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Title - Sujet EXCORE SMALL PLANETARY ROVER PLATFO	
Solicitation No. - N° de l'invitation 9F052-140062/A	**Amendment No. - N° modif.** 001
Client Reference No. - N° de référence du client 9F052-14-0062	**Date** 2014-07-31
GETS Reference No. - N° de référence de SEAG PW-$MTB-690-12835	
File No. - N° de dossier MTB-4-37072 (690)	**CCC No./N° CCC - FMS No./N° VME**
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Title: Small Planetary Rover Platform (SPRP)

An amendment is issued for: :

Insert : Annex entitled «Requirements Document»

ALL OTHER TERMS AND CONDITIONS REMAIN UNCHANGED

Agence spatiale canadienne | Canadian Space Agency

CSA-EXCO-RD-0014

Canadian Space Agency

Exploration Core

Small Planetary Rover Platform (SPRP)

Requirements Document

Initial Release

April 25, 2014

Canada

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1 INTRODUCTION

The Exploration Core (ExCore) program aims at developing and maturing technologies in preparation for future exploration mission opportunities. These activities include development of technologies from requirements definition, development of terrestrial prototypes, integration, deployment and testing up to flight analogue relevant environment such as thermo-vacuum, radiation and dusty chamber.

For full information on the background of this contract, please see section 1 of the Statement of Work (SOW).

1.1 PURPOSE

This document provides the technical requirements for a functional Technology Readiness Level (TRL) 4 prototype of the ***Small Planetary Rover Platform (SPRP)***. The main characteristics of this platform are:

1. Small footprint;
2. Low cost;
3. Low mass;
4. Rugged.

More specifically, the ***Small Planetary Rover Platform*** targeted architecture exhibits the following features:

- Four wheel, skid-steering platform;
- Fully passive suspension, manually lockable;
- Basic power system; and
- Power & mechanical interface to accommodate small ESM Payloads.

1.2 SCOPE

This document defines the functional, performance, interface, environmental and software requirements for the ***SPRP*** prototype, as well as the environment in which it will operate.

1.3 DOCUMENT CONVENTIONS

A number of the sections in this document describe controlled requirements and specifications and therefore the following verbs are used in the specific sense indicated below:

a) "Must" or "Required" is used to indicate a contractual obligation;

b) "Should" indicates a preferred alternative but is not a contractual obligation under the contract;

c) "May" indicates an option;

d) "Will" indicates a statement of intention or fact, as does the use of present indicative active verbs.

2 DOCUMENTS

2.1 APPLICABLE DOCUMENTS (AD)

This Requirements Document does not call any Applicable Documents.

AD No.	Document Number	Document Title	Rev. No.	Date
AD1.	CSA-EXCO-SOW-0011	Exploration Core (ExCore) Small Planetary Rover Prototype (SPRP) Statement Of Work (SOW)	IR	April 2014

2.2 REFERENCE DOCUMENTS (RD)

The following documents provide additional information or guidelines that either may clarify the contents or are pertinent to the history of this document.

TABLE 2-1: - REFERENCE DOCUMENTS

RD No.	Document Number	Document Title	Rev. No.	Date
RD1.	CSA-EXCO-MAN-0001	Exploration Core Program Mars Emulation Terrain User Guide ftp://ftp.asc-csa.gc.ca/users/excore-prototyping/pub/CSA_Mars_Emulation_Terrain_User_Guide.pdf		
RD2.	SAE J2180	A Tilt Table Procedure for Measuring the Static Rollover Threshold for Heavy Trucks		May 17, 2011
RD3.	SAE J1100	Motor Vehicle Dimensions		November 20, 2009

3 OPERATIONAL AND RELEVANT ENVIRONMENTS

In order to properly test and demonstrate the ***SPRP*** capabilities, mobility-wise, the targeted operational environment of the ***SPRP*** is a set of outdoor terrestrial analogue sites heading at emulating specific features that could be found on either the Moon or Mars. In general, the analogue sites considered for the ***SPRP*** will feature the following properties:

- large dry area, mostly free of vegetation;
- unstructured, rough and uneven terrains;
- soil composed of rocks, dirt, and/or sand, consolidated or not.

The ***SPRP*** will face challenging climatic conditions in the field, such as;

- ambient temperature ranging from -10°C to 40°C;
- intense dusty winds;
- full sun light or complete darkness;
- light rain and mud.

