8. MISSION INTEGRATION AND OPERATIONS

Overview

This section describes mission management, mission integration and launch operations for a typical Land Launch mission.

The detailed topics are:

- Mission management.
- Mission documentation and schedule.
- Mission analysis.
- Operations planning.
- Launch Campaign.
- Post flight operations.
- Safety.
- Quality Assurance.

The Launch Services Agreement (LSA) for a Land Launch mission contains a Statement of Work (SOW) that details the services shown in this section and identifies the tasks and deliverables. The mission integration master schedule will contain these tasks and deliverables.

8.1 Mission Management

Mission Manager

To provide the customer with efficient mission integration and launch operations processes, Land Launch assigns a Mission Manager to be the direct point of contact between the customer and the Land Launch organization throughout the program. The Mission Manager will be responsible for ensuring the timely and satisfactory completion of all aspects of the mission including technical analyses, documents, launch campaign and schedule.

The Mission Manager organizes and chairs all meetings and reviews according to the Mission Integration Schedule, of which an example is provided in Section 8.2. Land Launch and the customer will meet as often as necessary to support the mission.

Mission Team Roles and Responsibilities

The mission team is responsible for all mission analyses, operations planning, and launch campaign activities. On Land Launch the mission team is comprised of the Mission Manager, SIS (see Section 1 for a description of SIS) and Boeing's technical staff. SIS will perform the mission analyses in Section 8.3 as well as the launch campaign. Boeing's technical staff will be used in an oversight role.

8.2 Mission Documentation and Schedule

Overview

Land Launch will prepare all the documentation required for the launch service. Land Launch will maintain configuration control of all signed mission documentation. Changes to signed documentation will be made via formal change proposals.

Integration Documentation

At the beginning of the integration process, documentation needed for spacecraft integration will be coordinated with the customer and will be based on the Statement of Work (SOW) contained in the Launch Services Agreement (LSA).

Spacecraft/Land Launch System Interface Control Document

Land Launch will create the spacecraft/Land Launch system Interface Control Document (ICD) that defines the technical interface requirements for the launch service. It will be based on the customer Interface Requirements Document (IRD), any other spacecraft requirements, and the launch vehicle and launch site characteristics. Once signed by Land Launch and by the customer, this document will be under configuration control.

ICD Verification Matrix

The ICD verification matrix defines the process by which the ICD requirements and functions are to be verified. The matrix is included in the ICD. All requirements must be met and verified prior to launch.

Mission Integration Schedule

Land Launch will develop the mission specific integration schedule based on the launch date contained in the LSA. The schedule will contain all milestones necessary for a successful completion of the contract. A typical schedule for a non-recurring mission is provided in Table 8-1.

Table 8-1. Typical Mission Integration Schedule

Event/Milestone	Date
Program Management	
Program Kickoff Meeting	L - 18 Months
Program Management Plan	L - 17 Months
Quarterly Management Report	L - 15, 12, 9, 6, 3 Months
Interface Activities	
Spacecraft Interface Requirements Document (IRD)	L - 18 Months
Spacecraft Environmental Test Plan	L - 15 Months
Preliminary Interface Control Document (ICD)	L - 15 Months
Preliminary Design Review (PDR)	L - 11 Months
Final ICD	L - 10 Months
Matchmate/Shock Test Plan	L - 10 Months
Critical Design Review (CDR)	L - 6 Months
Matchmate/Shock Test (first of a type)	L - 5 Months
Safety	
Spacecraft Safety Data Package	L - 12 & L- 6 Months
Launch Campaign Activities	
Ground Operations Working Group (GOWG # 1)	L - 12 Months
Launch Operations Plan	L - 8 Months
Spacecraft Preshipment Review (GOWG #2)	L - 2 Months
Spacecraft arrival at Baikonur	L - 1 Month
Combined Operations Readiness Review	L – 1 Month
Transfer Readiness Review (rollout to pad)	L – 3 days
Launch Readiness Review (LRR)	L - 7 hours
Launch	L
Post Launch Activities	
Spacecraft Orbit Data	L + 45 Minutes
Spacecraft GSE Shipment from Baikonur	L + 3 days
Flight Data Report	L + 2 Months

