental Natural Frequency—Lateral	_____ Hz	_____ Hz
• Fundamental Natural Frequency—Longitudinal	_____ Hz	_____ Hz
• cg—Thrust Axis (Origin at Separation Plane)	_____ in.	_____ mm
• cg—Y Axis	_____ in.	_____ mm
• cg—Z Axis	_____ in.	_____ mm
• cg Tolerance—Thrust Axis	_____ ±in.	_____ ±mm
• cg Tolerance—Y Axis	_____ ±in.	_____ ±mm
• cg Tolerance—Z Axis	_____ ±in.	_____ ±mm
CONTAMINATION REQUIREMENTS		
• Fairing Air Cleanliness	_____ Class	_____ Class
• Maximum Deposition on Spacecraft Surfaces	_____ mg/m^2	_____ mg/m^2
• Outgassing—Total Weight Loss	_____ %	_____ %
• Outgassing—Volatile Condensable Material Weight Loss	_____ %	_____ %
SPACECRAFT DESIGN SAFETY FACTORS		
• Airborne Pressure Vessel Burst Safety Factor		
• Airborne Pressure System Burst Safety Factor		
• Structural Limit (Yield) Safety Factor		
• Structural Ultimate Safety Factor		
• Battery Burst Safety Factor		
SPACECRAFT QUALIFICAITON TEST PROGRAM		
• Acoustic Qualification	_____ +dB	_____ +dB
• Sine Vibration Qualification Safety Factor		
• Shock Qualification Safety Factor		
• Loads Qualification Safety Factor		

Note: For a preliminary compatibility assessment, all shaded items should be completed. For a detailed compatibility assessment, all items should be completed.

Table C.1-1 Spacecraft Information Worksheet (Part 3 of 3)

SPACECRAFT DESIGN PARAMETER	ENGLISH UNITS	SI UNITS
ORBIT INJECTION CONDITIONS		
• Range of Separation Velocity	_____ ft/s	_____ m/s
• Max Angular Rate at Separation—Roll	_____ rpm	_____ rpm
• Max Angular Rate Uncertainty—Roll	_____ ±rpm	_____ ±rpm
• Max Angular Rate at Separation—Pitch & Yaw	_____ rpm	_____ rpm
• Max Angular Rate Uncertainty—Pitch & Yaw	_____ ±rpm	_____ ±rpm
• Max Angular Acceleration	_____ rad/s^2	_____ rad/s^2
• Max Pointing Error Requirement	_____ deg	_____ deg
• Max Allowable Tip-Off Rate	_____ deg/s	_____ deg/s
• Coefficients of Inertia—Ixx (x=Thrust Axis)	_____ slug ft^2	_____ kg m^2
• Coefficients of Inertia—Ixx Tolerance	_____ ±slug ft^2	_____ ±kg m^2
• Coefficients of Inertia—Iyy	_____ slug ft^2	_____ kg m^2
• Coefficients of Inertia—Iyy Tolerance	_____ ±slug ft^2	_____ ±kg m^2
• Coefficients of Inertia—Izz	_____ slug ft^2	_____ kg m^2
• Coefficients of Inertia—Izz Tolerance	_____ ±slug ft^2	_____ ±kg m^2
• Coefficients of Inertia—Ixy	_____ slug ft^2	_____ kg m^2
• Coefficients of Inertia—Ixy Tolerance	_____ ±slug ft^2	_____ ±kg m^2
• Coefficients of Inertia—Iyz	_____ slug ft^2	_____ kg m^2
• Coefficients of Inertia—Iyz Tolerance	_____ ±slug ft^2	_____ ±kg m^2
• Coefficients of Inertia—Ixz	_____ slug ft^2	_____ kg m^2
• Coefficients of Inertia—Ixz Tolerance	_____ ±slug ft^2	_____ ±kg m^2

Note: For a preliminary compatibility assessment, all shaded items should be completed. For a detailed compatibility assessment, all items should be completed.