While an eventual planetary rover would be designed and optimized to operate in a reduced gravity environment, the current ***SPRP*** will remain a terrestrial prototype and as such, it is bound to operate and meet all its requirements in a full 1g environment.
Prior to deploying the ***SPRP*** in a remote analogue site, a mobility characterisation campaign will take place at the CSA Analogue Terrain (AT). The AT is located at the CSA Headquarters in Saint-Hubert, Québec, Canada. The AT was designed and built to support the development and testing of planetary rovers. As such, the terrain morphology has been designed to emulate a wide set of typical lunar and martian topographies. This variety of terrain types is used to challenge the mobility sub-systems of exploration rovers. Figure 3-1 shows an aerial photo of the CSA AT. The AT is 60 meters wide by 120 meters long, and features elevation variations up to 4 meters.

FIGURE 3-1: AERIAL PHOTO OF THE CSA ANALOGUE TERRAIN

Additional details regarding the CSA AT are available in RD1.

4 TECHNICAL REQUIREMENTS

The purpose of the contract is to design and build a basic small rover platform that will be used on Earth to qualify and quantify the effectiveness of its architecture in terms of mobility on natural terrain. The CSA already has a fleet of rovers showcasing a wide range of form factors. These were developed through the Exploration Surface Mobility (ESM) project. However, no “small” form factor platforms were developed as of today. This contract will therefore fill this gap and help establish to which extent the mobility capabilities seen with the larger rovers can be maintained as the form factor gets scaled down.

Figure 4-1 shows a generic SPRP concept. As illustrated, CSA seeks a small and simple four wheel skid-steered platform. The platform must be delivered with wheels and must also be compatible with CSA’s compliant wheels. The platform provides cargo volume and interface plates that allow future sub-systems and payloads integration. The platform provides its own power and energy storage systems to support motion and to accommodate future sub-systems and payloads. The platform uses RF remote controllers to control motion and emergency stops. Ethernet connectors are available to facilitate data interfacing with the payloads to be installed outside the chassis. The platform focuses on the mobility capability so it does not require complex avionics such as on-board computers and Ethernet switches.

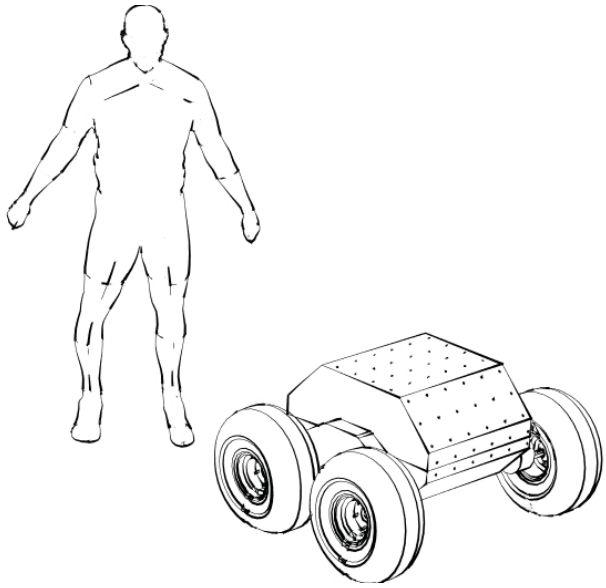


FIGURE 4-1: SPRP GENERIC CONCEPT (TO SCALE)

4.1 FUNCTIONAL REQUIREMENTS

MANDATORY-FNC-01 **Propulsion architecture**: The ***SPRP*** must be a four wheel platform.

MANDATORY-FNC-02 **Powertrain type**: The ***SPRP*** must be an all-wheel drive platform.

MANDATORY-FNC-03 **Steering**: The ***SPRP*** must be a skid-steering vehicle.

Note: Wheels orientation relative to the chassis must be fixed and constant.

MANDATORY-FNC-04 **Suspension Mechanisms**: All suspension mechanisms must be fully passive, i.e. no actuators.

MANDATORY-FNC-05 **Lockable Suspension**: The ***SPRP*** must allow manual locking of the suspension to its nominal position, effectively disabling all suspension behaviours.

Rationale: This feature will enable a quantitative evaluation of the impact of the suspension on the mobility performance of the platform, relative to a rigid (no suspension) configuration.

MANDATORY-FNC-06 **Motors**: All ***SPRP*** motors must be DC brushless motors.

MANDATORY-FNC-07 **Gear train**: The ***SPRP*** propulsion drive mechanism must have a fixed gear ratio.

Rationale: a double or multiple speed gear train would unnecessarily increase complexity.

MANDATORY-FNC-08 **Baseline Wheels**: The ***SPRP*** must be delivered with its own set of wheels whose outer diameter must be 50 cm +/- 1 cm.

Note: Pneumatic rubber wheels are an acceptable option.

MANDATORY-FNC-09 **Target Wheels**: The ***SPRP*** must be compatible with CSA's compliant wheels as per Figure 4-2.

