Public Works and Government Services Canada | Travaux publics et Services gouvernementaux Canada

RETURN BIDS TO:
RETOURNER LES SOUMISSIONS À:

Travaux publics et Services gouvernementaux Canada
Place Bonaventure,
800 rue de la Gauchetière Ouest
Voir aux présentes - See herein
Montréal
Québec
H5A 1L6
FAX pour soumissions: (514) 496-3822

REQUEST FOR PROPOSAL
DEMANDE DE PROPOSITION

Proposal To: Public Works and Government Services Canada

We hereby offer to sell to Her Majesty the Queen in right of Canada, in accordance with the terms and conditions set out herein, referred to herein or attached hereto, the goods, services, and construction listed herein and on any attached sheets at the price(s) set out therefor.

Proposition aux: Travaux Publics et Services Gouvernementaux Canada

Nous offrons par la présente de vendre à Sa Majesté la Reine du chef du Canada, aux conditions énoncées ou incluses par référence dans la présente et aux annexes ci-jointes, les biens, services et construction énumérés ici sur toute feuille ci-annexée, au(x) prix indiqué(s).

Comments - Commentaires

Title - Sujet
LSM PHASR Phase 0

Solicitation No. - N° de l'invitation	**Date**
9F050-170986/A	2018-06-20

Client Reference No. - N° de référence du client
9F050-17-0986

GETS Reference No. - N° de référence de SEAG
PW-$MTB-545-14921

File No. - N° de dossier	**CCC No./N° CCC - FMS No./N° VME**
MTB-8-41028 (545)	

Solicitation Closes - L'invitation prend fin
at - à 02:00 PM
on - le 2018-07-27

Time Zone
Fuseau horaire
Heure Avancée de l'Est
HAE

F.O.B. - F.A.B.
Plant-Usine: ☐ **Destination:** ☑ **Other-Autre:** ☐

Address Enquiries to: - Adresser toutes questions à:	**Buyer Id - Id de l'acheteur**
Niquette, Caroline	mtb545

Telephone No. - N° de téléphone	**FAX No. - N° de FAX**
(514) 712-5113 ( )	(514) 496-3822

Destination - of Goods, Services, and Construction:
Destination - des biens, services et construction:
AGENCE SPATIALE CANADIENNE
asc.facturation-invoicing.csa
@Canada.ca
9F050 - Exploration spatiale /
Space Exploration
6767 ROUTE DE L AEROPORT
ST HUBERT
Québec
J3Y8Y9
Canada

Instructions: See Herein

Instructions: Voir aux présentes

Vendor/Firm Name and Address
Raison sociale et adresse du fournisseur/de l'entrepreneur

Delivery Required - Livraison exigée	**Delivery Offered - Livraison proposée**
.	

Vendor/Firm Name and Address
Raison sociale et adresse du fournisseur/de l'entrepreneur

Telephone No. - N° de téléphone
Facsimile No. - N° de télécopieur

Name and title of person authorized to sign on behalf of Vendor/Firm (type or print)
Nom et titre de la personne autorisée à signer au nom du fournisseur/ de l'entrepreneur (taper ou écrire en caractères d'imprimerie)

Signature **Date**

Issuing Office - Bureau de distribution
Travaux publics et Services gouvernementaux Canada
Place Bonaventure, portail Sud-Oue
800, rue de La Gauchetière Ouest
7e étage, suite 7300
Montréal
Québec
H5A 1L6

Canada

TABLE OF CONTENTS

PART 1 - GENERAL INFORMATION

1.1 Introduction

The bid solicitation is divided into seven parts plus attachments and annexes, as follows:

Part 1 General Information: provides a general description of the requirement;

Part 2 Bidder Instructions: provides the instructions, clauses and conditions applicable to the bid solicitation;

Part 3 Bid Preparation Instructions: provides Bidders with instructions on how to prepare their bid;

Part 4 Evaluation Procedures and Basis of Selection: indicates how the evaluation will be conducted, the evaluation criteria that must be addressed in the bid, and the basis of selection;

Part 5 Certifications and Additional Information: includes the certifications and additional information to be provided;

Part 6 Security, Financial and Other Requirements: includes specific requirements that must be addressed by Bidders; and

Part 7 Resulting Contract Clauses: includes the clauses and conditions that will apply to any resulting contract.

The Annexes include the Statement of Work, the Basis of Payment, the Electronic Payment Instruments, and other Attachments.

1.2 Summary

Project title

Lunar Surface Mobility Precursor to Human and Science Rover- LSM PHASR- Phase 0

Description

Public Services and Procurement Canada (PSPC) on behalf of Canadian Space Agency (CSA) located in St-Hubert, (Quebec) is seeking bids for the project entitled LSM PHASR Phase 0.

Canada under the International Space Exploration Coordination Group (ISECG) and in particular for Lunar Surface Mobility (LSM) related activities through international partnership under the Lunar Exploration Demonstrator Mission Definition Study, is continuing its collaboration with international partners to define concepts for collaborative missions Beyond Low Earth Orbit (BLEO), as presented in the Global Exploration Roadmap (GER 2018).

As mentioned in the GER, an international common long term goal is the human exploration of Mars. One step towards this is to have human presence in the cis-Lunar space on an orbiting vehicle currently referred to as the Deep Space Gateway (DSG). Through the DSG, a crew of up to four astronauts would have access to the surface of the Moon to perform extended stays for science and exploration. As a robotics precursor demonstration and scientific mission, the European Space Agency (ESA)-led Human Enhanced Robotic Architecture and Capability for Lunar Exploration and Science (HERACLES) mission currently being studied propose an option for Canada to contribute a rover referred to as the Precursor to Human And Scientific Rover (PHASR). PHASR would be the precursor rover to a larger human rated

rover referred to as the Lunar Pressurized Rover (LPR) and would constitute a key asset for scientific research and return of lunar samples to Earth.

The Phase 0 study solicited herein is to inform Canada on key aspects of the PHASR contribution to the mission. The Phase 0 essentially is the “Mission Definition Phase” during which, based on Mission Objectives and Users’ Needs, all mission definition activities are performed and Mission Requirements are developed. One key result of a Phase 0 is to provide information for Canada to clearly understand the mission feasibility, options, costs, schedule, and risks associated with a PHASR possible contribution. Furthermore, at the end of the Phase 0 study, Canada should have all the key technical and programmatic information necessary to make an informed decision about a potential PHASR contribution and for subsequent immediate next steps. Work requirements include elements associated with mission analysis, planning and development, mission operations, systems engineering, trades assessments and support to CSA with respect to the HERACLES mission studies.

Up to two (2) contracts could be awarded.

Period of Contract

The contract issued will be for a period of 12 months for Phase 0.

Maximum Funding

The maximum funding available for each Contract resulting from the bid solicitation is $ 800 000.00 per contract (Applicable Taxes extra).

Intellectual Property

The Intellectual Property will vest with the Crown.

Security Requirements

There is no security requirement associated with this requirement.

Trade Agreements

This procurement is not subject to Trade Agreements.

Canadian Content

The requirement is limited to Canadian services.

1.3 Debriefings

Bidders may request a debriefing on the results of the bid solicitation process. Bidders should make the request to the Contracting Authority within 15 working days from receipt of the results of the bid solicitation process. The debriefing may be in writing, by telephone or in person.

1.4 Communications

As a courtesy and in order to coordinate any public announcements pertaining to this contract, the Government of Canada requests that successful Bidders notify the Contracting Authority 5 days in advance of their intention to make public an announcement related to the recommendation of a contract award, or any information related to the contract. The Government of Canada retains the right to make primary contract announcements.

PART 2 - BIDDER INSTRUCTIONS

2.1 Standard Instructions, Clauses and Conditions

All instructions, clauses and conditions identified in the bid solicitation by number, date and title are set out in the Standard Acquisition Clauses and Conditions Manual (https://buyandsell.gc.ca/policy-and-guidelines/standard-acquisition-clauses-and-conditions-manual) issued by Public Works and Government Services Canada.
Bidders who submit a bid agree to be bound by the instructions, clauses and conditions of the bid solicitation and accept the clauses and conditions of the resulting contract.

The 2003 (2017-04-27), Standard Instructions - Goods or Services - Competitive Requirements, are incorporated by reference into and form part of the bid solicitation.

Subsection 5.4 of 2003, Standard Instructions - Goods or Services - Competitive Requirements, is amended as follows:

Delete: 60 days
Insert: 240 days

2.2 Submission of Bids

Bids must be submitted only to Public Works and Government Services Canada (PWGSC) Bid Receiving Unit by the date, time and place indicated on page 1 of the bid solicitation:

In person or by mail:

Public Works and Government Services Canada
Quebec Region
Place Bonaventure, 7th Floor
800 de la Gauchetière Street West, Suite 7300
South-West Portal
Montreal (QC), H5A 1L6

Due to the nature of the bid solicitation, bids transmitted by facsimile to PWGSC will not be accepted.

2.3 Former Public Servant

Contracts awarded to former public servants (FPS) in receipt of a pension or of a lump sum payment must bear the closest public scrutiny, and reflect fairness in the spending of public funds. In order to

comply with Treasury Board policies and directives on contracts awarded to FPSs, bidders must provide the information required below before contract award. If the answer to the questions and, as applicable the information required have not been received by the time the evaluation of bids is completed, Canada will inform the Bidder of a time frame within which to provide the information. Failure to comply with Canada's request and meet the requirement within the prescribed time frame will render the bid non-responsive.

Definitions

For the purposes of this clause, "former public servant" is any former member of a department as defined in the *Financial Administration Act*, R.S., 1985, c. F-11, a former member of the Canadian Armed Forces or a former member of the Royal Canadian Mounted Police. A former public servant may be:

a. an individual;
b. an individual who has incorporated;
c. a partnership made of former public servants; or
d. a sole proprietorship or entity where the affected individual has a controlling or major interest in the entity.

"lump sum payment period" means the period measured in weeks of salary, for which payment has been made to facilitate the transition to retirement or to other employment as a result of the implementation of various programs to reduce the size of the Public Service. The lump sum payment period does not include the period of severance pay, which is measured in a like manner.

"pension" means a pension or annual allowance paid under the *Public Service Superannuation Act* (PSSA), R.S., 1985, c. P-36, and any increases paid pursuant to the *Supplementary Retirement Benefits Act*, R.S., 1985, c. S-24 as it affects the PSSA. It does not include pensions payable pursuant to the *Canadian Forces Superannuation Act*, R.S., 1985, c. C-17, the *Defence Services Pension Continuation Act*, 1970, c. D-3, the *Royal Canadian Mounted Police Pension Continuation Act* , 1970, c. R-10, and the *Royal Canadian Mounted Police Superannuation Act*, R.S., 1985, c. R-11, the *Members of Parliament Retiring Allowances Act*, R.S. 1985, c. M-5, and that portion of pension payable to the *Canada Pension Plan Act*, R.S., 1985, c. C-8.

Former Public Servant in Receipt of a Pension

As per the above definitions, is the Bidder a FPS in receipt of a pension? **Yes** ( ) **No** ( )

If so, the Bidder must provide the following information, for all FPSs in receipt of a pension, as applicable:

a. name of former public servant;
b. date of termination of employment or retirement from the Public Service.

By providing this information, Bidders agree that the successful Bidder's status, with respect to being a former public servant in receipt of a pension, will be reported on departmental websites as part of the published proactive disclosure reports in accordance with Contracting Policy Notice: 2012-2 and the Guidelines on the Proactive Disclosure of Contracts.

Work Force Adjustment Directive

Is the Bidder a FPS who received a lump sum payment pursuant to the terms of the Work Force Adjustment Directive? **Yes** ( ) **No** ( )

If so, the Bidder must provide the following information:

a. name of former public servant;
b. conditions of the lump sum payment incentive;
c. date of termination of employment;
d. amount of lump sum payment;
e. rate of pay on which lump sum payment is based;
f. period of lump sum payment including start date, end date and number of weeks;
g. number and amount (professional fees) of other contracts subject to the restrictions of a work force adjustment program.

For all contracts awarded during the lump sum payment period, the total amount of fees that may be paid to a FPS who received a lump sum payment is $5,000, including Applicable Taxes.

2.4 Enquiries - Bid Solicitation

All enquiries must be submitted in writing to the Contracting Authority no later than 10 days calendar days before the bid closing date. Enquiries received after that time may not be answered.

Bidders should reference as accurately as possible the numbered item of the bid solicitation to which the enquiry relates. Care should be taken by Bidders to explain each question in sufficient detail in order to enable Canada to provide an accurate answer. Technical enquiries that are of a proprietary nature must be clearly marked "proprietary" at each relevant item. Items identified as “proprietary” will be treated as such except where Canada determines that the enquiry is not of a proprietary nature. Canada may edit the question(s) or may request that the Bidder do so, so that the proprietary nature of the question(s) is eliminated and the enquiry can be answered to all Bidders. Enquiries not submitted in a form that can be distributed to all Bidders may not be answered by Canada.

2.5 Applicable Laws

Any resulting contract must be interpreted and governed, and the relations between the parties determined, by the laws in force in Quebec.

Bidders may, at their discretion, substitute the applicable laws of a Canadian province or territory of their choice without affecting the validity of their bid, by deleting the name of the Canadian province or territory specified and inserting the name of the Canadian province or territory of their choice. If no change is made, it acknowledges that the applicable laws specified are acceptable to the Bidders.

2.6 Improvement of Requirement during Solicitation Period

Should bidders consider that the specifications or Statement of Work contained in the bid solicitation could be improved technically or technologically, bidders are invited to make suggestions, in writing, to the Contracting Authority named in the bid solicitation. Bidders must clearly outline the suggested improvement as well as the reason for the suggestion. Suggestions that do not restrict the level of competition nor favour a particular bidder will be given consideration provided they are submitted to the Contracting Authority **at least 10 days before the bid closing date**. Canada will have the right to accept or reject any or all suggestions.

2.7 Maximum funding

The maximum funding available for each Contract resulting from the bid solicitation is $ 800 000.00 per contract (Applicable Taxes extra). Bids valued in excess of this amount will be considered non-responsive. This disclosure does not commit Canada to pay the maximum funding available.

2.8 Basis for Canada's Ownership of Intellectual Property

The Canadian Space Agency (CSA) has determined that any intellectual property rights arising from the performance of the Work under the resulting contract will belong to Canada, for the following reasons, as set out in the *Policy on Title to Intellectual Property Arising Under Crown Procurement Contracts*:

4.2 To augment an existing body of Crown Background as a prerequisite to the transfer of the expanded Background to the private sector, through licensing or assignment of ownership (not necessarily to the original contractor), for the purposes of Commercial Exploitation.

PART 3 - BID PREPARATION INSTRUCTIONS

3.1 Bid Preparation Instructions

Canada requests that Bidders provide their bid in separately bound sections as follows:

Section I: Technical Bid (1 hard copy and 2 soft copies on CD, DVD or BD)

Section II: Financial Bid (1 hard copy and 1 soft copy on CD, DVD or BD)

Section III: Certifications (1 hard copy and 1 soft copy on CD, DVD or BD)

If there is a discrepancy between the wording of the soft copy and the hard copy, the wording of the hard copy will have priority over the wording of the soft copy.

Prices must appear in the financial bid only. No prices must be indicated in any other section of the bid.

Canada requests that Bidders follow the format instructions described below in the preparation of their bid:

(a) use 8.5 x 11 inch (216 mm x 279 mm) paper;
(b) use a numbering system that corresponds to the bid solicitation.

In April 2006, Canada issued a policy directing federal departments and agencies to take the necessary steps to incorporate environmental considerations into the procurement process Policy on Green Procurement (http://www.tpsgc-pwgsc.gc.ca/ecologisation-greening/achats-procurement/politique-policy-eng.html). To assist Canada in reaching its objectives, Bidders should:

1) use 8.5 x 11 inch (216 mm x 279 mm) paper containing fibre certified as originating from a sustainably-managed forest and containing minimum 30% recycled content; and

2) use an environmentally-preferable format including black and white printing instead of colour printing, printing double sided/duplex, using staples or clips instead of cerlox, duotangs or binders.

Section I: Technical and Management Bid

In their technical bid, Bidders should demonstrate their understanding of the requirements contained in the bid solicitation and explain how they will meet these requirements. Bidders should demonstrate their capability and describe their approach in a thorough, concise and clear manner for carrying out the work.

The technical bid should address clearly and in sufficient depth the points that are subject to the evaluation criteria against which the bid will be evaluated. Simply repeating the statement contained in the bid solicitation is not sufficient. In order to facilitate the evaluation of the bid, Canada requests that Bidders address and present topics in the order of the evaluation criteria under the same headings. To avoid duplication, Bidders may refer to different sections of their bids by identifying the specific paragraph and page number where the subject topic has already been addressed.

In their management bid, Bidders must describe their capability and experience, the project management team and provide client contact(s).

The required structure and content of the technical and management proposal (Section I) is detailed in Attachment 1 to Part 3: Technical and Managerial Bid Preparation Instructions.

The Attachment 1 to Part 4- Point Rated Evaluation Criteria, contains additional instructions that Bidders should take into consideration while preparing their Bid.

Section II: Financial Bid

Bidders must submit their financial bid in accordance with the Basis of Payment in Annex "B".

3.1.1 The Bidders must present their financial proposal as follows:

(a) A firm, all-inclusive lot price for the Work, which must not exceed the maximum funding available for the contract resulting from the bid solicitation. The total amount of Applicable Taxes must be shown separately, if applicable;

(b) Prices must be in Canadian funds. The total amount of Applicable Taxes must be shown separately, if applicable.

3.1.2 Electronic Payment of Invoices – Bid

If you are willing to accept payment of invoices by Electronic Payment Instruments, complete Annex “C” Electronic Payment Instruments, to identify which ones are accepted.

If Annex “C” Electronic Payment Instruments is not completed, it will be considered as if Electronic Payment Instruments are not being accepted for payment of invoices.

Acceptance of Electronic Payment Instruments will not be considered as an evaluation criterion.

3.1.3 Exchange Rate Fluctuation

C3011T (2013-11-06), Exchange Rate Fluctuation

3.1.4 Price Breakdown

Bidders are requested to detail the following elements for the performance of each task, milestone or phase of the Work, broken down per WPD listed in the Statement of Work (SOW):

(a) Labour: For each individual and (or) labour category to be assigned to the Work, indicate:
   i) the hourly rate, inclusive of overhead and profit; and
   ii) the estimated number of hours.

(b) Equipment: Specify each item required to complete the Work and provide the pricing basis of each one, Canadian customs duty and excise taxes included, as applicable.

(c) Materials and Supplies: Identify each category of materials and supplies required to complete the Work and provide the pricing basis.

(d) Travel and Living Expenses: Indicate the number of trips and the number of days for each trip, the cost, destination and purpose of each journey, together with the basis of these costs which must not exceed the limits of the National Joint Council (NJC). With respect to the NJC's Directive, only the meal and private vehicle specified in Appendices B, C and D of the Directive **http://www.njc-cnm.gc.ca/directive/travelvoyage/index-eng.php**, and the other provisions of the Directive referring to "travellers", rather than those referring to "employees", are applicable and with the other provisions of the article 7 of the National Joint Council entitled "Special Travel Authorities" in the "Other related Documents" Section.

   Canada will not pay the Contractor any incidental expense allowance for authorized travel.

(e) Subcontracts: Identify any proposed subcontractor and provide for each one the same price breakdown information as contained in this article.

(f) Other Direct Charges: Identify any other direct charges anticipated, such as long distance communications and rentals, and provide the pricing basis.

(g) Applicable Taxes: Identify any Applicable Taxes separately.

Section III: Certifications

Bidders must submit the certifications and additional information required under Part 5.

PART 4 - EVALUATION PROCEDURES AND BASIS OF SELECTION

4.1 Evaluation Procedures

(a) Bids will be assessed in accordance with the entire requirement of the bid solicitation including the technical, management and financial evaluation criteria.

(b) An evaluation team composed of representatives of Canada will evaluate the bids.

(c) The evaluation team will determine first if there are two or more bids with a valid Canadian Content certification. In that event, the evaluation process will be limited to the bids with the certification; otherwise, all bids will be evaluated. If some of the bids with a valid certification are declared non-responsive, or are withdrawn, and less than two responsive bids with a valid certification remain, the evaluation will continue among those bids with a valid certification. If all bids with a valid certification are subsequently declared non-responsive, or are withdrawn, then all the other bids received will be evaluated.

4.1.1 Technical and Management Evaluation

The point rated technical evaluation criteria are included in Attachment 1 to Part 4- Point Rated Evaluation Criteria.

4.1.2 Financial Evaluation

4.1.2.1 Mandatory Financial Criteria

The Bidder must submit a firm, all-inclusive lot price for the Work, which must not exceed the maximum funding available of $800 000.00 applicable taxes extra.

Bids which fail to meet the mandatory financial criteria will be declared nonresponsive. Bids valued in excess of this amount will be considered nonresponsive.

This disclosure does not commit Canada to pay the maximum funding available.

4.1.2.2 Evaluation of Price

The price of the bid will be evaluated in Canadian dollars, Applicable Taxes excluded, FOB destination, Canadian customs duties and excise taxes included.

4.2 Basis of Selection

4.2.1 Basis of Selection- Highest Rated Within Budget

1. To be declared responsive, a bid must:

    a. comply with all the requirements of the bid solicitation;
    b. meet all mandatory technical evaluation criteria;
    c. meet the mandatory financial criteria;
    d. obtain the required minimum of 60 points overall for the technical evaluation criteria which are subject to point rating. The rating is performed on a scale of 100 points;
    e. obtain the required minimum 10 points for the criteria: 1- Relevance of the Concept.

2. Bids not meeting (a) or (b) or (c) or (d) or (e) will be declared non responsive. The 2 responsive bids with the highest number of points will be recommended for award of a contract, provided that the total evaluated price does not exceed the budget available for this requirement.

3. In the event the highest number of points for two or more bidders is identical, the contracts will be awarded to the bidders with the highest rated scores for the Engineering Relevance Criteria: Criterion 2- Understanding the Requirements and Technical Principles; Criterion 3- Feasibility of Achieving Goals and Technical Objectives; and Criterion 4- Scope of the Concept.

PART 5 – CERTIFICATIONS AND ADDITIONAL INFORMATION

Bidders must provide the required certifications and additional information to be awarded a contract.

The certifications provided by Bidders to Canada are subject to verification by Canada at all times. Unless specified otherwise, Canada will declare a bid non-responsive, or will declare a contractor in default if any certification made by the Bidder is found to be untrue, whether made knowingly or unknowingly, during the bid evaluation period or during the contract period.

The Contracting Authority will have the right to ask for additional information to verify the Bidder's certifications. Failure to comply and to cooperate with any request or requirement imposed by the Contracting Authority will render the bid non-responsive or constitute a default under the Contract.

5.1 Certifications Required with the Bid

Bidders must submit the following duly completed certifications as part of their bid.

5.1.1 Integrity Provisions - Declaration of Convicted Offences

In accordance with the Integrity Provisions of the Standard Instructions, all bidders must provide with their bid, **if applicable**, the Integrity declaration form available on the Forms for the Integrity Regime website (http://www.tpsgc-pwgsc.gc.ca/ci-if/declaration-eng.html), to be given further consideration in the procurement process.

5.2 Certifications Precedent to Contract Award and Additional Information

The certifications and additional information listed below should be submitted with the bid but may be submitted afterwards. If any of these required certifications or additional information is not completed and submitted as requested, the Contracting Authority will inform the Bidder of a time frame within which to provide the information. Failure to provide the certifications or the additional information listed below within the time frame specified will render the bid non-responsive.

5.2.1 Integrity Provisions – Required Documentation

In accordance with the section titled Information to be provided when bidding, contracting or entering into a real procurement agreement of the Ineligibility and Suspension Policy (http://www.tpsgc-pwgsc.gc.ca/ci-if/politique-policy-eng.html), the Bidder must provide the required documentation, as applicable, to be given further consideration in the procurement process.

5.2.2 Federal Contractors Program for Employment Equity - Bid Certification

By submitting a bid, the Bidder certifies that the Bidder, and any of the Bidder's members if the Bidder is a Joint Venture, is not named on the Federal Contractors Program (FCP) for employment equity "FCP Limited Eligibility to Bid" list available at the bottom of the page of the Employment and Social Development Canada (ESDC) - Labour's website (https://www.canada.ca/en/employment-social-development/programs/employment-equity/federal-contractor-program.html#).

Canada will have the right to declare a bid non-responsive if the Bidder, or any member of the Bidder if the Bidder is a Joint Venture, appears on the "FCP Limited Eligibility to Bid list at the time of contract award.

5.2.3 Additional Certifications Precedent to Contract Award

5.2.3.1 Canadian Content Certification

This procurement is limited to Canadian services.

The Bidder certifies that:

( ) the service offered is a Canadian service as defined in paragraph 2 of clause A3050T.

5.2.3.1.1 *SACC Manual* clause A3050T (2014-11-27), Canadian Content Definition.

5.2.3.2 Status and Availability of Resources

5.2.3.2.1 *SACC Manual* clause A3005T (2010-08-16), Status and Availability of Resources

5.2.3.3 Education and Experience

5.2.3.3.1 *SACC Manual* clause A3010T (2010-08-16), Education and Experience

5.2.3.4 Language Capability

The Bidder certifies that it has the language capability required to perform the Work, as stipulated in the Statement of Work.

5.2.3.5 List of Proposed Subcontractors

If the bid includes the use of subcontractors, the Bidder must provide a list of all subcontractors including a description of the things to be purchased, a description of the work to be performed and the location of the performance of that work. The list should not include the purchase of off-the-shelf items, software and such standard articles and materials as are ordinarily produced by manufacturers in the normal course of business, or the provision of such incidental services as might ordinarily be subcontracted in performing the Work

The Bidder must provide, for each subcontractor, the following:

a) The name of the subcontractor: complete name of its legal entity and place of incorporation;
b) The subcontractor contact: name, title, telephone, fax numbers and email address;
c) A description of the roles and responsibilities of the subcontractor and/or material to be purchased from that subcontractor;
d) A document signed by the subcontractor indicating its agreement to undertake the work as described in the Bidder's proposal.

PART 6 - SECURITY, FINANCIAL AND OTHER REQUIREMENTS

6.1 Security Requirements

There is no security requirement associated with this requirement.

6.2 Financial Capability

SACC Manual clause A9033T (2012-07-16), Financial Capability

PART 7 - RESULTING CONTRACT CLAUSES

The following clauses and conditions apply to and form part of any contract resulting from the bid solicitation.

7.1 Statement of Work

The Contractor must perform the Work in accordance with the Statement of Work at Annex "A" and the Contractor's technical bid entitled _____, dated _____.

7.2 Standard Clauses and Conditions

All clauses and conditions identified in the Contract by number, date and title are set out in the Standard Acquisition Clauses and Conditions Manual (https://buyandsell.gc.ca/policy-and-guidelines/standard-acquisition-clauses-and-conditions-manual) issued by Public Works and Government Services Canada.

7.2.1 General Conditions

2040 (2016-04-04), General Conditions - Research & Development, apply to and form part of the Contract.

7.2.2 Supplemental General Conditions

The following Supplemental General Conditions apply to and form part of the Contract:

K3410C (2015-02-25), Canada to Own Intellectual Property Rights in Foreground Information

7.2.3 Supplemental General Conditions

The following Supplemental General Conditions apply to and form part of the Contract:

4002 (2010-08-16), Software Development or Modification Services;
4003 (2010-08-16), Licensed Software;

7.3 Security Requirements

There is no security requirement associated with this requirement.

7.4 Term of Contract

7.4.1 Period of the Contract

The period of the Contract is from date of Contract to _____ inclusive.

7.5 Authorities

7.5.1 Contracting Authority

The Contracting Authority for the Contract is:

Name: Caroline Niquette
Title: Supply Specialist
Public Works and Government Services Canada
Acquisitions Branch
Address: Place Bonaventure, 7th Floor
800 rue de la Gauchetière West, Suite 7300
Portail South-West
Montréal (QC), H5A 1L6

Telephone: 514-712-5113
Facsimile: 514-496-3822
E-mail address: caroline.niquette@tpsgc-pwgsc.gc.ca

The Contracting Authority is responsible for the management of the Contract and any changes to the Contract must be authorized in writing by the Contracting Authority. The Contractor must not perform work in excess of or outside the scope of the Contract based on verbal or written requests or instructions from anybody other than the Contracting Authority.

7.5.2 Project Authority

The Project Authority for the Contract is:

Name: _____
Title: _____
Organization: _____
Address: _____

Telephone: ___-___-_____
Facsimile: ___-___-_____
E-mail address: _____

The Project Authority named above is the representative of the department or agency for whom the Work is being carried out under the Contract and is responsible for all matters concerning the evaluation, recommendations and approvals of Progress claims, Schedule or Cost and Acceptance of the deliverable items of the Work under this Contract. Such Progress claim, scheduling, cost or acceptance of deliverables matters may be discussed with the Project Authority, however the Project Authority has no

capacity to authorize changes to the scope of the Work. Changes to the scope of the Work can only be made through a contract amendment issued by the Contracting Authority.

7.5.3 Technical Authority

The Technical Authority for the Contract is:

Name: _____
Title: _____
Organization: _____
Address: _____
Telephone: ___-___-____
Facsimile: ___-___-____
E-mail: _____.

The Technical Authority named above is the representative of the department or agency for whom the Work is being carried out under the Contract and is responsible for all recommendations to the Project Authority concerning the technical content of the Work under the Contract. Technical matters may be discussed with the Technical Authority, however the Technical Authority has no capacity to authorize changes to the scope of the Work. Changes to the scope of the Work can only be made through a contract amendment issued by the Contracting Authority.

7.5.4 Contractor's Representative

Name: _____
Title: _____

Telephone: ___-___-_____
Facsimile: ___-___-_____
E-mail address: _____

7.6 Proactive Disclosure of Contracts with Former Public Servants

By providing information on its status, with respect to being a former public servant in receipt of a *Public Service Superannuation Act* (PSSA) pension, the Contractor has agreed that this information will be reported on departmental websites as part of the published proactive disclosure reports, in accordance with Contracting Policy Notice: 2012-2 of the Treasury Board Secretariat of Canada

7.7 Payment

7.7.1 Basis of Payment

In consideration of the Contractor satisfactorily completing all of its obligations under the Contract, the Contractor will be paid firm lot prices as specified in Annex B, for a cost of $ _____ . Customs duties are included and Applicable Taxes are extra.

Canada will not pay the Contractor for any design changes, modifications or interpretations of the Work, unless they have been approved, in writing, by the Contracting Authority before their incorporation into the Work.

7.7.2 Limitation of Price

SACC Manual clause C6000C (2011-05-16), Limitation of Price

7.7.3 Method of Payment- Milestone Payments

Canada will make milestone payments in accordance with the Schedule of Milestones detailed in the Contract and the payment provisions of the Contract if:

a. an accurate and complete claim for payment using PWGSC-TPSGC 1111, Claim for Progress Payment, and any other document required by the Contract have been submitted in accordance with the invoicing instructions provided in the Contract;

b. all the certificates appearing on form PWGSC-TPSGC 1111 have been signed by the respective authorized representatives;

c. all work associated with the milestone and as applicable any deliverable required has been completed and accepted by Canada.

7.7.3.1 Schedule of Milestones

The schedule of milestones for which payments will be made in accordance with the Contract is detailed in Annex B.

7.7.4 SACC Manual Clause

A9117C (2007-11-30), T1204 - Direct Request by Customer Department

7.7.5 Electronic Payment of Invoices – Contract

The Contractor accepts to be paid using any of the following Electronic Payment Instrument(s):

a. Visa Acquisition Card;
b. MasterCard Acquisition Card;
c. Direct Deposit (Domestic and International);
d. Electronic Data Interchange (EDI);
e. Wire Transfer (International Only);
f. Large Value Transfer System (LVTS) (Over $25M)

7.8 Invoicing Instructions

1. The Contractor must submit a claim for payment using form PWGSC-TPSGC 1111, Claim for Progress Payment.

   Each claim must show:

   a. all information required on form PWGSC-TPSGC 1111;

b. all applicable information detailed under the section entitled "Invoice Submission" of the general conditions;
c. the description and value of the milestone claimed as detailed in the Contract.

2. Applicable Taxes, must be calculated on the total amount of the claim before the holdback is applied. At the time the holdback is claimed, there will be no Applicable Taxes payable as it was claimed and payable under the previous claims for progress payments.

3. The Contractor must prepare and certify **one (1) original and two (2) copies** of the claim on form PWGSC-TPSGC 1111, and forward:

a) the **original and one (1) copy** to the Canadian Space Agency at the address shown on page 1 of the Contract under "Invoices" (Financial Services Section) for appropriate certification by the Project Authority identified herein after inspection and acceptance of the Work takes place;

and,

b) **one (1) copy of the original** progress claim to the Contracting Authority identified under the section entitled “Authorities” of the Contract.

4. The CSA's Financial Services Section will then forward **the original and one (1) copy** of the claim to the Contracting Authority for certification and onward submission to the Payment Office for the remaining certification and payment action.

5. The Contractor must not submit claims until all work identified in the claim is completed.

7.9 Certifications and Additional Information

7.9.1 Compliance

Unless specified otherwise, the continuous compliance with the certifications provided by the Contractor in its bid or precedent to contract award, and the ongoing cooperation in providing additional information are conditions of the Contract and failure to comply will constitute the Contractor in default. Certifications are subject to verification by Canada during the entire period of the Contract.

7.9.2 *SACC Manual* Clauses

A3060C (2008-05-12), Canadian Content Certification

7.10 Applicable Laws

The Contract must be interpreted and governed, and the relations between the parties determined, by the laws in force in _____.

7.11 Priority of Documents

If there is a discrepancy between the wording of any documents that appear on the list, the wording of the document that first appears on the list has priority over the wording of any document that subsequently appears on the list.

(a) the Articles of Agreement;

(b) the supplemental general conditions:
4002 (2010-08-16), Software Development or Modification Services;
4003 (2010-08-16), Licensed Software;
(c) the general conditions 2040 (2016-04-04), General Conditions - Research & Development;
(d) the general conditions - modification K3410C (2015-02-25), Canada to Own Intellectual Property Rights in Foreground Information;
(e) Annex A, Statement of Work;
(f) Annex B, Basis of Payment;
(g) the Contractor's bid dated _____.

7.12 Foreign Nationals (Canadian Contractor)

SACC Manual clause A2000C (2006-06-16), Foreign Nationals (Canadian Contractor)

7.13 Insurance

SACC Manual clause G1005C (2016-01-28), Insurance - No Specific Requirement

7.14 Work Site Access

SACC Manual clause A1009C (2008-05-12), Work Site Access

7.15 Directive on Communications with the Media

1. Definitions

"Communication Activity(ies)" includes: public information and recognition, the planning, development, production and delivery or publication, and any other type or form of dissemination of marketing, promotional or information activities, initiatives, reports, summaries or other products or materials, whether in print or electronic format that pertain to the present agreement, all communications, public relations events, press releases, social media releases, or any other communication directed to the general public in whatever form or media it may be in, including but without limiting the generality of the preceding done through any company web site.

