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

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

Title - Sujet
Generic Technologies

Solicitation No. - N° de l'invitation	**Date**
9F063-130093/A	2013-06-20

Client Reference No. - N° de référence du client
9F063-13-0093

GETS Reference No. - N° de référence de SEAG
PW-$MTB-450-12341

File No. - N° de dossier	**CCC No./N° CCC - FMS No./N° VME**
MTB-3-36035 (450)	

Solicitation Closes - L'invitation prend fin
at - à 02:00 PM
on - le 2013-07-30

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**

Canada

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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

Generic 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 Generic Technologies listed in Table 1.1 aimed at encouraging innovation in CSA-aligned technologies applicable to multiple platforms, payloads, or ground infrastructure. 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. The Priority Technologies are those that have the potential for innovation and/or technological impact and have been established by the CSA as strategic technologies to be developed to meet the objectives set forth by the Canadian Space Strategy.

Up to 13 contracts may be awarded.

Rank	PT #	Priority Technology Title	Maximum Funding (K$)
1	PT 1	High Pulse Energy Laser for Remote Sensing	500
2	PT 2	Fore-Optics for Wide Field-of-View (FOV) VNIR/SWIR Applications	250
3	PT 3	EMCCD for Astronomy	150
4	PT 4	Multi-function CFRP Structure	500
5	PT 5	Shock Attenuating System	250
6	PT 6	Thermal isolation technology for sensor reliability enhancement	250
7	PT 7	Development of Thermally Stable Composite Structures for Space Applications	250
8	PT 8	On-board propulsion system for Micro and Small Satellite Stationkeeping and De-Orbiting	250
9	PT 9	Protection from Debris (MMOD Shield)	250
10	PT 10	Advanced Autonomy for Space Robotics Servicing	300
11	PT 11	Highly compact low-frequency high-gain antenna	600
12	PT 12	Gallium Nitride (GaN) High Power Amplifier development for X-Band Applications	575
13	PT 13	Radiation Protective Textiles	375

Table 1.1: List of Generic Priority Technologies

Period of Contract

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

Actual Available Budget

The actual budget available under this RFP is $4.5M, 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 Manual

(https://buyandsell.gc.ca/policy-and-guidelines/standard-acquisition-clauses-and-conditions-manual) issued by Public Works and Government Services Canada.

Bidders who submit a bid agree to be bound by the instructions, clauses and conditions of the bid solicitation and accept the clauses and conditions of the resulting contract.

The 2003 (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 and forty (240) days

2.2 *Manual SACC* 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 by 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 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, Goods and Services Tax (GST) and Quebec Sales Tax (QST) extra, as appropriate, for each contract resulting from the bid solicitation is indicated in *Table 1.1: List of Generic 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 Generic 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 Generic Priority Technologies*. The total amount of Goods and Services Tax and 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 Generic Priority Technologies.* The total amount of Goods and Services Tax and Quebec Sales Tax is to be shown separately, if applicable.

(b) Prices must be in Canadian funds. The total amount of Goods and Services Tax and 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 GST 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) GST and QST: Bidder must identify any applicable GST and 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 Generic 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

5.1.1 Code of Conduct and Certifications - Related documentation

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. Additional Certifications Precedent to Contract Award

The certifications included in Attachment 1 to Part 5 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 – $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 (http://www.hrsdc.gc.ca/eng/labour/equality/fcp/index.shtml).

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.

Certification

By submitting a bid, the Bidder certifies that the information submitted by the Bidder in response to the above requirements is accurate and complete.

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.

PART 6 - FINANCIAL AND OTHER REQUIREMENTS

6.1 Financial Capability

Manual SACC 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 (2013-04-25), 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 Goods and Services Tax and Quebec Sales Tax (GST and QST), as applicable, must be calculated on the total amount of the claim. At the time the holdback is claimed, there will be no GST and 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 Goods and Services Tax and Quebec Sales Tax (GST and 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 GST and 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 (2013-04-25), 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 (Generic 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 Generic 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 Generic 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 Generic 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.

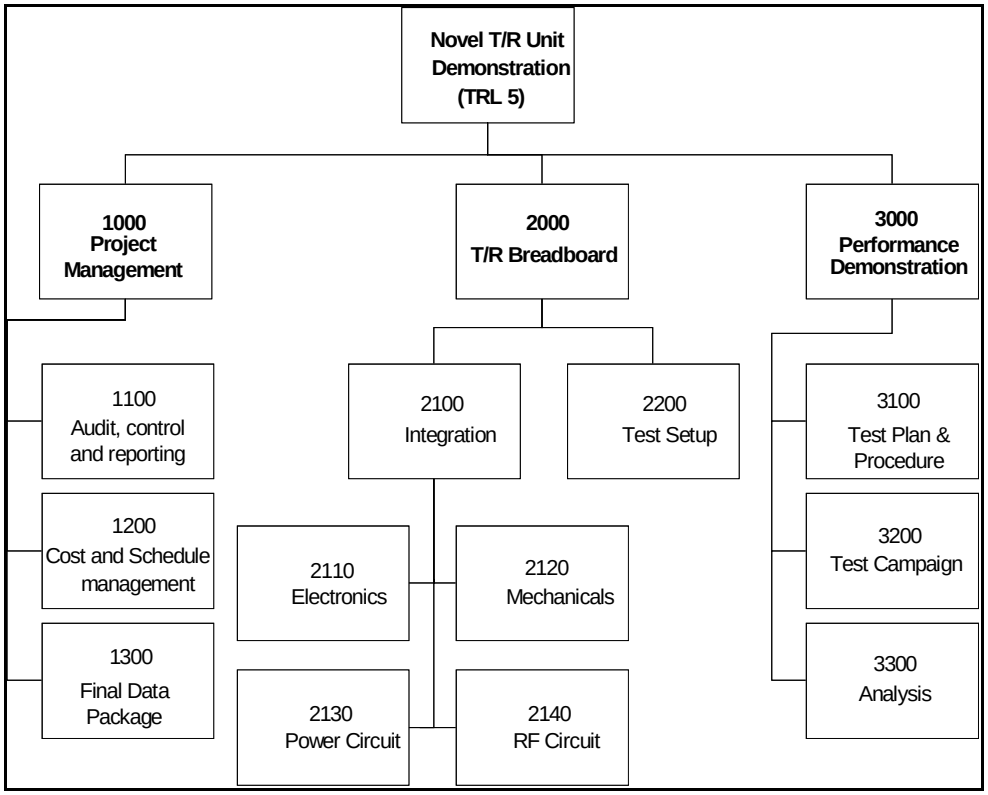

Figure 3A.1: Example of a Work Breakdown Structure

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:** Generic 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 $_____ (GST and 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: $ _____

(GST and 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 13 Generic Technologies aimed at encouraging innovation in CSA-aligned technologies applicable to multiple platforms, payloads, or ground infrastructure. 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).

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 GENERIC PRIORITY TECHNOLOGIES

Priority Technologies are those that have been established by the CSA as the strategic 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.

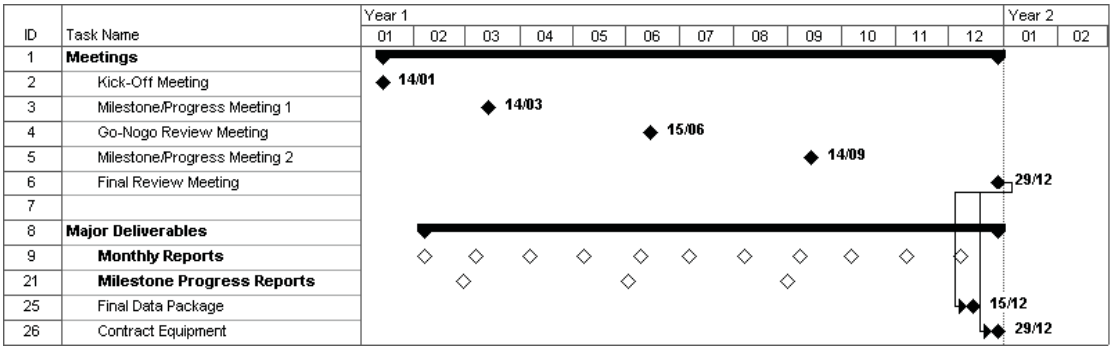

Figure A-1: Sample Meetings and Deliverables Master Schedule

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.
>
> 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	Maximum Funding (K$)
1	PT 1	High Performance Laser for Remote Sensing	500
2	PT 2	Detailed Design of a Fore-Optics Appropriate for Wide Field-of-View (FOV) VNIR/SWIR Applications	250
3	PT 3	Single Photon Counting Large Format Detectors with Enhanced UV Response for Space Astronomy Applications	150
4	PT 4	Multi-function CFRP Structure	500
5	PT 5	Shock Attenuating System	250
6	PT 6	Thermal isolation technology for sensor reliability enhancement	250
7	PT 7	Thermally Stable Composite Structures for Optical Payloads	250
8	PT 8	On-Board Green Propulsion Systems for Station-keeping & De-Orbiting of Microsatellites	250
9	PT 9	Protection from Space Debris Novel MMOD shields	250
10	PT 10	Advanced Autonomy for Space Robotics Servicing	300
11	PT 11	High-power deployable UHF antenna	600
12	PT 12	Gallium Nitride (GaN) High Power Amplifier development for X-Band Applications	575
13	PT 13	Space Radiation Shielding Materials	375

Table A-5-1: List of Generic Priority Technologies

PRIORITY TECHNOLOGIES SPECIFIC STATEMENT OF WORKS

Table of Contents

Priority Technology 1 (PT 01)

High Performance Laser For Remote Sensing

PT01 - High Performance Laser for Remote Sensing

List of Acronyms

AD:	Applicable Document
BB	Breadboard
CSA:	Canadian Space Agency
DIAL	Differential Absorption Lidar
EDU	Engineering Development Unit
HPLS	High Performance Laser System
ISS:	International Space Station
LIBS	Laser Induced Breakdown Spectroscopy
RD:	Reference Document
SOW	Statement of Work
TRL:	Technology Readiness Level
TRM	Technology Roadmap

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		Roadmap Framework: ExCore Concept Study TechnologyRoadmappingWorkbook.xlsx		

AD No.	Document Number	Document Title	Rev. No.	Date
		ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRM/		

Technology Description

This development targets advancement of a short (nanosecond) pulse solid-state laser technology. A short pulse high peak power laser, typically based on Q-switch technology, is a heart of many active optical remote sensing instruments. In 2008, a Canadian laser of this class has been flown onboard Phoenix Mars mission. This RFP targets advancement of this technology that would enable a larger array of future laser instrumentation in space.

The key improvement that this development is focused on is increasing the laser pulse energy up to 20 mJ level from the 1 mJ capability demonstrated during Phoenix mission. The expectation on the laser technology advancement is detailed in the Functional Characteristics and Performance Requirements section. This improvement will be crucial for future longer range and higher resolution atmospheric backscatter Lidars for Planetary Exploration (similar to Phoenix) or for Earth Observation, as well as analytical Lidars such as DIALs (Differential Absorption Lidar) for gas sensing (ozone, water vapor, etc.). This laser will enable a Flash Lidar concept where the scene is illuminated at once by a high energy laser and a focal plane array sensor takes ranging information without scanning. Science instruments, such as, Laser Induced Breakdown Spectroscopy (LIBS) and Raman Spectroscopy will also be enabled by this laser.

This development targets advancement of the described laser technology from TRL-2/3 to TRL-4.

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 High Performance Laser concept to TRL 4, where the technology has a path to flight. It is highly preferable that the laser 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:

- Project planning and management;
- Product Assurance and Configuration Management;
- Systems Engineering;
- Define the potential future missions and instruments for the high performance laser;
- Applicable technologies literature survey;
- Development of technical requirements and baseline configurations;
- Preliminary and detailed design;
- Manufacturing, Assembly and Verification of Breadboard (BB) model of the high performance laser;

- Manufacturing, Assembly and Verification of Engineering Development Unit (EDU) of the high performance laser;
- Demonstrations;
- Provision of all ground support equipment and shipping containers required for turn-key delivery and demonstrations of the above hardware;
- Provision of all related documentation; and
- Provision of all related software.

The Contractor must provide a Technology Development Plan, a.k.a. Technology Roadmap (TRM), including the required technology developments to meet potential 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-3.

Functional characteristics and performance requirements

The technology product resulting from this contract will be a functional laboratory bread board prototype of a high performance laser, demonstrated in a laboratory environment. To this end, the contractor must produce a breadboard model (BB) of the laser 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 laser design and development of software. There are no specific requirements for configuration and interface control; and
- Engineering Development Unit (EDU): an EDU will be an integrated unit 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 mass, volume and power consumption allocations should be in line with the expected protoflight model allocations.

