The Space Congress® Proceedings

1982 (19th) Making Space Work For Mankind

Apr 1st, 8:00 AM

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Michael D. Watson

Assistant to the Director, Canada Centre for Space Science, National Research Council of Canada

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Dr. Michael D. Watson
Assistant to the Director
Canada Centre for Space Science
National Research Council of Canada
Ottawa, Canada

ABSTRACT

This paper briefly describes some uses of the Space Shuttle and the Space Transportation System by Canada. The CANADARM (Shuttle Remote Manipulator System) has performed well in its early flight tests and should now be considered as a working tool. The possible Canadian uses of Shuttle in the next few years range from biosciences and space plasma investigations using Spacelab facilities, to launch of commercial communications satellites. Some medium- to long-term possibilities will also be discussed including large satellites and space structures.

INTRODUCTION

Although active in the field of space research for many years, and despite being the third country in the world to develop and orbit its own satellite (Alouette I, launched September 29, 1962), Canada has never developed its own launch vehicle. Rather, it is a deliberate Canadian policy to procure our launch vehicle requirements for satellites from other nations.

Further, from the inception of its space program, Canada has pursued a policy of international cooperation through agreements negotiated with other countries, primarily with the United States.

For these reasons, Canada has been extremely interested in the development of the Shuttle, and definitely considers itself to be a potential user of the Space Transportation System.

Under an agreement with NASA, Canada designed, developed and constructed the CANADARM or Shuttle Remote Manipulator System. The work was carried out by a Canadian industrial team with responsibility for project management resting with the National Research Council of Canada. The first flight unit, a contribution by Canada to the Space Shuttle program, was successfully flown and tested on the second Shuttle mission, November 12-14, 1981.

The CANADARM represents more than just a "use" of the Shuttle: it qualifies as a working, integral part of the overall Space Transportation System. Canada will have other uses for STS, and a number of these are described in the remainder of this paper.

APPROVED PROJECTS

This section describes projects which have received funding approval within Canada and are the subjects of negotiated (in some cases, signed) agreements between Canada and the USA. Launch dates are those given at the Shuttle Users' Conference of December 10, 1981.

Communications Satellites

Commercial communications satellites are owned and operated by Telesat Canada, which will use the Shuttle to launch future members of its ANIK family of spacecraft. (The word ANIK means "brother" in the language of the Inuit people of northern Canada.) Telesat is scheduled to launch its next four satellites on the following flights:

FLIGHT	DATE
5	Nov. 1982
7	Apr. 1983
14	Apr. 1984
35	Oct. 1985

These satellites will be elevated from low earth orbit (LEO) to geostationary transfer orbit using a PAM-D system.

Studies of Human Vestibular Function

These experiments involve the cooperative efforts of groups from the USA and Canada. The project includes the study of disorientation and motion sickness in space flight, and also the utilization of the weightless environment to investigate the basic physiology of the organ of balance of the inner ear. The descoping of the European Space Sled from the Spacelab 1 flight has caused some rescheduling of these experiments. They are presently planned to fly on Spacelab 1 (September 1983), Spacelab D-1 (May 1985) and Spacelab 4 (September 1985).

Space Effects on Composites

Canada will fly a Composite Materials Experiment on the first flight of the NASA Long Duration Exposure Facility (LDEF-1) scheduled for launch in December 1983 and retrieval in January 1985. The effects of exposure to space conditions will be studied for samples of four materials: graphite/epoxy, boron/epoxy, Kevlar/epoxy and glass/epoxy.

The long time lag between final readiness of the equipment and the probable date of launch has prompted an upgrading of the experiment from a passive one to a more active configuration. It is now planned to make daily recordings of temperatures and thermally-induced strains for selected samples. As well as producing data on temperature and inclination for the benefit of other LDEF experimenters, these recordings will also provide a reference baseline just prior to retrieval, so that any contamination or ground-handling effects can be calibrated out.

