

# **Proton Launch System Mission Planner's Guide**

## **SECTION 7**

### **Launch Campaign**



## 7. LAUNCH CAMPAIGN

### 7.1 ORGANIZATIONAL RESPONSIBILITIES

Many organizations are involved in a Launch Campaign (see Figure 7.1-1). What follows is a brief overview of the responsibilities of the primary organizations.

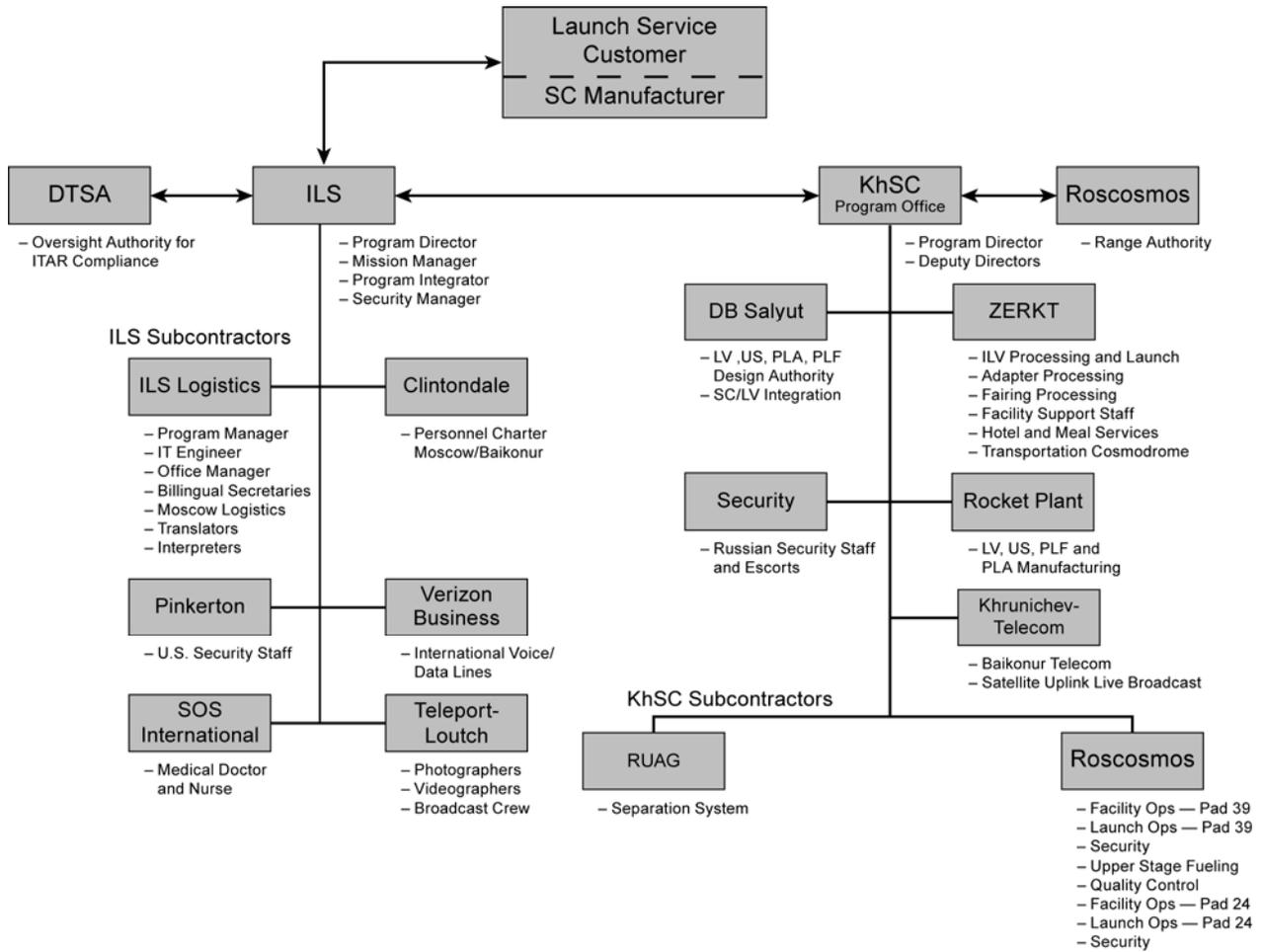
#### 7.1.1 Khrunichev

- Overall responsibility for coordinating work performed at the launch complex by Roscosmos.
- Engineering support and quality inspection for all testing performed on Stages 1 to 3 of the Launch Vehicle (LV), as well as the adapters and fairing. KhSC is also responsible for Breeze M engineering, inspection and test.
- Maintenance of Buildings 92A-50 and the hotel complex.
- Transportation and food services.
- Coordinating Baikonur Cosmodrome and the town of Baikonur medical services with Roscosmos.
- Integration facility security.

#### 7.1.2 Roscosmos

- Maintenance of the Breeze M fueling area and the launch complex.
- Provision of technicians for performing LV testing.
- Provision of quality inspectors.
- LV operations from integration in Building 92A-50, Hall 111 through erection on pad and launch.
- Launch complex security.

Figure 7.1-1: Organization During Launch Campaign



### **7.1.3 ILS**

- Prime interface between the Customer and KhSC.
- Coordinating campaign schedules and operations with the SC Customer and KhSC.
- Logistics.
- Safety overview as an advisory function to SC and Customer management.
- Physical security of SC assets while at Baikonur processing facilities.
- Translation and interpretation services.
- Medical staff and emergency medical evacuation.
- Compliance with U.S. regulations and licenses.

### **7.1.4 SC Customer**

- SC checkout and processing at the Baikonur Cosmodrome.

## **7.2 CAMPAIGN ORGANIZATION**

### **7.2.1 Contractual and Planning Organization**

The fundamental contractual relationships among the principal parties in a launch campaign are as follows:

- a) ILS is a contractor to the SC Customer.
- b) KhSC is a subcontractor to ILS.

