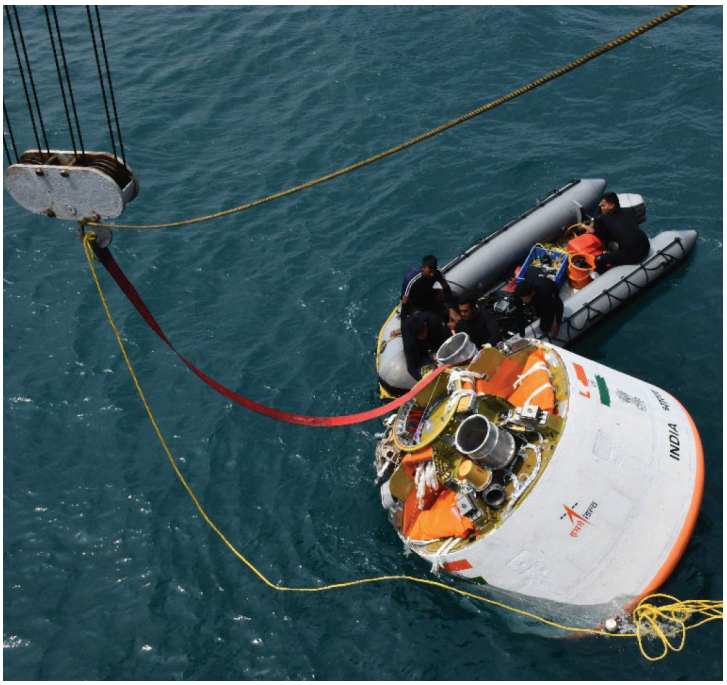
2.6 Gaganyaan

I. Major mission milestone

- Test Vehicle Abort mission - 01 (TV - D1) test flight accomplished on October 21, 2023. Crew Module sub-systems and Crew Escape System performed as intended.
- TV-D1 Crew Module safely recovered from the Bay of Bengal with the help of the Indian Navy on October 21, 2023.

TV-D1 Flight



TV-D1 Crew module recovery

II. TV-D1 Mission

Crew Module [CM]

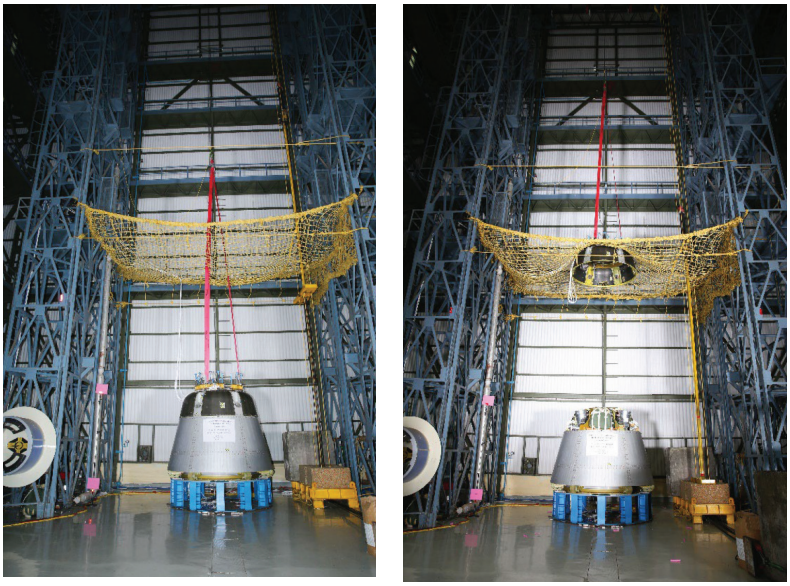
Structure: Structural testing of Crew Module (total 11 nos. of load cases) completed at INSTEF/VSSC. Crew Module and apex cover hardware realized. Interface generation, assembly and integration activities are completed on the hardware subsequently at ISITE, Bengaluru and SDSC. The Crew module underwent an acoustic test at ISITE, Bengaluru followed by a vibration test at SDSC-SHAR.

TV-D1 Crew module after integration

Deceleration systems: Drogue mortar & pilot mortar firing tests on crew module structure completed at VSSC.

Simulated Structures: Realization of all simulated structures required for TV-D1 flight completed. Integrated structural qualification testing of simulated SM Structure & simulated SM FE Ring with CM-SM Separation Joint completed satisfactorily on May 04, 2023, at FAST/ VSSC.

Separation systems: Realization of CM-CES, CM-SM and Apex Cover separation system completed.



Apex cover separation Test

Avionics: TV-D1 Crew module various simulation tests completed. Testing of the Location transmitter package (physically located at SAC, Ahmedabad) with the COSPAS-SARSAT (GEO-SAR) system is conducted at ISTRAC, Bengaluru. End-to-end testing of UHF beacon completed.

Crew Escape System [CES]

Thermal Protection System (TPS) layer application on CES Conical Shroud (CECS) and CES Ogive Shroud (CEOS) hardware completed. All Crew Escape System [CES] structures, motors and avionics components were realized for the mission. LEM Adaptor (LEA) vibration test (random & sine) completed for all three axes at ISDTF, VSSC.

III. IADT-01:

IADT Crew Module 1st Structure realised at industry and handed over to HSFC on March 24, 2023. The same hardware was utilized to carry-out the Ground resonance test (GRT) at SDSC.

2nd Crew Module structure realized for Integrated AirDrop Test and delivered to VSSC for final integration activities. Integration activities commenced on the structure.

Avionics packages are realized for IADT-01 and are available.

IV. G1 till H1:

Crew Module [CM]

Realization of Crew Module flight hardware is nearing completion. Crew Module 2nd un-pressurized structure realized and utilized to carry out shock survivability tests at VSSC. G1 ECLSS – Cold plate configuration with bracket mounting and dummy package mounting completed. Deck Plate optimization rework completed and ready for integration. Re-vibration of Check valves, Filter Venturi and Fill and Drain Valve completed as per TVD levels. FAT completed for 8 nos. of 100N injector.

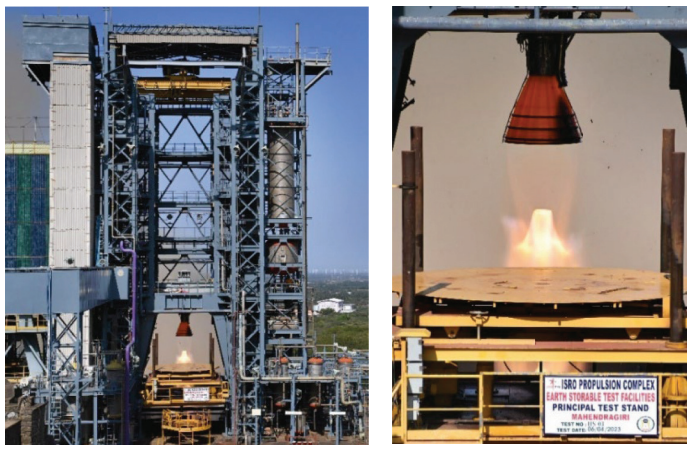
Service Module [SM]

Service Module 1st hardware identified for G1 is near completion. Dry assembly of the outer structure completed. Bonding of longerons with three runs completed. Shim requirement for Deck assembly completed. Primary bonding of vertical deck completed. And post bonding drawing of the vertical deck was also completed. Structural analysis for the defined load cases for static test configuration completed. Qualification of temperature sensor on Inconel gas tank initiated. Fabrication of diffuser plate for VD02 panel initiated.

V. Qualification/ Acceptance Test Programme:

a. HLVM3 - L110 - VIKAS Engine Qualification

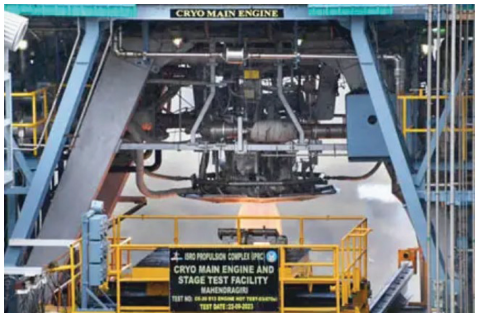
- Final long-duration hot test



L110 Vikas engine hot test

(HS-03) of human-rated - L110 Vikas engine successfully completed on April 06, 2023 at IPRC.

b. HLVM3 - Cryogenic CE20 - E13 Engine Qualification



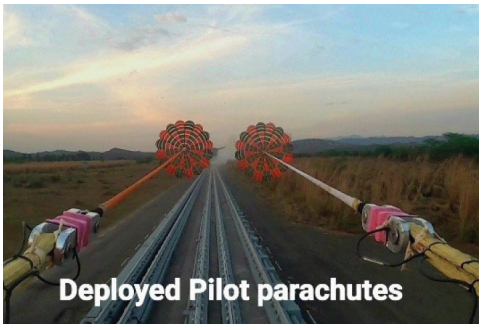
E13 Engine HT-03

- Long duration test (HT-02) successfully carried out (for 720 seconds) at IPRC, Mahendragiri on August 30, 2023.
- Cryogenic engine hot test (E13 Engine HT-03): Long duration test successfully carried out (for 630 seconds) at IPRC, Mahendragiri on September 22, 2023. All tests with respect to human rating of the stage completed.
- Flight acceptance hot test of CE-20 E12 Cryogenic engine successfully conducted for 25 seconds in High Altitude condition at IPRC on October 19, 2023.

Flight Acceptance test of E12 Engine for G1 mission in High Altitude test facility

c. Deceleration systems

Phase- I Rail Track Rocket Sled (RTRS) test of drogue parachutes completed at TBRL, Chandigarh on May 19, 2023. Grid Fin functional deployment test with aero-assisted load using the hydraulic system successfully completed on July 31, 2023, at ASMG, VSSC. Series of Drogue Parachute deployment tests successfully completed at Rail Track Rocket

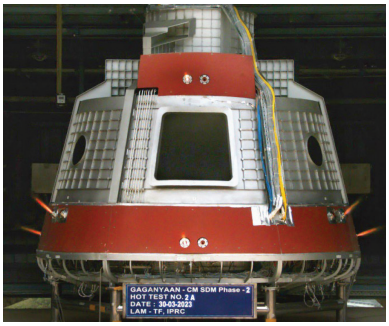


Sled (RTRS) facility of TBRL, Chandigarh from August 08-10, 2023. Drogue Mortar & Pilot Mortar Firing Tests on Crew Module Structure completed. The batch Test of Drogue Mortar was Carried out successfully.

d. Separation systems

System Level Functional test of CM-SM Separation system completed on June 16, 2023 at VSSC. Apex Cover separation test completed at Zero-g VSSC on August 21, 2023. CM-CES Separation System: System level functional test completed as part of CM shock survivability test, at ASMG/ VSSC. Functional qualification test of CMF-SMF separation system carried out at ASMG/VSSC.

e. Crew Module System Demonstration Tests (CM-SDM) Phase-II for CM propulsion



- **1st hot test [Test-2A]** of Crew Module- The 1st test [2A] for CMPS characterisation [5 sec ON (Primary thrusters), 5 sec OFF and 5 sec ON (redundant thrusters)] is completed on March 30, 2023.
- CM-SDM Phase-II tests: The **2nd test [2B]** for 650 sec. successfully completed on April 05, 2023.
- Crew Module Propulsion System-CM-SDM Phase-II tests: The **3rd test [2C]** for 50 sec. (pulse mode) successfully completed on April 13, 2023.
- Crew Module Propulsion System- CM-SDM Phase-II tests: The **4th test [2D]** for 81.52 sec. (pulse mode) successfully completed on April 19, 2023.
- Crew Module Propulsion System- CM-SDM Phase-II tests: **5th test [2E]** to **7th test [2G]** completed on April 27, 2023.

