PLD SPACE™

MIURA 1 – Payload User's guide

Version 1.3, 13 November 2018

I. VERSION CONTROL

Version	Date	Author	Chapters	Changes
1.0	22 March 2018	M. Nürmberger	All	Document Creation
1.1	31 May 2018	M. Nürmberger	II	Acronym List completed and updated
			1.3, 1.4	Description of Standard and Non-Standard Services included
			2.1.1	INTA logo used to mark launch site position
			2.2	Misleading Information (Figure 2-7) removed
			4.3	Information about required payload documentation and reviews updated
			4.5	Late access operation further explained
			4.4 & 4.5	Illustrations added
			2.1.2.4 & 5.2.2	Flexible composition of Payload Bay explained
			7	Chapter 7: Safety added
			All	Spelling and grammar mistakes corrected Small clarifications added
			Footer	Changed to “Public Information”
1.2	08 June 2018	M. Nürmberger	2.1.2	Small updates, Information about GMV included
			3.4	Figure 3-6 changed
			4.5	Countdown & flight timeline updated
			5.1.2	Orientation of coordinate frame updated
			5.2.2	Nosecone dimensions updated
			6.3.2.1	Random vibration spectrum source updated
1.3	13 Nov. 2018	M. Nürmberger	All	Name of launcher changed to MIURA

NOTE: This document is still in draft status. The provided information still is subject to change and does not commit PLD Space. Mechanical and electrical interfaces might evolve during the finalization of the design. Flight performance and environment data currently is the result of simulations and will be replaced with real data as soon as it is available.

II. ACRONYMS

CD	Countdown
C&DH	Command & Data Handling
FTS	Flight Termination System
HQ	Headquarters
ICD	Interface Control Document
LOX	Liquid Oxygen
MECO	Main Engine Cut Off
PDP	Payload Data Package
P/L	Payload
PLB	Payload Bay
PLC	Payload Computer
PLD	PLD Space – Payload Aerospace, S.L.
PQ	Payload Questionnaire
PUG	Payload User's guide
RCS	Reaction Control System
TEPREL	Tecnología Española de Propulsión Espacial para Lanzadores
TVC	Thrust Vector Control

III. PREFACE

The MIURA 1 Payload User's guide is a document published by PLD Space to provide general information about the MIURA 1 suborbital launch vehicle. This document provides information about the MIURA 1 launcher, its performance capabilities, payload interfaces and all the associated services that PLD Space provides to its customers.

Comments or suggestions on all aspects of this manual are appreciated. With inquiries concerning clarification or interpretation of this manual or for further information please contact:

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NOTE: This User's guide is a working document, and as such is revised and updated periodically. When working with this document, please ensure you have the latest and complete version which is available on the PLD Space website.

NOTE: Throughout the document, a dot "." is used as decimal mark.

IV. INDEX OF CONTENT

1. INTRODUCTION

1.1. PLD SPACE

PLD Space is a European space company which goal is to provide commercial and scientific access to space. We are developing a family of reusable microlaunchers to offer suborbital and orbital launch services for small satellites and payloads.

The first member of our launcher family is the MIURA 1 sounding rocket, designed for suborbital flights. It provides our customers with valuable microgravity time for scientific research or technology development.

1.2. WHY MIURA 1

With MIURA 1, PLD Space is fully committed to revolutionize the commercial access to space for scientific and technological purposes. We are focused to provide the best flight experience to our customers. Best experience is not only flying on a reliable system and meeting mission goals but also to meet an easy integration of your experiment.

By simplifying the way of integrating your experiment on the launcher, PLD Space reduces overall mission time but also simplifies the interface between the experiment and the launcher.

1.3. STANDARD SERVICES

As part of any flight, PLD Space offers the following services, which are also described in further detail in the following chapters:

- Execution of a launch campaign including one suborbital flight.
- Support during the payload development and documentation.
- Payload integration at PLD Space facilities.
- Functional and Interference testing.
- Several flight simulation tests to ensure payload compatibility with flight procedures and to train the customers ground control team.
- Facilitate the launch range safety process.
- One flight bulkhead and one flight set of electrical connectors.
- Payload interfaces for power supply, C&DH and mounting.
- Payload compartment conditioned with gaseous nitrogen or any other inert gas on request.
- Payload transport from PLD Space headquarters to the launch site.
- Late Access to the payload while the rocket is on the launch pad.
- Payload recovery.
- Distribution of a post flight performance report and vehicle housekeeping data.

1.4. NON-STANDARD SERVICES

Services which are not part of the standard flight ticket can be realized on a case-by-case basis in consultation with PLD Space.

2. VEHICLE OVERVIEW

2.1. VEHICLE DESCRIPTION

2.1.1. Baseline Configuration

MIURA 1 is a single stage launch vehicle powered by liquid oxygen (LOX) and kerosene. The vehicle is designed, integrated and operated by PLD Space. With a total length of 12.5 m, a diameter of 0.7 m and a lift-off mass of 2550 kg, MIURA 1 is capable of lifting a nominal net payload (P/L) mass of 100 kg – not including the avionics system, recovery system and payload bay structure – into a suborbital trajectory.

After a total flight time of about 12.5 minutes, including several minutes of microgravity, the rocket splashes down approximately 40 km off the coast. It is then recovered by boat and the payload is returned to the customer. An overview of MIURA 1 and its subsystems is shown in Figure 2-1. Its main parameters are summarized in Table 2-1.

MIURA 1 is mainly designed to be launched from the historic range site El Arenosillo, located near Huelva in the south-west of Spain, as shown in Figure 2-2.

Figure 2-1 MIURA 1 Rocket and Subsystems

Data	Value
Length	12.5 m
Diameter	0.7 m
Stages	1
Lift-off mass	2550 kg
Nominal payload mass	100 kg
Microgravity time	3.7-4.7 min
Microgravity quality	$< 10^{-4}$ g
Flight time	12.5 min
Nominal apogee	150 km
Ground range	40 km
Recovery time	< 6h
Main Launch site	El Arenosillo, Spain

Table 2-1 MIURA 1 Baseline Data

Figure 2-2 Location of the El Arenosillo Launch Site

2.1.2. Subsystems

2.1.2.1. Propulsion System

MIURA 1 is propelled by a single regeneratively cooled TEPREL-1B engine powered by liquid oxygen (LOX) and kerosene. This single stage propulsion system has been designed and optimized by PLD Space to provide the best mission performance scenario in every single flight.

The propellants are driven to the engine by using a pressure-fed cycle with Helium. The TEPREL-1B liquid rocket engine produces a total thrust at sea level of 30 kN for a total duration of 122 seconds until depletion of the propellant tanks. Furthermore, the propulsion system is equipped with actuators to tilt the engine for an active Thrust Vector Control (TVC) during the propelled ascent of MIURA 1.

2.1.2.2. Recovery System

The recovery system on board of MIURA 1 can safely return the whole launch vehicle to ground, enabling the payloads to be returned to the customers and the complete rocket to be used again. After reentry, two parachutes are deployed consecutively. At an altitude of approximately 5 km, a drogue parachute decelerates the rocket, until the main parachute can be opened safely. At an altitude of approximately 3 km, the main parachute is deployed and further slows-down the descent of MIURA 1. Finally, the vehicle splashes down with a terminal velocity of 10 m/s. With the last known GPS position and a beacon system, it is then possible to locate the vehicle floating on the sea surface and recover it with a boat.

2.1.2.3. Avionics System

The avionics system, developed by the Spanish technology group GMV, controls all vehicle functions during the flight. It is also the only system directly connected to the payloads flying on MIURA 1, as it is responsible for their power supply, telemetry and Command & Data Handling (C&DH). The general functions of the avionics system are:

Figure 2-3 GMV Logo

- **Guidance, Navigation & Control:** The avionics system controls the trajectory and the attitude of MIURA 1 during its flight by commanding the actuators of the main engines TVC and by an additional Reaction Control System (RCS). The RCS is composed of cold-gas thrusters using nitrogen.
- **Telemetry System:** Establishes the communication between the vehicle and the ground station to transfer vehicle and payload telemetry.
- **Power Storage and Distribution:** Equipped with batteries for power storage and a power conditioning and distribution unit, the avionics system is responsible for supporting all remaining rocket systems and the payloads with power.
- **Payload Management**: A dedicated Payload Computer (PLC) handles all communication between the avionics system and the individual payloads. It forwards the payload telemetry to the telemetry system, provides additional data storage capacities and sends control signals to the payloads.
- **Sensor Conditioning and Acquisition:** The MIURA 1 rocket is equipped with various sensors that are used for rocket control loops, but also deliver valuable housekeeping data to analyze the rocket's performance after the flight.

2.1.2.4. Payload Bay

The MIURA 1 payload bay (PLB) is placed on top of the avionics bay and extends into the tip of the rocket. It consists of the nosecone and several modules that are stacked below it. The payload bay is capable to house up to four different payloads inside separated payload compartments (shown in Figure 2-4). The bulkheads between them are equipped with an isogrid pattern of screw holes for payload mounting and provide connections to the avionics bay for power supply, telemetry and C&DH. Hatches allow easier access during the integration process and enable late access to the payload during the count-down. Each compartment is sealed airtight individually and stays pressurized during the flight. A more detailed description of the payload interfaces can be found in Section 5.

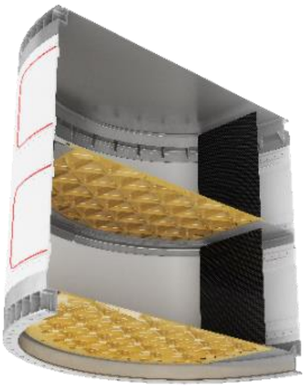


Figure 2-4 Cut view of two single compartments inside a payload bay module

Payload compartments exist in three different forms:

- **Single Compartment:** Suitable for simpler payloads, offering basic mass budget, power supply, data storage and telemetry data-rate.
- **Double Compartment:** Meant for more demanding payloads, offering twice the volume, mass limit, power supply, data storage capacity and telemetry data-rate.
- **Nosecone:** Can be utilized as either sized compartment, depending on the payload demands and composition of each mission.

The distribution of single and double compartments can be adapted individually for each flight, depending on the mission composition and the volume demands of the customer(s). Also, the combination of two or more compartments to form a triple or quadruple compartment is possible.

2.2. PERFORMANCE

The flight performance of each MIURA 1 flight is strongly depending on the total payload mass. Figure 2-5 shows simulation results estimating how the payload mass influences the total achievable microgravity (< 10^{-3} g) time. The achievable flight altitude also depends on the total payload mass. Simulation results are shown in Figure 2-6.