Figure 4-2 presents the CSA's compliant wheels dimensions including the bolt pattern required to assembly them onto the rover.

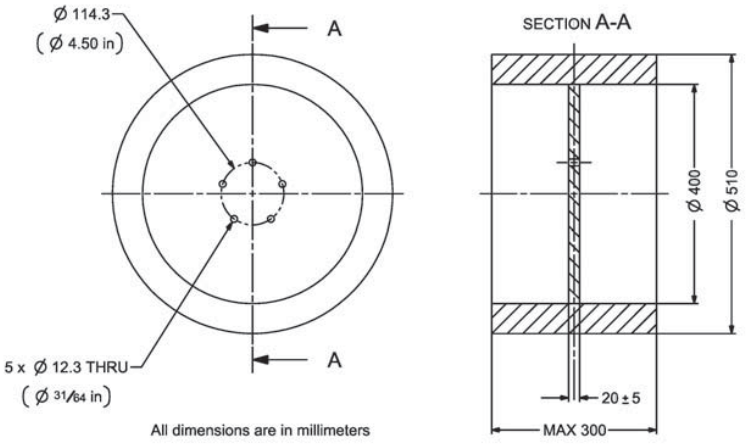


FIGURE 4-2: DIMENSIONS OF THE CSA'S COMPLIANT WHEELS

MANDATORY-FNC-010 **Brakes**: All ***SPRP*** propulsion actuators must be fitted with power off (fail safe) brakes, i.e. brakes are automatically applied when power is removed.

MANDATORY-FNC-011 **Encoders**: Encoders must be fitted into the propulsion system in such a way as to enable future odometry readings of every independently driven wheel.

Note: The encoder signal should be available inside the cargo volume specified in MANDATORY-INT-017 (i.e., encoder signal harness is routed to the cargo volume).

MANDATORY-FNC-012 **Power Source**: The ***SPRP*** must be powered by rechargeable batteries.

MANDATORY-FNC-013 **Power Autonomy**: The ***SPRP*** must have sufficient energy storage to drive for 2.5 hours at maximum speed on level ground at full gross vehicle weight.

Note: This considers that the rover is fitted with its baseline wheels (MANDATORY-FNC-08) at nominal operating pressure (if applicable) and that the payloads are drawing the average power specified by MANDATORY-INT-06 . The ground is a low motion resistance rough surface (e.g. packed gravel, rock dust, or equivalent).

MANDATORY-FNC-014 **Charging Equipment**: A standard 120 V AC 15A outlet (NEMA 5-15) powered charger must be provided with the ***SPRP*** to recharge its batteries.

MANDATORY-FNC-015 **Charging Behaviour:** While being recharged, the ***SPRP*** and the payload power outputs (MANDATORY-INT-07) must remain fully operational.

MANDATORY-FNC-016 **Charging Connection**: Enabling and disabling the charging process of the ***SPRP*** must not interrupt power to ***SPRP*** and payload power outputs.

MANDATORY-FNC-017 **Recharge Time**: Fully charging the ***SPRP*** batteries from 10% SOC, using the provided charger (MANDATORY-FNC-014) must not take longer than 4 hours.

MANDATORY-FNC-018 **Overnight Charging**: The charger, the batteries and the associated power system must be able to remain connected indefinitely without incurring any overcharge or overdischarge conditions to the rover and its components.

MANDATORY-FNC-019 **Battery Voltage Indicator**: The ***SPRP*** must be equipped with a visible battery voltage indicator that has a minimum resolution of 0.5 V.

4.2 PHYSICAL REQUIREMENTS

MANDATORY-PHY-01 **Mass**: The dry mass of the ***SPRP*** must not exceed 90 kg.

*Note: The **SPRP** mass includes the chassis, suspension, power subsystem, wheels, batteries.*

MANDATORY-PHY-02 **Payload-Cargo Mass**: The ***SPRP*** must be capable of transporting up to 50 kg of payloads and cargo.

Note: Cargo includes future sub-systems such as on-board computers, avionics, sensors, communication system. The center-of-gravity of the payload-cargo mass must be assumed to be located at 850 mm above the ground and centered with respect to the rover length and width.

MANDATORY-PHY-03 **Dimensions**: The ***SPRP*** overall dimensions must not exceed 1.2 x 1.2 x 0.8 meters (L x W x H).

MANDATORY-PHY-04 **Cargo Volume Accessibility**: The ***SPRP*** must be designed so that a user can access the inner cargo volume in less than 5 minutes.