Phase-II Qualification tests [7 Hot Tests] of CM-SDM are completed successfully.

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f. Service Module System Demonstration Tests (SM-SDM) Phase-II for SM propulsion

- **Test-2A** (Reference test) for 250 seconds on July 19, 2023.
- **Test-2B** (RCS thrusters & LAM engine calibration) for 723.6 seconds on July 26, 2023.
- **Test-2C** (Orbit circularization) for 350 seconds on July 26, 2023.
- **Test-2D** (De-boost) for 700 seconds on July 27, 2023.
- SM propulsion- System Demonstration Model (SDM) **Test-2E** was carried out for 670 seconds on August 09, 2023 simulating the SM-based abort condition.

g. Crew Escape Systems Motors

Crew Escape System (CES) comprises 5 different types of quick-acting solid motors viz., High Altitude Pitch Motor (HPM), Low Altitude Pitch Motor (LPM), CES Jettisoning Motor (CJM), High Altitude Escape Motors (HEM) and Low Altitude Escape Motor (LEM). All motor structure & nozzle realization and casting activities were completed before the respective static test.

HPM & LPM Static Test: High altitude Pitch Motor (HPM) Static Test (ST-03) successfully carried out at VSSC on March 15, 2023.

HEM Static Test: The high altitude Escape Motor (HEM) batch static test (ST-04) was completed at SDSC, SHAR on March 20, 2023. HEM batch static test (ST-05) completed at SDSC, SHAR on April 28, 2023. HEM ST-06 completed at SDSC, SHAR on May 19, 2023. HEM ST-07 was completed at SDSC, SHAR on May 12, 2023.


HEM Static Test


CJM Static Test

CJM Static Test: 2nd Static test of CJM was completed at SDSC, SHAR on February 13, 2023.

h. Acoustic test

Phase 1 acoustic test completed successfully on April 19, 2023, at NAL, Bengaluru.

TV-D1 Ph-I Acoustic test

TV-D1 Ph-II Acoustic test

GRT Setup

Crew Module Acoustic test (Phase-II) completed on TV-D1 Crew Module at ISITE on August 10, 2023.

i. Ground Resonance Test GRT

Base fixed boundary condition GRT completed on July 21, 2023, at SDSC, SHAR.

j. Crew Module Vibration Test

TV-D1 Crew Module Vibration test completed (all three Axis) at SMP-ETF, SDSC on August 25, 2023.

VI. Readiness of Launch Complex Systems

a. Second Launch Pad

Structural modification works - Fabrication of machining components for autolocking system completed. Shaft spline cutting and inspection completed. White room – White room panel testing completed. Bubble lift-all works completed and lift commissioned. Zipline system & Landing tower with CESB – Detailed design of Zipline system completed. CESB building construction completed up to 10.5 m FFL level.

b. Orbital Module Preparation Facility (OMPF)

Modular wall, Aft-end and fore-end access tower, EOT crane erection work, AC installation and other civil work inside the OMPF CM, SM and MAL bay completed. TV-D1 integration of CES Aft-end stack and Fore-end stack successfully carried out in OMPF building.

Orbital Module Preparation Facility [OMPF]

c. Gaganyaan Control Facility (GCF)

Cable race way works & FDA systems wiring completed. Wall panelling completed. False flooring and false ceiling were completed in all areas. Data cable laying in Orbital Module Control Centre (OMCC) completed.

Gaganyaan Control Facility [GCF]

VII. Recovery

Initial recovery trials of the Crew Module commenced on February 7, 2023 at the Water Survival Test Facility (WSTF) of the Indian Navy, at Kochi. Realization of 2 nos. of Crew Module Recovery Model (CMRM) completed. Harbour trials for the Gaganyaan Recovery operations were completed at the Naval Dockyard, Visakhapatnam.

VIII. Crew Training

Conduct of training and lectures for HLVM3, Aerothermodynamics and IISc courses for 2nd semester commenced. Cabin and communication systems for Gaganyaan Static Mock-up Simulator (SMS) realized and flagged off from SAC.

Cabin and communication systems Flag-off

IX. Programme management

The Gaganyaan project campaign office is set-up and operational at LVPO, zero-point, SDSC.

X. Procurement & Budget

The procurement actions are being carried out in-line with the programmatic progress and with respect to the overall project timeline. Based on the programmatic requirements, the BE allocation for FY 2023-'24 was ₹1200.0 Cr. However, after a detailed review mid-year, the RE allocation of ₹1090.0 Cr. was finalized for the FY 2023-'24. Expenditure as of November 14, 2023 is ₹622.67 Cr. which is 57.13 % of the RE 2023-'24. Plans are in place for achieving the expenditure targets. Realization of critical hardware at industries being fast-tracked. Vendors meet being organized periodically towards sensitizing the criticality of accomplishing the Gaganyaan Mission in a time-bound manner. Being a flagship programme of Govt. of India, top priority demanded at work centres, industries and all in-house facilities. Parallel realization is envisaged at various work centres. Availability of FIM being addressed.

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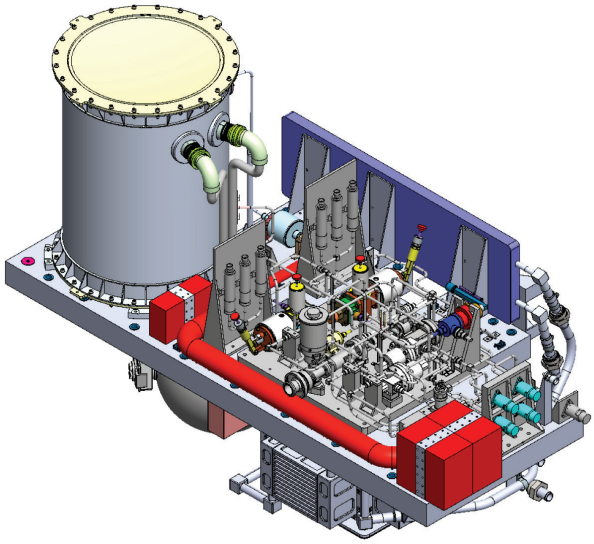
1. Environment Control and Life Support System

ECLSS provides a suitable human habitable earth-like environment in the Crew Module, during all the phases of the mission. ECLSS provides the crew with breathable air, a habitable environment, food and water to support crew for the entire mission duration.

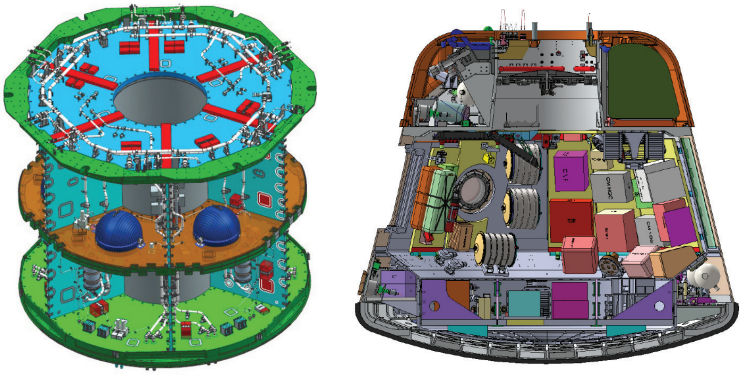
- Detailed planning of ECLSS facility completed, obtained necessary clearances and approvals. The foundation stone for ECLSS Integration and Test facility laid by Chairman ISRO on January 18, 2023.


Foundation laying ceremony

- Received Flight suit and crew seat items (as per contract no HSMN-2019 000 705 01 01, Batch 5 and 6) from GK, Russia.
- For the G1 mission, a demonstration of ECLSS in reduced configuration (Thermal control system and Cabin pressure control system) is planned. Configuration, design and accommodation are completed and clearance for the same is obtained from the respective DRT committee. Hardware realized and testing is under progress.
- Systems engineering of ECLSS in the crew module and service module is completed. Layout drawings were released for hardware realization.



ECLSS configuration for G1 mission



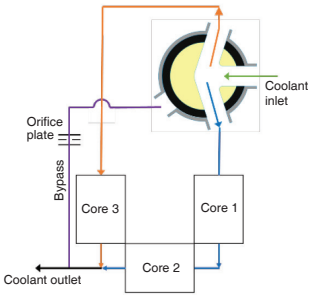
Layout and accommodation in SM and CM

- A Condensate Collection Tank for storing condensate water in the crew module is designed. Realization is under progress in industry.

Condensate collection tank

- The diverter valve of THCS for cabin temperature control is designed and realized. It is required to divert the coolant flow through different cores of the heat exchanger for temperature and humidity control.

Diverter valve



- Manual Condensate Pump is designed and is under realization. It is required to pump out water from the hygroscopic foam inside the condensing heat exchanger to the condensate tank for storage.

Manual Condensate Pump

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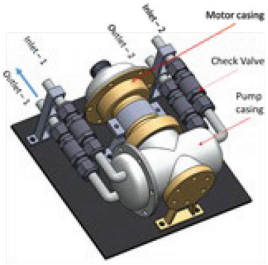
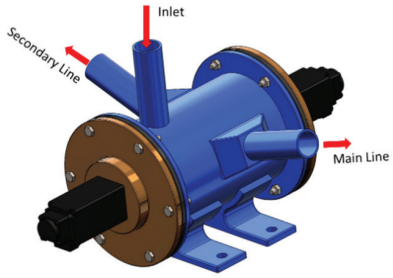
- Multi-Purpose Valve (MPV) is designed and realisation is in progress. It Allows air pumped into the condensate tank to return to the cabin.
- The Seawater Pump design is completed and fabrication drawings are generated. It is required for the thermal management of cabin post-landing.

