Minotaur Multiple Payload Adapter System (MPAS) User's Guide

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NORTHROP GRUMMAN

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REVISION SUMMARY			
VERSION	**DATE**	**CHANGE**	**PAGE**
1.0	November 2019	Initial Public Release	All
1.1	September 2020	Branding update. Updated contact information.	All

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The information provided in this MPAS User's Guide is for initial planning purposes for potential spacecraft customers to utilize Minotaur IV MPAS. This document provides an overview of the MPAS design.

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LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

GLOSSARY

A/D	Arm/Disarm
ACS	Attitude Control System
ATM	Acceleration Transformation Matrix
C/CAM	Collision/Contamination Avoidance Maneuver
CAD	Computer Aided Design
CCAFS	Cape Canaveral Air Force Station
CDRL	Contract Data Requirements List
CG	Center of Gravity
CIHS	Common Integration and Handling Stand
CLA	Coupled Loads Analysis
DNH	Do No Harm
DTM	Displacement Transformation Matrix
EDU	Engineering Design Unit
EELV	Evolved Expendable Launch Vehicle
EGSE	Electrical Ground Support Equipment
EM	Electro-Mechanical
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ENEC	Extendable Nozzle Exit Cone
ESPA	EELV Secondary Payload Adapter
FEM	Finite Element Model
FEMAP	Finite Element Modeling And Postprocessing
FTS	Flight Termination System
GCA	Guidance and Control Assembly
GFE	Government Furnished Equipment
GPS	Global Positioning System
GSE	Ground Support Equipment
HAPS	Hydrazine Auxiliary Propulsion System
IBF	Install Before Flight
ICD	Interface Control Document
ILC	Initial Launch Capability
KDP	Key Decision Point
KLC	Kodiak Launch Complex
LCR	Launch Control Room
LEV	Launch Equipment Vault
LTM	Load Transformation Matrix
LV	Launch Vehicle
MACH	Modular Avionics Control Hardware
MAXF	Multi Access X Fairing
MGSE	Mechanical Ground Support Equipment
MLB	Motorized Lightband
MPAP	Multiple Payload Adapter Plate
MPAS	Multiple Payload Adapter System
MPE	Maximum Predicted Environment
MRD	Mission Requirement Document
MSS	MPAS Separation System
MUF	Model Uncertainty Factor
NGIS	Northrop Grumman Innovation Systems
ODM	Ordnance Driver Module
OR	Operational Requirements
OSP	Orbital Suborbital Program
PAF	Payload Attack Fitting
PK	Peace Keeper
PRD	Program Requirements Document
PWS	Performance Work Statement
RBF	Remove Before Flight
RF	Radio Frequency
RFP	Request for Proposal
SDAR	Space Debris Assessment Report
SEB	Support Equipment Building
STEP	Standard for the Exchange of Product Model Data
SV	Space Vehicle
TBD	To Be Determined
TBR	To Be Reviewed
TBS	To Be Supplied
TM	Technical Manual
TRD	Technical Requirements Document
TVC	Thrust Vector Controller
VAFB	Vandenberg Air Force Base
WFF	Wallops Flight Facility

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1. INTRODUCTION

The objective of the Multiple Payload Adapter System (MPAS) User's Guide is to familiarize payload mission planners with the capabilities of the MPAS developed for the Minotaur IV launch vehicle.

The MPAS has been developed to accommodate flexible manifesting options post-contract award and during the integration process. This document establishes the Launch Vehicle (LV) standard interface that can accommodate Flexible Manifest missions with the following timeframe:

- 24 months prior to Launch (L-24): Generic Mission Requirements Document (MRD) provides Authorization to Proceed (ATP) and defines the baseline Minotaur IV configuration, defines required new vehicle development, fairing door locations, launch site (if Kodiak Launch Complex (KLC) is the launch site), and some predefined enhancements.
- 18 months prior to Launch (L-18): Define additional launch vehicle enhancements.
- 14 months prior to Launch (L-14): Determine launch site (for Vandenberg Air Force Base (VAFB), Cape Canaveral Air Force Station (CCAFS), and Wallops Flight Facility (WFF)).
- 12 months prior to Launch (L-12): Mission Specific MRD defines payload manifest (SV quantity, mass, volume, separation system), launch date, orbital parameters, and remaining launch vehicle enhancements.
- 6 months prior to Launch (L-6): Mission Specific MRD update defines final payload (this includes like-for-like payload swapping and payload de-manifest).

This document provides an overview of the MPAS design and a description of the standard launch services provided to our customers. Minotaur can offer a variety of upgraded services to allow maximum flexibility in satisfying customer requirements.

This User's Guide provides additional information to expand on the Minotaur IV User's Guide, TM-17589, that is specific to Flexible Manifest missions and MPAS. Where information provided in the Minotaur IV User's Guide is applicable, this document is referenced to avoid duplicating information. Minotaur's flexibility to adapt to non-standard interfaces remains one of its strongest attributes and will continue to be supported per the process and parameters discussed in the Minotaur IV User's Guide.

This User's Guide communicates the LV standard interface. Generic Interface Control Documents (ICDs) are available that define the Space Vehicle (SV) standard interface requirements that can be used for preliminary SV design. Reference 1045-0526, Generic Minotaur IV LV to SV ICD and 1045-0587, Generic Minotaur IV Stage 4 Deployer ICD.

Documents referenced in this User's Guide are summarized in Table 1-1.

Table 1-1. Reference Documents

Document Number	Document Title
TM-17589	Minotaur IV User's Guide
1045-0526	Generic Minotaur IV LV to SV ICD
1045-0587	Generic Minotaur IV Stage 4 Deployer ICD

1.1. Northrop Grumman Innovation Systems History

Northrop Grumman Innovation Systems (NGIS) is a leading developer and manufacturer of small, medium and heavy-class space launch systems. Northrop Grumman Innovation Systems has three decades of demonstrated reliable, rapid and affordable development and production experience, serving customers in the commercial, defense and civil government markets. Northrop Grumman Innovation Systems has delivered or is under contract for over 1,000 space products, including satellites and space systems, space and strategic launch vehicles, and sub-orbital target vehicles and sounding rockets.

Northrop Grumman Innovation Systems is a domestic launch service provider and an ISO-9001/2008 certified company. Northrop Grumman Innovation Systems has pioneered new classes of rockets, satellites, and other space-based technologies that help make the benefits of space more affordable and accessible.

2. CONFIGURATIONS

The MPAS allows the Minotaur IV LV to support numerous payload configurations and classes with a focus on EELV Secondary Payload Adapter (ESPA) Class SV, larger than ESPA Class SV, and CubeSat Deployers, but the flexibility and robustness of the design allows the system to support any class of satellites. Figure 2-1 provides an expanded view of the MPAS within the Minotaur IV LV. Key MPAS capabilities include, the ability to support:

- Current ESPA standards
- Proposed ESPA standards that increases the ESPA mass from 400 pounds to 485 pounds
- ESPA Grande standards

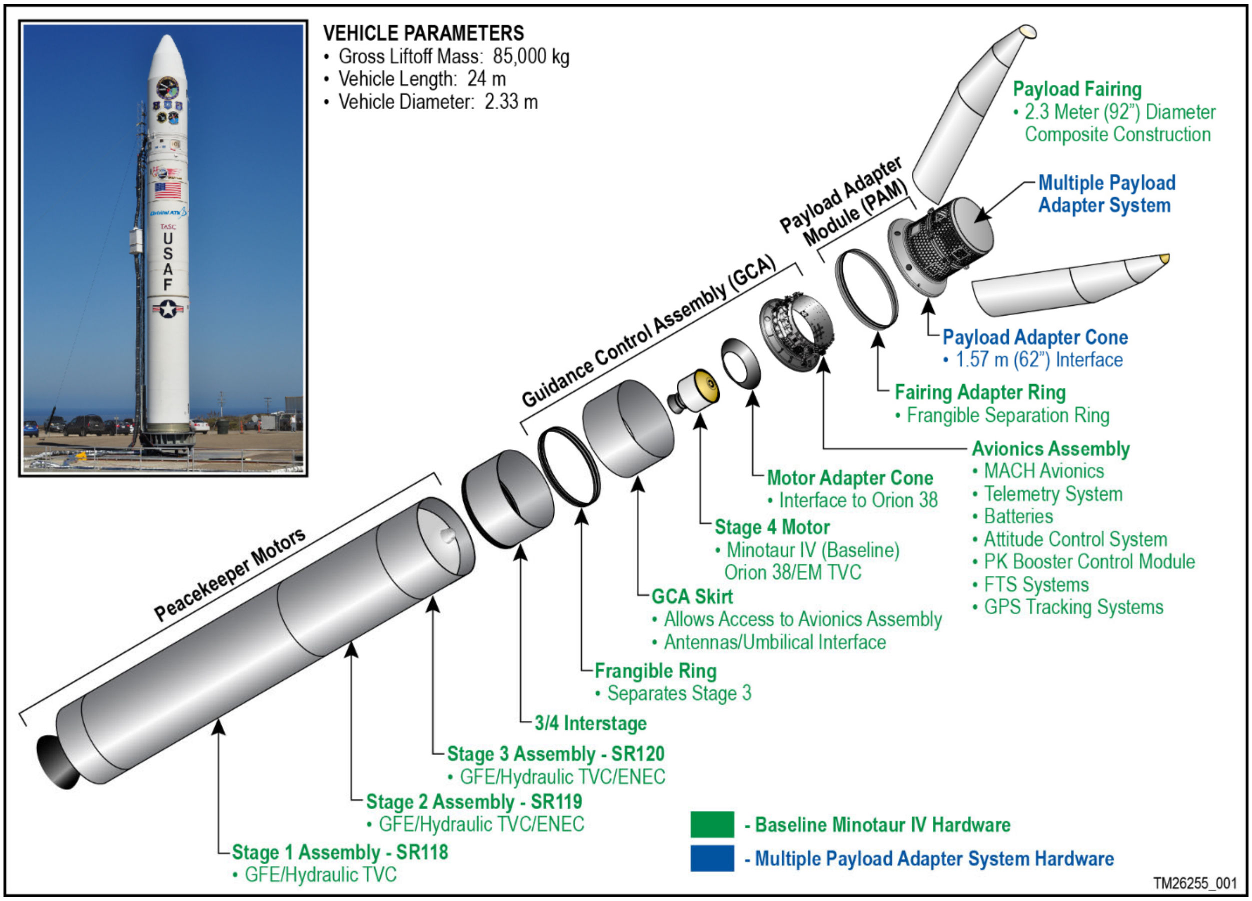

Figure 2-1. Expanded View of the Minotaur IV LV with MPAS

Figure 2-2 provides an expanded view of key MPAS hardware and Figure 2-3 shows the MPAS in a configuration that supports sixteen notional spacecraft including six ESPA Class SV, eight 6U CubeSat Deployers, and two 12U CubeSat Deployers. Figure 2-3 is one of several available MPAS configurations and additional configurations are presented within this section.

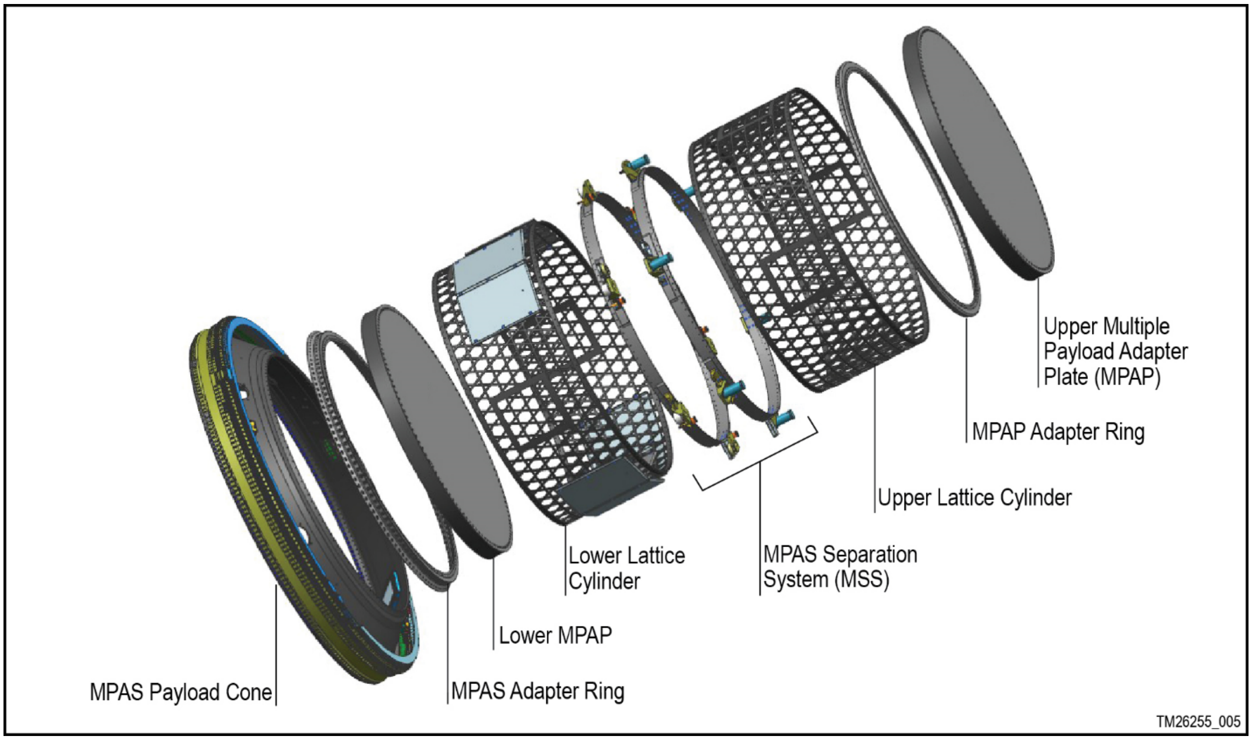

Figure 2-2. Expanded View of Key MPAS Hardware

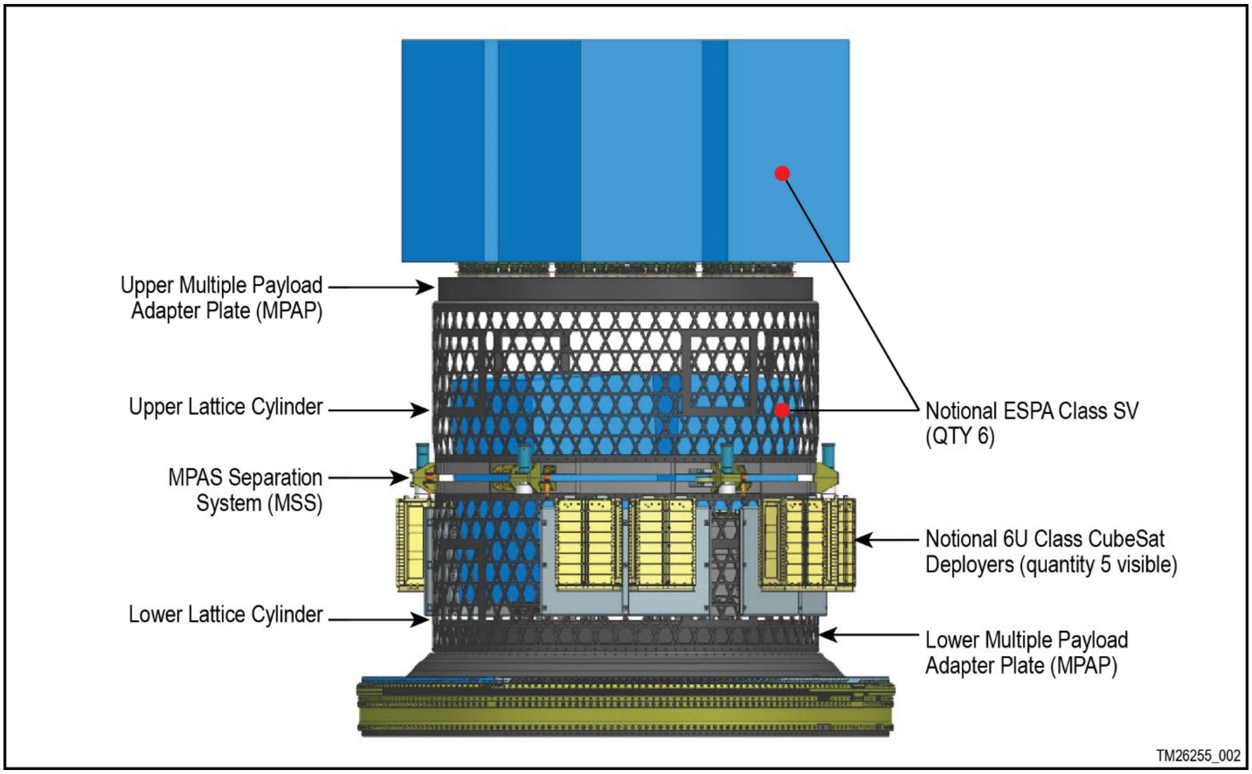

Figure 2-3. Full MPAS Configured with Upper MPAP and Notional SVs and Deployers

2.1. MPAS Configurations

The MPAS is a modular system designed with a 62.01" diameter interface and standardized bolt pattern to maximize mission manifest flexibility. Some possible configurations are shown in Figure 2.1-1, Figure 2.1-2, Figure 2.1-3 and Figure 2.1-4.

