The Exploration Company

Payload User's Guide - Nyx Mission Possible - V2

Project: Nyx

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1 About us

The mission of our French-German company is to democratize space exploration for space and non-space industries. To realize this mission, The Exploration Company develops, manufactures, and operates Nyx, a modular and reusable orbital vehicle that can be refueled in orbit. Nyx serves the low Earth orbit (LEO) and lunar destinations and starts with carrying cargo, with the growth potential to fly humans afterwards. The Exploration Company was founded in 2021 by experienced engineers and has raised one of the biggest Seed Series in Europe backed by tier-one investors (Promus Ventures, Cherry, Vsquared), and more recently the biggest Series A so far for Spacetech in Europe.

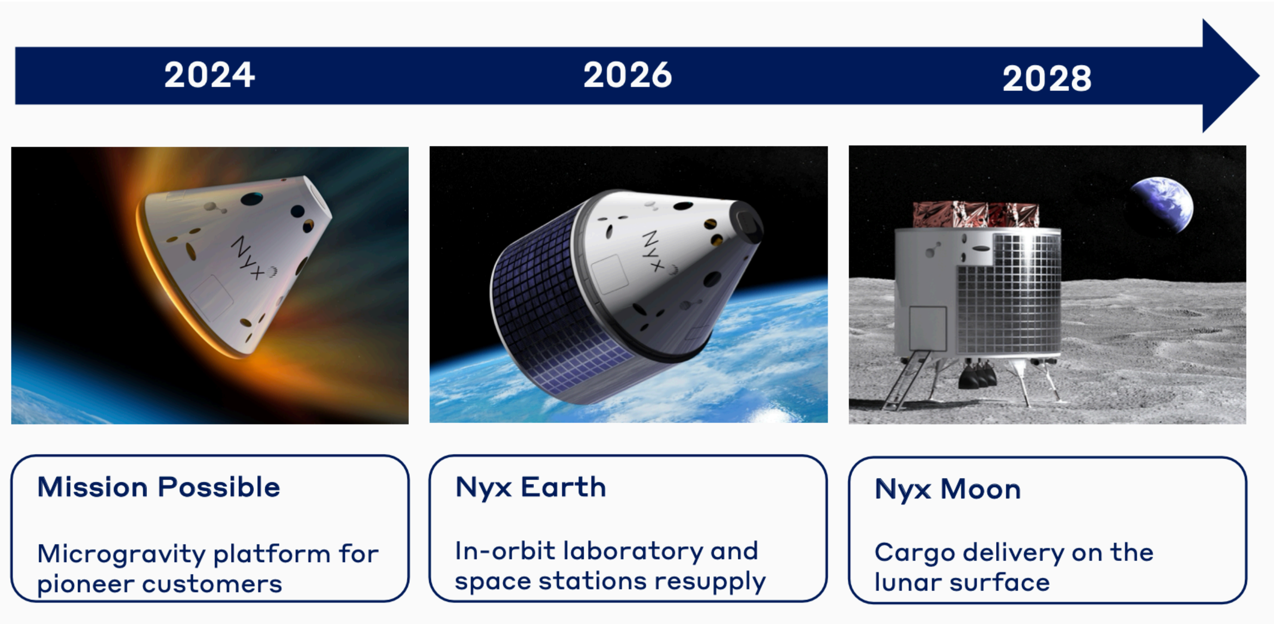
The Exploration Company has its headquarters in Munich, Germany where it is focusing on Software Development, GNC, Avionics, and the final assembly line of Nyx. The second site in Bordeaux, France focuses on the development, testing, and manufacturing of the propulsion system, design and system engineering.

For more information, visit exploration.space[1]

1 https://exploration.space/

2 About Nyx

With Nyx, we are enabling you to perform microgravity experiments, in-orbit technology demonstrations, entertainment, and educational missions but also cargo delivery to larger space infrastructures or lunar surface.



Mission Possible will be the first demonstration flight of Nyx with payloads on board. For this flight, Nyx capsule will be a sub-scale of the final one (2,5m diameter for a 4-meter final capsule) and will be launched without its service module for a short mission in LEO. It is planned to be launched in 2024 and will enable 300kg of payloads to experience a microgravity environment for up to one hour before the capsule performs a controlled re-entry, and splashes down in the Ocean. After the recovery of the capsule by our teams, we will be able to hand over back your payloads to you.

This first demonstration flight will enable us to test and validate the most critical phases of Nyx missions and help us maturate the operational configurations of the vehicle, to be then able to offer you an enhanced experience on board Nyx Earth, able to stay in-orbit for up to 6 months for you to perform on board a wide range of micro-gravity experiments, in-orbit demonstrations, in-space manufacturing and even be able to deliver your payloads to other space stations. Nyx Earth will eventually evolve in its lunar configuration, Nyx Moon, which will enable you to deliver your payloads to the lunar surface and even bring them back to Earth, with the ambition to fly humans in the next decade.

This User's Guide specifies the high level requirements to be taken into account for users willing to send payloads on board Nyx first demonstration flight - Mission Possible, which flight is planned in 2024.

For missions on board of Nyx Earth and Nyx Moon dedicated User's Guides will be released in the next months, the users will be offered enhanced capabilities and features.

3 User Experience

It is very important to us to prove a unique user experience to our customers. Therefore, we are not only focusing on the development and manufacturing of the hardware but also on software development to create an end-to-end experience.

Our mission manager will ensure that you will have all necessary documentation regarding the interfaces on board Nyx available so that you can plan your mission accordingly. In the case of microgravity experiments, we can provide you with scientific expertise through our partners offering support for various areas such as life sciences, biotech, pharma, cosmetics, or agriculture.

