UNITED
START

SPACE LAUNCH SYSTEM

START –1

USER'S HANDBOOK VOLUME II:

PRE-LAUNCH PREPARATION, LAUNCH, & COSMODROME OPERATIONS

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Abbreviations

ACCD	-	air contamination control device
ATB	–	assembly-and-test building
BAC	-	breath air compressor
EGSE	–	electronic ground support equipment
FC	-	fire cock
HM	–	head module
HMIS	-	head module integration stand
HMT	-	head module trolley
LNSS	-	liquid nitrogen supply system
LV	–	launch vehicle
MCC	–	mission control center
MS	–	measurement system
NCS	-	nitrogen cooling system
SC	–	spacecraft
SLS	–	space launch system
UPS	–	uninterrupted power supply

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1. Introduction

This Start-1 Launch Vehicle User's Handbook consists of two Volumes:

Volume 1: **Launch Vehicle & Spacecraft Interfaces**
Volume 2: **Pre-launch Preparation, Launch & Cosmodrome Operations**

This document *Pre-Launch Preparation, Launch & Cosmodrome Operations* covers cosmodrome infrastructure, spacecraft and launch vehicle processing and launch operations for the Start-1 Space Launch System.

The Users Handbook is administered by United Start Corporation out of Los Angeles, CA and Puskovie Uslugi out of Moscow Russia.

2. Svobodny Cosmodrome Infrastructure

The Svobodny cosmodrome infrastructure provides for all operations on the spacecraft and LV preparation for launch as well as launch implementation. The infrastructure includes the following:

- Technical Site and Launch Site
- Ground Instrumentation Sites
- Flightpath and LV spent elements impact areas
- Ground support equipment and facilities
- Communications system and power supply
- Residential area
- Road network.

Location plan of Svobodny Cosmodrome area is presented in Figure 2.1, Svobodny cosmodrome layout is presented in Figure 2.2.

2.1 Technical Site

The Technical Site is intended for implementation of assembly and test operations on preparation of LV, SC, head module and ground support equipment for launch.

The following facilities are located at the Technical Site:

- SC Assembly-and-Test Building (SC ATB) for SC and head module processing
- LV Assembly-and-Test Building (LV ATB) for LV and Space Launch System processing
- Pads for hardware unloading/reloading
- Storage facilities for ground support equipment and vehicles.

The Cosmodrome Technical Site facilities location are presented in Figure 2.3.

2.1.1 Spacecraft Assembly-and-Test Building

The SC ATB consists of working area A dedicated to SC and head module assembly and test, and working area B dedicated to placement of fueling system for SC propulsion system filling with hydrazine and compressed gas. The SC ATB layout is presented in Figure 2.4.