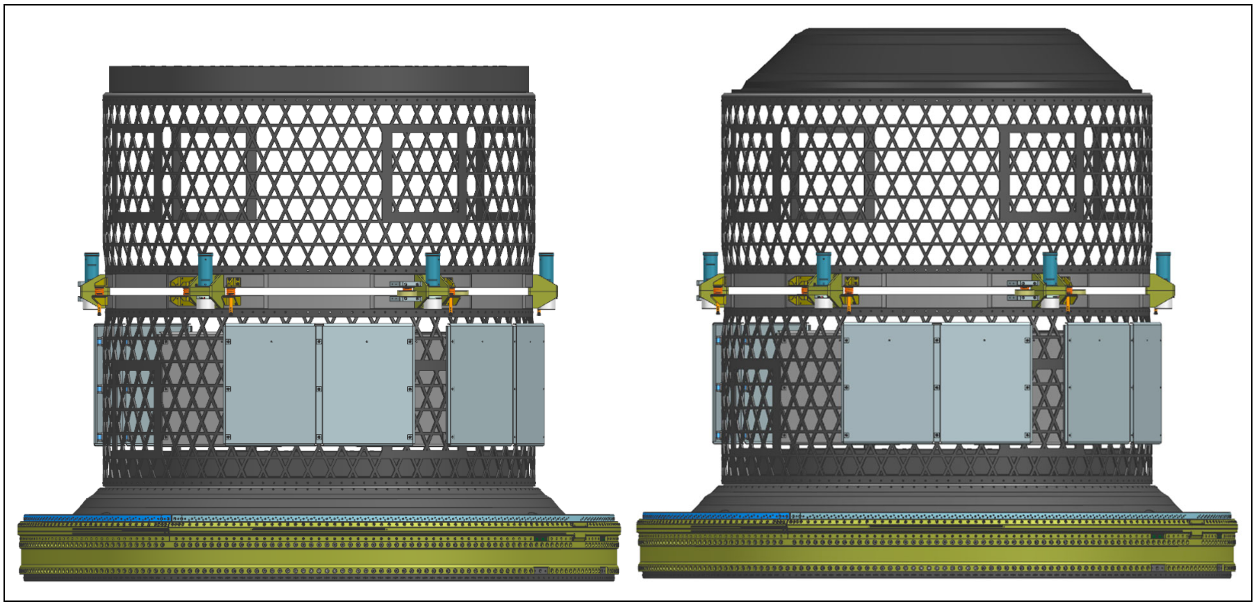

Figure 2.1-1. Full MPAS with Upper Plate or Payload Cone

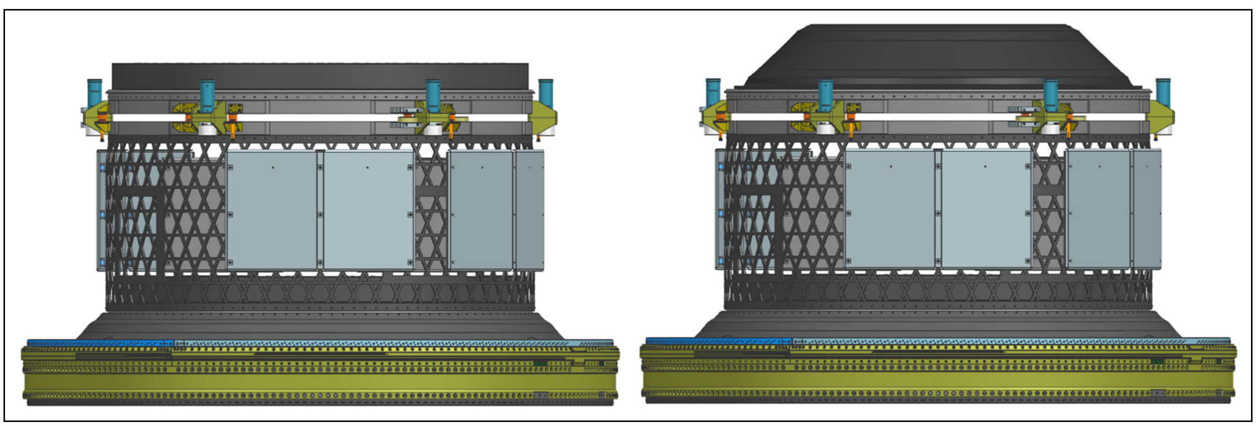

Figure 2.1-2. Half MPAS with Separation System and Upper Plate or Payload Cone

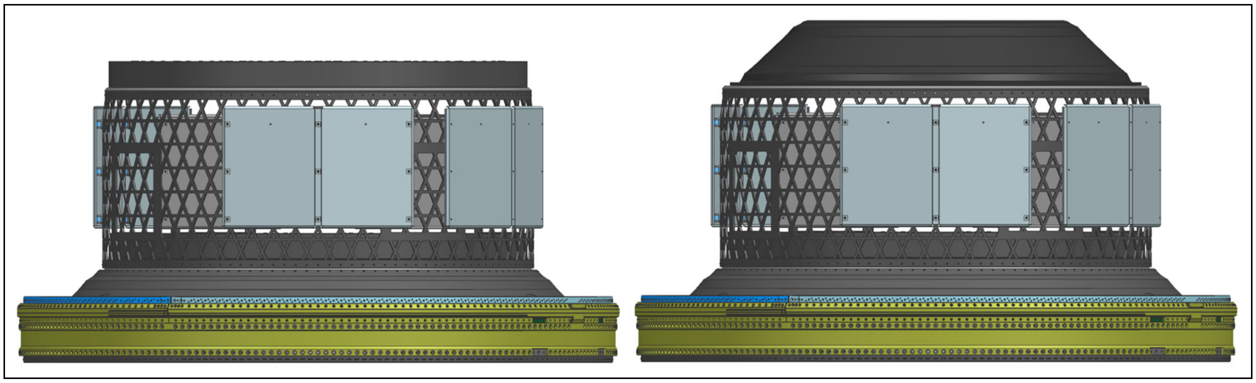

Figure 2.1-3. Half MPAS without Separation System and Upper Plate or Payload Cone

2.1.1. MPAS Payload Cone

A new truncated 45-degree cone has been developed to increase structural capability and joint stiffness above the heritage 30-degree cone described in TM-17589 Minotaur IV User's Guide. This Payload Cone was designed to interface between the standard Minotaur IV Fairing Adapter Ring and the MPAS. This new structure leverages payload cone designs flown on previous Minotaur missions and provides a mass savings when compared to the heritage design.

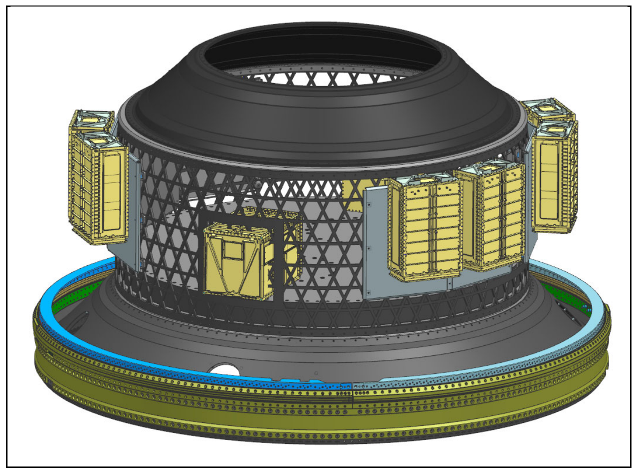

Figure 2.1-4. Half MPAS with 12U Radial Deployment

Flexible Manifest missions that do not use MPAS (one large SV in the encapsulated fairing envelope and S4 CubeSat Deployers) will use the heritage 30-degree cone detailed in TM-17589 Minotaur IV User's Guide.

2.1.2. Multiple Payload Adapter Plate (MPAP)

The MPAS can be configured with a lower and upper MPAP. The MPAP leverages the same sandwich panel construction as previous Minotaur missions.

After the Mission Specific MRD is provided at L-12 months, mission specific inserts will be installed that will be used to attach SV to the MPAP, 0.250 28 UNJF 3B inserts will be kept in stock for Flexible Manifest missions.

2.1.3. Lattice Cylinder

The Lattice Cylinder is constructed of carbon composite ribs and leverages design elements from previous Minotaur flights. The Lattice Cylinder is compatible with all major existing CubeSat Deployers. Mounting bracketry indexes inside of lattice ribs allowing CubeSat Deployers to be mounted wherever space is available.

2.1.4. Upper Payload Cone

The MPAS can be configured with the Upper Payload Cone, which provides the heritage Minotaur IV 38.810 inch industry standard non-separating interface with quantity 60 clearance holes for 0.250 inch fasteners.

2.1.5. MPAS Separation System

The MPAS can be configured with a Separation System to allow for SV mounting on the lower MPAP. The upper Lattice Cylinder can accommodate a Hydrazine Auxiliary Propulsion System (HAPS) stage for higher and more accurate orbit insertions for the SVs mounted on the upper MPAP. The MPAS Separation System includes separation springs, separation connectors, and uses separation nuts to initiate separation. Environments from this separation event are included in the levels provided in Section 4 Payload Environment.

2.1.6. 92" Multi Access X Fairing (MAXF)

The heritage Minotaur 92" Fairing has been modified to add eight payload access doors and two hand access doors. This Multi Access X Fairing (MAXF) door configuration will be standard for all future missions utilizing the MPAS, however the heritage Minotaur 92" Fairing can be configured with mission specific/customer defined payload access door locations if this optional enhancement is selected at L-24 months. The MAXF access doors are positioned to maximize access to upper and lower MPAS locations as shown in Figure 2.1.6-1.

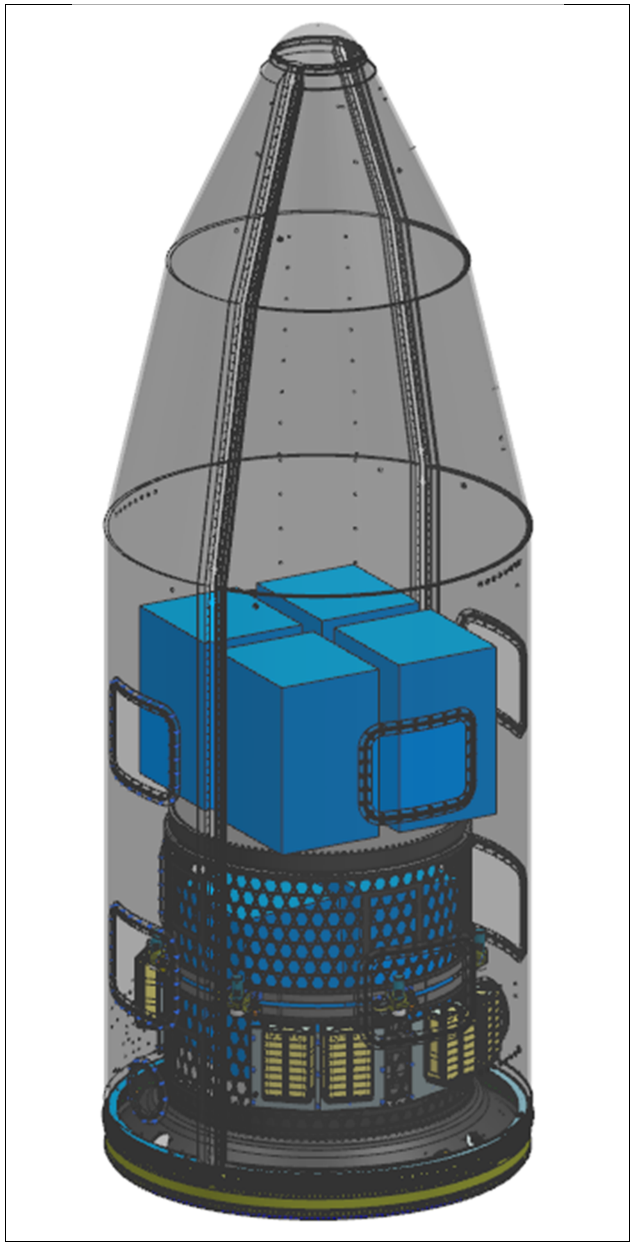

Figure 2.1.6-1. 92" Multi Access X Fairing (MAXF)

2.1.7. 110" Multi Access X Fairing

Reserved.

2.1.8. Minotaur IV Configurations

Information provided in TM-17589, Minotaur IV User's Guide, Section 2 regarding the Minotaur IV Launch System is applicable to Flexible Manifest missions using MPAS except for information provided in Section 2.3.4 Payload Interface, which has been superseded by this User's Guide.

2.2. Payload Configurations

The MPAS allows the Minotaur IV LV to support numerous payload configurations and classes with a focus on ESPA Class SV, larger than ESPA Class SV, and CubeSat Deployers, but the flexibility and robustness of the design allows the system to support any class of satellites.

This User's Guide communicates the LV standard interface. Generic Interface Control Documents (ICDs) are available that define the SV standard interface requirements that can be used for preliminary SV design. Reference 1045-0526, Generic Minotaur IV LV to SV ICD and 1045-0587, Generic Minotaur IV Stage 4 Deployer ICD.

2.2.1. CubeSat Deployers

2.2.1.1. Deployer

Deployers provide a common interface between the satellites and the LV, are mounted to the LV and carry satellites into orbit and deploy them once the proper signal is received from the LV. Deployers are typically rectangular box like structures with a door, door latch, internal rails, and an internal spring mechanism.

Deployer is used as a generic term in this document and can be applied to any deployer, dispenser, launch adapter, separation system, etc. that is intended to interface between the LV and miniaturized satellites and can be installed on the LV standard interface defined in this document.

MPAS was developed with a focus on 3U, 6U, and 12U class deployers; however, the system can support any class of deployer, which may be flown in place of ESPA Class SV and larger.

2.2.1.2. Loaded Deployer

Throughout this document, the term "Loaded Deployer" is representative of the full deployer assembly, including integrated satellites or deployer mass simulators, which will be delivered to the NGIS LV program. Additionally, mass properties information that is associated with the Loaded Deployer in the flight configuration is with all Remove Before Flight (RBF) and Install Before Flight (IBF) complete.

2.2.1.3. CubeSat

CubeSat (U class spacecraft) is a type of miniaturized satellite that is made up of multiples of 10 x 10 x 10 cm cubic units. CubeSats have a mass of no more than 1.33 kg per unit. The number of joined units classifies the size of CubeSat.

CubeSat is used as a generic term in this document and can be applied to any miniaturized satellite that can be launched by a Deployer that can be installed on the LV standard interface defined in this document.

2.2.2. Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA) Class SV

The ESPA is a payload adapter ring developed for launching secondary payloads on EELV-class orbital launch vehicles. The adapter design has become a de facto standard and has led to the colloquial designation of ESPA class payloads. The MPAS has been developed with a focus on ESPA class SVs and can accommodate the volume of six ESPA class SVs. Structurally, MPAS has been developed to accommodate the mass of six ESPA Class SV up to 485 pounds each; however, the Minotaur IV performance capability, launch site and orbital parameters would need to be considered for this scenario.

2.2.3. Larger than ESPA Class SV

For multiple payload missions that include Larger than ESPA class SV, the MPAS can be configured to support a single SV each on the upper and lower MPAPs. The Generic Minotaur IV LV to SV ICD, 1045-0526, defines standard interfaces for this class of SV that can be used for preliminary SV design and have been used to develop MPAS. This SV class includes ESPA Grande Class SV, Larger than ESPA class SV inside Full MPAS, and Larger than ESPA class SV on upper MPAP/Payload Cone.

2.2.4. Primary and Secondary Designation

SVs/CubeSat Deployers within a mission manifest may be designated as Primary or Secondary. This designation indicates priority and will be taken into consideration during mission planning. Primary SVs would get priority when establishing separation sequence, attitude, as well as launch schedule/window requirements if there is a conflict within the manifest. Secondary SVs would be accommodated on a non-interference basis with Primary SVs.

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3. GENERAL PERFORMANCE

3.1. Mission Profiles

The generic Minotaur IV Mission Profile shown in Section 3.1 of TM-17589 Minotaur IV User's Guide can be applied to Flexible Manifest missions using MPAS. A notional deployment sequence for six ESPA class SVs is shown in Figure 3.1-1 as an example of how multiple payloads and the upper MPAS structure will be separated.

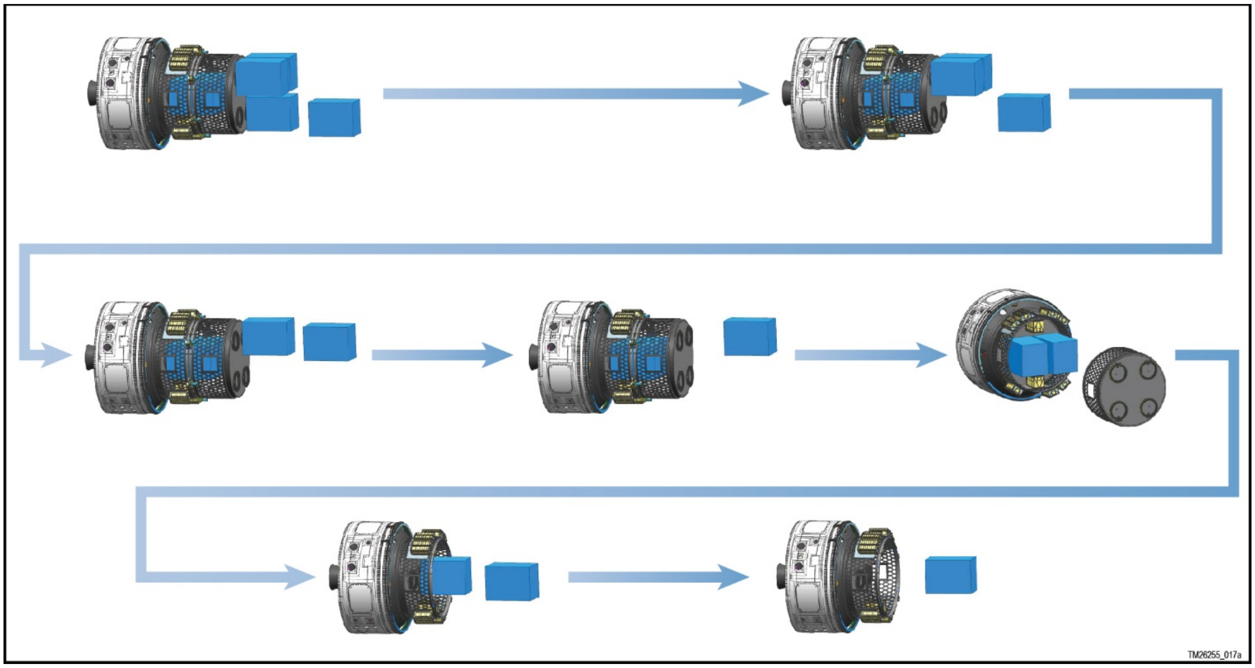

Figure 3.1-1. Notional SV Deployment Sequence

3.2. Launch Sites

Minotaur is required to be capable of operating at any of the primary launch sites discussed in Section 3.2 of TM-17589, Minotaur IV User's Guide. This information can be applied to Flexible Manifest missions using MPAS.