2. Communication Activities Format

The Contractor must coordinate early on with the Canadian Space Agency (CSA) all Communication Activities that pertain to the present contract.

Subject to review and approval by the CSA, the Contractor may mention and/or indicate visually, without any additional costs to the CSA, the CSA's participation in the contract through at least one of the following methods at the complete discretion of the CSA:

a. By clearly and prominently labelling publications, advertising and promotional products and any form of material and products sponsored or funded by the CSA, as follows, in the appropriate official language:

"This program/project/activity is undertaken with the financial support of the Canadian Space Agency."

"Ce programme/projet/activité est réalisé(e) avec l'appui financier de l'Agence spatiale canadienne."

b. By affixing CSA's corporate logo on print or electronic publications, advertising and promotional products and on any other form of material, products or displays sponsored or funded by the Canadian Space Agency.

Any and all mention or reference to the Canadian Space Agency in addition to those specified above in (a) and (b) must be specifically accepted by the CSA prior to publication.

The Contractor must obtain and use a high resolution printed or electronic copy of the CSA's corporate identity logo and seek advice on its application, by contacting the project authority as mentioned in Paragraph 7.5.2 of this contract.

3. Communication Activity Coordination Process

The contractor must coordinate with the CSA's Directorate of Communications and Public Affairs all Communication Activities pertaining to the present contract. To this end, the contractor must:

a. As soon as the Contractor intends to organize a Communication Activity, send a Notice to the CSA's Directorate of Communications and Public Affairs. The Communications Notice must include a complete description of the proposed Communication Activity. The Notice must be in writing in accordance with the clause Notice included in the general conditions applicable to the contract. The Communications Notice must include a copy or example of the proposed Communication Activity.

b. The contractor must provide to the CSA any and all additional document in any appropriate format, example or information that the CSA deems necessary, at its entire discretion to correctly and efficiently coordinate the proposed Communication Activity. The Contractor agrees to only proceed with the proposed Communication Activity after receiving a written confirmation of coordination of the Communication Activity from the CSA's Directorate of Communications and Public Affairs.

The Contractor must receive beforehand the authorization, approval and written confirmation from the CSA's Directorate of Communications and Public Affairs before organizing, proceeding or hosting a communication activity

ANNEX “A”
STATEMENT OF WORK

The Statement of Work (Annex A) appended to the bid solicitation package is to be inserted at this point and forms part of the document.

ANNEX "B"
BASIS OF PAYMENT AND
SCHEDULE OF MILESTONES

1. Bidders must provide a firm price for the overall project:

Phase 0
Total Firm Price CAN $.
(Taxes extra, if applicable) _____$

2. Milestones: The schedule of milestones for which payments will be made in accordance with the Contract is as follows:

No	Milestone	Deliverables	% of Total Price	Date (months after contract award)
1.			N/A	**+2 weeks**
2.				**+ 3 months**
3.				**+ 6 months**
4.				**+ 8 months**
5.				**+ 10 months**
6.				**+ 12 months**

ANNEX "C"
to PART 3 OF THE BID SOLICITATION

ELECTRONIC PAYMENT INSTRUMENTS

The Bidder accepts to be paid by any of the following Electronic Payment Instrument(s):

( ) VISA Acquisition Card;
( ) MasterCard Acquisition Card;
( ) Direct Deposit (Domestic and International);
( ) Electronic Data Interchange (EDI);
( ) Wire Transfer (International Only);
( ) Large Value Transfer System (LVTS) (Over $25M)

ATTACHMENT 1 TO PART 3
TECHNICAL AND MANAGERIAL BID PREPARATION INSTRUCTIONS

Outline and Content of Section I of the Bid

The required outline and content of Sections I and II of Part 3 - Bid Preparation Instructions, is detailed herein. Should clarification be required, it is the responsibility of the Bidder to contact the Contracting Authority prior to submitting the bid.

Sections I and II should address only one project and be contained within a single document/file, not exceeding **75** pages, excluding 6) Bid Appendices. The information should be organized in the following order:

1) Title / Project Identification Page;
2) Executive Summary;
3) Table of Contents;
4) Technical Bid;
5) Managerial Bid;
6) Bid Appendices:

    6.1) List of acronyms used in the Bid;
    6.2) Bidder's Criteria Substantiation (Refer to Section 1.2 of the Attachment 1 to Part 4: Point rated Evaluation Criteria, Section 1.2);
    6.3) Résumés or NSERC form 100, or equivalent (including résumés of subcontractors); and
    6.4) List of Contacts.

    If applicable:
    6.5) Corporate literature;
    6.6) Relevant technical papers published by team members;
    6.7) Any other Bid appendices deemed appropriate by the Bidder.

    Note: The structure of Sections I and its subsections are described below. Some of the subsection headings are followed by numbers in brackets. These numbers represent the Evaluation Criteria (see Attachment 1 to Part 4) that are applicable to that specific section/subsection.

1. Title / Project Identification Page

This is the first page of the Bid. It should be laid out in accordance with the requirements specified in Part 3 and should clearly state:

1) RFP file number;
2) The company's name and address;
3) The title of the proposed project (the use of acronyms in the title is discouraged, unless they are described);
4) A short summary of the Bid in 8 lines (maximum).

2. Executive Summary

The Executive Summary of Sections I and II of the Bid should be a stand-alone document suitable for public dissemination, for example, through the CSA web site, if the Bid is successful. It should not exceed one page in length (8.5" x 11") and should highlight the following elements:

1) Project objectives;
2) Targeted Technology;
3) Main technical innovations;
4) Major milestones and deliverables; and
5) Relevance to CSA strategy and programs;

3. Table of Contents

The table of contents should be formatted such that its headings are linked to their respective location in the Bid for ease of reference when using the Bid's electronic version.

4. Technical Bid

The Bid should describe the proposed project as outlined in the following subsections. The bidder should strive to address all items under the letter "D" of each criterion.

4.1 Mission Criteria

4.1.1 Relevance of the Concept (Evaluation Criterion 1)

This subsection should provide the substantiated evidence describing the relevance of the proposed concept relative to the scope of work and mission objectives. It should address and substantiate how the proposed contribution addresses the scope of the work presented in the SOW. The description should include an understanding of the stated performance and functional requirements with explanations as to how the proposed solution would achieve the stated requirements. In doing so, this section should describe the degree of relevance the proposed concept has with the Bidder's technology. The relevance of the proposed concept will consider the components selected including their suitability, design, maturity levels, and space heritage or path to spaceflight.

4.2 Engineering Criteria

4.2.1 Understanding the Requirements and Technical Principles (Evaluation Criterion 2)

This section should identify and substantiate in detail the underlying requirements and the technical principles and knowledge necessary for realizing the proposed work. It should thoroughly demonstrate an understanding of these requirements and principles. The proposal should include a presentation of proposed concept and operations requirements that will be addressed by the proposed activities and objectives, and their relationship to overall objectives. References to and a thorough discussion of the existing literature relevant to the central theme of the Phase 0 should be provided.

4.2.2 Feasibility of Achieving Goals and Technical Objectives (Evaluation Criterion 3)

In this subsection the Bidder should provide a description and overall feasibility assessment of the proposed approach and the degree to which it is capable of delivering on the goals and technical objectives. The bidder should elaborate on the technical risks associated with the eventual testing & integration, and address the suggested methodology on how to resolve the technical challenges during the project implementation of the concept, including providing engineering support during the spacecraft integration phase. The proposed effort should be well presented and substantiated through well-conceived and feasible concept and methods that can obtain the desired technical results. The bid should show and substantiate that the overall mission scenario is valid. It should be demonstrated that the proposed concept is based on a reasonable technology development plan or on well proven technology. A preliminary technology development roadmap should be presented in order to meet the technical basic requirements and mission objectives that will be further developed during phase 0. The CSA Technology Readiness Levels and Assessment Guidelines are provided in Annex A SOW , Applicable Documents section and the

Technology Readiness Levels Handbook for Space Applications can be provided on the CSA's FTP or ISEP sites, for further details on technology readiness.

4.2.3 Scope of the Study (Evaluation Criterion 4)

The section should address the scope and aspects of the proposed approach in relation to what is asked in the statement of work. It should provide a detailed description and substantiation of a relevant approach for the Phase 0 development including a conceptual design of potential systems and subsystems, and a description of the operational concept.

5. Managerial Bid

The Managerial Bid should demonstrate the effectiveness and commitment of the Bidder in delivering the project on time and budget. Its sub-sections should address in detail: key-personnel qualifications, team organisation and arrangements, previous project experience, and the Management Plan.

5.1 Corporate Resource Capabilities (Evaluation Criterion 5)

This criterion assesses the knowledge, experience, expertise and complementarities of the corporate entities to which the individuals of the proposed team belong, and the infrastructure and tools in place to perform the work.

5.1.1 Corporate Capabilities

This subsection should identify the organisations involved and their expertise outlining their respective qualifications. It should identify capacity of the organisation's capability to use resources effectively, the methods and tools available to perform the work stated in the SOW, and the experience with the partnering subcontractors in the past.

5.1.2 Team Organisation and Arrangements

This subsection should outline the roles and responsibilities of the proposed team members, and discuss and highlight the unique expertise they offer with respect to the capability of the team. Detailed résumés are to be put in an appendix of Sections I and II of the Bid. Provisions for back-up personnel for key positions are to be stated. Key personnel include at least the principal investigator, project manager and technical leads for all the top-level technical work packages.

This subsection should also provide details on the subcontractors' roles, responsibilities and on the nature of their contractual relationship with the prime contractor. An organisational chart should be included illustrating the structure of the proposed project team.

Letters of Agreement between the prime contractor, subcontractors, and other collaborators should be provided. These Letters of Agreement typically describe the scope-of-work, financial contributions *(in Financial Bid only*), IP ownership, commercialisation activities, and any other applicable items. For scientific co-investigators, this letter should include the proposed role and time commitment.

5.1.3 Previous Project Experience

The Bidder should identify any previous experience with projects of a similar scope as the one proposed, including any projects undertaken with the CSA or other government institutions. The Bidder should list previous projects and assignments undertaken, within the last ten years, which are relevant to proposed scope of work. The Bidder should identify any team members in the current Bid that participated in those other projects and describe the nature of their contributions to those projects.

Note: The Bidder may describe as many previous projects as it feel is necessary in order to adequately demonstrate the experience and qualifications of the company and of the proposed team, as long as the Bid length is compliant to the requirement.

5.2 Project Management Plan (Evaluation Criterion 6)

This subsection describes the Management Plan that will be retained in order to deliver the project, and to do so in the most effective manner. The Management Plan should contain, as a minimum, the following information: Work Breakdown Structure (WBS), WP definitions, personnel allocation, managerial risk assessment, milestones and deliverables, schedule (Gantt chart) with predecessors and successors, constraints, and project control system.

The Management Plan's presentation should be based on the recognised management tools most applicable to the proposed project, such as a scope planning (WBS), schedule development charts (e.g. Gantt chart, etc.). Equivalent company-developed, project-tailored tools/charts are also acceptable, provided that the information is complete and comprehensive.

5.2.1 Work Package Definition

This Management Plan subsection should define and specify the work to be executed according to the requirements of this SOW. The project should be broken down into Work Packages (WPs). Each WP should focus on specific activities that will form the total project and, as a minimum, should define and describe the specific work to be carried out and indicate: the person responsible, the WP's associated levels-of-effort and required resources, the schedule (start and finish dates), the risks, and its associated deliverable or output.

WPs stem from the WBS. The WBS should be taken to a low enough level and the associated WP should be defined in sufficient depth in order for the Bidder to demonstrate a clear understanding of the process that will be followed to perform the project.

As a guideline, Table 1 of this attachment presents a fictitious example of a Work Package Definition Sheet. The Bidder should provide a detailed SOW for each subcontractor along with a Letter of Agreement in Principle to be included in the Bid appendices. The subcontractors' price information should be included in the **Financial Bid only**.

Table 1: Example of Work Package Definition Sheet

Project Name:	Canadian Lunar Rover	Date:	
Customer:	CSA		

Work Package Title:	Thermal subsystem System Engineering	**Work Package Number:**	6.01.04.03.01
		Working toward Milestone:	
Estimated Effort:		**Human Resources (ordered by skills):**	
Estimated Duration:			
Work Package Objective:	The system engineering of thermal subsystem		
Inputs:			
Tasks/Activities:	Phase A: • Define the top-level thermal requirements of the rover. • Develop the thermal SOW of phase B/C/D. • Define the thermal WPs of phase B/C/D. • Define the deliverables of thermal designs. • Define the thermal interface controls between the rover and the payloads (SATS and RESOLVE), lander, and launch vehicle. • Budget the mass, volume, power, and telemetry of thermal subsystem. • Develop risk analysis of thermal subsystem. • Acquire tools for thermal subsystem of phase B/C/D/E. • Present/Review/evaluate/verify the thermal design philosophy, concept, analysis, and trade studies of phase A. Phase B/C/D:		
Outputs:	Documentation of "Thermal Analysis and Designs of Lunar Rover"; SOW, WP of phase B/C/D; mass, volume, power, telemetry budgets for the rover system level; ICD requirements;		
Assumptions for Effort Estimation:			
T&L :			
Material Cost:			
ToTal: ***(Labour & non-Labour)***			

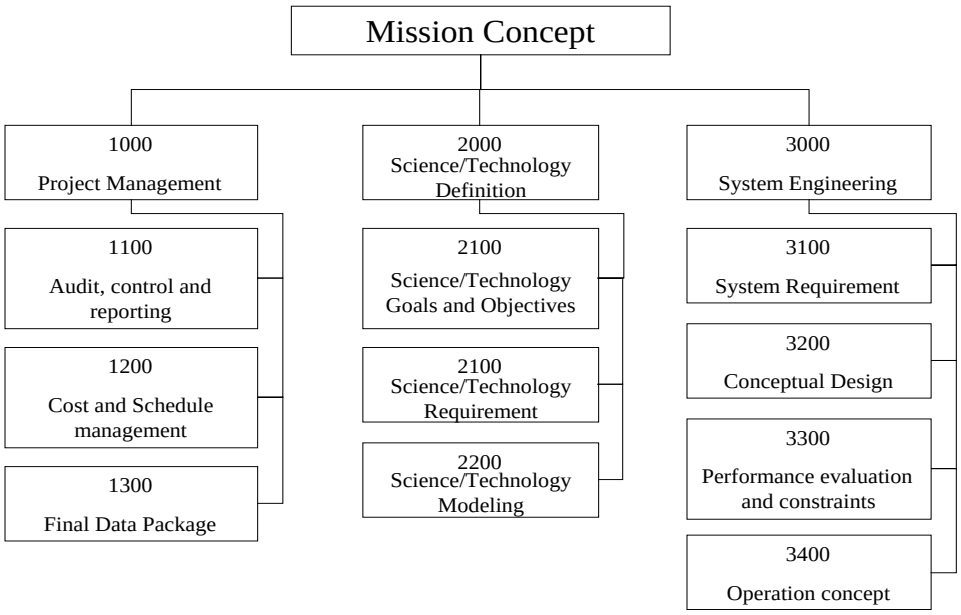

Figure 1: Example of a Work Breakdown Structure

5.2.2 Personnel Allocation

This Management Plan subsection should include a resource assignment matrix showing the level-of-effort for each individual team member that has been allocated to each WP. The matrix should identify each individual by name, and provide the estimated time (number of hours or days) required to complete each task. As a guideline, Table 2 of this attachment presents a fictitious example of a Responsibility Allocation Matrix (RAM). **The RAM should be presented in both the Managerial Bid and the Financial Bid**.

Table 2: Example of Responsibility Allocation Matrix

WBS number	Work Pack Title	*Resource A*		*Resource B*		*Resource C*		Total
1.1	Project Management	A	200	P	25	P	25	250
1.2	Literature Survey	A	25	P	100	-	0	125
1.3	Requirements	P	50	A	100	P	100	250
1.4	Design	P	100	A	100	P	150	350
1.5	Build	-	0	P	200	A	150	350
1.6	Test and Analysis	A	100	P	200	P	200	500
	Total		475		725		625	1825

P: Participant
A: Accountable

5.2.3 Managerial Risk Assessment

This Management Plan subsection should provide an assessment of the managerial risks involved in performing the work for the Phase 0 study, and identify critical issues that may jeopardise the successful completion of the project within cost and schedule constraints.

5.2.4 Milestones and Deliverables

Milestones and deliverables should be detailed in accordance to what is specified in Table 3-2: Proposed Project Milestones in Annex A - Statement of Work.

5.2.5 Schedule

This Management Plan subsection should relate tasks, milestones, predecessors&successors, Constraints, and deliverables to a project timetable (Gantt). For planning purposes, the project expected start date is September 1st 2018.

5.2.6 Project Control System

This Management Plan subsection should outline the methods and systems to be used to control tasks, schedules, and costs for the project. Any project management tool or a spreadsheet software package may be used as long as it contains, as a minimum, the information required in the Monthly Progress Report (DID-0006). Additionally, the Project Control System should provide the capability to report the amount of work per WBS item for each individual on a monthly basis. During phase D, the bidder should have the capacity to report based on Earned Value Management techniques.

The cost figures and values of all industrial contributions should be provided separately in the Financial Bid in Section II.

6. Bid Appendices

The following items should be addressed in individual appendices as part of the Bids.

Required Bid Appendices

6.1) List of acronyms used in the Bid
6.2) Bidder's Criteria Substantiation: Refer to Section 1.2 of the Attachment 1 to Part 4: Point rated Evaluation Criteria
6.3) Résumés: The Bid should include résumés (and/or NSERC form 100) of all key personnel and these should be appended to Sections I and II.
6.4) List of Contacts: The list of contacts should be appended to Sections I and II, in a format suitable for distribution and should include all of the Bidder's points-of-contact involved in the Bid development and/or contract negotiations. The following example format should be used:

Table 3: Sample List of Contacts

Role	Name	Telephone	Fax	E-mail
Project Manager				
Project Engineers/ Principal Investigator				
Contracting Authority				
Claims officer				
Communications (for press release)				
Etc.				

Applicable Bid Appendices

The following Bid appendices are to be provided, *if applicable,* with Sections I and II:
6.5) Corporate literature: Only literature that is relevant and will be useful to support the Bid.
6.6) Relevant technical papers published by team members.
6.7) Any other Bid appendices deemed appropriate by the Bidder.

Bidders are reminded that there is a limited number of pages that the bid must not exceed. If the number of pages of Sections I and II, as described herein, is exceeded, the evaluation will strictly be based on the first 75 pages submitted, excluding appendices.

ATTACHMENT 1 TO PART 4
POINT RATED EVALUATION CRITERIA

1.1 Point Rated Criteria

The Bidder must achieve the minimum score requirement as indicated in Table 1: List of Evaluation Criteria and Associated Ratings. The bid will be evaluated according to the point-rated criteria as specified in Table 1 and as described in Section 1.3 Evaluation Criteria and Benchmark Statements.

Proposals will be evaluated according to the point-rated criteria as specified in Table 1: List of Evaluation Criteria and Associated Ratings. The criteria are grouped under the following categories:

- Mission Criteria
- Engineering Relevance Criteria
- Management Criteria

To be responsive, the Bidder must achieve the minimum score requirements as indicated in Table 1. The Section 1.3: Evaluation Criteria and Benchmark Statements, contains a series of evaluation criteria, each supported by a set of 5 benchmark statements (0, A, B, C, D). Each of these statements has a corresponding relative value:

0 = 0 % of maximum point rating
A = 25 % of maximum point rating
B = 50 % of maximum point rating
C = 75 % of maximum point rating
D = 100 % of maximum point rating

As an example, the maximum point rating for the criterion is 10 points.

If a Bid receives a “C” for this criterion in the evaluation process, the score attributed will be:

75 % of 10 points = 7.5 points (score)

Table 1: List of Evaluation Criteria and Associated Ratings identifies:

l. The maximum point rating assigned to each criterion;
2. The maximum point rating possible for the overall score;
3. The minimum point rating required for the overall score.
4. The minimum point rating required for the Criterion 1 “Relevance of the Concept”

Table 1: List of Evaluation Criteria and Associated Ratings

Evaluation Criteria and Ratings	
	Ratings
Mission Criteria	
1. Criterion 1 - Relevance of the Concept	20
Minimum Score	***10***
Engineering Relevance Criteria	
2. Criterion 2 - Understanding the Requirements and Technical Principles	20
3. Criterion 3 - Feasibility of Achieving Goals and Technical Objectives	20
4. Criterion 4 - Scope of the Study	10
Minimum Score	*N/A*
Management Criteria	
5. Criterion 5 - Corporate Resource Capabilities	10
6. Criterion 6 - Project Management Plan	20
Minimum Score	*N/A*
Maximum Overall Score	***100***
Minimum Overall Score Requirement	***60***

1.2 Bidder's Evaluation

The Bidder is requested to provide their own substantiation, which should be submitted as an appendix to their Section 1.

For each of the criteria, provide the substantiation and summarized cross-reference (s) to the bid.

The substantiation should be concise yet sufficiently complete to give the evaluators a good overall appreciation of the bid's merit relative to each criterion. Cross-references to appropriate sections of the bid should be provided and the essence of the referenced information should be summarized in the substantiation.

For convenience, a template for the Substantiation Table is provided in Table 2 below. Enter each relevance/technical and management criterion section number, and the substantiation. Approximately half a page should be sufficient to make the Bidder's case for the rating assigned in the substantiation column.

Table 2: Bidder's Criteria Substantiation

Company: Project Title:	
Criteria	Substantiation
Ex: **1** *(criterion number)*	*Criterion substantiation and Bidder's bid cross-reference.* *It is expected that 300 words or so should be sufficient to make your case*

1.3 Evaluation Criteria and Benchmark Statements

Mission Criteria

1. Criterion 1 - Relevance of the Concept

This criterion evaluates the relevance of the proposed concept relative to the scope of work presented in the SOW.

Score	Benchmark Statements
0	The relevance of proposed concept is not addressed.
A	The relevance of the proposal concept are only partially addressed and not substantiated.
B	The relevance of the proposed concept are addressed and substantiated, but gaps exit.
C	The relevance of the proposed concept are addressed and substantiated and no gap exists.
D	The relevance of the proposed concept are addressed in detail and well substantiated and no gap exists.

Engineering Relevance Criteria

2. Criterion 2 - Understanding the Requirements and Technical Principles

This criterion assesses the degree to which the Bid identifies and substantiates in detail the underlying requirements and technical principles and also to what extent it thoroughly demonstrates an understanding of these requirements and principles and how they relate to the mission objectives as stated in Annex A – Statement of Work

Score	Benchmark Statements
0	The bid does not address the requirements, OR Does not identify the technical principles driving the proposed concept.
A	The proposal includes an incomplete overview of the main requirements OR The proposal demonstrates incomplete knowledge of the technical principles relevant to the goal of the Phase 0; OR The bid does not identify how the objectives will help in further defining these requirements; OR The proposal does not include an adequate review of the existing literature or that of previous relevant technology.
B	The proposal includes only an overview of the main requirements; AND The proposal exhibits a general understanding of these requirements and principles; AND The proposal demonstrates a basic knowledge of the technical principles relevant to the goal of the Phase 0; AND The proposal includes a cursory review of and references to existing literature or that of previous activities relevant to the central theme of the proposed concept
C	The proposal identifies and demonstrates understanding of the main requirements; AND

The proposal demonstrates knowledge of the technical principles relevant to the goal of the Phase 0; AND
The bid includes a presentation of the proposed concept and operations requirements that will be addressed by the proposed activities and objectives; AND
The proposal includes references to and a discussion of existing literature or previous activities relevant to the central theme of the proposed concept.

D The proposal includes an exhaustive identification and understanding of the requirements; AND
The proposal demonstrates a comprehensive knowledge of the technical principles relevant to the goal of the Phase 0; AND
The bid includes a presentation of proposed concept and operations requirements that will be addressed by the proposed activities and objectives, and their relationship to overall mission objectives; AND
The proposal includes references to and a thorough discussion of the existing literature relevant to the central theme of the proposed concept.

3. Criterion 3 - Feasibility of Achieving Goals and Technical Objectives

The criterion assesses the description and overall feasibility of the proposed approach and the degree to which it is capable of delivering the goals and technical objectives. This includes the compatibility of the technology selected and incorporation into the proposed design for addressing the technical requirements and enhancements. This criterion evaluates the technical risks associated with the eventual integration and implementation of the concept. It assesses if the proposed effort is well documented and substantiate.

Score Benchmark Statements

0 The feasibility of achieving the goals and technical objectives is not demonstrated

A The proposal does not present an adequate case with system(s) that can deliver the technical objectives; OR
The proposed concept can obtain the desired technical results, but gaps exist; OR
Main elements of a preliminary technology development road map, in order to meet the technical basic requirements, are lacking.

B The proposal presents an adequate case with system(s) that can deliver the technical objectives; AND
The proposed concept can obtain the desired technical results, but some details or information of limited importance are omitted; AND
Main elements of a preliminary technology development road map, in order to meet the technical basic requirements or enhancements, are lacking.

C The proposal presents a well-referenced case with system(s) that can deliver the technical objectives; AND
The proposed concept displays feasible and valid concepts and methods that can obtain the desired technical results with details; AND
Main elements of a preliminary technology development road map are presented in order to meet the technical basic requirements and enhancements of the study.

D The proposal presents a well-referenced and convincing case with system(s) that can confidently deliver the technical objectives. AND
The proposed concept relies on well proven technology with one or more components having flight heritage and is substantiated with ample details; AND

A preliminary technology development roadmap is presented in order to meet the technical basic requirements and enhancements of the study.

4. Criterion 4 - Scope of the Study

The criterion assesses the description and overall scope of the proposed Phase 0.

Score	Benchmark Statements
0	The bid does not address the scope and the aspects of what is requested in the SOW OR does not provide a description of the approach for the Phase 0 development.
A	The bid addresses the scope and the aspects of what is requested in the SOW, but gaps exist, AND It does not provide a description of the approach for the Phase 0 development.
B	The bid addresses the scope and the aspects of what is requested in the SOW, but gaps exist, AND It provides a description of the approach for the Phase 0 development, but either gaps exit or the approach is not relevant.
C	The bid addresses the full scope and aspects of what is requested in the SOW, AND It provides a description and substantiation of a relevant approach for the Phase 0 development.
D	The bid addresses the full scope and aspects of what is requested in the SOW. AND It provides a detailed description and substantiation of a relevant approach for Phase 0, AND The bid provides a preliminary design (lay-out) of the proposed system and a description of the operational concept.

Management Criteria

5. Criterion 5 - Corporate Resource Capabilities

This criterion assesses the knowledge, experience, expertise and complementarities of the corporate entities to which the individuals of the proposed team belong and of the personnel themselves, and the infrastructure and tools in place to perform the work.

Score	Benchmark Statements
0	No information about the capabilities of the Bidder's organization, Subcontractor and Partner's organizations is given.
A	Some of the organizations involved have a reasonable track record of successfully completing projects, however these projects are not of similar scope, complexity and technology. No details are given about the methods, processes or tools* in place to successfully complete projects. It is unclear whether the organizations involved have employees to provide back-up for members of the proposed team. The Bid demonstrates only little to no expertise in Project Management by the identified team and the roles and responsibilities of the team members are not defined. The Prime Contractor has little experience with subcontractors in the past. The Bidder has presented incomplete organization charts of some of the organizations involved.
B	Some of the organizations involved have a good track record of successfully completing projects of similar scope, complexity and technology but no details are given about the methods, processes

and tools* in place to successfully complete such projects. It is unclear whether the organizations involved have employees to provide back-up for members of the proposed team. The Bid demonstrates some expertise in Project Management but the team may have deficiencies in the overall skills of its members. The Bidder has presented organization charts of some of the organizations involved.

C Some of the organizations involved have a good track record of successfully completing projects of similar scope, complexity and technology. The Bid contains some information about methods, processes and tools* in place to successfully complete such projects. Some of the organizations have employees to provide back-up for their member(s) of the proposed team, the roles and responsibilities for most of the team members, including sub-contractors, are defined. The Bid demonstrates good expertise in Project Management by the Prime Contractor and the key personnel have experience in the design and development of at least two projects of similar complexity and in a similar environment as described in the SOW. Organization charts of some of the organizations involved are presented.

D Each organization involved has a good track record of successfully completing projects of similar scope, complexity and technology. The Bid demonstrates that each organization involved has the appropriate methods, processes and tools* in place to successfully complete such projects. Each organization has employees to provide back-up for their member(s) of the proposed team, the roles and responsibilities for most of the team members, including sub-contractors, are defined. The Bid demonstrates excellent expertise in Project Management by the Prime Contractor as well as by sub-contractors and/or partners with the key personnel having significant experience in the design and development of at least three projects of similar complexity and in a similar environment as described in the SOW. Organization charts of all the organizations involved are presented.

* Tools include key engineering software to perform space mission analyses & design, simulations, and analysis of high-level performance of rover/payload systems.

6. Criterion 6 - Project Management Plan

This criterion assesses the comprehensiveness of the management plan (including WBS, WPs, effective use of available resources, labor distribution, detailed schedule and milestones, and managerial risk assessment) and evaluates the effectiveness of the described methodology (eg. CPM, Agile, Scrum, etc.) in successfully achieving the stated objectives of the work to carry out this concept study for the whole mission.

Score Benchmark Statements

0 The work-plan does not follow methodological approach and is unlikely to obtain the appropriate objectives; OR
The proposal does not address this criterion.

A The proposal presents a poor work-plan; OR
The proposed methodology is not effective in achieving the objectives of the work; OR
There is a lack of correlation between the work-plan and the management method; OR
Risks are not identified.

B The proposal presents a basic work-plan; OR
The proposed methodology is not effective in achieving the objectives of the work; OR
There is a lack of correlation between the work-plan and the management method; OR
Risks are identified and mitigation strategies are insufficient.

C The work-plan as described in the proposal is based on a methodological approach; AND

The effectiveness of the proposed methodology in achieving the objectives of the work is credible; AND
The correlation between the work-plan and the management method exists; AND
Risks are identified and mitigation strategies are discussed.

D The work-plan as described in the proposal follows a clearly defined methodology; AND
The effectiveness of the proposed methodology in achieving the objectives of the work is highly credible; AND
The correlation between the work-plan and the management method is clear; AND
Comprehensive risk analysis and mitigation strategies are provided.

Glossary of Terms

Project Methodology	Project methodology life cycle defines the five project management phases or processes: define, plan, launch, manage, and close. Each phase addresses a specific aspect of managing a project or program from definition through close. The methodology can also encompass the different styles/processes including Agile, Waterfall, Scrum, CPM, PMI PMBoK, etc.
CPM	Critical Path Method: developed in the 1950s is based on the concept that there are some tasks you can't start until a previous one has been finished. It contains a list of activities and uses a WBS and a timeline, as well as dependencies, milestones, and deliverables. It outlines critical and noncritical activities by calculating the "longest" (on the critical path) and "shortest" (float) time to complete tasks to determine which activities are critical and which are not. Identifying and focusing on this critical path allows project managers to prioritize and allocate resources to get the most important work done, and reschedule any lower priority tasks that may be clogging up your team's bandwidth. This way, if changes need to be made to the project schedule, you can optimize your team's work process without delaying the end results.
PMI PMBok	Although debatable, some organizations say they use the PMBok as a project mgmt. methodology. What this means is that they use the five processes that are specified and agreed upon by the PMI, namely; initiating, planning, executing, controlling, and closing. This is acceptable to the CSA.

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CSA-LSM-SOW-0002

Canadian Space Agency

ANNEX "A"

LSM PHASR – Lunar Surface Mobility Precursor to Human And Science Rover - Phase 0

Statement of Work (SOW)

Initial Release
March 28th , 2018

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1 INTRODUCTION

A key aspect of the Space Policy Framework of Canada is: ensuring that Canada is a sought-after partner in the international space exploration Missions that serve Canada's national interests; and continuing to invest in the development of Canadian contributions in the form of advanced systems and scientific instruments as part of major international endeavours. As a member of the International Space Exploration Coordination Group (ISECG), one particular aspect of Canada's interest is Lunar Surface Mobility (LSM) related activities. Through international partnership under the Lunar Exploration Demonstrator Mission Definition Study; the CSA is continuing its collaboration to define concepts for collaborative missions Beyond Low Earth Orbit (BLEO), as presented in the Global Exploration Roadmap (GER) (RD-4). The goals are to expand International Partnerships (IPs), develop human exploration technologies and capabilities, synergize human and robotic capabilities, foster commercial industry and economic development, and advance scientific knowledge.

The key driver for LSM is to have Human presence in the cis-Lunar space on an orbiting vehicle previously referred as the Deep Space Gateway (DSG/LOP-G) and recently as the Lunar Orbiting Platform Gateway (LOP-G) that would orbit around the Moon and provide a relay point to a crew of four for performing lunar surface campaign up to a duration of 42 consecutive Earth days. This capability would provide a rather complete coverage of the surface of the Moon with a primary focus on the far-side South pole region. This area includes a number of zones that have been identified as very valuable sites for scientific missions of high interest resulting into key activities such as: Lunar Sample Return (LSR) missions, lunar volatiles characterization, and potential future In-Situ-Resources Utilization (ISRU) demonstration. Even considering the fundamental differences between the Moon and Mars, these activities would prepare, technically and operationally, the space community for the larger endeavour of landing humans on Mars with an orbiting spaceship around the red planet.

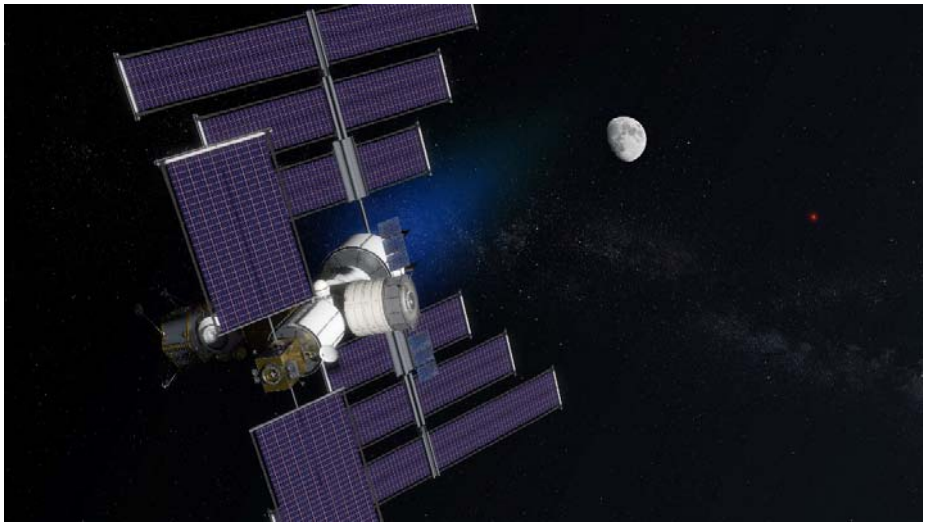


FIGURE 1-1 DEEP SPACE GATEWAY (DSG/LOP-G)/ LUNAR ORBITING PLATFORM GATEWAY

The current roadmap is targeting a human return at the surface of the Moon by the end of the 2020 decade. By 2024, this series of surface campaigns would be enabled by the DSG/LOP-G/LOP-G

in cis-lunar orbit providing a communication relay from Earth notionally, and as a base for astronauts to operate surface assets as well as being the spaceport enabling travel between the lunar surface and the orbiting station. The assumed architecture is based on a four crew members surface campaign per year; each of these extending for a duration of up to 42 days (14 day+ 14 night+ 14 day) and a total of 5 missions over 5 years. In order to prepare the human return, a minimum of one robotics mission is planned. This demonstrator/precursor mission will focus on lunar sample return to Earth via the DSG/LOP-G and hundreds of kilometers traverse completing many scientific and technical objectives such as night survival, a potential ISRU demonstration as a secondary objective, robotics sample return, etc. This preparatory demonstrator mission is referred as the human lunar surface demonstrator mission, formally known as: Human Enhanced Robotic Architecture and Capability for Lunar Exploration and Science (HERACLES) (see RD-5 and RD-7). The lunar rover component of this architecture will be referred as the Precursor to Human And Scientific Rover (PHASR).