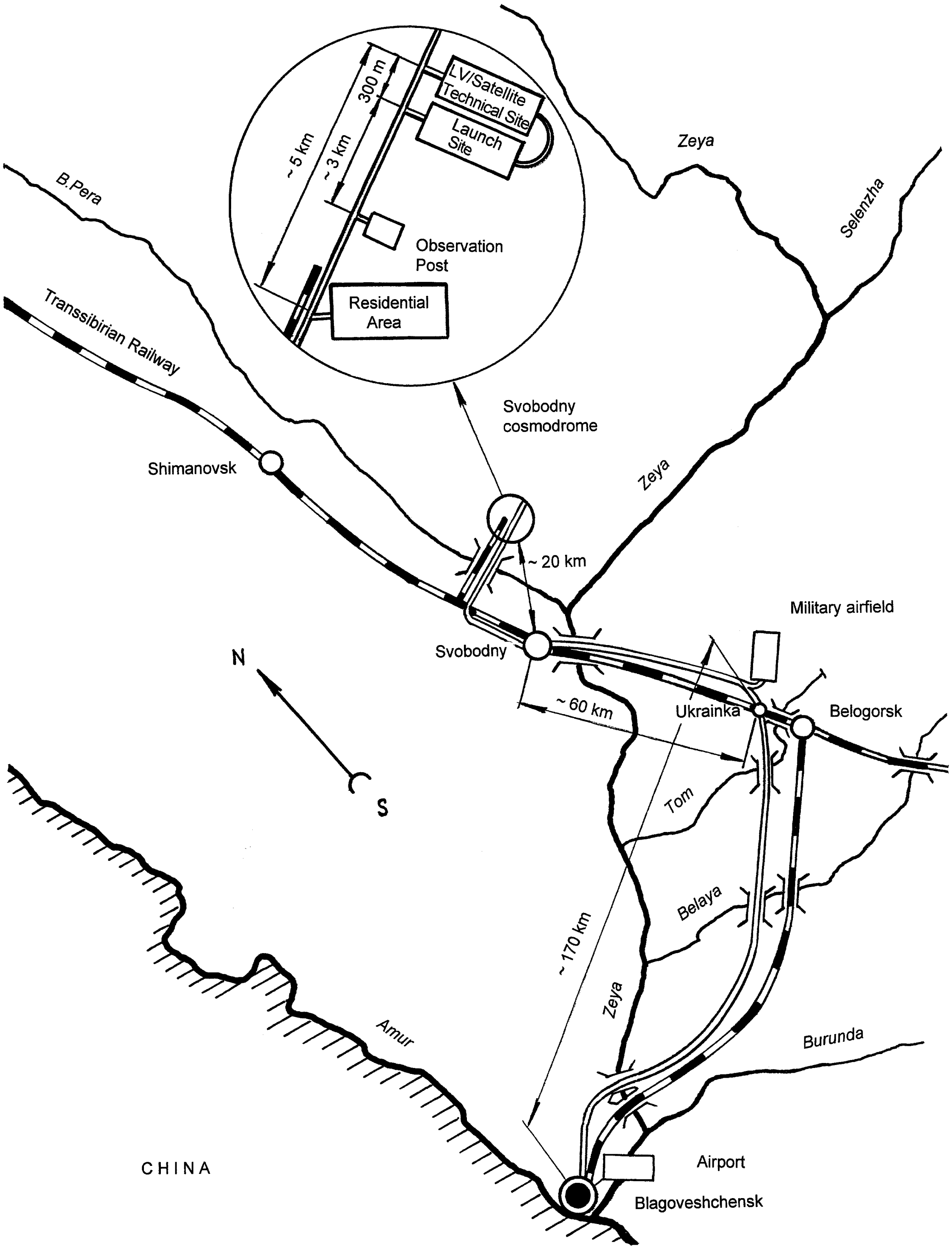


Fig. 2.1. Location Plan of Svobodny Cosmodrome Area

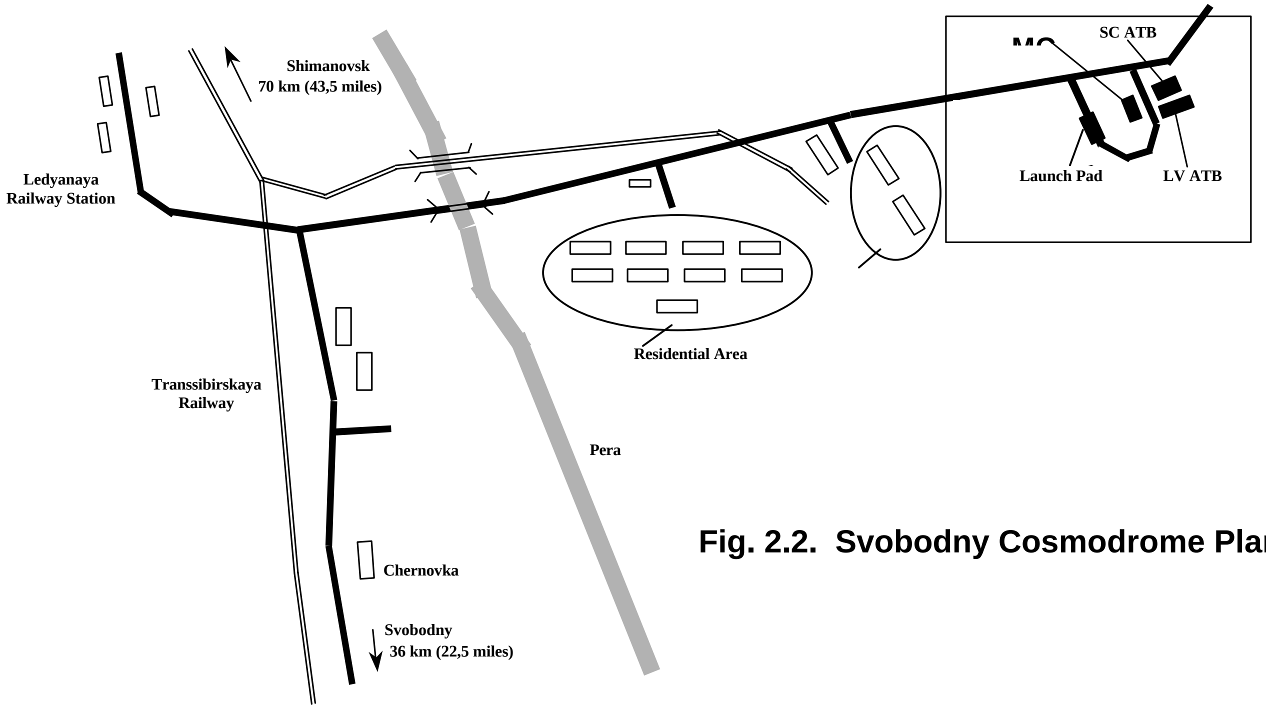


Fig. 2.2. Svobodny Cosmodrome Plan

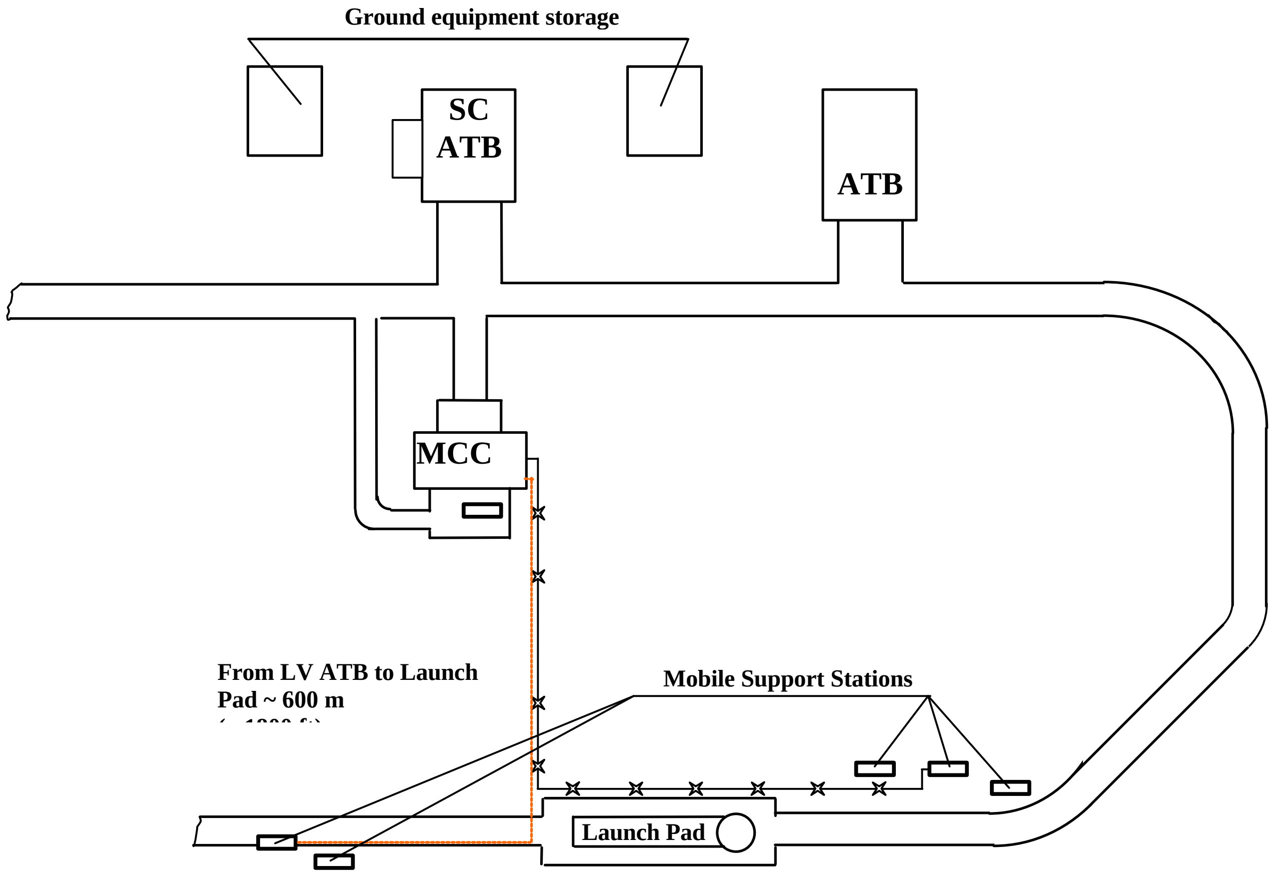


Fig. 2.3. Cosmodrome Technical Site Facilities Location

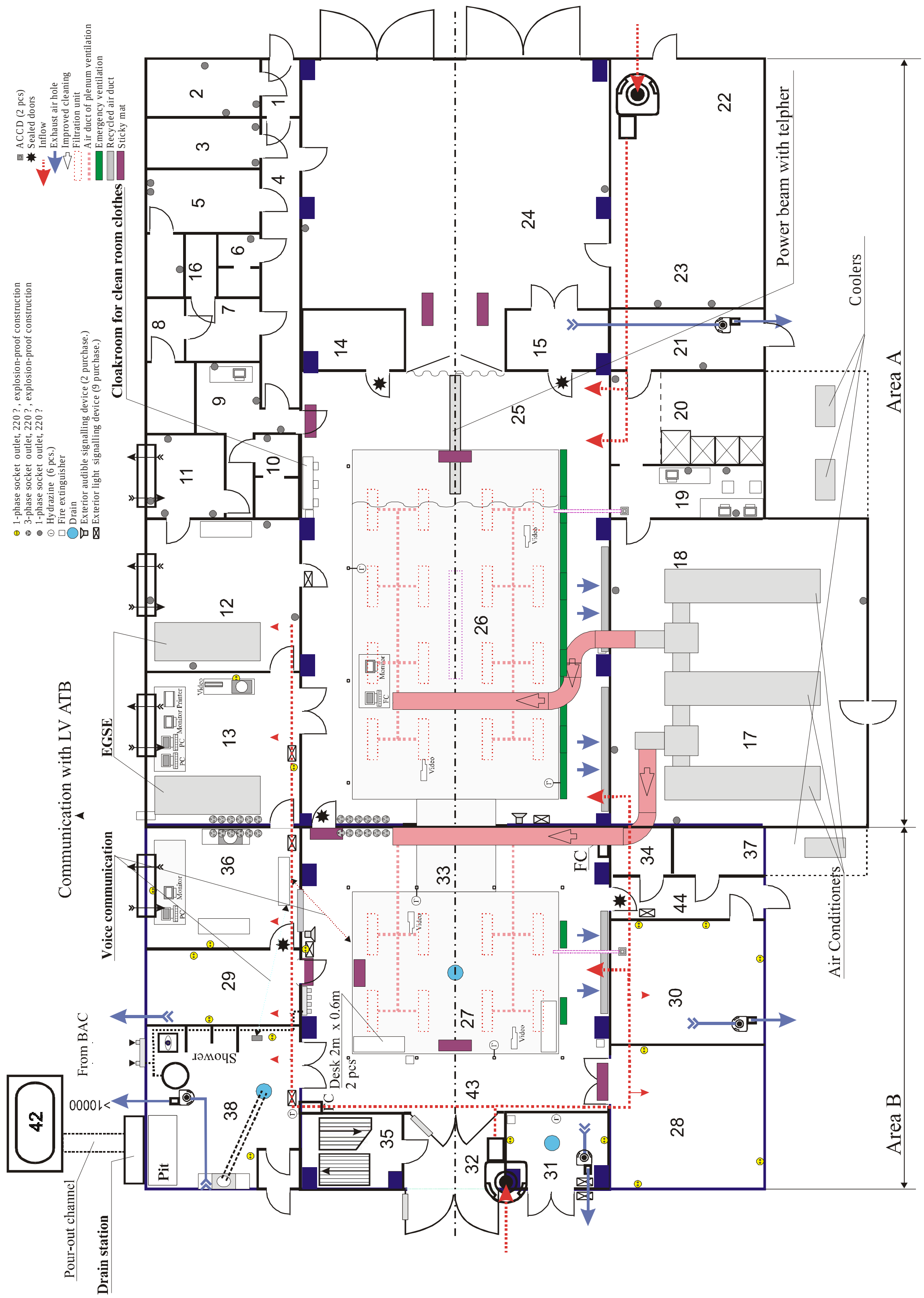


Fig.2.4. Spacecraft Assembly-and-Test Building Layout

Spacecraft Assembly-and-Test Building Room Identification (see Fig. 2-4)

Area A – SC processing and HM assembling	
1	entrance airlock
2	room for SC ATB duty officer
3	cloakroom for upper clothing
4	passage
5	refreshment room
6	lavatory
7, 8, 16	cloakrooms, shower room
9	room for Customer's security
10	lavatory
11	Customer's Manager room
12,13	rooms for EGSE placement
14 15	auxiliary room for water supply system auxiliary room
16	storage room for special clothing for Clean Room
17, 18	auxiliary room for air conditioning and ventilation equipment
19	room for accommodation of operating consoles of environment examination system, air conditioning and ventilation system, and NCS
20,21	Provider's auxiliary rooms
22	ventilation room
23	area for equipment and containers temporary storage
24	equipment unloading area
25	main hall for SC and HM processing
26	Clean Room-1 (for SC and HM processing)
Area B – Fueling system	
27	Clean Room-2 (for SC filling with hydrazine and compressed gas)
28	room for fuelling equipment dry cleaning and preparation
29	storage room for safety equipment
30	chemical laboratory
31	hydrazine storage
32	evacuation airlock
33	Clean Room-1/Clean Room-2 airlock passage
34	switchboard room
35	stairway to 2nd floor
36	control and visual monitoring room
37	thermal entry point (water/heat supply)
38	room for washing (neutralization) of equipment and personnel
39	plenum ventilation, air heater
40	filters

41	exhaust ventilation
42	special drainage tank
43	area for Clean Room-2 arrangement
44	evacuation airlock

Note: rooms 39, 40, 41 are located above rooms 31, 32, 35.

2.1.1.1 Clean Rooms

Clean rooms are intended for assembly and test operations with SC and HM under environmental conditions presented in Table 2.1.

Table 2.1

	Clean Rooms	**Environmental Conditions**			
		Dust Loading in Accordance with FED STD-F209E	Operating Temperature, °C	Humidity, %	Illumination, lux
1	Clean room 1 – for SC and HM processing	Class 100,000 – for operations with protected optics Class 10,000 – for operations with unprotected optics	(+19...+25) – for non-operating SC (+19...+23) – for operating SC	40...60	≥ 500
2	Clean room 2 – for SC fuelling with hydrazine	Class 100,000	+19...+25	40...60	≥ 500
3	Airlock passage	Class 100,000	+19...+25	40...60	400

Clean rooms are demountable structures of tent type consisting of supporting frame, suspended ceiling, filtering units built-in ceiling and antistatic film. Clean rooms 1 and 2 layout in SC ATB are presented in Fig. 2.4.

Required environmental conditions inside clean rooms are kept by the following systems:

- air conditioning and filtration system;
- emergency ventilation system;
- automatic environment control system.

Air conditioning and filtration system mixes plenum and return air, purifies and processes it in the central conditioner and then supplies prepared air to a clean room through filtering chamber and air duct.

Emergency ventilation system is independent for each clean room and ensures gas-laden air disposal from clean room through filter-absorber of hydrazine vapour by environment monitoring system command.

Automatic environment control system ensures measuring and keeping temperature and humidity within the required intervals, their displaying, recording and records keeping with print out capability. The Clean rooms location in SC ATB is presented in Fig. 2.5.

