Taurus® Launch System
Payload User's Guide

September 1999

Release 3.0

Orbital

Thank you for considering Orbital's Taurus launch system to fulfill your launch service needs. This revision to the Taurus User's Guide is designed to familiarize mission planners and designers with the current capabilities and interfaces of the Taurus launch system, with the goal of enabling potential customers to perform mission feasibility trade studies and complete preliminary mission designs.

Orbital's Taurus launch system has been designed to provide safe, successful, on-time launch services for a wide variety of payloads and mission designs. Our completely successful flights (March of 1994, and February and October of 1998) validated the Taurus system and operational concept as well as provided a solid foundation for our on-going Taurus Program. The Taurus team is in place, is fully dedicated to delivering a high quality launch service and is committed to mission success at all levels. In addition, Orbital's Launch Systems Group has achieved and is operating under ISO-9000 certification.

Orbital designed the Taurus launch service to satisfy the varied requirements of our payloads, since the Taurus vehicle is simply a tool to enable the payload to accomplish its mission. Orbital offers a range of payload accommodations and interfaces to provide flexibility in designing a particular mission. In addition, Taurus ground and launch operations have been structured to streamline vehicle integration efforts. Originally designed for rapid response from austere launch sites for Department of Defense missions, the aspects of the Taurus launch system that enable these rapid operations have distinct advantages for commercial and scientific missions as well.

Orbital's Taurus program team is eager to assist in your mission design and mission planning activities. This User's Guide is intended to provide the basic information to allow potential customers to perform preliminary assessments of Taurus' suitability for their mission. Please contact the Taurus Program Office at any stage of your mission design process for further information and a mission-specific assessment.

Thank you in advance for considering Taurus for your launch service needs.

William A. Wrobel
Taurus Program Manager
Orbital/Launch Systems Group

This Taurus® Launch System Payload User's Guide is intended to familiarize potential customers with the Taurus launch system, its capabilities and its associated services. The launch services described herein are available for commercial procurement directly from Orbital Sciences Corporation. This document is not intended to be an entirely comprehensive description of all aspects of the Taurus launch service. Readers desiring further information on Taurus or on the methods of procuring Taurus launch services should direct their inquiries to:

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This document will be revised periodically. Recipients are encouraged to e-mail us at Launch-Systems@orbital.com or call us at our New Business number, (703) 404-7400, to ensure they will be included on the mailing list for future updates.

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AIT	Assembly and Integration Trailer
APC	Aft Payload Capsule
CCAS	Cape Canaveral Air Station
CDR	Critical Design Review
CCTV	Closed Circuit Television
CG	Center of Gravity
CVCM	Collected Volatile Condensable Material
DADS	Dynamic Analysis and Design System
DARPA	Defense Advanced Research Projects Agency
dB	Decibel
DC	Direct Current
DPAF	Dual Payload Attach Fitting
DoT	Department of Transportation
ECE	Encapsulated Cargo Element
ECS	Environmental Control System
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
fps	Feet Per Second
FSPO	Flight Safety Project Officer
FSS	Flight Safety Station
GFO	GEOSAT Follow-On
GSE	Ground Support Equipment
GTO	Geosynchronous Transfer Orbit
Hz	Hertz
ICD	Interface Control Document
KOMPSAT	Korean Multi-Purpose Satellite
Lb_f	Pounds, Force
LC	Launch Complex
LDS	Launch Director Station
LEO	Low Earth Orbit
LEV	Launch Equipment Van
LSE	Launch Support Equipment
LSV	Launch Support Van
MAB	Missile Assembly Building
MDL	Mission Data Load
MIWG	Mission Integration Working Group
MSPSP	Missile System Pre-Launch Safety Package
MTI	Multi-Thermal Imager
MUX	Multiplexer
NASA	National Aeronautics and Space Administration
nm	Nautical Miles
NVAFB	North Vandenberg Air Force Base
OASPL	Overall Sound Pressure Level
OR	Operations Requirements
OSM	Operations Support Manager
PDU	Pyrotechnic Driver Unit
POST	Program to Optimize Simulated Trajectories
PPF	Payload Processing Facility
PRD	Program Requirements Document
PSA	Payload Support Area
RCC	Range Control Center
RCS	Reaction Control System
RF	Radio Frequency
RWG	Range Working Group
SLC	Space Launch Complex
SPL	Sound Pressure Level
SRM	Solid Rocket Motor
SRS	Shock Response Spectrum
SSLV	Standard Small Launch Vehicle
STEX	Space Technology Experiment
SVAFB	South Vandenberg Air Force Base
TAA	Technical Assistance Agreement
TCS	Test Conductor Station
TML	Total Mass Loss
TTL	Transitor - Transitor Logic
TVC	Thrust Vector Controller
TWP	Taurus Work Package
U.S.	United States
VAFB	Vandenberg Air Force Base
VC-HS	Visibly Clean-Highly Sensitive
VCS	Vehicle Control Station
VDC	Volts, Direct Current
VDL	Voice Direct Line
WBS	Work Breakdown Structure
WFF	Wallops Flight Facility

Section 1
Introduction

This Taurus User's Guide is intended to familiarize payload mission planners with the capabilities of Orbital Sciences Corporation's (Orbital's) Taurus launch service. This document provides an overview of the Taurus system design and a description of the services provided to our customers. Orbital offers a variety of service options to allow the maximum flexibility in satisfying the objectives of single or multiple payloads.

The Taurus Program's philosophy of placing mission success as the highest priority is reflected in the results of all Taurus missions to date. These missions not only demonstrated the reliability of the Taurus launch system design, but also provide a solid base from which to conduct our current Taurus missions.

The Taurus launch vehicle system is composed of a flight vehicle and ground support equipment. Each element of the Taurus system has been developed to simplify the mission design and payload integration process and to provide safe, reliable space launch services. This User's Guide describes the basic elements of the Taurus system as well as optional services that are available. In addition, this document provides general vehicle performance, defines payload accommodations and environments, and outlines the Taurus mission integration process.

The Taurus system can operate from a wide range of launch facilities and geographic locations. The system is compatible with, and will typically operate from, existing U.S. Government ranges at Vandenberg Air Force Base (VAFB), Cape Canaveral Air Station (CCAS), and Wallops Flight Facility (WFF). While most commercial missions do not require the rapid response capabilities of the original Taurus program, the same design features that allow the Taurus system to meet these requirements are used to streamline vehicle integration and launch operations for all Taurus missions. This User's Guide describes Taurus-unique integration and test approaches (including the typical operational timeline for payload integration with the Taurus vehicle) and the existing ground support equipment that is used to conduct Taurus operations.

Section 2
Description of Taurus Launch Services

2.1 Taurus Launch System Overview

The Taurus launch vehicle, shown in Figure 2-1, was privately developed by Orbital to provide a cost effective, reliable and flexible means of placing small satellites into orbit. An overview of the system and available launch services is provided within this section, with specific elements covered in greater detail in the subsequent sections of this User's Guide.

Taurus was originally designed to meet the needs of the Defense Advanced Research Projects Agency's (DARPA's) Standard Small Launch Vehicle (SSLV) Program. The requirements of that program stressed system reliability, transportability, and operation from austere launch sites. Following the successful Taurus maiden flight, Orbital initiated development work on an upgraded version of the Taurus vehicle. This configuration, which is the Taurus vehicle that is offered commercially and described within this User's Guide, differs from the SSLV configuration primarily through the use of Thiokol's Castor 120® solid rocket motor for the first stage in place of the Peacekeeper stage used on the first flight. Orbital's efforts have resulted in a simple, robust, self-contained launch system that has been completely successful in its three flights to date and is in production to support various government and commercial customers. The Taurus flight history and current manifest are depicted in Figure 2-2.

The Taurus system also includes a complete set of transportable Launch Support Equipment (LSE) designed to allow Taurus to be operated as a self-contained satellite delivery system. This LSE is pictorially represented in Figure 2-3 and includes the launch stand, Launch Equipment Van (LEV), Launch Support Van (LSV) and assorted mechanical and electrical ground support equipment. The LSV serves as the actual control center for conducting a Taurus launch and includes consoles for Orbital, range safety, and payload personnel. While the Taurus system is capable of self-contained operation, it is typically launched from an established range; thus, the vehicle and LSE are designed for compatibility

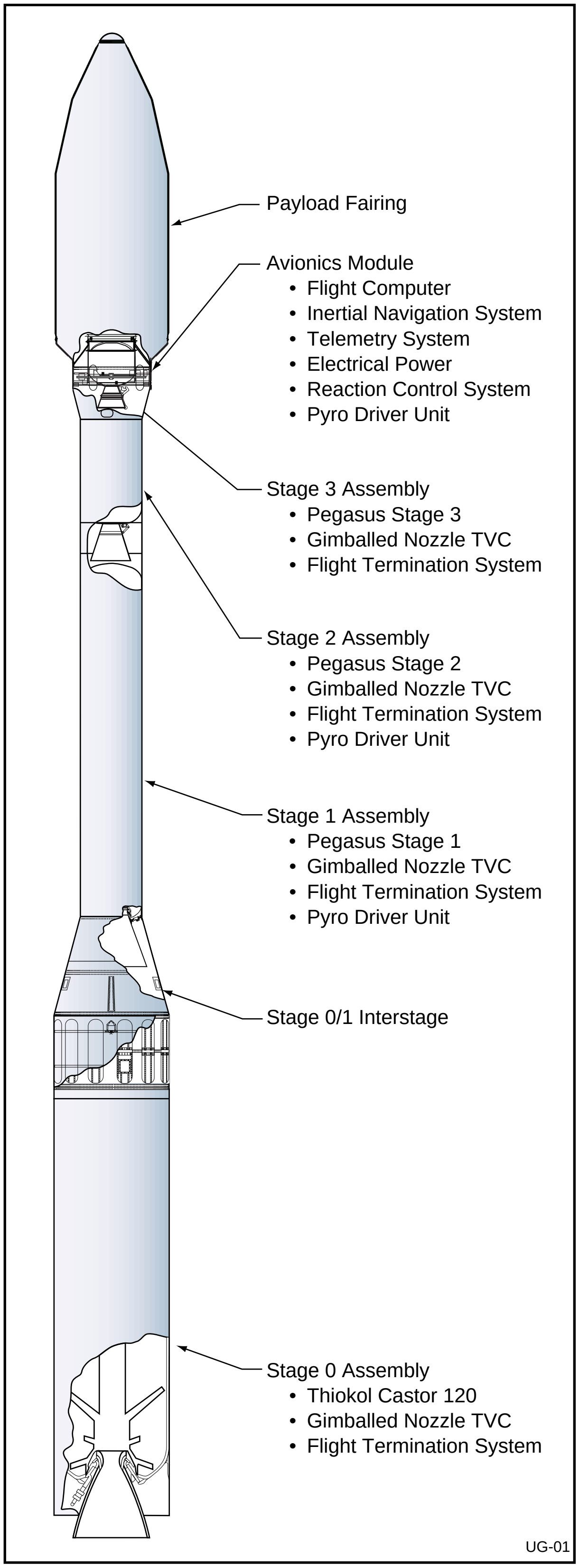

Figure 2-1. *Taurus Vehicle Configuration.*

Task Name	Launch Date	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
DARPA Taurus SSLV (T1)	Mar 13, 1994			▲ Successful										
Commercial Taurus Development				▲				▲						
Commercial Geosat Follow-On (GFO) (T2)	Feb 10, 1998							▲ Successful						
Air Force Space Technology Experiment (STEX) (T3)	Oct 3, 1998							▲	Successful					
Commercial KOMPSAT (T4)	Nov, 1999								▲					
Air Force Multi-Thermal Imager (MTI) (T5)	1st Qtr, 2000									▲				
Commercial OrbView-4 (T6)	3rd Qtr, 2000									▲				

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Figure 2-2. *Taurus Flight History and Current Launch Manifest.*

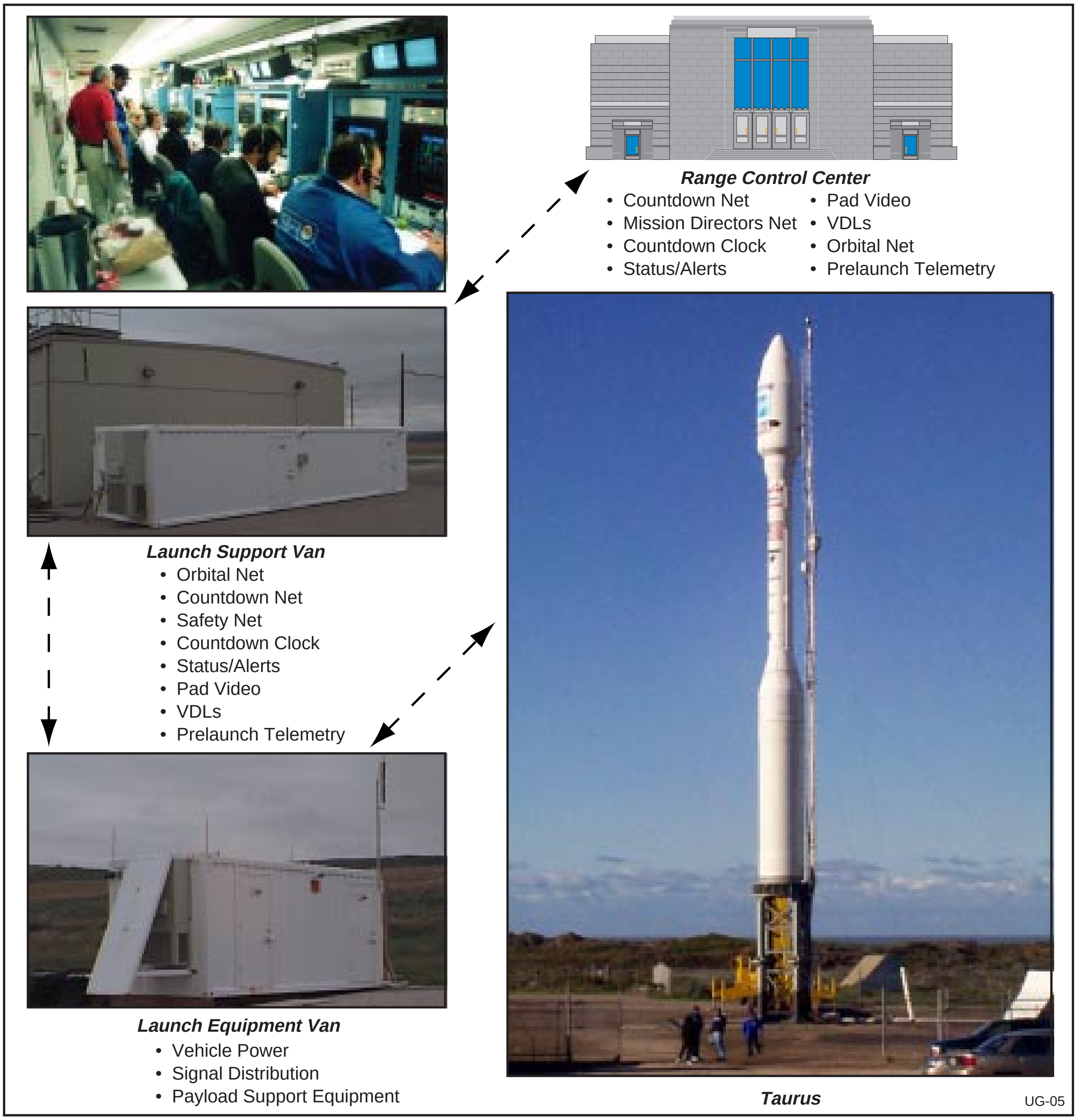

Figure 2-3. *Transportable Launch Support Equipment.*

with existing U.S. Government ranges at Vandenberg Air Force Base (VAFB), Cape Canaveral Air Station (CCAS) and Wallops Flight Facility (WFF). A communications network connects the LSV with the Range Control Center (RCC). Further description of the Launch Support Equipment is provided in Section 2.4.

2.2 Taurus Launch Service

As summarized in Figure 2-4, Orbital provides all of the necessary hardware, software and services to integrate, test and launch a satellite into its prescribed orbit. In addition, Orbital will complete all the required agreements, licenses and documentation to successfully conduct Taurus operations. All Taurus production and integration processes and procedures have been demonstrated and are in use for current Taurus missions. The Taurus mission integration process completely identifies, documents, and verifies all spacecraft and mission requirements. This provides a solid basis for initiating and streamlining the integration process for future Taurus customers.

2.3 Description of the Taurus Vehicle

The Taurus vehicle, shown in expanded view in Figure 2-5, is a four stage, inertially guided, all solid propellant ground launched vehicle. Conservative design margins, state-of-the-art structural systems, a distributed-processor avionics architecture, and simplified integration and test capability, yield a robust, highly reliable launch vehicle design. In addition, Taurus payload accommodations and interfaces have been designed to satisfy a wide range of potential payload requirements.

The Taurus vehicle was designed to enable payloads to choose the optimum configuration

Launch System Management And Production	***Launch Base Services***
• Furnish The Personnel, Facilities, And Materials To Manufacture, Test, Integrate, Support And Launch The Taurus Vehicle • Furnish The Personnel, Facilities, And Materials To Design, Manufacture, Test, And Integrate Mission-Unique Hardware And Software - Electrical, Mechanical And GSE Interfaces • Perform Standard Mission Analyses	• Conduct/Provide All Activities, Supplies and Services At The Integration Site Necessary To Build And Test Taurus • Create And Maintain Taurus-Unique And Mission-Integrated Field Site Procedures • Provide Facility For Payload Processing And Encapsulation • Provide Environmental Control Of Payload From Encapsulation Through Launch • Provide Space For Payload Personnel And Equipment In Orbital Support Vans • Provide Electrical Interface From The Payload Interface Connectors To The LSE • Transport Components To Launch Site
Mission Integration	***Launch Base Integrated Operations***
• Coordinate The Mission Integration Working Group (MIWG) Process • Create And Maintain The Taurus-to-Payload Interface Control Document • Define Mechanical And Electrical Interfaces, Payload Environments, Vehicle Performance Requirements • Conduct The Taurus-to-Payload Interface Verification Process • Support Interface Testing Prior To Payload Transport To The Field	• Prepare Payload Adapter, Fairing And Mission Support Hardware • Perform Encapsulation And Transportation Of Encapsulated Cargo Element (ECE) To The Launch Site • Conduct Mate Of ECE To Launch Vehicle And Interface Verification Testing
Range Interface	***Launch And Monitor Of Taurus System***
• Coordinate The Mission With Applicable Range And Environmental Agencies • Coordinate, Prepare And Maintain Range Documentation (UDS) Submittals With Customer-Provided Payload Input • Conduct Flight Planning And Trajectory Analyses	• Develop And Maintain Mission Constraints Document And Launch Checklist, Which Defines The Pre-Launch And Launch Activities And Procedures • Conduct Countdown Rehearsals With Full Range And Customer Participation To Assure Readiness For Launch • Provide Orbital Parameters (From Taurus Telemetry) • Confirm Payload Separation, Time Of Separation And Separation State Vector (If Within Sight Of Tracking Station) • Process Flight Data
Safety	***Commercial Services***
• Implement The Safety Program And Obtain All Necessary Flight Certification And Range Approvals • Complete The Missile System Pre-Launch Safety Package (MSPSP), Providing Detailed Technical Data Of All Launch Vehicle And Payload Hazardous Items • Submit The Flight Data Safety Package For Flight Plan Approval • Complete The Launch Complex Safety Plan	• Obtain And Maintain DoT Launch License • Obtain TAA for Non-U.S. Customers UG-23

Figure 2-4. *Overview of Taurus Launch Service.*

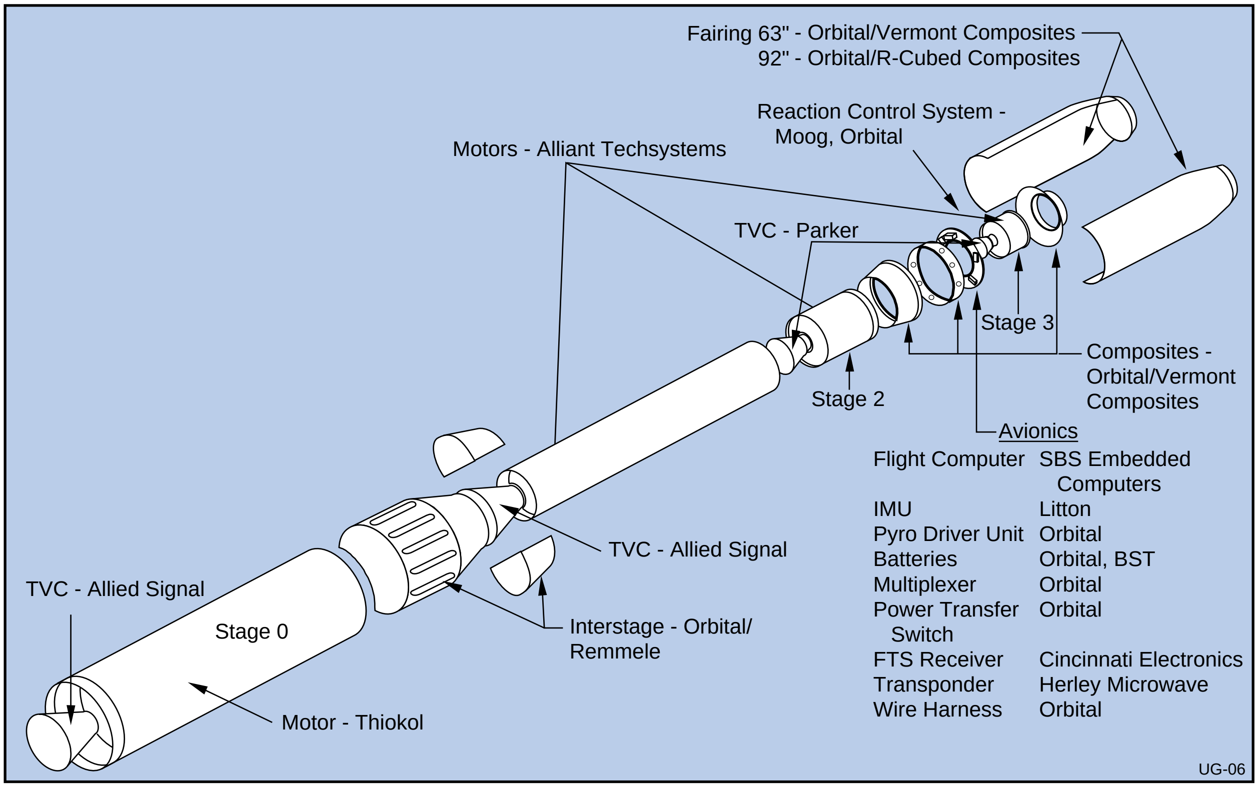

Figure 2-5. *Taurus Expanded View.*

that best meets mission requrements. In order to simplify the options offered, Orbital created a configuration numbering convention detailed in Figure 2-6. This numbering system is used to describe the performance of Taurus vehicles in the following sections.

Stage 0 — The Taurus first stage (known as Stage 0) is the Thiokol Castor 120 Solid Rocket Motor (SRM). The flight-proven Castor 120 SRM, is a commercial replacement of the reliable Peacekeeper first stage flown on the Taurus maiden flight. The Castor 120 physical and performance characteristics are closely related to the Peacekeeper motor. Propellant binder, aluminum and solid content are the same, length and weight are increased modestly, and ballistics are reshaped slightly to create a more benign thrust profile and flight environment while achieving higher performance. Castor 120 motor dimensions, mass and performance characteristics are provided in Figure 2-7.

Stage 0/1 Interstage — An aluminum skin and stringer construction interstage extends from the forward skirt of the Castor 120 Stage 0 motor to the aft end of the Stage 1 motor, tapering from a 92 inch (2.3 m) to a 50 inch (1.3 m) diameter. This interstage is fabricated in two sections: the lower interstage, which remains with Stage 0, and the upper interstage, which flies with Stage 1. A field joint between the upper and lower sections of the interstage allows the Taurus upper stage stack to be mated to the Castor 120 Stage 0, while a linear shaped charge separation system severs the interstage sections at Stage 1 ignition. The lower interstage is designed to accommodate a hot-fire separation of Stage 1 through the incorporation of vent ports in the cylindrical portion of the structure. Aerodynamic panels covering the ports are jettisoned just prior to Stage 1 ignition. This hot-fire separation has been successfully demonstrated on all Taurus missions.

Stages 1, 2, and 3 — The Taurus upper stages (known as Stages 1, 2 and 3) are the Alliant TechSystems Orion 50S-G, 50 and 38 SRMs, respectively. These motors were originally developed for Orbital's Pegasus program and

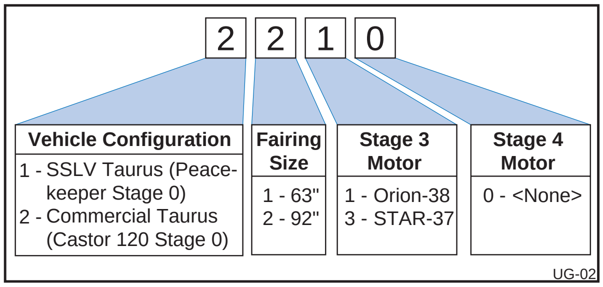

Figure 2-6. *Taurus Configuration Numbering Convention.*

have been adapted for use on the ground-launched Taurus vehicle. Common design features, materials and production techniques are applied to all three motors to maximize reliability and production efficiency. These motors are fully flight qualified based on heritage, design conservatism, ground static fires and multiple successful flights. Details of Stages 1, 2 and 3 are also provided in Figure 2-7.

As an optional service, the Orion 38 Stage 3 can be replaced by a spinning upper stage using Thiokol's STAR 37FM motor. This optional service is detailed in Section 8.6.

Avionics Section and Boattail — The graphite/epoxy boattail structure provides the transition from the 50 inch (1.3 m) diameter of the Stage 2 motor to the 63 inch (1.6 m) diameter of the avionics skirt. The boattail is a sandwich structure constructed using a foam core and graphite epoxy facesheets. The avionics skirt, also a graphite/epoxy structure, supports the avionics shelf and carries the primary structural loads from the fairing and payload cone. The aluminum avionics shelf supports the third stage avionics. The shelf is annular in shape to maximize the use of available volume and enable the Stage 3 motor to be suspended from the payload cone through the shelf. This removes the Stage 3 motor from the primary structural load path and provides the flexibility for alternate upper stage configurations.

Avionics — The Taurus avionics system is an all-digital distributed processor design. Mission reliability is achieved by the use of simple designs, high reliability components, high design margins and extensive testing at the box, subsystem, and system level. The heart of the avionics system is a multiprocessor, 32-bit flight computer manufactured by SBS Embedded Computers. The flight computer communicates with all vehicle subsystems and the LSE using standard RS-422 digital serial data links. All avionics on the vehicle feature integral microprocessors to perform local processing and to handle communications with the flight computer. This RS-422 architecture is central to Taurus' rapid integration and test, as it allows unit-, stage- and system-level testing to be accomplished using only personal computers outfitted with commercially available interface cards.

Payload Fairings — Orbital offers one of two flight-proven Taurus payload fairings to encapsulate the payload and provide protection and contamination control during ground handling, integration operations and flight. Both fairings are bisector shells constructed of graphite/epoxy facesheets with an aluminum honeycomb core. The Taurus 63" diameter fairing, manufactured by Vermont Composites, was successfully demonstrated on Taurus' first and third missions while the larger 92" diameter fairing, manufactured by R-Cubed Composites, was successfully demonstrated on the second Taurus mission. The fairings are further detailed in Section 5.2.

Propulsion Data	Stage 0	Stage 1	Stage 2	Stage 3
Engine/Motor	Castor 120	Orion 50S-G	Orion 50	Orion 38
Manufacturer	Thiokol	Alliant	Alliant	Alliant
Propellant	Solid HTPB	Solid HTPB	Solid HTPB	Solid HTPB
Length (ft/m)	41.9/12.8	28.3/8.6	10.1/3.1	4.4/1.3
Diameter (ft/m)	7.8/2.4	4.2/1.3	4.2 /1.3	3.2 /1.0
Propellant Weight (lb/kg)	107,408/48,720	26,780/12,147	6,667/3,024	1,697/770
Average Vacuum Thrust (lbf/kN)	363,087/1,615	106,000/471	25,910/115	7,155/31.8
Eff. Specific Impulse (sec)	277.9	285.0	290.2	286.7
Burn Time (sec)	82.5	72.4	75.1	68.5

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Figure 2-7. *Taurus Propulsion Data Table.*

The Taurus fairings have been designed to satisfy a range of payload interface requirements. Both designs provide for the off-line encapsulation of the payload within the fairing and the transportation of this encapsulated cargo element to the launch site for mating to the Taurus vehicle late in the launch operations flow. The fairings also provide for low payload contamination through prudent design and selection of low contaminating materials and processes. Each fairing incorporates acoustic blankets and internal air conditioning ducts to provide more benign payload environments.

With the addition of a structural adapter, either fairing can accommodate multiple payloads. This feature, described in more detail in Section 8.2 of this User's Guide, permits two or more smaller payloads to share the cost of a Taurus launch, resulting in a lower launch cost for each as compared to other launch options.

2.4 Primary Launch Support Equipment

The Taurus electrical LSE consists of two main operational units: the LSV and the LEV. These vans house all the electrical equipment required to safely and successfully monitor, control, and launch the Taurus vehicle. The LSV serves as the control center during the launch countdown and can accommodate ten personnel: three customer, two range safety, and five Orbital representatives. As shown in Figure 2-8, The LSV is located approximately 5 miles (8.0 km) away from the launch site. The unmanned LEV, located approximately 200 ft (61 m) from the launch pad, acts as a junction equipment room patching the fiber optic lines from the LSV into a copper connection with the vehicle. Both vans are similar in construction, consisting of corrugated steel shelters equipped with air conditioning, dual personnel exits, equipment loading doors, and interior lighting. Both shelters are prewired

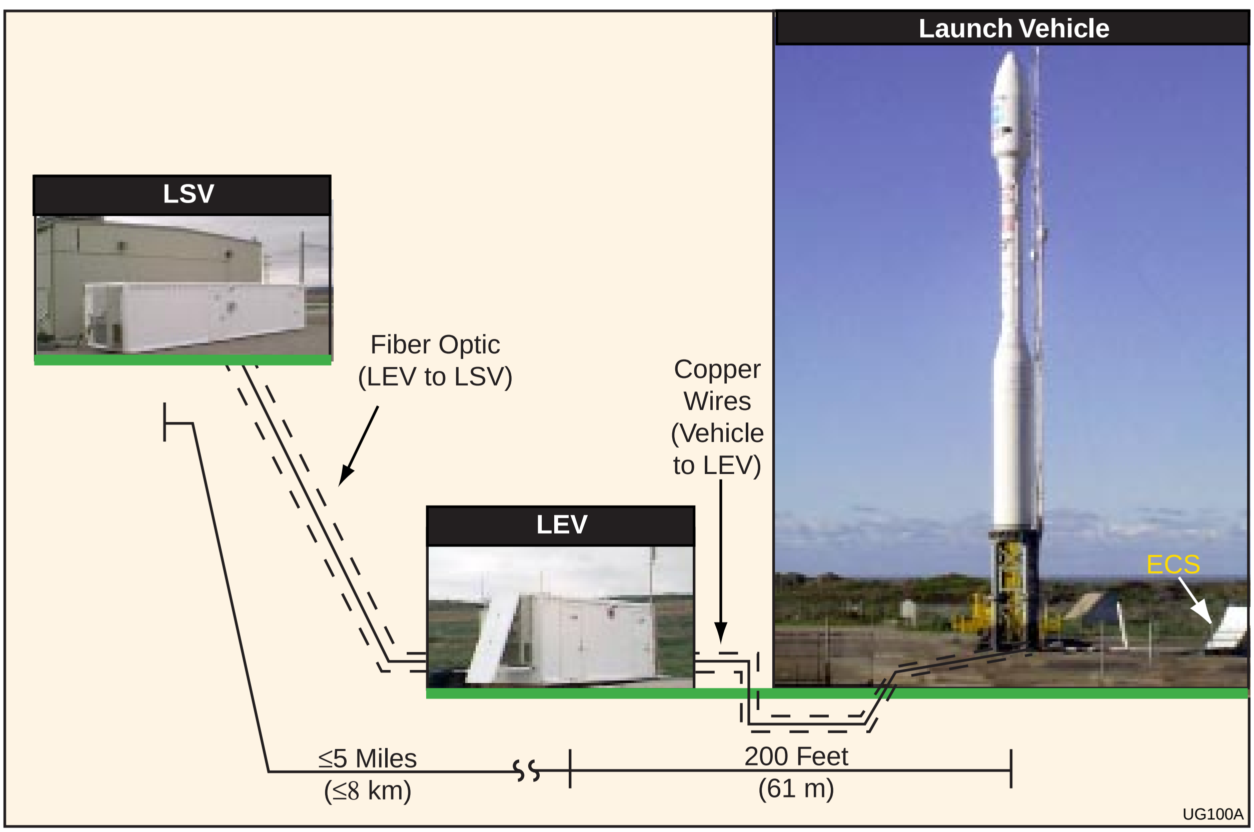


Figure 2-8. *Taurus LSE Configuration.*

to support up to 200 A of single phase 208V power.

Mission-unique, customer-supplied payload consoles and equipment can be supported in the LSV and LEV. Interface to the payload through the Taurus T-0 umbilicals and land lines provides the capability for direct monitoring of payload functions.

