control system.

C. Mission Safety Assessment

JSC's Safety Office traditionally prepares a mission assessment to support the flight readiness review process. Such an assessment is being prepared by ASTP. Their review considers previous Apollo spacecraft anomalies, modifications to the spacecraft, Docking Module and other new systems and experiments, Soyuz hardware and operations, operational procedures, and special analyses and test anomalies. The report will be updated as the program progresses. This summary of what was presented to the Panel is limited to the Soyuz spacecraft. Where the hazard analyses consider possible failures in a spacecraft, the fault tree approach used here postulates major events affecting crew safety and looks for credible causes. This technique was used on the Apollo and Skylab programs to ensure that no serious hazards were overlooked and is used here for the same purpose.

1. Failure to Separate.

Failure of the Soyuz vehicle to separate from the Docking Module following docked operations could prevent Soyuz's reentry and would result in an off-nominal reentry configuration for Apollo. This event could be caused by electrical malfunction of the Docking System circuitry and mechanical malfunction of the docking latches. The Safety Office's conclusion is that there is no direct hazard to the Apollo crew. The primary separation system is redundant. Apollo hardware alone can accomplish all separations. The backup Soyuz pyrotechnic separation system is available.

2. Attitude Control Loss.

Loss of Soyuz attitude control would prevent Soyuz from providing contingency attitude control and docked x-axis translation, and would require Soyuz crewmen to transfer to Apollo for reentry. This event could be caused by electrical malfunctions in the propulsion command system, failure of sensors and manual command devices, or mechanical failure causing loss of propellant. Their conclusion is that there is no direct hazard to the Apollo crew. The Soyuz attitude control system is passive during docking operations. Multiple failures would be necessary before there would be loss of Soyuz control.

3. Uncontrolled Thrusting.

Uncontrolled firing of the engines could result in undesired attitude or rotation and prevent the crew from performing critical functions. This even could be caused by electrical failures that turn on the thrusters or by mechanical failures that turn on the valves. The Soyuz propulsion system is passive during docked operations. Multiple failures would have to occur for undesired thrusting. The Apollo spacecraft is prime for control of the docked attitude. Control authority from the Apollo reaction control system will override any Soyuz uncontrolled thrusting.

4. Decompression.

Uncontrolled or rapid loss of pressure in the Soyuz could result in loss of Apollo crew. This event could be caused by pressure seal leakage, inadvertent actuation of Soyuz cabin penetrations, pressure hull failure or premature vehicle separation. Their assessment is that the Soyuz contains equipment to detect cabin pressure reduction. Significant seal leakage would be detected in prelaunch checks or during mission phase prior to docking. Docking seals are extensively tested and their integrity is verified in flight. All lines exposed to vacuum contain redundant isolation. Multiple failures or inadvertent operations are required for actuation of cabin penetrations. The OM and DV pressure hull are proof tested to 1.65 and 1.8 atmospheres, respectively, and inspected for flaws. System malfunctions could not increase internal pressure beyond structural limits. Separation system design and operation is adequate to prevent premature module separations. The only additional information needed are the results of Soyuz testing to verify that the module separation system pyrotechnics are not overly sensitive to RF energy.

5. Electrical Shock.

Electrical shock could cause injury or loss of crewmen. This could be caused by contact with exposed or faulty electrical equipment. However, as noted before, Soyuz utilizes a floating dual wire DC power distribution system. Non-conductive covering over a large percentage of Soyuz Orbital Module interior decreases chances of exposure to shock. Most electronics equipment is located outside the inhabited areas. Soyuz electrical circuits and components are verified prior to launch. Additional information is required on component grounding tests before the analysis can be completed.

6. Explosion.

Explosion of Soyuz pressure vessels, batteries or pyrotechnics could cause crew injury or decompression of the inhabited area. Their assessment concludes that the relief and safety factors on the pressure vessels are adequate. Batteries are vented to prevent internal pressure buildup. Soviet analyses indicate no excessive buildup of explosive gases from batteries. Pyrotechnic design and operations are adequate to prevent inadvertent firings. Mission plans do not call for firing of any Soyuz pyrotechnics during joint activities. Pyrotechnics are reported to be self-contained. In order to complete this assessment the results of the Soviet tests on the sensitivity of the pyros to the Apollo RF energy have been formally requested. Additional information is required to determine the capability of battery vent system to accommodate off-nominal conditions. Finally, additional information on tank safety factors has been requested.

7. Debris from Explosion on Inadvertent Pyro-Firing.

Apollo contact with Soyuz generated debris could result in vehicle damage. This debris could come from Soyuz separation from the launch vehicle, from the pyros fired during separation, and from explosion of a pressure vessel. Their assessment is that contact with Soyuz separation debris is remote due to relative orbital positions. The use of pyros for undocking is a contingency operation. It would release no high energy debris. Relief and safety factors for the pressure vessels are adequate. As noted above, additional data is needed on tank safety factors to conclude the analysis.

8. Collision or Structural Contact.

Undesired structural contact could result in spacecraft damage or depressurization. This event could be caused by uncontrolled thrusting at docking or by loss of visual contact. Their assessment notes the following as a basis for confidence that the risk is minimal. The vehicles hold a narrow attitude dead-band for docking. Soyuz systems contain sufficient safeguards for undesired thrusting. Both Apollo and Soyuz monitor closing rate. Abort criteria have been developed for contingencies during docking. Docking guides will automatically align vehicles. The slow closing rate minimizes possibility of high energy contact. Apollo controls the closing rate and alignment during active and passive docking.

9. Radiated Energy Effects.

Radiated energy from one spacecraft or its ground stations could affect the other spacecraft systems or pyrotechnic devices. Analyses and testing on Apollo systems do not indicate any adverse effects from Soyuz generated RF energy. Soviet analyses and component testing indicate Soyuz pyros are not overly sensitive to RF energy. Information needed to complete the analysis is the results of specific system tests. These tests will verify that the pyros have acceptable safety margins and the Soyuz receivers are not overly sensitive to RF energy.

10. Toxicity.

Toxic contaminants could cause illness or loss of crew. Such an event could be caused by malfunction of the Soyuz contaminant control system or by off-gassing of materials. Their assessment concludes that the testing and control program for exposed material is adequate to establish the safety of these materials. The contaminant control system is adequate. A warning system is provided to indicate any leakage from coolant loop or out-of-tolerance concentration of O_2 or CO_2. The cosmonauts are exposed to the Soyuz atmosphere for fifty-two hours before astronaut exposure.

11. Fire.

Fire, regardless of origin, is a critical crew hazard requiring immediate and correct response. Fire in the Soyuz vehicle, as in the Apollo, could result in loss of critical equipment, cabin pressure integrity, and injury or loss of crew. Based on experience, maximum effort has been focused on the essential ingredients for fire: electrical ignition sources, non-metallic materials, Soyuz atmosphere, and internal configuration. Detailed analyses of available data indicate that:

(a) Soyuz atmosphere is less conducive to the start and continuance of a fire.

(b) Floating ground (two-wire electrical system) reduces the chance of ignition from short circuit.

(c) Essential electrical circuit protection is provided for all systems except the abort and reentry systems. These systems are not covered by breakers or fuses because of their critical nature. Therefore, they use current limiting resistors and series switching redundancy.

(d) Main batteries and most electrical equipment are located outside of the crew areas.

(e) Soviet analysis shows that battery hydrogen levels are maintained below hazardous levels.

In addition to analyzing the causative factors and the ability to control them, NASA is also developing "fire procedures." NASA's intent is to train the crew to react instinctively to fire by being thoroughly familiar with the fire sensing/alert system, the characteristics of fire in the Soyuz, as well as Apollo, and the fire suppression and evacuation procedures. Several additional points are noteworthy. The Soyuz does not contain fire suppression equipment as such. In case of fire or smoke in the OM the crew will evacuate to either DM or DV and suppress the fire by dumping the OM atmosphere. Thereafter, the OM could be repressurized if it were safe to do so. The Soviets do not consider the initiation of fire in the DV a credible failure.

NASA, as a part of its continuing examination of the fire hazard in Soyuz has requested additional information on characteristics and control of Soyuz flammable material to assure a complete analysis. In addition, JSC is continuing its studies of hydrogen gas generation from Soyuz silver-zinc batteries and the control of hydrogen peroxide from any leakage in the fuel line.

D. Contingency Planning

The basic principal of contingency planning is to maximize crew safety and then, secondly, achieve mission objectives. Planning for contingencies is an integral part of the mission planning process. The first step is to develop the basic plan which meets the specified requirements of a nominal mission. The second step is to identify the events which are critical to the success of the plan and identify potential contingency situations related to these events.

Several fundamental categories of problems are considered: problems related to limited consumables, problems of events not occurring or occurring in the wrong time and place, and system malfunctions. In the third step, these situations are evaluated. Some situations can be eliminated with modifications to the basic plan and hardware. Some situations can be corrected with procedures. Some situations have trivial consequences or a low probability of occurrence. Some situations have to be worked until the hard core problems are reduced to a minimum or acceptable level.

As a consequence of the iterative contingency planning process, nominal plans will provide for adequate margins of critical consumables. The maximum allowable usage for each consumable as a function of time will be established. Thus real time monitoring will provide consumables status in terms of these limits so that corrective action can be taken if the usage rate is excessive. As for problems with the non-occurrence of events or occurrence at the wrong time, the nominal plan is written to provide adequate margins. Alternate plans are provided as appropriate. As for system problems, backup and malfunction procedures are written for each system as required. This requirement is based on the impact of the loss, design of the system plus previous experience, redundancy, and the ability to take corrective action.

Used in this work are such documents as ASTP 50500 "Contingency Plan," IED 50724 "Analysis of Non-nominal Situations Involving the Soyuz Life Support Systems and Apollo Environmental Control Systems," ASTP 40301, ASTP 40401, ASTP 40600, and WG4-353.

As an example of the work being done, backup procedures are being developed for situations involving Apollo active and passive docking, rapid loss of pressure, and crew transfer.

Planning and operations personnel participate in the preparation and review of the hazard analyses and unilateral safety reports. Items which result from these activities will be integrated into the mainstream planning and training as they are identified.

In response to a request by the Panel, a briefing was provided on studies on the possible use of EVA during the ASTP mission. The material covered included: (a) crew transfer sequences, (b) toxicity and fire considerations, (c) seal and structural reliability, (d) environmental control and life support systems, and (e) system redundancy and reliability.

The studies showed that crew safety considerations are satisfied without EVA capability, and EVA capability would, in fact, complicate the joint operations without an attendant improvement in crew safety. For example, if loss of Docking Module pressure is caused by a valve failing open and the valves cannot be closed, the emergency DM oxygen pressure regulator will maintain the cabin above 3.5 psia for a minimum of fifteen minutes. This should be sufficient time for the crew to equalize pressure between the DM and the CM, transfer to the CM, and isolate the CM from the DM. Also, there are no single failure points in the hatches which would require an EVA.

E. Training.

The Panel reviewed the approach to training mission control personnel and flight crews in both nominal and contingency situations.

1. Training of Flight Controllers.

NASA flight controllers trained in Moscow in September 1974. The twenty member group included a full team of flight controller, communication specialists, technical specialists and interpreters. Training for Soviet controllers at the NASA mission control center also began this year. Additional control center tests and simulations are scheduled for March, May, and June/July. There will most likely be NASA observers at Soviet sites and vice versa during these tests. These observers will be technical specialists who will support the flight control team as well as the on-going working group efforts.

2. <u>**Training** of Flight Crew</u>.

Joint training will provide the crews an opportunity to: (a) familiarize themselves with Soyuz and Apollo spacecraft systems supporting the flight, (b) study the joint crew documents, (c) review contingency planning, and (d) develop working relationships.

Joint flight crew training hours will approximate 640 hours during the period July 1974 to April 1975 period. Total training for the astronauts in both Apollo and joint phases will be in the neighborhood of 2187 hours per crewman. This compares with some 1285 hours for each member of the Apollo 7 crew. Language training has been intensified to assure complete understanding of phrases and acronyms as well as normal conversation and reading materials. A good number of Soviet personnel have a working command of the English language.

Each crew has flown in the others trainers. The NASA trainer has a mockup of both the Apollo and Docking Module cabins while the Soyuz trainer has a mockup of the descent vehicle and

Orbital Module. In each case flight effects are created by visual aids. These trainers are used for both training and simulation. Training assures knowledge of hardware and its operation but does not necessarily duplicate mission conditions. Simulation recreates the actual mission and includes both nominal and non-nominal conditions.

Simulations to date are using the nominal flight procedures. Procedures for non-nominal situations will then be introduced.

3.0 ATTACHMENT - 1

Attachment No. 1

AEROSPACE SAFETY ADVISORY PANEL

QUESTIONS OF DECEMBER 1974

Question: 1. What is the written ground-rule for mission management in the event of the loss of all nine long lines between Moscow and Houston during mission?

Answer: We currently plan to continue the joint mission as planned while troubleshooting progresses.

Question: 2. What is the situation where a fire in the Orbital Module results in retreat to the Descent Vehicle and depressurization of the Orbital Module? Would NASA want to repressurize the Orbital Module and transfer our crewman back to the Command Module? Could there be an toxic material remaining in the Orbital Module? What if fire was to destroy wiring to repressurize system, etc.?

Answer: The question of repressurizing the Orbital Module to complete a return transfer is still under consideration and must be discussed further with the USSR. The alternative is to return in the Soyuz Descent Vehicle. This course of action would also be required if the fire precluded repressurization.

Question: 3. What is the status on taking a fire extinguisher into the Orbital Module? Early meetings indicated that we would not take or use a fire extinguisher into the Orbital Module. Current ground-rules indicate we would.

Answer: Under nominal conditions, we currently do not plan to take a fire extinguisher into the Soyuz. However, we do have contingency procedures by which a member of the Apollo crew would stand by with the DM fire extinguisher in event of a fire in the Orbital Module. This subject including the potential use of the DM extinguisher in the DM will be discussed with the USSR in January.

Question: 4. What is the adequacy of the data base for the conclusion that there are no hazards associated with the Soyuz electrical system?

Answer: The data base is as provided in the unilateral system safety report for Soyuz electrical power system for the ASTP. Some additional questions have been defined as a result of the review of this report and these will be discussed with the USSR in January. In addition, one hazard, the potential for an explosive mixture existing in the descent batteries if a short occurs, will be further explored in January.

Question: 5. How does the safety of ASTP compare with the safety of the Skylab CSM? What is the basis for this conclusion?

Answer: The safety program for the US ASTP hardware is the same as that for the Skylab CSM. Based upon our overall approach to joint mission, i.e., planning to ensure a static and benign environment, and assuming satisfactory resolution of current open Soyuz safety questions, we feel the safety of the overall mission is comparable to that of the Skylab missions.

Question: 6. To what extent and in what areas are the mission rules significantly different than those for prior Skylab flights? What are the associated hazards, if any?

Answer: Major areas of difference are as follows:

a. Some rules related to joint mission provide for coordination between US & USSR control centers prior to implementation.

b. There is no overall spacecraft commander - the Soyuz commander is responsible for Soyuz and Apollo commander is responsible for Apollo.

c. New mission rules developed for Docking Module/Docking System operations.

d. Mission rules to cover transposition, docking and extraction of DM.

e. Experiment unique mission rules.

Question: 7. What is the current plan for translating the results of the hazard tree analyses, etc. into contingency planning and joint crew training in contingency procedures?

Answer: Planning and operations personnel are an integral part of the preparation and review of the hazard analysis and unilateral safety reports. Items which result from these activities will be integrated into the mainstream planning and training as they are identified.

Question: 8. What provision has been made for evaluating the age-life effects and reliability of the launch escape system on the CSM?

Answer: The age-life analysis for the launch escape system and the CSM have been completed and all components are within age-life limits.

Question: 9. What were the results of Soyuz 16? Were there configuration differences that would qualify the results?

Answer: Based upon preliminary telephone reports from the USSR, the Soyuz 16 spacecraft achieved the ASTP target orbit, depressurized to 10 psi, and exercised the Docking System successfully. Based upon previous discussions, we do not believe that there were any configuration differences which would negate the results of the flight. A more detailed evaluation cannot be made until after the January meeting.

Question: 10. What is the suit-donning time and the ability of the crew to transfer to their spacecraft?

The nominal 4th transfer time is 110 minutes. We have defined a quick return 4th transfer procedure which requires approximately 28 minutes. Once in the CSM, 15 to 30 minutes are estimated to don and pressurize the suits.

Question: 11. What assessment has been made of sharp projections in Apollo, DM and Soyuz? Is there a hazard to the crew?