All matters that could potentially affect the terms of the Launch Service Agreement (LSA) (the contract) between a SC Customer and ILS will be coordinated by the SC Customer and ILS. Matters affecting the terms of the subcontract between ILS and KhSC will be resolved by ILS and KhSC. In particular, any issues involving possible additional costs must be mutually agreed upon through these contractual relationships.

ILS will coordinate all logistics support and operations planning with both the SC Customer and KhSC.

ILS may assign a Mission Manager to monitor any operation to ensure that all activities are carried out in conformance with the mutually agreed upon Safety Plan. This Mission Manager is present for all hazardous operations.

### **7.2.2 Organization During Combined Operations**

Combined operations are those operations involving some combination of SC Customer organization, ILS, and KhSC personnel (e.g., KhSC adapter mating, Breeze M to payload mating, encapsulation, AU checkout, AU integration to mated Stages 1/2/3, and any other operations on the pad which require PLF access). For each such combined operation, one operation leader is assigned, either from KhSC or the SC Customer. This individual directs the operation and ensures that it is carried out in conformance with the mutually agreed upon procedures.

For each operation, one person from the SC Customer organization, ILS and KhSC is designated as team leader for their respective organizations. Agreements among organizations can only be reached among these three team leaders.

Security personnel from either or both ILS and KhSC may be present during any operation if required by the Security Plan.

ILS provides at least one interpreter for each combined operation. Special familiarization is conducted with the SC Customer and Russian personnel for joint crane operations to ensure reliable communications between English and Russian-speaking personnel.

Either KhSC or the SC Customer provides a Quality Assurance representative for each operation who documents any test discrepancies on a Quality Assurance Report.

Roscosmos personnel conduct many of the operations at the Baikonur Cosmodrome. Roscosmos acts as a KhSC subcontractor and coordinates directly with KhSC.