2.4.1 *Launch Support Van*

The LSV, shown in Figure 2-9, consists of a 10 ft x 40 ft (3.1 m x 12.2 m) shelter housing all the hardware required to monitor and control the vehicle and payload. This hardware includes four consoles (one control and three monitor consoles), a payload support area, and a single three-bay equipment rack for interfacing to the LEV and the range. The four consoles have dedicated functions and are differentiated as follows: Flight Safety Station (FSS), Vehicle Control Station (VCS), Test Conductor Station (TCS), and the Launch Director Station (LDS). The LSV also contains a telephone service, a centrally located countdown clock and communications and telemetry interfaces for connection with the RCC. All stations have uninterruptable power supplies.

Flight Safety Station — The FSS is divided into two sections, the Flight Safety Project Officer (FSPO) section and the Operations Support Manager (OSM) section. The FSPO section displays vehicle telemetry for monitoring vehicle safety, while the OSM section is dedicated to monitoring pad operations and includes dual Closed Circuit Television (CCTV) monitors. Both consoles maintain intercom and telemetry communication with the Range Safety Officer in the RCC.

Vehicle Control Station — The VCS is the primary control station for the vehicle and the LEV. Orbital engineers at this station monitor vehicle health and status and perform critical vehicle operations during countdown activities. The VCS also houses

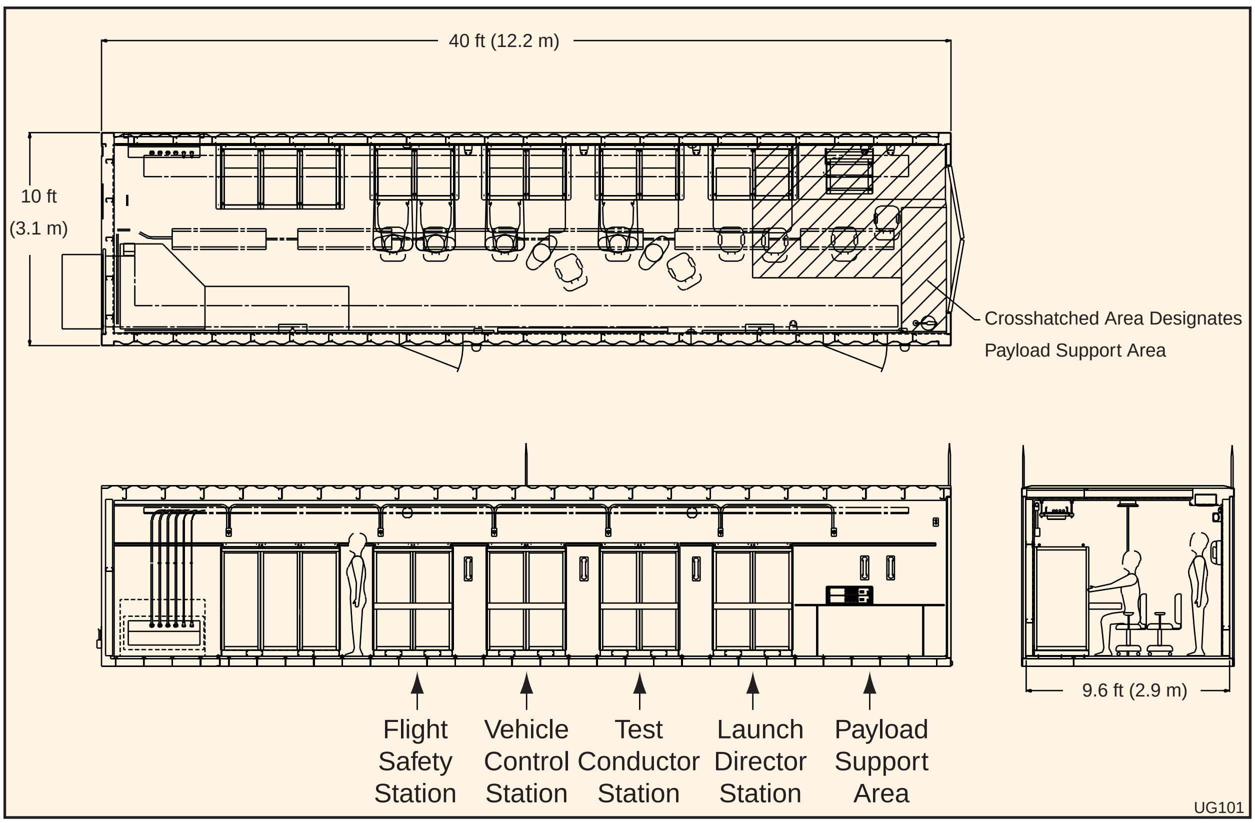


Figure 2-9. *LSV Layout.*

the manual switch panel which gives the operator manual vehicle safing and hold-fire capability. Two CCTV monitors are located above the console for viewing pad activities.

Test Conductor Station — The TCS is a monitor-only station from which the Test Conductor controls the final count activities.

Launch Director Station — The LDS is another monitor-only station where the customer and Orbital launch directors are located during launch. Each position is equipped with the capability of monitoring vehicle telemetry and communicating with the RCC. The customer position also has the capability of monitoring payload specific telemetry.

Payload Support Area (PSA) — The PSA is an area for payload use capable of supporting two payload personnel. Further detail is provided in Section 5.4.11.

2.4.2 *Launch Equipment Van*

The LEV, shown in Figure 2-10, is an 8 ft X 20 ft (2.4 m x 6.1 m) shelter that houses the interface between the LSV and the vehicle. This unmanned facility is located approximately 200 ft (61 m) from the launch pad and serves as a junction equipment room patching fiber optic lines from the LSV into a copper connection with the vehicle. The three-bay equipment rack within the LEV houses equipment required for ground command and checkout of the vehicle, including power supplies for battery charging, analog to digital converters for monitoring the vehicle analog status, and switching logic for commanding vehicle states. Equipment is provided in the LEV to allow complete communications with the LSV and launch site.

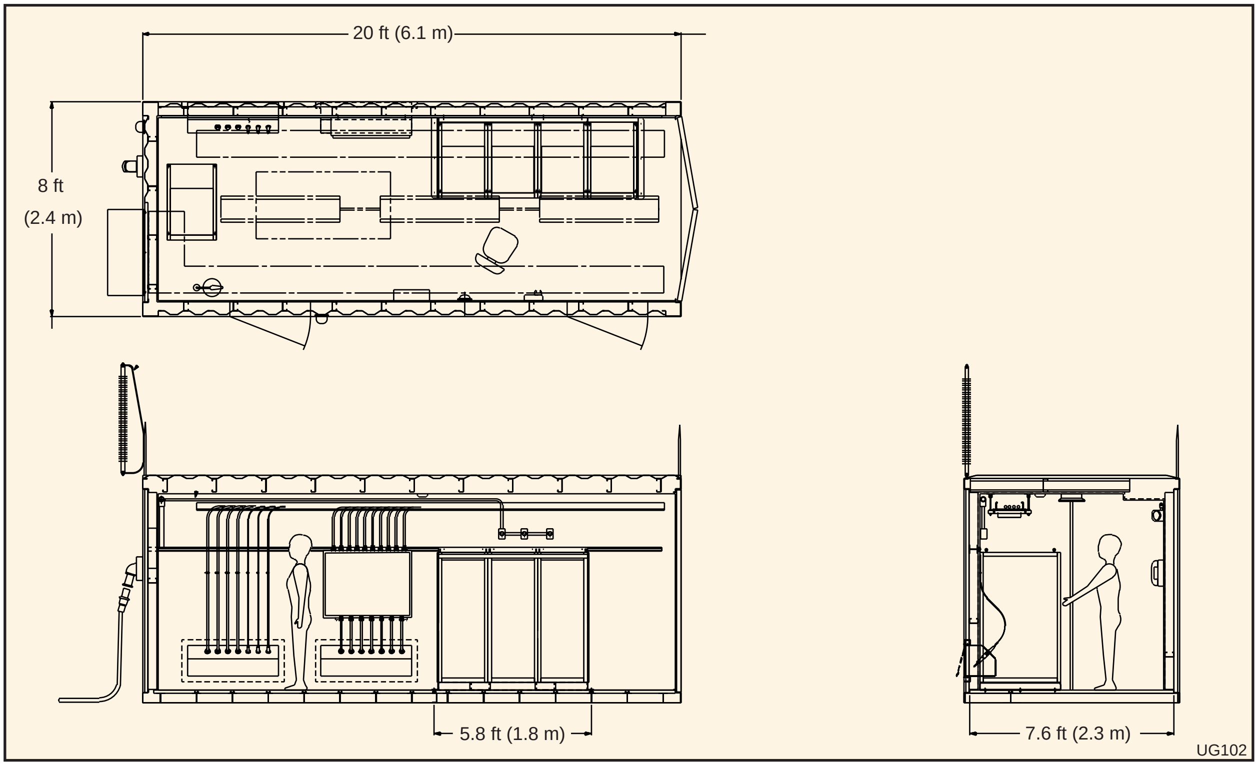


Figure 2-10. *LEV Layout.*

Section 3
General Performance

3.1 Vehicle Performance

This section describes the orbital performance capabilities of the Taurus vehicle. Taurus is well suited for Low Earth Orbit (LEO) missions to a wide variety of altitudes. Taurus can attain a range of posigrade and retrograde inclinations through the choice of launch sites made available by the transportable nature of the Taurus launch system. High energy and Geosynchronous Transfer Orbit (GTO) missions can also be achieved with the standard configuration. Performance to these orbits can be increased substantially using the performance enhancements discussed in Section 8.6.

3.2 Mission Description

Orbital provides each Taurus launch service customer a mission design optimized to meet critical requirements while satisfying payload, launch vehicle, and range safety constraints. Orbital uses the Program to Optimize Simulated Trajectories (POST) to provide projected Taurus performance values to candidate orbits. POST can be set to optimize for mass to a specified orbit, for the resultant orbit given a specified payload mass, or for a wide variety of other conditions. Specific orbit parameters, tolerances, and performance requirements for the mission are defined in the payload Interface Control Document (ICD).

There are several different types of trajectories that are used with the Taurus launch vehicle. Since Taurus uses solid rocket motors, the increments of velocity change are relatively fixed, driving the trajectory design based on the type of orbit that is required.

For LEO missions, Stages 0, 1 and 2 are burned in rapid succession to place the payload and upper stage in a suborbital trajectory with an apogee altitude equal to the perigee of the final orbit. The combined upper stage and payload coast up to this altitude, where the Stage 3 burn adds the velocity required to place the payload in its desired orbit.

There are certain spacecraft orbits where the position of apogee and perigee are constrained. Examples include GTO where perigee must be at the equator, Molniya orbits where the apogee is preferred over a certain Earth latitude, and escape trajectories where the escape velocity vector must satisfy direction constraints in the heliocentric reference frame. The conventional approach to these trajectories is to first insert the payload and upper stage into a parking orbit. When the vehicle reaches the desired perigee location, the upper stage is fired, putting the payload into its final orbit. Another technique can be used to further improve performance to these orbits. Orbital refers to this technique as “non-apsidal injection” since the upper stage motor fires at a point that is neither apogee nor perigee. The non-apsidal injection technique places the payload and upper stage into a suborbital "parking orbit" (perigee altitude <0 nm), which allows a heavier mass to be lofted to a lower energy state. The upper stage is ignited after the apogee of the suborbital trajectory to place perigee at the desired location. This technique can result in performance gains of greater than 25% over a conventional parking orbit technique to certain orbits, but it imposes more constraints on available apsidal alignment. Orbital will work with the customer to design the trajectory that best fits the needs of the payload.

3.3 Taurus Ascent Profile

Orbital shapes the trajectory flown by the Taurus vehicle to realize maximum performance without violating any vehicle design constraints (such as structural limits) or payload requirements (such as free molecular heating). This shaping is accomplished by controlling the product of dynamic pressure (Q) and angle of attack (α). The Taurus mission profile will vary significantly depending on the requirements of the payload. The following sections present typical mission profiles for a direct ascent mission of a standard Taurus 2210 vehicle to a 300 nm (556 km) circular sun-synchronous orbit, and a GTO mission using a Taurus 2110 vehicle and a 150 nm x 165 nm (278 km x 306 km) parking orbit. This information is for reference only and will vary on a mission-to-mission basis.

3.3.1 Direct Ascent

A Taurus direct ascent trajectory from a South VAFB launch site to a 300 nm (556 km) circular orbit inclined at 97.6° (sun-synchronous) is depicted in Figure 3-1. Following Stage 0 motor ignition, the vehicle performs a short vertical rise to clear the umbilical tower and then performs a pitch-over. This sequence, along with the rest of the Stage 0 flight profile, is performed by open-loop guidance governed by inertial steering tables. The open-loop steering tables are the result of a Q-α profile design driven by mission requirements and vehicle structural limits. At 75 seconds the vehicle assumes a zero angle of attack attitude for the Stage 0/1 separation event, which nominally occurs at 81 seconds. The staging event is initialized as the vehicle acceleration drops to 0.2 g's (corresponding to approximately 10,000 lbf [45 kN] of Stage 0 thrust). At this point the Stage 1 motor is ignited and, 95 msec later, the two stages are pyrotechnically separated. This sequence of events maintains acceptable control authority throughout the staging event.

Stage 1 guidance, like Stage 0, utilizes an open loop command table where the Taurus vehicle flies a pre-programmed pitch and yaw profile. The Stage 1 motor nominally burns for 76 seconds, during which time yaw steering, if required for range safety or orbital inclination reasons, is utilized. The coast time between Stage 1 burnout and Stage 2 ignition is typically 12 seconds, although it can be longer for low altitude missions. These missions may require more time to gain altitude and reduce free molecular heating prior to payload fairing separation. Nominally, the fairing is jettisoned three to five seconds into Stage 2 burn, after the free molecular heating has fallen below 360 BTU/ft^2/hr (1134 W/m^2).

During its 78 second burn, Stage 2 uses an explicit guidance routine that calculates the desired thrust attitude based on the measured vehicle energy state compared against the desired targets. This guidance scheme improves performance and reduces injection errors. Nominally, the Stage 2 burnout condition leaves the vehicle on a suborbital path peaking slightly

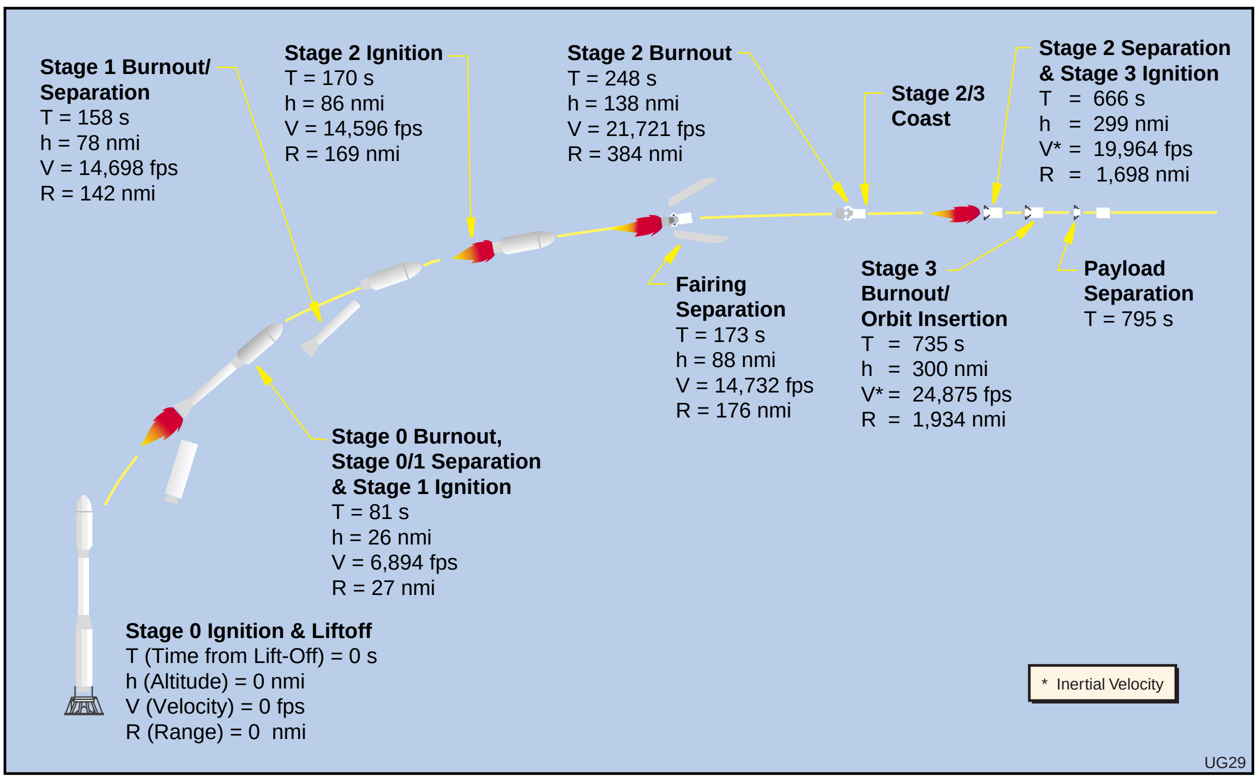


Figure 3-1. *Typical Taurus Direct Ascent Mission Profile.*

above the desired mission altitude (or perigee altitude for an elliptical orbit).

During the coast to the final burn point, the explicit guidance routine continues to operate, calculating the desired Stage 3 ignition point based on measured orbital parameters. The Stage 3 burn, which nominally lasts 69 seconds, provides injection into the final orbit.

3.3.2 Parking Orbit Ascent

The sequence of events for a parking orbit mission is shown in Figure 3-2. Stages 0 and 1 fly a mission profile similar to that of a direct ascent mission. Following Stage 1 burnout, a long coast allows the payload and remaining stages to reach the desired parking orbit injection point. The Stage 2 motor then ignites, placing the payload and Stage 3 in the parking orbit. The spent Stage 2 motor is jettisoned, leaving the Taurus avionics section and Stage 3 motor attached to the payload. Another long coast occurs as the guidance system waits for the appropriate true anomaly value to ignite Stage 3 and achieve the correct payload apsidal targets. The total mission time is constrained by vehicle power and thermal limitations, so the feasibility of this approach must be assessed on a mission-specific basis.

3.4 LEO Performance Capability

Taurus performance curves for circular orbits of various altitudes and inclinations are detailed in Figure 3-3 through Figure 3-8 for launches from CCAS and VAFB. These performance curves provide the total mass available to the payload—the mass of the Orbital-provided separation system has been accounted for in the Taurus mass properties. Note that the VAFB performance curves are provided for two launch sites: the existing Taurus Space Launch Complex 576E (SLC 576E) on North Base and a proposed South Base location. South Base launches do not typically require yaw steering to meet range safety over-flight constraints; hence, a performance benefit is realized. Figure 3-9 shows the available launch azimuths from VAFB and CCAS. Figure 3-10 illustrates the stage