The following specifications of the high performance laser (at a level of EDU) should be considered as initial design guidelines for this development.

- [HPLS – 001] High Performance Laser System (HPLS): The system shall generate repetitive short pulse laser radiation in a controlled manner that can be used for laser remote sensing applications.
- [HPLS – 002] Wavelength: The wavelength should be within the range from 900 nm to 1600 nm.
- [HPLS – 003] Pulse energy: The laser pulse energy should be 20 mJ as measured within 7 ns laser pulse interval. Pulse to pulse energy stability should be better than 1 %.
- [HPLS – 004] Pulse duration: The laser beam pulses should be in duration no more than 7 ns. Smaller duration (sub-nanosecond to picosecond) is considered as an advantage provided that the pulse energy specification is met. The duration is defined by 50 % level of the pulse peak.

- [HPLS – 005] Repetition rate: The laser should operate at a variable repetition rate from a single shot up to the maximum rate. The maximum rate should be 5 Hz or higher.
- [HPLS – 006] Beam quality: The system should target near-Gaussian beam quality. The deviation from the Gaussian quality should not exceed 50 %, corresponding to M-square parameter 1.5 or better.
- [HPLS – 007] Beam diameter: The system should provide circular beam output with the diameter of the beam in the range from 0.5 mm to 5 mm.
- [HPLS – 009] Laser lifetime: The system should be designed to operate continuously during 3 year period before its performance fail to meet the specifications.
- [HPLS – 010] Mass: The laser should be designed to allow scaling down such that the estimated mass of eventual flight laser will not exceed 2 kg.
- [HPLS – 011] Volume: The laser should be designed to allow scaling down such that the estimated volume of eventual flight laser will not exceed 1 litre.
- [HPLS – 012] Power: The laser should be designed to allow scaling down such that the estimated power consumption of eventual flight laser will not exceed 10 W.

TRL timeline

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

Targeted missions

The specific mission classes and classes of instruments that could directly benefit from the high performance laser technology include but not limited to the following:

- Servicing of orbital assets, including the ISS: flash Lidar, long range Lidar;
- Orbital debris mitigation: flash Lidar, long-range Lidar;
- Earth observation missions: analytical Lidars, DIALs, laser altimeters, cloud and vegetation profiling;
- Planetary exploration landing missions: navigation flash Lidars, atmospheric Lidars, LIBS and Raman sensors;
- Planetary exploration orbiting missions: analytical Lidars and DIALs.

Specific Deliverables

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

- Laser Concept Document including technology trade-offs;
- Breadboard model (BB) of the laser;
- BB laboratory demonstration of key performance parameters (Laser Pulse Energy, Pulse Duration, Beam quality, Repetition Rate);
- BB design and test report;

- Engineering Development Unit (EDU) and EDU user manual;
- EDU laboratory demonstration of key performance parameters as well as usability for a selected application scenario (for example, long-range Lidar, flash Lidar, LIBS, etc.);
- EDU design and test report;
- Technology Roadmap Worksheet;
- Final report including updated concept, design summary and path to flight analysis.

Priority Technology 2 (PT 02)

Detailed Design of a Fore-Optics Appropriate for Wide Field-of-View (FOV) VNIR/SWIR Applications.

PT02 - Detailed Design of a Fore-Optics Appropriate for Wide Field-of-View (FOV) VNIR/SWIR Applications

List of Acronyms

AD:	Applicable Document
AIT:	Alignment Integration and Test
CSA:	Canadian Space Agency
FOV:	Field of View
GSD:	Ground Sampling Distance
LEO:	Low Earth Observation Orbit
MTF:	Modulation Transfer Function
RD:	Reference Document
RSA:	Rapidly Solidified Aluminum
STOP:	Structural –Thermal- Optical
SWIR:	Short Wave Infrared
TMA:	Three Mirrors Anastigmat
TRL:	Technology Readiness Level
VNIR:	Visible to Near Infrared

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-	Iss. 1 / Rev. 6	March 2009

AD No.	Document Number	Document Title	Rev. No.	Date
		csa.gc.ca/users/TRP/pub/TRL-TRA		
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/	D	May 2013
AD-5		Roadmap Framework: ExCore Concept Study TechnologyRoadmappingWorkbook.xlsx ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRM/		

Technology Description

The development of an aspherical fore-optics (often referred to as a telescope) appropriate for space applications represents significant technological challenges in the VNIR and SWIR spectral ranges. Currently, international expertise exists in the complete process of a telescope design, fabrication, assembly, and testing. This expertise is coupled with proprietary manufacturing advances that have enabled the development of aspherical, large aperture, mirrors resulting in increased telescope performance. This expertise is largely absent domestically, where the main deficiency is the inability to fabricate the appropriate high quality mirrors. Although in general they can be fabricated using variety of materials like glass, silicon carbide or beryllium, from the current CSA perspective the main interest is in the aluminum. The technology of choice is the single point diamond turning with main challenges being low surface micro roughness (below 5nm rms) and thermal and structural stability of the individual mirrors and of the whole assembly. The final purpose of this technology development is to increase the Canadian industrial capacity to design, fabricate, assemble, and test fore-optics appropriate for VNIR/SWIR space applications. In the current technology implementation, the CSA is mostly interested in a FOV, moderate aperture telescope for hyperspectral applications from a microsat platform.

Scope of Work

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

PT02 - Detailed Design of a Fore-Optics Appropriate for Wide Field-of-View (FOV) VNIR/SWIR Applications

The contractor will perform the work required to bring a fore-optics concept to TRL 3 where the final design of the complete system is accomplished, together with trade off analysis for design and materials. It will include laboratory validation of the selected materials and processes supported by representative mirror coupons made of different type of aluminum (RSA, 6061-Al, Al-Si alloy, etc), plated or not plated, turned with different tools and speeds etc. As mentioned above aluminum is the current CSA preferred choice but other material options are not excluded with the stipulation that mirrors have to be manufactured in Canada.

The scope of this SOW encompasses the following activities:

- Project planning and management;
- Systems Engineering;
- Definition of the Design Reference Mission (DRM) for the wide FOV fore-optics.
- Applicable technologies literature survey;
- Development of technical requirements and baseline configurations;
- Preliminary and detailed design, including trade-off analyses, coupon tests and validations.
- Identification of a potential Canadian mirrors fabricator, including due diligence review of its capabilities.
- Manufacturing, Assembly and Verification Plan of the fore-optics Engineering Unit (EU);
- Provision of all related documentation.

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 detailed design of the wide FOV fore-optics, preferably in the form of a TMA telescope. To this end, the contractor must produce a detailed design defined as follows:

- Trade-off analysis for selected optical concept considering the following starting assumptions;
    - Hyperspectral pushbroom imager working in VNIR and SWIR from LEO type orbit (650 km, sun-synchronous)
    - F/#≤5

  - GSD =30m in VNIR and ≤60m in SWIR
  - FOV=250 km across the track (goal)
  - MTF≥0.7 for all fields and wavelengths at corresponding Nyquist frequency
  - Distortions<0.5 pixel (goal)
  - Telecentric in the image space

- Materials trade-off analysis for mirrors, mounts and optical bench for optimal optical, thermal and structural performance during launch and on-orbit.
- Selected mirror material sample tests validating basic trade-off analysis results like machinabilty, achievable micro-roughness or thermo-elastic properties.
- Complete opto-mechanical design, including mirrors mounts, enclosures, baffles etc
- STOP analysis
- Tolerance analysis
- Stray light analysis
- AIT plan

TRL timeline

- Initial TRL: 2
- Targeted TRL: 3+

Targeted missions

The specific mission classes that could directly benefit from the wide FOV fore-optics technology include:

- Hyperspectral/multispectral microsat mission;
- CASS/CATS
- PCW
- Planetary exploration missions

Specific Deliverables

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

- Detailed Design complete documentation
- Technology Readiness and Risk Assessment Worksheets
- Technology Roadmap Worksheet

Priority Technology 3 (PT 03)

Single Photon Counting Large Format Detectors with Enhanced UV Response for Space Astronomy Applications

PT03 - Single Photon Counting Large Format Detectors with Enhanced UV Response for Space Astronomy Applications

List of Acronyms

APS	Active Pixel Sensor
CCD	Charge Coupled device
CMOS	Complimentary Metal Oxide Semiconductor
CSA:	Canadian Space Agency
ESA	European space Agency
ICCD	Intensified Charge Coupled Device
ITAR:	International Traffic in Arms Regulations
JAXA	Japanese Space Agency
NASA:	National Aeronautics and Space Administration
QE	Quantum Efficiency
ROM	Rough Order of Magnitude
TRL:	Technology Readiness Level
UV	Ultra Violet
EMCCD	Electron Magnifying Charged Coupled Device

Applicable documents

N/A

Reference documents

N/A

Technology Description

PT03 - Single Photon Counting Large Format Detectors with Enhanced UV Response for Space Astronomy Applications

High efficiency ultraviolet (UV) photon detection is essential for many future space astronomy instruments and sensor concepts satisfying the goals of imaging spectroscopy to study topics ranging from the hot gas between galaxies through stars and the interstellar medium to exoplanets. This capability requires significant detector advances, particularly in quantum efficiency, low noise performance, resolution, and number of pixels in order to result in major new scientific impacts. New techniques such as EMCCD allow leveraging all the performance advantages of the mature CCD technology while enabling single photon detection. The goal of this project is to study the current status of UV sensor technology and to identify the technology development roadmap for flight qualified UV-enhanced large-area detectors for application to a 1-m class Canadian space telescope providing wide field imaging and spectroscopy in the UV and visible.

CSA has a long term interest in space qualified detector technology which has mostly been satisfied by foreign suppliers. Other agencies such as NASA, ESA and JAXA generally invest in the development of space-grade detectors by a process of customized design using national manufacturers. In contrast, optical instruments at CSA have used commercial off-the-shelf detectors from US or European suppliers. This approach requires significant compromise to address performance, cost, schedule, and design drivers associated with space applications.

Scope of Work

The purpose of this Statement of Work is to identify the development work-plan needed to support future Canadian astronomical, atmospheric science and earth-observation missions operating in the UV and visible spectral regions. The work executed during the term of this contract will identify the detector technologies which would meet CSA's future missions needs with minimum, moderate and substantial development efforts. The final report will also present analysis of the design and manufacturing gaps along with activities needed for the development of manufacturing capabilities for production of ruggedized high performance space qualified single photon counting detectors for the Canadian Space Sector.

The scope of work entails the following tasks:

Work Package	Description
General Support	Support technical meetings in which CSA will • describe the future priority missions (by mission class) and the preliminary detectors types under consideration to support mission goals, along design constraints and/or performance drivers needed to meet mission requirements. • describe the type, dose and energy of the radiation environment for various orbits.
Technology Survey	• Provide a survey of currently available single photon counting devices which may be suitable for space applications, such as CCD, EMCCD, CMOS, APS, diode arrays, ICCD, etc. and where appropriate provide a comparison of these technologies, considering factors such as but not limited to QE, radiation tolerance, etc. The comparison should be based

Work Package	Description
	on publicly available information and should include, at a minimum, existing capabilities in the United-States and in Europe. Prioritize the identified detectors based on their suitability to meet CSA's priority mission needs.
Capability Assessment	• Provide an assessment of Canadian capabilities for the design, development, manufacturing, tuning and customization of key manufacturing processes related to space qualified solid state detectors with enhanced UV response spectral range for use on CSA priority missions, including but not limited to as CCD, EMCCD, CMOS, APS, diode arrays, and ICCD. • Provide rough estimate of projected performance parameters, such as QE and radiation tolerance. • Summarize short-term, medium-term, and long-term drivers and risks for the development of technological capabilities (with minimum, moderate and substantial development efforts) to meet CSA's future missions needs • Identify mission applications that the proposed detector innovation will enable and/or enhance. • Summarize the findings (potential mission applications, technical milestones, development schedule, and potential costs) in a Detector Development Feasibility Analysis.
UV-enhanced Device Capacity Gap Analysis	The goals of this study are to investigate the current status of Canadian UV enhanced device technologies and to identify technology development activities needed to design and manufacture in a flight qualified single photon counting device for application to a Canadian spaceborne low light imaging camera system. • Present the status of research and development of the Canadian EMCCD with a summary of results achieved prior to the start of this feasibility study. • Perform a comparative assessment of the performance and technological capabilities of the proprietary EMCCD device, with regard to currently available products. • Examine the device design considerations and the time frame required to design an advanced chip with mission compatible area formats (e.g. 1024xl 024 and 2048x2048 pixels), etc. • Summarize the design approach to dealing with common device specific issues such as clock induced charge, bias stability control, precise control of voltage-clock timing, control over linearity of the amplification, temperature dependence of parameters, cooling requirements, power consumption, noise performance as a function of frame rate and operating temperature, etc. • Identify current manufacturing capabilities related to the device

Work Package	Description
	technology (such as ability to build a high QE back-illuminated deep depleted devices, etc.). Use an enhancement design libraries, mask sets, fabrication processes. • Describe packaging capabilities and the time frame required to design the package for a cooled device. • Describe the manufacturing and testing capability of the packaged device using standard testing capabilities. • Describe specialized space qualification for shock, vibration, radiation (X-ray, gamma-ray, electron, proton, etc), thermal and vacuum testing capabilities. • Provide ROM cost and schedule estimated for implementing items 4-8 above.

