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SOLICITATION AMENDMENT
MODIFICATION DE L'INVITATION

The referenced document is hereby revised; unless otherwise indicated, all other terms and conditions of the Solicitation remain the same.

Ce document est par la présente révisé; sauf indication contraire, les modalités de l'invitation demeurent les mêmes.

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Title - Sujet Surveillance of Space 2 RFI	
Solicitation No. - N° de l'invitation W8474-187639/A	**Amendment No. - N° modif.** 001
Client Reference No. - N° de référence du client W8474-187639	**Date** 2018-08-09
GETS Reference No. - N° de référence de SEAG PW-$$ST-047-33735	
File No. - N° de dossier 047st.W8474-187639	**CCC No./N° CCC - FMS No./N° VME**
Solicitation Closes - L'invitation prend fin **at - à 02:00 PM** **on - le 2020-01-15**	**Time Zone** **Fuseau horaire** Eastern Standard Time EST
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This amendment 1 is to replace the original pdf document which has track changes and comments showing in the documents. A clean version below is provided. However, the content has no difference to the original document.

1.0 Purpose and Nature of the Request for Information

1.1. Public Services and Procurement Canada (PSPC) is requesting Industry feedback regarding a Space Situational Awareness capability for the Department of National Defence (DND), and potentially other partners including Other Government Departments and Agencies (OGDAs).

1.2. The requirements associated with this capability are derived from Canada's continued need for Space Situational Awareness[1] (SSA). The new capability must be nationally controlled and also will be a contribution to the Space Surveillance Network (SSN) associated with membership in the Combined Space Operations (CSpO) initiative[2].

1.3. The objectives of this Surveillance of Space 2 (SofS 2) Request for Information (RFI) are to:

a. Inform Industry of the DND's SofS 2 requirements;

b. Obtain input from Industry on the feasibility, deficiencies and proposed improvements with respect to potential options to meet the requirements;

c. Align this requirement with the Industry's capabilities, as applicable;

d. Seek Industry input on potential economic leveraging opportunities; and

e. Obtain indicative costing estimates from Industry.

1.4. This RFI is neither a call for tender nor a Request for Proposal (RFP). No agreement or contract will be entered into based on this RFI. The issuance of this RFI is not in any way a commitment by Canada, nor an authority to potential Respondents to undertake any work that could be charged to Canada. This RFI is not to be considered as a commitment to issue a subsequent solicitation or award contract(s) for the work described herein. This RFI is solely for informational purposes only.

1.5. Although the information collected may be provided as commercial-in-confidence (and, if identified as such, will be treated accordingly by Canada), Canada may use the information to assist in defining a solution to meet the High Level Mandatory Requirements.

1.6. Respondents are encouraged to identify, in the information they share with Canada, any information that they feel is proprietary or confidential. Canada will handle the responses in accordance with the Access to Information Act and will not disclose proprietary or commercially

[1] SSA (Space Situational Awareness) is the knowledge of the orbital parameters of Resident Space Objects (RSO). An RSO is any object in orbit around the Earth, or entering Earth's space domain. Objects of interest are active and inactive satellites, and space debris (e.g., discarded launcher or deployment hardware, the products of collisions of RSOs, etc.).

[2] The CSpO initiative is an international collaboration initiative among Canada, US, UK, Australia and New Zealand to improve defence space coordination of efforts and to enhance individual space capabilities.

sensitive information concerning Respondents or third parties, except and only to the extent required by law. For more information, see: http://laws-loi s.justice.gc.ca/eng/acts/a-1/.

1.7. Respondents are asked to identify if their responses, or any part of their responses, are subject to the Controlled Goods (CG) regulations.

1.8. Participation in this RFI is encouraged, but is not mandatory. Respondents should note that this RFI is not a pre-selection process and that there will be no short-listing of potential suppliers for the purposes of undertaking any future work as a result of this RFI. Participation in this RFI is not a condition or prerequisite for the participation in any potential subsequent Industry Engagement activities, Invitation to Qualify (ITQ) (if applicable) or Request for Proposal (RFP) solicitation.

1.9. Respondents will not be reimbursed for any cost incurred by participating in this RFI or for any activities associated with the Industry consultation including, but not limited to, travel or hospitality

1.10. Responses to this RFI will not be returned to Respondents. Responses will not be formally evaluated. The responses received however, may be used by Canada to conduct analysis, and analyze possible procurement approaches. Canada will review all RFI responses.

1.11. A review team composed of representatives of the DND, PSPC; and Innovation, Science and Economic Development Canada (ISED) will review the responses. Not all members of the review team will necessarily review all aspects of each response. Canada reserves the right to hire any independent consultant, or use any of Canada's resources that it considers necessary to review any response. Independent consultants that may be provided access to responses will be subject to a Non-Disclosure Agreement.

1.12 A Fairness Monitor (RFP Solutions) has been appointed to oversee this project to ensure all potential bidders are treated equally throughout the whole engagement and procurement process.

2.0 Legislation, Trade Agreements, and Government Policies

2.1 National Security Exception

2.1.1 A National Security Exception (NSE), allows Canada to exclude a procurement from some or all of the obligations in the relevant trade agreement(s), where Canada considers it necessary to do so in order to protect its national security interests specified in the text of the NSE. Potential Respondents are advised that a NSE has been invoked under the authority of PSPC's Assistant Deputy Minister - Procurement Branch. Details are available at: https://buyandsell.gc.ca/policy-and-guidelines/supply-manual/section/3/105 ; The NSE is provided for in the following Agreements:

a. North America Free Trade Agreement;

b. Canada-European Comprehensive Economic and Trade Agreement;

c. World Trade Organization Agreement on Government Procurement;

d. Canada-Chile Free Trade Agreement;

e. Canadian Free Trade Agreement; and

f. Canada Free Trade Agreement (CFTA).

2.2 Controlled Goods Provisions

2.2.1 As SofS 2 may require the production of or access to Controlled Goods (CG) that are subject to the Defence Production Act, Respondents are encouraged to familiarize themselves with the provisions of the Controlled Goods Program (CGP) at the earliest opportunity. Details on how to register under the CGP are available at http://www.tpsgc-pwgsc.gc.ca/pmc-cgp/enregistrement-register-eng.html.

2.3 Industrial and Technological Benefits

2.3.1 The Industrial and Technological Benefits (ITB) Policy, including Value Proposition, may apply to SofS 2. For more information on the ITB Policy, consult the ITB website: www.canada.ca/itb.

2.4 Green Procurement

2.4.1 Respondents are requested to identify and cost potential areas of development, manufacturing and/or project delivery that leverage environmentally friendly standards and/or processes. For more information on the Green Procurement Policy, consult the Treasury Board Secretariat (TBS) website: http://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=32573

3.0 Project Background, Objectives, and Milestones

3.1 Project Background

3.1.1 In 2013, the Department of National Defence (DND) launched their first military satellite, Sapphire, a Space Based Optical (SBO) sensor that provides valuable Space Situational Awareness to both Canada and its allies. SSA products allow Canada to accurately assess the orbital positions and projected paths of space assets. From its Low-Earth Orbit, Sapphire looks outwards into the deep space orbits populated by communications, GPS and missile warning satellites, in order to track Resident Space Objects (RSOs). It provides critical data to the SSN which is used in the preparation of collision avoidance solutions for the space surveillance community and persistent surveillance of space assets to safeguard against potentially hostile acts from our adversaries. Sapphire is considered a highly valuable asset in the United States (US) SSN and has established Canada as a principal provider of space-based SSA data.

3.1.2 Sapphire's five-year design life was reached in early 2018 and, while currently operating within nominal parameters, projected mission life expectancy is now uncertain. The new Surveillance of Space 2 (SofS 2) sensor system is estimated to become operational no later than 2026. This results in a potential risk in Canada's SSA contribution to the SSN noting that risk mitigation strategies are under consideration. Given the significant Space mission assurance objectives outlined in Strong-Secure-Engaged, it is essential to avoid similar situations in the future by adopting an appropriate SofS 2 delivery mechanism that will ensure there are no future potential gaps in Canada's SSA capabilities.

3.1.3 The Canadian Armed Forces (CAF) rely heavily on space-based assets to conduct operations. The space environment is increasingly congested due to the current and projected dramatic increase in debris and presence of commercial and other satellites, including those of potential adversaries. Currently, there are over 500,000 objects in Earth's orbit greater than 1 cm in size traveling at velocities of over 29,000 km/hr and the number of objects is expected to increase significantly. As an example, there are approximately 13,000 "near misses" between RSOs per week and this is expected to increase to 20,000 by 2019[3]. In the context of this environment, access to SSA is essential to the security and integrity of national space-based capabilities, the awareness of space threats to Canadian territory, and support to CAF operations worldwide.

3.1.4 Following on the success of the Sapphire System, developed under the original SofS project, SofS 2 offers Canada the opportunity to enhance our status as a significant contributor to the SSN and the associated Space domain awareness it supports.

3.1.5 Space-enabled capabilities are increasingly enabling to many government departments and have become essential to the roles and missions the CAF performs on behalf of the Government of Canada. They protect Canada through space-enabled intelligence, surveillance, reconnaissance, communications, navigation, weather monitoring and forecasting, and contribute to international peace and security in cooperation with allies.