Multi-Purpose Valve

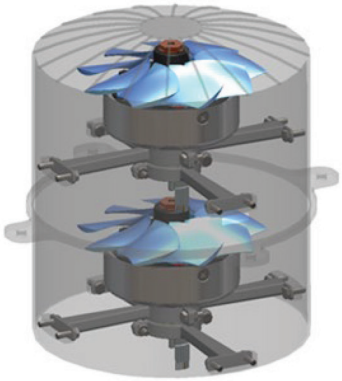


Seawater Pump

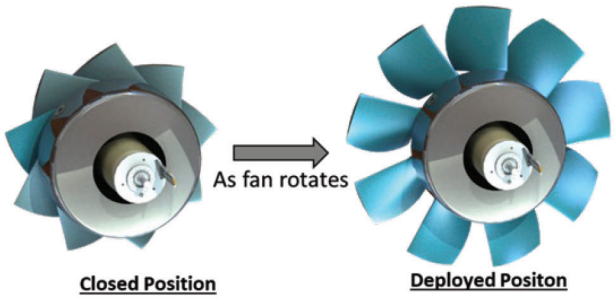
- Flow Switching Unit design is completed and fabrication drawings are generated.
- Deployable Fan design is completed. Fabrication is in progress in the industry.



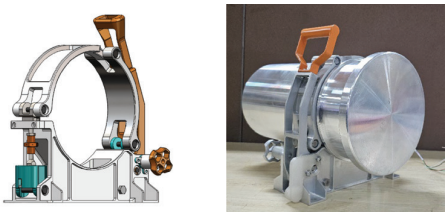
Flow Switching Unit



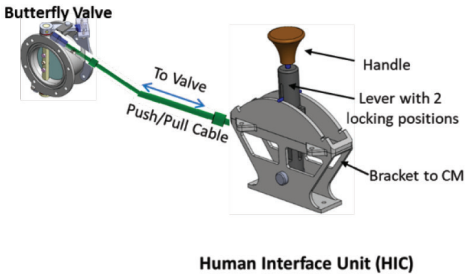
Deployable Fan

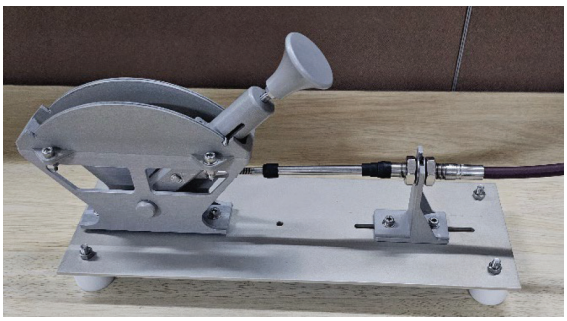


- Quick Action under-centre Mechanism (QAM) design for mounting fire suppression system completed and hardware realized. It provides quick response for fire suppression by crew.
- Post Landing Ventilation System design for cabin ventilation post touch down is completed and the engineering model realised.



Quick Action under-center Mechanism





Post Landing Ventilation System

- Qualification test plans of THCS components have been presented and cleared by the Test Review Board. Functional and environmental tests for components e.g. pumps, SV, PRV, CV, Filter etc. are completed in the industry.
- Initial Standard Room Condition (ISRC) tests have been completed for the following components as part of Qualification: 1) Inner Loop Pump, 2) Outer Loop Pump, 3) Solenoid Valve, 4) Check Valve, 5) Filter, 6) Pressure Relief Valve, 7) Axial fan for Non-condensing HEX, 8) Axial fan for Condensing HEX, 9) Cabin fan and 10) EMC pump.
- Environmental Tests (Sine Vibration, Random Vibration and Shock) have been completed for the following components as part of qualification: 1) Inner Loop Pump, 2) Outer Loop Pump, 3) Solenoid Valve, 4) Check Valve, 5) Filter, 6) Pressure Relief Valve, 7) Axial fan for Non-condensing HEX, 8) Cabin fan and 9) EMC pump.
- Thermo-vacuum test has been completed for the following components as part of qualification: 1) Outer Loop Pump, 2) Solenoid Valve, 3) Check Valve, 4) Filter, and 5) Pressure Relief Valve.
- EMI/EMC test has been completed for the following components as part of qualification: 1) Outer Loop Pump and 2) Solenoid Valve.
- Final Standard Room Condition (FSRC) tests have been completed for the following components as part of qualification: 1) Check Valve, 2) Filter, and 2) Pressure Relief Valve.

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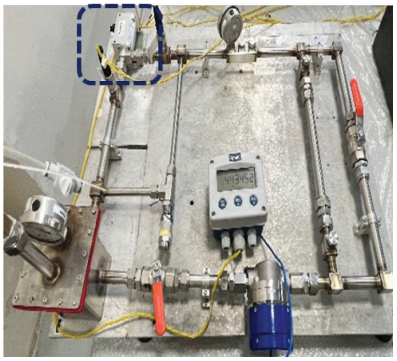
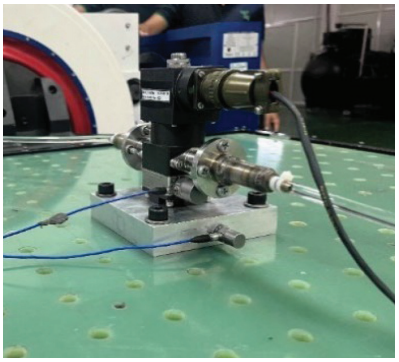
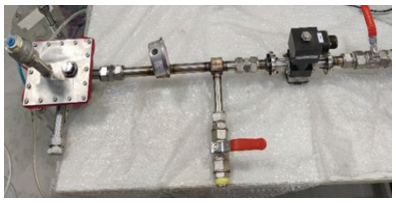


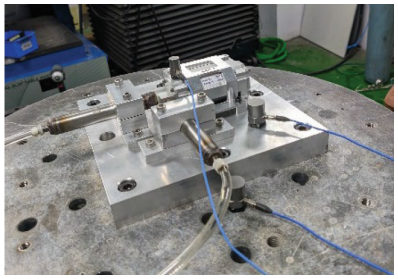
Pump performance tests



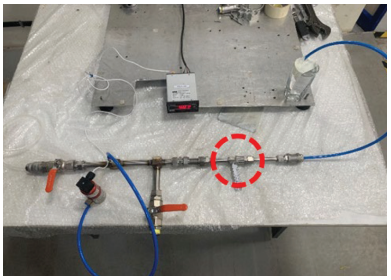
Pump Vibration/Shock test



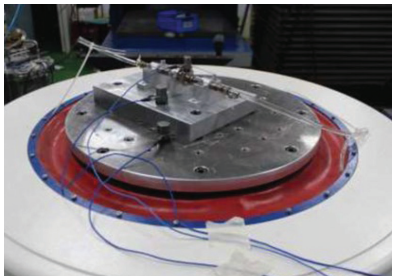
Solenoid Valve performance tests



Solenoid Valve Vibration/ Shock test

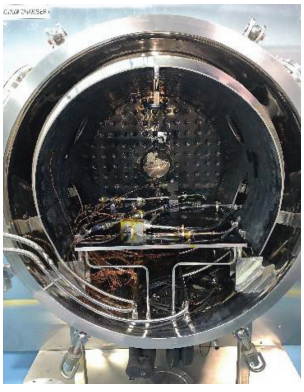


Check Valve performance test



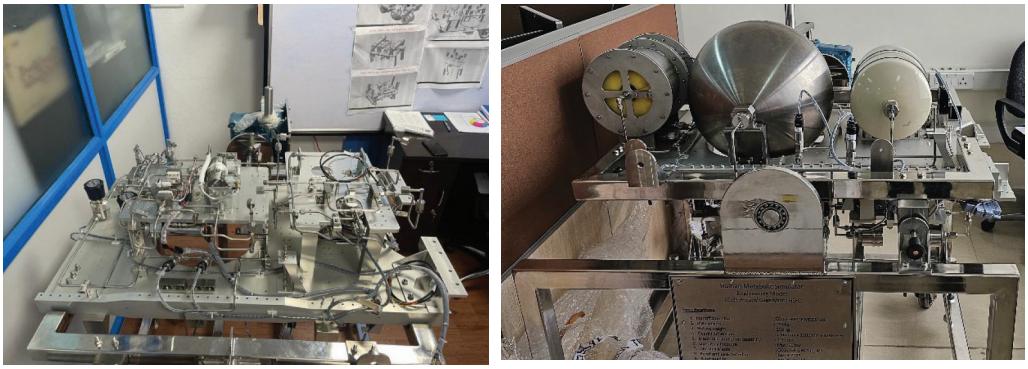
Check Valve Vibration/ Shock test

FEMC pump performance test



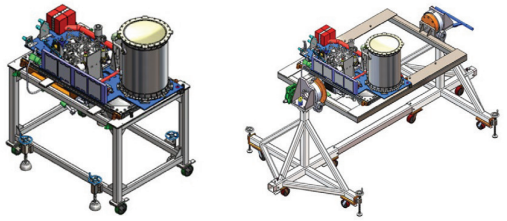
Thermo-vacuum test

- Completed raw material procurement, testing and clearance for the G1 mission.
- Welding procedure specification finalized for welding of plumb line.
- ECLSS integration and test facility layout and equipment specification finalized. Procurement is in progress.
- For testing the ECLSS on the ground and in an uncrewed mission, A Human metallic simulator is configured, and designed and an engineering model is realized.

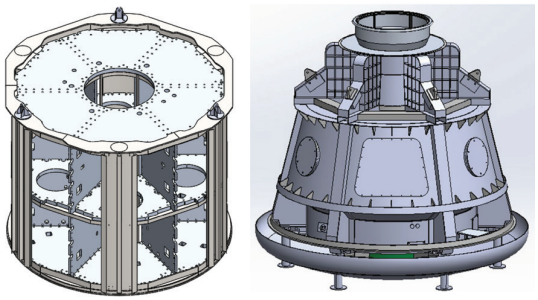


Human metabolic system-development model

- For integration of the ECLSS system in the crew module, various MGSE fixtures are under realization.
- Functional simulator and integration mock-up structure for service module and crew module is configured and designed for integrated ECLSS testing and integration activities.
- Human-centric product design is completed. Prototypes are realized. Qualification testing is in progress at various DRDO labs.