8.3 Mission Analyses

Mission Analyses Mission analyses are performed to verify that the spacecraft requirements are satisfied and to demonstrate the compatibility of the spacecraft with the launch vehicle. Typically all mission analyses will be performed to support the Preliminary Design Review (PDR), and then repeated with updated spacecraft information for the Critical Design Review (CDR). The typical analyses include:

- Mission design
- Spacecraft separation analysis
- Thermal analysis
- Coupled Loads Analysis (CLA)
- Clearance analysis
- Venting analysis
- RF link and EMC analyses
- Contamination analysis

The mission design will include the trajectory, orbit and dispersions, flight sequences through spacecraft separation, verification of attitude requirements through separation and collision avoidance.

The spacecraft separation analysis determines the relative velocity between the spacecraft and the launch vehicle upon separation, the angular velocity of the spacecraft, and the clearances.

Thermal analyses are performed to demonstrate the spacecraft compatibility with thermal environments to which it will be exposed, during ground operation and during launch through spacecraft separation. A spacecraft thermal model is required from the customer.

The CLA is performed to determine spacecraft loads, accelerations and displacements for the critical flight events. The CLA will allow the customer to determine structural margins. The CLA will determine the permissible notching during spacecraft sine vibration testing. A spacecraft dynamic model is required from the customer.

The clearance analysis is performed to determine the clearances between the spacecraft and fairing during encapsulation and during flight. Manufacturing tolerances are included in this analysis.

The venting analysis determines the fairing depressurization rate during flight.

The RF link analysis is performed to demonstrate that spacecraft RF requirements have been satisfied. The EMC analysis demonstrates RF compatibility between the spacecraft and launch vehicle at the launch base and during flight.

The contamination analysis is performed to verify that accumulated contamination during operations and flight will not exceed requirements.

8.4 Operations Planning

Launch Campaign Planning

Launch site operations planning will be conducted as necessary during the mission integration phase and will be concluded before the beginning of the launch campaign. During the operations planning phase, an Operations Plan and overall schedule will be produced.

The Operations Plan will be based on the spacecraft autonomous operations requirements, the launch vehicle autonomous requirements, the combined operations requirements and the ICD. This plan will include a description of all operations from spacecraft arrival through launch including SC GSE departure after launch. The plan will include a list of reviews and major milestones.

The operations overall schedule will be based on the Operations Plan and serve as the baseline schedule for the launch campaign. The schedule will include all operations and reviews identified in the plan and will be the basis for the daily schedules produced at the launch site. When necessary, the schedule will be modified to reflect the current status of activities. A typical launch campaign schedule is shown in Table 8-2.

Table 8-2. Typical Launch Campaign Schedule

Event/Milestone Completion	Launch +/- time
Spacecraft (SC) arrival at Baikonur, delivery to PPF	L - 30 days
SC to fueling area	L - 20 days
SC fueling complete	L - 15 days
SC mate to adapter	L - 14 days
Mate of SC/adapter stack to Block DM (Zenit-3SLB) or Intersection Bay (Zenit-2SLB)	L - 12 days
Encapsulation	L - 9 days
Mate of Ascent Unit (Zenit-3SLB) or PLU (Zenit-2SLB) to Zenit stages in Area 42	L - 6 days
Transfer Readiness Review	L - 3 days
Roll-out and erection on pad	L – 2 days
Launch Readiness Review (LRR)	L – 7 hours
Launch	L
SC GSE leaves Baikonur	L + 3 days

8.5 Launch Campaign

Overview

Land Launch makes use of existing facilities and processes for spacecraft autonomous, launch vehicle autonomous and combined operations. Land Launch will support the customer during spacecraft autonomous operations. Land Launch is responsible for all launch vehicle and combined operations.

The launch campaign begins with delivery of the spacecraft and GSE to the Baikonur Cosmodrome in Kazakhstan and is concluded with the shipment of the spacecraft GSE from Baikonur. The Spacecraft Preshipment Review verifies the readiness of the SC and GSE for shipment to Baikonur.