3.1.6 The products of SSA allow Canada to accurately assess the orbital positions of our assets. It also enables the detection and avoidance of potential collisions with debris or other orbiting objects, or hostile acts by adversaries, which could jeopardize Canadian assets or those of our allies. Furthermore, a continuing Canadian SSA contribution ensures continued access to the US SSN and access to products produced by key allied systems.

3.1.7 The objective of the SofS 2 capability is to replace and enhance contribution of the Sapphire System to meet the requirements of the future security environment and the CAF objectives detailed in SSE.

[3] Source: https://www.newscientist.com/article/dn18050-space-debris-threat-to-future-launches/

3.2 Project Business Outcomes

3.2.2 The desired business outcomes for the SofS 2 Project are DND's continued access to Space Situational Awareness (SSA) data products from the SSN by means of:

a. Ability to provide valuable space surveillance data to the SSN;

b. Enhanced capabilities to exploit technological innovations, to maintain the high value of our data products to the SSN, while operating within an evolving contested and congested environment;

c. Continued agreements to participate in the US SSN as a contributor and receiver of SSA data;

d. Continued contributions to and benefits from the CSpO Initiative;

e. Enhancement of Canada's reputation among our allies as a capable participant in SSA; and

f. An inherent capability to assign sensor taskings of specific Canadian interest in addition to supporting SSN directed taskings and contributing to space security.

3.3 Project Milestones

3.3.1 These dates are subject to change.

Milestone	Planning Date
Project Approval (Definition)	2020 - 2021
Project Approval (Implementation)	2023 - 2024
Initial Operating Capability	2026 - 2027
Full Operating Capability	2026 - 2027

Table 1 – Current Project Milestones and Schedule

4.0 Project Scope and Preliminary Requirements

4.1. Planned Architecture

4.1.1. The figure below shows the current configuration of the Canadian Space Surveillance System (CSSS). The CSSS encompasses the Sensor System Operations Centre (SSOC) and a contracted component, which currently includes the Sapphire System (Sapphire satellite and its ground system). The Sapphire System will be replaced by the SofS 2 capability. DND has overall control of the CSSS, and direct control of the SSOC.

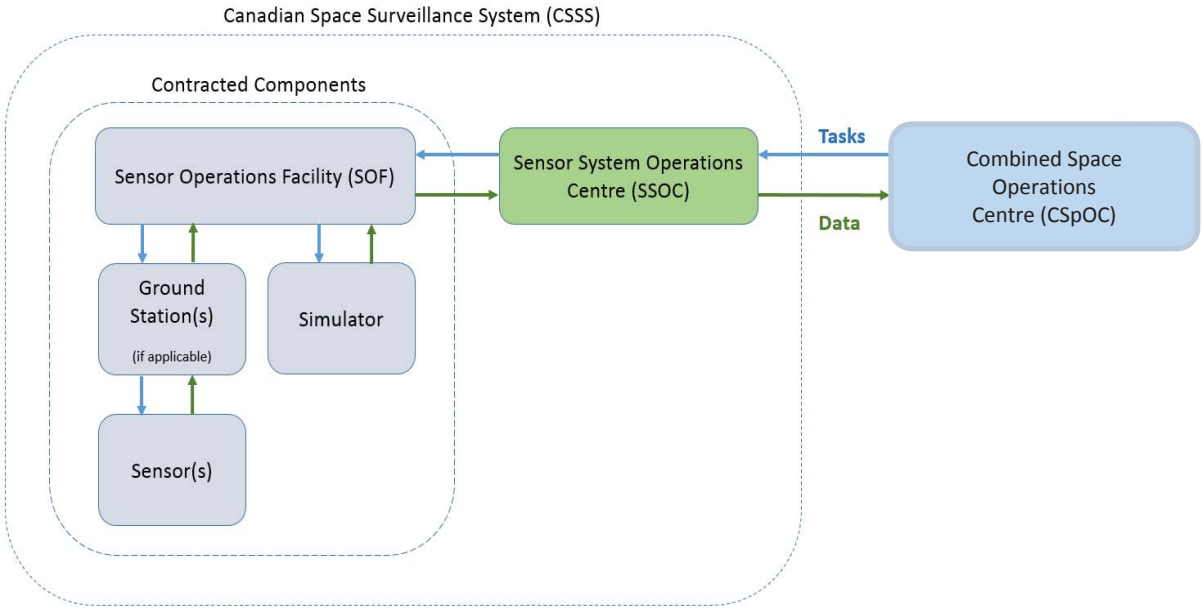


Figure 1 – System Configuration

4.1.3 Tasking requests are generated either by the US Combined Space Operations Center (CSpOC), the SSOC or the Canadian Space Operations Centre (CANSpOC). They come in the form of a prioritized task list of Two-Line Element sets (TLEs) which define the expected orbital parameters of each RSO to be tracked. Additional detail on TLEs can be found at https://www.space-track.org/documentation#/tle. The Sensor Operation Facility (SOF) processes sensor data and sends this data and the RSO image file to the SSOC. The SSOC then transfers this data to the SSN which is used to update TLEs.

4.1.3. Transmissions between the SSOC and CSpOC occurs over a dedicated circuit. All other ground transmissions use secure (encrypted) internet connections. The Ground Station(s) to Sensor(s) connection is a radio frequency space link for space based sensors.

4.1.4. Additional operational details are available in Annex D – Additional Operational Context. Further information on system interfaces and messages are contained in the guidance document "*SSOC to SSA Sensor Interface Control Document – DND Template*", which is available upon request. Note that the SofS 2 solution may include SSOC modifications and therefore some messages may change. Evolving SSN requirements may necessitate other changes as well.

4.1.5. The number and type of sensors to be employed in the SofS 2 capability has not yet been finalized. It is possible that one or more Ground Station(s) could be co-located with the Sensor Operation Facility. GBOs might similarly be co-located. Depending on the respondent solution and acquisition model, other differences may also be proposed.

4.2. Project Deliverables

4.2.1. Canada intends to release a competitive RFP for the delivery of the SofS 2 capability. In accordance with the proposed architecture, Canada is seeking an end-to-end space situational awareness solution that will acquire, track and report on RSOs, delivering data outputs in a format compatible for ingestion by the SSOC. This capability will be provided and supported for a minimum period of 10 years. Below is a list of planned deliverables, with several potential sensor options identified. Respondents may offer a different solution than the ones shown if they can demonstrate that their solution is competitive.

a. Commissioned Sensors and hardware spares. Solution could take one of the following forms:
    i. A Space-Based Optical (SBO) sensor in Low Earth Orbit (LEO);
    ii. A Space-Based Optical (SBO) sensor in Geostationary Orbit (GEO);
    iii. A small Ground-Based Optical (GBO) sensor (<1m telescope);
    iv. A large Ground-Based Optical (GBO) sensor, similar to US SSN Space Surveillance Telescope (SST); or
    v. Multiples and/or combinations of SBOs or GBOs.
b. Ground System, which shall include the elements necessary to facilitate operations between the SSOC and the sensor(s).
c. Model(s) such as an Engineering Model (EM) or Engineering Qualification Model (EQM) in support of the proposed verification approach (Annex F provides additional detail on guidelines for standards for these models);
d. Security measures such as encryption of space and ground links consistent with applicable standards (to be approved by DND).
e. Interface with a Sensor System Operations Centre (SSOC).

f. Standard documentation (pertaining to Space related projects) to support Preliminary Design Review (PDR), Critical Design Review (CDR) and progress reporting. Annex E – *Standard Practices for Space Projects* provides a list of references for guidance;

g. Contractual Data Requirements List (CDRLs), including identification of any foreground Intellectual Property (IP) developed and background IP used;

h. Launch Services with a minimum reliability of 90%, in accordance with Federal Aviation Administration (FAA) reliability estimation for expendable or reusable launchers will apply.

i. Operation services to include all ongoing and daily functions necessary to assure responsiveness to SSOC routine and ad-hoc taskings, which are described in Annex D – *Additional Operational* .

j. In-Service Support (ISS) including maintenance, engineering support, Integrated Logistics Support (ILS), and continuous improvement.

k. Disposal including demilitarization when required.

4.3. System High Level Mandatory Requirements

4.3.1. Functional and performance requirements will be derived from High-Level Mandatory Requirements (HLMRs).

Table 2 – System High Level Mandatory Requirements and Targets

HLMR	Requirement	Target
1 – Sensitivity	Be able to detect objects in space of a minimum specified size of a 30-cm sphere at 40,000 km, or equivalent brightness[4].	The goal is VisMag 18.0.
2 – Accuracy	Be able to determine a space object's position to a specified degree of precision measured as one sigma angle precision less than 1 arc second.	The goal is 0.5 arc-seconds.
3 – Capacity	Be able to obtain a minimum of 35 tracks per hour for space based sensors and 40 tracks per hour for ground based sensors.	The goal is 50 tracks per hour for both. Please see Annex B – *Definitions of Terms Used in this Document* for additional explanation of capacity and definition of a track.
4 – Availability	Be able to collect observations of space objects, at least 90% of the time during viewing conditions commensurate with the capability and available 98% of the time over a ten-day period.	The goal is 95% availability during viewing conditions commensurate with the capability.
5 – Interoperability	Be able to communicate with the SSOC, the SSN, the CANSpOC and the CSpO network by using common command and telemetry protocols, formatting and interfaces.	No target identified at this time.
6 – Protection	Be able to communicate within the entire CSSS and with the SSN at a security level that is consistent with DND SA&A guidelines.	Unclassified; Secret-level under consideration by DND.