TRL timeline

- Initial TRL: 2
- Targeted TRL: 2

Targeted missions

The specific mission/instruments that could directly benefit from High efficiency ultraviolet (UV) single photon detection are:

- 1-m class Canadian space telescope (CASTOR mission) providing wide field imaging and spectroscopy in the UV and visible.
- UV-enhanced spectrometer with narrow band imaging capability to study various space astronomy phenomena, from the hot gas between galaxies, through stars and the interstellar medium to exoplanets. This could be a complimentary instrument for the CASTOR mission or Canadian contribution to an international space astronomy mission.(IXO Athena).

Specific Deliverables

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

- Power point presentations
- Monthly progress reports
- Final Report, including
    - Technology Survey of currently available single photon counting devices with enhanced UV response which may be suitable for CSA space applications

- Detector Development Feasibility Analysis, to assess Canada's capabilities for the development of space qualified detectors to enable or enhance mission applications including budgetary estimates of technological advancements
- Capacity Gap Analysis (for the selected device technology)

Priority Technology 4 (PT 04)

Multi-function CFRP Structures

PT04 - Multi-function CFRP Structures

List of Acronyms

AD: Applicable Document

CFRP: Carbon Fiber Reinforced Polymer

CNT: Carbon Nano Tube

CSA: Canadian Space Agency

EMI: Electro Magnetic Interference

NASA: National Aeronautics and Space Administration

RD: Reference Document

TRL: Technology Readiness Level

TRM Technology Roadmap

TRRA: Technology Readiness and Risk Assessment

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		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	ASTM E595	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment, ASTM International, http://www.astm.org/Standards/E595.htm	Rev. 07	2007

Technology Description

CFRP (Carbon-Fiber-Reinforced-Polymer) has been used for spacecraft for many years because of its high strength/weight ration and high thermal stability. It is used for structures such as antennas and their support structures, solar panel substrates, and bus panels for its structural strength and stiffness, and thermal stability. However, heavy metallic materials still have to be used where radiation shielding, EMI shielding, good thermal conductivity, and surface protection are required. Technologies are sought that would enable multi-function CFRP structures with similar mechanical, electrical, and thermal properties to aluminum, but much lighter weight, so that CFRP can be used in broader range of structures in spacecraft and space vehicles for which aluminum is used today. This is especially beneficial to some space exploration missions that need light but thermally stable structures, for which aluminum may not be suitable.

The advances of nanotechnology have made available novel materials that could be integrated with CFRP to make it have the required properties for radiation shielding, EMI shielding, thermal conduction, and erosion protection. Recent studies have shown that thin films fabricated with carbon nanotubes (CNT) or nano-particles are suitable for space radiation shielding. Carbon Nanotube (CNT) is also one of the fillers with great potential in tailoring composites because of its remarkable electrical, thermal and mechanical properties. Polymer nanocomposites with CNT networks are demonstrated to have superior electrical properties. Nanocrystalline nickels and alloys have been proven to be able to protect CFRP surface from dust erosion and meanwhile provide some radiation and EMI shielding.

Integration of CFRP with nanomaterials would create novel multi-function structures that are light with high strength and thermally stable, and meanwhile have functions of radiation shielding, EMI shielding, thermal conduction, and erosion protection. The multi-function structure uses CFRP as the core laminated with different layers of advanced nanomaterials. The CFRP core provides structural strength and stiffness and the nanomaterial layers provide or enhance functions for radiation shielding, EMI shielding, thermal conduction, and erosion resistance. It takes the advantage of mature and reliable CFRP design, manufacturing, and testing technologies, and new properties provided by advanced nanomaterials. It would enable CFRP to have much broader applications in space, especially for space exploration.

The objective of this development work is to develop technologies to enhance standard space CFRP structure of M55J/RS-3 with nanomaterials to create new CFRP structure which is at least 30% lighter than equivalent aluminum structure but keeps the same mechanical properties of M55J/RS-3 with similar capabilities for radiation shielding, EMI shielding, thermal conduction, and surface erosion resistance similar to those of aluminum.

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 the multi-function CFRP structure technology to TRL 4 +, where the technology has a path to flight and a structure prototype is ready to be built for space environment tests. To achieve such a goal within the scope of this contract, it is required that the proposed technology has reached at least TRL 3 level, in other words, the technology has been verified and validated experimentally in lab environments as proof of concept, such that the project can effectively deliver at TRL 4+ technology. The contractor is required to provide the result of a TRL assessment of the proposed technology in the proposal.

The scope of this SOW can be divided into three phases, and each phase encompasses activities defined underneath:

Phase I – Development and optimization of nanomaterials for radiation shielding, EMI shielding, thermal conduction, and erosion protection

- Literature survey and review;
- Design, development and optimization of nanomaterials;
- Development and optimization of fabrication processes and procedures of the nanomaterials;
- Tests of the nanomaterials for required properties;
- Characterization of the nanomaterials for required properties;
- Investigation and optimization of integration methods of the nanomaterials with CFRP structure;

Phase II – Development of multi-function CFRP structure panel

- Design of a multi-function CFRP structure panel with M55J/RS-3 and the nanomaterials for required performance;
- Development and optimization of processes and procedures for integration of the nanomaterials with CFRP;
- Fabrication of multi-function CFRP structure test coupons and a demonstration panel with M55J/RS-3 and nanomaterials from the same batch if possible to ensure that test coupons and the panel have the same properties and quality;

- Mechanical tests of the multi-function CFRP coupons to characterize its physical and mechanical properties, such as size, weight, density, strength, and Young's modulus, and verify its performance;
- Radiation tests to characterize its properties for space radiation shielding and verify its performance;
- Electrical conductivity tests to characterize its electrical conductivity and verify its performance;
- EMI/EMC tests to characterize its properties for EMI shielding and verify its performance;
- Thermal conductivity tests to characterize its thermal conductivity and verify its performance;
- Thermal cycling tests to verify the design and the quality of fabrication against thermal stresses;
- Vacuum tests to assess the material outgassing following the standard of RD-1;
- Analysis of test results.

Phase III – Development of multi-function CFRP honeycomb panel

- Design of a multi-function CFRP honeycomb panel with M55J/RS-3 and the nanomaterials for required performance;
- Development and optimization of the fabrication processes and procedures for the CFRP honeycomb panel with nanomaterials;
- Fabrication of multi-function CFRP honeycomb test coupons and a demonstration panel with M55J/RS-3 and nanomaterials from the same batch if possible to ensure that test coupons and the panel have the same properties and quality;
- Electrical conductivity tests to verify its electrical conductivity performance;
- EMI/EMC tests to verify its EMI shielding performance;
- Thermal conductivity tests to verify its thermal conductivity performance;
- Thermal cycling tests to verify the quality of fabrication;
- Analysis of test results.

The Contractor must perform a TRL assessment of the proposed technology to determine its TRL level at the end of this contract work in accordance with the requirements of AD-1 and AD-2.

The Contractor must provide a Technology Development Plan, a.k.a. Technology Roadmap (TRM), including the required technology developments and a plan and timeline to reach TRL 8. The Technology Roadmap must be provided as well in the format of AD-3.

Functional characteristics and performance requirements

The technology products resulting from this contract will be a multi-function CFRP structure panel and a honeycomb panel that have the capabilities of radiation shielding, EMI shielding, thermal conduction, and erosion resistance. The overall requirement for this product is that it has equivalent or better performance than aluminum in mechanical strength and stiffness, space radiation shielding, EMI shielding, thermal conduction, and surface dust erosion resistance, but has at least 30% less mass.

The design and fabrication of the multi-function CFRP structure panel shall meet the following requirements:

- The panel shall have a minimum size of 300mmx300mm;
- The panel shall be made of M55J/RS-3 plies and nanomaterials;
- The panel should have at least 8 plies with laminate lay-up of (0, +45, +90, -45, -45, 90, +45, 0) with 0.005” thickness for each ply;
- The fabrication of the CFRP composite shall respect the following tolerances: Laminate Fiber Volume Fraction 60% ± 3%, lay-up orientation +/- 2 deg on layup direction, cured ply thickness tolerance shall be +/- 10%;
- Nominal curing temperature shall be +350°F;

The design and fabrication of the multi-function CFRP honeycomb panel shall meet the following requirements:

- The panel shall have a size of 1000mmx600mm;
- The skin shall be made of M55J/RS-3 plies;
- The panel should have 4 plies with laminate lay-up of (0, +45, +90, -45) with 0.005” thickness for each ply;
- The core should be Aluminum Alloy 5056 – 0.001" - 3.8 pcf – 5/32’’ with thickness 3/8”;
- The film adhesive between the core and the skin should be Cytec FM300-2U;
- The fabrication of the skin shall respect the following tolerances: Laminate Fiber Volume Fraction 60% ± 3%, lay-up orientation +/- 2 deg on layup direction, cured ply thickness tolerance shall be +/- 10%;
- Nominal curing temperature shall be +350°F;

The thermal cycling tests shall be performed according to the specifications in the following table

Temperature	-170°C, +130°C
Minimum time at plateaus	30 minutes
Number of cycles	10
Maximum rate of change	10°C/min

Tolerance	cold: -10°C, +0°C hot : -0°C, +5°C
Minimum of two (2) thermocouples affixed to each coupon type to monitor/record the coupon temperature during cycling.	
Thermal cycling shall be done under facility ambient pressure but under dry conditions only (<10% relative humidity)	

The selection of material used in the manufacturing of the CFRP panels shall be based on the NASA guidelines of <1.0% Total Mass Loss (TML) and <0.1% Collected Volatile Condensable Material (CVCM) when subjected to a pressure of 1.3 x 10-4 Pa, at a temperature of 125 +/-1 °C for a period of 24 hours as per RD-1.

TRL timeline

- Initial TRL: 3
- Targeted TRL: 4+

Targeted missions

The specific mission classes that could directly benefit from the multi-function CFRP structure technology include:

- Planetary exploration missions (on-planet sampling, sample return);
- Earth observation missions (RCM and PCW);
- Small/micro satellite missions.

Specific Deliverables

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

- A multi-function CFRP structure panel with a minimum of 300mmx300mm
- A multi-function CFRP honeycomb panel with a size of 1000mmx600mm
- Design and development reports
- Test plans and test reports
- Technology Readiness and Risk Assessment Worksheets and Rollup
- Technology Roadmap Worksheet

Priority Technology 5 (PT 05)

Shock Attenuating System

PT05 - Shock Attenuating System

List of Acronyms

AD: Applicable Document

CSA: Canadian Space Agency

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

Technology Description

Currently, very little is being done to shield a unit from shock environment on today's space systems, except relocating the unit as far as possible from the shock source and making the load path from the shock source to the unit as convoluted as possible. A few technologies to reduce the impact of shocks are on the market, but they are all custom made and require to ensure a proper thermal path between the unit and the structure. For these reasons, these devices are rarely used given that the technical complexity of integrating them, late during a program, to an existing design is too high. This technology development aims at developing the complete shock attenuation system of unit, including shock isolation or absorbing devices, and thermal path. This activity shall develop a qualified approach for shock isolation or attenuation, ensuring the system does not outgas, is resistant to radiation, provides adequate thermal and grounding path, while preventing an over amplification of other mechanical environments (i.e.: quasi-static, sine, random).

Scope of Work

The project must include the following steps:

1. **Identification of the starting conditions**
    - Review of the shock attenuation solutions available on the market.
    - Identification of a typical unit to be shock-proofed.