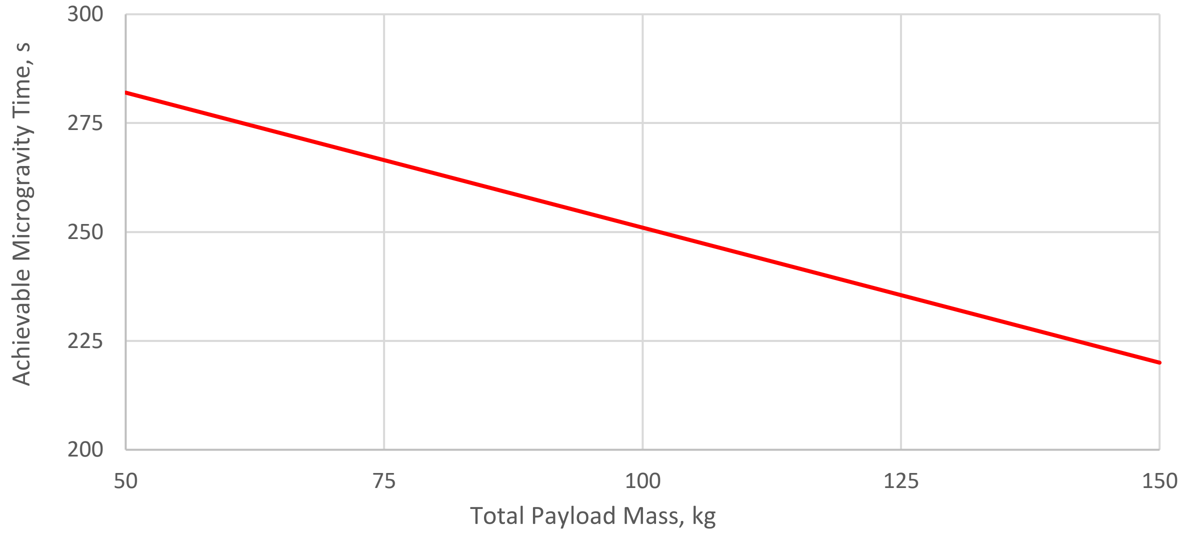


Figure 2-5 Achievable Microgravity Time vs. Total Payload Mass

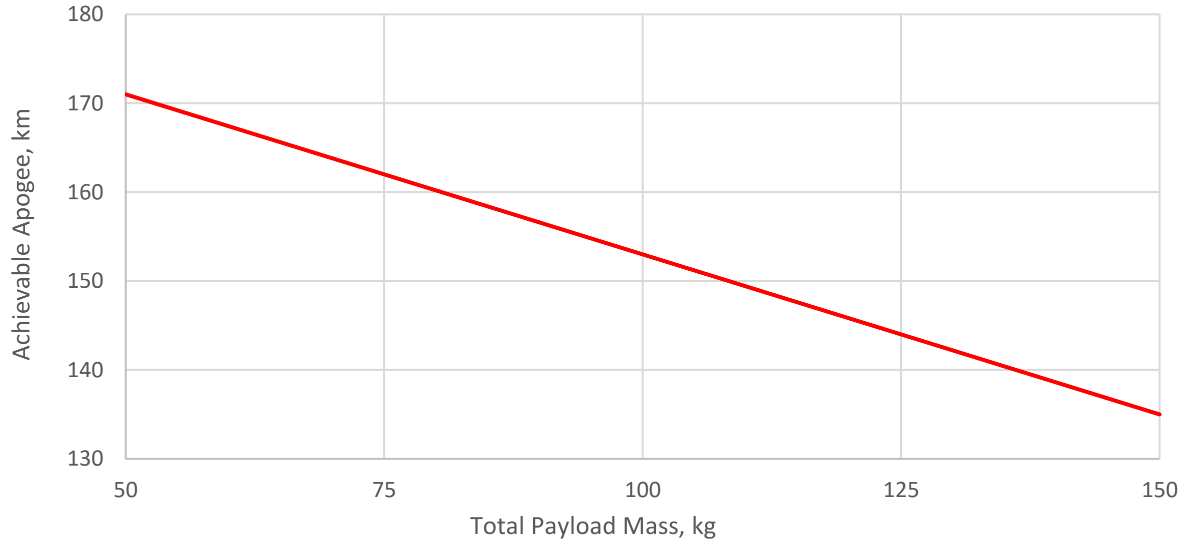


Figure 2-6 Achievable Altitude vs. Total Payload Mass

The estimated flight profiles (altitude vs. time) for payload masses of 50 kg, 100 kg and 150 kg are shown in Figure 2-7.

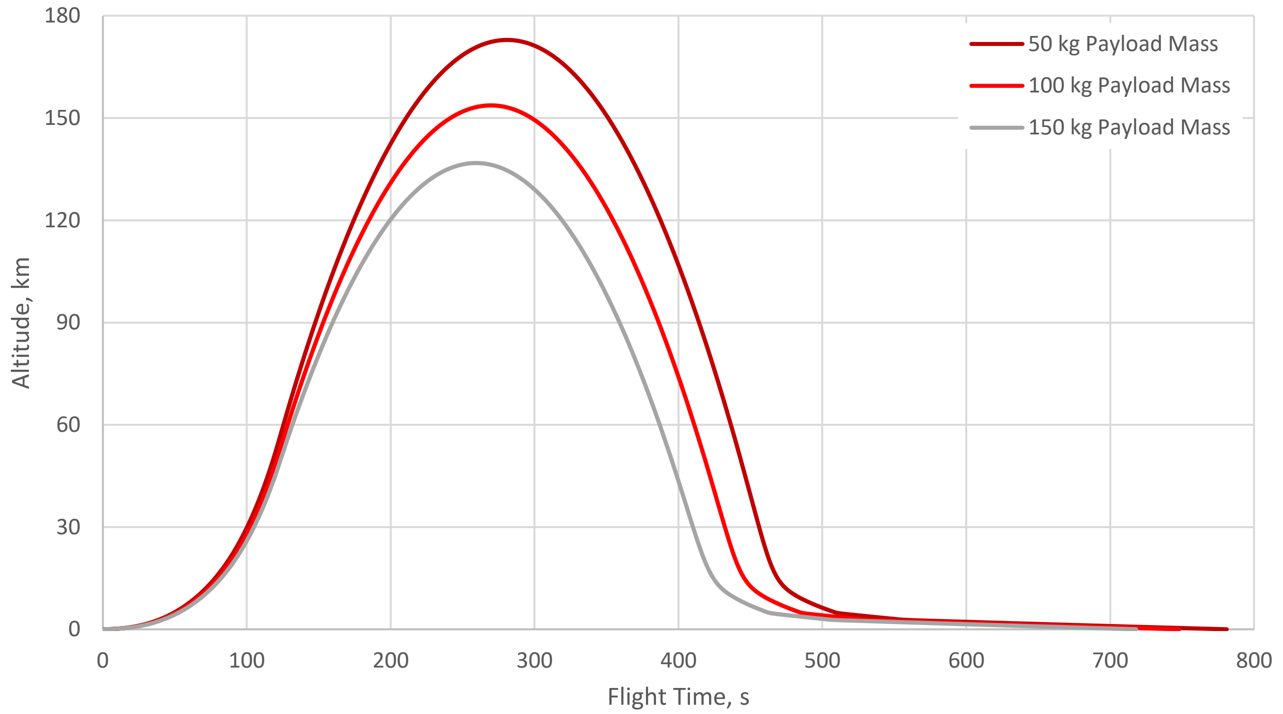
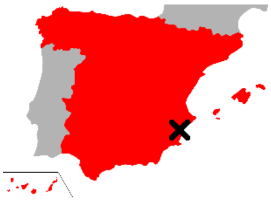


Figure 2-7 Altitude vs. Flight Time for varying Payload Mass

3. GROUND FACILITIES

3.1. HEADQUARTERS



The PLD Space headquarters are located in Elche, Spain (38°17'35.9"N, 0°37'26.5"W). All under one roof it houses the following areas:

- **Rocket Assembly Hall:** All subsystems of the MIURA 1 rocket are assembled in a specifically equipped rocket assembly hall, located in the ground floor of the PLD Space HQ. Also the payloads are integrated in this facility and parts of the payload acceptance testing is done here. A floor plan of the assembly hall is shown in Figure 3-3.
- **PLD Space Offices:** One floor above the rocket assembly hall, the majority of the PLD Space staff is located, performing their day to day duties.
- **Avionics Laboratory:** Equipped with all appliances needed for the integration and testing of the MIURA 1 avoinics system and other electronics.

Figure 3-1 PLD Space Headquarters

Figure 3-2 PLD Space Staff in the HQ Offices

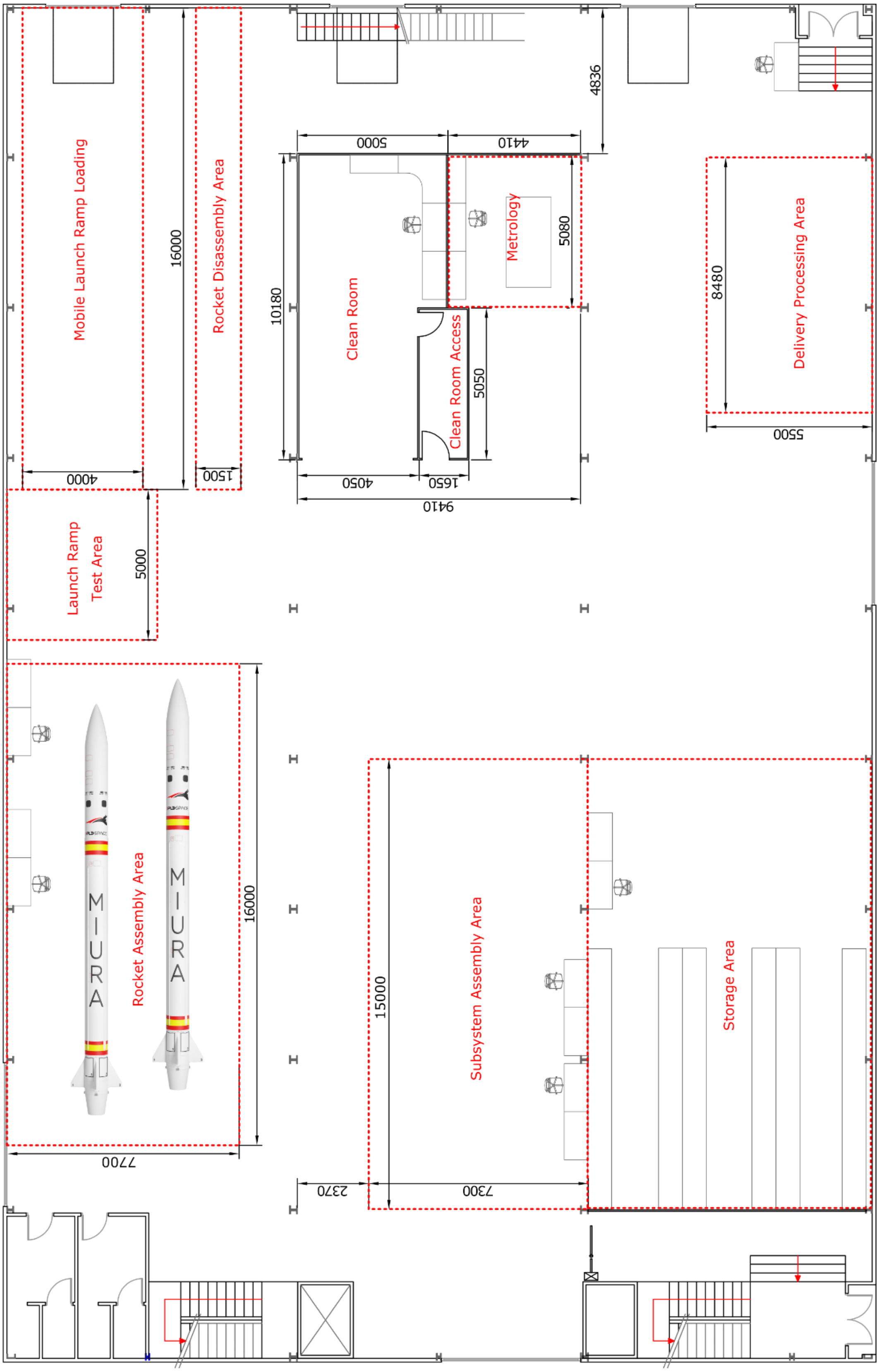


Figure 3-3 Floor Plan of the Rocket Assembly Hall inside the PLD Space HQ

3.2. MOBILE LAUNCH RAMP

A specialized mobile launch ramp, shown in Figure 3-4, is designed and built by PLD Space. This ramp combines several functions:

- **MIURA 1 transport:** After the MIURA 1 vehicle (without the payload bay) is assembled in the PLD Space HQ, it is loaded on the mobile launch ramp. The ramp is then used for the transport of MIURA 1 to the propulsion test facilities in Teruel and from there to the launch site. During these steps, the payload bay is not mounted on the remaining rocket systems. Instead, the payload bay is transported independently from the PLD Space HQ directly to the launch site.
- **Vertical Propulsion Test:** Before every flight, the MIURA 1 rocket is subject to a vertical propulsion test at the propulsion test facilities in Teruel, to confirm the proper functioning of the propulsive stage. For these tests, the launch ramp is utilized as test bench and equipped with necessary metrology.
- **Countdown & Launch:** After arriving at the launch site, the payload bay is mated with the remaining rocket systems already placed on the mobile launch ramp. The ramp is then used for the final testing and launch of MIURA 1.