Answer: Based upon our mock-up familiarization and training activities we have found no crew hazards due to sharp projections in Apollo, DM or Soyuz.

Question: 12. What were the results and problems, if any, of this December's "ground personnel procedures checkout," including the adequacy of the communication systems?

Answer: The test results were considered satisfactory.

4.0 TABLES AND FIGURES

TABLE I

DOCKING SYSTEM DEVELOPMENT PROBLEMS

	Problem	Resolution
1.	Capture latches failed to capture at -100°F. (flight predicted -58°F.).	Grease in bearings changed to F-50 oil. Screen latches at -100°F.
2.	Structural latch failed to reset at -31°F. (not a normal flight condition).	Definitive cause not established. Reset cable rigging revised and low temperature system screen implemented.
3.	Attenuator leakage detected.	Contamination in seals. Refurbished attenuators still show some leakage in quality test. Monitor leakage and replace if required.
4.	Indicator switch movement during quality and acceptance vibration test.	Redesigned switch mounting and conducted delta quality test to assure adequacy.
5.	Capture latch assembly shifted during quality vibration test.	Redesigned latch mounting for positive positioning (not dependent on friction) and incorporated in qualification test.
6.	DS-1 retract cable frayed following initial thermal/vacuum test.	Completed qualification test with frayed cable. Probable cause identified as rigging error which damaged cable. Inspected flight system.
7.	Intermittent capture identification.	Design permits intermittent operation; indicator is used as cue to terminate thrust for capture. Understand and accept.
8.	Tunnel insulation debonded during thermal/vacuum test.	Redesigned using beta cloth blanket and retained velcro and mechanical fasteners. Completed verification.
9.	Screws backed out during DS-5 vibration test.	Analysis of all screw installations. Reverification of critical applications. Disassembled gear boxes retorqued.
10.	Retract cable slack during acceptance test.	Redesigned to reduce sensitivity to cable slack.

TABLE II

CONTRACTOR ANALYSIS OF HARDWARE FOR ASTP DOCKING SYSTEM (TYPICAL)

Part:	Spring-motor, gear-box, cable-retract-system
Application:	To provide tension on cable during initial capture
Material:	PH15-7 Mo Cond A CRES Sheet - RH1075 Temper
Stress:	Residual stress arises from loading in the wound position at a calculated 69.5 in. lb. torque Calculated stress = 108,000 psi Stress corrosion threshold = 85,000 psi 85,000 ÷ 1.5 safety factor = 56.67 KSI (threshold)
Evaluation:	Stress Level: greater than threshold Consequence of Failure: criticality 3 - not adverse Environment: atmospheric air - adverse Surface Protection: passivated - not adverse Category: AC (one factor adverse - stress corrosion remote)
Rationale:	Function is strictly convenience - mission not impaired by failure. No corrective action warranted.

TABLE III

USSR AND UNITED STATES EXPERIMENTS

Astronomy

MA-048	Soft x-Ray
MA-083	Extreme UV Survey
MA-088	Helium Glow
MA-148	Artificial Solar Eclipse
MA-151	Crystal Activation

Earth's Environment

MA-059	UV Absorption
MA-007	Stratospheric Aerosol Measurement
MA-136	Earth Observations and Photography
MA-089	Doppler Tracking
MA-128	Geodynamics

Radiation Effects

MA-106	Light Flash
MA-107	Biostack
MA-147	Zone Forming Fungi

Immune System

AR-002	Microbial Exchange
MA-031	Cellular Immune Response
MA-032	Polymorphonuclear Leuko Cyte Response

Medical Applications

MA-011	Electrophoresis Technology
MA-041	Electrophoresis

Material Applications

MA-010	Multi-purpose Furnace
MA-028	Crystal Growth

TABLE IV

USSR ASTP GROUND TEST PROGRAM

Orbital Module structure static test.

Dynamic tests of Orbital Module structure.

Final development layout of compatible equipment in living compartments and of the exterior elements (target, etc.) in mockup.

Development of the Life Support System incorporating new and modified equipment.

Orbital Module thermal conditions development.

Spacecraft antenna mockup.

Docking dynamics development.

Docking system development and interface pressure integrity control check in the thermal/pressure chamber.

Bench set for docking system structure components development and verification.

USSR/USA nominal docking system fit check.

TABLE V

SOYUZ FACTORY CHECKOUT SEQUENCE

MODULE AND HYDROPNEUMATIC LINE PRESSURE INTEGRITY CHECK AFTER INSTALLATION ONBOARD THE SPACECRAFT

PYROS CIRCUIT CHECK

DOCKING SYSTEM AUTONOMOUS CHECK OF OPERATION

CHECK OF RF COMMUNICATION LINKS AND ANTENNAS

CHECK OF EXTERNAL DEVICE DEPLOYMENT MECHANISM AND ACCURACY OF INSTALLATION, INCLUDING DOCKING TARGET ALIGNMENT

SENSORS AND MEASUREMENT SYSTEMS EQUIPMENT CHECK

AUTONOMOUS ELECTRICAL VERIFICATION TESTS OF SPACECRAFT SYSTEMS

TEST ACTIVATION OF RADIO TELEMETRY SYSTEMS

TEST ACTIVATION OF LIFE SUPPORT SYSTEM, EVERYDAY USAGE EQUIPMENT, MOVIE AND PHOTO EQUIPMENT, ORIENTATION LIGHTS AND FLASHING BEACONS

INTEGRATED TESTS (ELECTRICAL)

PREPARATION FOR TRANSPORTATION

TRANSPORTATION TO TECHNICAL SITE OF THE LAUNCH COMPLEX

TABLE VI

PERMISSIBLE CONCENTRATIONS OF CONTAMINANTS IN THE SPACECRAFT ATMOSPHERE

a.	Carbon monoxide	0.01 mg/1
b.	Ammonia (and amines)	0.002 mg/1
c.	Acetone	0.04 mg/1
d.	Aldehydes	0.001 mg/1
e.	Acetic acid	0.001 mg/1
f.	Hydrogen sulfide (and mercaptans)	0.0015 mg/1
g.	Total organic oxidizable impurities	0.150 mg/1
h.	Helium	not more than 0.5% of the volume
i.	Hydrogen	not more than 1% of the volume

j. The following cleaning agent solvents, or chemicals must not be used in or around the spacecraft or during manufacture of its components:

Mercury

Materials containing organic-phosphorus compounds and other substances which may prove to be allergenic or carcinogenic.

Carbon tetrachloride

Chloroform

Trichloroethylene

TABLE VII

THE SOYUZ PYROTECHNICS

No.	Function	Type	Quantity
1.	APDS passive hooks' jettison	Explosive Bolt	8
2.	APDS active hooks' jettison	Explosive Bolt	8
3.	APDS latches' jettison	Explosive Bolt	3
4.	OE-ODE lines backup control	Pyrocartridge	11
5.	Service prop. backup pressurization	Pyrocartridge	2
6.	Unblocking of pressure unit	Pyrocartridge	1
7.	Control Unit of DV Control System	Pyrocartridge	11
8.	Sight jettison	Pyrocartridge	2
9.	OM-IAM cable path separation	Pyrocartridge	8
10.	DV-OM separation	Explosive Bolt	6
11.	DV-OM separation	Pyrocartridge	6
12.	Feed-through jettison	Pyrocartridge	4
13.	DV-IAM separation	Pyrocartridge	6
14.	Cover jettison, primary parachute container	Pyrocartridge	24
15.	Cover jettison, backup parachute container	Pyrocartridge	18
16.	Breathing vent unblocking	Pyrocartridge	4
17.	Front Shield separation	Pyrocartridge	12
18.	Arming of couch shock absorbers	Pyrocartridge	4
19.	Firing of soft landing engines	Pyrocartridge	4
20.	Cooling System line control	Pyrocartridge	4
21.	Antenna Control	Pyrocartridge	4

(No pyro devices to open solar panels, antenna and docking target are listed in the above table)

(APDS = Androgynous Peripheral Docking System)

TABLE VIII

COMPARISON OF APOLLO AND SOYUZ PYROTECHNIC INITIATORS

CHARACTERISTIC	SOYUZ	APOLLO
INITIATOR TYPES	USE TWO TYPES OF INITIATORS 1. Dual bridgewire cartridges 2. Pyrotechnic bolts	USES STANDARD SINGLE BRIDGE-WIRE INITIATOR FOR ALL FUNCTIONS (SBASI)
PYROTECHNIC MATERIALS	UNKNOWN	ZIRCONIUM AND POTASSIUM PERCHLORATE
DC SAFE POWER LEVEL (NO-FIRE LEVEL)	≈1.5 MILLIWATTS/50 MILLIAMPS	≈1 WATT/1AMP FOR 5 MINUTES
DC FIRE LEVEL	≈ 400 MILLIWATTS	≈3.5 WATTS
RF FIRING LEVELS	SAME AS FOR DC: PIN-TO-PIN MODE ONLY	VARIES WITH FREQUENCY: PIN-TO-PIN AND PIN-TO-CASE MODES
CIRCUIT SHIELDING	CONTINUOUS FROM FIRING RELAYS TO INITIATOR. 360° CONNECTION AT INITIATOR BACKSHELL	SHIELDING HAS DISCONTINUITIES AT BULKHEAD CONNECTORS. 360° CONNECTION AT INITIATOR BACK-SHELL
TWISTED PAIR WIRING	YES	YES
CIRCUIT GROUNDING	FLOATING FIRING CIRCUITS	GROUNDED/SHORTED FIRING CIRCUITS WHEN SAFED