3.1 Your journey

- **Feasibility phase:** based on your payloads needs and characteristics, we will perform a high level feasibility check to confirm compatibility with Nyx. We will then agree on the main performance requirements and primary milestones before we sign together the Orbital Service Agreement
- **Kick-off:** after contract signature, you will be supported by your mission manager to start a joint schedule and an Interface Control Document (ICD) for the mission
- **Mission preparation phase:** you will work closely with us to maturate the mission timeline, mission operation sequence, and mechanical & electrical interfaces between Nyx and the payload; we will also support the payload design cycle reviews as needed. Based on your payload mechanical and thermal models (if requested from us) and on your compliance status and qualification files, we will provide flight-worthiness approval to your payload.
- **Payload integration phase**: you will deliver the payload to our integration premises in Europe at least 4 months before launch for final acceptance and integration into Nyx payload compartment; as a standard service, the payload will be integrated to Nyx by TEC; payloads will be OFF during the integration and will be switched on punctually for health checks and interface checks
- **Transport phase**: we will transport Nyx, with your payload included, to dedicated launch site; payloads will be OFF during transport and might be switched on punctually for health checks and interface checks
- **Integration phase on Launcher**: we will take care of final integration and tests, installation on launcher and transport to launch pad along with the launch service provider.
- **Launch and ascent phase**: Nyx will be injected into a Low Earth Orbit by the launch vehicle; payloads will be OFF during launch and can be turned ON by Nyx Payload Interface Unit after orbit injection confirmation to prepare for the start of the microgravity phase
- **Orbital flight phase**: Nyx will remain attached to the launch vehicle for up to two hours, during which there will be dedicated micro-gravity periods; Nyx Payload Interface Unit will trigger the start of the customer experiment and payload operations will be performed; At least 30 min of uninterrupted micro-gravity phase at a level around 2*10^-3g will be provided to the payloads
- **De-orbiting phase**: the launch vehicle will perform a de-orbit burn, after which Nyx will be separated; Nyx will perform several reorientation maneuvers using its propulsion system before reorienting its heatshield towards the atmosphere, i.e. into the velocity direction, to prepare for re-entry; the payloads will typically be OFF during this phase
- **Re-entry and Landing phase**: Nyx will control its bank angle to provide heat load and g-load control; once the spacecraft has been sufficiently slowed down by atmospheric braking, the parachute system will be activated which will assure a splash down in the ocean
- **Recovery phase**: a recovery system will be activated after splashdown to allow the ground crew to locate the spacecraft and recover the vehicle on a boat; the boat will return Nyx to land for initial check-outs, before the full vehicle (incl. Payloads) is shipped back to our integration facilities in Europe
- **De-integration phase**: we will open the capsule, unload the payload rack and dismount the Payload from its shelf to make it ready for post-recovery inspection
- **Post-flight handover phase**: you will perform post-recovery inspection and ship the payload including all equipment back to your premises

3.2 Export Control

You will be requested to provide the classification of your Payload in terms of export control regulations. For this purpose a template, including a questionnaire will be provided to you. No Payload subject to ITAR will be flown on this mission.

4 Interfaces

4.1 Overall accommodation

There are two payload compartments available on Nyx:

1. **Pressurized compartment**: payloads are accommodated inside the central sealed tube of the capsule with a pressure maintained around 1bar through all phases of the mission.
2. **Unpressurized compartment**: payloads are accommodated on shelves directly connected to the heat shield main structure in a vented environment, thus experiencing de-pressurization during launch ascent, vacuum during the orbital phase, and re-pressurization during reentry.

All payloads will experience a microgravity phase during the mission.

No payload is exposed to outer space.

All payloads are static, no ejection is offered as a standard service.

4.2 Allocated volume

The static volume of the payload shall not exceed 1dm3 per kg in the pressurized area and 0,75dm3 per kg in the unpressurized area.

This volume shall encompass the complete box, including the mechanical interfaces and the electrical connectors.

The height of the payload shall not exceed 200mm. The width and the length shall be discussed with us at the initiation of the ICD.

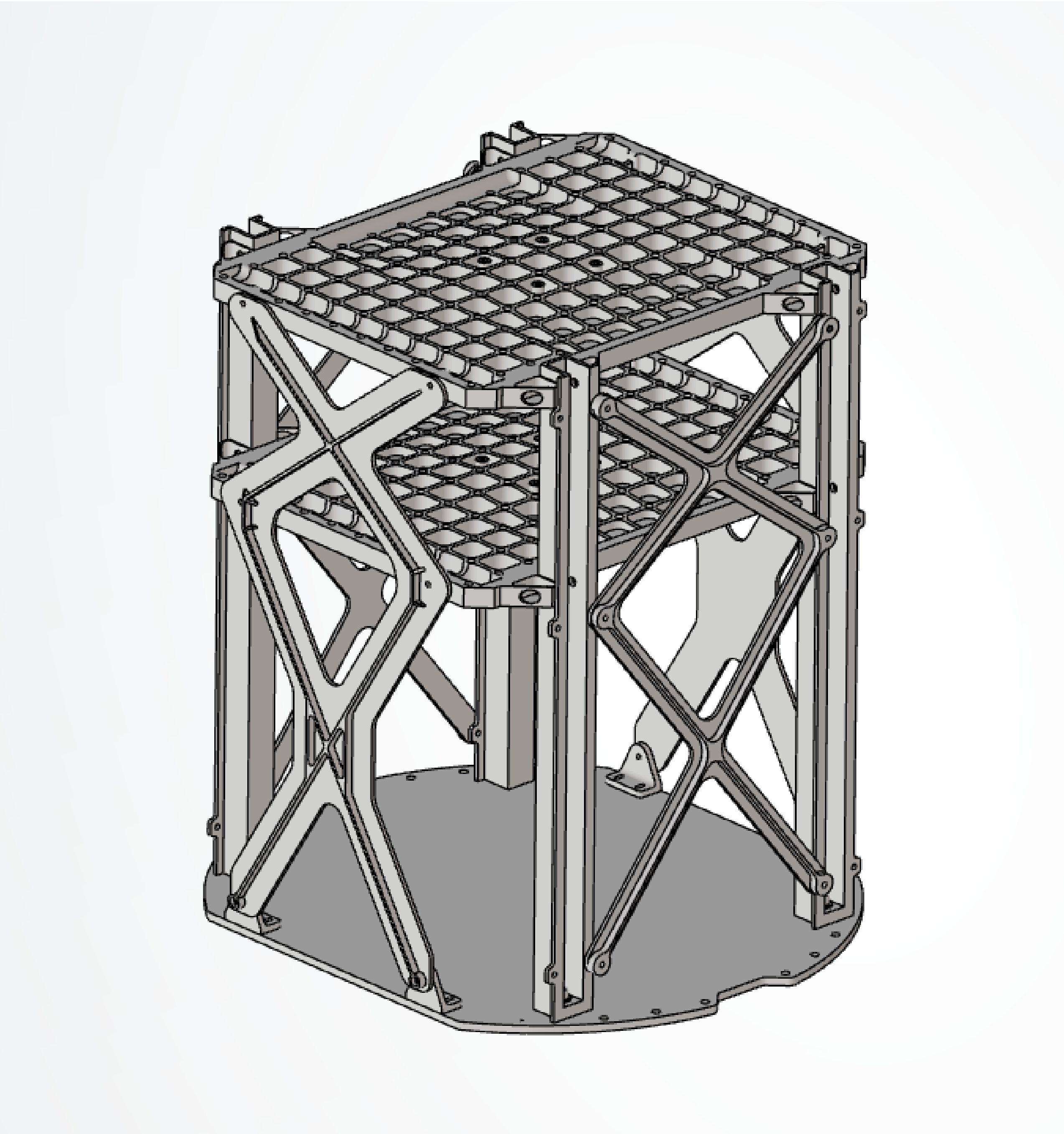
The typical maximum allocated volume for a 10kg payload in the pressurized area would be H:200mm / L:300mm / W:200mm.