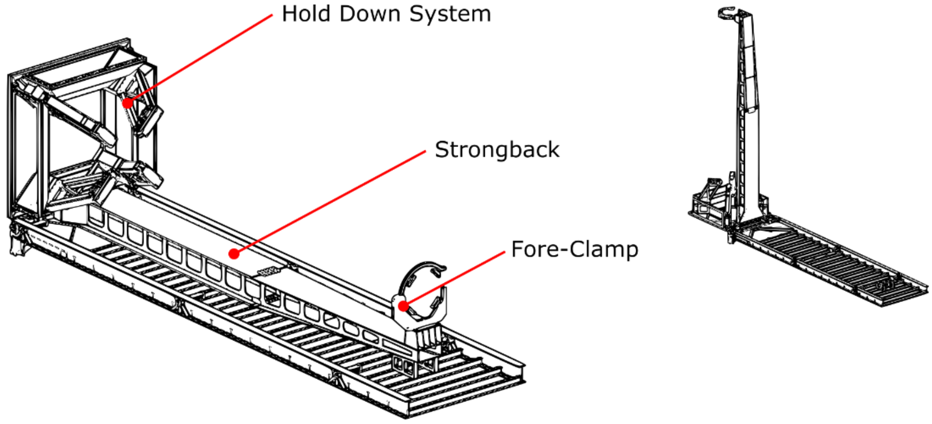
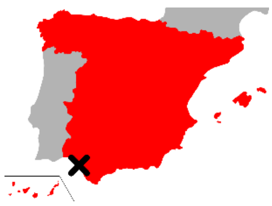


Figure 3-4 Mobile Launch Ramp (laid down and elevated)

3.3. LAUNCH SITE



MIURA 1 is launched from the historic El Arenosillo test range, located near Huelva in the south-west of Spain (37°05'59.96"N, 06°44'10.63"W). From this base over 550 sounding rockets have been launched to date. El Arenosillo is owned and managed by INTA (National Space Authority), an institution that belongs to the Spanish Minister of Defense. It has all the necessary equipment and facilities to support PLD Space's commercial launch operations. The following facilities are used by PLD Space during the campaign and flight of MIURA 1:

- **Instrumentation:** El Arenosillo is equipped with a net of sensors consisting of optronic systems, RADARs, IR cameras, telemetry and tracking systems. With this it is possible to track and link data between MIURA 1, instrumentation and ground equipment.
- **Mission Control Centre:** The El Arenosillo control center is used by PLD Space during the final testing and for performing the countdown and flight operations of MIURA 1. From a complementary payload operations room, it is possible to communicate with the payload during the countdown and to monitor payload telemetry during flight.

- **Meteorological Service:** The base has its own aeronautical meteo-information center, that is available 24 hours. Short and long weather forecasts can be performed, including high altitude conditions and jet streams.
- **Auxiliary Services:** Further facilities to support the launch operations are available. This includes e.g. offices, administration, access controls, medical services, fire equipment, generators and water supply.

In order to complete these facilities, PLD Space will build a dedicated launch complex for MIURA 1 on the premises of El Arenosillo. A concept of the planned MIURA 1 launch complex is shown in Figure 3-5. Inside this area all the facilities for preparing, fueling and launching MIURA 1 are placed:

- **Assembly Hall:** This hall is used for the final preparations of the payloads at the launch site, the mating of the payload bay to the remaining MIURA 1 rocket systems and final testing.
- **Launch Pad:** Here the mobile launch ramp is positioned for the countdown and launch of MIURA 1. The launch pad is equipped with all needed supply connections for supporting the ramp (e.g. power, communication lines, fueling lines).
- **Propellant and Inert Gas Storage:** Storage facilities for the used propellants and pressurized gases.
- **Water Deluge System:** A fire extinguishing system, that is used in case of emergencies.

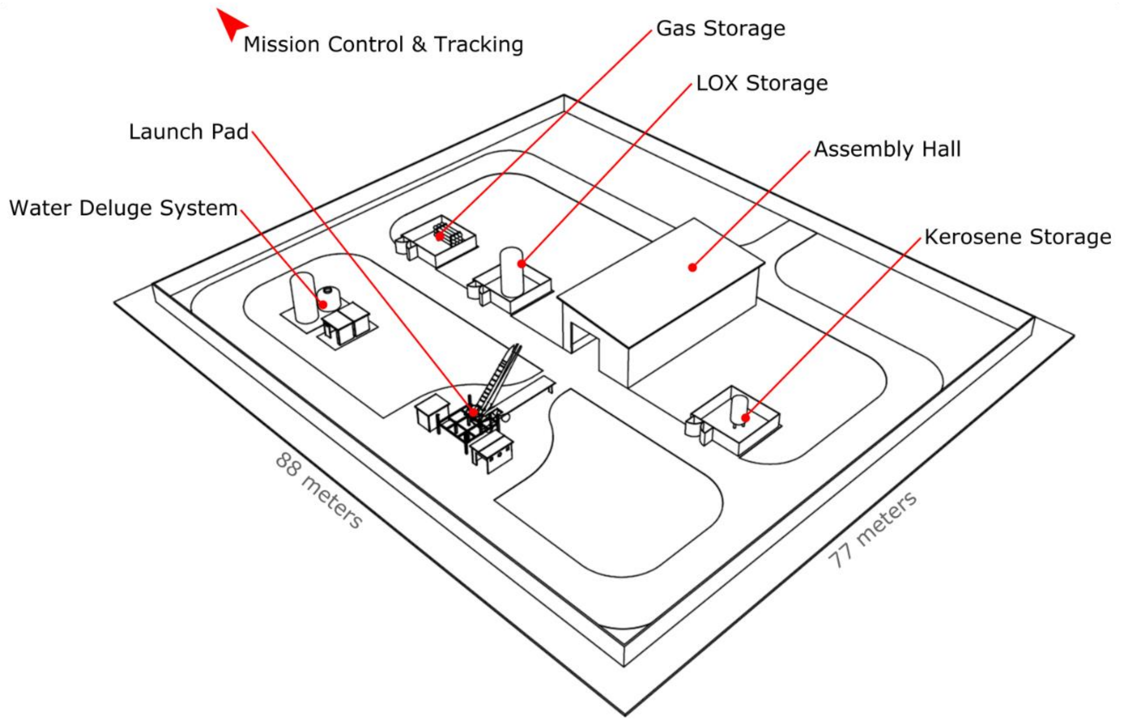


Figure 3-5 Draft concept of MIURA 1 Launch Complex

3.4. PROPULSION TEST FACILITIES

PLD Space owns and operates its own propulsion testing facilities located at the Teruel airport (40°24'49.3"N 1°14'25.0"W). An overview of the test site is shown in Figure 3-6. These facilities also include a vertical propulsion test stand, that is used to test each MIURA 1 propulsive stage before it is shipped to the launch site.

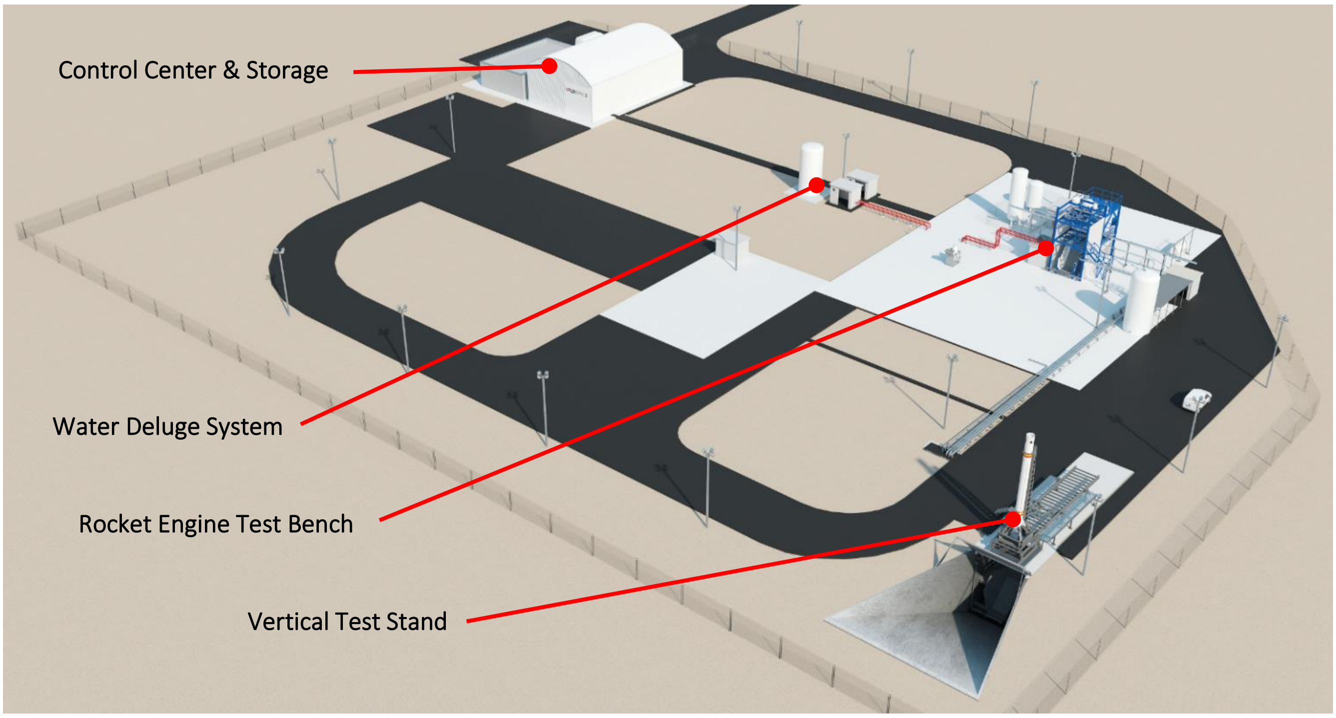


Figure 3-6 PLD Space's Propulsion Test Facilities

Figure 3-7 TEPREL Engine test at PLD Space's Propulsion Test Facilities in Teruel

4. MISSION TIMELINE

4.1. OVERVIEW

For a nominal MIURA 1 flight, the time between the flight ticket procurement and flight is one year, as shown in the mission timeline in Figure 4-1. If a different lead time is required by the user, it is possible to adapt this timeline. In this case, please contact PLD Space for further details.

