Advanced Notice

TITLE: Potential Post-ISS Human Spaceflight Contributions Portfolio, and Planetary Exploration and Space Astronomy Preparatory Activities

1. Purpose and Nature of this Advanced Notice

The aim of this Advanced Notice (AN) is to inform the Canadian space sector that the Canadian Space Agency (CSA) intends to proceed with Requests for Proposals (RFPs) for concept studies and phase 0 work. These activities form part of the CSA's effort to define potential opportunities for Canadian participation in future international Post- International Space Station (ISS) Human Spaceflight (HSF) and Space Exploration collaborative missions. A list of potential RFPs and their planned release dates are provided.

This AN is neither a call for tender nor a RFP. No agreement or contract will be entered into based on this AN. The issuance of this AN is not to be considered in any way a commitment by the Government of Canada, nor as authority to respondents to undertake any work that could be charged to Canada. This AN is not to be considered as a commitment to issue a subsequent solicitation or award contract(s) for the work described herein.

2. Context

The CSA located in Saint-Hubert (Quebec), has identified science and technology priorities in connection with potential opportunities for Canadian contributions to possible space exploration missions, including participation in flagship international programs.

3. Potential Work Scope and Constraints

As part of its planning, the CSA has established science and technology development priorities and now plans to inform the Canadian space sector and stakeholders prior to releasing the potential RFPs.

Science priorities are based on community recommendations derived from Space Exploration Topical Teams and the Canadian Space Exploration Workshop (CSEW) held in November 2016.

It is important to note that these priorities and descriptions may be subject to change prior to the official publication of the RFP. Based on the availability of funds, a list of studies that will be part of the potential RFPs is presented in APPENDIX A – CSA Priorities.

4. Schedule

The planned publication of the potential RFPs on the Government's electronic tendering service is planned to start in the second quarter of 2017 (i.e. April to June). Please note that several factors may influence these planned dates and could include the possibility to cancel any or all RFPs.

5. Important Notes

The AN is intended to provide lead time to respondents to prepare for the potential RFPs listed in APPENDIX A – CSA Priorities. Questions should be withheld until the specific RFPs in question are issued through the Government electronic tendering service.

This AN will be advertised on the Government Electronic Tendering System for a limited period and will not be subject to any update. Canada asks interested parties and potential bidders to visit Buyandsell.gc.ca regularly to check for newly published RFPs and or updates to previously posted RFPs, if any.

List of Acronyms

ACMS	Advanced Crew Medical System
AN	Advanced Notice
BLEO	Beyond Low Earth Orbit
CASCA	Canadian Astronomical Society
CASTOR	Cosmological Advanced Survey Telescope for Optical and UV Research
CMB	Cosmic Microwave Background
COBE	Cosmic Background Explorer
CS	Concept Study
CSA	Canadian Space Agency
CSEW	Canadian Space Exploration Workshop
DE	Dark Energy
DST	Deep Space Telecommunications
DSXR	Deep Space Exploration Robotics
EDSH	Evolvable Deep Space Habitat
EML-2	Earth-Moon Libration Point 2
ESA	European Space Agency
ESM	Exploration Surface Mobility
Euclid	Mission devised to provide insight into the nature of dark energy and dark matter
EVA	Extra Vehicular Activity
GNC	Guidance Navigation and Control
HLEPP	Human Lunar Exploration Precursor Program
HSF	Human Spaceflight
ISS	International Space Station
JAXA	Japan Aerospace Exploration Agency
LCSEM	Low Cost Space Exploration Missions
LEO	Low Earth Orbit
LPR	Lunar Pressurized Rover

LPRC	Lunar Pressurized Rover Core
LSM	Lunar Surface Mobility
MSRAD	Mars Sample Return Analogue Deployment
NASA	National Aeronautics and Space Administration
OP	Optical
PHASR	Precursor to Human and Scientific Rover
P0	Phase 0
Q2	Quarter 2 (meaning April, May, June 2017)
RelNav	Relative Navigation
RF	Radio Frequency
RFP	Request for Proposal
RHU	Radioisotope Heat Unit
RTG	Radioisotope Thermal Generator
SE	Space Exploration
SLS	Space Launch System
SMS	Science Maturation Study
STDP	Space Technology Development Program
TRL	Technology Readiness Level
UV	Ultra Violet
VV	Visiting Vehicle
WFIRST	Wide Field Infrared Survey Telescope
WMAP	Wilkinson Microwave Anisotropy Probe