[4] Equivalent to visual magnitude 17.5 at a viewing angle of 90 degrees (optimal viewing angle).

7 – Latency	Be able to report space object position data no later than 4 hours from the time of observation.	The goal is near real-time. Please see Annex B – *Definitions of Terms Used in this Document* for definitions of data and system latencies.
8 – Control	Be able to maintain national operational control over planning, monitoring, operation, and management of the capability in support of CAF operations. This includes being able to adjust the number and rate of observations as well as observe specific orbital regimes and/or objects of national interest and determine the scheduling of routine maintenance of the sensor(s).	No target identified at this time.
9 – Orbit Debris Mitigation	For space-based sensors, must be able to conform to the Peaceful Uses of Outer Space[5] guidelines for space debris mitigation.	No target identified at this time.
10 – Mission Life	Be able to maintain full capability for a minimum of 10 consecutive years.	No target identified at this time.

The following potential HLMR, Maneuverability, is under consideration as a system mission assurance measure, pending feasibility assessment and approval by DND.

11 – Maneuverability	Be able to maintain orbit parameters within a certain tolerance, and change orbit parameters to avoid collisions with space debris and other satellites.

[5] United Nations Office for Outer Space Affairs, "Space Debris Mitigation Guidelines of the Committee on the Peaceful uses of Outer Space", www.unoosa.org/pdf/publications/st_space_49E.pdf. *Technical recommendations for this document can be sourced from the Inter-Agency Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines (IADC-02-01 Revision 1 Sept 2007) accessible from* www.unoosa.org/.../IADC-2002-01-IADC-Space_Debris-Guidelines-Revision1.pdf .

4.4. References

4.4.1. The following information is provided as reference material to assist respondents with their understanding of the SofS 2 scope:

Annex A – Rules of Engagement

Annex B – Definition of Terms

Annex C – Acronyms and Glossary of Terms

Annex D – Additional Operational Context

Annex E – Standard Practices for Space Projects

Annex F – Manoeuvrability Framework Analysis Summary (DRDC)

SSOC to SSA Sensor Interface Control Document – DND Template, Upon Request

4.4.2. Additional information may be found at the following links to external resources:
Space Debris Mitigation Guidelines of the Committee on Peaceful Uses of Outer Space http://www.unoosa.org/res/oosadoc/data/documents/2010/stspace/stspace49_0_html/st_space_49E.pdf

5.4.3 Security Regulations for Classified Facility & Processing
https://www.cse-cst.gc.ca and http://www.tpsgc-pwgsc.gc.ca/esc-src/index-eng.html

5.0 Information to Include in Responses

5.0.1 Respondents are invited to submit a reply to the RFI that addresses each of the topics listed below. To facilitate the review of the responses to this RFI, respondents are asked to provide the requested information in the order in which the topics are presented below.

5.1. Respondent Information

5.1.1. Based on the documentation provided, the respondents should provide background information on its capability either individually or through partnership(s) or sub-contracting to deliver the SofS 2 solution; and

5.2. Respondent Representative

5.2.1. The respondents should provide the name, telephone number, and e-mail address of a representative who may be contacted for clarification or other matters related to the respondent's RFI response.

5.3. Scope Elements to be Addressed by Respondents

5.3.1. DND is interested in a complete end-to-end space situational awareness solution(s). It is understood, however that trade-offs in schedule, cost, performance, complexity, and risk are possible with different configurations. Respondents are requested to indicate that they can

provide all of the SofS 2 scope elements listed in Section 4.2 and identify elements for consideration as possible capability trade-offs.

5.3.2. Project Execution Model

5.3.2.1. The Respondents should propose a Project execution model that would provide the best value for cost. Consideration should be given to product assurance approach, essential documentation, verification approach, necessary reviews, etc. The following elements should be included:

a. A proposal for a WBS (Work Breakdown Structure) employed for work and deliverables of SofS 2.

b. An overview of the standard design/build and test processes for space hardware and related quality and product assurance oversight/processes employed at the respondent's facilities. Annex E – *Standard Practices for Space Projects* provides references which include Verification Guidelines for space system products;

c. An overview of the standard space project documentation (e.g. Phase A – D) proposed for reviews and progress reporting in addition to custom documentation provided by the respondent. Annex E – *Standard Practices for Space Projects* provides references which describe typical space project phases and reviews.

5.3.3. Solution/Capability Element Summaries

5.3.3.1. The respondents should describe their recommended solution(s) in as much detail as possible in order to demonstrate achieving the required performance / HLMRs and DND's target outcomes. The respondents are encouraged to include the following for each solution:

a. A general breakdown of all solution elements delivered with the following details:

   i. A description of how each element/module would be designed and tested in accordance with the project execution model proposed in response to Section 5.3.2 - *Project Execution Model*.

   ii. A description of the technical readiness levels (TRL) of all elements along with the ownership details for any background and foreground intellectual property (IP) to be used;

   iii. Details on the number, type, and location or orbital regime for the proposed sensor(s);

   iv. A description of the performance of each sensor and the combined solution showing that the mandatory requirements will be met and to what degree the desired targets will be achieved.

      (a) Where appropriate, element mission lives should have accompanying probabilities.

      (b) Include the probability of detection from the sensitivity HLMR to the performance limit VisMag of the proposed sensor.

v. Details on any limits or restrictions on distribution of data generated by the sensor(s).

vi. Details on the spatial and temporal coverage of the system by sensor and their associated limitations

(a) Instantaneous field of view of the sensor.

(b) The percentage of orbital regimes within view within a data acquisition period.

(c) The acquisition time of a target (e.g. slew rate, capture, processing).

(d) For GBO(s), the average annual percentage of time that viewing conditions are commensurate with the capability, based on proposed location(s).

vii. Details on the system operation including task upload and scheduling process. Specifically, how the system would re-prioritize and execute interrupt taskings.

viii. What functions would be carried out on and off-board the sensor (i.e., data processing, on-board timing standard, etc.) and the reasons for these decisions;

ix. Describe how the solution would be hardened to account for the space environment.

x. Details on the information included in the Graphical User Interface (GUI) at the SSOC (e.g. sensor & bus status, task list, next object acquisition, acquisition success, estimated date time group for data download, etc.) and any impacts it has on the ease of tasking and DND resource requirements.

xi. If applicable, respondents are requested to provide a description of their expected launch vehicle, launch vehicle heritage, number of launches required, launch configuration, launch schedule, and launch margin.

b. Identification of any or all sub-contractors that may be employed to build parts/modules for the system and simulator including their country of origin and history of work with the Industry;

c. Identification of any solution elements that are subject to export controls such as the International Traffic and Arms Regulations (ITAR) and Export Administration Regulations (EAR).

5.3.4. Capability Trade-Offs

5.3.4.1. Canada seeks to optimize the implementation of SofS 2 in such a way that the requirements are balanced with best overall value to Canada and its contribution to allied requirements. In consideration of the number of requirements and their respective targets, there is a large trade-off space to be considered for each potential solution. The Business Outcomes have been developed with the intent of encouraging innovative solutions that represent best value (i.e. the optimization of capability versus cost). Respondents are encouraged to respond in such a way that this trade-off space is clearly identified and design decisions are substantiated. As a minimum, Respondents are requested to identify the following when responding:

a. How the number, type, and location or orbital regime for the proposed sensor(s) was optimized. This includes the orbit inclination angle, eccentricity, apogee and perigee altitudes, period for SBO(s); the latitude and longitude of GBO(s) and proximity to existing infrastructure.

b. Any important payload and bus architecture decisions made for the sensor(s);

c. How the solution Sensitivity, Capacity, and Accuracy were optimized.

d. In the case of space based sensors:

   i. Spacecraft Size, Weight and Power (SWaP) design choices including a power budget;

   ii. The antenna configurations, beam patterns, beam coverage and overall link budget.

   iii. Given the UN COPUOS guidelines for the mitigation of space debris and the criteria and considerations for manoeuvrability defined in Annex F – *Maneuverability Framework Analysis Summary (DRDC)*, please provide the following analysis and details for the proposed solution:

      1. Describe the propulsion requirements or other deorbit systems which can economically deorbit the space-based sensor, within the required timeframe.
      2. Describe the propulsion requirements needed for Initial Orbit Insertion (e.g.: inclination tuning), if any.
      3. For the proposed orbit, describe the propulsion system requirements and the annual number of collision avoidance (COLA) maneuvers per year using the Hard Body Radius and timeframe specified in Annex F - Table 3 - Maneuverability Framework Parameters.
      4. Provide an estimate of the required satellite orbital changes for COLA and whether there is a need to return to the original orbit, post-event;
      5. Compare the cost of including a maneuverability capability to only delivering a de-orbit requirement. Identify initial development and in-service operations costs.
      6. Please provide details on the potential propulsion system(s) and their technological readiness level (TRL).
      7. Consider the impact of orbital maneuvers on the execution of the Data Acquisition Period (DAP) scheduling and tasking approach, or requirements for system recalibration post-maneuver.

e. If multiple sensors are proposed, what cost savings are estimated for follow-on sensors? How would entry into service be sequenced? How would technology refresh be managed?