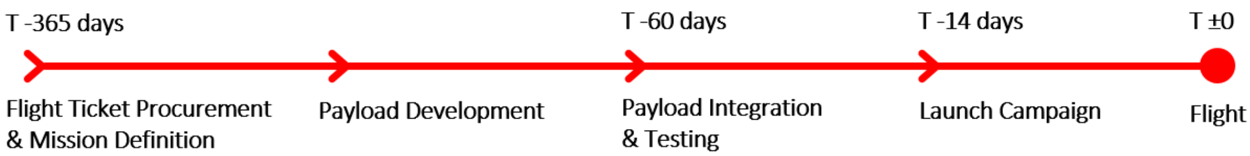


Figure 4-1 Nominal MIURA 1 Mission Timeline

4.2. FLIGHT TICKET PROCUREMENT

Payload Booking Request: Booking a payload compartment on MIURA 1 is done in two simple steps:

- **Register Interest:** Either by using a form on the PLD Space website or by contacting PLD Space directly, it is possible to register interest in an MIURA 1 flight and get access to the payload questionnaire.
- **Payload Questionnaire:** In order to successfully complete a booking request, a payload questionnaire has to be filled in and submitted to PLD Space. In this questionnaire, basic information about the planned payload has to be provided. This includes e.g. a payload description, flight requirements and a preferred launch date.

T -400 days: **Preliminary Mission Assignment:** PLD Space reviews the information provided in the payload questionnaire to assess if the proposed payload is applicable for an MIURA 1 flight. Also, possible interferences between individual payloads are analyzed, to exclude unwanted disturbances on a shared flight. If necessary, further information is requested to clear any doubts. Finally, PLD Space assigns a preliminary mission and launch date matching with customer requirements.

T -365 days: **Mission Definition Review:** After agreeing with the assigned mission, the customers sharing the same flight meet at the PLD Space HQ where the main characteristics of the mission are confirmed. The review is concluded by signature of the launch contract.

4.3. PAYLOAD DEVELOPMENT

T -365 days: **PLD Space Support:** At the beginning of the payload development phase, a PLD Space Payload Engineer is assigned, acting as key contact point between the customer and PLD Space in all questions regarding the payload interfaces, correct documentation, scheduling of events and other points that might arise during the development. Additionally, PLD Space provides templates and guidelines for the required payload documentation. An overview of the required documentation is shown in Figure 4-2.

T- 300 days: **Preliminary Design Review:** The first issue of the Payload Data Package (PDP) has to be handed in by the customer. PLD Space will perform a review of the documentation and follow up on potential arising issues. The PDP is a single document, containing the following information about the payload:

- **Payload Description:** Includes information about the payload's purpose and functions, as well as an explanation of the overall payload design and the performed operations during the countdown and flight.
- **Payload Interface Control:** Documents the design of the payload interfaces, to make sure the payload is compliant with the interfaces described in the Payload User's guide (PUG).
- **Payload Safety Data Package:** Lists all hazards and safety risks resulting from the payload during ground operations and flight.
- **Payload Campaign Requirements:** Lists needed facilities, necessary procedures and materials, allowed boundary conditions and other requirements for the launch campaign and flight.
- **Payload Integration Plan:** Describes the necessary integration procedures and correct handling of the payload. Explains which facilities need to be used and which materials are needed for the proper integration and acceptance testing of the payload at the PLD Space headquarters.
- **Payload Verification Results:** Documentation verifying that payload complies with test requirements specified by PLD Space.
- **CAD Model:** Used by PLD Space to do a virtual fit check and a preliminary determination of mass properties for evaluating vehicle flight dynamics and performance.

With the provided information, PLD Space will issue a first version of the Interface Control Document and update the Mission Plan, a document summarizing campaign and flight requirements of all payloads as well as describing the overall campaign schedule and foreseen flight performance. PLD Space will also start the launch range safety process.

T -215 days: **Critical Design Review:** A second iteration of the PDP is due. PLD Space will review the provided documentation, follow up on arising issues, update the Mission Plan and Interface Control Document and close the launch range safety process.

T -90 days: **Final Payload Documentation:** The customer is responsible to hand in the final version of the PDP with final updates prior commencing the payload integration at the PLD Space headquarters.

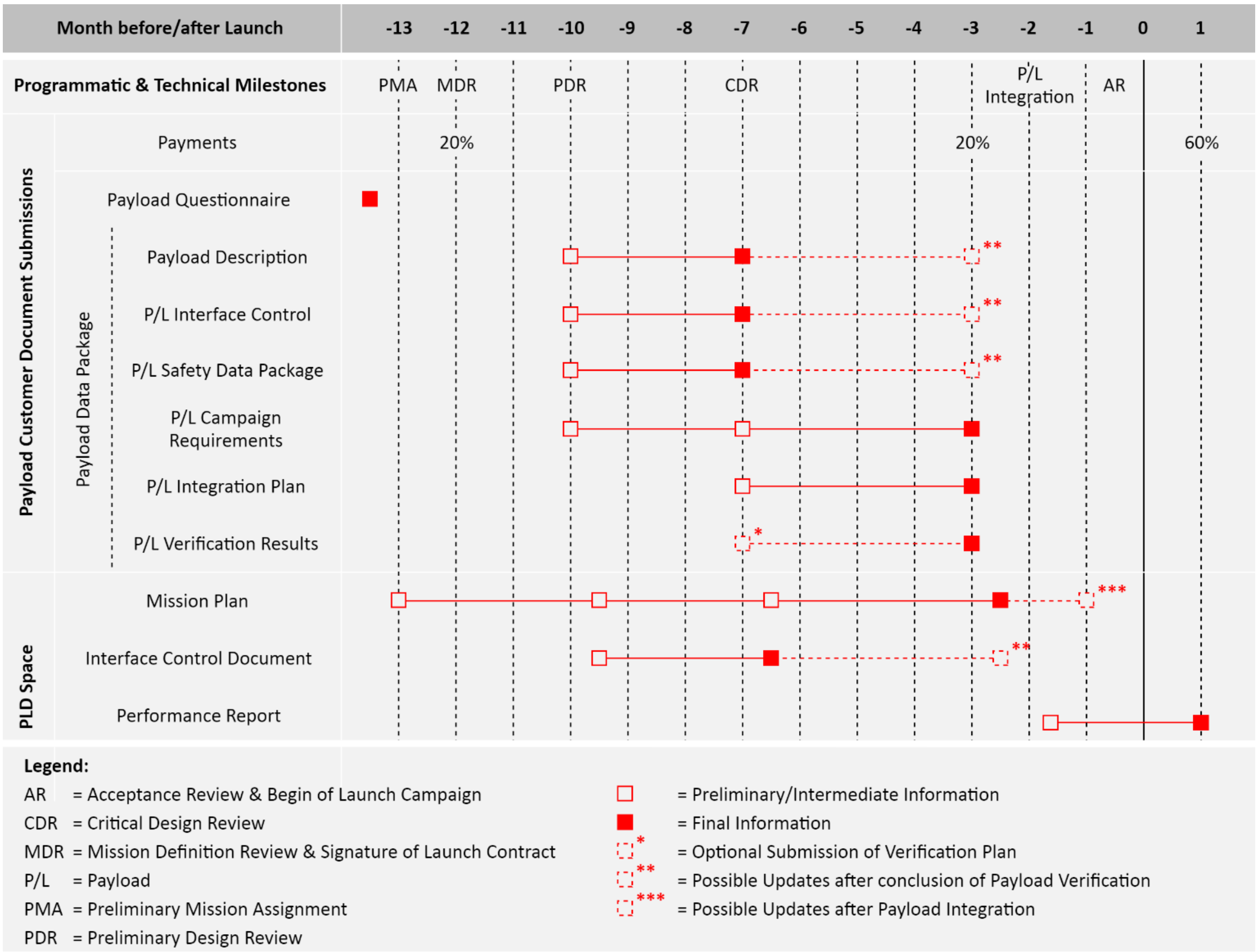
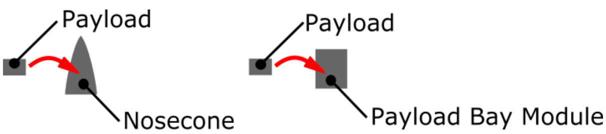


Figure 4-2 Payload Documentation Due Dates

4.4. PAYLOAD INTEGRATION AND TESTING

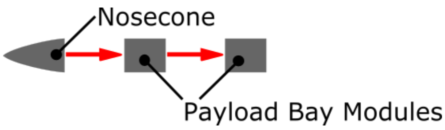
Once the payload has been delivered to PLD Space's HQ, the final integration into the payload bay and acceptance testing is performed. The main steps in this progress are:

T -60 days: **Payload Integration:** Upon arrival of the payload, the customer is responsible to perform an inspection to exclude transportation damage and approve the payload for integration. Afterwards, the customer, supervised by PLD Space, integrates the payload into the assigned compartment within the payload bay. During and after the integration PLD Space engineers perform a visual inspection of the payload.



T -55 days: **Individual Acceptance Testing:** Each payload is subject to individual functional and acceptance tests organized by PLD Space. During these tests, also the mechanical and electrical properties (mass, center of gravity, power consumption, data rates) are checked to comply with the allowed limits.

T -21 days: **Combined Acceptance Testing:** All payloads are tested together in a simulated countdown and flight, in order to rule out unexpected interferences. After successful testing, the payload bay is closed and prepared for the launch campaign. From this point on, modifications of the payloads are only possible with prior approval from PLD Space and users sharing the flight.

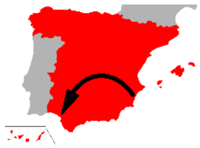


T -14 days: **Acceptance Review:** To conclude the payload integration and testing at PLD Space, an Acceptance Review is held with all users sharing the flight. The purpose is to confirm that all payloads are free of workmanship errors and are ready to be delivered to the launch site for the launch campaign.

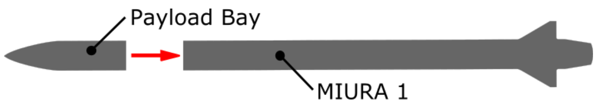
4.5. LAUNCH CAMPAIGN & FLIGHT

The main steps during the MIURA 1 launch campaign are:

T -14 days: **Transport to Huelva:** PLD Space takes care of the shipment of the payload bay from the PLD Space HQ to the launch site. Independent from the remaining rocket systems, the payload bay is transported fully assembled inside a specially equipped cargo van.



T -10 days: **Vehicle Mating:** The payload bay is brought into the assembly hall, where it is mated together with the remaining rocket systems on the mobile launch ramp. Afterwards MIURA 1 and the payloads undergo a final functional test, to rule out damage due to transport and faults during the mating process.



T -1 day: **Roll Out:** The mobile launch ramp holding the completely integrated MIURA 1 rocket is brought from the assembly hall to the launch pad and connected to auxiliary launch systems (e.g. power & C&DH umbilicals, fueling lines).

T -1 day: **Final Countdown Rehearsal:** A complete count down and flight is simulated. This includes all actions that also are performed during the hot countdown. Only the fueling of the rocket and ignition of the motor are not performed.

T -1 day: **Flight Readiness Review:** This review is held with all parties involved in the launch operations. The purpose is to confirm that flight and ground segments are finished with preparations for the launch and ready for the hot countdown.

T -5 hours: **Launch Readiness Review:** This review is held just prior to the start of the countdown. Its objective is to declare the readiness for launch of the flight and ground segments and to take the decision to start the hot countdown.

T -4 hours: **Hot Countdown:** The nominal countdown procedure for MIURA 1 lasts for 4 hours. In Table 4-1 the main steps that are carried out during the countdown are listed. As each mission is composed of different payloads, the countdown procedure is adapted as much as possible to the payload needs (e.g. late access times, switching of power).

