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, portail Sud-Est
800, rue de La Gauchetière Ouest
7 ième étage
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
Missions Enabling Technologies

Solicitation No. - N° de l'invitation	**Date**
9F063-120711/A	2013-04-24

Client Reference No. - N° de référence du client
9F063-12-0711

GETS Reference No. - N° de référence de SEAG
PW-$MTB-450-12304

File No. - N° de dossier	**CCC No./N° CCC - FMS No./N° VME**
MTB-2-35281 (450)	

Solicitation Closes - L'invitation prend fin
at - à 02:00 PM
on - le 2013-06-05

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**
Guérinik (mtb450), Naoual	mtb450

Telephone No. - N° de téléphone	**FAX No. - N° de FAX**
(514) 496-3409 ( )	(514) 496-3822

Destination - of Goods, Services, and Construction:
Destination - des biens, services et construction:
AGENCE SPATIALE CANADIENNE
6767 ROUTE DE L AEROPORT
9F063-Sciences & Tech. Spatiales
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-Est
800, rue de La Gauchetière Ouest
7 ième étage
Montréal
Québec
H5A 1L6

Canada

PART 1 - GENERAL INFORMATION

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PART 1 - GENERAL INFORMATION

1.1 Introduction

The bid solicitation document 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: includes the certifications to be provided;

Part 6 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 following attachments:

Attachment 1 to Part 3- Technical and Managerial Bid Preparation Instructions;
Attachment to Part 4 - Point Rated Evaluation Criteria;

And the following Annexes:

Annex A: Statement of Work and Requirement
Annex B: Basis of Payment.

1.2 Summary

Project title

Mission-Enabling Technologies

Description

Public Works and Government Services Canada (PWGSC) on behalf of Canadian Space Agency (CSA) located in St-Hubert, (Quebec), is seeking bids to develop Mission-Enabling Technologies listed in Table 1.1 below that are in line with the CSA's priorities and mission roadmaps. For every Priority Technologies (PTs) specified in the Statement of Work (Work), the work solicited is the development and advancement of these technologies up to potentially Technology Readiness Level (TRL) 6 to reduce technical uncertainties and support approval and implementation of specific potential future space

missions of interest to Canada. Priority Technologies are those that have been established by the CSA as the critical technologies to be developed to meet the objectives set forth by the Canadian Space Strategy.

Up to 11 contracts may be awarded.

Rank	PT #	Priority Technology Title	Maximum Funding (K$)
1	PT 1	Dust mitigation technologies (Moon, Mars)	800
2	PT 2	Sample Processing for on-orbit biomedical analysis	250
3	PT 3	Quantum Key Distribution Receiver (QKDR) for QEYSSat	600
4	PT 4	Focal Plane Array technologies for Astronomy	500
5	PT 5	Sensor breadboard for thin ice cloud experiments (TICFIRE)	500
6	PT 6	Methodologies and Tools for CPU intensive algorithms migration to FPGA based implementation	800
7	PT 7	Radarsat Next Generation, Enabling Technologies for 1-meter resolution.	600
8	PT 8	Technologies to advance a manipulator mounted microscope for planetary surface applications	600
9	PT 9	Novel DNA-based Dosimeter for Space	350
10	PT 10	Mid-wave Infrared Microbolometer Sensor Breadboard	500
11	PT 11	Dexterous robotic tools	500

Table 1.1: List of Mission-Enabling Priority Technologies

Period of Contract

Each contract issued will be for a period of twenty-four (24) months.

Actual Available Budget

The actual budget available under this RFP is 6.0M$, all applicable taxes extra. A contract will be awarded to the best compliant bid for each of the Priority Technologies in the order listed in Table 1.1 above i.e. the first contract to be awarded will cater to PT1, with the second to PT2 etc. Annex A (Statement of Work & Requirements) provides details regarding the Work required for each Priority Technology (PT).

In the event that there are no responsive bids in a particular Priority Technology or all available budget has not been spent, Canada may elect to award one or more contracts to responsive bids that finished second for a particular Priority Technology under the other remaining Priority Technologies (depending on availability of funding and solution proposed). Refer to Part 4 - Evaluation Procedures and Basis of Selection, section 4.3 Basis of Selection for more information.

Security Requirements

No security requirements apply to this project.

This requirement is not subject to the trade agreements.

Canadian Content

The requirement is limited to Canadian goods and/or services.

Controlled Goods Program

This procurement is subject to the Controlled Goods Program.

1.3 Debriefings

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

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 (http://ccua-sacc.tpsgc-pwgsc.gc.ca/pub/acho-eng.jsp) 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 (2012-11-19) 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: sixty (60) days
Insert: two-hundred-forty (240) days

2.2 SACC Manual Clauses

A7035T (2007-05-25), List of Proposed Subcontractors
A list of subcontractors is needed for regional distribution report.

2.3 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.

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

2.4 Enquiries - Bid Solicitation

All enquiries must be submitted in writing to the Contracting Authority no later than **ten(10) 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 questions or may request that the Bidder do so, so that the proprietary nature of the question is eliminated, and the enquiry can be answered with copies 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 Maximum Funding

The maximum funding available, Quebec Sales Tax (QST) extra, as appropriate, for each contract resulting from the bid solicitation is indicated in *Table 1.1: List of Mission-Enabling Priority Technologies of Part 1- General Information.* Bids valued in excess of this amount will be considered non-responsive, as per PART 4- Evaluation Procedures and Selection Process, section 4.3 Financial Evaluation. This disclosure does not commit Canada to pay the maximum funding available.

PART 3 - BID PREPARATION INSTRUCTIONS

3.1 Bid Preparation Instructions

A Bidder can bid on more than one Priority Technology specified in *Table 1.1: List of Mission-Enabling Priority Technologies of Part 1- General Information*, but must submit one separate bid for each Priority Technology. Canada requests that the bidder clearly identifies in the first page of its bid which Priority Technology he is bidding on. The Bidder must follow the same instructions described in this Request for proposal for each bid he submits.

Canada requests that bidders follow the format instructions described below in the preparation of each bid:

(a) Each bid must contain the following sections:

Section I: Technical and Managerial Bid as well as the Executive Summary: (1 hard copy and 2 soft copies on CD)

Section II: Financial Bid (1 hard copy and 1 soft copy on CD)

Section III: Certifications (1 hard copy)

(b) For the hard copies, each section must be bound separately;

(c) 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;

(d) For the soft copies of Section I (Technical and Managerial as well as the Executive Summary), all of the information must be contained in one file. The only acceptable formats are: MS Word, WordPerfect, PDF and HTML;

(e) For the soft copy of Section II (Financial Bid), all of the information must be contained in one file. The only acceptable formats are: MS Word, WordPerfect, PDF and HTML;

(f) The soft copy of Section II must be submitted on a separate CD than the soft copy submitted for Section I;

(g) Prices must appear in Section II (financial bid) only. No prices must be indicated in any other section of the bid;

(h) The total number of pages for Section I should not exceed 50 pages (8.5 X 11 inches) (216 mm X 279 mm) paper excluding bid appendices;

(i) The bid should 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

3.2 Section I: Technical and Managerial Bid

In their Technical and Managerial 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 and Managerial 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.

Part 4, Evaluation Procedures contains additional instructions that bidders should consider when preparing their technical Bid.

The structure and content requested for the Technical and Managerial Bid (Section I) are detailed in to Part 3- Attachment 1: Technical and Managerial Bid Preparation Instructions.

3.3 Section II: Financial Bid

3.3.1 Bidders must submit their financial bid in accordance with the following:

Option 1:

(a) A firm, all inclusive lot price for the Work, which must not exceed the maximum funding available for each contract resulting from the bid solicitation specified in Part 1, Table 1.1: *List of Mission-Enabling Priority Technologies*. The total amount of Quebec Sales Tax is to be shown separately, if applicable.

-OR-

Option 2:

(a) A Total Cost to a Ceiling Price, which must not exceed the maximum funding available for each contract resulting from the bid solicitation specified in Part 1, Table 1.1: *List of Mission-Enabling Priority Technologies.* The total amount of Quebec Sales Tax is to be shown separately, if applicable.

(b) Prices must be in Canadian funds. The total amount of Quebec Sales Tax must be shown separately, as applicable.

3.3.2 Bidders must submit their price for each Priority Technology Incoterms 2000 FOB destination; Canadian customs duties and excise taxes included, as applicable; and QST excluded.

3.3.3 When preparing their Financial bid, bidders must review the Basis of payment in Annex B and Section 4.3, Financial Evaluation of Part 4 Evaluation Procedures and Basis of Selection.

3.3.4 In each Financial bid he submits, Bidder must provide a price breakdown as follows for each firm lot price quoted in response to the pricing schedule detailed Section 3.3.1 a) Option 2 of Part 3 and in Annex B Basis of Payment;

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

(b) Equipment: Bidder must specify each item required to purchase and complete the Work and provide the pricing basis of each one, Canadian customs duty and excise taxes included, as applicable. These items will be deliverable to Canada upon completion of the contract.

(c) Materials and Supplies: Bidder must identify each category of materials and supplies required to purchase and provide the pricing basis of each one in order to complete the Work..

(d) Travel and Living Expenses: Bidder must 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 Treasury Board (TB) Travel Directive. With respect to the TB Directive, only the meal, private vehicle and incidental allowances specified in Appendices B, C and D of the Directive

http://www.njc-cnm.gc.ca/directive/travel-voyage/index-eng.php, and the other provisions of the Directive referring to "travellers", rather than those referring to "employees", are applicable.

(e) Subcontracts: Bidder must identify all of the proposed subcontractor and provide in the Financial bid for each one a price breakdown as contained in paragraph 3.3.4 of Part 3 of the bid solicitation.

(f) Other Direct Charges if applicable: Bidder must identify all other direct charges anticipated, such as long distance communications and rentals, and provide the pricing basis for each.

(g) QST: Bidder must identify any applicable QST separately.

3.4 Exchange Rate Fluctuation

C3011T (2010-01-11), Exchange Rate Fluctuation

3.5 Section III: Certifications

In Section III, Bidders must include the certifications 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.

4.2 Technical and Management Evaluation

4.2 .1 Point Rated Technical and Management Criteria

Point rated Technical and Management Evaluation Criteria are described in Attachment 1 Part 4 –Point Rated Technical and Management criteria not addressed will be given a score of zero.

4.3 Financial Evaluation

4.3.1 Mandatory Financial Criteria

Bids must meet the mandatory financial criteria. Bidder must respect the maximum funding available for each contract resulting from the bid solicitation as listed in Table 1.1 of PART 1: List of Mission-Enabling Priority Technologies (Goods and Services Tax or Harmonized Sales Tax extra, as appropriate).

Bids which fail to meet this mandatory financial criterion will be declared non-responsive. Bids valued in excess of this amount will be considered non-responsive.

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

4.3.2 Evaluation of Price

The price of the bid will be evaluated in Canadian dollars, the Goods and Services Tax or Harmonized Sales Tax excluded FOB destination, Canadian customs duties and excise taxes included.

4.4 Basis of Selection

Basis of Selection - Highest Combined Rating of Technical Merit (80%) and Price (20%)

Contracts will be awarded to the best responsive bids in the order of the Priority Technologies listed in Part 1, Table 1.1 i.e. the first contract to be awarded will cater to PT1, with the second to PT2 etc.

4.4.1. To be declared responsive, each bid must:

a) comply with all the requirements of the bid solicitation;

b) meet all mandatory evaluation criteria;

c) obtain the required minimum of 10 points on a scale of 15 points for the Evaluation Criterion #1 "Technical Relevance " as indicated in Table 4A.1 of Attachment 1 of Part 4 ;and

d) obtain the required minimum of (70) points for the overall Technical and Management portion of the bid as indicated in Table 4A.1 of Attachment 1 of Part 4.

4.4.2. Bids not meeting (a) or (b) or (c) or (d) will be declared non-responsive.

4.4.3. The selection will be based on the highest responsive combined rating of technical merit and price. The ratio will be 80% for the technical merit and 20 % for the price.

4.4.4. To establish the technical merit score, the overall technical score for each responsive bid will be determined as follows: total number of points obtained/maximum number of points available multiplied by the ratio of 80 %.

4.4.5. To establish the pricing score, each responsive bid will be prorated against the lowest evaluated price and the ratio of 20 %.

4.4.6. For each responsive bid, the technical merit score and the pricing score will be added to determine its combined rating.

4.4.7. Neither the responsive bid obtaining the highest technical score nor the one with the lowest evaluated price will necessarily be accepted. The responsive bid with the highest combined rating of technical merit and price will be recommended for award of a contract.

In the event that more than one responsive bid has the same combined rating of technical merit and price in a Priority Technology, the bid which obtained the highest number of points for the point rated Technical evaluation criteria will be recommended for award of a contract.

In the event that there are no responsive bids in a particular Priority Technology or all available budget has not been spent, Canada may elect to award one or more contracts to responsive bids that finished second for a particular Priority Technology under the other remaining Priority Technologies. The CSA will look at all the proposals that finished second and will make a decision based on the availability of funds and the complementary nature of the proposals that finished second. In this context, “complementary” means “a different technical acceptable approach of interest to CSA”.

The table below illustrates an example where all three bids are responsive and the selection of the contractor is determined by a 80/20 ratio of technical merit and price, respectively. The total available points equals 135 and the lowest evaluated price is $45,000 (45).

Basis of Selection - Highest Combined Rating Technical Merit (80%) and Price (20%)

Bidder	**Bidder 1**	**Bidder 2**	**Bidder 3**
Overall Technical	115/135	89/135	92/135
Bid Evaluated Price	$55,000.00	$50,000.00	$45,000.00

Calculation of Technical Merit Score	115/135 x 80 = 68,15	89/135 x 80 = 52,74	92/135 x 80 = 54,52
Calculation of Pricing Score	45/55 x 20 = 16,36	45/50 x 20 = 18,00	45/45 x 20 = 20,00
Combined Rating	84,51	70,74	74,52
Overall Rating	1st	3rd	2nd

PART 5 - CERTIFICATIONS

Bidders must provide the required certifications and related documentation to be awarded a contract. Canada will declare a bid non-responsive if the required certifications and related documentation are not completed and submitted as requested.

Compliance with the certifications bidders provide to Canada is subject to verification by Canada during the bid evaluation period (before award of a contract) and after award of a contract. The Contracting Authority will have the right to ask for additional information to verify bidders' compliance with the certifications before award of a contract. The bid will be declared non-responsive if any certification made by the Bidder is untrue, whether made knowingly or unknowingly. Failure to comply with the certifications, to provide the related documentation or to comply with the request of the Contracting Authority for additional information will also render the bid non-responsive.

5.1 **Mandatory** Certifications Precedent to Contract Award and Certifications Required with the Bid

1.1 Code of Conduct and Certifications-Related documentation

5.1.1 By submitting a bid, the Bidder certifies, for himself and his affiliates, to be in compliance with the

Code of Conduct and Certifications clause of the Standard instructions. The related documentation hereinafter mentioned will help Canada in confirming that the certifications are true. By submitting a bid, the Bidder certifies that it is aware, and that its affiliates are aware, that Canada may request additional information, certifications, consent forms and other evidentiary elements proving identity or eligibility. Canada may also verify the information provided by the Bidder, including the information relating to the acts or convictions specified herein, through Independent research, use of any government resources or by contacting third parties. Canada will declare non-responsive any bid in respect of which the information requested is missing or inaccurate, or in respect of which the information contained in the certifications is found to be untrue, in any respect, by Canada. The Bidder and any of the Bidder's affiliates, will also be required to remain free and clear of any acts or convictions specified herein during the period of any contract arising from this bid solicitation.

Bidders who are incorporated, including those bidding as a joint venture, must provide with their bid or promptly thereafter a complete list of names of all individuals who are currently directors of

the Bidder. Bidders bidding as sole proprietorship, including those bidding as a joint venture, must provide the name of the owner with their bid or promptly thereafter. Bidders bidding as societies, firms, partnerships or associations of persons do not need to provide lists of names. If

the required names 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 will render the bid non-responsive. Providing the required names is a mandatory requirement for contract award.

Canada may, at any time, request that a Bidder provide properly completed and Signed Consent Forms (Consent to a Criminal Record Verification form- PWGSC-TPSGC 229) (http://www.tpsgc-pwgsc.gc.ca/app-acq/forms/formulaires-forms-eng.html) for any or all individuals aforementioned within the time specified. Failure to provide such Consent Forms within the time period provided will result in the bid being declared non-responsive.

5.2 Addition Certifications Precedent to Contract Award

The certifications Precedent to Contract Award, should be completed and submitted with the bid but may be submitted afterwards. If any of these required certifications is not completed and submitted as requested, the Contracting Authority will so inform the Bidder and provide the Bidder with a time frame within which to meet the requirement. Failure to comply with the request of the Contracting Authority and meet the requirement within that time period will render the bid non-responsive.

5.3 Federal Contractors Program - Certification

Federal Contractors Program - $200,000 or more

1. The Federal Contractors Program (FCP) requires that some suppliers, including a supplier who is a member of a joint venture, bidding for federal government contracts, valued at $200,000 or more (including all applicable taxes), make a formal commitment to implement employment equity. This is a condition precedent to contract award. If the Bidder, or, if the Bidder is a joint venture and if any member of the joint venture, is subject to the FCP, evidence of its commitment must be provided before the award of the Contract.

   Suppliers who have been declared ineligible contractors by Human Resources and Skills Development Canada (HRSDC) are no longer eligible to receive government contracts over the threshold for solicitation of bids as set out in the Government Contracts Regulations. Suppliers may be declared ineligible contractors either as a result of a finding of non-compliance by HRSDC, or following their voluntary withdrawal from the FCP for a reason other than the reduction of their workforce to less than 100 employees. Any bids from ineligible contractors, including a bid from a joint venture that has a member who is an ineligible contractor, will be declared non-responsive.

2. If the Bidder does not fall within the exceptions enumerated in 3.(a)

or (b) below, or does not have a valid certificate number confirming its adherence to the FCP, the Bidder must fax (819-953-8768) a copy of the signed form LAB 1168, Certificate of Commitment to Implement Employment Equity, to the Labour Branch of HRSDC.

3. The Bidder, or, if the Bidder is a joint venture the member of the joint venture, certifies its status with the FCP, as follows:

The Bidder or the member of the joint venture

(a) ( ) is not subject to the FCP, having a workforce of less than 100 full-time or part-time permanent employees, and/or temporary employees having worked 12 weeks or more in Canada;

(b) ( ) is not subject to the FCP, being a regulated employer under the Employment Equity Act, S.C. 1995, c. 44;

(c) ( ) is subject to the requirements of the FCP, having a workforce of 100 or more full-time or part-time permanent employees, and/or temporary employees having worked 12 weeks or more in Canada, but has not previously obtained a certificate number from HRSDC (having not bid on requirements of $200,000 or more), in which case a duly signed certificate of commitment is attached;

(d) ( ) is subject to the FCP, and has a valid certificate number as follows: _____ (e.g. has not been declared an ineligible contractor by HRSDC.)

Further information on the FCP is available on the HRSDC Web site.

5.4 Former Public Servant Certification

Contracts with 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 with FPS, bidders must provide the information required below.

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, in the context of the fee abatement formula, 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

Is the Bidder a FPS in receipt of a pension as defined above?
YES ( ) NO ( )

If so, the Bidder must provide the following information:

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

Work Force Reduction Program

Is the Bidder a FPS who received a lump sum payment pursuant to the terms of a work force reduction program?

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 reduction 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 the Goods and Services Tax or Harmonized Sales Tax.

5.5 Canadian Content Certification

This procurement is conditionally limited to Canadian goods and Canadian services.

Subject to the evaluation procedures contained in the bid solicitation, bidders acknowledge that only bids with a certification that the goods and services offered are Canadian goods and Canadian services, as defined in clause A3050T, may be considered.

Failure to provide this certification completed with the bid will result in the goods and services offered being treated as non-Canadian goods and non-Canadian services.

The Bidder certifies that:

( ) a minimum of 80 percent of the total bid price consist of Canadian goods and Canadian services as defined in paragraph 5 of clause A3050T.

For more information on how to determine the Canadian content for a mix of goods, a mix of services or a mix of goods and services, consult Annex 3.6.(9), Example 2, of the Supply Manual. (https://buyandsell.gc.ca/policy-and-guidelines/supply-manual/annex/3/6).

Canadian Content Certification

SACC Manual clause A3050T (2010-01-11) Canadian Content Definition.

5.6 Status and Availability of Resources

The Bidder certifies that, should it be awarded a contract as a result of the bid solicitation, every individual proposed in its bid will be available to perform the Work as required by Canada's representatives and at the time specified in the bid solicitation or agreed to with Canada's representatives. If for reasons beyond its control, the Bidder is unable to provide the services of an individual named in its bid, the Bidder may propose a substitute with similar qualifications and experience. The Bidder must advise the Contracting Authority of the reason for the substitution and provide the name, qualifications and experience of the proposed replacement. For the purposes of this clause, only the following reasons will be considered as beyond the control of the Bidder: death, sickness, maternity and parental leave, retirement, resignation, dismissal for cause or termination of an agreement for default.

If the Bidder has proposed any individual who is not an employee of the Bidder, the Bidder certifies that it has the permission from that individual to propose his/her services in relation to the Work to be

performed and to submit his/her résumé to Canada. The Bidder must, upon request from the Contracting Authority, provide a written confirmation, signed by the individual, of the permission given to the Bidder and of his/her availability.

5.7 Education and Experience

The Bidder certifies that all the information provided in the résumés and supporting material submitted with its bid, particularly the information pertaining to education, achievements, experience and work history, has been verified by the Bidder to be true and accurate. Furthermore, the Bidder warrants that every individual proposed by the Bidder for the requirement is capable of performing the Work described in the resulting contract.

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PART 6 - FINANCIAL REQUIREMENT

6.1 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 in Annex A and the Contractor's technical and Managerial Bid entitled _____, dated _____***(will be inserted at contract award)***.

7.1.1 Work Authorization

Despite any other condition of the Contract, the Contractor is only authorized to perform the Work up to the "Work Authorization Meeting and Decisions" (see Annex A – Statement of Work, section A.6.2.3) (previously known as Go-No Go meetings). Depending on the results of the review and evaluation of the Work, Canada will decide at its discretion whether to continue with the Work.

If Canada decides to continue with the Work, the Contracting Authority will advise the Contractor in writing to continue with the work in accordance with the Statement of Work. The Contractor must immediately comply with the notice.

If Canada decides not to proceed with the Work, the Contracting Authority will advise the Contractor in writing of the decision and the Contract will be considered completed at no further costs to Canada. In no event will the Contractor be paid for any cost incurred for unauthorized work.

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 (2012-11-19), 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:

4001 (2013-01-28), Hardware Purchase, Lease and Maintenance
4002 (2010-08-16), Software Development or Modification Services
4003 (2010-08-16), Licensed Software

7.3. Term of Contract

7.3.1 Period of Contract

Each Contract period starts on the contract date for a maximum of twenty-four (24) months.

7.4 Authorities

7.4.1 Contracting Authority

The Contracting Authority for the Contract is:

Naoual Guerinik
Supply Specialist
Public Works and Government Services Canada
Quebec Region
7th Floor
Place Bonaventure, South-East Portal
800 de La Gauchetière Street West
Room 7300
Montreal, Quebec, H5A 1L6

Telephone: 514-496-3409
Facsimile: 514-496-3822
E-mail address: naoual.guerinik@tpsgc.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.

7.4.2 Project Authority

The Project Authority for the Contract is:

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

Telephone: ___-___-____
Facsimile: ___-___-____
E-mail: _____.

The Project Authority 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 technical content of the Work under the Contract. Technical matters may be discussed with the Project Authority, however the Project Authority has no authority 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.

7.4.3 Contractor's Representative

The Contractor's Representative for the Contract is:

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

Telephone: ___-___-____
Facsimile: ___-___-____
E-mail: _____.

7.5. Payment

7.5.1 Basis of Payment

Option 1

7.5.1.1 Basis of Payment - Firm Price

In consideration of the Contractor satisfactorily completing all of its obligations under the Contract, the Contractor will be paid a firm price of $ _____ Customs duties are included and Goods and Services Tax or Harmonized Sales Tax is extra, if applicable.

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.

-OR-

Option 2 -

7.5.1.1 Basis of Payment - Ceiling Price

The Contractor will be reimbursed for the costs reasonably and properly incurred in the performance of the Work, as determined in accordance with the Basis of Payment in Annex B, to a ceiling price of $_____ Customs duties are included and Goods and Services Tax or Harmonized Sales Tax is extra, if applicable.

The ceiling price is subject to downward adjustment so as not to exceed the actual cost reasonably incurred in the performance of the Work and computed in accordance with the Basis of Payment.

7.5.2 Limitation of Price

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.

7.5.3 Method of Payment

Option 1

7.5.3.1 Milestone Payments - Firm Price

Canada will make milestone payments in accordance with the Schedule of Milestones detailed in Annex B - Basis of Payment and the payment provisions of the Contract if:

(a) an accurate and complete claim for payment using form PWGSC-TPSGC 1111 (http://www.tpsgc-pwgsc.gc.ca/app-acq/forms/documents/1111.pdf) 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.