APPENDIX A – CSA Priorities

Part 1: Future international Post-ISS Human Spaceflight

ID	Title	Short Description	Expected Contract Duration	Estimated Release Dates
Studies				
CS-01	Advanced Crew Medical System (ACMS) - Medical Condition Requirements Study	Based on a concept of medical autonomy and a relevant Design Reference Mission, identify and quantify a prioritized list of medical conditions for which medical autonomy must be provided, and using a recommended evidence-based process, establish the probability, severity, diagnostic tests, and current treatment options in light of known constraints such as technologies, consumables, expertise among other factors.	18 months	2017-Q2
CS-02	Cislunar Mission Contribution Studies	Solicit alternative Cislunar contribution concepts. Up to 5 mission contribution studies could be proposed by Canadian organizations.	6 months	2017-Q2
CS-03-RF	Deep Space Telecommunications (DST) - RF Technology Studies	Telecommunications Systems - RF Technology Studies: One RFP to study Radio Frequency (RF) Communications as an option to communicate in Cislunar space.	6 months	2017-Q2
CS-03-OP	Deep Space Telecommunications (DST) - Optical Technology Studies	Telecommunications Systems - Optical Technology Studies: One RFP to study Optical Communications as an option and alternative to communicate in Cislunar space.	6 months	2017-Q2
CS-04	Lunar Surface Rovers Architecture Concept Studies	Up to two parallel studies to develop a detailed Lunar Surface Mobility (LSM) architecture for two main assets: Precursor to Human and Scientific Rover (PHASR) and a Lunar Pressurized Rover (LPR) Core (LPRC). Each study will cover the definition of an architecture that fulfills the need for lunar sample return and science using an unmanned rover that will evolve to a LPRC design.	6 months	2017-Q2
SMS-01	Lunar Surface Science Maturation Study	In parallel with PHASR studies, one study will be awarded to evolve potential science objectives, instrument and science operations requirements, and a plan for associated potential analogue activities, as Canadian science inputs to inform further development of an international Lunar Demonstration Mission concept using the PHASR rover technology. This mission concept is a possible Human Lunar Precursor Program mission element being studied by CSA and international partners.	12 months	2017-Q2

ID	Title	Short Description	Expected Contract Duration	Estimated Release Dates
Phase 0				
P0-01	Deep-Space Exploration Robotics (DSXR) Phase 0	This Phase 0 will address a robotic arm capability and likely include not only the robotic arm, but also tool caddy, grappling tools, and ground station requirements to validate mission objectives and stakeholder needs, develop a mission concept design and concept of operations, and develop mission requirements.	12 months	2017-Q2
P0-02	Relative Navigation System (RelNav System) Phase 0	The objective of this Phase 0 RFP is to validate mission objectives and stakeholder needs, develop a mission conceptual design including a system concept design and concept of operations, and develop mission requirements for a RelNav System. It will also seek to identify areas of risk and perform early risk mitigation. Given ongoing international coordination regarding human space exploration beyond LEO, the RFP will be looking to provide industry support to CSA on discussions regarding mission architecture and objectives.	7 months	2017-Q2

Part 2: Space Exploration Collaboration Missions

ID	Title	Short Description	Expected Contract Duration	Estimated Release Dates
Studies				
CS-06	Space Exploration (SE) Secondary Payloads and Nanomissions (SE Reference CS-2017-2)	Develop concepts for Canadian micro or nano-missions that piggyback on planetary flagships and other anticipated launch opportunities. This RFP is anticipated to result in up to 5 mission concept studies to define objectives and requirements, develop system and payload concepts, and provide cost and schedule estimates, and future development plans.	9-12 months	2017-Q2
CS-07	Mars Sample Return Mission (SE Reference CS-2017-3)	One concept study is anticipated with the purpose of positioning Canada for a possible contribution related to the Fetch rover element of Mars Sample Return. The Fetch rover will retrieve samples from the Martian surface and return them to a Mars Ascent Vehicle for return to Earth, and may conduct in situ science in support of preparing for human exploration. This study includes development of a mission and payload concept, definition of requirements, cost, and schedule estimates, and future development plans. Concepts should build on past investments (ExoMars, ESM, MSRAD Utah).	6 - 12 months	2017-Q3
CS-08	Space Exploration: planetary & space astronomy concept studies (SE Reference CS-2017-4)	Opportunity for up to 4 independent study contracts for new planetary and astronomy concepts or instrument contributions for potential future missions consistent with community priorities. Develop objectives, requirements, system or instrument concepts, schedule, cost, technology, and science development roadmaps.	12-24 months	2017-Q2
CS-09	Space Astronomy: LiteBIRD concept study (SE Reference CS-2017-5)	Define potential Canadian instrument and science contribution to JAXA's LiteBIRD (**Lite** 'light' satellite for the studies of **B**-mode polarization and **I**nflation from cosmic background **R**adiation **D**etection) space astronomy mission. Review requirements, interfaces, technology risks and developments needed and cost estimation.	8-10 months	2017-Q2