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Tables C.1-2 through C.1-8 indicate spacecraft data required after contract signature to start integration of the spacecraft. The asterisks in these tables indicate data desired at an initial meeting between Lockheed Martin and the customer. These data will provide the detailed information required to fully integrate the spacecraft with the launch vehicle and determine such items as optimum mission trajectory, and verify compatibility of the launch vehicle environments and interfaces.

Table C.1-2 Mission Requirements

TYPE OF DATA	SCOPE OF DATA
Number of Launches*	
Frequency of Launches*	
Spacecraft Orbit Parameters Including Tolerances (Park Orbit, Transfer Orbit)*	• Apogee Altitude • Perigee Altitude • Inclination • Argument of Perigee • RAAN
Launch Window Constraints • Preseparation Function*	• Prearm • Arm • Spacecraft Equipment Deployment Timing & Constraints • Acceleration Constraints (Pitch, Yaw, Roll) • Attitude Constraints • Spinup Requirements
• Separation Parameters (Including Tolerances)*	• Desired Spin Axis • Angular Rate of Spacecraft • Orientation (Pitch, Yaw & Roll Axis) • Acceleration Constraints
Any Special Trajectory Requirements	• Boost Phase • Coast Phase • Free Molecular Heating Constraints • Thermal Maneuvers • Separation Within View of Telemetry & Tracking Ground Station • Telemetry Dipout Maneuvers
Note: * Information Desired at Initial Meeting Between Lockheed Martin & Customer After Contract Award	003_0086_2.97

Table C.1-3 Spacecraft Characteristics (Part 1 of 2)

TYPE OF DATA	SCOPE OF DATA
Configuration Drawings*	• Drawings Showing the Configuration, Shape, Dimensions & Protrusions into the Mounting Adapter (Ground Launch & Deployment Configurations) • Coordinates (Spacecraft Relative to Launch Vehicle) • Special Clearance Requirements
Apogee Kick Motor*	• Manufacturer's Designation • Thrust • Specific Impulse • Burn Action Time • Propellant Offload Limit
Mass Properties (Launch & Orbit Configurations)*	• Weight—Specify Total, Separable & Retained Masses • Center of Gravity—Specify in 3 Orthogonal Coordinates Parallel to the Booster Roll, Pitch & Yaw Axes for Total, Separable & Retained Masses • Changes in cg Resulting from Deployment of Appendages • Propellant Slosh Models
Moments of Inertia (Launch & Orbit Configurations)	• Specify About the Axes Through the Spacecraft cg That Are Parallel to the LMLV Roll, Pitch & Yaw Axes for Total, Separable, & Retained Masses
Structural Characteristics	• Spring Ratio of Structure, Elastic Deflection Constants, Shear Stiffness, Dynamic Model, Bending Moments & Shear Loads at Spacecraft-to-Launch-Vehicle Interface & Limitations To Include Acoustic, Shock, Acceleration, Temperature & Bending Moments

Table C.1-3 Spacecraft Characteristics (Part 2 of 2)

TYPE OF DATA	SCOPE OF DATA
Dynamic Model for 3-D Loads Analysis	• Generalized Stiffness Matrix (See Paragraph C.3.2 for Details) • Generalized Mass Matrix • Description of the Model, Geometry & Coordinate System • Loads Transformation Matrix Note: Models Must Include Rigid Body & Normal Modes
Handling Constraints	• Spacecraft Orientation During Ground Transport • Spacecraft Handling Limits (e.g., Acceleration Constraints)
Spacecraft Critical Orientation During:	• Location & Direction of Antennas Checkout, Prelaunch & Orbit • Location, Look Angle & Frequency of Sensors • Location & Size of Solar Arrays
Safety Items	General Systems Description • Basic Spacecraft Mission • Prelaunch Through Launch Configuration • Orbital Parameters • Electrical & Electronic Subsystems • Nonionizing Radiation Subsystems (RF/Laser) • Ionizing Radiation Subsystems • Hazardous Materials • Thermal Control Subsystems • Acoustical Subsystems Note: Hazard Identification/Controls/Verification Method Summaries Required for Each Subsystem GSE Descriptions • Mechanical GSE • Propellant/Propulsion GSE • Pressure GSE • Ordnance GSE • Electrical GSE • RF/Laser GSE • Ionizing Radiation GSE • Hazardous Materials GSE Note: Hazard Identification/Controls/Verification Method Summaries Required for Each Item Ground Operations • Hazardous Ground Operations • Procedures • Transport Configuration Note: Identify Each Item/Operation Applicable to PPF, HPF, or Launch Site for Each Data Submittal
Thermal Characteristics	• Spacecraft Thermal Math Model (see Sect. C.3.3) • Emissivity • Conductivity • Resistivity • Thermal Constraints (Maximum & Minimum Allowable Temperature) • Heat Generation (e.g., Sources, Heat. Time of Operation)
Contamination Control	• Requirements for Ground-Supplied Services • In-Flight Conditions (e.g., During Ascent & After PLF Jettison) • Surface Sensitivity (e.g., Susceptibility to Propellants, Gases, & Exhaust Products)
RF Radiation	• Characteristics (e.g., Power Levels, Frequency, & Duration for Checkout & Flight Configuration) • Locations (e.g., Location of Receivers & Transmitters on Spacecraft) • Checkout Requirements (e.g., Open-Loop, Closed-Loop, Prelaunch, Ascent Phase)
Note: * Information Desired at Initial Meeting Between Lockheed Martin & Customer After Contract Award	003_0087_2.97