3.3. Performance Capability

Performance tables for circular orbits of most likely altitudes and inclinations from the four primary launch sites are shown in Table 3.3-1 and Table 3.3-2. These performance tables provide the total mass above the standard, non-separating interface of the Minotaur IV vehicle. The actual vehicle performance will need to be assessed based on the final launch site and orbital parameters.

Table 3.3-1. Minotaur IV Capability (lbm)

Launch Site	Cape Canaveral Air Force Station (CCAFS)		Wallops Flight Facility (WFF)		Kodiak Launch Complex (KLC)	Vandenberg Air Force Base (VAFB)		
Inclination	28.5	40	43	55	63.4	72	90	SSO
300 km	3452 *	3340 *	3265	3073	2998	2892	2615	2522

500 km	3252 *	3142	3040	2890	2813	2701	2445	2344
800 km	---	2813	2745	2588	2509	2396	2152	2041
*Potential stage drop over inhabited land. A case-by-case evaluation will need to be performed.								

Table 3.3-2. Minotaur IV+ Capability (lbm)

Launch Site	CCAFS		WFF		KLC	VAFB		
Inclination	28.5	40	43	55	63.4	72	90	SSO
300 km	3944	3816 *	3715	3565	3470	3362	3049	2965
500 km	3633 *	3503	3448	3265*	3181	3069	2795	2692
800 km	3139	3007	2981	2829*	2716	2615	2374	2224
*Potential stage drop over inhabited land. A case-by-case evaluation will need to be performed.								

Performance curves are provided in Section 3.3 of TM-17589, Minotaur IV User's Guide that provide the total mass above the standard, non-separating interface for several launch site, orbits, altitudes, and inclination scenarios. This information can be used to supplement the information provided in this User's Guide.

The total manifested mass including CubeSat/Deployers, SVs, SV separation systems, SV adapters and mounting hardware, MPAS components, and optional enhancements must be accounted for in the payload mass allocation and must be within the launch vehicle mass capability. Table 3.3-3 shows a number of common options and the mass associated with each.

Table 3.3-3. Common MPAS Options and Associated Masses
(These Masses Must Be Subtracted from the LV Performance)

Component	Total Mass (lbm)
Full MPAS with Upper MPAP[1]	581.07
Full MPAS with Upper Payload Cone[1]	473.79
Half MPAS with Separation System and Upper MPAP[1]	409.19
Half MPAS with Separation System and Upper Payload Cone[1]	301.91
Half MPAS without Separation System and Upper MPAP[1]	309.43
Half MPAS without Separation System and Upper Payload Cone[1]	202.15
3U/6U Single Wide Deployer Bracket and bracket to MPAS fastening hardware[2]	4.96 per unit
3U/6U Double Wide Deployer Bracket and bracket to MPAS fastening hardware[2]	8.67 per unit
12U Deployer Bracket and bracket to MPAS fastening hardware	6.01 per unit

Notes:

1. *MPAS masses include potted inserts for 2x ESPA on lower MPAP and 4x ESPA on upper MPAP (for configurations with Upper MPAP), account for mass savings from using the MPAS Payload Cone, and include an estimate of 45 lbm for harness.*
2. *The 3U/6U Single Wide Deployer Bracket can be used to mount quantity 1 6U Deployer or up to quantity 2 3U Deployers. The Double Wide Deployer Bracket can be used to mount quantity 2 6U Deployers or up to quantity 4 3U Deployers.*

3.4. Injection Accuracy

Information provided in TM-17589 Minotaur IV User's Guide Section 3.4 regarding the Minotaur IV injection accuracy limits can be applied to Flexible Manifest missions using MPAS.

3.5. Payload Deployment

Information provided in TM-17589 Minotaur IV User's Guide Section 3.5 regarding the Minotaur IV Payload Deployment capabilities can be applied to Flexible Manifest missions using MPAS, however Minotaur IV does not plan to support a spin stabilized attitude for multiple payload Flexible Manifest missions.

3.6. Payload Separation

Multiple Payload Flexible Manifest Missions using MPAS will require tighter controls regarding payload separation than is discussed in TM-17589 Minotaur IV User's Guide. SV may be placed in close proximity to neighboring SV and may also be in close proximity to the MPAS structure (for SV on the lower MPAP). SV tipoff rates will need to be minimized to ensure SVs do not contact neighboring hardware during separation.

Separation velocities are driven by the need to prevent recontact between SVs and the Minotaur final stage after separation and to prevent on-orbit recontact between SVs. Varying SV deployment velocities will need to be coordinated after the mission unique MRD is provided to prevent on orbit recontact and reduce risk on LV ACS gas margins.

Reference 1045-0526, Generic Minotaur IV LV to SV ICD and 1045-0587, Generic Minotaur IV Stage 4 Deployer ICD standard interfaces regarding parameters that affect payload separation such as SV mass, SV separation system minimum separation velocity, the ability to adjust separation velocity, maximum lateral and axial Center of Gravity (CG) offset, and separation tip-off.

3.7. Collision/Contamination Avoidance Maneuver (C/CAM)

Information provided in TM-17589, Minotaur IV User's Guide, Section 3.7 regarding the Minotaur IV C/CAM can be applied to Flexible Manifest missions using MPAS; however, Minotaur IV, in conjunction with the customer, will determine separation sequence and attitude of the SVs to minimize maneuvering and overall mission duration.

NGIS Mission Specific analyses will ensure no re-contact through one orbit as a standard service for Flexible Manifest missions. NGIS may not be required to perform a C/CAM after every SV deployment to minimize payload contamination due to implications with attitude control system gas margin and battery life concerns.

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4. PAYLOAD ENVIRONMENT

Much of the information provided in TM-17589, Minotaur IV User's Guide Section 4 regarding the payload environment can be applied to Flexible Manifest missions using MPAS. This User's Guide follows the same document organization and will attempt to make it clear which environments still apply from TM-17589, Minotaur IV User's Guide, and which environments are superseded by this User's Guide.

4.1. Steady State and Transient Acceleration Loads

A mission-specific Coupled Loads Analysis (CLA) will be performed, with SV provided Finite Element Models (FEM) of the SVs, in order to provide precise load predictions. Loaded Deployers will be modeled as a lumped mass and will not need to provide FEMs. Results will be referenced in the mission specific ICD. Loads in this User's Guide should be used for preliminary SV design as mission specific CLA results may not be available until 9 months prior to launch.

4.1.1. Transient Loads

Transient loads are highly dependent on SV mass, CG, natural frequencies, and moments of inertia as well as the chosen separation system. Reference 1045-0526, Generic Minotaur IV LV to SV ICD and 1045-0587, Generic Minotaur IV Stage 4 Deployer ICD standard interfaces regarding parameters that affect SV transient loads. This SV standard interface has been developed to communicate what has been assumed/analyzed during MPAS development. A parametric Coupled Loads Analysis (CLA) has been performed on multiple payload configurations with numerous different payloads to develop a range of transient accelerations at the typical dominant transient events.

For design purposes, the axial (LV X-axis) and lateral accelerations (LV Y- and Z-axes), applied at the CG, should be applied simultaneously. Transient loads include the steady state acceleration contribution that is present during the transient event.

Mission specific CLAs will be performed after the Mission Manifest is determined at L-12 where the SV FEMs are coupled to the vehicle model. Two CLAs will be conducted, the initial analysis after SV FEMs and the Mission Specific MRD are provided at L-12 months followed by a final verification after final manifest is determined at L-6 months and test correlated SV FEMs are provided. Deployers will be modeled as a lumped mass and will not need to provide FEMs. Forcing functions have been developed for all significant flight events and load cases. These analyses are used to determine potential dynamic envelope exceedances and inform the SV/Deployer providers about design concerns related to the launch dynamic environments. Results from the Mission Specific CLA are reported in the Acceleration Transformation Matrix (ATM) and/or Load Transformation Matrix (LTM) and/or Displacement Transformation Matrix (DTM) as requested by the SV provider.

4.1.1.1. Transient Loads, MPAS CubeSat Deployer

Table 4.1.1.1-1 summarizes results from the parametric CLA that apply to CubeSat Deployers on MPAS. Reference 1045-0587, Generic Minotaur IV Stage 4 Deployer ICD for transient loads that apply to CubeSat Deployer on Stage 4.

Table 4.1.1.1-1. Maximum MPAS CubeSat Deployer Transient Loads

Deployer	Axial Acceleration (LV X Axis) G	Lateral Acceleration (LV Y and Z Axes) G
3U/6U Class CubeSat Deployers	6.69	5.68
12U Class CubeSat Deployers	4.73	4.19

Load factors are in units of standard gravitational acceleration (G, where G=32.17 ft/sec²).

4.1.1.2. Transient Loads, ESPA Class SV and Larger

Figure 4.1.1.2-1, Figure 4.1.1.2-2 and Figure 4.1.1.2-3 summarize results from the parametric CLA that apply to ESPA class SV, ESPA Grande Class SV, and Larger than ESPA class SV on the lower and upper MPAP/Payload Cone. Results from the parametric CLA are shown and can be used by individual SV providers to determine loads that should be used for preliminary design. Parametric CLA results can be extracted for a specific SV if mass, CG, and first mode information is provided. SV providers are encouraged to contact NGIS to obtain this information to be used for preliminary design if the following figures are determined to be overly conservative.

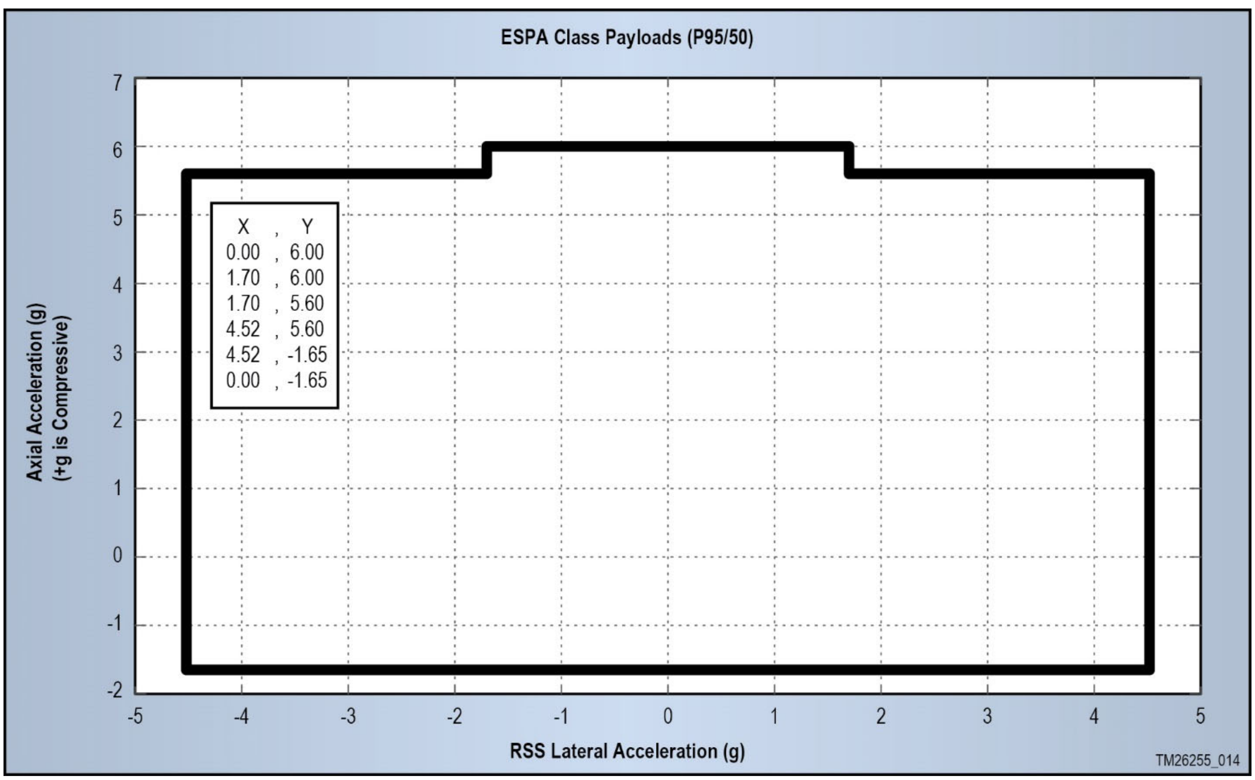

Figure 4.1.1.2-1. ESPA Class SV Peak Axial and Lateral Acceleration, 95 Percentile, 50% Confidence

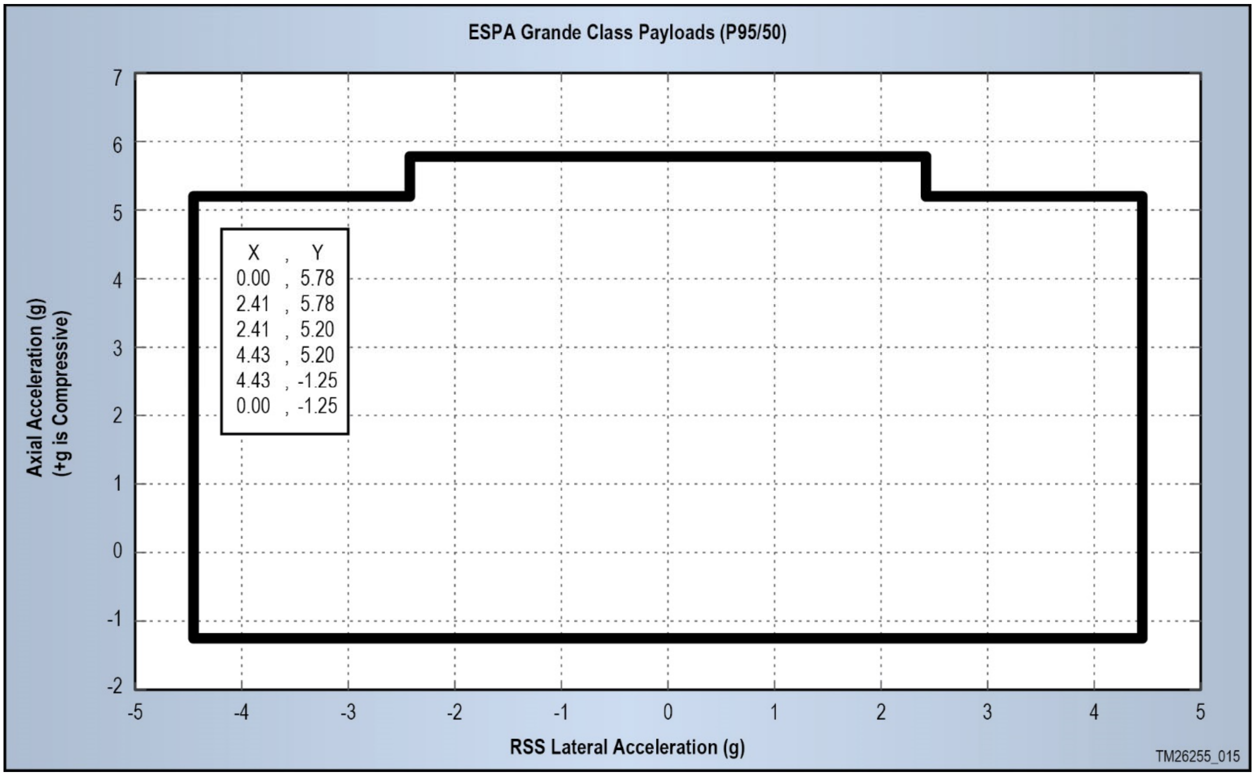

Figure 4.1.1.2-2. ESPA Grande Class SV Peak Axial and Lateral Acceleration, 95 Percentile, 50% Confidence

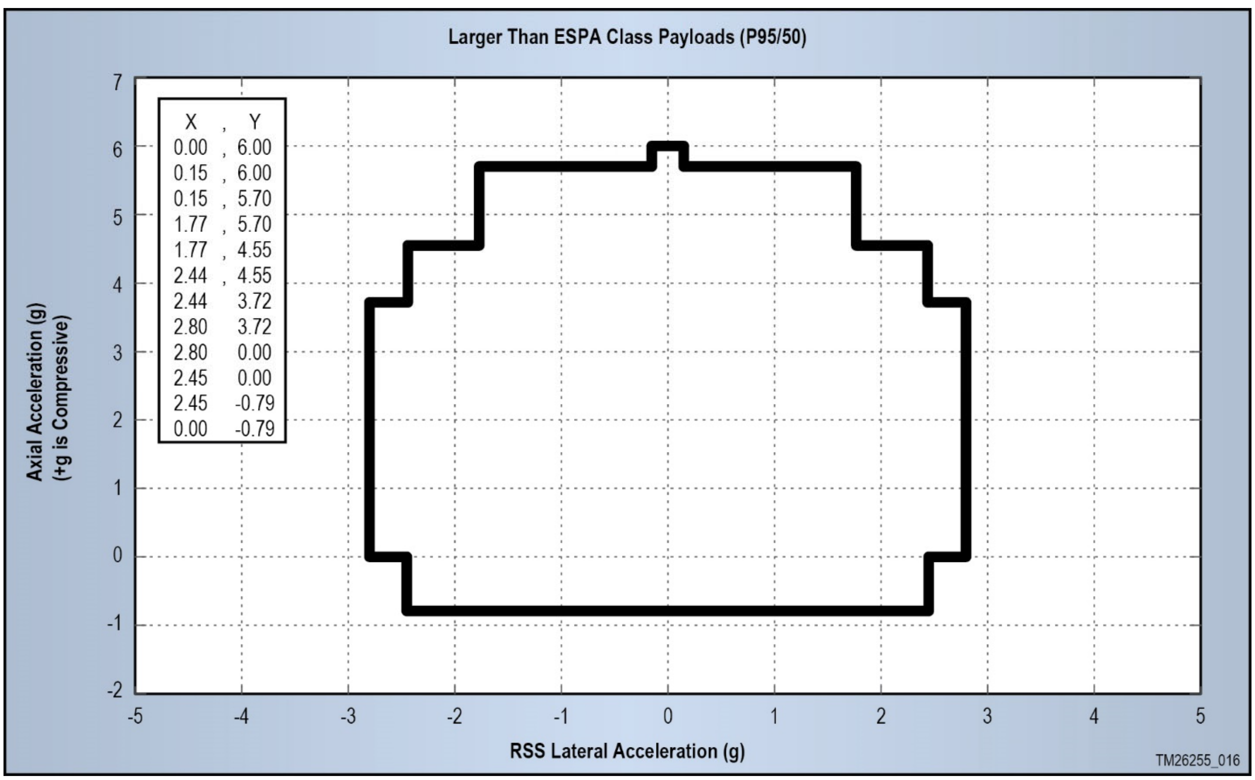

Figure 4.1.1.2-3. Larger Than ESPA Class SV Peak Axial and Lateral Acceleration, 95 Percentile, 50% Confidence

4.1.2. Steady-State Acceleration

Information provided in TM-17589, Minotaur IV User’s Guide Section 4.1.2 regarding steady-state acceleration can be applied to Flexible Manifest missions using MPAS, however individual SV/CubeSat Deployer providers may not know the full manifest payload mass needed to use the provided figure. Table 4.1.2-1 summarizes the maximum Minotaur IV steady state acceleration that should be used for preliminary SV/CubeSat design prior to manifest definition at L-12 months.