### **7.2.3 Planning Meetings**

ILS maintains the master schedule for operations planning and reviews it with the SC Customer and KhSC at a daily scheduling meeting. At this meeting, the current operations for the day are agreed upon and the operations for the following three days are reviewed. Following each meeting, ILS revises the master schedule for the following day. At a minimum, the following organizations must be represented at the daily scheduling meetings:

- SC Customer
- KhSC (and RUAG if needed)
- SC manufacturer
- ILS

At certain stages in the campaign, all agencies review their status to give the go-ahead for critical phases of a campaign. These critical phases include:

- SC off-load and move to integration hall
- SC processing and propellant loading
- SC encapsulation
- Launch

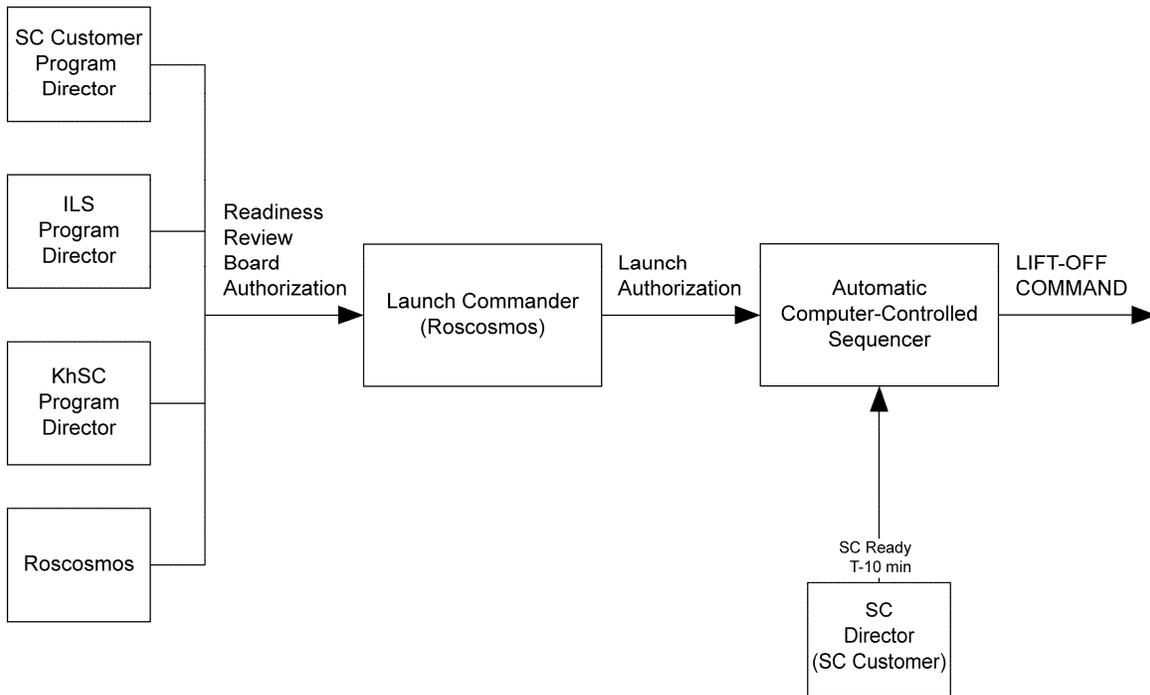
Two State Commission meetings, chaired by the Roscosmos, require high-level concurrence prior to proceeding to the next phase of the campaign. These are:

- Vehicle Readiness and Roll to Pad - six days prior to launch
- Vehicle Readiness for LV Propellant Load - eight hours prior to launch

### 7.3 COUNTDOWN ORGANIZATION

The countdown organization is illustrated in Figure 7.3-1.

Figure 7.3-1: Countdown Organization



Roscosmos directs the countdown, which follows a pre-approved script known as the 7/701 Script. The Launch Commander receives authorization to launch from the Readiness Review Board, which consists primarily of the four entities shown in Figure 7.3-1.