Table C.1-4 Aerospace Vehicle Equipment (AVE) Requirements (Mechanical)

TYPE OF DATA	SCOPE OF DATA
Mechanical Interfaces	• Base Diameter of Spacecraft Interface* • Structural Attachments at S/C Interface* • Required Accessibility to Spacecraft in Mated Condition* • Extent of Equipment Remaining with Adapter After Spacecraft Separation* • Degree of Environmental Control Required • Spacecraft Pressurization, Fueling System Connector Type & Location; Timeline for Pressure/Fuel System Operation • Spacecraft/Adapter Venting Requirements
PLF Requirements	• Heating Constraints • Venting Characteristics (e.g., Quantity, Timing & Nature of Gases Vented from P/L) • RF Reradiation System (RF Band, S/C Antenna Location, etc) • PLF Separation (e.g. Altitude, Cleanliness, Shock, Aeroheating & Airload Constraints) • Acoustic Environment Constraints • Special Environmental Requirements
Preflight Environment	• PLF Separation (e.g. Altitude, Cleanliness, Shock, Aeroheating & Airload Constraints) • Acoustic Environment Constraints • Special Environmental Requirements • Requirements — Cleanliness — Temperature & Relative Humidity — Air Conditioning — Air Impingement Limits • Monitoring & Verification Requirements
Umbilical Requirements*	• Separation from Launch Vehicle • Flyaway at Launch • Manual Disconnect (Including When)
Materials	• Special Compatibility Requirements • Outgassing Requirements
Note: * Information Desired at Initial Meeting Between Lockheed Martin & Customer After Contract Award	003_0088_2.97

Table C.1-5 Aerospace Vehicle Equipment (AVE) Requirements (Electrical)