7.5.3.1.1 Schedule of Milestones

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

OR

Option 2

7.5.3.1 Progress Payments - Ceiling Price

1. Canada will make progress payments in accordance with the payment provisions of the Contract, no more than once a month, for cost incurred in the performance of the Work up to 90 percent of the amount claimed and approved by Canada if:

   (a) an accurate and complete claim for payment using form PWGSC-TPSGC 1111(http://www.tpsgc-pwgsc.gc.ca/app-acq/forms/documents/1111.pdf) and any other document required by the Contract have been submitted in accordance with the invoicing instructions provided in the Contract;

   (b) the amount claimed is in accordance with the Annex B: Basis of Payment;

   (c) the total amount for all progress payments paid by Canada does not exceed 90 percent of the total amount to be paid under the Contract;

   (d) all certificates appearing on form PWGSC-TPSGC 1111 have been signed by the respective authorized representatives.

2. The balance of the amount payable will be paid in accordance with the payment provisions of the Contract upon completion and delivery of all work required under the Contract if the Work has been accepted by Canada and a final claim for the payment is submitted.

3. Progress payments are interim payments only. Canada may conduct a government audit and interim time and cost verifications and reserves the right to make adjustments to the Contract from time to time during the performance of the Work. Any overpayment resulting from progress payments or otherwise must be refunded promptly to Canada.

7.5.4 SACC Manual Clauses

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

C0305C (2008-05-12), Cost Submission (Applicable for "Ceiling Price" contracts)

7.6. Invoicing Instructions

Option 1

7.6.1 Invoicing Instructions - Progress Claim - Firm Price

1. The Contractor must submit a claim for progress payment using form PWGSC-TPSGC 1111 (http://www.tpsgc-pwgsc.gc.ca/app-acq/forms/documents/1111.pdf).

   Each claim must show:

   (a) all information required on form PWGSC-TPSGC 1111;
   (b) all applicable information detailed under the section entitled “Invoice Submission” ofthe general conditions;
   (c) the description and value of the milestone claimed as detailed in the Contract.

2. The Quebec Sales Tax (QST), as applicable, must be calculated on the total amount of the claim. At the time the holdback is claimed, there will be no QST 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, 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.

Option 2

7.6.1 Invoicing Instructions - Progress Claim - Ceiling Price

1. The Contractor must submit a claim for progress payment using form PWGSC-TPSGC 1111 (http://www.tpsgc-pwgsc.gc.ca/app-acq/forms/documents/1111.pdf).

   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) a list of all expenses;

   Each claim must be supported by:

   (a) a copy of time sheets to support the time claimed;
   (b) a copy of the invoices, receipts, vouchers for all direct expenses, and all travel and living expenses;
   (c) a copy of the monthly progress report.

2. The Quebec Sales Tax (QST), as applicable, must be calculated on the total amount of the claim before the holdback of 10% is applied. At the time the holdback is claimed, there will be no QST 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, 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.

7.7 Certifications

7.7.1 Compliance with the certifications provided by the Contractor in its bid is a condition of the Contract and subject to verification by Canada during the entire contract period. If the Contractor does not comply with any certification or it is determined that any certification made by the Contractor in its bid is untrue, whether made knowingly or unknowingly, Canada has the right, pursuant to the default provision of the Contract, to terminate the Contract for default.

7.7.2 SACC Manual Clauses

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

7.8 Applicable Laws

The Contract must be interpreted and governed, and the relations between the parties determined, by the laws in force in _____ *(to be inserted at contract award).*

7.9 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 4001 (2013-01-28),Hardware Purchase, Lease and Maintenance,4002 (2010-08-16), Software Development or Modification Services and 4003 (2010-08-16), Licensed Software;
(c) the general conditions 2040 (2012-07-16), General Conditions - Research & Development;
(d) Annex A, Statement of Work;
(e) Annex B, Basis of Payment;
(f) the Contractor's bid dated _____ as clarified / amended (if applicable) on _____.

7.10 Foreign Nationals (Canadian Contractor)

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

7.11 Insurance

SACC Manual clause G1005C (2008-05-12), Insurance

ATTACHMENT 1 TO PART 3

TECHNICAL AND MANAGERIAL BID PREPARATION INSTRUCTIONS

3A.1. TECHNICAL AND MANAGERIAL BID

The details provided in this Attachment complement the information introduced in paragraphs 3.1and 3.2 of Part 3 - Bid Preparation Instructions.

The Bidder should present the information about the Technical and Managerial Bid for each Priority Technology in the following order:

1. Title / Project Identification Page (see 3A.2);
2. Executive Summary (see 3A.3);
3. Table of Contents (see 3A.4);
4. Technical Relevance (see 3A.5);
5. Technical Section (see 3A.6);
6. Managerial Section (see 3A.7);
7. Bid Appendices (see 3A.8).

The structure of the Technical and Managerial Bid, and its subsections, are described below. Some of the subsection headings are followed by numbers in brackets. These numbers represent the Evaluation Criteria (see Table 4A.1 of Attachment 1 to Part 4) that are applicable to that specific section/subsection for each bid submitted by a Bidder.

3A.2 Title/Project Identification Page

The first page of the each bid submitted should state the following information.

a) The Request For Proposal file number (Mission-Enabling Technologies XXXX_XX);

b) The company's name and address;

c) The title of the proposed Work (the use of acronyms in the title is discouraged, unless they are described);

d) The Priority Technology (PT) addressed by the bid (refer to Table 1.1 of Part 1, List of Mission-Enabling Priority Technologies);

e) The current and targeted TRL (up to TRL 6) of the proposed technology (refer to Annex A, Appendix A-1 Technology readiness Levels (TRLs) for TRL descriptions); and

f) A short extract from the Executive Summary (maximum **7 lines**) of the bid. The technology development being proposed and its relevance to targeted Priority Technology list should be described.

3A.3 Executive Summary

The Bidder must provide an Executive Summary. The Executive Summary is a stand-alone document suitable for public dissemination, for example, through the CSA web site. The Executive Summary should not exceed two pages in length (8.5" x 11") and should highlight the following elements:

a) Work objectives;

b) Relevance to a targeted Priority Technology;

c) Main innovations;

d) TRL development;

e) Technical risks;

f) Major milestones and deliverables; and

g) Impact on the proposed technology and the associated targeted Future Mission(s).

Bidder should provide the Executive Summary in Soft copy with the only acceptable format: MS Word, WordPerfect, PDF or HTML in a separate file and not contain any proprietary markings.

3A.4 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 Soft copy version.

3A.5 Technical Relevance

3A.5.1 Relevance of the technology (Evaluation Criterion 1)

(see section 4A 3.1 Criterion 1 Technical Relevance of Attachment 1 to Part 4)

The criterion assesses the degree of relevance, which the proposed Work has with respect to CSA's list of Mission-Enabling Priority Technologies. More specifically, this criterion assesses the degree to which the bid exhibits an understanding of the stated performance and functional requirements and explains how the proposed technology will contribute to meeting these requirements.

The Bidder should address and substantiate the relevance of the proposed technology to one of the Mission-Enabling Priority Technologies defined in Appendix A-5 of Annex A Specific Statement of Work for each Priority Technologies. The relevance to one of the listed Priority Technologies is an essential element.

3A.6 Technical Section

The Technical Section should describe the technical aspects of the project as outlined in the following subsections.

3A.6.1 Team Technical Experience and Capacity (Evaluation Criterion 2)

(see section 4A.3.2 Criterion 2 Team Technical Experience and Capacity of Attachment 1 to Part 4)

This criterion assesses the combined technical capability and experience of the team assembled to carry out the Work. In order to do the assessment, the bidder should demonstrate capabilities and experience in developing technologies and engineering development of similar technology and comparable score and complexity to the Work detailed in the Appendix 5 of Annex A: Specific Statement of Work for each Priority Technologies.

3A.6.2 Understanding the Technology (Evaluation Criterion 3)

(see section 4A.3.3 Criterion 3 Understanding the Technology of Attachment 1 to Part 4)

Bidder should demonstrate in his proposal that this criterion assesses the degree to which the bid exhibits an understanding of the fundamental concepts and trade-offs on the needs of the technology and of the proposed application as they relate to the research activity proposed. In order to do the assessment, a concise statement of the technical objectives of the Work, both in terms of its functionality and performance is to be provided. Also, a description of the proposed technology must be provided, including a description of the overall problem, an overview of the background context, such as results of literature searches, prior development, state-of-the-art, and a general description of the expected improvement, results and benefits, based on the technical objectives described in the Appendix 5 of Annex A: Specific Statement of Work for each Priority Technologies.

3A.6.3 Technical Methodology (Evaluation Criterion 4)

(see section 4A.3.4 Criterion 4 Technical Methodology Criterion of Attachment 1 to Part 4)

For this criterion, the Bidder should provide an overview of the technical methodology and its correlation with the main activities of the work-plan. The methodology outlined should describe how the Work would be conducted through the utilisation of analytical methods, procedures, techniques, industry standards, best practices and the state-of-the-art for pertinent disciplines, such as “value engineering.” Methodology should clearly demonstrate maturation of the particular technology in terms of TRL and define conditions and criteria, pertinent to the technology in question, which should be met at each TRL level covered by the bid.

The Bidder should also elaborate on and substantiate the proposed methodology while making references to the main activities of the work-plan described in the body of the bid and appearing in the

Work Breakdown Structure (WBS), (see paragraph 3A.7.4 of Attachment 1 to Part 3). The effectiveness of the methodology and its correlation to the work-pan should be explained and substantiated.

The methodology and the corresponding work-plan should take in consideration the Technical Risk Assessment/Analysis (see paragraph 3A.6.4 of Attachment 1 to Part 3). For projects involving software development, the Bidder should outline the software development environment and methodology already in place (e.g., use of CASE tools, standards, quality assurance, etc.). The methodology being employed should include any of the relevant issue that could potentially affect the progression of the work-plan. As an example, the availability of equipment, facilities and infrastructure to support successful progression of the Work will be provided here.

3A.6.4. Technical Risk Assessment/Analysis

(will not be used as a proposal evaluation criterion)

In the technical methodology subsection the bidder should provide an assessment of the technical risks/uncertainties involved as well as the major assumptions upon which the work is based. In particular, this subsection should address any performance risks that pertain to the new technology. The risks should be identified and a Risk Mitigation Plan, that would include contingency plans, alternatives or other means of limiting adverse impacts of risks being realized, should be provided. As a guideline, Table 3A.1 presents a fictitious example of a Technical Risk Assessment Matrix, while Table 3A.2 presents an example of a Project Risk Profile Matrix.

Risk Event 1 (R1)	**Limited availability of key documents**	
Probability	Low	Low 1/20 Past experience demonstrates important number of different sources for patents and articles covering this subject.
Consequence to project	Low	$5 000 - $10 000 Cost growth Schedule delays

Risk Assessment	Low	$250 - $500 (R < 5% of overall project value, $250K)
Mitigation Plan	Secure at least 2 sources for each type of document	
Contingency Plan	Use second source	

Table 3A.1: Example of a Technical Risk Assessment Matrix

Probability			
High			R2
Medium			
Low	R1		
	Low	Medium	High
	Consequence		

Table 3A.2: Project Risk Profile Matrix

It is understood that in order to develop advanced technologies, a certain amount of technical risk should be assumed. The more innovative the technology is, the higher the technical risk will generally be. The extent to which higher technical risks are acceptable depends upon how well they have been identified, defined, assessed, planned for, and managed once realized. If the technical risks are poorly defined, or the risk mitigation is inadequately planned, then the project's evaluation score is likely to diminish.

3A.6.5 Performance Evaluation Criteria (PEC)

(will not be used as a proposal evaluation criterion)

The Bidder should provide a list of objectively measurable or binary (yes/no) Performance Evaluation Criteria (PEC) for use as the foundation to evaluate the progress of the project and compare with the initial technical objectives. This list will be reviewed, updated if needed, and accepted by the CSA at the Kick-Off Meeting and at each Milestones/ Progress Meetings for upcoming Milestones/Progress Review Meetings. See Annex A, section A.6.2. The PEC will be used at the Work AuthorizationMeeting and decision as a basis for a decision to proceed with the follow-on activities of the project.

3A.7 Managerial Section

The Managerial Section should demonstrate the effectiveness and commitment of the Bidder in delivering the Work and the overall technology development up to its integration into the targeted Future Mission(s). Its subsections are Key Resource Management Experience, Management Plan.

3A.7.1 Key Resource Management Experience (Evaluation Criterion 5)

(see section 4A.3.5 Criterion 5 Key Resource Management Experience of Attachment 1 to Part 4)

The Bidder should identify his Project Manager for each bid he submits and outline his/her qualifications. Bidder It should identify the key members of the project's technical and management teams and state their specific qualifications and experience for the work involved. Detailed resumes must be provided into an Appendix to Section I of the bid. Names of back-up personnel for key positions should also be included.

This section should also outline the roles and responsibilities of all the proposed resources, as well as discuss and highlight the unique expertise they offer with respect to the capability of the team. Bidder should include an organization chart that illustrates the structure of the proposed project team.

3A.7.2 Management Plan (Evaluation Criterion 6)

(see section 4A.3.6 Criterion 6 Management Plan of Attachment 1 to Part 4)

The Bidder should present a Management Plan. The Management Plan for its completeness and assesses its effectiveness in directing the project to a successful completion. Collaborative projects and/or projects led by University or Non-Profit Bidders should identify specific tasks and objectives related to an effective process for transfer of knowledge and technologies to industry. IP management approach must be described. The Management Plan's presentation must be based on the recognized management tools most applicable to the proposed project, such as a scope planning (Work Breakdown Structure), and schedule development charts (Gantt, Program Evaluation and Review Technique -PERT, etc). Equivalent Bidder-developed, project-tailored tools/charts are also acceptable, provided that the information is complete and comprehensive.

3A.7.2.1 Bidder Background and Related Experience

(will NOT be used as a proposal evaluation criterion)

This section should contain a concise overview of the Bidder. It should cover the following elements: the nature and structure of the Bidder's organization; the level of Canadian ownership; the location, size and general description of the plant facility; the size and composition of staff; the principal product or field of endeavour; the annual business volume and general nature of the company's client base; and a list of any applications for funding from other Government sources and/or Government contracts received for similar and/or related work. This section should identify the location where the Work will be performed.

3A.7.2.2 Work Breakdown Structure and Work Package Definition

(see section 4A.3.6 Criterion 6 Management Plan of Attachment 1 to Part 4)

This Management Plan subsection should define and specify the scope of Work to be executed according to the requirements of the Statement of Work, Contract Deliverables and Meetings (Annex A). Work Breakdown Structure (WBS) is a recognized scope definition technique, while Work Packages (WP) stem from the WBS. The WBS should flow down to a low enough level and the associated WP should be defined in sufficient depth in order for the Bidder to demonstrate the process that will be followed to perform the project.

Each WP should focus on specific activities that will form the total Work and, as a minimum, should define and describe the specific work to be carried out. It should also indicate: the person responsible, the WP's associated levels-of-effort and required resources, the schedule (start and finish dates), the risks, and the associated inputs and deliverable or output.

As a guideline, Figure 3A.1 presents a fictitious example of a WBS, while Table 3A.3 presents a fictitious example of a Work Package Definition Sheet. For each work packages the Bidder should provide a detailed statement of work and list the associated resources.

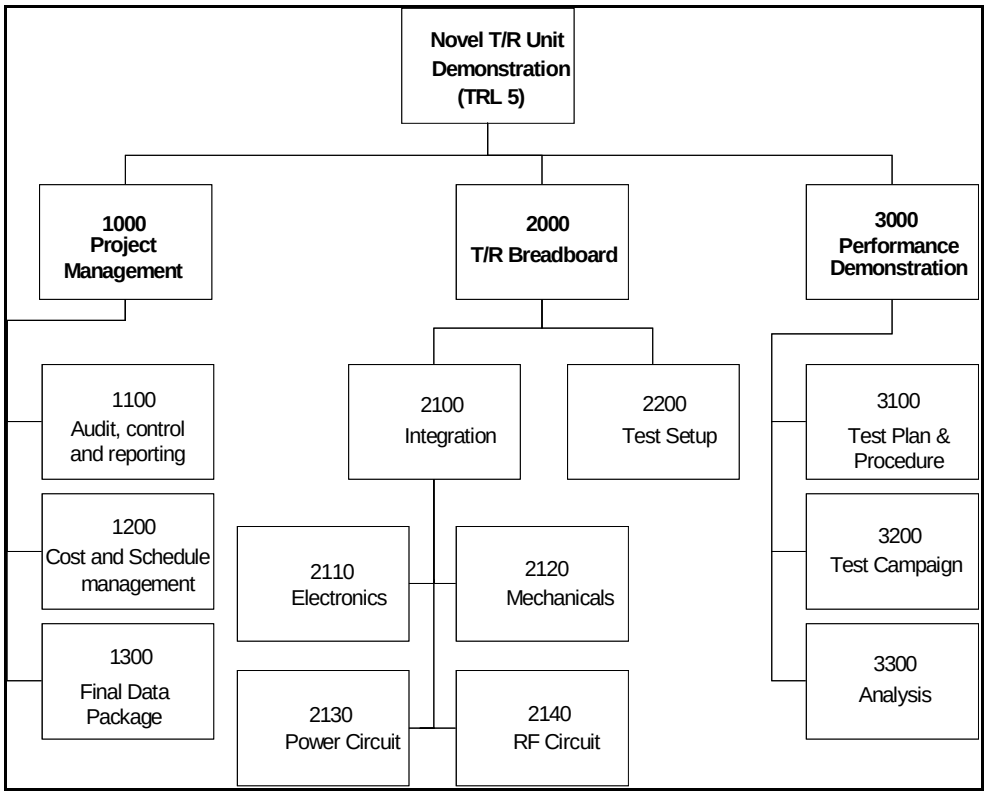

Figure 3A.1: Example of a Work Breakdown Structure

Project: T/R Unit Demonstration	
Work Pack Title: TEST SETUP	**WBS Ref: 2200**
Sheet: 1 of 1 WP Estimated Value: Do not indicate $ value in Section I of the bid, indicate value only in Section II	
Scheduled Start: T0 + 2 weeks	Accountable Manager: Resource A,
Scheduled End: T0 + 12 weeks	Resources: Resource A, Resource B, Resource C
Estimated Effort: 80 hours	

Objectives:

- Deliver a functional test setup for the T/R unit

Inputs:

- Test plan and procedure
- Unit drawings
- Unit Interface Control Documents

Tasks:

- Review input documentation
- Define requirements
- Produce initial concept
- Design test setup
- Fabricate test setup
- Commission and debug

Outputs and Deliverables:

- Fully functional T/R unit test setup
- Test setup log manual
- Test setup user manual

Table 3A.3: Example of Work Package Definition Sheet

3A.7.2.3 Personnel Allocation

(see section 4A.3.6 Criterion 6 Management Plan of Attachment 1 to Part 4)

This Management Plan subsection should include a Responsibility Assignment Matrix (RAM) 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. Also, the RAM should identify the role of the individual, either being the accountable person for the WP (A), or being a participant (P). As a guideline, Table 4 presents a fictitious example of a RAM. The RAM should be presented in both the technical bid and the financial bid.

WBS Number	Work Package 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

Table 3A.4: Example of Responsibility Allocation Matrix (RAM)

P: Participant

A: Accountable

3A.7.2.4 Managerial Risk Assessment

(see section 4A.3.6 Criterion 6 Management Plan of Attachment 1 to Part 4)

This Management Plan subsection should provide an assessment of the managerial risks involved, provide a Risk Mitigation Plan and identify critical issues that may jeopardize the successful completion of the Work within cost and schedule constraints. As a guideline, Table 3A.5 presents a fictitious example of a Managerial Risk Assessment Matrix. Additionally, Table 3A.6 presents an example of a Project Risk Profile Matrix**.**

Risk Event 2 (R2)	**Late delivery of test equipment**	
Probability	High	1/3 Past experience with provider demonstrated poor respect of schedule
Consequence to project	High	$110 000 (cost of securing optional test facility) Significant cost growth Significant schedule delays
Risk Assessment	High	$55 000 High (R > 25% of overall project value)
Mitigation Plan	Identify and secure equivalent equipment in immediate geographical region Ensure equipment will be available for needed time frame Memo of understanding with facility key managers	
Response Plan	Secure equipment with MOU Confirm time frame options with facility	

Table 3A. 5: Example of a Managerial Risk Assessment Matrix

Probability			
High			R2
Medium			
Low	R1		
	Low	Medium	High
	Consequence		

Table 3A.6: Example of a Project Risk Profile Matrix

3A.7.2.5 Milestones and Deliverables

(see section 4A.3.6 Criterion 6 Management Plan of Attachment 1 to Part 4)

This Management Plan subsection should contain a definition of the milestones and describe in details all expected deliverables, including hardware, software, and relevant documentation (refer to Annex A for more details). When appropriate, the milestones and deliverables should contain all elements identified in Table A-2 of Annex A and should relate to the corresponding WP definition in a manner enabling clear monitoring of progress (see paragraph 3A.7.4).

3A.7.2.6 Schedule

(see section 4A.3.6 Criterion 6 Management Plan of Attachment 1 to Part 4)

The Bidder should provide a project timetable that relates tasks, milestones and deliverables. A Gantt chart and/or PERT chart should be used to illustrate the schedule. The schedule should show significant details for events associated with achievement of major tasks, milestones and deliverables. The Bidder should demonstrate how required milestones will be met. Linkage between activities should also be identified in the schedule. For planning purposes, use a project start date of April 2013.

3A.7.2.7 Project Control System

(see section 4A.3.6 Criterion 6 Management Plan of Attachment 1 to Part 4)

This Management Plan subsection should outline the methods and systems to be used to control tasks, schedules, and costs for the Work. The Contract Plan and Report Form (PWGSC-TPSGC 9143) can be substituted by another project management tool or a spreadsheet software package as long as it contains, as a minimum, the information required in the Contract Plan and Report Form (see following link for document: http://www.tpsgc-pwgsc.gc.ca/app-acq/forms/formulaires-forms-eng.html). Additionally, the Project Control System should be capable of reporting the amount of work per WBS item for each individual on a monthly basis.

3A.7.2.8 Background Intellectual Property and Foreground Intellectual Property

(see section 4A.3.6 Criterion 6 Management Plan of Attachment 1 to Part 4)

This subsection should identify and describe all Background Intellectual Property (BIP) that is required to conduct and/or support the Work and all Foreground Intellectual Property (FIP) expected to arise from the proposed Work. BIP and FIP element should be described in sufficient detail so as to be clearly distinguishable. The expected format to provide this information is as per Tables 3A.7 and 3A.8.

BIP #	Title of the BIP	Types of IP (software algorithms, hardware design, patent)	Type of access to the BIP required to use/improve the FIP	Description of the BIP	Reference documentation (technical report, design document)	Origin of the BIP (internal R&D, project # or contract #)	Owner of the BIP (contractor, subcontractor)

Table 3A.7: Disclosure of Background Intellectual Property (BIP) expected to be required for the Contract

FIP #	Title of FIP	Type of FIP (copyright, invention, design, software, know-how, trade secret…)	Description of the FIP	Reference documentation (technical report, design document)	Owner of the FIP (contractor, subcontractor, or the Canada)

Table 3A.8: Disclosure of the Foreground Intellectual Property (FIP) expected to be developed under the Contract

Bidders should use of graphical representations that include block diagrams is encouraged in order to demonstrate the relationships between the various elements of the BIP and the FIP. The BIP and the expected FIP will be reviewed at the Kick-Off Meeting, and updated at each Review Meeting.

For each element of the BIP, this subsection should also specify:

a) In what way the BIP element will be incorporated into the FIP;

b) The type of access to each element of the BIP that is required in order to use, modify, improve and/or further develop the FIP; and

c) The owner of the BIP.

Bidder's realizations that are software oriented and propose to improve upon existing software programs/applications will be required to provide the initial source code and associated documentation along with the final deliverables, unless the improvements can be clearly distinguished from the existing software (i.e., can be divided in different modules). In this case, the Interface Configuration Document (ICD) between the existing and new modules, and the executables of the existing module would be a deliverable. Similarly, projects that propose to improve upon existing hardware apparatus, fabrication or other processes will be required to provide current drawings, documentation and process descriptions along with the deliverables.

The Bidder should address and confirm the availability of all BIP elements to the CSA, in particular, if the final deliverables and the proof-of-concept demonstration require a special proprietary environment or tools for their operation. The Bidder will only be allowed to claim for costs associated with acquiring a research license for third-party BIP in order to conduct an assessment of such BIP to determine its usefulness to the technology being developed. The Bidder should acquire, at its own cost, a commercial license for any required third-party BIP. The acquisition of such a commercial license is strongly encouraged, although not paid for by the contract, as a demonstration of the Bidder's commitment to commercializing the FIP.

3A.8. Bid Appendices

3A.8.1 Appendices Required with the Bid

The following item should be addressed in individual appendices as part of the bids:

a) List of Acronyms: All the acronyms used in the Section I: Technical and Managerial Bid, should be explained;

b) Resumes: The bid should include resumes of the proposed resources and these should be appended to Section I: Technical and Managerial Bid;

c) Relevant Technical Papers Published by Team Members: Only literature that is relevant and that would be useful to support the bid;

d) List of Contacts: The list of contacts should be appended to Section I: Technical and Managerial Bid, in a format suitable for distribution and should include all the Bidder's points-of-contacts involved in the bid development and/or during the Contract.