During the countdown it is possible to perform a **late access** operation. The late access is intended to perform final payload preparations, e.g. the installation of test samples for flight. The late access can be fit into the countdown according to the needs of the customer at any time before the beginning of the pressurization of the helium tank (T -2.5 hours).

Event	Time, T±h:min:sec
Start of Countdown	T-4:00:00
MIURA 1 is elevated	T-3:00:00
Last possibility for late access	T-2:45:00
Pad checkout and area safing	T-2:30:00
Helium tank pressurization	T-2:30:00
Propellant loading	T-0:45:00
Payload power on	T-0:10:00
Payload switch to internal power	T-0:03:00
Payload Go/No-Go decision	T-0:02:00
Launch Ramp Fore-Clamp released	
Launch Ramp Strongback retracted	
Umbilical disconnected	
Engine ignition	T-0:00:02
Hold Down System released and Lift-off	T±0:00:00

Table 4-1 MIURA 1 Main Countdown Events

T ±0: **Lift-Off & Flight:** An exemplary flight trajectory of MIURA 1 is shown in Figure 4-4. Table 4-2 lists the main events occurring during the flight. Launched from El Arenosillo, MIURA 1 flies in south-western direction. Shortly after lift-off, it starts to perform a first pitch maneuver to increase the downrange to the launch site. This maneuver uses the TVC of the main engine and ends shortly before the main engine cut-off (MECO).

After the MECO, MIURA 1 follows a ballistic trajectory reaching an apogee of about 150 km before heading back to earth. During this time, a second pitch maneuver is performed to align MIURA 1 nose down for the reentry, as shown in Figure 4-3. An internal logic performs two main RCS actuations at the beginning and end of the maneuver and minimizes the control during the microgravity phase as much as possible.

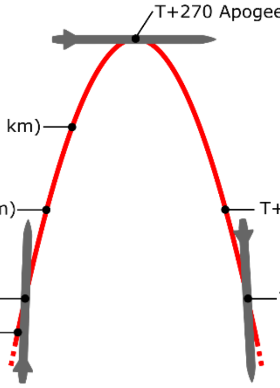


Figure 4-3 MIURA 1 Ballistic Flight Phase

During reentry, parachutes brake down MIURA 1, before it finally splashes down in the Gulf of Cádiz in the Atlantic Ocean at a downrange of approximately 40 km. The total flight lasts for about 12.5 minutes.

Event	Time*, T±sec	Altitude*, km
Engine ignition	T-2	0
Lift-off	T±0	0
Begin of downrange pitch maneuver	T+15	0.4
MECO	T+122	51
Begin of alignment pitch maneuver	T+127	58
Begin of microgravity	T+145	80
Space conditions (100 km)	T+163	100
Apogee	T+270	153
End of microgravity	T+396	80
End of alignment pitch maneuver	T+412	58
Drogue parachutes open	T+484	5
Main parachutes open	T+526	3
Splashdown	T+750	0
* Estimations for a payload mass of 100 kg.		

Table 4-2 MIURA 1 Flight Events

Figure 4-4 MIURA 1 Trajectory when launched from El Arenosillo

T +13 minutes: **MIURA 1 Recovery:** After splashdown, the complete MIURA 1 rocket is picked up by ship and brought back to El Arenosillo. There the vehicle is examined and disassembled by PLD Space personnel. After the PLB has been separated, the customers get access to their compartment for dismounting their payload. The timeline for the recovery operations is shown in Table 4-3.

Event	Time, T±h:min:sec
Recovery ships reach MIURA 1	T+0:30:00
MIURA 1 loaded on recovery ship	T+1:30:00
MIURA 1 returned to El Arenosillo	T+4:30:00
PLB clear for customer access	T+5:30:00

Table 4-3 MIURA 1 Recovery Timeline

T +1 day: **Mission Closeout Review:** To conclude the launch campaign, a mission closeout review is performed. Here, all involved parties summarize the performance of their systems or payloads.

T +30 days: **Mission Performance Report:** After the flight campaign, PLD Space creates and distributes this report. It summarizes the mission including information about the flight performance of MIURA 1 and the recovery operations. Furthermore, this report is complemented by the complete set of housekeeping data obtained during the flight.

5. PAYLOAD INTERFACES

5.1. DEFINITIONS

5.1.1. Dimensions and Tolerances

Unless specified otherwise, all linear dimensions are in millimeters (mm) and all angular dimensions are in degrees (°).

5.1.2. Coordinate Frame

The coordinate frame used for MIURA 1 is shown in Figure 5-1. Its origin lies on the center of the thrust frame, on the plane where the rocket engine is attached. The axes form a right-handed orthogonal system, with the x-axis pointing along the rocket and is coinciding with the rocket's rotational axis and the z-axis (90° position) pointing towards the impact point of the flight and away from the Strongback during the launch procedure.

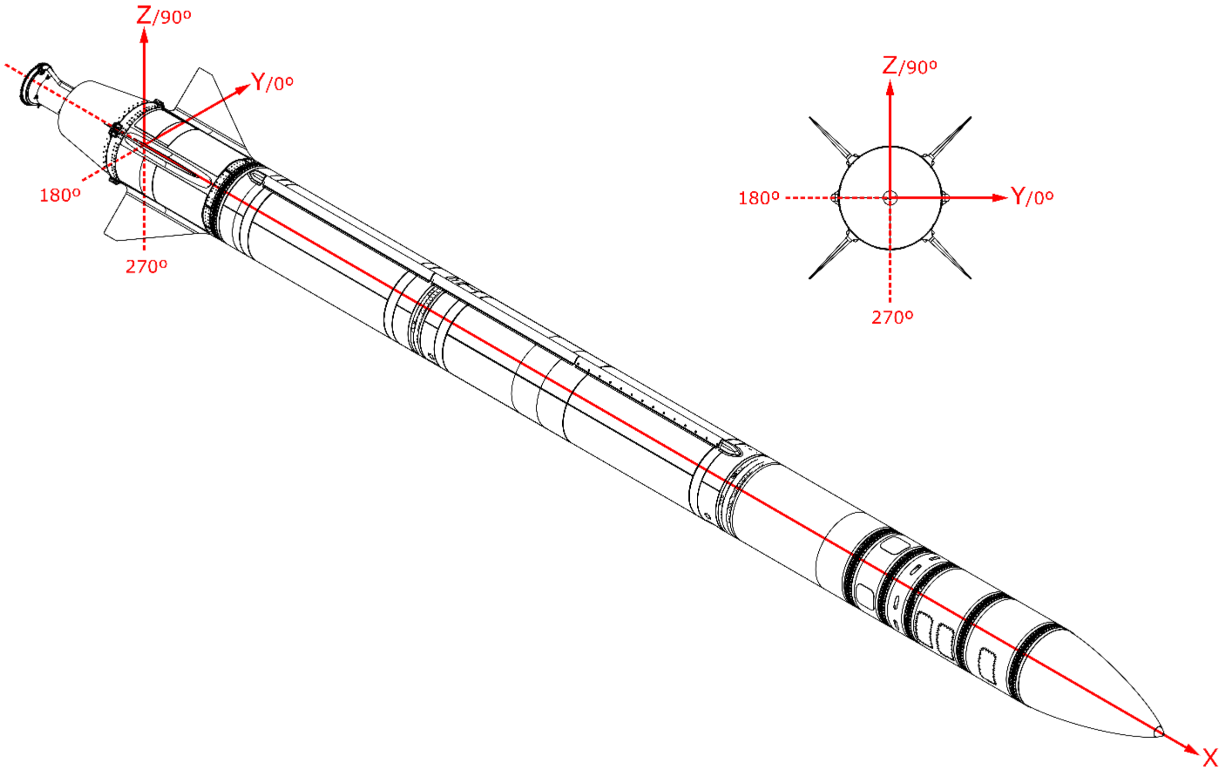


Figure 5-1 MIURA 1 structure coordinate frame

5.2. MECHANICAL INTERFACE

5.2.1. Payload Mass

The maximum allowed integrated payload mass for a single and double module is listed in Table 5-1. This mass is completely useable by the customer. The masses of the bulkhead and module structure do not have to be considered within this allowed budget.

Compartment Size	Maximum Payload Mass, kg
Single	25
Double	50

Table 5-1 Maximum payload mass single and double compartments

5.2.2. Payload Envelope

The available volume inside the single compartment, double compartment and the nosecone are shown in Figure 5-2 and Figure 5-3. A cable tunnel and electrical connectors are placed at the 0° position. If possible, payloads should not intersect with this area.

The distribution of single and double compartments can be adapted individually for each flight, depending on the mission composition and the volume demands of the customer(s). Also, the combination of two or more compartments to form a triple or quadruple compartment is possible.

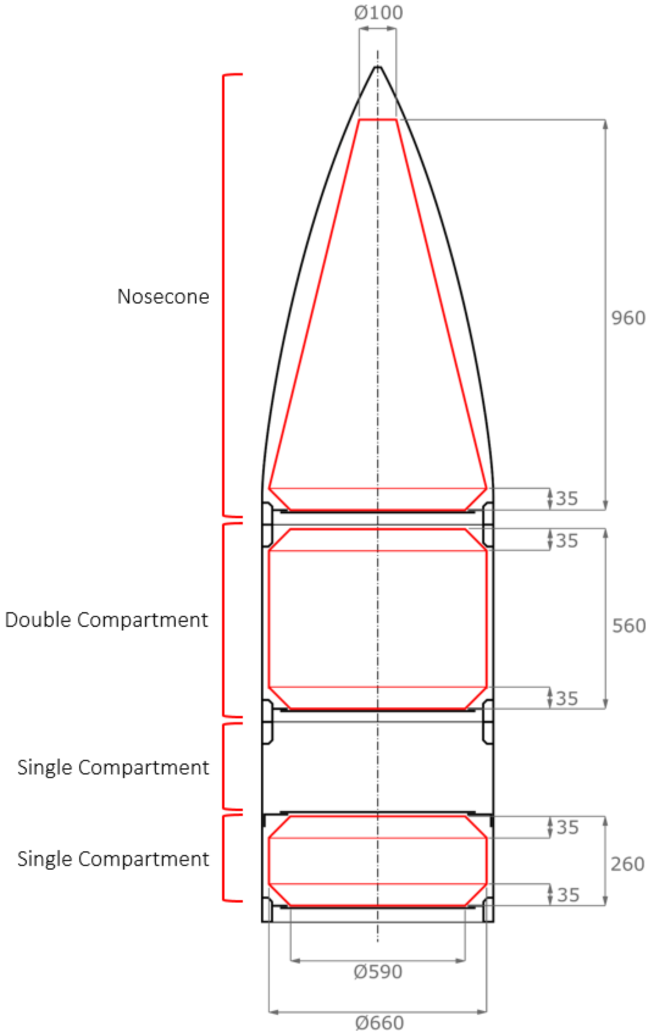


Figure 5-2 Payload Envelope - Side View

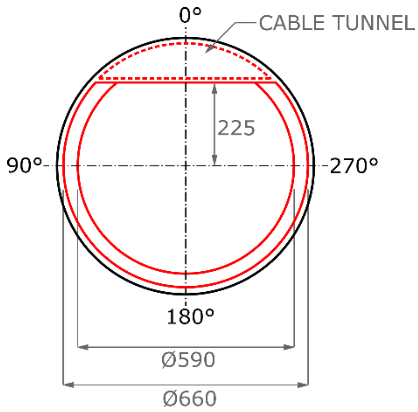


Figure 5-3 Payload Envelope - Top View

5.2.3. Payload Mounting

For mounting the payloads into the payload bay, an isogrid pattern of M5 threads is machined into the bulkheads separating the individual compartments from each other. The dimensions of this isogrid pattern are shown in Figure 5-4.