4.3 PERFORMANCE REQUIREMENTS

MANDATORY-PRF-01 Minimum speed: The SPRP must be capable of moving at a minimum speed of 1 cm/s (0.036 km/h) on level, unprepared terrain.

Rationale: Such capability is required to enable precision driving and positioning of the rover.

MANDATORY-PRF-02 **Maximum Speed**: The ***SPRP*** must be capable of moving at a maximum speed of at least 50 cm/s (1.8 km/h) on level, unprepared terrain.

MANDATORY-PRF-03 **Reverse Speed**: The ***SPRP*** speed requirements apply in forward and reverse directions.

MANDATORY-PRF-04 **Encoders Resolution**: The ***SPRP*** encoders must have an effective resolution of at least 1000 counts per wheel rotation.

MANDATORY-PRF-05 **Gradeability**: The ***SPRP*** must be capable of driving continuously at 10 cm/s (0.36 km/h) on a 15 degrees slope when at maximum gross vehicle weight.

MANDATORY-PRF-06 **Maximum Gradient**: The ***SPRP*** must be able to start, stop and drive at no less than 5 cm/s (0.18 km/h) for at least four vehicle lengths in a controlled fashion while ascending and descending a 25° slope at maximum gross vehicle weight, provided that the ground surface provides sufficient traction. Performance: There must be no stalling, overheating, upsetting or hesitation, as well as little to no slipping. This performance must be met under the maximum allowable ambient temperature defined by MANDATORY-ENV-01 .

MANDATORY-PRF-07 **Obstacle Crossing #1**: The ***SPRP*** must be capable of driving at low speed over a trapezoidal prism obstacle of 0.3m high, as defined by Figure 4-3.

MANDATORY-PRF-08 **Obstacle Crossing #2**: The ***SPRP*** must be capable of driving at low speed over a half cylindrical obstacle of 0.3m high, as defined by Figure 4-4.

MANDATORY-PRF-09 **Obstacle Crossing #3**: The ***SPRP*** must be capable of driving at low speed over a trapezoidal prism 0.45m high, as defined by Figure 4-5.

Note: "Driving over" implies that the rover wheels contact and roll over the obstacle, as depicted in Figure 4-6.