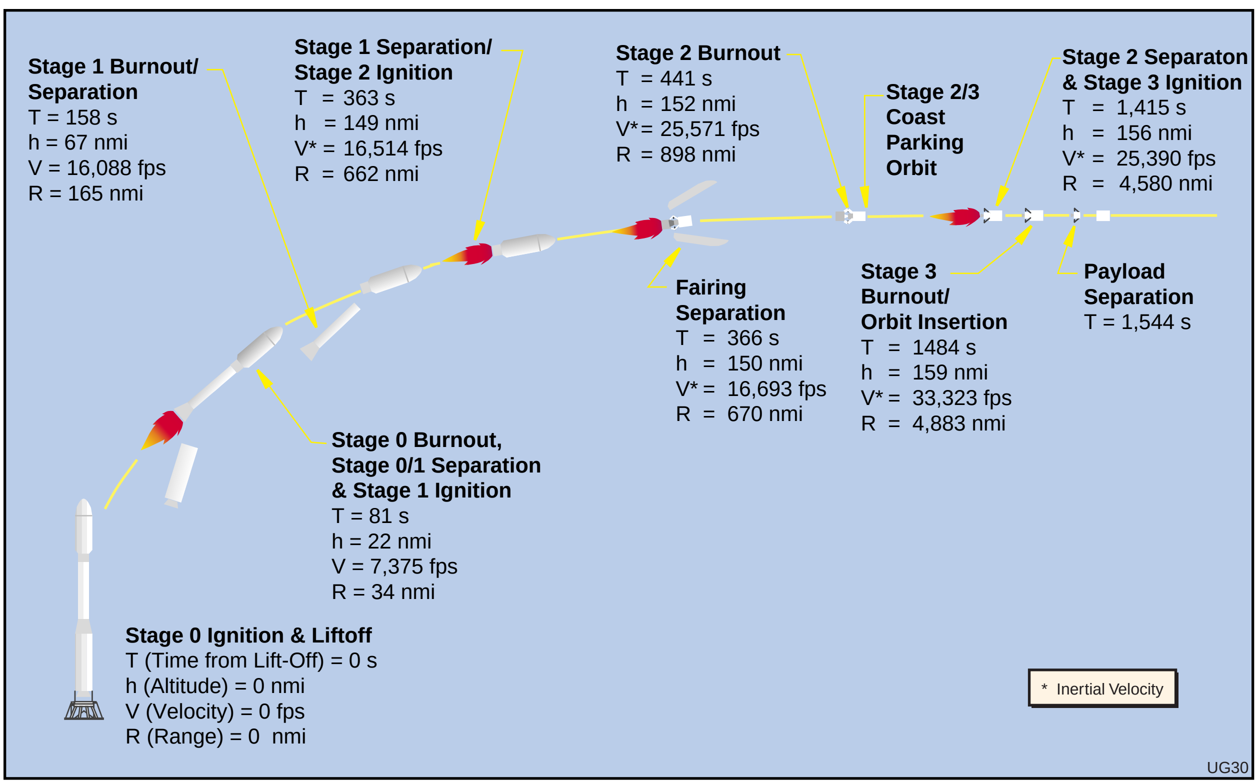


Figure 3-2. *Typical Taurus Parking Orbit Mission Profile.*

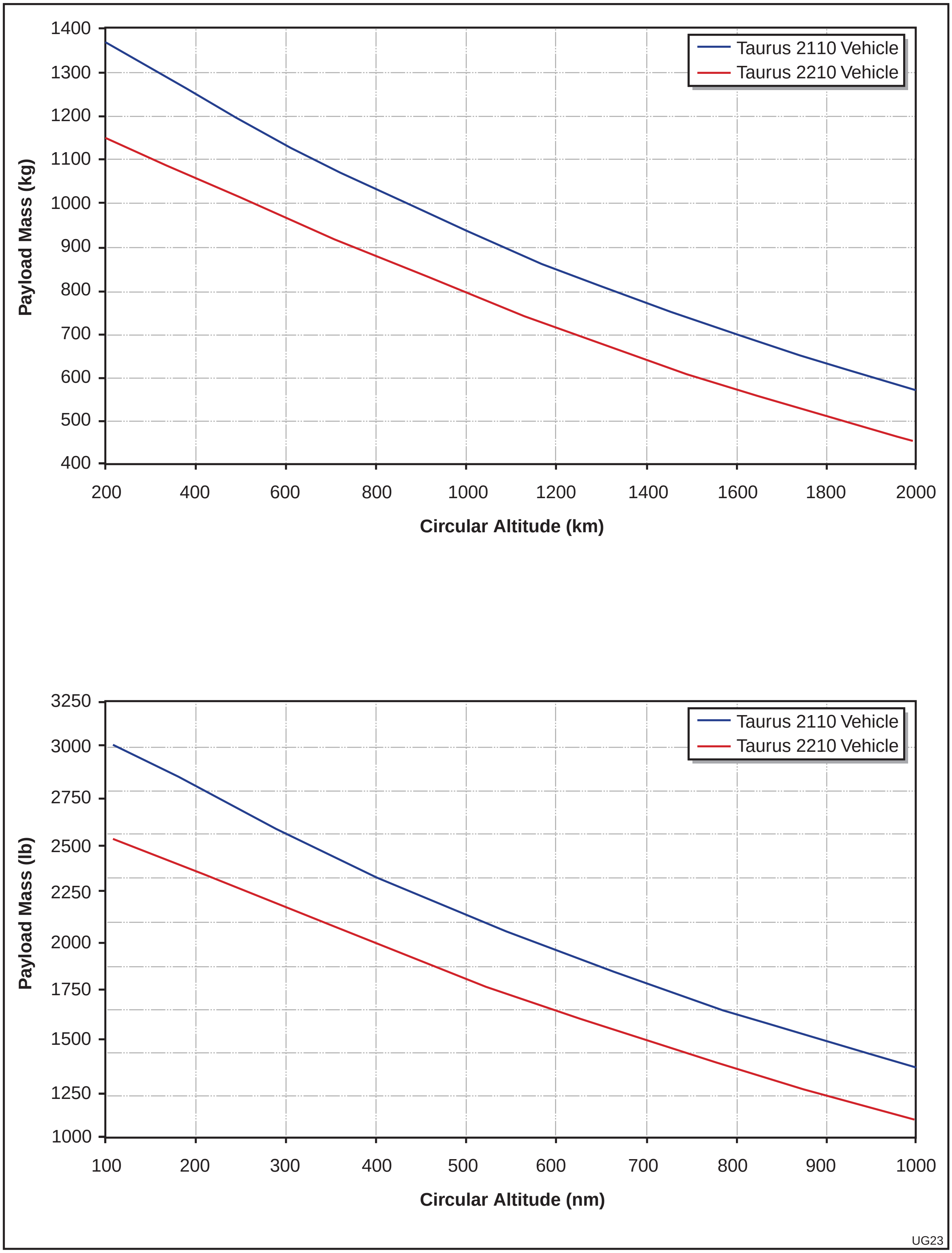


Figure 3-3. *Taurus Performance to 28.5° Orbits - CCAS Launch.*

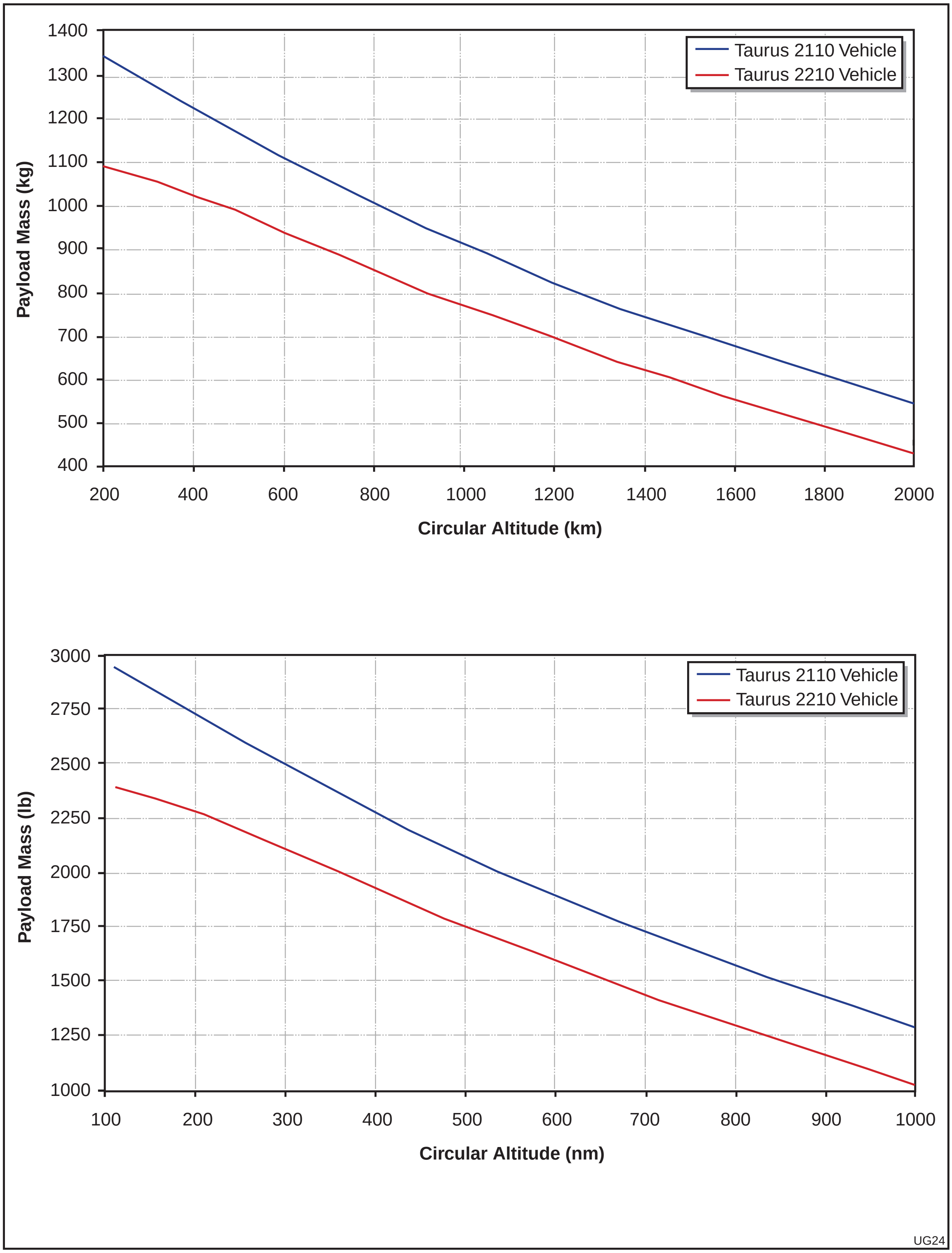


Figure 3-4. *Taurus Performance to 38° Orbits - CCAS Launch.*

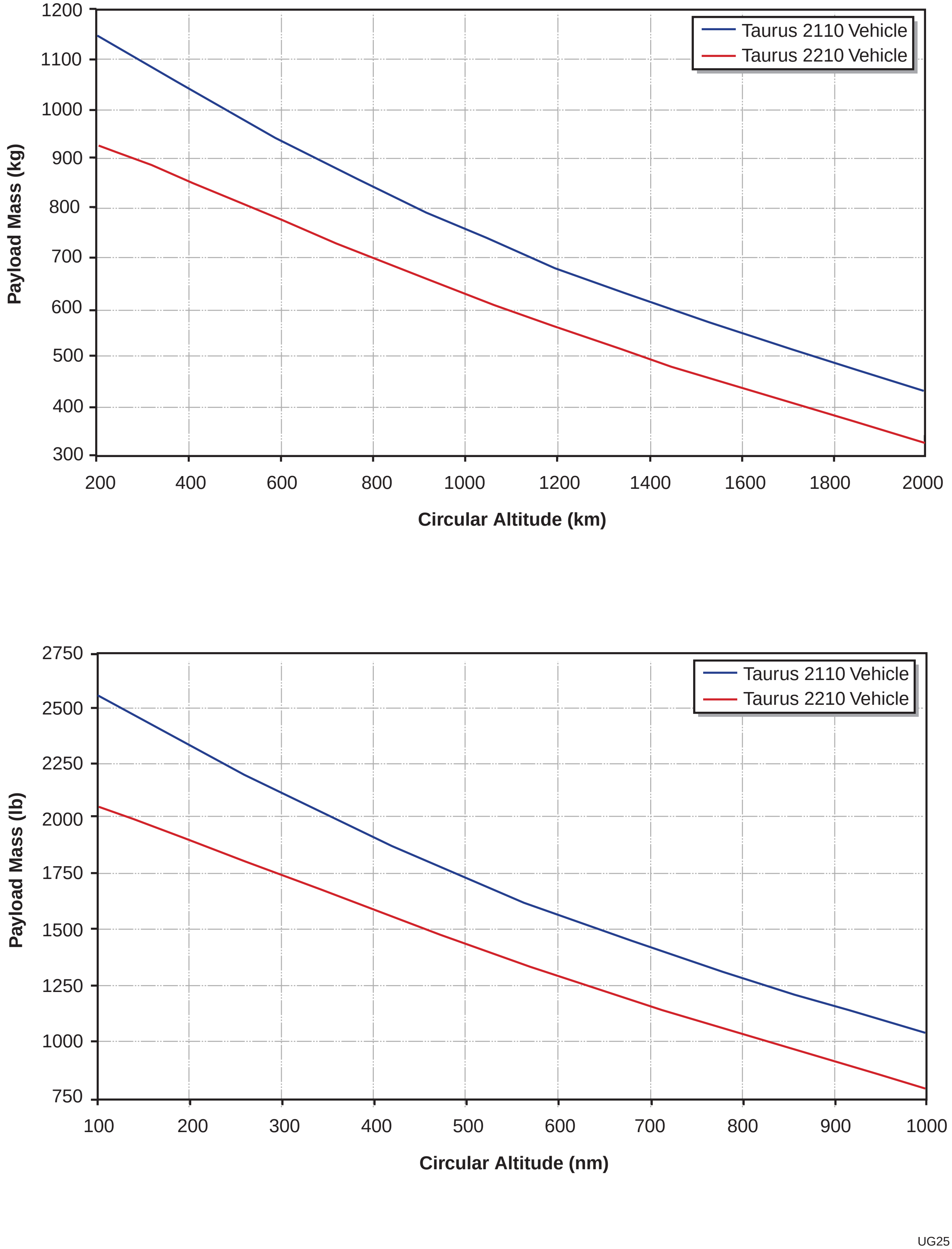


Figure 3-5. *Taurus Performance to 60° Orbits - South VAFB Launch.*

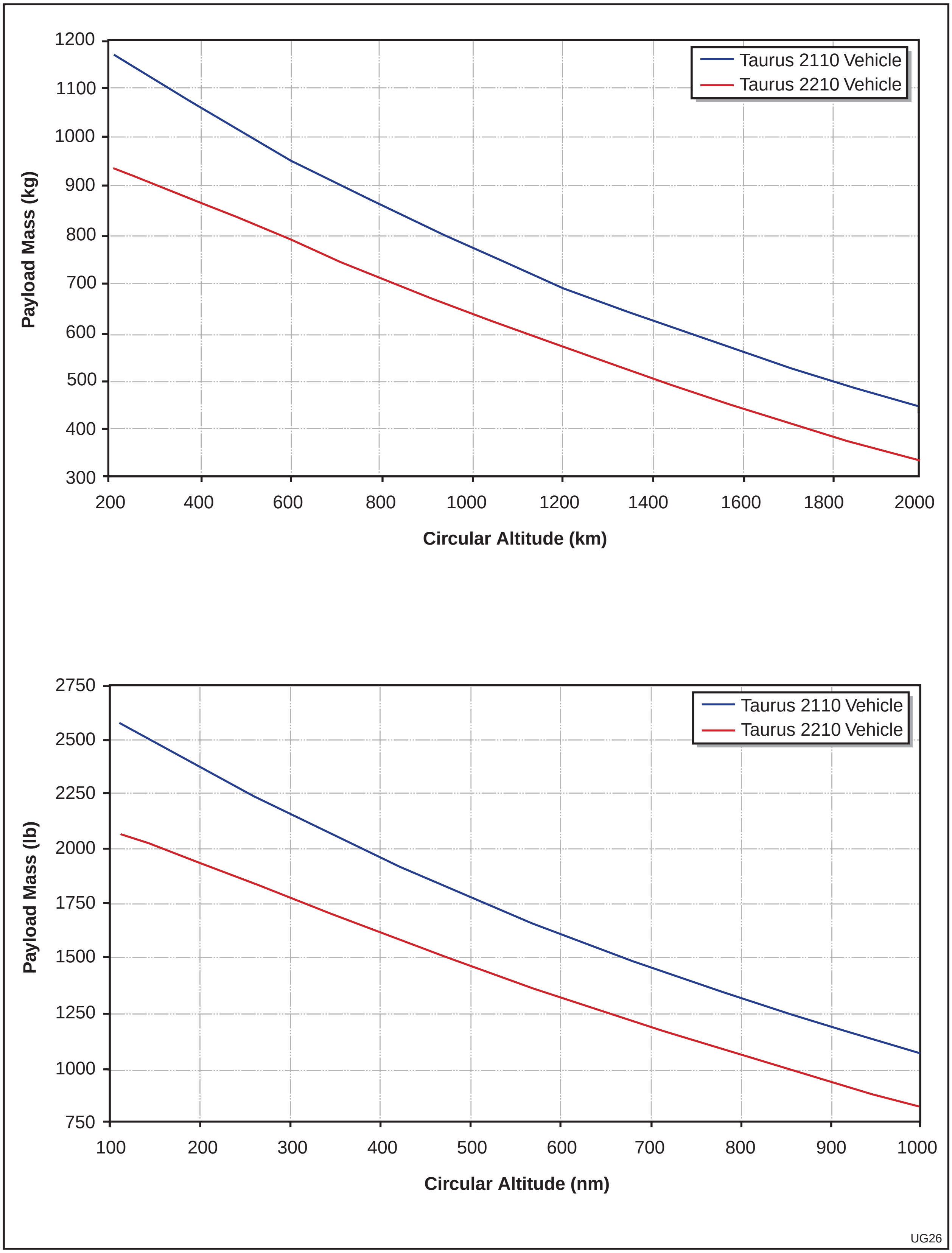


Figure 3-6. *Taurus Performance to 70° Orbits - South VAFB Launch.*

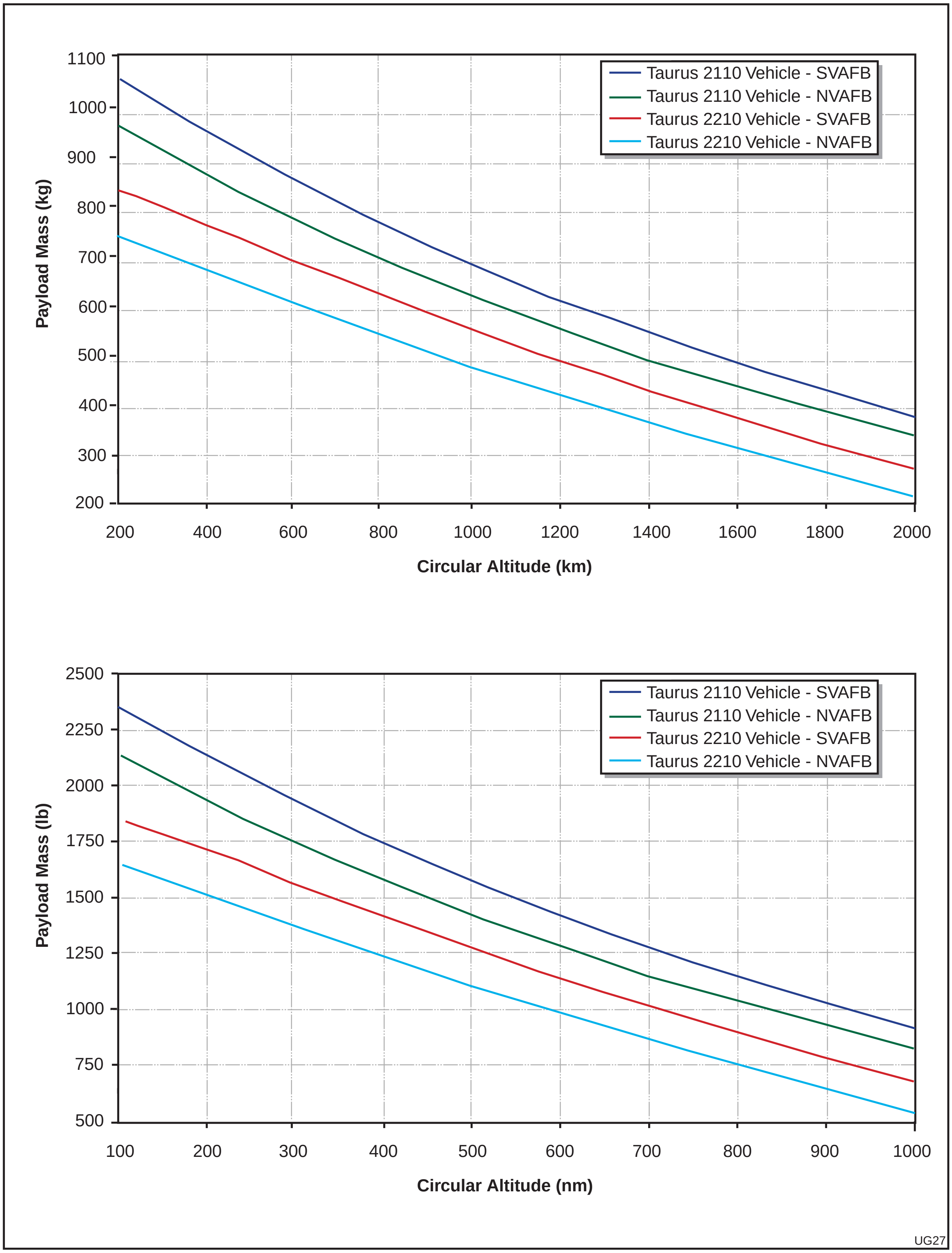


Figure 3-7. *Taurus Performance to 90° Orbits - VAFB Launch.*

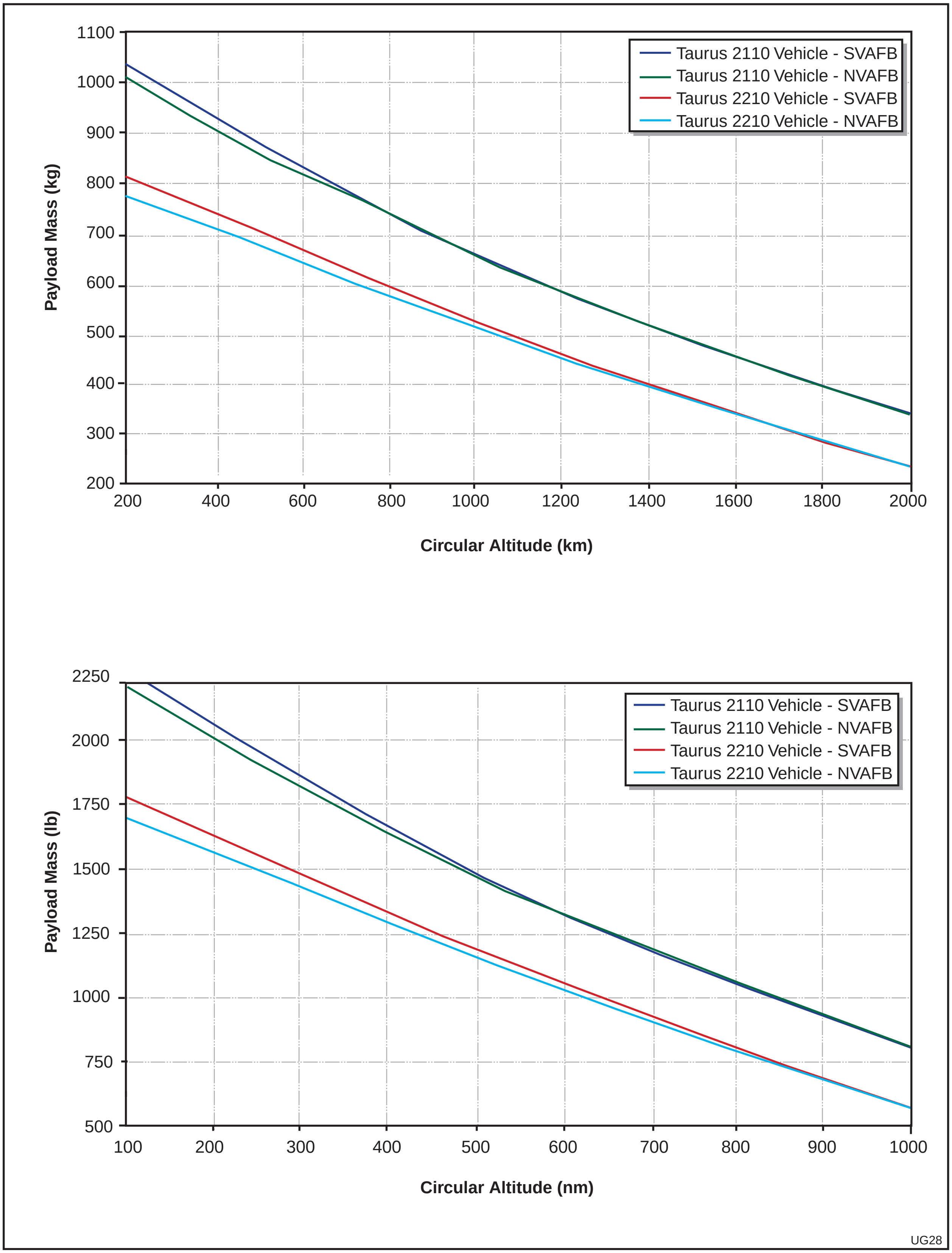


Figure 3-8. *Taurus Performance to Sun Synchronous Orbits - VAFB Launch.*

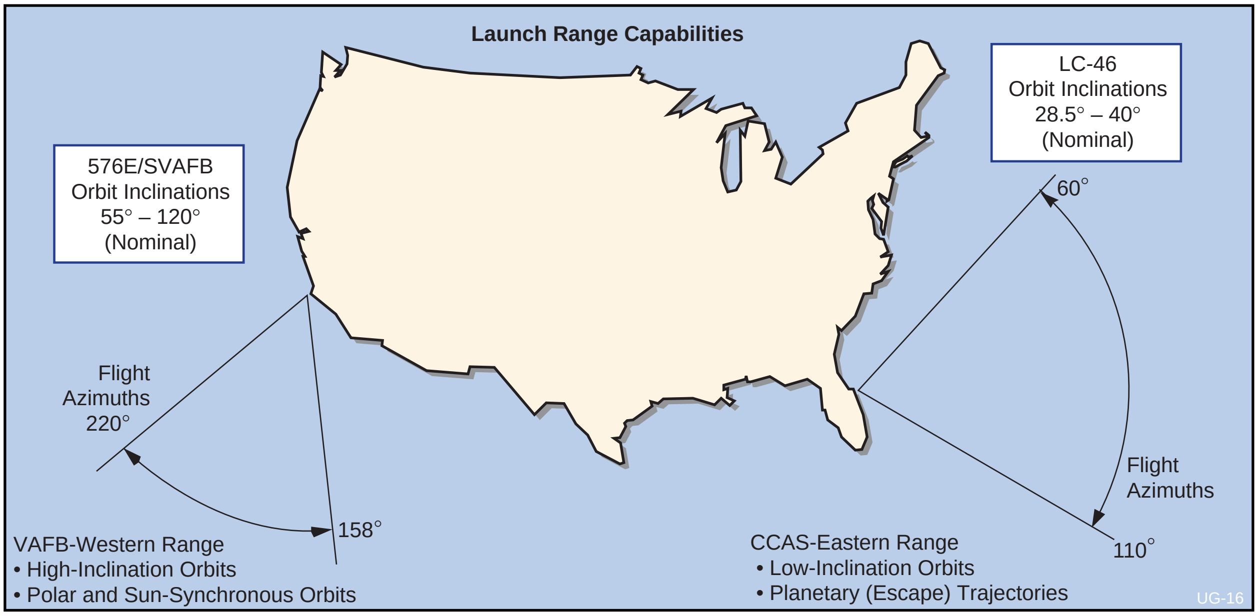


Figure 3-9. *Launch Range and Site Selection Are Tailored to Mission Performance and Safety Requirements.*

vacuum impact points for the two trajectories profiled in Section 3.3.

For missions that require high inclination orbits (greater than 55°), launches are conducted from VAFB. Orbital established SLC 576E on North VAFB for the first several Taurus flights and will have this facility available for future West Coast Taurus launches. The minimum launch azimuth acceptable from SLC 576E is 205°, requiring yaw steering (dogleg trajectories) for inclinations below approximately 105°. For intermediate inclinations (down to 55°), Orbital can utilize a launch site on South VAFB to avoid the performance penalty incurred by yaw steering. The effect of yaw

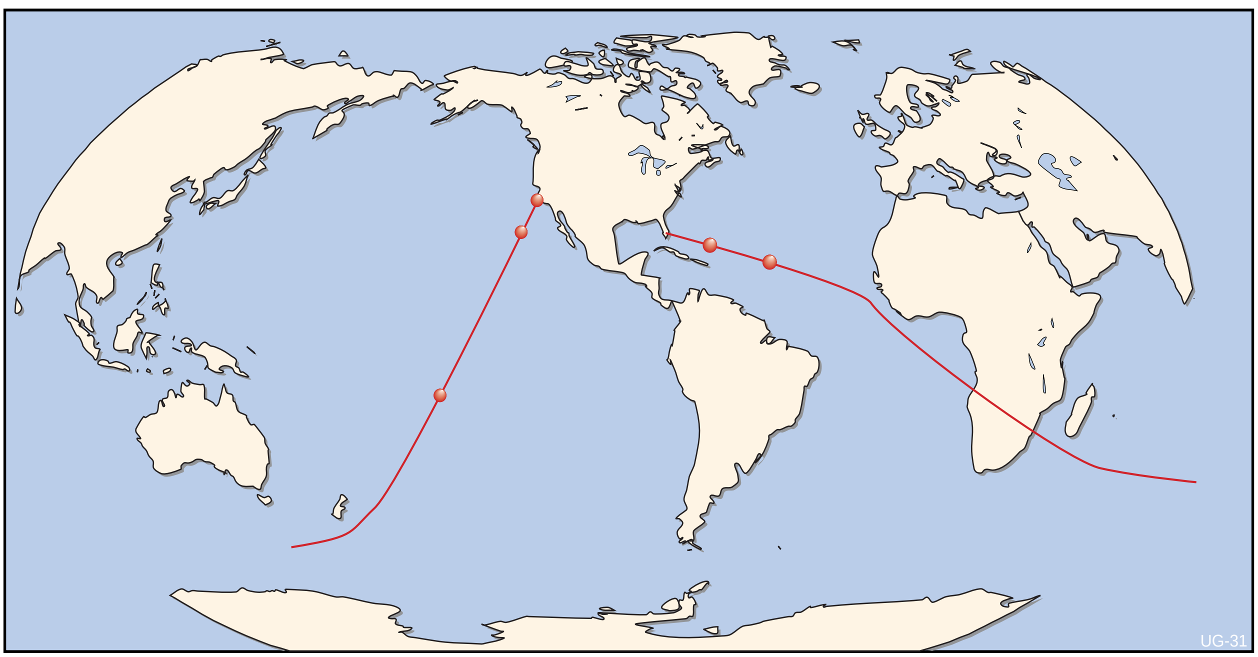


Figure 3-10. *Typical Stage Vacuum Impact Points for Taurus Launches from VAFB and CCAS.*

steering for range safety reasons is included where appropriate.

Orbital will use CCAS as the launch site for missions to orbital inclinations between 28.5° and 40°.

The NASA WFF launch site can be used for missions requiring intermediate orbital inclinations (38° - 55°). Southeast launches from WFF offer fewer overflight concerns than CCAS and inclinations up to 55° are feasible with doglegs and altitude constraints due to stage impact considerations.

3.5 Injection Accuracy

Orbital injection errors for Taurus are dominated by variations in the Stage 3 total impulse, navigation errors, and other stage performance parameters. Taurus 3-σ injection accuracies are summarized in Figure 3-11.

Error Type	Tolerance
Injection Apse	±5 nm (±10 km)
Non-Injection Apse	±27 nm (±50 km)
Mean Altitude	±16 nm (±30 km)
Inclination	±0.15°

UG-18

Figure 3-11. *Injection Accuracies to Low Earth Orbits (3-σ).*

3.6 Payload Deployment Attitude Options

Following orbit insertion, the Taurus Stage 3 avionics subsystem can execute a series of pre-programmed RCS maneuvers to provide the desired initial payload attitude prior to separation. This capability may also be used to incrementally reorient Stage 3 for the deployment of multiple spacecraft with independent attitude requirements. Either an inertially-fixed or spin-stabilized attitude may be specified by the customer.

The maximum spin rate for a specific mission depends upon the spin axis moment of inertia of the payload and the amount of RCS propellant needed for other attitude maneuvers, but cannot exceed 15 rpm. Figure 3-12 provides the typical payload pointing and spin rate accuracies, although these will vary with payload mass properties.

Error Type		Angle	Rate
3-Axis	Yaw	±0.7°	±0.4°/sec
	Pitch	±0.7°	±0.4°/sec
	Roll	±0.7°	±0.4°/sec
Spinning	Spin Axis	±1.0°	≤15 rpm
	Spin Rate	N/A	±1.5°/sec

UG-19

Figure 3-12. *Typical Pre-Separation Payload Pointing and Spin Rate Accuracies.*

3.7 Separation Tip-Off Rates and Velocities

Orbital performs preliminary and final mission-specific tip-off analyses for each payload, using the commercial Dynamic Analysis and Design System (DADS) software. These simulations verify that spacecraft tip-off and separation velocity requirements are met even under 3-σ conditions. Payload tip-off refers to the angular velocity imparted to the payload upon separation due to an uneven distribution of torques and forces. Tip-off rates are highly dependent on payload mass properties and geometry, but are typically on the order of 1°/sec.

Separation velocities are driven by the need to prevent recontact between the payload and the Taurus upper stage after separation. The actual value will vary with mass properties, but will typically be approximately 2 ft/sec (0.6 m/sec).

Section 4
Payload Environments

4.1 Payload Environments

This section provides details of the predicted environmental conditions that the payload will experience during Taurus ground operations, powered flight, and orbital operations.

Taurus ground operations include payload encapsulation within the fairing, subsequent transportation to the launch site and vehicle integration activities. Powered flight begins at Stage 0 ignition and ends at Stage 3 burnout. Taurus on-orbit operations begin after Stage 3 burnout and end following payload separation. In order to better define simultaneous conditions, the powered flight portion of the mission is further subdivided into smaller time segments bounded by critical flight events such as motor ignition, stage separation, and transonic crossover.

The environmental design and test criteria presented in the following section have been derived using measured data obtained from previous Taurus missions, motor static fire tests, and other system development tests. These criteria are applicable to Taurus configurations using either the 63" or 92" diameter fairings. The predicted levels presented are intended to be representative of mission specific levels. Mission specific analyses are performed as a standard service and are documented in the mission ICD.

Dynamic loading events that occur throughout the flight include steady state acceleration, transient low frequency acceleration, acoustic loading, sinusoidal and random vibration, and pyrotechnic shock events. Figure 4-1 identifies the time phasing of these dynamic loading events and their significance. Pyroshock events are not indicated as they do not occur simultaneous with any other significant dynamic loading events.

4.2 Steady State and Transient Accelerations

Design limit load factors due to the combined effects of steady state, low frequency transient and quasi-sinusoidal accelerations are defined in Figure 4-2. These values include uncertainty margins. Note that loads produced by pressure oscillations generated during solid rocket motor combustion, known as resonant burn, produce a response that is both transient and quasi-sinusoidal in nature.

Lateral lift-off transients are generated by wind loading at launch stand separation augmented by vortex shedding, and asymmetric ignition over pressure. Axial lift-off transients result from pressure oscillations at motor ignition. During the subsonic portion of flight, the maximum axial accelerations generally occur as a result of resonant burn excitation. Steady state lateral accelerations are relatively benign at this point in the flight. Near transonic crossover, gust and buffet induced lateral loads are assumed to act simultaneously with resonant burn induced axial loads. Later in the ascent, as the vehicle approaches maximum dynamic pressure (Max Q), buffeting becomes less severe although gust loading continues to contribute to lateral loads. Steady state axial accelerations continue to rise during Stage 0 ascent finally peaking at the end of burn. Toward the end of Stage 0 burn, transient accelerations are negligible. The maximum steady state accelerations occur at the end of Stage 1 burn. At this point in the ascent, the only other significant dynamic event occurring is resonant burn excitation. During upper stage motor ignition, burnout, and staging events, transient loads are relatively benign.

As dynamic response is largely governed by payload characteristics, mission specific coupled

Task Name	Liftoff	Subsonic	Transonic	Max. Q	Aeroacoustic Tail-Off	S1 Burn	S2 Burn	S3 Burn
Typical Flight Time (Sec)	0-3	4-14	15-25	25-45	45-75	80-155	157-232	650-725
Steady State Loads	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Transient Loads	Yes	Yes	Yes	Yes	No	Yes	No	No
Sinusoidal Vibration	Yes	Yes	Yes	No	No	Yes	No	No
Acoustic Loads	Yes	No	6 dB Down	Yes	6 dB Down	No	No	No
Random Vibration	Yes	No	6 dB Down	Yes	6 dB Down	Negligible	Negligible	Negligible

Figure 4-1. *Phasing of Dynamic Loading Events.* UG-032

Event	Axial (g's) Steady State ±Oscillating (Resultant)	Lateral (g's)
Lift-Off	-2.5±3.5 (-6.0/+1.0)	±2.0
Subsonic Resonant Burn	-3.0±4.0 (-7.0/+1.0)	±2.0
Transonic	-3.5±4.5 (-8.0/+1.0)	±2.5
Supersonic Gust	-4.0±0.5 (-4.5/-3.5)	±2.5
S1 Resonant Burn	-4.0±2.0 (-6.0/-2.0)	±1.5
Motor Burn Out	-7.2	±0.5

UG34

Figure 4-2. *Payload Design C.G. Limit Load Factors.*

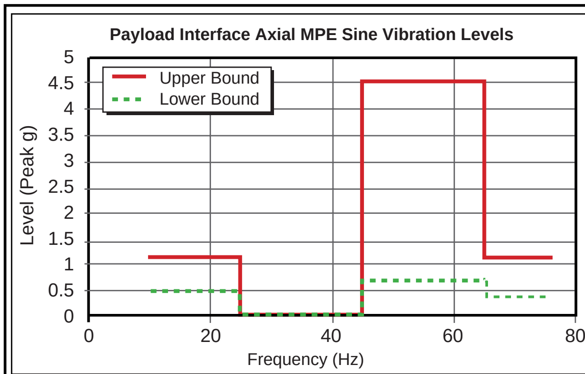
loads analyses will be performed in order to provide more precise load predictions. Results will be documented in the mission specific ICD.

4.3 Sine Vibration

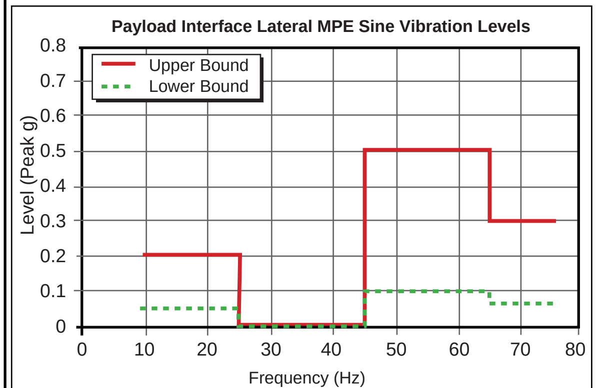
The Design Limit Load Factors presented in Figure 4-2 are suitable for static load purposes; however, they do not address possible fatigue associated with lift-off and resonant-burn induced quasi-sinusoidal response in the payload. The customer must determine whether sine vibration testing is required or not. Transient loads analysis, and acoustic, random vibration or other tests may provide suitable validation of the payload design integrity and/or workmanship such that sine testing is not required. In some cases, sufficient margin against the design limit loads may be available to argue that cycling at peak levels does not present a credible failure mode.

There are two means to address this quasi-sinusoidal excitation. The classical approach is to define this excitation in terms of a sine sweep environment. Figure 4-3 defines the maximum flight level payload interface sinusoidal vibration levels associated with the lift-off (10-25 Hz), Stage 0 resonant burn (45-65 Hz) and Stage 1 resonant burn (65-75 Hz) forcing functions. Also indicated on Figure 4-3 is the lower bound on the range of responses predicted for Taurus payloads to date. The advantage of the sine sweep approach is that it ensures that all the spacecraft resonances within the band of excitation are stimulated.

An alternative means of addressing the quasi-sinusoidal content is by means of a transient



Axial Sine Sweep Specification			
Frequency (Hz)	Upper Bound (Peak g)	Lower Bound (Peak g)	Sweep Rate
10-25	1.2	0.5	4 Oct/Min
45-65	4.5	0.7	24 Hz/Min
65-75	1.2	0.4	12 Hz/Min

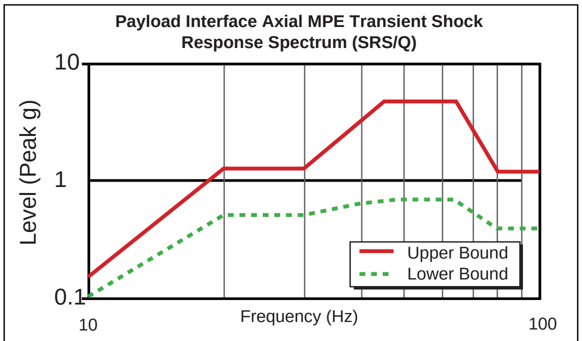


Lateral Sine Sweep Specification			
Frequency (Hz)	Upper Bound (Peak g)	Lower Bound (Peak g)	Sweep Rate
10-25	0.2	0.05	4 Oct/Min
45-65	0.5	0.1	24 Hz/Min
65-75	0.3	0.06	12 Hz/Min

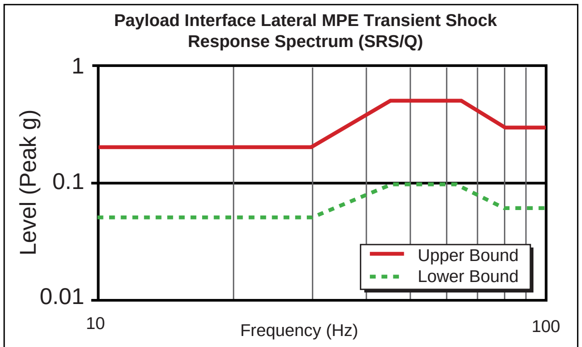
UG-096a

Figure 4-3. *Range of Sine Vibration Levels.*

shaker test. In this approach, the predicted response is defined in terms of a low frequency shock response spectrum (SRS). Figure 4-4 defines the maximum flight level payload interface quasi-sinusoidal vibration levels in terms of an SRS. The event duration is relatively short in this case consistent with the brief period over which the excitation frequencies and the payload response frequencies coincide as determined from coupled loads analysis. Also indicated in Figure 4-4 is the lower bound on the range of responses predicted for Taurus payloads to date. The advantage of this approach is that it provides exposure to a more realistic number of cycles at peak levels.



Frequency (Hz)	Upper Bound (Peak g)	Lower Bound (Peak g)
10	0.15	0.1
20	1.2	0.5
30	1.2	0.5
45	4.5	0.7
65	4.5	0.7
80	1.2	0.4
100	1.2	0.4



Frequency (Hz)	Upper Bound (Peak g)	Lower Bound (Peak g)
10	0.2	0.05
20	0.2	0.05
30	0.2	0.05
45	0.5	0.1
65	0.5	0.1
80	0.3	0.06
100	0.3	0.06

NOTE: Assumes 20 Cycles at Peak Levels UG-095

Figure 4-4. *Range of Shock Response Spectrums.*

4.4 Natural Frequency Requirements

In order to minimize loads and deflections as well as the potential for coupling with the launch vehicle guidance system, the first bending frequency of the payload assuming a fixed base should be maintained above 25 Hz. If the payload's first bending frequency falls below 25 Hz, payload lateral loads may exceed those defined in Figure 4-2.

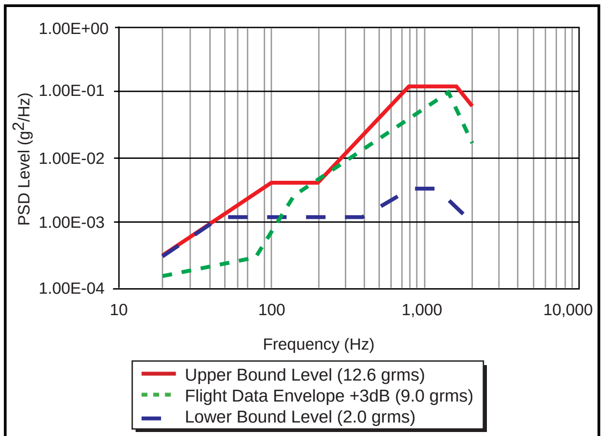
Furthermore, in order to minimize loads within the payload due to lift-off and resonant burn excitation, it is recommended that critical axial frequencies be specified such that the coupled vehicle/payload system frequencies lie between 35 and 45 Hz or exceed 75 Hz. If this guideline cannot be accommodated, payload acceleration loads may exceed those defined in Figure 4-2, Figure 4-3 and Figure 4-4.

Orbital understands that these requirements may be difficult to meet and will work with the customer to recommend practical solutions toward addressing these issues. Should the need arise, Orbital can provide a spacecraft isolation system as a non-standard service (as described in Section 8.5) in order to mitigate the effects of resonant burn excitation. Such a system was successfully flown twice on Taurus in 1998.

4.5 Random Vibration

The worst-case payload random vibration environment is created by acoustic noise generated during lift-off and during ascent near the point of maximum dynamic pressure. The transmission of this energy and its conversion into a vibration response at the payload interface is highly sensitive to spacecraft mass, geometry and structural design, and thus must be determined on a mission-by-mission basis. Figure 4-5 defines the maximum flight level payload interface random vibration levels as well as the lower bound on responses predicted for Taurus payloads to date. Also indicated is an envelope of the flight measured data.

The large spread in predicted response provides an indication of how sensitive the response levels are to payload configuration. The spectra defined in Figure 4-5 are provided for reference only. They are to be used to evaluate components mounted in the vicinity of the payload interface and low to mid frequency structure-borne vibration into the entire payload. In order to predict the payload interface response levels, mission-specific analyses will be conducted by Orbital as a standard service using a customer provided statistical energy model of the payload.



Upper Bound Levels

Frequency	PSD Level (g^2/Hz)
20	3.00E-04
100	4.00E-03
200	4.00E-03
800	1.20E-01
1,600	1.20E-01
2,000	6.00E-02
Grms	12.6

Lower Bound Levels

Frequency	PSD Level (g^2/Hz)
20	3.00E-04
50	1.20E-03
400	1.20E-03
800	3.20E-03
1,200	3.20E-03
2,000	1.00E-03
Grms	2.0

Flight Data Envelope

Frequency	PSD Level (g^2/Hz)
20	1.40E-04
80	3.00E-04
140	2.40E-03
1,400	1.00E-01
2,000	2.00E-02
Grms	9.0

UG37a

Figure 4-5. *Payload Interface Random Vibration Levels.*

4.6 Acoustic Environment

Fairing interior noise levels for the 63" and 92" diameter fairings are defined in Figure 4-6 and Figure 4-7, respectively. Levels are shown with a maximum fill factor included and with no fill factor included. Taurus flight microphone data shows that peak acoustic environments occur at lift-off and near the point of maximum dynamic pressure. As noted in the figures, acoustic levels are dependent on spacecraft geometry (fill factor) and, to a lesser extent, upon acoustic absorption characteristics. As a standard service, mission-specific analyses will be conducted by Orbital using a customer provided statistical energy model of the payload.