The following example format should be used:

Role	Name	Telephone	Fax	E-Mail
Project Manager				
Project Engineers/Head Investigator				
Contractor's Representative				
Claims(Invoicing) Officer				

Communications (for press release)				
Etc.				

Table 3A.9 : Bidder's List of Contacts

If possible, and for the Project Authority ease of reference, the Bidder is also encouraged to include an electronic business card for each of the points-of-contact.

ATTACHMENT 1 TO PART 4

POINT RATED EVALUATION CRITERIA

1. TECHNICAL AND MANAGEMENT CRITERIA AND RATINGS

The Bidder must achieve the minimum score requirements as indicated in Table 4A.1:"List of Evaluation Criteria and Associated Ratings". The bid will be evaluated according to the point-rated criteria as specified in Table 4A.1 and as described in section 4A.3 ‘‘Evaluation Criteria and Benchmark Statements".

The criteria are grouped under the following divisions:

a) Technical Relevance Criterion,
b) Technical Criteria, and
c) Management Criteria.

Section 4A.3 "Evaluation Criteria and Benchmark Statements" of the current attachment contains a series of evaluation criteria, each supported by a set of 5 benchmark statements (0, A, B, C, and D). Each of these statements has a corresponding relative value:

0 = 0% of the 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 “*Team Technical Experience and Capacity”* 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 4A.1 identifies:

a) The maximum point rating assigned to each criterion;
b) The minimum point rating required for the "Technical Relevance" criterion;
c) The maximum point rating possible for the overall score; and
d) The minimum point rating required for the overall score.

Evaluation Criteria and Ratings	
	Ratings
Technical Relevance Criterion	
1. Relevance of the technology	15
Minimum Score	**10**
Technical Criteria	
2. Team Technical Experience and Capacity	10
3. Understanding the Technology	25
4. Technical Methodology	25
Minimum Score	***N/A***
Management Criteria	
5. Key Resource Management Experience	10
6. Management Plan	15
Minimum Score	**N/A**
Maximum Overall Score	**100**
Minimum Overall Score Requirement	**70**

Table 4A.1: - List of Evaluation Criteria and Associated Ratings

4A.2. BIDDER'S CRITERIA SUBSTANTIATION

The Bidder is requested to provide a substantiation (supporting evidence), which should be submitted as an appendix to their Section I (see section 3A.8.1 “Appendices Required with the bid” of Attachment 1 of Part 3: Technical and Managerial Bid Preparation Instruction).

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

The substantiation should be concise yet sufficiently comprehensive to ensure that the evaluators get a good overall appreciation of the bid's merit relative to the specific criterion. Cross-references to appropriate sections of the bid should be provided and the essence of the referenced information should be summarised in the substantiation.

For convenience, a Substantiation Table is provided in Table 4A.2 below. Enter each relevance/technical/management criterion section number, and the substantiation. It is expected that approximately half a page should be sufficient to make the Bidder’s case for the rating chosen in the substantiation column.

Company: **Project Title:** Mission-Enabling Technologies	
Criteria **Substantiation**	
*Ex.: **1** (criterion number)*	*Relevance of the technology It is expected that 300 words or so should be sufficient to make your case.*

Table 4A.2: Substantiation Table

4A.3. EVALUATION CRITERIA AND BENCHMARK STATEMENTS

The evaluation criteria benchmark statements are used by the evaluators as guidelines to justify their score. Bidders should use them to focus on the relevant information to be provided.

TECHNICAL RELEVANCE CRITERION

4A.3.1 CRITERION 1 TECHNICAL RELEVANCE

This criterion assesses the degree of relevance which the proposed Work has with respect to CSA's list of Priority Technologies for Future Missions. More specifically, this criterion assesses the degree to which the bid exhibits an understanding of the stated performance and functional requirements and justification of the contribution of the proposed technology to meeting these requirements.

A minimum of 10 points are required for the bid to be considered compliant.

Score	Benchmark Statements
0	The bid does not address any of the technology being sought by CSA.

A The bid addresses one of the listed Priority Technologies defined in Appendix A-5 of Annex A but does not show an understanding of the driving needs nor does it demonstrate how the proposed technology will contribute to meeting the stated requirements.

B The bid addresses one of the Priority Technologies, defined in Appendix A-5 of Annex A but either shows a poor understanding of the driving needs, or a vague demonstration how the proposed technology will contribute to meeting the stated requirements.

C The bid addresses one of the Priority Technologies defined in Appendix A-5 of Annex A, shows an overall understanding of the driving needs, and generally demonstrates contribution of the proposed Work to meeting the stated requirements. However, some details regarding the contribution of the proposed technology to meeting the overall requirements and/or the expected characteristics remain unclear.

D The bid addresses one of the Priority Technologies defined in Appendix A-5 of Annex A, shows a complete grasp of the driving needs and its importance to Canada and its stakeholders, and demonstrates a solid understanding of the performance and functional characteristics being sought, as well as a clear link between the proposed technology and stated performance and functional expected requirements.

TECHNICAL CRITERIA

4A.3.2 CRITERION 2: TEAM TECHNICAL EXPERIENCE AND CAPACITY

This criterion assesses the combined technical capability and experience of the team assembled to carry out the Work.

The proposal substantiates that the technical team:

Score Benchmark Statements

0 Has not demonstrated capability and experience with closely related technologies.

A Has demonstrated limited capability and experience with closely related technologies.

B Has demonstrated some capability and experience with closely related technologies but key capabilities are missing to form a comprehensive team.

C Has worked actively with closely related technologies of comparable scope and complexity. The proposed team possesses all the capabilities and experience required to perform the Work.

D Is highly experienced in developing closely related technologies and in the related engineering development of similar technology of comparable scope and complexity. The proposed team possesses all the capabilities required to perform the Work.

4A.3.3 CRITERION 3: UNDERSTANDING THE TECHNOLOGY

This criterion assesses the degree to which the bid exhibits an understanding of the fundamental concepts of the technology and of the proposed application as they relate to the research activity proposed.

The bid:

Score	Benchmark Statements
0	Does not exhibit an understanding of the required concepts and/or of the associated applications.
A	Demonstrates only a limited understanding of the background or "state-of-the-art" of the technological concept(s) involved.
B	Demonstrates a general understanding of the state-of-the-art, includes a review of other work relevant to the concept, and explains why the proposed Work will lead to the expected results.
C	Demonstrates a detailed understanding of the state-of-the-art; includes a complete review of other work relevant to the central concept upon which the Work is based; and explains and provides some justification why the bid will lead to the expected results.
D	Broadens the review of fundamental concepts and other work underlying the bid to explain the full capabilities of the technology and its application, analyses and convincingly justifies the feasibility of achieving the technical objectives and the expected results.

4A.3.4 CRITERION 4: TECHNICAL METHODOLOGY

This criterion assesses the suggested Technical Methodology and its correlation with the work-plan as presented in the bid. It also evaluates the effectiveness of the described Methodology in resolving the technical challenges, in attaining the stated technical objectives of the Work, and in meeting requirements of the Statement of Work (SOW) described in ANNEX A.

Score	Benchmark Statements
0	The methodology described in the proposal does not demonstrate how it will address the stated objectives.
A	The methodology described in the proposal follows a weak methodical approach.

B The methodology described in the proposal demonstrates a somewhat acceptable approach. However, the proposal does not substantiate the effectiveness of the methodology being employed for achieving the stated objectives. Conditions and criteria to be met for each TRL level are not defined.

C The methodology as described in the proposal demonstrates a robust approach. The proposal substantiates the effectiveness of the methodology for achieving the stated objectives. Conditions and criteria to be met for each TRL level are defined.

D The methodology described in the proposal is based on state of the art expertise and demonstrates a robust approach. The proposal substantiates the effectiveness of the methodology being employed for achieving the technical objectives of the Work. Conditions and criteria to be met for each TRL level are well defined and elaborated.

MANAGEMENT CRITERIA

4A.3.5 CRITERION 5: KEY RESOURCE MANAGEMENT EXPERIENCE

This criterion assesses the qualifications and experience and past successes of the Project Manager and key project Scientists/Engineers identified to lead this proposal. Resumes requested to be appended to Section 1:Technical and Managerial Bid will be assessed for this criterion,

Score	Benchmark Statements
0	The key project management team has not been identified or has no experience in successfully completing projects of similar scope, complexity and technology similar to that required for this proposal.
A	The key project management team does not have a proven track record of successfully completing projects of similar scope, complexity and technology similar to that required for this proposal.
B	The key project management resource has a moderate track record of successfully executing projects of a scope, complexity and technology similar to that required for this proposal.
C	The Project Manager and Project Scientist/Engineer identified have a proven track record of success in executing and managing projects of a scope, complexity and technology similar to that required for this proposal.
D	The Project Manager and Project Scientist/Engineers identified have a proven strong track record of success in completing projects on time, budget and performance of at least the scope, complexity and technology similar to that required for this proposal.

4A.3.6 CRITERION 6: MANAGEMENT PLAN

This criterion evaluates the Management Plan for its completeness and also assesses its effectiveness in directing the contract to a successful completion. It also assesses the Bidder's IP management approach.

The bid:

Score	Benchmark Statements
0	Has no concrete management plan and thereby instills no confidence that the selected team will bring the contract to its successful completion.

A Does not provide an adequate Management Plan and more than one of the subsections of the paragraph 3A.7.2 of Attachment 1 of Part 3 is not covered. Moreover, there is no BIP and/or FIP identified.

B provides an adequate Management Plan, including identification of BIP and FIP; however, some subsections of Section 3A.7.2 of Attachment 1 of Part 3 are not covered. Consequently, the likelihood of delivering the proposed deliverables to the specified level of performance is not substantiated.

C Provides a credible Management Plan and provides a reasonable, but not complete, BIP and FIP management approach. The plan's ability to effectively deliver on the projects requirements is demonstrated, but is somewhat limited because of lack of details.

D Provides a coherent and comprehensive Management Plan. The plan's ability to effectively deliver on the project requirements is fully substantiated. A comprehensive IP management approach is provided.

ANNEX A

STATEMENT OF WORK (Work)

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

ANNEX B

BASIS OF PAYMENT

Option 1

FIRM PRICE
Schedule of Milestones

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

Milestone No.	Deliverable	Firm Amount	Delivery Date
1	Specify		
2	Specify		
3	Specify		
Etc			

Total Firm Price $_____ (QST Extra)

ANNEX B
BASIS OF PAYMENT

Option 2

CEILING PRICE

1. LABOUR: at the following firm rates

CATEGORY (OR NAME)	**FIRM HOURLY RATE**
_____	$_____
_____	$_____
etc.	

Est.: $ _____

2. EQUIPMENT: at laid down cost without markup **Est.: $** _____
(Specify type of equipment.)

3. RENTALS: at actual cost without markup **Est.: $** _____
(Specify what rentals.)

4. MATERIALS AND SUPPLIES: at laid down cost without markup **Est.: $** _____
(Specify what categories of materials and supplies.)

5. TRAVEL AND LIVING EXPENSES: **Est.: $** _____

The Contractor will be reimbursed its authorized travel and living expenses reasonably and properly incurred in the performance of the Work, at cost, without any allowance for profit and/or administrative overhead, in accordance with the meal, private vehicle and incidental expenses provided in Appendices B, C and D of the Treasury Board Travel Directive (http://www.tbs-sct.gc.ca/pubs_pol/hrpubs/TBM_113/td-dv_e.asp), and with the other provisions of the directive referring to “travellers”, rather than those referring to “employees” are applicable.

All travel must have prior authorization of the Project Authority. All payments are subject to government audit.

6. SUBCONTRACTS: at actual cost without markup **Est.: $** _____
(Identify subcontractors, if applicable.)

7. OTHER DIRECT CHARGES: at actual cost without markup **Est.: $** _____
(Specify what categories of direct charges.)

8. OVERHEAD: at a firm rate of __% of item __ above **Est.: $** _____
(Use for Canadian universities and colleges contracts and for other contracts, as applicable.)

9. PROFIT: at a firm rate of __% of item __ above **Est.: $** _____

Estimated Cost to a Ceiling Price: $ _____

(QST extra)

ANNEX A
STATEMENT OF WORK

A.1 SPACE TECHNOLOGY DEVELOPMENT PROGRAM BACKGROUND

The Space Technology Development Program (STDP) mandate is to formulate, implement and manage contracted out research and development (R&D) projects in response to identified needs and opportunities. Its objectives are to develop and demonstrate strategic technologies that have a strong potential for having a positive impact on:

- Reducing technical uncertainties for future Canadian space activities;
- Transforming key capabilities into wealth; and
- Creating knowledge through innovation.

The STDP will therefore support the development of technologies to meet the current and future needs of the Canadian Space Program (CSP).

A.2 OBJECTIVES

The objective of this Statement of Work (SOW) is to develop 11 Mission-Enabling Technologies that are in line with the Canada Space Agency's (CSA) priorities and mission roadmaps. For every Priority Technologies (PTs) listed herein (see APPENDIX A-1 of ANNEX A), the work solicited is the development and advancement of these technologies up to potentially TRL 6 (Technology Readiness Levels, see APPENDIX A-1 of ANNEX A) to reduce technical uncertainties and support approval and implementation of specific potential future space missions of interest to Canada.

A.3 SCOPE

This document provides the requirements and deliverables for projects selected to develop and advance technologies that are critical for the approval and implementation of potential or planned future Canadian space missions.

A.4 MISSION-ENABLING PRIORITY TECHNOLOGIES

Priority Technologies are those that have been established by the CSA as the critical technologies to be developed to meet the objectives of the CSA. The contracts to be awarded are to respond to one of the Priority Technologies Specific Statement of Work detailed in Appendix A-5 of ANNEX A.

A.5 GENERIC TASK DESCRIPTION

This section presents the potential activities that might take place during typical STDP projects and are deemed appropriate within the required TRL range. Tasks will vary for different projects according to targeted TRLs and may include, but are not limited to, the standard project activities listed below in Table A-1: Guideline of Activities. Contractor should use the following guideline table to select the appropriate required activities in order to satisfy the conditions for the targeted TRLs. Technology Readiness Levels (TRLs) describe the standard language of the maturation process for technology development and evolution. TRLs are described in APPENDIX A-1 of ANNEX A).

List of Activities
Project Management
▪ Scope Planning (Work Breakdown Structure and Work Packages)
▪ Schedule
▪ Meetings
▪ Progress Monitoring
▪ Finance Management
▪ Documentation and Reporting
▪ Final Data Package
▪ Risk Management
Risk Planning
Risk Identification & Characterization
Risk Analysis
Risk Mitigation and Tracking
▪ Configuration management
Sub-Contractor Management
▪ Procurement Plan
▪ IP Agreement
Needs Analysis
▪ Mission Definition
▪ Definition of Mission Requirements
▪ Environment Definition
▪ Technology Drivers and Constraints
Project Definition
▪ Objectives
Establish Objectives
Identification of Key Issues & Needs
▪ Requirements
Obtain Current Mission Documentation, and Technology Requirements
Define further Technology Requirements in terms of functional and performance characteristics
Conceptual Design
▪ Functional Analysis and Allocation
▪ Develop Operations and Development Concepts
▪ Cost Estimates
▪ Schedule Estimates
▪ Risk Analysis
▪ System Studies and Trades
▪ Identify Driving Requirements and Associated Risks
▪ Modeling and Prototyping
Design and Development Plan
Analysis
Simulation
Concept Design Review
Preliminary Design Review
Critical Design Review
Breadboard Development Plan
Algorithm Development

Define System Failure Modes
Failure Modes Effects and Analysis
Assembly processes development
Process and Test Documentation
Test Data Preparation
Evaluation of Performance
Test System Development
Component test
Acceptance test
Stand-alone functional test
Test procedures and reports
Develop formal specifications and interface control
Fabrication
Assembly and Test
Integration, Testing, Verification & Validation
Compliance
Field Trials and Demonstrations

Table A-1: Guideline of Activities

A.6 CONTRACT DELIVERABLES AND MEETINGS

This section reviews and describes the contract deliverables and meetings.

Figure A-1 is a guideline, which provides a master Milestone Schedule for typical contract duration of twelve (12) months. The figure highlights a sample schedule for the major meetings and deliverables.

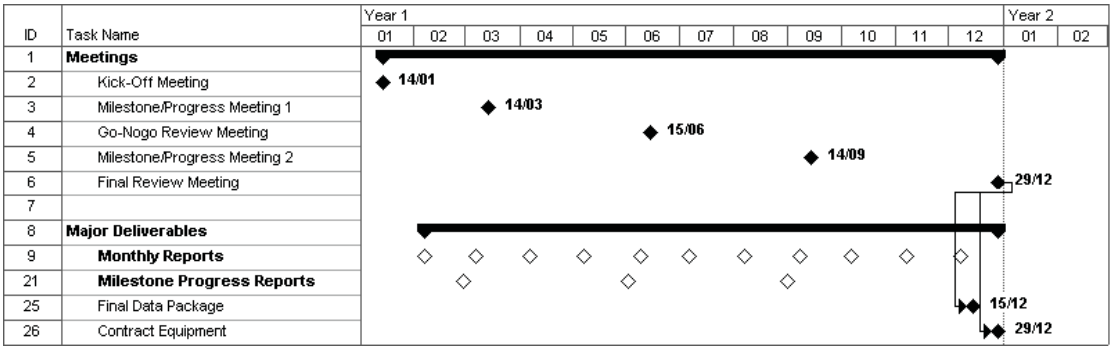

Figure A-1: Sample Meetings and Deliverables Master Schedule

Table A-2 contains the list of meetings, expected items to be covered during those meetings, and the associated contract deliverables. In addition to the mandatory deliverables (CDRL 1 to 16),

there may be deliverables specific to a given contract (CDRL 17 and others). Those should be identified in the bid and agreed upon at the kick-off meeting.

CDRL No.	Deliverable	Due Date	Version
1	Meeting Agendas	Meeting – 2 week	Final
2	Kick-off Meeting Presentation	Meeting – 1 week	Final
3	Quarterly or Milestone/Progress Review Meeting Presentation	Meeting – 2 week	Final
4	Final Review Meeting Presentation	Meeting – 2 week	Final
5	Meeting Minutes	Meeting + 1 week	Final
6	Action Items Log (AIL)	Meeting + 1 week	Final
7	Monthly Progress Reports	7th of each Month	Final
8	Milestone/Progress Technical Report	Meeting – 2 weeks	Final
9	Disclosure of Foreground Intellectual Property (FIP)	End of contract – 2 weeks	Final
10	Executive Report	End of contract – 2 weeks	Final
11	Contractor Performance Evaluation	End of contract – 2 weeks	Final
12	Final Milestone/Progress Technical Report, including Technology Readiness Assessment	End of contract – 2 weeks	
13	Prototypes	At Final Review Meeting	Final
14	Equipment (purchased under the contract)	At Final Review Meeting	Final
15	Software	Meeting – 2 weeks	
16	Government Furnished Equipment/Data	At contract end	
17	Contract Specific Deliverables	Identified in bid and agreed upon at kick-off meeting	

Table A - 2: Schedule of Contract Items

The decision regarding the delivery of any prototype is to be made by the CSA at the end of each contract completion.

A.6.1 DOCUMENTATION, REPORTING AND OTHER DELIVERABLES

This section contains the lists of deliverables and describes their respective content and format. All documents must be typed and all diagrams must be clearly drawn and labeled. The Contractor must submit an electronic copy of each of the deliverable documents. Each electronic file must be named in accordance with CSA directives and with the federal government legislation and policies on managing information so as to be easily identified. The following guidelines detail how to name electronic documents.

Documents must contain 3 main components:

- Project Identifier,
- Contract Number, and
- Date Tracking Number.

WXYZ-TYPE-NUM-CIE_Contract Number_sent Date Tracking Number

Project Identifier

The project identifier must contain:

- WXYZ: a 4- to 8-letter acronym of the project;
- TYPE: a 2-letter acronym according to the Table A-3 below:

Acronym	Description
AG	Agenda
MN	Minutes of meeting
PT	Presentation
PR	Progress Report
TN	Technical Note

Table A-3: Letter Acronym Definition

- NUM: a three digit sequential number (e.g., 001, 002, etc.); and
- CIE: name of company (no space, no hyphen).

Contract Number

For example: _9F028-07-4200-03

Date Tracking Number

This is to reflect the submission date and must follow the Year-Month-Day format. For example: _sent 2012-10-25 (for 25 October 2012).

Non-Disclosure

The documents will not be placed in the public domain, except for the Executive Report (see A.6.1.3.1). The Contractor must indicate the following proprietary notices ("Owner of Foreground Intellectual Property (FIP)" being either the CSA or the Contractor):

On the cover:

> This document is a deliverable under contract no. _____. It contains information proprietary to "Owner of Foreground Intellectual Property (FIP)", or to a third party to which "Owner of FIP" 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 "Owner of FIP" may otherwise agree to in writing.
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> Copyright 20XX "Owner of FIP"

On all internal pages:

> Use, duplication or disclosure of this document or any of the information contained herein is subject to the Proprietary Notice at the front of this document.

A.6.1.1 MONTHLY PROGRESS REPORT

On a monthly basis, no later than the seventh (7^{th}) of each month, the contractor must provide monthly progress reports. It is requested that an electronic copy of this report be sent to the Project Authority (PA) and the Contracting Authority (CA) as soon as it is available. Acceptable electronic formats are: MS Word, WordPerfect, PDF, and HTML. Refer to Section A.6.1 for instructions on how to name electronic documents. Monthly Reports are used by the PA to monitor the work on a monthly basis, these reports should be kept as brief as possible but should discuss the progress of the work and should include, but not be limited to, the following information:

- Statement indicating whether or not the project is on schedule and, if not, an explanation for any delays and/or a recovery plan. The report must include an updated schedule showing progress of work and modifications, if any;
- Statement indicating whether or not the project is within budget and, if not, an explanation for the deviation from the budget and a proposed recovery plan. The report must include an updated cash flow table showing, for each activity/milestone/Work Package, with start and end dates as well as actual cash flow with actual start and end dates;
- Brief summary of the technical progress of the work for each work package, including:
    - Description of major items developed, purchased or constructed during the reporting period, and
    - List of internal engineering reports produced during the reporting period;
- Summary of the proposed work for the following month, including:
    - Description of major items to be purchased during the next reporting period, including any software packages;
- Summary of problems encountered, their impact on the project and the subsequent solutions proposed or effected; and
- Trip reports for each conference attended or facilities visited in the course of this contract (and only if funded by the contract).

An overall assessment of the project health must be provided at the start of each report. The aim is to have an overview of the project status.

The following information should be included in the following format:

Project Element	Status	Trend	Comment
Cost	**Green**	↑	
Schedule	**Green**	↓	
Results / PEC	**Red**	↔	
Programmatic	**Yellow**	↑	

The first column identifies the project performance metrics to be assessed, namely **Project Element**. The four metrics to assess are:

- Cost,
- Schedule,
- Results against Performance Evaluation Criteria (PEC), and
- Programmatic.

The Cost, Schedule and Results/PEC metric are quantitative indicators, while the Programmatic metric is qualitative.

The second column of the table is the status for each project element.

The following table provides a definition of the different status with respect to the first three Project Elements.

	Interpretation		
Status Indicator	**Cost**	**Schedule**	**Technical**
Green	On or under planned project total budget	On or ahead of baseline schedule	Meets Performance Evaluation Criteria (PEC)
Yellow	Between 0 and 5% overrun	Between 0 and 5% behind schedule	Does not meet PEC but has approved recovery plan
Red	Greater than 5% overrun	Greater than 10% behind	Does not meet PEC and does not have approved recovery plan

As for the Programmatic element, the status is evaluated based on the status of the three other elements. Although the Programmatic metric takes into account Cost, Schedule and Results/PEC indicators, it is mostly influenced by the most critical element at that point in time in the project. The third column is an assessment of the trend the Project metric.

The choices are:

Trend Indicator	Interpretation
↑	The status has improved since the last review
↓	The status has worsened since the last review
↔	The status has not changed since the last review

The Fourth column is to provide the opportunity to comment the status and trend of the project element or to provide a general statement.

A.6.1.2 MILESTONE/PROGRESS TECHNICAL REPORTS

The Contractor must submit to the PA and CA at least two (2) weeks prior to the due date of Milestone and/or Progress Review Meetings, a draft Milestone and/or Progress Report. The PA will review the report and may request changes, as appropriate. The Contractor will then submit the revised version.

The Milestone and/or Progress Report, which must be protected, is to contain a complete description of the work undertaken and results obtained. As such it should include all pertinent technical documents that support engineering, fabrication and/or testing tasks. It should also include an updated version, if applicable, of the Technical and Managerial Plans initially submitted. Moreover, it must provide sufficient details of the work performed to date to enable the TA to perform a full and accurate progress evaluation.