Table 4.1.2-1. Maximum Minotaur IV Steady State Acceleration

	Axial Acceleration (LV X Axis) G	Lateral Acceleration (LV Y and Z Axes) G
Maximum Minotaur IV Steady State Acceleration	11.0	0.5

Load factors are in units of standard gravitational acceleration (G, where G=32.17 ft/sec^2).

4.2. Payload Vibration Environment

Information provided in TM-17589 Minotaur IV User’s Guide Section 4.2 regarding the payload vibration environment can be applied to Flexible Manifest missions using MPAS.

4.3. Payload Acoustic Environment

Information provided in TM-17589 Minotaur IV User’s Guide Section 4.3 regarding the payload acoustic environment can be applied to Flexible Manifest missions using MPAS.

4.4. Payload Shock Environment

The Maximum Predicted Environment (MPE) Shock Response Spectrum (SRS) at the LV to SV/Deployer interface from the LV will not exceed the flight limit levels (LV to SV) in Figure 4.4-1 for SV/Deployers mounted on the MPAS MPAP or Payload Cone. Since multiple payload manifests will have SVs within close proximity to each other and SVs are responsible for providing the separation systems, the same level will be used as the SV to LV and SV to SV shock MPE limit. This level envelops all MPAS configurations, upper and lower MPAP placement, and the MPAP located on the half MPAS above the MPAS separation system. This level includes contributions from SV separation systems.

Reference TM-17589 Minotaur IV User's Guide Section 4.4 Payload Shock Environment for Flexible Manifest missions that don't use MPAS, 1 large SV in the encapsulated fairing envelope using the heritage 30 degree Payload Cone.

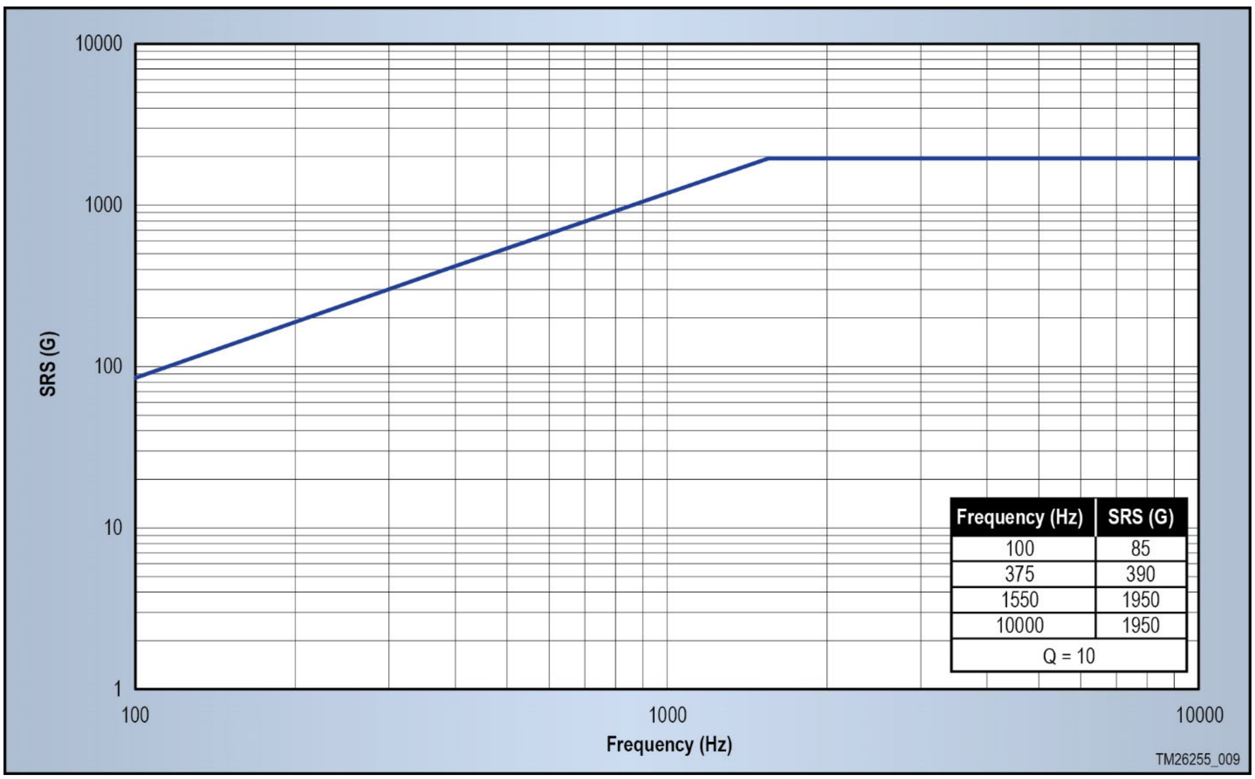

Figure 4.4-1. Maximum Shock MPE for MPAP/Payload Cone (LV to SV, SV to LV, SV to SV)

The MPE SRS from the LV at the LV to CubeSat Deployer interface for CubeSat Deployers mounted on the MPAS Lattice Cylinder will not exceed the flight limit levels in Figure 4.4-2.

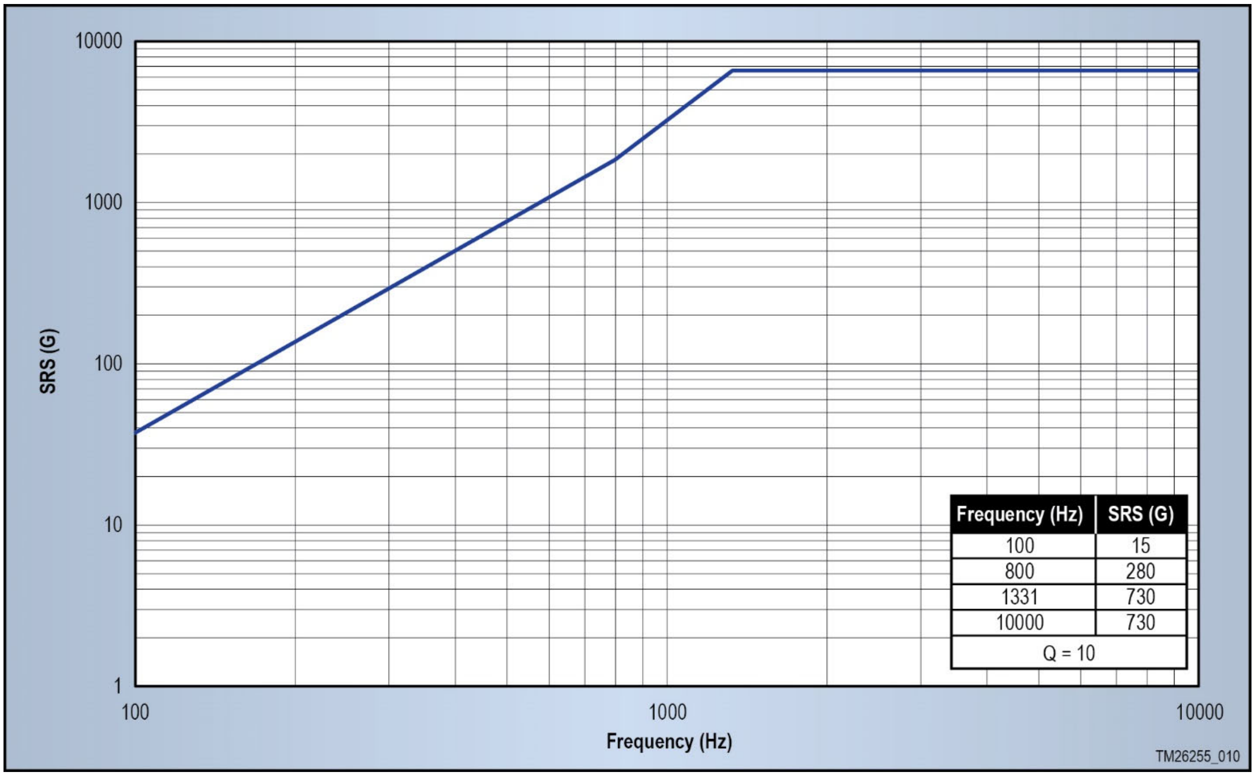

Figure 4.4-2. Maximum Shock MPE for Deployers Mounted on Lattice Cylinder

3U, 6U, and 12U Class CubeSat Deployer brackets will be attached vertically to the Lattice Cylinder (reference Figure 4.4-2). When MPAS is configured for radial deployment of 12U Class CubeSat Deployers, the 12U Class Deployer bracket will be installed horizontally on the lower MPAP (reference Figure 4.4-1). Special care should be taken to ensure the correct shock environment is determined for 12U Class Deployers.

Reference 1045-0587, Generic Minotaur IV Stage 4 Deployer ICD for environments that apply to CubeSat Deployers placed on Stage 4

4.5. Payload Structural Integrity and Environments Verification

Information provided in TM-17589, Minotaur IV User's Guide, Section 4.5 regarding the payload structural integrity and environments verification can be applied to Flexible Manifest missions using MPAS.

4.6. Thermal and Humidity Environment

Information provided in TM-17589, Minotaur IV User's Guide, Section 4.6 regarding the Minotaur thermal and humidity environments can be applied to Flexible Manifest missions using MPAS.

4.7. Payload Contamination Control

Information provided in TM-17589, Minotaur IV User's Guide, Section 4.7 regarding the Minotaur payload contamination control can be applied to Flexible Manifest missions using MPAS.

4.8. Payload Electromagnetic Environment

Information provided in TM-17589, Minotaur IV User's Guide, Section 4.8 regarding the payload electromagnetic environment can be applied to Flexible Manifest missions using MPAS.

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5. PAYLOAD INTERFACES

5.1. Payload Fairing

5.1.1. 92" Standard Minotaur Fairing

Information provided in TM-17589, Minotaur IV User's Guide, Section 5.1.1 can provide additional information regarding the 92" Standard Minotaur Fairing and can be applied to Flexible Manifest missions using MPAS. Figure 5.1.1-1 shows the maximum dynamic envelope available in the 92" standard Minotaur fairing for several MPAS configurations.

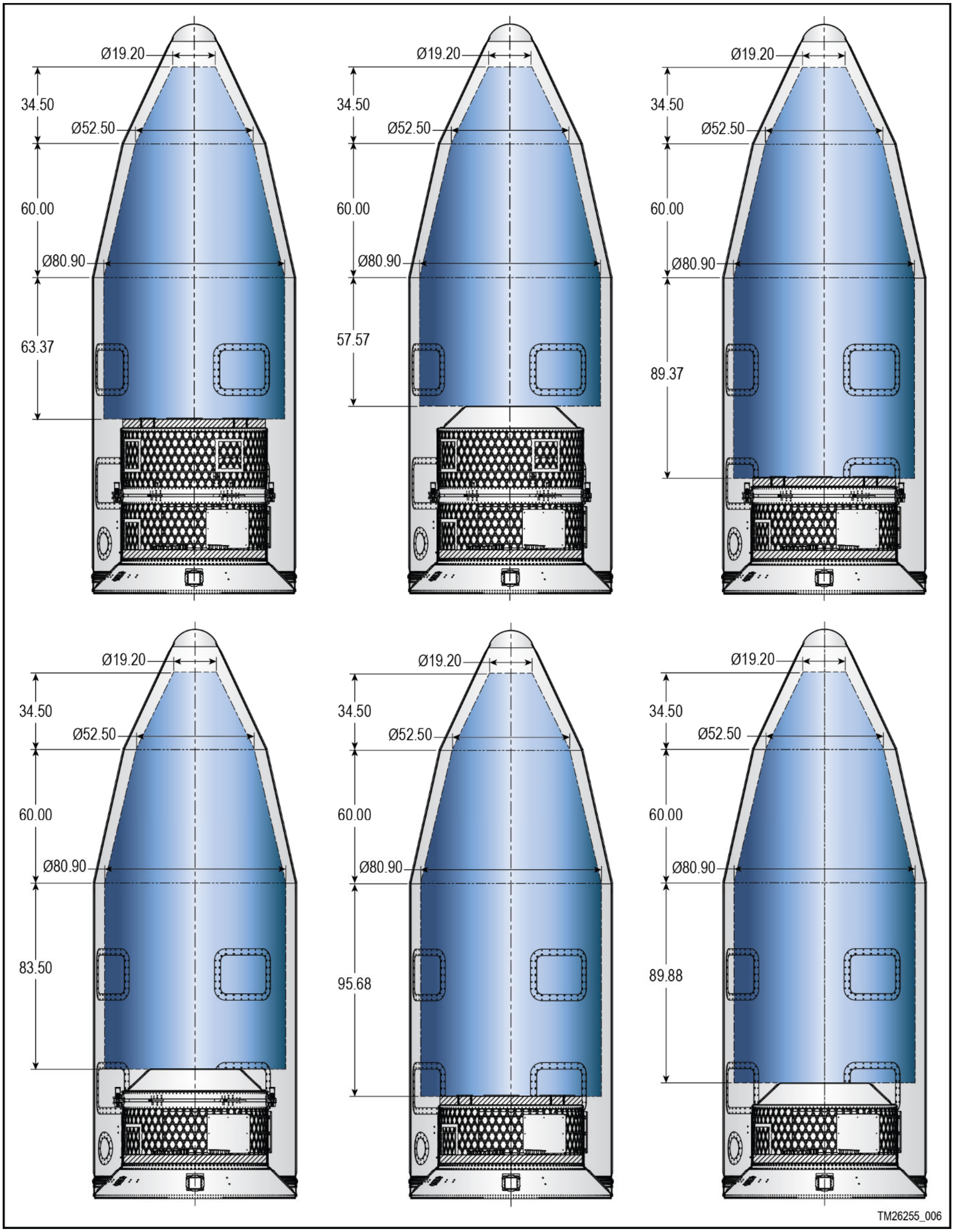

Figure 5.1.1-1. Maximum Dynamic Envelope for Standard 92" Fairing with MPAS

5.1.2. Optional 110" Fairing

Information provided in TM-17589, Minotaur IV User's Guide Section 5.1.2 can provide additional information regarding the optional 110" Fairing and can be applied to Flexible Manifest missions using MPAS. Figure 5.1.2-1 shows the maximum dynamic envelope available in the 110" optional fairing with a full MPAS configured with upper Payload Cone.

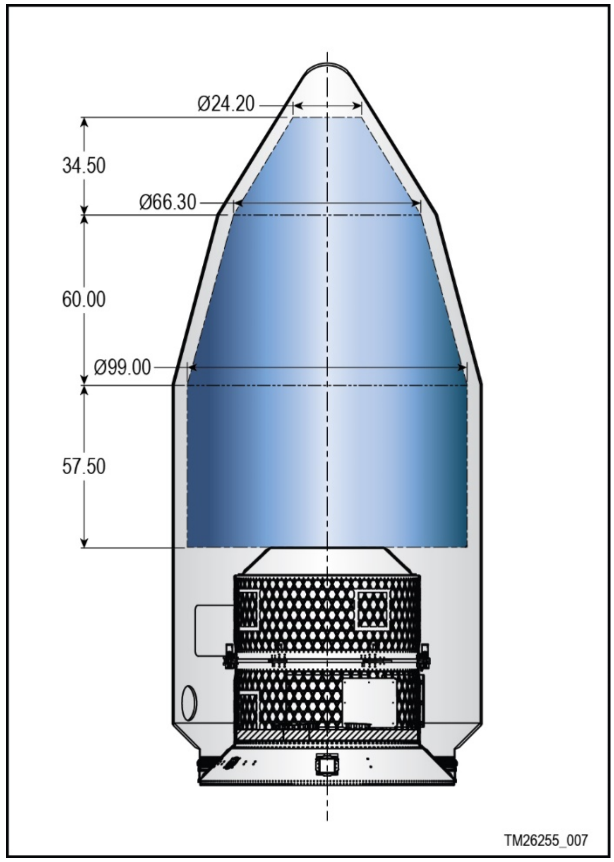

Figure 5.1.2-1 Maximum Dynamic Envelope for Optional 110" Fairing with MPAS

5.1.3. Payload Access Door

Information provided in TM-17589, Minotaur IV User's Guide Section 5.1.3 can provide additional information regarding mission specific/customer defined payload access door considerations that can be applied to Flexible Manifest missions using MPAS when this optional enhancement is selected at L-24 months.

5.1.3.1. Payload Access with MAXF

The Multi Access X Fairing (MAXF) has been developed to provide access to multiple SVs and includes eight payload access doors and two hand access doors. The MAXF access doors are positioned to maximize access to upper and lower MPAS locations. Figure 5.1.3.1-1 shows MAXF door locations relative to a notionally fully populated MPAS with station locations defined as well as the Minotaur IV coordinate system.

