

## Technology Status Overview for Space Exploration at the Canadian Space Agency

C. Lange<sup>1</sup>

<sup>1</sup> *Space Exploration Branch, Canadian Space Agency, Christian.Lange@asc-csa.gc.ca*

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### Abstract

This contribution presents the key findings of a comprehensive technology survey conducted by the Canadian Space Agency under the Exploration Core Program's Requirements Development/Data Analysis activity between October 2009 and May 2010. Based on an extensive literature review, this survey targeted six technology fields which were chosen based on their key role in future exploration missions. These fields are surface mobility systems; in-situ resource utilization systems; manipulators and tools; vision and sensing systems; communication systems; and operation centers. Spanning thirty missions and prototyping activities over the last four decades, the survey was designed to provide an unbiased assessment of the state-of-the-art in exploration technologies. For each of the six technology field, a Technology Readiness Assessment was performed, technology gaps were identified and possible opportunities for Canadian capabilities were highlighted.

**Keywords:** Exploration Core Program, Technology Status Review, Space Exploration.

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### Aperçu de l'état d'avancement technologique pour l'exploration de l'espace à l'Agence spatiale canadienne

#### Résumé

Cette contribution présente les principales conclusions d'un examen exhaustif de l'état de la technologie mené d'octobre 2009 à mai 2010 par l'Agence spatiale canadienne dans le cadre de l'activité de définition des exigences/analyse des données du Programme d'exploration de base. À partir d'une analyse documentaire approfondie, cet examen visait six domaines technologiques choisis en fonction de leur rôle essentiel dans les missions futures d'exploration. Ces domaines sont : les systèmes de mobilité de surface, les systèmes d'utilisation in situ des ressources, les manipulateurs et les outils, les systèmes de vision et de détection, les systèmes de communication et les centres d'exploitation. L'examen, qui portait sur trente missions et prototypes au cours des quatre dernières décennies, a été conçu de façon à donner une évaluation impartiale de l'état d'avancement technologique pour l'exploration spatiale. Pour chacun des six domaines technologiques, on a fait une évaluation de la maturité technologique, relevé les manques technologiques et souligné les occasions possibles pour les capacités canadiennes.

**Mots-clé:** Programme d'exploration de base, Aperçu de l'état d'avancement technologique, Exploration de l'espace

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## 1 INTRODUCTION

The exploration of space is a highly visible endeavour, a powerful driver for scientific and technical innovation, a magnet for world-class talent, and an incentive for young Canadians to pursue careers in science and technology. To shape and determine the nature of Canada's contribution to potential future international space exploration and astronomy missions CSA's Exploration Core program was created in 2007. Exploration Core engages in three types of activities: (i) requirements development; (ii) prototyping and deployment; and (iii) building and maintaining operational infrastructure required to support prototype integration and deployment. Through (i) requirements development, Exploration Core defines the science and technology developments most likely to be required in future space exploration missions of interest to Canada, and assesses potential contributions that Canada could make to such missions. Requirements development consists of: (A) data analysis of past and current missions, and of the development activity of other space agencies, leading to generation of requirements for possible future missions, systems or sub-systems; (B) concept studies of potential Canadian science and technology contributions to exploration missions including precursor missions and the proposal of systems concepts that will lead to the development of testable prototypes.

## 2 FINDINGS

This contribution presents the key findings of a comprehensive technology survey [1] conducted between Oct. 2009 and May 2010 for the Exploration Core Program's Requirements Development/Data Analysis activity. Based on an extensive literature review, this survey targeted six technology fields which were chosen based on their key role in future exploration missions, namely: surface mobility systems; in-situ resource utilization systems; manipulators and tools; vision and sensing systems; communication systems; and operation centers. Spanning thirty missions and prototyping activities, the survey was designed to provide an unbiased assessment of the state-of-the-art in exploration technologies. For each of these six technology fields, a Technology Readiness Assessment was performed, technology gaps were identified and possible opportunities for Canadian capabilities were highlighted. As part of this research work the following missions and prototyping activities were covered: ALHAT, Ames K-9, Ames K-10, Apollo 15 Lunar rover vehicle, Apollo 16 Lunar rover vehicle, Apollo 17 Lunar rover vehicle, ATHLETE, Beagle 2, CSA Ex-Doc, CSM Excavator, ESA AES Comms, ESA ATV LIDAR, ESA ROCC, Hayabusa, EXOMARS, LER / SPR, LSS / D-RATS Control centre, LSS COMMS prototype, Lunar surface manipulation system (LSMS), Lunokhod Mars Polar Lander, Mars Science Laboratory (MSL), MER-A (Spirit), MER-B (Opportunity), Pathfinder Sojourner, Phoenix, RESOLVE, Pilot, Scarab, US XSS-11 LIDAR. This contribution is based on the technical report [1] carried out by the following organizations: Artemis Innovation Management Solutions, LLC; Institut national d'optique; MacDonald, Dettwiler and Associates Ltd; Penguin Automated Systems Inc., Turquoise Technology Solutions Inc., and University of Toronto Institute for Aerospace Studies.

## REFERENCES

- [1] Exploration Core Data Analysis: Technology Status Overview for Space Exploration at the Canadian Space Agency, CSA, 2010. ([ftp link](#))