f. How mission continuity would be assured in a cost-effective manner. Design considerations might include adding redundancy within the sensor architecture, having multiple (active or available back-up) sensors and ground stations. Opting for a Proto-flight Model (PFM) could be another example.

g. What are the preferred/existing locations (if any) for the SOF and ground station(s);

h. How the proposed design optimizes end to end system responsiveness including:

    i. The cost delta between the maximum latency of 4 hours, the proposed latency, and what would be required to achieve near real time.

    ii. Estimates of the best and worst case times to report on targets within the solutions area of coverage.

i. Describe how the scalability and flexibility could be provided in a cost effective manner:

    i. If possible, to what degree could spatial and temporal capacity and coverage be augmented and at what additional cost?

    ii. Describe how the solution could accommodate possible changes to the mission life, including:

        a. What would be required to continue operation beyond the defined 10 year mission life? What are the major cost drivers in achieving and exceeding this requirement (i.e. life limited components)?

        b. The sensitivity of the total and amortized annual cost to increases in mission life beyond the minimum 10-year period of performance. What would be the cost for each additional year?

        c. What would be the optimal term for option periods? How much lead time would be required to exercise these extensions?

    iii. What elements of the solution could be designed for physical portability?

    iv. If DND desired to have an early capability fielded as soon as possible (to be followed by the full capability), how would this affect the proposed design? To what degree could the HLMRs be met by the early capability? What are the capability trade-offs and additional costs (if any) associated with this approach?

5.3.5. Acquisition Model

5.3.5.1. Respondents are requested to propose one or more acquisition models. Canada acknowledges that there are several ways to address the requirements. Options could range from a major crown acquisition, managed services, government-owned contractor-operated equipment, long-term SSA capacity and equipment leases, and others. Different models will offer Canada to compare between risks, cash flows, and personnel resource requirements. Respondents should describe their proposal in sufficient detail so that a comparison between acquisition models can be made. Regardless of the acquisition model, the following considerations should be addressed:

a. What are savings made possible by this approach and how will they be shared with the DND?
b. What opportunities exist for Canada to maximize value (longer contract terms, assuming certain risks).
c. How would data ownership and licensing be defined to allow unrestricted use by DND?
d. How would DND unique data be protected?
e. If access to commercial SSA network forms part of the solution, how does adding or removing a requirement for segregation of DND space and ground segments impact the service cost?
f. What performance metrics and basis of payment would be proposed?

5.3.6. Cost

5.3.6.1. The Respondent should provide indicative cost estimates and cash flows including identification of sub-contractor costs for the proposed solution(s). Regardless of the acquisition model, the respondent should decompose cost estimates to the greatest extent possible. Responsdents are invited to refer to Annex G - RFI Cost Structure Sample and to address the following in their estimates:

a. Acquisition costs for space and ground segment elements by sub-system;
b. Any overhead costs such as program management, transportation, travel, and insurance should also be included and identified.
c. Key cost drivers and risks should be identified. Risks may be captured using a multi-point estimate with the best and worst case scenario costs. For example, launch segment costs, if applicable, could be subject to unavailability of the desired launch type (dedicated or shared launch, and whether the SofS 2 payload would be primary or secondary).
d. Any underlying assumptions (i.e. inflation, type of contract, basis of payment, mark-up and fees) used to establish these cost estimates and cash flows should be described.
e. Currency exchange considerations should be highlighted where used.
f. Costs should reflect Nominal Dollars ($Current Year), which is defined as the dollar value of a product at the time it was produced.

5.3.7. Risk Assessment

5.3.7.1. The intent is to minimize risk by leveraging existing technology with an established Technology Readiness Level (TRL) where possible. Should new technology be incorporated or existing technology be used in a substantially innovative manner, it should be identified along with its TRL and an elaboration on how any associated risk has been minimized with respect to the added value gained by its use.

5.3.7.2. Respondents may also choose to describe risks that are avoided in comparison to other solution(s) or acquisition models.

5.3.8. Schedule

5.3.8.1. The Respondent should provide their schedule for delivery of the capability and any associated equipment required for operation. If the solution includes design, development, assembly, integration, launch, and testing, then a phased schedule (e.g., Phases A through D[6]) should be applied and key anticipated milestones shown. In order to deliver a fully commissioned system no later than 2027, the respondent should consider the following:

a. What is the critical path for a 2027 completion date (i.e. what conditions need to be met to make that date)? For example, to what degree would changes in contract award affect achieving FOC?

b. What Respondent-managed issues would significantly impact the Project in terms of cost and schedule (e.g.: export permits, licensing and frequency allocation)?

5.3.9. Security Requirements

5.3.9.1. It is possible that there will be a requirement for secret level clearances for staff and secret level accredited facilities to process and handle secret data (see HLMR 6 - Protection). Respondents are requested to comment on their current and planned capabilities/facilities, in terms of physical security and screened personnel, and the cost delta between an unclassified and a classified solution. An overview of the IT security design to include details on potential mechanisms for defense against cyber and physical attacks is also requested. Respondents may familiarize themselves with potential security provisions through the Communications Security Establishment (CSE) website (https://www.cse-cst.gc.ca) and PSPC website (http://www.tpsgc-pwgsc.gc.ca/esc-src/index-eng.html)

5.3.10. Recommendations, Suggestions and Comments

5.3.10.1. As much as possible, the SofS 2 requirements are not intended to impose unnecessary restrictions on potential solutions. Should any requirement impose a limitation on a

[6] Phase A = Concept; Phase B = Preliminary Design; Phase C = Detailed Design; Phase D1 = Build; Phase D2 = Launch and Commissioning. Reference: https://fpd.gsfc.nasa.gov/lifecyclephases.html

Respondent's optimal solution, it should be identified to Canada. Respondents should also specify any additions or amendments they would propose to the Business Outcomes in order to provide or ensure a more optimal solution. Respondents are highly encouraged to offer alternatives to any of the concepts outlined in this RFI. These alternatives should be accompanied by a comprehensive analysis that articulates how the proposed amendment is more advantageous to Canada with regard to operational suitability, effectiveness, schedule, cost, and risk.

5.3.11. Economic Benefits

5.3.11.1. The Canadian Space Systems industry generates valuable economic impacts to the Canadian economy in its roles as an innovation leader. With a Research & Development (R&D) intensity over 10 times higher than that of total Canadian manufacturing, it plays a vital role in developing and supporting a highly skilled workforce. The Canadian space systems industry is commercially oriented and export intensive, and with significant capabilities within the Key Industrial Capability areas of Space Systems and Earth Observation, the industry is well positioned growth opportunities.

5.3.11.2. Canada's Defence Policy Strong, Secure, Engaged, identifies space capabilities of critical importance to national security, sovereignty and defence. Through SofS 2, the DND will procure key SSA technologies of strategic importance for Canada's national security. These activities fall across key space domains that have potential to grow Canada's Space Systems Industry and provide opportunities to support future Canadian industrial growth.

5.3.11.3. Accordingly, Canada is seeking information on economic leveraging opportunities related to SofS 2. Respondents should be aware that any contracts entered into as a result of any subsequent RFP that may follow this RFI may contain socio-economic benefit requirements such as the ITB Policy. Under the ITB Policy, companies awarded defence procurement contracts are required to undertake business activities in Canada, equal to the value of the contract. In addition, a core element of the ITB Policy is a rated and weighted Value Proposition. Further information regarding the ITB Policy can be found at http://www.ic.gc.ca/eic/site/086.nsf/eng/home

5.3.11.4. The ITB Policy has (5) main objectives:

a. Support the long-term sustainability and growth of Canada's defence sector;
b. Support the growth of prime contractors and suppliers in Canada, including small and medium-sized enterprises in all regions of the country;
c. Enhance innovation through Research and Development (R&D) in Canada;
d. Increase the export potential of Canadian-based firms; and,
e. Identify skills development and training opportunities for Canadians.

5.3.12. Industry Responses

5.3.12.1. The industrial analysis conducted to date has revealed that there is capability for Canadian industry to provide significant contributions to the SofS 2 solution. It is therefore important for Respondents to consider how they might engage Canadian capability within their solution for SofS 2. Proposed economic benefits through the ITB Policy should respond to any of the procurement options currently under consideration by Canada.

5.3.12.2. Respondents are asked to provide as much detail as possible to the following:

a. General:
    i. What are the key issues your company faces within the current global space market?
    ii. How is your company positioning for future opportunities in the space sector?
    iii. What role does this procurement play in positioning your company/team for long-term growth?

b. Direct Canadian Content: What direct Canadian content do you consider is applicable to delivering SofS 2? What partnerships with Canadian industry/academia does your team have that could be leveraged?

c. Supplier Development: How can this procurement be used to leverage opportunities for Canadian suppliers and small and medium-sized businesses?

d. Research & Development: What opportunities for R&D do you see in relation to SofS 2 directly? Are there other potential R&D opportunities in the broader space sector that are of value to leverage?

e. Export: Do you see opportunities for growth that can position your company and Canadian suppliers for future exports? Please explain.

f. Skills Development and training: The space systems industry in Canada supports a highly skilled work force. How does your solution contribute to the sustainment of this workforce? What challenges does your company currently face regarding skills development and what strategies could be used to ensure a sustained workforce in Canada?