    - Determination of its size, mass, and footprint including attachment points. The project must demonstrate that this typical unit is representative of units experiencing shock issues on various flight programs.
- Determination of the shock level the system (typical unit and shock attenuating system) will be submitted to. The shock levels must be representative of flight programs by pointing to the GEVS, an ECSS standard, or a launcher user manual. No attenuation must be added to the chosen specification. The system shall be tested using various levels, in order to assess any non-linearity with respect to the SRS input level.
- Determination of the quasi-static level the system will be submitted to. The quasi-static level must be representative of flight programs by pointing to the GEVS, an ECSS standard, or a launcher user manual. As such, the first frequency of the unit mounted on isolation or attenuation system shall be no less then 140Hz, unless a lower frequency can be justified.
- In cases where F1 < 140Hz, the contractor shall determine a typical sinusoidal vibration level the system will be submitted to. The sine test level must be representative of flight programs by pointing to the GEVS, an ECSS standard, or a launcher user manual.
- Determination of the random vibration level the system will be submitted to. The random test level must be representative of flight programs by pointing to the GEVS or an ECSS standard for units having the type of mass chosen for the typical unit. The complete system shall be tested using at least three levels (same PSD), in order to assess non-linearities of the system.
- Determination of the minimum natural frequency that the shock attenuating system must have in all three directions to avoid coupling with the spacecraft and the typical unit. The minimum frequency should be representative of a flight program by pointing to a launcher user manual. Given that the orientation of the unit is not necessarily the orientation intended for the spacecraft, the axial value of the chosen launcher user manual must be selected.

2. Design of the shock attenuating system

- Design of the shock attenuating system by including existing shock absorbing or shock isolating devices or by an entirely new custom design. The design must be a system added to the typical unit and not integrated in the unit. The goal is to be able to add such a system to a unit after the design of the unit itself without modifying the design of the unit. The complete system comprising the typical unit and the shock attenuating system must provide for the mounting of the system on a flat panel. The typical unit must not be modified to accommodate the shock attenuating system.
- An analysis must demonstrate that the thermal dissipation between the typical unit and a flat conducting panel is entirely preserved when adding the shock attenuating system.

- An analysis must demonstrate that the minimum natural frequency requirement set for the system is met in all directions.
- An analysis must demonstrate that the quasi-static level set for the system is met in all directions.
- An analysis must demonstrate that the sine test level set for the system is met in all directions (if F1<140Hz).
- An analysis must demonstrate that the random level set for the system is met in all directions.

3. **Testing of the shock attenuating system**
    - Mass properties (mass and center of gravity)
    - Quasi-static test done in the three axis
    - Sine test done in the three axis
    - Random test done in the three axis, at different level (for instance: -9dB, -6dB, 0dB)
    - The shock test in all three axis and at different amplitudes.
    - All tests shall include a typical unit mock-up and be sufficiently instrumented to obtain transfer functions.

Functional characteristics and performance requirements

- The exposed materials of the shock attenuating system must meet the standard outgassing requirements for flight programs.
- If the shock attenuating system includes electronic devices, these devices must have an equivalent flight qualified counterpart that would be used on a flight model and would display the same mechanical properties or superior properties.
- The materials or devices used in the shock attenuating system must have constant properties throughout the temperature range seen during a launch, or it must be demonstrated by analysis that the shock attenuating system will meet all requirements throughout the temperature range seen during a launch.
- For all tests (quasi-static, sine, random, shock), a low-level sine survey shall be done prior to the test and after. The two low-level sine tests must measure the first frequency of the unit, show a good correlation with the FEM and demonstrate the integrity of the shock attenuating system after each test.
- During the shock test, the acceleration must be read on top of the unit and the accelerometer must show a reduction of 6 dB between the base plate and the top of the unit.
- The mass added by the shock attenuating system to the typical unit must be less than 25% of the mass of the typical unit.

TRL timeline

PT05 - Shock Attenuating System

- Initial TRL: 4
- Targeted TRL: 6

Targeted missions

The specific mission classes that could directly benefit from such a technology are:

- Satellites from micro-satellites to large satellites
- Robotic manipulators grasping moving targets
- Rovers landing on solar system bodies

Specific Deliverables

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

- Prototype of the shock attenuating system
- Reports from the thermal analysis, modal analysis, quasi-static analysis, sine vibration analysis, and random analysis
- Report showing the functional characteristics are met
- Test reports and test data
- Final presentation

Priority Technology 06 (PT 06)

Thermal Isolation Technology for Sensor Reliability Enhancement

PT06 - Thermal Isolation Technology for Sensor Reliability Enhancement

List of Acronyms

CSA:	Canadian Space Agency
RD:	Reference Document
TRL:	Technology Readiness Level
SOW:	Statement of Work
CMOS:	Complementary metal-oxide-semiconductor
CAD:	Computer aided design
FEM:	Finite element modeling

Technology Description

Focal plane arrays of thermal detectors provide a means for measuring radiance at infrared and far infrared wavelengths. When operated at room temperatures, the detector pixels require thermal isolation to generate detectivities sufficiently high to be suited for space applications. The current solution relies on fabricating detectors on top of free standing bridges in a vacuum sealed package so that the vacuum gap between the bridge and the wafer insulates thermally the detector [RD-1]. It is a difficult and expensive task to hermetically seal sensor packages that meet the stringent reliability, lifecycle and quality requirements of space missions. During operation, changes in vacuum pressure and structural deformation of bridge are the frequently encountered issues that affect sensor performance reliability. Further, the required compatibility of the package infrared window with the soldering process imposes restriction on the spectral channels that can be made available to the sensor.

The thermal isolation technology being considered here consists in filling the vacuum gap with a thick film of low conductance material. Optimization of film thickness is one approach to achieve adequate thermal isolation at ambient pressures. If effective, this alternative will remove the requirement for vacuum packaging and provide a mechanical support for the bridge. The intent is to introduce this technology into monolithic arrays of uncooled VOx microbolometers for far infrared measurements in future planetary exploration and Earth observation missions. Therefore, the following elements will need to be investigated:

- Synthesis of thermal isolation films, e.g. porous nanostructured films
- Compatibility of thermal isolation film with VOx microbolometer fabrication process, e.g. wafer size, process temperature, patterning, planarization

- Compatibility of thermal isolation film with monolithic CMOS readout electronics, e.g. vias fabrication
- Proof-of-concept detector performance

Scope of Work

The scope of work defined in this section complements Section A.5 Generic Task Description of Annex A. The bidders should identify clearly the low conductance materials that they propose to investigate as well as the process to be used for thick film synthesis of these materials. A preliminary analysis of the feasibility of microengineering the detector and achieving the necessary thermal isolation should also be presented in the proposal. The availability of the facilities required for the microengineering and characterization of thermal isolation films on Si wafer must be confirmed in support of the feasibility of the proposed approach. The successful bidder will develop thermal isolation technology to TRL 3 or 4 where the technology has a path to flight, taking into account the requirements outlined in the next section.

The main tasks of this SOW are as follow:

- Define the process flow and carry out iterative fabrication of thermal isolation films on multiple Si wafers
- Produce films with desired properties by examining the dependence of mechanical and thermal properties of the resulting films on film thickness and process parameters
- Confirm the compatibility of the produced films with the surface micromachining process for single pixels and arrays of VOx microbolometers by implementing lithography, film deposition, etching, thermal treatment
- Develop the patterning process forming vertical vias in the device layers for establishing electrical interconnections
- Microfabricate, hardwire, and test single pixels and arrays of VOx microbolometers with integrated thermal isolation films on Si wafer
- Identify the approach and parameters for optimizing the detector structure and performance

Requirements

The technology demonstrator resulting from this contract will be a functional laboratory prototype of VOx microbolometers with integrated thermal isolation films. The requirements for the detector prototype are as follow:

- The prototypes shall be fabricated on Si wafers of 6-inch diameter with and without monolithic CMOS readout electronics; those fabricated on the wafer with readout electronics will be used to validate the electrical interconnections through the vias
- The thickness of the thermal isolation film should be in the range from 30 to 70 um
- The thermal isolation film should have a conductance in the range from 0.01 to 0.04 W/m.K

- The thickness uniformity of thermal isolation film should be better than 10% across the wafer
- The roughness of the thermal isolation film should be smaller than 20 nm
- The thermal isolation film shall be compatible with the patterning of vias having diameter of 10 um or smaller
- The fabrication of thermal isolation films shall be subject to a maximum process temperature of 320 ^{0}C

TRL timeline

- Initial TRL: 2
- Targeted TRL: 3-4

Targeted missions

Typical missions that could directly benefit from the thermal isolation technology include:

- Planetary exploration missions, *e.g*. characterization of Mars climate and surface radiation budget
- Global monitoring for environment and security missions
- Far infrared characterization of arctic ice clouds for extreme weather prediction
- Airborne calibration and validation missions

Specific Deliverables

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

- A minimum of three prototypes of VO_x microbolometers with integrated thermal isolation film hardwired for performance characterization
- Other detector prototypes
- Processed and partially processed Si wafers with integrated thermal isolation films and / or VO_x microbolometers
- CAD files of photomask and mask sets produced during the contract
- Any FEM simulation files generated during the contract
- Microfabrication details including process parameters and setup configurations

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Priority Technology 7 (PT 07)

Thermally Stable Composite Structures for Optical Payloads

PT07 - Thermally Stable Composite Structures for Optical Payloads

List of Acronyms

AD: Applicable Document
AI&T: Assembly, Integration and Test
CAD: Computer Assisted Design
CFRP: Carbon-Fiber-Reinforced Polymer
CSA: Canadian Space Agency
CVCM: Collected Volatile Condensable Material
CME: Coefficient of Moisture Expansion
CTE: Coefficient of Thermal Expansion
FEA: Finite Element Analysis
FEM: Finite Element Model
RD: Reference Document
STDP: Space Technology Development Program
TML: Total Mass Loss
TRA: Technology Readiness Assessment
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

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	ASTM E595	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment, ASTM International, http://www.astm.org/Standards/E595.htm	Rev. 07	2007

Technology Description

The capability to define, design, produce, validate and qualify thermally stable composite structures, which are suitable for optical payloads mounting does not exist in Canada. This fact was pointed out at the Canadian Composites Workshop held in 2011 and it was reported as a key missing technology in Canada. It has to be noted that, within Canada, we have a strong industry having the level of expertise in optics and Composite manufacturing, necessary to develop this new capability.

The technology consists in the development of advanced structural elements providing high stiffness to weight ratio and high dimensional stability (and low distorsion) in stringent conditions (ie. space environment). Composite Structure properties are highly dependent on manufacturer's processes and typical optical payloads require very high dimensional stability. Under this STDP project, the definition and validation of the Composite fabrication process against stability performance such as Coefficient of Thermal Expansion (CTE), Coefficient of Moisture Expansion (CME), angular motion (warping), etc. under temperature will be made. Requirements for typical structural elements for optical payload mounting and packaging will be defined. Based on these requirements, generic structural elements (ex. honeycomb benches, tubes/struts, support structures, interfaces/inserts, joints etc.), applicable to such type of payloads, will be defined and designed. Materials selection and material qualification, as well as development and qualification of manufacturing processes, which are suitable for the application, will be performed. The development of design "allowables", through appropriate and justified representative coupons-level testing is also part of the suggested work. A complete activity of prediction (i.e. structures behaviour) and validation, under representative environment (i.e. Space), including development of analysis tools and verification methods will be performed. Predicted distortions (done through FEAs) of the structural elements of interest will be compared with test results, on a statistical basis.

The outcomes of the suggested development activity will lead to a better understanding of the materials and processes that needs to be used and controlled in order to meet requirements of typical thermally stable structures for optical instruments. Remaining uncertainties regarding the capability of CFRP structures, interfaces/joints (and the associated workmanship) to meet the stringent set of requirements for optical payload mounting structures will be addressed through analyses, testing and comparisons (predictions vs statistically valid test results). Allowables database will be developed and directly reusable on any other programs involving the same technologies.

Scope of Work

The contractor will perform the work required to bring the technology to TRL 4 +. It is highly preferable that the structural elements of interest, at least conceptually, be already well understood (at least TRL 2), such that the project can effectively deliver a TRL 4+ technology. In general, the scope of this SOW encompasses the following activities:

- Project planning and management;
- Systems, Optics, Mechanical and Thermal Engineering;
- Applicable technologies literature survey (i.e. needs, requirements, materials, processes, etc);
- Development of technical requirements and baseline configurations (i.e. structure);
- Preliminary and detailed design;
- Procurement
- Manufacturing and assembly of structural elements (and samples) in Composites;
- Analyses, Testing and Verification;
- Documentation

1. Definition of key requirements for typical (and representative) optical payload mounting structures (i.e. structural elements) such as honeycomb benches, tubes & struts, interfaces/inserts, joints, etc.), including environmental requirements, technical requirements, interface requirements, AI&T requirements, etc.

   This activity consists in defining and deriving a representative set of requirements for CFRP structural elements, which are suitable to be used in applications where thermal stability is important. The identification of requirements is crucial and shall be based on;

   - Representative optical payload(s) for Micro and/or Small satellites
   - Users (ie. optical payload developers) specific needs (i.e. Stability, Type of structures/elements, Interfaces, etc.)
   - Spacecraft and BUS developers specific requirements and constraints (i.e. Interface requirements, AI&T requirements, PA requirements, etc.)
   - Future space missions requiring thermally stable structures, especially in optics (i.e. Environmental requirements, mission specific requirements)
   - Etc.