The description of the work undertaken and the results obtained should include:

- Review of technical results and accomplishments;
- Assessment of results with respect to the PEC provided in the bid (supported with the necessary design documents, engineering drawings, test plans, test results and the like);
- A clear identification of the technology advancements required to meet the objectives, along with the expected new IP and results of applicable patent searches;
- A detailed description of all FIP generated during this period and additional BIP used during the period under review;
- Details of all R&D and/or commercial licenses required to secure access to third-party BIP, if applicable;
- A detailed description of all equipment purchased during this period;
- All other Contractor's findings prior to the milestones; and
- Changes to the team, Work Breakdown Structure (WBS), level-of-effort, schedule, resource assignment matrix,

A.6.1.3 FINAL DATA PACKAGE

At least two (2) weeks prior to the due date, the Contractor must submit to the PA a draft Final Data Package. The PA will review the package and may request changes, as appropriate. The Contractor will then submit the final revised version. This data package must consist of stand-alone documents and will encompass all work performed throughout the contract.

The Final Data Package must consist of the following separate elements (electronic format only):

a. Executive Report,
b. Technical Report,
c. Contractor's Disclosure of FIP (APPENDIX A-3 to ANNEX A)
d. Asset Declaration Form – Prototypes and Equipment (APPENDIX A-4 to ANNEX A)

The Executive and Technical Reports should include the CSA Report Documentation Page (APPENDIX A-2 to ANNEX A).

A.6.1.3.1 EXECUTIVE REPORT

The Executive Report will be placed in the public domain (e.g., CSA's library, publication and/or website, to promote the transfer and diffusion of space technologies). The report must not exceed ten (10) pages. The Contractor must submit an electronic copy of the Executive Report in the Final Data Package. Any confidential information concerning potential spin-off and commercialization, or any information that would constitute a public disclosure of the FIP should be placed in the Technical Report.

A recommended structure for the Executive Report is as follows:

1. Covering page;
2. Introduction;
3. Technical Objectives;
4. Approach / Project Tasks;
5. Accomplishments;
6. Technology:
    a) Description / Status of Technology (Initial TRL, Targeted TRL and Actual TRL at completion),
    b) Innovative Aspects, and
    c) Application Fields
7. Business Potential, Benefit and Impact on Company;
8. Ownership of Intellectual Property; and
9. Publications / References.

The CSA and the Contractor, or others designated by them, have the right to unrestricted reproduction and distribution of the Executive Report. The report must include the following proprietary notice ("Owner of FIP" being either the CSA or the Contractor):

> Copyright ©20XX "Owner of FIP"
>
> Permission is granted to reproduce this document provided that written acknowledgement to the "Contractor name" or the Canadian Space Agency is made.

A.6.1.3.2 TECHNICAL REPORT

The report will contain a detailed account of all work performed under the contract. This will enable a full and accurate evaluation of the work by the PA. The report should include, as appropriate, the following:

a) Covering page;

b) Executive Summary;

c) Background information and references to relevant documentation;

d) Review of results and accomplishments;

   Where applicable, the following items should be included:

   - A summary of the literature search, with copies of the main publications supplied in an appendix (without infringing upon any copyrights),
   - The system requirements specification and the interface requirements specification,
   - Feasibility studies and identification of technological risks, alternatives approaches, and trade-off analysis results,
   - Design documents,
   - Implementation documents,
   - Test plan and procedures, and
   - Concept demonstration results;

e) Assessment of results with respect to the Performance Evaluation Criteria. This should support a statement qualifying and/or quantifying three aspects:

   - Performance: the project successfully met and/or exceeded none/few/some/most or all the Performance Evaluation Criteria
   - Impact: the project identified none/few or several potential and/or actual impacts/benefits
   - Success: the project has none/some or significant potential of becoming, or already is, a success story

f) Technology Readiness Assessment (TRL reached);

g) Detailed description of all equipment purchased during this period;

h) All other Contractor findings;

i) Recommendations including the potential for any further R&D of a follow-on nature;

j) An explicit and detailed description of all Foreground Intellectual Property (FIP) and Background Intellectual Property (BIP), if any (refer to Appendix A-3 to ANNEX A);

k) Conclusion;

l) Supporting tables, technical drawings and figures;

m) A copy of all R&D and/or commercial licenses required securing access to third party BIP, if applicable; and

n) Any additional relevant information deemed important by the Contractor.

A.6.1.3.3 CONTRACTOR DISCLOSURE OF INTELLECTUAL PROPERTY

At the end of the contract, a list and descriptions of all BIP required for CSA use of the FIP must be provided in the Final Data Package and reviewed at the Final Review Meeting. A list and description of all FIP resulting from project work must also be provided. Furthermore, the Contractor will complete and submit as a stand-alone document entitled “Contractor Disclosure of Intellectual Property”, provided in APPENDIX A-3 of ANNEX A. The Contractor must submit an electronic copy of the Contractor Disclosure of Intellectual Property.

A.6.1.3.4 PROTOTYPES AND EQUIPMENT

All prototypes developed during the Contract must be disclosed to Canada and reviewed by the PA who will advise on their final disposal and /or delivery.

The Contractor should also maintain a list of all non-consumable items procured or fabricated under the contract and/or provided by the government. As part of the Final Data Package, the Contractor must complete and submit the Asset Declaration Form found in APPENDIX A-4 of ANNEX A, for which the CSA will issue inventory bar codes at the end of the contract. The Contractor will be notified as to how the assets (equipment) should be handled after the PA and TA have reviewed the list.

A.6.1.4 CONTRACT SPECIFIC DELIVERABLES

The following is a list of contract specific deliverables that could be identified in the bid and be required depending on the TRL progression of the technology. The schedule for these and other contract specific deliverables should be identified in the bid and agreed upon at the kick-off meeting.

- Performance and functional requirements document;
- Compilation of Literature Review and Establishment of Benchmark Technical Notes (TN);
- Trade-off and Feasibility studies TN;
- Procurement Plan;
- Subcontractor IP agreement;
- Technology Design and Development Plan;
- Conceptual Design Document, including drawings and models;
- Preliminary Design Document, including drawings and models;
- Detail Design Document, including drawings and models;
- Breadboard Development Plan;
- Interface Control Documents, including drawings and models;
- Failure Modes Effects and Analysis;
- Assembly Processes Development;
- Process Documentation;
- Test Procedures and Results Reports;;
- Formal Specifications, including drawings and models;
- Qualification Plan;
- Breadboards;
- Prototypes;
- Compliance Statement;
- Electrical Model;
- Engineering Qualification Model; and
- Qualification Model.

A.6.1.5 SOFTWARE

The developed software and associated documentation will be in accordance with the software design standards and/or specifications stated in the proposal. The Contractor must provide an electronic copy of all Contractor documents describing the software development cycle, including user, maintenance and operation manuals. The developed software must also be provided in the form of well-documented source code in computer compatible format, with run-time libraries and executable files.

A.6.2 MEETINGS

As per Table A-4 below, the Contractor will schedule and co-ordinate with all the stakeholders the following meetings:

- Kick-Off Meeting,
- Milestone and Progress Review Meetings,
- Work Authorization Meeting, and
- Final Review Meeting.

Meeting	Date	Location
Kick-off Meeting	No later than 2 weeks After Contract Award (ACA)	Contractor's premises
Milestone and Progress Review Meetings	At least every 4 months	CSA's premises
Work Authorization Meeting	At the Contract Mid-point.	CSA's premises
Work Authorization Decision	On March 31st of each year during Contract	N/A
Final Review Meeting	End of Contract	CSA's premises

Table A-4: Meetings and Decision Schedule

For all meetings, the Contractor will:

- Suggest the meeting content and deliver the suggested meeting agenda to the PA and the TA at least ten working days before the meeting;
- Deliver to the PA and the TA, all required reports and technical documents relating to the work about which the meeting is about;
- Record the minutes of the meeting; and
- Deliver one (1) electronic copy of the minutes of the meeting to the PA five working days after the meeting.

In support of the project meetings, viewgraphs and supporting presentation materials should be prepared. One (1) electronic copy should be presented to the PA. Documented video materials should be prepared by the Contractor along with the supporting visual presentation material to support any demonstration of the technology. A copy of the supporting visual material should be delivered to the PA.

A.6.2.1 KICK-OFF MEETING

Within two weeks of the contract award (or at a date mutually agreeable to by the PA and the Contractor) a Kick-Off Meeting (KOM) must be held to:

- Review the proposed **Performance Evaluation Criteria (PEC).** This is a list of criteria that will be used throughout the project to evaluate the Contractor's technological progress. It will be provided in the Contractor's bid and accepted at the KOM and reviewed at each Milestone/Progress Review Meeting as well as at the Contract Mid-point Work Authorization Meeting;
- Review contract deliverables;
- Review the requirements of the work;
- Review the work schedules;
- Review risk assessment and mitigation plan;
- Review Work Breakdown Structure and Work Packages;
- Review capability to deliver work packages at agreed cost and schedule;
- Discuss exploitation strategy of technology and company capabilities;
- Discuss the BIP and review the provided list;
- Discuss the expected FIP and review the provided list (review Disclosure of FIP issues);
- Review expected cash flow, and claim format;
- Review reporting requirements;
- Review communications deliverables;
- Discuss any licensing issues; and
- Meet the personnel assigned to the work.

A.6.2.2 MILESTONE AND PROGRESS REVIEW MEETINGS

Milestone Meetings and Review Meetings will be help periodically throughout the life of a Contract to provide formal opportunities for face-to-face information exchanges as well as for progress monitoring discussions and decision making. At a minimum, a Milestone Review Meeting will be held at the end-point of each milestone. Between milestones, Progress Review Meetings should also be held with the maximum interval between such meetings not exceeding 4 months. These meetings will be scheduled by the Contractor.

The Milestone Meetings and Progress Review Meetings are intended to provide an opportunity for the Contractor, the PA, the TA, and other invited attendees to review and discuss the following in detail:

- The contents of the Milestone and/or Progress Report;
- The current % of completion and accomplishments;
- The technical work of each task;
- The current financial status (provide a table indicating planned vs. actual cash flow);
- The performance results with respect to the PEC;
- The status of Contractor's contributions (if applicable);
- The newly generated IP, status and progress of any inventions, including any experiments or other work needed to support a patent application;

- Commercialization progress, when required;
- Discuss Work Authorization Decisions by CSA, if applicable;
- Discuss relevant results achieved;
- Project management issues; and
- Other items as deemed appropriate.

A.6.2.3 WORK AUTHORIZATION MEETING AND DECISIONS

In addition to the Milestone Review and Progress Review Meetings, there will be a Work Authorization Meeting to be held approximately mid-way through the Contract (i.e., when approximately 50% of the contract value has been reached). This Work Authorization Meeting will serve as a basis for a decision to be made about whether or not to proceed with the follow-on activities of the Contract. This decision will be based primarily on the review of the achieved PEC in comparison with the PEC accepted at the Kick-Off Meeting and/or as revised at previous Milestone or Progress Review Meetings.

A Work Authorization decision will also be taken at each Government Fiscal Year end (March 31st) if there is no Work Authorization Meeting or no Final Review Meeting scheduled in the month of March. This decision will be based on availability of Government funding at that time.

At the discretion of the CSA, the Kick-off and Quarterly Progress Review Meetings may be held via teleconference instead of at the contractor premises.

The Contractor may request Ad-hoc Meetings with CSA whenever required to resolve unforeseen and urgent issues. The CSA may also request such Ad-hoc Meetings with the Contractor. The selection of participants will depend on the nature of the issue.

The PA and the TA reserve the right to invite additional knowledgeable people (Public Servants or others under Non-disclosure Agreement) to Milestone/Progress Review Meetings. Key Contractor personnel involved in the work under review will attend Milestone/Project Review Meetings. The exact location, date and time of the Progress Review Meetings will be mutually agreeable to by the PA, the TA, and the Contractor.

A.6.2.4 FINAL REVIEW MEETING

The Final Review Meeting will be held at the end of the contract. The specific intent of this meeting will be to discuss in detail the results obtained (as compared to the agreed-upon PEC) and the proposed follow-on activities.

The Final Review Meeting is intended to provide an opportunity for the Contractor, the PA, the TA, and other invited attendees to review and discuss in detail:

- The contents of the Final Data Package;
- The Executive and Technical Reports;
- Disclosure of FIP;
- Meeting presentation material;
- Prototypes, technical drawings, hardware, software, equipment, as applicable; and
- Other items as deemed appropriate.

The PA and the TA reserve the right to invite additional knowledgeable people to the Final Review Meeting. Key Contractor personnel involved in the work under review should attend the Final Review Meeting. The exact location, date and time of the Final Review Meeting is to be mutually agreeable to the PA, the TA, and the Contractor.

A.6.3 FORMS

The Report Documentation Page (see Appendix A-2 of Annex A) should be included in both the Executive Report and Technical Report.

As part of the Final Data Package, the Contractor must complete and submit the Asset Declaration Form in Appendix A-4 of ANNEX A, for which CSA will issue inventory bar codes at the end of the contract. The Contractor will be notified as to how the assets (prototypes and equipment) should be handled after the PA and TA have reviewed the list.

Also, the Disclosure of Intellectual Property (APPENDIX A-3 of ANNEX A) must be completed by the Contractor and submitted as part of the Final Data Package.

List of Appendices

Appendix A-1	Technology Readiness Levels (TRLs)
Appendix A-2	Report Documentation Page
Appendix A-3	Contractor Disclosure of Intellectual Property
Appendix A-4	Asset Declaration Form - Prototypes and Equipment
Appendix A-5	List of Priority Technologies and associated specific statement of works

APPENDIX A-1

TECHNOLOGY READINESS LEVELS (TRLs)

Source: RD-1 (CSA-ST-GDL-0001 Revision A - Technology Readiness Assessment Guidelines)

Readiness Level	Definition	Explanation
TRL 1	Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development.
TRL 2	Technology concept and/or application formulated	Once basic principles are observed, practical applications can be invented and R&D started. Applications are speculative and may be unproven.
TRL 3	Analytical and experimental critical function and/or characteristic proof-of-concept	Active research and development is initiated, including analytical / laboratory studies to validate predictions regarding the technology.
TRL 4	Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that they will work together.
TRL 5	Component and/or breadboard validation in relevant environment	The basic technological components are integrated with reasonably realistic supporting elements so it can be tested in a simulated environment.
TRL 6	System/subsystem model or prototype demonstration in a relevant environment (ground or space)	A representative model or prototype system is tested in a relevant environment.
TRL 7	System prototype demonstration in a space environment	A prototype system that is near, or at, the planned operational system.
TRL 8	Actual system completed and “flight qualified” through test and demonstration (ground or space)	In an actual system, the technology has been proven to work in its final form and under expected conditions.
TRL 9	Actual system “flight proven” through successful mission operations	The system incorporating the new technology in its final form has been used under actual mission conditions.

Table A-1-1: Definition of Technology Readiness Levels

APPENDIX A-2

Canadian Space Agency Agence spatiale canadienne	REPORT DOCUMENTATION PAGE	
Report Date:		
Title:		
Author(s):		
Performing Organization(s) Name and Address(es):		
Contract # and Title:		
Sponsoring Agency Name(s) and Address(es): Canadian Space Agency 6767 Route de l'Aéroport Saint-Hubert, Québec, Canada J3Y 8Y9 Tel: (450) 926-4800 Fax: (450) 926-4613 **Scientific Authority:** **Project Manager:**		
Abstract:		
Key Words:		
Supplementary Notes:		
Distribution/Availability:		

Table A-2-1: Template for Report Documentation Page

APPENDIX A-3

Contractor Disclosure of Intellectual Property

Background Intellectual Property (BIP)

Before contract closure, the Contractor must review its BIP disclosure and update the information provided as part of the Contractor's proposal. For the purpose of updating the BIP information, Table A-3-1 below is provided and must be filled out.

Table A-3-1 requires that each of the following be provided for each BIP:

- BIP #: simply assign a sequential number to each BIP in the table;
- Title of the BIP: provide a descriptive title of the BIP;
- Type of BIP: specify it the BIP relates to software algorithms, hardware design, invention patent, or other;
- Type of BIP access: describe the type of access to the BIP that was required in order to use, modify, improve and further develop the FIP;
- BIP Description: provide an explicit and detailed description of the BIP (refer to pertinent sections of the Technical Report, if necessary).
- Reference Documentation: specify if the documentation referred to was a technical report, design document, test results, other;
- Origin of the BIP: specify if the BIP originated from internal R&D, collaborative project, a specific contract, other; and
- Owner of the BIP: provide names and addresses of the owner of the BIP (contractor, subcontractor or Canada).

BIP #	Title of the BIP	Types of BIP	Type of access	BIP Description	Reference Documentation	Origin of the BIP	Owner of the BIP

Table A-3-1: Disclosure of actual Background Intellectual Property (BIP) used for the Contract

Please specify the name and the position of the person approving/authorizing this disclosure. This person is to sign and date the disclosure.The following notice must be visible at the top of every page of the BIP disclosure:

"Use, duplication or disclosure of this document or any of the information contained in this document, in whole or in part, without the prior written permission of "Owner of BIP" is expressly prohibited."

Foreground Intellectual Property (FIP)

In addition to the BIP disclosure, the Contractor must respond to the following for each FIP element (Table A-3-2 below must be filled out).

- FIP #: simply assign a sequential number to each FIP in the table;
- Title of FIP: provide a descriptive title of the FIP;
- Type of FIP: specify it the FIP relates to copyright, invention, design, software, know-how, trade secret, algorithms, other;
- FIP Description: provide an explicit and detailed description of the FIP (refer to pertinent sections of the Technical Report, if necessary).
- Reference Documentation: specify if the documentation referred to was a technical report, design document, test results, other;
- Owner of the FIP: provide names and addresses of the owner of the FIP (contractor, subcontractor, or the Canada).

FIP #	Title of FIP	Type of FIP	FIP Description	Reference Documentation	Owner of the FIP*

Table A-3-2: Disclosure of the Foreground Intellectual Property (FIP) developed under the Contract

If Canada is the owner of the FIP, the Contractor must complete Table A-3-3 below and provide the following information:

- FIP #: simply assign a sequential number to each FIP in the table;
- Title of FIP: provide a descriptive title of the FIP;
- FIP Description: provide an explicit and detailed description as well as aspects that are novel, useful and non obvious;
- Limitation: Provide limitations or drawback of the FIP;
- References: Provide references in literature or patents pertaining to the FIP;
- Has the FIP been prototyped, tested or demonstrated (e.g., analytically, simulation, hardware)? If so, provide results;
- Inventors: Provide name, coordinates and company of inventor(s) – (e.g., the person(s) who created the FIP); and
- IP Disclosure: Was the FIP or any element declared, disclosed to other parties? If so, when, where, to whom?

FIP #	Title of FIP	FIP Description	Limitations or drawback	References	Has the FIP been prototyped, tested or demonstrated	Inventors	IP Disclosure

Table A-3-3: Canadian Owned FIP Additional Information

Provide the name and the position of the person approving/authorizing this disclosure. This person is to sign and date the disclosure.

This following notice must be visible at the top of every page of the FIP disclosure:

"Use, duplication or disclosure of this document or any of the information contained in this document, in whole or in part, without the prior written permission of "Owner of FIP" or the government of Canada is expressly prohibited."

APPENDIX A-4

ASSET DECLARATION FORM - PROTOTYPES AND EQUIPMENT

Equipment Declaration: The Contractor must fill out the following form so as to identify all equipment procured under this contract.

Equipment #	Equipment description	Inventory #	Acquisition Value	Currency	Acquisition date	Manufacturer	Country	Model #	Serial #

Table A-4-1: Equipment Declaration Form

Prototype List: The Contractor must provide a list of all prototypes developed under this contract.

Prototype Name	Prototype description

Table A-4-2: Prototype Declaration Form

The decision regarding the delivery of any prototype is to be made by the CSA at the end of each contract completion

Note: Canada may reserve the right not to request compensation or replacement of government-furnished equipment (GFE) if the use of the said equipment is an integral part of the proposed research and development study or work.

APPENDIX A-5

LIST OF PRIORITY TECHNOLOGIES AND ASSOCIATED SPECIFIC STATEMENT OF WORKS

Rank	PT #	Priority Technology Title
1	PT 1	Dust mitigation technologies (Moon, Mars)
2	PT 2	Sample Processing for on-orbit biomedical analysis
3	PT 3	Quantum Key Distribution Receiver (QKDR) for QEYSSat
4	PT 4	Focal Plane Array technologies for Astronomy
5	PT 5	Sensor breadboard for thin ice cloud experiments (TICFIRE)
6	PT 6	Methodologies and Tools for CPU intensive algorithms migration to FPGA based implementation
7	PT 7	Radarsat Next Generation, Enabling Technologies for 1-meter resolution.
8	PT 8	Technologies to advance a manipulator mounted microscope for planetary surface applications
9	PT 9	Novel DNA-based Dosimeter for Space
10	PT 10	Mid-wave Infrared Microbolometer Sensor Breadboard
11	PT 11	Dexterous robotic tools

Table A-5-1: List of Mission-Enabling Priority Technologies

PRIORITY TECHNOLOGIES SPECIFIC STATEMENT OF WORKS

Priority Technology 1 (PT 1)

Dust Mitigation Technologies (Moon, Mars)

Dust mitigation technologies (Moon, Mars)

List of Acronyms

CSA	Canadian Space Agency
GSE	Ground Support Equipment
LOE	Level of Effort
ROM	Rough Order of Magnitude
SOW	Statement Of Work
TRL	Technology Readiness Level
UUT	Unit Under Test

Applicable documents

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

RD No.	Document Number	Document Title	Rev. No.	Date
AD-1	CSA-ST-GDL-0001	CSA Technology Readiness Levels and Assessment Guidelines *ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA*	Rev A	October 2010
AD-2	ESTEC TEC-SHS/5574/MG/ap	Technology Readiness Levels Handbook for Space Applications *ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA*	Iss. 1 / Rev. 6	March 2009
AD-3		Technology Readiness and Risk Assessment Worksheet: TRA Assessment Worksheet.pdf ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA/		
AD-4		Technology Readiness and Risk Assessment Rollup: TRA_Assessment_Tool.xlsm ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA/		
AD-5		Roadmap Framework: ExCore Concept Study TechnologyRoadmappingWorkbook.xlsx ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRM/		

Reference documents

This section lists document that provide additional information to the bidder, but are not required to develop the proposal.

RD No.	Document Number	Document Title	Rev. No.	Date
RD-1.	NASA/TP-2006-213726	Wagner, "The Apollo Experience Lessons Learned for Constellation Lunar Dust Management." NASA/TP-213726, National Aeronautics and Space Administration, Johnson Space Center, September 2006.		
RD-2.		Taylor, L.A., H.H. Schmitt, W.D. Carrier III, and M. Nakagawa. "The lunar dust problem: From liability to asset," AIAA, Proc. 1st Space Exploration Conf., Orlando, CD ROM, 2005.		
RD-3.		J.-F. Labrecque-Piedboeuf, A. Bergeron, V. Biron, F. Marcil-St-Onge,H. Bois-Von Kursk, M. Jacques, M.-J. Potvin, L. Shu et M. Lalumière Boucher *Design of a Lunar Dust Resistant Connection Interface Using Biomimetic Strategies,* in Proceedings of 15th Canadian Astronautics Conference ASTRO 2010, 4-6 mai 2010, Toronto, Canada.		
RD-4.		Calle, Immer, Ferreira, Hogue, Chen, Csonka, Suetendael, Snyder, "Integration of the Electrodynamic Dust Shield on a Lunar Habitat Demonstration Unit." Proceedings of the Annual Meeting of the Electrostatics Society of America, Paper D1, Charlotte, NC, June 2010.		
RD-5.		Davidson, M., Bligh, D., Maloney, N., McKnight, C., Young, W., Shu, L.H., Potvin, M.-J., Warkentin, A., *Biomimetic Design of a Multi-Layered Dust Protection System for Optical Instruments Operating in the Lunar Environment,* in Proceedings of the 6th International Conference on Innovation and Practices in Engineering Design and Engineering Education, juillet 2009, Hamilton, Ontario.		
RD-6.		Clark, Curtis, Marshall, Nuth, Minetto, Calle, "SPARCLED: Lunar Dust Capture, Containment, and Extraction Tool." Poster presentation at 3rd Annual NASA Lunar Science Forum, Ames Research Center, Moffet Field, CA , July 2010.		
RD-7.		Calle, Buhler, McFall, and Snyder, "Particle removal by electrostatic and dielectrophoretic forces for dust control		

RD No.	Document Number	Document Title	Rev. No.	Date
		during lunar exploration missions," Journal of Electrostatics, Volume 67, pages 89-92, 2009.		
RD-8.		Cadogan, Ferl, "Dust Mitigation Solutions for Lunar and Mars Surface Systems." International Conference on Environmental Systems, Chicago, IL, SAE International Paper Number 2007-01-3213, July 2007.		
RD-9.		Calle, Clements, Thompson, Cox, Hogue, Johansen, and Williams, "Electrostatic precipitation of dust in the Martian atmosphere: Implications for the utilization of resources during future manned exploration missions," 4th International Symposium on Physical Sciences in Space, Bonn, Germany, July 11-15, 2011.		
RD-10.		Kruzelecky, Aissa, Wong et. al, "MoonDust Characterization and Mitigation." ICES2011, Portland, Oregon		

Technology Description

Planetary missions must by necessity deal with the local environment which is significantly different than plain vacuum. With the proliferation of potential missions to locations such as the Moon, Mars or Asteroids**,** care must be taken that equipment is adequately designed and protected from the local environment.