6.0 Confidentiality

a) Respondents are advised that any information submitted to Canada in response to this RFI may be used by Canada in the development of a subsequent competitive RFQ and/or RFP; and

b) As such, respondents responding to this RFI should identify any submitted information that is to be considered as either company confidential or proprietary.

7.0 Contracting Authority

a) Enquiries are to be made in writing (preferably by e-mail) exclusively to the Contracting Authority indicated below;

b) Enquiries should be received no less than ten (10) working days prior to the RFI closing date to allow sufficient time to provide a response or to prepare a meeting. Enquiries received after that time might not be answered prior to the RFI closing date.

c) To ensure consistency and quality of information provided to Respondents, the replies to enquiries will be provided to all Respondents having signed the Rules of Engagementagreement (Annex B), without revealing the sources of the enquiries.

d) It should be noted that any information provided in relation to this RFI will not be binding upon Canada under any circumstances; and

e) Requests for clarification or meetings should be sent to the Contracting Authority:

Alan Chan
Supply Team Leader
Services and Technology Acquisition Management Sector
Acquisitions Branch
Public Service Procurement Canada (PSPC)
Telephone Number: 613-858-9358
E-mail address: alan.chan@tpsgc-pwgsc.gc.ca

8.0 Engagement Process

8.1. The Industry Engagement Process will begin with the publication on *BuyAndSell* http://www.buyandsell.gc.ca/tenders of this RFI. The Industry Engagement Process consists of the following events:

a. Release of one or more RFIs;

b. One-on-One Industry Day Meetings and a general briefing to respondents;

c. Submission of the RFI Responses;

d. Release of the RFI Summary of Feedback and Outcomes; and

e. Release of the draft RFP including SOW and evaluation criteria at a later date.

8.2. At any point within the Industry Engagement Process, the above-listed Industry Engagement events or their scheduling may change. Except for changes brought about by unforeseen events or adverse weather, Canada will endeavour to provide a minimum of five (5) calendar days' notice to respondents of any planned change. Industry Day, as well as all one-on-one meetings will be held at a location within the National Capital Region (Ottawa, ON, Canada).

8.3. Proceedings from all of the consultation workshops, such as one-on-one meetings will be recorded. A summary of information not subject to controlled goods or industry proprietary gathered during these workshops will be summarized and published on BuyandSell.

9.0 Industry Day Information Session

a) An industry day followed by one-on-one sessions are planned for 28 -30th August 2018 as an opportunity to pose and address questions with regard to this RFI. These sessions will be held at a location to be determined in Ottawa ON. These meetings will provide an opportunity for respondents to clarify their presentation and to present relevant technical input for the upcoming RFP;

b) Registration for the above events will be required. Upon registration, a meeting time will be allocated to each registering respondent on a first come first served basis. To register please contact the Public Service Procurement Canada (PSPC) Contracting Authority listed above;

c) Attendance to these sessions are not required in order to submit a response to the RFI nor any follow-on RFP;

d) Questions should be submitted to PSPC at least ten (10) working days before the event. At this information session, there will be an opportunity for interested potential respondents to seek clarifications from the SofS 2 Project Team concerning the requirements;

e) The information gathered on these questions (excluding proprietary or commercially sensitive information) will be summarized and published via the RFI Summary of Feedback and Outcomes on http://www.buyandsell.gc.ca/ .

f) Please note that all parties intending to participate in the one-on-one industry day sessions must:

   i. Have completed and submitted a signed Rules of Engagement form to the Contracting Authority referenced above; and

   ii. Please register at least five (5) days in advance of the session date by contacting the Contracting Authority referenced above.

Annex A – Rules of Engagement

An overriding principle of the industry consultation is that it be conducted in a fair and equitable manner between all parties. No one person or organization must receive nor be perceived to have received any unusual or unfair advantage over the others.

All Crown documentation provided throughout the industry consultative process, which begins with the publication on the www.buyandsell.gc.ca/procurement-data/tenders of this RFI.

The Consultative Process will consist of the following events:

a. Release of one or more RFIs;

b. Industry Day(s) if required;

c. One-on-One Industry Day Meetings upon request;

d. Submission of the RFI Responses;

e. One-on-One Post-RFI Submission Question and Answer (Q&A) Meetings;

f. Release of the RFI Summary of the feedback and outcomes; and

g. Draft RFP

A number of consultations will be conducted on various topics to solicit industry feedback/comments. Initially, Public Works and Government Services Canada will hold an Industry Day information session for the SofS 2 Project.

Canada will not disclose proprietary or commercially sensitive information concerning a Participant to other Participants or third parties, except and only to the extent required by law.

TERMS AND CONDITIONS:

The following terms and conditions apply to the Consultative Process. In order to encourage open dialogue, Participants agree to:

a. Discuss their views concerning the SofS 2 requirement and to provide positive resolutions to the issues in question. Everyone shall have equal opportunity to share their ideas and suggestions;

b. Not reveal or discuss any information to the media regarding the SofS 2 requirement during this Consultative Process. Any media questions will be directed to the PSPC Media Relations Office at 819-956-2315;

c. Industry shall direct inquiries and comments to the Contracting Authority unless advised otherwise. Please note that any communication to unauthorized representatives of Canada may be subject to full disclosure by Canada on *BuyAndSell;*

d. Canada is not obligated to issue any RFP, or to negotiate any contract for the SofS 2 Project;

e. If Canada does release a RFP, the terms and conditions of the RFP shall be subject to Canada's absolute discretion;

f. Canada will not reimburse any person or entity for any cost incurred in participating in this Consultative Process;

g. All inquiries with regard to the procurement of the SofS 2 Project are to be directed to the Contracting Authority;

h. Participation is not a mandatory requirement. Not participating in this consultative process will not preclude a bidder from submitting a proposal;

i. If Canada proceeds with the project, a Draft RFP will be provided to Industry for its comments;

j. Failure to agree to and sign the Rules of Engagement will result in the exclusion from participation in this Consultative Process; and,

k. A dispute resolution process to manage impasses throughout this Consultative Process shall be adhered to as follows:

DISPUTE RESOLUTION PROCESS:

1. By informal discussion and good faith negotiation, each of the parties shall make all reasonable efforts to resolve any dispute, controversy or claim arising out of or in any way connected with this Consultative Process.

2. Any dispute between the Parties of any nature arising out of or in connection with this Consultative Process shall be resolved by the following process:

   a. Any such dispute shall first be referred to the Participant's Representative and the PSPC Manager managing the Industry Engagement. The parties will have 5 Business Days in which to resolve the dispute;

   b. In the event the representatives of the Parties specified Article 2.a. above are unable to resolve the dispute, it shall be referred to the Participant's Project Director and the PSPC Senior Director of the Division responsible to manage the Industry Engagement. The parties will have 3 Business Days to resolve the dispute;

   c. In the event the representatives of the Parties specified in Article 2.b. above are unable to resolve the dispute, it shall be referred to the Participant's President and the PSPC Director General, who will have 3 Business Days to resolve the dispute;

   d. In the event the representatives of the Parties specified in Article 2.c. above are unable to resolve the dispute, it shall be referred to the Participant's CEO and the PSPC Assistant Deputy Minister, Acquisitions Branch who will have *5 Business Days* to resolve the dispute; and

   e. In the event the representatives of the Parties specified in Article 2.d. above are unable to resolve the dispute, the Contracting Authority shall within 5 Business Days render a written decision which decision shall include a detailed description of the dispute and the reasons supporting the Contracting Authority's decision. The Contracting Authority shall deliver a signed copy thereof to the Participant.

By signing this document, the individual represents that he/she has full authority to bind the company listed below and that the individual and the company agree to be bound by all the terms and conditions contained herein.

Name of Company: _____

Name of individual: _____

Telephone: _____

E-mail: _____

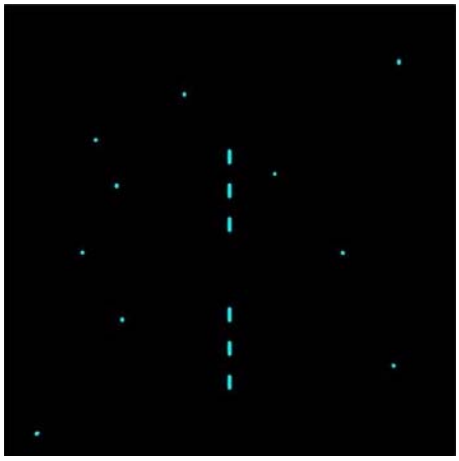
Signature: _____

Date: _____

Correspondence: ❑ French ❑ English

Annex B – Definitions of Terms Used in this Document

Track



A track is a series of individual observations of a Resident Space Object (RSO). A *track* is divided into two *tracklets*, each composed of three individual observations. Observation duration and separation of observations/tracklets will be defined for each RSO to be tracked. Typically, these durations are specified in seconds or fractions of seconds.