1.1 HUMAN SURFACE MISSION ARCHITECTURE OVERVIEW

The Human Surface Mission Architecture concept is based on a minimum surface capability that would enable five campaigns at a targeted rate of one per year of 42 days each as a nominal baseline. Proposed science sites are described in the lunar science report: A Global Lunar Landing Site Study to Provide the Scientific Context for Exploration of the Moon (RD-18). Schrodinger crater is the reference landing site for the HERACLES surface demonstration mission and is further described in Figure 1-15. A final HERACLES landing site will be determined after confirmation of the mission. It will be consistent with the surface properties of the reference landing site.

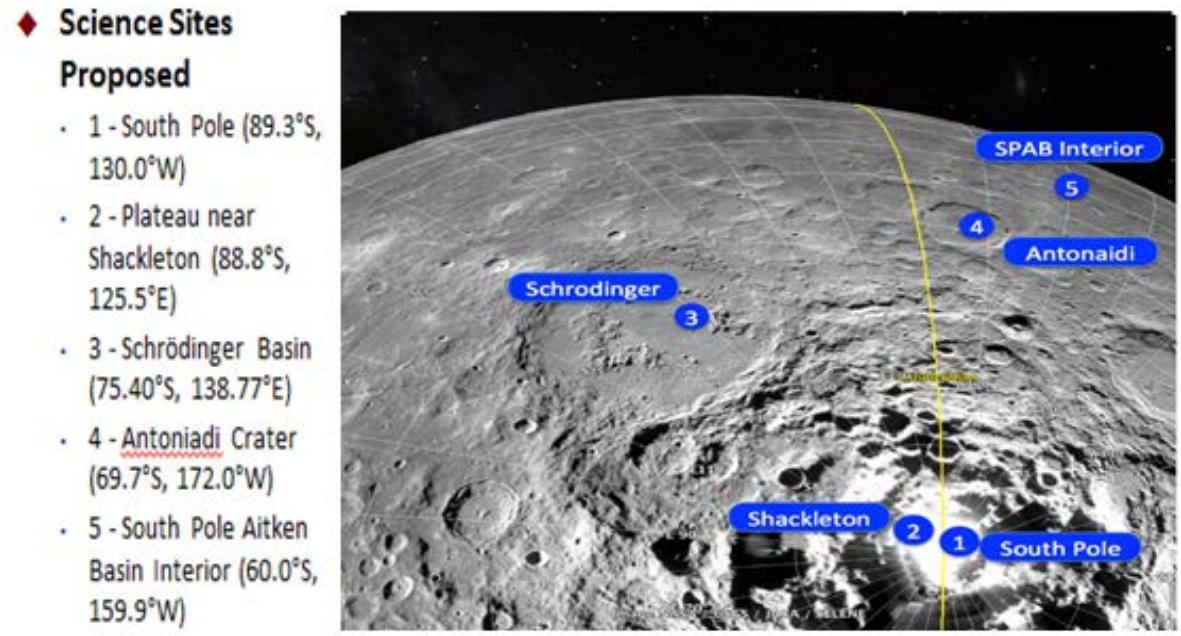


FIGURE 1-2 PROPOSED LANDING SITES

In order to achieve this goal, the architecture illustrated in Figure 1-3 relies on the provision of the following elements:

a. The **Launch Vehicle**: the Space Launch Services (SLS) rocket in different configurations either it transports the crew or cargo such as the two rovers.
b. The **Human Lunar Lander** that includes two parts: the Descent Module or stage (DM) and the Ascent Module (AM)
c. The **Lunar Pressurized Rover(s) (LPRs)**: two rovers providing accommodation for two crew members each. Both rovers are manifested on the same SLS cargo launch prior to the first lunar manned mission.
Some of the references and illustrations in this document refer to the LPRs as the Small Pressurized Rovers (SPRs).

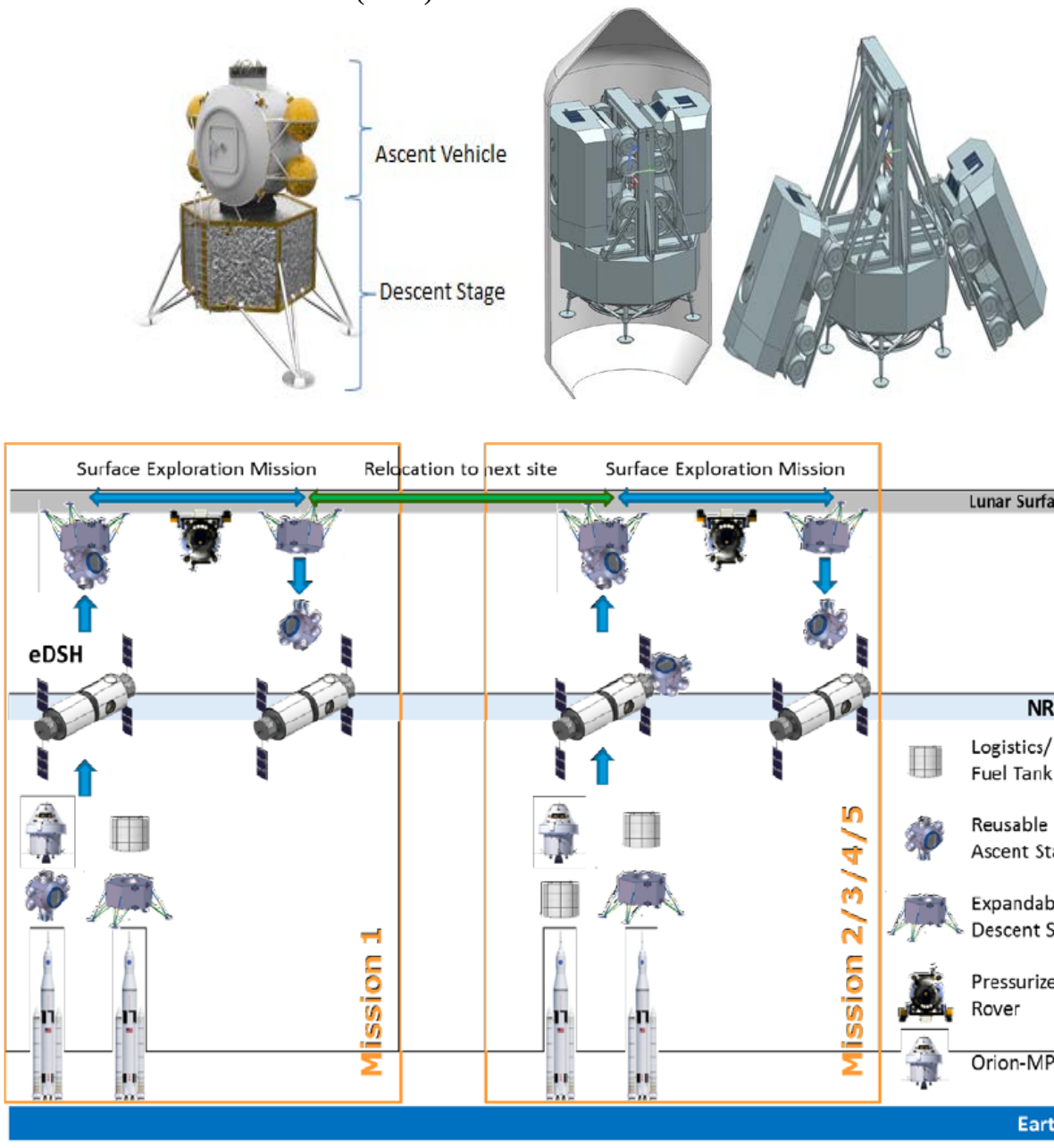


FIGURE 1-3 HUMAN LUNAR SURFACE CONCEPT & MISSION CYCLES

1.2 HUMAN SURFACE DEMONSTRATOR OVERVIEW

As a demonstrator phase to the delivery of the two LPRs, and later of the first crew of four at the lunar surface, at least one robotic precursor mission is planned under the HERACLES initiative. This mission fulfills many facets of the lunar and planetary exploration; it will be used to develop, mitigate and demonstrate critical technologies required for the LPR, as well as delivering multiple lunar samples to Earth via the DSG/LOP-G. To do so, it will provide a rover (PHASR) to accomplish a number of scientific and potential ISRU objectives as introduced in previous section. The architecture for the demonstrator mission is very similar to the human one but at a smaller scale.

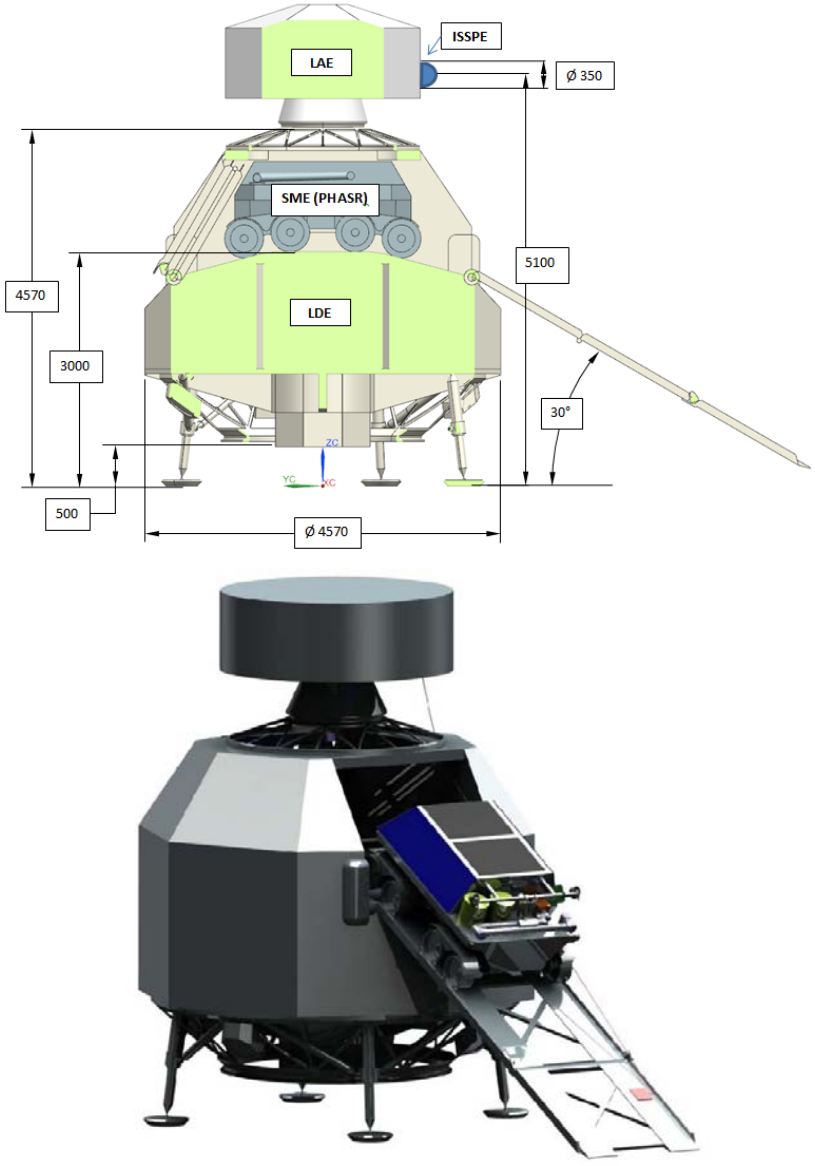


FIGURE 1-4 NOTIONAL DEMONSTRATOR LANDED ELEMENTS CONCEPT

Similarly to the Human Lunar Architecture, the demonstrator and scientific mission consists of the following elements illustrated by Figure 1-5:

a. The **Launch Vehicle:** Ariane 6
b. The **Lunar Descent Element (LDE)** (lander) that has the function of delivering the elements to the lunar surface. The LDE includes a capability to host the Surface Mobility Element (SME) or PHASR and deliver it along with the LAE to the lunar surface.
c. The **Lunar Ascent Element (LAE)**: It is the upper segment of the lunar lander stack that has the function of launching from the lunar surface to return the lunar samples to the DSG/LOP-G for transfer and then delivery to Earth via the crew vehicle.
d. The **In-Space Sample Preservation Element (ISSPE)** (or Sample Transfer Canister (STC)) hosts the surface samples and preserve them in their pristine state from the time of sealing until it is opened in the sample retrieval facility on Earth.
e. The **Lunar Surface Element (SME) or Precursor to Human And Science Rover (PHASR)** is the rover element providing the mobile asset at the lunar surface including a sampling and transfer capability as well as various scientific and potential ISRU prospecting instruments.

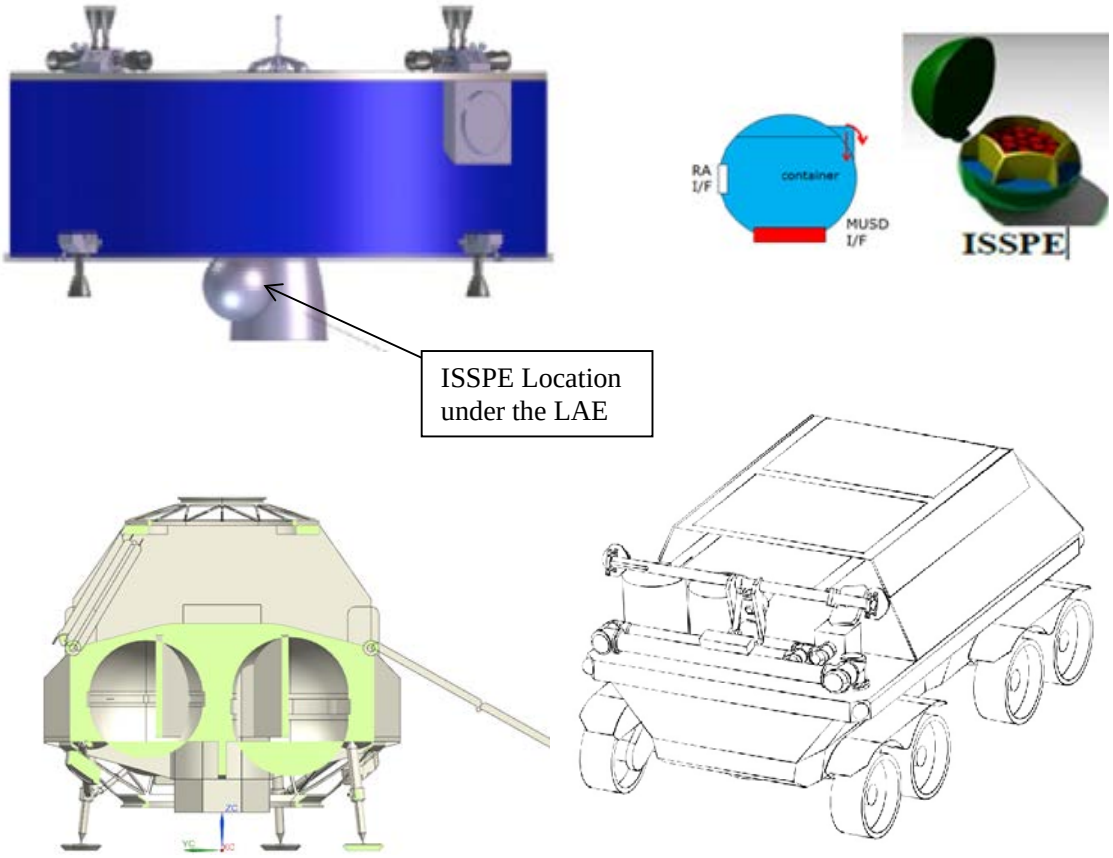


FIGURE 1-5 LAE, ISSPE, LDE AND PHASR

1.3 MISSION OPERATIONS CONCEPT OVERVIEW

The following paragraphs provide an overview and context for both mission architectures. The details of the sample collection and identification of these is still being elaborated via parallel international studies. For the benefit of establishing a baseline for this phase 0, it is assumed that both the PHASR and human architecture vehicles require the following scientific capabilities:

collect and store samples on the rover (scoop/rake, split tool), transfer these to an ascent vehicle while including scientific instruments for selection of samples and in-situ resources detection such as: scientific cameras, Laser Induced Breakdown System (LIBS)/RAMAN, Laser Imaging, Detection And Ranging (LIDAR), Remote Micro-Imager (RMI), radiation detector, Alpha Particle X-ray Spectrometer (APXS), Ground Penetrating Radar (GPR) and Neutron Spectrometer (NS). Proper power, mass, volume, thermal and data allocation must be accounted for these. The initial requirements to be considered as starting point for the threshold, baseline and augmented configurations are covered in section 1.4.2 and the Appendix F of this SOW.

a. Demonstrator/Precursor:

The current Demonstrator/Precursor scenario implies that the PHASR is launched on an Ariane 6 rocket. The PHASR is then inserted into either a minimum energy transfer orbit or a direct orbit (still being considered) and lands on the lunar surface with an accuracy of 100 m using soft landing technology and sensors. The rover is then deployed, checked-out and operated first from the ground, secondly from the DSG/LOP-G and then alternatively as DSG/LOP-G crew availability and presence on orbit. As previously described, the rover will require the capabilities for tele and semi-autonomous operations from both operating locations with a focus on the proper level of autonomy and required sensors to minimize the operator interaction and enable long distance driving. The objective is to perform an initial traverse over a maximum period of 70 days including the return of the rover to the landing site, and to transfer the ISSPE to the ascent module for transport to the DSG/LOP-G. After the transfer is completed, the rover will continue its mission with the option of a second on-board ISSPE that could be then retrieved by either a second mission or via the following human mission. For this extended mission phase, the rover will continue its scientific quest as well as technology testing for night survivability, locomotion, autonomy, etc., all functions required for the LPR. The nominal minimum mission duration envisaged is for one year with a design provision for a second year at the lunar surface with options to extend its life to bridge with the human surface return if allowable.

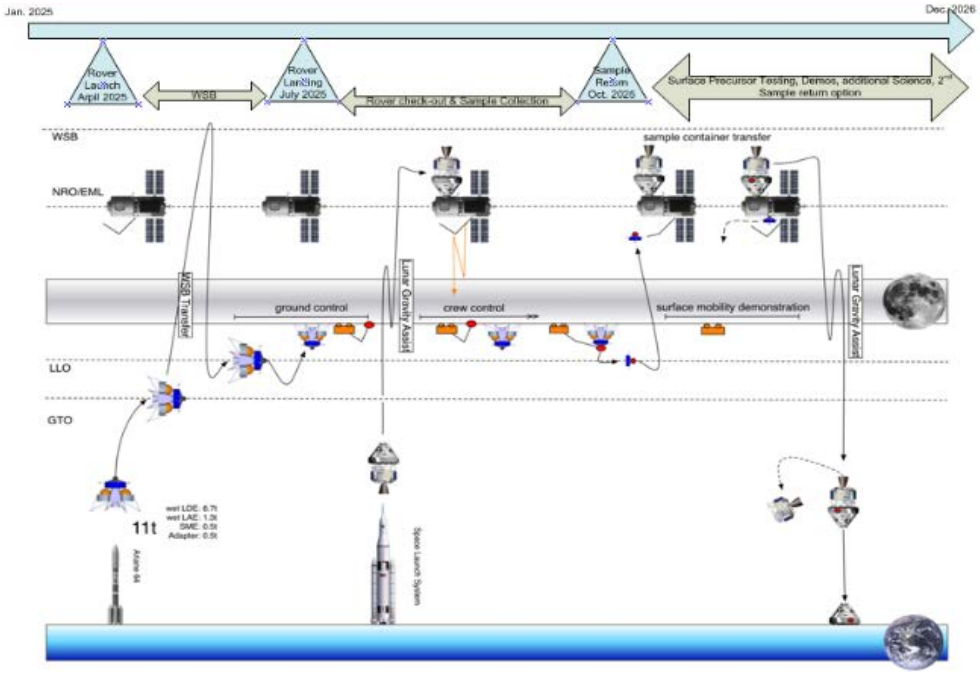


FIGURE 1-6 DEMONSTRATOR/PRECURSOR MISSION FLOW

b. Human Scenario:

In the case of the human missions, the initial launch is the delivery of the two pressurized rovers (LPRs or SPRs) on a large cargo mission about a year before the first crew mission to the surface. The two pressurized rovers will then be controlled as per the demonstrator rover architecture and could be controlled in parallel with the last portion of the PHASR extended mission. This initial phase will be used to commission all the possible subsystems on the LPRs prior to crew arrival and perform remote science and prospecting activities. The two LPRs will then arrive at the initial human landing site where a small cargo lander (PHASR size lander) will deliver the required consumables for the crew. Crew will then rendezvous with the rover and small lander to perform the initial campaign to perform their 42 days mission at the surface and come back to the ascent stage for return to DSG/LOP-G and to Earth. Then the unmanned LPRs are migrating to the next site ready for the next crew and so on up to a nominal value of 5 campaigns completed.

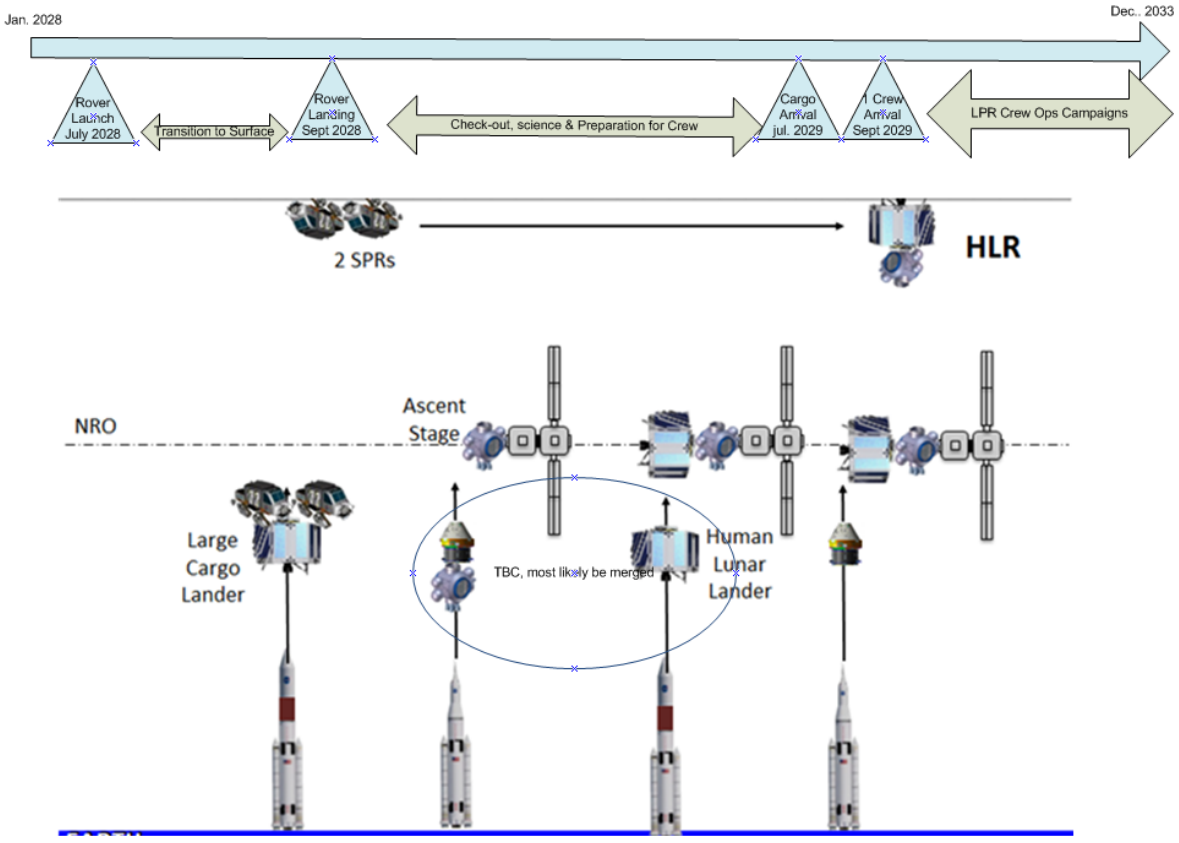


FIGURE 1-7 HUMAN SURFACE CAMPAINS MISSION FLOW

c. HERACLES Mission Statement and Objectives:

The HERACLES mission statement is to establish key elements and capabilities for sustainable human exploration of the Moon and human-robotic exploration of Mars by implementing lunar surface operations while maximizing opportunities for unprecedented scientific knowledge gain. This statement englobes two main key objectives that require some level of trade-off for implementation. This aspect will be further addressed in this document.

The HERACLES mission, within the context of the human return scenario, is illustrated in Figure 1-8. The current plan assumes that the human return capability development cycle will have to start before the HERACLES mission has landed and being operated. For purpose of planning, it is assumed that at a minimum the HERACLES mission should have landed and provided sufficient essential data for the human architecture to enter into production (CSA Phase D) in order for the human phase to benefit from the HERACLES outcomes. The work also performed in the previous phase of this development also indicated that the HERACLES project cycle (phase A to D) should be between 6 to 7 years. One of the objective of this Phase 0 is to inform and address this in the context of the HERACLES mission itself in assessing the feasibility of landing by the 2025 timeframe and for the human capability (LPRs) to land at the surface by 2029-2030.

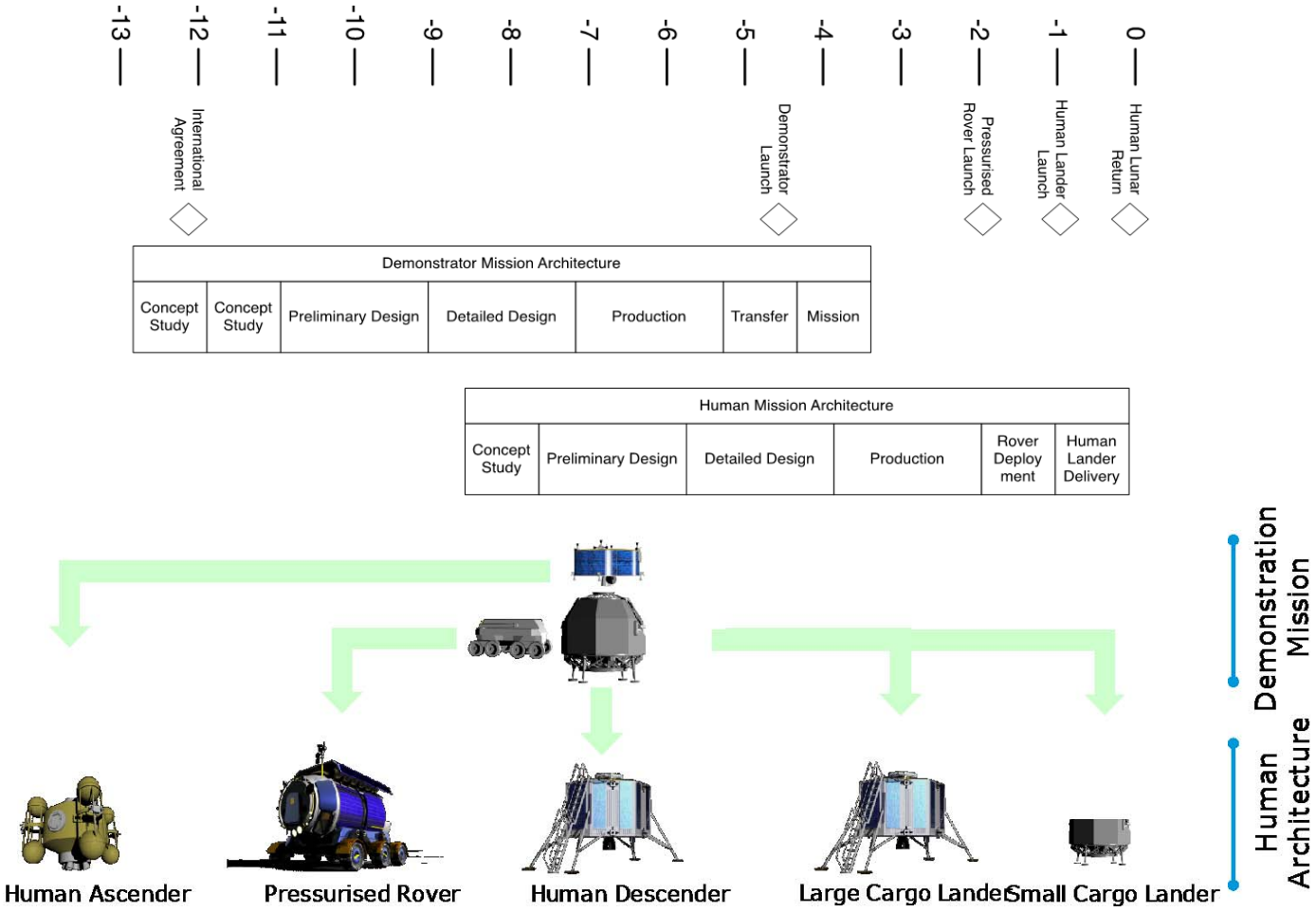


FIGURE 1-8 HERACLES & HUMAN MISSION ARCHITECTURE EVOLUTION

1.4 HERACLES ROVER (PHASR) KEY FUNCTIONS AND CONSTRAINTS

The primary objective of this SOW is to focus on the HERACLES rover referred as PHASR. The rover is considered to provide the following main capabilities:

a. The rovers will be transported to the lunar surface by International Partners vehicles and the LDE. It must be capable of withstanding the forces and environmental conditions of launch, transit and landing with no detrimental effects. The rovers must be capable of egressing from the LDE to begin its mission. Current plans foresee landing and operations at the South Pole of the Moon (e.g. Schrödinger basin). The current approach is proposing a ramp for the rover and should be used as a starting baseline. Further options will be analyzed by CSA and the partners and shared during the contract period.
b. Traverse capability of at least 150 km with a primary mission loop of 40 km (32 km+ contingency) in 70 days and a minimum total lifetime distance of at least 600 km.
c. Demonstrate lunar night survival over multiple lunar days and night cycles at the pole (14 Earth days each).
d. Respect the Launch volumes and mass constraints available by the LDE volume and mass budgets.
e. Provide a payload mass capability of 120 kg including margins.
f. Drive at speeds between 0.1 to 3.6 km/h with a target of reaching a maximum speed of 5 km/h.
g. Provide tele-operations and the appropriate level of autonomy for accomplishing its mission while subject to transmission delays (Earth to DSG/LOP-G and DSG/LOP-G to Moon) and Lost Of Signal (LOS) management and recovery.
h. Capability to select, collect and transfer lunar samples to the ISSPE
i. Capability to transfer the ISSPE back to the LDE. Two options are to be considered: return of the ISSPE to a mechanism that will bring back the ISSPE to the top of the LAE, or return sample driving back the LDE ramp.
j. Capability to de-risk and demonstrate key technologies for the LPR that must survive lunar night with crew on-board.

The following sections provide a summary of the previous PHASR concept development and key considerations for this Phase 0. Mission requirements and preliminary systems and interfaces requirements applicable to this SOW are presented in Appendix D.

1.4.1 Concepts overview and key considerations

During the 2017-2018 government fiscal year, the CSA and two Canadian Space industry teams have developed parallel concepts for both the PHASR and LPR. These concepts, in addition to the analogue experiments conducted by the CSA and ESA in 2017, have generated key considerations and assumptions that are provided as inputs to this Phase 0 SOW. The initial LSM Concept Studies RFP (RD-7) addressed the PHASR allocated mass and volume based on the available capacity of the LDE. The LDE accommodation for the PHASR implies significant mass and volume constraints; in particular with respect to the height that is limited to 1.2 m (see Figure 1-9 for currently defined stow volume). This may lead to the need for a deployment capability for elements such as sensors, telecommunications antennas and solar arrays. From this initial allocation and requirements formulated for the concept studies , two concepts have been produced (illustrated in Figure 1-10. CSA has also performed internal concept definition and experiments to orient the upcoming Phase 0. Figure 1-10 demonstrates a combined evolution that illustrates a notional

PHASR concept that would fulfill the mission requirement within the current constraints. Based on the latest international development from HERACLES and the work performed in the previous phase, it has been demonstrated that the mission architecture is subject to significant mass budget challenges. For this reason, and based on previous work performed, one important aspect of this phase 0 is to look into two options for PHASR. They will then be prioritized and addressed at different levels given the progression of the international mission architecture. The current baselined mass allocation for PHASR remains at 500 kg, but an option to reduce this mass down to a 330 kg range is being requested. To put this into context, the Apollo LRV was 218 kg dry mass and 708 kg gross mass (i.e. with payloads and astronauts). This reduction of mass will have an impact on the level of risk reduction or proof of concept for the LPR and/or a reduced science capability. For the purpose of this SOW, the contractor must look into both options and clearly address the impacts of this mass reduction in terms of meeting the HERACLES mission expectations. The factors and priorities will be further addressed in this SOW.