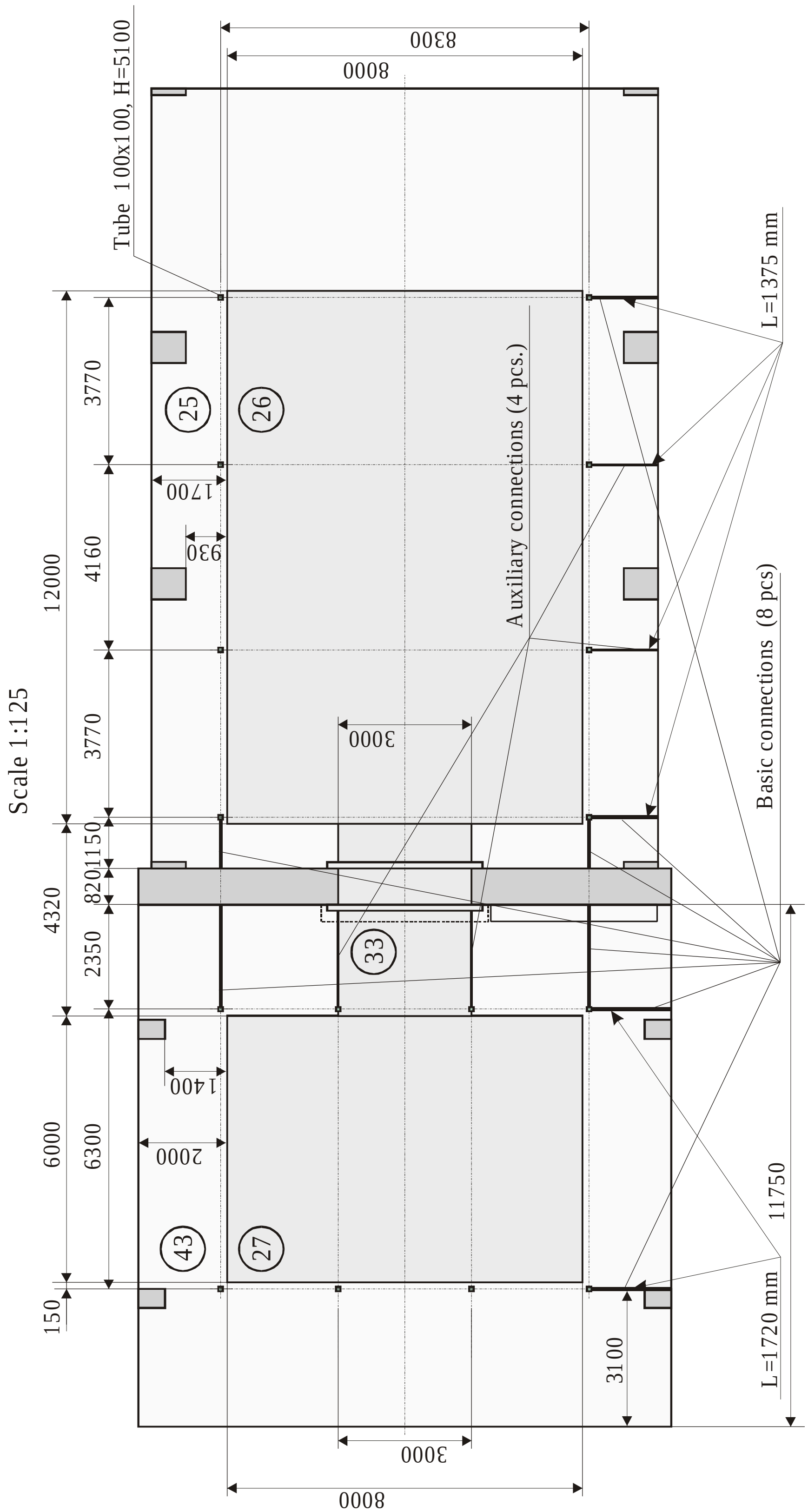


Fig. 2.5. Clean Room Load-Bearing Frame Stubs Layout

2.1.1.2 Environment Monitoring in Spacecraft ATB

In the process of SC processing the following environment for parameters are monitored continuously

- Dust loading
- Temperature
- Relative humidity
- Hydrazine vapour concentration
- Oxygen percentage.

Control over air conditioning and filtration system and environment monitoring system is carried out by Provider personnel.

2.1.1.3 Technical Site Mechanical Equipment

Operations with spacecraft, head module and launch vehicle at the Technical Site are conducted with the use of special mechanical hoisting equipment. The operations with the use of mechanical equipment in SC ATB and LV ATB are as follows:

- hardware transportation to the Technical Site;
- Technical Site facilities preparation and equipping;
- unloading and accommodation of Customer's and Provider's hardware in the working rooms;
- assembly operations with SC, HM and LV;
- Customer/Provider joint assembly operations;
- Ground equipment dismantling and removing after launch.

The SC ATB (see Fig.2.4) is equipped with three bridge cranes installed in rooms 24, 25 and 43 and one telpher in room 25. The SC ATB crane equipment performance data is presented in Table 2.2.

Table 2.2, Crane Equipment Performance Data

Performance Data	**Room 24**	**Room 25**	**Room 43**	**Room 25**
Crane Type	**Bridge crane 5T15**			**Telpher**
Hoisting capacity, tons	5.0	5.0	5.0	3.0
Bridge speed, m/min	19.6	16.0	19.6	-
Trolley speed, m/min	11.8	11.8	11.8	6.0
Hook speed, m/min	1.7	1.7	0.96	2.0
Hook max. altitude, m	6.0	6.0	6.2	7.0

The LV ATB crane equipment performance data is presented in Table 2.3.

Table 2.3

Performance data	**Room 11**		**Room 12**
	15-ton	**5-ton**	**3-ton hoist**
Hook speed, m/min			
high speed	2.4	2.1	2.1
low speed	0.24	0.23	0.23

The parameters of hoists hooks used during rigging operations at Cosmodrome including crane truck are presented in Table 2.4 and Fig. 2.6.

Table 2.4

Equipment	**Hook Dimensions (mm)**					
	S	**D**	**d**	**h**	**l**	**a**
Bridge crane 5T15 (SC ATB) Bridge crane 5T15 (LV ATB)	65	85	56	82	130	86
Bridge crane 15T15 (LV ATB)	120	150	85	150	210	96
Telpher – 3T (LV ATB)	65	70	56	60	130	42
Telpher – 1.5T (SC ATB) Truck crane KC-3576	90	120	80	115	180	86

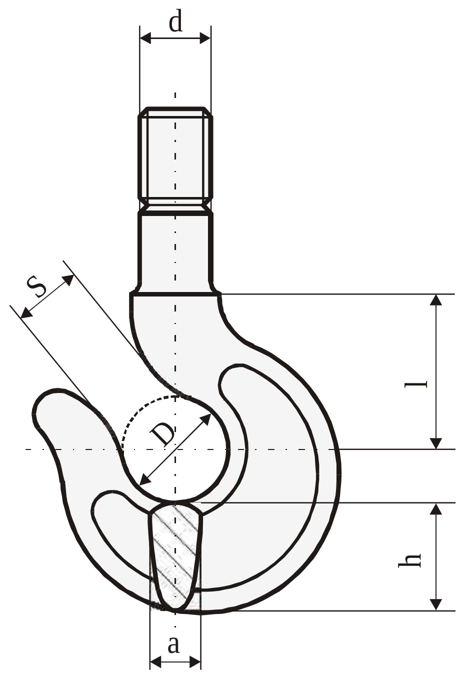


Fig. 2.6. Hoist Hook

2.1.1.4 Head Module Assembly Support Equipment

Assembly support equipment provides head module assembling in horizontal position.
The Head Module Integration Stand (HMIS) and Head Module Trolley (HMT) are used for HM assembling.

HM Integration Stand (Fig.2.7) is a structure consisting of frame (1) carried by four swivel wheels (2).

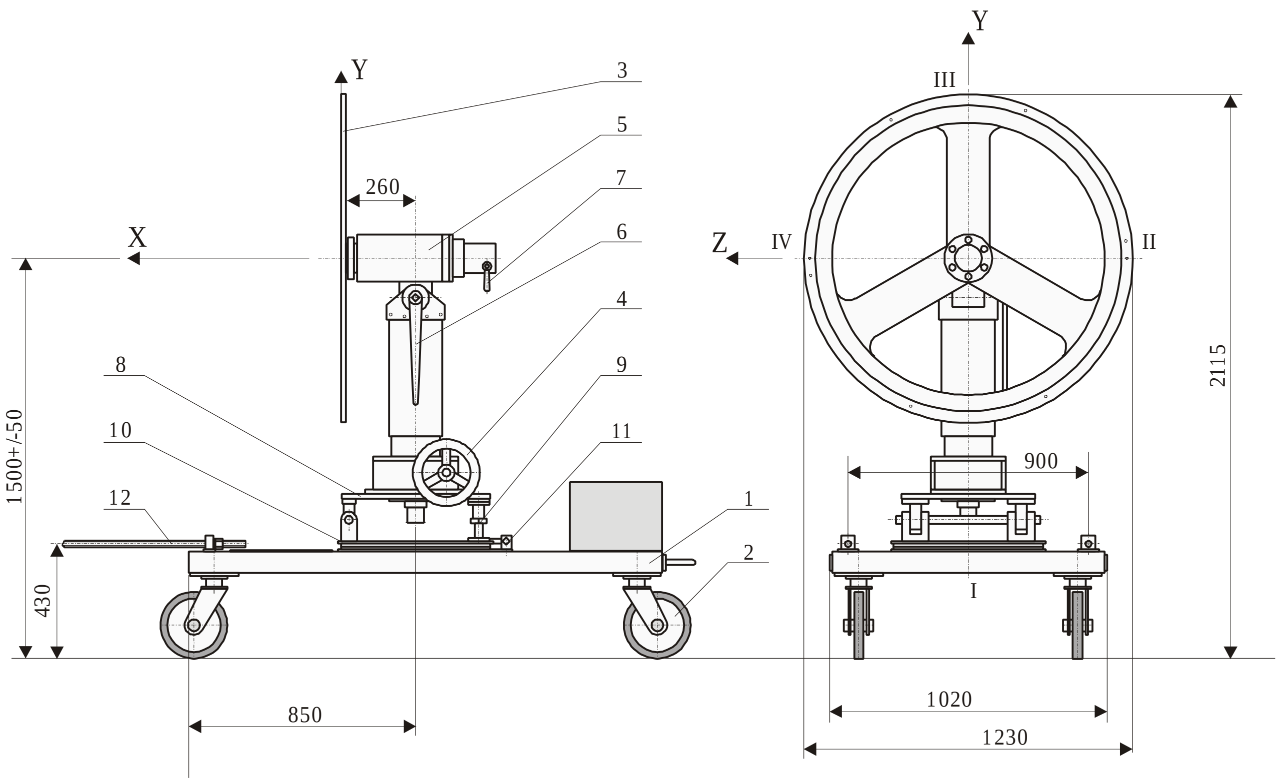


Fig.2.7. HM Integration Stand

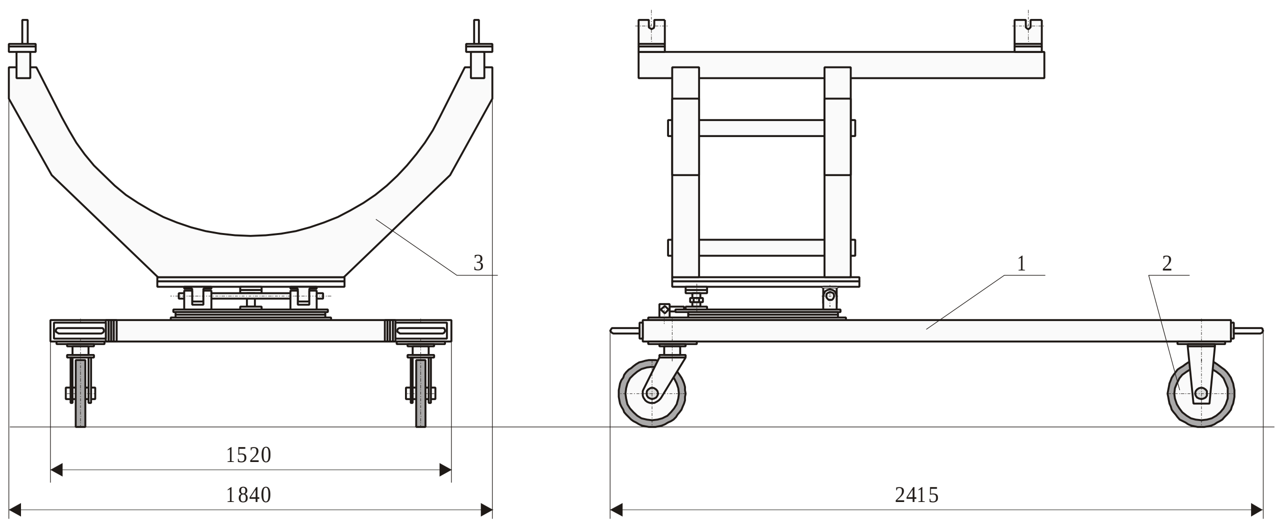


Fig.2.8. HM Trolley

Special devices providing 5 degrees of freedom for head module elements (adapter and spacecraft) to be fixed on faceplate (3) are mounted on the frame.