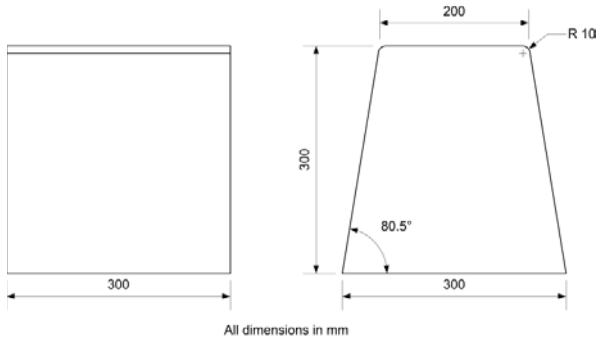


FIGURE 4-3: OBSTACLE #1 (30 CM TRAPEZOIDAL PRISM) SPECIFICATIONS

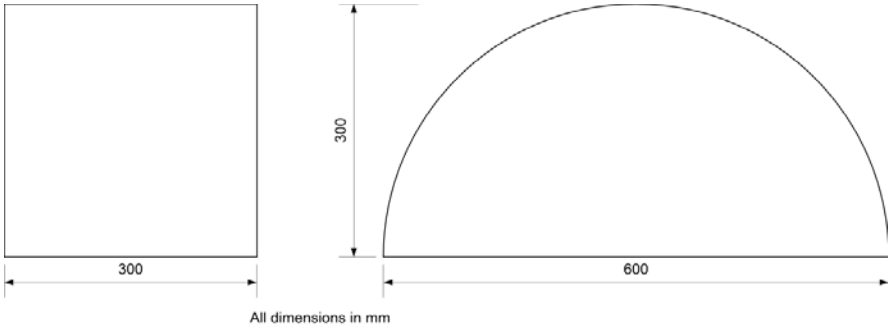


FIGURE 4-4: OBSTACLE #2 (30 CM HALF CYLINDER) SPECIFICATIONS

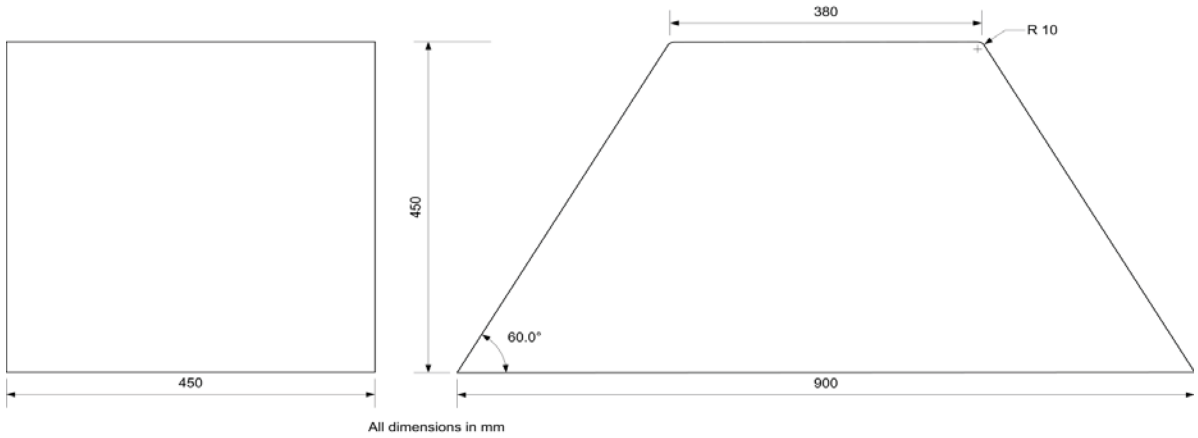


FIGURE 4-5: OBSTACLE #3 (45 CM TRAPEZOIDAL PRISM) SPECIFICATIONS

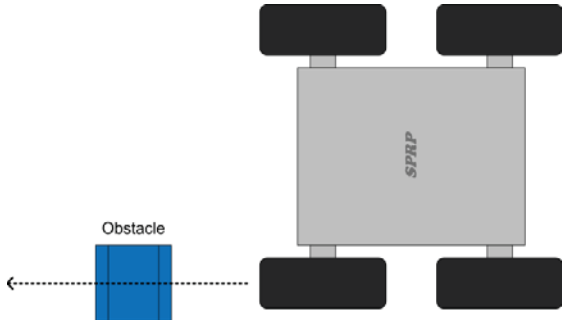


FIGURE 4-6: "DRIVING OVER" DEFINITION

MANDATORY-PRF-010 **Ground Clearance**: The ***SPRP*** chassis must be high enough to clear an obstacle of 200 mm × 600 mm (height × width) without having the wheels or any part of the rover in contact with the obstacle, as depicted in Figure 4-7.

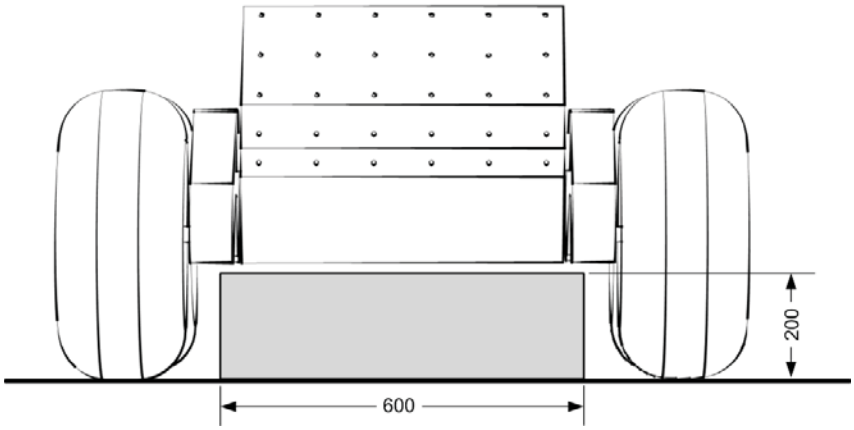


FIGURE 4-7: OBSTACLE GROUND CLEARANCE OBSTACLE DEFINITION (DIM. IN MM)

MANDATORY-PRF-011 **Skid-plate**: The ***SPRP*** underbody must be protected against damage from possible rock impacts.

MANDATORY-PRF-012 **Side Slope**: The ***SPRP*** must drive across slopes with a tilt angle of 25° at maximum gross vehicle weight, provided that the ground surface provides sufficient traction. Performance: There must be no stalling, overheating, upsetting or hesitation, as well as little to no slipping.

MANDATORY-PRF-013 **Rollover threshold**: The rollover threshold of the full gross vehicle weight of the ***SPRP*** must be at least 30° when measured in accordance with SAE J2180 (RD2).

MANDATORY-PRF-014 **Angle of Approach**: The angle of approach (H106 in SAE J1100) (RD3) for the ***SPRP*** must not be less than 40°.

MANDATORY-PRF-015 **Angle of Departure**: The angle of departure (H107 in SAE J1100) (RD3) for the ***SPRP*** must be greater than 40°.