5.1.3.2. Payload Access with Full MPAS

There are four possible hand access cutout locations for each MPAS Lattice Cylinder. The MPAS Access doors are centered about 30°, 120°, 210°, and 300°. Two access door locations will be cut out as a standard configuration (the locations centered about 120° and 300°), and the remaining two locations can be cut out on a mission specific basis (the locations centered about 30° and 210°). The two locations that can be cut out on a mission specific basis remove the ability to locate CubeSat Deployers at these locations on the outside of the Lattice Cylinder but can be cut out for missions that need more access to the MPAS interior, want to deploy 12Us radially or don't have a fully populated deployer manifest. This applies to the lower lattice, all four locations can be removed on the upper lattice without impacting CubeSat Deployers.

Regardless of quantity of MPAS Lattice Cylinder hand access cutouts, access to SVs inside MPAS will lose the majority of access post MPAS installation. Lattice Cylinder hand access cutouts are aligned with the MAXF access doors and provide limited access post fairing installation (should not be considered accessible for normal process flow, should be considered contingency capability as access is very limited). It should be noted that SVs inside MPAS nominally will begin integration to the LV at L-2 months for Flexible Manifest missions.

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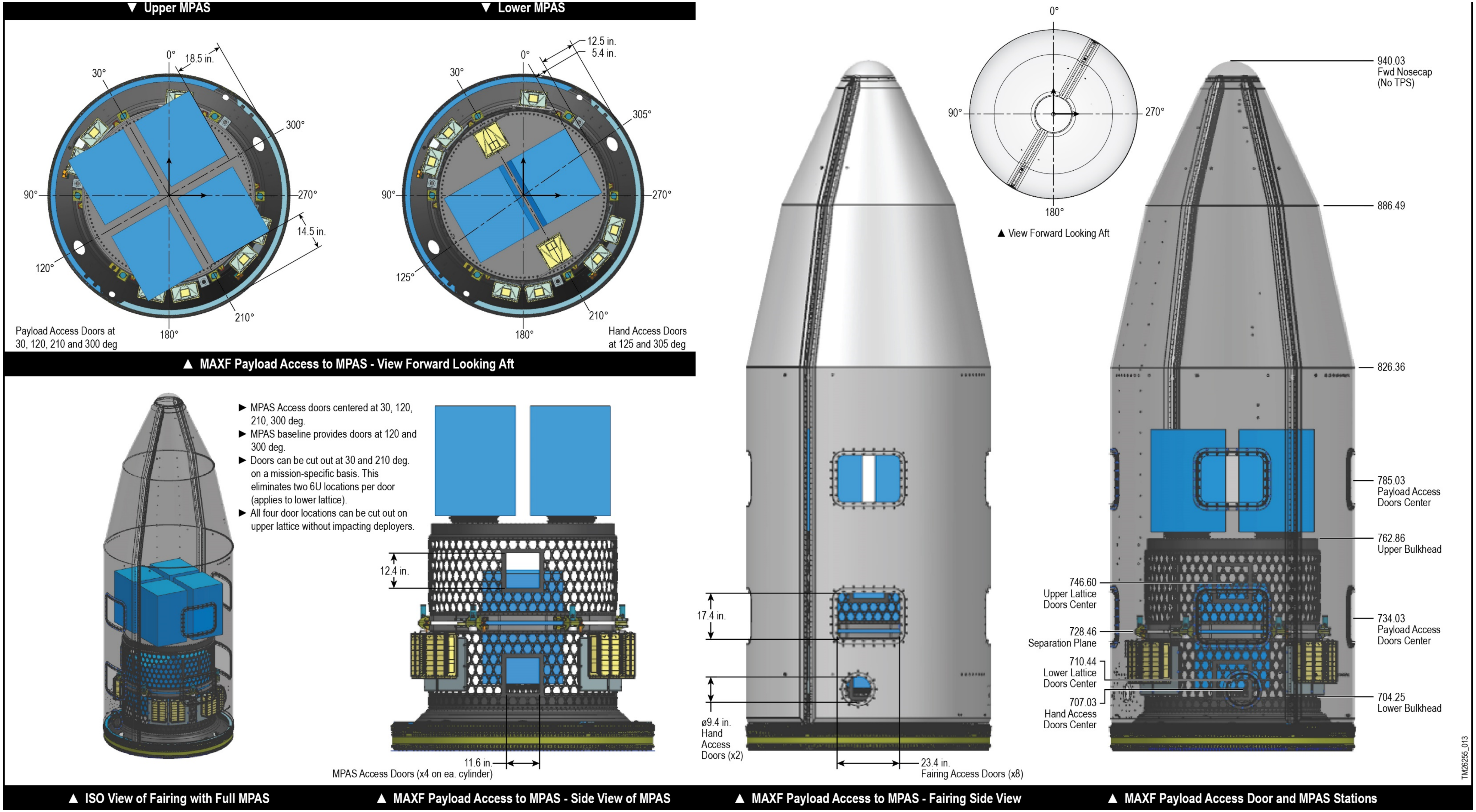

Figure 5.1.3.1-1. Minotaur IV Coordinate System with Full MPAS and MAXF Payload Access to MPAS and Stations

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5.2. Payload Mechanical Interface and Separation System

For Flexible Manifest Missions using MPAS, Minotaur will provide standard non-separating payload interfaces. NGIS will provide integration services for CubeSat Deployers. ESPA class SV and Larger than ESPA class SV providers will be required to provide all MGSE and personnel required to prepare the SV before mating to the LV interface and to bring the SV to the LV interface. All attachment hardware, whether NGIS or SV provided, must contain locking features consisting of locking nuts, inserts or fasteners.

5.2.1. Minotaur Coordinate System

The Minotaur IV Launch Vehicle coordinate system is also shown in Figure 5.1.3.1-1 with a full MPAS. For clocking references, degree marks are counterclockwise when forward looking aft. The positive X-axis is forward along the vehicle longitudinal centerline, the positive Z-axis is along the 180 deg angular, and the positive Y-axis is along the 90 deg angular station, and completes the orthogonal system. The origin of the LV coordinate system is centered at the Stage 1 nozzle exit plane of the LV and the vehicle centerline (X = 0.0 in., Y = 0.0 in., Z = 0.0 in.).

5.2.2. NGIS Supplied Mechanical Interface Control Drawing

Information provided in TM-17589 Minotaur IV User's Guide Section 5.2.2 regarding the Mechanical Interface Control Drawing can be applied to Flexible Manifest missions using MPAS if MPAS is configured with the standard, non-separating 38.81" diameter payload mechanical interface, referred to as the Upper Payload Cone in this User's Guide. This can also be applied to Flexible Manifest Missions using the heritage payload cone instead of MPAS.

5.2.3. Standard Non-Separating Mechanical Interface

Information provided in TM-17589 Minotaur IV User's Guide Section 5.2.3 regarding the Standard Non-Separating Mechanical Interface can be applied to Flexible Manifest missions using MPAS if MPAS is configured with the standard, non-separating 38.81" diameter payload mechanical interface, referred to as the Upper Payload Cone in this User's Guide. This can also be applied to Flexible Manifest Missions using the heritage payload cone instead of MPAS.

5.2.4. Optional Mechanical Interfaces

Information provided in TM-17589 Minotaur IV User's Guide Section 5.2.4 regarding the Minotaur Optional Mechanical Interfaces can be applied to Flexible Manifest missions not using MPAS, when the baseline Minotaur IV Vehicle is defined or Optional Enhancement A.12 is selected at L-24 months.

5.2.5. Optional Separation Systems

Information provided in TM-17589 Minotaur IV User's Guide Section 5.2.5 regarding the Minotaur provided Optional Separation Systems can be applied to Flexible Manifest missions using or not using MPAS, if the Optional Enhancement A.1 is selected at L-18 months.

5.2.6. MPAS Standard Mechanical Interfaces

5.2.6.1. MPAS CubeSat Deployer Bracket

The LV will provide a CubeSat Deployer bracket to provide a flat mounting surface to interface between the CubeSat Deployers and MPAS Lattice Cylinder. Blank MPAS CubeSat Deployer brackets will be kept in stock for Flexible Manifest missions. Figure 5.2.6.1-1 shows the Single MPAS CubeSat Deployer Bracket that can be used to mount one 6U or two 3U CubeSat Deployers. Figure 5.2.6.1-2 shows a Double MPAS CubeSat Deployer Bracket that can be used to mount two 6U or four 3U CubeSat Deployers. These figures show the blank brackets kept in stock for Flexible Manifest missions, the holes shown are used to attach the Deployer Bracket to the MPAS Lattice Cylinder. After the Mission Specific MRD is provided at L-12 months, mission specific thru holes will be added that will be used to attach the CubeSat Deployers to the LV provided CubeSat Deployer bracket.

Figure 5.2.6.1-3 shows the LV to Deployer Interface, several requirements for SV providers are defined from this interface and are documented in 1045-0526 Generic Minotaur IV LV to SV ICD. Loaded CubeSat Deployers will be installed onto the LV provided Deployer brackets away from the LV by NGIS. The LV provided Deployer Bracket with attached Loaded CubeSat Deployer will then be installed onto the Lattice Cylinder by NGIS.

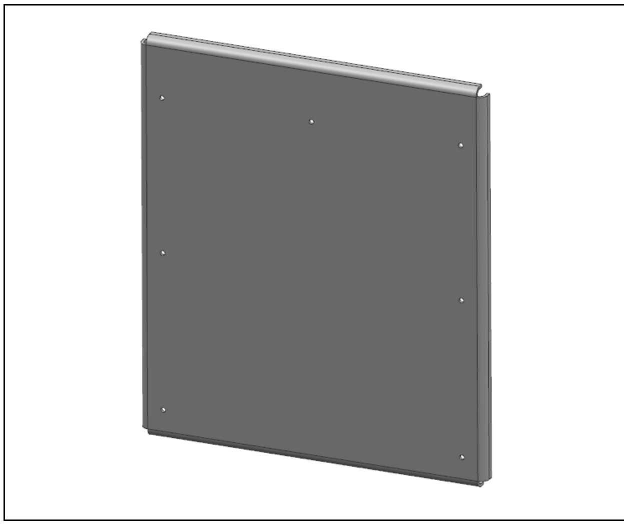

Figure 5.2.6.1-1. Single MPAS CubeSat Deployer Bracket

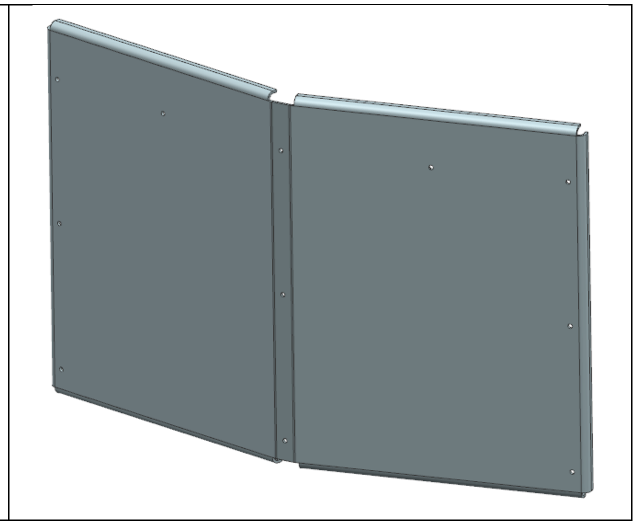

Figure 5.2.6.1-2. Double MPAS CubeSat Deployer Bracket

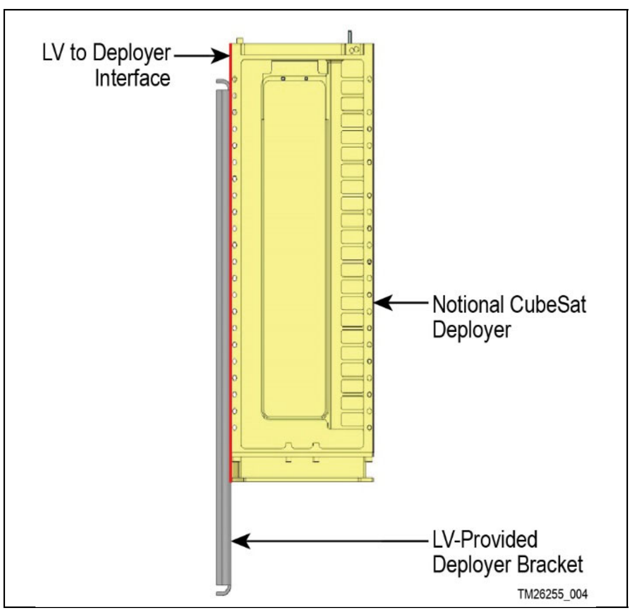

Figure 5.2.6.1-3. LV to Deployer Interface for MPAS Lattice Cylinder

5.2.6.2. Multiple Payload Adapter Plate (MPAP)

The MPAS can be configured with a lower and upper MPAP. The MPAP leverages the same sandwich panel construction as previous Minotaur missions, has a diameter of 64 inches and thickness of 3.95 inches.

After the Mission Specific MRD is provided at L-12 months, mission specific inserts will be installed that will be used to attach SV to the MPAP, 0.250 28 UNJF 3B inserts will be kept in stock for Flexible Manifest missions. Figure 5.2.6.2-1 shows a blank MPAP that will be in stock before mission specific information is provided.

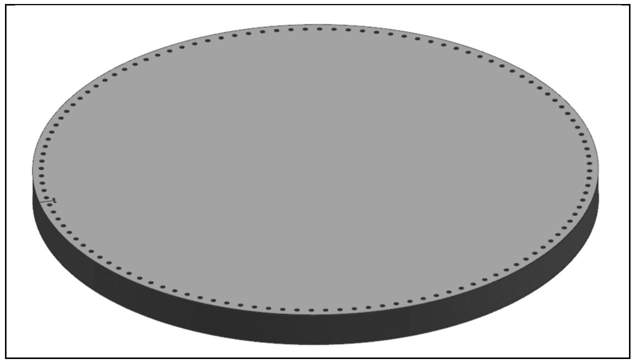

Figure 5.2.6.2-1. Generic MPAP

If manifested SVs provide a Motorized Lightband (MLB) separation system, a 0.5 inch thick spacer ring with thru holes will be sandwiched between the MPAP and SV provided separation system to provide a flat mounting surface and will be designed/specified on a mission specific basis. Figure 5.2.6.2-2 shows this configuration. Interface provisions needed between the MPAP and SV provided separation systems from other manufacturers will be designed/specified on a mission specific basis.

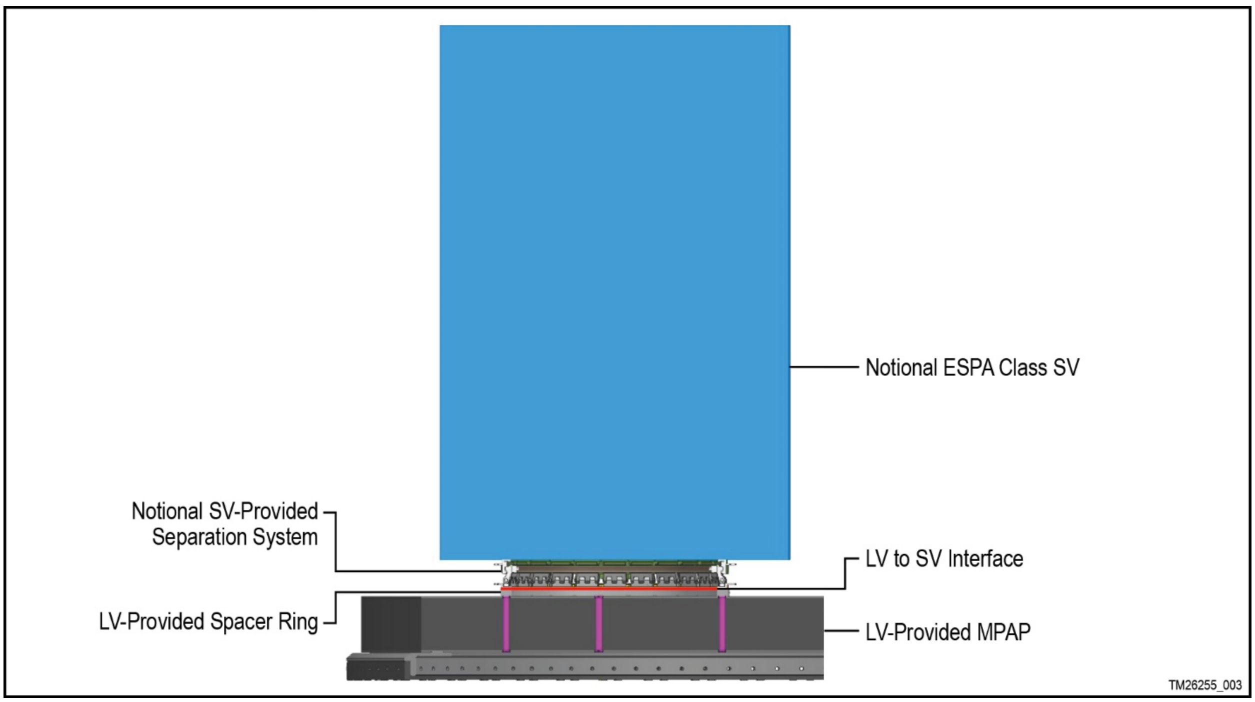

Figure 5.2.6.2-2. Notional LV to SV Interface with MPAP and ESPA Class SV using MLB

5.2.6.3. Upper Payload Cone

The MPAS can be configured with the Upper Payload Cone, which provides the heritage Minotaur IV 38.810 inch industry standard non-separating interface with quantity 60 clearance holes for 0.250 inch fasteners. The interface information for the Upper Payload Cone is detailed in TM-17589 Minotaur IV User's Guide Section 5.2.3 and is shown in Figure 5.2.6.3-1 for reference.

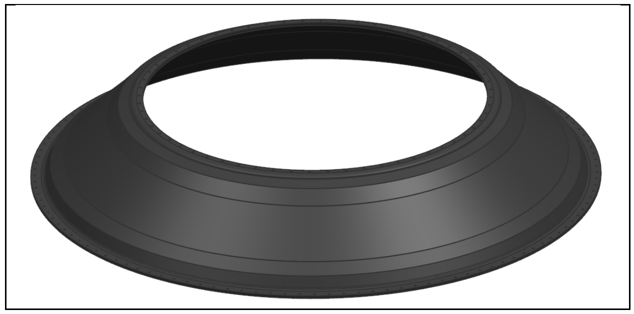

Figure 5.2.6.3-1. Heritage Minotaur IV Payload Cone

5.2.6.4. MPAS Mechanical Capability, Mass

Mass ranges for each MPAS SV/Deployer Class is defined in 1045-0526, Generic Minotaur IV LV to SV ICD, and is summarized in Table 5.2.6.4-1. These masses keep SV/Deployers within parameters analyzed for MPAS development per the MPAS parametric CLA, MPAS Separation Study and MPAS Structural analysis.