The Payload should be encapsulated in a closed volume, so that no component of the Payload can leave this volume and cause any harm in the capsule or towards Co-Payloads. In case an opening on this volume is required for sensors, venting or other purposes, this opening needs to be secured by a grid as to contain any parts of the Payload inside the volume at any time.

4.3 Mechanical interface

4.3.1 Pressurized area

The customer payload will be accommodated on one of the shelves of the payload rack. The payload rack contains three shelves, each of them able to welcome several payloads, depending on their masses and volumes. The bottom shelf can welcome specific interfaces for a unique large payload, whereas the two other shelves are identical and provide a standardized hole pattern to welcome a large diversity of payload volumes.



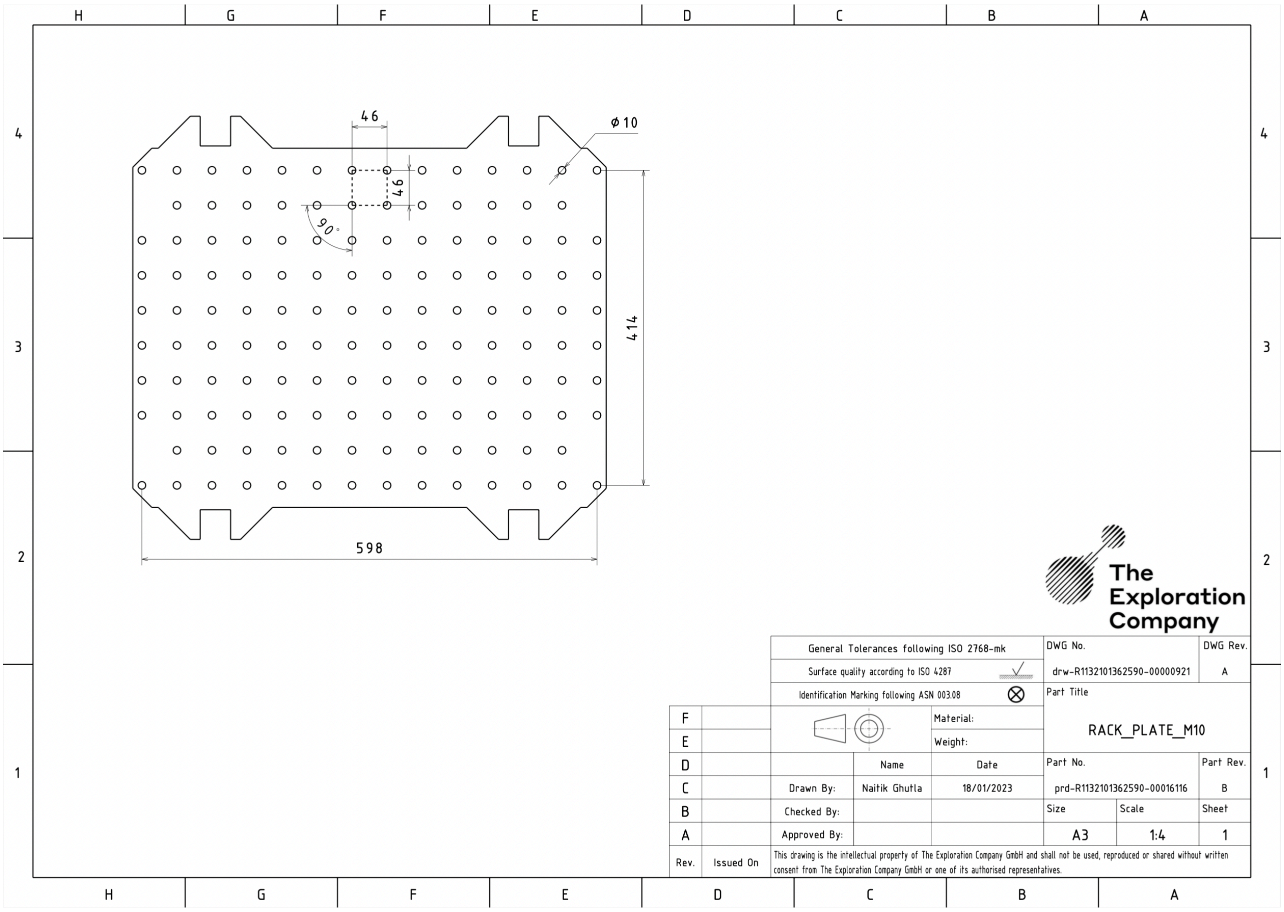
Each of these two standardized shelves corresponds to a stiffened plate of aluminum offering a regular pattern of M10 holes to welcome the payloads mechanical interfaces, as described in the view below.