2. Based on previously defined requirements, the definition and sizing (i.e. Design) of typical element of structures and interfaces, which are suitable for

optical payload mounting and/or packaging has to be completed. The resulting structural elements (or complete structures) will be used throughout the whole development project as baseline design. The selection of the baseline design shall result from an in-depth trade-off study or an appropriate justification. Following is a list of structural elements that could be considered in the baseline design;

- Honeycomb benches
- Tubes and struts
- Laminates
- Flexures and mounts
- Bonded joints and other interfacing elements
- Inserts (co-cured, potted-in, etc.)
- Adhesives and coatings
- Etc.

3. Identification of key materials and fabrication "variables" such as fiber volume, curing parameters, fiber orientation, CTE, layup, etc. to manage in order to meet the requirements, especially those impacting the stability and the distortion under the space environment.

4. Identify and justify baseline (required) values for the above identified "variables". An approach for controlling/measuring them throughout the project shall be described.

5. Selection of composite materials, which will be used in the construction of the pre-defined structure (i.e. Baseline design of thermally stable structure elements).
   - Prepregs
   - Fibers and resins
   - Adhesives
   - Cores
   - Potting compounds
   - Inserts
   - Etc.

6. Material procurement including;
   - Material specifications (properties, allowable, etc.)
   - Receiving inspections

7. Development and validation of fabrication processes appropriate to meet pre-defined requirements.

8. Development of tooling used in fabrication, assembly, curing, etc.

9. Determination of "allowables" and in-process test on coupons;
    - The B-basis allowable shall be selected for the mechanical properties of the composites materials and the A-basis allowable shall be selected for the mechanical properties of the metallic materials (ex. inserts).

    - For composite materials and potted inserts, the strength "allowable" shall be based on test data on samples manufactured to the same process specifications as for the thermally stable structural elements produced.

    - Coupons testing shall be performed in order to verify that the selected materials and fabrication processes have adequate properties at different levels of assembly (or different phases of manufacturing). The test coupons shall be prepared using the same materials, surface preparation techniques and application techniques as will be used for thermally stable structural elements to ensure that the coupon test results are representative of the expected structural elements behaviour.

10. Prediction (by analyses) of the stability, loading, structural integrity and distortion of the baseline design under pre-defined space and launch environments, including;
    - Modal analyses
    - Load analyses (static, vibro-acoustic, shock, etc.)
    - Thermal analyses
    - Thermo-elastic deformations
    - Fatigue analyses (5-7 years in orbit)
    - STOP analysis (TBC)
    - Etc.

11. Fabrication of structural elements, including production of in-process coupons for validation by testing (i.e. assumptions, allowables and other mechanical properties, etc.)

12. Preparation of test plans and test procedures for testing and validation at different stages during the project
    - Materials
    - Lamina
    - Laminate
    - Sandwich
    - Coupon
    - Part

- Assembly

13. Development of specialized test setups & chambers, and development of precise verification and measurement techniques and tools allowing to measure key parameters such as warping in u-rads, deflections of 0.001", etc.

14. Comparison of test results vs prediction (i.e. results from analyses, statistical data, previous results, etc.)

15. Reporting on materials and fabrication "variables" resulting to CFRP parts or structural elements offering high thermal stability.

16. Documentation, Test plan and Reports

Functional characteristics and performance requirements

- The set of requirements identified for the thermally stable structural elements reflects payload (i.e. optical) developer needs as well as typical requirements for spacecraft development, including outgassing, environmental requirements, interface requirements and AI&T requirements.
- The environmental requirements (i.e. during launch and in space) shall be representative of a typical earth-orbit mission for optical payloads.
- The identification and the design of structural elements, which are used as baseline design for this project, shall be representative of typical structures for optical payload mounting and/or packaging. It shall be demonstrated that they are suitable for space applications.
- The selection of material used in the manufacturing of the thermally stable elements shall be based on the NASA guidelines of <1.0% Total Mass Loss (TML) and <0.1% Collected Volatile Condensable Material (CVCM) when subjected to a pressure of 1.3 x 10-4 Pa, at a temperature of 125 +/-1 °C for a period of 24 hours as per RD-1.
- Key materials and fabrication "variables", which have impact on the thermal stability of an element shall be identified and documented prior to procure materials.
- Material specifications, including desired properties and required inspections shall be identified and documented prior to procure materials.
- The baseline design shall be analyzed (i.e. FEAs) for the application and the predicted behavior under representative environment shall be documented.
- The predicted behavior of the baseline design shall be validated by test and the FEM shall be correlated using valid test results.
- "Allowables" and other mechanical properties used in FEAs shall be validated by test (ex. previous test results on similar samples, in-process coupons, etc.)
- Test plans shall be prepared and reviewed prior test campaigns
- Comparison of test results versus results from analyses shall be performed and documented.

- Measured warping dimensional stability of less than 15 urad for the full temperature range.

TRL timeline

- Initial TRL: 2 to 3
- Targeted TRL: 4+

Targeted missions

The specific mission classes that could directly benefit from this technology include:

- Any earth orbit missions requiring low weight and high thermal stability structures, especially Micro and Small satellite missions
- Planetary exploration missions

Specific Deliverables

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

- Requirements Document (i.e. Environmental, Functional/Technical, Interface, AI&T, Design constraints, etc.)
- Procurement specifications for materials
- Process specifications and manufacturing procedures (on-site review)
- Design Document
- Analyses Report
- CAD Models
- Finite Element Models (FEMs)
- Test Plans
- Test Reports
- Final Report
- Final Presentation
- Monthly Reports

Priority Technology 8 (PT 08)

On-Board Green Propulsion Systems for Stationkeeping & De-Orbiting of Microsatellites

PT08 - On-Board Green Propulsion Systems for Stationkeeping & De-Orbiting of Microsatellites

List of Acronyms

AD: Applicable Document
ASAT: Anti Satellite
CAM: Collision Avoidance Maneuvers
COPUOS: Committee on Peaceful Uses of Outer Space
CSA: Canadian Space Agency
ESA: European Space Agency
ESTEC: ESA Space Technology & Engineering Center
ITAR: International Traffic in Arms Regulations
LEO: Low Earth Orbit
MSFC: Marshall Space Flight Center
NANOPS: Nanosatellite Propulsion System
NASA: National Aeronautics and Space Administration
RD: Reference Document
SOCRATES: Satellite Orbital Conjunction Reports Assessing Threatening Encounters in Space
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 No.	Document Number	Document Title	Rev. No.	Date
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/	D	May 2013
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		Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space, UN Office for Outer Space Affairs http://orbitaldebris.jsc.nasa.gov/library/Space%20Debris%20Mitigation%20Guidelines_COPUOS.pdf		January, 2010
RD-2		http://www.nasa.gov/mission_pages/smallsats/nanosaild.html		
RD-3		http://celestrak.com/SOCRATES/		
RD-4		http://www.utias-sfl.net/nanosatellites/CanX2/system.html		

RD No.	Document Number	Document Title	Rev. No.	Date
RD-5		D. Haesler, et al. "Green Propellant Propulsion Concepts for Space Transportation and Technology Development Needs," Proc. 2nd Int. Conf. on Green Propellants for Space Propulsion, Sardinia, Italy. http://adsabs.harvard.edu/full/2004ESASP.557E...4H		June 2004
RD-6		http://www.moog.com/news/operating-group-news/2011/green-propulsion-technology-from-ecaps-moog-outshines-hydrazine/		October 2012

Technology Description

In December 2007, the General Assembly of United Nations Office for Outer Space Affairs endorsed the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space (COPUOS) and agreed that the voluntary guidelines for the mitigation of space debris reflected the existing practices as developed by a number national and international organizations, and invited Member States to implement those guidelines through relevant national mechanisms. In particular, the Guideline 6 states "Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission" [RD-1]. The commonly adopted definition of "long-term presence" by international organizations is 25 years.

The deliberate ASAT test in 2007 by Chinese authority resulted in thousands of debris fragments of Fengyun 1C. This event was unfortunately followed by the accidental collision of Iridium 33 and Cosmos 2251 in 2009. Owing to these two events, the LEO environment is at risk of another accidental collision. Every day, the daily top ten collision risks identified by the SOCRATES website [RD-3] show at least one high risk collision involving the debris from Fengyun 1c, Iridium 33 or Cosmos 2251. For operators of LEO satellites, Collision Avoidance Maneuvers (CAM) become more and more regular events.

With the adoption of these guidelines and the increasing frequencies of CAM, all future Canadian satellites to LEO should carry an on-board propulsion system for stationkeeping as well as for de-orbit purposes. Although passive mechanisms, such as drag sail and tether, can be used for de-orbit, they cannot be used for either stationkeeping or CAM. Further, the only drag sail that has been demonstrated successfully is the NASA MSFC NanoSail-D mission. It was launched in December 2009 to an altitude of 640 km. It was de-orbited by a 10m2 drag sail after 204 days [RD-2]. However, the effectiveness of such a device at higher altitude (> 700 km)

remains to be proven. Using tether as a de-orbit mechanism is validated through numerical simulations. There is no successful demonstration in space yet.

UTIAS Space Flight Laboratory has demonstrated the first Canadian made liquid propulsion systems, known as NANOPS, on board its CanX2 mission [RD-4]. The propellant selected was Sulfur Hexafluoride (SF6). Besides NANOPS, it is fair to say that there is no other Canadian indigenous on-board propulsion system. Procurement of a propulsion system outside Canada is challenging. A US made system is subjected to the ITAR control and technical details are often not available to Canadian eyes. Even a European system usually requires export approval from the country where the manufacturer is based. Because some European system also utilizes US made components such as the valves, there is a similar technical information disclosure restriction.

Another aspect of the propulsion system is the green aspect. ESA/ESTEC has issued a contract study on green propulsion for both high and low thrust in the 2000s and the definition of green propellants are listed in [RD-5]. Essentially, a green propulsion system shall have low toxicity, low environmental impact (in bench tests as well as operations in space), low cost and performance similar to non-green propellant. Hydrazine is commonly cited as the reference of a non-green propellant. It is an efficient propellant and yet it is highly corrosive and toxic. Swedish Space Corp and Moog Engineering is the first one to market a green on-board liquid propulsion system [RD-6]. For solid propulsion system, there is no commonly cited non -green reference. Yet, there is no commercial solid propulsion system that is labeled as green. As a minimum, a green solid propulsion system shall be safe to handle, shall not produce toxic gases and shall not produce particles as combustion byproducts of significant size that can cause damage to other satellites on impact.

The ultimate goal of this technology development is the Canadian know-how in design, test and build a green on-board propulsion system for both stationkeeping and de-orbiting requirements of future Canadian small and micro satellite missions. The solution proposed shall be price and performance competitive with other commercial solutions. The contractor is free to propose an all liquid, all solid or a hybrid system. Likewise, the contractor can propose one single unit for both stationkeeping and de-orbiting or two units with one dedicated for stationkeeping and the other for de-orbiting.

Scope of Work

The baseline for the design is a system capable of supporting up to a 150 kg (dry mass) satellite. As LEO missions are usually at a maximum altitude of 800 km, the proposed solution shall have a minimum ΔV of 100 m/s of which 65-75 m/s for de-orbiting and 25-35 m/s for stationkeeping purposes.

The contractor shall develop work that will bring the TRL of a Canadian on-board propulsion system to a minimum TRL 4. The scope of this SOW encompasses the following activities:

- Applicable technologies literature survey;
- Identification of candidate propellants and comparison of green properties;
- Propellant evaluation plan;
- Baseline configuration design and detailed parts list;
- Technology Development Plan or Technology Roadmap including ground support equipment;
- Performance targets supported by analysis, tests and/or simulations
- Preliminary estimation, including margins, of power, mass and volume of the baseline configuration;
- Identification of technical risks and mitigation strategy;
- Estimate of development cost

In the case where one or more components will be purchased outside Canada, the contractor shall identify whether they are under export control.

TRL timeline

- Initial TRL: 2
- Targeted TRL: 4

Targeted missions

All future Canadian microsat, and smallsat missions

Specific Deliverables

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

- Technology Development Plan including all ground support equipment
- Technology Readiness and Risk Assessment Worksheets and Rollup
- Technology Roadmap Worksheet

Priority Technology 9 (PT 09)

Protection from Space Debris
Novel MMOD Shields

PT09 - Protection from Space Debris Novel MMOD Shields

List of Acronyms

AD: Applicable Document
ASAT: Anti-Satellite Test
BLEs: Ballistic Limit Equations
CSA: Canadian Space Agency
HVI: Hyper Velocity Impact
IADC: Inter-Agency Space Debris Coordination Committee
IP: Intellectual Property
LEO: Low Earth Orbit
MMOD: Micro-Meteoroid and Orbital Debris
SOW: Statement Of Work
SSN: US Space Surveillance
RD: Reference Document
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		http://www.esa.int/Our_Activities/Operations/Space_Debris/Global_experts_agree_action_needed_on_space_debris.		