TYPE OF DATA	SCOPE OF DATA
Power Rqmts (Current, Duration, Function Time & Tolerances)*	• 28-Vdc Power • Other Power • Overcurrent Protection
Command Discrete Signals	• Number* • Sequence • Timing (Including Duration, Tolerance, Repetition Rate, etc) • Voltage (Nominal & Tolerance) • Frequency (Nominal & Tolerance) • Current (Nominal & Tolerance) • When Discretes Are for EED Activation, Specify Minimum, Maximum & Nominal Fire Current; Minimum & Maximum Resistance; Minimum Fire Time; Operating Temperature Range & Manufacturer's Identification of Device
Other Command & Status Signals	• Status Displays • Abort Signals • Range Safety Destruct • Inadvertent Separation Destruct
Ordnance Circuits	• Safe/Arm Requirements
Telemetry Requirements	• Quantity of Spacecraft Measurements Required To Be Transmitted by LMLV Telemetry & Type (e.g., Temperature, Vibration, Pressure, etc); Details Concerned with Related System Including Operating Characteristics (Response Definition of System), and Locations & Anticipated Time of Operation • Impedance, Capacitance, Operating Range & Full-Scale Range of Each Measurement • Signal Conditioning Requirements (e.g., Input Impedance, Impedance Circuit Load Limits, Overcurrent Protection & Signal-to-Noise Ratio) • Discrete Events (Bilevel) • Analog Measurements • Minimum Acceptable Frequency Response for Each Measurement • Minimum Acceptable System Error for Each Measurement. (Sampling Rate Is Also Governed by This Requirement) • Period of Flight for Which Data from Each Measurement Are of Interest (e.g., from Liftoff to Space Vehicle Separation)*
Bonding	• Bonding Requirements at Interface (MIL-B-5087, Class R for LV) • Material & Finishes at Interface (For Compatibility with LV Adapter)
EMC	• Test or Analyze Spacecraft Emissions & Susceptibility • EMC Protection Philosophy for Low-Power, High-Power & Pyrotechnic Circuits • LV & Site Emissions (Provided by Lockheed Martin)
Grounding Philosophy	• Structure (e.g., Use of Structural As Ground & Current Levels) • Electrical Equipment (e.g., Grounding Method for Signals & Power Supplies) • Single-Point Ground (e.g., Location & Related Equipment)
Interface Connectors	• Connector Item (e.g., Location & Function)* • Connector Details • Electrical Characteristics of Signal on Each Pin
Shielding Requirements	• Each Conductor or Pair • Overall • Grounding Locations for Termination

Note: * Desired for Initial Integration Meeting with Lockheed Martin After Contract Award

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Table C.1-6 AGE/Facility Requirements (Mechanical)

TYPE OF DATA	SCOPE OF DATA
Spacecraft Launch Vehicle Integration	• Sequence from Spacecraft Delivery Through Mating with the LV • Handling Equipment Required • Lockheed Martin-Provided Protective Covers or Work Shields Required • Identify the Space Envelope, Installation, Clearance & Work Area Requirements • Any Special Encapsulation Requirements • Support Services Required
Spacecraft Checkout AGE & Cabinet Data	• List of All AGE & Location Where Used (e.g.. Storage Requirements on the Launch Pad) • Installation Criteria for AGE Items: — Size & Weight — Mounting Provisions — Grounding & Bonding Requirements — Proximity to the Spacecraft When in Use — Period of Use — Environmental Requirements — Compatibility with Range Safety Requirements & LV Propellants — Access Space to Cabinets Required for Work Area, Door Swing, Slideout Panels, etc — Cable Entry Provisions & Terminal Board Types in Cabinets and/or Interface Receptacle Locations & Types — Power Requirements & Characteristics of Power for Each Cabinet
Spacecraft Environmental Protection (Preflight)	• Environmental Protection Requirements by Area, Including Cleanliness Requirements: — Spacecraft Room — Transport to Launch Pad — Mating — Inside PLF — During Countdown • Air-Conditioning Requirements for Applicable Area (Pad Area) by: — Temperature Range — Humidity Range — Particle Limitation — Impingement Velocity Limit — Flow Rate • Indicate if Space Vehicle Is Not Compatible with LV Propellants & What Safety Measures Will Be Required • Environmental Monitoring & Verification Requirements
Space Access Requirements	• Access for Space Vehicle Mating & Checkout • Access During Transportation to the Launch Pad & Erection Onto the LMLV • Access for Checkout & Achieving Readiness Before Fairing Installation • Access After Fairing Installation; State Location, Size of Opening & Inside Reach Required • Access During the Final Countdown, if Any • AGE Requirements for Emergency Removal
Umbilicals	• Ground Servicing Umbilicals by Function & Location in Excess of LMLV Standard Umbilical • Structural Support Requirements & Retraction Mechanisms • Installation (e.g., When & by Whom Supplied & Installed)
Commodities Required for Both Spacecraft, AGE & Personnel	• Gases, Propellants, Chilled Water & Cryogenics in Compliance with Ozone-Depleting Chemicals Requirements • Source (e.g., Spacecraft or LV) • Commodities for Personnel (e.g., Work Areas, Desks, Phones)
Miscellaneous	Spacecraft Guidance Alignment Requirements

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Table C.1-7 AGE/Facility Requirements (Electrical)