Static fixture and Tilting fixture



SM and CM Functional simulator and integration mock up Modal

2. Crew Training Simulators

Astronaut training needs to be carried out to prepare the Gaganyaan Crew for all the conceivable situations including contingencies and equip them to manage all the mission situations. Crew Training Simulators identified for Gaganyaan mission are Independent Training Simulator (ITS), Virtual Reality Training Simulator (VRTS), Dynamic Training Simulator (DTS) and Static Mock-up Simulator (SMS).

Independent Training Simulator (ITS)

ITS is a table top simulator primarily aimed at familiarization of the Crew with Crew control interface, both electrical and mechanical. It necessitates a similar user interface as that of the Crew Module such as a Display system, pages, alerts and control buttons. It incorporates the procedural training for various crew activities including Crew response training during off-nominal scenarios.

ITS Set-up

ITS has four main components:

1. Simulation environment and hardware interface system.
2. Simulation system.
3. Mission team console.
4. Trainer console.

Current Activities:

- The initial version of the Simulator was developed and used for the collection of feedback from the Astronaut designers. Based on the feedback from them, the updates required in the Console and display pages were identified. This will be realized as a Version 2 simulator. Necessary updates in hardware and software were identified and implemented.
- The console with the updated hardware and software is realized and ready for integration. The simulation software is also ready for integration. The console in the format of emulation software is also designed and ready for experience.

Virtual Reality Training Simulator (VRTS)

VR simulator uses technology that enables users to interact with a computer-generated

environment that simulates physical presence and interaction by artificially creating sensory experiences using a special human-computer interface equipment. Usually, head-mounted displays and hand-tracking systems are employed to enable the user to observe, move around and manipulate the virtual environment.

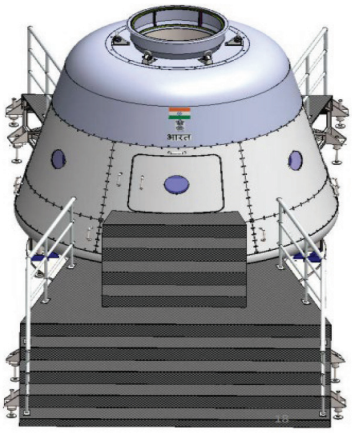
A typical Virtual Environment

Current Activities:

- Phase 1 simulator was realized and available for experience. Based on the experience of version 1, updated design requirements were worked out for the phase 2 simulator and an order was placed with the vendor for end-to-end realization.
- Initial inputs have been shared with the vendor to initiate the design including story board, CAD model of the Crew Module, and operations in the module as well as system-level descriptions.

Static Mock-up Simulator (SMS)

Static Mockup Simulator provides a close to realistic ambience and acquaintance with the Gaganyaan-CM including the distance and approach estimation of the crew control buttons and display systems. The available space for any crew activity will be the same as that of an actual CM. It requires the crew module mockup with every component like Avionics, ECLSS system, CPCS system, DRDO systems, etc. in the habitable area placed in exact congruence to that of the flight crew module for a near-real experience of the crew.



SMS Structure

Current Activities:

- The simulator configuration was defined and requirements were given to various design agencies for subsystem realization including Crew Module, ECLSS, Crew seat, cabin subsystems etc.
- For the Crew Module, the design of the structure was completed including reviews and an order was placed with the vendor for the realization of the CM structure, Dummy packages, Crew seat, Cabin System, etc.

- Various ECLSS subsystems were received for integration. Console and various cabin subsystems were also received for integration. The assembly sequence is prepared for mounting packages and decks inside the structure. Plan of electrical harnessing was discussed with the integration team. Electrical interface details were prepared for all the power supplies and packages and shared with the integration team.

- The Crew Module structure is expected in November first week and on receipt, the integration of various subsystems in the module is planned and deployed for training.

Dynamic Training Simulator (DTS)

DTS provides a signature of motion sensations expected to be felt by the crew during the actual flight. It trains the crew trainee for audio and dynamics experience such as jerk, vibration, acceleration, body rates and shock during various phases of the mission such as stage separation, parachute deployment, touchdown and CES trigger events. It incorporates the Stewart platform and possibly other vibration/actuation platforms for providing dynamics perception to the crew trainee.

Dynamic Motion Platform

Current Activities:

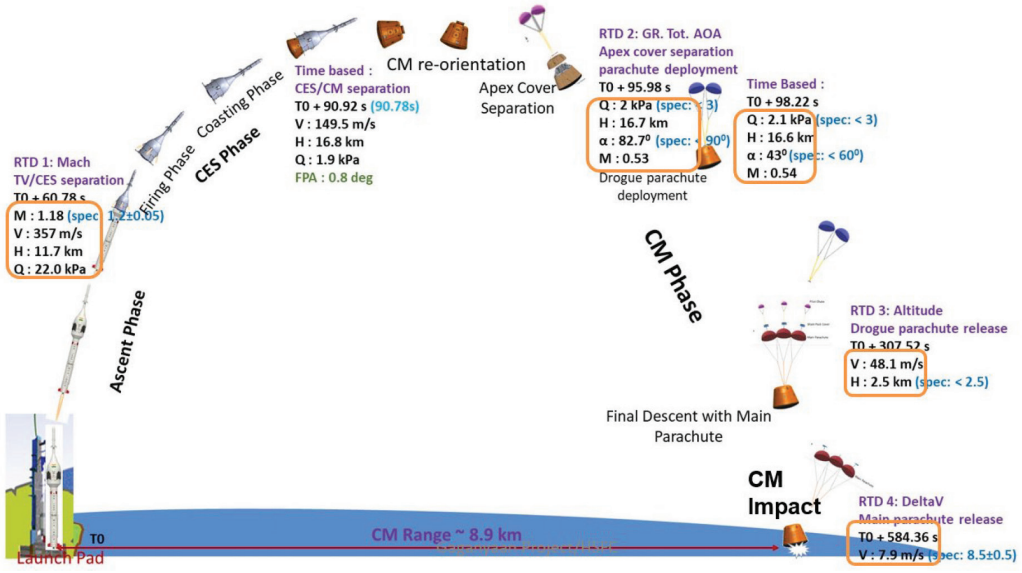
- An overall configuration of the dynamic simulator was designed including various subsystems, interfaces, specifications etc. A detailed RFP document for end-to-end realization of the simulator by a qualified vendor was prepared.

- The discussion was conducted with various vendors, domestic and international and after a lot of clarifications regarding the experience of the vendors in the realization of the simulator, suitable vendors were identified for the simulator realization.

3. Mission

TV-D1 Mission

An integrated mission plan for demonstrating the safe escape of the Crew from a simulated mission abort situation in a TV-D1 flight was generated. Mission definition, requirements, objectives, sign convention documents, Crew Module (CM) vehicle data document and event sequence documents for mission design were prepared. The documents enabled the implementation of event sequence and performed detailed mission simulations to identify trajectory parameters as well as appropriate window timings to make on-board Real-Time Decisions for the safe descent of the Crew Module under parachutes. The planned mission scheme worked flawlessly in the TV-D1 mission and preliminary post-flight analysis of flight data indicates that all major on-board event decisions occurred within specified timings.



Mission Performance in TV D1 Mission

G1 Mission

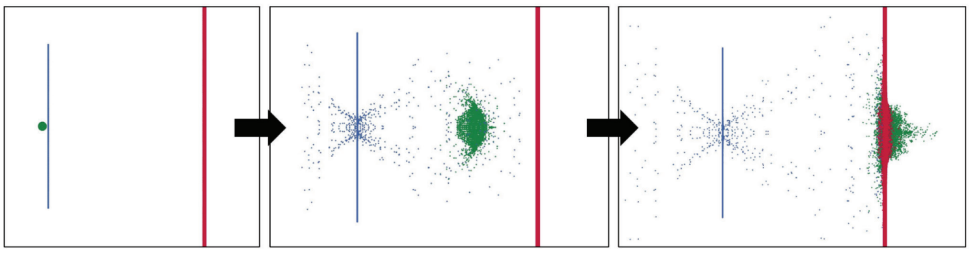
For the major ground qualification test of the Orbital Module Propulsion system, various mission profiles that would demand different sequences of operation of main engines and control thrusters in the Orbital module were generated and subjected to successful testing. Similarly, thruster operation profiles of the Crew Module during normal earth return missions and abort earth return mission were generated and subjected successfully to ground static tests. With these tests, the propulsion system in the Crew Module and Service Module are qualified for mission operations for the upcoming unmanned Gaganyaan G1 mission.

H1 and Other Missions

- To maintain human physiological levels within tolerable limits during the space flight, the best position and orientation of the crew have been specified in terms of the acceptable spine angle of crew in the seated conditions. Physiological standards issued by NASA are taken into consideration while arriving at the spine angle. A Coupled Parachute-Payload Dynamics simulator was developed in C++ language to analyse the rotational behaviour of the crew module and crew during the parachute descent phase and check whether the dynamic behaviour is acceptable from a human physiological view point.

Micro-Meteoroid and Orbital Debris (MMOD)

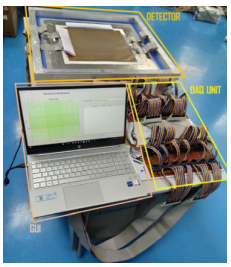
- A realistic assessment of the Orbital Module structure capability to withstand the impact of Orbiting debris (present in the specified 400 km circular orbit) and protect the crew has been completed using the ESA's proprietary software ESABASE. For this assessment, two different world standard space debris flux database catalogues MASTER 8 and ORDEM 3.0 were used to estimate the worst case highest debris flux environment that the Orbital Module can face. This software-based assessment was subjected to validation in hypervelocity impact tests at the Terminal Ballistic Research Laboratory (TBRL), DRDO with an Aluminum projectile of 7 mm impacting at 5 km/s. The performance of the Whipple shield design for protecting the debris impact was as predicted. In addition, Hydrocode simulations were performed to simulate hypervelocity impact with Al2O3 projectiles. Simulation results show a good match with the experimental results obtained from NASA during the Interagency Space Debris Coordination Committee. In continutaion of this activity, S/N (Signal to Noise) ratio and ANOVA (ANalysis Of VAriation) analysis were performed on a set of 16 Hydrocode simulations, to identify the percentage contribution of each parameter and the parameter combinations resulting in extreme results.



Al_2O_3 ball impacting on Whipple shield

- As a technology development Effort to detect the impact of Orbital debris on the orbital module in real time, developed an orbital debris impact detector consisting

of the resistive grid and acoustic sensing. Bench bench-level resistive grid system was demonstrated. Worked out a logic using acoustic sensors for location determination using trilateration of hyperbolas.