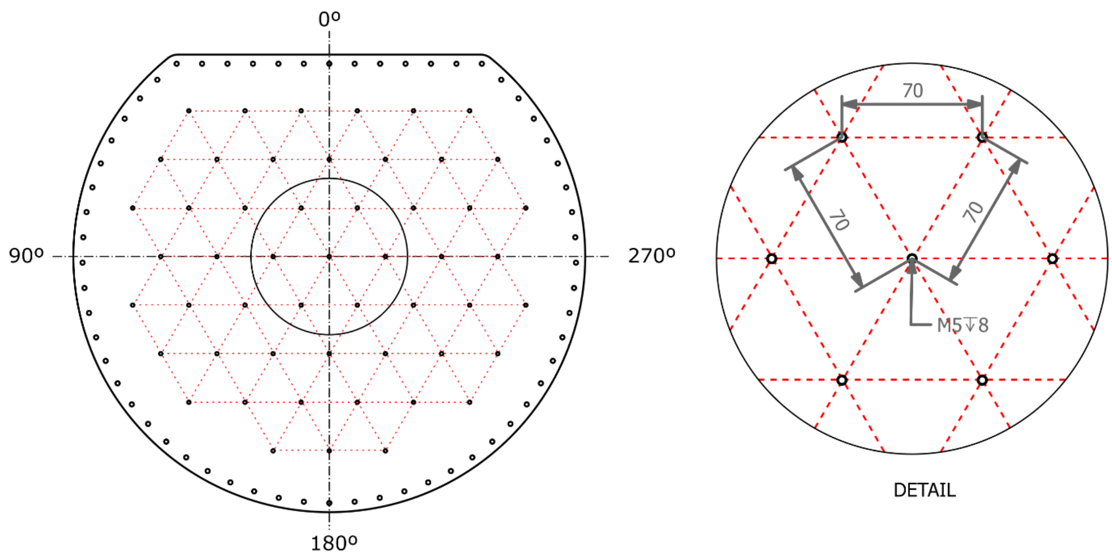


Figure 5-4 Dimensions of the isogrid pattern machined in the payload bay bulkheads

5.2.4. Payload Compartment Access

5.2.4.1. Bulkhead Fitting Clearance

On the bottom of each payload compartment, there is a fitting for mounting the bulkhead. In the lower single compartment and the double compartment, the bulkheads are installed to this fitting from below. The bulkhead of the upper single compartment is fitted from above. The dimensions of the fitting clearance are shown in Figure 5-5.

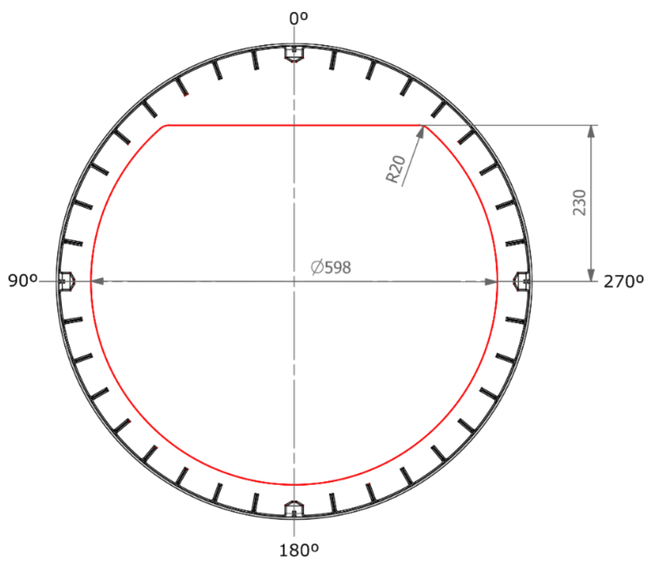


Figure 5-5 Bulkhead Fitting Clearance Dimensions

5.2.4.2. Hatch Dimensions

For easier access during integration and to enable late access operations during the countdown, each payload compartment is equipped with two hatches. Their dimensions and positions are shown in Figure 5-6.

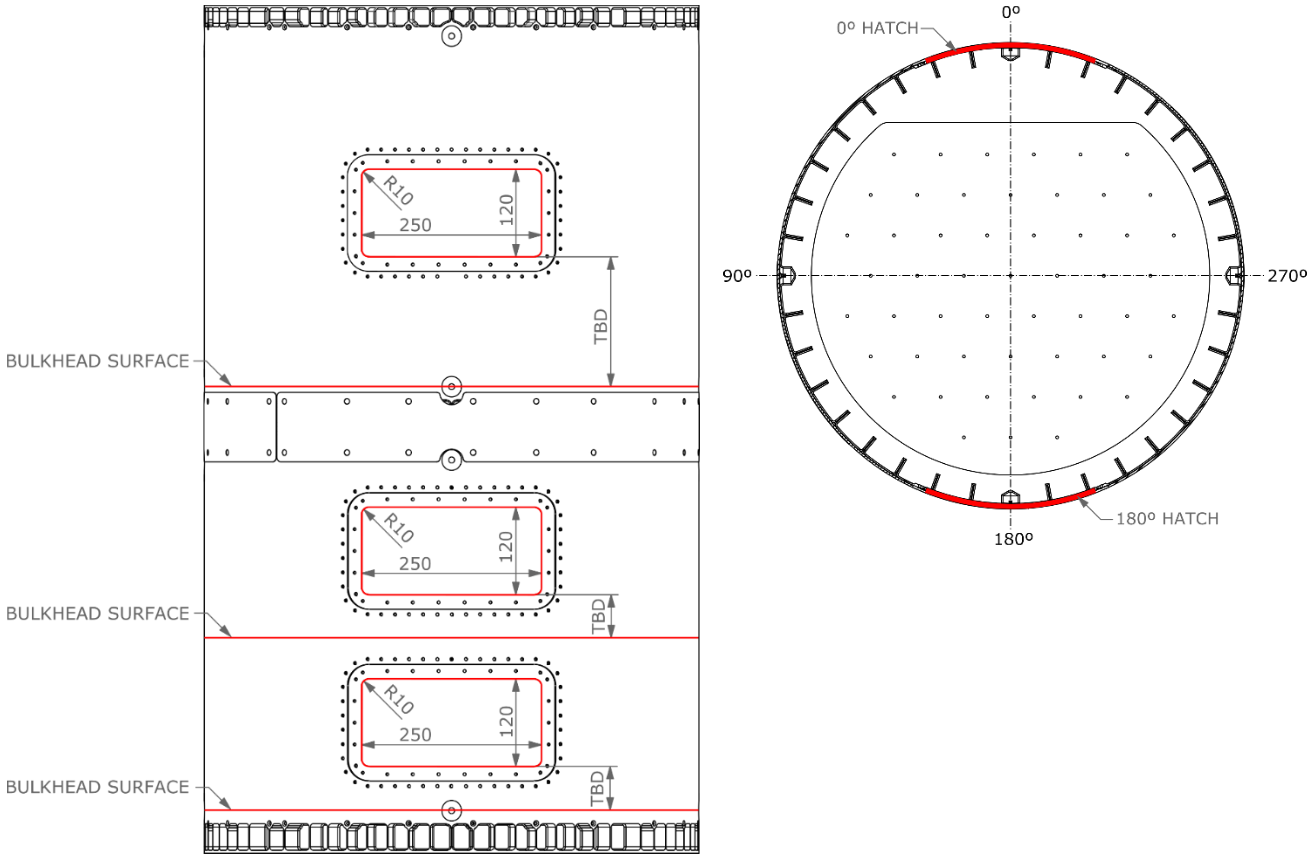


Figure 5-6 Payload Bay Hatch Dimensions and Position.

5.3. ELECTRICAL INTERFACE

5.3.1. Power Supply

5.3.1.1. Power Supply Characteristics

The payload power supply provides a voltage of 28 V DC to the payloads. Per power connector a maximum continuous current of 10 A is available, while MIURA 1 is connected to external power.

While the payload is connected to external power, it is possible to manually switch the power supply (on/off), if required.

On external power, it is also possible to charge additional payload batteries for the flight. If such batteries are needed, consult with PLD Space. It is advised to make use of the available on-board power as good as possible, before including additional batteries.

During the switch from external to internal battery power the payloads might experience a voltage step. Once the payloads are supported by the on-board batteries, the nominal voltage stays at 28 V DC, but may vary depending on the batteries temperature and charge condition.

The maximum current that can be drawn from the on-board batteries and the available capacity is shown in Table 5-2.

Compartment Size	Maximum Continuous Discharge Current, A	Battery Capacity, Ah
Single	10	1
Double	2 x 10	2

Table 5-2 Payload Power Supply – On-board Battery Current Limits and Capacity

5.3.1.2. Power Connector

Each single compartment is equipped with one power connector, each double compartment is equipped with two power connectors. The connectors are placed on the end of a free cable of 700 mm length, originating from the cable tunnel area indicated in Figure 5-3.

5.3.2. Command & Data Handling

5.3.2.1. C&DH System Overview

For realizing the payload C&DH, a point to point Ethernet connection is established between each payload and the PLC in the avionics system. Over this connection it is possible to control the payload, send telemetry data to the ground station and store data on an additional mass storage inside the PLC.

5.3.2.2. Payload Control

To control the payload during the countdown and flight, the PLC sends status messages via the Ethernet connection. These messages give information about the current countdown or flight phase and contain a timer starting at lift off.

During the countdown, as long as the umbilical is connected to MIURA 1, a transparent Ethernet connection between ground station and payload is available. This can be used to send custom telecommands to the payload. The TCP or UDP protocol can be used for these telecommands.

5.3.2.3. Payload Telemetry and Data Storage

Each payload is assigned four logical ports, that can freely be allocated either to send data to ground (as telemetry) or to store data on the mass memory in the PLC. In both cases, either TCP or UDP protocol can be used to send the data to the PLC.

Telemetry data is sent to the ground station via a transparent connection.

The characteristics of the on-board data storage are shown in Table 5-3.

Compartment Size	Available Storage Space, GB	Maximum Data Rate, MB/s
Single	16	5
Double	32	10

Table 5-3 On-Board Data Storage Characteristics

5.3.2.4. C&DH Connector

Each payload compartment is equipped with one connector for realizing the Ethernet connection between the payload and the PLC. The connector is placed on the end of a free cable of 700 mm length, originating from the cable tunnel area indicated in Figure 5-3.

6. PAYLOAD EVNIRONMENTAL CONDITIONS

6.1. ATMOSPHERIC CONDITIONS

6.1.1. Payload Bay

The payload compartments are separately sealed airtight. This is done to protect the payload from damages due to the sea air at the launch site (see section 6.1.2) and from sea water after splashdown.

The payload compartments are filled with 99.9% gaseous nitrogen once the payloads are sealed. The use of other gases is possible and must be requested with PLD Space. As the payload compartments are sealed independently from each other, each customer can decide when the associated compartment is sealed and filled with nitrogen. The earliest possibility is right after the payload has been integrated into the payload bay, so the payloads can already be tested under nitrogen environment. The latest possibility for sealing the payload compartment is after all payloads passed the combined acceptance testing and the complete payload bay is prepared for its transport to the launch site.

For the transport, the payload compartments stay closed and filled with nitrogen. While at the launch site, PLD Space recommends limiting the time the payload compartments need to be opened (e.g. late access) as much as possible to prevent the corrosive ambient air from entering.

6.1.2. Launch Site

The relative humidity at the El Arenosillo varies between 50% (Jul) and 80% (Dec). The average values throughout the year are shown in Figure 6-1. Due to the launch sites proximity to the Atlantic Ocean, resulting in a high airborne salinity, a high atmospheric corrosion (concurrent to corrosion class C4 according to ISO 12944-2) should be expected.