TYPE OF DATA	SCOPE OF DATA
Space Vehicle Electrical Conductor Data	S/C System Schematic Showing All Connectors Required Between S/C Equipment, & S/C Terminal Board Position or Receptacle Pin Assigned to Each Conductor; Electrical Characteristics of Each Connector Including Maximum End-to-End Resistance, Shielding, Capacitance, etc, & Spare Conductors
Electrical Power (AGE & Facility)	• Frequency, Voltage, Watts, Tolerance, Source • Isolation Requirements • Identify if Values Are Steady or Peak Loads • High-Voltage Transient Susceptibility
RF Transmission	• Antenna Rqmts (e.g., Function, Location, Physical Characteristics, Beam Width & Direction & Line-of-Sight) • Frequency & Power Transmission • Operation
Cabling	Any Cabling, Ducting, or Conduits To Be Installed in the Mobile Service Tower; Who Will Supply, Install, Check Out & Remove
Monitors & Controls	• Specify Which Signals from the S/C Are To Be Monitored During Readiness & Countdown • Transmission Method (e.g., S/C Tlm, LV Tlm) • Location of Data Evaluation Center, Evaluation Responsibility, Measurement Limits & Go/No-Go Constraints; Identify Where in the Operational Sequence Measurements Are To Be Monitored & Evaluated; Specify Frequency & Duration of Measurements • Video Output Characteristics of Telepaks (if Available) for Closed-Loop Prelaunch Checkout at the Launch Pad; Data To Include Location & Type of Interface Connector(s), & Characteristics of Signal at Source; This Includes Voltage Level, Output Impedance, Output Current Limitation, Maximum Frequency of Data Train & Output Loading Requirements 003_0091_2.97

Table C.1-8 Test Operations

TYPE OF DATA	SCOPE OF DATA
Hardware Needs (Including Dates)	• Electrical Simulators • Structural Simulators • Master Drill Gage*
Interface Test Requirements	• Structural Test • Fit Test • Compatibility Testing of Interfaces (Functional) • EMC Demonstration • LV/Spacecraft RF Interference Test • Environmental Demonstration Test
Launch Operations	• Detailed Sequence & Time Span of All Spacecraft-Related Launch Site Activities Including: AGE Installation, Facility Installation & Activities, Spacecraft Testing & Spacecraft Servicing • Recycle Requirements • Restrictions To Include Launch Site Activity Limitations, Constraints on Launch Vehicle Operations, Security Requirements & Personnel Access Limitations & Safety Precautions • Special Requirements Include Handling of Radioactive Materials, Security & Access Control • Support Requirements To Include Personnel, Communications & Data Reduction • Launch & Flight Requirements for Real-Time Data Readout, Postflight Data Analysis, Data Distribution, Postflight Facilities
Note: * Desired for Initial Integration Meeting with Lockheed Martin After Contract Award 003_0092_2.97	

C.2 SPACECRAFT DESIGN REQUIREMENTS

Table C.2-1 lists specific requirements that should be certified by analysis and/or test by the spacecraft agency to be compatible for launch with the LMLV. Should the spacecraft not meet any of these requirements, Lockheed Martin will work with the customer to resolve the incompatibility.