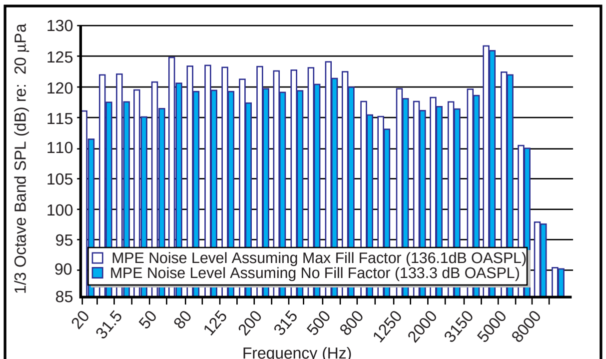
4.7 Pyro Shock

The maximum predicted shock levels at the payload interface are presented in Figure 4-8. These levels are applicable to a payload using Taurus' standard payload separation system.

4.8 Thermal and Humidity

Ground Operations — Upon encapsulation within the fairing and for the remainder of ground operations, the payload environment will be maintained by the Taurus Environmental Control System (ECS). Fairing inlet conditions are selected by the customer, and are bounded as follows:

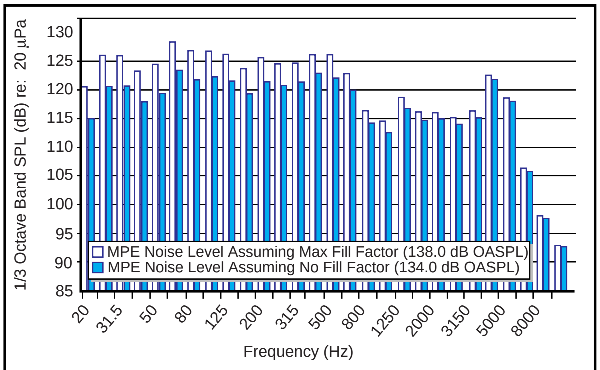
- Dry Bulb Temperature: 55-85°F (13-29°C) controllable to ±3°F (±2°C) of setpoint;
- Dew Point Temperature: 38-62°F (3-17°C);
- Relative Humidity: determined by drybulb and dewpoint temperature selections and



Frequency (Hz)	Max Fill Factor 1/3 Oct Band SPL (dB)	Min Fill Factor 1/3 Oct Band SPL (dB)	Frequency (Hz)	Max Fill Factor 1/3 Oct Band SPL (dB)	Min Fill Factor 1/3 Oct Band SPL (dB)
20	116.1	111.5	500	124.3	121.5
25	122.1	117.5	630	122.6	120.0
31.5	122.1	117.6	800	117.8	115.5
40	119.6	115.1	1,000	115.3	113.3
50	120.9	116.5	1,250	119.9	118.2
63	125.0	120.6	1,600	117.8	116.3
80	123.4	119.1	2,000	118.4	117.1
100	123.7	119.5	2,500	117.7	116.6
125	123.4	119.3	3,150	119.7	118.7
160	121.4	117.5	4,000	126.8	126.0
200	123.3	119.6	5,000	122.6	122.0
250	122.7	119.1	6,300	110.5	110.1
315	122.7	119.4	8,000	98.0	97.8
400	123.3	120.2	10,000	90.5	90.4
Duration	1 Minute	1 Minute	Overall SPL	136.1	133.3

UG38a

Figure 4-6. *63" Diameter Fairing Maximum Flight Level Payload Acoustic Environment.*



Frequency (Hz)	Max Fill Factor 1/3 Oct Band SPL (dB)	Min Fill Factor 1/3 Oct Band SPL (dB)	Frequency (Hz)	Max Fill Factor 1/3 Oct Band SPL (dB)	Min Fill Factor 1/3 Oct Band SPL (dB)
20	120.5	115.1	500	125.2	122.2
25	126.0	120.7	630	122.7	120.1
31.5	125.9	120.6	800	116.6	114.3
40	123.2	118.0	1,000	114.7	112.7
50	124.5	119.4	1,250	118.8	117.0
63	128.5	123.5	1,600	116.3	114.8
80	126.9	122.0	2,000	116.1	114.8
100	127.0	122.3	2,500	115.2	114.1
125	126.2	121.7	3,150	116.4	115.4
160	123.8	119.5	4,000	122.9	122.2
200	125.7	121.6	5,000	118.9	118.3
250	124.7	120.9	6,300	106.5	106.0
315	125.1	121.5	8,000	98.3	97.9
400	126.3	123.0	10,000	93.2	92.9
Duration	1 Minute	1 Minute	Overall SPL	138.0	134.0

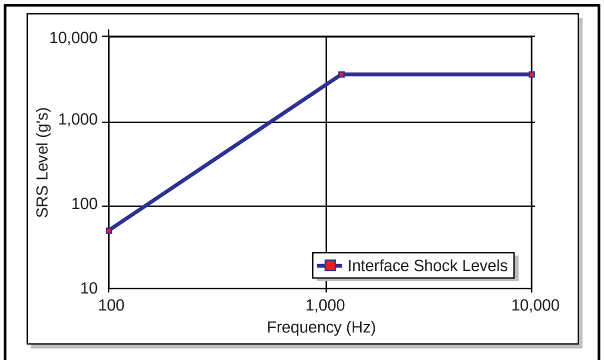
UG39a

Figure 4-7. *92" Diameter Fairing Maximum Flight Level Payload Acoustic Environment.*

generally controlled to within ±3%. Relative humidity is bound by the psychrometric chart and will be controlled such that the dew point within the fairing is never reached.

Powered Flight — The maximum fairing inside wall temperature will be maintained at less than 250°F (121°C), with an emissivity of 0.92. This temperature limit envelopes the maximum temperature of any component inside the payload fairing with a view factor to the payload with the exception of the Stage 3 motor.

The maximum upper stage motor surface temperature exposed to the payload will not exceed 350°F (177°C), assuming no shielding between the aft end of the payload and the forward dome of the motor assembly. Whether this temperature is attained prior to payload separation is dependent upon mission timeline. Fairing deployment will be initiated such that the maximum free molecular heating rate is less than 360 BTU/ft^2/hr (1134 W/m^2).



Frequency	SRS Level (g's)
100	50
1,300	3,500
10,000	3,500

UG39

Figure 4-8. *Maximum Flight Level Pyroshock at the Payload Interface.*

4.9 Contamination Control

The Taurus vehicle, all payload integration procedures, and Orbital's contamination control program have been designed to minimize the payload's exposure to contamination from the time the payload arrives at the payload processing facility through orbit insertion and separation.

The payload processing area will be in a FED-STD-209 Class M6.5 (100,000) clean room environment. The clean room and anteroom(s) utilize HEPA filter units to filter the air. Orbital will provide the necessary clean room garments.

The Taurus assemblies that affect cleanliness within the encapsulated payload volume include the fairing, the acoustic blankets and the payload cone assembly. The inner surface of these assemblies and the blanket exterior surface are all cleaned and verified to Visibly Clean Highly Sensitive (VC-HS) per JSC-SN-C-0005.

Orbital provides an ECS from payload encapsulation through vehicle lift-off. The ECS continuously purges the fairing volume with clean filtered air. Orbital's ECS incorporates a HEPA filter unit to provide FED-STD-209 Class M5.5 (10,000) air. Orbital monitors the supply air for particulates via a probe installed upstream of the fairing inlet duct.

The fairing and payload cone assemblies are graphite reinforced epoxy composite structures with a total mass loss (TML) value of approximately 0.54% by weight and collected volatile condensable material (CVCM) value of approximately 0.02%. Other materials used within the payload encapsulated environment have been reviewed for their outgassing characteristics, and either have a outgassing characteristic of less than 1.0% TML and less than 0.1% CVCM or are identified within Taurus' Outgassing Data Report.

4.10 RF Environment

Ascent Environment — As shown in Figure 4-9, Taurus possesses three RF sources: two S-Band transmitters at 2288.5 MHz and 2269.5 MHz, respectively, and a C-Band Transponder which transmits at 5765 MHz. The payload fairing attenuates the payload environment produced by these sources during flight until the fairing is deployed. After fairing deployment, the maximum field strength produced by these sources at the payload interface (Taurus station 0.0) is 10 V/m in S-Band and 88 V/m in C-Band.

Ground Processing Environment — Specific RF environments experienced by the payload during ground processing at the PPF and the launch site will depend on the specific facilities that are utilized as well as operational details. Typically the field strengths experienced within the PPF during payload processing and within the fairing at the launch site during final vehicle processing will be less than 2 V/m from continuous sources and less than 10 V/m from pulse sources. Detailed environments for these operational phases will be defined during the mission integration process.

RF Source	Tx Power	Location (x-station)	Frequency
C-Band Transponder	400 W (peak)*	-28.7"	5765 MHz
S-Band Transmitter	5 W	-28.6"	2288.5 MHz
S-Band Transmitter	5 W	-28.6"	2269.5 MHz

* The C-Band transponder average power dissipation is 1.5 W

UG34-1

Figure 4-9. *Taurus RF Sources.*

Section 5
Payload Interfaces

5.1 Payload Interfaces

This section describes the available mechanical, electrical and LSE interfaces between the Taurus launch vehicle and the payload. Many of these interfaces are payload-specific and will be detailed in the ICD developed for a given mission.

5.2 Payload Fairings

Taurus offers two payload fairing configurations, enabling the customer to optimize performance and volume requirements. The 92” diameter payload fairing provides the largest payload envelope in its class, while the 63” diameter fairing provides increased performance-to-orbit with a smaller payload envelope. Both provide security and environmental control during ground processing, integration operations, and ascent. The fairings utilize graphite/epoxy composite construction, are RF-opaque, and include internal acoustic blankets to control the payload acoustic environment. The standard blankets are one inch (25.4 mm) thick, but the thickness may be tailored to meet mission-specific requirements as discussed in Section 8.3.3.

The two halves of the fairing are structurally joined along their longitudinal interface using Orbital’s low contamination frangible joint system. An additional circumferential frangible joint at the base of the fairing supports the fairing loads. At separation, a gas pressurization system is activated to pressurize the fairing deployment thrusters. The fairing halves then rotate about external hinges that control the fairing deployment to ensure that payload and launch vehicle clearances are maintained. All elements of the deployment system have been demonstrated through test to comply with stringent contamination requirements.

5.2.1 Payload Dynamic Envelope

Figure 5-1 and Figure 5-2 define the dynamic envelope available to the payload in the 63” and 92” fairings, respectively. The dynamic envelopes account for the deflection and manufacturing tolerances of the payload fairing and the payload cone. The customer must verify that the payload remains within the dynamic envelope when both payload manufacturing tolerances and payload dynamic deflections are taken into account. Coupled Loads Analysis results will be provided so that this verification can be performed.

Protrusions beyond the standard dynamic envelope can be evaluated on a case-by-case basis. Any payload extension aft of the payload interface also requires specific evaluation and agreement from Orbital.

5.2.2 Payload Access Door

One access door is provided for the payload as a standard service. For the 63” fairing, the size of this door is 12 inches x 12 inches (305 mm x 305 mm). For the 92” fairing, the door is 18 inches x 24 inches (457 mm x 610 mm), with the 18 inch (457 mm) dimension in the direction of the launch vehicle thrust axis and the 24 inch (610 mm) dimension in the circumferential direction. The access doors are RF-opaque.

The standard door will be provided in the cylindrical section of the fairing, with the specific location determined through the Mission Integration Working Group process. The location of the door must be defined no later than L-15 months.

Additional doors, doors of non-standard sizes or door locations other than in the fairing cylinder can be provided as non-standard services. These services are discussed in Section 8.3.

5.3 Payload Mechanical Interface

Orbital will provide all hardware and integration services necessary to attach the payload to and separate the payload from the Taurus vehicle. Orbital offers either a 38.81inch (986 mm) or 37.15 inch (944 mm) diameter bolt circle payload separation system as a standard service. Orbital can also provide alternate size and capability separation systems (23.25" and 38.81" high capacity) and a 38.81" non-separating interface as optional services. These optional service are detailed in Section 8.4. Payloads employing customer-furnished separation systems can also be accomodated, pending coordination of the interfaces with the launch vehicle.

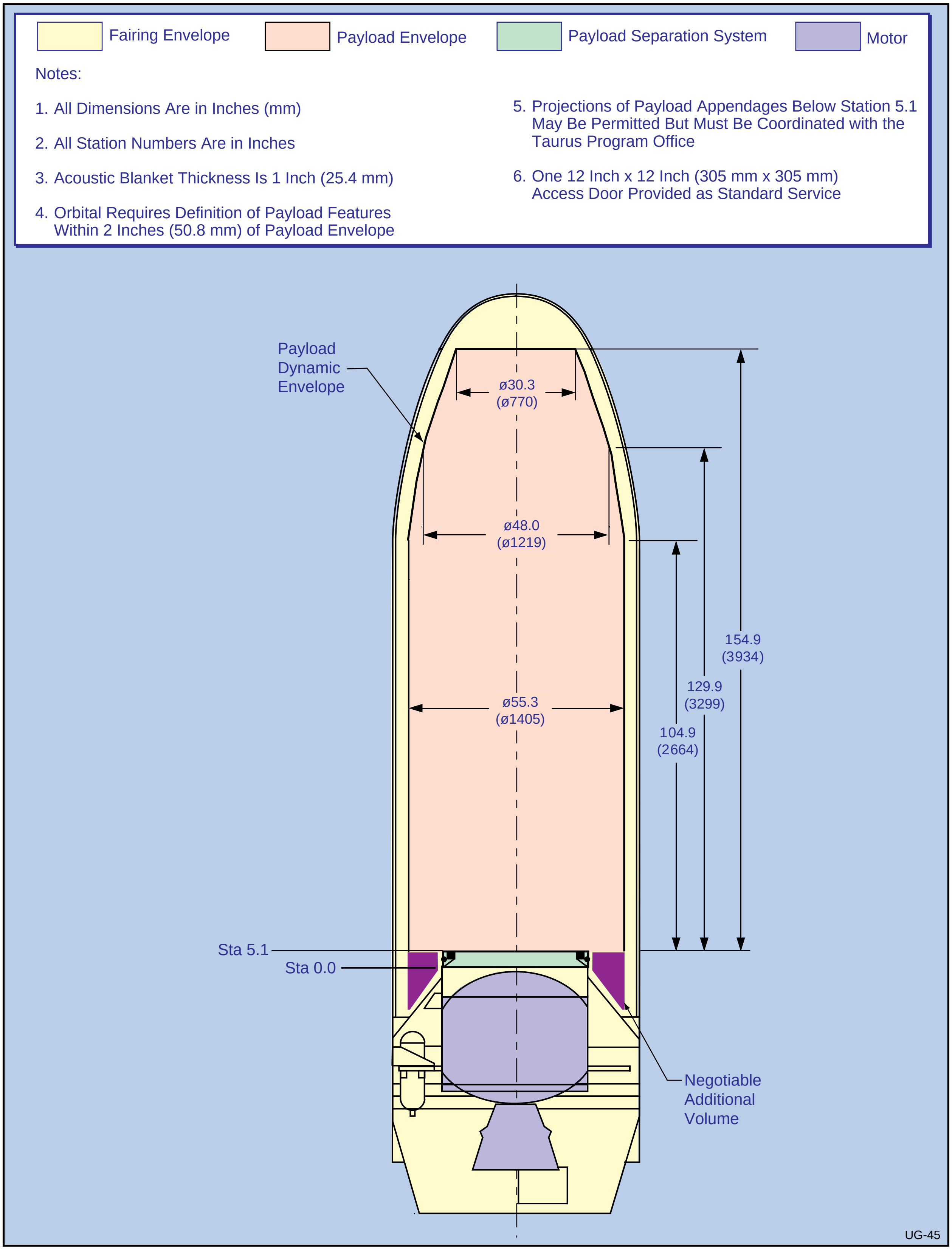


Figure 5-1. *Payload Dynamic Envelope for 63" Diameter Fairing.*

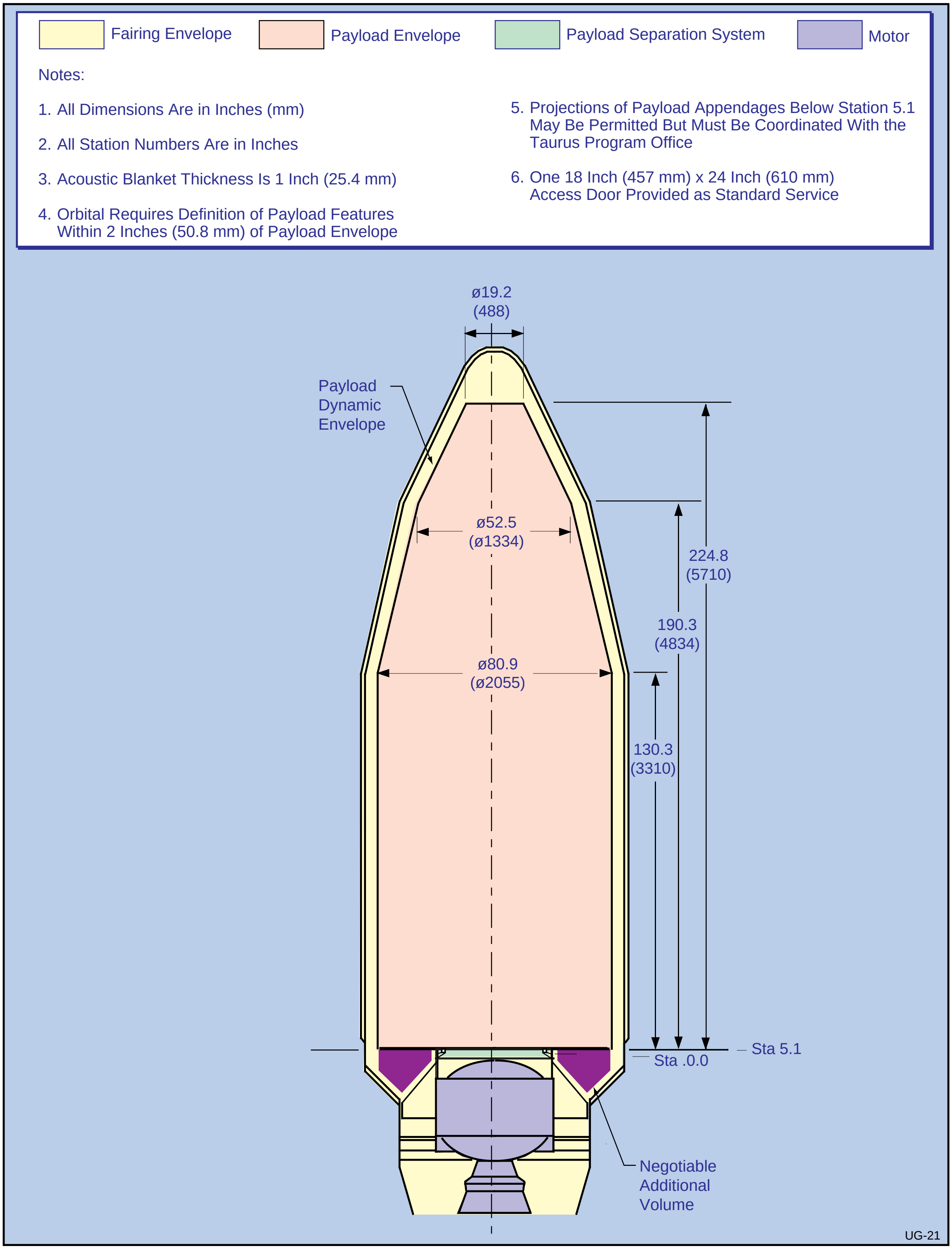


Figure 5-2. *Payload Dynamic Envelope for 92" Diameter Fairing.*

Orbital's 37.15" payload separation system is shown in Figure 5-3. The 37.15" and 38.81" standard configurations, which vary only in their forward interface ring geometry, have the same structural and separation performance. The interface flange geometries are provided in Figure 5-4. The separation systems are manufactured for Orbital by Saab Ericsson Space of Sweden. Saab has extensive experience in supplying separation systems for a wide range of launch vehicles and payloads. The system is based on a separation system that has flown over 30 times with 100% success.

The separation system is a marmon clamp band design that employs two aluminum interface rings that are clamped by dual, semi-circular stainless steel clamp bands with aluminum clamp shoes. Each of the two retention bolts is severed by a redundantly initiated bolt cutter. Upon band release, the movement and parking of each band is controlled by a set of four extraction spring assemblies and two band catchers that are designed to prevent recontact with the upper ring. Separation velocity is provided by up to eight matched spring actuators that impart up to 27.7 ft-lb (37.6 Joules) of energy. The spring assemblies may be tailored to mitigate the effects of payload center of gravity (C.G.) offset. The typical tip-off performance of the systems is described in Section 3.7. A typical layout of the separation system is shown in Figure 5-5 while the structural capacity of the separation system is detailed in Figure 5-6.

The mass of the separation system hardware that remains with the payload is approximately 12.5 lb (5.7 kg) for the 38.81" system and 10.0 lb (4.6 kg) for the 37.15" system. This includes the interface fasteners, upper interface ring, separation connector bodies and connector bracketry.

Figure 5-3. *Taurus Separation System.*

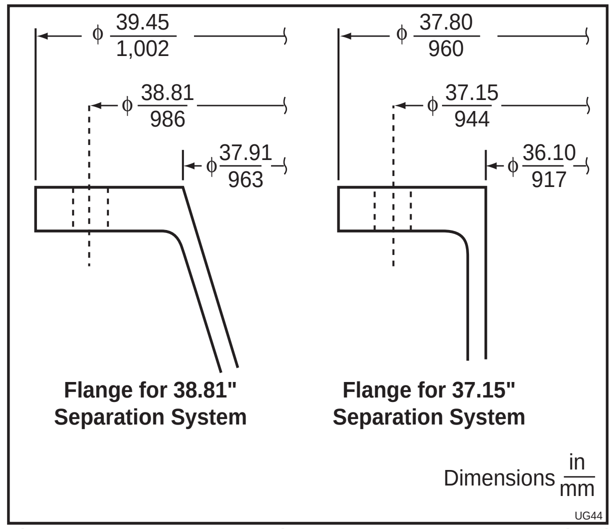


Figure 5-4. *Interface Flanges for Taurus' Standard Separation Systems.*

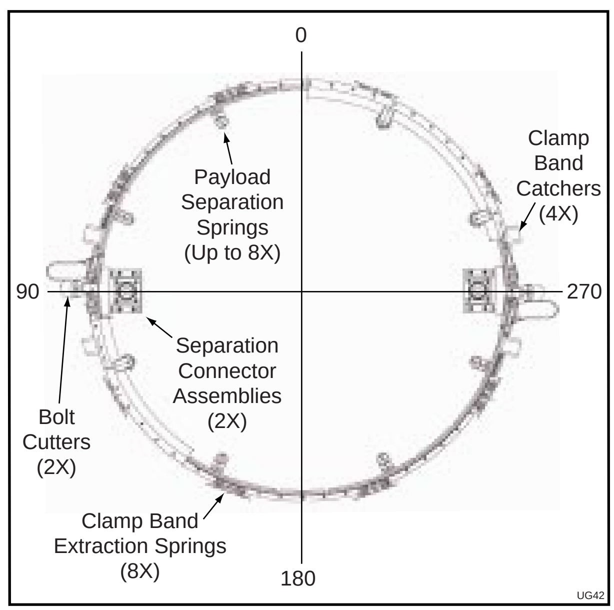
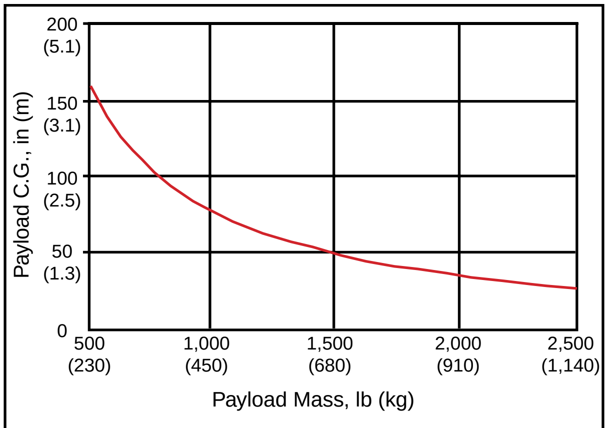


Figure 5-5. *Typical Layout of Taurus Separation System (38.81" System Shown with Forward Ring Partially Removed to Show Lower Ring).*



Assumptions: Axial Accel = 2 g's (Tension), Lateral Accel = 3.5 g's, Load Peaking Factor = 1.0 (Where Load Peaking Is Defined as: Ratio of Maximum Predicted Line Load to Maximum Line Load Which Would Occur for an Ideal Uniform Structure.)

Figure 5-6. *38.81"/37.15" Separation System Structural Capability.*

Interface fasteners may be inserted from either the launch vehicle or payload side of the interface. The standard finish on the upper interface ring is Alodine 1200. It is also permissible to apply thermal protection tape to certain non-critical areas of the system. Other surface finishes are available on non-critical surfaces as a non-standard service.

Orbital will provide a drill tool to the payload for precision drilling of the payload/launch vehicle interface. Use of the drill tool is dependent on coordination with other mission requirements. Delivery outside of the United States or to foreign personnel within the United States will be subject to United States Department of State approval.

5.4 Electrical Interfaces

Orbital provides a flexible set of electrical interface capabilities to accommodate Taurus payload requirements. Figure 5-7 provides a graphical depiction of the electrical interface configuration and options. The physical interface to the spacecraft is provided by two separation connectors. A mission-unique wire harness runs from the separation connectors to the Taurus avionics shelf, where signals are then distributed as appropriate to the T-0 umbilical connectors, the flight computer, and the telemetry multiplexer.

5.4.1 Payload Separation Connectors

As a standard service, Orbital provides two 56-pin low-impulse separation connector assemblies. The assemblies include a separation connector with strain relief backshell and all required mounting bracketry. Each connector provides 48 20-gauge contacts and eight 16-gauge contacts. The connector design is based upon a standard Mil-C-38999, 25-4 insert and uses a tunable internal spring package to minimize forces imparted during separation; thus, reducing payload tip-off rates. Two of the 20-gauge contacts in each connector are used by Orbital to verify payload separation via continuity loops, leaving up to 54 pins in each connector available for payload use.

Orbital will provide both halves of each separation connector and all the mission-unique wiring on the launch vehicle side of the interface. The forward half of each flight connector will be provided to the customer for integration into an interface pig-tail harness. The aft side of each flight connector will be integrated into the mission-unique launch vehicle wire harness provided by Orbital. If additional connectors are required as part of the payload test program, they can be provided as a non-standard service.

5.4.2 Umbilical Harness Pass-Throughs

The T-0 umbilical connectors provide the interface between the launch vehicle wire harness and the ground support harnesses to the LEV. Up to 64 conductors (32 twisted shielded pairs), are available to pass payload signals to the payload electrical ground support equipment located in the LEV. Four pairs of the 32 available wire pairs have a total round trip resistance of less than three ohms. These lines provide minimal power loss to support battery charging, external power, and other current needs of less than four amps. The remaining 28 pairs have a round trip resistance of less than 20 ohms. These lines are typically used for signal and communication.

5.4.3 Payload Command and Control

The Taurus flight computer can provide discrete sequencing commands to the payload based on

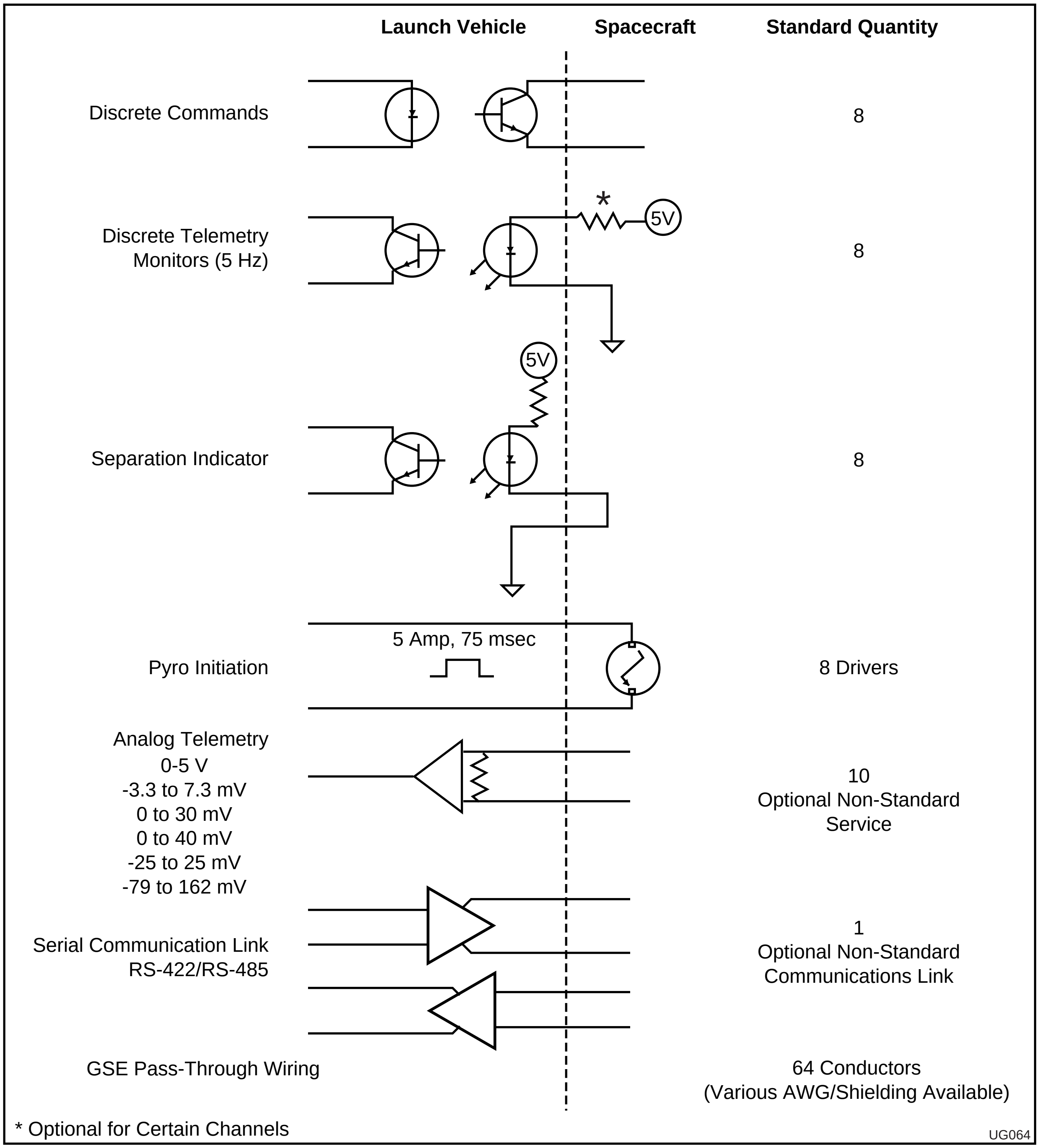


Figure 5-7. *Taurus Electrical Interface Block Diagram.*

mission time or mission events. The discrete commands are optically isolated pulses of programmable lengths in multiples of 40 milliseconds. Up to eight optically isolated discrete outputs or switch closures are available, each capable of multiple pulses. The payload supplies the voltage (≤40 VDC) and the current must be limited to less than 20 milliamps in a fashion similar to using a dry contact relay.

5.4.4 Payload Discrete Status Monitoring

Up to eight optically isolated payload discrete telemetry inputs points can be monitored during pre-launch operations and down-linked during ascent. The eight discrete inputs can be ground-mode type, used for breakwire monitoring or voltage-mode type used for bus "on/off" monitoring. In the ground-mode type, a 5.0 VDC source is current limited to 500 microamps. In the voltage-mode type, the payload supplies the DC voltage and the current resistor to limit the current to less than five milliamps. These discretes are typically monitored at five samples per second and, depending on the launch vehicle telemetry format, they can also be sampled at 25 samples per second.

Note that critical telemetry points that must be monitored at the customer's convenience during ground processing should be routed through the umbilical pass-throughs, as the Taurus telemetry is available only during a limited number of pre-launch test operations.

5.4.5 Pyrotechnic Initiation Signals

Taurus has the ability to provide up to eight separate initiation signals for electro-explosive type devices. Up to four one-ohm electro-explosive type devices can be initiated simultaneously. The pulses are provided by Taurus' Pyrotechnic Driver Unit (PDU), which is commanded by the flight computer through a serial communication link. The PDU is capable of delivering a pulse of 5 to 10 amps for 75 milliseconds across a one-ohm load. This pulse is suitable for initiation of any standard electro-explosive device.

If the customer chooses to use the pyrotechnic initiation service, the pyrotechnic signals must be segregated onto one of the two separation connectors. If payload requirements do not permit one of the two separation connectors to be dedicated to the pyrotechnic signals, then a third separation connector can be provided as a non-standard service.

5.4.6 Payload Analog Telemetry Monitoring

As a non-standard service, up to ten analog telemetry points may be monitored by the telemetry multiplexer during pre-launch operations and down-linked during ascent. The multiplexer has eight-bit resolution for analog telemetry and samples at five samples per second. The multiplexer has flexibility to accommodate a range of sensor types as detailed in Figure 5-7. Note that the ten available analog inputs consist of a combination of the various inputs and that the customer must provide the scale and bias values for the Taurus multiplexer.

Note that critical telemetry points that must be monitored at the customer's convenience during ground processing should be routed through the umbilical pass-throughs, as the Taurus telemetry is available only during a limited number of pre-launch test operations.