AD No.	Document Number	Document Title	Rev. No.	Date
AD-4		Technology Readiness and Risk Assessment Rollup: TRA_Assessment_Tool.xlsm ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRL-TRA/	Rev D	May 2013
AD-5		Inter-Agency Debris Coordination Committee (IADC) http://www.iadc-online.org/index.cgi		
AD-6		ISO Space Standards http://www.oosa.unvienna.org/pdf/pres/stsc2013/2013lts-02E.pdf		2013

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		1st CSA Workshop on Space Debris can be found at: http://www.asc-csa.gc.ca/eng/events/2011/debris.asp	Final	
RD-2		CSA 1st Orbital Debris Workshop Summary Report ftp://ftp.asc-csa.gc.ca/users/codw/pub/Orbital%20Debris%20Workshop%20Summary%20Final%20Oct%20%2024-2011.pdf.	Final	

Technology Description

Since the dawn of the space age, as a result of over 4900 launches, there has been a steady increase in man-made space objects, known as space debris, in the Near Earth Orbits.

The majority of catalogue objects (>65%), tracked by the US Space Surveillance network (SSN), originate from more than 250 break-ups, from mainly explosions in orbit. The Low Earth Orbit (LEO) debris population however has increased significantly due to an Anti-Satellite Test (ASAT) in 2007, followed by the first ever accidental collision between two satellites (Iridium-33 and Kosmos-2251) in 2009. About 20% of catalogued objects are from spacecraft, less than

1/3 are operational, about 17% are spent rocket bodies and others are mission related objects. Fragmentation debris dominates the smaller size regimes down to 1mm. Objects below 1mm are dominated by dust, slag and other particles.

The SSN tracked and correlated and catalogues 23000 objects (2012) larger than 5cm-in Earth Orbit of which 17000 were published. (AD-3)

Using debris environment models estimated debris numbers range from 30,000 objects >10cm and 750000 objects >1cm, and more than 166 million >1mm.

In November 2010, as a result of actively undertaking space debris research activities and contribution to an increased understanding of space debris issues, Canada become a full member of the Inter-Agency Space Debris Coordination Committee (IADC). IADC committee is an international governmental forum for the worldwide coordination of activities related to the issues of man-made and natural debris in space (AD-5).

Furthermore one of the outcomes of the 1st CSA Workshop on Orbital Debris (RD-1) on the subject of spacecraft protection from MMOD impact, concluded with the need for the development of novel MMOD shield designs, validated through a calibrated Hyper Velocity Impact (HVI) facility. Furthermore associated activities, such as development of debris risk assessment methodologies, development of Ballistic Limit Equations (BLEs) and procedures for the validation for HVI codes, where identified as areas where CSA needs to build capacity in Canada in support of future Orbital Debris activities, including Canadian participation in future OD removal/remediation missions (RD-2).

This Statement of Work (SOW) describes the requirements to develop novel Micro-Meteoroid and Orbital Debris (MMOD) shield technologies to protect spacecraft from MMOD impacts.

The Canadian Space Agency has a requirement for the services of a commercial entity to arrive at mass optimized designs for novel MMOD shields in order to protect spacecraft from MMOD impacts of at least 1mm diameter travelling at hypervelocity impact velocities ≥ 7 km/s.

For the purposes of this design development/ test activity it can be assumed that the spacecraft is in a 800km altitude, Sun Synchronous orbit.

The designs to be considered include protection of spacecraft external parts and appendages of spacecraft bus and payload critical components. These can include antennas, sensors, solar arrays and other spacecraft component in such ways as not to interfere with the functionality of the part or equipment.

The MMOD shield designs are to include embodiments, such as new materials including methods to absorb or stop small particles without releasing additional debris (eg self healing materials) and debris impact detection sensors.

As an optional activity: the MMOD shields to protect spacecraft pressurized propellant tanks against hypervelocity impacts are to be developed and tested in a hypervelocity impact facility. In this optional task, a titanium propellant tank reinforced with different composite layers and thicknesses to be investigated with reinforcement fibre/fabrics and/or integrating self-healing concepts with the aim of preventing catastrophic MMOD penetration while maintaining acceptable tank strength after impact. As a reference, a spherical tank of 0.5 meter (20”) diameter could be considered.

Scope of Work

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

The spacecraft MMOD shield is to protect against a 1mm debris impact. The contractor shall develop the technology, considering applicable ISO standards (AD-6), to bring the Technology Readiness Level TRL of a Canadian MMOD spacecraft shield to a minimum TRL 3 (AD-1, AD-2, AD-4).

The scope of this SOW encompasses the following activities:

- Applicable technologies literature survey;
- Identification of candidate spacecraft MMOD shield design concepts
- Technology Development Plan or Technology Roadmap to develop the MMOD shield technology
- Assess the performance using a breadboard level MMOD shield after impact with HVI targets of at least 1mm diameter, supported by relevant analysis, tests and/or hydrocode simulations
- Preliminary estimate of mass and volume impact of the optimized MMOD shield compared to no shield designs.
- Identification of technical risks and mitigation strategies;
- Estimate of development costs for an engineering model
- For the optional activity: MMOD shields to protect spacecraft pressurized propellant tanks against catastrophic MMOD penetration.

Functional Characteristics and Performance Requirements

The spacecraft MMOD shield must be able to protect against a 1 mm debris impact at a velocity ≥ 7 km/s. The performance of the MMOD shield is to be verified through HVI tests performed at an impact velocity speed ≥ 7 km/s. The following required tolerances shall be respected during these tests:

- Velocity = +/- 0.2 km/s
- Velocity measurements: +/- 0.05 km/s
- Projectile diameter = +/- 0.003 cm
- Projectile Mass +/- 0.005 g (All projectiles should come from the same lots.)
- Angle of Incidence: +/- 1 deg.

TRL Timeline

- Initial TRL: 1
- Targeted TRL: 3+

Targeted Missions

The target missions are for all future Canadian spacecraft in order to be compliant, as reasonably as possible, with debris IADC and UNCOPUOS debris mitigation guidelines.

Specific Deliverables

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

- All MMOD shield designs, tested samples, breadboard models and prototypes
- A full description of the MMOD shield design, (including drawings, photos etc.), simulation using hydrocodes or test results.
- A summary table of test or simulation results providing the impact penetration data (hole diameter, damaged area).
- A comparative table of substructure hole area versus areal density, in order to better understand the influence of MMOD shield parameters. The area of hole or the sum of the areas of multiple holes will be used as a damage parameter of the front wall and the innermost wall to quantify the amount of damage.
- For MMOD tested shields, a substructure damage characteristics table where the front wall and innermost wall damage will be examined qualitatively with observation of potential:
    - Cratering
    - Fragment holes
    - Rear wall bulge
    - Real wall fracture
    - Discoloration

Priority Technology 10 (PT 10)

Advanced Autonomy for Space Robotics Servicing

PT10 - Advanced Autonomy for Space Robotics Servicing

List of Acronyms

CSA	Canadian Space Agency
AVU	Artificial Vision Unit
MAC	MSS Autonomous Control
MACU	MSS Autonomous Control Unit
MACS	MSS Autonomous Control Software

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.	GEN.26142	AVU Repurposing Feasibility Assessment - Executive Summary ftp://ftp.asc-csa.gc.ca/users/STDP/pub/	Rev 1	February 7, 2013
RD-2.	MACU-ES-0006	MSS Autonomous Control Feasibility Assessment - Executive Summary ftp://ftp.asc-csa.gc.ca/users/STDP/pub/	Rev 1	May 3, 2013

Technology Description

The development of technologies enabling autonomous robotic manipulator operations is required for the management of deep-space infrastructure where availability of crew is limited and communications bandwidth limitations hinder timely ground control. Implementation of this technology will significantly reduce the cost of ground support as well as risk through regular autonomous system inspection/monitoring and the performance of preventative or corrective maintenance.

CSA recently assessed the feasibility of adding autonomous control capability to the Mobile Servicing System onboard the ISS. In the concept under consideration, the MSS Autonomous Control (MAC) function would be executed by the AVUs on-board the ISS. These units would be re-purposed with MSS Autonomy Control Units (MACU) running the MSS Autonomous Control Software (MACS), which would provide services to host autonomy tasks. The MACS would execute autonomy tasks defined by user scripts as opposed to compiled programs. However, programs may be required when functionality cannot be implemented in scripts or where efficiencies are deemed beneficial by the user. Such programs would be invoked by scripts.

The syntax of the scripts will need to be defined, however a standard scripting language such as LUA or an Extensible Markup Language (XML) based format would provide readily available tools and expertise.

User scripts should be capable of calling one another and define the following aspects of an autonomy task:

- Input telemetry
- Output (telemetry or commands)
- Algorithms and frequency of execution
- Calls to MACU system functions

User scripts should support the development of state machines.

Initially, it is expected that a tool set would be provided for the development of user scripts and programs which provide a minimum level of validation. High level operations analysts would define the robotics automation task in terms of starting conditions, required actions, contingencies, dependencies, safety and goals. The task definition would be converted into the required algorithms including inputs (ex. telemetry parameter list) and outputs (ex. MSS commands). It is likely that high level tools would be used to model these automation tasks and the required algorithms, inputs, outputs and script behaviour.

However, for the advanced autonomy concept considered in this statement of work, the contractor must investigate to what extent the work of the operations analyst can be automated, simplified or reduced for a variety of robotics servicing tasks, not limited to MSS operations.

The proposed approach should consist primarily of the integration of existing technologies. The high-level autonomy system will need to know the state of the deep-space infrastructure (database), it will need to be able to process high-level commands and react to them (reactive engine), schedule activities accordingly (scheduler and task dependencies management) and finally send low-level commands to the robotic systems to execute the tasks (script/state-machine generation). The challenge will be to define/achieve the right level of autonomy, such that the systems architecture flexibility/versatility is maintained while ensuring robustness and reliability.

Scope of Work

The scope of the technology development includes:

- **Definition of the tasks that can be performed autonomously by robotic systems to support operations of a human-tended deep-space infrastructure**
    - Perform a literature survey of autonomy enabling technologies and identify the most suitable technologies to implement this automation.
    - Identify the tasks that can be automated (ex. assembly and construction, capture of visiting vehicle, inspections, maintenance, etc.). The goal is to automate as much as possible and abstract the tasks at a very high level so as to minimize or eliminate the need to have crew present. As an example, based on knowledge of the state of the infrastructure and the needs thereof, the autonomous system would have the capability of knowing which object to capture using what tool and moving it to which location and how. This requires high-level decision making capability as well as low-level autonomy capability.
    - Develop a technology roadmap for autonomous robotic manipulator operations technology including a plan and timeline for achieving TRL 4.
- **Identification and assessment of key considerations/constraints for implementation of an autonomous robotic servicing system**

        - Determine the key considerations/constraints that need to be taken into account when developing an autonomous robotic servicing system (ex. state determination, task dependencies, situational awareness, contingency operations, alignment/tolerance requirements, etc.).
        - Analyze how these considerations/constraints will be addressed or implemented and the impact they will have on the degree to which automation can be achieved.
        - Identify specific requirements that need to be levied on the servicing system to enable it to deal autonomously with these constraints.
    - **Identification of interface requirements**
        - Determine how the autonomous robotic servicing system will interface with or replace existing systems, both on-board and on ground.
        - Determine operational impacts that arise from interface requirements.
    - **Development of system architecture**
        - Define the system architecture that implements this automation.
            - Identify the components and their functions
            - Identify the nature of data flow between components and interface requirements
            - Identify the location where each component of the system architecture should reside.
    - **Development of a workflow analysis**
        - Provide a detailed analysis of how a given autonomous task (to be determined by CSA from the possible list of autonomous tasks generated in earlier work) would be performed along with a comparison to how the task is currently performed using existing technology. Topics to be included in the analysis include, but are not limited to: task preparation time, task execution time, impact on safety of operations, operational benefits of autonomy, and an assessment of cost reductions. The contractor will also examine what new capabilities are enabled by the advanced autonomy.

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 Technology Roadmap must be provided in the format of AD-5.

Functional characteristics and performance requirements

N/A

TRL timeline

- Current TRL: TRL2
- Targeted TRL: TRL 3
- Duration to reach targeted TRL: 9 months

Targeted missions

Development of autonomous space robotic servicing systems will secure an important and critical role in the future international space exploration architectures. Having this capability will open new options in the architectures, and these can bring down costs by reducing the need for high payload mass delivery capability (e.g. automated assembly), or making it possible to sustain an unmanned infrastructure over a longer period of time. Securing a niche role for robotic manipulator technology is key to enabling its longevity.