Vertical movement along the Y axis is provided by rotating the handwheel (4) installed on reduction gear worm. Lateral movement along Z-axis is provided by moving the carriage (5) with the help of handle (6).

Rotation about HM longitudinal X-axis is provided by rotating of the faceplate, which has a brake (7). To measure adapter angular position there are marks on faceplate and case. Rotation about transversal Z-axis is provided by raising/lowering the right (in Fig. 2.7) edge of pad (8) by rotating the screw (9). Rotation about vertical Y-axis is provided by turning the platform (10) with help of screws (11).

HM trolley (Fig. 2.7) consists of frame (1) on four wheels (2), two of which are swivel ones. Two semi-ring supports 3 are mounted on the frame to provide installation of two banding rings with HM fairing (Fig. 7.9 of Volume I). Herewith fairing can be rotated about Y and Z-axes.
Mechanisms of rotation are similar to ones used in HMIS.

2.1.1.5. Spacecraft ATB Video Monitoring System

The SC ATB monitoring system is intended for video monitoring by Customer's personnel of SC assembly in clean room 1 and SC fueling in clean room 2 and also SC and ground equipment safe keeping. The video monitoring system consists of the following parts:
- two video cameras in clean room 1
- two video cameras in clean room 2
- four monitors each is able to display information from four video cameras simultaneously
- power cables and signal cables.

2.1.1.6. Spacecraft Fueling Equipment

The SC is fueled with hydrazine by joint Customer/Provider team with the use of the following equipment:
- Fueling system for SC propulsion system filling with hydrazine and gas (supplied by Customer)
- Breathing air system (including breath air compressor, air ducts, heaters, air dispensers, cables, etc.) for clean air supply to protective suits of fuelling team.

- Protective suits for fueling team (supplied by Customer)
- Special materials for hydrazine neutralization (supplied by Customer)
- Liquid nitrogen supply equipment and self-contained cryogenic tanks (supplied by Provider)
- Fire engines and medical team with means for treating for hydrazine contamination injuries (supplied by Provider)
- Vehicles for transportation of the above mentioned equipment (provided by Provider).

There is a chemical laboratory in SC ATB to carry out chemical analysis of hydrazine samples. Procedure of hydrazine samples analysis is complied with MIL-PRF-26536E. Arrangement of equipment during SC fueling with hydrazine is presented in Fig. 2.9.

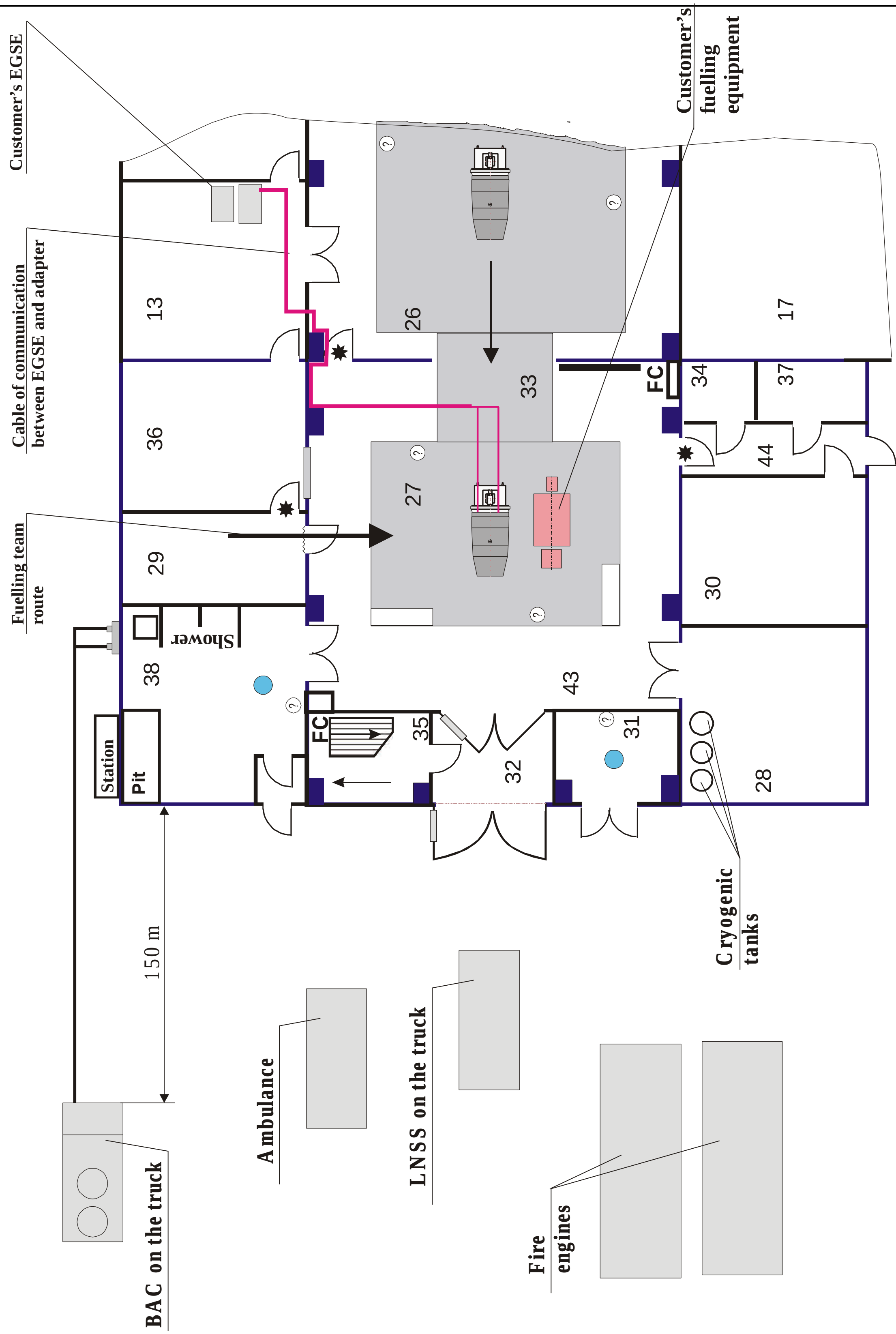


Fig. 2.9. Equipment arrangement during spacecraft fuelling with hydrazine (✸ - sealed doors)

2.1.1.7 Spacecraft ATB Electrical Power Supply System

Electrical power to the SC ATB equipment and devices are supplied from SC ATB Power Supply System as a part of the Cosmodrome power supply system (see paragraph 2.3). The SC ATB electrical power supply system consists of:

- distribution devices – 3 pcs;
- voltage check device – 1 pc;
- socket outlets.

Two distribution devices are intended for supplying the consumers which need uninterrupted power supply, and one distribution device is intended for consumers allowing interruption of power supply no more than 45 s (power backup).

Distribution devices provide short-circuit protection and overload protection of supply units as well as load cable connections.

The maximum permissible load (steady current) for each feeder of distribution devices of uninterrupted power supply is 25 A, power backup – 60 A.

Total power loads of all feeders for each uninterrupted power supply unit may not exceed 8 kW, and for power backup – 16 kW.

Explosion-proof sockets (2P+, 16 A, 6")are intended for connection of Customer's equipment cables 220 V, 50 Hz.

Voltage check device is intended for checking the parameters and correctness of phase sequence of voltage 380/220 V, 50 Hz for most critical consumers. In the event that parameters of voltage or phase sequence do not meet the specifications within more than 45s, the check device generates audible and light signals.

2.1.2 Launch Vehicle Assembly-and-Test Building

Launch Vehicle Assembly-and-Test Building Rooms

1	Airlock	40.3 m^2
2	Power supply switchboard room	11.1 m^2
3	Airlock	4.2 m^2
4	Measuring system laboratory	36.8 m^2
5	Passage	13.4 m^2
6	Entrance airlock	14.6 m^2
7	Stairway	-
8	Spare parts storage	45.0 m^2

9	Guidance and control system laboratory	21.8 m^2
10	Laboratory (shielded)	47.0 m^2
11	Assembly and maintenance hall	425.0 m^2
12	HM room	67.0 m^2
13	Auxiliary room for personnel	20.1 m^2
14	Auxiliary room for personnel	3.0 m^2
15	Passage	20.7 m^2
16	Duty officer's room	9.86 m^2
17	Stairway	-
18	Service room	18.3 m^2
19	Power supply switchboard room	13.4 m^2
20	Power supply switchboard room	15.4 m^2
21	Transformer substation	7.2 m^2
22	Transformer substation	7.2 m^2
23	Hall	37.9 m^2
24	Office	20.6 m^2
25	Office	21.3 m^2
26	Office	23.8 m^2
27	Hall	51.4 m^2
28	Passage	28.4 m^2
29	Ventilation chamber	63.1 m^2
30	Communications center	14.1 m^2
31	Service room	22.1 m^2
32	File of technical documentation	12.0 m^2
33	Passage	66.4 m^2
34	Ventilation chamber	22.5 m^2

The layout of the LV ATB is presented in Fig. 2.10.