MANDATORY-PRF-016 **Ramp Break-over Angle**: The ramp break-over angle (H147 in SAE J1100) (RD3) for the SPRP must not be less than 34°.

4.4 INTERFACE REQUIREMENTS

MANDATORY-INT-01 **Remote Control**: The ***SPRP*** must be remotely controlled with a Spektrum DX6i radio-frequency controller.

MANDATORY-INT-02 **E-Stop**: The ***SPRP*** must be equipped with a Torc E-STOP (SafeStop SS03 Wireless Emergency Stop, 900 MHz version).

MANDATORY-INT-03 **E-Stop Behaviour**: Activation of the E-Stop must, within one second, remove all power from the propulsion system actuators, including, but not limited to, the motors, brakes, and power amplifiers (motor drives). Activation of the E-Stop must not remove power from the other avionics systems, sensors and payloads.

MANDATORY-INT-04 **E-Stop Recovery**: Clearing of the E-Stop condition must re-activate the propulsion system and put the rover in a fully operational state without any need to shut down or reboot sub-systems and/or the rover itself.

MANDATORY-INT-05 **Power-Button**: The ***SPRP*** must be powered ON and OFF using a single main power switch and provide a power status indicator to the operator.

MANDATORY-INT-06 **Payload Power**: The ***SPRP*** must be capable of providing a total average power of 150 W for the payloads.

MANDATORY-INT-07 **Payload Power Outlets**: The ***SPRP*** must have two regulated 28 V DC power outlets capable of providing at least 250 W of total combined power to the payloads while each outlet must be able to individually deliver at least 250 W.

Note: Assuming no load on one outlet in order for the other to provide the full power is acceptable. Tying both outlets to a single regulated voltage source of sufficient capacity is acceptable.

MANDATORY-INT-08 **Cargo Inner Volume Power:** The ***SPRP*** must be capable of providing a total average power of 100 W for the inner cargo volume sub-systems.

MANDATORY-INT-09 **Cargo Inner Volume Power Connection:** The ***SPRP*** inner cargo volume must provide a fused interface to the battery bus for future inner cargo subsystems addition.

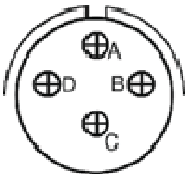
Note: Terminal block or harness with adequate connectors are both acceptable.

MANDATORY-INT-010 **Payload Power Circuit Protection:** Each ***SPRP*** power output must be equipped with a resettable protection device to provide protection from over-current and short-circuit conditions .

Note: The circuit protection devices (e.g. breakers) must be resettable, either manually or automatically. The use of fuses is not acceptable, as it would require changing components to recover from fault conditions.

MANDATORY-INT-011 **Payload Power Connector**: The power output payload connectors must be 4-Pole female connector Amphenol D38999/20FC4SN with sealing cap D38999/33M13R to maintain environmental protection when unmated with the pinout as per Table 4-1.

TABLE 4-1: - POWER OUTPUT PINOUT

Pin	Signal Description	Front face of pin inserts illustrated
A	BUS +	
B	Chassis GND	
C	BUS Return	
D	Chassis GND	

MANDATORY-INT-012 **Number of Data Ports**: Two data connectors Amphenol RJFTV2 must be fitted on the ***SPRP*** chassis (e.g. interface plates).

MANDATORY-INT-013 **Cargo Inner Volume Mechanical Interface**: The ***SPRP*** inner volume must provide standard metric threaded holes of size M6 regularly spaced on a square hole pattern of 100 mm apart (center to centre).

Note: The threaded holes should have a steel helical insert if the plate is not made of steel.

MANDATORY-INT-014 **Payload Mechanical Interface**: The ***SPRP*** must provide standard metric threaded holes of size M8 regularly spaced on a square hole pattern of 100 mm apart (center to centre).

Note: The threaded holes should have a steel helical insert if plate is not made of steel. Figure 4-1 shows an example of the hole pattern stated in this requirement and MANDATORY-INT-013 .

MANDATORY-INT-015 **Payload Top Plate Strength:** The ***SPRP*** must be capable of supporting 50 kg applied on the top plate.

MANDATORY-INT-016 **Payload Front and Rear Plates Strength**: The ***SPRP*** must be capable of supporting 25 kg applied on each of the front and rear plates.

MANDATORY-INT-017 **Cargo Volume**: The ***SPRP*** must provide a minimum of 75 L of cargo volume.

Note: Figure 4-8shows a possible cargo volume configuration.