Based primarily upon experience NASA gained during the Apollo missions, of special concern is the impact that lunar dust (defined in this context as the fraction of lunar regolith smaller than 50 microns) will have on equipment that is expected to function on the Moon. Since then, several strategies for defending and surviving with lunar dust have been proposed and investigated in the laboratory. These techniques range from passive, (such as part hardening, surface coatings, passive and energized seals), to active (generally based on electrostatic, magnetic or vibratory methods). Many of these methods are anticipated to function in other dust laden environments such as an asteroid or the surface of Mars.

In anticipation of these missions, the CSA is pursuing the development of technologies for dust (Moon, Mars) protection of mechanisms (e.g., manipulators, wheels, sample handling), structures (e.g.: solar panels, thermal radiators) and instruments (e.g., optics and encoders). Lunar dust will have a profound effect on the design of lunar bound equipment such as rovers, sample acquisition and transfer systems, and instruments. The extent of the impact is related to the anticipated mission duration. Generic strategies to deal with the dust are avoidance, removal, tolerance, or maintenance. For the purposes of this development the equipment survival duration is best characterized as a minimum of approximately 14 Earth days,

preferably several full lunar days without the luxury of locally replacing parts. The developed technologies also need to be assessed for their suitability for protecting against Martian dust. Dust-inhibiting design (avoidance), inclusion of mitigation strategies (removal), and robust design (redundancy and tolerance) will be the philosophy followed in every aspect of system design.

Scope of Work

The scope of work defined here complements Section A.5 Generic Task Description of Annex A.

The scope of the technology development includes several phases including a nominal associated LOE with that phase:

- **Identification and acquisition of appropriate lunar stimulant. Estimated LOE: 2.5%**
    - The ideal stimulant mimics to a high degree both lunar Mare and Highlands regolith. Notionally for such a system particle abrasion, grain size and size distribution, electrostatic and magnetic properties are deemed most relevant. As there are a variety of lunar simulants available, including some that mimic magnetic properties (such as the University of Winnipeg UW-H1 and UW-M1) that this phase is considered an enabler and not actually part of the technology development beyond acquiring relevant stimulant. Mars simulants being more problematic at this time that JSC Mars-1A or Hawaiian tephra is adequate.
- **Baseline component tests. Estimated LOE: 20%**
    - In order to determine the effectiveness of the dust mitigation technology, it is necessary to have an understanding of how relevant parts, components and sub-systems will behave and survive exposure to the 'raw' lunar environment. As a minimum, the following vacuum rated items with associated minimum parameters are expected to be baselined:
        - Motors (current, temperature, load, RPM, torque, total rotation)
        - Optical encoder (accuracy, repeatability)
        - Hall effect sensor (trigger point, repeatability, # of cycles)
        - Solar panel (efficiency, temperature)
        - Limit switch (# of cycles)
        - Bearing (RPM, torque, load, total # of rotations)
        - Seals (quantity of dust leaked, seal integrity)
        - Energized seals (same as seals)
        - Camera Lens (transmittance)
        - Thermal Radiator (thermal efficiency)
    - Automated electronic logging must be used to record relevant parameters.
    - Preliminary test reports are expected during the course of testing.
- **Dust mitigation technology development. Estimated LOE: 40%**
    - In order to allow flexibility in the solution the method will not be imposed. A careful literature search will unearth previous efforts and prototypes targeting dust mitigation. What the CSA requires at this time are functional prototypes that have minimal impacts on the hosting system (i.e., low power, low mass, small footprint, low complexity, robust) able to withstand the main environmental lunar parameters: vacuum and temperature (both equatorial, and polar). Ideally, the system should also be robust to radiation, vibrations and minimize EMI.
    - Specific tasks:

        - Identify candidate technologies appropriate for mitigating the effects of dust for the following category of components:
            - Components needing mainly a good seal (complementary methods such as dust repelling are likely required to further extend the useful component life)
                - Motors
                - Bearings
                - Seals
                - Limit Switch
            - Components needing mainly to be maintained dust free (could be achieved with one strategy or a combination of strategies, such as, but not limited to, repelling dust, wiping dust, shaking component, etc.).
                - Optical encoders
                - Limit switches
                - Solar panels
                - Camera lens
                - Thermal Radiators
                - Hall effect sensor
        - Select candidate technologies for development suitable to mitigate both classes, and UUT.
        - Design prototypes of the mitigating technology suitable for each category. The categories of components can be refined as approved by the CSA.
        - Build prototypes of the mitigating technology for use in the component testing phase defined below.
        - Build a prototype of the mitigating technology for the environmental testing defined below. The intent is to perform destructive testing in order to gain a good understanding of their limitations.
    - It is likely that different items to be protected require different solutions. It is also equally likely that several well matched solutions are required.
- **Dust mitigation technology environmental testing Estimated LOE: 7.5%**
    - The dust mitigation technology must be tested to lunar thermal and vacuum conditions in order to determine its operational and survival envelopes. This can be a separate test environment from the mitigating technology.
    - This test should be designed as a destructive test in order to help gain understanding on the full strengths and weaknesses of the emerging technology. Of particular relevance are maximum operating conditions with as much relevant operational parameters and performance values, including operational and survival temperatures.
- **Component testing with mitigating technology: Estimated LOE: 25%**
    - In order to gain confidence in the technology, it must be tested under relevant conditions. Re-test priority should be given first to UUT that showed the worst response ensuring the baseline tests. For each item that showed failure or degradation during the baseline testing, that item is to be retested with its appropriate mitigation strategy to determine the effectiveness of the strategy. These tests must follow as closely as possible the conditions and measure the same parameters as the baseline tests. The test duration must be at least 2 weeks.
- **Support: Estimated LOE: 5%**

    - While the majority of the documentation relating to the above phases is included in the relevant ROM LOE, additional support is expected. This includes interim reporting, telephone conversations, etc.

The Contractor must perform a Technology Readiness and Risk Assessment (TRRA) of key technologies foreseen to be used in the proposed system, in accordance with the requirements of AD-1 and in AD-2 while using AD-3 and AD-4, and must describe the performance characteristics of the technology with respect to the needs of the targeted mission for the given target environment.

The Contractor must provide a Technology Development Plan, a.k.a. Technology Roadmap (TRM), including the required technology developments to meet targeted mission needs, and a plan and timeline to reach TRL 6 and 8. The Technology Roadmap must be provided in the format of AD-5.

Functional characteristics and performance requirements

    - Identification and acquisition of appropriate simulant sufficient to perform both the baseline and retests with mitigating technology.
- Baseline component tests
    - number and variety of units under test as per bid
    - Constant and quantified exposure to dust during test, with a variety of simulant
    - Minimum exposure time of UUT is either
        - failure
        - 2 weeks (for non moving parts)
        - 20,000,000 (motor side) rotations
        - 1,000,000 bearing rotations
        - 1,000 cycles limit switches and exposed hall effect sensors
- Dust mitigation technology development
    - Mitigation technology suite protects all items agreed upon review and approval by the CSA
- Dust mitigation technology minimum environmental testing
    - Operates in hard vacuum (~10^-7 Torr)
        - 24 hours at -40C (minimum), 100K (TBC)
        - 24 hours at +40C
    - Survives in hard vacuum (~10^-7 Torr)
        - 12 hours at -60C (minimum), 100K (target – TBC)
        - 12 hours at +60C

- Component testing with mitigating technology
    - Mitigated items efficiency decrease over time halved /survival time doubled (minimum)
    - Target is order of magnitude improvement

TRL timeline

- Targeted TRL for this technology development is 5 (regolith, vacuum, thermal)
- Duration to reach targeted TRL: 12 - 24 months

The testing and design aspects of this project are expected to be performed in parallel. Near continuous baseline testing until the first mitigation technology device is available. This is roughly pegged as near the mid-point of the project.

Targeted missions

The CSA is developing technology that would enable a future Moon missions for lunar prospecting and technology demonstration. The nature of dust mitigation technology applies itself for nearly any Moon mission, and to a lesser extent future Mars missions.

Specific Deliverables

The deliverables defined here complement Section A.8 Contract Deliverables and Meetings of Annex A

- Preliminary Test plan: This should provide an overview of the test environment, facility, tools, instrumentation, timeline, etc.
- Baseline Test procedures (For review and comments , expected ~ 1 – week before actual test)
    - This should include changes/modifications to the test plan, the UUT, the recorded parameters, test duration, and specifics relevant to the UUT.
- Baseline test report per item (preliminary – for Info, 1 week after test)
    - UUT, test facility, personnel, exposed dust quantity, test duration and condition, relevant metric to UUT before and after test, automated test logs, calibration information, deviations to procedure, test equipment calibration date, comments
- Baseline test report (final report for review and comment)
    - All of the preliminary UUT reports, additional findings and analysis as applicable, conclusion
    - Recommendation of mitigation testing priority
        - Dust mitigation Concept(s) Report (For review and comments, before detailed design).Expansion of what was outlined in the bid
- Candidate technology report (1 week before choosing technology).
    - This report is expected to include relevant information indicating the rationale for being selected as a candidate, anticipated properties of the technology, strength, weakness, risks and rough implementation plan, including a preliminary test plan.
    - The selection must be performed in conjunction with CSA.
- Dust Mitigation Design Report and Data package (1-2 weeks before implementation for review and comment)
    - Detailed information: drawings, algorithms, electronics, S/W, specifications, requirements, relevant supporting analysis and design choice information and justification.
    - New/modified test equipment, support equipment
- Dust Mitigation Fabrication report and data package (1-2 week after completion for info)
    - As built detailed information
    - Manufacturing details
- Mitigated test plan (1 week prior test, for review and comment)
    - Identify changes with respect to baseline testing plan.

- Dust Mitigation Environmental Test Procedure (1 week prior to test, for review and comment)
- Dust mitigation Environmental Test Report (1-2 week after testing)
    - Similar information to the baseline test report
    - Dedicated to the mitigating technology environmental performance
- Mitigated Test Procedures (1 week before test, review and comment)
    - Changes relative to baseline tests
- Mitigated Test Report per item (preliminary – 1 week after test)
    - Essentially the same as baseline test report per item
- Mitigated Test Report (final, for information - Milestone)
    - Same as baseline report but also includes comparison with baseline
- Final Report
    - Summary of work
        - Points to previous documents as applicable for details
        - Challenges, lessons learned
        - Relevant project information not reported previously
        - Project Documentation list
    - Future work
    - Overall comparative performance
    - Recommendations
- A turnkey functional demonstration unit for each developed class and a supervised demonstration operated by CSA at CSA.- This includes:
    - H/W
    - S/W
    - Ground Support Equipment (GSE)
- Technology Readiness and Risk Assessment Worksheets and Rollup Technology Roadmap Worksheet.

Priority Technology 2 (PT 2)

Sample Processing For On-Orbit Biomedical Analysis

Sample Processing For On-Orbit Biomedical Analysis

List of Acronyms

CBA: Cytometric Bead Array

ISS: International Space Station

MORD: Medical Operations Requirements Document

TEDP: Test Equipment Data Package

Applicable documents

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

AD No.	Document Number	Document Title	Rev. No.	Date
AD-1	CSA-ST-GDL-0001	CSA Technology Readiness Levels and Assessment Guidelines *ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA*	Rev A	October 2010
AD-2	ESTEC TEC-SHS/5574/MG/ap	Technology Readiness Levels Handbook for Space Applications *ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA*	Iss. 1 / Rev. 6	March 2009
AD-3		Technology Readiness and Risk Assessment Worksheet: TRA Assessment Worksheet.pdf ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA/		
AD-4		Technology Readiness and Risk Assessment Rollup: TRA_Assessment_Tool.xlsm ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA/		
AD-5		Roadmap Framework: ExCore Concept Study TechnologyRoadmappingWorkbook.xlsx ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRM/		

Reference documents

This section lists document that provide additional information to the bidder, but are not required to develop the proposal.

RD No.	Document Number	Document Title	Rev. No.	Date
RD-1.		Cohen L.Y., Fortin M., Leclair S., Mermut O., Dubeau-Laramee G., and Provencal D. Cellular and molecular biology during space flight. **Gravitational and Space Biology** 25-1, 60-63, 2011. Link: *http://gravitationalandspacebiology.org/index.php/journal/article/view/536/568*		
RD-2.		TH1/Th2 CBA kit instructions Link: http://www.google.ca/url?q=http://www.bdbiosciences.com/external_files/pm/doc/manuals/live/web_enabled/23-12495-00.pdf&sa=U&ei=Z-PQUJOpHsjMyQGD04DwCg&ved=0CBQQFjAA&usg=AFQjCNE0WObPK0lFN50hcjePP0gYeIvy5w		

Technology Description

Microflow1 is a flow cytometry technology demonstration scheduled on the International Space Station (ISS) in early 2013. The purpose of this flight opportunity is to evaluate and validate sample analysis as well as in-flight operations in the microgravity environment (RD-1). As flow cytometric sample preparation technology for space applications has not yet been developed, the Microflow1 instrument will be launched with samples prepared on the ground. However a future permanent facility, able to perform on-orbit biomedical analysis, will require a biological sample preparation system onboard the ISS. This system must allow manipulation of small volumes of biological or experimental fluids in preparation for flow cytometric analysis by the next generation Microflow payload. This instrument would support real-time medical diagnostic (as described in the ISS Medical Operations Requirements Document (MORD)) as well as space life science experiments on the ISS and would decrease the requirement to store and return biological samples to Earth.

Scope of Work

The scope of work defined here complements Section A.5 Generic Task Description of Annex A.

The scope of the project is to adapt existing laboratory sample preparation technology such that it can be performed in the spaceflight environment. The goal is to produce a prototype able to perform simple experimental steps in the laboratory using low fluid volumes, in a secure and automated manner (with minimal operator/crew interaction).

As part of this contract, the prototype must be tested in parabolic flights to assess performance in microgravity. Required documentation (e.g., TEDP) and cost estimate for preparation and participation in parabolic flight campaign must be produced. The cost of the

parabolic flights is outside the funding of this contract and will be covered by the CSA through its MOU with the National Research Council.

The Contractor must perform a Technology Readiness and Risk Assessment (TRRA) of key technologies foreseen to be used in the proposed system, in accordance with the requirements of AD-1 and in AD-2 while using AD-3 and AD-4, and must describe the performance characteristics of the technology with respect to the needs of the targeted mission for the given target environment.

The Contractor must provide a Technology Development Plan, a.k.a. Technology Roadmap (TRM), including the required technology developments to meet targeted mission needs, and a plan and timeline to reach TRL 6 and 8. The Technology Roadmap must be provided in the format of AD-5.

Functional characteristics and performance requirements

The technology will be developed to prepare biological samples for flow cytometric analysis on board the ISS. It will perform safe and automated mixing of fluids and reagents to label cells or biological molecules that will then be quantified using the Microflow flow cytometer. One or both types of biological assays must be supported: cell staining (protocol 1) and micro-bead assay (protocol 2). The following information is provided as guidelines.

The purpose of protocol 1 is to label white blood cells or cell suspensions with fluorescent antibodies to quantify surface protein expression. The technology must be able to mix approximately 0.05 to 0.1 ml from a phlebotomy (blood draw) or a cell culture sample with fluorescent antibodies specific for human cell surface markers, such as CD45, CD4, CD8, etc (fluorochromes to be confirmed over the course of the project) and incubated for 15 to 30 minutes at room temperature in the dark. The system must automatically mix cells and antibodies, perform the incubation and remove red blood cells and excess antibodies. Stained cells must be transferred to the next generation Microflow instrument for flow cytometric analysis.

Protocol 2 is based on the CBA (RD-2) micro-bead assay. The objective is to quantify soluble molecules in a biological fluid or cell culture medium. The technology must be able to mix approximately 0.05 to 0.1 ml of serum, cell culture supernatant or biological fluid with antibody-conjugated micro-beads, fluorochrome-conjugated antibodies and an assay buffer (to be defined over the course of the project) and incubated for 1 hour at room temperature in the dark. Micro-beads will be isolated from the liquid and collected for flow cytometric analysis.

This sample processing system will be automated, provide three levels of containment, and function independently of gravity levels. The assay could be performed in specific cartridge where reagents such as antibodies or beads could be modified, supporting various types of staining. Priority will be given to system supporting both protocols.

TRL timeline

- The targeted TRL for this technology development is TRL 6.

Targeted missions

The sample processing system developed as part of this contract will be a component of a future Microflow instrument. It is anticipated that this potential payload will be a permanently

installed flow cytometer for biomedical monitoring and space life science analyses on board the ISS.

Specific Deliverables

The deliverables defined here complement Section A.8 Contract Deliverables and Meetings of Annex A

- Design documents on the technology hardware
- Hardware prototype
- Laboratory demonstration
- Parabolic flight Test Equipment Data Package (TEDP) document
- Utilization instructions for the sample preparation system
- Technology Readiness and Risk Assessment Worksheets and Rollup
- Technology Roadmap Worksheet

Priority Technology 3 (PT 3)

Quantum Key Distribution Receiver (QKDR) for QEYSSat

1. Introduction

1.1 Scope

This Statement of Work (SOW) describes activities to define, design and develop a compact prototype of Quantum Key Distribution Receiver for the 'Quantum Encryption and Science Satellite' (QEYSSAT).

1.2 Background

The Canadian Space Agency (CSA) recently completed a "Feasibility Study on Quantum Entanglement Experiments in Space". As a result of this study, the QEYSSAT mission concept has been defined. QEYSSAT main mission objectives are a) demonstration of the transmission of encrypted keys based on quantum principles between a ground station and a micro-satellite and b) science investigations of quantum entanglements over long-distance. The feasibility of such a mission relies on the maturity of several technologies. Two technologies were deemed critical: the Acquisition Pointing and Tracking Sub-System (APT) and the Quantum Key Distribution Receiver (QKDR) sub-system. In 2012-2013, CSA awarded a contract to confirm and demonstrate the performance of the APT. The activities completed in March 2013 with a lab demonstration of the main components of the tracking system.

This Statement of Work targets development of a receiver module for quantum key distribution (QKD) technology that has form, fit and function of a future flight version of the QKDR. It is expected that Bidder has extensive experience with QKD research and development at least at a breadboard level. Current laboratory breadboard prototypes that may exist must be converted to a compact design that has a clear path to flight. The major effort then is expected to focus on miniaturizing optical assembly, receiving amplifiers and digital processing circuits. In addition to these design efforts, the space qualification of quantum detectors addressing radiation susceptibility must be undertaken. This work must be completed by an end-to-end demonstration of the quantum key distribution functionalities of the compact QKDR over simulated long distance.

This development targets advancement of the described technology from TRL-3 to TRL-4.

1.3 Document Conventions

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

a) "Must" is used to indicate a mandatory requirement;

b) "Should" indicates a goal or preferred alternative rather than a requirement. Such goals or alternatives are to be treated on a 'best efforts' basis, and are subject to verification as requirements are. The actual performance achieved must be included in the appropriate verification report, whether or not the performance goal 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 other than those listed at a-d above.

2. Documents

The following documents (on CD) can be obtained upon request from the PWGSC Contracting Authority named in the Request for Proposal and resulting contract.

2.1 Applicable Documents (AD)

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 No.	Document Number	Document Title	Rev. No.	Date
AD-1	QEYS-MD-001	Quantum Encryption and Science Satellite: Mission Objectives	P0.1	July 29, 2011

Table 2.1: Applicable Documents

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.

RD No.	Document Number	Document Title	Rev. No.	Date
RD-1.	CSA-ST-GDL-0001	CSA Technology Readiness Levels and Assessment Guidelines *ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA*	Rev A.	October 2010

Table 2.2: Reference Documents

3. Requirements

3.1 General

This activity targets development of a critical sub-system of a quantum key distribution payload and is required to increase overall maturity level of the QEYSSAT concept prior to starting a follow on phase of the project which is outside the scope of this requirement.

QEYSSAT is a mission to demonstrate new technology for the distribution of encrypted keys from space. The mission will also aim at performing science experiments in the area of long-distance quantum entanglement. The Mission Objectives document [AD-1], which has been prepared by the Core User Team, describes the mission objectives and goals. In the previous phase of the work, a mission conceptual design has been prepared that would allow meeting the users' objectives with a micro-satellite platform.

The QEYSSAT baseline mission concept is to fly a receive-only quantum communication payload[1] to establish encrypted keys when in view of dedicated ground stations. The ground stations would transmit weakly coherent pulses (WCP) at two different intensities to support a variant of the BB84 encryption protocol. Using the quantum communication protocol, a secure key would be established between the ground station and the satellite. Later, the satellite would establish a second key with another dedicated station. Acting as a trusted node, the satellite would then establish a secure key between the two stations (Figure 3.1-1). The process could be repeated at several stations to establish a global quantum key distribution network, however the mission demonstration only requires accessing two stations. Adding an entangled photon source at a ground station, the satellite could also support long-distance quantum entanglement experiments.

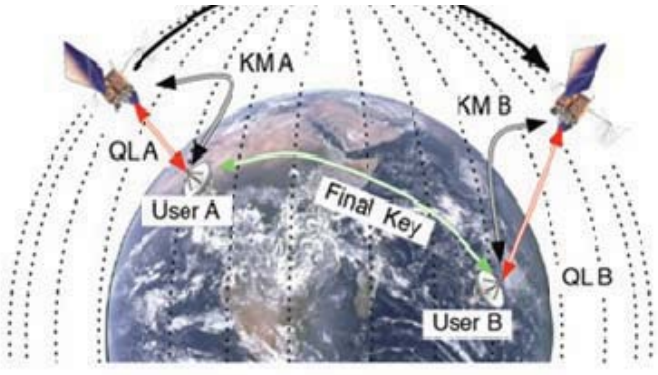

Figure 3.1-1 Mission Concept for Global Quantum Key Distribution.

A diagram of the proposed payload is shown in Figure 3.1-2. The payload is normally in idle mode until it comes in view of a dedicated ground station. To minimize background photons received at the ground station, quantum communication are established at night when the satellite is in eclipse. Typical duration of a pass is between 150 to 500 seconds. First, both the satellite and the ground station acquire each other beacon signals and initiate continuous tracking, such that the direct line of sight is maintained for the quantum signal. The tracking sub-system concept has been recently elaborated in greater details and key functionalities have been demonstrated. Consequently, the interfaces between the QKDR and collection and tracking sub-systems can be considered well defined. As far as the QKDR is concerned, the only relevant information about the APT is that is provides a collimated quantum signal at 785

[1]The satellite also transmits RF and beacon optical signals to a ground station.

nm at its exit pupil in tracking mode and a 2-bit status telemetry to flag the following conditions: not operating, idle, signal acquisition and signal tracking.

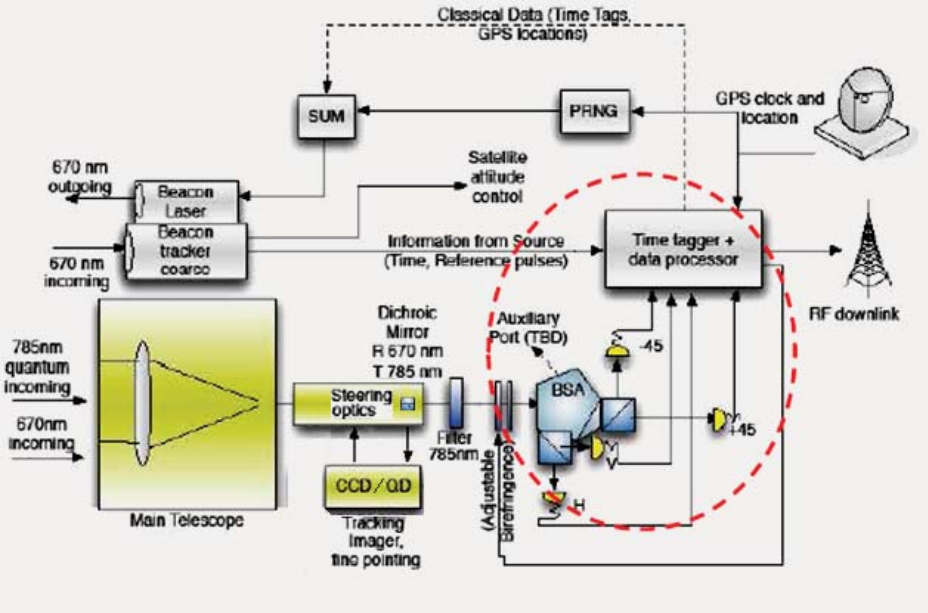

Figure 3.1-2 Payload Concept Schematic. The elements inside the dashed red ellipse are part of the quantum receiver (QKDR) subsystem.

The quantum signals are transmitted from the ground at a high pulse repetition frequency, with less than one photon per pulse on average. The main telescope and the steering optics ensure that a quantum channel photon is properly focused on one of the four (SPD) that follow the Beam Splitter Assembly (BSA).

As currently envisioned QKDR consists of two sub-assemblies: Optical Receiver Assembly (ORA) and Control and Data Processing Unit (CDPU). ORA holds the four photon sensors, contains necessary beam splitters for splitting out of the four quantum channels and interfaced with collection and steering optics. CDPU is the main payload computer. It receives the photon detection signals from each polarization, time tags and stores them. It also interleaves required time stamps and GPS data into the recorded data stream. All required for the key generation protocol processing and management of the stored payload data must be achieved here.