Resistive Grid Detector Setup

Human Factors Engineering / समानव कारक अभियांत्रिकी

Human Strength Measurement equipment has been installed and commissioned at HSFC. The equipment can generate the maximum voluntary force that a crew can exert which is important for the design of crew interfaces. Moreover, it can generate inputs for deriving scaling factors for all relevant joints of the musculoskeletal model and establish an Indian population-specific strength database for future space flight missions.

Activities including a comparison of human strength data from NASA HIDH (Human Interface Design Handbook) with the strength values of Indian subjects for shoulder arm in/out action using the Human Strength Measurement equipment have been completed. A simplified musculoskeletal model of humans was also developed, based on the physiological cross-section area for elbow flexors.

Measurements of isokinetic and isometric strength data of humans using the strength measurement equipment have been initiated to modify the default European human muscle models present in the commercially procured musculoskeletal analysis software.

Human Strength Measurement Equipment Installed at HSFC

Human ergonomics analysis has been carried out with a dynamic model of an Arm to optimize the posture of the Arm for maximum comfort within a given bounded volume. The torque data derived from in-house experiments were then used in the Arm model to predict the end effector force at different postures.

A comprehensive assessment of all Gaganyaan mission scenarios was made to identify the demands for manual operation of ECLSS control valves under different flight environmental conditions like low/high gravity, crew unsuited/suited (pressurised and unpressurised) and crew restrained/unrestrained conditions.

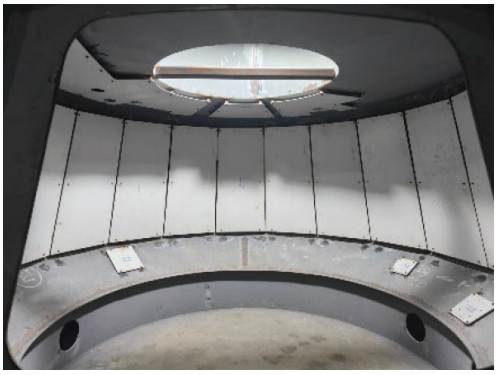
4. Mechanical Systems

Static-Mockup Simulator for Crew Training (SMS-CTS)

- Design of handling ring, hatches, simulated decks, packages, & Crew Seat Assembly through welding route completed.
- SMS-CTS Crew Module Internal layout generated and its assembly sequence finalized.
- Scheme finalized for load testing of SMS-CTS structure.
- Fabrication of the twin walled SMS CTS Structure and assembly of decks with structure completed.

Static Mockup – Crew Training Simulator

CTS CM Structure



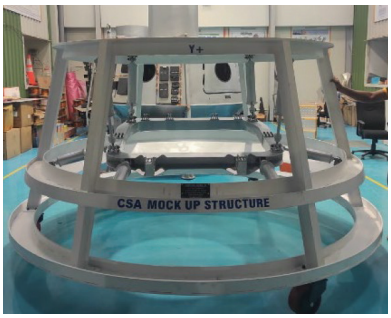
CTS Structure Inner view with Decks assembled

Conical Panels

Apex Cover

Crew Seat Assembly (CSA)

- Demonstrated the negative **DoF (Degree of Freedom) of CSA** (in locked condition) with realised CSA mockup structure using 100N modal shaker.
- Design and analysis of CSA for the G1 mission carrying Half humanoid and ECLSS deck completed. Detailed CAD model generated for G1 CSA.
- Detailed study carried out for CSA attachment with respect to **number of linkages and its orientation**. Configuration finalized based on overall stiffness and Dynamic response index.
- Seven different configurations of pallet frame were studied. Topology optimization was also carried for the selected configurations.

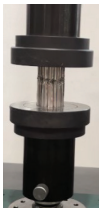


CSA Mockup structure

- **Integrated non-linear structural analysis and multibody dynamic studies** were carried out for CSA with seat, pallet and attenuators for the selected configurations of pallet frame.

- **Indigenous seat bucket** analysis completed with welded configuration and model developed for riveted configuration.

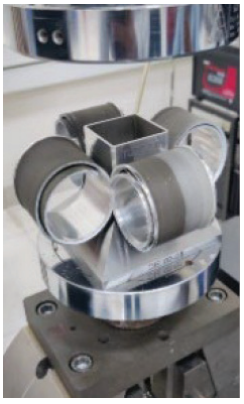
- Attenuation System Development
  - For **Honeycomb based attenuation system**, configuration design and Structural analysis (non-linear) was carried out. Honeycomb sandwich stacks were realized and tested using UTM. Mockup model realized with honeycomb based attenuation system.



Honeycomb Stack UTM Test

Mockup model for honeycomb attenuator

  - For **Splitting & Curling based attenuation System**, Finite Element Analysis (FEA) carried out for splitting & curling trials using damage modelling. UTM tests were carried out with different tube and dye configurations based on literature.
  - For **Wire Bender based attenuation system**, FEA carried out for wire bender configuration to achieve the desired force. Test setup configuration for characterize the wire bender attenuation system worked out.



Splitting & Curling UTM Test

- Technical specifications finalized for Anthropomorphic Test Devices.

Indigenous Viewport Development

- Engineering model of viewport realized through 3D printing.
- Viewport **structural and transient thermal analysis** carried out integrated with the crew module's internal and external panels.
- **Axisymmetric thermo-structural analysis** carried out for various thicknesses of thermal seals, based on literature.

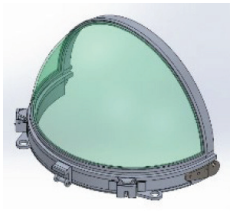
2.6 Gaganyaan

3D printed components for engineering model

Indigenous Viewport engineering model

Helmet Visor Assembly

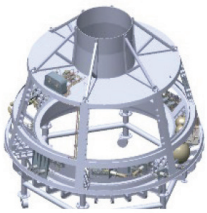
Helmet Visor Assembly configuration design and preliminary structural analysis completed for field training suit.



Helmet Visor Assembly configuration

CM Mockup for Water Calibration

Design and analysis of Crew Module mockup structure (welded route) for water calibration activities completed.



Water Calibration Mockup with Propulsion Systems

Realisation of CM Structure for Integrated Air Drop Test (IADT)

- 15CDV6 Ring, Forgings & Sheets, AA2014 Forgings, 8CD12 Filler Wire were realized for the components & subsystems for the CM Structure.
- Realised the Apex, Dome & Conical Subassemblies and integrated them to complete the CM Structure.
- Fabricated & Supplied 02 Nos. of CM Structures for IADT to validate Gaganyaan Parachute systems.

1st CM Structure realised for IADT

2nd CM Structure realised for IADT

Realisation of Simulated SM Structure & SM FE Ring for TVD1, PAT Missions

- Realised & Delivered 04 Nos. of Simulated SM Structures
- Realised & Delivered 03 Ns. Of SM Simulated FE Rings

SM Simulated Structure & SM FE Ring

Mechanical Ground Support Systems Fabrication Related

- Realised & Delivered the Ground Support Structure for the CM-CES Stack Acoustic Test.
- Realised the CM-CES Link Brackets for the Acoustic test of TV at NAL.
- Realised & Delivered the Orbital Module Handling Ring for Transportation & handling of Orbital Module.

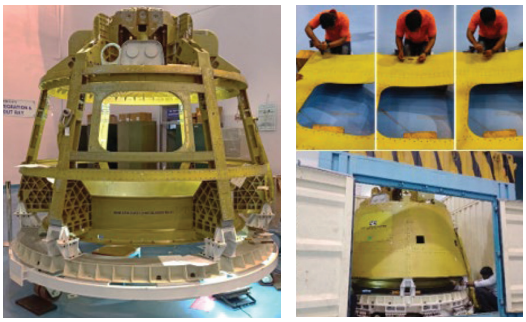
Ground Support Structure

Orbital Module Handling Ring for IADT

5. Assembly System Testing and Recovery

TV-D1 Activities

- ASTRE commenced activities on the TV-D1 Crew Module (CM) structure at VSSC in March, 2023. The Crew Module was then transported to AITF-2, ISITE for further integration activities.
- TV-D1 Crew Module (CM) integration activities at AITF-2, ISITE began from April, 2023 onwards. Several activities including flight harness testing & transfer, flight deck mounting, etc. were completed towards the commencement of Phase-1 checks.



Commencement of Integration activities on TV-D1 CM Structure at VSSC

TV-D1 Crew Module integration activities at AITF-2, ISITE

- Phase-1 checks for TV-D1 CM were commenced in April 2023. Checks for the Power System, Instrumentation, and NGC were carried out to validate the integrated Crew Module avionics.

2.6 Gaganyaan

TV-D1 CM Phase-1 checks at AITF-2, ISITE

- Chairman, ISRO visited the premises on July 24, 2023, during TV-D1 CM Phase-1 Checks and integration activities at AITF-2, ISITE.

Visit of Chairman, ISRO for Phase-1 TV-D1 CM Activities at AITF-2, ISITE

- Acoustic Tests for TV-D1 CM were completed on August 10, 2023, at ETF, ISITE. Post-test analysis, the Crew Module was cleared for transport to SDSC-SHAR.


Successful Completion of Acoustic Tests for TV-D1 CM at ETF, ISITE

- TV-D1 CM was flagged off to SDSC, SHAR on August 12, 2023. The Crew Module and the checkout systems were shifted to VTF, SHAR towards preparation for CM Vibration Tests.

Flag-off of TV-D1 CM to SDSC-SHAR

2.6 Gaganyaan

- Vibration Test for TV-D1 CM was completed in August 2023 at VTF, SHAR.
- Phase-2 Checks for TV-D1 CM were completed in October 2023 at OMPF, SHAR. Pyro Wiring of CM, assembly & integration of CMEA, and CMEA electrical checks were completed prior to stacking with Test Vehicle and CES.

Completion of TV-D1 CM Vibration Tests at VTF, SHAR

Completion of Phase-2 checks for TV-D1 CM & stacking operations of CM with CES

- TV-D1 mission was successfully launched on October 21, 2023, at FLP, SHAR. All systems, including the Crew Module, performed nominally. Recovery operations were successful for the TV-D1 CM using INS Shakti, and the recovered CM was brought to SHAR for post-flight analysis.
- Activities post recovery of the TV-D1 Crew Module were completed in October, 2023 at AITF-2, ISITE. Post-flight analysis was conducted for all systems; all onboard avionics were disassembled, and preparations for refurbishment of recovered CM were also completed.