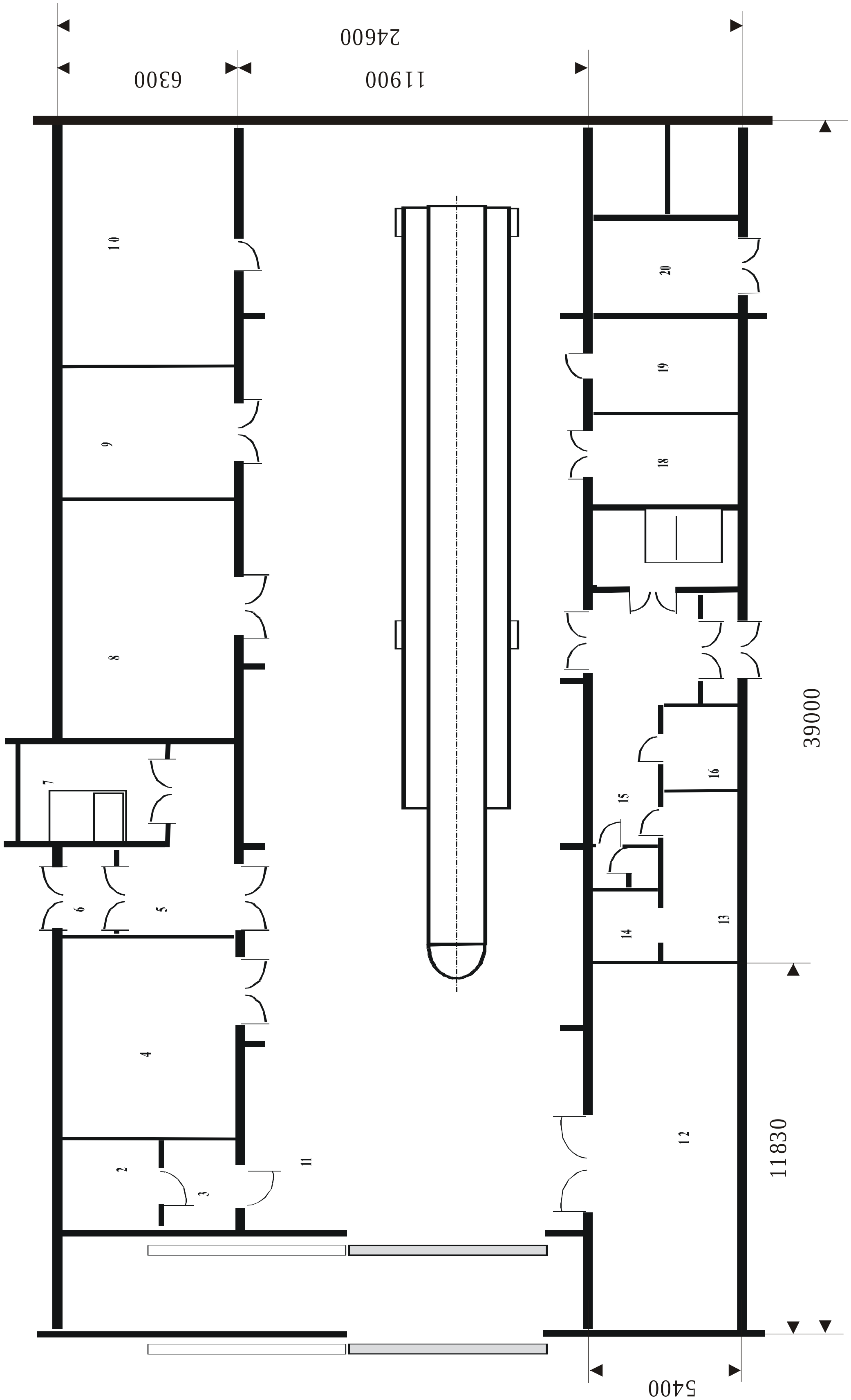


Fig. 2.10. Launch Vehicle Assembly-and-Test Building Layout

2.2 Launch Site

The launch Site is used for implementation of pre-launch operations with the space launch system, launch vehicle and spacecraft, launch and post-launch operations.

The launch Site includes the following facilities:

- mission control center fitted out with the required equipment (measurement system receivers and transmitters, base timing system equipment, remote control panel, communication means, etc.)
- Launch Pad fitted out with base of astronomical orientation system, three geodetic reference points, diverters, etc.

The layout of facilities and units of START-1 Space Launch System at Launch Site is presented in Fig. 2.11.

The process of LV launch is monitored from an observation post located at 3 km from the Launch Pad.

The layout of the mission control center and equipment arrangement is presented in Fig. 2.12.

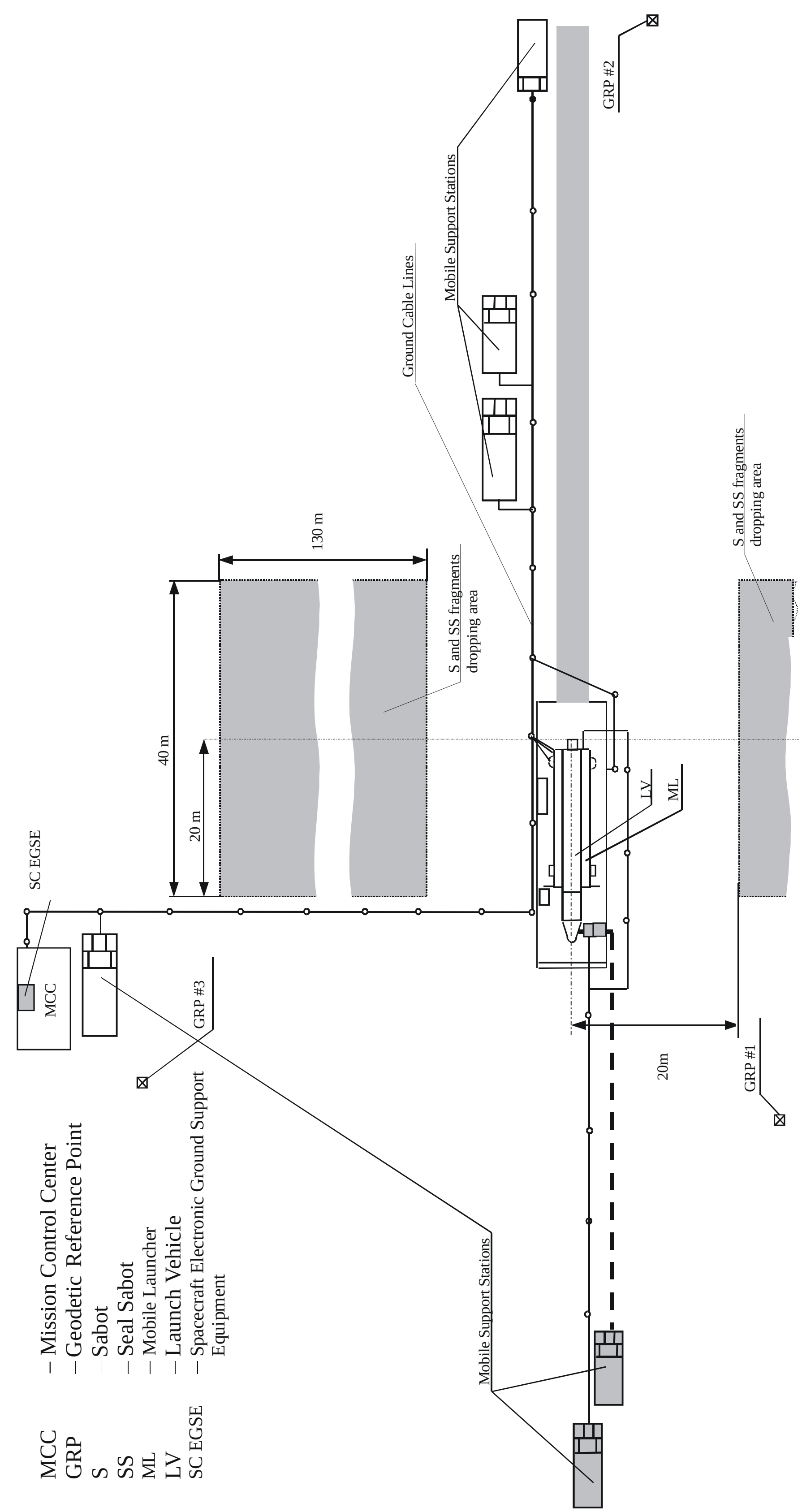
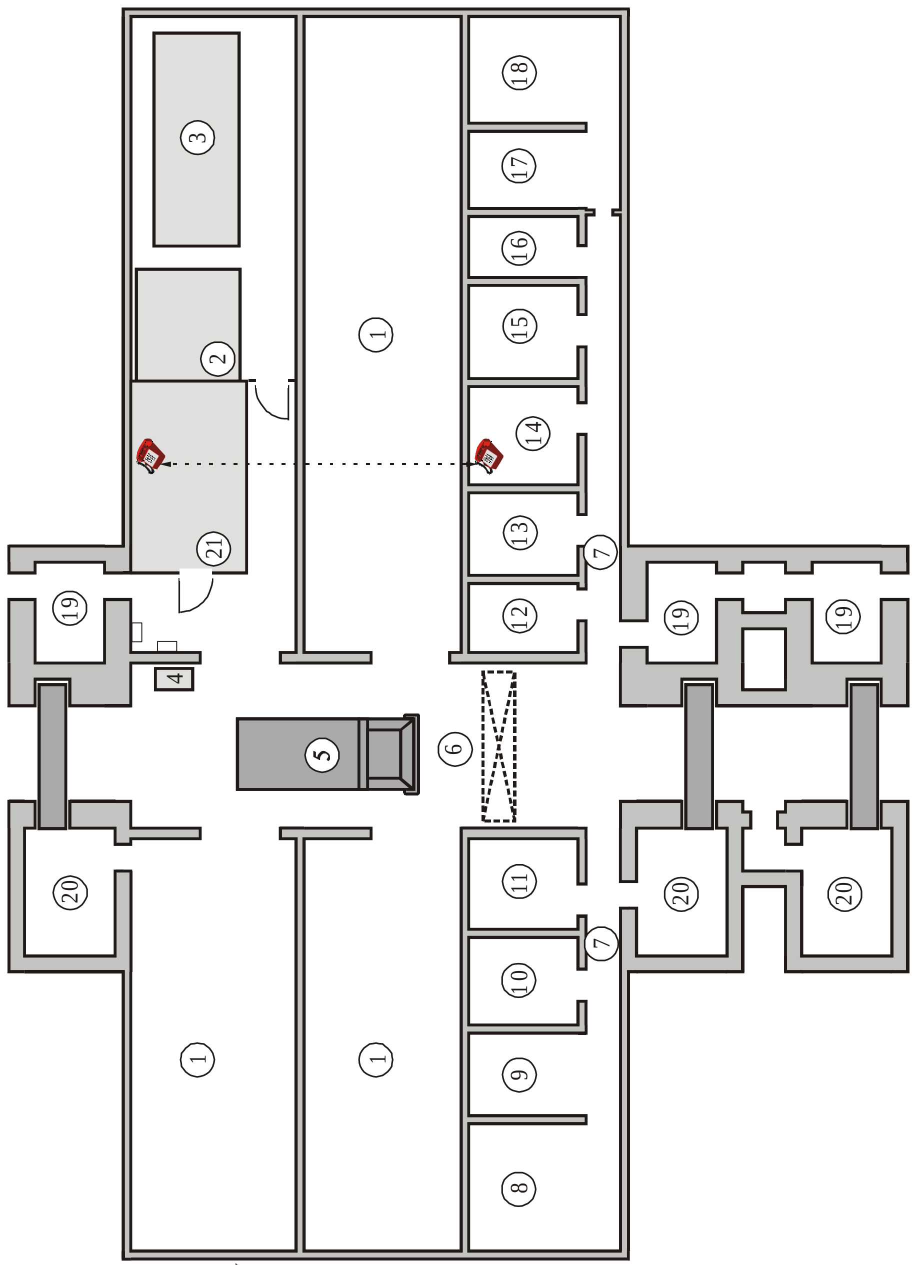


Fig. 2.11. Launch Pad



1 - storage room
2 - measurement system laboratory
3 - receiving/recording equipment laboratory
4 - power supply switchboard
5 - truck with apparatus
6 - crane (hoisting capacity 5t)
7 - passage
8 - diesel-generator set
9 - switchboard
10 - batteries
11 - vessels
12 - auxiliary room
13 - base timing system laboratory
14 - Launch Manager office (remote control panel)
15 - reportage room
16 - ventilation room
17 - hall
18 - recreation room
19 - entrance airlock
20 - shutter room
21 - room for SC processing team

Fig.2.12. Layout of MCC and Equipment Arrangement

2.3 Cosmodrome Electrical Power Supply

The cosmodrome electrical power system is supplied by the federal power network and a self-contained backup power supply. The scheme of electrical power supply is presented in Fig. 2.13.