ASTP/ATS-6 RELAY

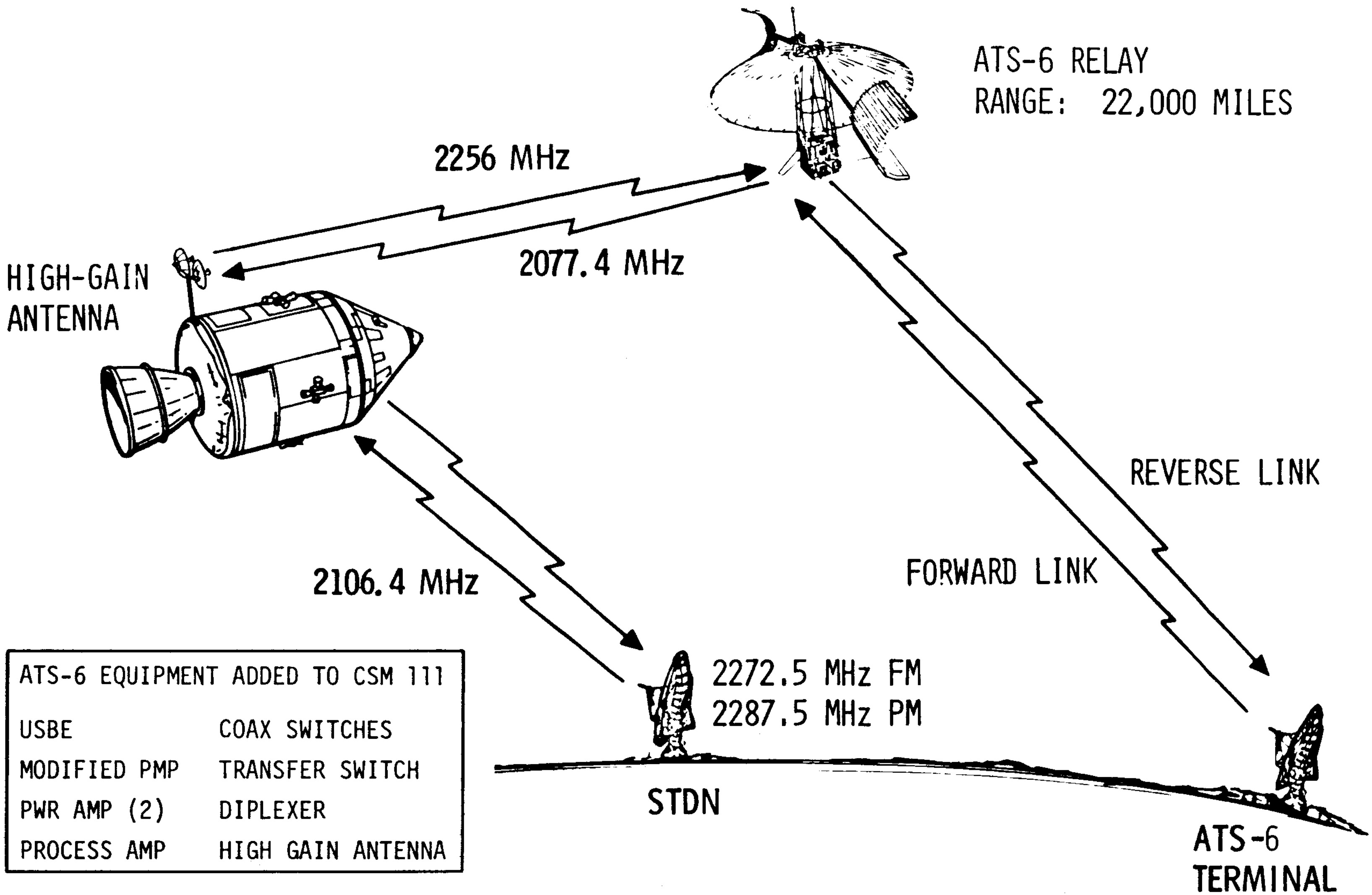


Figure 1

DM ON TRUSS IN SLA

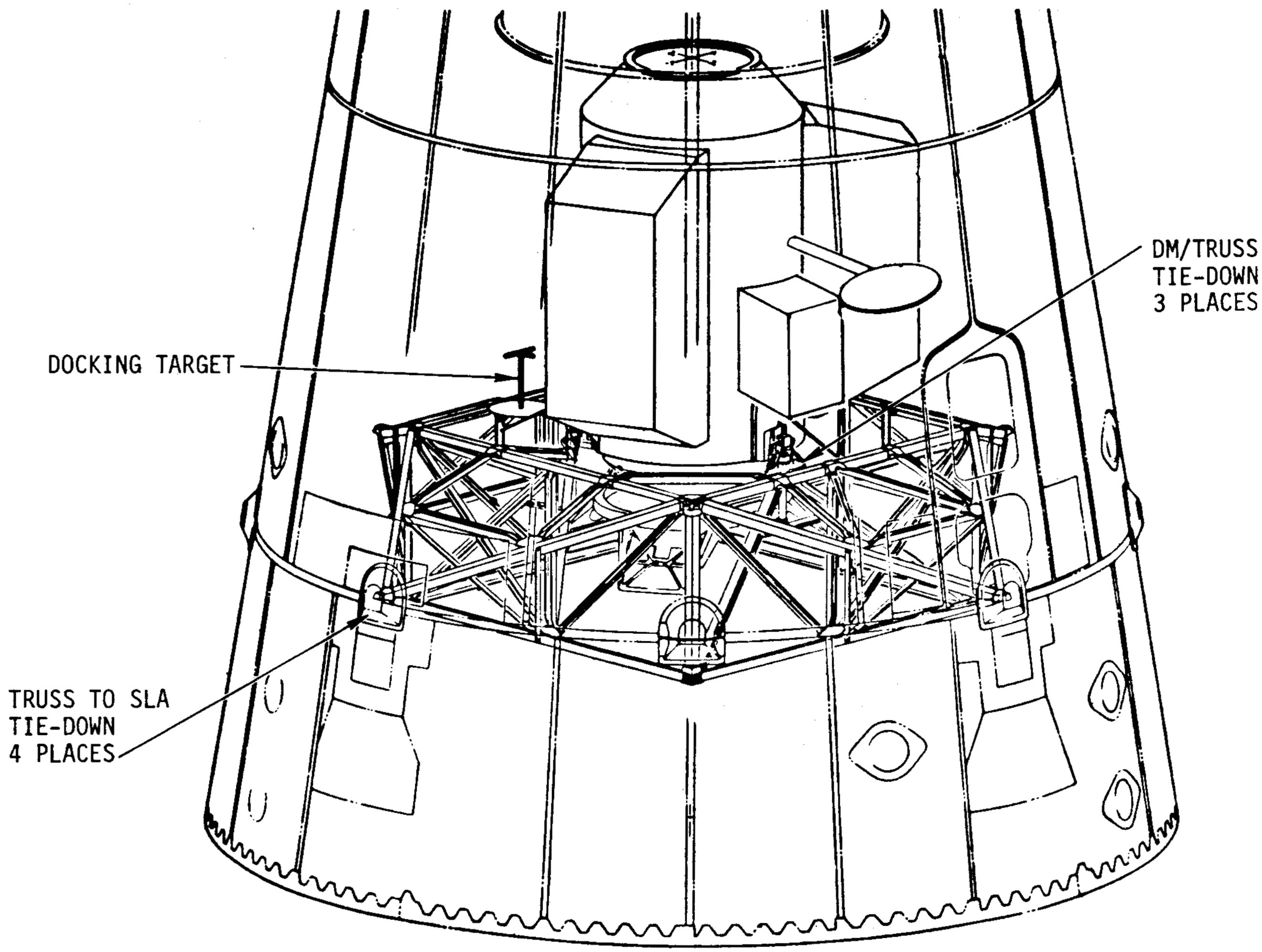
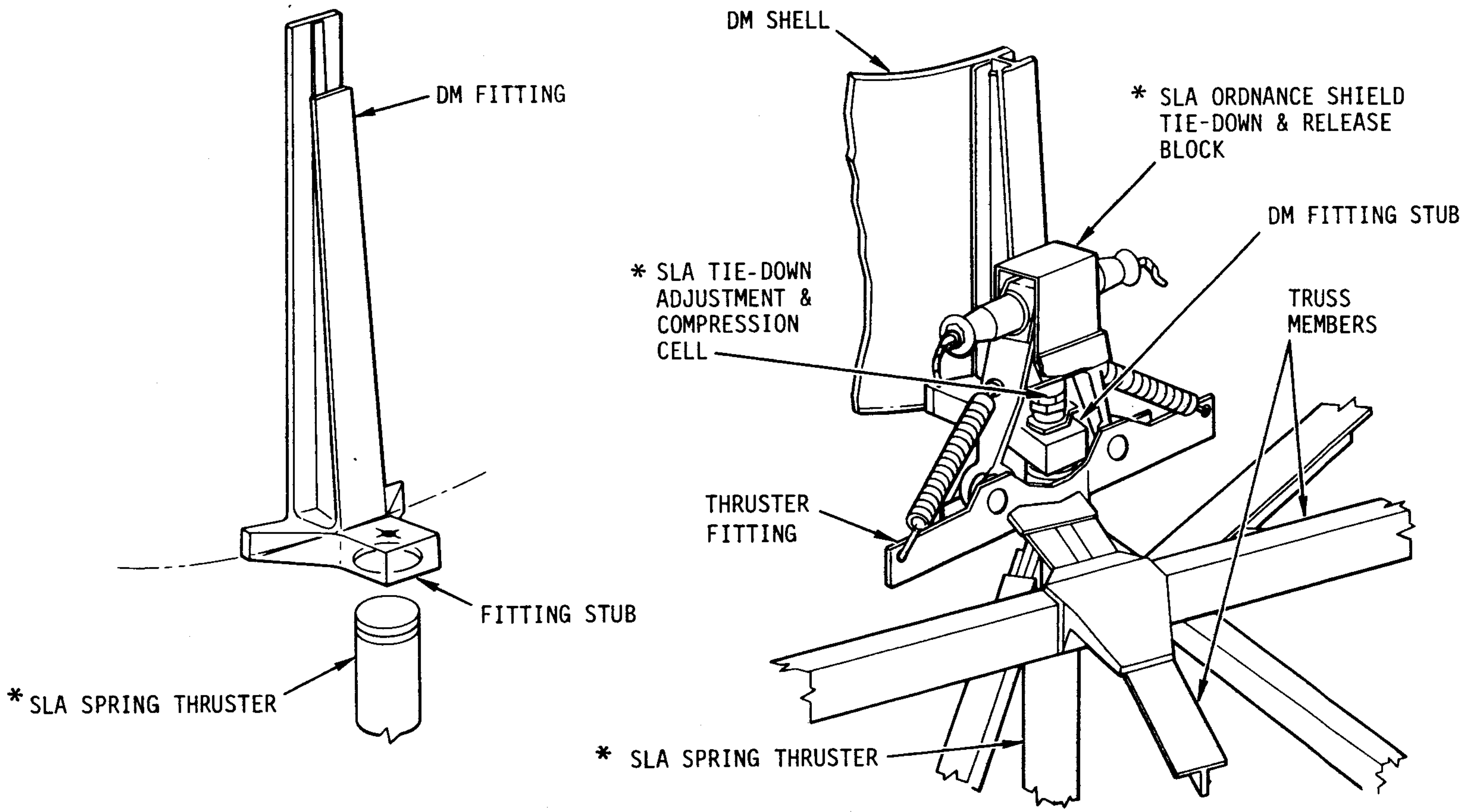