TV-D1 launch at SDSC, SHAR with successful CM recovery operations

Successful Disassembly of recovered TV-D1 Crew Module at ISITE

TV-D2 Activities

- A review of TV-D2 CM avionics layout and mounting configuration from the EMI/EMC point of view was studied by the EMI/EMC committee.
- The following documents are CC released
  - Avionics Package list
  - Umbilical Scheme
  - Electrical Architecture
  - Powering scheme
  - Pyro scheme
  - Grounding scheme
- Matched EID for HILs setup is prepared and shared with the URSC team.

TV Checkout – Overall

- Delivery and inspection of items including Power rack, spare racks, PCI cards, LAN & RF cables, completed at vendor site etc.
- 12 Types of Gerber files designed, verified by QC team and PCBs under fabrication at the vendor site.

- HCPSO
- Latching relay
- Non-latching Relay
- Selection Relay
- Current Sensor
- Resistor Buffer Card
- LCPSO
- Monoshot
- Switching Relay
- Reset card
- Isolation Amplifier
- TM-TC card

- Multiple sessions with the vendor for technical understanding of TTCP equipment for Telemetry and Telecommand operations completed
- Simulator-in-loop test with TTCP for telemetry acquisition demonstration completed

Checkout Hardware

- Reviews with the vendor for Power Rack harnessing activities completed
- Mounting of Equipment for Power Rack Completed
- Discussions with the vendor for Command Rack layout and harness routing plan in progress

Checkout Software

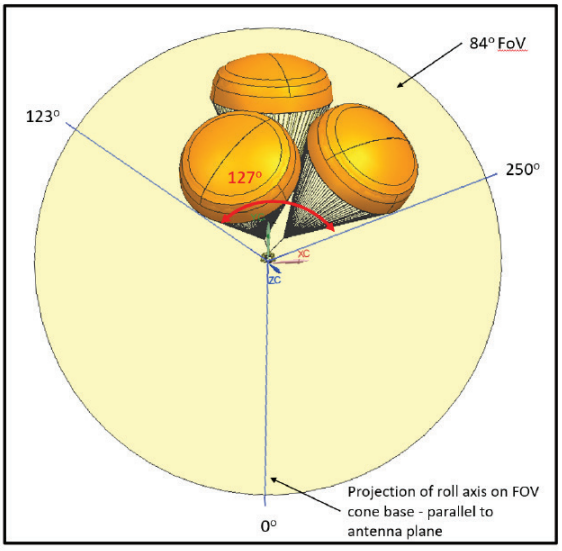
- Design of UI module with System Admin features for software health management
- Understanding of checkout software requirements for TTCP management & control
- Designer-level Testing and Bug fixing of the Parameter Module, Network Module

G1 Mission Activities

- Following sub-system accommodation in the G1–CM 3D model was carried out:
  - Deceleration system
  - Propulsion system
  - Thermal protection system
  - Separation interface
  - Up-righting system

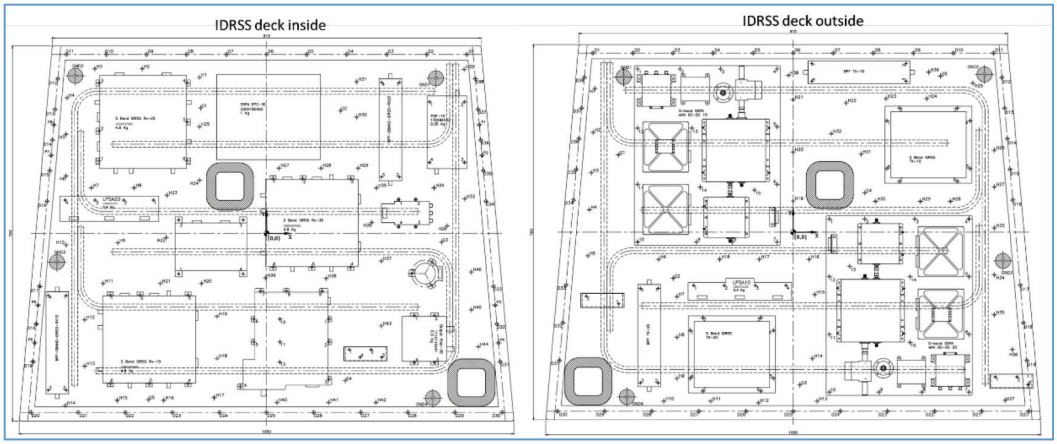
- Avionics system (Total packages – 181 Nos)
- Recovery aids
- Crew Seat
- Half Humanoid
- Reduced ECLSS

- The Heat Pipe Layout for the bottom deck was released.
- ILDs for the following have been realized and ready for release:
  - Bottom deck
  - Bus-1 deck
  - Bus-2 deck
  - Bus-3 deck
  - SARB deck
  - 3 No's of Apex decks
- Fabrication Drawings of Side decks, Apex decks, Annular decks and Aft conical decks have been completed and approved by HPDD (VSSC) for CC release.
- Fabrication drawing of radial stiffener for bottom deck and one annular deck has been put on hold by HPDD (VSSC) for further analysis. Bottom deck fabrication drawing in discussion with URSC.
- Four Nos of side deck layout approved by all agencies concerned and same in the process of release. The bottom deck and apex deck are in progress. DGL deck pending discussion.
- G1-Cut-outs on conical panel note is released. The antenna backup plate and mounting plate are configured and the is shared with the structures team for inclusion in the panel fabrication drawing.
- FoV blockage of CM SPS antenna with drogue and main parachute; L1 band transfer antenna with grid fins were studied and shared with the mission team for further analysis.
- IDRSS deck layout was worked out and shared with thermal, AIT and RF teams for final clearances.



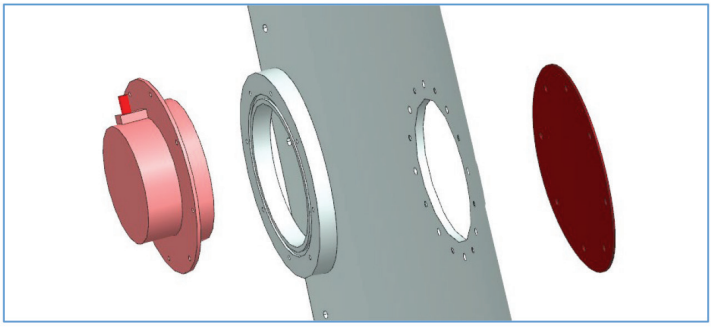
FoV blockage of CM SPS Antenna due to Main parachute

2.6 Gaganyaan



IDRSS deck layout with packages, heat pipe and harness tie mounts

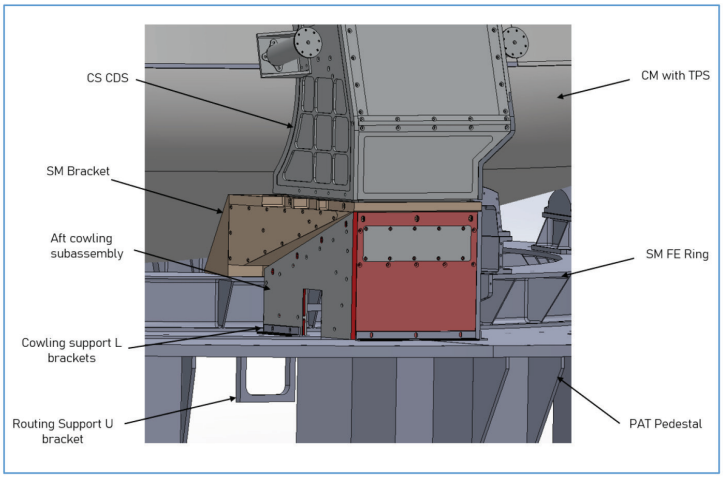
- G1- Cut-outs on conical panel note is released. The antenna backup plate and mounting plate have been configured and the is shared with the structures team for inclusion in the panel fabrication drawing.



S-band audio video antenna, antenna backup plate, conical panel and GFRP panel

PAT Mission Activities

- The following Baseline documents are ready and signed.
  - Avionics Package list
  - Umbilical Scheme
  - Electrical Architecture
  - Powering scheme
  - Pyro scheme
  - Grounding scheme

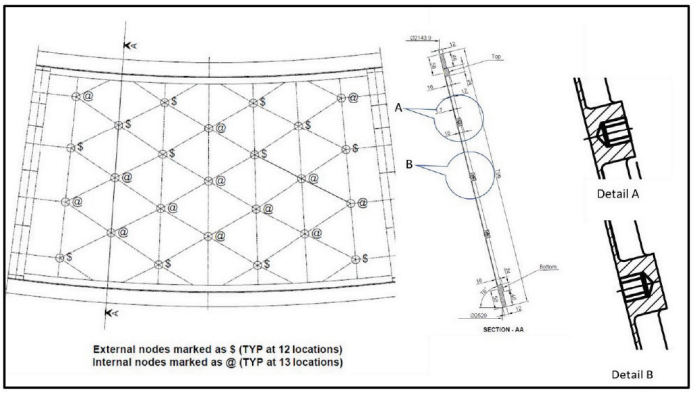


CS-CDS - assembly - PAT mission

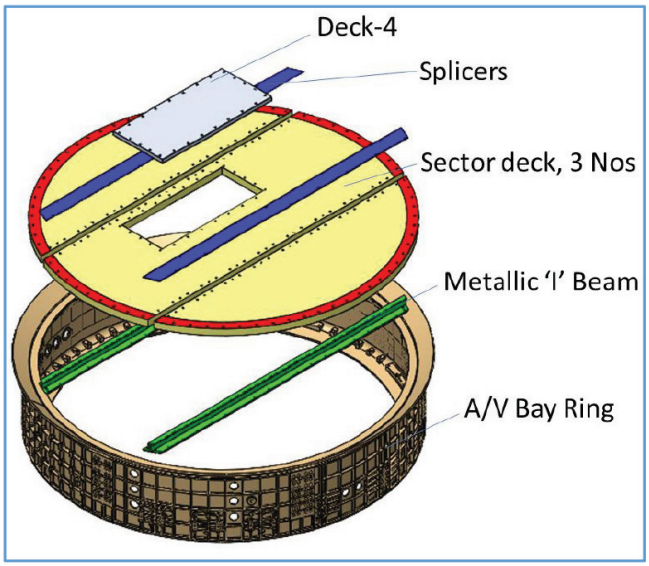
- Harnessing activities for PAT mission Inaugurated by Director HSFC.
- The Aft Cowling configuration in CS CDS assembly is finalized for PAT mission ensuring accommodation of the Crew Module on PAT Pedestal.