Table 5.2.6.4-1. MPAS SV/CubeSat Deployer Mass

	Minimum Mass (lbm)	Maximum Mass (lbm)
3U Loaded Deployer	not specified	22.75
6U Loaded Deployer	not specified	45.50
12U Loaded Deployer	not specified	64.00
ESPA Class SV	200	485
ESPA Grande Class SV	400	700
Larger than ESPA Class SV Inside MPAS	400	1000
Larger than ESPA Class SV on Upper MPAP/Payload Cone	600	2100
Note: 1045-0587, Generic Minotaur Stage 4 Deployer ICD, defines the maximum mass for 3U and 6U CubeSat Deployers, which are slightly lower than has been analyzed for MPAS.		

5.2.6.5. Maximum MPAS Mechanical Capability, Mass

Section 3.3 Performance Capability should be referenced when determining the full manifest mass capability.

5.2.6.6. MPAS Mechanical Capability, Volume

Available volume for each MPAS SV/Deployer Class is defined in 1045-0526, Generic Minotaur IV LV to SV ICD, and is summarized in Table 5.2.6.6-1. The volume has been defined by the MPAS parametric CLA and MPAS Separation Study. If an SV/Deployer cannot fit within the available standard interface volume for a specific class, it can be accommodated in the place of a larger SV/Deployer Class if it fits within the larger available volume.

Table 5.2.6.6-1. MPAS SV/CubeSat Deployer Maximum Static Envelope

<table>
<tr><th>Deployer Class</th><th>Length (Inches)</th><th>Width (Inches)</th><th>Height (Inches)</th><th>LV Interface</th></tr>
<tr><td>3U Class Deployer</td><td>16.91</td><td>5.29</td><td>6.20</td><td rowspan="3">Length/Width Plane</td></tr>
<tr><td>6U Class Deployer</td><td>16.91</td><td>10.37</td><td>6.20</td></tr>
<tr><td>12U Class Deployer</td><td>15.83</td><td>10.37</td><td>10.65</td></tr>
<tr><td>ESPA Class SV</td><td>38.00</td><td>24.00</td><td>28.00</td><td rowspan="3">Length is measured from the LV to SV interface</td></tr>
<tr><td>ESPA Grande Class SV</td><td>49.20</td><td>39.40</td><td>45.30</td></tr>
<tr><td>Larger than ESPA Class SV Inside MPAS</td><td>50.00</td><td>40.00</td><td>40.00</td></tr>
<tr><td>Larger than ESPA Class SV on Upper MPAP or Payload Cone</td><td colspan="4">Defined by Fairing Dynamic Envelope in Section 5.1</td></tr>
<tr><td colspan="5">Notes:
1. A 3U class deployer can be flown in the place of a 6U class deployer if it can be mounted to fit within the defined 6U volume. For example, the 3U P POD height does not fit within the available 3U volume, but it can be mounted on the Length/Height plane within the available 6U volume. In this scenario, one 3U would be accommodated in the place of one 6U Deployer.
2. 1045-0587, Generic Minotaur Stage 4 Deployer ICD, defines the available volume for 3U and 6U CubeSat Deployers, which are slightly larger than can be accommodated on MPAS.</td></tr>
</table>

5.2.6.7. Maximum MPAS Mechanical Capability, Volume

The MPAS has been developed to accommodate any number of manifest configurations, some possible combinations are summarized in Table 5.2.6.7-1.

Table 5.2.6.7-1. Maximum Manifest Combination Examples Based on Volume

<table>
<tr><th>Fully Populated Manifest on the following LV/MPAS Configurations</th><th>3U/6U Deployer[1] Quantity</th><th>12U Deployer Quantity</th><th>ESPA Class SV Quantity</th><th>Larger than ESPA Class SV Inside MPAS Quantity</th><th>Larger than ESPA Class SV on upper MPAP/Payload Cone Quantity</th></tr>
<tr><td rowspan="2">Full MPAS with Lower and Upper MPAP</td><td rowspan="6">16/8</td><td>2</td><td>6</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>4</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Full MPAS with Lower MPAP and Upper MPAP or Payload Cone</td><td>2</td><td>2</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td rowspan="2">Half MPAS with Separation System and Upper MPAP or Payload Cone[2]</td><td rowspan="2">2</td><td>4</td><td rowspan="8">0</td><td>0</td></tr>
<tr><td>0</td><td>1</td></tr>
<tr><td rowspan="6">Half MPAS without Separation System, Radial 12U Deployment and Upper MPAP or Payload Cone</td><td>8/4</td><td>4</td><td rowspan="3">4</td><td rowspan="3">0</td></tr>
<tr><td>12/6</td><td>3</td></tr>
<tr><td>16/8</td><td>2</td></tr>
<tr><td>8/4</td><td>4</td><td rowspan="3">0</td><td rowspan="3">1</td></tr>
<tr><td>12/6</td><td>3</td></tr>
<tr><td>16/8</td><td>2</td></tr>
<tr><td colspan="6">Notes:
1. A quantity of two 3U Class CubeSat Deployers can typically be accommodated in place of one 6U CubeSat Deployer, however some 3U Class CubeSat Deployers may need the entire volume available to 6U Class CubeSat Deployers.
2. When MPAS is configured as a Half MPAS with Separation System, the CubeSat Deployer Quantities shown are for the standard locations but more can be accommodated in the available volume, and would likely be limited by available electrical interfaces.</td></tr>
</table>

5.3. Payload Electrical Interfaces

The payload electrical interface supports battery charging, external power, payload separation indications, and up to twenty-five (25) separate (redundant) ordnance events and/or discrete commands. 19 are available to payloads on MPAS (4 cross the MPAS Separation System) and 6 are available to CubeSat Deployers located on Stage 4 as the standard LV interface. Additional CubeSat Deployers can be accommodated if single separation commands are acceptable; this has been accepted by CubeSat Deployers on previous Minotaur missions. SV providers will be responsible to provide the wiring from the spacecraft to the separation plane and may be asked to use standard connector options for umbilical connections and CubeSat Deployers for Flexible Manifest missions.

5.3.1. Payload Umbilical Interfaces

Information provided in TM-17589, Minotaur IV User's Guide Section 5.3.1 regarding the Minotaur Payload Umbilical Interface can be applied to Flexible Manifest missions using MPAS.

The information in the Minotaur IV User's Guide–two dedicated payload umbilicals provided with 60 circuits each–is the full manifest capability. Table 5.3.1-1 attempts to allocate the full umbilical capability to each SV Class to increase SV rideshare opportunities, but can be allocated as needed to each SV on a mission specific basis.

Table 5.3.1-1. Umbilical Allocations by SV Class

SV/CubeSat Deployer Class	Umbilical Allocation Circuits per SV
3U/6U/12U CubeSat Deployer	No standard access allocated
ESPA Class SV	20
Larger than ESPA Class SV Inside MPAS	40
Larger than ESPA Class SV on Upper MPAP/Payload Cone	80

For Flexible Manifest missions, where Mission Specific manifest is known 12 months prior to launch and manifest changes can be made 6 months prior to launch, SV providers will be asked to mate up to standard umbilical connectors. There are three candidate connectors available providing flexibility depending on the number of circuits allocated to each SV. The final selection will be determined at L-12 months when the manifest is defined and the umbilical interface requirements for each SV are agreed upon. NGIS will keep a number of these standard connectors in stock so mission specific harness builds can start as soon as manifest information is finalized. Table 5.3.1-2 summarizes this standard umbilical interface.

Table 5.3.1-2. Flexible Manifest Missions Standard Umbilical Interface Connectors

SV Interface Harness	LV MPAS Harness	Shell Size	#20 Contacts	LV LEV Umbilical Harness	SV/EGSE Interface Harness
SV Connector (Jam Nut Receptacle, Pins)	LV Connector (Plug, Sockets)			LEV Connector (Jam Nut Receptacle, Pins)	SV EGSE Connector (Plug, Sockets)
D38999/24FE26PN	D38999/26FE26SN	17	26	D38999/24FE26PN	D38999/26FE26SN
D38999/24FG41PN	D38999/26FG41SN	21	41	D38999/24FG41PN	D38999/26FG41SN
D38999/24FJ61PN	D38999/26FJ61SN	25	61	D38999/24FJ61PN	D38999/26FJ61SN

5.3.2. Payload Interface Circuitry

Information provided in TM-17589 Minotaur IV User's Guide Section 5.3.2 regarding Payload Interface Circuitry does not apply to Flexible Manifest missions using MPAS.

5.3.3. Payload Battery Charging

Information provided in TM-17589 Minotaur IV User's Guide Section 5.3.3 regarding Payload Battery Charging can be applied to Flexible Manifest missions using MPAS for SVs that use the payload umbilical cables.

5.3.4. Payload Command and Control

The Minotaur standard interface provides payload separation commands generated by the launch vehicle's Ordnance Driver Module (ODM). The total number of ODM discretes is twenty-five (25) and can be used for any combination of (redundant) ordnance events and/or discrete commands depending on the payload requirements. The total number of ODM discretes available to payloads is 25, 19 are available to payloads on MPAS (4 cross the MPAS Separation System) and 6 are available to CubeSat Deployers located on Stage 4 as the standard LV interface. Additional CubeSat Deployers can be accommodated if single separation commands are acceptable, this has been accepted by CubeSat Deployers on previous Minotaur missions.

5.3.5. Pyrotechnic Initiation Signals

The ODM outputs described in Section 5.3.4 can be used as ordnance driver outputs for SV separation events, or they can also be reprogrammed to be used as a command discrete that meets the ODM voltage and current characteristics that depend on the SV interface to be commanded. As ordnance, the maximum single event current pulse amplitude is 18 amps, and the duration can be programmed from 30 milliseconds to much longer durations as needed by individual SVs and balanced with all manifested SVs. Typical ordnance loads are 1.0 ohms but other load resistance values are supportable. Safing for all SV ordnance events will be accomplished with Safe Plugs.

5.3.6. Payload Telemetry

Information provided in TM-17589, Minotaur IV User's Guide Section 5.3.6 regarding Payload Telemetry does not apply to Flexible Manifest missions using MPAS. Minotaur will not imbed payload telemetry as a standard interface for Flexible Manifest Missions. SVs will be provided a separation confirmation and state vector.

5.3.7. Payload Separation Monitor Loopbacks

Separation breakwire monitors are required on both sides of the SV separation plane. Note that under some circumstances, separation loops at the spacecraft separation connector can limit the number of vehicle umbilical circuits available.

The SV will provide two separation loopback circuits on the SV side of the separation plane. These are typically wired into different separation connectors for redundancy. These breakwires are used for positive separation indication telemetry.

The total number of fully redundant separation monitor loop backs available to payloads is 25, 19 are available to payloads on MPAS (4 cross the MPAS Separation System) and 6 are available to CubeSat Deployers located on Stage 4 as the standard LV interface. Additional CubeSat Deployers can be accommodated if single separation monitor loop backs are acceptable, this has been accepted by CubeSat Deployers on previous Minotaur missions.

5.3.8. Telemetry Interfaces

Information provided in TM-17589, Minotaur IV User's Guide Section 5.3.8 regarding Telemetry Interfaces does not apply to Flexible Manifest missions using MPAS. Minotaur will not imbed payload telemetry as a standard interface for Flexible Manifest Missions. SVs will be provided a separation confirmation and state vector.

5.3.9. Non-Standard Electrical Interfaces

Information provided in TM-17589, Minotaur IV User's Guide Section 5.3.9 regarding Non-Standard Electrical Interfaces does not apply to Flexible Manifest missions using MPAS. Non-standard services such as serial command and telemetry interfaces can be negotiated between NGIS and the SV provider on a mission-by-mission basis at mission ATP, 24 months prior to launch.

5.3.10. Electrical Launch Support Equipment

Information provided in TM-17589, Minotaur IV User's Guide Section 5.3.10 regarding the Electrical launch Support Equipment can be applied to Flexible Manifest missions using MPAS.

5.3.11. Flexible Manifest Standard Electrical Interface Approach

For Flexible Manifest Missions using MPAS, manifest information is not known until 12 months prior to launch and can change 6 months prior to launch. Due to this short duration, standard connectors will be kept in stock.

NGIS will supply the cable harnessing that routes the LV provided initiation commands from the LV Ordnance Driver Module (ODM) to all SV separation system connectors. The SV provider is asked to provide this electrical interface information as early as possible and no later than L-12 months.

CubeSat Deployers are asked to meet standard interface requirements defined in 1045-0526, Generic Minotaur IV LV to SV ICD and 1045-0587, Generic Minotaur IV Stage 4 Deployer ICD. Requirements include the deployer provider using the deployer half of the electrical connector (part number: D38999/24FC8PN) and backshell (part number: 380HS115M1308A3 63) that forms the interface between the LV and the deployer.

5.4. Payload Design Constraints

Reference 1045-0526, Generic Minotaur IV LV to SV ICD and 1045-0587, Generic Minotaur IV Stage 4 Deployer ICD.

6. MISSION INTEGRATION

6.1. Mission Management Approach

Information provided in TM-17589, Minotaur IV User's Guide Section 6.1 regarding the Minotaur Mission Management Approach can be referenced for Flexible Manifest missions using MPAS.

6.2. Mission Planning and Development

Some of the information provided in TM-17589 Minotaur IV User's Guide Section 6.2 regarding the Minotaur Mission Planning and Development can be referenced for Flexible Manifest missions using MPAS as a general familiarization to Minotaur. However, Flexible Manifest mission will follow the Typical Mission Integration Schedule shown in Figure 6.2-1.

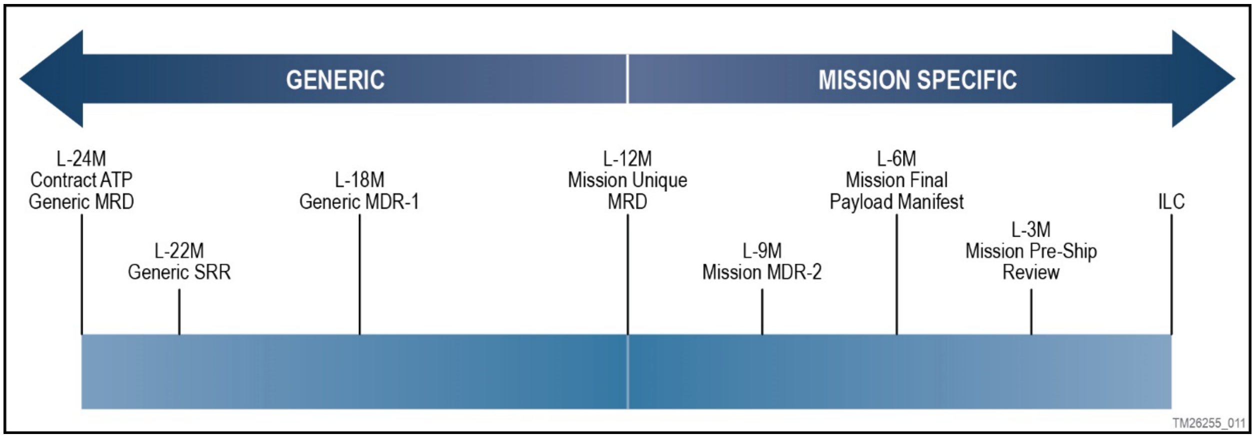

Figure 6.2-1. Typical Flexible Manifest Mission Integration Schedule

Typical Mission Field Integration Schedule, shown in TM-17589 indicates Payload Mate occurs approximately around L-30 days, however for Flexible Manifest mission, specifically if a full manifest is flown with 25+ SVs/Deployers, Payload Mate will nominally begin at L-2 months.

6.3. Mission Integration Process

Information provided in TM-17589 Minotaur IV User's Guide Section 6.3 regarding the Mission Integration Process can be referenced for Flexible Manifest missions using MPAS.

6.4. Documentation

Due to the rapid pace of Flexible Manifest missions, timely information exchange is paramount. NGIS will need information provided per the timelines shown in Table 6.4-1 and 6.4-2 to ensure LV schedule commitments can be met.

Table 6.4-1. Key Decision Points and Timeline

Time (Months Before ILC)	Key Decision Points (KDP)	Discussion	Requirement Define			
			Initial Generic MRD	Generic MRD Revision	Mission Specific MRD	Mission Specific MRD Revision
L-24	Baseline	Baseline Minotaur IV vehicle	X			
L-24	KDP1	New vehicle development defined	X			
L-24	KDP2	Fairing door locations defined (select MAXF or mission specific door locations defined by customer).	X			
L-24	KDP3	Launch site (If KLC is the launch site).	X			
L-14	KDP4	Launch site (for VAFB, CCAFS, and WFF).		X		
L-12	KDP5	Mission Unique requirements document may include: • Payload manifest (SV quantity, mass, volume, separation system) • Launch date • Orbital parameters			X	
L-6	KDP6	Final Payload Manifest (this includes like-for-like swapping and de-manifest scenarios).				X

Table 6.4-2. Timeline for Determining Optional Enhancements

Months Before the ILC	OSP-3 TRD Enhancement	Title	Requirement Define		
			Initial Generic MRD	Generic MRD Revision	Mission Specific MRD
L-18	A.1	Separation System		X	
L-12	A.2	Conditioned Air[1]			X
L-12	A.3	Nitrogen Purge			X
L-24	A.4	Additional Access Panel	X		
L-18	A.5	Enhanced Telemetry		X	
L-18	A.6	Enhanced Contamination Control		X	
L-24	A.7	Secure FTS	X		
L-18	A.8	Over Horizon Telemetry		X	
L-24	A.9	Increased Insertion Accuracy	X		
L-18	A.10	Payload Isolation System[2]		X	
L-24	A.11	Orbital Debris Mitigation System	X		
L-24	A.12	Dual/Multi-payload Adapter	X		
L-24	A.13	Enhanced Performance	X		
L-24	A.14	Large Fairing	X		
L-18	A.15	Hydrazine Servicing		X	
L-18	A.16	Nitrogen Tetroxide Servicing		X	
L-12	A.17	Poly-Pico Orbital Deployer			X
L-18	A.18	Suborbital Performance Modification		X	
L-24	A.19	Alternate Launch Location[3,4]	X		

Notes:

1. Conditioned air is included in the baseline vehicle cost for Minotaur IV.
2. If a payload isolation system is required then the final manifest selection/launch vehicle configuration must be defined prior to L-18.
3. Classified integration may not be supported within a 24 month timeline.
4. If a launch site has not previously supported a Minotaur mission, then the 24 month timeline may not be achievable.