Certain organizations have pre-assigned abort capability. Each of these organizations is asked to acknowledge the readiness of their subsystems on launch day according to the launch day script. These subsystem readiness checks are as follows:

- a) Stages 1, 2, and 3 Readiness: KhSC
- b) Breeze M Readiness: KhSC
- c) SC Readiness: SC Customer

Each organization designates a single individual to provide readiness status to authorities on launch day, and each representative is vested with abort authority over the launch sequencer for their respective area of responsibility. For example, the SC Customer may abort the start sequence as late as 3.1 seconds prior to lift-off contact.

#### **7.4 ABORT CAPABILITY**

The Proton M LV has a digital Guidance, Navigation and Control (GN&C) system, which provides the SC Customer, as well as the Breeze M and booster, the capability to abort the launch. The Ground Launch Support & Test Equipment (GLSTE), as part of the LV GN&C, constitutes the principal hardware to support the readiness sequence during pre-launch activities. The GLSTE configures the LV GN&C for launch, leads the launch countdown, generates command signals to adjacent LV systems, performs LV and Breeze M airborne/ground systems health checks, and monitors a launch abort signal generated via the launch abort unit. The LV first stage ignites automatically on command from the LV GN&C.

Launch roles and communications are crucial to ensure that critical activities are performed on time, and that anomalies are clearly communicated and coordinated between all agencies. ILS is the interface between the LV provider and the SC services Customer. In the event of an abort, it is essential that communications remain absolutely clear, not only to ensure that proper action is taken, but because of the contractual relationships involved. The major tool used for coordination is the 7/701 Script, which is coordinated between ILS, the Customer, the SC manufacturer, and KhSC. KhSC coordinates the final 7/701 Script with the LV agencies and LV operator, typically Roscosmos.

The SC Customer is responsible for providing the SC "GO" status and also for initiating an abort, if required. Due to the close proximity of the Bunker to the Launch Pad, only the ILS Program Director will man the Launch Abort Switch in the Bunker.

Event Timelines:

- T-11 hr 30 min Breeze M GN&C GLSTE activated. Breeze M countdown activities commence.
- T-8 hr Launch GO/NO GO decision made by Russian Intergovernmental Commission. Launch pad is cleared of all non-essential personnel.
- T-6 hr 10 min LV GN&C GLSTE activated. SC abort unit power is applied.
- T-6 hr LV propellant loading commences.
- T-5 hr LV countdown activities commence.
- T-2 hr 30 min Launch pad re-opens for final closeouts.
- T-2 hr All personnel should be in their final positions for launch.
- T-1 hr Rollback of the Mobile Service Tower commences.
- T-45 min LV final countdown activities commence. Propulsion system GO signal is generated by the LV GN&C GLSTE. Countdown display system remote units are synchronized to the master CD clock.
- T-35 min LV GN&C GLSTE arms the launch abort systems. Readiness green indicator light illuminates on the launch abort unit front panel. Two redundant displays on the launch abort unit are synchronized to the CD clock and start countdown. SC launch unit abort switch is active.
- T-10 min SC Customer (701) gives verbal readiness on countdown network.
- T-5 min LV GN&C GLSTE sends a T-300 sec command signal to the Breeze M GN&C GLSTE to synchronize the lift-off time. Breeze M begins transfer to internal power.
- T-2 min LV GN&C begins transfer to internal power. Breeze M completes transfer to internal power, sends "BREEZE M GO" signal to LV GN&C GLSTE.
- T-3.1 sec LV GN&C GLSTE performs a final GO/NO-GO check of the LV, Breeze M and SC. If all the integrated LV components are GO, the first stage ignition sequence start is sent at the estimated time.
- ~T-0 Lift-off contact signal received (approximately T+2.49 ms).
- T+40 sec If the lift-off contact signal is not received, the Breeze M systems begin transfer to ground power.

### **7.4.1 Recycle Scenarios**

In the event that the launch count is aborted, recycle operations depend on the configuration of the SC and LV and the cause of the abort. An abort at any time in the count requires a minimum of 24 hours recycle.