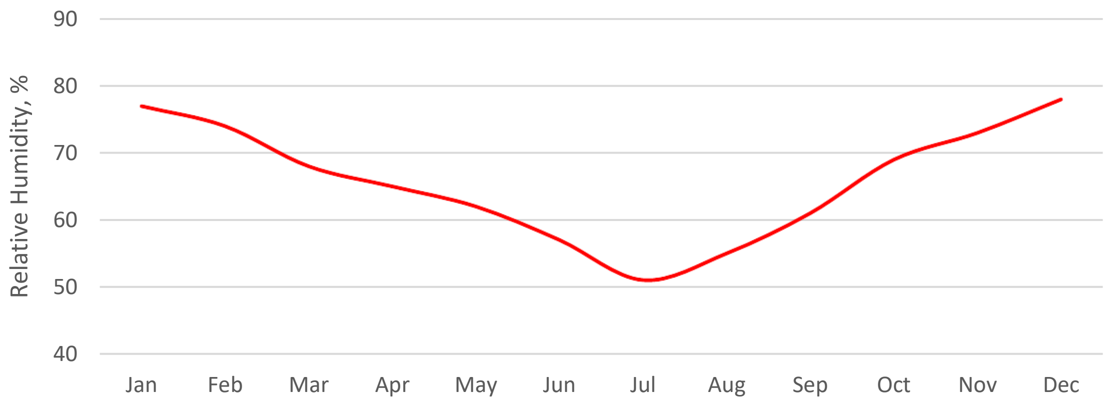


Figure 6-1 Average values for the relative humidity in El Arenosillo throughout the year [1]

6.2. THERMAL ENVIRONMENT

6.2.1. Pre-Flight

6.2.1.1. Payload Integration and Testing

The integration and final testing of the payloads is performed at the PLD Space Headquarters. The temperature inside the integration hall and test facilities can vary from 20°C to 35 °C. Additional heating or cooling can be provided in coordination with PLD Space.

6.2.1.2. Payload Transport

During the transport from the PLD Space Headquarters to the launch site, the temperatures inside the cargo van varies between 15 °C and 30 °C, depending on the time of the year. The transport is usually realized in less than a day.

6.2.1.3. Launch Preparations

For the final launch preparations, the MIURA 1 rocket is kept inside the preparation hall at El Arenosillo as long as possible in order to avoid the rocket heating up too much due to possible high outdoor temperatures. The temperature inside the preparation hall can vary from 20°C to 35 °C.

The record outdoor temperatures measured in El Arenosillo range between -5 °C (Jan) and + 45 °C (Jul). Average temperatures throughout the year are shown in Figure 6-2. After prolonged periods in the sun, the temperature inside the payload bay can reach up to 30 °C above these ambient conditions.

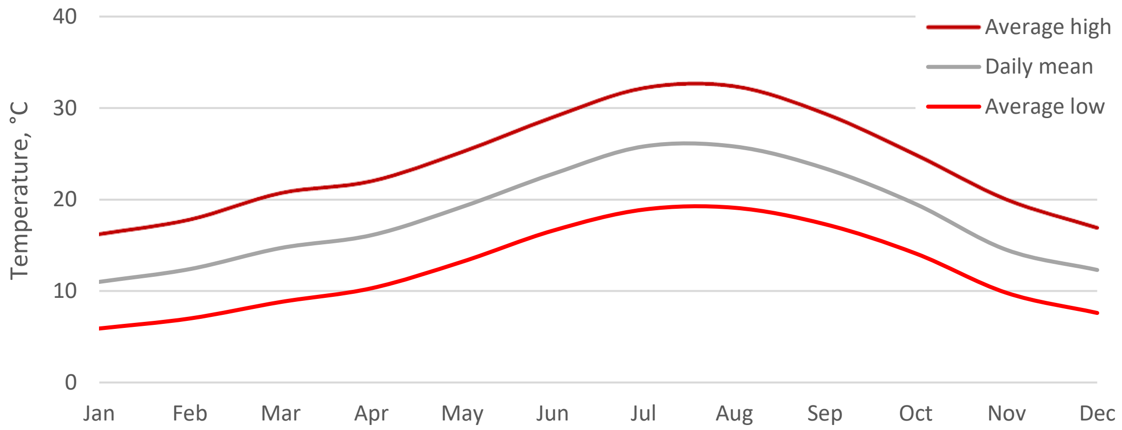


Figure 6-2 Average outdoor temperatures in El Arenosillo throughout the year [1]

Inside the preparation hall as well as on the launch pad, additional heating or cooling can be provided in coordination with PLD Space.

6.2.2. Flight

During the flight, the temperature inside the payload bay increases as the rocket skin heats up due to air friction. The highest temperatures are expected during the reentry phase. Figure 6-3 shows simulation results of the expected temperature on the inner skin of the payload bay.

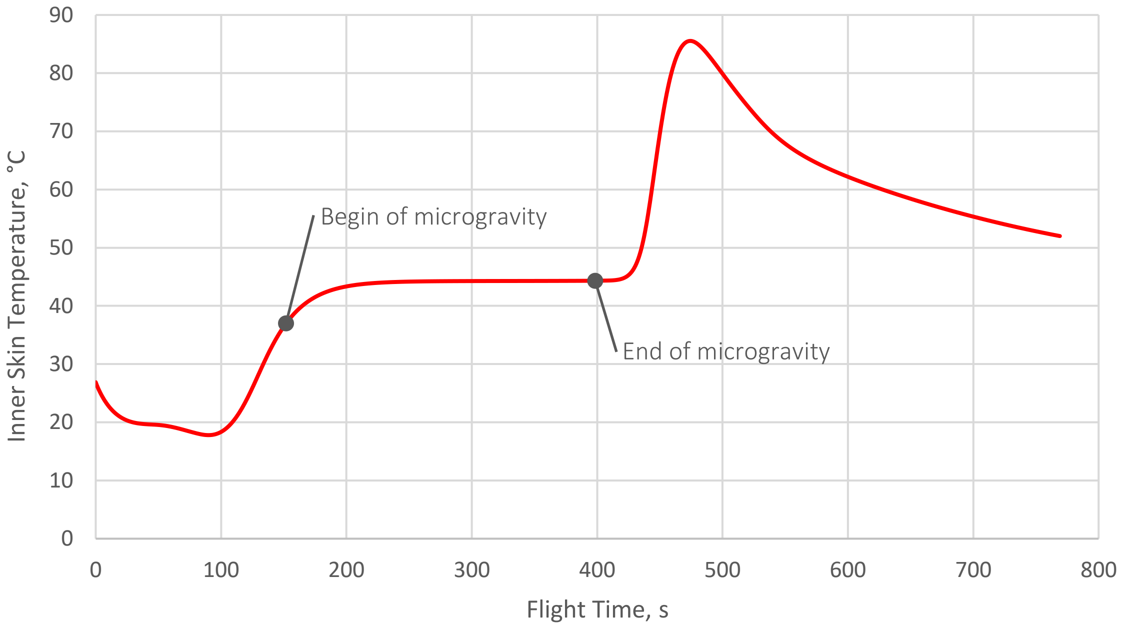


Figure 6-3 Simulation results of the MIURA 1 payload bay inner skin temperature vs. flight time

6.2.3. Post-Flight

The sea temperature in the downrange area in the Gulf of Cádiz varies between 14 °C (Mar) and 25 °C (Aug). Figure 6-4 shows the average sea temperatures throughout the year. After splashdown, MIURA 1 cools down and the temperature inside the payload bay approaches the sea temperature level.

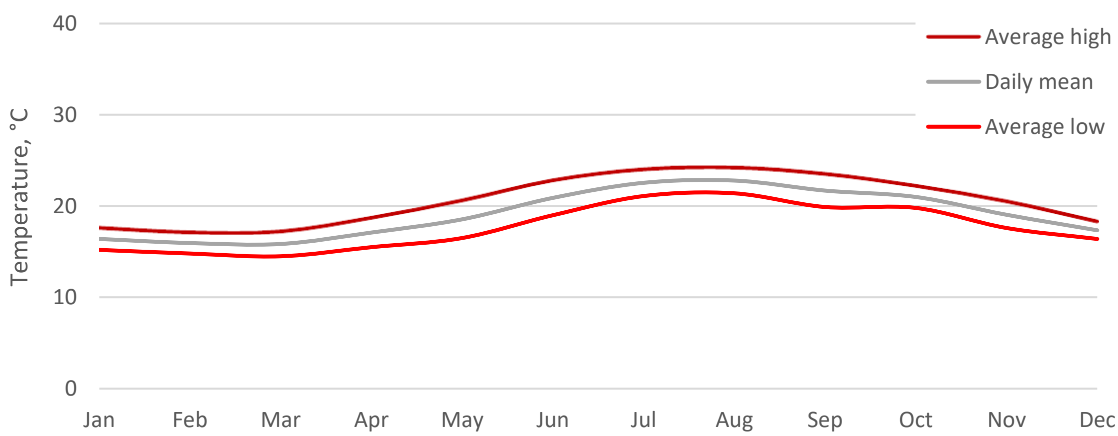


Figure 6-4 Average sea temperatures in the downrange area throughout the year [2]

6.3. MECHANICAL LOADS

6.3.1. Pre-Flight

6.3.1.1. Random Vibrations

For the transport from the PLD Space Headquarters to the launch site, the payloads are exposed to random vibrations. The vibration profile is in line with MIL-STD-810G - Environmental Engineering Considerations and Laboratory Tests [3] for a truck transportation over US highways. The exposure levels are shown in Figure 6-5 and Table 6-1, more details can be found in the referred standard.

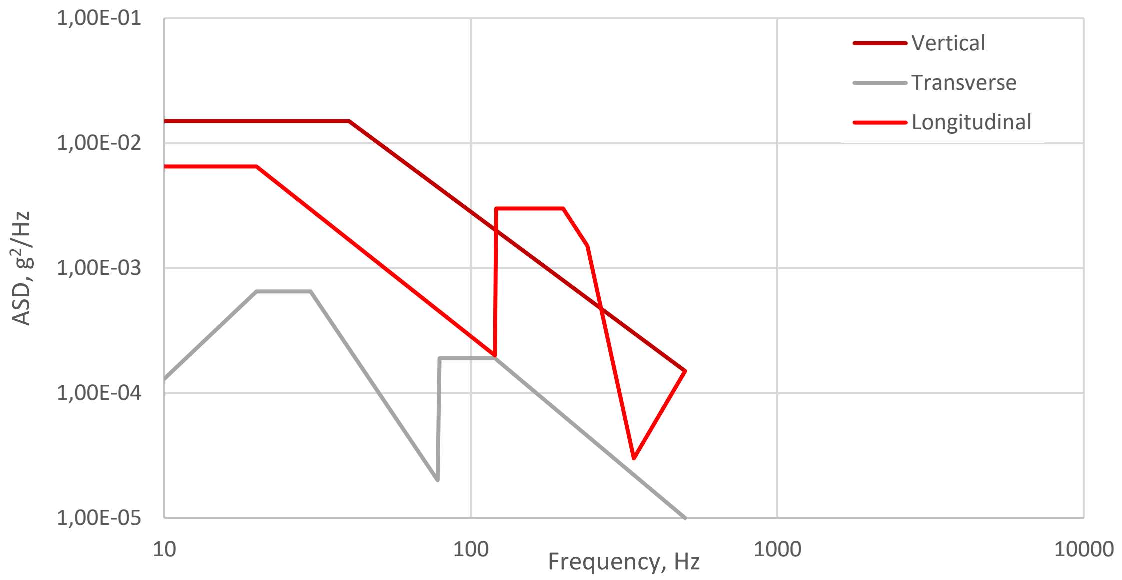


Figure 6-5 Vibration profile during transport, according to [4] (US highway truck transport)

Vertical		Transverse		Longitudinal	
Frequency, Hz	ASD, g^2/Hz	Frequency, Hz	ASD, g^2/Hz	Frequency, Hz	ASD, g^2/Hz
10	0.01500	10	0.00013	10	0.00650
40	0.01500	20	0.00065	20	0.00650
500	0.00015	30	0.00065	120	0.00020
rms = 1.04 g		78	0.00002	121	0.00300
		79	0.00019	200	0.00300
		120	0.00019	240	0.00150
		500	0.00001	340	0.00003
		rms = 0.20 g		500	0.00015
				rms = 0.74 g	

Table 6-1 Breaking points for curves of Figure 6-5, according to [4]

6.3.1.2. *Static Loads*

The expected static loads, the payload has to endure during the transport form the PLD Space Headquarters to the launch site are shown in Table 6-2.