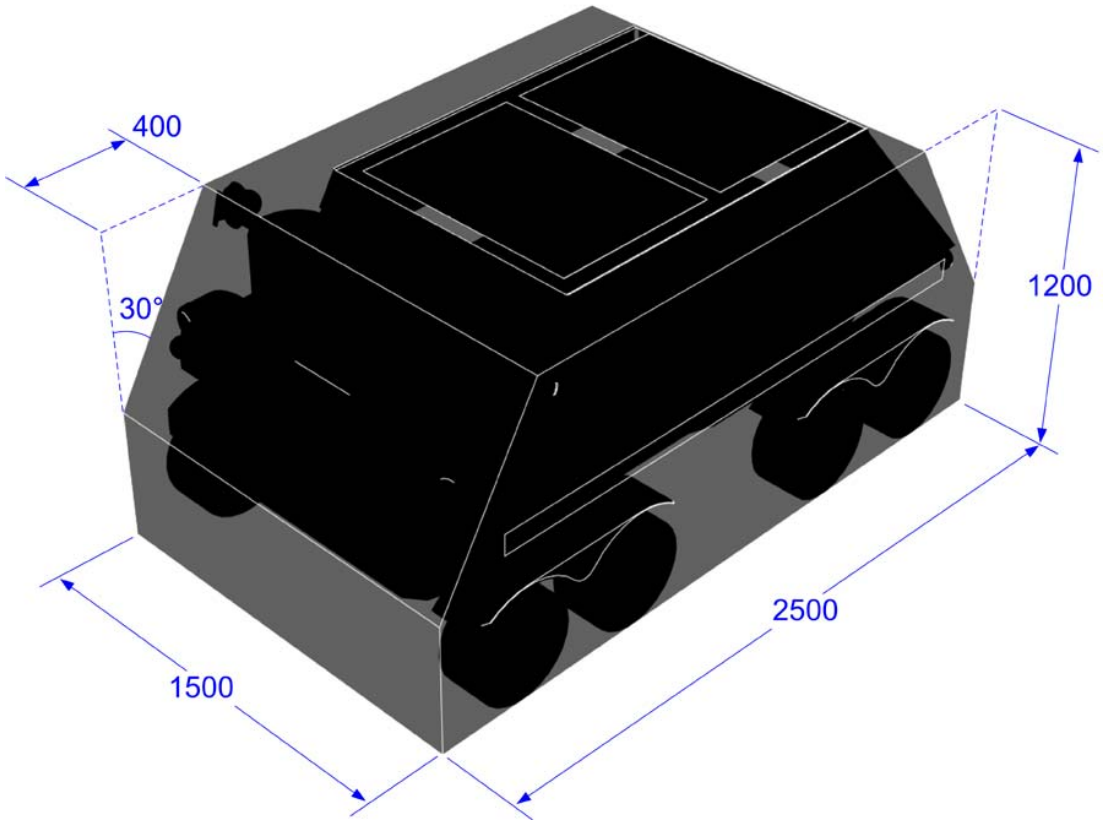


FIGURE 1-9: PHASR STOW VOLUME ENVELOPPE (DIMENSIONS IN MM)

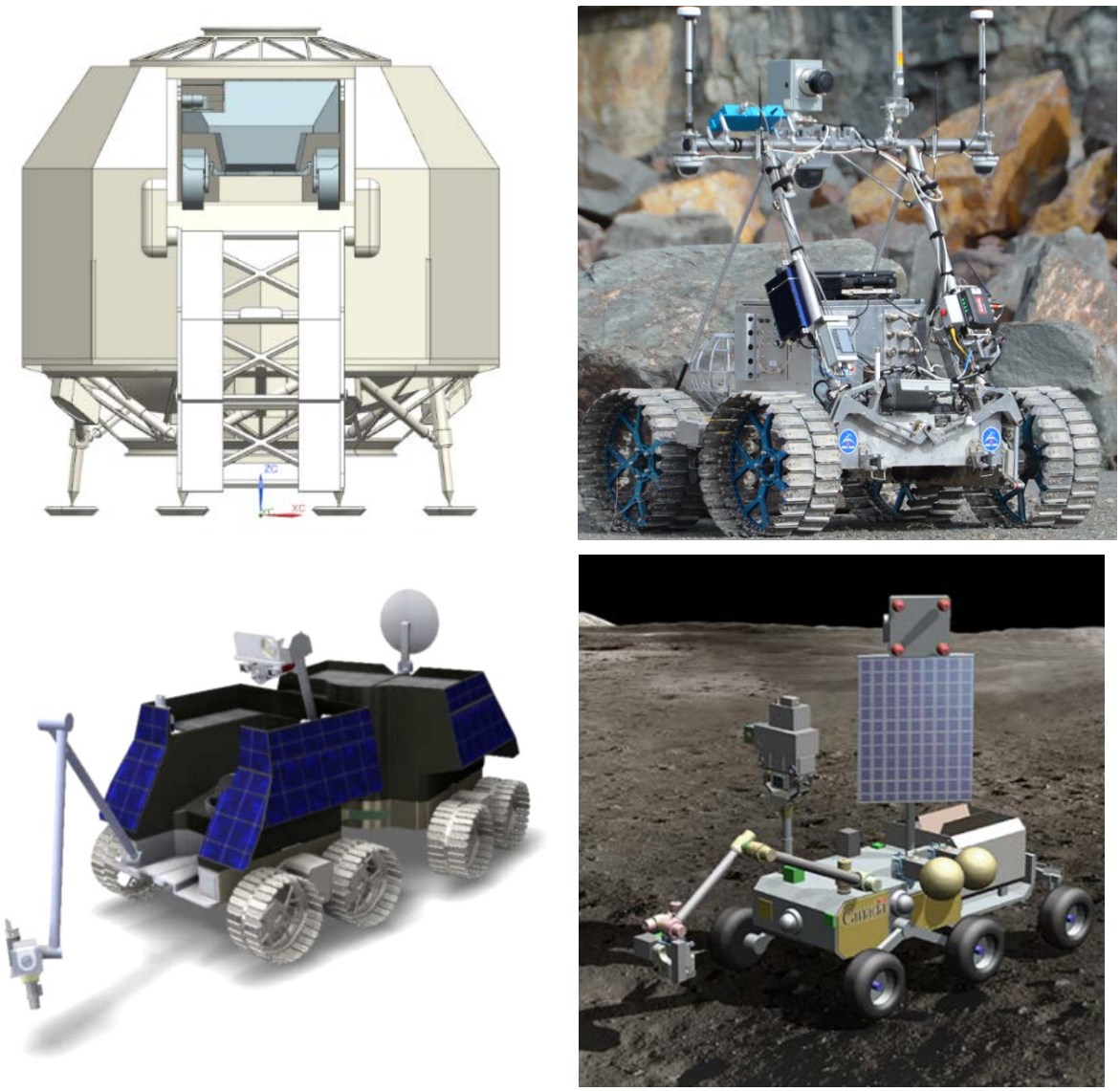


FIGURE 1-10: PHASR RELATED PREVIOUS WORK

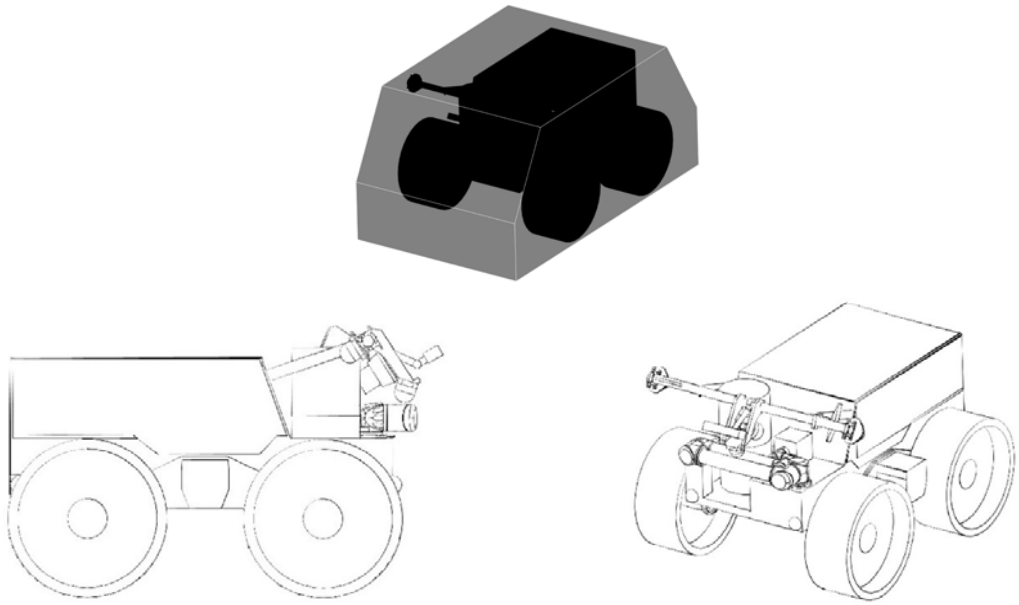


FIGURE 1-11: PHASR 4-WHEEL NOTIONAL ROVER, STOWED CONFIGURATION

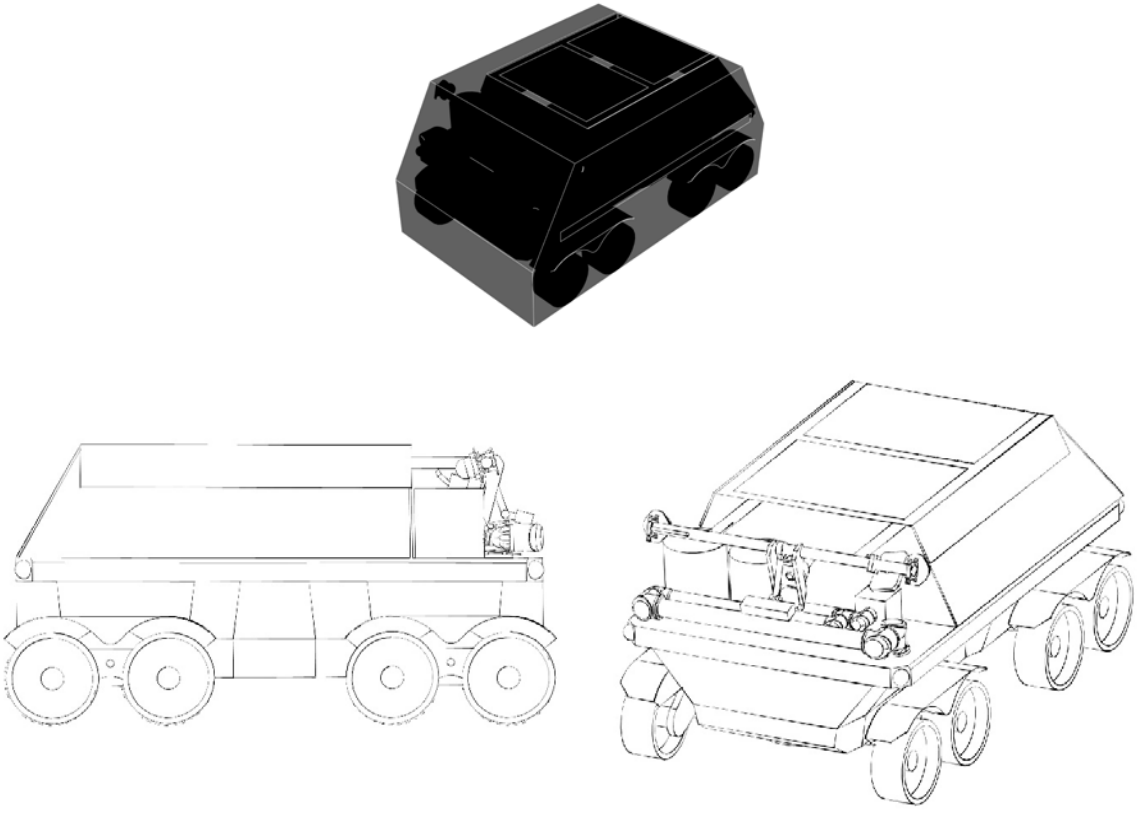


FIGURE 1-12: PHASR 8-WHEEL NOTIONAL ROVER, STOWED CONFIGURATION

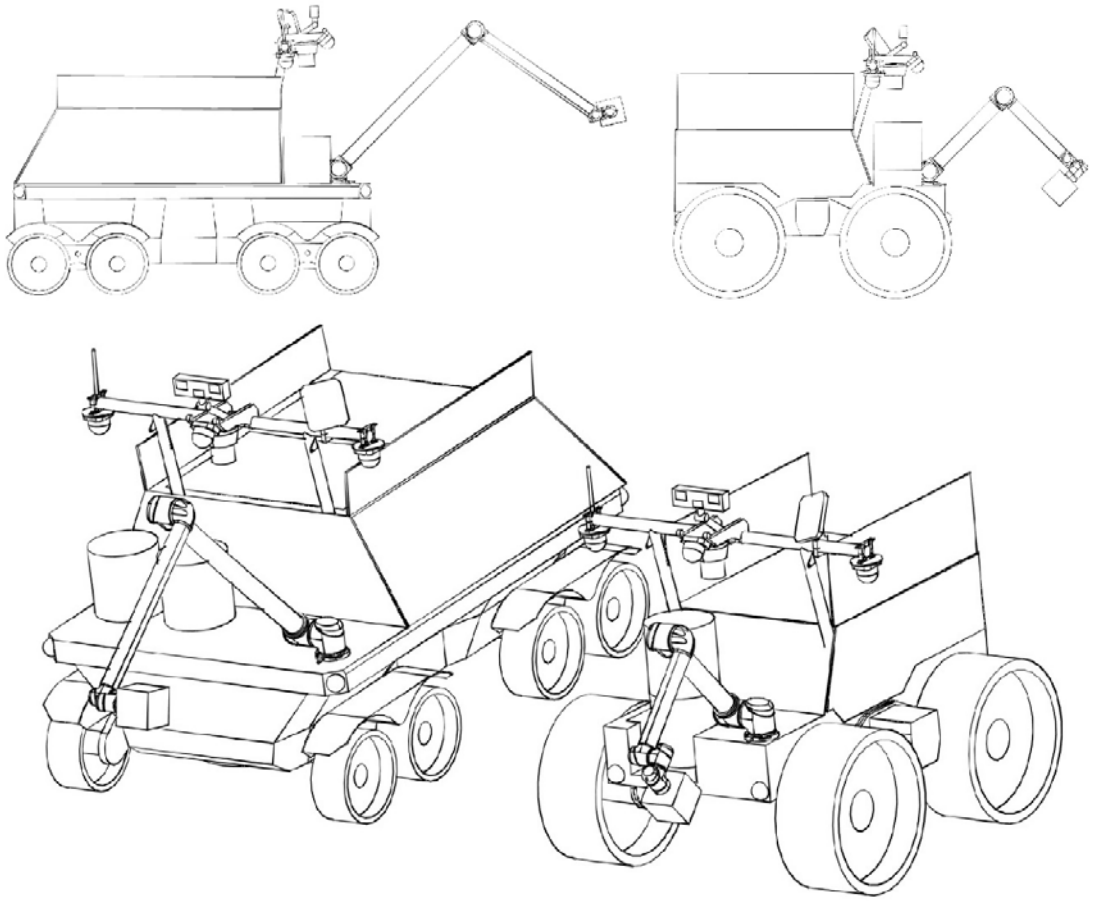


FIGURE 1-13: PHASR NOTIONAL ROVERS, UNSTOWED CONFIGURATIONS

1.4.2 Science payload overview and key considerations

The HERACLES science payload definition is an on-going international exercise that will extend beyond Phase 0. In order to establish a starting point for this phase and assume a starting allocation and formulation of the type and nature of the instruments, an initial allocation is provided in Appendix F. As time progresses, updates will be provided by the CSA and the science team on an 'as received' basis. The payload accommodation has been subdivided into three configuration: Threshold, Baseline and Augmented.

For any of these configuration, a manipulator is required on-board the PHASR. The manipulator is required to select, collect, transfer and store samples into the ISSPE. The manipulator is also required to transfer the ISSPE back to the LAE. In an augmented scenario looking forward at the LPR, it could also be considered that this manipulator could be used to perform robotics maintenance. A functional representation of the PHASR and its manipulator is illustrated in Figure 1-14.

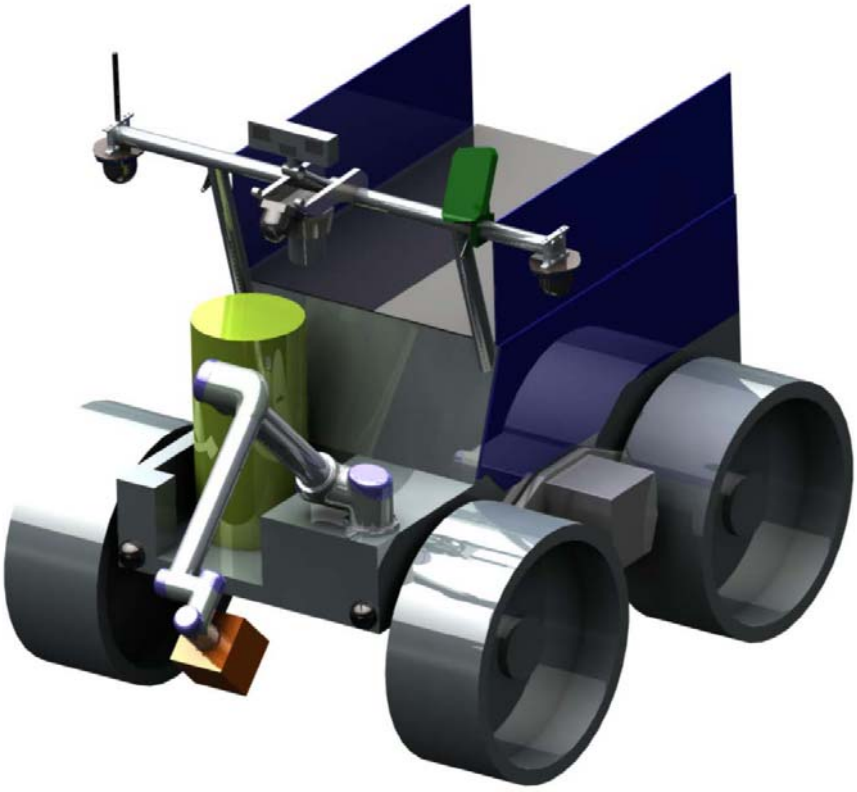


FIGURE 1-14 NOTIONAL PHASR WITH MANIPULATOR DEPLOYED

1.4.3 PHASR Operations Concept

The HERACLES mission concept development is an on-going international activity. This section provides a summary of the PHASR operations concept. Figure 1-16 illustrates the high level mission concept steps and provides a further breakdown for the core LSR phase.

The initial surface mission considered proposes a 32 km long traverse (40 km including contingency) covering pyroclastic deposits, inter peak ring impact belt breccia, peak ring material, and fracture material. This mission would start with the landing of the LDE in the flat planes east of a relatively young pyroclastic vent in the Schrödinger basin and follow the intended path to be later traversed by the LPRs as part of the human lunar campaigns. This proposed traverse is currently defined by a loop of 32 (map distance) including 9 sites as per Figure 1-15. Given the capabilities and constraints of the LAE, the timeline currently requires to have the samples returned to the LAE and departure for the DSG/LOP-G within a maximum of 70 days from landing at the surface. The optimal initial assumption should be that the LDE will land on day 1 of the lunar day period. This will result into the following cycle: 14d (light), 14d (night), 14d (light), 14d (night), 14d (light) for a total of 42 days of sun light and the remaining in hibernation mode. Considering 8 days to account for landing, egress, check-out, return of the ISSPE to the LAE and contingency, a maximum of 34 days should therefore be assumed for travelling the 35 km and performing science. Accounting for contingencies, a 40 km total traversed distance should be considered over a maximum period of 34 days.

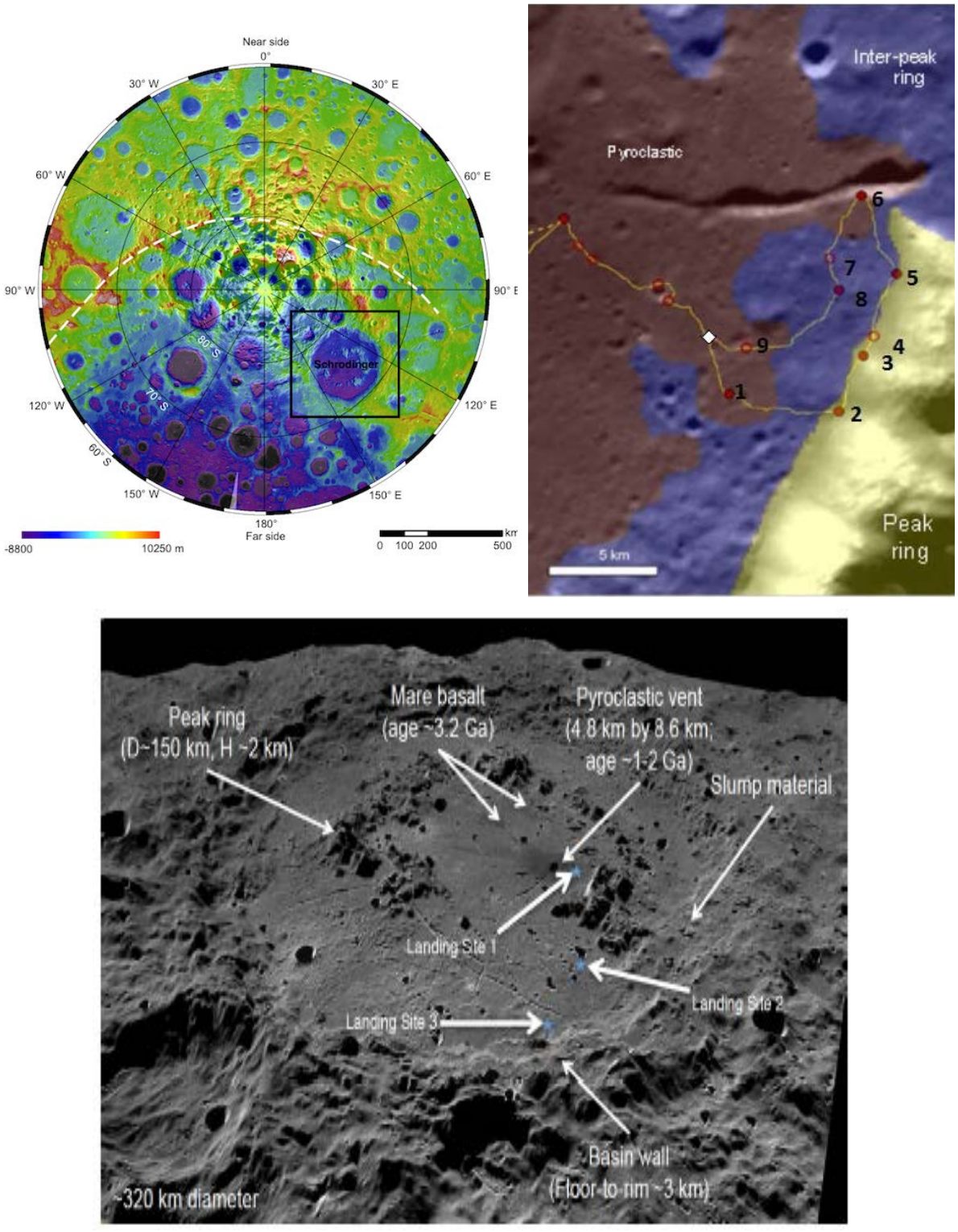
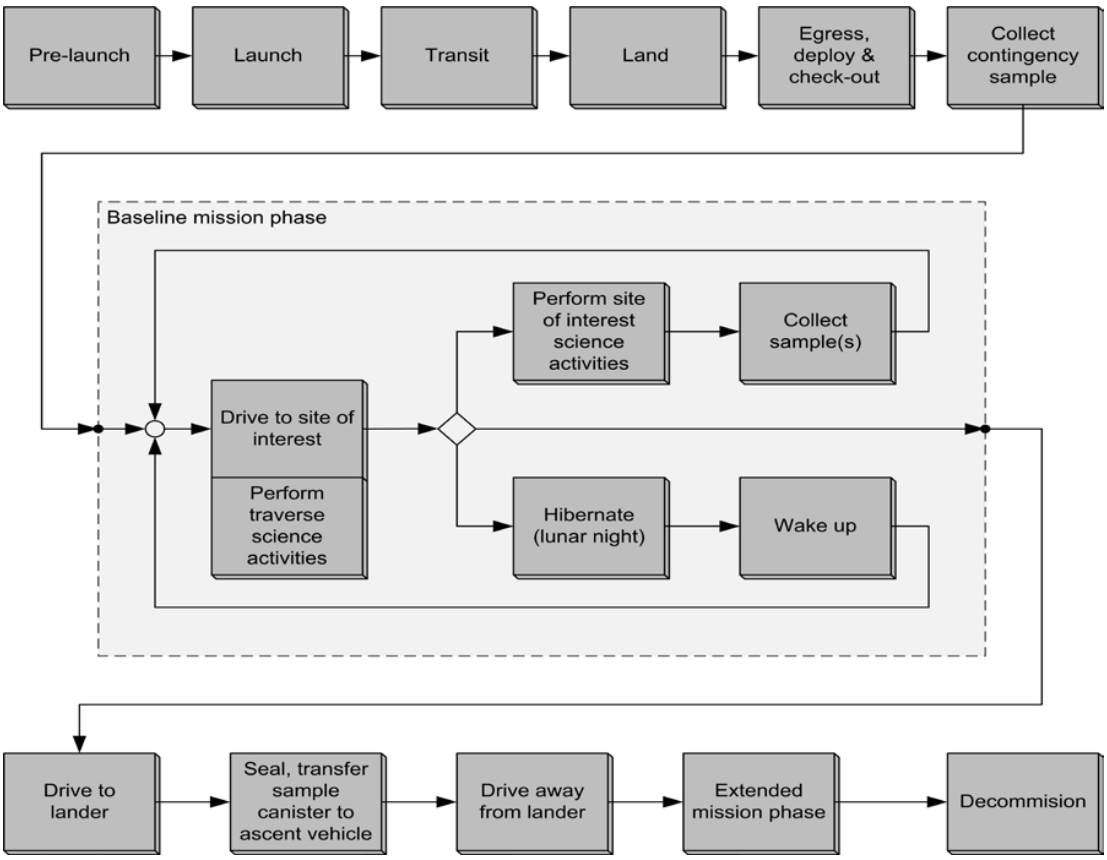


FIGURE 1-15: HERACLES NOTIONAL SURFACE MISSION BASELINE PHASE LOCATION



Sample Collection Cycle:

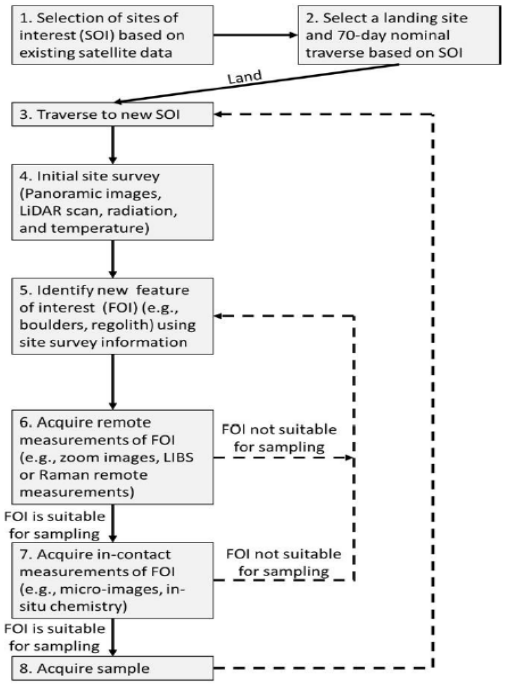


FIGURE 1-16 PHASR MISSION OPERATIONS STEPS SUMMARY

Figure 1-17 illustrates what a typical egress, deploy & check-out sequence could be. The rover is initially stowed inside the lander. The ramps are deployed and the rover drives out onto the ramps. Once outside, the sensor mast and solar arrays are deployed. The rover subsequently completes its drive down the ramps. On the ground, the full system check-out is then conducted.

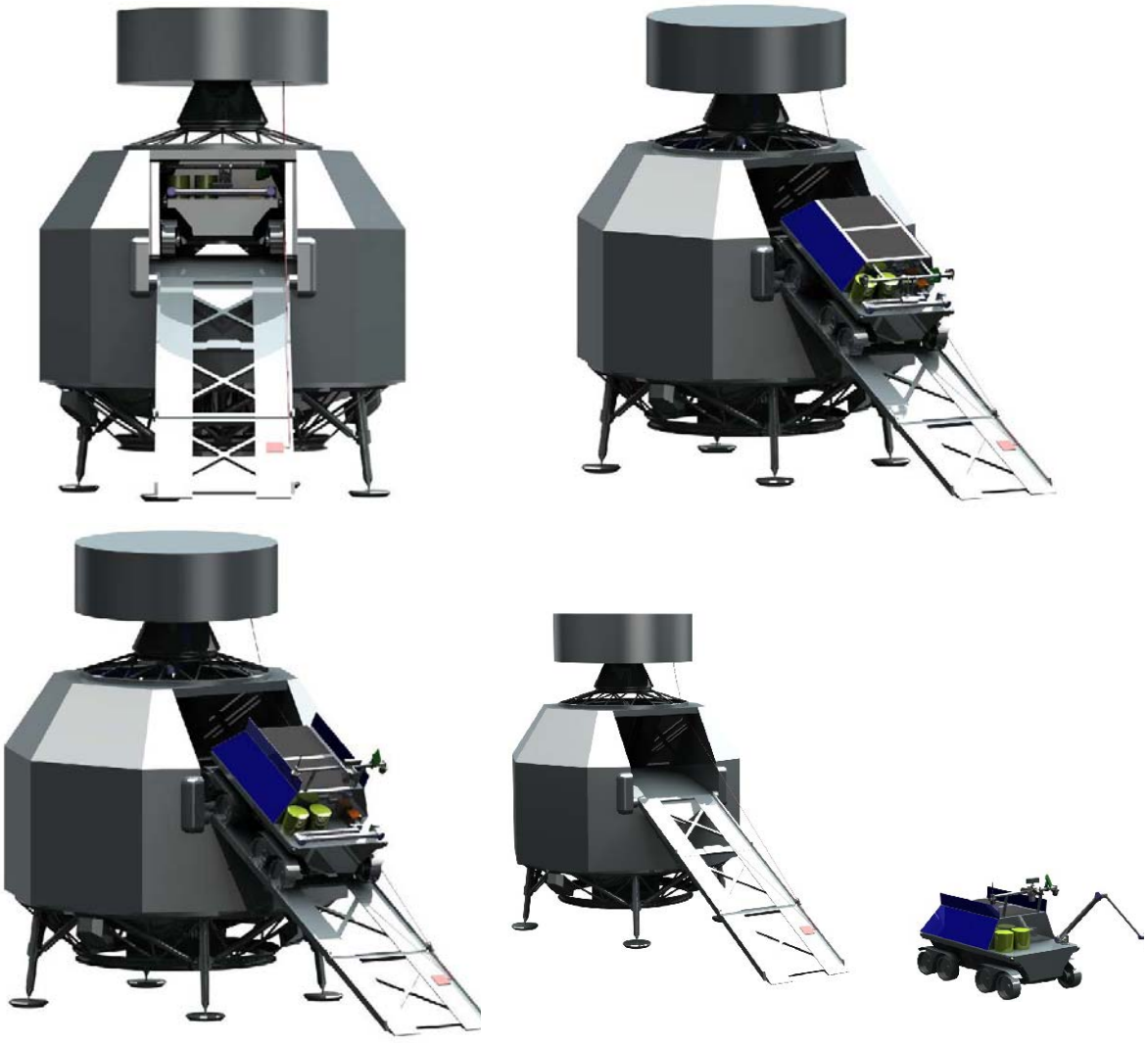


FIGURE 1-17: PHASR EGRESS SEQUENCE

Figure 1-18 illustrates the preferred concept to transfer the sample canister (ISSPE) from the rover to the lander. The transfer fixture attached to the ramps, receiving the ISSPE, is tied to a wire rope routed back up to the LAE. Once the ISSPE is docked to the fixture, it gets winched up into the LAE. Whether the winching mechanism is part of the LAE or attached to the lander for the rover to actuate it (e.g. using its robotic arm) is still to be determined at this point. A secondary alternative to be considered is the return of the ISSPE by climbing back the ramp and use the rover manipulator to return the ISSPE to the LAE directly.

FIGURE 1-18: PHASR TRANSFERRING THE SAMPLE CONTAINER TO THE LANDER

1.5 SCOPE

This Statement of Work (SOW) defines the overall work to be performed for Phase 0 of a potential Canadian Space Agency contribution to a space mission associated with the Lunar Surface Mobility (LSM) Precursor to Human And Scientific Rover (PHASR). It also identifies the deliverables and the technical, programmatic, and administrative tasks to be performed during phase 0.

One key result of a Phase 0 is to provide information for CSA to clearly understand the options, costs, schedule, and risks. The systems, being either hardware or software sub-systems, that are being studied in Phase 0, remain options subject to further down-selection or de-scope. For that reason, it is important to provide information for all the elements separately. Details of the elements will be included in separate Contract Data Requirements List (CDRL) and Data Item Description (DID) (as described in Section 3 - Work Requirements). The CSA must have all the information necessary to make a decision as to whether or not to proceed with the development of the next phase, that is for starters developing the system requirements.

1.6 OBJECTIVE

The objectives of the Phase 0 are to validate and consolidate users' needs, validate mission requirements, validate concept definition and design, provide a concept of operations, identify critical technologies and preliminary systems requirements and provide key analyses to support

the feasibility of the proposed concept, and prepare development plans for follow-on phases of a potential LSM PHASR contribution to the HERACLES mission. This must also include the dual aspects of PHASR: science and precursor/demonstrator to the LPR; and show an applicable path, reuse, scaling to flight for the LPR with respect to the options that are requested: PHASR 500 kg full capability versus PHASR reduced mass (330 kg or less) (PHASR Light).

At the end of this Phase 0, the CSA should have all the technical and programmatic information necessary to make an informed decision about the PHASR contribution.

1.7 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” is used to indicate a mandatory requirement;

b) “Should” indicates a goal or preferred alternative. Such goals or alternatives must be treated as requirements on a best efforts basis, and verified as for other requirements. The actual performance achieved must be included in the appropriate verification report, whether or not the goal performance is achieved;

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 section lists the documents that are required for the bidder to develop the proposal.

The following documents of the exact issue date and revision level shown are applicable and form an integral part of this document to the extent specified herein; AD-1, AD-2, AD-3 and AD-4 can be obtained from the following File Transfer Protocol (FTP) site:

ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRRA/.

TABLE 2-1: APPLICABLE DOCUMENTS

AD No.	Document Number	Document Title	Rev. No.	Date
AD-1.	CSA-ST-GDL-0001	CSA Technology Readiness Levels and Assessment Guidelines	C	March 2017
AD-2.	CSA-ST-FORM-0003	Critical Technology Element (CTE) Identification Criteria Worksheet	A	March, 2014
AD-3.	CSA-ST-FORM-0001	Technology Readiness and Risk Assessment (TRRA) Worksheet (PDF)	F	March 2017
AD-4.	CSA-SE-STD-0001	CSA Systems Engineering Technical Reviews Standard	Rev. A	Nov 7, 2008

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, but are not required to develop the proposal.

RD-2 and RD-5 can be obtained from the following FTP site: ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRRA/.