The holes on the payload side shall then be compatible with this M10 pattern and shall allow proper access to perform the bolted junction axially from the top. There will be helicoils on shelf side to welcome the bolts, so only through holes need to be planned on payload side.

The payload structure in the area of the junctions with the shelf shall have a minimum thickness of 10mm and shall be verified by mechanical justification.

The number of bolted junctions between payload and shelf will be defined and justified by the customer based on the mechanical properties of the payload and shall be a minimum of 4.

The payload interface plane with the shelf shall be flush.



4.3.2 Unpressurized area

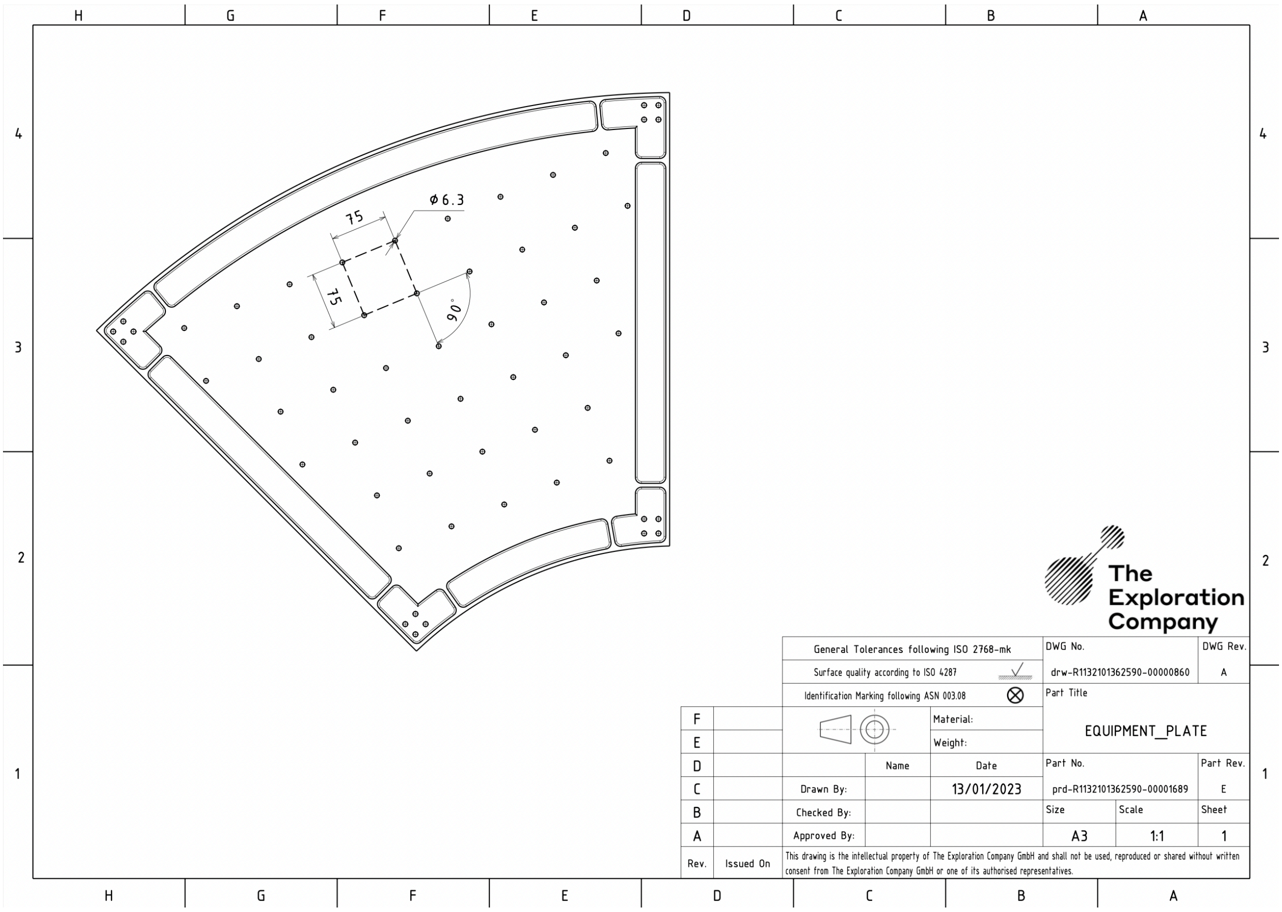
In the unpressurized area, the payloads will be mounted on shelves that will be directly mounted to the main structure of Nyx.

The holes on the payload side shall be compatible with the pattern described in the drawing below and shall allow proper access to perform the bolted junction axially from the top. There will be helicoils on shelf side to welcome the bolts, so only through holes need to be planned on payload side. The diameter of the bolts and holes can be increased if needed depending on payload characteristics.

The payload structure in the area of the junctions with the shelf shall have a minimum thickness of 10mm and shall be verified by mechanical justification.

The number of bolted junctions between payload and shelf will be defined and justified by the customer based on the mechanical properties of the payload and shall be a minimum of 4.

The payload interface plane with the shelf shall be flush.