ID	Title	Short Description	Expected Contract Duration	Estimated Release Dates
SMS-02	Space Exploration: planetary and space astronomy studies (SE Reference SMS-2017-1)	Up to 5 Science Maturation Studies for planetary and space astronomy community priorities. Science Maturation Studies typically follow concept studies to refine requirements, undertake preliminary validation and assess impacts to science objectives of proposed approach and instrument requirements trades through simulation and experiment.	24-36 months	2017-Q2
SMS-03	Space Astronomy: CASTOR Canadian led space telescope concept (SE Reference SMS-2017-3)	Science Maturation Study: Follows previous CASTOR concept study, a UV/optical wide field space telescope, to refine science objectives and requirements (risks to science success, instrument needs, baseline mission requirements, performance floor, science plans, scientific capacity, collaborations and estimate of cost and schedule).	12-16 months	2017-Q2

CS-01 Advanced Crew Medical System (ACMS) - Medical Condition Requirements

As exploration missions extend beyond Low Earth Orbit (LEO), crews will require enhanced medical autonomy in order to manage their health, including diagnosis and treatment of medical conditions. Based on a concept of medical autonomy and relevant Design Reference Mission, a prioritized list of medical conditions, as well as a process and database have been proposed for an evidence-based approach to determine medical condition requirements. That (The) process involved identifying the necessary parameters to be defined/developed for each medical condition (e.g. evidence-based risk assessment probability, severity, diagnostic tests, medical consumables, and potential treatment options etc.).

This contract will review and revise the previously developed prioritized list and evidence-based process and will develop the medical condition requirements for those conditions requiring medical autonomy. For each identified medical condition, the tasks will involve performing an evidenced-based review of the literature to determine, amongst other parameters, the signs, symptoms, diagnostic tests and treatment options. The process will be enhanced to include other factors that will be a basis for future work in developing concepts and prototypes for decision support processes for exploration. Other factors could include identification of: diagnostic and treatment constraints (technologies, consumables, expertise, crew training requirements); terrestrial ground-based clinical guidelines and best practices for the medical conditions; any known best practices for spaceflight for these medical conditions; known or predicted influences of the spaceflight environment on diagnosis and treatment, as well as identification of potential predictive correlates.

CS-02 Cislunar Mission Contribution Studies

INTRODUCTION

The global space exploration community plans to pursue deep space exploration in phases over the coming decades, leveraging their collective experience on the ISS. Over the next decade, Cislunar space will be a possible destination to practice operations with decreasing reliance on the Earth, thus gaining experience and building the systems necessary to explore deep space beyond the Moon. The CSA is currently examining options for possible Canadian technology contributions. The CSA is soliciting ideas that would utilize and exploit other Canadian technologies not specifically addressed in APPENDIX A – CSA Priorities.

CONSIDERATIONS

Some critical technology areas include new types of propulsion systems, robotic servicing systems, cargo logistics delivery systems, an evolvable habitat, and navigation and communication systems to name but a few.

CANADIAN CORE TECHNOLOGIES

Apart from the RFPs presented in this Advanced Notice, this particular RFP is intended to solicit alternative Cislunar contribution concepts, which would result in up to five (5) mission contribution studies.