Figure 2

DM/TRUSS SUPPORT FITTING AND TRUSS RELEASE MECHANISM



* SLA INDICATES PARTS USED FOR LM/SLA TIE-DOWN ON APOLLO MISSIONS

Figure 3

DOCKING MODULE
PRIMARY STRUCTURE

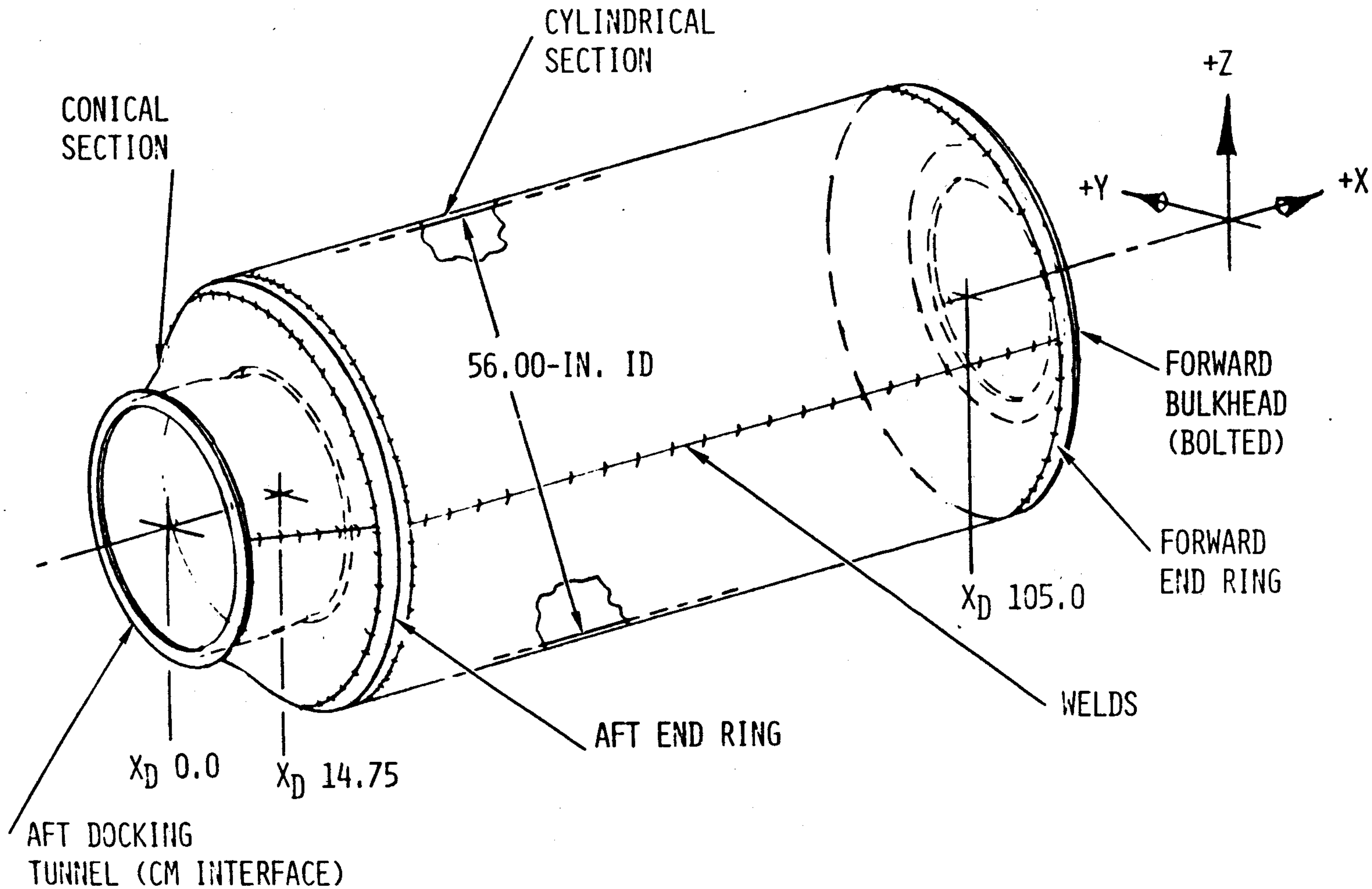


Figure 4

DM IN-FLIGHT STOWAGE CONFIGURATION

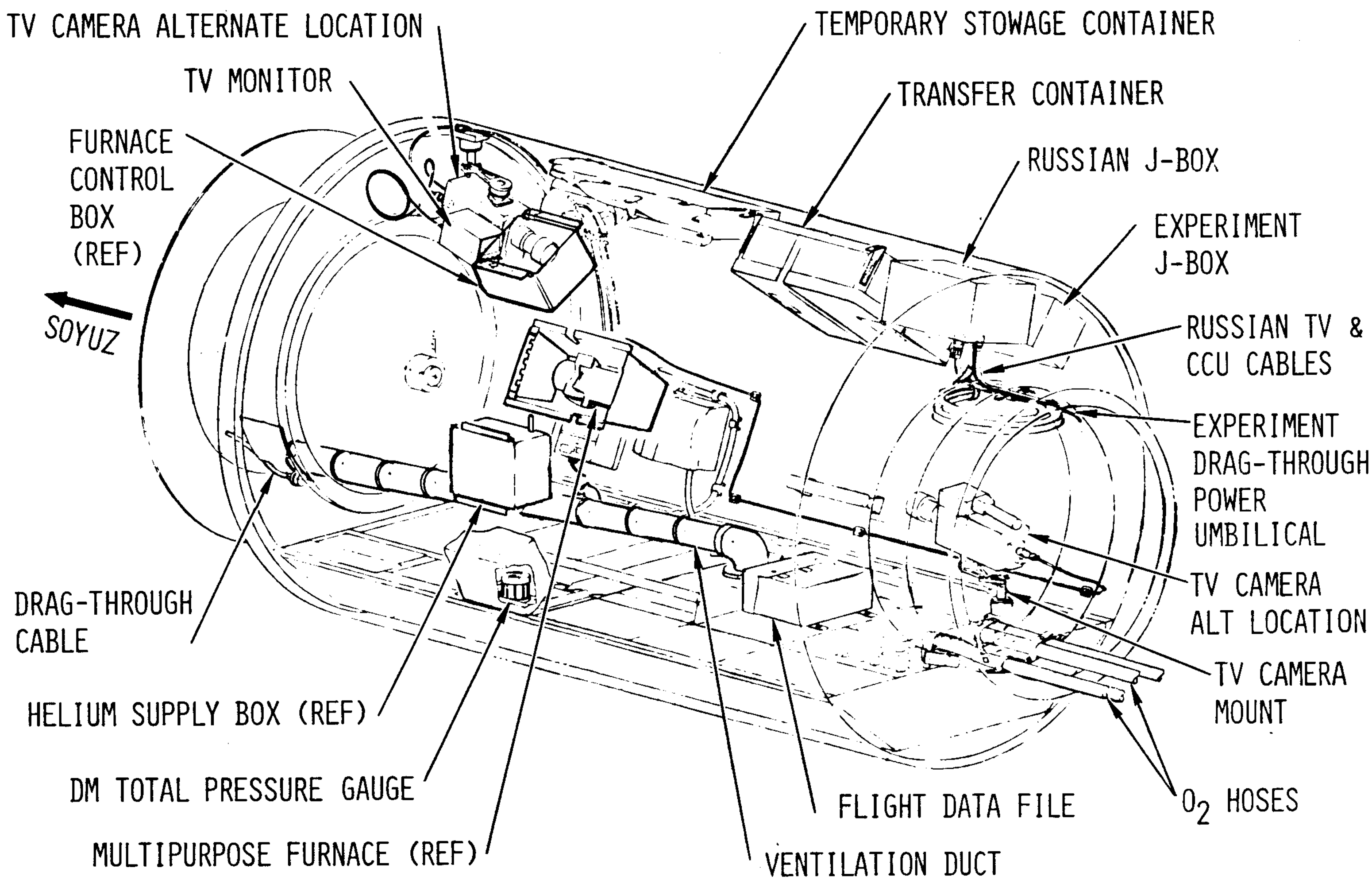


Figure 5

DOCKING MODULE
GAS STORAGE TANK

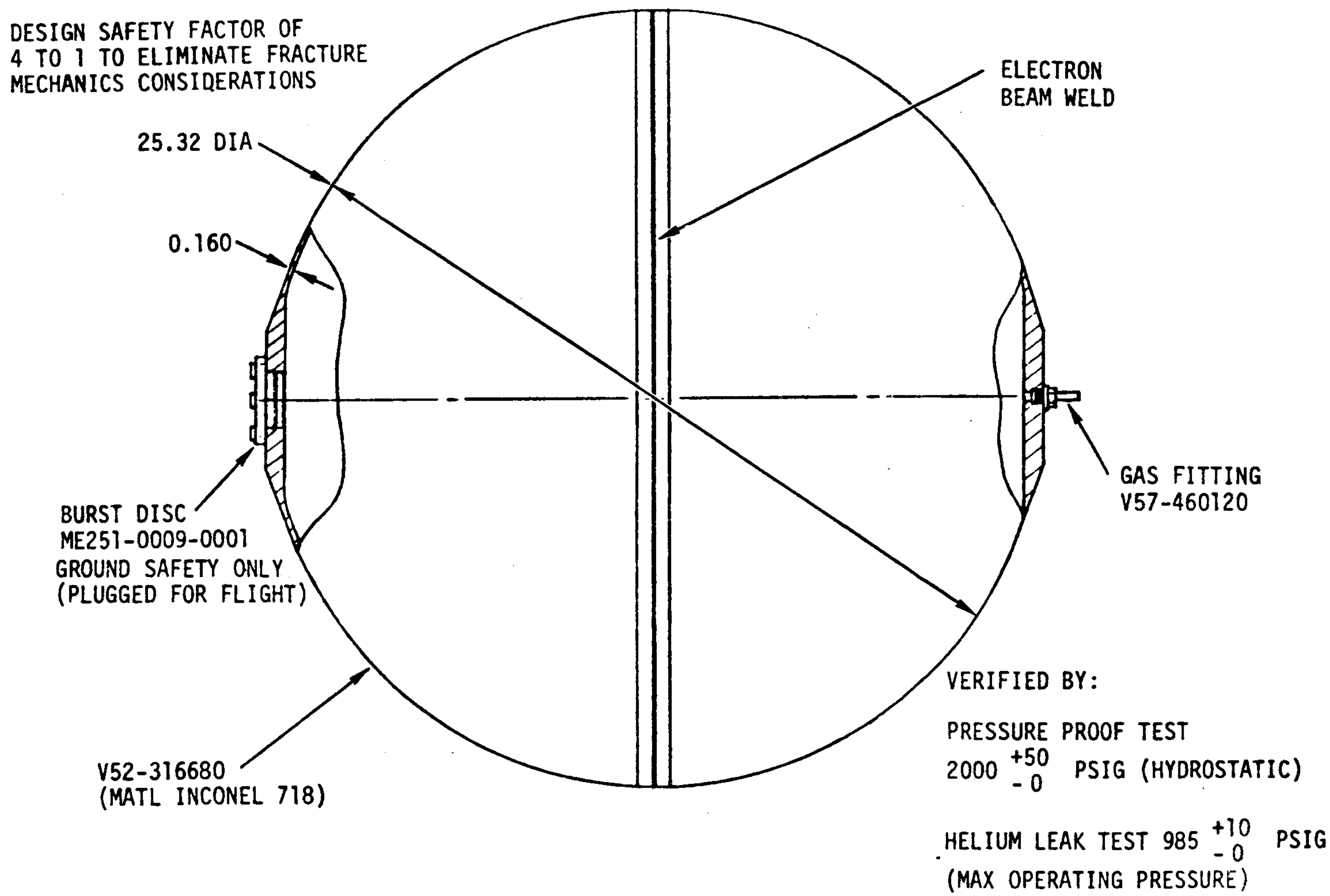


Figure 6

DOCKING MODULE

DOCKING SYSTEM AND FORWARD BULKHEAD JOINT SEALS

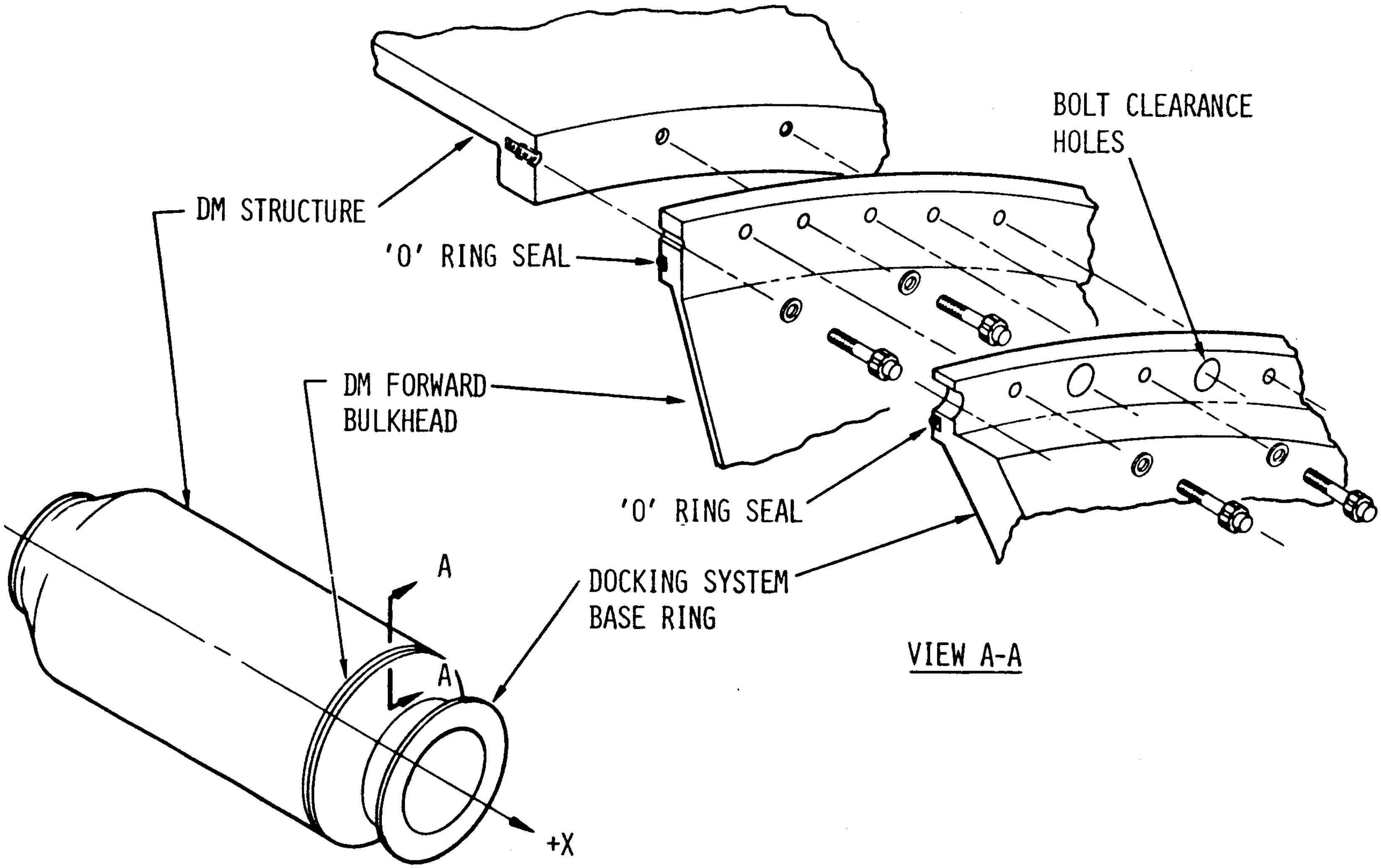


Figure 7

ASTP DM ELECTRICAL POWER SYSTEM
CM/DM POWER DISTRIBUTION AND CONTROL SCHEMATIC

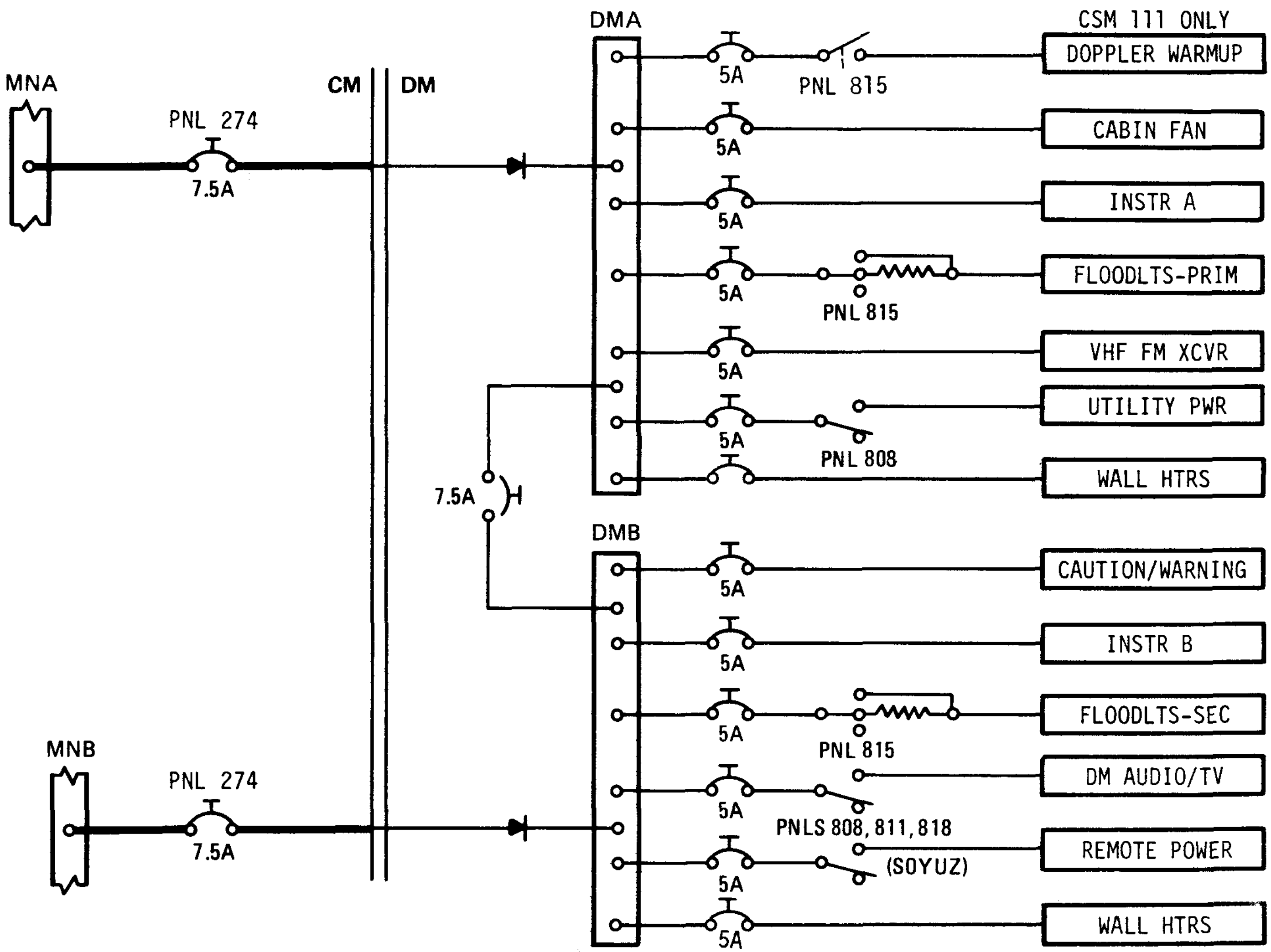


Figure 8

ASTP/DM ELECTRICAL POWER SYSTEM
SIMPLIFIED DM HARNESS DIAGRAM

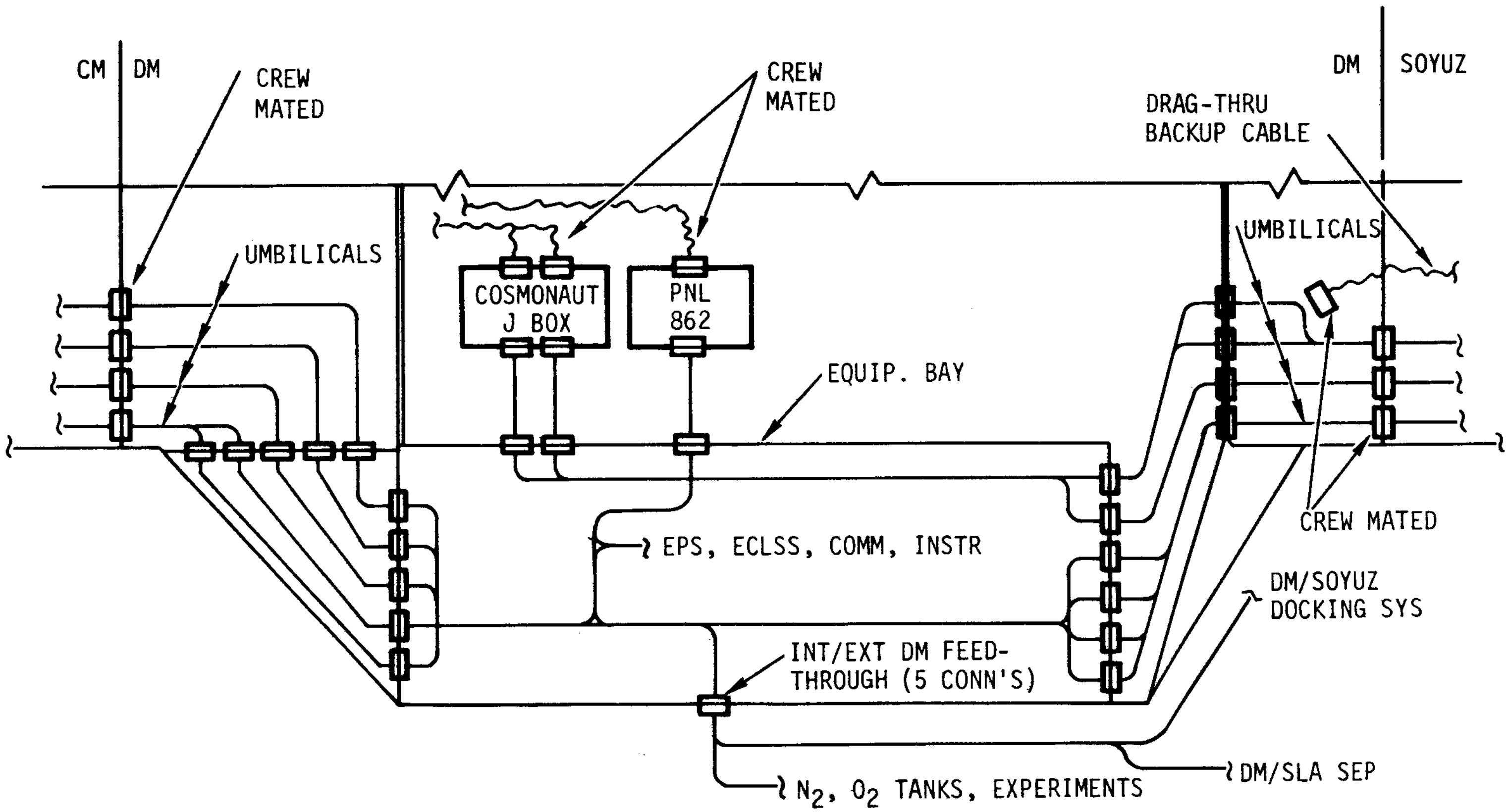


Figure 9

ASTP ELECTRICAL POWER SYSTEM
CM/DM UMBILICAL CONNECTIONS

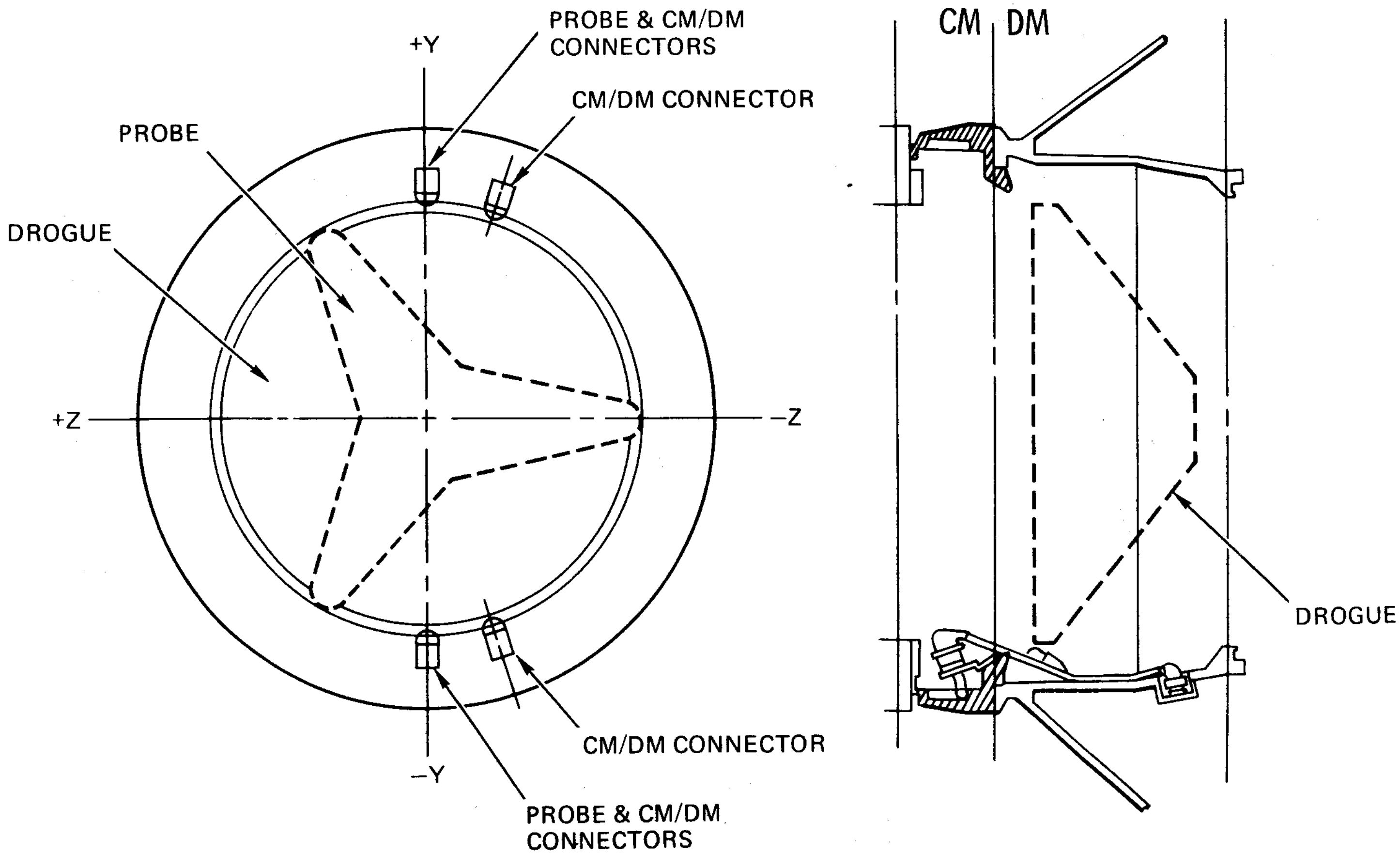


Figure 10

ASTP ELECTRICAL POWER SYSTEM
DM/SOYUZ INTERFACE CONNECTIONS

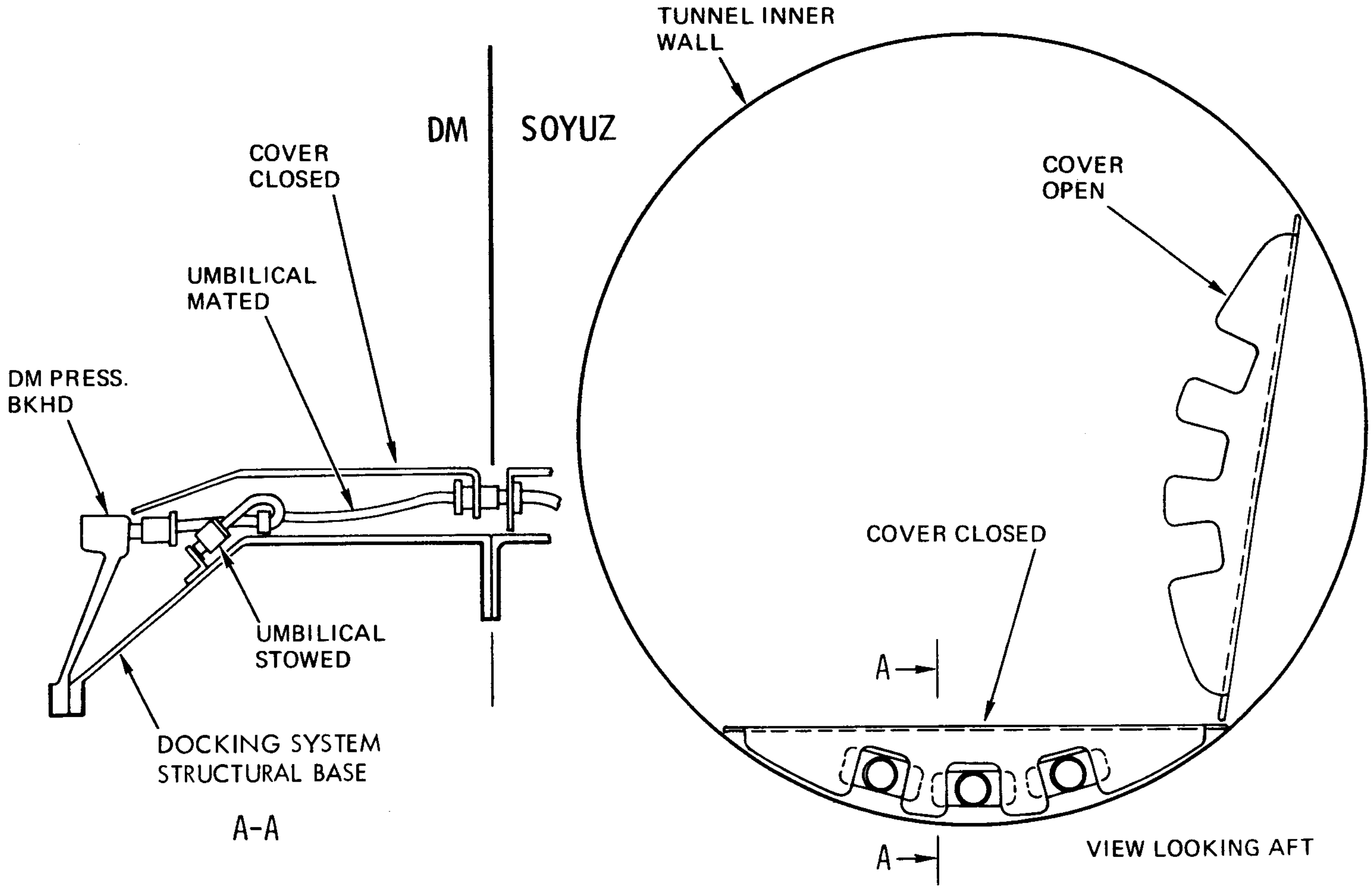


Figure 11

ASTP DOCKING SYSTEMS 5 & 7

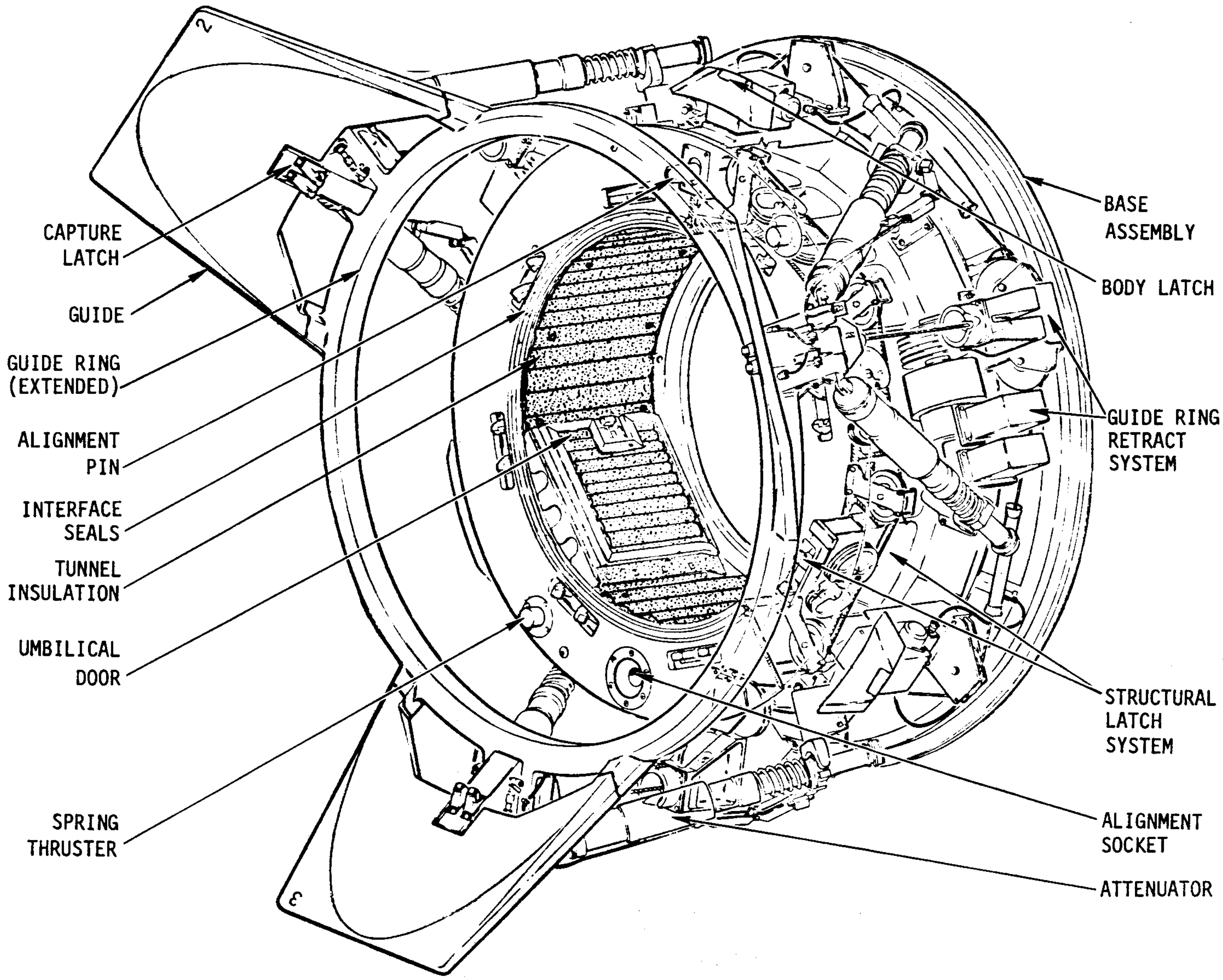


Figure 12

ASTP DOCKING SYSTEM
INTERFACE SEALS

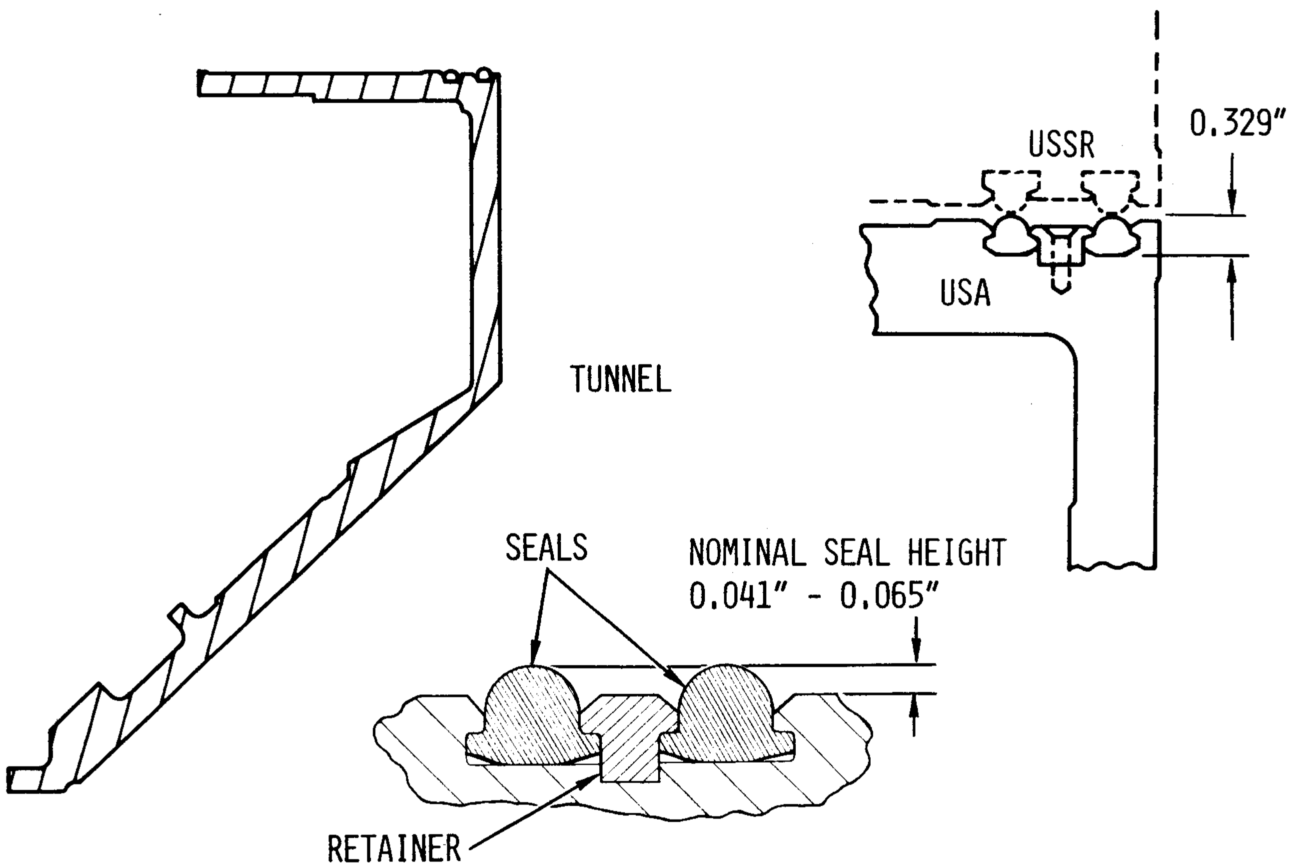


Figure 13

ASTP EXPERIMENT LOCATION

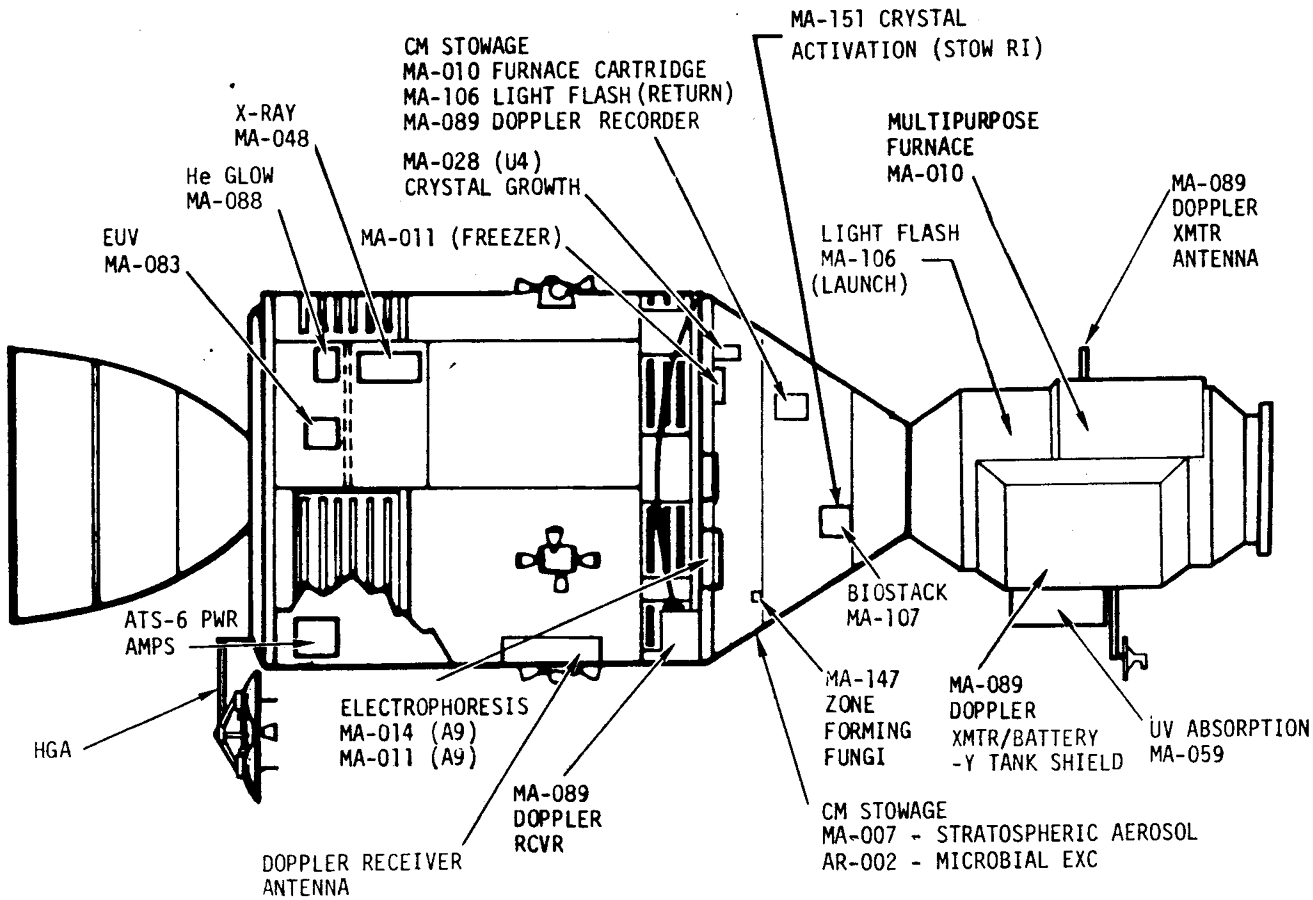


Figure 14

SOYUZ LAUNCH SITE CHECKOUT FLOW

1 INSPECTION & PREP FOR ASSEMBLY