SV/CubeSat Deployer providers will be asked to meet the submittal requirements and timing shown in the Tables 6.4-3 through 6.4-9. Reference 1045-0526, Generic Minotaur IV LV to SV ICD, for additional details.

Table 6.4-3. SV/Deployer Submittals Required 12 Months Prior to Launch

SV/Deployer Deliverable	Requirements
SV/Deployer Completed MPAS User's Guide Payload Questionnaire	
SV/Deployer CAD model and drawings	CAD model data translated through the Standard for the Exchange of Product Model Data (STEP) converter. Dimensioned three view drawing showing outer mold line of the SV/Deployer in launch/stowed configuration, include coordinate system.
SV FEM/Craig Bampton model Deployers will be modeled as a point mass in the Mission Specific CLA.	• Model per 042-1782 Guidelines for Payload Models Used in Launch Vehicle System Dynamic Analyses. • Craig Bampton model is preferred. • SV provider to communicate selected SV nodes and desired CLA outputs (Acceleration Transformation Matrix (ATM) and/or Load Transformation Matrix (LTM) and/or Displacement Transformation Matrix (DTM)). • SV provider to communicate estimate of model maturity and/or recommend MUF to be used on their model.
SV/Deployer Preliminary Mass Properties	Reference Mass Properties Section for details on this submittal
SV/Deployer Slosh Model, if applicable	• In the pendulum or spring-mass format. • Data on first sloshing mode are required and data on higher order modes are desirable • Slosh frequency to an accuracy of 0.2 Hz.
SV/Deployer inputs requested per section 3 of this ICD	
SV Separation System Interface details	
SV/Deployer separation system details, including expected/desired SV/CubeSat deployment velocity and tip-off.	
SV/Deployer information regarding SV provided hardware remaining with the LV after SV separation.	
SV/Deployer Qualification and Acceptance Test Plan	
SV access requirements post LV installation and post fairing encapsulation	
SV/Deployer Mission Assurance and Certification letter and verification artifacts needed as inputs to the Do No Harm (DNH) analysis.	
SV Electrical Characteristics (voltage, current, pulse duration)	
Deployer End to End internal resistance of deployer actuator and harness	
SV/Deployer Electrical Schematics	For separation detection and grounding compatibility
SV/Deployer EMI/EMC inputs	• Radiated Emissions, Susceptibility • RF characteristics (power levels, frequencies, duration, frequency bandwidth), locations, etc.
SV Predicted SV to LV environments	Shock
SV Launch Operations Plan	Information regarding sequence and time span of SV launch site activities such as GSE, installation, SV testing and servicing, etc.
SV/Deployer Requirements Compliance Verification Documents	

Table 6.4-3. SV/Deployer Submittals Required 12 Months Prior to Launch

SV/Deployer Deliverable	Requirements
SV Preliminary Debris Catalog needed for breakup analysis	Submittal is required for SV breakup in the event of an LV aerodynamic breakup or LV Flight Termination, not debris from an SV re-entry. Deployers will be assumed to stay intact.
SV volume and venting information, if applicable.	SV venting (volume, rate, etc.), non-ventable volume, venting characteristics.
SV/Deployer Security Requirements	
SV Launch Operation Requirements (OR) inputs	
SV Program Requirements Document (PRD) Mission Specific Annex Inputs	
EGSE accommodation requirements (size, power, and communication)	
Thermal dissipation, if applicable. SV thermal model, geometric math model, and power dissipation timeline, if applicable. LV Integrated Thermal Analysis is performed as a non-standard service and will not apply to all Flexible Manifest Missions.	• The preferred thermal model format is Thermal Desktop, although FEMAP and SINDA/G can also be provided. • Less than 400 nodes. Information to be included: illustrations of all surfaces, description of surface properties, and correspondence between the nodes of the thermal model and geometric model. This model should include illustrations of all thermal modeling, detailed component power dissipation for pre-launch, ascent, and on-orbit mission phases, steady state and transient test case boundary conditions, output minimum allowable component temperature limits and internal SV convection and radiation modeling.

Table 6.4-4. SV/Deployer Submittals Required 9 Months Prior to Launch

SV/Deployer Deliverable	Requirements
SV/Deployer Mission Constraints, if applicable	Day of launch Go/No Go criteria

Table 6.4-5. SV/Deployer Submittals Required 6 Months Prior to Launch

SV/Deployer Deliverable	Requirements
SV/Deployer Final CAD model and drawings	
SV Final FEM/Craig Bampton test verified model	• The final FEM/Craig Bampton SV model shall contain modes up to 150 Hz. • The SV FEM first bending mode along with any modes below 50Hz which have greater than 15% effective mass shall be correlated to within 5% of the test data. Any modes above 50Hz which have more that 15% effective mass shall be correlated to within 10%. • The SV shall identify any additional dynamic SV systems (e.g., gimbals, momentum wheels, etc.) that may contribute to combined vehicle dynamics during ascent and provide a model of the forces the systems will apply to the LV.
SV/Deployer High Fidelity Mass Properties	Reference Mass Properties Section for details on this submittal
SV/Deployer Final Slosh Model, if applicable	
SV/Deployer Final ICD updates	
SV Launch Operations Plan, update as required	Information regarding sequence and time span of SV launch site activities such as GSE, installation, SV testing and servicing, etc.

Table 6.4-5. SV/Deployer Submittals Required 6 Months Prior to Launch

SV/Deployer Deliverable	Requirements
	Update should include procedure list.
SV/Deployer Hardware (EDU) for Mechanical Interface Verification and Electrical Verification Test)	• No Later Than L-3 months • Send to NGIS facility in Chandler, AZ.
SV/Deployer Qualification and Acceptance Test Report	At a minimum, this is needed for DNH assessment.
SV/Deployer Space Debris Assessment Report (SDAR)	
SV Final thermal model, geometric math model, and power dissipation timeline, if applicable.	

Table 6.4-6. SV/Deployer Submittals Required 4 Months Prior to Launch

SV/Deployer Deliverable	Requirements
SV Hazardous and Safety Critical Procedures	Procedures are due to NGIS 45 days before use.

Table 6.4-7. SV/Deployer Submittals Required 3 Months Prior to Launch

SV/Deployer Deliverable	Requirements
SV/Deployer Generic LV to SV ICD Verification/Compliance Assessment	
SV/Deployer Final Mission Constraints	• Day of launch Go/No Go criteria • Last update to Mission Constraints Document and inputs to launch notebook
SV Final Debris Catalog needed for breakup	Submittal is required for SV breakup in the event of an LV aerodynamic breakup or LV Flight Termination, not debris from an SV re-entry.

Table 6.4-8. SV/Deployer Submittals Required 2 Months Prior to Launch

SV/Deployer Deliverable	Requirements
SV/Deployer Delivery of Flight Hardware, MGSE, EGSE (or SV Mass Simulator if applicable)	• Delivery of flight hardware, ready to integrate on the LV, to the Payload Processing Facility. • No Later Than L-30 days
SV/Deployer Final Measured Mass Properties	Reference Mass Properties Section for details on this submittal

Table 6.4-9. SV/Deployer Submittals Required 1 Month Prior to Launch to After Launch

SV/Deployer Deliverable	Requirements
Flight Readiness Certification and inputs needed for readiness reviews	
After launch: Acquisition notification (notification is acquisition + 12 hours)	• Indication of Payload Acquisition, command/telemetry status, and initial vehicle state-of-health assessment. • Health assessment can be limited due to SV security level.

6.5. Safety

Information provided in TM-17589 Minotaur IV User's Guide Section 6.5 regarding Safety can be applied to Flexible Manifest missions using MPAS. Documentation submittals can be made directly with Range Safety or to NGIS to be included with our safety submittals. If SV safety documentation submittals are made directly to Range Safety, then NGIS will request specific safety data information to verify LV/SV interface safety.

NGIS has made this safety documentation process easier for SV/Deployer providers by creating a condensed version of requirements that apply to SV design and operations, reference TM-26481, AFSPCMAN 91-710, or TM-26482, GSFC-STD-8009 WFF RSM, for WFF.

If safety documentation submittals (System Safety Program Plan, Range Safety Requirements Compliance Matrix, Missile System Prelaunch Safety Package, Ground Operations Plan) are to be provided to NGIS to be included with our safety submittals, documentation must be provided per the submittal schedule in TM-26481 and/or TM-26482 as applicable.

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7. GROUND AND LAUNCH OPERATIONS

Information provided in TM-17589, Minotaur IV User's Guide Section 7 regarding Ground and Launch Operations can be applied to Flexible Manifest missions using MPAS. The following information details the integration concepts specific to a Full MPAS with upper and lower MPAP, and a notional payload manifest. This information will change slightly for different MPAS configurations and payload manifests, but is provided for situational awareness and is meant to supplement the information provided in TM-17589.

In this scenario, MPAS hardware will be assembled to the level shown in Figure 7-1 prior to SV mate. MPAS Payload Cone assembly will be integration on the Minotaur Common Integration and Handling Stand (CIHS). MPAS Structures will be integrated on universal handling carts, this will allow access inside and outside of the structure. Cable harness on both the MPAS and Payload Cone assembly will be routed to the full extent possible.

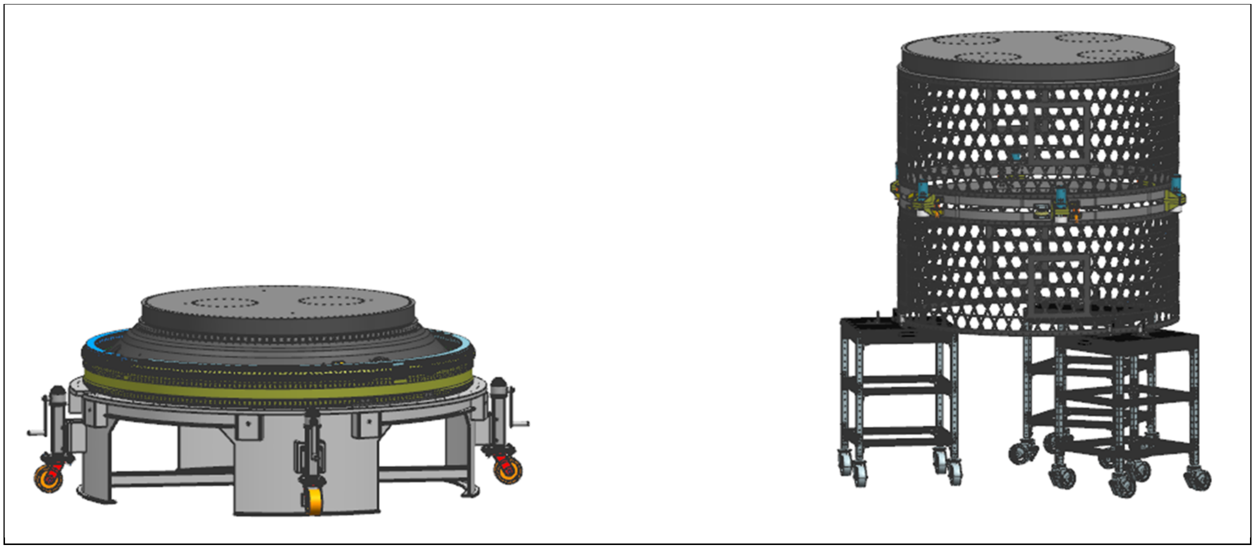

Figure 7-1. Full MPAS Integration

Next, satellites and/or CubeSat Deployers would be installed on the lower MPAP. Figure 7-2 shows one Larger than ESPA class SV being installed on the lower MPAP. Ideally, harness routing and final closeout (remove RBF, install arm plugs, etc.) of this lower SV will be completed at this stage of MPAS integration.

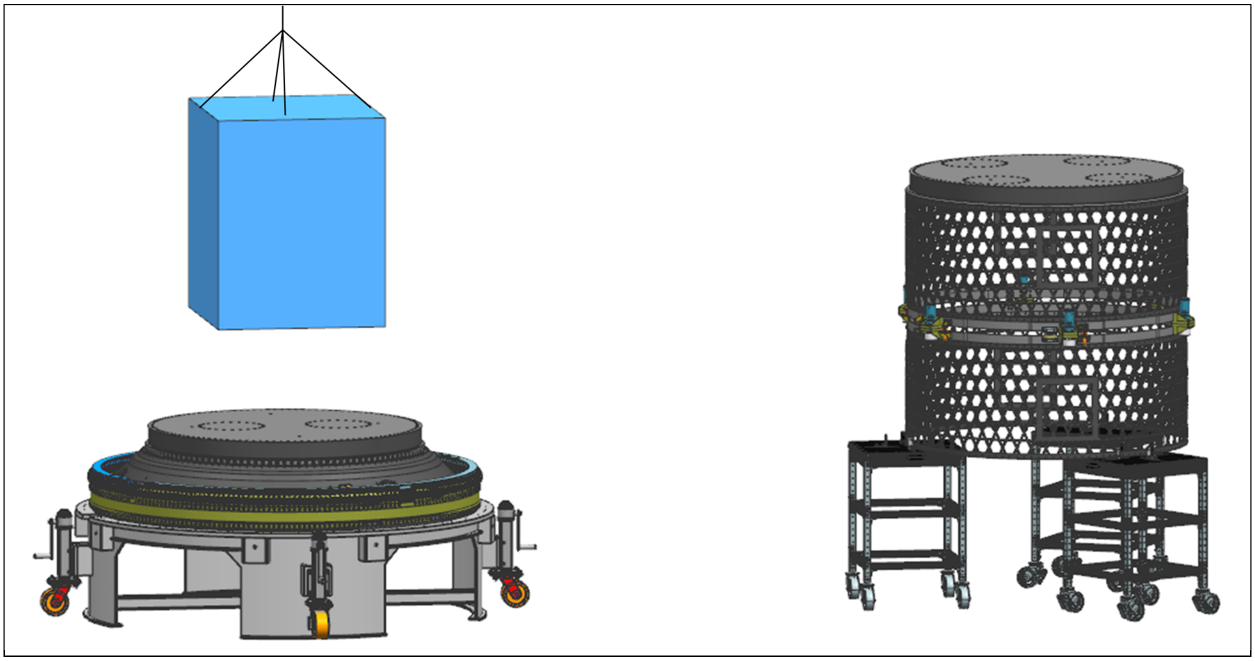

Figure 7-2. Lower MPAP Integration with Notional SV

Next, the assembled Lattice Cylinders and MPAS Separation System will be mechanically mated to the MPAS adapter ring as shown in Figure 7-3. Remaining harness spanning the MPAS to Payload Cone interface will be electrically mated. All remaining flight harness will be routed and flight dressed.

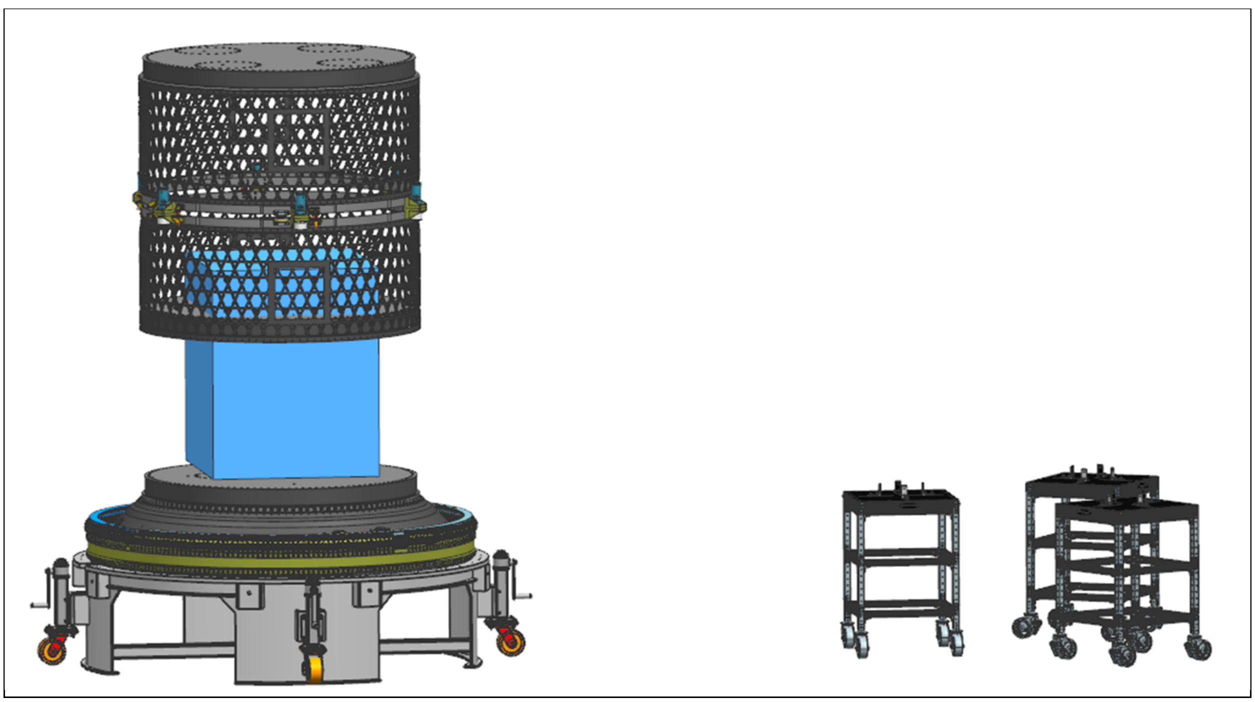

Figure 7-3. Lattice Cylinder and MPAS Separation System Integration

Next, a personnel platform will be assembled to ease integration of the Upper MPAP. Figure 7-4 shows four ESPA class SV being installed on the upper MPAP. It should be noted, SV lifting equipment must be designed so as not to protrude more than two inches beyond the ESPA envelope, otherwise interference to surrounding SVs may occur.