Specific Deliverables

The final deliverable will constitute a report containing the following elements:

- **Definition of the tasks that can be performed autonomously by robotic systems to support operations of a human-tended deep-space infrastructure**
  - Literature survey of autonomy enabling technologies including the most suitable technologies to implement this automation.
  - A listing of tasks that can be automated including definition of high-level decision making type tasks as well as low-level operational/functional tasks.
  - Technology roadmap for autonomous robotic manipulator operations technology including a plan and timeline for achieving TRL 4.
- **Identification and assessment of key considerations/constraints for implementation of an autonomous robotic servicing system**
  - A listing of key considerations/constraints that need to be taken into account when developing an autonomous robotic servicing system.
  - An analysis of how these considerations/constraints will be addressed or implemented and the impact they will have on the degree to which automation can be achieved.
  - The list of the specific requirements that need to be levied on the servicing system to enable it to deal autonomously with the constraints and a suggested approach, if possible, how these could be met.
- **Identification of interface requirements**
  - A description of how the autonomous robotic servicing system will interface with or replace existing systems.
  - An analysis of the operational impacts that arise from interface requirements.
- **Development of system architecture**
  - A complete system architecture that implements this automation.
- **Development of a workflow analysis**
  - A complete workflow analysis for a given autonomous task.

Priority Technology 11 (PT 11)

High-Power Deployable UHF Antenna

PT11 - High-Power Deployable UHF Antenna

List of Acronyms

AD: Applicable Document

CSA: Canadian Space Agency

ISS: International Space Station

RD: Reference Document

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/	D	May 2013
AD-5		Roadmap Framework: ExCore Concept Study		

AD No.	Document Number	Document Title	Rev. No.	Date
		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	MIL-STD-188-181	Interoperability Standard for Access to 5-kHz and 25-kHz UHF Satellite Communications Channels	Rev. C	2008
RD-2	MIL-STD-188-182	Interoperability Standard for UHF SATCOM DAMA Orderwire Messages and Protocols	Rev. B	2008
RD-3	MIL-STD-188-183	Interoperability Standard for Multiple-Access 5-kHz and 25-kHz UHF Satellite Communications Channels	Rev. B	2008

Introduction and Technology Description

Non-deployable UHF antennas have been used for decades and have a long space heritage. They offer good performances, a relatively good gain, generate very weak level of product of intermodulation (PIM) interference signals and they handle significant amount of power. This is not the case for deployable UHF antennas: the level of emission of PIM of these deployable antennas is known to be higher and moreover they handle much less power. However they have a very small stowed enveloped which can be critical if the volume becomes an important issue (for instance if the platform is sharing several different payloads).

The CSA identified the need for a generic compact UHF antenna which stowed envelope is small in comparison with the current state-of-art technology (such as fixed non deployable UHF antennas) but offer similar RF performances.

This technology development project will investigate the technical feasibility of a High-power UHF deployable antenna capable of withstanding 6 simultaneous channels (goal 12 channels) of 100W each.

The UHF antenna sub-system includes the radiating element and any matching network and any flexible cable needed to connect the antenna to the transponder.

Scope of Work

PT11 - High-Power Deployable UHF Antenna

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

The contractor must perform the work required to bring this technology to a TRL of 6 (AD-1 to AD-5), where the technology has a path to flight and is close to an engineering model (see functional characteristics and performance requirements section). The scope of this SOW encompasses the following activities:

- Project planning and management;
- Systems Engineering;
- Development of technical requirements and baseline configurations;
- Preliminary and detailed design;
- Manufacturing, Assembly and Verification of an Engineering Model (EM) of the UHF deployable antenna (radiator element, matching network, cable connecting to the radios or transponders);
- Environmental testing of antenna (including a demonstration of the deployment of the antenna in a relevant environment);
    - As a minimum, vibration testing of the stowed unit;
- PIM testing in temperature;
- Compliance to Multipaction requirements;
- Compliance to gain and axial ratio requirements;
- Provision of all related documentation;

The Contractor must provide a Technology Development Plan, including the required technology developments to meet targeted functional characteristics and performance, and a plan and timeline to reach TRL 8 (AD-1 to AD-5).

Functional Characteristics and Performances

The technology is expected to provide a UHF antenna system with the following performances:

- the Tx and Rx operating frequency shall be compatible with the latest release of RD1, RD2 and RD3;
- the antenna must have a right-hand circular polarization;
- the antenna must have an EOC gain within a beamwidth of ±3.6° higher than 14.5dBi;
- The antenna must be capable of handling a minimum of 6 channels with a bandwidth of 25 kHz and RF power of 100 Watt/channel (goal of 12 channels);
- the level of 3rd order Product of intermodulation (PIM) level must be lower than -140 dBm given 2 channels of 60 Watt/channel (and 100 Watt/channel as a goal) when the Tx and Rx antennas are parallel but separated by a distance of 1.6 m, in direct line of sight (no shadow created by the spacecraft bus);
- the stowed volume of the antenna must be smaller than 90 cm x 90 cm x 61 cm;
- the axial ratio must be better than 2.5 dB ;
- the antenna mass must be lower than 20 kg;
- the antenna including the matching network (if needed) must have a return loss better than -20 dB;

The technology product resulting from this contract will be a deployable UHF antenna whose RF performances will be as good as or better than rigid non-deployable UHF antennas but with a much smaller stowed volume.

TRL timeline

- Initial TRL: 2 to 3
- Targeted TRL: 6
- Duration to reach targeted TRL: 24 months

Targeted missions

The specific mission classes:

- PCW UHF payload or any Arctic UHF coverage mission;
- Next generation DND military Satcom (Skynet, optus, comsat BW)

Specific Deliverables

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

- Engineering Model (EM)
- Electromagnetic CAD models
- Antenna system requirements
- Detailed Antenna description report
- Technical notes as required
- Test report
- Development plan

Milestones and Meetings

- Kick-Off Meeting
- Milestone 1: Antenna Requirements Review (Go/No go meeting).
- Milestone 2: Antenna Design Review Meeting.
- Milestone 3: Breadboard and Testing Activity Review Meeting
- Final Review Meeting

Priority Technology 12 (PT 12)

Gallium Nitride (GaN) High Power Amplifier Development for X-Band Applications

PT12 - Gallium Nitride (GaN) High Power Amplifier Development for X-Band Applications

List of Acronyms

AD:	Applicable Document
BB	Breadboard
CAD	Computer aided design
CMOS	Complementary Metal Oxide Semiconductor
CSA:	Canadian Space Agency
CW	Continuous wave
GaAs	Gallium Arsenide
GaN	Gallium Nitride
HPA	High Power Amplifier
ITAR	International Trading in Arms Regulation (US)
JAXA	Japanese Aerospace Exploration Agency
MMIC	Monolithic Microwave Integrated Circuit
OBO	Output Back-Off
PRF	Pulse repetition frequency
RD	Reference Document
RCM	RADARSAT Constellation Mission
SA	Scientific Authority
SAR	Synthetic Aperture Radar
SiGe	Silicon-Germanium
TA	Technical Authority
TRL	Technology Readiness Level
US	United States of America
USD	US dollar

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

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	GaN Technologies and Developments: Status and Trends M. Buchta, K. Beilenhoff, H. Blanck, J. Thorpe, R. Behtash, S. Heckmann, H. Jung, Z. Ouarch, M. Camiade IEEE, Microwave and Millimeter Wave Technology (ICMMT), 2010 International Conference http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5525238	N/A	2010

Technology Description

The ever evolving needs for high communication data rates and high resolution SAR Earth Observation satellites at microwave frequencies are already pushing the limits of what performance can be achieved using conventional semiconductor materials such as Gallium

Arsenide (GaAs) and Silicon Germanium (SiGe). Other semiconductor processes such as CMOS are not very well suited for operation in harsh environments, especially radiation.

Characteristics of GaN-based semiconductors, such as high power density, high operating voltage and temperature, accompanied by an inherent robustness to radiation damage make GaN devices a potentially outstanding choice for applications in the harsh environments encountered in space missions, be they communications, Earth observations or even planetary exploration.

Furthermore, GaN promises big improvements in the performance of wide bandwidth communications and radar systems because it can deliver up to 10 times as much power at microwave frequencies as the silicon and gallium-arsenide semiconductors currently used in satellite radar systems and communication transmitters. Other non-space applications include automotive, aeronautical, defence and mining/oil.

Compared to other semiconductor technologies, amplifiers based on GaN offer:

- higher operating voltages,
- higher output power,
- higher efficiency
- increased reliability

The resultant circuit and system performance improvements include:

- greater bandwidth due to higher impedance match for a given output power
- improved system efficiency due to lower IR losses in dc feed networks.
- possibility of retrofitting TWT-based systems with high-voltage GaN SSPA
- more reliable, smaller SSPA

However this comes with associated challenges:

- higher heat flux density
- higher DC voltage operation
- lacking on-orbit heritage

Note: *The ALOS-2 Earth Observation SAR satellite, currently under test at JAXA will be equipped with L-band GaN-based TR modules. This will be one of the first commercial space mission using GaN semiconductors. Launch date is currently planned for December 2013 for a 5-year design life.*

Indeed, GaN device can be used at higher power and efficiency levels over wider bandwidths than currently possible with Gallium Arsenide (GaAs) based devices providing that associated thermal management challenges are overcome.

The development of broadband high-power, high efficiency components for Earth Observation and data relay applications using GaN components with efficient thermal management will no doubt be an asset for future space missions such as the follow-on to the current RADARSAT Constellation Mission (RCM).

This Statement of Work covers two significant challenges faced when considering using GaN for space missions: to develop building blocks for future radar applications and address thermal management challenges.

The first challenge is addressed in this SOW by the development, manufacture and test of an X-band High Power Amplifier (HPA).

Thermal challenges posed by high-power GaN devices and especially surrounding components will require development of novel thermal management approaches by evaluating materials and structures which will enable increased power density without impacting performance of Monolithic Microwave Integrated Circuit (MMIC) and their reliability.

The development of advanced GaN-based semiconductor functional building blocks is consistent with the goals and strategy of the CSA and will extend the capability of a signature technology. Establishing Canada as a leader in GaN microelectronics promises a rich scientific and commercial return, while securing Canada's highly visible and critical participation in the next era of space utilization.

Scope of Work

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

The contractor must perform the work required to complete a first iteration HPA design and its associated thermal management approach. It is highly preferable that the MMIC HPA design concepts and techniques be already well understood by the bidding team, such that the project can effectively deliver a HPA meeting most of the requirements on the first pass and reach a maturity level of TRL 3.

The scope of this SOW encompasses the following activities:

- Project planning and management;
- Applicable technologies literature survey;
- Search and selection of a suitable GaN MMIC foundry,
- Development of technical requirements and baseline configurations for thermal management approaches;
- Preliminary and detailed design;
- Procurement
- Manufacturing, Assembly and Verification of the HPA(s) and thermal management;
- Provision of all related documentation; and
- Provision of all related software.

The work can be subdivided into three parts:

1. HPA design and test (preferably more than one design)
2. MMIC foundry selection and wafer procurement/fabrication **See note 1**
3. Thermal design, fabrication and test **See note 2**

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, and must describe the performance characteristics of the technology with respect to the specifications listed herein.

Note 1: The selection of a suitable foundry and process must satisfy the following conditions:

a) Be capable of providing sufficient gain and power to meet requirements at the operating frequency with some margin,
b) Be qualified for space applications or be in the process of being qualified,
c) The selected foundry/process, when used in space mission applications such as Earth Observation, is not subject to US ITAR regulations.

For budgetary considerations, the expected cost for a 100 mm development wafer should range of $150K to $200K USD.

Note 2: It would be highly desirable for the thermal design approach to be integrated with the GaN X-band HPA BB and tested as a combination.

Performance requirements

This section presents the GaN X-band HPA specifications. The design should meet the minimum requirements and seek to satisfy expressed goals set forth in Table A.

Table A: Specifications

Parameter	Specification			Units	Notes
	Min.	Max.	Goal		
Output Power (P_{out}) **See note 3**	20 (43.0)			Watts (dBm)	@ 2 dB gain compression Continuous Wave (CW)
	30 (44.8)		50 (47.0)	Watts (dBm)	@ 2 dB gain compression Pulsed mode
Center Frequency (f_c)	9.6		9.9	GHz	
Bandwidth (BW)	600		1200	MHz	Wider BW @ upper goal f_c
Linear Gain	12			dB	@ 10 dB OBO
Flatness		0.5	0.1	dB $_{p-p}$	@ 2 dB compression
Power-Added Efficiency (PAE)	40		60	%	@ 2 dB compression (die only)
Pulse mode parameters					
Pulse Repetition Frequency (PRF)	1	6		kHz	
Duty Cycle	10	25		%	

Note 3: At first approximation, the associated thermal flux at the chip mounting surface may range from 200 to 900 W/cm^2 depending on the fabrication process, MMIC layout, output power and associated PAE.