2 CHECKOUT POWER SUPPLY CIRCUITS
3 MODULE & LINE INTEGRITY CHECKS
4 DS VERIFICATION TESTS
5 SPACECRAFT ASSEMBLY
6 SPACECRAFT WEIGHT/PROPULSION SYST INSTALL
7 CHECK OF ANTENNAS & DOCKING TARGET DEPLOYMENT
8 GROUND TESTING CABLE CONNECTION
9 PYROCIRCUIT CHECKOUT
10 TEST SWITCHING OF RADIO/TELEMETRY SYSTEMS
11 TEST OF MOVIE & PHOTO EQUIP. & CREW EQUIP.
12 TEST OF ORIENTATION LIGHTS & FLASHING BEACONS
13 SPACECRAFT INTEGRATED TESTS (ELECTRICAL)
14 SPACECRAFT PRESSURE INTEGRITY CHECK IN THE ALTITUDE CHAMBER
15 PRESSURE INTEGRITY CHECK - THERMAL CONTROL SYSTEM
16 SPACECRAFT EQUIPMENT INSTALLATION
17 TEST OF LIFE SUPPORT & POWER SUPPLY
18 MANNED TESTS OF SYSTEM OPERATION
19 SPACECRAFT PYROS CIRCUIT CHECKOUT
20 SPACECRAFT PROPULSION SYSTEMS LOADING
21 SOLAR PANEL INTEGRATION AND CHECKOUT
22 HATCH PRESSURE INTEGRITY CHECK
23 MATING WITH THE VEHICLE SHROUD
24 MATING WITH THE LAUNCH VEHICLE & MOVE TO PAD

CHECKS ON THE LAUNCHING PAD

25 RADIO SYSTEM VERIFICATION
26 PYROS CIRCUIT CHECKOUT
27 HATCHES INTEGRITY CHECK
28 EMERGENCY ESCAPE SYSTEM PYROS CONNECTION AND CHECK
29 ENVIRONMENT AND THERMAL CONTROL SYSTEM
30 CREW INGRESS
31 HATCHES PRESSURE INTEGRITY CHECKS
32 ONBOARD SYSTEM STATUS MONITORING USING COSMONAUT PANEL
33 CREW GROUND COMMUNICATION VERIFICATION
34 MEDICAL MONITORING
35 LAUNCH READINESS CONFIRMATION & LAUNCH