The Proton LV does not have a launch window, rather it has a specific launch moment, which is determined during mission analysis and is driven by Customer performance requirements. The State Commission will convene immediately following receipt of an abort signal or certificate and safe completion of an abort. Follow-on actions will be briefed to the Customer if the abort was due to a LV or Breeze M NO-GO. The Customer will be requested for time estimates and requirements in the event of a Customer NO-GO. LV de-fueling and de-erection requirements will be determined at this time. The LV may remain loaded, depending on ambient conditions, if a simple 24-hour recycle is anticipated.

## **7.5 LAUNCH CAMPAIGN OVERVIEW**

This section provides an overview of LV and SC processing.

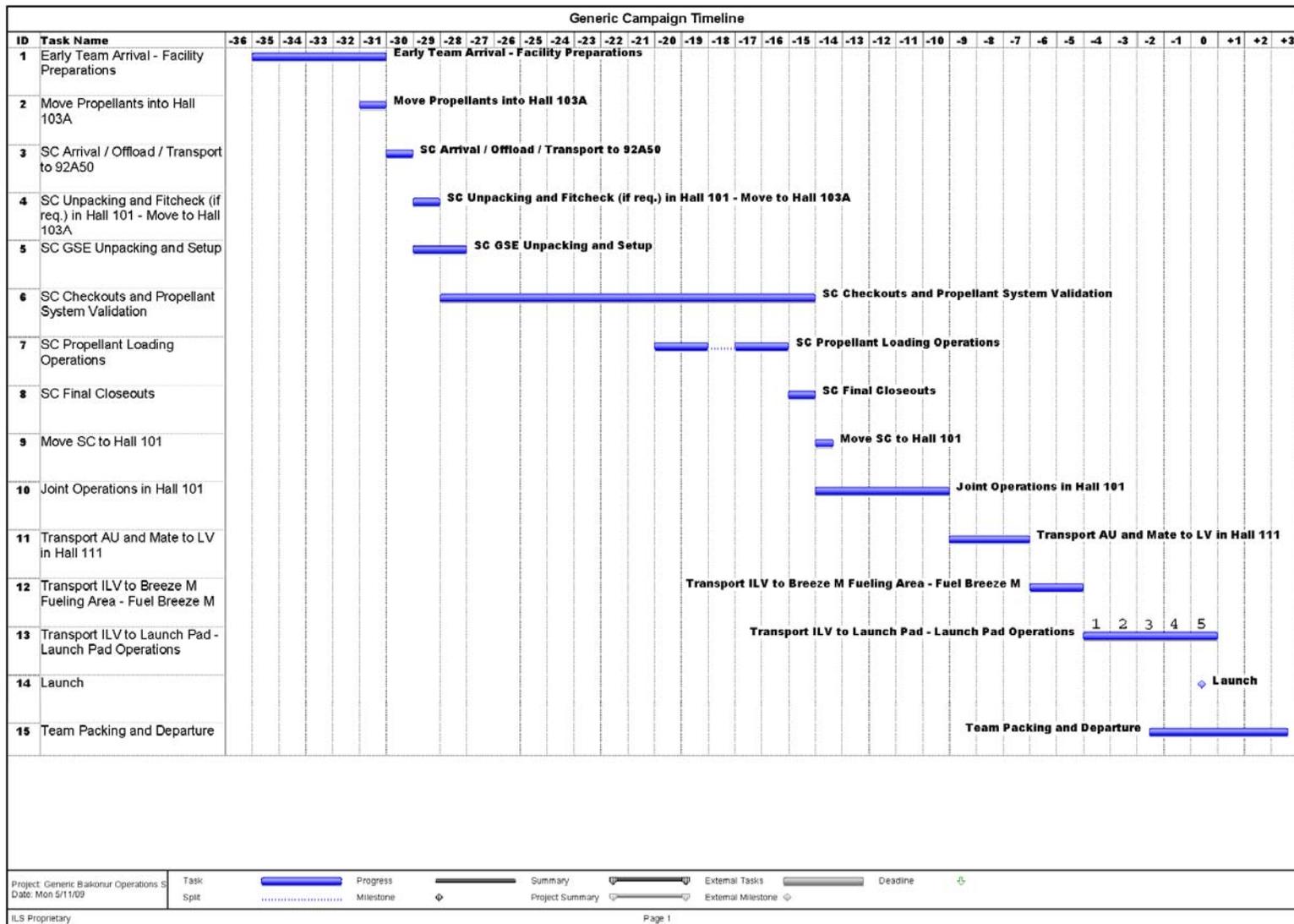
Figure 7.5-1 provides a generic launch campaign schedule.