5.4.7 Serial Communication Interface

As a non-standard service, a serial RS-422/RS-485 communication interface between the Taurus flight computer and the payload can be provided. The flight computer will interrogate the payload at a pre-determined rate and will receive payload telemetry to be interleaved into the downlinked telemetry stream.

5.4.8 Payload Battery Charging

Payload battery charging can be remotely controlled from the LSV. Payload charging equipment, which is supplied by the customer, will be located in the LEV. The pass-through lines from the LEV to the payload can accommodate a maximum charging current of four amps. The pass-through conductor resistances are defined in Section 5.4.2.

5.4.9 Pre-Launch Electrical Constraints

Prior to launch, all payload and payload electrical ground support equipment circuits shall be constrained to ensure that the current flow across the umbilical interface is less than or equal to ten milliamps.

5.4.10 Pre-Separation Electrical Constraints

Prior to payload separation, all launch vehicle and payload interface circuits shall be constrained so that the current across the separation connectors is less than or equal to ten milliamps.

5.4.11 Electrical Launch Support Equipment

The Taurus electrical launch support equipment consists of two main operational units: the LSV and the LEV. Mission-unique, customer-supplied payload consoles and equipment can be supported in the LSV and LEV. Interface to the payload through the Taurus T-0 umbilicals and land lines provides the capability for direct monitoring of payload functions. Orbital provides the cabling from the T-0 umbilicals to the LEV, the junction box in the LEV, the fiber optic cables from the LEV to the LSV, and the associated communications and multiplexing equipment. Any additional mission-unique equipment must be provided by the customer.

Launch Support Van — The LSV houses all the hardware required to monitor and control the vehicle and payload.

The Payload Support Area (PSA) in the LSV is capable of supporting two customer personnel. A removable 72 inch x 30 inch (1.8 m x 0.8 m) work surface is available for positioning the payload-provided computer and monitoring equipment. Communication interfaces provided at the PSA consist of an RS-422 telemetry signal, an ethernet link, and up to 14 conductors of “patchable” signals which can be interfaced to the LEV in a combination of RS-422 and TTL. Two intercoms are provided at the station. These intercoms can be set up per the customer's communication requirements. Power (120V/ single phase) for payload equipment is available via several standard duplex receptacles.

Launch Equipment Van — The LEV houses the interface between the LSV and the vehicle. This unmanned facility serves as a junction equipment room patching fiber optic lines from the LSV into a copper connection with the vehicle. The LEV contains a 60 in x 66 in x 32 in (1.5 m x 1.7 m x 0.8 m){WxHxD} space for installation of payload racks and associated equipment. Power—120V, single phase, 60Hz—is available via several standard 15 amp duplex receptacles.

The payload interface at the LEV is accomplished through the patch panel and MUX/DeMUX. All signals connected to the LSV will either use the MUX/DeMUX or the Optelcom Interface.

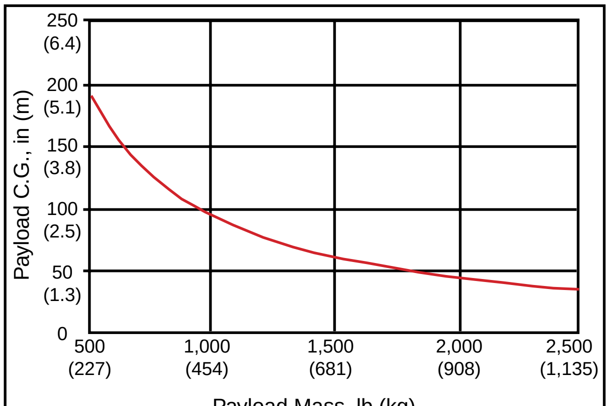
5.5 Payload Design Constraints

The following sections provide design constraints to ensure payload compatibility with the Taurus system.

5.5.1 Payload Center of Mass Constraints

The axial location of the payload center of mass is typically constrained by the structural capability of the payload separation system. The separation system structural capability is defined as a function of payload mass and center of gravity in Figure 5-6. If the Taurus payload separation system is not used, then the axial location of the payload center of mass is constrained by the structural capability of the payload cone. The structural capability of the payload cone is defined in Figure 5-8.

The lateral offset of the payload center of mass is constrained by the payload separation tip-off rate requirements and the structural capability of the separation system. Because the payload separation system has a demonstrated capability of tailoring the separation springs to accommodate center of gravity offset and the additional moment loads due to center of gravity offset tend to be small compared to the total capability of the separation system, Orbital does not place a hard



Assumptions: Axial Accel = +5/-2 g's, Lateral Accel = 3.5 g's, Load Peaking Factor = 1.0 (Where Load Peaking Is Defined as: Ratio of Maximum Predicted Line Load to Maximum Line Load Which Would Occur for an Ideal Uniform Structure.)

UG066

Figure 5-8. *Payload Cone Structural Capability.*

constraint on the lateral offset of the payload center of gravity. If preliminary design assessments indicate that the lateral center of gravity offset of the payload may exceed one inch (25.4 mm), the customer is encouraged to contact the Taurus Program Office to verify the feasibility of achieving the specific payload tip-off requirements.

5.5.2 Final Mass Properties Accuracy

The final payload mass properties statement shall specify the payload weight to an accuracy of 0.5%, the center of gravity to an accuracy of 0.25 inches (6.4 mm) in each axis, and the inertia matrix components to an accuracy of 5%.

If the payload uses liquid propellant, the slosh frequency shall be provided to an accuracy of 0.2 Hz, along with a summary of the method used to determine slosh frequency.

5.5.3 Payload EMI/EMC Constraints

The Taurus avionics RF susceptibility levels have been verified by test. The payload design must incorporate inhibits that are at least single-fault tolerant to inadvertent RF radiation. The time after separation at which the payload may transmit will be defined during the Mission Integration Working Group process.

Prior to launch, Orbital will review the payload radiated emissions (MIL-STD-461, RE02) to verify overall launch vehicle EMI safety margins in accordance with MIL-E-6051.

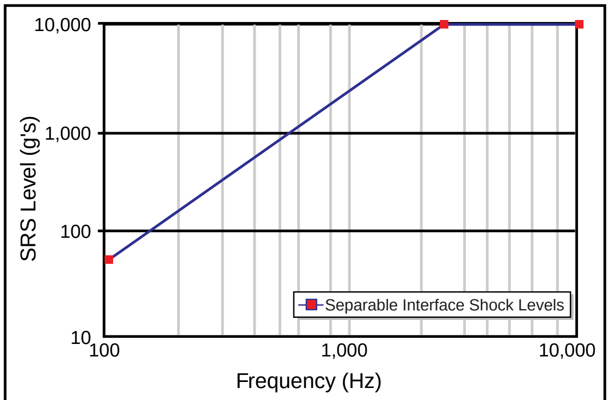
Payload RF transmission frequencies must be coordinated with Orbital and range officials to ensure non-interference with Taurus and other range transmissions. Additionally, the customer must schedule all RF tests at the processing facility with Orbital in order to obtain proper range clearances and frequency protection. Once the payload is encapsulated within the payload fairing, Orbital does not allow any payload RF transmissions.

5.5.4 Payload Dynamic Frequencies

To avoid unfavorable dynamic coupling with launch vehicle forcing functions, the payload should meet the dynamic frequency requirements specified in Section 4.4.

5.5.5 Payload-Supplied Separation Systems

Should the payload provide the separation system, the shock delivered to the payload cone interface flange must not exceed the levels defined in Figure 5-9.



Frequency (Hz)	SRS Level (Peak G)
100	50
3,500	10,000
10,000	10,000

UG67

Figure 5-9. *Maximum Payload Induced Flight Pyroshock Levels at the Payload Interface.*

5.5.6 System Safety Constraints

Orbital considers the safety of personnel and equipment to be of paramount importance. Each customer is required to conduct at least one dedicated payload safety review in addition to submitting to Orbital safety documentation as summarized in Section 7.7.3 and defined in EWR 127-1.

Customers designing payloads that employ hazardous subsystems are advised to contact Orbital early in the design process to verify compliance with system safety standards.

EWR 127-1 outlines the safety design criteria for Taurus payloads. These are compliance documents and must be strictly followed. It is the responsibility of the customer to ensure that the payload meets all Orbital and range imposed safety standards.

Section 6
Ground and Launch Operations

6.1 Taurus/Payload Integration Overview

The Taurus system has been designed to minimize vehicle and payload handling complexity and launch base operations time. Horizontal integration of the Taurus vehicle's upper stages simplifies integration procedures, increases safety and provides excellent access for the integration team. In addition, simple mechanical and electrical interfaces and checkout procedures reduce vehicle and payload integration times, increase system reliability and minimize vehicle demands on payload availability.

Orbital's approach to integration also places few requirements on the payload. Payload processing is conducted a short distance away from the launch site in an environmentally controlled facility such as Astrotech. Orbital encapsulates the payload and transports the assembly to the launch site 13 days before launch. A portable air conditioning unit supplies clean, temperature- and humidity- controlled air to the payload from encapsulation through launch.

This section describes the integration facilities, the vehicle and payload integration activities, and the final integration operations performed at the launch site in preparation for a Taurus mission.

6.2 Facilities

6.2.1 Western Range Facilities

The Western Range at VAFB is typically used for Taurus payloads requiring high inclination orbits. Taurus launches from the Western Range are conducted from Space Launch Complex 576E (SLC 576E), located on the coast of North VAFB (NVAFB). Payload processing for commercial launches is normally performed at Astrotech VAFB, a commercial payload processing facility. The Missile Assembly Building (MAB), located on NVAFB, is used for Taurus stage integration activities.

6.2.1.1 Payload Processing

A commercial facility, Astrotech Space Operations VAFB (ASO), is the primary Payload Processing Facility (PPF) for commercial Taurus launches conducted from the Western Range. Astrotech VAFB is located near the northwest end of the VAFB airfield at the corner of Tangair and Red Roads, approximately 3.5 miles from SLC 576E. This facility has been successfully used for processing payloads launched on Taurus, Pegasus, Delta and Atlas launch vehicles.

The Astrotech complex consists of the following major structures:

a. **Payload Processing Facility**: Used for all payload preparation operations, hazardous operations, payload fueling, etc.

b. **Technical Support/Customer Office**: Located in the non-hazardous work area, this facility supports customer administrative functions, as well as serving as ASO administrative headquarters.

c. **Warehouse**: Used for ASO storage, but may be used for customer GSE storage.

The PPF, depicted in Figure 6-1 and detailed in Figure 6-2, consists of the following customer areas:

a. **West Highbay**: The West Highbay is a 2400 ft^2 (223 m^2) cleanroom with an adjacent dedicated control room. Two cleanroom lowbays are attached to West Highbay, each with highbay access through 13.5 x 10 ft (4.1 x 3.0 m) roll-up doors.

b. **East Highbay**: The East Highbay is a 3500 ft^2 (325 m^2) cleanroom with an adjacent dedicated control room. A single cleanroom lowbay is attached with highbay access through a 13.5 x 10 ft (4.1 x 3.0 m) roll-up door.

c. **Airlock**: The airlock is a 2400 ft^2 (223 m^2) cleanroom capable area with a 20 x 40 ft (6.1 x 12.1 m) exterior roll-up door and a 20 x 45 ft (6.1 x 13.7 m) roll-up door to the West Highbay.

d. **Change Rooms/Air Showers**: Each highbay has a dedicated change room with lockers and an air shower that can be used prior to highbay entry.

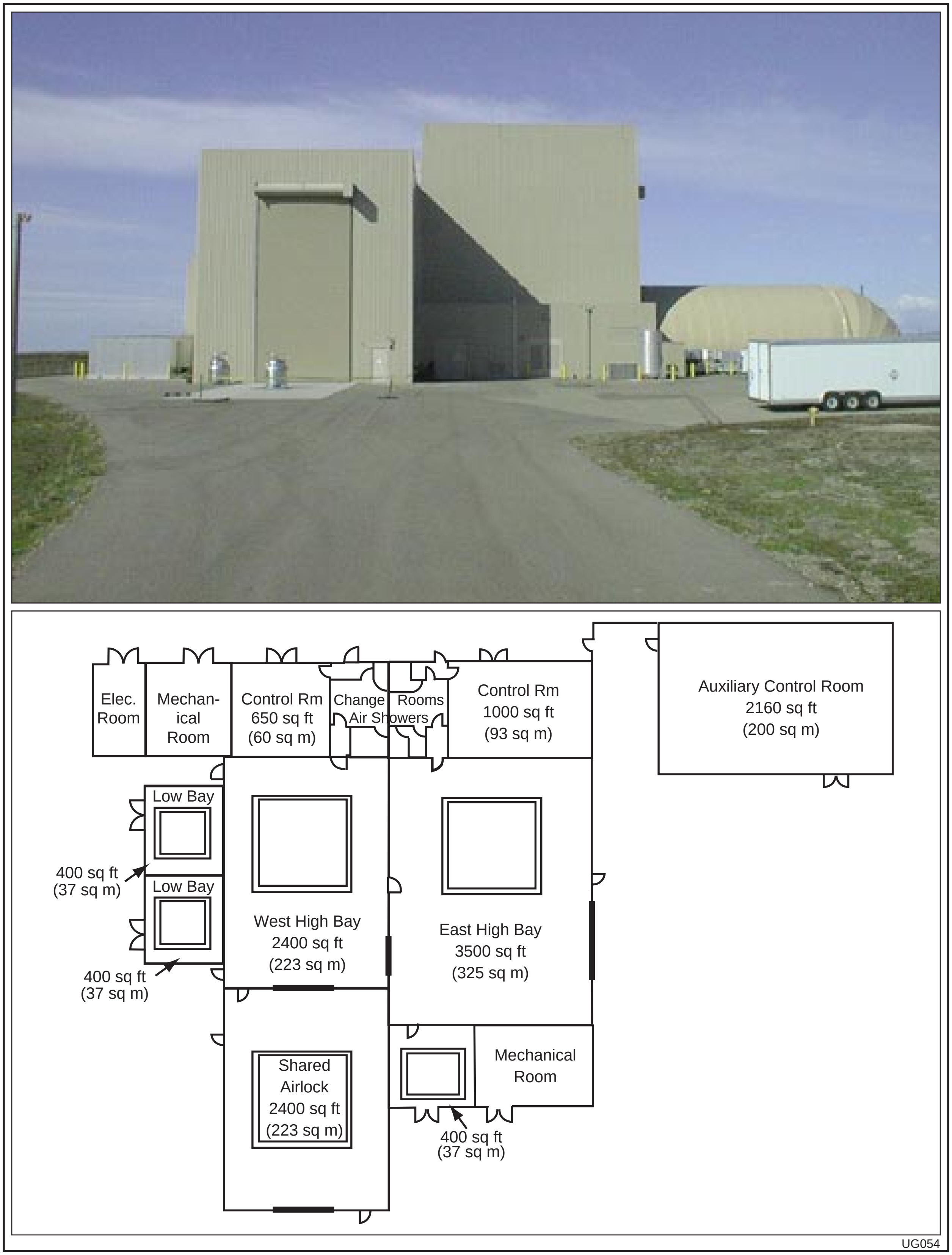


Figure 6-1. *Astrotech VAFB Payload Processing Facility.*

	West Highbay	East Highbay	Airlock	Lowbays	West Control Room	East Control Room
Floor Area (ft/m)	40 x 60 / 12.1 x 18.3	50 x 70 / 15.2 x 21.3	40 x 60 / 12.1 x 18.3	20 x 23 / 6.1 x 7.0	24 x 27 / 7.3 x 8.2	23 x 42.5 / 7.0 x 13.0
Fueling Island (ft/m)	25 x 25 / 7.6 x 7.6	25 x 25 / 7.6 x 7.6	25 x 25 / 7.6 x 7.6	6 x 6 / 1.8 x 1.8	N/A	N/A
Cleanliness	100,000 *	100,000 *	100,000 *	100,000 *	N/A	N/A
Temperature (°F/°C)	70 ±2 / 21 ±1	70 ±2 / 21 ±1	70 ±2 / 21 ±1	70 ±2 / 21 ±1	50-75 ±2 / 10-24 ±1	50-75 ±2 / 10-24 ±1
Relative Humidity	45 ±10%	45 ±10%	45 ±10%	45 ±10%	**	**
Crane Capacity/ Hook Height	10 ton/37 ft (9,100 kg/ 11.3 m)	30 ton/55 ft (27,000 kg/ 16.8 m)	10 ton/37 ft (9,100 kg/ 11.3 m)	N/A	N/A	N/A
Exterior Doors (ft/m)	N/A	20 x 50 / 6.1 x 15.2	20 x 40 / 6.1 x 12.1	8 x 10 / 2.4 x 3.0	8 x 10 / 2.4 x 3.0	8 x 10 / 2.4 x 3.0
Interior Doors (ft/m)	13.5 x 10 / 4.1 x 3.0 (lowbays) 20 x 45 / 6.1 x 13.7 (airlock)	20 x 45 / 6.1 x 13.7 (E. Highbay) 13.5 x 10 / 4.1 x 3.0 (lowbay)	See E. Highbay			

* Rooms are functional to below class 10,000 ** RH control capability is dependent on the selected temperature

UG010

Figure 6-2. *Astrotech VAFB PPF Details.*

6.2.1.1.1 Security

ASO has a Defense Investigative Service facility clearance designation. Access to the Astrotech complex and the PPF is controlled through a card reader access system. The customer can specify the individuals who are authorized access to their specific control room and clean room areas during facility usage.

6.2.1.1.2 Thermal and Cleanliness

The air conditioning system is computer controlled and monitored and maintains the cleanroom areas to 70 ± 2° F (21 ±1°C) and 45 ± 10 % relative humidity. A positive pressure is maintained in all clean room areas with air circulated through HEPA filters at a rate of 3.5 – 4.0 air changes per hour.

Cleanliness in the bays and airlock is certified to Class 100,000 and is functional to below Class 10,000.

6.2.1.1.3 Cranes

The airlock and West Highbay are equipped with a 10-ton (9,100 kg) overhead trolley bridge crane with a 37 ft (11.3 m) hook height. The East Highbay is equipped with a 30-ton (27,000 kg) overhead trolley bridge crane with a 55 ft (16.8 m) hook height. Both cranes have multi-speed control including microspeed control. For payload personnel designated to perform crane operations, Astrotech will conduct crane operation training classes.

6.2.1.1.4 Electrical

Astrotech is served by a 480 Volt/3 phase facility power feed. Figure 6-3 indicates isolated and surge protected power sources that are available in the PPF to accommodate payload needs. The PPF is supported by a 250 kW diesel powered backup generator.

Power Source	Receptacle
110 Volt/1 Phase/ 60 Hz	Standard 20 amp Duplex Receptacles
208 Volt/2 Phase/ 60 Hz	Crouse Hinds BHRE 658NW, 60 Amp
480 Volt/3 Phase/ 60 Hz	Crouse Hinds BHRE 3583NW, 30 Amp UG011

Figure 6-3. *Astrotech PPF Power Sources.*

6.2.1.1.5 Communications

Telephone/Fax — Phones for voice and facsimile are available throughout the ASO complex. The customer can set up voice mail systems if desired.

Voice Net — ASO maintains an operational voice net system capable of simiItaneous access to 12 voice nets that may connect to various Western Range facilities.

Paging — A paging system is available and operable throughout the complex.

Closed Circuit Television — Two color cameras with remote control zoom lenses and pan capability are installed in each highbay cleanroom. A single camera is installed in the airlock. The video signals can be transmitted to any building in the ASO complex.

Fiber Link — ASO is connected to the VAFB fiber optic cable communications network and data can be transmitted to any end use location on the network.

6.2.1.1.6 Payload Fueling Capability

The ASO facility is fully capable of supporting payload fueling operations. As a non-standard service (see Section 8.9), ASO provides a turn-key service for customers to support propellant loading operations to include the following: propellant transport, sample transport and analysis, life support services, loading facilities, and decontamination/waste handling services.

For those payloads requiring it, hydrazine is available from ASO through their agreement with the Air Force. Propellant costs are passed directly to the customer with no additional charges.

6.2.1.1.7 Other Equipment and Services

Other equipment and services provided by ASO include:

- Forklift – 3,000 lb (1,360 kg) capacity, cleanroom compatible;
- Highreach – electrically driven and cleanroom compatible;
- Compressed Air – for breathing, shop, and pallet jack operations; and
- Compressed Gases – limited quantities meeting applicable MIL specifications are available.

6.2.1.2 Stage Integration Facility

The stage integration facility for all Taurus launches is the MAB located on NVAFB and shown in Figure 6-4. Taurus uses this facility to horizontally integrate and test the launch vehicle components prior to their delivery to the launch site for final launch operations. The building is 356 ft (109 m) long by 138 ft (42 m) wide with a peak height of 143 ft (43.6 m). There are two overhead bridge cranes with hook heights of 104 ft (31.7 m) and capacities of 50 tons (45.4k kg) and 150 tons (136k kg).

The facility houses an array of Taurus GSE, including:

- An Assembly and Integration Trailer (AIT), stationary rails,and motor dollies for processing of Taurus hardware;
- Equipment for transportation, delivery, loading, and unloading of the Taurus vehicle components;
- Equipment for integration and test of a Taurus vehicle; and
- Equipment to maintain standard payload environmental control requirements.

6.2.1.3 Launch Site Facilities

SLC 576E, shown in Figure 6-5, is the primary launch facility for Taurus at the Western Range. This facility, formerly used for launching Atlas ICBMs, is relatively austere with few permanent structures. SLC 576E contains a launch pad surrounded by security fencing, lighting and camera towers, and is supported by facility power and the VAFB Communications Network.

Figure 6-4. *Missile Assembly Building.*

6.2.1.3.1 Launch Support Equipment

During launch campaigns, Orbital supplies and installs mobile Launch Support Equipment (LSE) to provide all the additional site support necessary for launch operations. The primary LSE components are summarized in the following paragraphs.

LEV — As previously described in Section 2, the LEV contains both launch vehicle and payload interface equipment and serves as the fiber-to-copper interface between the LSV and the launch vehicle. The LEV is positioned approximately 200 ft (61 m) from the launch stand and is unmanned during launch operations.

Launch Stand — The Taurus launch stand is installed on the launch pad well before flight hardware arrives at the site.

Integration Tent — This clamshell tent serves as the facility for final vehicle testing and payload-to-vehicle mating operations. The tent is located adjacent to the launch stand and is moved prior to upper stack mating.

Scaffolding — An OSHA approved scaffold is constructed around the Stage 0 motor and 0/1 interstage, providing pre-launch access to these structures. The scaffold is removed prior to launch.

Aerial Manlift Trucks — These vehicles are used to access the Taurus upper stages and fairing areas once the entire launch vehicle has been vertically erected on the launch stand (typically at L-6 days).

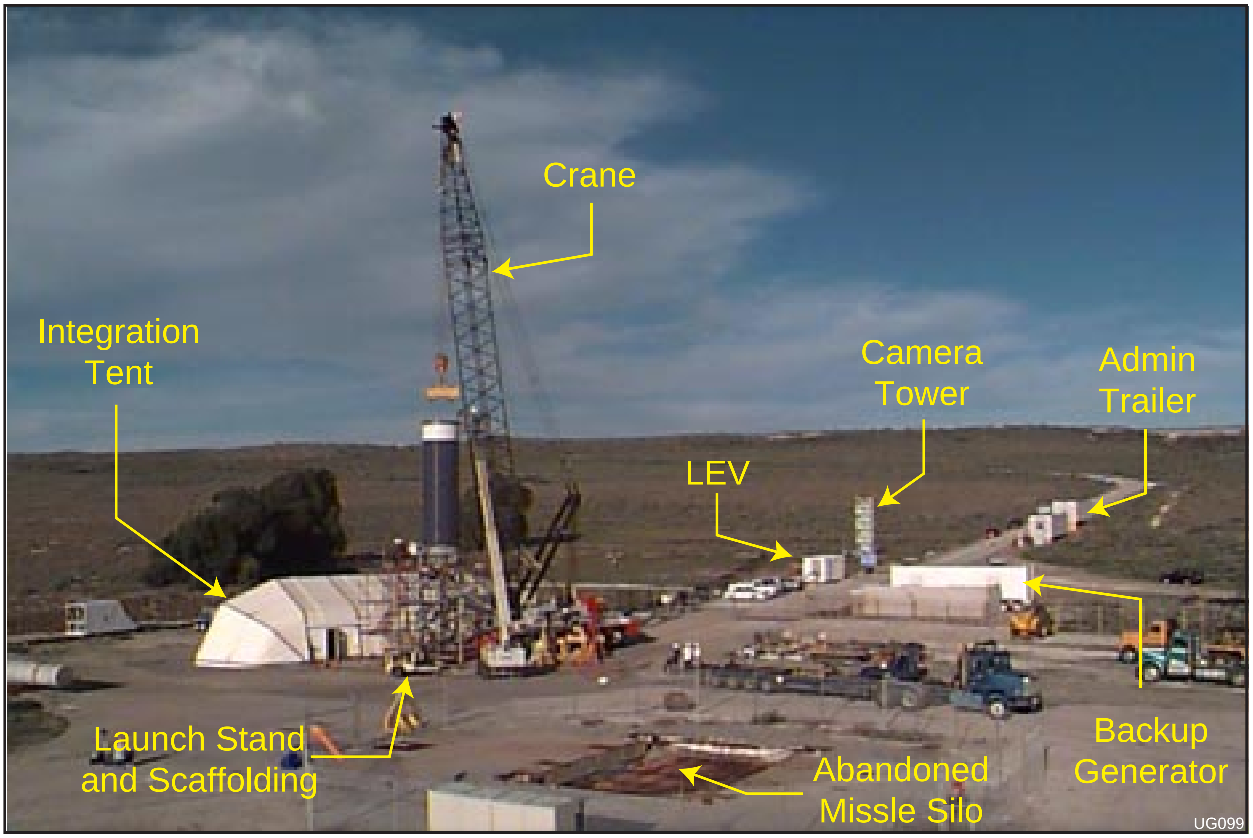


Figure 6-5. *SLC-576: Primary Launch Facility for Taurus at the Western Range.*

Equipment Support Trailer — Orbital provides a portable container for housing tools and other LSE.

Administrative Trailer — Located outside the hazard operations zone, this facility provides administrative space for Orbital and customer representatives. This trailer contains telephone, facsimile, computer, restroom and other resources.

6.2.1.3.2 Electrical

SLC 576E has a 60 Hz facility power feed which is distributed throughout the launch complex at 208-480V/3phase and 110-208V/1phase. All flight critical equipment/components (e.g., LEV, Payload Environmental Control System, etc.) are supported on an emergency backup power generator system which automatically transfers power within seconds of sensing a loss of facility power.

Specific payload GSE power requirements should be coordinated with Orbital early in the mission planning process.

6.2.1.3.3 Communications

Telephone/Fax: Telephone and facsimile support is available at the Administrative Trailer.

LSV Launch Control: Launch vehicle and payload communications from the LSV are provided through the LSV-LEV fiber optic cable and LEV-launch vehicle umbilical cables.

Fiber Optic Network: SLC 576E contains a termination point for the VAFB fiber optic communications network.

6.2.1.3.4 Security

The launch site is surrounded by a chain link perimeter fence with a 3-strand barbed wire top. During periods when flight hardware is at the site, access is controlled by a security force.

6.2.2 Eastern Range Facilities

Taurus integration operations at the Eastern Range mirror those conducted at the Western Range. The obvious difference is that payload processing as well as the final vehicle integration and launch occurs at CCAS.

For an Eastern Range launch, Orbital integrates the Taurus stages at the MAB on VAFB. Once the vehicle has completed stage integration and preliminary systems testing, the integrated Taurus stages are delivered to the launch site on CCAS and the Taurus payload cone and fairing are delivered to the PPF at CCAS.

Like Astrotech on VAFB, Orbital will provide a PPF at CCAS for commercial Taurus customers. The PPF will provide the same basic support and services (described in Section 6.2.1.1) required to integrate, test and encapsulate the payload.

For CCAS launches, Orbital will use the commercial Launch Complex 46 (LC-46), developed by the Spaceport Florida Authority in conjunction with launch industry partners (including Orbital). LC-46, shown in Figure 6-6 and Figure 6-7, is a proven commercial launch facility capable of supporting a variety of launch vehicles. Orbital has signed an agreement with Spaceport Florida to use LC-46 for Taurus missions that require an East Coast launch. Following integration at the MAB, Taurus hardware will be shipped to CCAS via rail and truck. Once at LC-46, Orbital will perform standard launch site integration procedures to verify the hardware was not damaged during transport, mate the encapsulated cargo element with the Taurus vehicle, conduct the integrated systems tests, and perform the final erection and close-out of the vehicle.

Figure 6-6. *LC-46 Launch Complex.*

Figure 6-7. *LC-46 Tower.*

6.3 Vehicle and Payload Integration Operations

Taurus ground and launch operations are conducted in three major phases:

- ***Launch Vehicle Integration***: Assembly and test of the Taurus vehicle at the MAB;
- ***Payload Processing***: Receipt and checkout of the payload at the PPF followed by encapsulation into the Taurus fairing; and
- ***Launch Operations***: Transport of vehicle components and the encapsulated payload to the launch site, final integrated systems testing, erection of the vehicle onto the launch stand, and launch.

Each of these phases is more fully described in the following sections. Orbital maintains launch site management and test scheduling responsibilities throughout the entire integration cycle. Additionally, all Orbital integration activities are controlled by a comprehensive set of Taurus Work Packages (TWPs), which describe and document every aspect of integrating Taurus and its payload. Mission specific work packages are developed for mission unique or payload specific operations.

6.3.1 Launch Vehicle Integration

All launch vehicle motors, parts, and completed subassemblies are delivered to the MAB from either the assembly vendor or Orbital's Chandler production facility. Figure 6-8 depicts the typical flow of hardware from the factory to the launch site.

The transformation of solid rocket motors, avionics, and sub-assembled structures into an integrated launch vehicle begins at the MAB. Figure 6-9 outlines the typical activity flow for MAB operations while Figure 6-10 depicts a typical vehicle configuration during MAB testing. A small group of skilled engineers and technicians perform the following major functions:

- Receive and inspect all motors, sub-assemblies and vehicle components;
- Integrate mechanical and electrical components and sub-assemblies onto the individual motors;
- Perform electrical and systems testing of the integrated motors, composite sub-assemblies and the avionics section; and
- Physically and electrically mate the vehicle upper stages (i.e., Stages 1, 2, 3, and the avionics section).

The Taurus upper stages are integrated horizontally at the MAB prior to their shipment to the launch site. This integration is performed at a convenient working height which allows for easy access for component installation, test and inspection. The integration and test process ensures that all vehicle components and sub-systems are thoroughly tested before and after final flight connections are made.

Vehicle systems tests verify operation of all subsystems prior to stage mate. For each of these tests, a specialized test software load is installed into the Flight Computer. The major tests include:

- ***Vehicle Verification:*** A test that efficiently commands all subsystems (TVCs, RCS, pyro commands, etc.) in an accelerated timeline.
- ***Phasing Test:*** A test to verify the sign of the control loop of the flight actuators and dynamic operation of the IMU. In this test the IMU is moved manually while the motion of the flight actuators (TVCs and RCS) is observed and recorded.
- ***Flight Simulation Testing:*** This series of tests uses the actual flight code and simulates a "fly to orbit" scenario. All flight actuators, pyro commands and flight computer commands are exercised. A Flight Simulation is repeated after each major vehicle configuration change (i.e., Flight Simulation #1 occurs after subsystem and component installation; Flight Simulation #2a occurs after upper stage mate; Flight Simulation #2b occurs after transport to the launch site; and Flight Simulation #3 occurs after the payload is electrically mated to the vehicle). After each test the configuration of the vehicle remains unchanged until a full and compete data review of the test is complete. The payload nominally participates in Flight Simulation #3.

The successful completion of Flight Simulation #2a completes MAB operations. At this point, the fairing and payload cone assemblies are shipped to the PPF for payload encapsulation operations. The Stage 0 motor, the Stage 0/1 interstage, and the upper stage assembly are prepared for shipment to the launch site.