CS-03-RF Deep Space Telecommunications (DST) - RF Technology Studies

The CSA along with participating agencies and in support of future planetary exploration and deep space missions are interested in understanding the available technologies that could provide the most appropriate communication systems between the Earth and space exploration vehicles or infrastructure elements. The needed communication links and their expected notional performances are shown below:

1) Earth to space vehicle
   a) in orbit around the Moon,
      i. Forward Information data rates: 50 Mbps. Return Information data rates: 100Mbps
   b) traveling to and from Mars, its moons, and other deep space destinations,
      ii. Forward Information data rates: 15Mbps. Return Information data rates: 30Mbps
2) Space Vehicle to Moon & Mars Surface Elements (and other Deep Space Destinations):
   a) Forward Information data rates: 10Mbps. Return Information data rates: 25Mbps
3) Elements to elements remaining on the Moon, Mars, and other deep space destinations,
   a) Information data rates between elements: 20Mbps
4) Space vehicle to elements
   a) remaining on the Moon, Mars, and other deep space destination,
   b) in the proximity of space vehicle such as an Extra Vehicular Activity (EVA) crewmember or resupply vehicles, and
   c) Forward information data rates: 1Mbps. Return information data rates: 10Mbps.

The idea of this concept study is to provide a full picture of the different systems needed for the communication links mentioned above, as well as a list of equipment along with their specifications which Canada could provide as a contribution to a potential international project. The main deliverables needed for this concept study include communication architecture and concept of operation, preliminary system requirements, a list and an analysis of viable systems which Canada could contribute to, and a system design on the selected sub-systems.

The CSA is interested in innovative concepts that could integrate new ground breaking technologies such as for example artificial intelligence, mesh, star network using regenerative payloads (similar to an internet network). For instance the proposed architecture or design could include intelligent network control which would facilitate the network exchanges or the communication system could be reused to communicate with different entities by using reconfigurable radios and antennas, etc. It is also in the interest of the Canadian contractor to propose innovative concepts as it has more likelihood to stand-out along-side worldwide competition in the space telecom industry. The proposed communication systems may be considered as Canadian contributions to post-ISS missions.

CS-03-OP Deep Space Telecommunications (DST) - Optical Technology Studies

Free-space optical communication technology is emerging as a new efficient tool to deliver data from space in the context of future Earth observation, planetary exploration, and deep space missions. The study aims at developing specific mission scenarios for Beyond Low Earth Orbit (BLEO) communication contribution based on optical technology. The scope includes concept definition that presents the best benefit for Canada, defining mission and system requirements, system architecture, feasibility assessment, assessing business potential, and establishing the programmatic factors for achieving success. Within the context of post-ISS exploration vision, CSA sees the need to focus the study on the one (or several) of the following high data-rate communication scenarios by means of optical technology.

Scenario (1) Earth to Space Vehicle

Option (a) Communication from a Space Vehicle orbit around the Moon to Earth (return link) and vice versa (forward link)

The following three potential orbits around moon will be considered:

i. Lissajous orbit around Earth-Moon Libration Point 2 (EML-2);
ii. Halo orbit around EML-2;
iii. Near-rectilinear orbit around the Moon

The proposed system must allow data rates in the range of 100-500 Mbps on the return link and in the range 50-100 Mbps on the forward link.

Option (b) Communication from a Space Vehicle on excursion to Mars (fly-around from Moon Near-rectilinear orbit) to Earth (return link) and vice versa (forward link)

A circular 200 km to 500 km altitude Mars orbit will be considered as a baseline for the purpose of this assessment. The proposed system must allow data rates in the range of 30-150 Mbps on the return link and in the range of 15-40 Mbps on the forward link.

Scenario (2) Surface Element (rover or lander) to Space Vehicle or Earth

Option (a) Communication from a Surface Elements on the Moon (e.g. rover) (return link) to a Space Vehicle around the Moon and vice versa (forward link).

Option (b) Communication from a Surface Elements on Mars (e.g. rover) (return link) to a Space Vehicle around Mars and vice versa (forward link).

Option (c) Communication from Surface Elements on Moon or Mars (e.g. rover) (return link) to Earth and vice versa (forward link).

The system must allow data rates of minimum 25 Mbps on the return link and minimum 10 Mbps on the forward link for each of the three options. The orbital parameters to be considered in this scenario are as per scenario 1.

Scenario (3) Element to Element on Surface of Moon & Mars (and other Deep Space Destinations)

Option Communication to and from a surface element and other surface elements on the Moon & Mars

The system must allow data rates of minimum 100 Mbps to and from elements separated by a maximum distance of 10 km.