In the mission control center the following stationary self-contained power supplies are accommodated:

- Stationary automatic diesel-generator set
- Batteries incorporated in uninterrupted power supply (UPS) system.

In order to provide uninterrupted power supply to consumers, two uninterrupted power supply systems are used. Each system includes static inverters and batteries.

3-phase alternating voltage 380/220V, 50 Hz is supplied to uninterrupted power supply system from the federal power network or from automatic diesel-generator sets, which are automatically started and connected to power buses if federal power network fails. In this case interruption is no more than 45 s.

In case of absence of input voltage the power is supplied by UPS batteries through the inverter. UPS performance data is presented in Table 2.5.

Table 2.5

	Parameter	
	(a) Input Parameters	
1	(2) Nominal voltage (phase/line), V	220/380
2	A number of phases	3
3	Frequency, Hz	50
4	Voltage tolerance, %	+10, -15
	(a) Output Parameters	
1	Total power, kVA	17, 25
2	Nominal voltage, V • phase • line	 220 380
3	Nominal current, A • at cos f = 1.0 • at cos f = 0.8	 20 25

4	Frequency, Hz	50
5	Duration of batteries continuous operation, min	10
6	Voltage maintenance accuracy, %	±3
7	Frequency maintenance accuracy, %	±1
8	Voltage transient deviation at 100% load-off/load-on	+10, -15
9	Transient process duration, s	=3

During operations with the SC at the Technical Site and Launch Site the stationery self-contained power supplies and two mobile support stations, which are included in START-1 Space Launch System, are used. Each mobile support station has two diesel-generator sets.

There are two schemes of power supply providing uninterrupted power supply:
- Scheme 1 (primary scheme) – the main power supply is federal power network and the reserve power is diesel-generator set of mobile support station or stationary automatic diesel-generator set through UPS providing continuity of power supply during automatic transfer from main power supply to reserve one and back
- Scheme 2(reserve scheme) – power is supplied from two diesel-generator sets of mobile support station to common buses with the load allowable for one diesel-generator set.

2.4 Telemetry Measurements

The LV on-board measurement system is used to receive telemetry and trajectory information (see paragraph 1.5, Volume I).

Telemetry information transmitted from LV is received during the powered flight using the receiving equipment of ground measurement stations.

LV flight sequence and SC separation are controlled through the use of telemetry and trajectory measurement systems in real time.

Based on the telemetry information received at SC separation from LV, the Provider presents spacecraft state vector to Customer 90 minutes after launch in order to estimate spacecraft orbit. SC separation is confirmed by the telemetry information.

While launching from Svobodny cosmodrome the following operations are performed:

- determination of LV and MS readiness for launch
- determination of exact time of LV launch
- reporting about LV flight sequence in real time
- refining the predicted parameters of SC separation
- post-launch analysis of LV systems operation based on the telemetry information received.

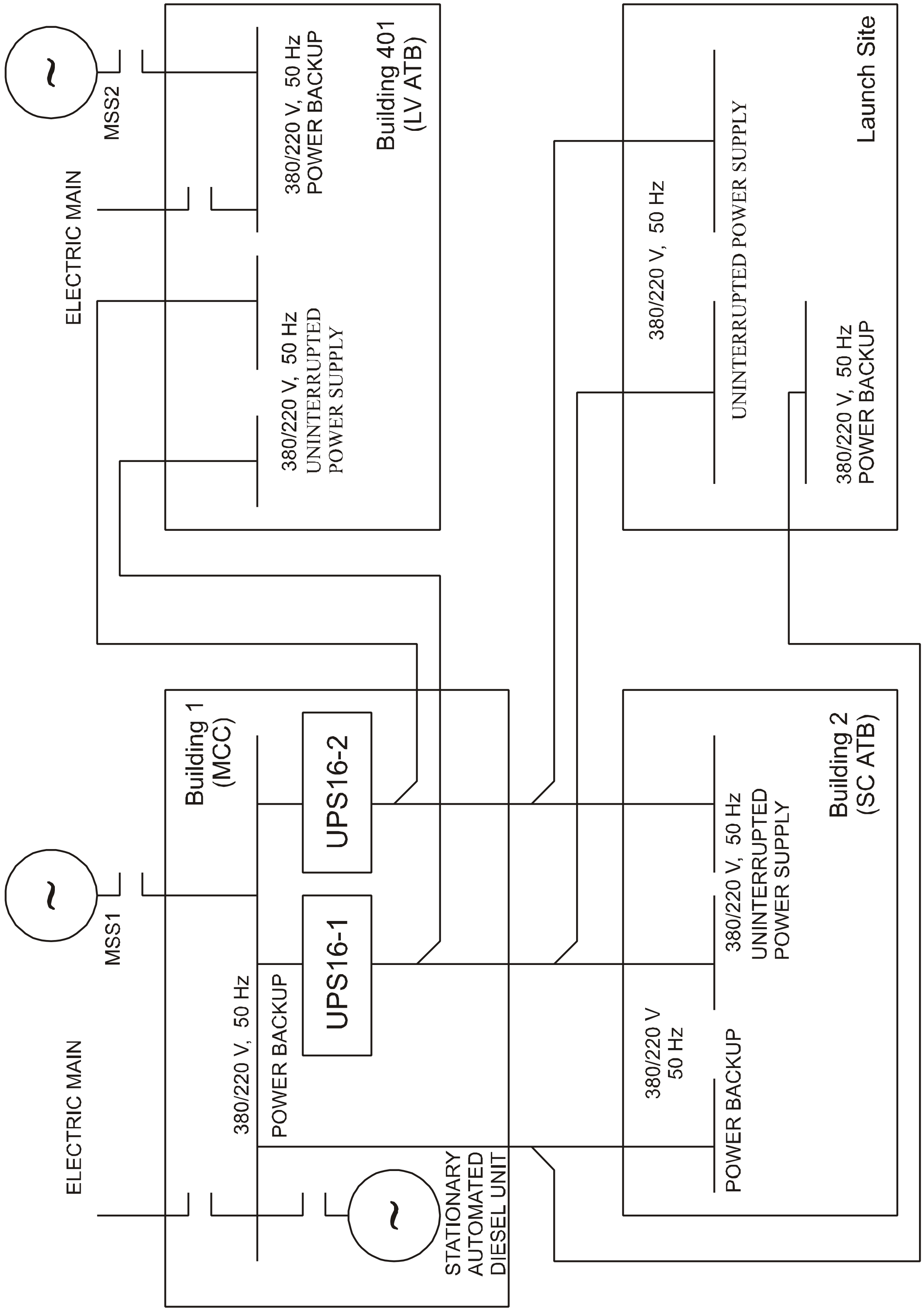


Fig. 2.13. Scheme of Cosmodrome Electrical Power Supply System

2.5 Communications

The Technical and Launch Sites facilities and also some facilities in residential area are equipped with the following communications:

- Voice communication (intercom or telephone communication) between all rooms for SC preparation
- Two international telephone lines including fax machine with dedicated phone line
- Video monitoring system for clean rooms monitoring from SC control room
- Cable lines between computer terminals and between ground equipment elements
- Audible and light alarm.

If necessary two-way radio communication between EGSA and SC can be provided. Also satellite communication system may be used (satellite communication equipment is supplied by Customer).

2.6 Residential Area

The Customer's personnel involved in the launch campaign are accommodated in a hotel located in a residential area, where the appropriate conditions are assured for comfort and safety.

There are one room and two room apartments in the hotel. Each apartment has well-equipped bathroom. Cable and satellite TV is available in each room.

On the ground floor there are recreation rooms and dinning room. Three meals per day are served for Customer's team.

Customer's team is provided with every day services and medical care. Cosmodrome hospital is available for Customer's personnel, other hospitals and clinics can be reached in 2-3 hours.

2.7. Optional Services: HM Environmental Conditions

2.7.1 Nitrogen Cooling System

In order to ensure required SC environmental conditions at the Technical Site and Launch Site, Provider can supply a Nitrogen Cooling System (NCS) to carry out the following ground operation:

- HM purging with dry nitrogen and creation of inert medium over SC
- Cooling the battery of SC integrated with HM
- Operations with SC battery out of HM with the use of Customer equipment (cryostat).

2.7.2 Control of Environmental Conditions Inside Head Module

In order to provide continuous measurement, display and control of parameters of nitrogen medium over SC at Technical and Launch Sites a NCS local computer network can be supplied.

The parameters to be controlled as follows:

- Temperature and pressure (flow rate) of gaseous nitrogen in adapter/SC separation plane during HM pressurization
- Temperature of nitrogen dew point at NCS outlet
- Temperature and pressure under fairing
- Temperature of fairing internal surface.

In order to adapt the Nitrogen Cooling System to specific spacecraft the Customer shall provide the requirements for environmental conditions inside HM (nitrogen temperature, flow rate, dew point, etc.) and SC specifications (thermal characteristics and operating regimes).

3. Spacecraft Preparation at the Cosmodrome

Spacecraft preparation at the cosmodrome begins from the Customer hardware unloading from an aircraft in Blagoveschensk airport and its further transportation to cosmodrome Technical Site (about 250 km from the airport).

3.1. Transportation of Spacecraft and Ground Equipment

The Customer's hardware is transported from Blagoveschensk to cosmodrome by cosmodrome's trucks escorted by security and cosmodrome's, Customer's and Provider's technical personnel.