The rest of the protocol is performed by the QKDR sub-system. The main steps are:

1. The ground station randomly chooses three parameters for each quantum: a basis to encode in (H/V or +45°/-45°), a bit value (0/1), and a laser intensity (μ/μ_{decoy}).
2. Using the selected laser intensity the ground station encodes the photon with the chosen basis and bit value and sends it over the free-space channel to the satellite; at the same time the ground station saves a list of all of the parameters for each photon sent.
3. The satellite payload receives the photon and randomly chooses one of the two bases (H/V or +45°/-45°) to measure the photon in. It records the basis, the result of the measurement, and the arrival time of the photon (time-tag list).
4. The ground station and satellite perform many rounds of this distribution until enough raw signals have been detected by the satellite to meet the necessary security conditions.

5. The satellite then sends to the ground station its list of time-tags so that it can filter its list down to only those events which satellite received. This is called the Raw Key.
6. Each laser intensity, μ and μ_{decoy}, have certain photon number statistics. The ground station checks to make sure that the measured statistics match the theoretical ones closely enough to assure security.
7. The satellite sends to the ground station a list of the bases it used for each of its measurements. The ground station sifts its list down to only those results where it encoded its bit on the same basis that the satellite measured. It also sends this index list to satellite so that it can also sift its results. This is called the Sifted Key.
8. Since the channel and QKD system itself will likely have errors, the ground station and satellite perform error reconciliation on their sifted keys to correct these errors.

All exchanges to establish a secure key occur while the satellite is in view of the station, but it is also possible to perform the key sifting and privacy amplification steps later at another ground station connected to the quantum communication station if the quantum communication ground station does not provide a RF communication link with the satellite.

3.2 Objectives of The Work

The objective of the activities covered by this SOW is to develop a receiver module for quantum key distribution (QKD) technology that has form, fit and function of a future flight sub-system. It is expected that Bidder has extensive experience with QKD research and development at least at a breadboard level. Current laboratory breadboard prototypes that may exist must be converted to a compact design that has a clear path to flight. The major effort then is expected to focus on miniaturizing optical assembly, receiving amplifiers and digital processing circuits. In addition to these design efforts, the space qualification of quantum detectors addressing radiation susceptibility must be undertaken. This work must be completed by an end-to-end demonstration of the quantum key distribution functionalities of the compact QKDR over simulated long distance.

At the end of the activity, the state of technology development should reach Technology Readiness Level TRL-4 [see RD-1 in Table 2-2] with a credible path to flight.

3.3 Detailed Tasks

The detailed tasks define the activities and deliverables that must be produced to define concept of QKDR, its detailed design, and demonstrate a compact prototype with a clear path to flight.

3.3.1 QKDR Requirements and Concept

This activity must elaborate QKDR requirements based on QEYSSat concept. Current key preliminary requirements for QKDR are listed in the Table -1 below. This activity also must review current state of the art of QKDR architectures, existing breadboard laboratory systems and select the approach for a space borne instrument. This task must be concluded by a QKDR Requirements document and by a QKDR Concept document that elaborates on the technology trade-offs.

[QKDR-001] QKD Protocol	The QKDR must support as a minimum the BB84 protocol for a Weak Coherent Pulse and decoy states source, or BBM92 protocol for an entangled photon source.
[QKDR-002] Raw data content	The data acquired from the quantum link must consist of time tagged polarization measurements, consisting of a 34 bit time tag ensuring 0.078 ns resolution, 1 bit measurement basis, and 1 bit polarization.
[QKDR-003] Secure key	QKDR must be able to generate 5kB secure key in 100 s link time.
[QKDR-004] Link loss	44 dB of loss on the transmission path must not impede ability to generate the above secure key.
[QKDR-005] Dark Counts	QKDR dark counts must not exceed 200 counts per second.
[QKDR-006] Clock accuracy	QKDR clock accuracy must be no larger than 0.5 ns after post processing.
[QKDR-007] CDPU storage capacity	CDPU must have no less than 2 GB storage capacity.
[QKDR-008] ORA Volume	ORA volume must not exceed 150 mm x 150 mm x 200 mm.
[QKDR-009] CDPU Volume	CDPU volume must not exceed 150 mm x 150 mm x 200 mm, excluding allocation for power conditioning electronics.
[QKDR-010] Mass	Total mass of QKDR (both ORA and CDPU) must not exceed 12 kg, excluding allocation for power conditioning electronics.
[QKDR-011] Power	Total power consumption of QKDR must not exceed 6 W, excluding allocation for power dissipation in power conditioning electronics.
[QKDR-012] Reliability	The QKDR must have a predicted reliability better than 90% after one-year of operation.
[QKDR-013] Environment	The QKDR must be compatible with the thermal and radiation environment of a Sun Synchronous Orbit, midnight/noon orbit at 600 km.
[QKDR-014] Survivability	The QKDR must be able to survive and operate with no significant degradation in case the instrument is exposed to direct sun illumination, which can be intentional or accidental.

Table 3.3.1-: QKDR Preliminary Requirements

3.3.2 QKDR Design

This activity addresses detailed design of the compact QKDR. This includes parts selection, mechanical designs of applicable parts and circuit card assembly designs. Engineering and performance budgets must be assessed at this point for the compact prototype and for the projected flight system. The path to flight must be assessed at this point. This task must be concluded by a Design document that includes applicable design files, analysis spreadsheets and parts list.

3.3.3 Detector Qualification to Radiation Environment

This activity addresses space qualification of the selected single photon detectors relative to the radiation environment projected for QEYSSat mission. This includes radiation environment assessment, identification of the test facility, definition of qualification plan, and conduction of qualification tests. This part of work must be concluded by a Detector Radiation Qualification document that includes applicable test plans, data and analysis.

3.3.4 Manufacturing, Assembly and Functional Tests of the QKDR

This activity deals with parts procurement, manufacturing, assembly and tests of the breadboard model. A report addressing the compliance of the prototype to the QKDR requirements must be delivered by completion of this task.

3.3.5 End-to-End QKD Demonstration

This activity addresses planning and implementation of a laboratory or outdoor tests those simulate a long distance QKD experiment. It would be desirable that tests include moving source or target to demonstrate proper synchronization when relative distance is changed. Analysis must extrapolate the results of the test to a QEYSSat mission scenario. This task must be completed with a final report that includes the test results and analysis spreadsheets. The QKD demonstration must be conducted in conjunction with the final review to be witnessed by CSA representatives.

Priority Technology 4 (PT 4)

Focal Plane Array technologies for Astronomy

Focal Plane Detector Array (FPA) Technologies with Enhanced UV Response for Space Astronomy Applications

List of Acronyms

CASTOR	Cosmological Advanced Survey Telescope for Optical and ultraviolet Research;
CCD	Charge Coupled Device;
CMOS	Complimentary Metal-Oxide Semiconductor;
CSTM	Canadian Space Telescope Mission (concept);
JWST	James Webb Space Telescope;
GEO	Geostationary orbit 35,786 kilometers above the Earth's equator;
L2	an orbit about the Sun-Earth second Lagrange point (L2), approximately 1.5 million km from Earth;
LEO	Low Earth Orbit, an orbit below an altitude of approximately 2,000 kilometers;
QE	Quantum Efficiency;
RFQ	Request for Quotation;
UV	Ultraviolet

Applicable documents

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

AD No.	Document Number	Document Title	Rev. No.	Date
AD-1	CSA-ST-GDL-0001	CSA Technology Readiness Levels and Assessment Guidelines *ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA*	Rev A	October 2010
AD-2	ESTEC TEC-SHS/5574/MG/ap	Technology Readiness Levels Handbook for Space Applications *ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA*	Iss. 1 / Rev. 6	March 2009
AD-3		Technology Readiness and Risk Assessment Worksheet: TRA Assessment Worksheet.pdf ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA/		
AD-4		Technology Readiness and Risk Assessment Rollup: TRA_Assessment_Tool.xlsm ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA/		

AD No.	Document Number	Document Title	Rev. No.	Date
AD-5		Roadmap Framework: ExCore Concept Study TechnologyRoadmappingWorkbook.xlsx ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRM/		

Reference Documents

This section lists document that provide additional information to the bidder, but are not required to develop the proposal.

RD No.	Document Number	Document Title	Rev. No.	Date
RD-1.		"CASTOR: the Cosmological Advanced Survey Telescope for Optical and Ultraviolet Research", Patrick Côte et al, http://casca.ca/wp-content/uploads/2013/03/CASTOR_summary.pdf		2012
RD-2.		"First Use of a HyViSI H4RG for astronomical observations", Lance M. Simms et al, Proc. SPIE. 6690, Focal Plane Arrays for Space Telescopes III 66900H		Aug 2007

Technology Description

Large format and high resolution focal plane arrays (FPA) with high efficiency ultraviolet (UV) photon detection are essential for many instrument and sensor concepts and have been the focus of recent research endeavours in astronomy, astrophysics, and planetary science. For example, future space observations, including space astronomy imaging, spectroscopy, will require significant detector advances, particularly in quantum efficiency, noise, resolution, and number of pixels in order to satisfy requirements of wide field imaging for sky survey in the 150 to 550 nm spectral region and result in major new scientific impacts. Suitable detector choices include mature backside illuminated CCDs and CMOS devices with hybrid architecture. State-of-the-art hybrid CMOS devices are very attractive for future scientific missions because they are available in formats as large as 4Kx4K four-side buttable that is essential for making large FPA mosaics and radiation tolerant by design. Unlike CCDs, CMOS detectors do not suffer from charge transfer efficiency (CTE) degradation due to radiation damage in orbit. CMOS detectors have very low power consumption and allow non-destructive random access to the pixels and on-chip integration of analog and digital circuitry which significantly reduces the imaging system mass, volume, power and thermal output and overall complexity for space use. These technological innovations could be used as the basis for development of the FPA subsystem for the Canadian Space Telescope Mission (CSTM),

also known as the “Cosmological Advanced Survey Telescope for Optical and ultraviolet Research” (CASTOR), which has been proposed by the Canadian space astronomy community. The project is aimed at the investigation of the current status of high resolution focal plane arrays (FPA) with high efficiency ultraviolet (UV) photon detection, procurement and laboratory characterization of the most suitable detectors. While the focus of this project is on the UV-enhanced device technologies (UV band 150-300nm) it is important to emphasize that the same detector type must be used for all bands (UV/visible).

Detectors for CASTOR program

Detector candidates suitable for CASTOR program have been identified and described in Section IVd of (RD-1) as follows.

It would ease procurement, qualification, and readout electronics design if the same basic type of detector were to be used for the entire FPA. Detector coatings can vary with little system impact in this case. Detectors are therefore selected to be sensitive over the entire waveband. Silicon based photovoltaic array detectors are known to be highly sensitive over the full spectral range down to 0.12 μm. Suitably mature detector choices include monolithic Back Illuminated CMOS (BICMOS), silicon PIN hybridized to CMOS ROIC (e.g., Teledyne HyVisI), and various flavors of back illuminated CCD (BICCD). “Back illumination” refers to the geometry where light is incident directly on the active area of the silicon, and is not vignetted by the pixel circuitry and gate contacts as in typical commercial camera chips. This is extremely important for blue and UV sensitivity where the typical photon penetration depth is very small.

With their random access, non-destructive readout capability, random access sub-windowing capability, simplified readout electronics, and intrinsic proton radiation tolerance, we consider CMOS the choice for detectors. An additional advantage is that the Silicon PIN can be hybridized to familiar infrared astronomy ROICs such as the H2RG, recently used by the CSA in the JWST program. One competing drawback, however, is that the PIN material needs extra thickness to retain structural integrity during indium bump bond hybridization (>50 m), and this leads to a larger dark current at fixed operating temperature and higher transient sensitivity to trapped proton flux. CMOS sensors have the additional important operational benefit that many of them support high speed sub-windowing readout without affecting the rest of the scientific data collecting area. This would allow using the main scientific camera as the source for
fine guidance information. Indications from Teledyne are that the H4RG-10 will provide less than 0.01 *e/ p/s* at around 160 K operating temperature. This will keep the dark current at or below the expected read noise levels on a 10 minute exposure. They have also developed and delivered a 4-side buttable packaging design in collaboration with GL Scientific. This is important for minimizing the gaps between nearby arrays in the FPA. The design allows for <3 mm gaps between active areas of subsequent arrays on 3 sides and <6 mm gap on the fourth bondpad side. The H4RG-10 detectors have been selected as the baseline due to their high TRL, space-qualified status, and mission criticality.

Because the imaging sensor technology is rapidly advancing it is important to confirm the selection of the baseline device for CASTOR mission.

Scope of Work

The scope of work defined here complements Section A.5 Generic Task Description of Annex A.

The goal of this project is to develop a specification, evaluate the-state-of-the-art technology, select supplier, procure and characterize the performance of a large area silicon focal plane array detector with enhanced response in the ultraviolet spectral region based on preliminary requirements derived in the Concept Study for a potential future Canadian Space Telescope Mission (RD-1).

Specific tasks have been defined with respect to the project work as follows:

1. Confirm the focal plane specifications goals using the instrument level requirements derived from the CASTOR mission requirements (RD-1).
2. Provide a survey and comparative analysis of the state-of-the-art large format and high resolution focal plane arrays (FPA) with high efficiency ultraviolet (UV) photon detection. Noise performance, operating temperature and temperature dependence of key performance parameters of CMOS detectors and deep cooled CCD cameras shall be included in the comparative analysis. Assess which device technologies are most promising for use in space given the radiation environment for various orbits (LEO, GEO and Sun-Earth L2).
3. Identify current manufacturing capabilities including design, production, packaging, test, flight heritage and justification for the selection of the detector supplier(s). Summarize the findings in a Detector Technology Roadmap report identifying technical milestones, development schedule and potential costs. Develop mutually agreeable criteria and recommend a device to be further advanced.
4. Define requirements and prepare the specification for the device selected for procurement. Select a supplier by sending RFQs to multiple suppliers and comparing the quotations to determine which supplier can best meet the needs. In addition to the technical performance specification, the capability to build space qualified devices and ability to meet the delivery schedule and project budget shall be included in the list of mandatory requirements. Receive responses from vendors and evaluate quotes in terms of technical characteristics, work to be performed, total cost including all applicable taxes and shipping charges and the ability of the lead time to meet the required date. Prepare the summary report with recommendation for selected technology and supplier and submit it to CSA for approval. Upon receiving the approval initiate the procurement process.
5. Perform laboratory characterization of FPAs for use in astronomical applications following a similar program used to characterize large-area detectors (RD-2). The characterization shall yield measurements of the most relevant properties such as quantum efficiency, gain, read noise, dark current, linearity, and operability over a wide range of operational variations such as temperature, readout mode and post-processing electronic architecture.

6. Carry out the data reduction and analysis of the characterization results to demonstrate the performance and advantages of the selected FPA technology for space astronomy applications.
7. Summarize the results in the final report identifying mission applications that the selected detector innovation will enable and/or enhance. Summarize short-term, medium-term and long term drivers and risks for the full development of the selected technology towards a space instrument. Identify the technical milestones, development schedule and potential costs.
8. The Contractor must perform a Technology Readiness and Risk Assessment (TRRA) of key technologies foreseen to be used in the proposed system, in accordance with the requirements of AD-1 and in AD-2 while using AD-3 and AD-4, and must describe the performance characteristics of the technology with respect to the needs of the targeted mission for the given target environment.
9. The Contractor must provide a Technology Development Plan, a.k.a. Technology Roadmap (TRM), including the required technology developments to meet targeted mission needs, and a plan and timeline to reach TRL 6 and 8. The Technology Roadmap must be provided as well in the format of AD-5.

Milestones for Part 1	Milestone Name	Start	Completion
WP0	Start / Kick-off meeting	Contract Award	Contract Award plus 2 weeks
WP1	Analysis of the CASTOR mission requirements and flow down requirements from the mission level to the instrument level and from instrument level to focal plane specifications.	Contract award	Contract award plus 1 month
WP2	Analysis of the state-of-the-art technology, supplier evaluation and selection.	Contract award	Contract award plus 3 month
WP3	Review meeting	Contract award plus 3 month	Contract award plus 3 month
WP4	FPA procurement.	Contract Award plus 3 month	Contract Award plus 12 months
WP5	Laboratory characterization of FPAs for use in astronomical applications.	Contract Award plus 12 months	Contract Award plus 18 months
WP6	Data reduction and analysis of the characterization results.	Contract Award plus 18 months	Contract Award plus 21 months
WP7	Prepare final report.	Contract Award plus 21 months	Contract Award plus 23 months
End	Final review meeting presentation	Contract Award plus 24 months	Contract Award plus 24 months

Table 1 Project Milestones

Functional characteristics and performance requirements

Preliminary requirements for the Focal Plane Array are the following:

Format (columns x rows), pixels	2048x2048 or larger (4096x4096 goal)
Pixel pitch	≤10 um
Quantum efficiency (UV band)	>25% (40% goal)
Dark current	≤5 nA/cm2 at room temperature

Slow (up to 500 kHz/pixel) and fast (up to 5 MHz/pixel) readout modes

Selected FPA must be space qualifiable by design, process and tests and capable to withstand environmental requirements for a space mission (vibration, thermal, vacuum, radiation).

TRL timeline

- Targeted TRL 4
- Duration to reach targeted TRL 24 months

Targeted missions

Space telescope missions like CASTOR (RD-1) mission proposed by the Canadian space astronomy community.

Specific Deliverables

The deliverables defined here complement Section A.8 Contract Deliverables and Meetings of Annex A

1) Technical Report including:
   - Analysis of the CASTOR mission requirements and flow down requirements from the mission level to the instrument level and from instrument level to focal plane specifications.
   - Technology survey and comparative analysis of the state-of-the-art large format and high resolution focal plane arrays (FPA) with high efficiency ultraviolet (UV) photon detection.
   - Supplier selection justification.
   - Detailed description of the detector technology selected for procurement.
   - Description of the test equipment, test procedures and data analysis methodologies used for the device characterization.
   - Results of the FPA characterization.
   - Data reduction and analysis of the characterization results to demonstrate the performance and advantages of the selected FPA technology for space astronomy applications.
   - Summary of the results identifying mission applications that the selected detector innovation will enable and/or enhance as well as identification of short-term, medium-term and long term drivers and risks for the development of the selected technology, technical milestones, development schedule and potential costs.

- Gap analysis for the design, manufacturing, packaging and testing of the flight FPA.
- ROM cost and schedule estimates for the development of a flight-ready FPA for use on future space mission.

2) Focal plane arrays, test samples, dummies, packages, materials and equipment purchased during the term of this contract shall be delivered to CSA by the end of the contract.
3) Technology Readiness and Risk Assessment Worksheets and Rollup
4) Technology Roadmap Worksheet

Priority Technology 5 (PT 5)

Sensor breadboard for thin ice cloud experiments (TICFIRE)

Sensor breadboard for thin ice cloud experiments (TICFIRE)

Under this contractual work, the breadboard will be used to support sensor characterization at instrument level. The purpose is to validate whether the sensor technology and performance are adequate for multispectral imaging of thin ice clouds in the far infrared (7-50 um).

Objective

Thin ice clouds in far infrared experiment (TICFIRE) is a mission concept developed by a science team led by Université du Québec à Montréal. This mission aims to determine the contribution of thin ice clouds to the energy balance and improve extreme weather forecasting. To this end the measurement of thin ice cloud in several far infrared bands (7 to 50 um) is required.

The aim of this work is to advance the technology of far infrared sensor and determine whether the sensor performance is adequate for use in an airborne instrument that may be used to validate science requirements for a spaceborne TICFIRE mission. This is accomplished by developing a laboratory breadboard for performance characterization at the instrument level. The breadboard is built on an optical bench and consists of a front broadband telescope and a back camera housing which encloses: (i) a far infrared focal plane array vacuum sealed in radiometric package; and (ii) circuit boards of proximity and control electronics with interfaces to the radiometric package and data acquisition computer. A series of far infrared interference filters compatible with rotating filter wheel for spectral separation. The characteristics of the sensor breadboard, including noise equivalent temperature difference and radiometric accuracy, will be investigated for each spectral band and compared to the science requirements.

This development is designed to advance the technology readiness level (TRL) of airborne TICFIRE sensor from TRL-3 to TRL-4.

Tasks

The main tasks to be performed are as follow:

- Microfabrication of far infrared detectors
    - Microfabricate focal planes of far infrared microbolometers on monolithic readout electronics
    - Perform goldblack coating of microbolometer pixels
    - Perform on-wafer probing for the screening and selection of dies
    - Perform dicing to remove selected dies

- Growth of multilayered interference filters
    - Design interference bandpass filters for each of the spectral bands (up to ten bands)
    - Procure suited substrates and grow multilayered filters on these substrates (two filters per spectral band)
    - Measure the central wavelength, transmittance, full width at half maximum and out-of-band transmission of the filters

- Development of vacuum sealed radiometric package

  - Design the radiometric package with required optomechanical and electrical interfaces
  - Procure the components for the package fabrication
  - Integrate the focal plane of microbolometers into package
  - Develop the soldering process to seal the infrared window onto the package
  - Perform vacuum bake-out and seal
  - Conduct electrical tests and characterization of vacuum integrity and lifetime

- Development of sensor breadboard

  - Design a sensor breadboard that is compatible with airborne measuring conditions
  - Design the proximity and control electronics and fabricate their circuit boards
  - Design and manufacture or procure optical bench, camera housing, telescope and filter wheel
  - Design the support and interface for the electronics
  - Integrate and align radiometric package into the circuit boards in the housing
  - Develop scripts to control the acquisition parameters and read the data

- Tests

  - Test the data acquisition functionalities
  - Measure the spectral reflectance, noise equivalent power, and response time at the pixel level
  - Measure the noise equivalent temperature difference for each spectral band at the system level
  - Perform radiometric characterization and analyis of radiometric accuracy for each spectral band
  - Perform environmental tests on the bandpass filters and radiometric packages

Deliverables

- Specification sheets for breadboard components
- Manufacturing procedures
- Integration plan
- Test plan and procedures
- Radiometric package assembly drawings
- Breadboard assembly drawings
- Electrical and mechanical interface control designs
- Up to twenty (20) bandpass filters, two for each specified spectral band
- One (1) standalone, portable sensor breadboard on optical bench with one (1) radiometric package, proximity and control electronics, and telescope
- Control and data acquisition software

Requirements

Detector Requirements:

[DET-R01] - The thermally sensitive element of the detector shall be uncooled resistive microbolometer

[DET-R02] - The detector pitch shall be larger than 100 x 100 um^2

[DET-R03] - The detector shall be goldblack coated

[DET-R04] - The reflectance of the coated detector shall be smaller than 0.15 over the spectral range from 7 to 50 um

[DET-R05] - In each spectral band, the responsivity of the detector at each wavelength should exceed 85% of the maximum responsivity

[DET-R06] - The detector shall be pulsed current biased in operation

[DET-R07] - The noise equivalent power of the coated detector shall be inferior to 80 $pW/Hz^{1/2}$ at room temperatures in each spectral band

[DET-R08] - The response time of the coated detector shall be smaller than 200 ms

[DET-R09] - The size of the focal plane array shall be 32x32 detectors or larger

[DET-R10] - The fill factor of the focal plane array shall exceed 90%

[DET-R11] - The focal plane array shall include a number of detectors insensitive to in-field radiation to compensate for the effects of die temperature drift

Interference Bandpass Filter:

[IBF-R01] - The filter substrate shall be of circular shape with a nominal diameter of 25.4 mm

[IBF-R02] - The thickness of the filter substrate shall be smaller than 6.5 mm

[IBF-R03] - The filter transmission bands should be, at a minimum, as outlined in Table 1 below; up to four additional bands within the spectral range from 7 to 50 um may be added by CSA at a later stage, e.g. by splitting a given band into sub-bands or by varying the cut-on and cut-off wavelengths of a given band

[IBF-R04] - The out-of-band transmission of the filter should be less than 5%

[IBF-R05] - The central wavelength, transmittance, full width at half maximum and out-of-band transmission of each bandpass filter should be characterized over the spectral range from 0.2 μm to 200 μm

Filter	Transmission range
1	7.9 – 9.5 μm
2	10 – 12 μm
3	12 – 14 μm
4	17.25 – 19.75 μm
5	22.5 – 27.5 μm
6	30 – 50 μm

Table 1 - Spectral ranges of bandpass filters

Vacuum Radiometric Package:

[VRP-R01] - The radiometric package shall enclose a far infrared detector, a pressure gauge, a routing circuit, a getter, and a combination of thermoelectric cooler and thermistor for temperature control

[VPR-R02] - The radiometric package should fit in an envelope of 75 mm by 60 mm by 20 mm or smaller

[VPR-R03] - The radiometric package should weigh less than 150 g

[VRP-R04] - The baseline pressure inside the radiometric package should be less than 10 mTorr for a period of at least three (3) years. It is acceptable that this condition be achieved by a dedicated activation of the getter throughout the time period specified here, in which case the required vacuum pressure should be maintained for at least six (6) months.