The data rates, identified above are indicative. It will be possible to propose alternative specifications with related rationale. The options involving down-/up-links must assume NASA and ESA Optical Ground Station capabilities. The Contractor must plan to coordinate and must be able to adjust the concept with the stakeholders' needs and vision, including CSA and any potential partners. The Government Furnished Information will be provided at the beginning and throughout the contract to guide the concept development and synchronise it with the efforts of the International working group.

CS-04 Lunar Surface Rovers Architecture Concept Studies

This concept study provides a common gateway for the study of initial concepts for potential post-ISS space exploration opportunities in global partnerships to define a bold vision for Canada's future in space. The focus of this activity will be to develop a detailed Lunar Surface Mobility (LSM) concept for two main assets: the Precursor to Human and Scientific Rover (PHASR) and the Lunar Pressurized Rover (LPR) Core (LPRC). These rovers may be used to provide early lunar samples returned via an orbiting asset called the Evolvable Deep Space Habitat (EDSH) and later enabling humans to perform campaigns at the surface of the Moon and from the EDSH. The strategy being to use the PHASR as a scientific return mission coupled with a precursor role to the return of humans using the two LPRs as habitat and mobile bases for lunar surface campaigns up-to a 42 day's journey for a nominal crew of 4 (2 nominal crew members per LPR) at the surface of the Moon. The architecture is currently planning up-to five missions at the lunar surface notionally starting in 2029 with the two LPRs delivered one year before at the surface using the Space Launch System (SLS). Prior to the launch of the LPR in 2025, a precursor flight will be used to deliver the PHASR. This rover will be operated remotely from the EDSH and/or Earth using the EDSH as a relay station.

The scope of work envisaged is for the contractor to provide a detailed LSM concept based on two main assets:

a) Precursor to Human And Scientific Rover (PHASR) as a demonstrator/precursor to the LPR and lunar sample return/scientific and resources prospector rover.

b) Lunar Pressurized Rover (LPR) Core (LPRC): The LPR concept relies on a capability to reuse and maximize a building block approach. For this reason, it is assumed for the benefit of this concept study that Canada would be responsible for delivering the entire LPR, but components such as pressurized module, airlock, Radioisotope Thermal Generator (RTG) or Radioisotope Heat Unit (RHU), would be international contributions. The focus for CSA would then be to develop the core vehicle system focusing on mobility, avionics, Guidance Navigation and Control (GNC), tele-communications, sensors, manipulator(s) and scientific instruments.

The Contractor must develop a concept that will integrate both rovers into a complete solution to deliver the capabilities described and applicable at the required time and as per the established requirements.

The contractor must also develop a complete end-to-end concept that leverage on previous technological work and development performed. The proposed solution should rely on proven capabilities developed or in development that are synchronized with the current timeline and objectives. New development of low Technology Readiness Level (TRL) core technology should be avoided as much as possible in order to deliver a capability that can land on the Moon in the next decade.

SMS-01 Lunar Surface Science Maturation Studies

This Science Maturation Study (SMS) helps prepare the Canadian science community for potential future contribution to post-ISS Human space exploration opportunities in global partnerships and define a bold vision for Canada's future in space.

This study will be informed by the parallel **Lunar Surface Rovers Architecture Concept Studies (CS-04)** which will consider payload accommodation, rover operations and resource needs.

The purpose of this study is to evolve potential science objectives, science experiments, science operations requirements, and a plan for associated potential analogue activities, as Canadian science community input to early definition of a potential unmanned international Lunar Demonstration Mission concept using the PHASR rover technology. The Lunar Demonstration Mission concept is a possible Human Lunar Exploration Precursor Program (HLEPP) mission element being studied by CSA and international partners.

The primary deliverables of this study are a Science Maturation Study report and a Lunar Analogue Mission Implementation Plan focussing on science objectives and science operations.

Initial science objectives and strawman payload requirements will be provided. The nominal lunar landing site for this mission concept is Schrodinger basin, on the lunar dark side near the South Pole.

The evolution of science and payload requirements will respond to PHASR concept capabilities and is expected to reflect Canadian community science priorities as established through recent Canadian Space Exploration Topical Teams activities and the 2016 Canadian Space Exploration Workshop, as well as feedback from international partners.

Post-ISS Human Spaceflight (HSF) Contribution plans include both a Planetary Science Program and a Life Science Program.