Any hydrazine (hazardous) containers are transported by special truck equipped with temperature and humidity control system, hydrazine vapour control system, communication system and neutralizing materials in case of hydrazine spillage.

The time taken to transport SC and ground equipment form airport to cosmodrome does not exceed 11 hours.

3.1.1. Transportation Conditions

The temperature and humidity environments during transportation are presented in Table 3.1.

Table 3.1

	Transported Equipment	Temperature, °C	Humidity, %	Environment Control equipment
1	Container with SC	+20±10	35…80	Shall be provided
2	Container with sensitive equipment and hazardous materials	+25±15	35…80	Shall be provided
3	Containers not containing sensitive equipment	-40…+50	35…95	-
4	Containers with hydrazine	+5…+40	35…80	Shall be provided

3.1.2. Vehicles

Vehicles for cargo transportation from Blagoveschensk to the cosmodrome are as follows:

- Four-axle all-wheel drive tractor on the basis of MAZ-543A truck – for transportation of container with SC, sensitive equipment and hazardous materials

- Standard vehicles on the basis of trucks ZIL-130 (ZIL-131) and KAMAZ-4310 – for transportation of ground mechanical equipment and other cargo
- Vehicle on the basis of GAZ-66 KUNG – for transportation of containers with hydrazine
- Escort trucks including fire fighting and hydrazine neutralizing truck, handling vehicles, etc.

In transportation of spacecraft and ground equipment by the above mentioned vehicles vibration induced accelerations affecting shipping containers for frequency band 0.5…20 Hz do not exceed the values presented in Table 3.2.

Table 3.2

Direction of Acceleration Load	(3) Maximum Values of Vibro-Accelerations, g			
	Vehicle			
	MAZ-543	**ZIL-130/131**		**GAZ-66**
1 Vertical	0.75	2.5	2.0	2.5
2 Transversal	0.6	2.0	1.8	2.0
3 Longitudinal	0.6	2.0	1.8	2.0

Permissible transportation speed for vehicles on the basis of MAZ-543A and KAMAZ-4310 trucks is no more than 40 km/h and for vehicles on the basis of ZIL-130 (ZIL-131) and GAZ-66 is no more than 25 km/h.

- Vibro-accelerations for SC fixing points during transportation of LV integrated with SC by mobile launcher are presented in Table 3.3.

Table 3.3

Frequency Band	**Root-Mean-Square Acceleration, g**
1 0.1…7.5 Hz	0.35

2	7.5…50 Hz	0.25

Speed of transportation by mobile launcher does not exceed 15 km/h. The Table 3.3 shows vibro-accelerations acting along vertical axis, vibro-accelerations acting along longitudinal and lateral axes are 30% of the given values.

3.1.3. Hoisting Equipment

Hardware unloading from aircraft and loading to vehicles at Blagoveschensk airport are carried out with the use of aircraft hoisting equipment or special lorry-mounted crane with hoisting capacity no less than 10 tons.

Hardware unloading in SC ATB from the cosmodrome vehicles is also carried out by special lorry-mounted crane with the use of low-bed cargo trolley.

Lorry-mounted crane specifications:

- Type - hydraulic
- Hoisting capacity (maximum) - 10 t
- Hoisting altitude - 12.6 m
- Hoisting speed - (0…6) m/s.

3.1.4. Customer's Hardware Storage Conditions

Customer's spacecraft and clean ground equipment are stored at SC ATB under the following conditions:

- Temperature - (22±3)°C
- Relative humidity - (50±10)%

Containers with hydrazine and fueling equipment are stored at Special Fuelling Complex under the following conditions:

- Temperature - (+5…+35)°C
- Relative humidity - (60±20)%

Shipping containers are stored at the site located near SC ATB.

3.2. Spacecraft Preparation in SC ATB

Operations with spacecraft in SC ATB begin from delivery of SC in shipping container by vehicle in SC ATB.

3.2.1. Spacecraft Processing

Customer personnel carry out operations with spacecraft in Clean Room 1 using Customer's equipment (integration stand, mountings, and rotation fixture other handling devices).

After completion of SC processing joint Customer/Provider team moves the spacecraft from Customer's stand to Provider's head module integration stand.

Herewith the following options of SC installation on HM adapter are possible:

- HM adapter and SC are placed on Customer's integration stand and then this adapter/spacecraft assembly is rotated to horizontal position (Fig. 3.1)
- HM adapter is integrated with SC after the SC is rotated to horizontal position using rotation fixture (Fig. 3.2).

Spacecraft is moved from Customer's stand to Provider's HMIS by bridge crane in Clean Room 1, options are presented in Figures 3.3 and 3.4.

3.2.2. Spacecraft Fueling with Hydrazine in Clean Room 2

After spacecraft has been placed on HMIS and cosmodrome personnel have prepared for fuelling the spacecraft on HMIS is moved from Clean Room 1 to Clean Room 2 and SC propulsion system is fuelled (see Fig. 2.9).

Preparation for fuelling and the fuelling are conducted by Customer's personnel. After propulsion system has been fuelled the spacecraft is moved to Clean Room 1, where its final assembly and electrical checkouts are carried out.

3.2.3. Head Module Assembling in Clean Room 1

HM assembly in Clean Room 1 is conducted by Provider's personnel. Beforehand HM trolley with installed fairing is delivered to SC ATB. HM trolley with fairing is moved to hall 24, where they are preliminarily cleaned, and then they are delivered to hall 25 and Clean Room 1. The fairing placed on HM trolley is integrated with SC by HM trolley pushing in HMIS, which has internal guiding rails for HM trolley. The process of head module assembling is presented in Figures 3.5, 3.6 and 3.7.

Electrical checkout of SC as a part of HM is a final phase of HM assembly operations in SC ATB, and after this head module on HM trolley is moved to hall 24 and then transported to LV ATB.

3.2.4. Head Module Transportation to LV ATB

HM inside standard sealed fairing container is transported from SC ATB to LV ATB (distance is about 200 m) by vehicle.

Hardware is placed in LV ATB in hall 11 with the use of bridge crane.

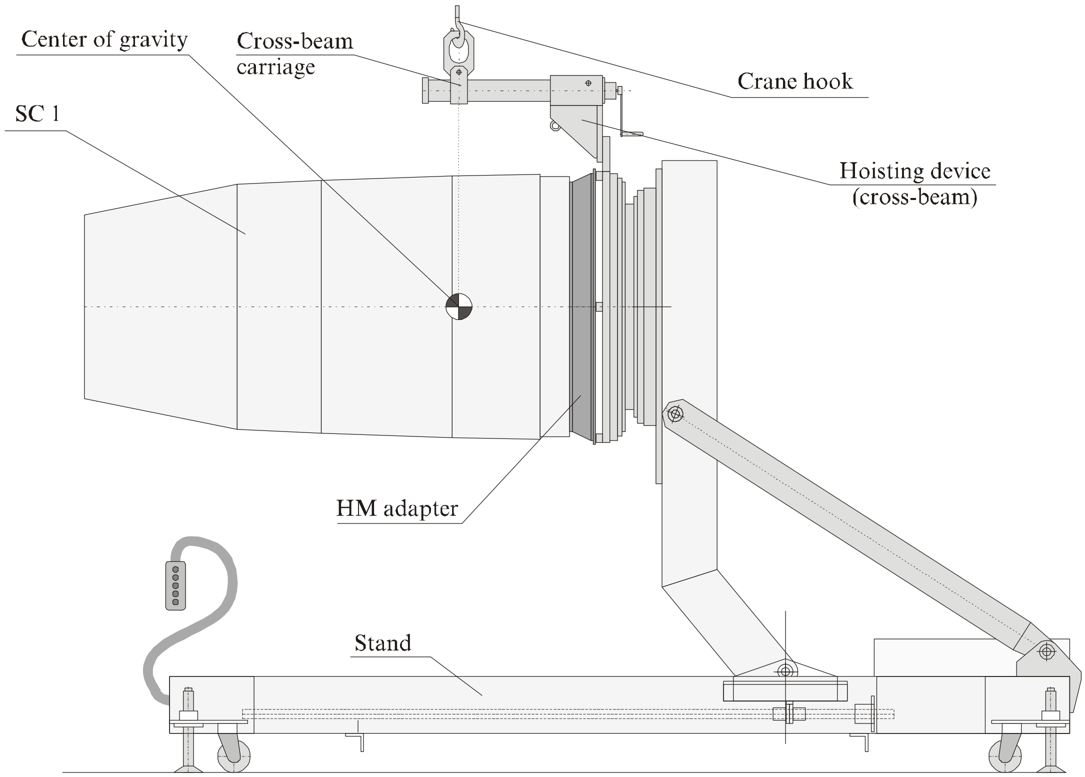


Fig. 3.1. Spacecraft with HM adapter on Customer's stand in horizontal position

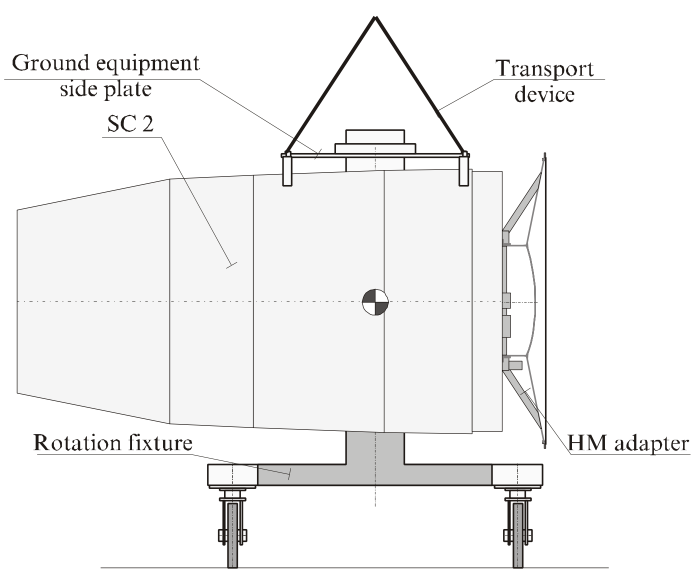


Fig. 3.2. Spacecraft with HM adapter on Customer's rotation fixture in horizontal position