[VPR-R05] - The temperature of the far infrared detector should be controlled to a stability of better than 10 mK for heat sink temperatures in the range from 283 to 291 K

[VPR-R06] - The window of the package shall have a transmittance exceeding 0.6 over the spectral range from 7 μm to 50 μm

Sensor Breadboard:

[SBB-R01] - The sensor breadboard shall be a standalone and portable optical bench supporting a front telescope, a back camera housing and an integrated filter wheel

[SBB-R02] - The camera housing should fit in an envelope of 230 mm by 150 mm by 150 mm and shall enclose the radiometric package and the proximity and control electronics

[SBB-R03] - The control and data acquisition software shall be compatible with Windows XP and Window 7 operating system

[SBB-R04] - The control and data acquisition software shall include, at a minimum, the functions for modifying the bias current of the detector and for random access to different sections of the focal plane array

Priority Technology 6 (PT 6)

Methodologies And Tools For CPU Intensive Algorithms Migration To FPGA Based Implementation

Methodologies and Tools for CPU intensive algorithms migration to FPGA based implementation

List of Acronyms

CPU	Central Processing Unit
FPGA	Field-Programmable Gate Array
GN&C	Guidance Navigation and Control
IP Core	Intellectual Property Core (A reusable design unit – Firmware - within an FPGA circuit)
SAR	Synthetic Aperture Radar

Applicable documents

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

AD No.	Document Number	Document Title	Rev. No.	Date
AD-1	CSA-ST-GDL-0001	CSA Technology Readiness Levels and Assessment Guidelines *ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA*	Rev A	October 2010
AD-2	ESTEC TEC-SHS/5574/MG/ap	Technology Readiness Levels Handbook for Space Applications *ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA*	Iss. 1 / Rev. 6	March 2009
AD-3		Technology Readiness and Risk Assessment Worksheet: TRA Assessment Worksheet.pdf at ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA/		
AD-4		Technology Readiness and Risk Assessment Rollup: TRA_Assessment_Tool.xlsm at ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA/		
AD-5		Roadmap Framework: ExCore Concept Study TechnologyRoadmappingWorkbook.xlsx at ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRM/		

Reference documents

This section lists document that provide additional information to the bidder, but are not required to develop the proposal.

RD No.	Document Number	Document Title	Rev. No.	Date
RD-1.		Xilinx Spartan-6 FPGA Family *http://www.xilinx.com/products/silicon-devices/fpga/spartan-6/index.htm*		

Technology Description

Usage of hybrid solution consisting of logic and processor is an excellent approach to maximize usage of space qualified processors. Development of custom logic cores is a way to free-up the CPUs and to remain high-performing even in the context of a low power processing unit. Parallelization has a lot of advantages but may be time consuming in term of algorithms refactoring. It is difficult to transform procedural into a logic based recipe. Over the last few years, tools and techniques were developed to facilitate the way toward logic based implementation and to make that task easier. This is particularly required in the context of rover guidance and navigation (GN&C), optical image compression and SAR processing that are CPU intensive algorithms, where such transformations are absolutely necessary to ensure a path to flight. A lot of procedural algorithms are not yet transferable preventing advance capability enablement in the context of space missions. The main goal of this technology development is exactly to reduce the risk and to allow the implementation of complex algorithms in the context of low power processing units.

This technology development has four parts. The first part consists of a review of the logic core availability, feasibility and performance versus typical application domains with their associated performance. The second part consists in a review of the state-of-the-art methodologies and tools to facilitate the port of procedural algorithms into logic based solutions. The third part consists in the development of a prototype board that will support these complex algorithms. At last, the goal is to demonstrate the benefits of the selected methodologies, methods and development platform on a GN&C and imagery algorithms by implementing, demonstrating and characterizing their performance.

Scope of Work

The scope of work defined here complements Section A.5 Generic Task Description of Annex A.

The technology development includes four tasks. The Table 1 provides the description of the tasks and the relative level of effort expected according to the whole project. Task T3 must have the highest level of effort. To maximize outputs of task T4, each algorithm under investigation must be handled one at a time. Test results must be provided as soon as possible to CSA.

Task	Description	Expected Level of Effort
T1 - FPGA IP Cores Survey	Review of the logic core availability, feasibility and performance versus typical application domains with their associated performance including but not limited to the areas of image processing, rover GN&C algorithms and generic mathematic operations (e.g. matrix, vector processing). Type (open, commercial), provider, price, application, core family shall all be provided in the survey.	5%
T2 - IP Cores Development Methodologies and Tools Survey	Review of the state-of-the-art methodologies and tools that facilitate transfer of procedural algorithms into IP cores. The survey must consider at least Xilinx Spartan-6 family as FPGA candidate. The report must also provide recommendations with proper justifications.	10%
T3 – FPGA Processing Platform Development	Review the list of the proposed algorithm and defined a processing platform meeting the hardware requirements to implement these algorithms. Demonstrate that the selected platform has a clear path to flight for robotic mission and operational earth observation missions with design life of 7 to 10 year in a LEO orbit. Design and build a prototype of the processing platform with commercial grade components.	50%
T4 - FPGA IP Cores Prototyping and Performance Tests	IP cores prototyping and implementation of procedural algorithms candidates including but not limited to the list provided in Table 2. This task must exercise the methodology and tools recommended in T2. Performance tests must be conducted in order to measure the time required to perform one algorithm cycle. Test plan and test reports shall be produced.	35%

Table 1: Task Definitions

The Table 2 provides a list of CPU intensive algorithms including imagery and rover GN&C algorithms. As mentioned in table 1, task T4 shall consider logic based implementations, tests and characterization of algorithms included in the list. Other algorithms could be considered. The final list of algorithms must be discussed and accepted by CSA.

Algorithm	Description
Stereo Images Matching	Generate 3D points cloud based on stereo cameras (e.g. Stereo Block Matching http://docs.opencv.org/modules/calib3d/doc/camera_calibration_and_3d_reconstruction.html#stereobm)
SURF / SIFT	Robust local feature detector for computer vision. This algorithm has

	been already deployed on a FPGA system (http://labe.felk.cvut.cz/~tkrajnik/fpga-surf/)
ICP	Iterative Closest Point
ORF	SURF equivalent but less processing intensive. http://docs.opencv.org/modules/features2d/doc/feature_detection_and_description.html?highlight=orb#orb, Ethan Rublee, Vincent Rabaud, Kurt Konolige, Gary R. Bradski: ORB: An efficient alternative to SIFT or SURF. ICCV 2011: 2564-2571.
Voxel Subsampling	Reduce the number of points of a point cloud using a voxelized grid. This algorithm is available open-source into the Willow-Garage's PCL (http://pointclouds.org/)
KD-Tree	Nearest neighbour search
2D Delaunay Triangulation	Create a convex 2D irregular triangular mesh from an unstructured point cloud. There is a open-source version on http://www.qhull.org/
QSlim	Qslim is an optimized mesh simplification algorithm. Code : http://mgarland.org/software/qslim.html
A*	A* is a well known graph search algorithm used in path planning.
Image Processing	Gaussian Filter Median Filter Threshold Filter Adaptative Threshold (http://docs.opencv.org/modules/imgproc/doc/miscellaneous_transformations.html?highlight=cvthreshold#void%20adaptiveThreshold%28InputArray%20src,%20OutputArray%20dst,%20double%20maxValue,%20int%20adaptiveMethod,%20int%20thresholdType,%20int%20blockSize,%20double%20C%29)
Optical Flow Estimation	http://docs.opencv.org/modules/legacy/doc/motion_analysis.html?highlight=optical%20flow#calcopticalflowbm
Specan SAR Processing	Synthetic Aperture Radar, Systems & signal processing.
Lossless Multispectral & Hyperspectral Image Compression.	CCSDS 123.0-R-1

Table 2: Potential Algorithm Candidates

The Contractor must perform a Technology Readiness and Risk Assessment (TRRA) of key technologies foreseen to be used in the proposed system, in accordance with the requirements of AD-1 and in AD-2 while using AD-3 and AD-4, and must describe the performance characteristics of the technology with respect to the needs of the targeted mission for the given target environment.

The Contractor must provide a Technology Development Plan, a.k.a. Technology Roadmap (TRM), including the required technology developments to meet targeted mission needs, and a plan and timeline to reach TRL 6 and 8. The Technology Roadmap must be provided in the format of AD-5.

Functional characteristics and performance requirements

The characteristics and performance requirements rely on the nature of each task.

Task	Success Criteria
T1 - FPGA IP Cores Survey	The survey shall provide a complete and exhaustive list of cores related to the proposed technology development. The list includes but is not limited to imagery and GN&C algorithms. Furthermore, the study must not be limited to Xilinx core technologies but must absolutely consider and must be functional with Spartan-6 devices.
T2 - IP Cores Development Methodologies and Tools Survey	Quality, simplicity and efficiency of the methods and tools proposed are the main success criteria for this task. Open-source tools and software may be considered in the study. This study is not limited to Xilinx core technologies but must absolutely consider and must be functional with Spartan-6 devices. The review study depth and spectrum is a main evaluation factor.
T3 - FPGA Processing Platform Development	The goal is to demonstrate that it is possible to build the required hardware to implement the selected algorithms in a space environment. The platform shall provide enough resources to implement the algorithm and also provide enough I/O speed to handle high speed applications. The processing platform shall define a standard set of interface both a low and high speed to enable the future development of I/O interface board to maximize the reusability of the hardware for multiples applications. The design shall have a high availability, tolerance to radiation and survive the thermal and mechanical environment of robotic and earth observation missions. The platform should also allows to either use high quality components for long duration missions and lower grade components for shorter mission where cost is critical. A secondary goal is to be able to use the FPGA flexibility and performance to be able to reuse the same unit for more conventional control applications (platform and payload controller) by embedding an industry standard CPU core (ARM, LEON) within the FPGA logic.
T4 - FPGA IP Cores Prototyping and Performance Tests	The goal is to demonstrate, test and characterize as many IP cores as possible. Commercial or open IP cores can be considered in the list of algorithms but at least one IP core shall be developed and demonstrated using the methodology and tools recommended in task T2. A list of algorithms shall be provided and agreed by CSA. At least one algorithm shall be run on the processing platform developed in task T3.

Table 3: Functional Characteristics and Performance Requirements

TRL timeline

TRL timeline is not applicable for tasks T1 and T2. Successful demonstration, tests and characterization of FPGA IP cores increase the TRL of the identified algorithms due to its maturity nature. Nevertheless, TRL timeline must be provided by the bidder.

Targeted missions

The main goals of this technology development are to facilitate and enable transferability of procedural algorithms into IP cores. This generic flavor would permit enablement and implementation of high-performing algorithms onto low power processing units. The potential mission opportunities below could exploit such enablement:

- Novel MSS Visions Systems,
- Satellite On-Board Imagery Processing
- Rover or/and vision system opportunities (Mars, Moon)
- Hyperspectral/Super Spectral Mission
- Next Generation Radarsat

Specific Deliverables

The deliverables defined in table 4 complement Section A.6 Contract Deliverables and Meetings of Annex A.

ID	Task	Deliverable	Type
D1	T1	FPGA IP Cores Survey Report	Technical Report
D2	T2	IP Cores Development Methodologies and Tools Survey Report	Technical Report
D3	T3	Algorithm Hardware Requirement	Technical Report
D4	T3	Processing Platform Design and Analysis Report	Technical Report
D5	T3	Processing Platform Hardware	Prototypes, Breadboards, EQMs Equipment purchased under the contract
D6	T4	Algorithm Candidates IP core, design, documentation	Technical Report
D7	T4	Algorithm Candidates IP core source	Software Code

		(or binary core if commercial core)	
D8	T4	Algorithm Candidates IP core test plans and tests report	Technical Report
D9	T4	FPGA Board + Equipment used for the development, testing and characterization	Prototypes, Breadboards, EQMs Equipment purchased under the contract
D10	T4	Tools License	Prototypes, Breadboards, EQMs Equipment purchased under the contract
D11	T4	Tools User's Manuals and Installation Instructions	Prototypes, Breadboards, EQMs Equipment purchased under the contract
D12		Technology Readiness and Risk Assessment Worksheets and Rollup	
D13		Technology Roadmap Worksheet	

Table 4: Deliverables

Schedule

This technology development is up to 24 months duration. It is highly recommended to have M2, M3 and M4 early in the schedule. For the M5, it is highly recommended to adopt an iterative approach where each algorithm is tackled one at a time.

Milestones	Description
M1 - Kickoff Meeting	Kickoff
M2 - FPGA IP Cores Survey Review	Review about the survey.
M3 - IP Cores Development Methodologies and Tools Survey Review	Review about the survey.
M4 – Algorithm Hardware Requirement Review	Review of the processing platform hardware requirement
M5 - FPGA IP Cores Prototyping and Performance Tests Algorithm Candidates Review	Selection and presentation of the algorithms being considered for further investigation (e.g. Implementation, Performance Tests). Approval of CSA required on the selected candidates. Tests plan must be presented and accepted by CSA.

M6 – Processing Platform Design Review	Review of the Processing Platform Design.
M7 - FPGA IP Cores Prototyping and Performance Tests Algorithm Candidates Review	Presentation of the test reports.
M8 - Final Review	Contract Closure

Table 5: Schedule Overview

Priority Technology 7 (PT 7)

Radarsat Next Generation, Enabling Technologies for 1 meter resolution.

Radarsat Next Generation, 1-meter resolution SAR with GMTI capabilities

1. Technology Description

In parallel to RADARSAT Constellation development, activities have been conducted with DND and other departments to identify their needs in the post-RCM area. The main drivers are the needs for surveillance expressed by DND that require several satellites at C and X band to monitor large areas and provide high-resolution imagery.

This technology development is to improve the bandwidth of the current C-band SAR instruments to the limit authorized by ITU, which is about 300 MHz. This will allow taking high-resolution imagery as requested by user, improve C-band system performance in many areas and firm up the current band allocation that will be lost for remote sensing if no significant activities are undertaken.

The system definition of a follow-up system to RCM has not been made yet and the implementation scenario is not yet known. At this point in time, there are three scenarios:

- RCM Augmentation: A decision is taken to augment rapidly the number of satellites in RCM constellation, therefore the first satellites must be ready for launch in 2018.
- RCM Replenishment: Technology development are undertaken to ready a replacement of one or several RCM satellite in case of an anomaly in the middle of the planned initial life of the constellation. In that scenario, technology developments must be completed such that the new satellites are ready by 2022.
- RCM Replacement: Technology developments are for a system that would perating after RCM planned life therefore first satellites are not planned before 2025.

The first two scenarios are concerned by this activity and their likelyhood will dicdate the priority of the activities to be conducted. In the RCM augmentation scenario, there is a rationale to improve the capabilities with a minimum of changes to the current RCM system. Under this scenario, changes should be minimal on most units in order to minimize the NRE and optimize the development schedule. In the RCM replenishment scenario, there is an opening to modify the RCM architecture more significantly in order to fully exploit the available C-band bandwidth. In the latter scenario, it is important for the CSA to confirm if the current technologies used in RCM can be adapted or if more radical changes must be planned for.

The approach to be followed in this activity will be to review systematically RCM payload subsystems and identify possible upgrades for the augmentation scenario. In parallel, a preliminary system architecture for the replenishment scenario shall be worked out and upgrades for the scenario be identified. By the time the initial system analyses are completed, the development scenario will have been discussed with the system users and CSA will be in a position to identify the best use of the investment.

The last step will be to perform selected development activities to confirm the technology readiness and prepare development plans for future activities.

2. System Requirements:

This technology development activity is expected to enable the design of very high resolution SAR payloads with GMTI capabilities. The main targeted characteristics of the SAR payload are:

→ Frequency of operation must be in C-band (5.4 GHz); The usable frequency bandwidth is 300 MHz;

→ The payload must provide 1 m spotlight image (both in ground range and azimuth) with the following characteristics:

- NESZ better than -17 dB;
- At least 450 km accessible swath;
- Ambiguity ratio better than -16.5 dB;
- 10 km spotsize.

→ The payload should, as a goal, support a High Resolution Wide Swath mode with the following characteristics:

- NESZ better than -22 dB;
- Wide swath;
- Azimuth and Ground Range Resolution better than 5 m;
- Ambiguity Ratio better than -16.5 dB.

→ The SAR payload must support H, V and circular polarization in transmit. The SAR payload must provide simultaneous reception of H and V polarization;

→ The scanning capability must be better than ±20° in elevation. The scanning capability in azimuth must be sufficient to enable a spotlight mode with 1 m resolution and 10 km spot size.

→ The SAR payload must be able to operate at full power for a period of 15 minutes every orbit. The SAR payload must support this power dissipation in a sun-synchronous orbit either in a dusk-dawn plane or in a noon-midnight plane.

3. Specific requirements

3.1 Requirement Review

The contractor for this technology development activity must perform an assessment of the targeted characteristics and identify the most significant technical challenges and cost drivers. The contractor must derive the SAR payload requirements from the main targeted characteristics. A requirements review will be held to agree on the final requirements of the SAR payload.

3.2 Trade-off Analysis

The contractor must perform a trade-off analysis between several implementation architectures for the SAR payload to determine the most promising solution for each scenario presented in Section 1.

The trade-off must consider at least the performance of proposed technology, the development risks, the development cost and the manufacturing cost of the proposed design. The result of this analysis must be presented in a Trade-off Analysis Report. The trade-off will also recommend the best option which will fulfill the mandatory mission requirements and another (if different) for the mission goal. This meeting will also be a formal Go/No Go meeting.

3.3 List of Technology Developments

Following the selection of the best options, the contractor must propose two lists (one for the mandatory and another one for the goal) of critical subsystems which will require further technological development in order to augment their TRL level and, in the end, demonstrate the feasibility of a high resolution C-band SAR. The list of these critical subsystems for the mandatory requirements must be ranked in order of priority with respect to each possible scenario. The ranking must as a minimum take into consideration the risk reduction provided by an early development, the reduction of the critical path length and the benefits of the development towards meeting the goal requirements. For the remaining critical items not dealt within this current contract, a development report (presenting schedule and estimated development costs) must be produced.

The following technologies have been identified as critical and may be used as an example, but are by no mean imposed to the contractor:

- A C-band Sub-array with a bandwidth of 300 MHz;
- A Central unit with a bandwidth of 300 MHz;
- A TRM with a bandwidth of 300 MHz (and as a goal capable of outputting 30W RF peak per unit);
- A SAR panel packaging solution capable of withstanding a TRM density higher than the RCM antenna design;
- Multi-apertures operations (2 or more apertures in receive).

3.4 Technology Development of critical sub-systems

The contractor must design, fabricate and perform functional tests of selected elements of sub-system(s) identified by the contractor and agreed upon with the Technical Authority. The selection of sub-system(s) and elements to be built and tested will depend on the TRL improvement, cost, complexity and feasibility within the remaing time and budget for the activity. An initial list of possible breadboarding activities with cost estimates must be provided with the Contractor' s proposal to confirm that it possible to achieve development within the proposed budget for the activity.

4. TRL Timeline:

Targeted TRL: 3 Analytical and experimental critical function and/or characteristic proof-of-concept. Demonstration of technical feasibility using breadboard

Duration to Reach Targeted TRL: 24 months

5. Deliverables:

Compliant with the target TRL, the following technical deliverables, as well as the list detailed in section A.6 of Annex A, are expected:

- SAR payload requirements;
- Trade-off Analysis;
- A report showing a high level description of the selected option including, electrical, RF, Thermal and Mechanical Budgets and supporting analysis;
- breadboards of the developed critical technologies developed.
- A final test report showing the results and a conclusion explaining if the concept is feasible
- A development plan containing a development schedule and a cost estimate for the remaining items to be developed.

6. Milestones and Meetings

- Kick-Off Meeting: Requirements Review.
- Milestone 1: Tradeoff analysis (Work Authorization meeting).
- Milestone 2: List of Technology Development of critical sub-systems. Design Review Meeting.
- Milestone 3: Technology Development of critical sub-systems. Breadboard Activity. Interim Review Meeting
- Milestone 4: Test Results presentation. Final Review Meeting

Priority Technology 8 (PT 8)

Technologies To Advance A Manipulator Mounted Microscope For Planetary Surface Applications

Technologies to advance a manipulator mounted microscope for planetary surface applications

List of Acronyms

CSA	Canadian Space Agency
dB	decibels
DHMR	Dry Heat Microbial Reduction
DLP	Digital Light Projector
DMD	Digital Micromirror Device
FOV	Field of View
LED	Light Emitting Diode
TRM	Technology Roadmap
TRRA	Technology Readiness and Risk Assessment
TEMMI	Three Dimensional Exploration Manipulator Mounted Imager
3-D	Three dimensional

Applicable documents

This section lists documents that are required for the bidder to develop the proposal. (Note, only use freely, publically accessible documents. If CSA authored, EN and FR version should be available)

AD No.	Document Number	Document Title	Rev. No.	Date
AD-1	CSA-ST-GDL-0001	CSA Technology Readiness Levels and Assessment Guidelines *ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA*	Rev A	October 2010
AD-2	ESTEC TEC-SHS/5574/MG/ap	Technology Readiness Levels Handbook for Space Applications *ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA*	Iss. 1 / Rev. 6	March 2009
AD-3		Technology Readiness and Risk Assessment Worksheet: TRA Assessment Worksheet.pdf at ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA/		
AD-4		Technology Readiness and Risk Assessment Rollup: TRA_Assessment_Tool.xlsm at ftp://ftp.asc-		

AD No.	Document Number	Document Title	Rev. No.	Date
		csa.gc.ca/users/TRP/pub/TRL-TRA/		
AD-5		Roadmap Framework: ExCore Concept Study TechnologyRoadmappingWorkbook.xlsx at ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRM/		
AD-6	NPR 8020.12D	Planetary Protection Provisions for Robotic Extraterrestrial Missions, Appendix D http://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_8020_012D_&page_name=AppendixD	N/A	(current) April 20, 2011

Reference documents

This section lists document that provide additional information to the bidder, but are not required to develop the proposal.

RD No.	Document Number	Document Title	Rev. No.	Date
RD-1.	Abstract #1081	TEMMI: A Three Dimensional Exploration Multispectral Microscope Imager for Future Planetary Missions. Coulter et al., International Workshop on Instruments for Planetary Missions, http://www.lpi.usra.edu/meetings/ipm2012/pdf/1081.pdf	N/A	Oct 11, 2012
RD-2.	D-27202	NASA Mars Science Laboratory Proposal Information Package	FINAL	April 14, 2004

Technology Description

This technology development advances key subsystems of a Three Dimensional Exploration Manipulator Mounted Imager (TEMMI) prototype, developed under the Canadian Space Agency (CSA)'s Exploration Surface Mobility Project, for flight. The objectives of TEMMI are to produce three dimensional (3D) images of scientifically interesting target surfaces on other planets. As noted below, the primary planetary target is Mars, but the Moon and asteroids could also be of interest. TEMMI is designed to be mounted on a manipulator, and would most likely be deployed on a rover rather than lander mission, providing access to a variety of target rocks and outcrops.

TEMMI primary performance requirements are optical resolution of 5um and Field of View (FOV) of 5mm. Nine wavelengths for illumination from UV to near-infrared are chosen to

respond to characteristic reflectance or fluorescence bands that identify important minerals or potential biomarkers. More details are provided in AD-6.

TEMMI is comprised of the following components:

- Optical microscope
- Translation stage
- Colour LED illumination
- Digital Light Projector (DLP)
- Structure, brackets and baffle
- Avionics and cabling

Technology development in this statement of work is aimed at advancing flight readiness of the **Digital Light Projector** and **translation stage** subsystems, with the expectation that these subsystems may have most risk associated with flight qualification.

The purpose of the Digital Light Projector is to project a light pattern on the target surface which is used to derive 3D images with vertical resolution around 5um. The mass estimate for the current DLP implementation is 810g (Including DLP components: Projector/DMD, LED Illumination, Objective, Control Card). This is a significant proportion of the mass loading on the translation stage in the current TEMMI prototype design (1.6kg).

The purpose of the translation stage is to move the combined microscope/DLP assembly over a depth of field of 25mm. To allow for more flexibility in manipulator positioning, three-axis translation is required. The translation stage must be rugged and accurate and withstand vibration and shock related to launch, and modes transmitted through the manipulator while the rover is in motion.

Scope of Work

The scope of work defined here complements Section A.5 Generic Task Description of Annex A.

The scope of this work is to develop and test a miniaturized, reduced mass DLP solution that maintains performance specifications, and to build and test a low mass translation stage solution that will withstand typical flight vibration and shock loads. The designs must be tested for Mars like environment requirements. The designs must also be analysed for sterilization (Planetary protection category 4c) by Dry Heat Microbial Reduction (DHMR), or hydrogen peroxide gas or other methods, for planetary protection purposes. Requirements are specified in AD-6.

The Contractor must perform a Technology Readiness and Risk Assessment (TRRA) of key technologies foreseen to be used in the proposed system, in accordance with the requirements of AD-1 and in AD-2 while using AD-3 and AD-4, and must describe the performance characteristics of the technology with respect to the needs of the targeted mission for the given target environment.

The Contractor must provide a Technology Development Plan, a.k.a. Technology Roadmap (TRM), including the required technology developments to meet targeted mission needs, and a plan and timeline to reach TRL 6 and 8. The Technology Roadmap must be provided as well in the format of AD-5.