Table C.2-1 Spacecraft Design Requirements

SPACECRAFT DESIGN REQUIREMENTS	COMMENT
MECHANICAL • Payload Fairing Envelope (Sect. 4.1.1) • Payload Adapter and Separation Systems (Sect. 4.1.2)	
ELECTRICAL • Command and Control Interfaces (Sect. 4.1.3.2) • Telemetry Interfaces (Sect. 4.1.3.3) • Spacecraft Separation Signals (Sect. 4.1.3.4) • Spacecraft Separation Connectors (Sect. 4.1.3.5) • Spacecraft Destruct Option (Sect. 4.1.3.6)	
STRUCTURE & LOADS • Design Load Factors (Sect. 3.1.1 and 3.2.1) • First Lateral Modes and First Axial Modes (Sect. 3.2.2) • Spacecraft Mass vs cg Range (Sect. 4.1.2.4) • Design Factor of Safety per Applicable Range Safety Documentation	
ENVIRONMENT • Radiation and Electromagnetic (Sect. 3.1.3) • Quasi-Sinusoidal Vibration (Sect. 3.2.2) • Random Vibration (Sect. 3.2.3) • Acoustic Levels in the PLF (3.2.4) • Shock Induced by First-Stage Ignition and Separation Events (Sect. 3.2.5) • Ascent Aerodynamic Heating (Sect. 3.2.6) • Payload Fairing Depressurization Rates (Sect. 3.2.7) • Spacecraft Test Requirements (Sect. TBS)	
SAFETY • All Spacecraft Propellant Fill & Drain Valves & All Pressurant Fill & Vent Valves Readily Accessible When Spacecraft Is Fully Assembled & Serviced in Launch Configuration (Encapsulated and on Pad) • Requirements in Range Safety Regulation	It Is Advisable To Accommodate Normal Servicing/ Deservicing & Potential Emergency Backout Situation for New S/C Design
MISCELLANEOUS • Spacecraft Propellants & Pressurant Specifications	
Note: Compliance with Ozone-Depleting Chemicals Regulation Is Required.	003_0093_2.97

C.3 SPACECRAFT INTEGRATION INPUTS

Table C.3-1 provides a list of typical spacecraft inputs required for the integration process, the approximate need date, and a brief description of the contents. Further details on some items are provided in the following sections.

C.3.1 Computer-Aided Design Data Transfer Requirements

Computer-Aided Design (CAD) data must be provided according to the specified formats. Lockheed Martin supports two CAD systems, Structural Dynamics Research Corporation's (SDRC) I-DEAS 6.1 or higher and Computervision's (CV) CADDS 4X or CADDS 5. When the CAD data do not come from SDRC or CV, Lockheed Martin prefers to receive an Initial Graphics Exchange Specification (IGES) 4.0 or higher file from a three-dimensional (3-D) wireframe system or wireframe extracted from solids.

Table C.3-1 Spacecraft Inputs to Integration Process

S/C DATA INPUT	TYPICAL NEED DATE	COMMENTS
Interface Rqmts Doc	Program Kickoff	See Sect. C.1
Initial Target Specification	Program Kickoff	S/C Weight, Target Orbit, Separation Attitude See Sect. C.3.3
Range Safety Mission Orientation Briefing Input	6 wk Before Meeting Date	Top-Level Description of the Spacecraft & Mission Design
CAD Model	30 days After Program Kickoff	See Sect. C.3.1
Coupled Loads Model	6 mo Before Design Review	See Sect. C.3.2
Preliminary Launch Windows	5 mo Before Design Review	Target Orbit See Sect. C.3.3
In-Flight Breakup Data	14 mo Before Launch	See Sect. C.3.5.4.3
Intact Impact Breakup Data	14 mo Before Launch	See Sect. C.3.5.4.2
Prelim S/C MSPSP	14 mo Before Launch	See Sect. C.3.5.1
S/C EMI/EMC Cert Ltr	6 mo Before Launch	See Sect. C.3.4
S/C EED Analysis	6 mo Before Launch	See Sect. C.3.4
Procedures Used at CCAS	5 mo Before Launch	See Sect. C.3.5.2
Procedures Used at Astrotech	2 mo Before S/C Arrival at Astrotech	See Sect. C.3.5.2
Final Target Specification	90 days Before Launch	Date Depends on Mission Design See Sect. C.3.3
S/C Envir Qual Test Rpts	As Available	See Table C.2-1 for Envir Qual Rqmts

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The following criteria should be met before transferring CAD or IGES data that do not come from SDRC:

Master Series Model Files—There are two options that can be used in transferring data using SDRC Master Series model files. Both incorporate the use of the "export" command. The following criteria should be met before transferring SDRC Master Series data:

Option 1—Using Archive Files

1) Verify the current revision of software being used. Model files and associated archive files are only upward compatible.
2) Export the model file to an archive file. The archive file is an ASCII file and will contain all assemblies, subassemblies, and parts within the model file. It is recognized by the filename and its ".arc" extension.