P0-01 Deep-Space Exploration Robotics (DSXR) Phase 0

Canada has participated in international discussions to determine the next step for human exploration. A common long term goal is the human exploration of Mars. One step towards this long term goal is demonstrating and proving technologies beyond LEO. A deep-space habitat platform in a lunar orbit will extend human presence and further demonstrate and prove technologies and operations at a larger distance from Earth, which is described in the Global Exploration Roadmap (2013).

A Deep-Space Exploration Robotic System (DSXR) is a critical capability and a potential Canadian contribution. As such, a Phase 0 study is intended to be solicited so as to inform Canada on key aspects of a DSXR mission. Like the Canadarm2 on the ISS, a DSXR System will assure the logistics and maintenance and assembly of this outpost. Phase 0 essentially is the “Mission Definition Phase” during which, based on Mission Objectives and Users’ Needs, all mission definition activities are performed and Mission Requirements are developed. One key result of a Phase 0 is to provide information for Canada to clearly understand the mission feasibility, options, costs, schedule, and risks associated with a DSXR contribution. Furthermore, at the end of the Phase 0 study, Canada should have all the technical and programmatic information necessary to make an informed decision about a potential DSXR system contribution and for subsequent immediate next steps.

Work requirements of the intended solicitation will include elements associated with mission analysis, planning and development, mission operations, systems engineering, trades assessments, support to CSA with respect to the overall deep-space habitat mission development, and project management of the study.

P0-02 Relative Navigation System (RelNav System) Phase 0

In 2011, CSA, in a joint effort with NASA, investigated the feasibility of deploying a system to monitor incoming and departing Visiting Vehicles (VV) on the ISS. This system was envisioned to be installed at different locations on the ISS, thus covering the different approaches of the different docking and berthing ports of the orbital station. The study demonstrated the feasibility of such a system, although the requirement to monitor the relative attitude of the VV was levied on the spacecraft. It was determined that a global relative navigation system, based on the Space Station side (as opposed to a spacecraft mounted system) would be the preferred solution for the future. The planning of the next generation space platform, such as a deep-space habitat, is therefore a good opportunity to assess the development of a relative navigation system on this new space platform.

Canada has undertaken discussions with the international partners to determine the next step for human exploration. A rendezvous working group has been put in place under this partnership. This working group is in charge of providing recommendations with respect to relative navigation and rendezvous on a future deep-space habitat. One of the recommendations is that the habitat be equipped with a proximity operations sensor to support VV system redundancy. This sensor would be useful in helping VVs achieve sensor independence and sensor dissimilarity, thus, levying the requirement on the habitat instead of the current paradigm which levies the requirement for redundancy and dissimilarity on the VV.

As such, Phase 0 study services are intended to be solicited so as to inform Canada on key aspects of relative navigation and rendezvous technology. The concept of operations involves having the sensor package re-position-able by a robotic arm in order to limit the mass launched to cislunar space. In the current concept, the sensor package would be positioned prior to each docking event near the docking port where the VV will mate. The relative navigation technology functions include providing range, range-rate, relative position, velocity, attitude and attitude rates of the VV at key positions from the habitat. At the end of the Phase 0 study, Canada should have all the technical and programmatic information necessary to make an informed decision about a potential relative navigation sensor system contribution and for subsequent immediate next steps.

Work requirements of the intended solicitation will include elements associated with mission analysis, planning and development, mission operations, systems engineering, trades assessments, support to CSA with respect to the applicable deep-space habitat mission development, and project management of the study.

CS-06 Space Exploration Secondary Payloads and Nanomissions

This investment will develop concept studies for Canadian micro or nano missions that piggyback on planetary missions or other anticipated launch opportunities. It is anticipated that, based on available funding, several planetary priorities from 2016 Canadian Space Exploration Workshop (CSEW) will be developed for consideration as options for continued investment towards flight. Low TRL and high TRL options are sought, targeting destinations of high interest to Canada including the Moon, Mars and Jupiter system/Europa.

The recommendation from the joint CSA-NASA Ames 2015 Low Cost Space Exploration Missions (LCSEM) workshop is to build and have ready for future partner launch opportunities which can arise rapidly. In 2016, NASA publically announced the intent to have secondary payloads on all future planetary flagships. The purpose of these concept studies is to develop mission concepts such that the mission could be fully realised in a shorter period of time to take advantage of opportunities as they arise.