The typical duration of a launch campaign from SC arrival to launch is approximately 30 days, depending on SC manufacturer and Customer requirements.

### **7.5.1 LV Processing**

The Proton LV stages, PLA, and fairings are built in Moscow by KhSC and transported by rail to the Baikonur Cosmodrome. After transportation of the Proton's stages and fairing by rail, LV assembly takes place in an integration and test facility. Prior to SC arrival, the fairing is moved to Building 92A-50 for SC integration, where it is stored and cleaned in preparation for encapsulation. The Breeze M US is manufactured by KhSC in Moscow and transported by air to Baikonur. After arrival, the Breeze M is delivered to Building 92A-50 for pre-launch checkout and testing. The Breeze M is then delivered to Building 44 in Area 31, the propellant fueling hall, where MMH and  $N_2O_4$  are loaded in the high pressure tanks of the low-thrust settling/attitude control system thrusters. The Breeze M helium pressurant tanks are also loaded in Building 44. Following these operations the Breeze M is then moved to Building 92A-50 for integration with the SC. Payload adapters are similarly delivered to Building 92A-50, where they are cleaned and prepared for assembly of the AU.

Figure 7.5-1: Generic Launch Campaign Schedule



### **7.5.2 SC Preparations Through Arrival**

Prior to campaign start, SC propellants are shipped by rail from St. Petersburg to the Baikonur Cosmodrome. They can be stored in the same temperature-controlled railcars used for transport from St. Petersburg until required for fueling. The propellant containers are transferred to a storage/conditioning room for temperature stabilization prior to SC arrival in Hall 103A.

In advance of SC arrival, the payload processing facilities undergo facility activation and certification. Building 92A-50 is verified to meet environmental control and cleanliness requirements, in addition to commodities and power support requirements, usually three or four days prior to the SC arrival date.

The SC and its GSE arrive at Yubileiny Airfield via a SC Customer-chartered aircraft, where they are loaded onto railcars and trucks. These operations are supported by KhSC-supplied mobile cranes, K-loader, and forklifts, as required. After the SC container is placed on a railcar, it may be connected to a thermal control railcar via two air duct flanges (inlet and outlet air flow) to provide thermal conditioning during transport. Some SC containers are completely self-contained thermally and environmentally and do not require this support option. The thermal car also provides a dynamic load monitoring system. SC Customer personnel effects may be transported directly to the hotel by truck.

### **7.5.3 Area 92 (Building 92A-50) - SC Testing, Fueling and AU Integration**

In this processing scenario, the SC and its GSE are transported by rail approximately 40 km to Building 92A-50, where external cleaning of the SC container is performed in Hall 102. Initial cleaning is conducted while in Hall 102, and final cleaning is performed after the move into Hall 101. Hall 101 is an ISO Class 8 cleanroom, and the SC container cover may be removed here or in Hall 103A as required by the unique mission-specific SC processing flow.

A typical flow is as follows:

- a) Move the SC container into Hall 101 on railcar.
- b) Remove container from the railcar and place on the floor in Hall 101.
- c) Verify environment is within specification.
- d) Remove the container lid.
- e) Remove the SC from the container.
- f) Place the SC on the transporter.
- g) Move SC on transporter into Hall 103A for processing.

The SC container may be stored in Hall 101. Electrical test equipment is brought into the control room by means of an external door, which opens directly into the control room loading area. This is a small buffer zone between two sets of double doors.