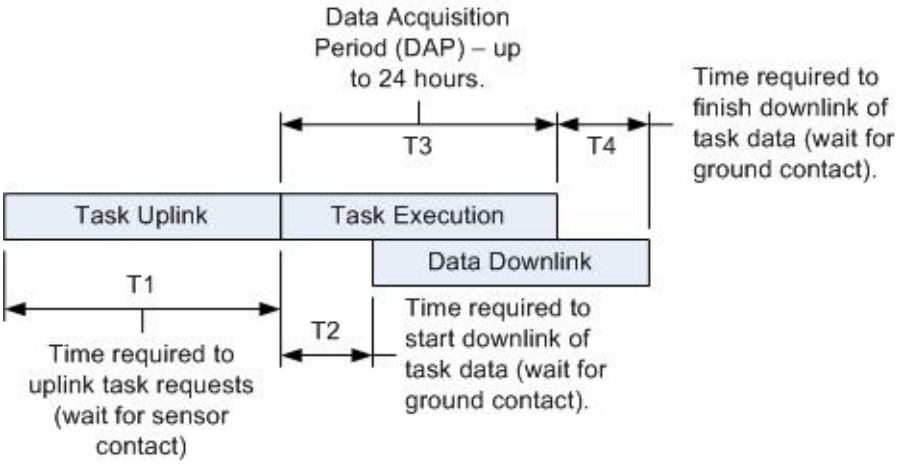
The figure to the left shows a sample track, where the sensor is in *Stare* mode (fixed viewing of an area where the RSO is expected to appear). The RSO appears in the image as a series of streaks, and background stars are shown as point sources. In *Track* mode, where the sensor follows the expected position of the RSO, the RSO will appear as a point source in the image, and background stars will appear as streaks. The relative position of the stars to the RSO is used to accurately assess the RSO's position.

Capacity

Capacity is the ability of the sensor to complete a number of tracks in a certain time period. For the SofS 2 capability, the time period is a Data Acquisition Period (DAP) of 24 hours, starting at GMT 00:00. For the SofS 2 capability this DAP is further divided into 1-hour periods, where the requirement is specified in a minimum number of tracks per hour.

Data Latency

Data latency (HLMR 7) is the time between acquiring a track of an RSO and the time that the data for that RSO is transmitted to the SSOC. Data latency will depend on the amount of time that the sensor (if it is an SBO) has to wait for ground contact after a particular task request is executed. This time is shown as T2 and T4 in the following figure. T2 and T4 are different because the wait for contact will depend on when a task is executed within the DAP.



System latency is the time between when the SSOC forwards a task request list to the SOF, and when the last task data is returned to the SSOC. This time is the sum of T1 + T3 + T4.

For operations where the sensor must wait for ground station contact (SBOs) or suitable observation conditions (GBOs) T1 to T4 may be measured in hours. For *near-real-time* operations, T1 to T4 may be on the order of minutes.

Ideally, an urgent task request (an interrupt task request) would only be delayed by the relatively short time required for processing at each of the stages in the system chain.

Annex C – Acronyms and Glossary of Terms

The following are definitions that relate to the SofS 2 project, and the DND organization that supports it.

Term	Description
ADM(IM)	**Assistant Deputy Minister (Information Management).**
ADM(Mat)	**Assistant Deputy Minister (Materiel).**
ADM(Pol)	**Assistant Deputy Minister (Policy).**
CANSpOC	**Canadian Space Operations Centre.** The CANSpOC provides a wide range of services to the Commander Canadian Joint Operations Command (CJOC), including missile warning, notification of space launches, satellite conjunction analysis (through its partnership with the US Joint Space Operations Center), and other space-related intelligence operations.
BC, BCA	**Business Case, Business Case Analysis.**
CAF	**Canadian Armed Forces.**
CCR	**Commissioning Complete Review.** Normally signifies IOC.
CC&T	**Command, Control and Telemetry.** Command and Control are uplinks to the satellite for its operations. Telemetry is downlinked data on the status of the satellite.
CO	**Contracts Officer.** Normally provided to the project by PSPC.
CONOPS	**Concept of Operations.**
CORA	**Centre for Operational Research and Analysis.**
CSE	**Communications Security Establishment.**
CSpO	**Combined Space Operations.** The US STRATCOM-led organization tasked with acquiring and Sharing SSA intelligence. Member nations include Australia, Canada, New Zealand, the UK and the US. A major element of the "Five-Eyes" military alliance comprising the same member nations.
CSSS	**Canadian Space Surveillance System.** The existing CSSS comprises the Sapphire system (the satellite and its ground segment) and the SSOC. The SSOC is owned by Canada, and operated by the RCAF. The Sapphire system is owned by Canada and loaned to MacDonald Dettwiler and Associates (MDA) for operations and in-service support. The CSSS will include the future Sapphire 2 system.
DAP	**Data Acquisition Period.** Typically a 24-hour period starting at GMT 00.00.
Data	For a GBO or an SBO, this is the product of the observation process. It is provided to the SOF (or SPSF in the case of Sapphire) for analysis and formatting. Once completed, it is sent to CSpOC via the SSOC.

Term	Description
DCB	**Defence Capability Board.**
DGCSI	**Director General Capability and Structure Integration.**
DGIMO	**Director General Information Management Operations.**
DGIMPD	**Director General Information Management Project Delivery.**
DIM Secur	**Director Information Management Security**
DND	**Department of National Defence.**
DPDCS	**Directorate Research and Development Communications and Space**
DPS	**Defence Procurement Strategy**
FOC	**Full Operational Capability.** The system has been certified as a contributing sensor to the SSN.
FOR	**Field of Regard.** The total area of sky that a telescope can view, by moving its Field of View (FOV).
FOV	**Field of View.** The total area of sky that a telescope can view without moving its pointing direction.
GBO	**Ground Based Optical.** A ground-based optical telescope and its ancillary equipment, with the capability to track RSOs and report their orbital parameters to the CSSS.
GEO	**Geosynchronous Orbit.** About 35,786 km altitude. The satellite's orbit position is synchronized with the earth's rotation, such that it remains over a particular point on the earth's surface. Commonly used for communications satellites.
Ground Station	An RF antenna and its ancillary equipment. A ground station passes on uplink commands from the SOF to the SBO, and relays downlink telemetry and data to the SOF. The ground to space link is RF, and the SOF to ground station is a secure internet connection.
HLMRs	**High-Level Mandatory Requirements.**
IOC	**Initial Operational Capability.** The system has been deployed, commissioned and is ready to begin preliminary operations.
IRMC	**Investment and Resource Management Committee,**
IPCP	**Investment Plan Change Proposal.**
IRPDA	**Independent Review Panel for Defence Acquisition.**
ITB	**Industrial and Technological Benefits.**
ILS	**Integrated Logistics Support.**
ISS	**In Service Support.** Typically comprising maintenance, repair, engineering support and Integrated Logistics Support (ILS).

Term	Description
ITAR	**International Traffic in Arms Regulations.** The US regulations governing the transfer of sensitive defense equipment and information to foreign countries.
CSpOC	**Combined Space Operations Center.** The US organization that operates the SSN.
LCMM	**Life Cycle Materiel Manager.** Manages the system after acquisition is complete.
LEO	**Low Earth Orbit.** Up to 2000 km altitude. Commonly used by earth observation satellites (e.g., Radarsat series). Used by Sapphire.
LEOP	**Launch and Early Operations.**
MC	**Memorandum to Cabinet.**
MEO	**Medium Earth Orbit.** Normally above 5000 km and commonly used for GPS satellites.
MOU	**Memorandum of Understanding.**
MRD	**Mission Requirements Document.**
MRO	**Months after Receipt of Order.**
NORAD	**North American Aerospace Defence Command.**
PA	**Project Approval.**
PCRA	**Project Complexity and Risk Assessment.**
PD	**Project Director.**
PL	**Project Leader.**
PM	**Project Manager.**
PMB	**Project Management Board.**
PMO	**Project Management Office.**
PSLV	**Polar Satellite Launch Vehicle.** One of the two main Indian launch vehicles.
PSPC	**Public Services and Procurement Canada.** Responsible for contractual aspects of the project.
PWGSC	**Public Works and Government Services Canada.** Former name of PSPC.
RF	**Radio Frequency.**
RFI	**Request for Information.** Also Letter of Interest (LOI).
RFP	**Request for Proposal.**
RFQ	**Request for Qualification.**

Term	Description
RSO	**Resident Space Object.** Man-made objects in orbit around the Earth. Includes satellites, left-over objects from the launch and deployment process (e.g., spent boosters), and debris from collisions.
SBO	**Space Based Optical.** A space-based optical sensor (satellite) with the capability to track RSOs and report their orbital parameters to the SSOC.
SCC	**Satellite Control Centre.** The control element of the Sapphire ground segment, which manages satellite operations via Command, Control and Telemetry (CC&T).
SCD	**Strategic Context Document.**
Sensor	For the Sapphire system, this refers to the Satellite (SBO), but could equally apply to a GBO.
SIM	**System Simulator.** An emulation of the sensor, used for training and debugging anomalies.
SLA	**Support Level Agreement.** A method for procuring services from other government departments.
SOF	**Sensor Operations Facility.** Manages satellite operations via Command, Control and Telemetry (CC&T) as well as RSO data acquisition and analysis. For Sapphire, this functionality is provided by the SCC and SPSF, which are two separate facilities.
SPSF	**Sensor Processing and Scheduling Facility.** The Sapphire ground segment element, which manages RSO data acquisition and analysis.
SofS	**Surveillance of Space.** The original Canadian space surveillance project.
SofS 2	**Surveillance of Space 2.** The follow-on Canadian space surveillance project.
SOI	**Space Object Identification.**
SOR	**Statement of Requirement.**
SPSF	**Sensor Processing and Scheduling Facility.**
SRB	**Senior Review Board.**
SSA	**Space Situational Awareness.** The ability to view, understand and predict the physical location of natural and manmade objects in orbit around the Earth.
SSN	**Space Surveillance Network.** A network of ground and space sensors, operated by CSpOC, and tasked with tracking and identifying RSOs and missile launches.