6.3.2 Payload Processing Operations

The integrated payload processing activities, outlined in Figure 6-11, are designed to simplify final launch processing while providing a comprehensive verification of the payload interface. Payload processing is conducted

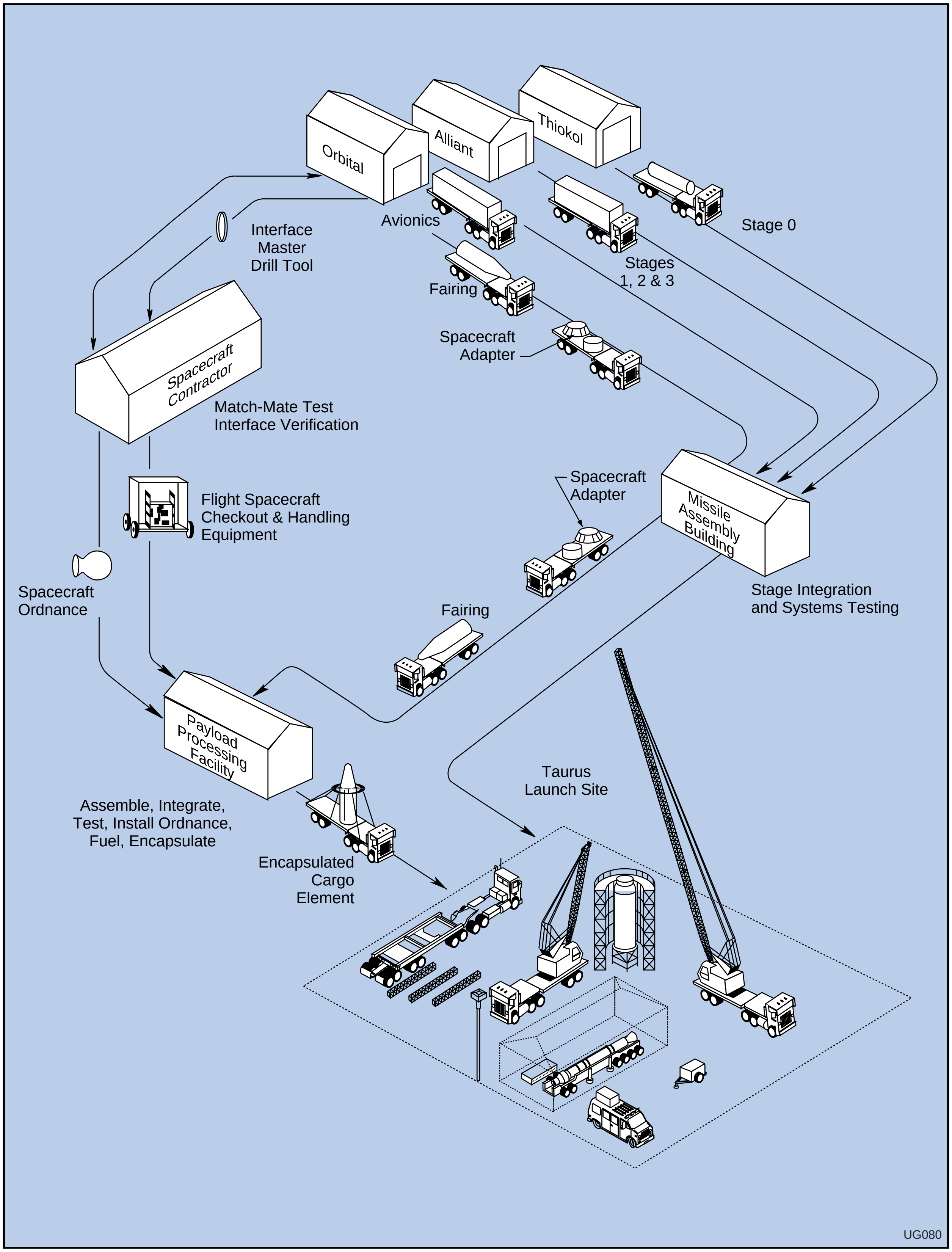


Figure 6-8. *Hardware Flow - Factory to Launch Site.*

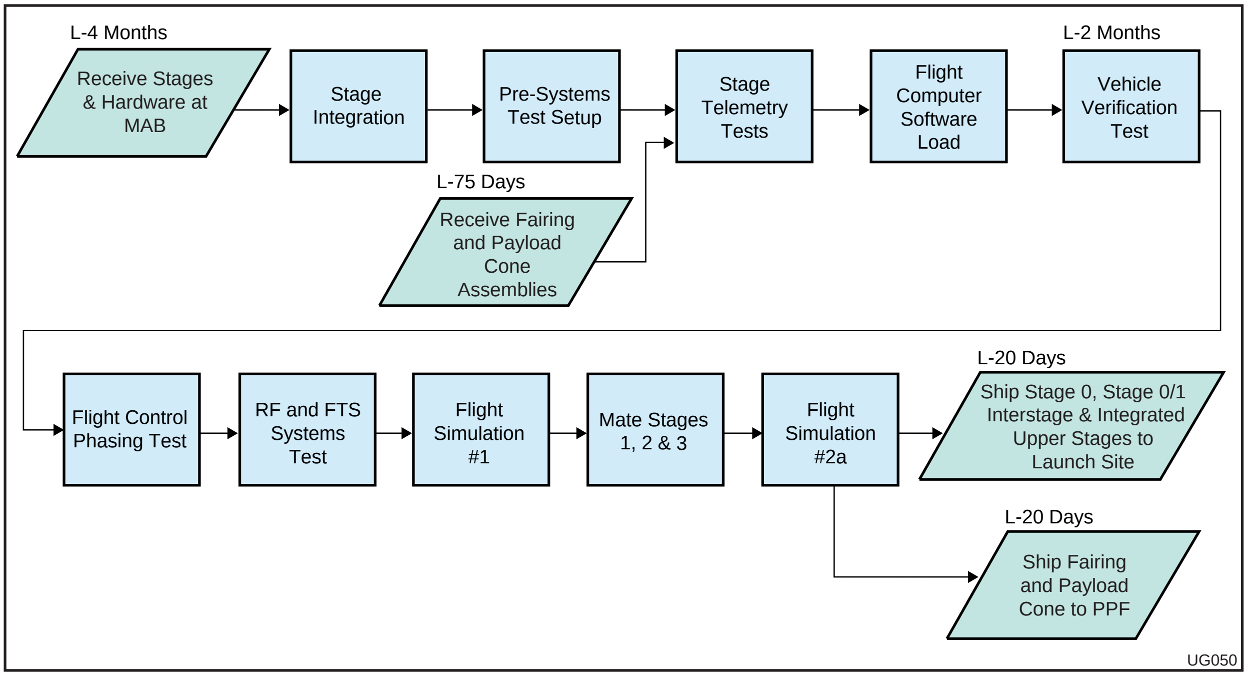


Figure 6-9. *Vehicle Processing Flow at the MAB.*

independently of Taurus vehicle processing, allowing the payload to determine and control the length of time required for checkout within the PPF. Once the payload has completed its own independent verification and checkout, Orbital will deliver the fairing and payload cone assemblies to the PPF. The nominal PPF integrated operations include mating the payload to the Taurus payload cone, performing interface verifications, and encapsulating the payload within the Taurus fairing halves. Orbital will then transport the encapsulated payload to the launch site. The standard launch service includes up to 30 days in the PPF with four of these days slated for payload-to-Taurus integrated activities.

For planning purposes, typical PPF activities and their timelines follow.

- L-42 days: Payload arrival, preparation, and checkout
- L-20 days: Fairing and payload cone delivery to the PPF
- L-16 days: Begin payload mate and encapsulation activities
- L-13 days: Encapsulation complete; ready for transport to launch site.

Payload Integration and Encapsulation — After Flight Simulation #2a is completed at the MAB, the fairing and payload cone assemblies are released and delivered to the PPF with the associated GSE. In parallel with other PPF operations, the fairing halves are lifted from their as-shipped horizontal configuration to vertical and secured in Orbital-provided handling carts. Orbital then performs fairing system checks and stores the fairing halves until needed for installation as shown in Figure 6-12. The payload cone is strategically placed in the PPF to facilitate both payload mate and fairing installation. Once the payload cone assembly has been positioned, and the separation system has been installed, the payload is lifted from its GSE stand (using customer provided lifting fixtures), and mated to the payload cone assembly, as shown in Figure 6-13.

Following the payload-to-Taurus mechanical and electrical mating and interface verification testing, the payload is ready for encapsulation within the fairing. The first fairing half is rolled into place and mated, as depicted in Figure 6-14. Following any final payload closeout operations, the second fairing half is rolled into place and mated,

Figure 6-10. *Stage Integration in the MAB.*

completing the encapsulation process, as shown in Figure 6-15. Final assembly of the handling fixture completes the Encapsulated Cargo Element (ECE). At this point, access to the payload is available only through the fairing access door.

The ECE may remain at the PPF in this configuration for any length of time until transport to the launch site is required.

6.3.3 Payload Transport to the Launch Site

In preparation for transporting the ECE, Orbital verifies that the Taurus mobile environmental control system (ECS) meets applicable temperature, humidity, and cleanliness requirements. The system is then attached to the fairing via insulated flexible ducting and begins providing environmental control to the payload

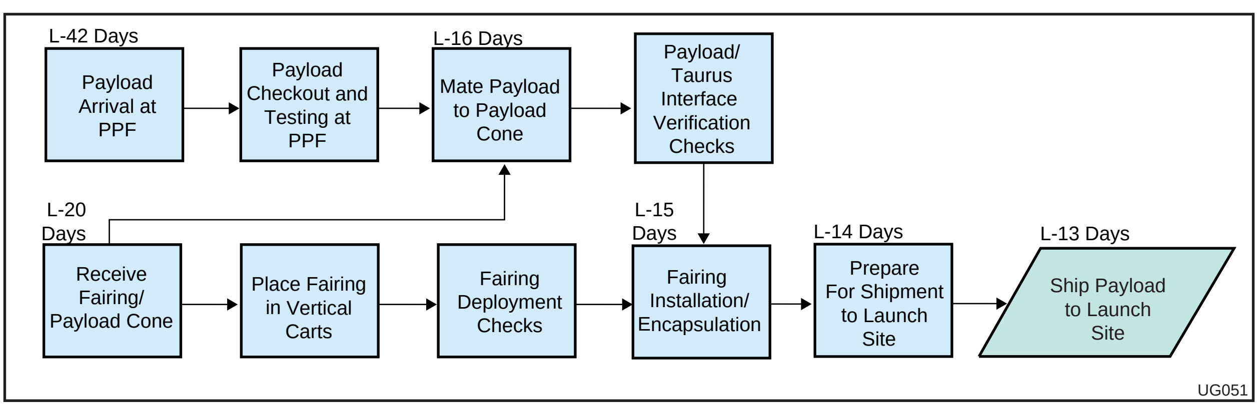


Figure 6-11. *Payload and LV Processing Flow at the PPF.*

Figure 6-12. *Fairing Stowed in PPF.*

volume. The payload volume temperature and humidity levels will be monitored and controlled in this manner for the remainder of ground operations. An Orbital provided air-ride trailer, already loaded with the ECS and power generator, is then backed into the PPF airlock. The ECE is hoisted onto the trailer, secured, and prepared for road transportation to the launch site, as shown in Figure 6-16. A limited amount of space is available on the transporter for any required payload monitoring GSE. Power (120V/1phase/ 60hz) is also available for powering GSE during the transport.

6.4 Launch Operations

Launch operations consist of the following major activities:

- Verification of LSE, facilities, and utilities;
- Delivery of the Taurus launch vehicle components to the launch site for final integration and test;
- Transportation of the ECE to the launch site for testing and integration with the Taurus vehicle;
- Final system testing and vehicle mate; and
- Vehicle arming and launch.

6.4.1 Facility and LSE Checkout

Prior to the arrival of any flight hardware at the launch site, Orbital erects the launch stand and integration tent, verifies the power and electrical interfaces, and installs the remaining LSE. Orbital also thoroughly tests communications between the Range, LSV, LEV and SLC 576E. Payload GSE interfaces with the LSV and LEV must also be verified well in advance of flight hardware delivery to the site. Orbital recommends that these interface verifications occur prior to the payload arrival at the PPF.

6.4.2 Delivery of Taurus to the Launch Site

The launch site processing flow is detailed in

Figure 6-13. *Payload Mated to Payload Cone.*

Figure 6-14. *First Fairing Half Installation.*

Figure 6-17. Within three weeks of launch, the integrated Taurus hardware is transported from the MAB to the launch site in three major pieces: the Stage 0 motor, the Stage 0/1 interstage and the upper stage assembly. Upon arrival at the site, the Stage 0 motor and Stage 0/1 interstage are immediately erected onto the launch stand and the upper stage assembly is positioned inside the integration tent in preparation for final vehicle testing. At this time, Stage 0 is electrically connected to the upper stages using a jumper harness and the T-0 umbilicals are connected, establishing vehicle control from the LSV. Orbital then performs a flight simulation test (Flight Simulation #2b) to verify that the vehicle health was unaffected by the transport. The test also verifies communication with and control of the vehicle from the LSV. In addition, Orbital verifies that the interfaces of the payload GSE meet the ICD requirements. These tests, customized for each mission, typically checkout the LSV/LEV controls, launch vehicle sequencing, and any off-nominal modes of the payload. It is

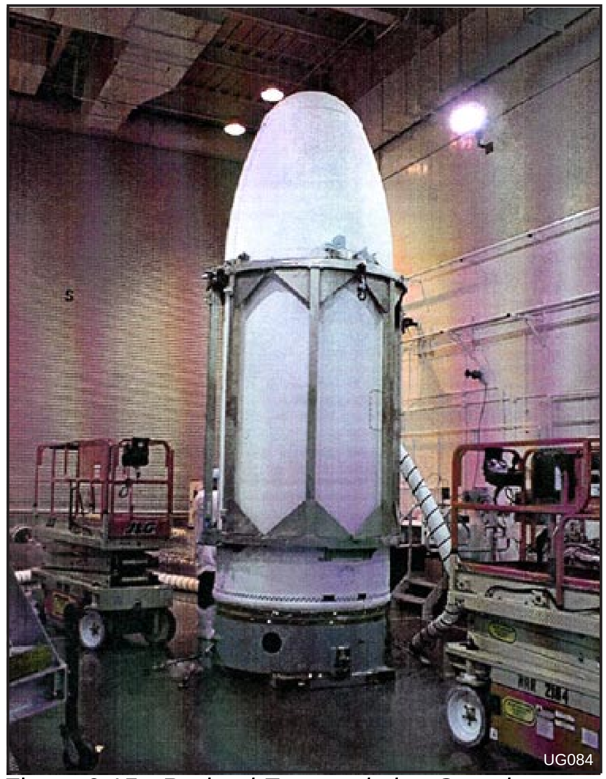


Figure 6-15. *Payload Encapsulation Complete.*

recommended that the customer complete this activity for the payload side of the interface as well.

6.4.3 Payload Arrival and Activities at the Launch Site

Once Flight Simulation #2b is successfully completed, Taurus is “ready” for payload transport. This typically occurs at L-13 days. As previously described, the ECE is loaded vertically onto its transporter at the PPF and is then

Figure 6-16. *ECE Transport to Launch Site.*

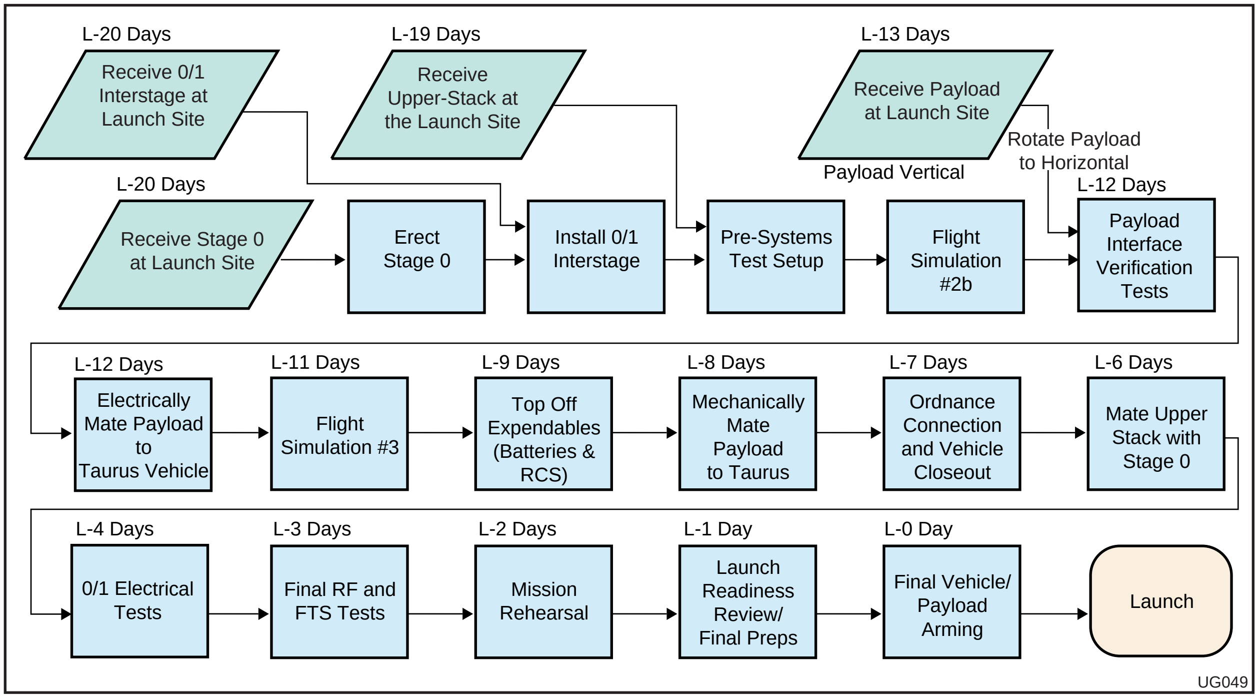


Figure 6-17. *Launch Site Processing Flow.*

transported to the launch site via convoy. Once at the site, the ECE is crane-lifted from the transporter, rotated to a horizontal position, and placed next to the Taurus Upper Stage Assembly inside the Integration Tent, as depicted in Figure 6-18. Flight electrical connections are then made between the ECE and the launch vehicle. Once the ECE is electrically mated to Taurus, battery charging and communication with the payload are nominally controlled from the payload station in the LSV.

6.4.4 Integrated Testing and Vehicle Mate

A final integrated systems test (Flight Simulation #3) is performed with the vehicle in a full flight configuration (e.g., flight cables mated, systems on internal power, RCS firing, etc.), allowing a complete check of all interfaces, including the payload-to-launch vehicle interface. The payload participates in Flight Simulation #3 by being in a powered mode and monitoring telemetry. Following the successful completion of this test, the ECE is mechanically mated to the Taurus upper stage assembly.

Using a special handling fixture and two cranes, the upper vehicle stack with ECE is hoisted, rotated to vertical and mated to the previously erected Stage 0, as shown in Figure 6-19. Payload environmental control and electrical continuity is maintained throughout the hoisting and mating operations. Final end-to-end continuity and functional tests are performed following the mating.

6.4.5 Vehicle Arming

Following final vehicle testing, Taurus is armed and the pad area is cleared for launch. These

Figure 6-18. *ECE in Position for Integration With the Launch Vehicle.*

activities, which typically commence on L-1 day and conclude by L-12 hours, take the Taurus vehicle to a launch-ready configuration as shown in Figure 6-20. This timeframe also represents the final period for payload access under normal situations.

The launch countdown is performed from the LSV located outside the caution/hazard corridor.

6.4.6 Launch

Following Taurus and payload closeout activities during L-1 day operations, the final countdown procedure begins. Figure 6-21 lists the key Taurus tasks completed during the final two hour countdown. These activities methodically transition the vehicle from a safe state to that of launch readiness. Payload tasks, as necessary, are included in the countdown procedure and are coordinated by the Taurus Test Conductor.

6.4.6.1 Launch Control Organization

The Launch Control Organization consists of two groups with distinct responsibilities. Figure 6-22 shows the typical communication flow required to make the launch decision.

The management group includes key personnel representing the payload, launch vehicle, and range. This group, headed either by the customer Mission Director (MD) or the Orbital Launch Director, has the final decision authority for the launch. The management lead polls the necessary payload personnel to ascertain the status of the payload and receives the final Go/No-Go recommendation from the Payload Launch Director. The appropriate launch range Commander provides the final range recommendation for launch. This recommendation encompasses all aspects of the range's responsibility including, but not limited

Figure 6-19. *Upper Stack Lift.*

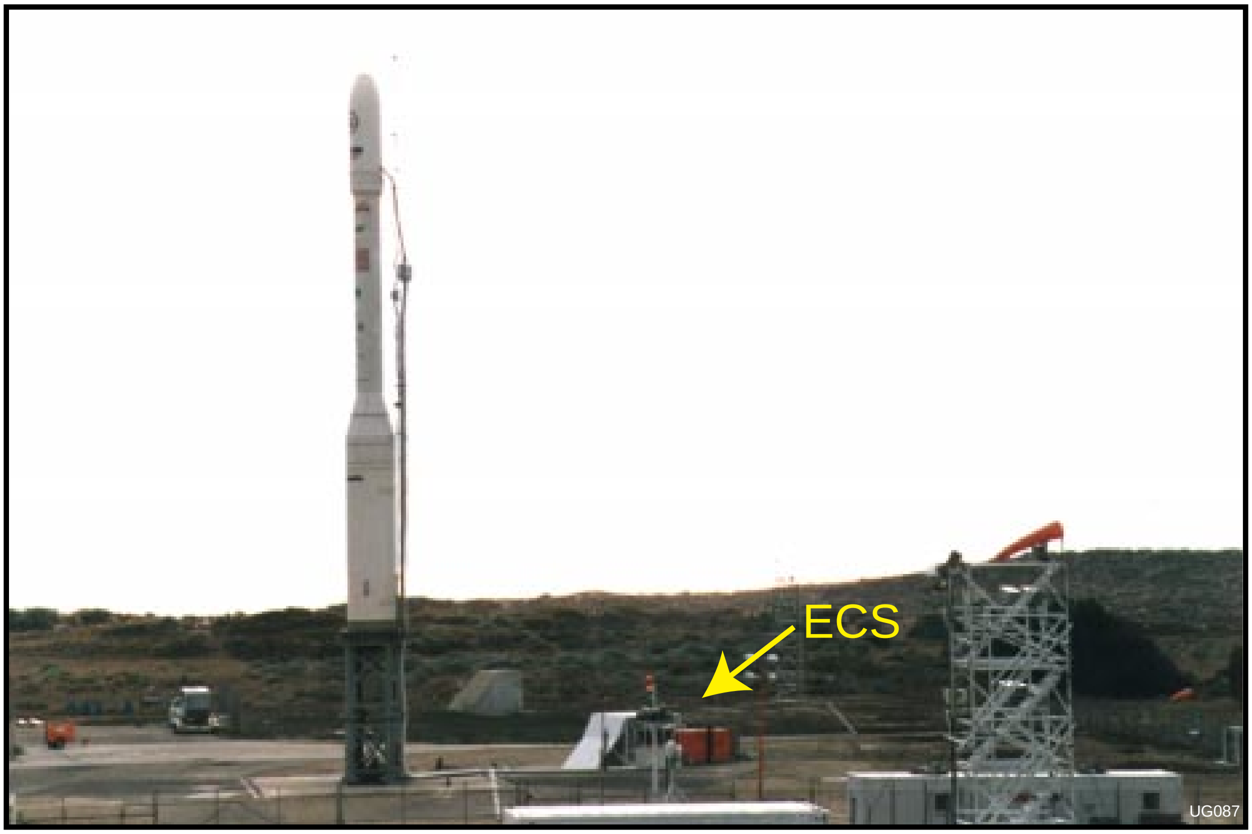


Figure 6-20. *Taurus Ready for Launch.*

to, flight safety, ground safety, hazard corridor status, local and downrange telemetry, tracking and command assets, and weather. The Orbital Launch Director provides the launch vehicle status and launch recommendation based on inputs from the Taurus launch team.

The second group is the operations/engineering staff, including the Test Conductor, the Taurus engineering team, payload engineering team, and the Range Control Officers. The Test Conductor, an Orbital employee, is responsible for running the countdown procedure. The Orbital Vehicle Engineer has the overall responsibility for Taurus readiness while the Taurus Operations Engineer performs the necessary commands to prepare the vehicle for launch. The Taurus Test Conductor, Vehicle Engineer, and Operations Engineer reside in the LSV. In addition, both the Taurus and Payload Launch Directors are positioned in the LSV. There is also space for up to two additional payload support team members in the LSV. These payload personnel provide satellite status and readiness to the Payload Launch Director.

Nominal Time	Major Events
-120 min.	Countdown Begins Prelaunch Operation Checklist Verified Complete Call to Stations Final Site Clear and LEV Activation
-90 min.	Vehicle on External Avionics Power Range Evaluation of Telemetry
-75 min.	C-Band Transponder Checkout
-45 min.	Weather Briefing
-35 min.	Verify Upper Level Winds Acceptable for Launch
-26 min.	FTS to Internal Power FTS-Open Loop Check on Internal Power
-15 min.	Enable LSV for Launch
-10 min.	C-Band Interrogation Through Launch
-8 min.	Avionics Bus to Internal Power
-7 min.	Final Range TLM Evaluation
-5 min.	Final Launch Go/No-Go Poll
-4 min.	Transient Power On Vehicle S&As Armed
-2 min.	Auto Sequence Initiated
-1 min.	IMU to Free Inertial
T0	Liftoff

UG053

Figure 6-21. *Final Countdown Sequence.*

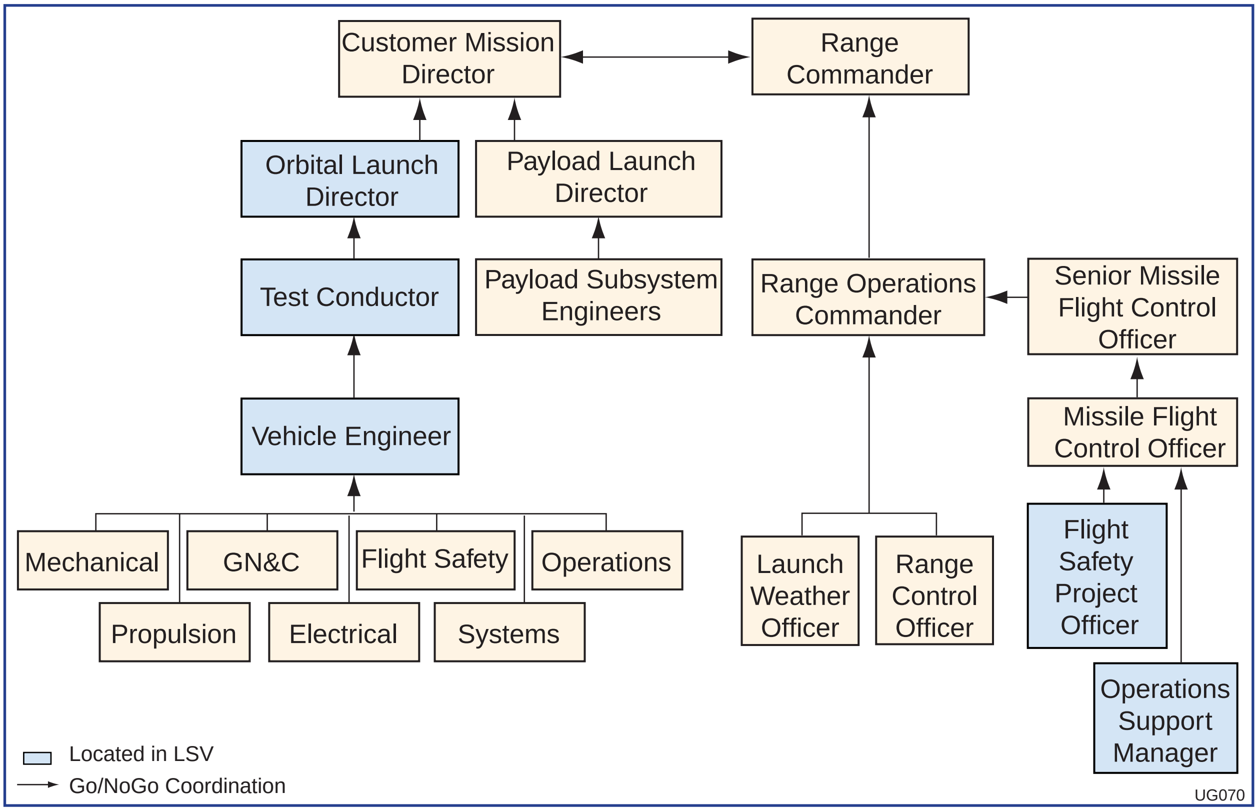


Figure 6-22. *Typical Launch Decision Flow.*

The remainder of the launch team is positioned in the Range Control Center. Figure 6-23 shows a typical Range Control Center configuration for a VAFB launch. The Mission Director console and (four) additional customer consoles are typically available for customer use. Additional space for key customer personnel and dignitaries is available in the Technical Support Room.

6.4.6.2 Launch Rehearsals

Two rehearsals are conducted prior to each launch. The first is conducted at approximately L-1 month and is used to acquaint the launch team with communications systems, reporting, problem solving, launch procedures and constraints, and the decision making process. The rehearsal is a full day in duration and consists of a number of countdowns performed using abbreviated timelines. All aspects of the team's performance are exercised, as well as hold, scrub, and recycle procedures. The operations are critiqued and lessons learned are incorporated prior to the Mission Dress Rehearsal (MDR) at L-2 days. The MDR is the final rehearsal prior to entering the countdown and will ensure problems encountered during the first rehearsal have been resolved. The MDR is typically a half day in duration. All customer personnel involved with launch day activities participate in both rehearsals.

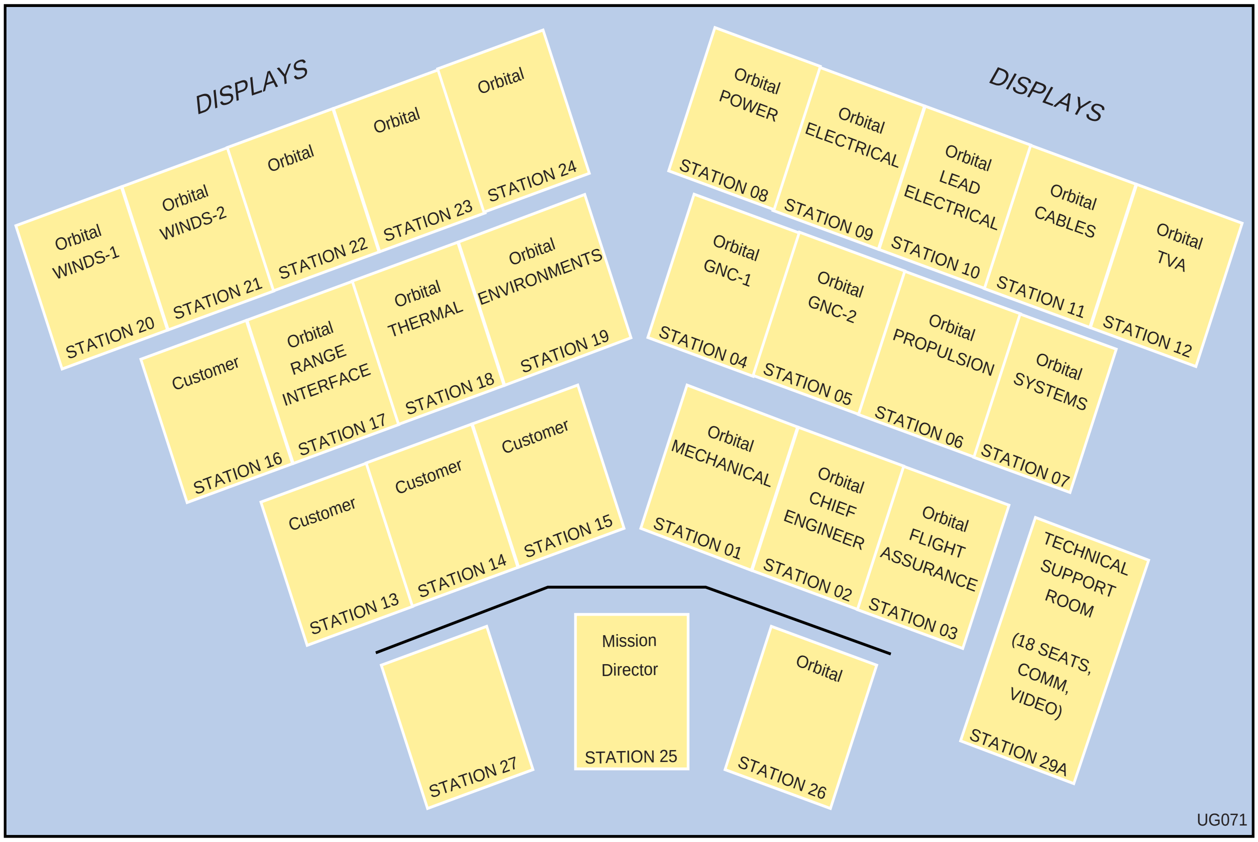


Figure 6-23. *Typical VAFB RCC Seating Arrangement.*

Section 7
Mission Integration

7.1 Management Approach

The Taurus program is managed through the implementation of an integrated project plan. This plan is prepared by the Program Manager, based on inputs from the program team, and approved by the General Manager of Orbital's Launch Systems Group. This project plan includes master schedules, the Work Breakdown Structure (WBS) dictionary, and organization and staffing plans and provides the baseline for tracking progress in the areas of technical and schedule performance.

7.2 Orbital Mission Responsibilities

A mission unique organizational structure is established for each Taurus mission to manage and execute key mission roles and responsibilities. Open communication between Orbital and the customer, emphasizing timely transfer of data and prudent decision-making, ensures efficient launch vehicle/payload integration operations. As the launch service provider, Orbital's responsibilities fall into four primary areas:

1) Program Management;
2) Mission Management;
3) Engineering; and
4) Launch Site Operations.

The Taurus program organization is depicted in Figure 7-1, while the four areas of responsibilities are summarized in Figure 7-2 and in the following sections.

Orbital Taurus Program Manager — The Orbital Program Manager has direct responsibility and accountability for the Taurus Program at Orbital, including all elements required to provide a reliable and timely launch service and to ensure customer satisfaction. The Program Manager's responsibilities include management of schedules, budgets and deliverables; customer interface; vehicle engineering; change control; manufacturing; and integration and launch operations.