Spacecraft Arrival and Transport

The SC and GSE arrive at the Yubileiny airfield within the confines of Baikonur Cosmodrome. The SC and GSE are offloaded from the aircraft and loaded onto rail cars on an adjacent railhead. The aircraft offloading area is located approximately 50 meters from the railway loading area. Land Launch will support the offload and provide equipment to load the SC and GSE onto rail cars, and to supply conditioning air to the SC container during rail transport. Land Launch will transfer the SC and GSE from the airfield to the Payload Processing Facility (PPF), either area 31 or 254 as previously agreed with the customer, where the containers are offloaded in an airlock.

Spacecraft Processing

The customer will perform the necessary standalone spacecraft operations and tests in the PPF to prepare the spacecraft for fueling. These operations may include:

- Unpacking and visual inspection.
- Assembly and functional tests.
- Electrical checkout.

Land Launch provides the customer with the use of the PPF during standalone spacecraft operations, and will transfer the SC and GSE from the PPF to the Hazardous Processing Facility (HPF). At Area 31 where the PPF and HPF are in separate buildings, the SC will be enclosed in a container and supplied with conditioned air during transfer.

Spacecraft Fueling

Spacecraft fueling is performed in the HPF. Land Launch and the customer will perform the following operations that include:

- Setup of SC.
- Setup of equipment.

- Setup of propellant tanks.
- Fill of the SC propellant and pressure tanks.

Hazardous operations are performed from a control room that is either safely remote from the fueling cell (Area 254 PPF) or blast-hardened (Area 31 PPF). Land Launch oversees these hazardous operations and ensures their safety.

Land Launch will transfer the fueled SC from the HPF to the PPF integration bay.

Spacecraft Mating with Launch Vehicle Elements in the PPF Integration Bay

After SC fueling and return to the integration bay, the following operations are performed:

- Final preparations of the SC and spacecraft adapter.
- SC mate on the adapter and attachment of the separation system.
- Mate of the spacecraft umbilical connectors.
- Electrical check.
- Mate of the SC/adapter stack with the Block DM-SLB (Zenit-3SLB) or Intersection Bay (Zenit-2SLB).
- Electrical check.
- Rotation of the stack to the horizontal position.
- Enclosure of the SC with the fairing.
- Integrated testing and checkout.
- Preparation for transfer to Area 42, the LV integration building. The Ascent Unit (Zenit-3SLB) or PLU (Zenit-2SLB) is installed on a railroad car and a thermal conditioning unit is connected to the Ascent Unit/PLU. The environmental characteristics provided by conditioning unit are shown in Section 4.

The Ascent Unit (or PLU) is then transferred to Area 42 via rail, with an air supply system providing the fairing volume with clean, conditioned air whose characteristics are described in Section 4.

Launch Vehicle Autonomous Processing

Autonomous processing of the Zenit stages and the Block DM-SLB (Zenit-3SLB missions) is completed before the start of combined operations.

Mating with Zenit Stages

Integration of the Ascent Unit (AU) or PLU with the Zenit stages takes place inside a clean room within Area 42. The AU/PLU is delivered by rail, then transferred to a rail-mounted integration trolley for horizontal mate to the Zenit second stage, much like assembly of the Sea Launch Zenit-3SL on the center rail of the Assembly and Command Ship. Zenit electrical connections are fully verified end-to-end beforehand.

Integrated Testing

Integrated testing is performed following PLU/AU mating with the Zenit. The customer may perform SC battery charging prior to the ILV transfer to the pad. The clean room in Area 42 that is used for mating the AU/PLU to the Zenit may also be used to enclose the access door areas on the fairing if the customer needs to physically access the SC. The complete Integrated Launch Vehicle (ILV) is fully checked out prior to transfer to the launch pad (Area 45).

Transfer Readiness Review (TRR) and Transfer to the Launch Pad

A TRR is held prior to the transfer to the pad. This review verifies the readiness of the ILV, ground systems and launch base. The TRR authorizes the ILV transfer to the pad and subsequent final launch preparations.