TABLE 2-2: REFERENCE DOCUMENTS

RD No.	Document Number	Document Title	Rev. No.	Date
RD-1.	PMBOK Guide	A Guide to the Project Management Body of Knowledge	6thEdition	2017
RD-2.	CSA-SE-PR-0001	CSA Systems Engineering Methods and Practices	Rev. B	Mar 2010
RD-3.	Guidelines on Costing (Treasury Board)	https://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=30375		
RD-4.	N/A	Global Exploration Roadmap (GER) https://www.globalspaceexploration.org/wordpress/	3rd edition	Feb 2018
RD-5.	ESA-HSO-K-RS-0149	Human-Enhanced Robotic Architecture and Capability for Lunar Exploration and Science (HERACLES) Objectives and Requirements Document (ORD)	Rev 3.0 or above	Nov 2017, June 2018
RD-6.		NASA Project Cost Estimating Capability (PCEC) https://software.nasa.gov/featuredsoftware/pcec	N/A	
RD-7.	9F050-16-0980/A	Lunar Surface Mobility Concept Study (C3P-CSA-04) https://buyandsell.gc.ca/procurement-data/tender-notice/PW-17-00775233	Rev A.	May 2017
RD-8.	Apogy Website	https://projects.eclipse.org/proposals/apogy		
RD-9.	Xcore documentation	https://wiki.eclipse.org/Xcore		
RD-10.	Core Flight System Documentation and Opensource Code	https://cfs.gsfc.nasa.gov/		
RD-11.	ESD 30000	Space Launch System (SLS) Mission Planner's Guide https://ntrs.nasa.gov/search.jsp?R=20170005323	IR	April 2017
RD-12.	SLS-SPEC-159	Cross-Program Design Specification for Natural Environments (DSNE) http://ntrs.nasa.gov/search.jsp?R=20160004378	Rev. D or latest	Nov 2015
RD-13.	ANSI/AIAA G-043-2012	Guide to the Preparation of Operational Concept Documents http://arc.aiaa.org/doi/abs/10.2514/4.869297		2012
RD-14.		Ariane 6 User's Manual http://www.arianespace.com/wp-content/uploads/2017/02/Ariane6_Users-Manual_February2017.pdf		2017
RD-15.	ISBN 0-521-33444-6	Lunar Source Book: A User Guide To The Moon, Grant H. Heiken, David T. Vaniman, Bevan M. French		
RD-16.	NASA-STD-6016	Standard Materials And Processes Requirements For Spacecraft		Oct 2009
RD-17.		Visions and Voyages for Planetary Science in the Decade 2013 - 2022 - a report of the National Research Council of USA*http://solarsystem.nasa.gov/multimedia/downloads/Vision_and_Voyages-FINAL1.pdf*	N/A	2011
RD-18.		A Global Lunar Landing Site Study to Provide the Scientific Context for Exploration of the Moon http://www.lpi.usra.edu/exploration/CLSE-landing-site-study/	N/A	2012
RD-19.	SAE J1100	Motor Vehicle Dimensions https://www.sae.org/standards/content/j1100_200911/	200911	Nov. 2009
RD-20.	SAE J2180	A Tilt Table Procedure for Measuring the Static Rollover Threshold for Heavy Trucks(STABILIZED May 2011) https://www.sae.org/standards/content/j2180_201105/	201105	May 2011

3 WORK REQUIREMENTS

The Contractor must manage the project to effectively achieve project performance, scope, quality, cost and schedule requirements of this SOW. The Contractor must provide the management, technical leadership, and support necessary to ensure effective and efficient performance of all project efforts and activities.

The Contractor must report project costs, schedule, technical, performance and risks issues as defined herein.

3.1 MISSION ANALYSIS, PLANNING AND DEVELOPMENT

The CSA in concert with the International Partners will define the Mission Objectives and User requirements at the overall program level 1, 2 and 3 for the overall mission. For the PHASR at level 3, the initial mission objective are derived from the HERACLES mission statement as follow:

Mission Statement:

The HERACLES mission statement is to establish key elements and capabilities for sustainable human exploration of the Moon and human-robotic exploration of Mars by implementing lunar surface operations while maximizing opportunities for unprecedented scientific knowledge gain.

Derived Objectives:

a. PHASR, a precursor for LPR:

As per the mission statement, the PHASR as part of the HERACLES mission must demonstrate and maximize critical technologies and operations concept testing and demonstration for the LPR in order to demonstrate and leverage readiness for the human phase. This is part of the initial mission phase explained in item b, however is further applicable to the second long traverse and extended phase of the mission post LSR. Maximizing critical technologies and operations concept testing has to be considered in terms of what must be previously demonstrated completely on the Moon via PHASR versus what could be left to the LPR by terrestrial demonstration and testing either in a specialized facility or via analogue missions.

b. PHASR, a scientific LSR mission opportunity:

The secondary objective is to enable meaningful science, exploration and return of lunar sample to Earth via the DSG/LOP-G. This objective relates to the initial PHASR 70 days mission phase: PHASR must perform an initial traverse of 40 km (including margin), select, collect store samples over a maximum period of 70 days including the return of the rover to the landing site and transfer the ISSPE to the LAE for transport to the DSG/LOP-G.
With respect to definition of success criteria and users' needs the following statements are to be considered:

a. **Minimum Success Criteria:** The baseline LSR mission has been completed. Samples have been collected and return to Earth via the DSG/LOP-G. More specifically PHASR has visited the identified and required sites, conduct the necessary science measurement and collected the required samples in the ISSPE, returned the ISSPE to the LAE and move away from the LAE for return of the samples to Earth via the DSG/LOP-G. While accomplishing this, PHASR critical systems identified as demonstrator for LPR have been checked-out and their performance monitored.

b. Full Success Criteria: Following the completion of the LSR initial 70 days mission, the extended mission phase has been conducted successfully as the rover has performed its long term demonstration mission for 1 year and as target would survive 2 years at the surface.

Based upon the initial user requirements, the Contractor must support the CSA in performing the following tasks to refine and capture the needs:

i. Collect User Requirements/Science Requirements/Demonstration or Commercial Requirements from the CSA and its mission stakeholders (incl. universities and international science definition team).

ii. Parsing of requirements to distinguish essential from desirable. Requirements can be captured in a User Requirements Document, Science Requirement Document, Product Requirement, etc.

iii. Initial Analysis comprising Concept Formulation, Feasibility Assessment, Analysis, and Derivation of Mission Requirements.

iv. Key technical budgets or constraints for the PHASR that must be completed are systems mass allocation, thermal analysis and power analysis to confirm and quantify the feasibility of the proposed concept against the mission requirements.

It is expected that the complete PHASR must be considered in the Phase 0 concept scope. The level of details of the concept and requirements are expected to be further detailed for the rover sub-systems rather than for the payload (e.g. manipulator) as an initial approach.

3.1.1 Lunar Architecture and Draft Standards Review

It is expected that the Lunar Architecture will evolve and that international standards will be proposed to facilitate interoperability, reduce costs, and inform early definition and design work. The Contractor will have to take those standards into account and these will be maintained and addressed with the CSA and the international partners.

3.1.2 Mission Objectives and User Needs Definition

The Contractor must use the preliminary requirements listed and explained in this document, in particular in Appendix D derived from the HERACLES ORD [RD-5] currently being revised and produce inputs that will be captured in the appropriate CRDLs as per Appendix B for the Canadian contribution. There should be a review of the current requirements formulated.

These inputs must capture and summarize the pertinent mission goals, assumptions and objectives, identify the stakeholders and provide a clear articulation of the requirements expressed by the user community applying to PHASR.

Initial high level user needs can be summarized based on the mission objectives as:

a. Technology Demonstrator: Demonstrate a relevant span of technologies and capabilities required to enable future human and robotic exploration of the Moon.

b. Science Prospector: Acquire data and return lunar samples to advance our knowledge and understanding of the Moon, Earth System and address a high number of Scientific Knowledge Gaps (SKGs) being elaborated by the parallel science studies.

c. Resource Prospector: Acquire data that enable a better mapping and understanding of potential resources available as well as their distribution on the Moon (e.g. water ice).

3.1.3 Mission Conceptual Design

The Contractor must develop a Mission Concept Document (MCD) (CDRL MD1) that supports the definition, development, and operation of the system. This document communicates to systems developers and users, in the user's language, the desired characteristics of the system to be developed. This document will focus on the actual PHASR contribution with respect to the global referenced documents describing the overall international mission concept and describe the Canadian mission contribution.

The Canadian science team in a parallel study is tasked to recommend one of the nominal science payload instruments as a science payload for potential contribution by Canada to the HERACLES mission. This nominal Canadian payload will be confirmed at the phase 0 kick-off meeting. The Contractor will support the Canadian science team in developing accommodation, detailed requirements and PHASR interfaces for this nominal Canadian payload.

3.1.4 HERACLES Mission and PHASR Requirements

The Contractor must review the preliminary list of HERACLES mission and PHASR systems requirements provided in this SOW, and modify and further develop as needed with CSA which details/contains the mission requirements required to proceed with the development of system requirements (CDRL MD2). The Performance and Functional Requirements Document (PFR) must be a separate document as the intent is to use this document in subsequent phases of the project. The focus of the requirement development should be aligned with the priority expressed in the analysis of the elements provided under the required analysis in section 3.3.4.

3.1.5 Mission Development Plan

The contractor must breakdown the mission into sub-systems at a level sufficient to estimate required developments, cost, risk and performance. In order to standardize and have a clear understanding of the system breakdown the contractor should use the proposed CSA Product Breakdown Structure (PBS) listed in Appendix E. The system breakdown must be the basis of the Technology Readiness and Risk Assessment (TRRA) and Development Plan for the mission.

The Mission Development Plan includes:

a. identification of the mission cost;

b. identification of the mission schedule;

c. identification of the technology development tasks required to bring the technology readiness to the appropriate level at the appropriate time;

d. identification of the development and manufacturing approach; (e.g. Prototyping, etc.)

e. identification of scientific ground support needs;

f. approach for calibration, data product, application development and simulation;

g. provision of a mission risk assessment;

h. identification of potential collaborations;

i. provision of a Canadian capabilities development strategy; and

The information requested in sections 3.1.5.1 through 3.1.5.6 must be presented in the Mission Development Plan (CDRL MD3).

3.1.5.1 Mission Cost Estimate

The Contractor must provide an indicative LSM PHASR System Cost, in accordance with Treasury Board (TB) guidelines (RD-3), as per Table 3-1 Template for Cost Breakdown, broken down per Work Breakdown Structure (WBS), for all phases leading to the development, implementation, operation and disposal. In addition, and within the table, the cost breakdown shall also be done by Government Fiscal Year beginning on April 1st within the phase breakdown. Along with the cost estimate, a detailed justification for those costs must be included. The justification must describe the type of analysis (analogous, bottom-up, etc.), as well as the assumptions made (CDRL PM6). Cost estimates must provide sufficient granularity to allow cost estimating of the LSM PHASR System across the life cycle of the mission.

The contract should refer to the NASA Project Cost Estimating Capability (PCEC) (RD-6) for reference and approach to link the PBS for breakdown and costing.

TABLE 3-1: TEMPLATE FOR COST BREAKDOWN (EXAMPLE)

Category (per WBS)		Phase A		Phase B	Phase C	Phase D	Phase E	Phase F
	GFY (example)	FY20	FY21	Etc.				
Labour	Management							
	Technology Development							
	Design							
	Documentation							
	Reviews							
	Manufacturing							
	Assembly							
	Testing							
	Product Assurance							
	Operations Team Support							
	Total Labour							
Non-Labour	Hardware / Software Procurement							
	Testing, Prototyping							
	Operations Team Support							
	Tools, Equipment and Facilities (incl. for testing)							

	Travel and Living						
	Subcontracts						
	Other Direct Charges						
	Total Non-Labour						
	SubTotal						
	G&A						
Risk	Risk Contingency						
	Fee						
Taxes	GST						
Total By Phase							
Total All Phases							

3.1.5.2 Overall Mission Schedule

The Contractor must suggest a preliminary Mission Schedule relative to the overall life cycle of the mission including the impact of hardware (including payloads) integration and qualification milestones. The timeline must include key milestones from Phase A to Phase F completion, such as Preliminary Design Review, Critical Design Review and Launch. Refer to CSA Systems Engineering Technical Review Standard (AD-4) for a full description of all the possible reviews, which may vary depending on the nature of the mission architecture. The project schedule prepared by the Contractor must provide a graphical representation of predicted tasks, milestones, dependencies, task duration, and the critical path. The project schedule must be detailed enough to show each WBS task to be performed. The project's master schedule must inter-relate all tasks on a common time scale and be in the form of a Gantt chart. The Contractor must demonstrate the link between the PHASR schedule and the LPR schedule as a successor program and how the PHASR would timely address risks and prepare for the LPR mission and be compatible with this timeline. In the case where not all the critical elements are demonstrated via the PHASR mission, the schedule must address alternate proposed methods to achieve readiness to meet the LPR readiness level (e.g. Radioisotope Thermal Generator (RTG) testing/demonstration on Earth versus PHASR flight demonstration). Also, although the funding may be provided by the Government of Canada in the yearly budget announcements, usually around March of every year, the contractor should assume a period of 6 month processing time before the issuing agency has the expenditure authority to issue a contract for the work in phase A. Following which, once the contractor provides the substantive LCC values for the follow-on phases to complete the work at the end of phase A, the authority to proceed in to the next phases may take anywhere from 6 months to a year until the approval and authority from Treasury Board is given. These intervals must be included in the mission schedule.

3.1.5.3 Development and Manufacturing Approach

The Contractor must provide an overview of the development and manufacturing approach, specifying the major tasks required in the development and manufacturing cycles and the general strategy best suited for this approach. This may imply the creation of breadboards, mock-ups, prototypes, and simulations to ensure the path to flight is viable for the development cycle.

Obviously, theses costs are included in the LCC of the project. Identification of the potential long-lead items is also required. All this should be explained in the proposal in order to be evaluated properly. The contractor must also present the proposed work with respect to previous development and availability in the context of using existing or COTS technologies or used these as a basis to the development of custom assets for meeting the requirements. Another important consideration is the testing campaign necessary for the qualification of space systems. The bidder's proposal must explain how the testing will be done and where. Also, has the facility been contacted to verify if they have an open reservation to allow the contractor to schedule their testing, has it been verified that the facility is available at the time required (or are they undergoing renovations)? Have their costs been taken into account for the LCC? These are important issues that will be evaluated by the committee.

If subcontractors will be used, qualifications of their manufacturing process (QA) must be provided in the proposal. It should be cognizant on the contractor that manufacturing certifications are usually done per the NASA standards, however, if the contractor wants to use their own certifications (e.g. welding certifications) , there certifications must be sent to NASA for their concurrence.

Specific needs for testing at analogue sites should be described where other test methods are insufficient, including test objectives and rationale.

3.1.5.4 Preliminary Mission Risk Assessment

The Contractor must provide a preliminary technical, schedule, cost and programmatic risk assessment for the entire mission lifecycle, starting with Phase A through to Phase F. For each risk identified, the Contractor must identify the phase of the mission to which the risk applies, the likelihood of occurrence, the quantitative assessment of the impact should the risk occur (i.e. costs) and any possible mitigation actions that may be taken in the near term to decrease either the likelihood or the impact. Specific mitigation actions must be identified for medium and high risks. Contingency plans (i.e.: identifying alternative strategies) must also be developed for medium and high risks, or when it is uncertain that mitigation plans will be effective.

Stating simply a 'schedule risk' is not an acceptable consideration.. Rather, what risk factor causes the schedule slippage and what mitigation/contingency does the contractor propose to do about it, is what the committee will evaluate.

The Contractor must integrate all risks when producing risk-related information and document it in a Risk Assessment Matrix. The risk assessment process and matrix are generally provided in (RD-1).

3.1.5.5 Collaboration

The Contractor must identify potential partners/stakeholders either at the national or international level. State the benefits of their participation in such a mission and provide a preliminary assessment of roles and responsibilities. The basis and process of stakeholder analysis is described in the Project Management Book of Knowledge (PMBoK) (RD-1).

3.1.5.6 Canadian Capabilities Development

This report must provide an estimate of the anticipated percentage of Canadian content relative to the overall cost presented in Table 3-1, what options could be undertaken to maximize the

Canadian content and their corresponding impacts and benefits. The Contractor must describe the Canadian supply chain involved in this current Phase 0 study, and expected to be involved in subsequent phases.

The report must also provide an overview of the Contractor's strategy to develop and maintain Canadian capabilities. If the overall approach of the Contractor implies technology transfer and partnership with foreign entities to develop the Canadian capabilities, the Contractor must specify teaming arrangements, Intellectual Property (IP) ownership issues, licensing, royalties and opportunities that this partnership would open.

3.1.6 Technology Readiness and Risk Assessment (TRRA)

The Contractor must conduct a Technology Readiness and Risk Assessment (TRRA) in accordance with the requirements of the CSA TRRA guidelines (AD-1).

The main steps of the TRRA are:

a. Logically breakdown the instrument into technology elements (CDRL MD4);

b. Classify technology elements as critical or non-critical using the criteria defined in the Critical Technology Elements (CTE) worksheet (AD-2) and provide sufficient rationale for that classification (CDRL MD5);

c. Produce a Technology Readiness and Risks Assessment for each Critical Technology Element using the PDF form provided in AD-3 (CDRL MD6).

d. Prepare a report according to CDRL MD7.

As the maturity of the technology grows and requirements are better defined, the TRRA may need to be updated to reflect this progress.

The Contractor must update the Technology Readiness and Risk Assessment to reflect the change in maturity of the system as a result of the work performed in Phase 0. For purposes of technology development, the Contractor should also provide driving requirements, cost estimate, and schedule to reach the next Technology Readiness Level (TRL) for Critical Technology Elements (CTE).

3.1.7 Technology Roadmap

The Contractor must provide a Technology Development Plan, also known as Technology Roadmap (TRM) including the recommended timeline and sequence of required technology developments to reach TRL 6 and eventually TRL 8 (CDRL MD8). The TRM will also provide a notional budget providing estimated costing for the proposed technology development steps.

The TRM must show how the technology development plan and associated TRL progression aligns with the system's mission phases/milestones versus the NASA mission phases/milestones.

The Technology Roadmap may be provided as a chapter of the Mission Development Plan (CDRL MD3).

3.1.8 Intellectual Property

The Contractor must complete the Contractor Disclosure of Intellectual Property CSA Form (CDRL MD9), identifying the Background and Foreground Intellectual Property (BIP and FIP) that will be generated in this Phase 0 contract, the owners of the BIP and how it will be managed and coordinated among the various collaborators and entities involved.

3.2 OPERATIONS

3.2.1 Preliminary Concept of Operations

The Contractor must develop a Preliminary Concept of Operations (CONOps) (CDRL OP1) in order to meet the mission objectives. This document must provide a comprehensive summary of all operability aspects of the mission with a focus on the surface core mission operations for PHASR. This includes the TLI ops (if any), commissioning, debarking, normal ops, abnormal ops, and post-mission ops. An initial concept of operations and reference documents will be provided by the beginning period of the contract in order to orient the Concept of Operations and establish a baseline starting configuration for the contractor. This will be a joint effort between the CSA and the international partners (IPs). Specific needs for validation of the operations concept at analogue sites and training of operations staff should be described where other test methods are insufficient, including analogue test objectives and rationale.

During its development, the Preliminary Concept of Operations may be reviewed by the Canadian and international science teams.

The contractor will support at least one science meeting to present the concept of operations to the international science team and receive feedback. Feedback should be incorporated as mutually agreed by the Contractor and Project Authority.

3.3 ENGINEERING

3.3.1 Preliminary System Conceptual Design

The Contractor must develop a Preliminary System Conceptual Design Document (CDRL EN1) that meets the LSM PHASR System Mission, Performance and Functional Requirements. This concept must be substantiated by analysis as described in section 3.3.4.

3.3.2 Preliminary Interface Control Document

The Contractor must prepare a Preliminary Interface Control Document (ICD) (CDRL EN2), to the extent of the information available, in which:

a. All external interfaces are identified and characterized.
b. All internal interfaces are identified and characterized between all sub-systems
c. All software interfaces are identified and characterized.

International reference documents will be provided during the contract as inputs to the international interfaces. Initial interfaces for launch vehicles and environments are provided in the reference document of this SOW (RD-11 and RD-14).

The initial CAD layouts must be available by the MCR

3.3.3 Preliminary Apogy Model Definition

Over the last years, the CSA has initiated a centralized initiative called Apogy, a multi-mission software framework that simplifies the integration and operations of assemblies of modular systems in different environments. Apogy provides a single expandable tool that supports the operation cycle (development, test, execution and monitoring). The framework only uses open-source software and in particular the Eclipse platform. Apogy exploits modern model based software development tools and techniques such as the Eclipse Modeling Framework (EMF). This

approach inherently promotes a highly modular and extendable software architecture that allows customization of functionalities with reduced effort. The usage of Eclipse provides state-of-the-art user interface experience that reflects today's best user interface technologies.

1. Provided Government Furnished Equipment (GFE) and Government Furnished Information (GFI): Apogy Training
    a. 2 people from contractor will get a 2-day Apogy training at CSA.
    b. How to install Apogy on a PC,
    c. How to use and conduct operations through Apogy,
    d. How to create new rover/instrument drivers to plug into the Apogy framework.
2. The contractor must perform and provide the following to create and develop Apogy drivers and views to integrate the rover and instruments such as the PHASR0 into the Apogy framework (100 hours approximately):
    a. Create Apogy PHASR0 (main system and subsystems) meta-models,
    b. Implement a simple simulator for each Apogy drivers.
    c. Integrate, assemble and simplify PHASR0 CAD models into Apogy associated drivers
    d. Based on existing Apogy UI capabilities, assemble a Control Station to control the simulated PHASR0 from the Apogy framework (Custom PHASR0 control pages could be required as well)
3. Deliverables: The Apogy deliverables are Eclipse plugins and must be compliant with Appendix G Table G-1.

3.3.4 Supporting Analyses

The Contractor must provide the analyses in support to the conceptual design and feasibility assessment exercises (CDRL EN4). The contractor must in particular deliver analyses and models as per the DID required for establishing the mass budget, power and data budget as well as a viable thermal concept and design. This is to make sure that the proposed concept is fully characterized against the thermal, power, data and mass budgets and provide a viable concept and inline with the requirements.

3.4 MISSION REQUIREMENTS VERIFICATION MATRIX

The Contractor must develop the Mission Requirements Verification Matrix (CDRL EN3) to identify the various requirements developed to meet the Phase 0 scope.

3.5 PROJECT MANAGEMENT

The Contractor is responsible for establishing and maintaining a project management control system necessary to ensure the cost, schedule, technical and programmatic requirements of this SOW are met. If there is information missing from this SOW for the contractor to fulfill its responsibilities to complete the contract, it is the duty of the contractor to inform the CSA as soon as this situation comes to light. If CSA does not have the information on hand or cannot obtain the information, the contractor and CSA must make and document an assumption so that the work will not be stopped. Refer to Appendix A, for the minimum required Contract Data Requirement List (CDRL).

3.5.1 Team Organization

The Contractor must set up and maintain a project organization specific to this project. The Contractor must provide and maintain a current Project Organizational Chart showing personnel assignments by name and function, and showing subcontractor-reporting relationships.

The Contractor must nominate an experienced Project Manager, who will be responsible for all aspects of the work carried out by the Contractor and will act as single point of contact within its project organization for communications between the Contractor and the Technical Authority (TA) for the contract. Usually at this interval, it would be the CSA Mission Manager. In the absence of the single point of contact, the Contractor must designate an alternate to maintain continuity of communication between the Contractor and the TA.

The Contractor must also identify other key personnel who are considered essential to the performance of the contract. The Contractor must assign personnel with appropriate qualifications and experience to all posts within the project organization, including scientists with the necessary expertise to define/interpret the science requirements for the mission and data products (for the purpose of the contract work).

The Contractor must include, within its program management structure, the necessary leadership to effectively manage the performance of subcontractors in keeping with the project objectives. This implies that the subcontractors have the correct processes and/or policies in place to be able to perform and track the work to the highest standards (e.g. ISO-9000s).

3.5.2 Contractor Work Breakdown Structure

The Contractor must prepare and maintain a detailed Contractor Work Breakdown Structure (CWBS) (CDRL PM4). The CWBS must include all project management, product assurance, mission and operations planning and engineering work identified in this SOW, including subcontractors' work. Since, this work also includes the planning analysis for all the phases until completion, the CWBS must contain all the work packages (WPs) necessary to carry out all the work for a complete mission.

3.5.3 Detailed Schedule and Critical Path

The Contractor must prepare and maintain a detailed schedule (CDRL PM5) based on the CWBS for all the work to be performed under this Phase 0 contract.

The schedule must show dependencies between the activities to identify the critical path and marked on the schedule chart. The schedule must be updated at each major milestones. The schedule must include all the milestones listed in Table 3-2 : Proposed Project Milestones.

Since this work also includes the planning analysis for all the phases until completion, the schedule must contain all the work packages (WPs) and tasks necessary to carry out all the work for a complete mission.

TABLE 3-2 : PROPOSED PROJECT MILESTONES

ID	Milestone
M1	Kick-off Meeting (KoM)
M2	Mission Concept Review (MCR)
M3	Technology Readiness and Risk Assessment
M4	Mission Requirements Review (MRR)
M5	Preliminary Systems Requirements Review
M6	Phase 0 Final Review

3.5.4 Communications and Access

The Contractor must establish and maintain a close management and technical interface with CSA to assure a coordinated program effort and monitoring of the total program cost, schedule and performance.

The Contractor must provide access to its plant and personnel, as well as to its subcontractor plants and personnel , at mutually agreeable dates, by representatives of CSA (such as CSA QA) or other organizations nominated by the CSA, for review of program status.

The Contractor must provide temporary accommodation and other facilities for the use of the CSA representatives (and the nominated attendees) visiting the Contractor's premises for reviews, meetings, audits, liaison, etc.

The accommodation must be adequate for the purposes of the visit and the facilities provided must include telephone, faxing, photocopying and Internet access.

All documentation and data generated by the Contractor for the project must be accessible to the CSA Mission Manager and TA for review.

3.5.5 Project Meetings

The Contractor must hold the meetings described in Table 3-3 Planned Meetings. Some or all of these meetings may be attended by representatives of the CSA, and/or other organizations nominated by the CSA.

All meetings between the Contractor and CSA will be held at a mutually agreeable time and location . The Contractor must provide formal notification of the proposed meeting date to the CSA TA no less than 10 working days before the meeting (with the exception of the KoM where the Contractor must provide formal notification no less than 5 working days before the meeting).

For meetings held at government venues, the Contractor must inform the CSA TA of the names of Contractor and Subcontractor attendees no less than 10 working days before each meeting.

Additional teleconferences and face-to-face review meetings must be held if necessary when mutually agreed to by the Contractor and the CSA Mission Manager.

Meetings can be alternatively replaced by teleconferences for cost and/or time savings and when appropriate to support the scope of the meeting. All technical reviews will be chaired by the CSA Mission Manager.

TABLE 3-3: PLANNED MEETINGS

ID	Meetings	Date Time after Contract Award	Venue
M1	Kick-off Meeting (KoM)	2 weeks	CSA/Telecon
M2	Mission Concept Review (MCR)	3 months	CSA
M3	Technology Readiness and Risk Assessment (TRRA)	6 months	CSA/Telecon
M4	Mission Requirements Review (MRR)	8 months	CSA
M5	Preliminary Systems Requirements Review	10 months	CSA/Telecon
M6	Phase 0 Final Review	12 months	CSA
	Weekly Meetings	As required	Telecon
	Provision to: 1) support one (1) international meeting, which may include meetings to present the payload and/or operations concept to an international science team and 2) one (1) to two (2) visits 2 peoples each for participation into an analogue mission activity at CSA.	TBD June 2019 (TBC)	TBD, could be Europe, Japan or USA CSA

3.5.5.1 Monthly Teleconference Meetings

The Contractor must hold monthly teleconference meetings with the Project Manager (PM) when requested by the CSA and/or contractor to address the monthly report, and the duration should be limited to one hour. The teleconference is mainly to address technical issues and to discuss progress.

3.5.5.2 M1 – Kick-off Meeting

This meeting will serve as an opportunity for CSA and Public Services and Procurement Canada (PSPC) to review the Contractor's plans, the requirements of the work (SOW), schedules, deliverables, risks, and address issues (CDRL PM8).

3.5.5.3 M2 – Mission Concept Review (MCR)

The MCR affirms the mission needs and examines the proposed mission's objectives and the concept for meeting those objectives and determines the project readiness to proceed with the development of mission requirements.

The Contractor must make a presentation (CDRL PM9) such as to demonstrate that the MCR entry and exit criteria are met, including the common entry and exit criteria, as per AD-4.

The deliverables for this review will be as per Table A-1.

3.5.5.4 M3 – Technology Readiness and Risk Assessment (TRRA)

The focus of the TRRA process is to provide inputs to the Technology Development Plan by identifying critical technologies and assess their maturity level. The intent of this milestone is to review the PDF worksheets (CDRL MD6) for each Critical Technology Element.

Please refer to section 3.1.6 for more information.

3.5.5.5 M4 – Mission Requirements Review (MRR)

The purpose of the MRR is to examine and demonstrate the validity of the mission requirements, examine the mission architecture, and the project readiness to proceed with the development of system requirements.

The Contractor must make a presentation (CDRL PM10) such as to demonstrate that the MRR entry and exit criteria are met, including the common entry and exit criteria, as per AD-4.

The deliverables for this review will be as per Table A-1.

3.5.5.6 M5 – Preliminary System Requirements Review (PSRR)

The purpose of the PSRR is to prepare for the PHASR Mission SRR for each subsystem of the PHASR.

The Contractor must make a presentation (CDRL PM11) such as to demonstrate that the PSRR entry and exit criteria are met.

The deliverables for this review will be as per Table A-1.

3.5.5.7 M6 – Final Review Meeting (FR)

The Final Review will serve to review all final deliverables, and close all open actions.

The Contractor must make a presentation (CDRL PM12) to close the contract.

The deliverables for this review will be as per Table A-1.

3.5.6 Agendas, Minutes and Action Item Log

The Contractor must provide a Meeting Agenda (CDRL PM1) for all reviews and meetings including teleconferences and must deliver these to the CSA Mission Manager and/or TA no less

than 5 working days before the meeting and must have it approved by the CSA Mission Manager and/or TA. Agenda can be combined with the meeting presentation as long as the information required are provided.

The Contractor must produce the minutes for all reviews and meetings including teleconferences and must deliver these to CSA (CDRL PM2). In the case of teleconferences, they must be delivered the next business day.

The Contractor must maintain a detailed Action Item Log (AIL) throughout the project to track actions resulting from all reviews and meetings including teleconferences using the following red-yellow-green stoplight method:

- 'Green' implying that the action item will be completed on-time.
- 'Yellow' implying that there exist an issue which will prevent meeting the deadline, and
- 'Red' implying that the action is past due.

Also, a chart indicating how many action items are open and how many are closed since the beginning of the project must be produced for the monthly progress report and at the meetings. The AIL (CDRL PM3) must be delivered with the Monthly Progress Report PM7.

3.5.7 Project Reporting

3.5.7.1 Monthly Progress Reports

The Contractor must submit monthly Progress Reports (CDRL PM7).

The Monthly Progress Reports must be delivered no later than five working days after the end of the month. As all deliverables, it must be submitted via CSA CM Library for the LSM PHASR mission, and a copy must also be sent by email to the PSPC Contracting Officer.

3.5.8 Document Deliverables

The Contractor must deliver all documentation content listed in the CDRL tables (Appendix A) as a minimum. Documents may be combined or divided by mutual agreement to optimize production and avoid unnecessary duplication of information. The format and content of the deliverables must be in accordance with the requirements specified in the Data Item Descriptions (DIDs) (Appendix B), both the specific DID identified in the CDRL and the DID-100 “General Preparation Instructions”.

Except for the documents that will remain CSA documents, the Contractor may propose documents in a contractor's format provided the purpose, scope and content equal or exceed the DID requirements. Subject to CSA approval, the content of the contractor's document will replace the content of the document specified in the DID.

All documents must be delivered via the CSA CM Library for the LSM PHASR mission. Login credentials will be provided after the KOM.

SI units must be used/supplied by the Contractor. Conversion factors must be supplied for all non-SI units used in the deliverable documents (including dates as YYYY-MM-DD).

The delivery schedule for all documentation must be as defined in the CDRL table.

The Contractor must obtain approval from the CSA for all CDRL Documents so indicated in the CDRL table.

3.5.8.1 Documents Delivered for Approval

The term "Approval" as used in this document and in other documents referred to herein, means written approval by CSA Mission Manager, of documents submitted by the Contractor. Once approved, the document is authorized for further use by CSA. The CSA does not take responsibility for the validity of the data, or statements, and the Contractor is fully responsible for the content and secondary effects derived there from.

The document may not be changed without the CSA Mission Manager approval. No request or document for which approval is required must be acted upon or implemented by the Contractor until such approval is provided. Such requests and documents will be reviewed promptly by the CSA Mission Manager and the necessary written approval or disapproval will be provided after their receipt by CSA. In the event of a failure by the CSA Mission Manager to approve or disapprove the document within fifteen (15) working days, the document may be deemed approved.

In the event that a request or document is disapproved, the CSA Mission Manager will advise the Contractor in writing as to the reasons for such disapproval and will define the additions, deletions or corrections that the CSA Mission Manager deems necessary to render the request or document acceptable. Disapproved requests or documents that are subsequently amended by the Contractor and resubmitted for approval will be either approved or disapproved by the CSA. Approval or disapproval of resubmitted requests or documents will be based solely on those points that were not previously deemed to be acceptable.

3.5.8.2 Documents Delivered for Review

The term "Review" as used in this document and in all other documents referred to herein, means, unless specifically stated otherwise, a CSA review of the documents submitted for that purpose by the Contractor. The acceptance by the CSA Mission Manager of a document for review must imply that the document has been reviewed, commented on, revised as necessary, and has been determined to meet the requirements.

The CSA does not take responsibility for the validity of the data, or statements, and the Contractor is fully responsible for the content and secondary effects derived there from.

In the event that the CSA Mission Manager does not concur with a document submitted for review, the CSA Mission Manager will so notify the Contractor. Such notification will include a full explanation of the reasons for the lack of concurrence and will recommend the additions, deletions and/or corrections that the CSA Mission Manager deems are beneficial to the needs of the project.

The Contractor is obligated to consider implementation of the changes suggested by CSA insofar as the changes are in accordance with the relevant DID in Appendix B and this SOW. If written notification of concurrence is not provided by the CSA Mission Manager within fifteen (15) working days of the receipt of the document, the document must be deemed to have been reviewed and accepted by the CSA Mission Manager without comment.

3.5.9 Subcontract Management

The Contractor must be fully responsible for implementation and execution of all tasks, including those subcontracted to others. Whenever this is the case, the Contractor must prepare and maintain subcontract Statements of Work, technical requirements documents, etc., necessary to effectively manage the subcontractors' work.

At the request of the CSA Mission Manager and/or TA, copies of subcontractor documentation must be delivered to the CSA Mission Manager and/or TA.

The Contractor must ensure that all of the relevant requirements of this Statement of Work are flowed down to the subcontract Statements of Work.

3.6 OPTIONAL SERVICES

It is expected that the mission architecture and associated standards will undergo modifications during this period and that the LSM PHASR concept will need to be updated, and that the International Partners will have special requests or raise new questions regarding the proposed concept and architecture. The Contractor should:

Project Management:

1. Plan, schedule, assign and organize resources and ensure completion of all work carried out under the contract.
2. Maintain project management interface with the CSA project team.
3. Monitor and report on technical, cost and schedule progress, on a monthly basis according to CDRL-PM7.
4. Provide the management, technical leadership, applicable technical experts and disciplines, and the support necessary to ensure effective and efficient performance of all project efforts and activities.