Taurus Mission Manager — The mission integration management structure is illustrated in Figure 7-3. The Taurus Mission Manager is the single point of contact for all aspects of a specific mission. This person has overall program authority and responsibility to ensure that payload requirements are met and that the appropriate launch services are provided. The Taurus Mission Manager will chair the Mission Integration Working Groups (MIWGs). The Mission Manager's responsibilities include detailed mission planning, launch vehicle production

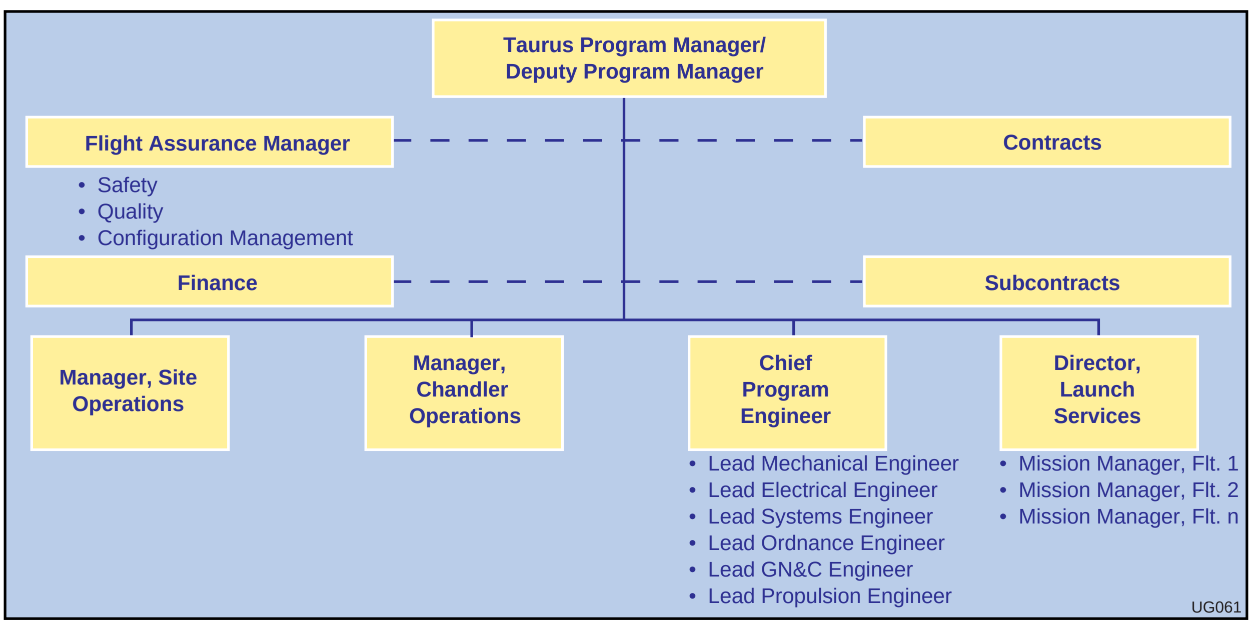


Figure 7-1. *Taurus Program Organization.*

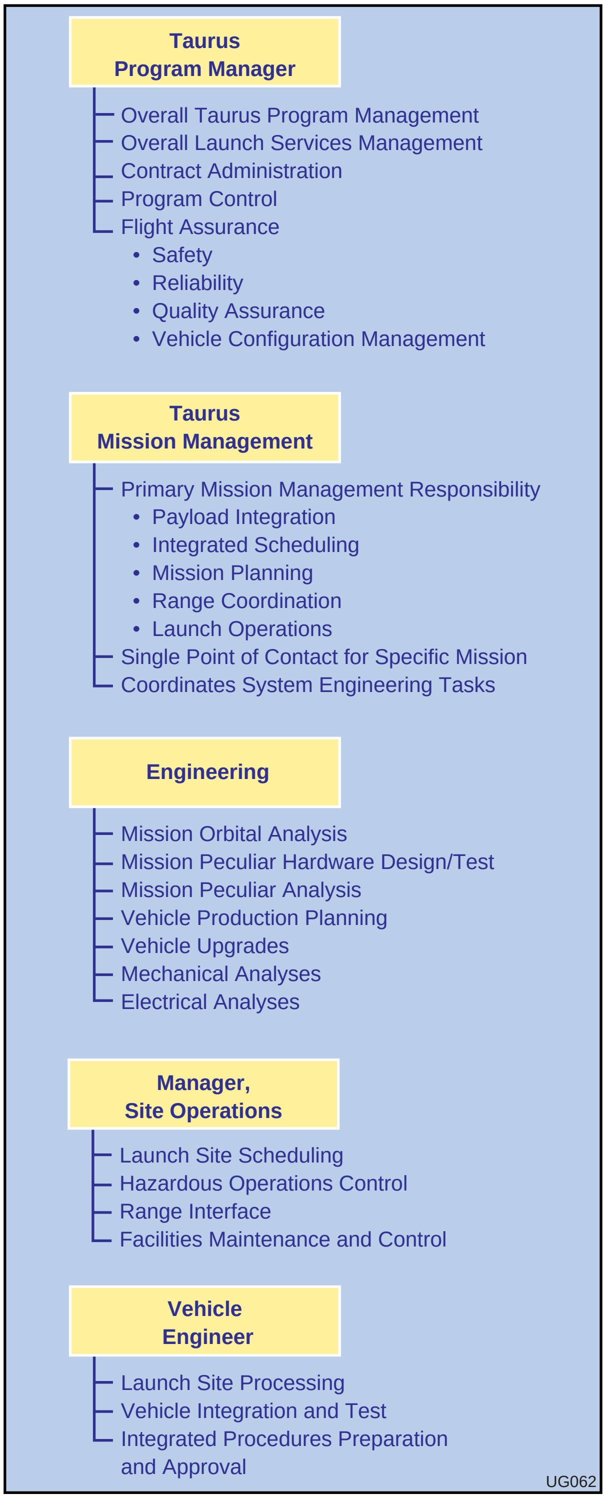


Figure 7-2. *Orbital Mission Responsibilities.*

coordination, payload integration services, systems engineering, mission-peculiar design and analyses coordination, payload interface definition, launch range coordination, integrated scheduling, launch site processing, and flight operations.

Taurus Chief Program Engineer/Engineering Leads—The Orbital engineering activities within the Taurus Program are directed by the Taurus Chief Program Engineer. The Chief Program Engineer is supported by a team of engineering leads and support staffs representing all of the required engineering disciplines. This group of individuals is responsible for supporting mission integration activities for all Taurus missions. The primary mission engineering support tasks include mission analyses, software development, mission-peculiar hardware design and testing, and mission-peculiar analyses.

Manager, Site Operations — The Manager of Site Operations is responsible for supporting operations for all Taurus missions. Primary mission responsibilities include overall integration planning, vehicle procedure development, and range and production facility coordination.

Vehicle Engineer—The Orbital Vehicle Engineer is responsible for the integration of a specific mission. This person has overall technical program authority and responsibility to ensure that a vehicle is integrated to support a specific launch. The Orbital Vehicle Engineer supports the Taurus Mission Manager to ensure that vehicle preparation is on schedule.

All work that is scheduled to be performed on the vehicle is directed and approved by the Vehicle Engineer. This includes preparation and execution of work procedures, launch vehicle processing, and control of hazardous operations. All hazardous procedures are approved by the launch range safety representative, the Orbital Vehicle Engineer, and the Orbital Safety Manager prior to execution. In addition, Orbital Safety and Quality Assurance engineers are always present to monitor critical and hazardous operations. Scheduling of payload encapsulation and integration with the launch vehicle and all related activities are also coordinated by the Vehicle Engineer.

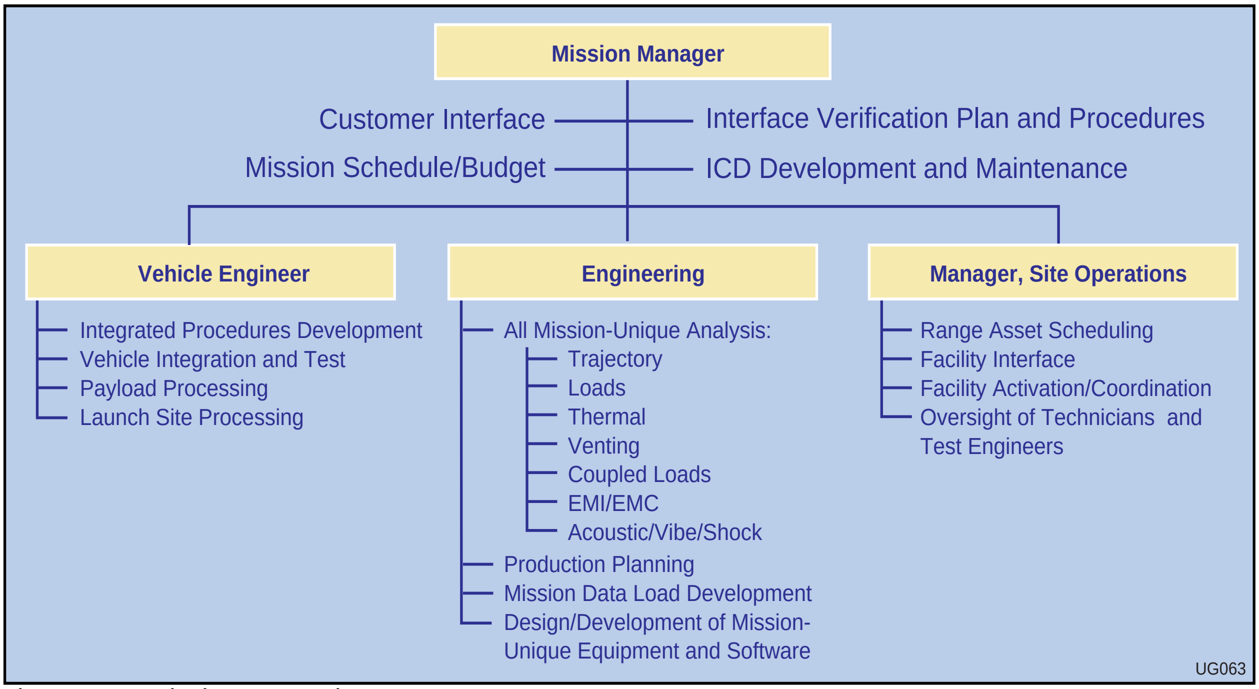


Figure 7-3. *Mission Integration Management Structure.*

7.2.1 Customer Mission Responsibilities

The customer mission responsibilities are summarized in Figure 7-4. The Payload Mission Manager is responsible for ensuring that the interests of the mission are best served. Once the mission services are defined, the Payload Mission Manager has insight into the mission integration analyses and tests that are performed by Orbital. In addition, the Payload Mission Manager remains fully apprised of launch vehicle production and testing activities as well as launch site activities prior to payload arrival. Once the payload is delivered to the launch site, all activities are controlled by an integrated processing schedule which is developed by the Mission Managers and approved by all organizations prior to implementation.

7.3 Working Groups

The core of the mission integration process consists of a series of Mission Integration and Range Working Groups (MIWG and RWG, respectively). The MIWG has responsibility for all physical interfaces between the payload and the launch vehicle. As such, the MIWG creates and implements the Payload-to-Taurus ICD in addition to all mission-unique analyses, hardware, software, and integrated procedures. The RWG is responsible for the areas of launch site operations; range interfaces; safety review and approval; and flight design, trajectory, and guidance. Documentation produced by the RWG includes all required range and safety submittals.

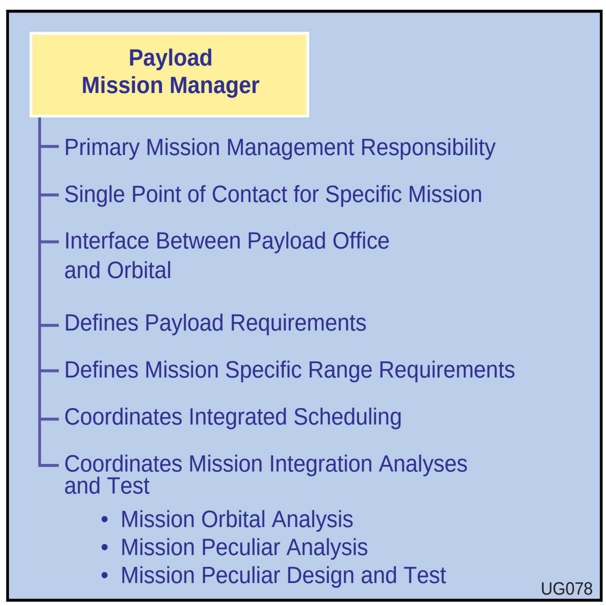


Figure 7-4. *Customer Mission Responsibilities.*

Working Group membership consists of the Mission Manager and representatives from Taurus' engineering and operations organizations, as well as their counterparts from the customer organization. While the number of meetings, both formal and informal, required to develop and implement the mission integration process will vary with the complexity of the spacecraft, bi-monthly meetings are typical.

7.4 Mission Planning and Development

Orbital will assist the customer with mission planning and development associated with Taurus launch vehicle systems. These services include interface design and configuration control, development of integration processes, launch and launch vehicle related analyses, facilities planning, launch campaign planning to include range services and special operations, and integrated schedules.

The procurement, analysis, integration and test activities required to place a customer's payload into orbit are typically conducted over a 26 month long standard sequence of events called the Mission Cycle. This cycle begins 24 months before launch, and extends to eight weeks after launch. The duration of the Mission Cycle can be adjusted to meet customer constraints.

Once contract authority to proceed is received, the Mission Cycle is initiated. The contract designates the payload, launch date, and basic mission parameters. In response, the Taurus Program Manager designates an Orbital Mission Manager who ensures that the launch service is supplied efficiently, reliably, and on-schedule.

The typical Mission Cycle interweaves the following activities:

a. Mission management, document exchanges, meetings, and formal reviews required to coordinate and manage the launch service.
b. Mission analyses and payload integration, document exchanges, and meetings.
c. Design, review, procurement, testing and integration of all mission-peculiar hardware and software.
d. Range interface, safety, and flight operations activities, document exchanges, meetings and reviews.

Figure 7-5 details the typical Mission Cycle for a specific launch and how this cycle folds into the Orbital vehicle production schedule with typical payload activities and milestones. A typical Mission Cycle is based on a 24 month interval between mission authorization and launch. This interval reflects the most efficient schedule based on Orbital's Taurus and Pegasus program experience. However, Orbital is flexible to negotiate either accelerated cycles, which take advantage of the Taurus/Pegasus multi-customer production sets, or extended cycles required by unusual payload requirements, such as extensive analysis or complex payload-launch vehicle integrated designs or tests.

7.5 Reviews

During the integration process, reviews are held to provide the coordination of mission participants and management outside of the regular contact of the Working Groups. Due to the variability in complexity of different payloads and missions, the content and number of these reviews can be tailored to customer requirements. At a minimum, Orbital will conduct two readiness reviews as described below.

Mission Readiness Review — Conducted within one month of launch, the Mission Readiness Review (MRR) provides a pre-launch assessment of integrated launch vehicle/payload/facility readiness prior to committing significant resources to the launch campaign.

Launch Readiness Review — The Launch Readiness Review (LRR) is conducted at L-1 day and serves as the final assessment of mission readiness prior to activation of range resources on the day of launch.

7.6 Documentation

Integration of the payload requires detailed, complete, and timely preparation and submittal of interface documentation. As the launch service provider, Orbital is the primary communication path with support agencies, which include—but

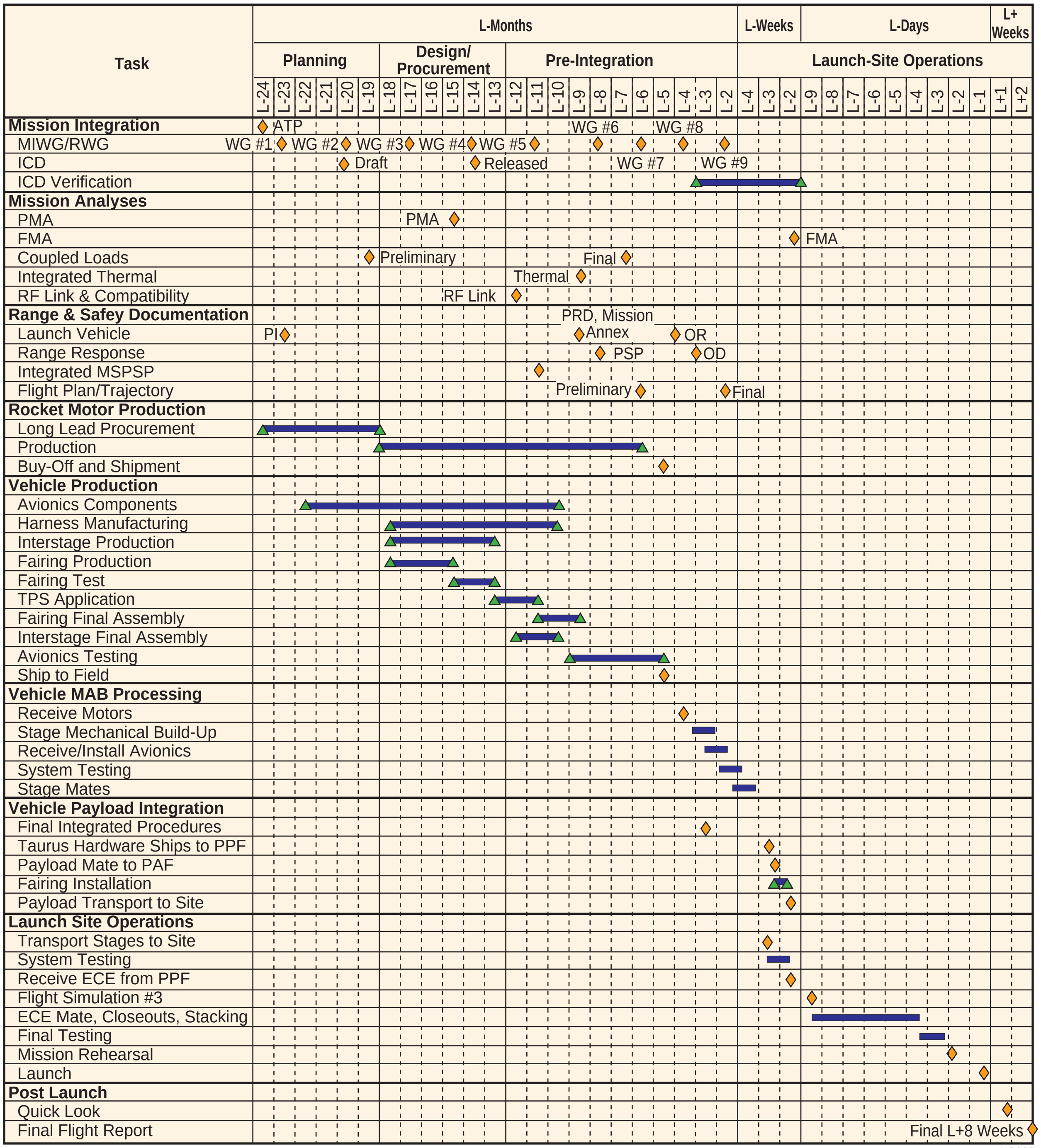


Figure 7-5. *Typical Master Schedule.*

are not limited to—the various Range support agencies and U.S. Government agencies such as the FAA, U.S. Department of Transportation and U.S. State Department. Customer-provided documents represent the formal communication of requirements, safety data, system descriptions, and mission operations planning. The major products and submittal times associated with these organizations are divided into two areas—those products that are provided by the customer, and those produced by Orbital.

7.7 Customer-Provided Documentation

Documentation produced by the customer is summarized in Figure 7-6 and detailed in the following paragraphs.

7.7.1 Payload Questionnaire

The Payload Questionnaire is designed to provide the initial definition of payload requirements, interface details, launch site facilities, and preliminary safety data to Orbital. The customer shall provide a response to the Payload Questionnaire form (Appendix A) as soon as the spacecraft definition is reasonably firm (e.g., when the RFP is released) but not later than one week after authority to proceed has been provided. The customer's responses to the payload questionaire define the most current payload requirements and interfaces and are instrumental in Orbital's preparation of numerous documents including the ICD, Preliminary Mission Analysis, and launch range documentation. Additional pertinent information, as well as preliminary payload drawings, should also be included with the response. Orbital understands that a definitive response to some questions may not be feasible. These items are defined during the normal mission integration process.

7.7.2 Payload Finite Element Model

A payload mathematical model is required for use in Orbital's preliminary coupled loads analyses. Acceptable forms include either a Craig-Bampton model to 120 Hz or a NASTRAN model limited to 50,000 DOF.

7.7.3 Safety Documentation

For each Taurus mission, Orbital acts as the interface between the mission and Range Safety. In order to fulfill this role, Orbital requires safety information from the payload. For launches from either the Eastern or Western Ranges, EWR 127-1 provides detailed range safety regulations. To obtain approval to use the launch site facilities, specified data must be prepared and submitted to the Taurus Program Office. This information includes a description of each payload hazardous system and evidence of compliance with safety requirements for each system. Drawings, schematics, and assembly and handling procedures, including proof test data for all lifting

Deliverable	Delivery Date
Payload Questionnaire	ATP + 1 Week
Payload Finite Element Model	ATP + 1 Month
Payload Safety Documentation	L-15 Months
PPF Requirements	L-14 Months
Payload Inputs to PRD Mission Annex	L-13 Months
Payload Input for Acoustic Analysis	L-13 Months
Payload Thermal Model	L-11 Months
Test Verified Finite Element Model	L-9 Months
Payload Input for Launch OR	L-6 Months
Payload Launch Site Procedures	L-5 Months
Payload Inputs to Integrated Test Procedures	L-4 Months
Final Payload Mass Properties	L-2 Months
ICD Verification Documentation	L-2 Weeks

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Figure 7-6. *Customer-Provided Documentation.*

equipment, as well as any other information that will aid in assessing the respective systems should be included. Major categories of hazardous systems are ordnance devices, radioactive materials, propellants, pressurized systems, toxic materials, cyrogenics, and RF radiation. Procedures relating to these systems as well as any procedures relating to lifting operations or battery operations should be prepared for safety review submittal. Orbital will provide this information to the appropriate safety offices for approval.

7.7.4 PPF Requirements

The customer is required to provide data on all payload activities to be performed at the PPF. This includes detailed information of all facilities, services, and support requested by Orbital and the PPF provider.

7.7.5 Program Requirements Document (PRD) Mission Specific Annex Inputs

To obtain range support from ER and WR, a PRD must be prepared. A Taurus PRD has been submitted and approved by the range. This document describes requirements needed to support the Taurus launch vehicle. For each launch, an annex is submitted to specify the range support needed to meet the mission's requirements. This annex includes all payload requirements as well as any additional Taurus requirements that may arise to support a particular mission. The customer completes all appropriate PRD forms for submittal to Orbital.

7.7.6 Payload Vibroacoustic Model

An acoustic model is required for use in Orbital's mission-specific vibroacoustic analysis. The analysis is performed using a customer provided statistical energy model of the payload in VAPEPS format or, alternatively, Orbital will construct a suitable model using customer supplied geometric data, cross-sectional properties, and mass properties of the payload.

7.7.7 Payload Thermal Model for Integrated Thermal Analysis

A payload thermal model is required for use in Orbital's integrated thermal analysis. The analysis is conducted for three mission phases:

(1) Prelaunch ground operations;
(2) Ascent from liftoff until fairing jettision; and
(3) Fairing jettison through payload deployment.

Models must be provided in SINDA format. There is no limit on model size although turn-around time may be increased for excessively large models.

7.7.8 Test Verified Payload Finite Element Model

A test verified payload model is required for use in Orbital's final coupled loads analysis. Acceptable forms include either a Craig-Bampton model to 120 Hz or a NASTRAN model limited to 50,000 DOF.

7.7.9 Launch Operations Requirements (OR) Inputs

To obtain range support for the launch operation and associated rehearsals, an OR must be prepared. The customer must provide all payload launch day requirements for incorporation into the mission OR.

7.7.10 Payload Launch Site Test Procedures

All hazardous procedures to be conducted at the launch facility must be prepared for safety approval, as discussed in Section 7.7.3. In addition, any payload procedures that are performed after fairing encapsulation must be presented to Orbital for review prior to use.

7.7.11 Payload Integrated Test Procedure Inputs

For each mission, Orbital requires detailed spacecraft requirements for integrated activities. With these requirements, Orbital will produce the procedures discussed in Section 7.8.14.

7.7.12 Payload Final Mass Properties

Accurate mass properties are required two months prior to launch so that Orbital may submit the final trajectory analysis to the range no later than 45 days prior to launch. Since the "final" spacecraft mass properties may not be determined until after propellant loading or other operations at the launch site, the requirement for the mass properties provided to Orbital is that they be within the specified ICD tolerances to those mass properties measured after final launch site operations.

7.7.13 Taurus/Payload ICD Verification Documentation

Orbital conducts a rigorous verification program to ensure all requirements on both sides of the interface have been successfully fulfilled. As part of the ICD, Orbital produces a verification matrix that indicates how each ICD requirement will be verified (e.g., test, analysis, demonstration, etc.). As part of the verification process, Orbital will provide the customer with a form to complete for each interface that is the responsibility of the payload to meet. The form clearly identifies the documentation to be provided as proof of verification. Likewise, Orbital provides similar data for all interfaces that are the responsibility of the Taurus vehicle, as discussed in Section 7.8.18.

7.8 Orbital Produced Documentation

Documentation produced by Orbital is summarized in Figure 7-7 and detailed in the following paragraphs.

7.8.1 Payload Separation Analysis

Orbital performs the necessary evaluations using the Taurus STEP 6-DOF simulation and the Dynamic Analysis and Design System (DADS) tools to ensure that the payload is in the desired orientation for successful separation at the end of boost. This analysis verifies that sufficient separation distance exists between the payload and the final stage and will include the effects of separation system operation and residual final stage thrust. Attitude and rate errors are defined as part of this process. For customers using the Orbital supplied separation system, the expected spacecraft tip off rates are also provided.

7.8.2 PPF Requirements Document

Orbital will prepare the necessary documentation to secure the use and required services of an appropriate PPF. The documentation is based on inputs received from the customer.

7.8.3 Program Introduction (PI)

The PI provides the initial notification to the launch range that a mission is beginning. It identifies the general requirement and schedule for the mission. The resulting response from the launch range (Statement of Capabilities) describes the range's ability to meet the mission requirements. Based on inputs from the payload payload questionnaire, Orbital will produce the PI and submit the PI to the range. If agreeable to the range, the PI can be accomplished by a short presentation. It is recommended that payload representatives be present at such a meeting.

7.8.4 Coupled Loads Analysis (Preliminary and Final)

Orbital has developed and validated finite element structural models of the Taurus vehicle for use in coupled loads analyses with Taurus payloads. Orbital will incorporate the customer-provided payload model into the Taurus finite element model and perform a preliminary coupled loads analysis to determine the maximum responses of the entire stack under transient loads. Once a test validated spacecraft model has been delivered to

Deliverable	Dependent On	Delivery Date
Preliminary Separation Analysis	Payload Questionnaire Payload Drawings	ATP + 1 Month
PPF Requirements	Payload PPF Requirements Input	L-23 Months
Program Introduction	Payload Questionnaire	L-23 Months
Preliminary Coupled Loads Analysis	Finite Element Model	L-19 Months
Preliminary Mission Analysis (PMA)	Payload Questionnaire Draft ICD	L-15 Months
Released Interface Control Document	Payload Questionnaire Payload Drawings MIWG	L-14 Months
RF Compatibility Analysis	Payload Questionnaire Payload Definition	L-12 Months
Vibroacoustic Analysis	Statistical Energy Model of Payload	L-11 Months
Integrated MSPSP	Payload Safety Package	L-11 Months
Program Requirements Mission Annex	Payload PRD Forms	L-9 Months
Integrated Thermal Analysis	SINDA or Equivalent Payload Model	L-9 Months
Final Coupled Loads Analysis	Test Verified FEM	L-7 Months
Fairing Clearance Analysis	Final Coupled Loads Analysis Taurus Structural Test Results	L-6 Months
Operations Requirements	Payload Inputs	L-4 Months
Integrated Launch Site Test Procedures	Payload Procedure Inputs	L-3 Months
Mission Constraints Document	Payload Mission Constraints	L-2 Months
Countdown Procedure	Payload Inputs	L-1 Month
Final Mission Analysis	Final Mass Properties	L-2 Weeks
Taurus ICD Verification Documentation	No Payload Input Required	L-2 Weeks
Quick Look Report	Launch	L+3 Days
Final Flight Report	Range Data	L+8 Weeks

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Figure 7-7. *Orbital Produced Documentation.*

Orbital, a final load cycle is completed. In both cases, results are provided to the customer in a timely fashion after each load cycle is complete. In some cases, interim results can be made available. Close coordination between the customer and the Taurus program office is essential to ensure correct output format and work schedule for the analysis.

7.8.5 Preliminary Mission Analysis

Orbital performs preliminary mission analyses using the industry standard POST and Orbital-developed STEP simulation tools. The primary objective is to determine the compatibility of the payload with Taurus and to provide succinct, detailed mission requirements, such as performance capability, accuracy estimates and preliminary mission sequencing. The results of these analyses are incorporated in the Mission ICD.

7.8.6 Interface Control Document (ICD)

The Taurus-to-Payload ICD documents all mission-peculiar requirements agreed upon by Orbital and the customer. The ICD contains the payload description, electrical and mechanical interfaces, fairing requirements, targeting criteria, description of the mission-peculiar vehicle, and a description of special LSE and facilities required. As part of this document, Orbital provides a comprehensive matrix which lists all ICD requirements and the method in which they are validated. The initial issue of the mission ICD is based upon data provided in the Payload Questionnaire and initial meetings between the two organizations. The ICD is updated as required. As a subset of the ICD, the Payload Mechanical Interface Control Drawing (MICD) and Electrical Interface Control Drawing (EICD) are described in the following paragraphs.

7.8.6.1 Payload Mechanical Interface Control Drawing (MICD)

The Payload MICD is generated by Orbital using the customer-provided configuration drawings. This drawing combines the payload and pertinent Taurus components and illustrates all mechanical interfaces. The Payload MICD shows the payload-fairing dynamic envelope, payload access door locations, and other interface details. The payload MICD will be accepted as part of the ICD between Orbital and the customer.

7.8.6.2 Payload Electrical Interface Control Drawing (EICD)

The Payload EICD is generated by Orbital. Like the MICD, the EICD shows all payload-to-Taurus electrical interfaces. The EICD includes a wiring diagram and pin assignments for all power, control, telemetry, and monitor interfaces required to support the payload. The Payload EICD is formally accepted as part of the ICD between Orbital and the customer. If the electrical interface can be adequately illustrated within the size limitations of the ICD, it will be included as part of the Taurus-to-Payload ICD and a separate electrical drawing will not be required.

7.8.7 RF Compatibility Analysis

Orbital performs the analysis necessary to ensure electromagnetic compatibility of the launch vehicle with the payload and the appropriate range.

7.8.8 Vibroacoustic Analysis

A mission-specific vibroacoustic analysis using the VAPEPS analytic tool is conducted by Orbital to determine acoustic levels within the fairing and random vibration levels at the payload interface using a customer-supplied payload statistical energy model. Alternatively, Orbital will construct a suitable model using customer supplied geometric data, cross-sectional properties, and mass properties of the payload.

7.8.9 Integrated Missile System Pre-Launch Safety Package (MSPSP)

This information includes an assessment of any hazards which may arise from mission specific vehicle functions and by the payload, and is provided as an appendix to the baseline MSPSP. The customer must provide the information pertaining to the payload. Orbital assesses the combined vehicle and payload for hazards and prepares a report of the findings. Orbital will then forward the integrated assessment to the appropriate launch range for approval.

7.8.10 PRD Mission Specific Annex Inputs

Once customer PRD inputs are received, Orbital reviews the inputs and, upon issue resolution, submits the mission specific PRD annex to the range for approval. The range will respond with a Program Support Plan (PSP) indicating their ability to support the stated requirements.

7.8.11 Integrated Thermal Analysis

Orbital performs thermal analyses using our PATRAN model to derive form factors to be used as input into the industry-standard SINDA finite difference model. Integrated Taurus/payload thermal analyses are performed using the payload parameters supplied to Orbital by the customer.

7.8.12 Fairing Clearance Analysis

Combining coupled loads analysis results, Taurus structural test deflection results, stackup tolerances, and misalignments, Orbital validates the adequacy of the payload dynamic envelope within the Taurus payload fairing.

7.8.13 OR Inputs

Orbital submits the OR to obtain range support for the launch operation and associated rehearsals. Detailed information regarding all aspects of launch day, particularly communication requirements, are detailed in the OR. Orbital generates the document, solicits comments from the customer, and, upon comment resolution, forwards the mission OR to the range for approval. The range generates the Operations Directive (OD) which is used by range support personnel as guidance for providing the launch day service.

7.8.14 Integrated Launch Site Test Procedures

For each mission, Orbital prepares integrated procedures for various operations that involve the payload. These include, but are not limited to: payload mate to the Taurus adapter; fairing encapsulation; encapsulated payload transport to the launch site; flight simulations; and final vehicle closeouts. Once customer inputs are received, Orbital will provide draft procedures for review and comment. Once concurrence is reached regarding all comments, final procedures will be released prior to use. Draft hazardous procedures must be presented to the appropriate launch site safety organization 90 days prior to use and final hazardous procedures are due 30 days prior to use.

7.8.15 Mission Constraints Document

This Orbital-produced document summarizes launch day operations for the Taurus vehicle as well as for the payload. Included in this document is a comprehensive definition of the Taurus and payload launch operations constraints, the established criteria for each constraint, the decision making chain of command, and a summary of personnel, equipment, communications, and facilities that will support the launch.

7.8.16 Final Countdown Procedure

Orbital produces the launch countdown procedure that readies the Taurus and payload for launch. All Taurus and payload activities that are required to be performed during the final countdown are included in the procedure.