In Area 42, the ILV is loaded onto the transporter-erector railcar (familiar to users of Sea Launch). This hoisting operation (no more than 1 hour) is the only time the payload enclosure is not either in the clean room or purged with clean, conditioned air. The ILV is transferred to the pad via rail, a distance of about four kilometers, in about 15 minutes.

Launch Pad Operations

Typical launch pad operations include:

- Erection of the ILV.
- Automated mating of all connectors (electrical, pneumatic, propellants, etc.).
- LV and SC checkouts and rehearsals.
- Integrated launch countdown rehearsals.
- Launch day countdown and launch.

Because of the highly automated nature of the Zenit, pad operations are typically very brief and launch can occur as little as 26-hours after arrival of the ILV at the launch pad unless the customer needs additional time for SC tests. The ILV can remain erect on the pad for up to four days, if necessary. Clean air to the fairing is maintained throughout.

Launch Readiness Review (LRR)

The LRR is held during launch day and prior to LV fueling, at approximately L-7 hours. The purpose of the review is to status the readiness of all systems including the LV, SC and the range. This review authorizes the fueling of the LV and continuation of the launch countdown.

Propellant Loading

Loading the ILV with compressed gasses begins 25 hours before launch. Propellant loading begins at L-3 hr after a poll of launch management and the customer gives the "go" for launch. From this point forward until T – 50 seconds, launch holds of up to 20 minutes (or the length of the launch window, if less than 20 minutes) are possible. If a launch abort is called, a recycle to a second launch attempt can normally be accomplished in two days.

Second "Go" Poll and Launch

The second "go" poll of launch management and the customer is conducted before disconnecting the transporter/erector from the launch vehicle at approximately L-12 minutes.

Launch Control Center

During all phases of launch processing and flight, the launch control center has ultimate responsibility and authority for all decisions and commands affecting the ILV. The Master Countdown Procedure as described in the SOW defines the communication architecture and protocol to be used by all parties during launch operations.

8.6 Post-Flight Activities

Land Launch will provide the customer with orbital data at spacecraft separation within 50 minutes after separation. Land Launch will support the customer in transferring GSE and containers from the work sites to Yubileiny airfield for shipment to the customer facility. Normally this activity is completed within three days after launch. Land Launch will transport the customer's propellant containers to the port of entry into Russia for shipment from there to the customer facility.

8.7 Safety

A safety evaluation of the spacecraft and launch processes is necessary to demonstrate that equipment and operations are safe for a Baikonur launch campaign. The customer will need to provide necessary data to assess all potential hazards introduced by the spacecraft processing during the launch campaign.

Land Launch will define the data required and will conduct reviews for new launch customers or first of a kind spacecraft. Follow-on missions with similar spacecraft and operations use an abbreviated version of this approach in which changes to the previously approved mission are identified. A safety demonstration will be accomplished through the submission of documents describing and defining all hazardous items and their processing. Submission documents are prepared by the customer and are identified in the customer SOW. The details of the necessary documents will be a topic at the program kick-off meeting.

A safety compliance certificate will be issued after Land Launch has verified that the customer has demonstrated that the spacecraft and procedures are in compliance for a launch from Baikonur.

8.8 Quality Assurance

General

Quality assurance, comprising qualification, acceptance, configuration management, quality, and reliability, falls under the purview of the Sea Launch Mission Assurance process. Sea Launch Mission Assurance is performed by the Mission Assurance organization and comprises the integrated set of systems and processes that ensures mission success and ever-increasing product reliability. Quality assurance is a continuous cycle that starts with the review of qualified flight-proven hardware and continues through the mission postflight data review and implementation of corrective actions and lessons learned for the next mission. Between

these points, the Sea Launch quality control and change management functions ensure that the vehicle reliability and system performance characteristics are maintained through a contolled set of launch vehicle processes and procedures

Hardware Review

A distinguishing feature of Sea Launch as an international launch services partnership is the hardware quality review that is performed at the factory level by Boeing engineers. This adds an extra layer of quality control and oversight to the rigorous systems already in place at each sub-contractor, and contributes to the outstanding launch success record at Sea Launch. This proven and existing hardware review system will be used to provide the same quality control and oversight for hardware that is destined for Land Launch missions.

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