This contract will consist of multiple studies spread over a two (2) year period, and will deliver standard concept study documentation. To help inform potential follow on investments, Contractors will also be asked to suggest systems engineering approaches for the path to flight that might be accommodated by CSA, appropriate to low cost secondary payloads.

CS-07 Mars Sample Return Mission

One concept study is anticipated with the purpose of positioning Canada for a possible contribution related to the Fetch rover element of Mars Sample Return. Samples from known context on Mars will be returned to Earth for sensitive analysis in state of the art laboratories to make significant steps forward in our understanding of the evolution of Mars and the potential for mars life. A nominal implementation of this mission campaign includes a cache rover to select samples and a fetch rover to transfer these to a Mars Ascent Vehicle which will rendezvous with a Mars orbiter/ Mars return vehicle for return to Earth.

The Fetch rover which is the focus of this study will retrieve samples from the Martian surface that have been selected and acquired by the previous cache rover mission and transfer them to a Mars Ascent Vehicle for return to Earth. For the purpose of this study, the mission concept should assume follow-on from the NASA Mars 2020 cache mission, with Fetch rover operations at the NASA Mars 2020 landing site. The concept study should also include in situ science in support of preparing for human exploration.

Deliverables:

Typical concept study report with objectives defined, technology feasibility assessment and science and technology development plans to inform future investments. Cost and schedule for pre-mission development and Phases A through E.

CS-08 Planetary and Space Astronomy Concept Studies for Instruments or Missions

These studies will focus on new planetary and astronomy concepts for potential missions or instrument contributions in response to community priorities.

- Missions are expected to launch no earlier than the mid-2020s.
- Both low and high TRL options will be considered.
- Develops objectives, requirements, system or instrument concepts, schedule, cost, technology and science development roadmaps.
- Early investment in concept studies provides lead time for risk reduction through subsequent STDP, Capability Demonstration, and Science Maturation investments.

Deliverables:

Typical concept study report with science objectives defined and technology feasibility assessment and science and technology development plans to inform future investments.

CS-09 Space Astronomy: LiteBIRD Concept Study

LiteBIRD ((**Lite** 'light' satellite for the studies of **B**-mode polarization and **I**nflation from cosmic background **R**adiation **D**etection) is a JAXA proposed satellite that will search for primordial gravitational waves in the Cosmic Microwave Background (CMB). It follows the success of other CMB missions, such as Cosmic Background Explorer (COBE), Wilkinson Microwave Anisotropy Probe (WMAP) and Planck, that had important Canadian scientific expertise contributions.

JAXA has expressed interest in unique Canadian detector readout electronics (Frequency Domain Multiplexing). This concept study is needed to identify interfaces with the electronics for the cryogenic bolometers detectors.

Deliverables:

Report on requirements, interfaces with mission payload, feasibility validation, tech development roadmap, cost, and schedule.

SMS-01 Five (5) Planetary and space astronomy studies (5) - following CSEW priorities

Science Maturation Studies for (SMS) of up to three (3) planetary and two (2) space astronomy studies which reflect community priorities for continued development. SMS are the equivalent of Space Technology Development Program (STDP) for science, and serve to advance science for concepts or prototypes in which CSA may have already invested. These investments develop simulations and experiments to assess impacts to science objectives of potential upscope and descope options to inform potential phases A/B system trades.

Deliverables:

A report defining refined objectives and requirements with preliminary validation, as well as a science plan and estimated costing for Phases A through E.

SMS-03 Space Astronomy: CASTOR Canadian led Space Telescope Concept

CASTOR (Cosmological Advanced Survey Telescope for Optical and UV Research) is a concept for a powerful Canadian led space telescope that could make important and lasting contributions to astrophysics and knowledge. It is described as a priority in the space astronomy Canadian Astronomical Society (CASCA) Long Range Plan for investigations in Dark Energy (DE). The purpose of this study is to refine the science objectives and requirements and review the CASTOR mission concept including risks to science success. This follows a mission concept study done in 2012 for a baseline 1-m space telescope on a small-satellite platform. The study will review instrument needs, baseline mission requirements, performance floor, science plans, identify scientific capacity and potential collaborators (including potential international partners interested). The study will also examine: links and complementarity with other space missions (Wide Field Infrared Survey Telescope (WFIRST), Euclid); identify technology needs and risks and provide some order of magnitude cost and schedule.

Deliverables:

A report defining refined objectives and requirements with preliminary validation, as well as a science plan and estimated costing for Phases A through E.