Engineering:

1. Support CSA via providing the analyses and delivered specified herein in the review, evaluation and development of recommendations regarding modifications to the mission element concepts and the proposed standards. The standards include External Robotic Interfaces, Power, Avionics, Software, and Thermal.
2. Provide technical leadership on the conceptual design and architecture of the LSM PHASR including preparation and presentation of special topics, as requested by CSA.
3. Provide support as requested by CSA to develop/evaluate new/novel concepts for LSM PHASR and its subsystems in order to remain compatible with modifications to the HERACLES architecture.
4. As requested by CSA, generate CSA ICD material for novel operations and/or review external ICD material related to the rover. Support CSA in the identification and evolution of interface definition. This includes the preparation of draft technical drawings or models.
5. As requested by CSA, perform relevant analysis, model updates, operational flows, and deliver associated documentation as required to address technical aspects and changes related to the LSM PHASR concept, requirements or operations.
6. Maintain and update Phase 0 documentation, as applicable, based on international developments.

International Meeting Support:

1. Prepare/review/update presentations in support of international discussions and meetings with respect to technical aspects of the LSM PHASR.
2. As requested by CSA, participate in concept and mission review meetings at international partner locations. For planning purpose, one international, week-long meetings should be assumed, supported onsite by a maximum of two members of the Contractor team.

Analogue Mission Participation:

1. Participate in providing up to 2 employees in CSA led testing and analogue mission at CSA St-Hubert and its vicinity (e.g. Granby QC) during the 2019 season. This will be for training and conduct of a series of test related to the HERACLES mission. It will either be one or two trip of a total of 1 day each at the CSA.

4 CONTRACTOR DELIVERABLES

4.1 HARDWARE

The Contractor must deliver any breadboard developed as part of the Work that was subsidized by the GoC.

4.2 SOFTWARE

The Contractor must deliver source code of the software developed as part of the Work.

4.3 DOCUMENTATION

The Contractor must deliver all documentation requested in Appendix A.

The Contractor may propose to combine documents called by more than one CDRL into one document, but this is subject to prior approval from the CSA. Where this approval is granted, the document cover page must list all the CDRL numbers that are covered by this document (see DID-100 – General Preparation Instructions).

Documentation, reporting and other deliverables must be according to instructions provided in Appendix B of this SOW, which also provides naming convention. Presentation material should be in Power Point format. Documents provided in Adobe PDF format must not be protected against copy of text and figures.

Documents must be delivered in the original software application format. One electronic copy of each deliverable document must be transferred to the CSA to the address and in the format specified in DID-100 – General Preparation Instruction. No paper copy is to be delivered.

All documents must be provided as soon as completed but no less than 10 working days prior to the specified Review/Meeting unless otherwise indicated.

5 GOVERNMENT FURNISHED EQUIPMENT

Aside from the government furnished equipment/service listed in section 3.3.3 for Apogy training, no other government furnished equipment is expected to be deliverable under this internal study. If applicable, any government furnished equipment must be returned to the Crown at the conclusion of the Contract.

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APPENDICES

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A CONTRACT DATA REQUIREMENTS LIST (CDRL)

This Appendix defines the documentation to be delivered by the Contractor.

LEGEND:

1) DID No.

- CF = Contractor's format

2) Document Versions:

- D: Draft (under Version Control, expected to be updated – up to 50% complete and correct)
- P:Preliminary (under Version Control, expected to be updated - 70% complete and correct).
- IR: Initial Release (under Configuration Control, may well be revised during normal project life - 95-100% complete & correct).
- U: Update (expected revision, but not final; under Configuration Control, previous versions remain unchanged under Configuration Control).
- F: Final (under Configuration Control, normally not expected to be revised, but could be if necessary - 100% complete and correct).

TABLE A-1: CONTRACT DATA REQUIREMENTS LIST

CDRL No.	Title	SOW Sect. No.	DID No.	Initial Release	Update	Final	Acceptance Category
A.1 PROJECT MANAGEMENT							
PM1	Meeting Agenda	3.5.6	110	M1, M3, M4			Review
PM2	Minutes of Meetings	3.5.6	111	M1, M3, M4			Approval
PM3	Action Items Log (AIL)	3.5.6	112	M1, M3, M4	As required		Approval
PM4	CWBS and Work Package Descriptions	3.5.2	102	Proposal	M1 KoM		Approval
PM5	Phase 0 Project Schedule	3.5.3	105	M1 KoM	Monthly		Review
PM6	Mission Life-Cycle Cost Estimates	3.1.5.1	Table 3-1	M2 MCR		M4 MRR	Approval
PM7	Progress Report	3.5.7.1	107		Monthly		Review
PM8	Kick-Off Meeting Presentation	3.5.5.2	CF	M1 KoM			Review
PM9	Mission Concept Review Presentation	3.5.5.3	CF	M2 MCR			Review
PM10	Mission Requirements Review Presentation	3.5.5.5	CF	M4 MRR			Review
PM11	Preliminary Systems Requirement Review Presentation	3.5.5.6	CF	M5 PSRR			Review
PM12	Final Review Presentation	3.5.5.7	CF	M6 FR			Review
A.2 MISSION DOCUMENTATION							
MD1.	Mission Concept Document (MCD)	3.1.3	002	M2 MCR	As required	M4 MRR	Review
MD2.	PHASR Performance and Functional Requirements Document (PFR)	3.1.4	008	M4 MRR	As required	M6 FRR	Approval
MD3.	Mission Development Plan (MDP)	3.1.5	007	M2 MCR	As required	M4 MRR	Approval
MD4.	Product Breakdown Structure (PBS) for the mission and sub-systems (to be used in TRRA and Mission Development Plan)	3.1.6	CF	M2 MCR		M4 MRR	Approval
MD5.	Criticality Technology Element (CTE) Report	3.1.6	AD-2	M3 TRRA		M4 MRR	Approval
MD6.	TRRA for Critical Element (PDF Worksheets)	3.1.6	AD-3	M3 TRRA		M4 MRR	Approval
MD7.	TRRA Stand Alone Report	3.1.6	0013	M3 TRRA	As required	M4 MRR	Approval
MD8.	Technology Roadmap (TRM)	3.1.7	CF	M3 TRRA		M4 MRR	Approval

CDRL No.	Title	SOW Sect. No.	DID No.	Initial Release	Update	Final	Acceptance Category
MD9.	Contractor Disclosure of IP	3.1.8	App. C	Proposal		M6 FR	Approval
MD10.	Science Payload Proposal Information package		850	M2 MCR		M6 FRR	Approval
A.3 OPERATIONS							
OP1.	Preliminary Concept of Operations (ConOps)	3.2.1	825	M2 MCR		M4 MRR	Approval
A.4 ENGINEERING							
EN1.	Preliminary System Conceptual Design Document	3.3.1	700	M4 MRR		M6 FR	Review
EN2.	Preliminary Interface Control Document (ICD)	3.3.2	501	M5 PSRR		M6 FR	Review
EN3.	Requirements Verification Matrix	3.4	CF	M4 MRR	M5 PSRR	M6 FR	Review
EN4.	Models & Analyses	3.3.4	600	M4 MRR	M5 PSRR	M6 FR	Review
EN5.	Software Interface Definition in Xcore Format	3.3.3	App. G	M4 MRR	M5 PSRR	M6 FR	Review

B DATA ITEMS DESCRIPTIONS (DIDS)

DID-100 – General Preparation Instructions

PURPOSE:

This DID specifies:

a) format requirements for the preparation and formatting of deliverable project documentation;

b) document and data delivery methods, notifications and identification requirements;

c) document and data structure requirements;

d) metadata requirements for all document and data submissions.

When documentation is prepared in the Contractor's format, it must still meet the requirements of this DID.

PREPARATION INSTRUCTIONS:

1. GENERAL INSTRUCTIONS

1.1. Preparation

All documentation must be written in English and must be delivered in electronic format. Documents must be prepared using the most appropriate software (Microsoft Word, Excel, etc.). Schedules must be submitted in Microsoft Project format. Documents whose native format is not a common office program must be delivered in PDF in addition to the native format.

The electronic file name and the identification number written on the document itself must have the following format:

WXYZ CDRL-NUM CIE document title (ABCD)rev no._sentYYYY-MM-DD

where:

WXYZ:	3-8 letter acronym of the project (eg.: LSM)
CDRL NUM:	The CDRL Identifier (e.g. PM1)
CIE:	Company Name or Agency center originating document
Document Title	Short descriptive text
(ABCD)	Contractor's document number, in brackets, this is optional
Revision no. or letter	1st release can be revIR, rev0, or revNC (no spaces)
_sentYEAR-MONTH-DAY	Date Tracking Number

For example : LSM PM1 ACME Test Report on TVAC rev0_sent2018-03-31

Note the absence of underscores or hyphens, except for the date. Failure to observe the file naming convention will be cause for rejection of the deliverable and incur delays in the payment of the claim.

1.2. Electronic Documents Format

Electronic copies of text documents must be formatted for printing on 8.5" x 11" paper.

1.2.1. Page Numbering

General format of documents should include page numbers and be formatted according to the contractor's normal standard. If the document is divided into volumes, each such volume must restart the page numbering sequence.

1.2.2. Document Numbers

All pages must contain the Document Number at the top of the page. Document Numbers must include revision status and volume identification as applicable.

1.3. Delivery, Notifications and Identification Requirements

Data must be submitted with a Letter of Transmittal (or an electronic equivalent as mutually agreed by the CSA and the Contractor), and acknowledged. The Letter of Transmittal must be forwarded by the Contractor in two copies; one copy of acknowledgement to be signed and returned to the Contractor by the recipient. The Letter of Transmittal will contain as a minimum, the Contract Serial Number, the CDRL Number and the Title.

Documents may be delivered via e-mail or direct transfer (FTP) or on optical disks.

CSA will provide a secure FTP site (CSA PIE-ISEP portal) for delivery and sharing of documents. All deliverables must be submitted via this secure CSA portal.

Login credentials will be provided after the Kick-Off Meeting.

The CSA PIE-ISEP portal offers automatic email notification when an new document is added or removed. This notification can be personalized with a message from the sender. These notifications will be treated as a Letter of Transmittal and acknowledgement of receipt.

1.3.1. E-mailed documents

E-mailed documents must be sent to:

asc.bibliothequegc-cmlibrary.csa@canada.ca

Covering e-mails must contain the project/program acronym or equivalent identifier in the "Subject" line and include the CDRL identifier under which deliverable documents are being submitted.

1.3.2. Direct Transferred Documents

For direct transfer, a notification of the document's availability and location on a contractor repository must be sent to:

asc.bibliothequegc-cmlibrary.csa@canada.ca

If deliverables contain ITAR content, notifications of their availability on contractor repositories must be sent to: the CSA CM ITAR Receipt Desk:

CSA-CM-ITAR@asc-csa.gc.ca

The notification must include the project/program acronym or equivalent identifier and the CDRL identifier under which deliverable documents are being submitted.

1.3.3. Documents Delivered on optical disks

Hard copy and media deliverables are to be addressed to:

CM Library, 6A-100
Attention: CSA LSM PHASR Phase 0 Project Manager
Canadian Space Agency
6767, Route de l'Aéroport
Longueuil, QC, J3Y 8Y9
CANADA

The DVD or CD-ROM label must show the following information:

a) Company Name
b) Document Title
c) Document Number and Revision Status
d) CSA SOW Number
e) CDRL Number and Title
f) Contract Number

2. DOCUMENT STRUCTURE AND CONTENT

Except as otherwise specified, all documents must have the overall structure as follows:

a) Cover/Title Page;
b) Table of Contents;
c) Introduction;
d) Applicable and Reference Documents;
e) Body of Document; and
f) Appendices

2.2. Cover/Title Page

The title page must contain the following information:

a) Document Number and date: Volume x of y (if multivolume)
b) Rev. indicator / date of Rev.
c) Document Title
d) Project Name
e) Contract No.

f) CDRL Item No. or Nos., if one document responds to more than one CDRL, subject to prior approval from the PA.
g) Prepared for: Canadian Space Agency
h) Prepared by: Contractor name, CAGE Code, address, and phone number
i) Product tree identifier, if applicable
j) © HER MAJESTY THE QUEEN IN RIGHT OF CANADA [YEAR].
k) The following proprietary notice: This document is a deliverable under contract no. _____. It contains information proprietary to the Crown, or to a third party to which the Crown may have legal obligation to protect such information from unauthorized disclosure, use or duplication. Any disclosure, use or duplication of this document or of any of the information contained herein for other than the specific purpose for which it was disclosed is expressly prohibited outside the Government of Canada except as the Crown may otherwise agree to in writing.

2.3. Table of Contents

The table of contents must list the title and page number of each titled paragraph and subparagraph, at least down to the third level inclusive. The table of contents must then list the title and page number of each appendix, figure and table, in that order.

2.4. Introduction

This section must be identified as section 1 and must, as a minimum, provide the following information:

a) Project description and background;
b) Identification (number, title) and a brief overview of the system, hardware, or software to which the document applies;
c) Purpose of the document;
d) Scope of the document (what it includes and what it does not include);
e) Document conventions; and
f) Roles and responsibilities of the participants and stakeholders.

The requirements specified in the following DIDs are the minimum expected. The Contractor must include in all documents all additional information required in order to ensure that the document provided will achieve its purpose as stated in the DID.

2.5. Applicable and Reference Documents

This section must list by Document Number and title, all applicable and reference documents. This section must also identify the source of all applicable and reference documents and the revision indicator.

2.6. Body of Document

The body of the document must be prepared in accordance with the content and format requirements defined in the specific Data Item Description.

2.7. Appendices

Appendices may be used to provide information published separately for convenience of document maintenance. Acronyms must be in the last appendix.

3. METADATA ON DELIVERABLES

This section is optional at the discretion of the CSA Project Manager.

In order for CSA to be able to properly manage deliverables and the system configuration as well as to process contractor's deliverables in an efficient manner, the contractor must, for each deliverable, provide metadata as described in the following table.

Provided by Supplier	Metadata Description	Comments
Yes	CSA Project Identifier	Project Acronym
Yes	Contract Identifier	PSPC identifier
Yes	Contract Revision Identifier	PSPC identifier
Optional	Contract Revision Date	
Yes	SOW Identifier	CSA Doc ID
Yes	SOW Revision Identifier	CSA Doc Revision ID
Yes	Document Type	Dwg, Doc, RFD, RFW, ECR, ECN, IP CR, IP CN/CD, QN, etc.
Yes	CDRL Identifier	Per CSA SOW (e.g. EN-006)
Yes	CDRL Sub-category Identifier	If multiple, separate subject documents per CDRL item (e.g. EN-006.03) (can be contractor defined)
Optional	Project WBS identifier	
Optional	SOW paragraph identifier.	
Optional	DID/ DRD Identifier	
Yes	Deliverable submission format	Electronic, Hard copy, On media (CD-ROM, etc.)
Yes	Deliverable Transmittal Identifier	e.g. CADM09-0123. Can also be a notification of delivery identifier
Yes	Deliverable Transmittal Date	
Yes	Originator's Organization Identifier	CAGE code, company name, short name, etc.
Optional	Document Author	
Yes	Deliverable Type	Dwg, Doc, RFD, RFW, ECR, ECN, NCR, Problem Report, IP CR, IP CN/CD, QN, etc.
Yes	Document Type	Specification, Design, Plan, Tech Note, Report, etc.
Yes	Originator's Document Identifier	
When applicable	Originator's Document Volume Identifier	
When applicable	Originator's Document Part Identifier	
When applicable	Originator's Document Issue Identifier	When both Issue and Revision are used concurrently to identify released documents
Yes	Originator's Document Revision Identifier	
Yes	Originator's Document Title	
Yes	Document Release Date	
Yes	Document Effective Date	Applicable to document changes, deviations, waivers,
Yes	Document Expiry Date	If applicable
When applicable	Originator's Authorizing ECN Identifier	Class 2 ECN approving document release and submission to customer
Yes	Document Maturity	Draft, Preliminary, Initial Release, Updated Revision, etc.
When applicable	Class	If deliverable is a change, deviation, waiver, etc. to a released item. (Class I, Class II)

Provided by Supplier	Metadata Description	Comments
Yes	Security Classification of Deliverable	Per Government of Canada definitions for Classified and Protected data (C,S,TS,PA,PB,PC)
Yes	Sensitivity of Document contents	Company Proprietary, Trade Secret, etc.
Yes	ITAR Content Indicator	Yes or No
Yes	Export Controlled Content Indicator	Yes or No
Yes	Affected Document Identifier	If deliverable is a change, deviation, waiver, etc. to a released document/drawing/model. Enables change-to-document, waiver-to-document relationships, etc.
Yes	Affected Document Revision Identifier	As above
Yes	Affected Document Title	As above
Yes	Product Breakdown Structure / Item Hierarchy Identifier	Critical for Item-to-Document Relationship
Yes	Associated Project/System Milestone Review	PDR, CDR, etc. When Reviews are at sub-system level, identify accordingly. e.g. Bus PDR
When applicable	Associated System Baseline	If different from Project Milestone
Yes	Filename of Deliverable	Filename and file type (for all representations submitted - .doc, .pdf, etc.). Original, revisable format to be delivered before contract completion.
Yes	Format of Deliverable / Application used to produce	MS WORD 2007, Project Scheduler 9, etc.
When applicable	Filename of Parent Deliverable Bundle	If part of a document Bill of Material
When applicable	Identification of Delivery Media	If physically delivered
When applicable	Originator's Repository Address of deliverable	To identify source location of document

DID-002 – Mission Concept Document (MCD)

PURPOSE:

To support the definition, development, and operation of the system or instrument. This document communicates to systems developers and users, in the user's language, the desired characteristics of the system or instrument to be developed.

PREPARATION INSTRUCTIONS:

The MCD is an important complementary document to the System Requirements Document (SRD), the Interface Requirements Document (IRD), and the Environmental Requirements and Test Specification (ERTS). Written in a narrative form and non-specification-type prose, it describes the way in which the system is envisioned to fit and function within its operational environment.

The contents of the MCD must be tailored as outlined below.

4. Introduction
    - 4.1. Identification
    - 4.2. Scope
    - 4.3. System overview
    - 4.4. Document overview
5. Referenced documents
6. System description
    - 6.1. System goals and objectives
    - 6.2. System scope
    - 6.3. Minimum supporting documentation
    - 6.4. System states and modes
    - 6.5. System architecture
    - 6.6. System Block Diagram
    - 6.7. System interfaces
    - 6.8. System capabilities
7. Operational needs
    - 7.1. Mission needs
    - 7.2. Users' needs
8. Operations
    - 8.1. Operational overview
        - 8.1.1.Mission

DID-007 – Mission Development Plan

PURPOSE:

To define the programmatic activities required to initiate and develop the mission.

PREPARATION INSTRUCTIONS:

The plan must include the following:

1) An introduction including the scope, the purpose and a list of assumptions (if any);
2) A description of the mission including goals and objectives;
3) Identification of stakeholders and their needs and expectations;
4) A description of the estimated mission life cycle cost;
5) A description of the estimated mission schedule including all major milestones;
6) A description of the technology development required; (mock-ups/prototypes/breadboards/etc.)
7) A description of the proposed development and manufacturing approach; including the testing process
8) A description of the preliminary mission risk assessment;
9) A description of the preliminary Concept of Operation;
10) A description of potential collaborations;
11) A description of the intellectual property to be generated throughout the whole project (not just Phase 0);
12) A description of the proposed Canadian capabilities development strategy;
13) A description of the proposed commercialisation plan; and
14) Recommendations for follow-on activities.

DID-008 – Performance and Functional Requirements Document

PURPOSE:

It is proposed that a PHASR Performance and Functional Requirements (PFR) be used to capture the subset of mission requirements that will be applicable to the development of the PHASR. The PFR will include functional and performance requirements, interface requirements, mission environmental requirements and operational requirements. It will also serve to distinguish essential requirements from goals (desirable objectives), and identify gaps, assumptions, TBDs, TBCs and unknowns that must be addressed.

PREPARATION INSTRUCTIONS:

The document must include the following:

1) An introduction including the scope and purpose
2) A short description of the mission including background objectives and a list of assumptions (if any);
3) A list of applicable and reference documents (if any);
4) User requirements, which represent a clear articulation of the data and applications needs as expressed by the user community and flowing down the mission capabilities and government priorities; these requirements must be summarized in a table at the end of this section or in an Appendix;
5) Mission specific requirements applicable to PHASR including performance and functional requirements that respond to user requirements and break down as follows:
    a) functional requirements,
    b) performance requirements,
    c) operational requirements,
    d) resource allocation requirements,
    e) verification requirements, other applicable requirements types.
6) Interface Requirements, including but not limited to:
    a) Electrical Interface Requirements;
    b) Thermal Interface Requirements;
    c) Mechanical Interface Requirements;
    d) Data Interface Requirements;
7) Mission environmental requirements will likely be derived from GSFC Standard GEVS and lunar specific standards to be provided during the contract and will cover topics such as mechanical, thermal, vacuum, contamination, outgassing, EMC/EMI, acoustics, shock, radiation, for the following environments:
    a) Ground operations and handling
    b) Integration to launch vehicle environment (for flight segment only)

c) Launch environment (for flight segment only)

d) On-orbit environment (for flight segment only)

8) In-flight requirements:

a) Operational modes

b) Upload and download of data/telemetry requirements

c) Telemetry availability

d) Commanding capabilities

e) Staffing requirements (ground and flight segments)

9) Recovery of samples (for flight segment only, the rover and its manipulator will retrieve lunar or asteroid samples for transfer back to the DSG/LOP-G)

a) Timing and location of recovery

b) Contamination protection requirements (reciprocal)

The mission requirements must be summarized in one or more tables at the end of this section or in an Appendix.

DID-013 – Technology Readiness and Risk Assessment with Stand Alone Report

PURPOSE:

The Technology Readiness and Risk Assessment (TRRA) Report is used to describe in a systematic and objective fashion, at a specific point in time (milestone) in the development process, the technological readiness of a system for a particular spaceflight mission, the criticality of the constituent technologies, and the expected degree of difficulty in achieving the remaining technology development steps.

The TRRA provides for all the Critical Technology Elements (CTEs) of the proposed concept, as per the Product Breakdown Structure (PBS), a high-level summary of the maturity of the technologies and the technology development risks.

The TRRA Report is used to assess project status and technical risks, and to guide definition of risk reduction work in following phases.

Agreement on the appropriate PBS level and identification of the CTEs is required prior to the TRRA leading to the elaboration of the TRRA Report. For each CTE the TRRA Report captures the key requirements, heritage, Technology Readiness Level (TRL) achieved, Technology Need Value (TNV), the Research and Development Degree of Difficulty (R&D3) to complete the development, and references to supporting evidence for all assessments.

PREPARATION INSTRUCTIONS:

The TRRA Report must contain the following information, as a minimum:

1. INTRODUCTION

This section should include

1.1. Project Description;

1.2. Purpose of Document;

1.3. Scope.

2. DOCUMENTS

This section must include

2.1. Applicable Documents (which must include the following):

a) TRRA Guidelines (CSA-ST-GDL-0001 at latest approved revision).

2.2. Reference Documents (which must include the following):

a) TRL Handbook for Space Applications (TEC-SHS/5574; ESTEC);

b) (all evidence documents referred to in body of report).

3. MISSION OBJECTIVES

This section must provide an overview of the mission, describing the key mission requirements and any assumptions.

4. MISSION ENVIRONMENT

This section must describe in detail the mission environment and any assumptions.

This section should include a summary comparison table(s) between heritage and current mission environments with references to source documents.

5. PRODUCT BREAKDOWN STRUCTURE

This section must provide a table or diagram with hierarchy of PBS and element numbers.

This section must provide schematics illustrating the elements of the PBS and their parts.

This section should use the CSA proposed PBS provided in Appendix E to this SOW.

6. KEY PERFORMANCE PARAMETERS (KPPS) FOR EACH CTE

This section must describe the Key Performance Parameter(s) identified for each PBS element (where applicable). The KPP description must identify what parameter value/range is currently achievable and what is required.

7. CRITICAL TECHNOLOGY ELEMENTS (CTES)

7.1. Description of the CTE;

7.2. Rationale for selecting the CTEs.

The intent of this section can be met by completing and cross-referencing the Critical Technologies Elements Identification Criteria Worksheet (CSA-ST-FORM-0003).

8. TECHNOLOGY MATURITY AND VIABILITY ASSESSMENTS

This section must include a sub-section for each CTE covering:

8.1. Description;

8.2. Main requirements (including KPP(s) associated with this CTE);

8.3. Heritage and compliance;

8.4. TRL achieved;

8.5. R&D3;

8.6. TNV.

The intent of this section can be met by completing and cross-referencing the applicable Technology Readiness and Risk Assessment Worksheet (CSA-ST-FORM-0001) for each CTE and including the Technology Risk Matrix generated from the Technology Readiness and Risk Assessment Data Rollup Tool (CSA-ST-RPT-0002).

9. TRRA SUMMARY AND RECOMMENDATIONS

This section must include a Summary table of results with columns covering:

- PBS # ; Technology Name; TRL (calculated); TNV (user input);
- R&D3 (user input); TNV • Δ-TRL (calculated); /R&D3/ (calculated).

This section must present a summary of remaining Technology R&D Options, Risks, Cost, and Feasibility for each CTE of the PBS.

This section must summarize the recommended technology development plan and should refer to a separate Technology Development Plan report if appropriate.

10. CONCLUSIONS

This section should include a statement regarding current overall state of TRRA assessment and identify any open work.

11. APPENDIX A – TECHNOLOGY READINESS AND RISK ASSESSMENT WORKSHEETS

This section must include, or refer to an attachment which includes, all of the completed worksheets: the Critical Technologies Elements Identification Criteria Worksheet (CSA-ST-FORM-0003 – AD-2), the Technology Readiness and Risk Assessment Worksheet (CSA-ST-FORM-0001 (AD-3) for each CTE and rollup using the Technology Readiness and Risk Assessment Data Rollup Tool (CSA-ST-RPT-0002). These worksheets can be obtained from the FTP site:

ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRRA/.

DID-102 – CWBS and Work Package Descriptions

PURPOSE:

The Contractor Work Breakdown Structure (CWBS) is used during planning for estimating resources and scheduling the work. During the implementation phase, it is used for reporting and controlling costs and schedule.

PREPARATION INSTRUCTIONS:

The Contractor must provide a Work Breakdown Structure (WBS) chart describing all the project elements that organize and define the total scope of the project, including subcontracted work, and must be deliverable-oriented.

The Contractor must prepare and maintain a WBS Dictionary made up of Work Package Descriptions (WPDs) for every element to the lowest level of the WBS. Each WPD must include, as a minimum:

a) A unique identifier traceable to the WBS;

b) A title;

c) The name of the individual responsible for completion of the work;

d) The **scope** of the work package;

e) The start date and duration;

f) Required **inputs** and dependencies;

g) A description of every activity covered by the WPD including the level of effort and earned value measurement method for each activity, and all non-labour costs;

h) Assumptions;

i) **Output** and work package acceptance criteria;

j) Issue date;

k) Version number; and

l) List of deliverable with delivery milestone.

DID-105 – Project Schedule

PURPOSE:

To provide a schedule planning and control system for the project and to provide visibility to the CSA of the program progress and status.

PREPARATION INSTRUCTIONS:

The project schedule must be based on the CWBS, in the form of a Gantt chart. The schedule must be provided in MS Project software format, and in PDF (8.5 x 14" sheet or larger). The project schedule must be detailed enough to show each CWBS task to be performed, and must provide the following information:

1) dependencies,
2) resource requirements,
3) the start and end date of each task (baseline and actual),
4) task duration,
5) completion status in percentage;
6) deadlines and milestones, and
7) critical path.

The schedule must show dependencies between the Contractor and other organizations.

The tasks related to deliverables must be limited to three months in the project schedule. When applicable, the Contractor must divide longer tasks into smaller significant tasks.

Tasks that are not related to any specific deliverable, such as Project Management and S&MA activities, must be grouped separately from the deliverables, and must be shown at the top of the chart.

DID-107 – Progress Report

PURPOSE:

The Progress Report presents the results of the work done to date in the contract, and in particular since the previous report. The Progress Report is used by the Government to assess the Contractor's progress in performance of the work.

PREPARATION INSTRUCTIONS:

The Monthly Progress Report must include status data and information summarizing project management, technical and schedule progress and accomplishment for each element of the Contractor's Work Breakdown Structure (CWBS). The report must address the major activities of the reporting period and must emphasize major achievements and events of special significance. Difficulties and/or problems that have affected the work progress, proposed corrective actions, project impact expected and concerns for the future, must also be reported.

Each progress report must answer the following three questions:

1) Is the project on schedule?
2) Is the project within budget?
3) Is the project free of any areas of concern in which the assistance or guidance of the CSA may be required?

Each negative response must be supported with an explanation.

The Progress Report must include the following information, as a minimum:

1) Summary outlook, including technical performance, work performed, schedule and cost status (at CWBS level 2), organization and key personnel changes and areas of concerns;
2) Financial status including actual and forecasted expenditures, by month, as compared to the original monthly planned expenditure profile;
3) Updated milestones payment plan;
4) A detailed integrated project schedule status including:
    a) Dependencies between activities,
    b) Percent of completion for all activities,
    c) List of completed milestones,
    d) Critical path,
    e) 1st level subcontractor's activities having impact on WP delivery date;
    f) All other activities having an impact on WP delivery date.
5) Schedule variances from the plan, including deviations from schedule and proposed corrective actions for significant variances;
6) Major meetings schedule update;

7) Status of the work in progress, specifically the work performed in the previous calendar period; sufficient sketches, diagrams, photographs, etc. must be included, if necessary, to describe the progress accomplished;
8) The work projected for the next period, and estimated date of completion of next milestone;
9) Outline of technical and programmatic issues, with solutions recommended;
10) Contractual issues, including changes to activities and costs;
11) Subcontracts events, status and issues;
12) Equipment ordered, received, made and assembled;
13) Description of trips or conferences connected with the Contract during the period of the report;
14) Risk status report including previous issues resolved, status of on-going risks (changes, likelihoods and impacts), and identification of new risks, their likelihood and impact, and proposed mitigation action;
15) Status of all action items from previous review(s) and meeting(s).

DID-110 – Meeting Agenda

PURPOSE:

The Meeting Agenda specifies the purpose and content of a meeting.

PREPARATION INSTRUCTIONS:

The meeting agendas must contain the following information, as a minimum.

1. **DOCUMENT HEADER:**
   a) Title;
   b) Type of meeting;
   c) Project title, project number, and contract number;
   d) Date, time, and place;
   e) Chairperson; and
   f) Expected duration.
2. **DOCUMENT BODY:**
   a) Introduction;
   b) Opening Remarks: CSA;
   c) Opening Remarks: Contractor;
   d) Review of previous minutes and all open action items;
   e) Project technical issues;
   f) Project management issues;
   g) Other topics;
   h) Review of newly created/closed action items, decisions, agreements and minutes; and
   i) Set or confirm dates of future meetings.

DID-111 – Minutes of Meetings

PURPOSE:

The minutes of reviews or meetings provide a record of decisions and agreements reached during reviews/meetings.

PREPARATION INSTRUCTIONS:

Minutes of meeting must be prepared for each formal review or meeting in the Contractor's format and must, as a minimum, include the following information:

1) Title page containing the following:
    a) Title, type of meeting and date
    b) Project title, project number, and contract number
2) Purpose and objective of the meeting;
3) Location;
4) Agenda;
5) Summary of the discussions, decisions and agreements reached;
6) List of attendees by name, position, phone numbers and e-mail addresses as appropriate;
7) Listing of open action items and responsibility for each action to be implemented as a result of the review;
8) Other data and information as mutually agreed; and
9) The minutes must include the following statement:

"All parties involved in contractual obligations concerning the project acknowledge that minutes of a review/meeting do not modify, subtract from, or add to the obligations of the parties, as defined in the contract."

DID-112 – Action Items Log (AIL)

PURPOSE:

The Action Item Log (AIL) lists, in chronological order, all items on which some action is required, allows tracking of the action, and in the end provides a permanent record of those Action Items (AI).

PREPARATION INSTRUCTIONS:

The Action Item Log (AIL) must be in a tabular form, with the following headings in this order:

1) Item Number;
2) Item Title;
3) Description of the action required;
4) Open Date;
5) Source of AI (e.g. PDR meeting, RID, etc.);
6) Originator;
7) Person responsible (for taking action);
8) Target/Actual Date of Resolution;
9) Progress update;
10) Rationale for closure;
11) Status (Open or Closed); and
12) Remarks.

The date in column 8) will be the target date as long as the item is open, and the actual date once the item is closed.

DID-501 – Interface Control Document (ICD)

PURPOSE:

To define and control the interface between several cooperating or attached Hardware Configuration Items (HWCI) or Configuration Software Configuration Items (CSCI).

PREPARATION INSTRUCTIONS:

The ICD may describe the interfaces between a system or subsystem and all external systems or subsystems with which it interfaces (External ICD), or it may define all interfaces amongst subsystems within a system (Internal ICD).

Examples of External ICDs are:

- Spacecraft-to-Launch Vehicle ICD
- Spacecraft-to-Ground Segment ICD

Examples of Internal ICDs are:

- Spacecraft Internal ICD (e.g. between Bus and Payloads)
- Ground Segment Internal ICD

Systems may be manned or unmanned; they may be space or ground systems such as Ground Segment facilities. The specific requirements below must be tailored accordingly.

The ICD may be structured by types of interfaces (as defined above), or by subsystem and then by types of interfaces under each subsystem.

The ICD must contain the following information, as a minimum, tailored as required by the type of ICD as described above, and the particular system and interfaces being defined:

1. Purpose and Scope
2. Applicable and Reference Documents
3. Identification (name, number) and brief overview of the system and role within the system, of the interfaces to which the ICD applies
4. Interface diagrams showing by name and identifier all interfaces among the HWCIs and CSCIs to which this ICD applies
5. Identification (name, identifier) and purpose of each of the interfaces
6. Physical / Mechanical Interfaces
    - 6.1. Coordinate System
    - 6.2. Dimensions and tolerances
    - 6.3. Units of measurement
    - 6.4. Envelope, Volume and Mass Properties
    - 6.5. Attachment methods

6.6. Alignment features

7. Structural/Mechanical Interfaces
   7.1. Applied Loads and Disturbances (including random vibrations, frequency spectrum)
   7.2. Acoustics
   7.3. Depressurization/Repressurization
   7.4. Ground Handling Environment
8. Thermal/Fluids Interfaces
   8.1. General Requirements (touch temperature, condensation prevention, etc.)
   8.2. Thermal Environment
   8.3. Payload/Subsystems Cooling
   8.4. Vacuum Exhaust Interfaces
9. Electrical Power Interfaces
   9.1. Electrical Power Requirements, Sources and Allocation
   9.2. Power Supply characteristics and limits
   9.3. Overload protection and limits
   9.4. Power control
   9.5. Electrical connectors (types, pinouts, locations, mating and demating)
   9.6. Cable schematics
10. Electromagnetic Compatibility (EMC)
   10.1. EMC Classifications
   10.2. Host system produced interference environment
   10.3. Payload produced interference environment
   10.4. Bonding and grounding
   10.5. Power and signal circuits isolation
11. Command and Data Handling (C&DH)
   11.1. Communications Technology (RS-422, Ethernet, Analog, Discrete, video, laptop, etc.)
   11.2. Signal Characteristics
   11.3. Response / Telemetry Format
   11.4. Request/Command Format
   11.5. Processing Requirements
   11.6. Connector/Pin Interface
   11.7. Data Acquisition, Storage and Management
   11.8. Synchronization

11.9. Application Programming Interfaces

12. Environmental Interfaces
13. Any environmental factors not addressed elsewhere in the ICD (e.g. radiation, atmosphere, illumination, etc.)
14. Materials and Processes Interfaces
15. Human Factors Interfaces
16. Propulsion Interfaces
17. Pyrotechnic Interfaces
18. Fire Prevention
19. Ground Operations and scientific data processing
    19.1. Facilities
    19.2. Payload Handling
    19.3. Ground Support Equipment (GSE)
    19.4. Communications Requirements
    19.5. Power Requirements
    19.6. Special Equipment
    19.7. Storage

DID-600 – Models and Analyses

PURPOSE:

To support the feasibility assessment and provide background information on the concept and design at system level, it is required to conduct analyses. This DID is to provide guidelines on deliverables related to analyses conducted including CAD models, tools and data to be delivered to the CSA focusing on thermal and power related analysis and models.