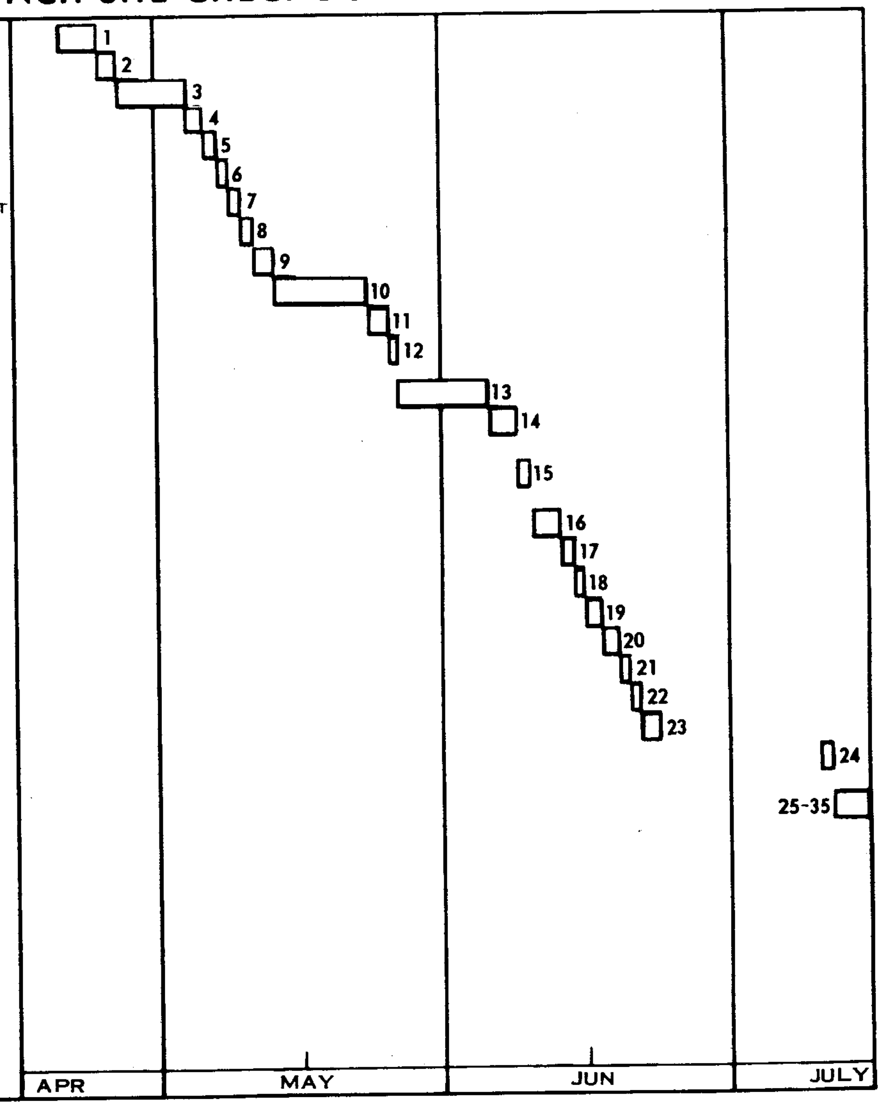


Figure 15

SOYUZ SPACECRAFT
КОСМИЧЕСКИЙ КОРАБЛЬ „СОЮЗ"

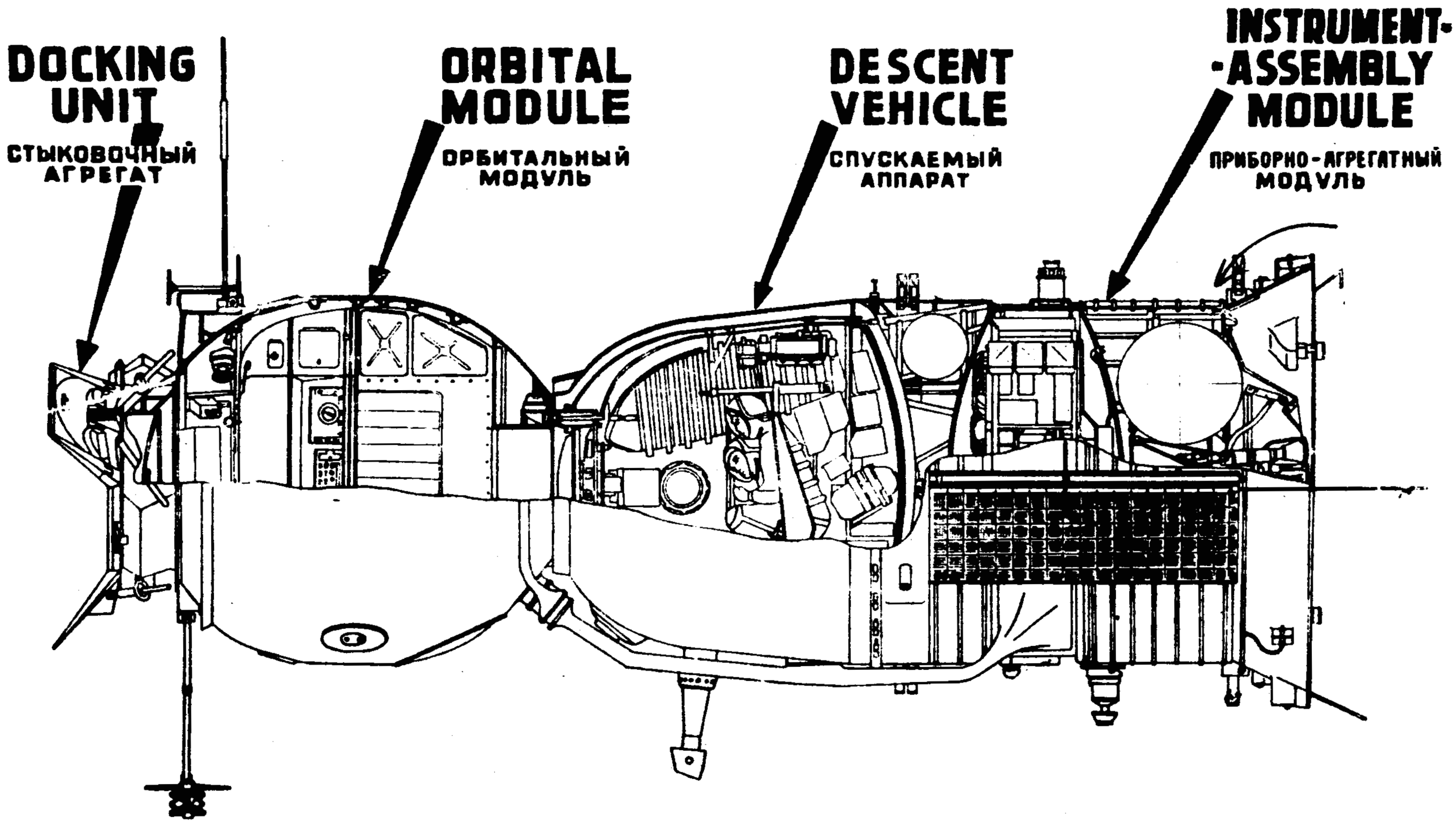


Figure 16

OPTICAL ALINEMENT AIDS FOR DOCKING

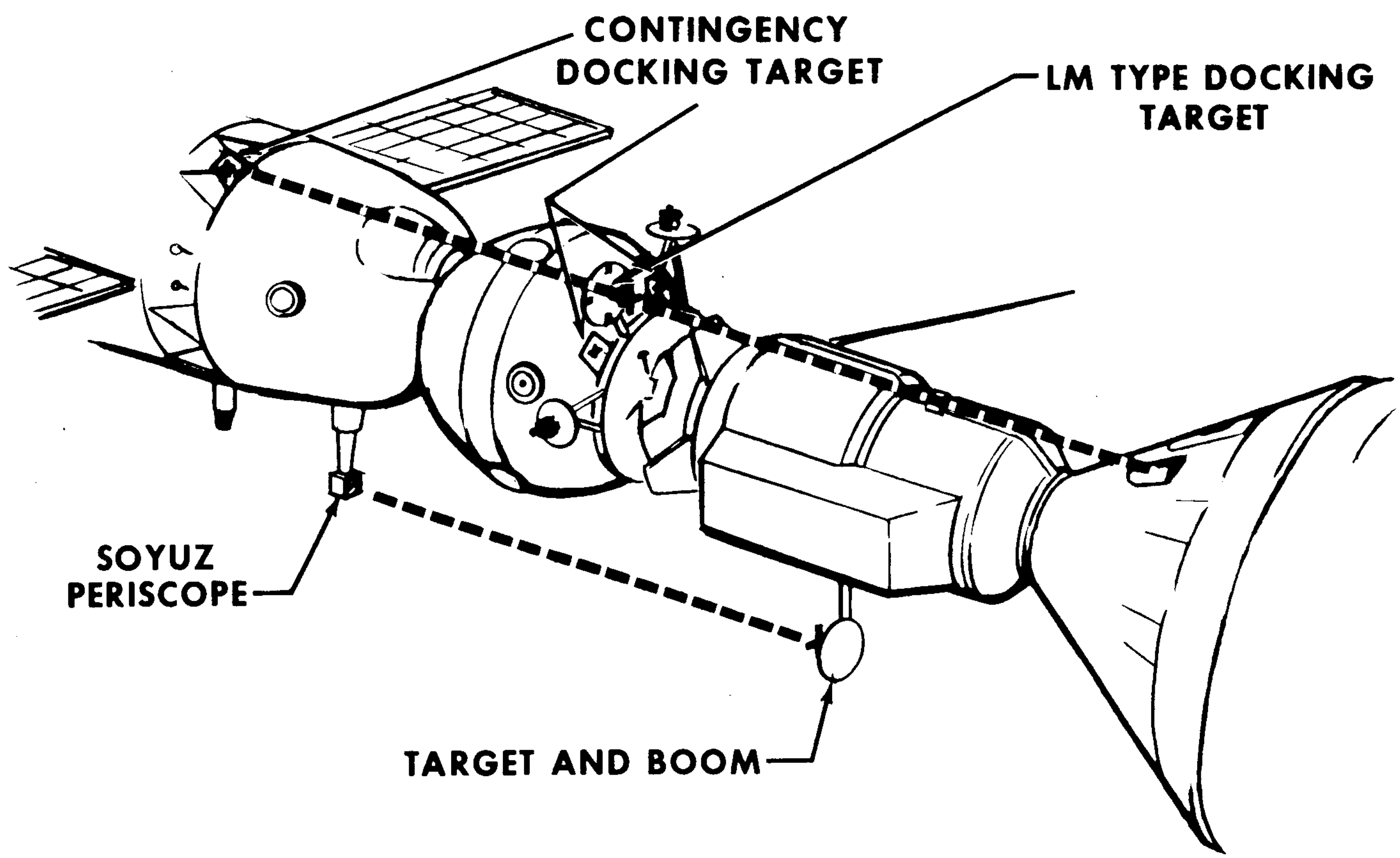


Figure 17

APOLLO/SOYUZ - MISSION RADIO COMMUNICATIONS LINKS

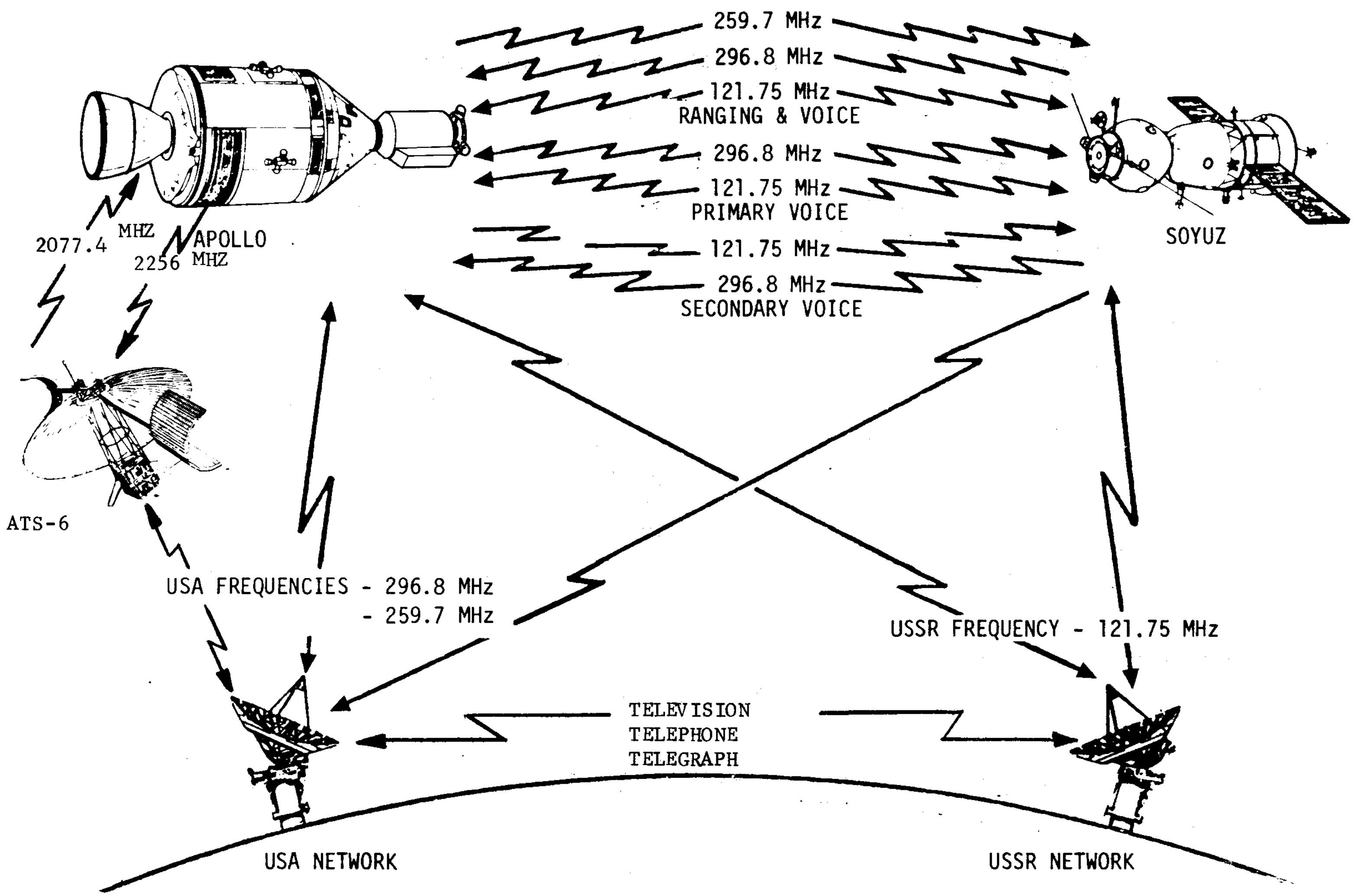


Figure 18

SEQUENCE OF NORMAL OPERATION APOLLO ACTIVE FOR DOCKING AND UNDOCKING

(ALL TIMES ARE APPROXIMATE)