Meetings

This section reviews and describes the contract meetings and deliverables. The meetings defined here complement Section A.6 Contract Deliverables and Meetings of Annex A

Table B: Meetings

Meeting	*Date*	*Location*
Kick-off Meeting	***Contract Start Date + 1 week***	***Contractor***
Interim Review Meeting	***Wafer Procurement Date - two weeks*** *See note 4*	***Contractor***
Final Review	***Contract End Date -1 Week***	***CSA***

Note 4: The Interim Review Meeting should occur and subsequent wafer procurement initiated prior to the end of the first year of the contract (March 31).

All key participants under the contract, including at least one representative from each subcontractor (if applicable), must attend all the meetings. To reduce travel costs, some participants may attend the meeting via teleconference.

The specific intent of the Interim Review Meeting will be to review in detail the HPA design prior to submitting for fabrication by the foundry. The HPA MMIC design must be accepted as error-free, as confirmed by the supplier, prior to this meeting.

The specific intent of the Final Review Meeting will be to review in detail the results obtained. This meeting is intended to provide an opportunity for the Contractor, the Technical Authority (TA) or the Scientific Authority (SA), as the case may be, and other invited attendees to review and discuss the project. CSA reserves the right to invite additional knowledgeable individuals [Public Servants or others under Non-Disclosure Agreement (NDA)] to this meeting. Key Contractor personnel involved in the work under review must attend the meetings. The exact

date and time of the review meeting will be mutually agreed to by the PA, the TA or SA, and the Contractor.

TRL timeline

N/A

Targeted missions

N/A

Specific Deliverables

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

- Breadboard model (BB) of the amplifier and thermal management prototype
- All CAD design files, custom software source code (if applicable), spreadsheets
- GaN wafer

Priority Technology 13 (PT 13)

Space Radiation Shielding Materials

PT13 - Space Radiation Shielding Materials

List of Acronyms

AD:	Applicable Document
CSA:	Canadian Space Agency
ISS:	International Space Station
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
NASA:	National Aeronautics and Space Administration
RD:	Reference Document
TRL:	Technology Readiness Level
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		

PT13 - Space Radiation Shielding Materials

AD No.	Document Number	Document Title	Rev. No.	Date
		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/	D	May 2013
AD-5		Roadmap Framework: ExCore Concept Study TechnologyRoadmappingWorkbook.xlsx ftp://ftp.asc-csa.gc.ca/users/TRP/pub/TRM/		

Reference documents

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

RD No.	Document Number	Document Title	Rev. No.	Date
RD-1		Space Station Requirements for Materials and Processes – International Space Station http://snebulos.mit.edu/projects/reference/International-Space-Station/SSP30233RF.pdf	Rev. F	Aug 2007
RD-2		Reference Guide to the International Space Station http://www.nasa.gov/pdf/508318main_ISS_ref_guide_nov2010.pdf		Nov 2010
RD-3		Research in Space, Facilities on the International Space Station http://www.nasa.gov/pdf/393789main_iss_utilization_brochure.pdf		
RD-4		The Era of International Space Station Utilization, Perspectives on Strategy From International Research Leaders		

PT13 - Space Radiation Shielding Materials

RD No.	Document Number	Document Title	Rev. No.	Date
		http://www.nasa.gov/pdf/506512main_Summary_PSF_ISS_Utilization_2010.pdf		
RD-5		ESA – ISS User Guide (Website with multiple documents) http://www.esa.int/Our_Activities/Human_Spaceflight/Human_Spaceflight_Research/European_User_Guide_to_Low-Gravity_Platforms		
RD-6	NASA SP-2009-3405	Human Health and Performance Risks of Space Exploration Missions http://ston.jsc.nasa.gov/collections/TRS/_techrep/SP-2009-3405.pdf		2009
		CSA's Webpage on Space Radiation http://www.asc-csa.gc.ca/eng/astronauts/osm_radiation.asp		

Technology Description

Future human exploration is likely to occur beyond Low Earth Orbit (LEO), thus exposing crews to dangerous levels of radiation. The major concern is with ionizing radiation; current mission scenarios predict that crews will experience effective doses from 50 to 2,000 mSv (milli-Sievert). This level of radiation is within the range known to increase the risk of carcinogenesis and other health problems, such as cataracts. Most of the radiation in the beyond-LEO environment consists of protons and high-Z high energy ions as well as secondary radiation (e.g. neutrons), which is generated from spacecraft materials exposed to space radiation. Space radiation also consists of ultraviolet radiation. However, UV radiation is efficiently blocked by spacecraft materials, so is not relevant to this competition.

On Earth, the strategy used to limit occupational exposure to dangerous levels of ionizing radiation is to closely monitor radiation levels, and to limit the time that workers are exposed to high levels of radiation. In cases when the environment itself is contaminated (e.g. a nuclear power plant that has leaked radioactive substances into the environment), workers don suits and breathing apparatus that do not confer themselves protection against radiation, but prevent workers from ingesting or inhaling radioactive particles.

In long duration spaceflight missions beyond LEO, such strategies alone are not effective. Consequently, space agencies have sponsored research on nutritional or pharmaceutical countermeasures to radiation exposure, and explored the possibility of protecting crews on planetary surfaces through the use of surface materials (e.g. regolith on the moon). Efforts are also underway to develop screening methods that would allow the selection of crewmembers most resistant to radiation effects.

There has also been research within academia, industry, and government on the development of novel materials that confer direct protection against ionizing radiation.

The objective of this Request for Proposals is to select and fund proposals for the development and testing of space radiation-shielding materials. Such materials could be wearable or non-wearable flexible materials or textiles, or other materials such as creams applied directly to skin.

Current materials (e.g., aluminum) used for spacecraft confer some protection against radiation, but not enough to protect crews beyond LEO. Conventional shielding materials such as water are effective but require too much mass to be considered practical for spacecraft. The technology proposed in response to this RFP must have relatively low requirements for mass and volume and must be targeted for use inside a spacecraft. The material can be powered, but must have low power requirements. Mass, volume, and power requirements must be compatible with the proposed use (e.g. as a component of clothing, or as a material that can be deployed on a wall or as a shelter).

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 radiation shielding material or concept to TRL 4 (see AD-2), where the basic technological components are integrated to establish that they will work together and meet the specifications and requirements (see functional characteristics and performance requirements section). For example, if the selected technology is a piece of clothing made of a technical textile, the component to be manufactured must allow the complete testing program to be implemented and all other requirements for this project to be demonstrated.

It is highly preferable that the basis of radiation shielding be already well understood (at least TRL 2 or 3), such that the project can effectively deliver at TRL 4 technology.

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

1. Complete a survey and comparative analysis of the space radiation shielding materials or concepts. Assess which materials or concepts are most promising for use in spacecrafts given the radiation environment for various orbits (LEO, GEO and Sun-Earth L2).

2. Adapt and detail specific functional specifications and performance requirements for this specific technology, based on the Functional specifications and performance requirements section below and on the applicable space agencies standards.
3. Identify current materials or components supplier(s) and manufacturing capabilities.
4. Complete complementary laboratory analysis on materials or conceptual testing or verifications if needed.
5. Identify the technology which will be advanced to TRL 4 during this project, in function of the functional specifications and performance requirements, its potential to become “flight qualified”, space agencies’ space exploration objectives and plans for the future, and expertise of the contractor and Canadian suppliers.
6. Complete the Preliminary Design of the component or breadboard.
7. Once the Preliminary Design is accepted, complete the Detail Design of the component or breadboard.
8. Manufacture or purchase the pieces or materials in order to assembly the component or breadboard to be tested.
9. Plan a testing program for the component or breadboard in a laboratory environment, including testing of the radiation shielding performance, and a crew safety assessment.
10. Implement the program mentioned in 9.
11. Produce a Technical Report summarizing the main decisions and results obtained during steps 1 to 10.
12. 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.
13. 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.

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Table 1 - Proposed Schedule for Main Milestones and Work Packages

Milestones	Milestone Name	Start	Completion
WP0	Start / Kick-off meeting	*Contract Award*	*Contract Award plus 2 weeks*
WP1	Survey and comparative analysis. Identification of the technology.	*Contract award*	*Contract award plus 8 months*
WP2	Adapt and detail functional specifications and performance requirements for this specific technology	*Contract award*	*Contract award plus 8 months*
WP3	Complementary laboratory analysis or conceptual verifications.	*Contract award*	*Contract award plus 8 months*
WP4	Review meeting	*Contract award plus 8 months*	*Contract award plus 8 months*
WP5	Identify current materials or components supplier(s) and manufacturing capabilities.	*Contract award*	*Contract award plus 11 months*
WP6	Complete the Preliminary Design of the component or breadboard	*Contract award plus 8 months*	*Contract award plus 12 months*
WP7	Review meeting	*Contract award plus 12 months*	*Contract award plus 12 months*
WP8	Complete the Detail Design of the component or breadboard.	*Contract award plus 12 months*	*Contract award plus 14 months*
WP9	Manufacture or purchase the pieces or materials in order to assembly the component or breadboard.	*Contract award plus 12 months*	*Contract award plus 16 months*
WP10	Plan a testing program for the component or breadboard in a laboratory or radiation beam facility environment, including a crew safety assessment.	*Contract Award plus 12 months*	*Contract Award plus 18 months*
WP11	Review meeting	*Contract Award plus 18 months*	*Contract Award plus 18 months*
WP12	Implement the testing program.	*Contract Award plus 18 months*	*Contract Award plus 22 months*
WP13	Prepare reports.	*Contract Award*	*Contract Award*

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Milestones	Milestone Name	Start	Completion
		plus 22 months	*plus 24 months*
WP14	Final Review meeting	*Contract Award plus 24 months*	*Contract Award plus 24 months*

Functional characteristics and performance requirements

The technology product resulting from this contract will be a component or breadboard, depending of the technology selected previously under this contract, allowing its testing in a laboratory using an appropriate radiation source(s) (e.g. a beam facility). This component or breadboard must be usable for testing of its functional characteristics and performance requirements, including:

- Shielding against a specific type of radiation characteristic of space radiation.
- If the technology is a wearable textile or material directly applied to clothing or skin, the material must be tested for comfort and durability, with an analysis, supported by testing, of the need for washing and the effects of washing on performance.
- Resistance for radiation –in this context 'resistance' refers to the capacity of the technology itself to resist radiation-imposed changes in its physical and chemical structure. Tests are expected to include measures of physical structure and characteristics, and tests of volatile release.
- Safety for crew members as the technology will be used within a closed human-rated spacecraft. Examples of safety hazards are toxicity of materials, flammability, off-gassing, release of particulates, abrasive or sharp edges or burrs, allergenicity. The component or breadboard must be usable for testing of its adherence to crew safety standards.

The testing program must have the following features:

- The radiation source must be capable of generating radiation similar to one of the components found in the beyond-LEO environment (e.g. high Z, high energy ions);
- Capable of measuring the shielding performance of the material. Shielding performance targets will vary with the specific type of radiation tested, but must at a minimum determine if there is a statistically significant decrease in radiation transmittance.
- Post-testing analysis must determine if the magnitude of the observed decrease in radiation transmittance is biologically significant, i.e. will result in a significant reduction in the accumulated dose received by a crewmember. Tissue-equivalent doses should be calculated. Since it is currently impossible to define a threshold radiation dose for cumulative

exposure for the crew of long term missions outside LEO, precise dose targets cannot be set.
- The testing facility must be accessible for use by the contractor for the purpose of testing the component or breadboard during the period of the contract.

TRL timeline

- Initial TRL: preferably 2 to 3
- Targeted TRL: 4
- Duration to reach targeted TRL: 24 months

Targeted missions

The specific mission class that could directly benefit from the radiation shielding material or technology is a human spaceflight mission that requires prolonged (i.e. greater than six months) exposure to the beyond-LEO environment. However, the material may have extensive additional mission applications, including the use on satellites for the protection of radiation-sensitive electronics.

The radiation-shielding material or technology could be used in the following ways:

- A wearable system or piece of clothing for crew protection;
- A cream applied to skin;
- A deployable 'storm shelter' for use during solar storms;
- A material or technology that can be deployed directly on the inner wall of a spacecraft.

Specific Deliverables

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

- The component or breadboard assembled during this project and all material samples received or purchased during the term of this contract shall be delivered to CSA by the end of the contract.
- Technology Readiness and Risk Assessment Worksheets and Rollup.
- Technology Roadmap Worksheet.
- Technical Report must include detailed results of the performance requirements and functional characteristics testing and crew safety assessment.