PREPARATION INSTRUCTIONS:

GENERIC FORMAT AND CONTENT FOR ALL ANALYSES

All CAD models developed must be delivered as appropriate. Models must be delivered in the following formats:

a) Mechanical design: STEP AP203 (.stp)

b) Electrical design: .dsn, .sch, Pspice and Gerber formats, or applicable native format and a .pdf export

c) NX Space Systems Thermal native format (NX 10 or higher)

d) Software design: UML 2., XML or specific format definition provided as part of the SOW

e) Model-based Systems Engineering Model (if required): Artisan Studio.

f) Optical design models: Zemax

In cases where a different tool is used from the one CSA uses, the model and outputs must be supplied in native format in addition to the required format. For generic modeling and analyses that don't use a specialty tool, CSA will accept Matlab, Excel, CSV and MathCad format data. Where a highly specialized tool is used, the delivery format must be negotiated with the TA. Translation from the Contractor's tool to the required format is only acceptable where the results can be repeated in CSA's tool. Translation that corrupts the model, loses data, or produces data that is interpreted differently, is not acceptable.

Analysis documents must contain all analysis work that is performed in support of the design. This includes, but is not limited to, any spreadsheet (e.g. Excel) and script (e.g. Matlab) used to elaborate the analysis. The analysis material must be sufficiently detailed that, in combination with the delivered models, CSA or an external reviewer can reproduce the results. The analysis must establish feasibility and verification of the design to meet the requirements.

The data must include references to sources such as equations, material values, parameters and properties.

Each report must contain the following information, as a minimum:

a) Objectives of the analysis;

b) Reference to the relevant requirements;

c) Description of the analysis tools used;

d) Description of the model developed to aid the model user (if applicable);

e) Identification of the assumption(s) made;

f) Description of the main analysis steps and intermediate results;

g) Results of the analysis and compatibility with the requirements;

h) Identification of potential problem areas and presentation of alternative design solutions; and

i) Conclusion.

Delivered models must contain at least example outputs so that the user can validate their function, and should contain the main outputs used in the analysis documents.

SPECIFIC CONTENTS

THERMAL MODEL AND ANALYSIS:

The Thermal Model and Analysis must predict the operating temperature of the electronic or other heat-sensitive components, allowable flight temperature margins, and internal and external heat exchange breakdown. The analysis must cover the worst cases of the operating environment using beginning and end of life properties. Furthermore, sensitivity analyses must be performed on critical and marginal components.

Thermal analysis and budgeting must include allowance for contamination build-up (i.e. regolith) for cryogenically operated equipment and radiative surface. Sources of thermal and thermo-optical properties, including contact conductances must be provided.

Specific attention must be given to account for thermal contact resistance variation with key parameters of contact (pressure, material, surface finish, flatness) as they vary with temperature.

Margins for temporal stability must be determined both for spatial and temporal variations, and must cover transient events such as operational manoeuvres worst-case variations, and operational states.

ELECTRICAL POWER AND DISTRIBUTION MODEL AND ANALYSIS:

The Electrical Power and Distribution Analysis must document all analyses and activities performed to evaluate the system electrical power and distribution design, providing information on the following aspects, as a minimum:

1) Electrical architecture: power, grounding, shielding, data, and redundancy;

Electronics: circuitry, protection, and switching of components; and

Power budgets and distribution.

The power analysis must consider the whole life of the system, if the design is such that power generation or consumption properties change. Power analysis must cover mean and peak behaviour for each mode of operation of the system. A power operational profile must be defined, indicating, for each phase of the mission, the corresponding maximum and average power during the sunlight and eclipse portion of the mission and the energy margin (if applicable).

The power analysis must be complete, showing all calculations and assumptions used for every item estimated.

DID-700 – System Conceptual Design Document

PURPOSE:

In its preliminary form, to describe the preliminary system conceptual design proposed to meet the mission requirements.

In its final form, to describe the conceptual design of the system, to assist in finalizing the design of the system and allocating the requirements to subsystems, to demonstrate its feasibility and to support programmatic estimates.

PREPARATION INSTRUCTIONS:

NOTE: This DID comprises two sets of requirements: the first for the preliminary form of the document and the second for its final form.

Preliminary form

The preliminary document must include the following:

1) An introduction including the scope, the purpose and a list of assumptions (if any);
2) A description of the overall system conceptual design;
3) A description of any payload detailed analysis, breadboard design and performance (field) testing, if applicable; and
4) A description of any trade-off studies performed.

Final form

The final document must include the following:

1) Introduction: recalling the major objectives and guidelines for the project;
2) Architecture, design and interfaces: giving a high level description of the architecture and design of the system and its subsystems, including internal and external interfaces;
3) Trade-offs: criteria definition, analysis, criteria results, decisions;
4) Design decisions: rationales for design choices;
5) Budgets: a summary of the engineering budgets and TPMs, and margins, their allocation to subsystems;
6) Drawings and schematics: architectural diagrams for the main aspects of the system (structure, electronics, power, communications, software, etc.) describing and referencing important design drawings such as functional interconnect diagrams, activity flow diagrams, ICDs;
7) Analyses: summarizing the analyses performed, main results and problems encountered; this is a summary of each full analysis report presented separately;
8) Tests: summarizing all the tests to be performed to verify the performance and environmental requirements;

9) Operations concepts: summarizing the operations of the system in both nominal and contingency conditions;

10) Maintenance approach: describing the maintenance approach especially for maintainable items such as the spares for manned systems, flight software and ground systems;

11) Matrix: To demonstrate design compliance to requirements by providing clear link between design and requirements. Indication of design compliance, non-compliance and partial compliance.

The contractor must provide substantiated analyses and/or test results that support the feasibility of the concept as a minimum for the following: thermal, energy, mass and data budgets. These analysis and/or tests must be provided.

DID-825 –System Concept of Operations

PURPOSE:

To define the overall end-to-end System Concept of Operations.

PREPARATION INSTRUCTIONS:

This document must be prepared in accordance with standard ANSI/AIAA G-043-1992 - Guide for the Preparation of Operational Concept Documents.
The System Concept of Operations must contain the following information:

1) Introduction including the scope, the purpose and a list of assumptions (if any);
2) Description of the overall concept of operations that proves the feasibility of command and control, housekeeping and payload data acquisition, downlinking, turnaround time, processing, analysis and distribution and payload calibration;
3) System operations requirements and constraints:
    a) System description,
    b) End-users description and requirements,
    c) System Health and Safety requirements,
    d) Programmatic and operational constraints,
    e) Relationship with other missions / programs,
    f) External dependencies or interfaces with other organizations;
4) Space segment characteristics including spacecraft monitoring and control, and spacecraft modes;
5) Ground segment characteristics including Command & Control and Data Reception for the LEOP, commissioning phase and routine operations phase;
6) System operations concepts:
    a) Planning processes,
    b) Operations execution processes,
    c) Evaluation processes,
    d) Data Reception,
    e) Data Transfer,
    f) Data processing,
    g) Data turnaround time,
    h) Instrument calibration,
    i) Support processes,
    j) Operations team,
    k) Orbit determination and maintenance;
7) Operational Scenarios.

DID-850 –Science Payload Proposal Information package

PURPOSE:

To provide rover accommodation information for a future Request for Proposals for Science Instrument Payloads. This document must be prepared with the intent that the information will be published by space agencies providing payloads to PHASR.

PREPARATION INSTRUCTIONS:

The Science Payload Proposal Information package must contain the following information:

- General mission description: Introduction and short description of the PHASR rover mission
  a) Launch configuration
  b) Landed configuration
- Science payload accommodation and constraints imposed by the rover and mission
  a) PHASR resources and payloads available for science operations
    i) PHASR navigation and hazard cameras
    ii) PHASR robotic arm
    iii) PHASR remote sensing mast accommodation
    iv) PHASR deck-mounted accommodation
    v) PHASR belly-mounted accommodation
    vi) PHASR interior body accommodation
    vii) PHASR mobility capability
    viii) Payload resources allocation
      (1) Mass allocation
      (2) Volume (mechanical) allocation
      (3) Power / Energy allocation
      (4) Data Volume allocation
    ix) Computational resources
      (1) Requirements imposed on the Instrument Data Systems
- Engineering use of science imaging data
- Payload interface definitions
  a) Thermal control and thermal interfaces
  b) Science payload power interfaces
  c) Power on /reset and Power interruption
  d) Science payload grounding and shielding interfaces
  e) Science payload data interfaces

f) Instrument unique interface accommodation items

- Rover environments
  a) Dynamic environment
  b) Charged particle /neutron, radiation environment
  c) Lunar surface operations – additional environmental requirements
     i) Lunar day thermal environment
     ii) Lunar night thermal environment
  d) Electromagnetic compatibility
- Mission Scenarios
  a) Pre-launch through launch flight system flow
  b) Landing
  c) Surface operations phase initialisation
  d) Surface operations sample return prime mission scenario
  e) Surface operations long distance traverse mission scenario
- Mission operations systems
  a) Operations concept and expected science instrument payload team support for operations
  b) Operations timelines for surface phase
     i) PHASR Data flow context
     ii) Operations planning hierarchy and timeline
- Ground Data System Configuration Overview
  a) Science payload team responsibilities
- Science Payload Management: PHASR integration and test elements
  a) Science Payload development schedule
  b) Flight like science payload bus interface
  c) Science payload operations computer
  d) Post-delivery hardware support
- Other elements as mutually agreed

C CONTRACTOR DISCLOSURE OF INTELLECTUAL PROPERTY

C.1 PURPOSE

The BIP/FIP Disclosure Report serves to identify FIP produced under the Contract with the CSA, as well as any BIP elements that were used to develop the FIP.

This is not to be confused with the identification of the FIP and BIP that will be generated throughout the entire project, which is documented in DID-007 – Mission Development Plan.

C.2 DEFINITIONS

Intellectual Property (IP)	means any information or knowledge of an industrial, scientific, technical, commercial artistic or otherwise creative nature relating to the work recorded in any form or medium; this includes patents, copyright, industrial design, integrated circuit topography, patterns, samples, know-how, prototypes, reports, plans, drawings, Software, etc.
Background Intellectual Property (BIP)	IP that is incorporated into the Work or necessary for the performance of the Work and that is proprietary to or confidential information of the Contractor, its subcontractors or any other third party.
Foreground Intellectual Property (FIP)	IP that is first conceived, developed, produced or reduced to practice as part of the Work under the Contract.

C.3 INSTRUCTIONS FOR COMPLETING IP DISCLOSURE TABLES

Identification

The Contractor must respond to the 7 questions in Table C-1when Foreground Intellectual Property (FIP) is created under the Contract with the CSA.

BIP

If the Contractor intends to use Background Intellectual Property (BIP) to develop the FIP, the Contractor must complete Table C-2 (Disclosure of BIP brought to the project by the Contractor) and forward it to the CSA Project Manager before the beginning of the Contract if any.

At the end of the Contract, the Contractor must review and update the BIP disclosure (Table C-2) when applicable.

Only the BIP elements that were used to develop the FIP elements should be listed.

FIP

At the end of the Contract, the Contractor must complete Table C-3 (Disclosure of the FIP developed under the Contract).

If Canada is the owner of the FIP and identifies some FIP elements that would benefit from being patented by Canada, the Contractor must also complete Table C-4 (Canada's Owned FIP Additional Information).

General Instructions for BIP and FIP tables

Tables must be structured according to the CSA IP form provided.

Each IP element must have a unique ID # in order to easily link the elements of the different tables.

Titles of IP elements must be descriptive enough for project stakeholders to get a general idea of the nature of the IP.

Numbers and complete titles of reference documents must be included.

TABLE C-1: CONTRACTOR DISCLOSURE OF INTELLECTUAL PROPERTY

Contractor Legal Name:	
Project Title supported by the Contract:	
CSA Project Manager of the Contract:	
Contract #:	
Date of the disclosure:	

Will there be Contractor's Background Intellectual Property brought to the project:

☐ Yes - Complete Table C-2 - Disclosure of Background Intellectual Property

☐ No

For Canada's owned IP, are there any IP elements that, to your opinion, would benefit from being patented by Canada?

☐ Not applicable, FIP resides with the Contractor

☐ Yes - Complete Table 5 5 - Canada's Owned Additional Information

☐ No

For the Contractor:

Signature	Date

For CSA Project Manager:

Signature	Date

TABLE C-2 : BIP DISCLOSURE

1 **BIP ID#**	2 **Project Element**	3 **Title of the BIP**	4 **Type of IP**	5 **Type of access to the BIP required to use/improve the FIP**	6 **Description of the BIP**	7 **Reference documentation**	8 **Origin of the BIP**	9 **Owner of the BIP**
Provide ID # specific to each BIP element brought to the project *(e.g. BIP-CON-99, where CON is the contract acronym)*	*Describe the system or sub system in which BIP is integrated (e.g. camera, control unit, etc.)*	*Use a title that is descriptive of the BIP element integrated to the work*	*Is the BIP in the form of an invention, trade secret, copyright, design?*	*Describe how the BIP will be available for Canada to use the FIP(e.g. BIP information will be incorporated in deliverable documents, software will be in object code, etc.)*	*Describe briefly the nature of the BIP(e.g. mechanical design, algorithm, software, method, etc.)*	*Provide the number and fill title of the reference documents where the BIP is fully described, The reference document must be available to Canada. Provide patent# for Canada if BIP is patented.*	*Describe circumstances of the creation of the BIP Was it developed from internal research or through a contract with Canada? If so, provide contract number.*	*Name the organization that owns the BIP. Provide the name of the subcontractor if not owned by the prime contractor.*

TABLE C-3 : FIP DISCLOSURE

1 **FIP ID #**	2 **Project Element**	3 **Title of FIP**	4 **Type of FIP**	5 **Description of the FIP**	6 **Reference documentation**	7 **BIP used to generate the FIP**	8 **Owner of the FIP**	9 **Patentability**
Enter an ID # specific to each FIP element *(e.g.FIP-CON-99, where CON is the contract acronym)*	*Describe the system or sub-system for which the FIP element was developed (e.g. a camera, ground control, etc.)*	*Use a title that is descriptive of the FIP element.*	*Specify the form of the FIP e.g. invention, trade secret, copyright, industrial design*	*Specify the nature of the FIP e.g. software, design, algorithm, etc.?*	*Provide the full title and number of the reference document where the FIP is fully described. The reference document must be available to Canada*	*BIP referenced in Table C-2 (e.g. BIP-CON-2, 15)*	*Specify which organization owns the FIP e.g. Contractor, Canada* or Subcontractor.* *Provide the name of the subcontractor if not owned by the prime contractor.* **If Canada is the owner of the FIP, complete Table C-4 below.* *Provide reference to contract clauses that support FIP ownership.* *Provide reference to WPDs under which the technical work has been performed.*	*In the case where the IP is owned by Canada, indicate with an "X", any IP elements described is patentable and complete Table C-4 only for this IP.*

TABLE C-4 : CANADA'S OWNED FIP ADDITIONAL INFORMATION

1 **FIP ID #**	2 **Title of FIP**	3 **Aspects of FIP that are novel, useful and non obvious**	4 **Limitations or drawback of the FIP**	5 **References in literature or patents pertaining to the FIP**	6 **Has the FIP been prototyped, tested or demonstrated?** (e.g. analytically, simulation, hardware)? Provide results	7 **Inventor(s)**	8 **Was the FIP disclosed to other parties?**
ID# should be same as corresponding FIP element in Table C-3.	*Title of FIP should be same as corresponding FIP element in Table C-3.*	*How is the FIP addressing a problem (useful) and what is thought to be novel in this solution (novel)?*	*Describe the limitations of present apparatus, product or process*	*Provide references in published literature or patents relating to the problem or subject if any.*	*Describe briefly how the process, product or apparatus performed during testing or simulation. Provide reference document # where the performance is compiled if applicable.*	*Provide name and coordinates of the person(s) who created the FIP*	*Has any publication or disclosure of the FIP or any of its elements been made to third parties? If so, provide when, where and to whom.*

D PRELIMINARY REQUIREMENTS

This section presents the mission level 3 requirements. Some portions of the requirements are intentionally left as ‘to be determined’ (TBD) to avoid driving toward a specific technical solution. It is expected that these numbers will be jointly developed between CSA and the Contractor during this study. Moreover, these requirements are meant as a starting point for developing the concept of the mission. It is thus expected that these requirements will be reviewed, tailored and that additional requirements will be developed during this Phase 0.

D.1 ENVIRONMENTAL REQUIREMENTS

Requirement ID	Title	Description	Rationale/Note
M-ENV-PHASR-001	Launch Ariane 6	The PHASR must survive the launch environment as described in (RD-14) and derived as applicable.	The current baseline is that the PHASR will launch on an Ariane 6.4 rocket.
T-ENV-PHASR-001	Launch SLS	The PHASR should survive the launch environment as described in (RD-11) and derived as applicable.	There is an option that the PHASR be launched on a SLS, the PHASR is also a precursor to the LPR that will be launched on the SLS.
M-ENV-PHASR-002	Earth-Moon Transit Ariane 6	The PHASR must survive the Earth-Moon transit in an Ariane 6 (RD-14) configuration.	The current baseline is that the PHASR will launch on an Ariane 6.4 rocket. Respective transits and duration are specified in the introduction and operations concept section timelines and can be derived from the applicable launcher references.
T-ENV-PHASR-002	Earth-Moon Transit SLS	The PHASR should survive the Earth-Moon transit in a SLS (RD-11) configuration.	There is an option that the PHASR be launched on a SLS, the PHASR is also a precursor to the LPR that will be launched on the SLS. Respective transits and duration are specified in the introduction and operations concept sections' timelines and can be derived from the applicable launcher references.
M-ENV-PHASR-003	Landing	The PHASR must survive the lunar landing.	More information on the landing stack will be provided at the KOM and throughout the contract as interfaces are developed with the international community. The initial assumption is this is considered a "soft" landing approach.
M-ENV-PHASR-004	Lunar Shadow Ops	The PHASR must be fully operational with sufficient power & thermal resources for a minimum of 6 consecutive hours in a lunar Permanently Shadowed Region (PSR).	This case is to allow sufficient energy for the rover to be fully operational to perform shadow operations outside of its lunar night operations/survival mode. The current design case should be: 2 hours drive into shadow, 2 hours of static operations (e.g. science measurements, sample collection) and 2 hours to drive out of the PSR. This approach can also be traded against distance and number of sample to acquire. This will be looked at as part of the Phase 0.
M-ENV-PHASR-005	Extended Lunar survival	The PHASR must survive multiple lunar day and night cycles as per its operational life requirements at the location specified in the HERACLES mission description.	Both the PHASR & LPR missions require the rover to survive and even operate at a lower power consumptions rate during night survival. Nominal condition supposes the rover remains static during extended night stay (e.g. 14 night extended darkness). In addition, the pressurized rover will have to enable the crew to survive and perform tasks inside the rover during the lunar night. EVAs and extended operations would be limited to emergency as a baseline. PHASR must demonstrate how it will facilitate the LPR to enable the crew to survive. If the option is not to demonstrate the LPR required thermal capability via the PHASR on-orbit element, Ground

			Support Equipment (GSE), facilities and appropriate terrestrial modeling and analyses must be proposed to fulfill this requirement.
M-ENV-PHASR-006	Sun and shadow	The PHASR must survive and operate while having areas subjected to direct sunlight while other areas are facing the cold surface of the lunar environment or empty space at the location in the HERACLES mission description.	The operations concept and design must take into consideration that the rover will rarely be exposed to the same thermal environment from one area to another. In general one side will be exposed to the light and the other to the darkness.
M-ENV-PHASR-007	Regolith Exposure	The PHASR must withstand bombardment, exposure to and accumulation of small-particle lunar dust/regolith.	There is a wide range of particle sizes in the regolith, down to nano-particle sized dust. Lunar regolith and dust can have ferromagnetic properties and accumulate electrostatic charges (e.g. from exposure to solar wind). Due to lack of weathering, these particles are typically very abrasive and jagged. As a result, the lunar dust tends to accumulate and stick on to surfaces, having the following impacts: a) Accumulates on to surfaces b) Changes/degrades thermo-optical properties of materials; c) Tends to ingress movable parts and joints, potentially clogging/damaging moving mechanisms; d) Prevents seals from closing properly; e) May cause false reading of sensors; f) Remains hard or impossible to be cleaned off completely.
M-ENV-PHASR-008	Vacuum	The PHASR must be able to achieve its mission in the lunar vacuum environment at the specified HERACLES mission locations	For the benefit of testing it is assumed that as a minimum the elements should be tested at a pressure of 1x10-4 Torr or less. Elements that should be tested in the presence of dust and vacuum and without dust or only dust at ambient pressure are to be considered.
M-ENV-PHASR-009	Radiation	The PHASR must be able to achieve its missions withstanding and protecting itself from radiations exposure at the specified HERACLES mission locations.	In addition to its own PHASR equipment protection, similarly to the night survival, the PHASR should be the baseline for the LPR approach to withstand and protect the crew against radiations. If the option is not to demonstrate the LPR required radiation protection via the PHASR on-orbit element, Ground Support Equipment (GSE), facilities and terrestrial models must be proposed to fulfill this requirement.

D.2 PHYSICAL REQUIREMENTS

Requirement ID	Title	Description	Rationale/Note
M-PHY-PHASR-001	Mass, baseline	The PHASR baseline mass must not exceed 500 kg, including margin and payloads.	Appropriate margins rules following the guidelines and standards from the DSG/LOP-G and HERACLES international community must be applied. These will be provided at the KOM and updated as need be. The space standard and TRL maturity rules can be used as a starting point.
M-PHY-PHASR-002	Mass, light	The PHASR-Light (PHASR -L) mass must not exceed 330 kg, including margin and payloads.	Appropriate margins rules following the guidelines and standards from the DSG/LOP-G and HERACLES international community must be applied. These will be provided at the KOM and updated as need be. The space standard and TRL maturity rules can be used as a starting point.
M-PHY-PHASR-003	Payload mass	The PHASR must accommodate a total payload mass of up to 120 kg.	The sample canisters, robotic arm, end-effector tools and science instruments all fall within the payload mass budget. The Appendix F provides the description of the different payload allocations. It is possible to reduce this allocation with respect to the configuration selected and recommended. This will also evolve during the contract period in order to optimize the configuration for the PHASR and PHASR -L options.
M-PHY-PHASR-004	Stowed volume	The PHASR in its stowed configuration must fit within the LDE available volume considering the allocated margins for launch, transit and delivery of the launcher as illustrated in Figure 1-9.	This is for stowed configuration used for transit. Once egress from lander is complete, PHASR can deploy it subsystems (e.g. mast, solar arrays…) that exceed this envelope. Minimizing the elements to be deployed should be considered.

D.3 FUNCTIONNAL REQUIREMENTS

Requirement ID	Title	Description	Rationale/Note
M-FCT-PHASR-001	Total distance	The PHASR must be capable of: a. completing a total traverse of at least 150 km per mission campaign. b. cumulating a total distance traverse over its lifetime of 600 km.	In addressing these requirements, the element of critical components, risk mitigation and development must be addressed along with the impact on cost, schedule and resources. There is also a desire to extend this distance as required for LPR readiness assessment that must be traded.
M-FCT-PHASR-002	Traverse range	The PHASR must be able to conduct at least a 40 km, map-based distance, round-trip traverse between the LDE and the target sites of interest.	Actual rover odometry distance will be higher than the map-based distance due to slippage, local topography and path deviations. Proper margin must be accounted for to that end. Margin of 30% is recommended. The main Design Reference Mission (DRM) in work is for the PHASR to complete a loop of ~32 to 35 km while visiting 9 sites of interest and return samples in ~34 days of sun light.
M-FCT-PHASR-003	Traverse time	The PHASR must be able to complete its round-trip traverse between the LDE and the target sites of interest within a 70 days period including egress, check-out, night survival and return of the sample to the LAE.	Excluding the night period, the assumption is that the rover will have ~34 days to complete the loop visiting all the sites, collecting samples and returning them to the LAE. The current DRM in work includes 9 sites across this loop.
M-FCT-PHASR-004	Life	The PHASR must operate a minimum of 2 years at the surface of the Moon at the locations specified in the Precursor Surface Mission Architecture section.	This requirement must be analyzed in terms of what would be the impacts and logical approach and key risks and items to achieve this requirement versus cost and technology development required.
M-FCT-PHASR-005	Mobility	The PHASR must, upon command, place itself so that a target of interest is within the workspace of a contact sensor or sampling device.	This requirement must consider the mobility of the rover to facilitate and enable these manoeuver. For instance a large turning radius and the manoeuverability of the rover would impact this significantly.
M-FCT-PHASR-006	Direction	The PHASR must be able to drive forward and backward.	It is acceptable to have reduced velocity performance and capabilities when driving backward.
M-FCT-PHASR-007	High Rate Data Telecommunications	The PHASR must have a directional telecommunications capability to communicate with Earth.	A directional high-rate communications system is required for the rover to communicate with Earth and the DSG/LOP-G via the DSG/LOP-G interfaces. The bandwidth requirements will be established as part of the current mission phase.
M-FCT-PHASR-008	Low Rate Data Telecommunications	The PHASR must have an Omni directional telecommunications capability to communicate with Earth.	An Omni-directional low-rate communications system is required for the rover to communicate with Earth and the DSG/LOP-G via the DSG/LOP-G interfaces. The bandwidth requirements will be established as part of the current mission phase.

T-FCT-PHASR-009	Fixed solar arrays	The PHASR solar arrays should have a fixed configuration relative to the rover chassis.	Orientable solar arrays add a level of complexity which increases program cost and risk, potentially reducing reliability. Current studies indicate a fixed solar array solution is feasible and sufficient. Arrays can be stowed for transit and deployed once during the egress & check-out phase. A combination of properly sized arrays on both sides of the rover and on its back, with minimal operational constraints should provide sufficient power to cover the power budgets put forward by the LSM concept studies.
T-FCT-PHASR-010	No RTG	The PHASR should not rely on a Radio-isotope Thermal Generator (RTG) for its power source.	RTGs imposes many technical, logistical and political constraints, while bringing very little advantages in the PHASR context. RTG technology has been used and demonstrated under numerous flight missions already. Having RTG or not on PHASR should be measured with respect to the benefit of the HERACLES mission and for the feed-forward to LPR that could be demonstrated by terrestrial adequate validation or other approaches.
M-FCT-PHASR-011	Powertrain type	The PHASR must be an all-wheel drive platform.	
M-FCT-PHASR-012	Passive suspension	If suspension is required by design, the PHASR suspension mechanisms must be fully passive, i.e. uses no actuators.	This favors simplicity, which reduces cost and increases reliability.
M-FCT-PHASR-013	Suspension state	If a suspension is required by design, then the PHASR suspension must be instrumented.	Complete state of the suspension (e.g. angle(s), geometry) must be made available on a continuous basis to the control system and the operators.
M-FCT-PHASR-014	Localization self-sufficiency	The PHASR must be able to localise it-self without reference to external navigational aids (e.g., GPS).	The PHASR must be able to perform a self-localization, i.e., relying only on embedded sensors (proprioceptive and exterioceptive sensors).
M-FCT-PHASR-015	Localization external pose correction	The PHASR must allow its localization to be updated by external pose corrections sent by an operator.	
M-FCT-PHASR-016	Absolute orientation estimation	The PHASR must estimate its absolute orientation.	The absolute orientation estimation could be achieved when the vehicle is stationary (TBC). In that case, this estimation would be used to correct the drift encountered by the main relative localization system.

M-FCT-PHASR-017	Harsh lighting condition localization	The PHASR must be able to localize itself under harsh lighting conditions.	PHASR mission will include operations in permanently shadowed regions and where the sun is constantly low on the horizon (lunar polar regions). Very high contrast and long shadows are therefore expected. Thus, pure camera-based localization (e.g., visual odometry (VO)) is not a viable solution to establish rover localization. A reliable solution might be the fusion of wheel odometry and IMU data, potentially adding VO. Enabling VO using illuminators is likely not feasible due to resulting power consumption.
M-FCT-PHASR-018	Absolute position localization sensors	The PHASR must be equipped with sensors that enable the estimation of the rover absolute position.	Fiber Optical Gyro signal could be used to establish PHASR latitude position while the rover is stationary. Accelerometer signal could be registered with gravity maps of the Moon to estimate the rover absolute position. Sextant which is based on stars observation could provide absolute positions (i.e., celestial navigation).
M-FCT-PHASR-019	Main navigation active 3D range sensor	The PHASR must be equipped with an active 3D range sensor (LIDAR) capable of collecting a dense point-cloud of the rover's surroundings.	PHASR mission will take place under harsh and challenging lighting conditions. Thus, a LIDAR system would be a preferred solution. This 3D range sensor would be mainly used for GN&C and teleoperation purposes (e.g., terrain assessment, path-planning). The density of the point cloud remains a trade to be investigated and quantified during the Phase 0.
M-FCT-PHASR-020	Driving hazard detection sensors	The PHASR must be equipped with sensors to detect driving hazards.	These sensors (e.g., LIDAR or stereo-camera) would be used to detect hazards (e.g., rocks, holes, sudden drops) while the rover is driving. These sensors could also be used to fill occluded zones from the main LIDAR, if any.
M-FCT-PHASR-021	Drive camera	The PHASR must be equipped with a front drive camera.	A camera with a wide angle field of view is likely a good option for the front drive camera.
M-FCT-PHASR-022	Rover surrounding situational awareness	The PHASR camera suite must provide complete visibility of the rover's surroundings, including underneath the chassis.	Combined cameras coverage projected on the ground must offer visibility everywhere around the rover and underneath the chassis. Based on CSA Tele-Robotics Testbed (TRT) project past experience, fitting each side of the rover with a down-pointing ("bird's-eye view"), wide angle camera, is a simple and useful approach to cover sideways situational awareness and monitor wheel clearance relative to obstacles.

M-FCT-PHASR-023	Teledriving control mode	The PHASR must be controllable in teledriving mode	In teledriving mode, the operators would typically use a hand-controller to send direct velocity commands (both linear and angular) to the vehicle. This mode should not be the prime operating mode, as it is demanding and not the most efficient when dealing with the delays involved. It is rather a mode that could be used in case of issues. For example, if the localization system is down, other more advanced modes of operation may not be usable anymore. A workaround could be to manually teledrive the rover, effectively having the operators close the position loop from the ground.
M-FCT-PHASR-024	Scripted driving control mode	The PHASR must allow the operators to control the rover in a scripted driving mode	In scripted driving mode, the operators can send simple position-level commands such as "move-by-distance" or a change in orientation command like "turn-by-angle". This mode also allows operators to send a list of waypoints to follow (i.e., a path).
M-FCT-PHASR-025	Autonomous navigation mode	The PHASR must allow the operators to control the rover in autonomous navigation mode	In autonomous navigation mode, the operators can send one (or many) destination command(s) that could be outside of the rover's sensor horizon. The rover then autonomously and safely drives to the commanded destination(s). The extent to which this autonomy level is required will be part of the on-going assessments under the Phase 0 and via parallel experiments.

D.4 INTERFACE REQUIREMENTS

Requirement ID	Title	Description	Rationale/Note
M-INT-PHASR-001	Data Telecommunications, Earth	The PHASR must communicate with the Control Centre(s) on Earth via the DSG/LOP-G during operations and the lander stack during transit to: 1. Receive Data, including but not limited to: a. Remote commands: Commands and scripts for the PHASR and its subsystems. b. Software updates: Configuration files, executable files, firmware. 2. Transmit Data, including but not limited to: a. Received Data: Any data that is received can be retransmitted for verification or to provide updates. b. Systems telemetry: Health and status monitoring data for all subsystems. c. Imagery: Imagery generated by instrument subsystems such as cameras and vision systems. d. Navigation: Speed, distance, odometry, pose, geo-localization data (relative and absolute). e. Scientific data: Any relevant information related to science instruments, measurements and experiments performed on-board.	Details of the architecture and interfaces with the DSG/LOP-G, data rates and communications frequencies interfaces standards and documents will be provided at KOM and updated during the contract.

M-INT-PHASR-002	Data Telecommunications, DSG/LOP-G	The PHASR must communicate with the DSG/LOP-G crew during DSG/LOP-G manned operations to: 1. Receive Data, including but not limited to: a. Remote commands: Commands and scripts for the PHASR and its subsystems. b. Software updates: Configuration files, executable files, firmware. 2. Transmit Data, including but not limited to: a. Received Data: Any data that is received can be retransmitted for verification or to provide updates. b. Systems telemetry: Health and status monitoring data for all subsystems. c. Imagery: Imagery generated by instrument subsystems such as cameras and vision systems. d. Navigation: Speed, distance, odometry, pose, geo-localization data (relative and absolute). e. Scientific data: Any relevant information related to science instruments, measurements and experiments performed on-board.	Details of the architecture and interfaces with the DSG/LOP-G, data rates and communications frequencies interfaces standards and documents will be provided at KOM and updated during the contract.
M-INT-PHASR-003	LDE Interfaces	The PHASR must have the following interfaces with the LDE: a. Mechanical b. Electrical c. Thermal d. Data communication	Details of the interfaces and requirements will be developed during the Phase 0 and refined in the upcoming phases. The PHASR will be installed in the LDE for launch, transit, landing and deployment.
M-INT-PHASR-004	LAE Interfaces	The PHASR must interface to the ISSP for its transport and transfer to the LAE: a. Mechanical b. Electrical c. Thermal d. Data communication	The current mission scenario is that the two ISSPEs will be launched on the PHASR and then one will be returned to the LAE once the initial mission is completed to return the samples.
M-INT-PHASR-005	Payloads Interfaces	The PHASR must interface with its payloads in addition to the ISSPE interfaces: a. Mechanical b. Electrical c. Thermal d. Data communication	Interfaces will be required to the Manipulator, science instruments and arm mounted instruments.