Option 2—Using Model Files

1) Verify the current revision of software being used. Model files and associated archive files are only upward compatible. Model files can only be copied between binary-compatible platforms.
2) Export the model file from a project. By exporting the model file (using a file name other than the current model file name), it creates the "mf1," "mf2" and "erf" files that contain all assemblies, subassemblies, and parts within the model file; the "erf" file contains all the attributes of the model file. All three files are necessary for "importing" back into Master Series.

Pre-Master Series Model Files

1) All entries should be visible (unblanked) and fontless (e.g., no center lines, phantom lines, thick lines).
2) Critical construction planes or working coordinate systems should be converted to independent entities.
3) Critical sculpted surfaces should be accompanied by a mesh of checkpoints lying on the

surface at a minimum density of at least three points between each patch boundary.

4) Solids coming from systems other than SDRC or CV should be converted to 3-D wireframe and surface entities for the IGES file.

The following criteria should be met before transferring SDRC I-DEAS data:

1) Write a universal file in metric units.
2) Send the model files with the universal file if Level 6.1 was used.
3) All subsystems should reflect a common orientation so that a minimum of orientation work is required when bringing subsystems into upper level systems.
4) If the universal file is written from a larger model file and the "ALL" modifier was not used, the universal file should include pertinent data that could be helpful outside of the systems that are included. This includes working construction geometry, colors, etc.

The following criteria should be met before transferring CV data:

1) Single model files containing 30,000 entities or more should be divided into smaller model files, all having the same origin.
2) Single CADDS 5 models (containing _pd, _fd, vp_links, draw files, and execute routines) should be contained in the same subdirectory structure. The entire directory structure should then be transferred as a single compressed file.
3) No subfigures should be in the model, unless the subfigures are included in the data transfer.

Data Transfer—The preferred transfer method for all data files from any CAD system is file transfer protocol (FTP) via the Internet. This can be accomplished by allowing a Lockheed Martin representative to establish a temporary account on the contractor's computer and allowing retrieval of the files from that system once notified of their completion. An alternative would involve the contractor establishing a temporary account on a Lockheed Martin system and using FTP to transfer the files to the Lockheed Martin machine once completed. In either case, the transfer type should be set to "binary."

If FTP is not feasible, the data can also be supplied directly from UNIX-based systems and written to tape with the default block size of 512 using the tape archive (tar) command syntax as follows:

tar cvf/dev/rmt0 partfiles

The spacecraft contractor should verify that the files contain the correct data by reading the files back onto the originating CAD system from tape before transmittal to Lockheed Martin.

The following information must be sent with the CAD data file regardless of the transfer method:

1) Name and phone number of the computer system administrator/operator;
2) Name and phone number of the contact person (who is familiar with the model) if problems or questions arise;
3) Size of file (Mb);
4) Number of lines in IGES file;
5) List of entities, including total count and types;
6) Spacecraft axis and coordinate system;
7) Spacecraft access requirements for structure that is not defined on CAD model (i.e., fill and drain valve locations);
8) Multiview plot of the drawings(s);
9) SDRC Data (identify top-level system and bin number; specify all subsystems and their bin numbers if model is not fully assembled into one top-level system);
10) Tapes;
11) Data format (e.g., ASCII, CVASCII);
12) Tape drive brand name (e.g., Sun quarter-inch cartridge [QIC], Hewlett-Packard [HP] digital audio tape [DAT], Digital Equipment Corporation [DEC], 8 mm);
13) Blocking factor;
14) Number of records.

C.3.2 Coupled Loads Analysis Model Requirements

The customer-supplied dynamic mathematical model of the spacecraft should consist of generalized mass and stiffness matrices and a recommended modal damping schedule. The desired

format is Craig-Bampton, constrained at the SV-to-LV interface in terms of spacecraft modal coordinates and discrete interface points. The dynamics model should have an upper frequency cutoff of 70 Hz. The output transformation matrices (OTM) should be in the form that, when multiplied by the spacecraft modal and interface generalized coordinate responses, will recover the desired accelerations, displacements, or internal loads. One of the OTMs should contain data that will allow calculation of loss of clearance between the payload fairing (PLF) and critical points on the spacecraft. Typically, the size of the OTMs is 200 to 500 rows for accelerations, 50 to 200 rows for displacements, and 300 to 1,000 rows for internal loads.