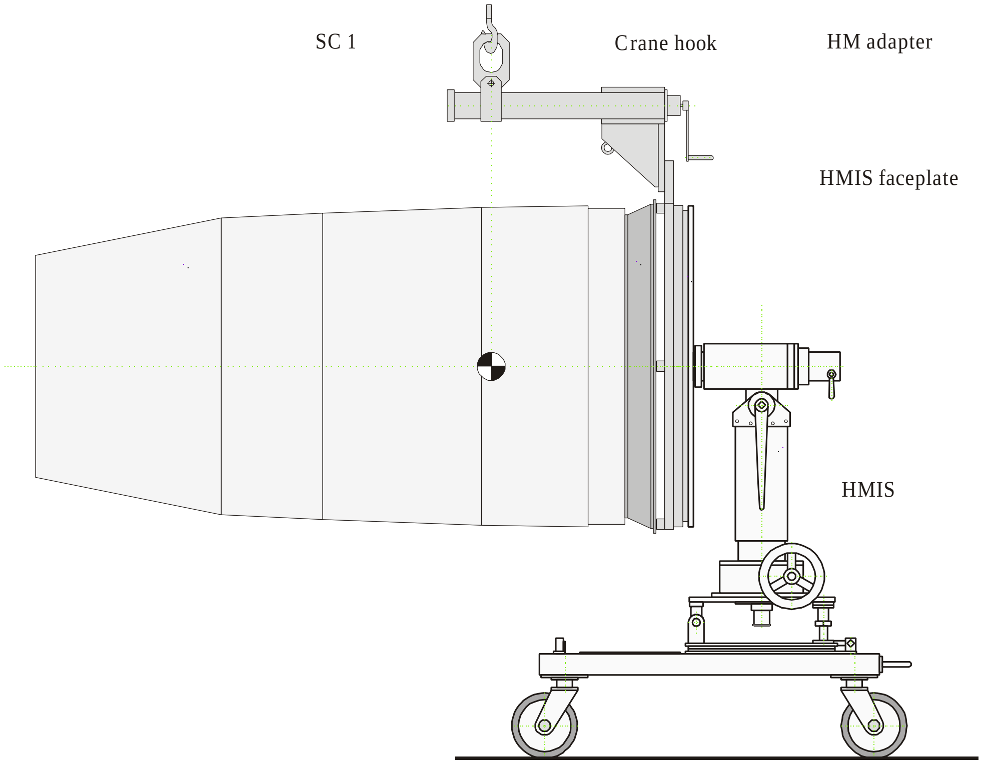


Fig. 3.3. Transfer of spacecraft 1 with adapter to HMIS by crane

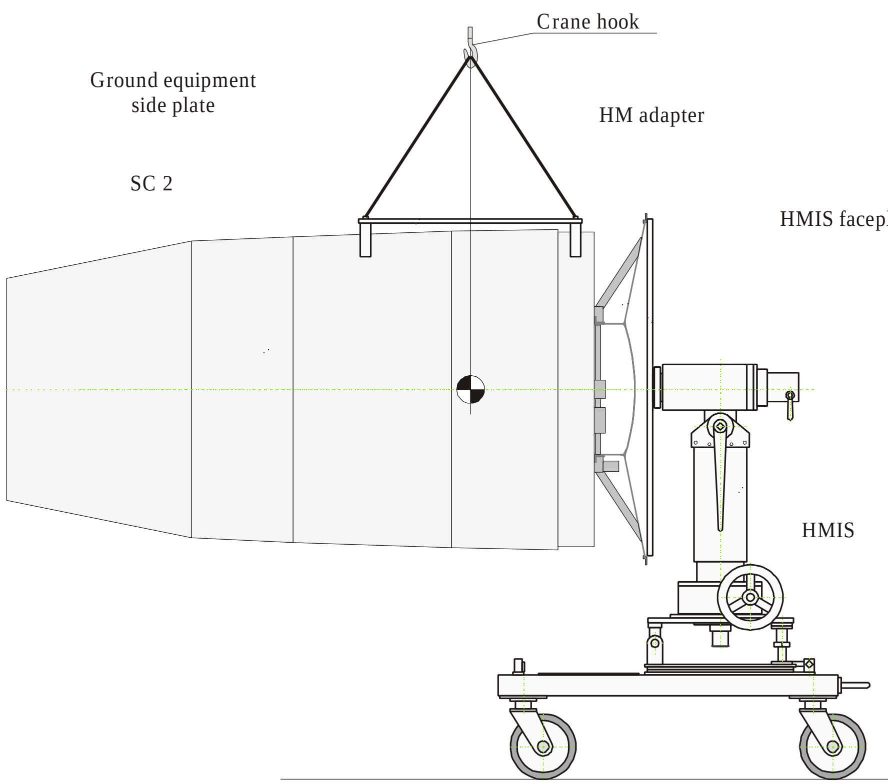


Fig. 3.4. Transfer of spacecraft 2 with adapter to HMIS by crane

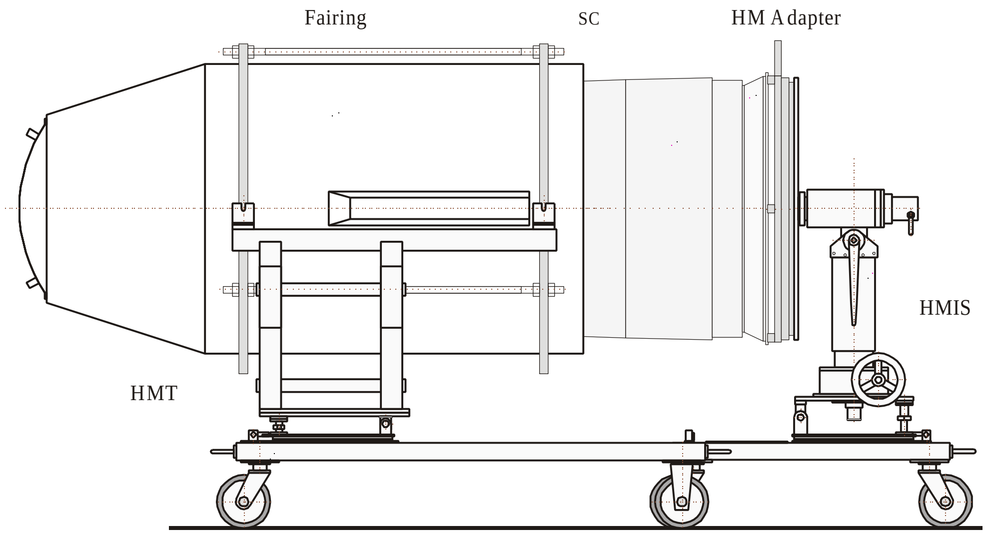


Fig. 3.5. Spacecraft placement inside the fairing

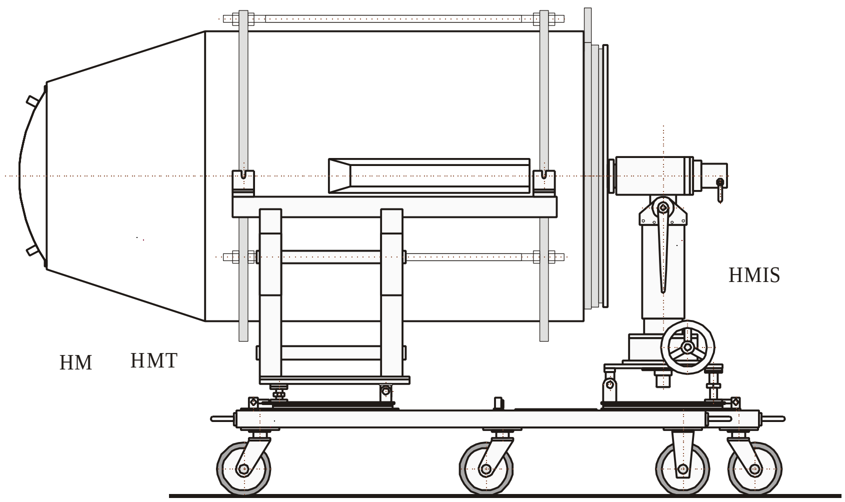


Fig. 3.6. Head module assembling

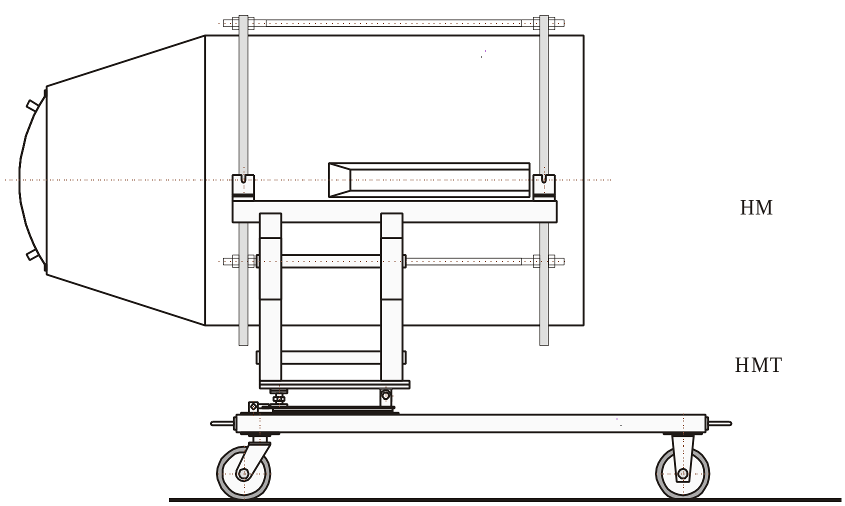


Fig. 3.7. Head module preparation for checkout and transport to LV ATB

3.3. Head Module Preparation in LV ATB

Operations in LV ATB are as follows:
- HM processing
- HM integration with LV
- Operations with S LV
- LV transportation to Launch Site.

After the head module is integrated with LV, during LV integrated tests in the LV ATB, the SC/LV transportation to Launch Site, ptr-launch preparation and launch operations at Launch Site, the initial SC temperature and humidity conditions are maintained by TLC temperature and humidity control system and they kept up to the launch time within the temperature range from 15°C to 25°C at relative humidity of less than 60%.
LV integrated with HM is transported to Launch Site by mobile launcher with a speed of about 5 – 7 km/h.

3.4. Launch Vehicle with Spacecraft Preparation at Launch Site

At Launch Site the following operations are conducted:
- Placement of launcher with LV and ground equipment at Launch Pad
- LV azimuthal orientation
- Electrical integration test of LV with SC and ground support equipment with recording of their operation parameters by MS receiving-and-recording equipment
- Launch
- Post-launch operations and equipment removing from Launch Pad.

Decision about launch implementation is taken based on the results of integration test.

Before launch three launch readiness regimes are set: 2-hours readiness, 1-hour readiness and 30-minutes readiness, during which countdown operations are implemented.

Arrangement of main facilities and components of START-1 Space Launch System at Launch Site is presented in Fig. 2.11, and Mission Control Center layout is presented in Fig. 2.12.

3.5 Post-Launch Operations

Final post-operations include dismantling and evacuation of Customer's and Provider's hardware from Launch Site to Technical Site and then its storage and placing into shipping cargo containers.

After launch under mutual agreement it is possible to place and store Customer's hardware for example, ground equipment, which is to be used for additional operations, in Technical Site facilities.

Specific program of hardware transportation from Svobodny Cosmodrome by air or by rail shall be agreed upon additionally.