4.4 Electrical interface

4.4.1 Connectors

The payload shall use a D-SUB connector as its single electrical interface connector.

The connectors on the payload side shall be located on one of the side walls, not on top nor on the bottom, to ensure easy access and routing. Exact location will be defined in the ICD.

A common electrical interface will be implemented at the Nyx payload interface unit, then the harness between this common IF and the dedicated connectors on the payload side will be TEC's responsibility to ease routing aspects.

The exact location, type, and pin allocation of the connector will be agreed upon between the customer and TEC and documented in the Interface Control Document.

4.4.2 Voltage

The interface to each payload provides a switchable 28V DC power output as a standard. 28 V power shall be DC isolated from chassis, structure, equipment conditioned power return/reference, and signal returns by a minimum of 1 megohm.

4.4.3 Power

The max peak power that can be provided to a given payload is 84W with an average power of 1W/kg for the complete mission.

To manage power dissipation and to ensure a reasonable thermal environment inside the payload compartment, the power consumption timeline will be discussed with each of the customers and defined by TEC based on a global approach.

To ensure reliability of the thermal models in terms of power dissipation, the customer will be requested to characterize the payload power consumption profile by test based on requirements to be provided in the ICD.

4.4.4 Grounding

An equipment bonding stud connected to the unit housing shall be provided as a ground reference at equipment level.

The DC resistance between the equipment bonding stud and each connector housing shall be less than 10 mΩ.

4.5 Data & communication

To ease the communication between the spacecraft and the payloads, Nyx will offer a payload interface unit acting as an onboard server. The payloads communicate with this server in a secured and clearly defined manner. The basic services offered are:

- Upload data to the storage on Nyx (up to 1GB*) and on a data recovery system that will be jettisoned from Nyx just before splashdown as redundancy (up to 100MB*)
- Receive time-triggered commands from Nyx, such as entering the microgravity phase or preparing for the re-entry phase

**If higher amounts of data are needed, please contact us.*

On top of the ethernet link, the communication between Nyx and the payloads is based on well-known standard protocols that are used for communication on the Internet. This enables the customer to use existing software to communicate with Nyx.

The data storage is implemented as a first-in-first-out buffer. This means as soon as the customer uploads more data than offered, the oldest data will be deleted. In terms of data format, there will be no limitations. The customer will have an API endpoint to which they can upload messages that will be stored on the file storage. The messages will have size limitations but the content of the messages is up to the customer. We suggest the use of JSON (Javascript Object Notation).

Data transmission to the ground is not part of the standard service for this mission.

4.6 Radio Frequency

For this mission, no RF transmissions are planned for the Payloads and no RF emission by the payload is allowed. Thus, no individual telecommands from ground through the customer are possible. Instead, time-triggered commands will be sent through Nyx Payload Communication Interface Unit, if required by the customer.

5 Environments

5.1 Mechanical environment

Nyx mechanical environments are enveloped by those of the launch phase. The maximum environments, presented below, are preliminary and will be confirmed by The Exploration Company during the mission preparation phase, based on payload characteristics and configuration.

5.1.1 Stiffness requirement

Payloads shall maintain the primary lateral and longitudinal frequencies above 165Hz to avoid interactions with Nyx and launcher structural dynamics.

All intermediate plates have to be included into this frequency analysis.

The frequencies are defined as any frequency response of the Payload with any modal participation, as computed through a fixed-base modal analysis.

5.1.2 Mass, Centering, and Inertia (MCI)

The Mass, Centering, and Inertia (MCI) of the payload will be documented and tracked through the Interface Control Document (ICD).

5.1.3 Quasi-Static Loads (QSL)

For a payload complying with frequency requirements defined above, and with a mass <40kg the limit levels of quasi-static loads (QSL) to be considered for the design and justification of the payload primary structure are the following:

Axis	**Quasi-static loads**
Xpl	+/- 30g
Ypl	+/- 30g
Zpl	+/- 30g

These load factors shall be combined to cover all load orientations.

Testing is REQUIRED to the quasi-static load levels described in the Verification section in accordance with the maximum predicted environment defined in this section. Quasi-static load test requirements can be achieved through a vibration test, such as sine burst testing, sine sweep testing, random vibration, or static load tests.

5.1.4 Sine

If the payload is compliant with the stiffness requirements, no additional demonstration or testing is required for sine. In case the stiffness requirement cannot be met in full, testing is REQUIRED and sine test levels will be provided accordingly.

5.1.5 Random & Acoustics

The random environment to be considered for the design and the justification of the payloads is provided in the tables below, for both pressurized and unpressurized bays.

Once the complete payload configuration is frozen, a dedicated vibro-acoustic analysis will be performed at system level to confirm the levels specified in here.

Most of the payloads sizing should be driven by random vibration rather than acoustic environment.

PSD - Pressurized Compartment	
Frequency (Hz)	**PSD (g^2/Hz)**
20	0.1
100	0.35
400	0.35
2000	0.0001
grms	**12.6**
PSD - Unpressurized Compartment	
Frequency (Hz)	**PSD (g^2/Hz)**
20	0.1
100	0.4
400	0.4
2000	0.001
grms	**14.1**

These load factors are applicable to each of the three axes.

Testing is REQUIRED to the random vibration test levels and durations defined in the Verification section in accordance with the maximum predicted environment defined in this section, for pressurized and unpressurized compartment respectively. This random vibration test can also be used to meet the design loads factors requirement defined in Quasi-Static Loads, e.g. retrieving the loads at the payload interface during the random vibration test.

5.1.6 Shock

The payload shall sustain the shocks related to the launcher fairing and stages separation events as well as the spacecraft separation and parachute deployment, as specified below:

Frequency (Hz)	SRS (g)
100	100
1000	1300
10000	1300

Testing is REQUIRED to the shock test levels and durations defined in the Verification section in accordance with the maximum predicted environment defined in this section.