Term	Description
SSOC	**Sensor System Operations Center.** The Canadian operations centre that serves as the interface between the SSN and the Sapphire system (and the future Sapphire 2 system).
TAA	**Technical Assistance Agreement.** An agreed to "rule book" that governs how and what technical information will be discussed, presented, and/or conveyed by any means to a foreign national.
TBS	**Treasury Board Secretariat.**
TLE	**Two-Line Element.** A TLE set completely describes the orbital parameters of an RSO.
Track	Tracks will be a grouping of six observations divided into two sets of three called tracklets. Observations will be separated by a minimum of six seconds within a tracklet. There will be a minimum of 12 seconds between the last observation of the first tracklet and the first observation of the second tracklet. Maximum track length will be 1.5 minutes.
STRATCOM	**Strategic Command (US).**
VCDS	**Vice Chief of Defence Staff.**
VisMag, M_v	**Visual Magnitude.** The apparent brightness of an object in space, such as a star, or an RSO, as seen by the human eye. Each decrement of VisMag is a factor of 2.512, i.e., a larger number represents a dimmer object. For example, a VisMag 5 object is 2.512 times dimmer than a VisMag 4 object.

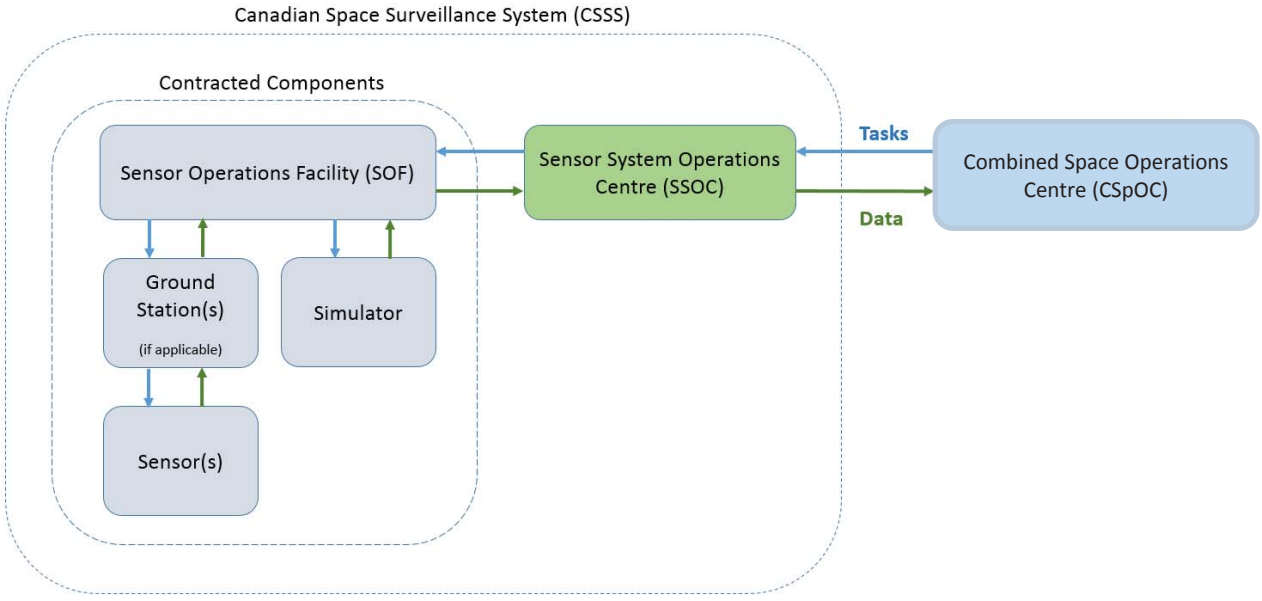
Annex D – Additional Operational Context

As a contributing sensor, the SofS 2 capability will provide Space Situational Awareness (SSA) data to the US Space Surveillance Network (SSN). The system will include one or more sensors (GBO, SBO or combination/multiples of the two).

The main users of the SofS 2 SSA data will include DND and its allies. Sapphire and the SofS 2 capability are not *dedicated*[7] sensors to the SSN; they are *contributing*[7] sensors, and as such, Canada maintains full control. This allows Canada to perform additional surveillance operations that may be in its own interest. The key user requirements are stated as High Level Mandatory Requirements (HLMRs). These HLMRs were derived from evolving SSN performance requirements, such as sensitivity and accuracy, plus Canadian-sourced requirements such as interoperability and de-orbit capability. To meet the evolving needs of the SSN, the SofS 2 capability will require performance upgrades beyond Sapphire's capability.

The SofS 2 system will provide updated orbital parameters for tracked objects, which will be used by the SSN to generate Two-Line Elements (TLEs)[8]. Currently, the TLE Set is comprised of a two line file that fully defines the orbital characteristics of the object; this format is subject to change. If unclassified, this information is made available on *Space-track.org*, a website that is publically available.

The figure below shows, at a high level, the communication between the sensors and the SSOC.



[7] A *dedicated* sensor only provides data to the SSN, while a *contributing* sensor may also serve other purposes.

[8] Orbital parameter definitions may change, thus the SofS 2 system should be modifiable to accommodate a newly defined orbital element set.

Task requests originate at the CSpOC and are sent to the SSOC. At this point, Canada-specific task requests may be added to the list. The SSOC processes the requests and composes a list of task requests to be sent to the sensor system. Once the tasks are executed by the sensor, data flows back to the SSOC, via the SOF, and is subsequently air-gapped and returned to the CSpOC.

D1 Operational Scenarios

Routine operations are based on *pre-planned* tasking for a full Data Acquisition Period (DAP), which is normally a 24-hour period. Ad-hoc operations are based on *interrupt* tasking which seeks to minimize turn-around for a single or small number of *urgent* task requests.

D1.1 Routine Operations

For routine operations:

a. The US CSpOC, operator of the Space Surveillance Network (SSN), sends *Routine Task Requests* to the Canadian Sensor System Operations Centre (SSOC) via a dedicated circuit. The task requests are in the form of a prioritized *Task List* comprising Two-Line Element (TLE) sets for each individual task request. The TLE sets define the expected orbital parameters of each Resident Space Object (RSO) to be tracked.

b. The task request is optimized to a maximum number of tasks that can be executed in a single Data Acquisition Period (DAP) based on priorities and the availability of an RSO during the DAP.

c. The optimized task request list is sent to the sensor.

d. The sensor executes the list of task requests over the period of the DAP. The output of an executed task request is the tracking data of the RSO being viewed. A track is a set of individual observations of the RSO, evenly spaced.

e. Tracking data will include the image file of the track, plus metadata, which includes additional data needed to create a TLE file with the complete orbital parameters of the RSO. Metadata will include the time of each observation, the sensor's position in its orbit at the time of observation, etc.

f. Throughout the DAP, accumulated tracking data is distributed to the SSOC for transmission to the CSpOC, whenever a link to ground is available (e.g., a ground station).

D1.2 AD-Hoc Operations

Ad-hoc operations are performed in response to *interrupt task requests*. Interrupt task requests always take priority over routine task requests. The operational processes and products are much the same as for routine task requests. The differences are as follows:

a. When an interrupt task request is sent from the SSOC the interrupt task or tasks are entered into a re-planned task request list, as the highest priority.

b. The new task request list is sent to the sensor, via the SOF, at the earliest opportunity.

c. The task data is returned to the SSOC and relayed to the CSpOC at the earliest opportunity.

System latency will be the main determinant of the turn-around time for an interrupt task request.

D2 Sensor Modes

Operational scenarios for the SofS 2 system include, but are not limited to the modes in the following sub-paragraphs.

For all operational modes, the sensor may function in *Track Mode* or *Stare Mode*.

D2.1 Track Mode

The sensor follows ("tracks") the expected path of the RSO. In this case, the RSO will appear as a point source in the image and background stars will appear as streaks. Track mode is better at detecting dimmer objects, but produces a larger image file.

D2.2 Stare Mode

The sensor points to the expected location of the RSO and maintains that position ("stares"). In this case, the RSO will appear as a streak in the image, and the background stars will appear as point sources. Stare mode produces a smaller image file, and is better if more than one RSO is expected to appear in the image.

D2.3 Search Mode

Searches may be implemented in either track or stare mode. Since this mode may be required if a target RSO has not been found in track of stare mode, it becomes necessary to search the vicinity where the RSO was expected to be. The quantity and location of these tasks will depend on the expected velocity vector of the RSO, and the amount of nearby space to be searched.

D2.4 Photometric Mode

For this operational mode, the objective is to measure the brightness of an RSO over time. To achieve this, single observations of the RSO are taken over some time interval. The task may also be embedded in a routine task schedule, or executed as a number of individual task requests (where brightness is expected to vary over a long time period).

D2.5 Image Enhancement

In order to detect the dimmest RSOs, methods may be used to enhance the observation images. As an example, one of these methods is *image stacking*, which overlays several image files of the same RSO in such a way that the signal-to-noise ratio is increased.