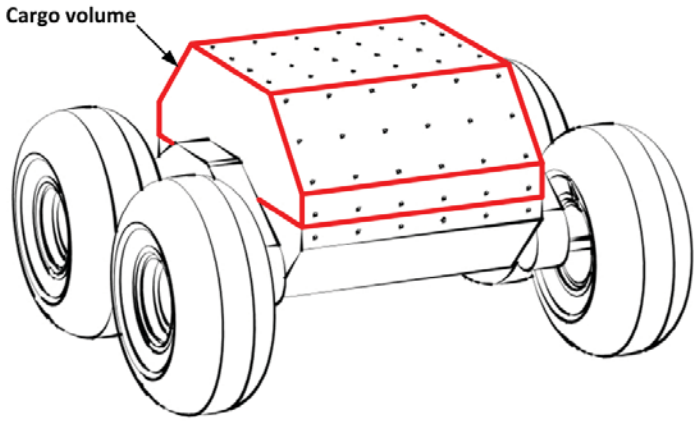


FIGURE 4-8: EXAMPLE OF A CARGO VOLUME

MANDATORY-INT-018 **Free Payload Zone**: The ***SPRP*** back and front chassis planes must be at least 150 mm from the ***SPRP*** overall footprint, as shown in Figure 4-9.

Rationale: This is to insure there are free areas, both front and rear of the rover, to accommodate future potential payloads and instruments, without exceeding the rover envelope.

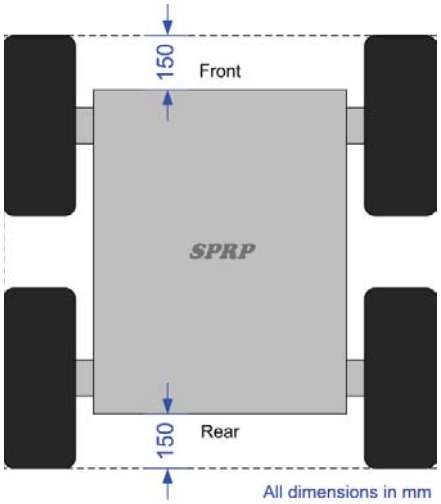


FIGURE 4-9: FRONT AND REAR FREE ZONE DEFINITION

4.5 OPERATIONAL REQUIREMENTS

Not Applicable.

4.6 ENVIRONMENTAL REQUIREMENTS

The aim of the ***SPRP*** contract being to achieve TRL-4, it is not required to test and qualify for the operational environment. The purpose of the following requirements sections is to ensure the prototype can be operated as a terrestrial rover and that the TRL advancement towards a path to flight unit is addressed. These requirements can be verified by testing in a laboratory or analogue environment.

MANDATORY-ENV-01 **Operating Temperature**: The ***SPRP*** must meet its requirements between -10 and +40 degrees C.

MANDATORY-ENV-02 **Mud**: The ***SPRP*** must meet all requirements if it is splashed with moist soil or mud.

Note: Operation after rain means that there is the potential for getting mud on the rover. The intent is not to operate in mud on a continuous basis.

MANDATORY-ENV-03 **Dust and waterproofing**: The ***SPRP*** must feature an environmental protection level equivalent to IP54 or better.

Note: The SPRP is not required to meet operating requirements in precipitation (snow, rain, etc.). The SPRP must resist light rain or light snow, but is not required to be waterproof. The SPRP must meet its requirements while resisting small-particle dust and blowing sand at high winds.

MANDATORY-ENV-04 **Solar Radiation**: The ***SPRP*** must meet its requirements under expected solar radiation conditions in the analogue environment.

4.7 PRODUCT ASSURANCE REQUIREMENTS

MANDATORY-PA-01 **Life**: The ***SPRP*** must be designed for a mission life of 1000 km driving and 5 years use and storage. Maintenance may be used (lubrication, limited life part replacement, etc.) to achieve this requirement.

Rationale: 1000 km distance rounded from operating 0.25m/s x 3600s/hr x 4hrs/day x 2 days/week x 30 weeks/year x 5 years x 1 km/1000m

4.8 VERIFICATION REQUIREMENTS

The Statement of Work (SOW) stipulates that the Contractor must prepare a Verification Plan and a Verification Compliance Matrix (VCM). It also requires the Contractor to perform all verification activities stipulated in this Requirements Document. Table 4-2 lists all the requirements along with the verification method that must be used to verify each requirement.