5.2 Thermal environment

Nyx will provide the following thermal environment inside the capsule during the different phases of the mission:

<table>
<tr><th></th><th>Ground (before launch)</th><th>Ascent phase</th><th>Orbital & reentry phases</th></tr>
<tr><td>Pressurized payloads</td><td rowspan="2">[10;32]°C</td><td rowspan="2">[0; 35]°C</td><td>[0; 50]°C</td></tr>
<tr><td>Unpressurized payloads</td><td>[-10; 60]°C</td></tr>
</table>

Testing is ADVISED to the thermal cycle test levels and durations defined in the Verification section in accordance with the maximum predicted environment defined in this section.

Testing is HIGHLY RECOMMENDED for payload in the unpressurized compartment to the thermal vacuum cycle test levels and durations defined in the Verification section in accordance with the maximum predicted environment defined in this section.

5.3 Pressure environment

Nyx will provide the following pressure environment inside the capsule during the different phases of the mission:

<table>
<tr><th></th><th>Pre-launch</th><th>Launch - before fairing separation</th><th>Orbital phase</th><th>Reentry phase</th><th>Recovery phase</th></tr>
<tr><td>Pressurized area</td><td>Atmospheric pressure</td><td colspan="4">Limited pressure drop to be expected, rate will be defined in the next release of the document.</td></tr>
</table>

Unpressurized area	Atmospheric pressure	The payload compartment will be vented to ensure a low depressurization rate during launch ascent: drop of -3 kPa/s for most of the flight with a local drop to -5kPa/s during the transonic phase for a few seconds	Space Vacuum	Re-pressurization of maximum + 0,5 kPa/s	Atmospheric pressure

For the pressurized compartment no venting will take place.

In the unpressurized compartment, the customer shall assure that vents are placed on the Payload so that depressurization can take place unimpededly and in accordance with the depressurization of the Payload compartment described above.

5.4 Humidity environment

Nyx will provide the following humidity environment inside the capsule during the different phases of the mission:

	pre-launch/launch	**orbital phase/reentry**
Pressurized area (dry air)	<50%	
Unpressurized area	50% +/- 15%	0% (space vacuum)

A higher humidity level is to be expected during splashdown and recovery. If the payload is particularly sensitive to the humidity environment, please contact us.

5.5 Contamination control

Payload Processing Facilities shall provide a clean environment but not following ISO standard.

Customer is responsible for verifying compliance to this requirement in the form of a Payload contamination report.

A list of used material and their outgassing properties shall be provided to TEC.

Payload that will be exposed to vacuum must not exceed a total mass loss of 1.0% and the volatile condensable matter must be less than 0.1% when tested per ASTM E595.

5.6 Radiation environment

In space, the payloads will be exposed to the LEO radiation environment. This radiation can cause single event effects in electronics and the payloads shall take these effects into account in their design. Typical radiation levels depend on the position and orientation of each payload: please contact us when radiation-sensitive equipment is present.

5.7 Electromagnetic environment

5.7.1 Payload Radiated Susceptibility

Payload shall be compatible with the following radiated environment :

Frequency Range (MHz)	E-Field Limit (dBµV/m)
1 - 2200	120
2200 - 2300	140
2300 - 18000	120

Testing or verification by analysis is REQUIRED to the compatibility test levels defined in the Verification section in accordance with the maximum predicted environment defined in this section.

5.7.2 Payload Radiated Emission

The payload emission in the range [30 MHz, 18 GHz] shall be lower than the values provided in the following table:

Frequency Range (Mhz)	Fields Emission Limits (dBµV/m)
0.014 - 1164	90
1164 - 1300	54
1300 - 1555	90
1555 - 1595	54
1595 - 18000	90

Testing or verification by analysis is REQUIRED to the compatibility test levels defined in the Verification section in accordance with the maximum predicted environment defined in this section.

5.7.3 Payload Conducted Emission

Payload conducted emissions shall be compliant with :

- MIL-STD-461 CE101-4 (Curve #2)
- MIL-STD-461 CE102-1 (Basic Curve)

5.7.4 Payload Conducted Susceptibility

Payloads conducted susceptibility shall be compliant with :

- MIL-STD-461 CS101-1 (Curve #2)
- MIL-STD-461 CS114-1 (Curve #3)

6 Payload Design

6.1 Materials

6.1.1 Hazardous Materials

Hazardous materials are defined as in: Federal Register: Hazardous Materials[2] as well as radioactive materials and amounts of each.

A list of all used hazardous materials shall be provided to TEC, together with an explanation why this material was chosen and no other. A detailed description of the taken/installed precautions to prevent the hazardous materials from causing any harm during launch and recovery operations shall also be provided to TEC.

Selection Criteria

The least flammable material that meets design requirements while minimizing potential ignition sources and fire propagation paths shall be used. If more than one material satisfies the performance requirement, the least toxic material shall be used.

Materials that will not give off a toxic gas if ignited shall be used wherever/whenever possible.

If contact of material with a non-compatible material can cause a critical or catastrophic hazard, the hazard shall be mitigated to a level.

Hazardous materials shall not retain a static charge that presents an ignition source to ordnance or propellants or a shock hazard to personnel acceptable to Wing Safety.