7.8.17 Final Mission Analysis

The Final Mission Analysis consists of several detailed analyses which thoroughly evaluate the planned mission and its effects throughout powered flight. These analyses include, but are not limited to: trajectory, injection accuracy, re-contact and CCAM, venting, launch window, guidance, and stability/control analyses. This analysis, along with other analyses and software verification efforts, results in a verified mission-unique Mission Data Load used for final flight simulations performed at the launch site as well as for launch.

7.8.18 Taurus/Spacecraft ICD Verification Documentation

Orbital is responsible for providing documentation for all Taurus interface requirements. This documentation will be provided for customer review and approval as part of the team effort to complete a thorough verification that ICD requirements have been met. For non-U.S. customers, this information is limited by the rules set forth in Orbital's Technical Assistance Agreement (TAA) from the State Department.

7.8.19 Post-Launch Analyses

Orbital provides post-launch analyses to the payload in two forms. The first is a quick-look assessment provided within three days of launch. The quick-look data report includes preliminary trajectory performance data, orbital accuracy estimates, system performance preliminary evaluations, and a preliminary assessment of mission success. The second, a more detailed final report of the mission, will be provided to the customer within eight weeks of launch. Included in the final mission report is the actual mission trajectory, event times, significant events, environments, orbital parameters and other pertinent data reduced from on-board telemetry and range tracking sensors. Photographic and video documentation, as available, is included as well. Orbital also analyzes telemetry data from each launch to validate Taurus' performance against the mission ICD requirements. In the case of any mission anomaly, Orbital will conduct an investigation and closeout review.

Section 8
Optional Services

8.1 Optional Services

Orbital offers a variety of optional services to satisfy the varied requirements of Taurus payloads. This section of the User's Guide details the optional services that are currently available to Taurus customers. If a unique requirement exists that is not addressed within this section, please inquire directly to the Taurus Program to determine how best to meet the need.

8.2 Dual Manifest Options

The Taurus Program possesses significant experience in implementing dual-manifest configurations. Two of the three launches conducted to date have delivered multiple spacecraft to orbit, as will two of the next three missions on the manifest. Orbital provides two payload support structures that enable dual payload manifesting while maintaining independent load paths for the payloads. The 63" (1.6 m) diameter Dual Payload Attach Fitting (DPAF) was successfully flown on the second Taurus mission. The 50" (1.3 m) diameter Aft Payload Capsule (APC) will fly on the fourth and sixth Taurus missions.

8.2.1 63″ Dual Payload Attach Fitting

The 63" DPAF is comprised of a graphite/epoxy cylinder, a 63" diameter frangible joint separation system, and a graphite/epoxy forward payload cone. The forward payload cone utilizes the same basic design as the standard Taurus payload cone with only minor modifications for use in the DPAF application. The forward payload cone and the cylindrical section carry the loads induced by the forward payload, while an aft payload cone supports the loads induced by the aft payload. A contamination shield is provided to prevent cross-contamination between the two payload cavities. After the forward payload is successfully separated, the forward payload cone is deployed to allow for the successful separation of the aft payload. The deployment sequence is designed to ensure collision avoidance among the multiple bodies.

The DPAF has been designed and qualified so that the DPAF length can be tailored to meet mission-unique requirements. The DPAF cylinder has been qualified for use in lengths up to 85 inches (2.2 m). Figure 8-1 depicts the payload dynamic envelopes available for the forward and aft payloads as a function of DPAF length. Note that the diameter of the envelope available for the secondary payload is a function of payload separation clearances, and, as such, is dependent on payload geometry and mass properties and the separation system that is selected. Typically, the available envelope is approximately 48 inches (1.2 m) in diameter.

8.2.2 50″ Aft Payload Capsule

The 50" APC is comprised of two graphite/epoxy shells joined by a 50" diameter frangible joint

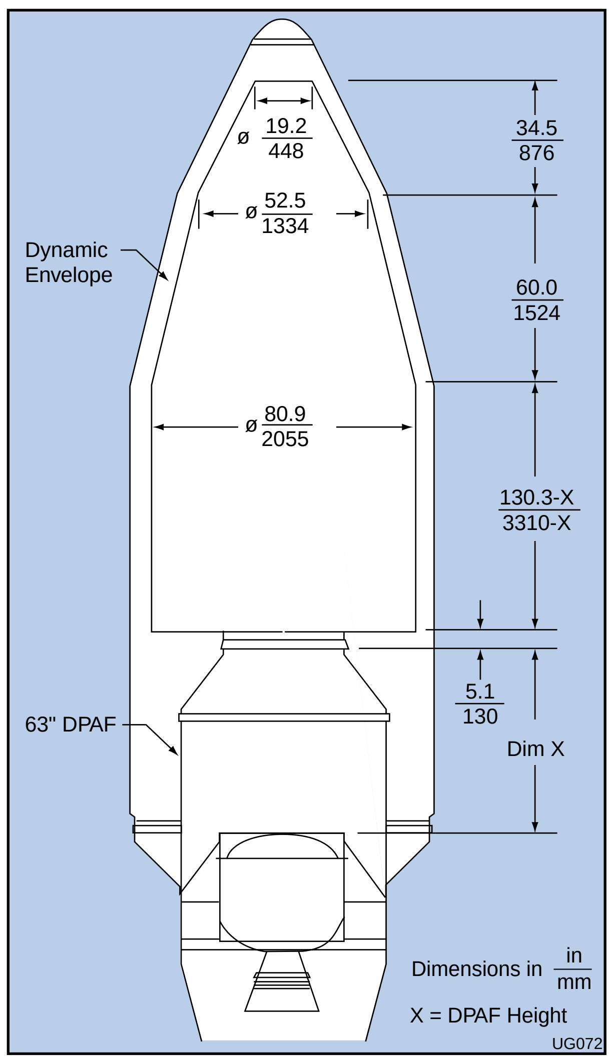


Figure 8-1. *92" Fairing with 63" DPAF.*

separation system. The graphite/epoxy shells isolate the aft payload from the loads induced by the forward payload. A contamination shield is provided to prevent cross-contamination between the two payload cavities. After the forward payload is successfully separated, the forward APC section is deployed to allow for the successful separation of the aft payload. The deployment sequence is designed to ensure collision avoidance among the multiple bodies.

The APC has been designed and qualified so that its length can be tailored to meet mission-unique requirements. The maximum available length is 72 inches (1.8 m). Figure 8-2 depicts the payload dynamic envelopes available for the forward and aft payloads as a function of APC length. The diameter of the envelope available for the secondary payload is a function of payload separation clearances, and, as such, is dependent on payload geometry and mass properties and the separation system that is selected. Typically the available envelope is approximately 40 inches (1.0 m) in diameter. Note that the APC may be used with either the 63" or 92" payload fairing configurations.

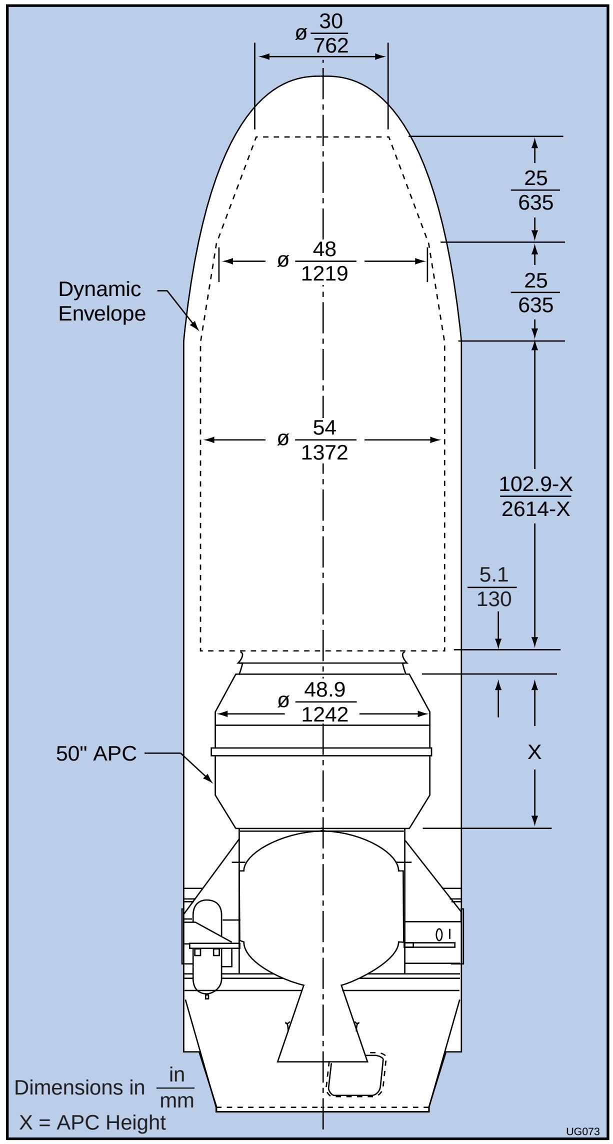


Figure 8-2. *63" Fairing with APC.*

8.3 Payload Fairing Options

Orbital offers a number of non-standard services that can be selected to customize Taurus' payload fairings to meet the requirements of a particular mission. These services are detailed in the subsequent paragraphs.

8.3.1 Additional Fairing Access Doors

Additional access doors can be provided for either payload fairing configuration. The standard door sizes are 12 in x 12 in (305 mm x 305 mm) for the 63" payload fairing and 18 in x 24 in (457 mm x 610 mm) for the 92" payload fairing. As part of this non-standard service, Orbital will perform structural analyses to verify the acceptability of the mission-specific door configuration.

8.3.2 Fairing Access Doors of Non-Standard Size

Access doors of non-standard size can be provided for either payload fairing configuration. Included in this non-standard service are structural analyses of the payload fairing, design and analysis of the access cover and mounting frame, and modification of the fairing acoustic blanket layout. This non-standard service may also be used to provide access doors in locations beside the cylindrical section of the payload fairing.

8.3.3 Fairing Acoustic Blanket Tailoring

The thickness of the payload fairing acoustic blankets can be tailored to meet mission-unique environmental requirements. There will be a corresponding impact on vehicle performance and the available payload fairing dynamic envelope.

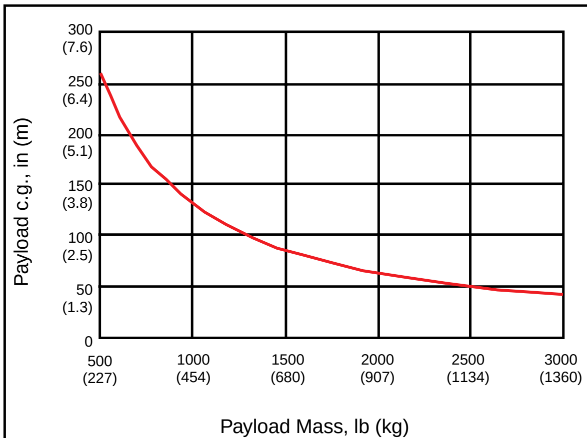
8.4 Optional Mechanical Interfaces

Orbital offers two alternate separating interfaces and one non-separating interface as optional services. These systems are discussed in the following paragraphs along with an optional surface treatment for thermal control purposes.

8.4.1 High Capacity Payload Separation System

Orbital can provide a high capacity payload separation system with a 38.81 inch (986 mm) diameter payload bolted interface. This system provides a significantly higher payload capability at the cost of a somewhat lower tip-off performance and a higher interface shock environment. The separation system is manufactured for Orbital by Saab Ericsson Space of Sweden. Saab has extensive experience supplying separation systems for a wide range of launch vehicles and payloads. The high capacity Taurus 38.81" system is based on a separation system with considerable flight heritage.

The separation system is a marmon clamp band design that employs two aluminum interface rings that are clamped by dual, semi-circular stainless steel clamp bands with aluminum clamp shoes. Separation velocity is provided by up to eight matched spring actuators that impart up to 27.7 ft-lb (37.6 Joules) of energy. The electrical interface across the separation plane is accomplished via two low separation impulse connector assemblies. The structural capacity of the separation system is detailed in Figure 8-3.



Assumptions: Axial Accel = 2 g's (Tension), Lateral Accel = 3.5 g's, Load Peaking Factor = 1.0 (Where Load Peaking Is Defined as: Ratio of Maximum Predicted Line Load to Maximum Line Load Which Would Occur for an Ideal Uniform Structure.) UG074

Figure 8-3. *High Capacity Payload Separation System Structural Capability.*

8.4.2 23″ Payload Separation System

Orbital can also provide a payload separation system with a 23.25 inch (591 mm) diameter payload bolted interface as a non-standard service. Orbital developed this system for the Pegasus program to support smaller payloads.

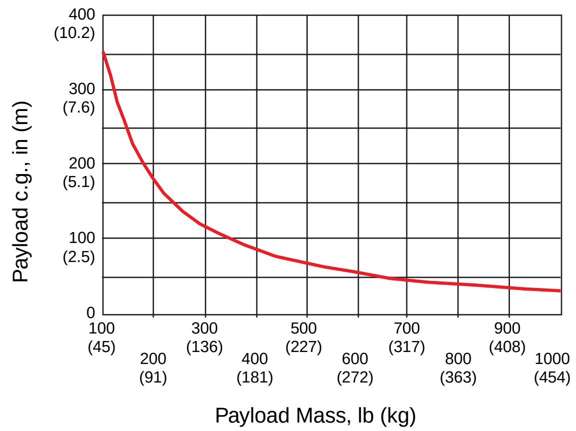
The 23.25" separation system is a marmon clamp band design that employs two aluminum interface rings that are clamped by a titanium clamp band with aluminum clamp shoes. Separation velocity is provided by a set of four matched separation springs that impart 16.4 ft-lbs (22.2 Joules) of energy. An adapter cone is provided with the 23.25" separation system to interface with the standard Taurus 38.81" interface. The electrical interface across the separation plane is accomplished via two connector assemblies. One connector assembly is dedicated for payload telemetry and the other for pyro commands. Each assembly includes a MIL-C-38999 Series, Type II connector (with the locking collar removed) and all required mounting bracketry. The structural capacity of the 23.25" separation system is provided in Figure 8-4.

8.4.3 Non-Separating Payload Interface

Orbital can provide a non-separating payload interface as a non-standard service. The non-separating interface is a 38.81" diameter bolt circle. In this optional service, the customer will supply any required separation connectors/ harnessing. This harnessing must interface with a connector plate located on the payload support structure.

8.4.4 Separation System Thermal Treatment

As a non-standard service, the forward ring of the payload separation system can be coated with surface treatments for on-orbit thermal control purposes.



Assumptions: Axial Accel = 2 g's (Tension), Lateral Accel = 3.5 g's, Load Peaking Factor = 1.0 (Where Load Peaking Is Defined as: Ratio of Maximum Predicted Line Load to Maximum Line Load Which Would Occur for an Ideal Uniform Structure.)

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Figure 8-4. *23.25" Payload Separation System Structural Capability.*

8.5 Payload Isolation System

Orbital offers a flight-proven payload isolation system as a non-standard service. This mechanical isolation system has demonstrated the capability to significantly alleviate the dynamic loads induced by the resonant burn environment inherent to the Castor 120 solid rocket motor. The isolation system can provide relief to both the overall payload center of gravity loads and component or subsystem responses. The isolation system does impact overall vehicle performance (by approximately 20-40 lb [9-18 kg]) and the available payload dynamic envelope (by approximately 1.0 in [25.4 mm]).

8.6 Performance Enhancements

If more performance is required than can be provided by the standard Taurus configuration, there are several options for increasing the available mass-to-orbit. Using stretched Orion motors for Stages 1 and 2 (known as "XL" motors) increases Taurus performance to low earth orbits by approximately 440 lb (200 kg).

In another option, the Orion 38 Stage 3 motor can be replaced with a spinning STAR 37FM motor as a non-standard service. The payload dynamic envelopes provided by this option are depicted in Figure 8-5 and Figure 8-6 for the 63" and 92" payload fairings, respectively. Use of the STAR 37FM spinning upper stage boosts Taurus performance to low Earth orbits by approximately 350 lb (160 kg), in large part because the avionics structure is jettisoned once the STAR 37/payload stack has been spun up. The spinning upper stage option is particularly useful for high energy trajectories, as shown by the performance curves in Figure 8-7.

Along with the STAR 37FM motor itself, this non-standard service includes a de-spin system, a tumble system for collision and contamination avoidance, a nutation control system, a payload separation system, and spin-balancing of the spacecraft and motor assembly.

8.7 Contamination Control Options

Understanding that payloads have varying requirements for cleanliness, Orbital offers a number of contamination control options. Taurus customers can select any combination of these options to meet the unique needs of their payloads.

8.7.1 Class 10,000 Integration Environment

As a non-standard service, the payload processing facility can maintain a Class 10,000 environment. The Class 10,000 environment will be certified and maintained for all payload processing operations up to and including the fairing encapsulation procedure.

8.7.2 Fairing Surface Cleanliness Options

The internal surfaces of the payload fairing and payload cone structures can be cleaned and certified to precision cleaning levels. Included in this non-standard service are development of a mission-unique contamination control plan, cleaning of the fairing and payload cone internal surfaces and components, and certification per Mil-Std-1246. Cleanliness levels as stringent as Level 500A can be provided.

8.7.3 Instrument Purge or Spot Cooling System

Orbital can provide gaseous nitrogen or helium purges to the payload. The instrument purge system will supply the purge gas to a disconnect fitting on the payload separation system from the

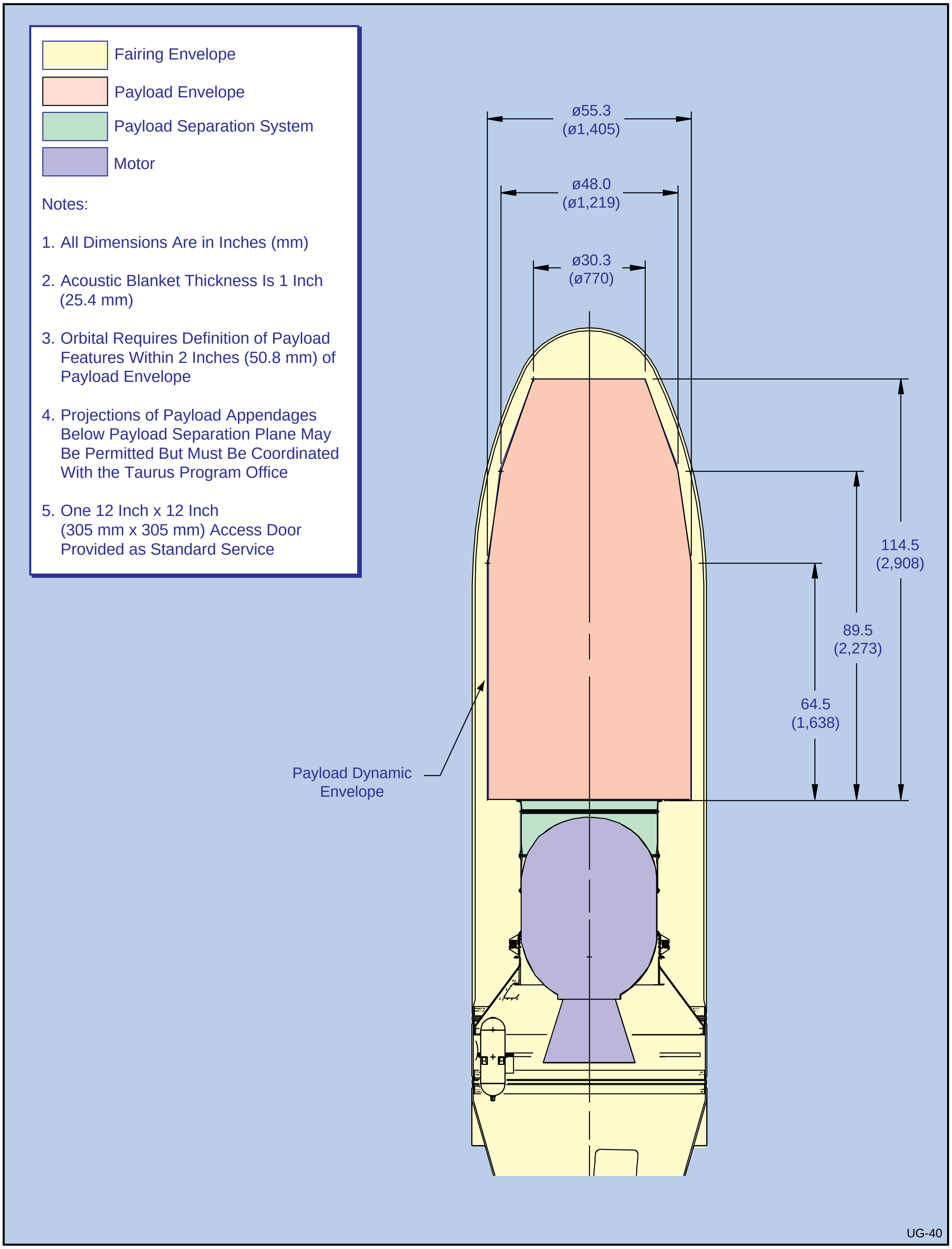

Figure 8-5. *Payload Dynamic Envelope for 63" Diameter Fairing, STAR 37FM Configuration.*

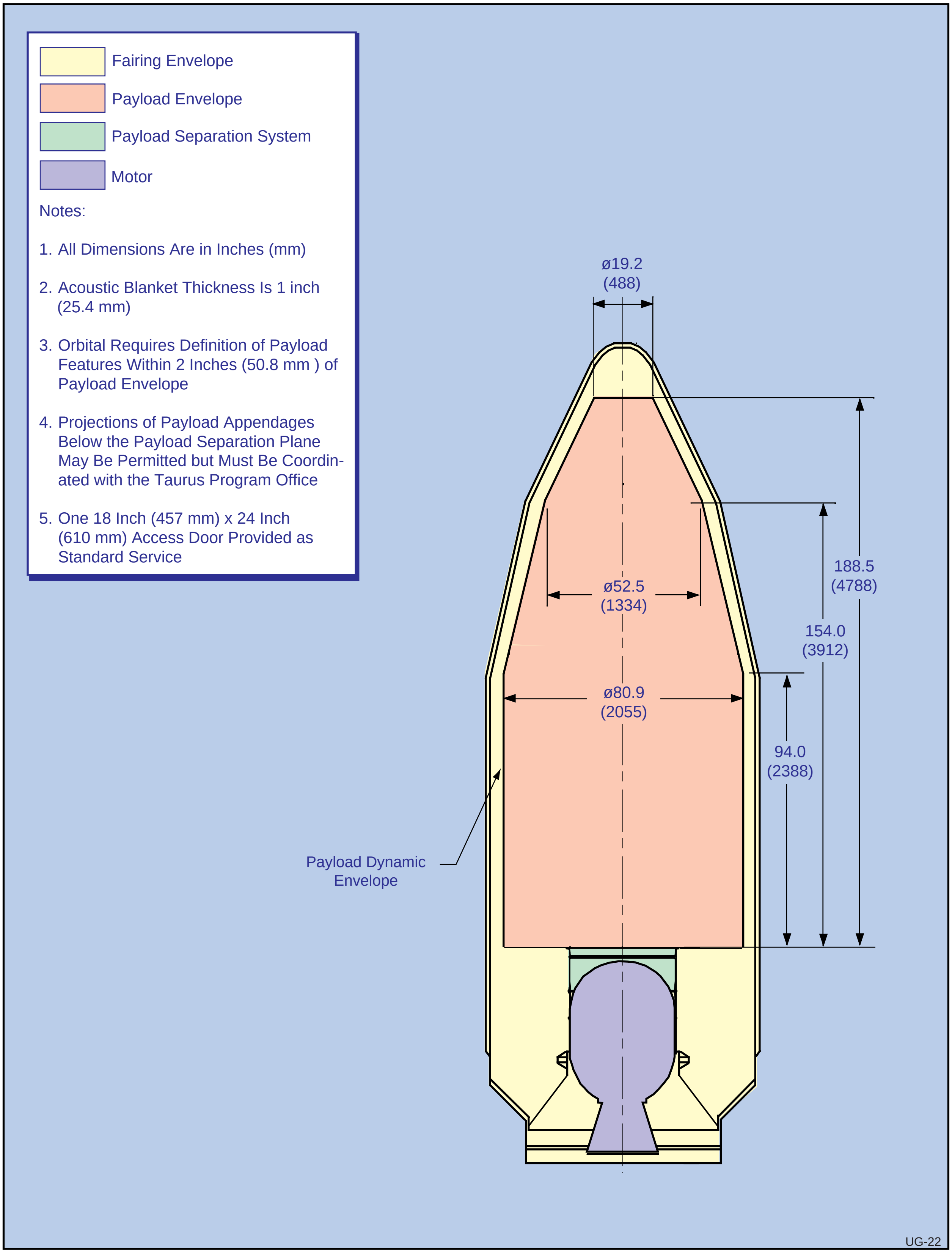

Figure 8-6. *Payload Dynamic Envelope for 92" Diameter Fairing, STAR 37FM Configuration.*

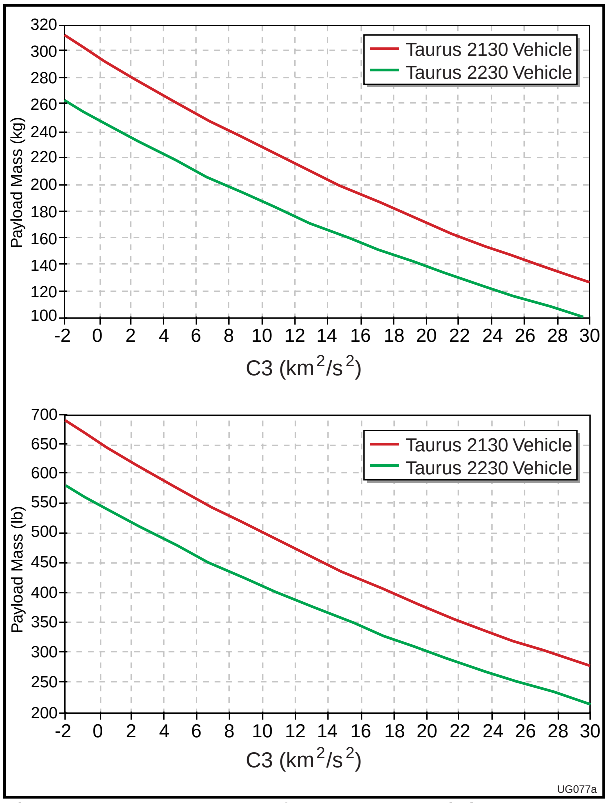

Figure 8-7. *Taurus Performance to High Energy Trajectories.*

time of fairing encapsulation through lift-off. The gas flow rate and cleanliness can be tailored to meet mission-unique requirements. This system can also be used for cooling a specific location on the payload.

8.7.4 Hydrocarbon Monitoring

As a non-standard service, Orbital can monitor hydrocarbon levels in the PPF and inside the payload fairing after encapsulation. The detailed monitoring requirements will be tailored on a mission-unique basis.

8.8 Real-Time Telemetry Downlink Through Payload Separation

For some Taurus missions, payload separation occurs after loss of the telemetry signal from the range. This non-standard service provides real-time telemetry through payload separation using mobile assets.

8.9 Payload Propellant Loading

Payload loading services for mono-propellant hydrazine or bi-propellant systems can be provided by Orbital at the PPF.

8.10 On-Board Video System

Orbital can provide an on-board video camera system. The camera system provides a real-time video downlink from forward- and aft-looking cameras mounted on the Taurus Stage 2 motor. The cameras switch views (between forward and aft) as commanded by the flight computer to capture critical staging events and fairing separation.

Appendix A
Taurus Payload Questionnaire

TAURUS®
PAYLOAD QUESTIONNAIRE

SATELLITE IDENTIFICATION

FULL NAME:	
ACRONYM:	
OWNER/OPERATOR:	
INTEGRATOR(s):	

ORBIT INSERTION REQUIREMENTS*

SPHEROID	❑ Standard (WGS-84, R_e = 6378.137 km) ❑ Other: ____	
ALTITUDE	Insertion Apse: ____ ± ____ ❑ nmi ❑ km	Opposite Apse: ____ ± ____ ❑ nmi ❑ km
or...	Semi-Major Axis: ____ ± ____ ❑ nmi ❑ km	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:
OTHER CONSTRAINTS (if not already implicit from LAN or RAAN requirements, e.g., solar beta angle, eclipse time constraints, early on-orbit ops, etc):

EARLY ON-ORBIT OPERATIONS

Briefly describe the satellite early on-orbit operations, e.g., event triggers (separation sense, sun acquisition, etc), array deployment(s), spin ups/downs, etc:

SATELLITE 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 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
	Xcg: ____________	❑ in ❑ cm	Ixx: ____________ Iyy: ____________
	Ycg: ____________	❑ in ❑ cm	Izz: ____________ Ixy: ____________
	Zcg: ____________	❑ in ❑ cm	Iyz: ____________ Ixz: ____________
POST-SEPARATION (non-separating adapter remaining with launch vehicle)	Mass: ____________	❑ lb_m ❑ kg	Inertia units: ❑ lb_m-in^2 ❑ kg-m^2
	Xcg: ____________	❑ in ❑ cm	Ixx: ____________ Iyy: ____________
	Ycg: ____________	❑ in ❑ cm	Izz: ____________ Ixy: ____________
	Zcg: ____________	❑ in ❑ cm	Iyz: ____________ Ixz: ____________

* Stowed configuration, spacecraft coordinate frame

ASCENT TRAJECTORY REQUIREMENTS	
Free Molecular Heating at Fairing Separation: (Standard Service: ≤ 360 Btu/ft²/hr)	FMH ≤ ________ ❑ Btu/ft²/hr ❑ W/m²
Fairing Internal Wall Temperature (Standard Service: ≤ 250°F)	T ≤ ________ ❑ deg F ❑ deg C
Dynamic Pressure at Fairing Separation: (Standard Service: ≤ 0.01 lb_f/ft^2)	q ≤ ________ ❑ lb_f/ft^2 ❑ N/m²
Ambient Pressure at Fairing Separation: (Standard Service: ≤ 0.3 psia)	P ≤ ________ ❑ lb_f/in^2 ❑ N/m²
Maximum Pressure Decay During Ascent: (Standard Service: ≤ 0.6 psi/sec)	Δ P ≤ ________ ❑ $lb_f/in^2/sec$ ❑ N/m²/sec
Thermal Maneuvers During Coast Periods: (Standard Service: none)	

	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 (Standard Service is 55°F to 80°F)
	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 (Standard Service is 37 deg F)
NITROGEN PURGE	Specify Any Nitrogen Purge Requirements, 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

TAURUS®
PAYLOAD QUESTIONNAIRE

ELECTRICAL INTERFACE		
Bonding Requirements:		
Are Launch Vehicle Supplied Pyro Commands Required? Yes / No	If Yes, magnitude: ________ amps for ________ msec (Standard Service is 5 amps for 75 msec)	
Are Launch Vehicle Supplied Discrete Commands Required? Yes / No	If Yes, describe:	
Is Electrical Access to the Satellite Required...	...in the PPF After Encapsulation?	Yes / No
	...at Launch Site Prior to Mating T-0 Umbilical?	Yes / No
Is Satellite Battery Charging Required...	...in the PPF After Encapsulation?	Yes / No
	...at Launch Site Prior to Mating T-0 Umbilical?	Yes / No
Is a Telemetry Interface with the Launch Vehicle Flight Computer Required? Yes / No If Yes, describe:		
Other Electrical Requirements:		

Please complete attached sheet of required pass-through signals.

RF RADIATION		
Time After Separation Until RF Devices Are Activated: (Note: Typically, no spacecraft radiation is allowed from encapsulation until 45 minutes after liftoff.)		
Frequency: ______________ MHz	Power: ______________ Watts	
Location(s) on Satellite (spacecraft coordinate frame):		
Longitudinal ________ ❑ in ❑ cm	Clocking (deg), Describe:	
Longitudinal ________ ❑ in ❑ cm	Clocking (deg), Describe:	

REQUIRED PASS-THROUGH SIGNALS

Item #	Pin	Signal Name	From LEV	To Satellite	Shielding	Max Current (amps)	Total Line Resisitance (ohms)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
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21							
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25							
26							
27							
28							

MECHANICAL INTERFACE

DIAMETER	Describe Diameter of Interface (e.g. Bolt Circle, etc):
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:
SURFACE FLATNESS	Flatness Requirements for Sep System or Mating Surface of Launch Vehicle:
FAIRING ACCESS	Payload Fairing Access Doors (spacecraft coordinate frame): Longitudinal _________ ❑ in ❑ cm Clocking (deg), Describe: Longitudinal _________ ❑ in ❑ cm Clocking (deg), Describe: Note: Standard Service is one door
DYNAMICS	Spacecraft Natural Frequency: Axial ___________ Hz Lateral ___________ Hz Recommended: > 35 Hz > 25 Hz
OTHER	Other Mechanical Interface Requirements:

GROUND SUPPORT EQUIPMENT

Describe any additional control facilities (other than Taurus provided Launch Support Van and Launch Equipment Van) which the satellite intends to use:

LSV

Describe (in the table below) Satellite EGSE to be located in the LSV.
[Note: Space limitations exist in the LSV]

Equipment Name / Type	Approximate Size (LxWxH)	Power Requirements
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....

Is UPS required for equipment in the LSV? Yes / No
Is Fax connection required in the LSV? Yes / No

LEV

Describe (in the table below) Satellite EGSE to be located in the LEV.
[Note: Space limitations exist in the LEV]

Equipment Name / Type	Approximate Size (LxWxH)	Power Requirements
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....

Is UPS required for equipment in the LEV? Yes / No
Is Ethernet connection between LSV and LEV required? Yes / No