D.5 PERFORMANCE REQUIREMENTS

Requirement ID	Title	Description	Rationale/Note
M-PRF-PHASR-001	Maximum speed	The PHASR must be capable of moving at a maximum speed of at least 100 cm/s (3.6 km/h) on level, unprepared terrain.	Fast traverse capability is required to cover the long distances between lander and sites of interest.
T-PRF-PHASR-001	Maximum target speed	The PHASR should be capable of moving at a maximum speed of at least 138 cm/s (5 km/h) on level, unprepared terrain.	
M-PRF-PHASR-002	Minimum speed	The PHASR must be capable of moving at a minimum speed of no more than 2.5 cm/s (0.09 km/h) on level, unprepared terrain.	Controlled low speed capability is required to enable precision driving and positioning of the rover.
M-PRF-PHASR-003	Angle of approach	The angle of approach (H106 in SAE J1100) (RD-19) for the PHASR must not be less than 45°.	
M-PRF-PHASR-004	Angle of departure	The angle of departure (H107 in SAE J1100) (RD-19) for the PHASR must not be less than 45°.	
M-PRF-PHASR-005	Ramp break-over angle	The ramp break-over angle (H147 in SAE J1100) (RD-19) for the PHASR must not be less than 45°.	
M-PRF-PHASR-006	Rollover threshold	The rollover threshold of the PHASR at its full gross vehicle weight must be at least 35° when measured in accordance with SAE J2180 (RD-20).	
M-PRF-PHASR-007	Maximum gradient	The PHASR must be able to start, stop and drive at no less than 10 cm/s (0.36 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.	
M-PRF-PHASR-008	Gradeability	The PHASR must be capable of driving continuously at 10 cm/s (0.36 km/h) under a load equivalent to going up a 15° slope when at maximum gross vehicle weight.	This requirement is used to constrain the mobility torque, power and thermal handling capabilities of the rover. It is not intended to be driving the batteries' sizing in terms of capacity.

M-PRF-PHASR-009	Side slope	The PHASR must drive across slopes with a tilt angle of up to 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.	
M-PRF-PHASR-010	Ground clearance	The PHASR chassis must be high enough to clear an obstacle of 300 mm × 600 mm (height × width) without having the wheels or any part of the rover in contact with the obstacle, as depicted in Figure D-1.	
M-PRF-PHASR-011	Obstacle crossing #1	The PHASR must be capable of driving at low speed over a trapezoidal prism obstacle 30 cm high, as defined by Figure D-2.	“Driving over” implies that the rover wheels contact and roll over the obstacle, as depicted in Figure D-5
M-PRF-PHASR-012	Obstacle crossing #2	The PHASR must be capable of driving at low speed over a half cylindrical prism obstacle 30 cm high, as defined by Figure D-3.	“Driving over” implies that the rover wheels contact and roll over the obstacle, as depicted in Figure D-5
M-PRF-PHASR-013	Obstacle crossing #3	The PHASR must be capable of driving at low speed over a trapezoidal prism obstacle 45 cm high, as defined by Figure D-4.	“Driving over” implies that the rover wheels contact and roll over the obstacle, as depicted in Figure D-5
M-PRF-PHASR-014	Robotic arm workspace	The robotic arm must at a minimum be able to reach and operate anywhere within the workspace envelope defined by Figure D-6 and Figure D-7.	
M-PRF-PHASR-015	Turning radius	The PHASR must be able to turn within a circle where the turning circle diameter is lesser or equal to 1.3 time the wheelbase length.	The turning circle is the path traced by a point at the centerline of the vehicle, halfway between the front and rear axles or their equivalent, as the vehicle travels around in a low-speed, steady-state turn. Minimizing the turning radius is a critical function to the versatility of the vehicle and be considered with the other design factors and constraints. In order to precisely and quickly position the rover for science investigation and sample collection, the rover must have a very versatile and optimize turning approach.
M-PRF-PHASR-016	Relative position localization accuracy	The PHASR must establish its relative position to within 4 % of the distance traveled from its starting point for the scenario.	The fusion of wheel odometry with accurate IMU signals using a dynamic observer at high frequency (e.g., 100 Hz) should enable this level of accuracy.

M-PRF-PHASR-017	Absolute position localization accuracy	The PHASR must establish its absolute position to within 100 m.	The computation of the absolute position could be achieved offline from the ground. In that case, ground support team would analyse different rover signals (e.g., IMU, sky images) or other signals (e.g., orbital imagery, Doppler effect in communication link) to estimate the rover absolute position. Then, ground operators may send the position update to the rover localization system.
M-PRF-PHASR-018	Absolute heading localization accuracy	The PHASR must establish its absolute heading to within 1 degree of accuracy	This could be achieved while the rover is stationary. On Earth, 2 degrees accuracy could be achieved from an accurate IMU that can sense Earth rotation and a known rough absolute position. Sun and/or star tracking should allow to reach 1 degree of heading estimation accuracy.
M-PRF-PHASR-019	Main LIDAR field-of-view	The PHASR's main LIDAR must feature a horizontal field-of-view greater or equal to 180 degrees and a vertical field-of-view greater or equal to 45 degrees.	This field-of-view covers the front of the rover and ideally offers coverage on the side of the rover as well.
M-PRF-PHASR-020	Main LIDAR maximum range	The PHASR's main LIDAR maximum range must be at least 25 m.	
M-PRF-PHASR-021	Main LIDAR minimum range	The PHASR's main LIDAR minimum range must be no more than 1 m.	This is to ensure minimal blind zone in front of the rover.
M-PRF-PHASR-022	Main LIDAR spatial sampling	The PHASR's main LIDAR must feature a spatial sampling capability on the ground of 7 cm at 10 m from the sensor.	
M-PRF-PHASR-023	Main LIDAR bearing accuracy	The PHASR's main LIDAR must feature a bearing accuracy of 3 mrad.	
M-PRF-PHASR-024	Main LIDAR range accuracy	The PHASR's main LIDAR must feature an average range accuracy of 3 cm.	
M-PRF-PHASR-025	Main LIDAR acquisition time	The PHASR's main LIDAR must be able to collect a full scan within 30 seconds.	
M-PRF-PHASR-026	Driving hazard detection sensors coverage	The PHASR's driving hazard detection sensors must cover at least the first 3 meters in front of the rover.	
M-PRF-PHASR-027	Driving hazard detection sensors update rate	The PHASR's driving hazard detection sensors must feature an update rate greater or equal to 5 Hz.	This value should be derived from rover speed and braking distance.
M-PRF-PHASR-028	Front point-cloud no blind zone	The PHASR must be able to collect point clouds in front of the rover with no blind zone on the first 10 m.	This could be achieved by a combination of different sensor outputs (e.g., main LIDAR and Driving hazard detection sensors)

M-PRF-PHASR-029	Drive camera horizontal field-of-view	The PHASR's drive camera must feature a wide angle field-of-view around 140°.	The front drive camera is a wide-angle camera primary used to drive or to provide situational awareness in front of the rover. Based on CSA experience from the TRT experiments, drive cameras should be wide angle, i.e. 120° FOV or more (140° used for TRT).
M-PRF-PHASR-030	Drive camera height from the ground	The PHASR's drive camera height from the ground must be greater or equal to 1.25 m.	Based on CSA experience from the TRT experiments, it is difficult to teleoperate a rover from a wide-angle drive camera mounted low above the ground. Terrain assessment is easier to perform from a camera mounted high, providing more of a bird's-eye view.
M-PRF-PHASR-031	Temporary loss of communication	The PHASR must be tolerant to temporary loss of communication ranging from a few seconds to a few minutes.	The rover operations must keep going whenever possible and safe when communication is lost. The rover state must gracefully and rapidly recover when communication is re-established. Some automated communications recovery sequences might be necessary under some circumstances (e.g. extended communication loss). Exact numbers will be defined as part of the Phase 0 and upcoming phases.
M-PRF-PHASR-032	Communication delays	The PHASR control scheme must be tolerant to delays up to 10 seconds round-trip.	

D.6 SOFTWARE REQUIREMENTS

This section presents a preliminary set of software requirements, reflecting the need for standardized data and software updates from ground.

Requirement ID	Title	Description	Rationale/Note
M-SFW-PHASR-001	Upgradable from ground	The PHASR must have the capability to upgrade its different CSCIs, namely software, firmware and configuration files, from ground.	Allow for growth, bug fixes, configuration changes as needed.
M-SFW-PHASR-002	Simulator	There must be a simulator of the PHASR system.	To incorporate into an integrated simulation environment to be defined. The fidelity of the simulator is to be defined.
M-SFW-PHASR-003	Software API	There must be a software API provided for both the simulated and the real PHASR system.	To integrate into existing tools.

D.7 REQUIREMENTS ASSOCIATED FIGURES

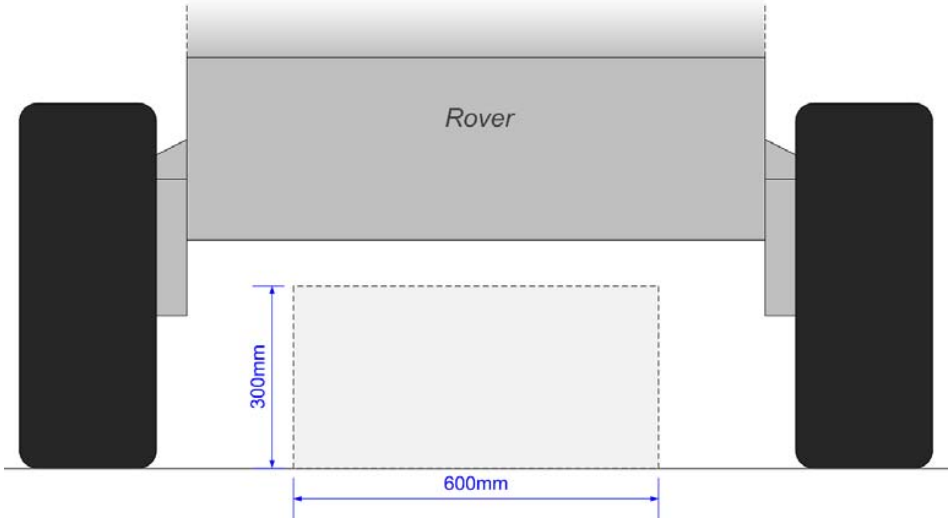

FIGURE D-1: GROUND CLEARANCE REQUIREMENT DEFINITION

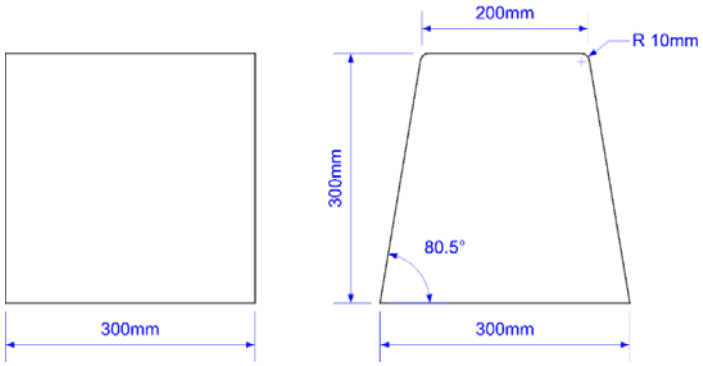

FIGURE D-2: OBSTACLE #1 (30 CM TRAPEZOIDAL PRISM) SPECIFICATIONS

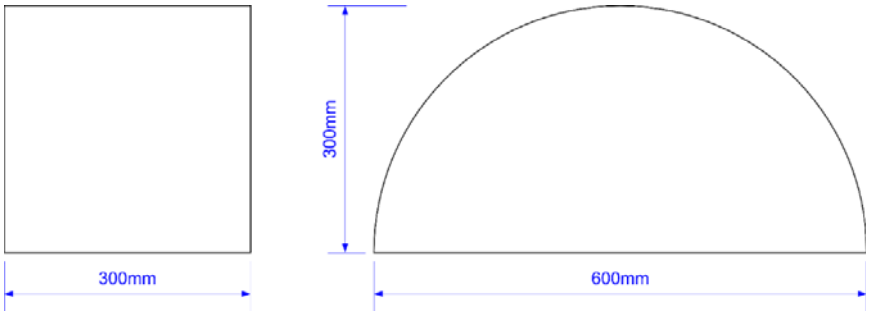

FIGURE D-3: OBSTACLE #2 (30 CM HALF CYLINDER) SPECIFICATIONS

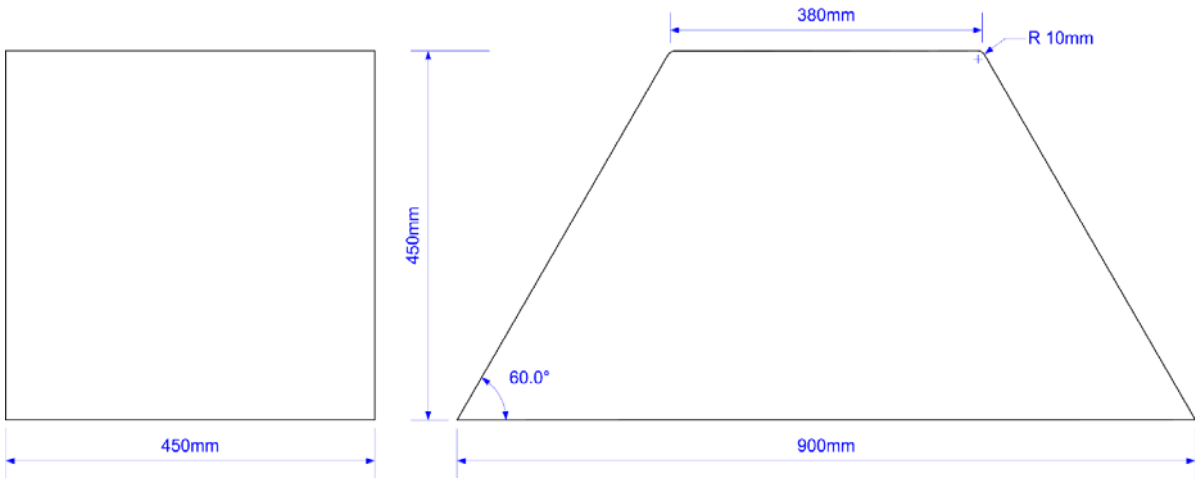

FIGURE D-4: OBSTACLE #3 (45 CM TRAPEZOIDAL PRISM) SPECIFICATIONS

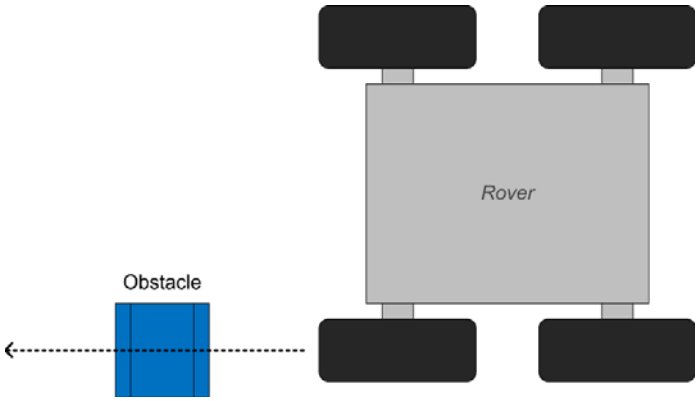

FIGURE D-5: "DRIVING OVER" DEFINITION

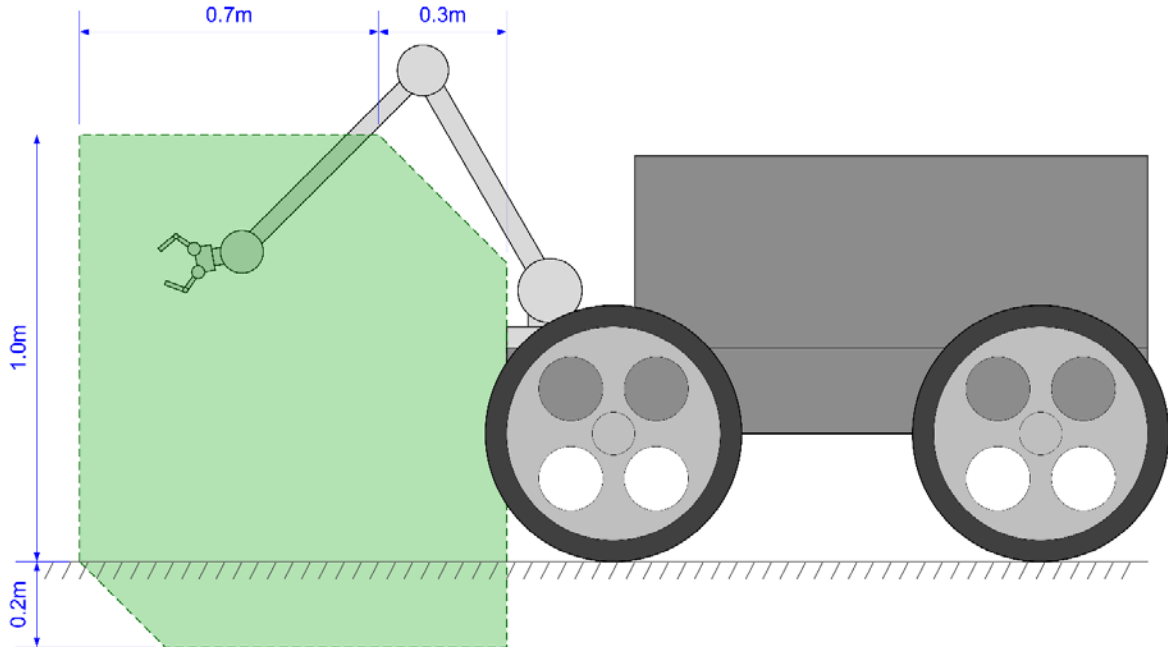

FIGURE D-6: ROBOTIC ARM WORKSPACE, SIDE VIEW

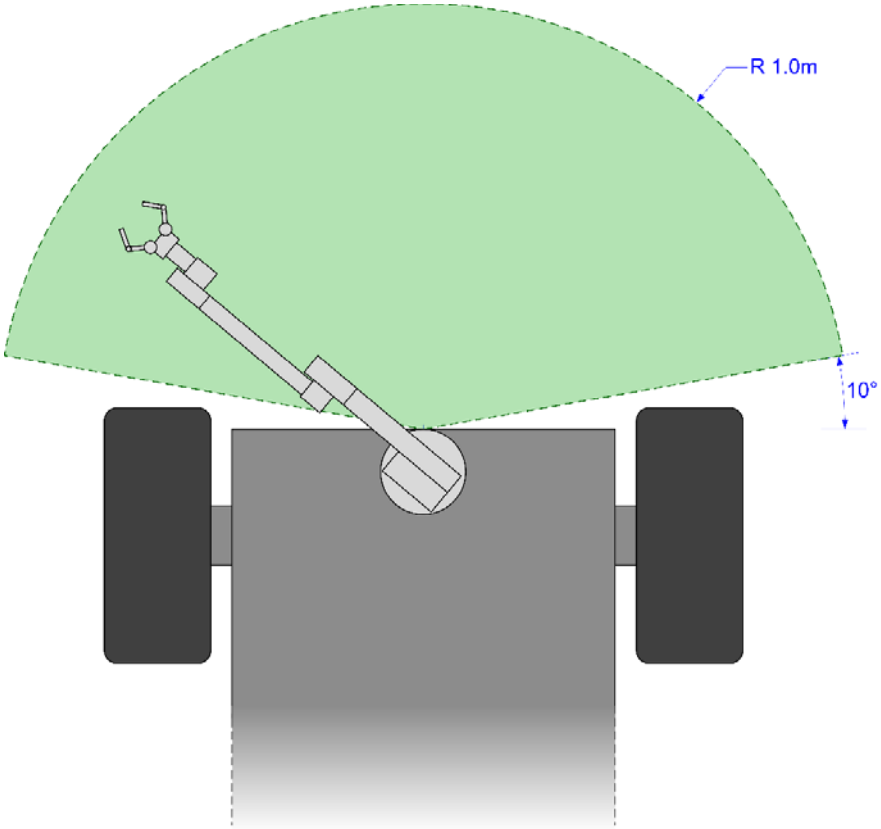

FIGURE D-7: ROBOTIC ARM WORKSPACE, TOP VIEW

E PRODUCT BREAKOWN STRUCTURE DEFINITION

In order to standardize the Product Structure Breakdown (PBS) to clearly identify what belongs to which part of the PHASR, the contractor should use the PBS below as a reference for the PHASR architecture.

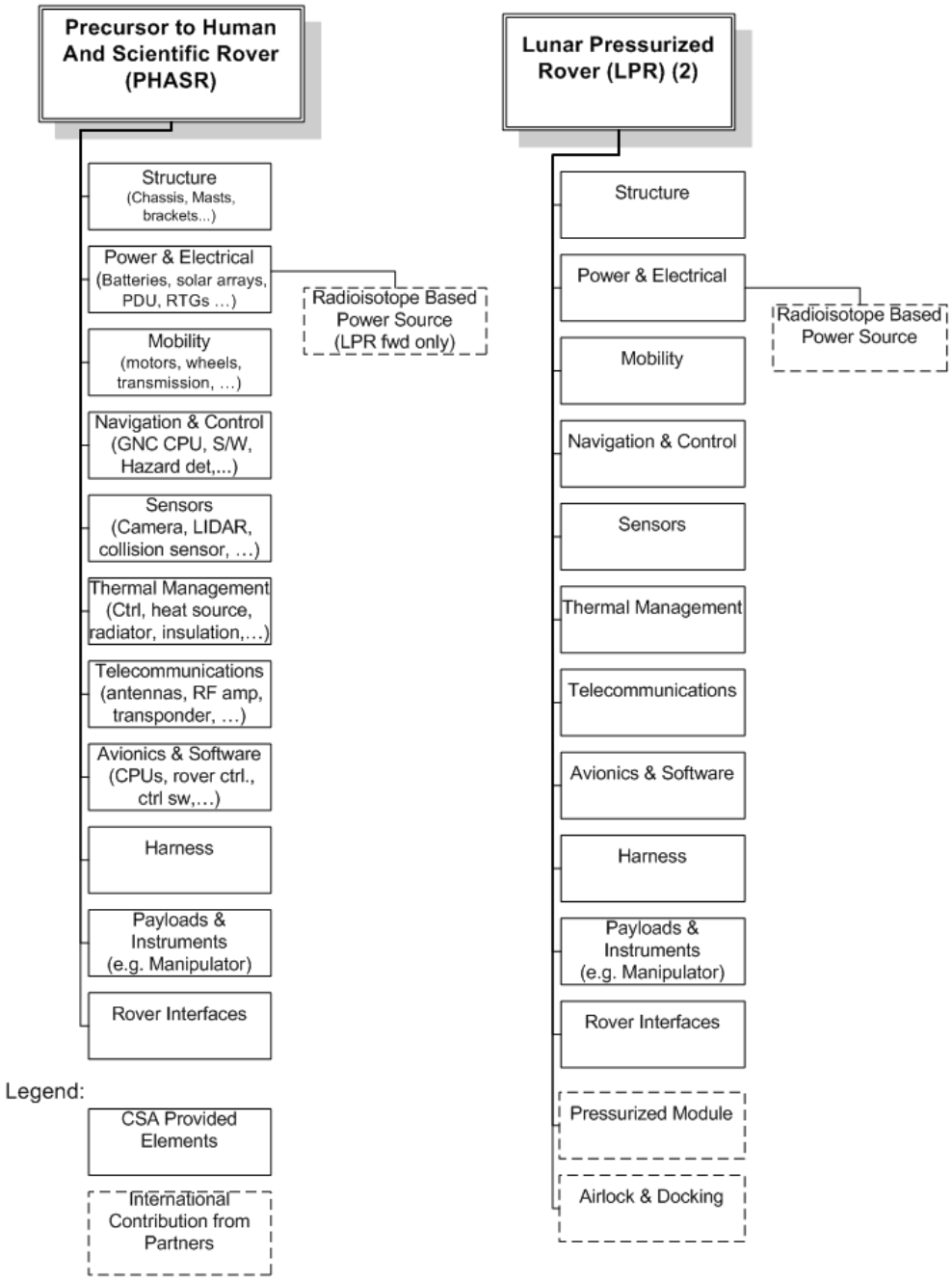

FIGURE E-8: CSA ROVERS PRODUCT BREAKDOWN STRUCTURE (PBS)

F PRELIMINARY SCIENCE PAYLOAD DESCRIPTION

This section provides an initial set of payload requirements, allocation, examples and references to be used as a starting point for this phase 0. These will be refined and adjusted as the parallel science definition studies (Canadian and international) progress and will be provided as inputs to this phase 0. At the end of phase 0, accommodation requirements for a nominal payload must be output as DID-850. This is anticipated to be used by CSA and partner space agencies to compete a science payload according to the latest requirements from an international science definition team.

TABLE F-1 : NOMINAL SCIENCE PAYLOAD REQUIREMENTS: TRESHOLD, BASELINE AND AUGMENTED

Payload type	Nominal Instrument	Measurement objective	Assumptions[1]			References
			Mass estimate: Sensor Head/ Electronics	Volume estimate: Sensor head/ Electronics- box	Power	
THRESHOLD:						
Deck mounted	Calibration target(s)	Provide calibration reference for multi-spectral imaging, remote sensing and elemental composition instruments	0.8 kg	2 targets x 8 cm x 8 cm x 2 cm	N/A	Individual instruments (see reference list at end of document)
Mast based remote sensing	Science camera	Colour, multispectral and 3D imaging. Panoramic colour & textural information on rocks	4 kg	15 cm x 15 cm x 30 cm (head); 20 cm x 15 cm x 6 cm (elec)	20 W	PanCam (ExoMars); Mastcam-Z (Mars 2020)
	LIBS & Remote Micro Imager (RMI)	Identify the chemical composition of rocks and soils	6 kg (head); 5 kg (body)	40 cm x 22 cm x 17 cm (head); 20 cm x 24 cm x 16 cm (body)	65 W (few sec.); 12 W (min); TEC within body unit draws 13.5 W	ChemCam (MSL)
Deck mounted	Radiation Detector	Detects energetic particles to measure a broad spectrum of radiation	1.6 kg	11 cm x 13 cm x 21 cm	4.2 W	RAD (MSL)
Total Mass						**17.4 kg**
Margin to be added (30%)						**~5.2 kg**
Total Mass with Margin						**~22.6 kg**
BASELINE:						

[1] Published literature on reference instruments should be reviewed - Resource budgets should be at least as large as stated in literature for reference instruments.

Payload type	Nominal Instrument	Measurement objective	Assumptions[1]			References
			Mass estimate: Sensor Head/ Electronics	Volume estimate: Sensor head/ Electronics- box	Power	
Mast-based remote sensing	LIBS & RAMAN & RMI[1]	To identify the chemical composition of rocks and soils, including their atomic and molecular makeup	5.6 kg (head); 4.8 kg (electronics)	38 cm x 24cm x 19 cm (head); 20 cm x 24 cm x 16 cm (body)[2]	17.9 W	SuperCam (Mars 2020)
	Spectrometer (UV-VIS-NIR)	For mineralogy and physical properties; to detect differentiated materials	2.4 kg	23.5 cm x 16.3 cm x 15.5 cm	5.6 W	
Arm-mounted contact science	Micro-Imager	Provide imagery of grain sizes and small-scale textural info	1 kg	17 cm x 8 cm x 10 cm	15 W	CLUPI (ExoMars), or MALHI (MSL)
	In situ geochemistry	Analyze chemical elements in rocks and soils	1.6 kg (head); 1.6 kg (electronics)	16 cm x 13cm x 12 cm (head) 18 cm x 12cm x 6 cm (body)	9 W night, 20 W day (with translation mechanism active)	APXS (MSL, MER)[3] PIXL (Mars 2020)
Total Mass (includes Threshold)						**23.4 kg**
Margin to be added (30%)						**~7 kg**
Total Mass with Margin						**~30.4 kg**
	AUGMENTED:					
Body-mounted	GPR	Investigate the geology of the subsurface	3 kg	20 cm x 12 cm x 7 cm (antenna); 15 cm x 10 cm x 5 cm (electronics)[4]	10 W	RIMFAX (Mars 2020)
	Neutron spectrometer	Measures content of hydrogen along the path of the rover	3 kg	15 cm x 5 cm x 35 cm	15 W	DAN (MSL)
Package to be installed on surface	Self contained science experiment	Possible life sciences or space environment experiment	1kg	20 x 20 x 20 cm	0 W	
Total Mass (includes Threshold and Baseline)						**30.4**
Margin to be added (30%)						**~10.1 kg**
Total Mass with Margin						**~40.5 kg**

[1] Replaces the LIBS & RMI instrument from the Threshold Investigation.
[2] Based on the dimensions of the electronics of ChemCam (SuperCam electronics box dimensions are not readily available).
[3] Resource assumptions are provided by CSA for a next generation APXS instrument with translation mechanism. The translation mechanism provides instrument autonomy to generate a raster of the target, and hence sub-Field Of View (FOV) resolution. FOV ~2cm.
[4] The RIMFAX GPR has an electronics box of unknown size, but the WISDOM GRP electronics box is approximately 15 x 10 x 5 cm (see Figure in RIMFAX literature for scale).

TABLE F-2 : SCIENCE PAYLOAD INSTRUMENT ACCOMODATION REQUIREMENTS

Accommodation type	**Accommodation**			**Instrument type**
	Where on rover	**Field of View**	**Interoperability considerations**	
Cal target	Deck	N/A	Visible to mast instruments and turret instruments; separate cal targets may be needed if viewing geometry complex	
Mast mounted science imaging and remote sensing payloads	Mast	360 degrees +180 degrees; -180 degrees		Nominal Exemple: Science Camera, LIBS & RMI
Deck mounted payload	Deck-mounted	Must be mounted on ‘deck’ of rover, with clear view above		Nominal Example: Radiation detector. See RAD instrument geometry on MSL
Internal payload elements	Inside rover		Thermal control for electronics	Nominal Example: instrument electronics boxes; spectrometer subsystem for mast based camera.
Arm mounted payload	Arm-mounted			Nominal Exemple: APXS & Micro-imager
Body mounted geophysics packages	Under body-mounted		May require deployment close to lunar surface for accurate measurements	Nominal Example: GPR and Neutron Spectrometer. SeeRIMFAX geometry in literature

TABLE F-3 : SCIENCE PAYLOAD SAMPLE ACQUISITION REQUIREMENTS

Scenario	Approach	Operations	Sample type/size	Sample handling considerations	Notes
Threshold	Scoop/rake	2 modes: (1) acquire regolith with small rock fragments (scoop) (2) acquire only small rock fragments and dump unwanted regolith (rake)	Loose material, ~400cc per scoop	No thermal, orientation or hermetic sealing reqts. Engineering team to determine sample container that will ensure no cross-contamination.	Scoop contents and acquisition site to be imaged before and after acquisition. Each sample acquisition to be preceded by an acquisition and dump to clean scoop and minimise cross contamination (see MoonRise literature)
Baseline	Scoop/rake + SPLIT	Scoop/rake modes as Threshold scenario plus percussive removal of rock hand-sized chunks from float rocks/boulders or outcrop			SPLIT is a prototype in development from the UK (mass of 1.8 kg, 26 cm x 6.5 cm x 6.5 cm, and requires 15 W to 20 W of power)
Augmented	Same as Baseline	Same as Baseline			Same as Baseline

G APOGY COMPATIBLE SELECTED CONCEPT REPRESENTATION

TABLE G-1: APOGY CDRL DEFINITION

Eclipse Plugins Qualifier	Content
<prefix>.c3p.lsm. phasr0.doc	1. Tutorials 2. Javadoc 3. Technical Documentation
<prefix>.c3p.lsm.phasr0	1. Fully documented Abstract PHASR0 meta-model (.xcore format). 2. Implementation Classes XCore meta-models and implementation classes shall be documented using Javadoc annotations.
<prefix>.c3p.lsm.phasr0.apogy	PHASR0 Apogy plugin (see Apogy examples) PHASR0 topology PHASR0 CAD Models (Wavefront .obj format)
<prefix>.c3p.lsm.phasr0.edit	Automatically PHASR0 generated UI support classes
<prefix>.c3p.lsm.phasr0.ui	Custom User Interfaces PHASR0 UI Implementation Classes. Classes shall be documented using Javadoc annotations.
<prefix>.c3p.lsm.phasr0.simulator	1. Fully documented PHASR0 Simulator meta-model (.xcore format). This model extends the Abstract PHASR0 model. 2. Implementation Classes XCore meta-models and implementation classes shall be documented using Javadoc annotations.
<prefix>.c3p.lsm.phasr0.simulator.edit	Automatically PHASR0 Simulator generated UI support classes
<prefix>.c3p.lsm.phasr0.examples	Workspace that includes an Apogy Session to control the simulated PHASR0 on a simulated terrain available in Apogy.
<prefix>.c3p.lsm.phasr0.feature	Eclipse feature that includes all the LSM plugins.

H ACRONYMS AND ABBREVIATIONS

AD	Applicable Document
AI	Approach Initiation
AIL	Action Item Log
API	Application Programming Interface
BIP	Background Intellectual Property
CAD	Computer Assisted Design
CDRL	Contract Data Requirements List
CF	Contractor's Format
cFS	Core File System
CSA	Canadian Space Agency
CTE	Critical Technology Element
CWBS	Cost Work Breakdown Structure
DID	Data Item Description
DOF	Degrees of Freedom
DSG	Deep Space Gateway
DSNE	Design Specification for Natural Environments
DTE	Direct-to-Earth
ESA	European Space Agency
FIP	Foreground Intellectual Property
FTP	File Transfer Protocol
GEVS	Goddard Technical Standard: General Environmental Verification Standard
GSFC	Goddard Space Flight Center
HERACLES	Human Enhanced Robotic Architecture and Capability for Lunar Exploration and Science
ICD	Interface Control Document
IP	Intellectual Property
IPs	International Partners
ISRU	In-Situ Resource Utilization
ISS	International Space Station
ISSPE	In-Space Sample Preservation
JAXA	Japan Aerospace Exploration Agency
KOM	Kick-Off Meeting
KOS	Keep Out Sphere
LAE	Lunar Ascent Element
LAN	Local Area Network

LDE	Lunar Descent Element
LEO	Low Earth Orbit
LOP-G	Lunar Orbiting Platform - Gateway
LPR	Lunar Pressurized Rover
LSM	Lunar Surface Mobility
LSR	Lunar Sample Return
MCD	Mission Concept Document
MCR	Mission Concept Review
MM	Mission Manager
MRD	Mission Requirements Document
MRR	Mission Requirements Review
NASA	National Aeronautics and Space Administration
OSAL	Operating System Abstraction Layer
PHASR	Precursor to Human And Science Rover
PM	Project Manager
PSPC	Public Services and Procurement Canada
RD	Reference Document
SI	« Système International »
SLS	Space Launch System
SPR	Small Pressurized Rover
SME	Surface Mobility Element
SOW	Statement of Work
SRR	Systems Requirement Review
STC	Sample Transfer Container
TA	Technical Authority
TB	Treasury Board
TBD	To be determined
TRRA	Technology Readiness and Risk Assessment
TRL	Technology Readiness Level
WAM	Work Authorization Meeting
WLAN	Wireless LAN