6.1.2 Forbidden and Restricted Materials

Material	**Commonly Found**	**Restricted Environment**	**Reason**
Silicones	Adhesives and tapes	Any	Creep and contamination of surfaces
PVC, cellulose, acetates, polyvinylacteate and butyrate	General	Unpressurised (vacuum)	Breakdown and contamination
Pure Tin	Lead-free solder	Vacuum, low temperature	Forms whiskers in vacuum Forms “tin pest” at low temperatures

2 https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-172/subpart-B/section-172.101

Material	Commonly Found	Restricted Environment	Reason
Mercury	Various	Any	Causes accelerated degradation of aluminium and titanium alloys
Materials prone to outgassing/offgassing in vacuum	Various	Unpressurised (vacuum)	All materials subject to vacuum must meet low outgassing requirements: TML less than 1% and CVCM less than 0.1%
Materials included in the FAA Hazardous Materials Table[3]	Various	Various	Various
Cadmium and Zinc	Metal platings	Unpressurised (vacuum)	Evaporate and redeposit Embrittle Titanium
Beryllium and Beryllia	Lightweight structures	Any	Toxic, carcinogenic, sensitizing
Articles containing > 0,1 % by weight SHVCs	Various	Any	Various
Any particle shedding or generating materials	General	Any	Shedding or flaking surfaces or coatings, materials producing debris used in mechanisms for moving part lubrication

Note: In case of questions or concerns please contact TEC, exceptions can be made in certain circumstances/ volumes only with our express permission.

6.1.3 Liquids

All payload containing liquids will have to ensure that no liquid can escape their system. Double-sealing must be used in order to do so and dedicated test is required to demonstrate no leak during the mission. The configuration of this leak test will be defined conjointly based on the payloads characteristics and operational scenario.

3 https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-172/subpart-B/section-172.101

6.1.4 Pressure system and pressure vessel materials

All Customers must provide a comprehensive list of Pressure System materials for a compatibility assessment. The list must include:

1. All Pressure System materials within the Pressure Vessel, and all other pressurized components
2. All working fluids, processing fluids, and expected/potential by-product fluids

Accepted material compatibility are per the following industry accepted design guide:

- “Material Compatibility with Space Storable Propellant. Design Guidebook,” P.E. Uney, et al, Martin Marietta Corporation. March 1972.

Any material combinations that are outside of this specification require TEC approval.

6.2 Pressure vessels

A Pressure Vessel is any system containing more than 20,000 J of stored energy (pneumatic and chemical energy) or a maximum expected operating pressure greater than 100 PsiD (6.9 barD). Systems that contain pressure but do not meet the above are considered “pressure components” or “Pressure Systems”.

Pressure Vessel classification and use:

- Type 1: All metallic. Conforms to AIAA-S-080 (current approved release).
- Type 2: Metallic liner with composite hoop. Conforms to AIAA-S-081 (current approved release).
- Type 3: Metallic liner with full, wound composite overwrap. Conforms to AIAA-S-081 (current approved release).
- Type 4: Non-metallic liner with full, wound composite overwrap. Conform to applicable sections of AIAA-S-081 until such a time as AIAA G-082 is fully released.
    - Use is not recommended.
- Type 5: All-Composite Pressure Vessels (liner-less)
    - Use is not recommended.

6.2.1 Pressure Vessel Leak Test

Each individual Pressure Vessel must undergo leak testing to demonstrate a maximum leak rate of 10-6 sccs at maximum expected operating pressure. The Pressure Vessel leak test configuration and success criteria shall be submitted to TEC for approval. Test report documentation must be submitted to TEC in order to evaluate conformance.

Pressure Vessel tests must take proper precautions to ensure safety.

6.3 Pressure System

A “Pressure System” is any system that is intended to be pressurized beyond 0.5 atmospheres. This includes both Pressure Vessels and pressure components such as valves, fittings, and tubes that have potential to see internal pressure in the time between Customer delivery to the Integration Site and on-orbit deployment. For all pressurized systems, the following information must be provided to TEC:

1. Document detailing system design criteria, maximum expected operating pressure derivation for flight, and ground cases for all pressurized components, features, and Pressure Vessels, including valve set points and relief-device sizing.
2. System schematic using standard P&ID symbols and an (excel) tabulated parts list, including valves, reliefs, transducers, and reference designators for all parts.
3. List of all single-point failures in the system.

4. Qualification and acceptance testing for each component of the Pressure System, and the overall system qualification strategy.
5. Document detailing combined system test-like-you-fly deviations between test and flight including rationale.

6.3.1 Pressure System Leak Test

The fully integrated Pressure System must be leak tested demonstrating a maximum leak rate of 10-4 sccs at maximum expected operating pressure. The Pressure System leak test configuration and success criteria shall be submitted to TEC for approval. Test report documentation must be submitted to TEC in order to evaluate conformance.

Pressure System tests must take proper precautions to ensure safety.

6.4 Batteries

No internal batteries are allowed for the payloads. The power consumption shall rely only on the power provided by Nyx.

7 Verification method

7.1 Environments

TEC allows two approaches to environmental verification testing:

- *Qualification*: A qualification unit is subjected to testing at qualification levels and every flight unit is tested to acceptance test levels. The acceptance tests must be performed at the fully integrated Payload assembly level, even if the Payload consists of multiple smaller Payload Constituents. Qualification can be performed at the Payload Constituent level. With this approach the qualification test validates the structural design while the acceptance test(s) validate workmanship.
- *Flight Unit Protoqualification*: Each Payload flight unit is subjected to protoqualification test levels. Testing must be performed at the fully integrated Payload assembly level, even if the Payload consists of multiple smaller Payload Constituents. With this approach the protoqualification test validates both structural design and workmanship.

Every Payload flying with Nyx must undergo either fleet qualification or flight unit protoqualification environmental verification testing. Payloads using a fleet qualification approach must submit evidence that the qualification unit is sufficiently similar to the flight unit. The environments verification approach in this section is designed to ensure the safety of Co-Payloads, the Orbital Vehicle and the Launch Vehicle. Tests that are “Advised” are designed to ensure on-orbit health and functionality of the Payload but are not required in order to fly on a Nyx Orbital Flight Vehicle. Tests that are “Required” must be completed by the Customer to be able to get the flight worthiness approval for their Payload and have it fly on Nyx.