H1 Mission Activities

- Interface requirements on the Avionics Bay ring, forward conical region, aft annular region, Apex base ring and avionics bay dome were worked out and presented in AD VSSC review.
- Technical Note on Interface requirements for the accommodation of Avionics and ECLSS sub-systems in CMIS for H1-CM (draft version) was prepared and shared with SDED, STR Entity, and VSSC for generation of updated design drawings. This note describes in detail the interface requirements as well as cut-out requirements in CMIS.
- Configuration of mounting interface for various sub-systems (Avionics, ECLSS etc.) was carried out.
- Technical Note on Interface requirements for the accommodation of Avionics and ECLSS sub-systems in CMIS for H1-CM (draft version) was prepared and shared with SDED, STR Entity, and VSSC for generation of updated design drawings. This note describes in detail the interface requirements as well as cut-out requirements in CMIS.
- Provisional design drawings of the Apex base ring (shared by SDED, VSSC), Forward conical panel, Aft



Forward cone with details of internal/external nodes (typical at 3 locations)



Bottom deck mounting configuration on Avionics Bay ring

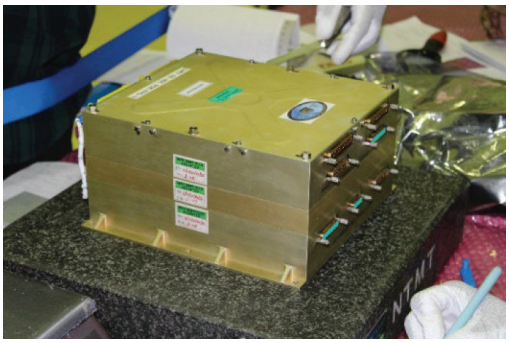
conical panel and Avionics Bay ring were verified for the availability of all interfaces as per 'Technical Note on Interface requirements for the accommodation of Avionics and ECLSS sub-systems in CMIS for H1-CM'

- ASF Connector-
  - Qualification tests completed & were presented to TT-ECQ team.

Quality Control Activities

- Screening of flight connectors completed
  - CHES clearance related activities:
    * Tool, Locator and shield soldering Inspection with respect to harness fabrication log book verified
    * All the harness details (8 Nos) verified
    * Harness fabrication log book verified
    * CC released face plate drawing verified
    * CC released bottom deck sector-1, 2,3,4,5,6, drawing verified
    * All the change proposals verified
    * NC connectors verified
- Audit of production files, crimping logs, and production log books verified
- Harness visual inspection observations are completed and observations are noted
- Activities at VSSC:
  - All fight sensor locations verified on crew module structure with respect to CC released mechanical drawings
  - Strain gauge bonding is completed on the Apex cylinder in PRU RH and PRU LH compartment (4 nos.) and the same verified
  - Strain gauge sensor bonding completed on aft bottom dome (13 nos.) and same verified
- Inspection and testing were completed for 22 nos. of Y-extenders & 9 nos. of one-to-one extenders
- All 5 nos. of checkout rack inspected & cleared for BURN-IN test
- 36 Hrs. BURN-IN test of the checkout system was monitored and observations recorded
- Isolation checks of pyro simulator extenders by mating to pyro simulator panel performed & cleared

- Pre-delivery inspection was carried out at the vendor's work centre for 50 Nos. of Deck Interface plate
- Interim Clearance Reports were generated for CM-CES Type 1 and Type 6 brackets, and NavIC antenna mounting brackets for Surface treatment operation
- Interim Clearance Report was generated for SCM Aft Heat Shield for TPS bonding activity
- Subsystem Inspection Procedure checks (SIP) were carried out for 61 Nos. of packages
- Non-conformance reports were generated for the following:
  - 26 NCs observed during Interface generation activities carried out at ICF, TERLS, VSSC.
  - Battery package mounting pitch mismatch in Battery deck.



SIP checks being carries out on a Type-1 package

- Online QC was carried out during the following activities for TV-D1-CM at AITF-2, ISITE and ICF, TERLS.
  - Interface generation activities on CM by ASTRE
  - CM reception at ISITE
  - Handling of CM using Crane and LLP
  - Harness tie mounts final assembly on CM
  - Trial assembly of secondary brackets with CM
  - Trial assembly of SAC deliverable antenna on antenna mounting brackets
  - Trial assembly of Flight packages on metallic sector decks
  - Trial assembly of Metallic sector decks with Deck interface plate and Honeycomb decks inside CM structure
  - Trial Positioning of Apex Cover (without CFRP panels) with the CM structure
  - Movement of CM within Air lock, Harness Lab and Cleanroom
  - Other trial/ final assembly operations as mentioned in the TV-D1 activities section
- QC check was carried out for the following drawings and documents:
  - Bottom deck assembly R1
  - Annular deck assembly R1
  - Deck interface plate

- Structure interface drawings R2
- Apex cover ballast mass drawings
- TV-D1 ballast mass drawings
- Ballast mass support plate drawings
- Central dome support plate drawing
- Heat flux sensor bracket drawing
- Heat flux cork spacer drawing
- Acoustic sensor TPS plug drawing
- Interface generation battery deck LH bracket
- Interface generation in TV-D1 Apex cover
- Interface generation on SM FE ring

- LSC meeting was conducted and NCs/ SNAGs were cleared for the following:
  - 26 NCs observed during Interface generation activities carried out at ICF, TERLS, VSSC
  - Battery package mounting pitch mismatch in Battery deck
  - SNAGs in Mini AINS RH and LH Brackets, Go-Pro camera mounting brackets 1 and 2, AVIS Camera mounting brackets 1 and 2, and Termination brackets 1, 4, 5, 7, 9, 10, 11, 12, 13 and 14
- A total 190 nos QC clearance reports released by QC team

Recovery Activities

- CMRM-02 (Crew Module Recovery Model) realized at industry

Handing over of Crew Module Recovery Module

- Multiple meetings of ICRO were conducted with members from the Indian Navy, Indian Army, IAF, ICG, NIOT & SCI for recovery operations.

- Detailed deliberations were carried out on communication requirements, establishment of communications network, communication equipment on recovery ships and Ship-Borne-Terminal (SBT) for tracking.

- Gaganyaan Recovery Training Plan was released at the Water Survival Training Facility (WSTF) at INS Garuda, Kochi on May 24, 2023
  - The document highlights the training plan for the recovery of the crew module for the mission. It defines overall requirements with respect to the training of various teams participating in Recovery operations viz. MARCOs, Para jumpers, medical specialists, technicians etc.
- Phase-1 Recovery Training for TV-D1 CM was completed in June 2023 at WSTF, Kochi.

Successful completion of Phase-1 TV-D1 CM Recovery training at WSTF, Kochi by ISRO & Indian Navy

- Phase 2 of TV-D1 CM Recovery Training was completed in July 2023 at Vishakhapatnam with ISRO and Indian Navy.

Successful completion of Harbour trials for TV-D1 CM recovery training at Vishakhapatnam by ISRO and Indian Navy

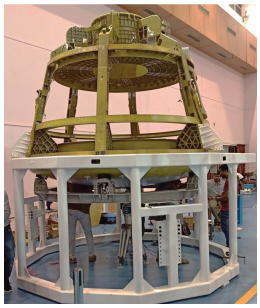
- The final Phase of TV-D1 CM recovery training was completed in August 2023 with ISRO & Indian Navy teams. Harbour trials were performed with the CM Recovery Model (CMRM) and was towed using INS Shakti in Vishakhapatnam.

2.6 Gaganyaan

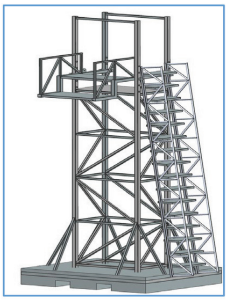
Harbour Trials for TV D1 CM Recovery with Indian Navy at Vishakhapatnam

MGSE Activities

- Assembly sequence for CM Acoustic and vibration test configurations at respective facilities and readiness of MGSE was presented to the Dynamic test committee.
- Load testing was carried out for MPIF and Bottom deck adapter.
- MPIF, CM Trolley, CM IF Ring, CES integration IF ring and CM handling brackets were loaded and transported to ICF/VSSC for TV-D1 CM Integration activities.
- Trial assembly was carried out for the following systems
  - Radial support brackets with CM and MPIF
  - SM FE Ring with MPIF
  - Aft Heatshield dome with MPIF
- Flight assembly of SM FE Ring with CM was carried out using MPIF and the required alignment was achieved.
- An Arming platform is configured for accessing the annular space between CM and CMF for the arming operation on FLP was presented to DRT-MGSE and all the actions were implemented.

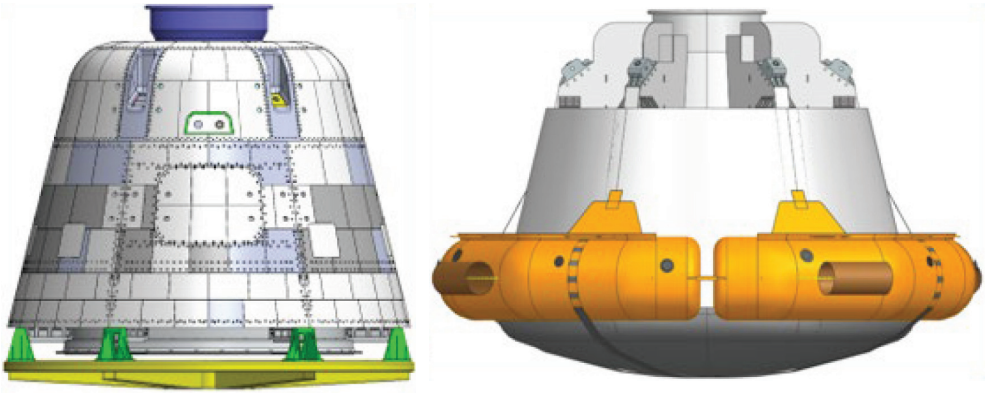


Flight assembly of SM FE Ring with CM using MPIF



Arming Platform Configuration

- An Adapter was configured to facilitate CGMI properties measurement of the Crew



Crew Module with adapter for CGMI measurements, CM with Toroidal buoy

Module without Aft Heatshield dome.