After container removal, SC electrical testing, pneumatic testing, and propellant fueling occur in Hall 103A. Pass-throughs from the control room are available for cabling. These cable feeds are verified to be leak-tight prior to propellant operations. The 380 V/220 V/50 Hz and 208 V/120 V/60 Hz power source is provided by an UPS. Typically, the UPS is activated three or four days prior to SC arrival and not deactivated until launch and all parties agree that no further requirement for it exists. A portable blast shield is available for high-pressure tests.

For propellant operations, the facility is configured with liquid waste aspirators, passive vent scrubbers, and a vapor detection system, which alarms locally in the control room and at the Security Command Post. Breathing air is supplied by a single source, which is sampled prior to operations. GN<sub>2</sub>, water, and shop air are provided on demand. A fire suppression system, which will arm but not release on alarm, is also active in Hall 103A. The command to activate the suppression system deluge is made in the control room, and is not an automatic function of the alarm system. Liquid Nitrogen (LN<sub>2</sub>) is available with 24-hour call-up.

The loaded SC is transported back to Hall 101 using the transport dolly. The SC is lifted from the transporter and mated to the SC adapter using the 10-MT bridge crane. The adapter clampband is installed and tensioned. The SC/adapter unit is then lifted and mated to the Breeze M, which has been previously installed in the integration stand. Incremental electrical continuity tests are performed at each phase, with the final check being an end-to-end test with the SC mated to the Breeze M.

After SC integration, final closeout operations and photographs are performed. The combined Breeze M/SC is rotated to the horizontal position on the integration stand. After the upper fairing half is emplaced, an RF GO/NO-GO test is performed to ensure that the SC link has not been disturbed and that the RF window is transparent to RF. This is performed as soon as the fairing half is mechanically emplaced and before continuation of encapsulation sealing operations. If any anomaly is found, the fairing may be removed relatively easily at this point. After determining a good RF signal, encapsulation is completed.

After encapsulation and required RF testing, the integrated AU is placed on a railcar for transport to Hall 111 for integration with the Proton LV.

## **7.6 LV INTEGRATION THROUGH LAUNCH PAD OPERATIONS**

The AU is transported to Hall 111 of Building 92A-50 for integration with the Proton M LV, where it is uncoupled from the thermal conditioning car and loaded onto the integration dollies. The AU is brought horizontally to the docking plane of the assembled Proton LV third stage by the integration dollies. An end-to-end electrical check is performed on the SC/LV umbilical cables. A thermal blanket is installed over the fairing to protect the payload from temperature extremes during periods when there is no active thermal control. The Integrated Launch Vehicle (ILV) is then transferred to the transporter-erector. A typical launch flow requires three to four days of integration hall activities. Integration hall operations are based on the LV pre-launch schedule.

The ILV is transported to the Breeze M fueling station for loading of the low-pressure MMH and N<sub>2</sub>O<sub>4</sub> Breeze M propellant tanks on its way to Pads 24 or 39 for launch.

The first of two State Commission Meetings is held on ~ Day L-6, prior to vehicle roll-out to the pad, to ensure all agencies are ready for pad roll-out. All agencies, including the SC manufacturer acting in support of the Customer, will be called upon to provide a launch readiness statement.

## **7.7 LAUNCH PAD OPERATIONS**

The ILV is transported to the launch pad and erected in one piece at Day L-4 using the LV transporter. From Day L-4 and on, the launch schedule is driven by Roscosmos overall countdown schedule. Coordination of SC-related pad activities is performed through the 7/701 Script (see Table 7-1 of the PLCG for an example). The 7/701 Script is generated by KhSC with SCC/Customer input and should include all pad access requirements and requirements for RF radiation and commanding the SC. Operator "7" is the KhSC Program Director, while Operator "701" is the SC point of contact. The following pad activity information is required from the SC/Customer: RF radiation, battery charging, SC commanding, and pad access. Note that ILS functions, such as scheduling of pad access, will also be coordinated through this script. Figure 7.7-1 provides a generic detailed on-pad operations flow.