Functional characteristics and performance requirements

Digital Light Projector

- Projected image dimensions: 4.5 ±1mm x 4.5±1mm (driving choice of DLP sensor size and objective magnification, desired magnification is around 1 to limit distortion)
- Control to program different projected pattern images
- Baseline testing and analysis with projected image with spatial frequency of projected cosine fringes of approximately 100um period, 8 pixels per period
- 12 bit image
- White light illumination with dimming and pulsed modes
- Mass of DLP based on pico-projector implementation
- Power reduction modes, low duty cycle enabled.

Translation Stage

- Translation stage to maintain performance and accuracy specifications listed here, tested for loads of 0.5kg, 1.00kg, 1.50kg, with test volume cubes of 0.70m x 0.70m x 0.70m, centre of mass at geometrical centre of cube
- Minimum travel range 25mm in each of x,y,z axes
- Origin repeatability better than 1um
- Origin precision better than 1um
- Translation stage step sensor resolution better than 0.1um
- Translation stage step Repeatability better than 0.15um
- Maximum position error over minimum travel range 0.2mm
- Programmable with sequence of steps of variable size and at variable time intervals
- If a lock down mechanism is included for rover traverse, it must be capable of being reset remotely before each rover traverse
- Light weight materials, low mass design
- Low power design

Environmental requirements for test (from RD-2)

- Random vibration, to Qualification/Prototype level

Frequency, Hz	Flight Acceptence Level	Qualification/Prototype Level
20-80	+6 dB/octave	+6 dB/octave
80-450	0.04 g^2/Hz	0.08 g^2/Hz
450-2000	-6 dB/octave	-6 dB/octave
Overall	5.5 g_{rms}	7.7 g_{rms}

Frequency, Hz	Force Spectral Density Level (N^2/Hz)
20 - f_0	$S_{FF} = 96\, C^2 M_0^2 S_{AA}$

F_0 – 2000	$S_{FF} = 96\ C^2 M_0^2 S_{AA}\ (f_0/f)^2$

Where:
S_{FF} is the force spectral density
S_{AA} is the acceleration spectral density
C^2 is a constant ranging from usually 2 to 5 depending on the weight and the attachment stiffness of the test article
M_0 is the weight of the test article in kg
f_0 is the fundamental frequency of the test article in the axis of test
g is gravitational acceleration, $g=9.81 ms^{-2}$

- Swept sine vibration acceleration inputs for manipulator mounted instruments

Frequency, Hz	Qualification Test Levels
20 – 100 Hz	5.0 g (zero-to-peak)
100 – 2000Hz	- 6 dB / octave
Sweep rate: 1 octave/minute, with 5 repeated up-sweeps	

- Pryoshock

Frequency, Hz	Qualification, Protoflight Peak Shock Response Spectrum (SRS) Response (Q=10)
100	20 g
100-1600	+10.0 dB / octave
1600-10000	2000 g

- Thermal-vacuum
  - Mars ambient, 9mb-13mb
    - Hot case +50C
    - Nominal +20C
    - Cold case -40C

TRL timeline

- Targeted TRL for these technologies is TRL 5: TVAC and vibration testing must be undertaken, and impact of sterilization process to meet AD-6 analyzed. Further testing can be proposed to increase TRL.
- Proposer to propose duration to reach target TRL. Anticipated to be 18 months or less.

Targeted missions

TEMMI could be a potential payload contribution for a potential Mars 2020 rover mission. It may also be a candidate contribution to future lunar missions.

Specific Deliverables

The deliverables defined here complement Section A.6 Contract Deliverables and Meetings of Annex A.

- Test data and test reports (contractor's format)
- Sterilization analysis report for planetary protection (contractor's format)
- Tested hardware units of each technology solution
- Associated control equipment/software, as relevant
- User guides (contractor's format)
- Other equipment purchased under the contract
- Technology Readiness and Risk Assessment Worksheets and Rollup
- Technology Roadmap Worksheet

Priority Technology 9 (PT 9)

Novel DNA-based Dosimeter for Space

Novel DNA-based Dosimeter for Space

List of Acronyms

ISS: International Space Station
DNA: Deoxyribonucleic Acid
ROM: Rough Order Magnitude

Applicable documents

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

AD No.	Document Number	Document Title	Rev. No.	Date
AD-1	CSA-ST-GDL-0001	CSA Technology Readiness Levels and Assessment Guidelines *ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA*	Rev A	October 2010
AD-2	ESTEC TEC-SHS/5574/MG/ap	Technology Readiness Levels Handbook for Space Applications *ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA*	Iss. 1 / Rev. 6	March 2009
AD-3		Technology Readiness and Risk Assessment Worksheet: TRA Assessment Worksheet.pdf ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA/		
AD-4		Technology Readiness and Risk Assessment Rollup: TRA_Assessment_Tool.xlsm ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA/		
AD-5		Roadmap Framework: ExCore Concept Study TechnologyRoadmappingWorkbook.xlsx ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRM/		

Reference documents

This section lists document that provide additional information to the bidder, but are not required to develop the proposal.

RD No.	Document Number	Document Title	Rev. No.	Date
RD-1.	n/a	T. Wood, B.J. Lewis, K. McDermott, L.G.I. Bennett, K. Avarmaa, E.C. Corcoran, D. Wilkinson, A. Jones, T. Jones, L. Prud'homme-Lalonde, D. Boudreau, J.-F. Gravel, C. Drolet, A. Kerr, L.J. Schreiner, M. Pierre, R. Blagoeva and T. Veres, "Use of a Dual-Labelled Oligonucleotide as a DNA Dosimeter for Radiological Exposure Detection," Radiation Protection Dosimetry 148 (2012) 20-33., Oxford Journals		2012

Technology Description

A novel deoxyribonucleic acid (DNA) dosimeter technology, aimed at measuring dose exposure to ionizing radiation for all radiation types and in possible mixed-field applications, has the potential of providing crucial information on the radiation effects on space crews. Current prototypes of DNA-dosimeters, made for terrestrial use, consist of short DNA strands suspended in water (cell-like environment). These dosimeters are designed to provide key real-time information that directly relates to the radiation damage on human DNA. This kind of information is currently not available for health risk monitoring and assessment of space crews. However, the current liquid-based system is not suitable for use in space, and work is required to assess the feasibility of a gel-state version of the DNA-dosimeter and the development of a functional prototype.

The DNA dosimeter would be compatible and critically complementary with physical dosimetry and biodosimetry methods currently used for radiation exposure monitoring of space crews. It would be complementary in being able to provide unique information: unlike all the other devices currently used for crew radiation health monitoring, the DNA dosimeter is completely biologically-based and capable of detecting doses from all types of radiation, including a mixed-radiation field, and operates over a wide range of exposure as experienced in space. Because it is "naked" (i.e., not subject to repair mechanisms), it also does not suffer from individual-sensitivity effects.

Scope of Work

The scope of work defined here complements Section A.5 Generic Task Description of Annex A.

The scope of the work is to develop and test a terrestrial prototype of a gel-based DNA-dosimeter (instead of an aqueous-based one) suitable for use in space environment.

The Contractor must perform a Technology Readiness and Risk Assessment (TRRA) of key technologies foreseen to be used in the proposed system, in accordance with the requirements of AD-1 and in AD-2 while using AD-3 and AD-4, and must describe the performance characteristics of the technology with respect to the needs of the targeted mission for the given target environment.

The Contractor must provide a Technology Development Plan, a.k.a. Technology Roadmap (TRM), including the required technology developments to meet targeted mission needs, and a plan and timeline to reach TRL 6 and 8. The Technology Roadmap must be provided as well in the format of AD-5.

Functional characteristics and performance requirements

In order to develop a terrestrial prototype of a gel-based DNA-dosimeter (instead of an aqueous-based one) the following research and development steps in a laboratory setting are required: identifying a suitable gel, identifying and testing a method to embed the DNA dosimeter (preferably double-strand) in the selected gel (to form a polymer); testing and verifying the functionality and stability of the assembly to validate functional predictions regarding this technology (including optimization of the signal-to-noise ratio, assess the effects of photo-bleaching on continuous detector reading, and assess the long-term effects of radiation exposure on the black hole quencher and fluor signaling components of the device); determine the response of the dosimeter for single versus double strand breaks in order to assess the radiation quality and risk; and construction of a full gel-based prototype. The gel-based DNA dosimeter, once developed, will be a stand-alone system with no power requirements with a portable reader system. It is also expected to be a more stable device (i.e., less temperature sensitive) with a longer shelf-life and greater sensitivity, than the current liquid-based versions. Also, it is expected to be more sensitive than those for terrestrial use, where the aqueous-based system currently has a lower limit of detection (i.e. sensitivity) of ~100-150 mGy.

TRL timeline

- The targeted TRL for this technology development is TRL 3 within the contract period.

Targeted missions

The DNA- dosimeter is applicable for all human space missions for in-space, real-time radiation health risk assessment and monitoring.

Specific Deliverables

The deliverables defined here complement Section A.6 Contract Deliverables and Meetings of Annex A

- Technical Report also outlining the identification and testing of a suitable gel
- Technical Report also outlining a method to embed the DNA dosimeter (preferably double-strand) in the selected gel (to form a polymer)
- Technical Report also outlining testing and verification of the functionality of the new gel-based assembly

- Technical Report also outlining the details of a full gel-based prototype, including full construction details allowing the re-fabrication of the prototype.
- Technology Readiness and Risk Assessment Worksheets and Rollup
- Technology Roadmap Worksheet

Priority Technology 10 (PT 10)

Mid-wave Infrared Microbolometer Sensor Breadboard

Mid-wave Infrared Microbolometer Sensor Breadboard

This work is for the development of a mid-wave infrared microbolometer sensor breadboard. This breadboard is intended for the investigation of a microbolometer-based multispectral scanner concept. Specifically, it will be used to evaluate the spectral radiometric performance of microbolometer sensor at mid-wave infrared wavelengths.

1. Objective:

The Linear Array MUltispectral Scanner (LAMUS) is part of a suite of instruments proposed in a recent concept study for CSA microsatellite missions. LAMUS is a scientific instrument derived from the New Infrared Sensor Technology (NIRST) demonstrator previously built under a Collaborative Agreement between the CSA and the Comision Nacional de Actividades Espaciales (CONAE) of Argentina. LAMUS relies on the use of two linear arrays of microbolometers that are sensitive, respectively, to the mid-wave infrared (MWIR) and long-wave infrared (LWIR) spectral bands. Co-registration of images in these bands will be performed for the purpose of retrieving a variety of science data including surface temperatures of biomass fire. To improve the noise equivalent temperature difference (NETD) and radiometric accuracy of the sensor, dedicated microbolometer pixel design and microengineering process will need to be developed for each spectral band. In addition, the integration of blackbodies for in-flight radiometric calibration of the sensor will be required.

The objective of this work is to advance the microbolometer sensor technologies in the MWIR as this is critical for fire studies. This will mainly be accomplished by modifying the microbolometer structure to increase its MWIR absortance and detectivity, and by implementing the capacity of in-flight radiometric calibration for the sensor. To evaluate the effects of these new features a sensor breadboard is needed for the characterization of sensor performance. This breadboard consists of a front telescope and a back camera housing. The latter encloses: (i) a linear array of microbolometers with monolithic readout electronics and MWIR bandpass filter assembly, all vacuum sealed in a radiometric package; and (ii) circuit boards of proximity and control electronics for control and data acquisition. The breadboard provides also for the integration of radiometric calibration blackbodies in the optical path.

This development is designed to advance the technology readiness level (TRL) of LAMUS sensor from TRL-3 to TRL-4.

2. Tasks:

The main tasks to be performed are as follows:

2.1 - Optimization of MWIR performance of linear arrays of microbolometers

- Perform tradeoff between shunt and blind reference pixels
- Perform design of microbolometer pixel and predict the MWIR performance through modeling
- Characterize monolithic readout electronics for screening and selection
- Fabricate linear arrays of microbolometers over selected readout electronics
- Perform on-wafer probing for the screening and selection of dies

2.2 - Development of vacuum sealed radiometric package

- Design the radiometric package with required optomechanical and electrical interfaces
- Procure the components for the package manufacturing
- Determine the spectral characteristics of the MWIR bandpass filter and package window
- Assemble the bandpass filter on the array and perform precision alignment
- Provide temperature control for array and filter
- Develop the soldering process to seal the MWIR window onto the package
- Perform vacuum bake-out and seal
- Conduct electrical tests and characterization of vacuum integrity and lifetime

2.3 - Development of sensor breadboard

- Design the sensor breadboard including provision for the integration and test of calibration blackbodies and of future LWIR sensor
- Design the proximity and control electronics and fabricate the circuit boards
- Design and manufacture or procure optical bench, camera housing, and telescope
- Design the support and interface for the electronics
- Integrate the radiometric package into the circuit boards and perform alignment
- Write codes for control and data acquisition parameters

2.4 - Tests

- Confirm functionalities of control and data acquisition
- Measure the yield, spectral response, noise equivalent power, and response time of the pixel
- Measure the noise equivalent temperature difference at the system level
- Measure the Allan variance and Allan time and derive optimum conditions for in-flight radiometric calibration
- Perform radiometric characterization and evaluate the radiometric accuracy
- Inspect pixel crosstalk in presence of high temperature targets
- Perform environmental tests on the linear arrays, bandpass filters, and radiometric packages; evaluate changes in their characteristics following the tests

3. Deliverables:

- Specification sheets for breadboard components
- Manufacturing procedures
- Integration plan
- Test plan and procedures
- Radiometric calibration plan and procedure
- Radiometric package assembly drawings
- Breadboard assembly drawings
- Electrical and mechanical interface control designs
- One (1) standalone, portable sensor breadboard on optical bench with one (1) radiometric package, proximity and control electronics, and telescope
- Control and data acquisition software

- Test report and data
- All other documents and data generated during the work

4. Requirements:

4.1 Linear array of microbolometers

[LAM-R01] - The format of the linear array shall be 512x3 or of a larger size

[LAM-R02] - The thermally sensitive element of the pixel shall be uncooled resistive microbolometer

[LAM-R03] - The pixel unit should be made of active and reference pixels

[LAM-R04] - The lateral pitch of each pixel shall be smaller than 40 um

[LAM-R05] - The fill factor of the linear array should exceed 90%

[LAM-R06] - The readout electronics shall enable simultaneous readout of all pixels for scanning periods of up to 140 ms

[LAM-R07] - The readout electronics shall provide for integrate-while-read operating mode

[LAM-R08] - The pixel output shall be digitized to at least 14 bits

[LAM-R09] - The pixel responsivity should exceed 85% of the maximum responsivity in the MWIR band

[LAM-R10] - The pixel response to radiance input should be linear for scene temperatures of up to 700 K

[LAM-R11] - The power consumption of each line of the array should be less than 800 mW

[LAM-R12] - The detectivity of the active pixel shall exceed 10^9 cm.$Hz^{1/2}$/W at room temperatures in the spectral band from 3.4 to 4.2 um under normal operating conditions

[LAM-R13] - The response time of the active pixel shall be smaller than 10 ms

[LAM-R14] - The absorptance of pixel in the spectral band from 3.4 to 4.2 um shall exceed 0.7

[LAM-R15] - The noise equivalent temperature difference for the spectral band from 3.4 to 4.2 um should be smaller than 500 mK when acquiring a 400 K target during a 50-ms period of integration using F/1.0 optics

4.2 Interference bandpass filter

[IBF-R01] - The transmittance of the bandpass filter should exceed 0.9 in the spectral band from 3.4 to 4.2 um

[IBF-R02] - The full width at half maximum of the bandpass filter shall be 0.8 +/- 0.05 um

[IBF-R03] - The out-of-band transmission of the bandpass filter shall be less than 3% when measured over the spectral ranges from 1.8 μm to 3.1 μm and from 4.7 to 15 um

[IBF-R04] - The angle of incidence of the bandpass filter shall be 0 to 45 degrees

[IBF-R05] - The filter-to-array separation distance shall be smaller than 2 mm

4.3 Vacuum radiometric package

[VRP-R01] - The radiometric package shall enclose the following components: (i) linear array of microbolometers; (ii) bandpass filter assembly; (iii) thermoelectric cooler and thermistor; (iv) routing circuit; (v) pressure gauge; and (vi) getter

[VPR-R02] - The radiometric package should fit in an envelope of 75 mm by 60 mm by 20 mm

[VPR-R03] - The radiometric package should weigh less than 150 g

[VRP-R04] - The baseline pressure inside the radiometric package should be less than 10 mTorr for a period of at least three (3) years.

[VPR-R05] - The temperature of the linear array should be controlled to a stability of better than 10 mK for heat sink temperatures in the range from 283 to 291 K

[VPR-R06] - The transmittance of the MWIR window of the package shall exceed 0.8 in the spectral band from 3.4 to 4.2 um

4.4 Sensor breadboard

[SBB-R01] - The sensor breadboard shall be standalone and portable

[SBB-R02] - The breadboard camera housing should fit in an envelope of 230 mm by 150 mm by 150 mm and shall enclose the radiometric package and the proximity and control electronics

[SBB-R03] - The control and data acquisition software shall be compatible with Windows XP and Window 7 operating system

[SBB-R04] - The proximity and control electronics shall provide the following functions: (i) quality control of readout electronics and linear arrays; (ii) radiometric characterization; (iii) activation of selected lines of array; (iv) control of operating parameters such as integration time and reference voltage

Priority Technology 11 (PT 11)

Dexterous Robotic Tools

Dexterous Robotic Tools

List of Acronyms

AD: Applicable Document
CSA: Canadian Space Agency
GSFC: Godard Space Flight Center
ISS: International Space Station
NASA: National Aeronautics and Space Administration
ORU: Orbital Replaceable Unit
OTCM: ORU Tool Change-Out Mechanism
RD: Reference Document
RRM: Robotic Refuelling Mission
TRL: Technology Readiness Level

Applicable documents

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

AD No.	Document Number	Document Title	Rev. No.	Date
AD-1	CSA-ST-GDL-0001	CSA Technology Readiness Levels and Assessment Guidelines *ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA*	Rev A	October 2010
AD-2	ESTEC TEC-SHS/5574/MG/ap	Technology Readiness Levels Handbook for Space Applications *ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA*	Iss. 1 / Rev. 6	March 2009
AD-3		Technology Readiness and Risk Assessment Worksheet: TRA Assessment Worksheet.pdf ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA/		
AD-4		Technology Readiness and Risk Assessment Rollup: TRA_Assessment_Tool.xlsm ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA/		
AD-5		Roadmap Framework: ExCore Concept Study TechnologyRoadmappingWorkbook.xlsx ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRM/		

Reference documents

This section lists document that provide additional information to the bidder, but are not required to develop the proposal.

RD No.	Document Number	Document Title	Rev. No.	Date
RD-1.	RPT-MODEL-M-0002	Mission for Orbit Debris Elimination—Executive Report	Rev. P1	Mar 9, 2012
RD-2.	COARSE-ER-008-MDA-9F052-101461-004	Canadian On-Orbit Automated Robotic Servicing Experiment—Executive Summary	Final	Mar 30, 2012

Technology Description

A prepared spacecraft is one that has been designed with servicing features in mind, such as a grapple fixture that can be captured by a manipulator, while an unprepared space vehicle makes no such accommodations. The large majority of space vehicles in orbit today, and even the large majority of space vehicles that are still on the drawing board or in various stages of preparation for launch, can be classified as unprepared. There are many different agencies and companies developing spaceflight hardware, however, at present, there are few agreed upon robotic servicing standards, and it is expected that this will take years to resolve. A servicing standard imposing only a small set of interface requirements on hardware providers, however, is more likely to be readily adopted. The abundance of unprepared space vehicles and the greater likelihood of achieving acceptance for servicing standards that minimize impacts to spaceflight hardware providers points to an inescapable conclusion: dexterous robotic tool technologies that enable the servicing of unprepared (or lightly prepared) space vehicles are critically important for the execution of future servicing missions.

Critical operations for servicing missions involve either docking (i.e., direct mating of a servicing vehicle to a client vehicle to be serviced), capture and berth operation (i.e., robotic arm capture, handling and berthing of a client vehicle to be serviced to a servicing vehicle), as well as the servicing tasks themselves. There are different methods currently under consideration to capture intact objects and smaller orbital debris segments but, only Canada has demonstrated successful on-orbit robotic capture of an intact object. There is some technology development required to complete the offering for a robotic orbital debris capture system, and in particular the capture tool technology.

In 2012, the Robotics Refuelling Mission (RRM) demonstrated on-orbit robotic servicing tasks. It was a collaborative effort between CSA and NASA, using specialized tooling hardware designed by NASA and Canadian robotic assets on the ISS. NASA's Goddard Space Flight Center (GSFC) designed the RRM payload and tools that were used by Dextre to simulate robotics servicing of an unprepared client satellite on ISS. The RRM payload consisted of a main body that included worksites hosting representative satellite interfaces for coolant, fuelling, power, and data transfer and video. In order for Dextre to perform the necessary tasks, specialized tools were required to act as interfaces between Dextre's Orbital Replaceable Unit (ORU) Tool Change-Out Mechanisms (OTCMs) and the multiple worksite types integrated into the RRM. Canada has not yet produced high TRL, flight-ready tools with these capabilities although prototypes of such technologies have been developed in past

technology development programs. Advancing the TRL of the Canadian technologies would give Canada the opportunity to secure a solid role in on-orbit asset capture and servicing.

The development of advanced dexterous robotic tools enabling capture and servicing of orbital assets is consistent with the goals and strategy of the CSA and will extend the capability of a signature technology. Maintaining Canada's lead in robotic servicing technologies promises a rich scientific and commercial return, while securing Canada's highly visible and critical participation in the next era of exploration activities.

Scope of Work

The scope of work defined here complements Section A.5 Generic Task Description of Annex A.

The contractor will perform the work required to bring a dexterous robotic tool concept to TRL 4 +, where the technology has a path to flight and is close to a protoflight model (see functional characteristics and performance requirements section). It is highly preferable that the tool concept be already well understood (at least TRL 2 or 3), such that the project can effectively deliver at TRL 4+ technology. The scope of this SOW encompasses the following activities:

1. Project planning and management;
2. Product Assurance and Configuration Management;
3. Systems Engineering;
4. Define the Design Reference Mission (DRM) for the dexterous robotic tool, or set of tools;
5. Applicable technologies literature survey;
6. Development of technical requirements and baseline configurations;
7. Preliminary and detailed design;
8. Manufacturing, Assembly and Verification of Breadboard (BB) model of the dexterous robotic tool(s);
9. Manufacturing, Assembly and Verification Engineering Development Unit (EDU) of the dexterous robotic tool(s);
10. Demonstrations;
11. Provision of all ground support equipment and shipping containers required for turn-key delivery and demonstrations of the above hardware;
12. Provision of all related documentation; and
13. Provision of all related software including configuration and change management repositories.

The Contractor must perform a Technology Readiness and Risk Assessment (TRRA) of key technologies foreseen to be used in the proposed system, in accordance with the requirements of AD-1 and in AD-2 while using AD-3 and AD-4, and must describe the performance characteristics of the technology with respect to the needs of the targeted mission for the given target environment.

The Contractor must provide a Technology Development Plan, a.k.a. Technology Roadmap (TRM), including the required technology developments to meet targeted mission needs, and a plan and timeline to reach TRL 6 and 8. The Technology Roadmap must be provided as well in the format of AD-5.

Functional characteristics and performance requirements

The technology product resulting from this contract will be a functional laboratory prototype of a dexterous robotic tool, demonstrated using a representative robotic facility. To this end, the contractor must produce a breadboard model (BB) of the tool and an Engineering Development Unit (EDU) defined as follows:

- Breadboard (BB): a BB model will be functionally and electrically representative of key parts of the system. It will be used to validate a new or critical feature of the design and development of software. There are no specific requirements for configuration and interface control; and
- Engineering Development Unit (EDU): an EDU will be built for ambient functional testing. A lower standard may be used for the EEE parts but they will be of the same type and same package as for a protoflight model.

The representative robotic facility must have the following features:

1. Representative number of Degrees of Freedom (DoF) consistent with the needs of the DRM;
2. Representative accuracy and control capability consistent with the needs of the DRM;
3. Enough load carrying capability to operate the EDU;
4. Have a workspace and reach consistent with the needs of the DRM;
5. Be capable of carrying out the functional demonstration of the tool;
6. Be equipped with an end-effector such that the tool can be fixed to it or grasped by it; and
7. Be accessible for use by the contractor for the purpose of demonstrating the tool.

TRL timeline

- Initial TRL: 2 to 3
- Targeted TRL: 4+ (EDU)

Targeted missions

The specific mission classes that could directly benefit from the manipulator and servicing tool technology include:

- Satellite servicing, repair, de-orbiting;
- Servicing of orbital assets, including the ISS;
- Orbital debris mitigation; and
- Planetary exploration missions (on-planet sampling, sample return).

Specific Deliverables

The deliverables defined here complement Section A.6 Contract Deliverables and Meetings of Annex A

- Breadboard model (BB) of the tool

- Engineering Development Unit (EDU)
- Technology Readiness and Risk Assessment Worksheets and Rollup
- Technology Roadmap Worksheet