D3 System Maintenance

System maintenance may be required for calibration, anomaly resolution or the upload of software changes. During these operations, the system may be unable to perform normal operations. System unavailability for these operations must be in accordance with the *Availability* HLMR. System maintenance will be planned by the operator of the system and coordinated with DND and the CSpOC.

D4 Manoeuvering

For a SBO, if maneuverability becomes a requirement, then the time to perform the manoeuver will be considered to be included as part of routine operations (i.e., a SBO is not considered to be *unavailable* for the period of the manoeuver). A manoeuver would be allowed to reduce the required number of executed tasks within a DAP. The process to initiate and execute a manoeuver is to be determined if/when it has been approved as an HLMR.

D5 Operations Organization

Throughout the SofS 2 acquisition phase, a Life-Cycle Mission Manager (LCMM) will be assigned to the project in order to be familiarized with the system. Operations may be performed by a contractor or by Canada; however, In-Service Support (ISS) will likely be performed by a contractor, typically the provider of the system.

During the preliminary operations phase, the working relationship will be between the Project Management Office (PMO) and the operator. For the normal operations phase, that relationship will be between the LCMM and the operator. These relationships are applicable to both operations and ISS.

Annex E – Standard Practices for Space Projects

The following are for reference, only. Respondents may follow other recognized standards and practices.

European Cooperation for Space Standards (ECSS)

The following European Commission for Space Standards serve as guidance for standard documentation and verification methodologies:

1. ECSS-M-ST-10-01C – Organization and conduct of reviews (15 November 2008), Reference: http://ecss.nl/standard/ecss-m-st-10-01c-organization-and-conduct-of-reviews/
2. ECSS-E-ST-10-02C – Verification (6 March 2009), Reference: http://ecss.nl/standard/ecss-e-st-10-02c-verification/
3. ECSS-E-HB-10-02A – Verification guidelines (17 December 2010), Reference: http://ecss.nl/hbstms/ecss-e-10-02a-verification-guidelines/

National Aeronautics and Space Administration (NASA) Procedural Requirements and Instructions

The NASA Flight Project Directorate provides a description of the standard Space Flight Program Lifecycle and the Office of Safety and Mission Assurance guides part selection and qualification:

1. Lifecycle Phase, Reference: https://fpd.gsfc.nasa.gov/lifecyclephases.html
2. NASA Procedural Requirement (NPR) 7120.5E NASA Space Flight Program and Project Requirements, Reference: https://fpd.gsfc.nasa.gov/docs/N_PR_7120_005E_.pdf]
3. EEE-INST-002: Instructions for EEE Parts Selection, Screening, Qualification, and Derating, Reference: https://nepp.nasa.gov/docuploads/FFB52B88-36AE-4378.../EEE-INST-002_add1.pdf

Annex F – Maneuverability Framework Analysis Summary (DRDC)

The purpose of this section is to include a standard framework for industry to answer the questions about maneuverability, so that all respondents answer in a similar manner. This framework will be based on the results of the maneuverability study done by DRDC as well as current practices.

Criteria for assessing the requirement to conduct a maneuver are: TCA (Time of Closest Approach) <= 3 days, PoC (Probability of Collision) <= e^-4, miss distance <= 1km with a forecast of orbit congestion in 2026. Additionally, the maneuver planner must provide the predicted ephemeris for the maneuver and post maneuver location of the satellite so it can be screened for safety and coordinated with the CSpOC.

Definition of collision avoidance: The use of thrusters to change a satellite's orbital parameters when certain criteria are met in order to avoid a collision with another object.

Station keeping: Adjustments made by thrusters to the satellite's orbit in order to counteract the effects of precession, drag and other environmental elements (e.g. solar radiation) that can cause orbital decay.

De-orbit: At the end of the satellite's useful life it should be "removed from orbit in a controlled fashion" in accordance with (IAW) the Committee on the Peaceful Uses of Outer Space (COPUOS) Space Debris Mitigation Guidelines.

The following additional information is provided by DND's research branch for the respondents' consideration:

A space-based space surveillance sensor may need to perform orbital maneuvers over the course of its mission life. These maneuvers may be required for initial orbit insertion collision avoidance, orbital maintenance (e.g. drag makeup) or deorbit and disposal operations. The framework below contains some general parameters for the addition of maneuverability to a space-based solution for SofS 2. The objective of this annex is to provide the respondents baseline requirements to cost-estimate a maneuvering capability to the SofS 2 space segment.

Table 3 - Maneuverability Framework Parameters

Parameter	LEO	GEO	Notes
Timeframe for analysis	2026 - 2036	2026 - 2036	Estimated for the 2026+ timeframe.
SofS 2 sensor Hard Body Radius	2 m	2 m	
Smallest debris object size	0.02 m (2 cm)	0.3 m (30 cm)	
Nominal Sensor Altitude (LEO)	LEO: 600-900 km	GEO: ~36,000 km	
Nominal debris Avoidance Probability of Collision Limit	1e-4	1e-4	

Initial Orbit Acquisition: The Sapphire satellite is a free-flyer vehicle which does not feature orbital control. After its 2013 launch into its dawn-dusk orbit a slight inclination injection error resulted in a slow drift moving Sapphire's ascending node toward the Sun. This orbital drift results in some imagery being exposed to backscattered light from Earth's dayside lowering the sensitivity of the space surveillance imager. If Sapphire had the ability to perform inclination adjustment this nodal drift could have been arrested. The respondent should consider initial orbit acquisition requirements in their estimate for the SofS 2 maneuvering capability.

Collision Avoidance (COLA) Maneuvers: A conjunction (close-approach) warning is generally issued by 18 SPCS (CSpOC) when an operational satellite is predicted to pass another space object within a proximity box[9] of 0.2 x 1 x 1 km in LEO or 10x10x10 km box in GEO centered on the primary (operational) satellite. In general, a satellite operator has less than 3 days warning before the Time of Closest Approach (TCA) to mitigate the risk of collision by performing a COLA maneuver.[10]

COLA maneuvers are generally performed when the Probability of Collison (PoC) between the primary satellite and a secondary object (space debris) exceeds 1e-4. The COLA maneuver is generally performed in a manner such that at least a 10x reduction in the PoC is achieved prior to the conjunction.

Orbit Maintenance: For some low altitude LEO orbits (~600 km) drag makeup may be required for some space-segment solutions. GEO satellites use North-South and East-West maneuvers for normal station keeping orbital control. The respondent should consider orbital maintenance requirements when responding to this RFI.

Deorbit: Deorbit maneuvers are expected to be the largest propulsion requirement for any space-based SofS 2 solution. Alternative deorbit approaches, such as drag sails or re-orbiting to disposal orbits, should be considered with a view toward reliability, flight heritage and economic viability of the proposed solution.

Other Considerations:

- The maneuvering system's compatibility with the needs of high accuracy attitude control while imaging (fuel slosh, mass properties, etc.).
- The products of reaction should ensure chemical compatibility as to not degrade optical surfaces or the payload of the space segment.
- Some propulsion systems use highly toxic and reactive chemicals. The cost estimate should include estimates for safe handling, testing, use and disposal of such reactants. Solutions incorporating non-toxic propellants with suitable flight heritage can be considered.

[9] The proximity box is centered on the primary satellite with dimensions referenced to the Radial, in-track and cross-track directions of the primary satellite's orbit.

[10] Radial in-track cross-track.

- Requirements for flight planning software to perform orbit determination, maneuver trade space assessment, and post-maneuver orbit determination.

Proposed SofS 2 solutions using orbital regimes such as MEO and GEO, can be considered if the mandatory SofS 2 performance criteria are met and maneuverability, collision avoidance, disposal, system costs and operations are adequately described.

General Note on Conjunction Assessment: Many of the collision risk assessment techniques are based on the work of Foster[11] who outlines the tools needed for the analysis of close approaches. Based on this work, the ESA MASTER and DRAMA software, available from the *ESA Space Debris User Portal* (https://sdup.esoc.esa.int/web/csdtf/home), contain useful prediction and analysis tools to estimate the future space debris environment. These tools are available as a free download after registration with the Space Debris user portal.

[11] Foster, J.L., "The Analytic Basis for Debris Avoidance Operations for the International Space Station", Proceedings of the Third European Conference on Space Debris, 19 - 21 March 2001.

Annex G – RFI Costing Structure Sample

Major Cost Element	Minor Cost Elements
Space Systems (if applicable)	Bus
	Space Based Sensor(s)
	Additional Payload(s)
	… others as applicable
Ground Systems	Sensor Operations Facility
	Ground Station(s) (if applicable)
	Ground Based Sensor(s) (if applicable)
	Interfaces
	… others as applicable
System Test, Trial and Evaluation	
Launch / Deployment	Launch Service
	Launch System Integration
	Launch Operations
	Initial Training
	… others as applicable
Sustainment	Maintenance
	Engineeirng Support
	Integrated Logistic Support
	Continuous Improvement
Operations	Operations
	Indirect Support
Disposal	
… others as applicable	

Notes:

1. Further decomposition of the costing elements is desirable, if possible.
2. Adiditonal guidance is available in the following U.S. Department of defence Documents:
    a. MIL-STD-881C, 3 October 2011
    b. U.S. Department of Defence, Operating and Support Cost-Estimating Guide, March 2014