Active commanding of the SC is prohibited during critical LV processing functions. Starting at Day L-5 and every day thereafter, KhSC identifies the RF silence and no-command times. The on-pad operations flow schedule is updated to incorporate these changes and active commanding of the SC is prohibited during these times.

The following items represent typical SC inhibits to RF radiation at the pad:

1. Personnel in vicinity of antenna/couplers
2. KhSC interface command/telemetry and calibration with LV
3. Roscosmos testing (usually a tracking facility or radar)
4. KhSC fueling operations
5. Others as specified by KhSC or Roscosmos

The SC Customer participates in a launch countdown rehearsal on Day L-2 on pad. This countdown rehearsal is supported by a full LV launch crew countdown and requires the SC Customer to indicate SC readiness to go at the required time. The rehearsal also includes a planned abort. SC full fidelity countdown rehearsal is not required for this exercise, simply the operation of the readiness switch at the planned time in accordance with the 7/701 Script.

The second State Commission Meeting is held at T-8 hours to ensure all agencies are GO for launch prior to propellant load of the LV. At T-8 hours, the launch pad is cleared of all non-essential personnel, and at T-6 hours, propellant load commences. At T-2.5 hours, the pad is open for final closeouts and service tower removal. At T-2 hours, all personnel should be in their final positions for launch (i.e., Bunker, Control Room, Viewing Area, and Communications Center). Note that personnel in the Bunker and the Communications Center should be limited to essential personnel only. All personnel must be cleared from the hotel areas for launches from Pad 24.

The SC Customer participates in the final countdown launch day activities including sending a SC readiness to launch signal at T-10 minutes, as noted in the countdown organization discussion.

Figure 7.7-1: Launch Pad Operations Timeline (Generic)

ID	Task Name	L - 5	L - 4	L - 3	L - 2	L - 1	L - 0
1	Rollout Government Commission Meeting (Bldg. 92A-50)	▲	17:00				
2	Transport ILV to Launch Pad		■	06:30 - 09:30			
3	ILV Visual Inspection, Remove RF Window Covering		■	09:30 - 10:00			
4	Erect ILV		■	10:00 - 12:30			
5	Switch PLF to LTMCS		■	12:30			
6	SC Power On and RF Link Checks		■	13:00 - 14:00			
7	Checkout of LV Systems		■	13:45 - 18:00			
8	Roll MST Forward		■	14:10 - 15:00			
9	Connect AC Ducts and activate ATMCS		■	15:30 - 16:00			
10	Switch Off LTMCS		■	16:10			
11	Remove Thermal Cover, Verify Clampband Tension		■	15:30 - 18:00			
12	Checkout RF Link (Tower Forward), Charge SC Batteries		■	19:00 - 00:00			
13	SC Operations, Battery Charging, RF Link Checks			■	10:30 - 18:30		
14	SC Operations, Battery Charging, RF Link Checks				■	07:00 - 20:00	
15	Clear Vault and MST				■	10:00 - 20:00	
16	Launch Countdown Rehearsal				■	12:30 - 17:30	
17	Remove Protective Devices from PLF, Closeout Photos					■	07:00 - 09:00
18	Install Launch Pad Cameras					■	10:00 - 14:00
19	SC Operations, Battery Charging, RF Link Checks					■	15:00 - 20:00
20	Clear Vault and MST					■	19:30 - Launch
21	LV Load Government Commission Meeting					▲	20:00 - 21:00
22	LV Propellant Load					■	21:00 - 00:30
23	Switch to LTMCS					■	0:30
24	Switch Off ATMCS, Final PLF Closeouts					■	02:15 - 02:50
25	Move MST to Launch Position					■	02:50 - 03:15
26	Switch Off LTMCS (L - 10 Minutes)					■	3:50
27	Final Launch Pad Operations					■	03:50 - 04:00
28	Launch (L - 0)						▲