C.3.3 Target Specifications

Target specifications normally include the final mission transfer orbit (apogee and perigee radius, argument of perigee, and inclination); spacecraft mass properties; and launch windows. The final target specifications are due to Lockheed Martin no less than 60 days before launch.

C.3.4 Spacecraft Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) Certification Letter and Electroexplosive Device (EED) Analysis

A final confirmation of spacecraft transmitter and receiver parameters and emission and susceptibility levels of the electronic systems is required 6 months before launch. This includes consideration of emissions from such electronic equipment as internal clocks, oscillators, and signal or data generators and susceptibility of both electronics and items such as electroexplosive devices (EED) to cause upset, damage, or inadvertent activation. These characteristics are to be considered according to MIL-STD-1541 requirements to assure that appropriate margins are available during launch operations. Lockheed Martin will use the spacecraft data to develop a final analysis and certification for the combined spacecraft/launch vehicle and site environment.

C.3.5 Safety Data

The spacecraft must show compliance with Eastern/Western Range Regulation (EWR) 127-1 to receive Range Safety approval to launch from Cape Canaveral Air Station (CCAS) or Vandenberg Air Force Base (VAFB). Spacecraft documentation required for submittal to Range Safety is briefly described below. Details of the spacecraft submittals will be coordinated in mission integration working group meetings and other channels during the integration process.

C.3.5.1 Missile System Prelaunch Safety Package—The Missile System Prelaunch Safety Package (MSPSP) is the data package that describes in detail all hazardous and safety-critical systems or subsystems and their interfaces in the spacecraft and its ground support equipment (GSE). In addition, the MSPSP provides verification of compliance with Chapters 3, 5, and 7 of EWR 127-1. The MSPSP must be approved by Range Safety before the arrival of any spacecraft elements on the launch site.

C.3.5.2 Spacecraft Launch Site Procedures—All hazardous spacecraft procedures must be approved by Range Safety or by the Astrotech Safety Officer, depending on where the procedures will be used, before they are run. Because the approving authority must also concur in the nonhazardous designation of procedures, all spacecraft launch site procedures must be submitted for review. The Lockheed Martin System Safety group is the customer point of contact for launch site safety authorities.

C.3.5.3 Radiation Protection Officer Data—Permission must be secured from the Range Radiation Protection Officer (RPO) before a spacecraft is allowed to radiate radio frequency (RF) emissions on pad. The required data include descriptions of the equipment involved, the procedures that will be used, and data forms on the personnel who will be running the procedures.

C.3.5.4 Spacecraft Breakup Data Requirements—The data described in the following three subsections are required to perform analyses that satisfy 45th Space Wing/SEY

requirements for submitting a request for Range Safety flight plan approval.

C.3.5.4.1 Inadvertent Spacecraft Separation and Propulsion Hazard Analysis—This set of data is related to inadvertent separation of the spacecraft during early ascent and the potential for launch area hazard that could exist in the event the spacecraft engine(s) fire. Typical spacecraft propulsion system data provided by the customer include the maximum tanked weight, maximum loaded propellant weight, maximum axial thrust (all motors), and maximum resultant specific impulse.

C.3.5.4.2 Intact Impact Analysis—This set of data is related to the ground impact of the spacecraft. The intact impact analysis assumes ground impact of a fully loaded, fueled, intact spacecraft and assumes the propellants combine and explode. Typical spacecraft data provided by the customer include the types and weights of explosive propellants; estimates of the number of pieces of the spacecraft that could break off resulting from an explosion; and locations, size, weight, and shape of each piece.

C.3.5.4.3 Destruct Action Analysis—This set of data is related to the flight termination system (FTS) destruction of the launch vehicle. The destruct action analysis assumes in-flight destruction of the vehicle by detonation of the Range Safety charge. Typical spacecraft data provided by the customer include an estimate of the number of spacecraft pieces that could break off as a result of commanded vehicle destruction and estimates of their size, weight, shape, and mounting location on the spacecraft.