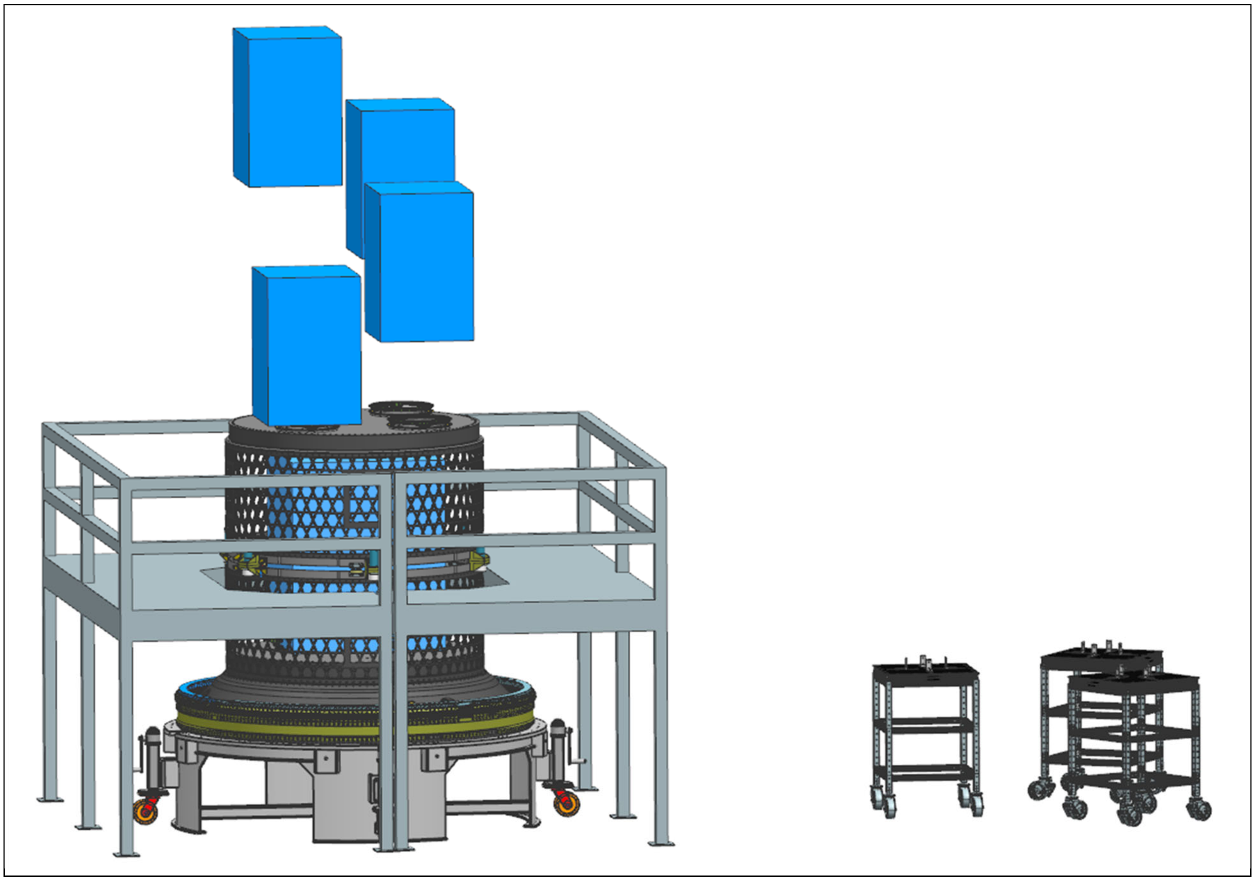

Figure 7-4. Upper MPAP Integration with Notional SV

Finally, as shown in Figure 7-5, the personnel platforms will be removed. CubeSat Deployers will be installed on the outside of the Lower Lattice Cylinder. CubeSat Deployer harness will be routed and flight dressed and full assembly will be finalized for fairing encapsulation.

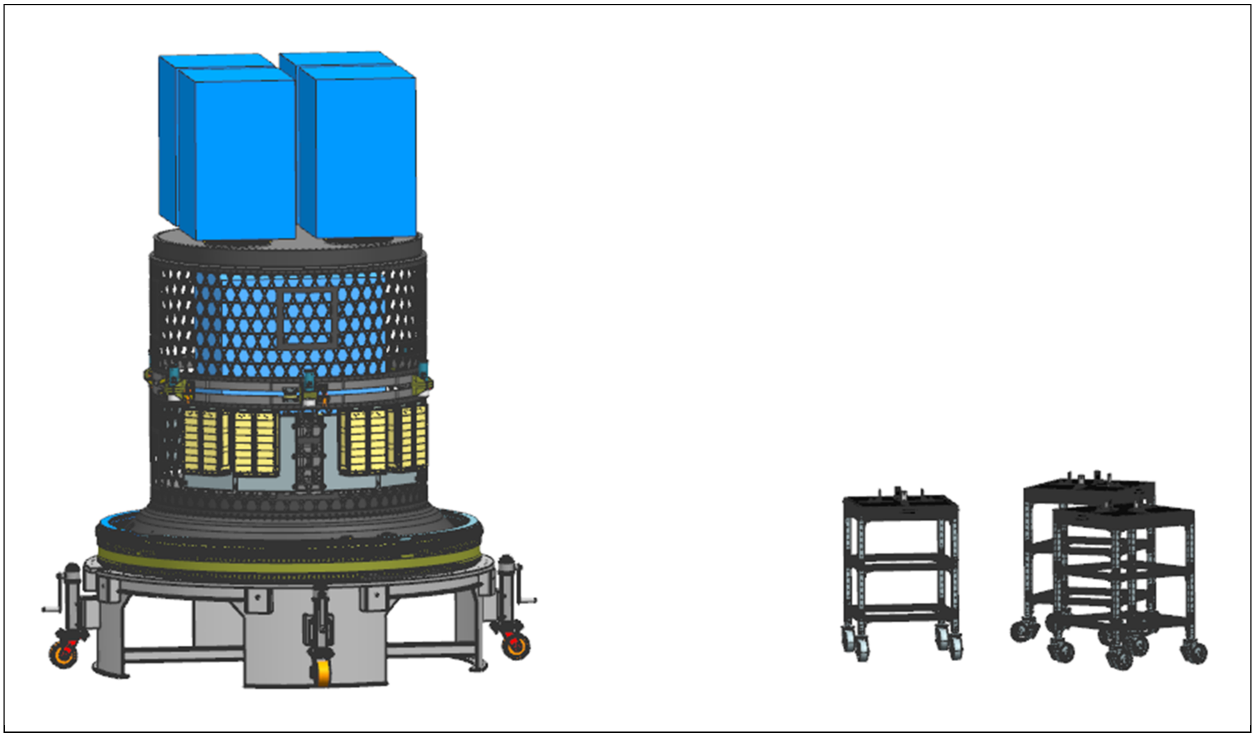

Figure 7-5. Full MPAS Ready for Fairing Encapsulation with Notional SV/CubeSat Deployers

8. OPTIONAL ENHANCED CAPABILITIES

Information provided in TM-17589 Minotaur IV User's Guide Section 8 regarding Optional Enhanced Capabilities can be applied to Minotaur missions using MPAS.

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APPENDIX A

PAYLOAD QUESTIONNAIRE

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SPACECRAFT IDENTIFICATION	
FULL NAME:	
ACRONYM:	
OWNER/OPERATOR:	
INTEGRATOR(s):	
CLASS (CUBESAT, ESPA, ETC.):	
MISSION NARATIVE:	
POTENTIAL HAZARDS:	

ORBIT INSERTION REQUIREMENTS*		
SPHEROID	❑ Standard ❑ Other:	
ALTITUDE	Insertion Apse: ______ ± ______ ❑ km ______ ± ______ ❑ nmi	Opposite Apse: ______ ± ______ ❑ km ______ ± ______ ❑ nmi
or...	Semi-Major Axis: ______ ± ______ ❑ km ______ ± ______ ❑ nmi	Eccentricity: ______ ≤ e ≤ ______
INCLINATION	______ ± ______ deg	
ORIENTATION	Argument of Perigee: ______ ± ______ deg	Longitude of Ascending Node (LAN): ______ ± ______ deg
	Right Ascension of Ascending Node (RAAN): ______ ± ______ deg...for Launch Date: ______	

* Note: Mean orbital elements

LAUNCH WINDOW REQUIREMENTS
NOMINAL LAUNCH DATE:
NOMINAL LAUNCH SITE:
OTHER CONSTRAINTS (if not already implicit from LAN or RAAN requirements, e.g., solar beta angle, eclipse time constraints, early on-orbit ops, etc.):

<table>
<tr><th colspan="4">GROUND SUPPORT EQUIPMENT</th></tr>
<tr><td colspan="4">Describe any ground support equipment, mission control facilities (e.g.; LCC, MCC) and Range facilities (e.g., Launch Equipment Vault (LEV) which the Spacecraft intends to use:</td></tr>
<tr><td rowspan="7">LEV</td><td colspan="3">Describe (in the table below) Spacecraft EGSE to be located in the LEV.</td></tr>
<tr><td>Equipment Name / Type</td><td>Approximate Size (LxWxH)</td><td>Power Requirements</td></tr>
<tr><td></td><td></td><td></td></tr>
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</table>

EARLY ON-ORBIT OPERATIONS	
Briefly describe the spacecraft early on-orbit operations, e.g., event triggers (separation sense, sun acquisition, etc.), array deployment(s), spin ups/downs, etc.:	
SPACECRAFT SEPARATION REQUIREMENTS	
ACCELERATION	Longitudinal: = _________ g's Lateral: = _________ g's
VELOCITY	Relative Separation Velocity Constraints:
ANGULAR RATES (pre-separation)	Longitudinal: _________________ ± ________________ deg/sec Pitch: ________________________ ± _______ deg/sec Yaw: _________________________ ± _______ deg/sec
ANGULAR RATES (post-separation)	Longitudinal: ________________ ± ________________ deg/sec Pitch: __________ ± _________ deg/sec Yaw: ___________ ± _________ deg/sec
ATTITUDE (at deployment)	Describe Pointing Requirements Including Tolerances:
SPIN UP	Longitudinal Spin Rate: _____________ ± ____________ deg/sec
OTHER	Describe Any Other Separation Requirements:
SPACECRAFT COORDINATE SYSTEM	
Describe the Origin and Orientation of the spacecraft reference coordinate system, including its orientation with respect to the launch vehicle (provide illustration if available):	

SPACECRAFT PHYSICAL DIMENSIONS	
STOWED CONFIGURATION	Length/Height:________ ❑in ❑cm Diameter: ___________ ❑in ❑cm Other Pertinent Dimension(s):
	Describe any appendages/antennas/etc. which extend beyond the basic satellite envelope:
ON-ORBIT CONFIGURATION	Describe size and shape:

If available, provide electronic files of dimensioned drawings for both stowed and on-orbit configurations.

SPACECRAFT MASS PROPERTIES*	
PRE-SEPARATION	Mass:______________ ❑ lb_m ❑ kg Inertia units: ❑ lb_m-in^2 ❑ kg-m^2 Ixx:__________ Ixy:__________ XCG:______________ ❑ in ❑ cm Iyy:__________ Iyy:__________ YCG:______________ ❑ in ❑ cm Izz:__________ Ixz:__________ ZCG:______________ ❑ in ❑ cm
POST-SEPARATION (non-separating adapter remaining with launch vehicle)	Mass:______________ ❑ lb_m ❑ kg Inertia units: ❑ lb_m-in^2 ❑ kg-m^2 Ixx:__________ Ixy:__________ XCG:______________ ❑ in ❑ cm Iyy:__________ Iyy:__________ YCG:______________ ❑ in ❑ cm Izz:__________ Ixz:__________ ZCG:______________ ❑ in ❑ cm

** Stowed configuration, spacecraft coordinate frame*

SPACECRAFT SLOSH MODEL*	
SLOSH MODEL UNDER 0 g	Pendulum Mass:__________________ ❑ lbm ❑ kg Pendulum Length:_________________ ❑ ft ❑ m Pendulum Xs:__________________ ❑ in ❑ cm Attachment Ys:__________________ ❑ in ❑ cm Point Zs:___________________ ❑ in ❑ cm Natural Frequency of Fundamental Sloshing Mode (Hz): ________.
SLOSH MODEL UNDER 1 g	Pendulum Mass:__________________ ❑ lbm ❑ kg Pendulum Length:_________________ ❑ ft ❑ m Pendulum Xs:__________________ ❑ in ❑ cm Attachment Ys:__________________ ❑ in ❑ cm Point Zs:___________________ ❑ in ❑ cm Natural Frequency of Fundamental Sloshing Mode (Hz): ________.

** Stowed configuration, spacecraft coordinate frame*

ASCENT TRAJECTORY REQUIREMENTS	
Free Molecular Heating at Fairing Separation:	FMH = ____________ ❑ W/m^2 ❑ $Btu/ft^2/hr$
Fairing Internal Wall Temperature	T = ____________ ❑ deg C ❑ deg F
Dynamic Pressure at Fairing Separation:	q = ________ ❑ N/m^2 ❑ lb_f/ft^2
Ambient Pressure at Fairing Separation:	P = ________ ❑ N/m^2 ❑ lb_f/in^2
Maximum Pressure Decay During Ascent:	Δ P = ________ ❑ $N/m^2/sec$ ❑ $lb_f/in^2/sec$
Thermal Maneuvers During Coast Periods:	

SPACECRAFT ENVIRONMENTS	
THERMAL DISSIPATION	Spacecraft Thermal Dissipation, Pre-Launch Encapsulated: ___________ Watts Approximate Location of Heat Source:
TEMPERATURE	Temperature Limits During Ground/Launch Operations: Max ___________ ❑ deg F ❑ deg C Min ___________ ❑ deg F ❑ deg C
	Component(s) Driving Temperature Constraint: Approximate Location(s):
HUMIDITY	Relative Humidity: Max ________ % Min ________ % ***or***, Dew Point: Max ___________ ❑ deg F ❑ deg C Min ___________ ❑ deg F ❑ deg C
GAS PURGE	Specify Any Gas Purge Requirements (e.g.; Nitrogen), Including Component Description, Location, and Required Flow Rate: (Nitrogen Purge is a Non-Standard Service)
CLEANLINESS	Volumetric Requirements (e.g. Class 100,000): ____________________ Surface Cleanliness (e.g. Visually Clean): ________________________ Other:
LOAD LIMITS	Ground Transportation Load Limits: Axial = _______ g's Lateral = _______ g's

MECHANICAL INTERFACE	
DIAMETER	Describe Diameter of Interface (e.g. Bolt Circle, Separation System, etc.) and provide illustration if available:
SURFACE FLATNESS	Flatness Requirements for Sep System or Mating Surface of Launch Vehicle:
SEPARATION SYSTEM	Will Launch Vehicle Supply the Separation System? Yes / No If Yes, Approximate location of electrical connectors: Special thermal finishes (tape, paint, MLI) needed: If No, Provide a brief description of the proposed system:
FAIRING ACCESS	Payload Fairing Access Doors (spacecraft coordinate frame): Longitudinal __________ ❑ in ❑ cm Clocking (deg), Describe: Longitudinal __________ ❑ in ❑ cm Clocking (deg), Describe: Longitudinal __________ ❑ in ❑ cm Clocking (deg), Describe:
DYNAMICS	Spacecraft Natural Frequency: Axial ____________ Hz Lateral ____________ Hz Recommended: > TBD Hz > TBD Hz
OTHER	Other Mechanical Interface Requirements:

ELECTRICAL INTERFACE
Bonding Requirements:
Are Launch Vehicle Supplied Pyro Commands Required? Yes / No If Yes, magnitude: __________ amps for _________ msec When _________ seconds before separation
Are Launch Vehicle Supplied Discrete Commands Required? Yes / No If Yes, describe:
Is Electrical Access to the Satellite Required? After Encapsulation? Yes / No At Launch Site?Yes / No
Is Spacecraft Battery Charging Required? After Encapsulation? Yes / No At Launch Site?Yes / No
Is a Telemetry Interface with the Launch Vehicle Flight Computer Required? Yes / No If Yes, describe:
Other Electrical Requirements (e.g.; coax, fiber, etc.):

Please complete attached sheet of required pass-through signals.

RF RADIATION
Time After Separation Until RF Devices Are Activated: (Note: Typically, spacecraft radiation is not allowed from encapsulation until after fairing separation.)
Frequency: _________________ MHz Power: _______________ Watts
Location(s) on Spacecraft (spacecraft coordinate frame): Longitudinal __________ ❑ in ❑ cm Clocking (deg), Describe: Longitudinal __________ ❑ in ❑ cm Clocking (deg), Describe:

REQUIRED PASS-THROUGH SIGNALS

Item No.	Pin	Signal Name	From LEV	To Satellite	Shielding	Max Cur-rent (amps)	Total Line Resistance (ohms)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
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23							
24							
25							
26							
27							
28							
29							
30							

REQUIRED PASS-THROUGH SIGNALS

Item No.	Pin	Signal Name	From LEV	To Satellite	Shielding	Max Current (amps)	Total Line Resistance (ohms)
31							
32							
33							
34							
35							
36							
37							
38							
39							
40							
41							
42							
43							
44							
45							
46							
47							
48							
49							
50							
51							
52							
53							
54							
55							
56							
57							
58							
59							
60	---	Reserved for separation loop	---	---	---	---	---

REQUIRED PASS-THROUGH SIGNALS

Item No.	Pin	Signal Name	From LEV	To Satellite	Shielding	Max Current (amps)	Total Line Resistance (ohms)
61	---	Reserved for separation loop	---	---	---	---	---
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
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91							

REQUIRED PASS-THROUGH SIGNALS

Item No.	Pin	Signal Name	From LEV	To Satellite	Shielding	Max Cur-rent (amps)	Total Line Resistance (ohms)
92							
93							
94							
95							
96							
97							
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