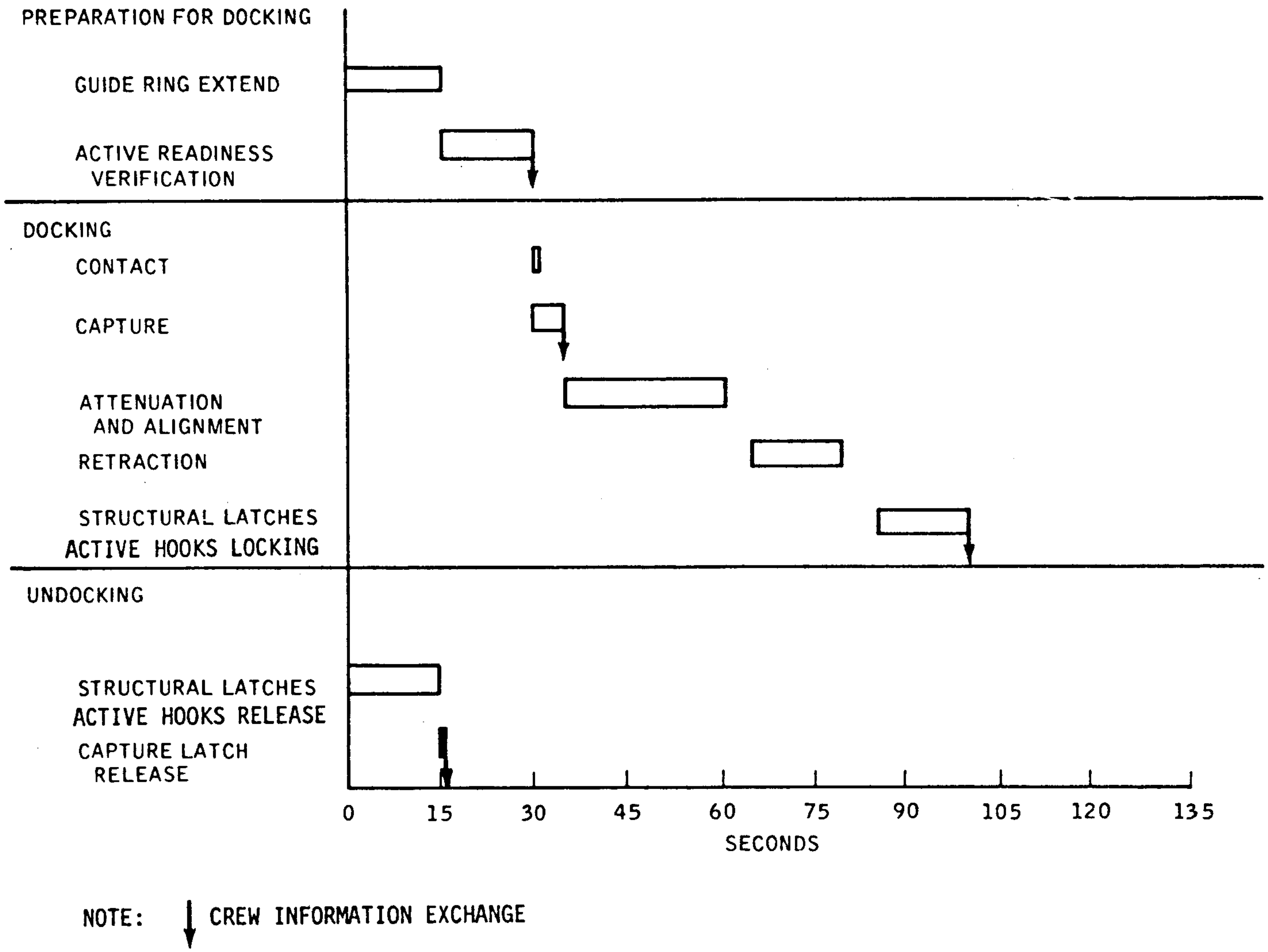


Figure 19

SEQUENCE OF NORMAL OPERATION FOR SOYUZ ACTIVE DOCKING AND UNDOCKING
(ALL TIMES ARE APPROXIMATE)