TABLE 4-2: - VERIFICATION METHOD

Requirement No.	Name	Method	Note
I: Inspection, T: Test, A: Analysis, D: Demonstration, RoD: Review of Design			
MANDATORY-FNC-01	Propulsion architecture	RoD, I	
MANDATORY-FNC-02	Powertrain type	RoD, I	
MANDATORY-FNC-03	Steering	RoD, I	
MANDATORY-FNC-04	Suspension Mechanisms	RoD, I	
MANDATORY-FNC-05	Lockable Suspension	D	
MANDATORY-FNC-06	Motors	RoD, I	
MANDATORY-FNC-07	Gear train	RoD, I	
MANDATORY-FNC-08	Baseline Wheels	RoD, I	
MANDATORY-FNC-09	Target Wheels	RoD, D	
MANDATORY-FNC-010	Brakes	D	
MANDATORY-FNC-011	Encoders	RoD, I	
MANDATORY-FNC-012	Power Source	RoD, I	
MANDATORY-FNC-013	Power Autonomy	T	

Requirement No.	Name	Method	Note
I: Inspection, T: Test, A: Analysis, D: Demonstration, RoD: Review of Design			
MANDATORY-FNC-014	Charging Equipment	RoD, I	
MANDATORY-FNC-015	Charging Behaviour	D	
MANDATORY-FNC-016	Charging Connection	D	
MANDATORY-FNC-017	Recharge Time	T	
MANDATORY-FNC-018	Overnight Charging	RoD	
MANDATORY-FNC-019	Battery Voltage Indicator	RoD, I	
MANDATORY-PHY-01	Mass		
MANDATORY-PHY-02	Payload-Cargo Mass	D	
MANDATORY-PHY-03	Dimensions	RoD, I	
MANDATORY-PHY-04	Cargo Volume Accessibility	D	
MANDATORY-PRF-01	Minimum speed	T	
MANDATORY-PRF-02	Maximum Speed	T	
MANDATORY-PRF-03	Reverse Speed	T	
MANDATORY-PRF-04	Encoders Resolution	T	
MANDATORY-PRF-05	Gradeability	T	
MANDATORY-PRF-06	Maximum Gradient	T	
MANDATORY-PRF-07	Obstacle Crossing #1	D	
MANDATORY-PRF-08	Obstacle Crossing #2	D	
MANDATORY-PRF-09	Obstacle Crossing #3	D	
MANDATORY-PRF-10	Ground Clearance	D	
MANDATORY-PRF-011	Skid-plate	RoD, I	
MANDATORY-PRF-012	Side Slope	D	
MANDATORY-PRF-013	Rollover threshold	T	
MANDATORY-PRF-014	Angle of Approach	RoD	
MANDATORY-PRF-015	Angle of Departure	RoD	
MANDATORY-PRF-016	Ramp Break over Angle	RoD	
MANDATORY-INT-01	Remote Control	D	
MANDATORY-INT-02	E-Stop	RoD, I	
MANDATORY-INT-03	E-Stop Behaviour	D	
MANDATORY-INT-04	E-Stop Recovery	D	
MANDATORY-INT-05	Power-Button	D	
MANDATORY-INT-06	Payload Power	T	
MANDATORY-INT-07	Payload Power Outlets	T	
MANDATORY-INT-08	Cargo Inner Volume Power	T	
MANDATORY-INT-09	Cargo Inner Volume Power Connection	RoD, I	
MANDATORY-INT-010	Payload Power Circuit Protection	RoD, I	
MANDATORY-INT-011	Payload Power Connector	RoD, I	
MANDATORY-INT-012	Number of Data Ports	RoD, I	
MANDATORY-INT-013	Cargo Inner Volume Mechanical Interface	RoD, I	
MANDATORY-INT-014	Payload Mechanical Interface	RoD, I	

Requirement No.	Name	Method	Note
I: Inspection, T: Test, A: Analysis, D: Demonstration, RoD: Review of Design			
MANDATORY-INT-015	Payload Top Plate Strength	RoD, D	
MANDATORY-INT-016	Payload Front and Rear Plate Strength	RoD, D	
MANDATORY-INT-017	Cargo Volume	RoD	
MANDATORY-INT-018	Free Payload Zone	RoD, I	
MANDATORY-ENV-01	Operating Temperature	RoD, D	
MANDATORY-ENV-02	Mud	RoD, D	
MANDATORY-ENV-03	Dust and waterproofing	RoD, D	
MANDATORY-ENV-04	Solar Radiation	RoD, I	
MANDATORY-PA-01	Life	RoD	

APPENDICES

APPENDIX A ACRONYMS

AD	Applicable Document
AT	Analogue terrain
CSA	Canadian Space Agency
GSE	Ground Support Equipment
IP	Ingress Protection (e.g. IP54)
PSR	Permanently Shadowed Regions
RD	Reference Document
SOC	State-Of-Charge
SOW	Statement of Work
SPRP	Small Planetary Rover Platform
TA	Technical Authority
TRL	Technology Readiness Level
VCM	Verification Compliance Matrix