Test	**Necessity**	**Qualification**	**Acceptance Must be performed on fully integrated Payload assembly**	**Protoqualification Must be performed on fully integrated Payload assembly**
		Qualification Unit		**Flight Unit**
Quasi-static load[1]	Required	1.25 times the limit load	1.1 times the limit load	1.25 times the limit load
Sine Vibration	Advised	1.25 times limit levels, two octave/ minute sweep rate in each of 3 axes	1.0 times limit levels, four octave/ minute sweep rate in each of 3 axes	1.25 times limit levels, two octave/ minute sweep rate in each of 3 axes
Shock	Required	3 dB above MPE, 3 times in each of 3 orthogonal axes	Not Required	3 dB above MPE, 2 times in each of 3 orthogonal axes
Random Vibration	Required	3 dB above acceptance for 2 minutes in each of 3 axes	MPE spectrum for 1 minute in each of 3 axes	3 dB above acceptance for 1 minutes in each of 3 axes

Test	Necessity	Qualification	Acceptance Must be performed on fully integrated Payload assembly	Protoqualification Must be performed on fully integrated Payload assembly
		Qualification Unit		Flight Unit
Emission Compatibility	Required	6 dBµV/m by Test or 12 dBµV/m by Analysis	Not Required	6 dBµV/m by Test or 12 dBµV/m by Analysis
Radiated Environment	Required	6 dB EMISM by Test or 12 dB EMISM by Analysis	Not Required	6 dB EMISM by Test or 12 dB EMISM by Analysis
Thermal Cycle	Advised	+/-10°C beyond the acceptance for 6 cycles total	Envelope and minimum range (-24°C to 61°C) for 4 cycles	+/- 5°C beyond acceptance for 6 cycles
Thermal Vacuum Cycle	Highly recommended (for unpressurized payloads)	+/-10°C beyond the acceptance for 6 cycles total	Envelope and minimum range (-24°C to 61°C) for 4 cycles	+/- 5°C beyond acceptance for 6 cycles
Pressure Vessel Leak Test	Required	Not required	Full Pressure Vessel Leak Test	Full Pressure Vessel Leak Test
Pressure System Leak Test	Required	Nor required	Full Pressure System Leak Test	Full Pressure System Leak Test

Notes:

1. Static load testing can be achieved through a sine-burst test. In some instances, either random vibration or sine vibration testing at the levels described in this table may surpass the static load factors.

7.2 Materials

7.2.1 Hazardous Materials Test Requirements

Material properties shall be determined by test processes defined in this section or be selected from Authority approved material database: FAA Hazardous Materials Table[4]

4 https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-172/subpart-B/section-172.101

Plastic materials that may pose a hazard because of compatibility or toxicity shall be tested IAW the requirements described in Kennedy Documented Procedure (KDP)-KSC-P-6001, KSC Materials and Processes Control Program. Plastic materials that may pose a hazard because of flammability shall be tested IAW requirements described in NASA-STD-6001, Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion. Plastic materials that may pose a hazard because of electrostatic discharge shall be tested IAW the requirements described in KSC/Report MMA-1985-79, Standard Test Method for Evaluating Triboelectric Charge Generation and Decay. Plastic materials that may pose a hazard because of hypergolic ignition/breakthrough shall be tested IAW the procedures described in KSC/MTB-175-88, Procedure for Casual Exposure of Materials to Hypergolic Fluids.

The results of these tests shall be submitted to TEC for review. Approval will be granted after coordination with the launcher company and responsible authorities, based on use.

7.2.2 Other Material Test Requirements

Authorities may require the testing of materials whose properties are not well defined. Toxicity, reactivity, compatibility, flammability and/or combustibility testing requirements shall be determined by TEC after coordination with the launcher company and responsible authorities on a case-by-case basis.

Testing shall consider the following material characteristics:

- Ability to build up a charge (triboelectric test)
- Ability of that charge to decay (triboelectric test). Note: A material is considered to have good electrostatic dissipation properties if it can dissipate voltage down to 350 volts in 5 seconds using the triboelectric test.
- Flammability
- Compatibility with other materials and liquids the material may come into contact with.

Material restrictions may also arise from other limitations such as being humidity dependent (for charge dissipation) or degradable in sunlight (ultraviolet).

8 Mission preparation timeline

The launch window is Oct 2024 - July 2025.

L: Launch date

T0: Contract signature and preliminary ICD

- Signature of agreement
- Preliminary inputs for ICD
- Consolidation of pre-agreement feasibility analysis

L-18 months: Feasibility analysis and requirements convergence

- ICD V0
- Payload envelope volume
- Payload mass properties
- Payload electrical interfaces
- Payload data/communication interfaces
- Payload mission timeline (incl. power consumption profile) agreed
- Preliminary mechanical interface between payload and shelf
- Delivery of payload CAD/FEM
- Preliminary compliance status of the payload from customer
- Preliminary verification logic and qualification plan from customer

L-12 months: Compatibility analysis

- ICD v1
- Delivery of updated payload CAD/FEM
- Delivery of payload dynamic model
- Delivery of payload thermal model
- Delivery of inputs for safety submission from customer
- Consolidated compliance status of the payload from customer

L-9 months: ICD freezing

- Preparation ICD final revision
- Delivery of payload operation schedule by customer
- Test plan from customer

L-5 months: Flight-worthiness analysis and integration campaign readiness review

- Delivery of payload qualification file demonstrating compliance to ICD requirements, in consistence with the agreed verification logic
- Flight-worthiness analysis by TEC

L-4 months: Latest payload arrival

- Delivery of the payload to TEC
- Payload acceptance tests and review by TEC

L-4 to L-3 months: Payload integration operations

- Integration of the payload to Nyx by TEC

L-2 months: Shipment of Nyx (incl. payloads) to launch site

L : Launch and recovery operations

- Launch preparation operations
- Launch

- Recovery of the capsule
- Delivery of the capsule to Europe

L+2months: Handover operations

- Delivery of the payload data to the customer
- Handover of the payload hardware back to the customer