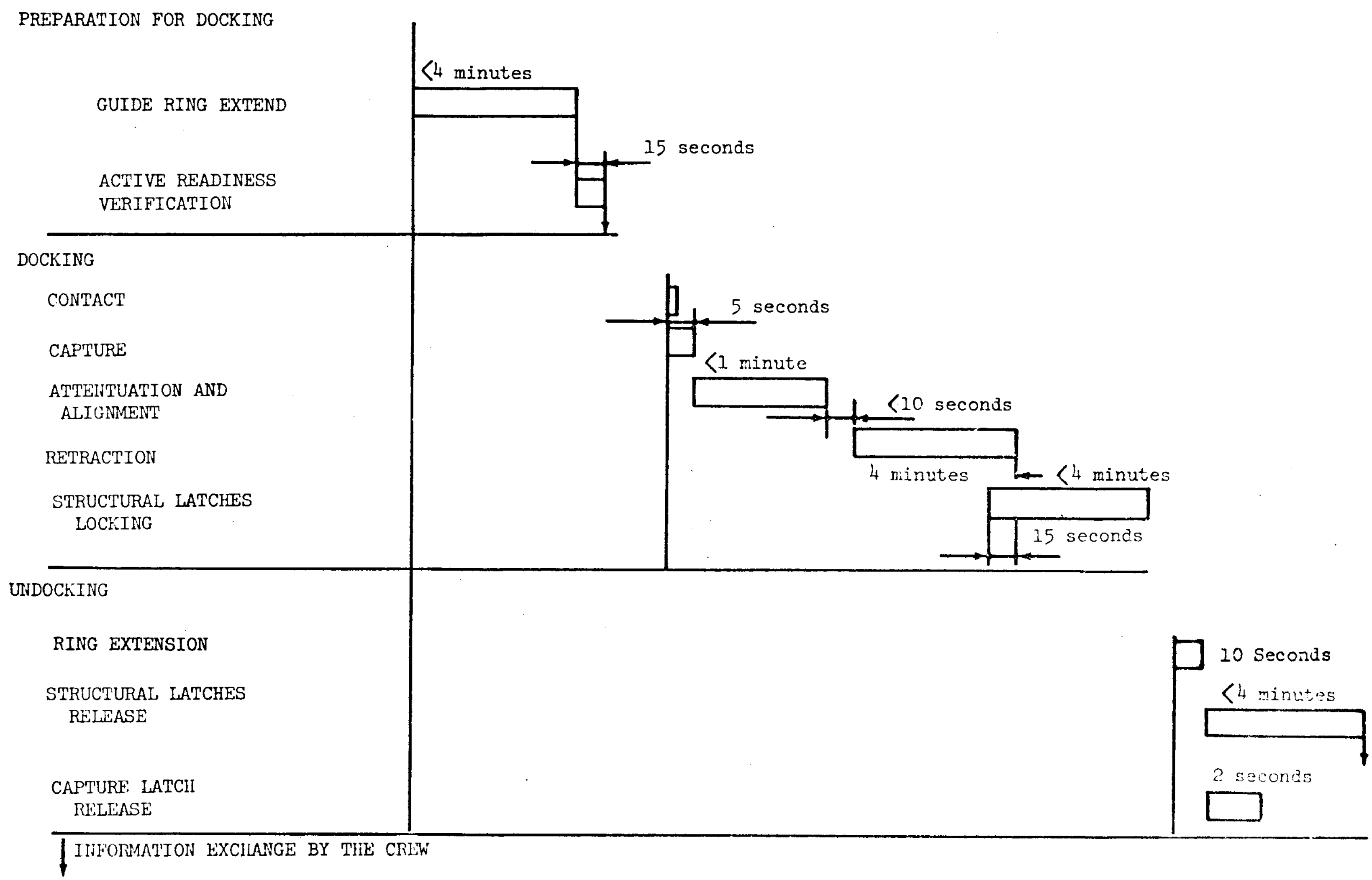


Figure 20

SOYUZ ECS SCHEMATIC

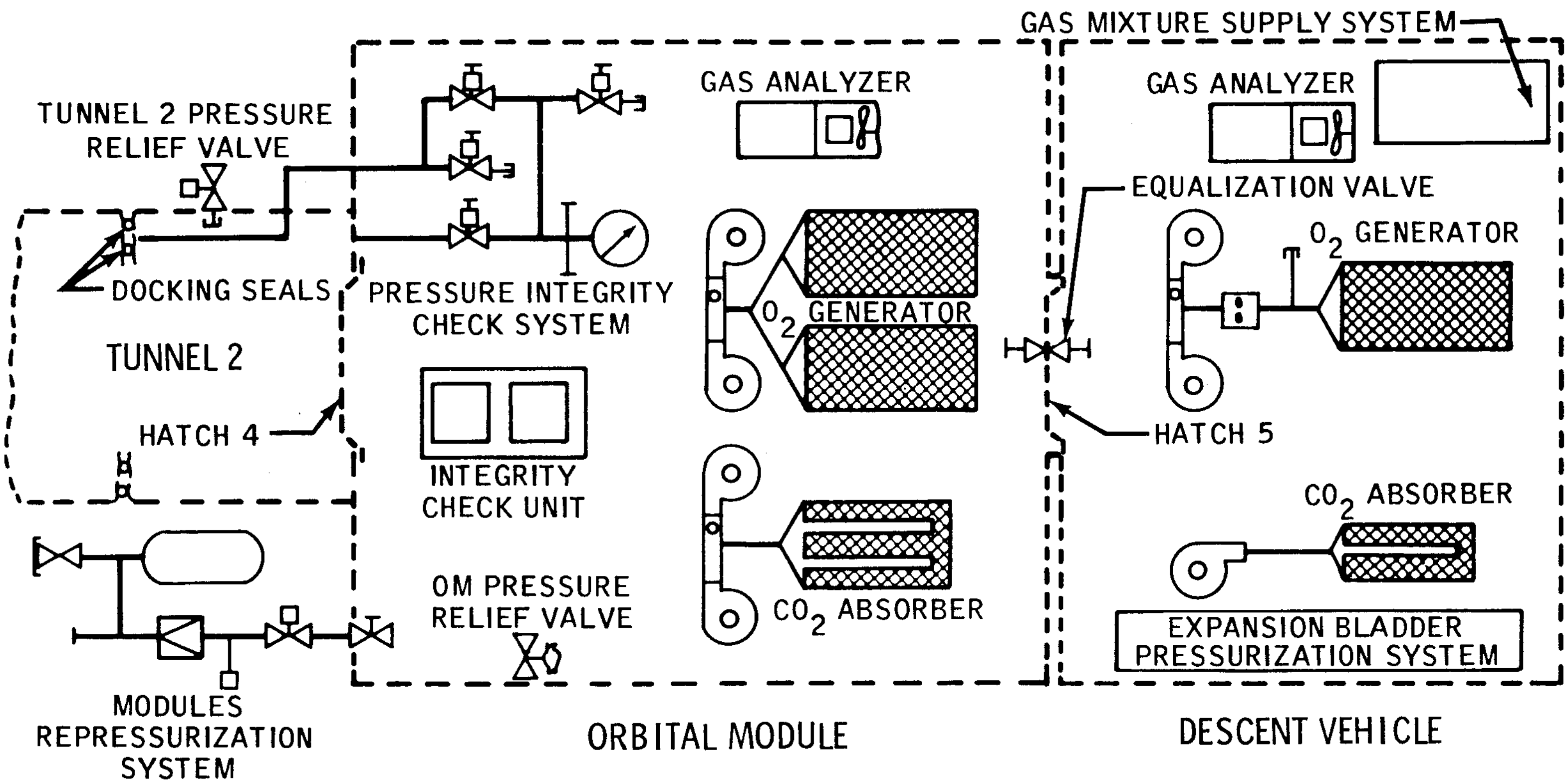


Figure 21

GAS MIXTURE SUPPLY SYSTEM

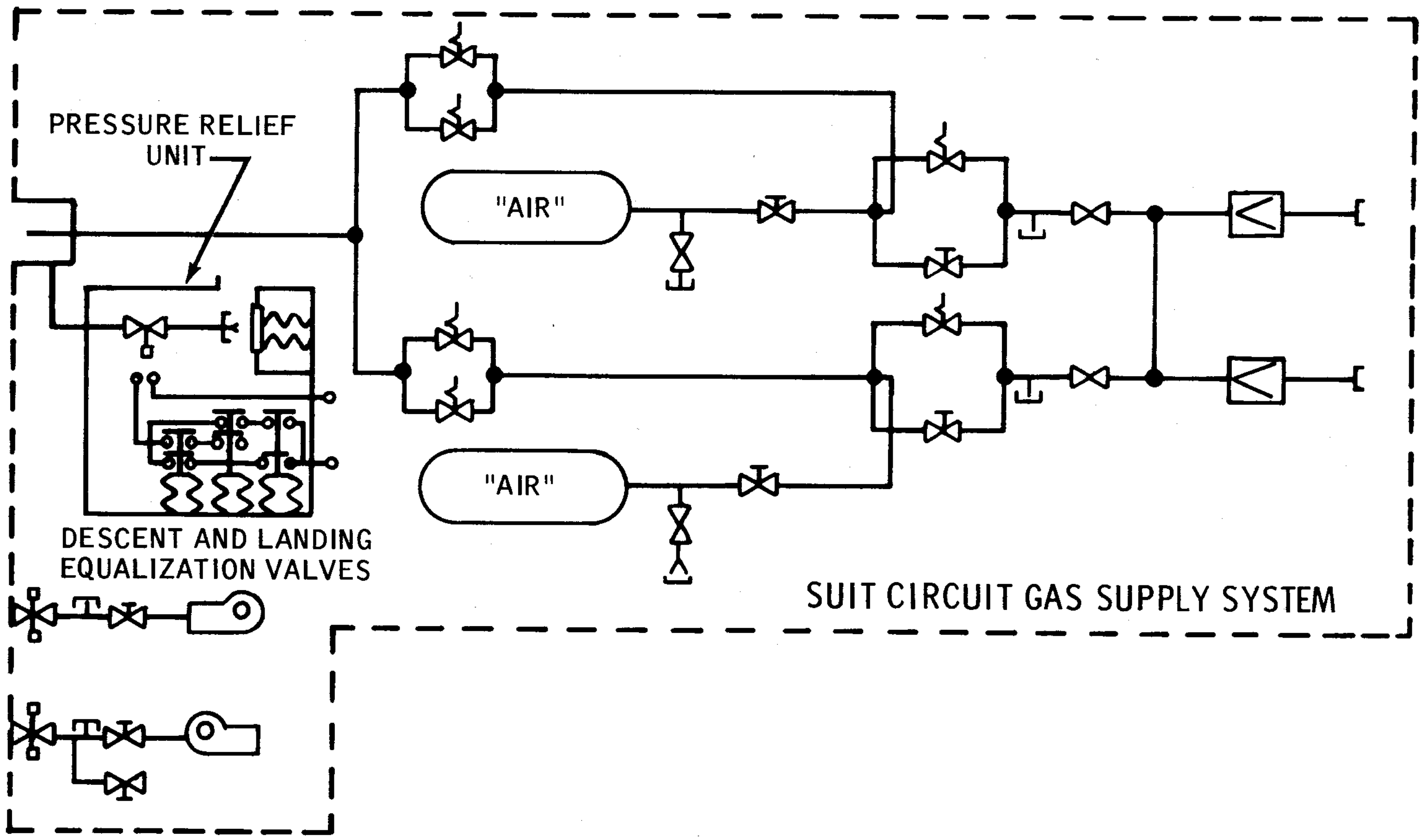


Figure 22

SOYUZ THERMAL CONTROL SCHEMATIC

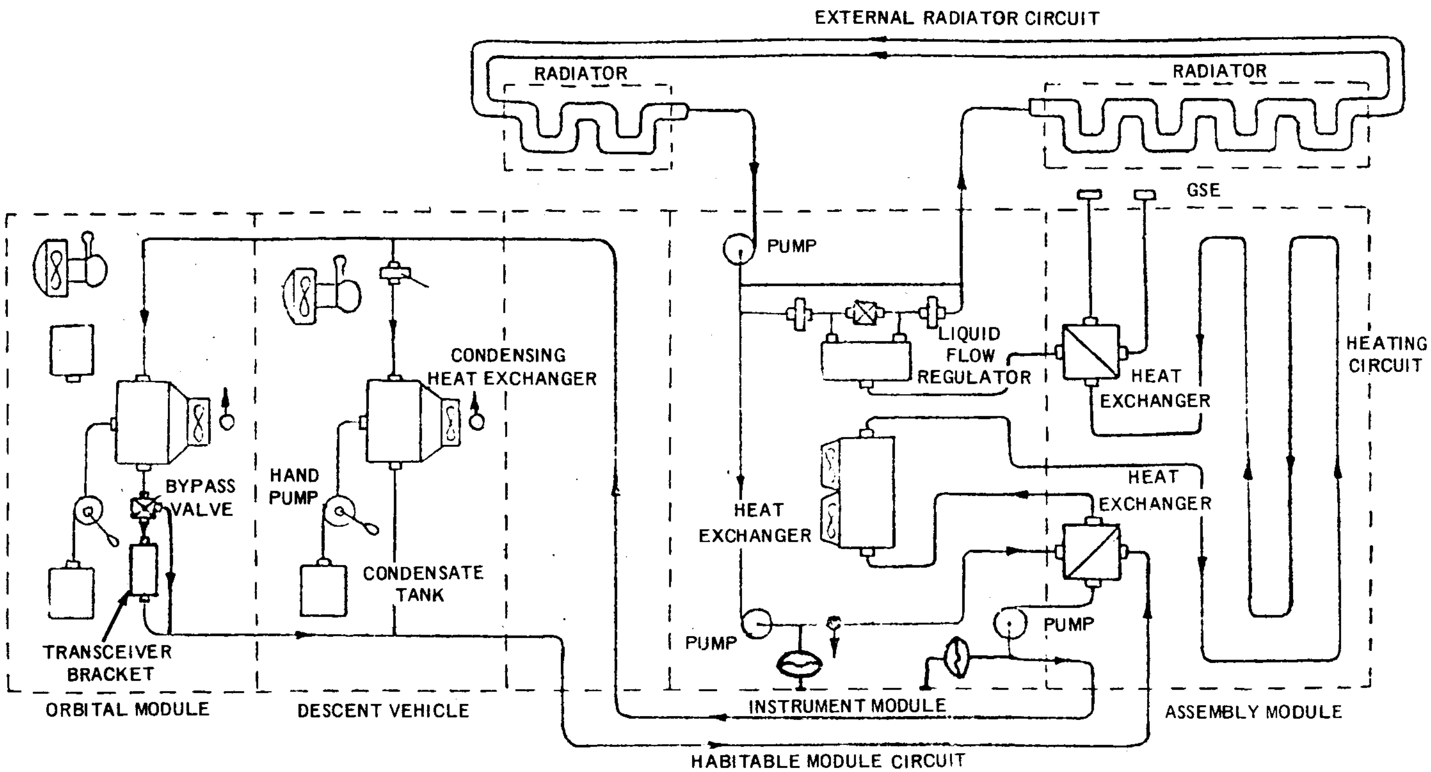


Figure 23

USA/USSR CABLE COMMUNICATIONS

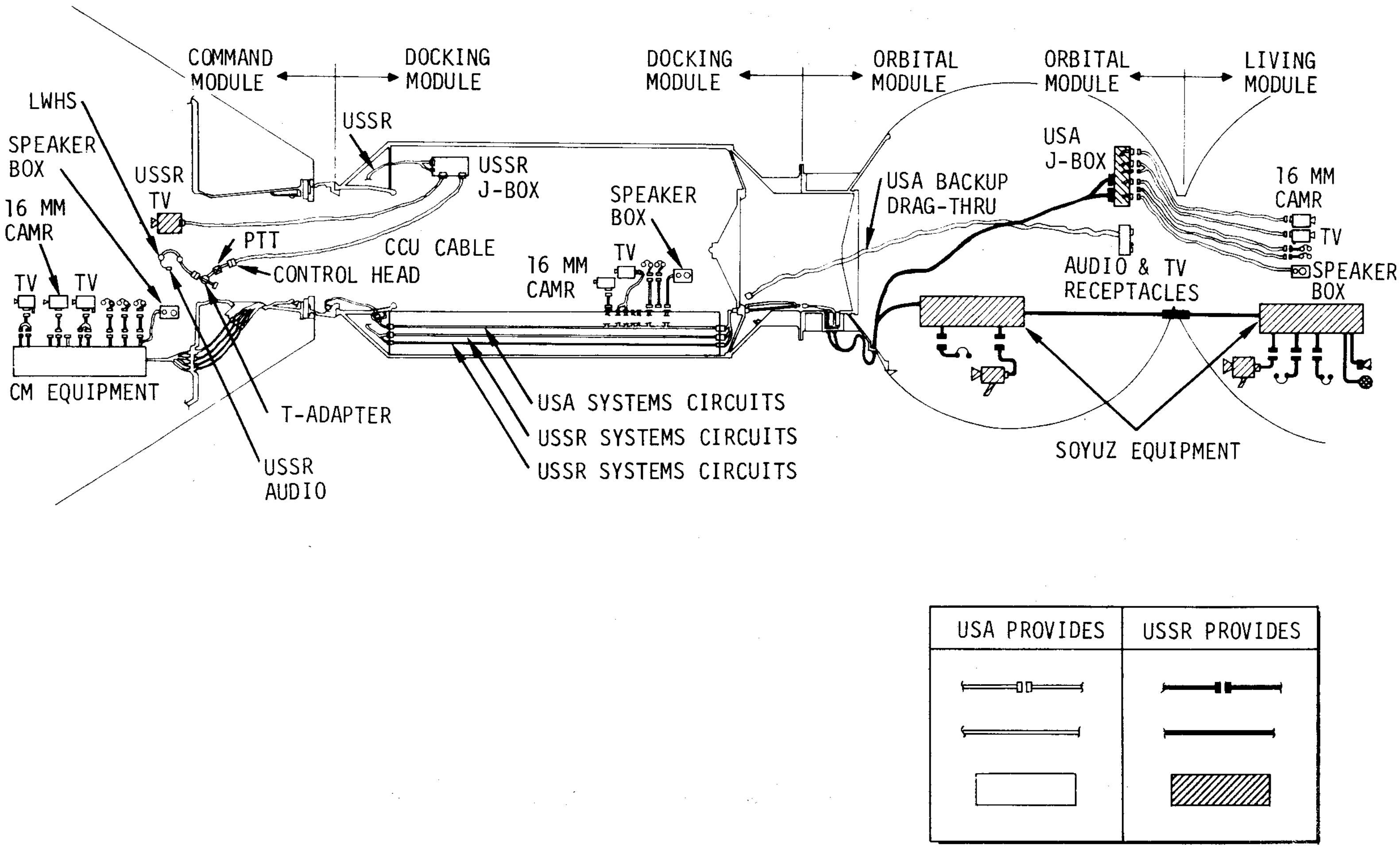


Figure 24

APOLLO CIRCUIT BREAKER ACCEPTANCE CRITERIA

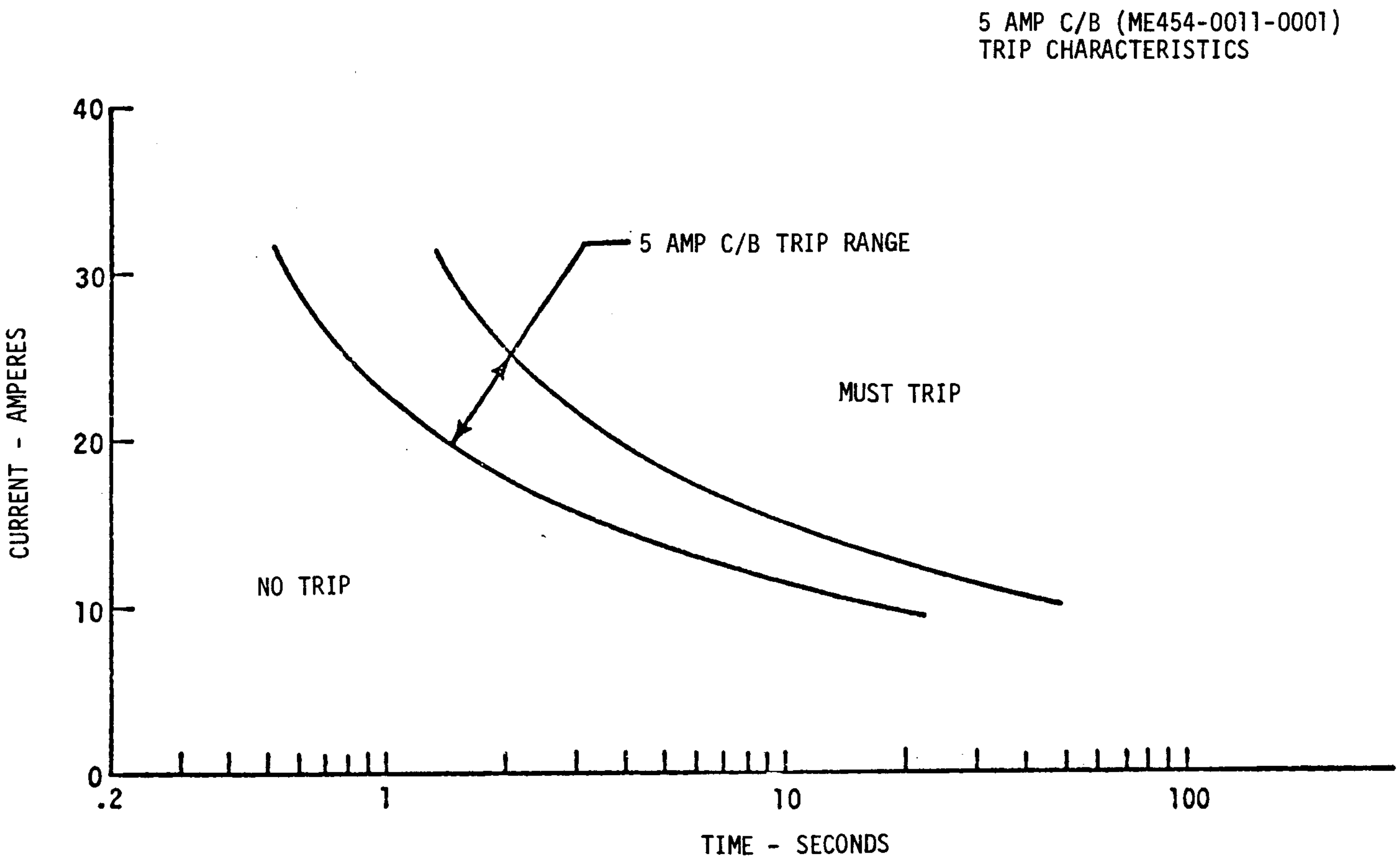


Figure 25

SOYUZ CIRCUIT BREAKER ACCEPTANCE CRITERIA

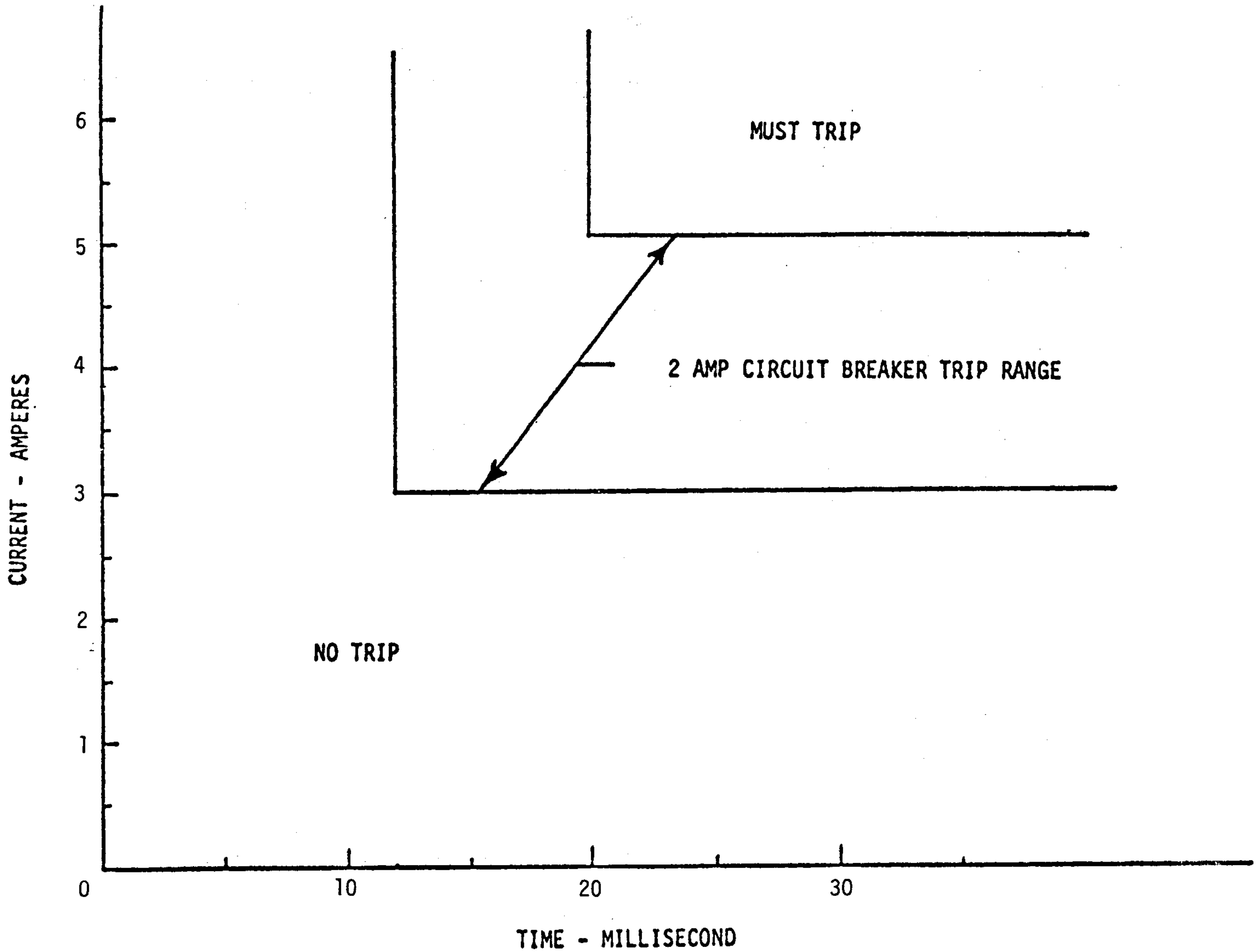
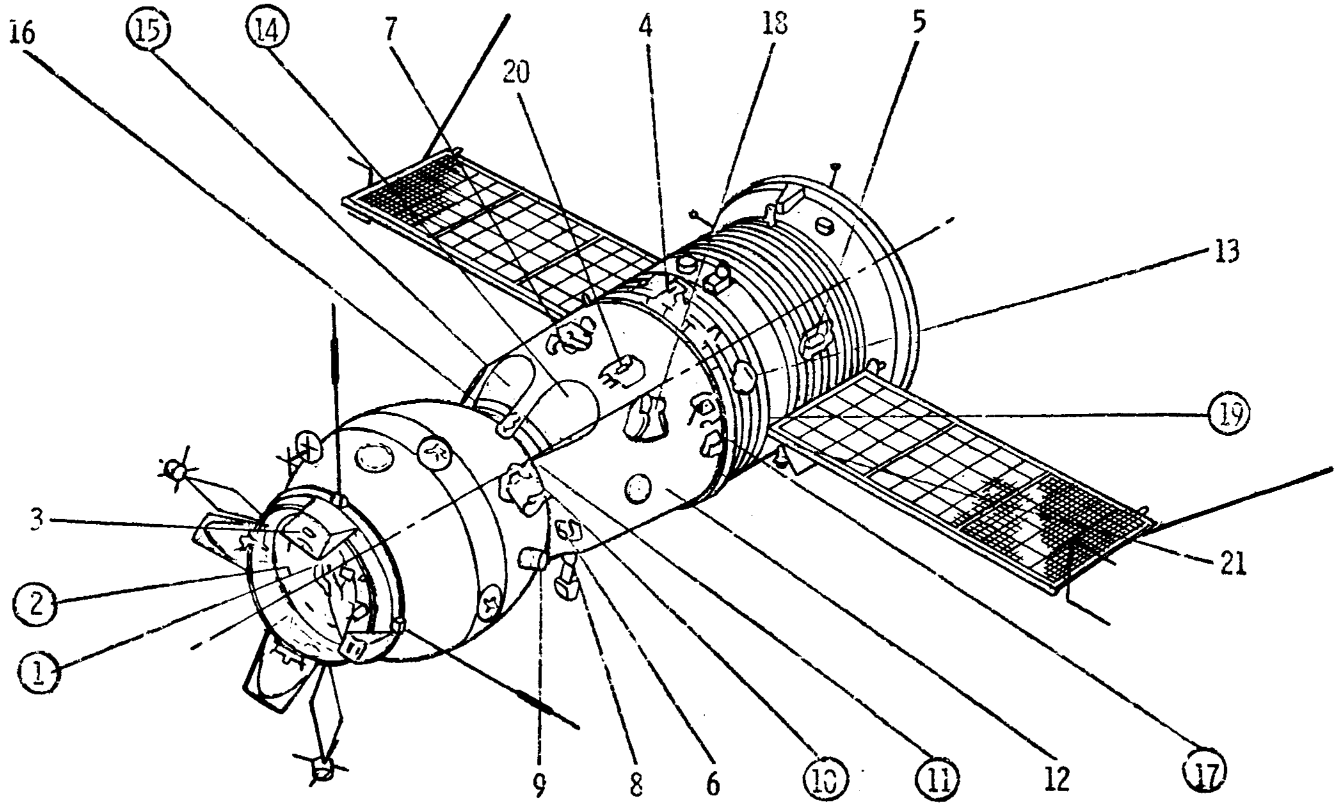


Figure 26

SOYUZ PYROTECHNIC DEVICES



Location of Soyuz Pyrotechnics

Figure 27