Vertical Static Load, g	Transverse Static Load, g	Longitudinal Static Load, g
± 6.0	± 2.0	± 3.5

Table 6-2 Static loads during transport [3]

6.3.2. Flight

6.3.2.1. *Random Vibrations*

During the flight, the payloads are suspect to random vibrations. The expected vibration loads are in line with SMC-S-016 - Test Requirements for Launch, Upper-Stage and Space Vehicles [5]. The acceptance levels for units with a mass smaller than 23 kg are shown in Figure 6-6 and Table 6-3.

For other systems, exceeding 23 kg (50 lb), the random vibration specification may be reduced using the following relation [5]:

$$\text{Reduced spectrum level } (\mathrm{g}^2/\mathrm{Hz}) = 0.04\left(\frac{23\text{ kg}}{\mathrm{m}}\right)$$

where m is the unit weight in kilograms. The reduction cannot be more than 6 dB. Figure 6-6 and Table 6-3 show the minimum spectra for units weighing 23, 45, and 90 kg, respectively. For each of these weights, the flat portion of the spectrum was extended into the low-frequency regime without reducing the spectrum roll-off level to assure adequate excitation of the lower frequency modes resulting from the increased weight.

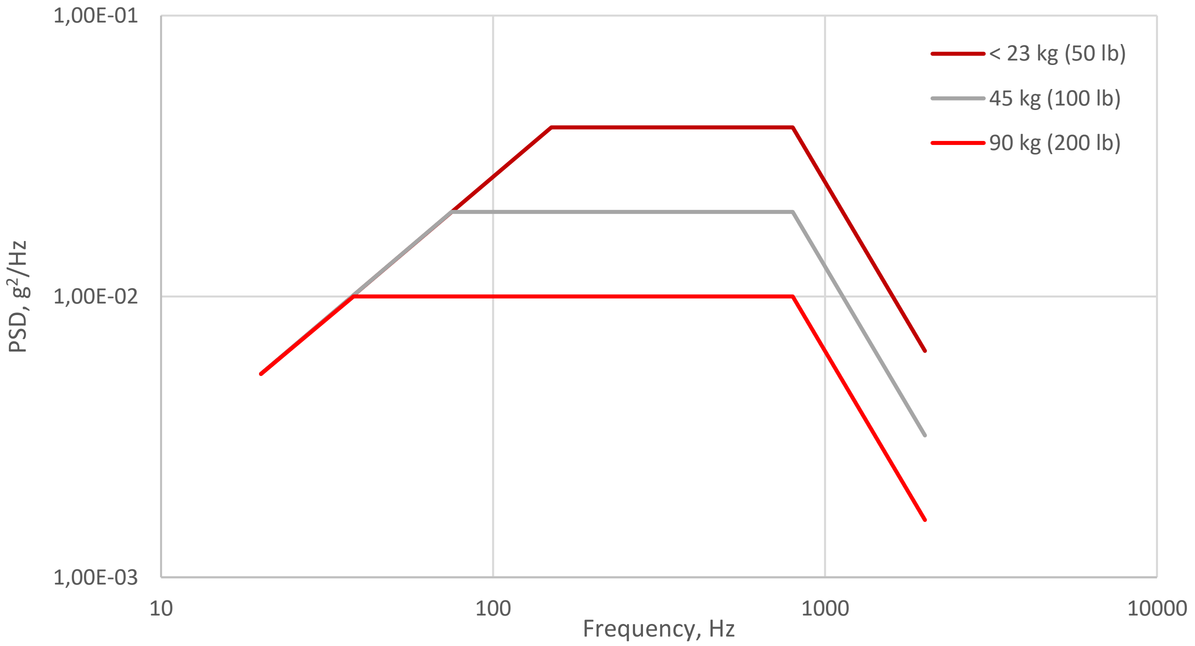


Figure 6-6 Random Vibration Spectrum, according to [5] (Unit Acceptance Test)

Unit Mass < 23 kg (50 lb)		Unit Mass 45 kg (100 lb)		Unit Mass 90 kg (200 lb)	
Frequency, Hz	PSD, g^2/Hz	Frequency, Hz	PSD, g^2/Hz	Frequency, Hz	PSD, g^2/Hz
20	0.0053	20	0.0053	20	0.0053
150	0.04	75	0.02	38	0.01
800	0.04	800	0.02	800	0.01
2000	0.0064	2000	0.0032	2000	0.0016
rms = 6.90 g		rms = 4.87 g		rms = 3.52 g	

Table 6-3 Breaking points for curve in Figure 6-6, according to [5]

6.3.2.1. Static Loads

The maximum static loads during the flight appear in the propelled ascent and in the re-entry phase while breaking the rocket with the parachutes. Expected loads, resulting from flight simulations, are summarized in Table 6-4.

Flight Phase	Axial Static Load, g	Lateral Static Load, g
Ascent	+ 6.0	± 1.0
Re-entry	- 15.0	± 3.0

Table 6-4 Static loads during flight

6.3.2.2. Acoustic Loads

During the flight, the payloads are subjected to a high acoustic environment. Highest levels appear at liftoff and during the transonic phase. The expected maximum acoustic pressure levels are shown in Figure 6-7 and Table 6-5. These values were obtained through flight simulations performed by PLD Space.

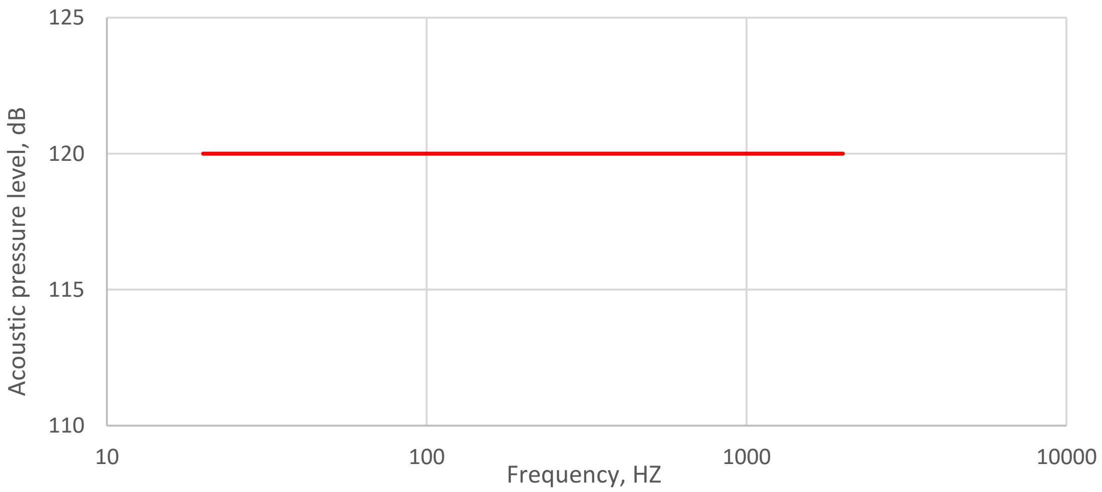


Figure 6-7 Maximum predicted MIURA 1 acoustic pressure environment

Frequency, Hz	Acoustic pressure level, dB
20	120
2000	120

Table 6-5 Breaking points for curve of Figure 6-7

6.3.2.3. Shock Loads

The expected shock loads appearing through the flight are shown in Figure 6-8 and Table 6-6. These values were obtained through flight simulations performed by PLD Space.

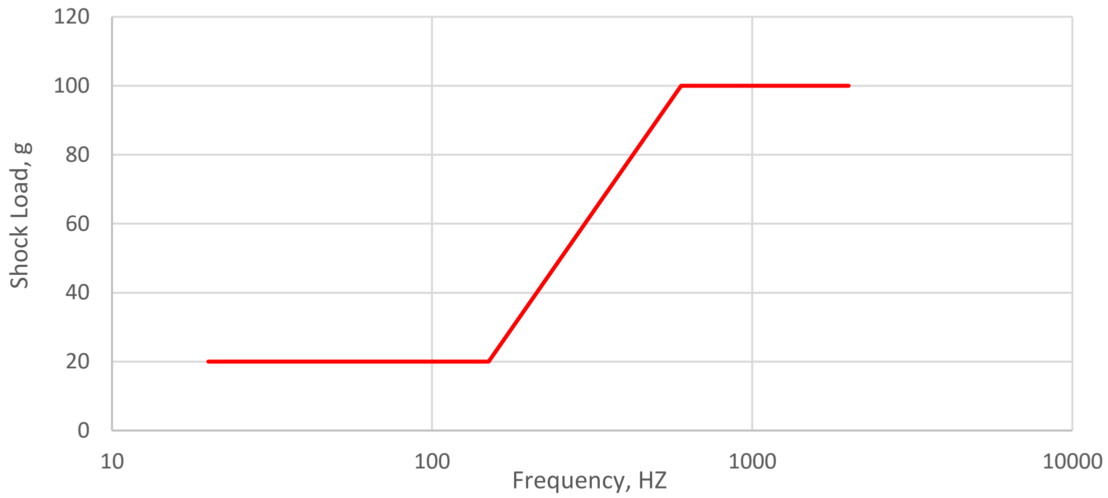


Figure 6-8 MIURA 1 shock loads

Frequency, Hz	Shock Load, g
20	20
150	20
600	100
2000	100

Table 6-6 Breaking points for curve of Figure 6-8

7. SAFETY

7.1. SAFETY REQUIREMENTS

Payloads on MIURA 1 and payload operations have to comply with the safety requirements of the used launch site. These safety requirements usually concern systems and operations comprising hazardous electrical systems, mechanical systems, chemicals, pressure systems, radiation sources (ionizing, non-ionizing/RF, optical e.g. lasers) and a variety of other systems and operations. PLD Space assists the users in identifying hazardous systems and operations within their payload.

To ensure adequate safety measures and procedures are implemented, information regarding these safety critical elements has to be provided to the launch site authority. PLD Space acts as interface between MIURA 1 payload users and the launch site authority. The entry point for this is the payload questionnaire, which is enquiring about the most common safety hazards. Further information then has to be provided in the PDP.

7.2. WAIVERS

If any safety requirement cannot be satisfied by the payload, but the user still believes the payload is acceptable for launch, a written request for waiver must be submitted to the launch site authority.

8. DOCUMENT REFERENCES

8.1. LIST OF FIGURES

8.2. LIST OF TABLES

9. BIBLIOGRAPHY

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MIURA 1 – Payload User's guide

Version 1.3, 13 November 2018