- 9 Nos. of Operation Procedure documents for MGSE assembly were prepared listed as below and reviewed by an internal team.
  - Aft Dome support bracket assembly with Aft Heatshield
  - Aft Dome support bracket assembly with SCM
  - CM Bare structure support brackets assembly with SCM
  - CM Crane Handling fixture assembly with SCM
  - Conical Panel assembly with Handling brackets and support fixture
  - MPIF and Aft Heatshield dome assembly
  - MPIF and Radial support brackets assembly
  - MPIF and SMA assembly
  - Swivel Hoist assembly with SCM

6. Safety, Reliability & Quality

1. Human Rating Certification

A robust Human Rating Certification mechanism is established and the system is in place. Two meetings of the National Advisory Panel (NAP) for Human Rating Certification were conducted to review and streamline the certification activities being carried out for Gaganyaan. The human rating certification plan was endorsed and approved by the NAP.

Parachute being a critical system, an audit was carried out at ADRDE, Agra to ensure the fabrication of the parachute meets the requirement and suggested following the QA augmentation during various phases of fabrication from yarn to packaging of the parachute.

A methodology has been developed to estimate the initial value of the risk threshold for Gaganyaan from lift-off to recovery of the astronaut.

2. Probabilistic Risk Assessment (PRA)

Equipped all ISRO centres to carry out PRA studies for the Gaganyaan mission and gave hands-on training to engineers at VSSC, LPSC and SDSC to perform the PRA.

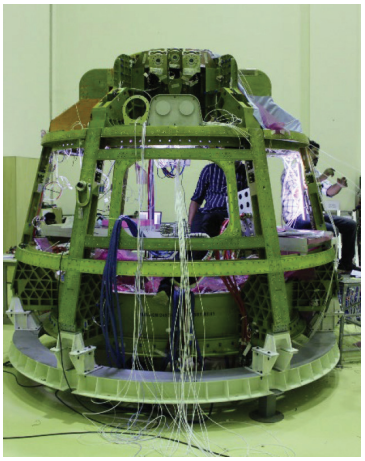
A framework has been generated to integrate the PRA studies across ISRO centres to estimate the probability of end-state at the Gaganyaan mission level. Accident scenarios from lift-off to reaching orbit were identified and captured in event trees. Identified 88 unique fault trees to be integrated into the framework.

A strategy was developed to estimate the reliability of space systems and components using the limited data based on the Bayesian approach which in turn gives the input to the PRA studies.

3. Quality Assurance activities

TV-D1 Crew Module (CM) mechanical integration

QA teams were built, with fresh engineers, and equipped to carry out the QA activities. The following QA activities have been carried out for the successful flight of TVD1 mission.



- QA surveillance during the interface generation, assembly of secondary structures, avionics packages, flight sensors, CG measurement activities and torque verification pre and post-acoustic and vibration tests.
- Ensured all the hardware and the system had undergone the review process non-conformances observed were addressed in NCRB and recommendations were implemented.
- All requirements and procedures for Crew Module Integration activities are complied with. Quality Assessment Report (QAR) issued and cleared for TV-D1 launch.
- Verified the correctness of mass property data (CG, MI and PI) in the mass property of the TV-D1 CM document with respect to the 3D model.

TVD1 CM electrical integration and checkout

- Verification of baseline documents for the TV-D1 crew module including FMR, ATS gain

scheduling and channel allocation, avionics package list, powering scheme, grounding scheme, and pyro circuits. Verification of harness details and electrical integration of TV-D1 crew module with respect to baseline documents. Verification of checklists (integration and Checkout-T&E). Verification for data consistency before CC release of all electrical integration and checkout documents.

- Auditing of QC reports of electrical integration tools and testing devices. Participation in testing of the checkout system, auditing of results and ratification. QA surveillance during various phases of checks and countdown time. NGC chain and Instrumentation chain data analysis at each phase of testing and appraisal to appropriate review forums. Strengthening QC process in checkout data file update procedure.

Integrated Air Drop Test (IADT) Crew Module fabrication

Two IADT hardware have been fabricated to carry out the deceleration system qualification test. Quality assessment was provided for raw materials, fabrication drawings and process plan. Issued Raw Material Certificate and Test Certificate for the material. Ensured the fabrication adhered to approved process plans, based on CC released fabrication drawings. The inspection was carried out at identified stages at the component, sub-assembly and assembly levels. Deviations observed were discussed in LSC/NCRB and ensured the recommendations are implemented. Quality Assessment Report released and cleared for further use.

Crew Training Simulators (CTS)

Released Quality Assurance plan for Crew Training Simulator and Software. Fabrication drawing and process plan reviewed and cleared. Reviewed the Dimensional Inspection Report at the component/sub-assembly and assembly level. Identified Functionally Critical Dimensions w.r.t Crew access for various systems. Inspection was carried out at various stages of fabrication and appraised to the review forums.

Environmental Control and Life Support Systems (ECLSS)

Testing and qualification of various ECLSS Components. Pre-Dispatch Inspection for raw materials and review of process plans for fabrication.

Human Centric Products

- **Crew Seat Assembly (CSA):** Provided Test Certificate for raw material for Pallet and rigid links in CSA.
- **Active Dosimeter:** Participation in vibration and hot-cold temperature tests and audited the test results.

- QA participation in the storage of procured spacesuits in storage cabinets.
- CM-CES scaffolding load testing and inspection

4. Publication

- A paper on "Evaluation of intermodulation products and auto-allotment of carrier frequency in space missions" was selected for poster presentation at SMOPS-2023.
- A paper titled "Strategy for Developing Prior and Likelihood Functions to Estimate the Reliability of Space Systems using a Bayesian Approach" got accepted at ICRESH-2024 for publication.

5. Internal Reports

Quality Assessment Report: 09
Quality Assurance Note: 62

7. Biomedical Research, Crew Administration and Training

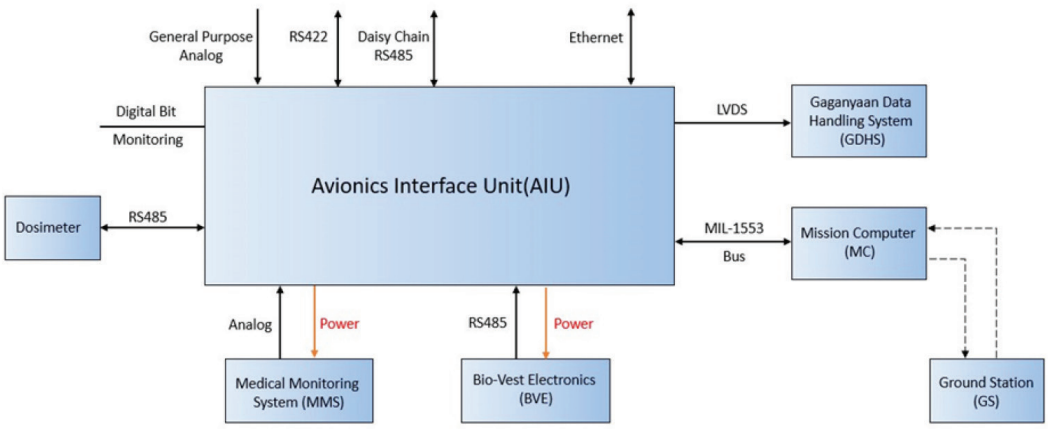
I. Biomedical Engineering

1. Biomedical Instrumentation

a. Avionics Interface Unit

System & functional requirements worked out for the Avionics Interface Unit for analogue and digital payload data acquisition and subsequent communication to Mission Computer as well as the Gaganyaan Data Handling System.

Interface & FPGA schematics, Isolation and power management schemes worked out and Components selected.



b. Human Centric Products

NDA with NID formed for the development of various Human Centric Products.

Prototyping of vomit bag and water sipper with lock mechanism done. Functional requirement generated and shared with NID.

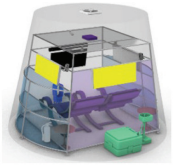
Vomit bag

Water dispenser

Collaborated with IIT Madras for the delivery of an Anthropometric measurement system and associated software for anthropometric data collection and analysis.

c. Space Analog Testbed

Design of a space analogous testbed to study the effects of various spaceflight stressors on human physiology and psychology in controlled and simulated conditions.



Test bed

2. Radiation Studies

a. Passive Dosimetry

Worked out the characterization plan for the passive dosimetry kit for Gaganyaan w.r.t. space-relevant radiation at NASA's Space Radiation Lab, BNL. Proposal submitted and accepted by NSRL.

Passive dosimeter

b. Active Dosimetry

System design of a semiconductor-based charged particle detector. Substrate & sensor selection, sub-system parameters, block diagram and signal flow worked out. Engineer model design in progress.

Reviewed the outcome of repeat qualification tests of DLJ's active dosimeter and contributed to the analysis of failures observed during the same.

Active dosimeter

c. Radiation Biology

Started collaborative projects with researchers from IISc, IIT-BHU and IIST to study specific effects of space radiation on biological organisms.

3. Flight Suit Testing & Development

Suit Storage

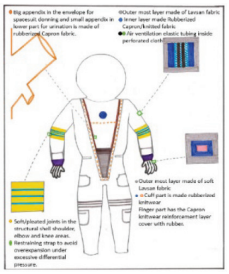
a. Flight Suit Storage & Test Facility

Designed cleanroom and pneumatic test rig for periodic testing of SOKOL KV2 suits. The pneumatic test rig is augmented for simulator training as well. Augmented the storage facility for high-pressure gas storage.

b. Field Training Suit and IVA Suit

Worked out the system & functional requirements for the development of field training suit to be used during sea survival and launch complex training and training.

IVA suit design and development are being worked on in collaboration with NID.



FTS stitching scheme

c. Thermo-regulation Studies

Developed a 16-node model for studying the thermos-regulation of the anatomical human chest and subsequently optimizing the ventilation system of the indigenous flight suit.

II. Crew Training

a. Integrated training Repository Software

Developed and deployed software for management and archival of classroom training, physical training, evaluation & feedback and training resources.

b. Classroom Training & Physical Fitness

Second semester of classroom training on various Gaganyaan subsystems and mission plan completed. Regular Physical Training and swimming sessions are being conducted in conjunction with medical checks.

c. Nutrition & Diet

Astronaut kitchen infrastructure set-up completed. A meticulous nutrition plan worked out in conjunction with the National Institute of Nutrition and to cater to the planned diet.

ATF Kitchen

d. Flight Procedures

Drafted the Astronaut Reference Note for Medical procedures in consultation with IAM covering SOPs, medical kit contents & layout, usage of medicines and surgical items and medical waste disposal.

Worked out the guidelines for writing Flight Procedure Documents.

Worked on FPDs for ECLSS operations, crew flight plan and ARN on communication in conjunction with respective teams.

III. Sea Survival Training

Analyzed various post-touchdown contingency scenarios and subsequently devised a training plan. Assessed each test case w.r.t. the hazard analysis matrix to finalize the protocols for sea survival training.