Solar Polar Mission

Canada is participating in the International Solar Polar Mission (ISPM). The deep space mission will fly a spacecraft over the pole of the sun via Jupiter and provide scientists with an entirely new view of galactic cosmic rays, solar magnetic fields, the sun's corona and solar particles. Canada is preparing a particle telescope to measure cosmic ray activity throughout the mission and provide a profile of the influence of the outbound solar particles. Our responsibility includes the provision of the high flux telescope, power conditioner and software support for this Cosmic Ray and Solar Particle Investigation (COSPIN). ISPM is presently scheduled to be launched on Shuttle flight 44 in May 1986.

Spacelab Instruments

As part of a cooperative program with the USA, Canada will provide three facility-type instruments now scheduled to be flown on the Spacelab 6 mission in January 1987.

WISP/HF. Canada will supply the high-frequency subsystem of the NASA "Waves in Space Plasma" experiment. This facility will explore the response of the earth's atmosphere and magnetosphere to electromagnetic radiation in the 0.3 to 30 MHz frequency range. In particular, experiments will be carried out on wave propagation, resonances, ionization density distributions, nonlinear effects, wave/particle interactions, and antenna impedance. The instrument will consist of a sophisticated transmitter/receiver/antenna combination under microprocessor control.

EIMS. This Energetic Ion Mass Spectrometer is also planned as a collaborative effort with NASA. It is designed to measure ion composition, energy distribution, source regions, transport and loss mechanisms, and other characteristics of the plasma in the vicinity of the Shuttle. The sensitivity and mass resolution of EIMS will greatly exceed those of any previous flown instrument since the weight-carrying capability of the Shuttle makes possible the use of a large scanning magnet.

WAMDII. The objective of the Wide Angle Michelson Doppler Imaging Interferometer is to provide vertical profiles of winds in the upper atmosphere, and exploratory data on small scale irregularities. This Canadian-funded optical device permits high resolution measurements of the Doppler shifts, caused by air motions, in the wavelengths of light emitted from atmospheric atoms or molecules.

PROJECTS UNDER CONSIDERATION

The projects described in this section are at stages of development ranging from near-certainty to preliminary discussion. In most cases funding has been received, at least for the early planning phases.

Communications Satellites

As part of its continuing telecommunications service, Telesat Canada intends to follow the current ANIK satellite launches with a series of five more ANIK's. Telesat has made firm requests accompanied by earnest money for Shuttle launches in February 1987, May 1988, July 1989, November 1990 and February 1991. These are reserved against the use of a growth PAM.

RADARSAT

Up to now, Canadian remote sensing activities have been concentrated on the ground segment of satellite remote sensing systems, and these facilities will continue to be upgraded. Recent studies, using data from the SEASAT program, have shown that ice, land and ocean monitoring are feasible with a satellite-borne imaging radar. Accordingly, the RADARSAT program is now underway to define mission requirements, conduct an R&D program with Canadian industry on space radar technologies, and develop a conceptual design for a Canadian radar satellite primarily to provide Arctic operators with the all-weather ice movement information required for safe and efficient exploitation of energy resources.

The RADARSAT spacecraft would be a large and heavy one and therefore a potential user of the Shuttle, although that decision has not yet been made. A polar orbit is required, which would necessitate a launch from Vandenberg AFB. The present project planning envisages a single launch by 1990, with a follow-on program of three more satellites each decade if the original mission proved successful. Canada has an agreement with the USA to define the mission requirements of both countries for a radar satellite, and is also actively participating in the earth resources satellite program in Europe.

MSAT

Canada has begun the development of a Mobile Satellite (MSAT) program. The objective is to provide a facility to satisfy urgent national needs for improved mobile communications to remote areas of Canada, including resource development activities in the north. The MSAT program will introduce satellite service to mobile terminals in Canada in the most cost-effective and timely manner and will contribute effectively to industrial development, through the development, manufacture and launch of a UHF communications satellite. In the Public Band (806-890 MHz) the services will supplement ground based mobile radio and telephony systems. In the Government Band (270-400 MHz) communications will be provided to portable and mobile small terminals, for military and civilian uses. It is probable that MSAT would also carry other services operating in higher frequency bands. Again, as a large, heavy spacecraft, MSAT will be a potential Shuttle launch user.

Surveillance Satellite

Canada is presently negotiating with the USA for a shared surveillance satellite program. Sensor types have not yet been decided for this satellite, which would be a large structure and therefore would probably need to be launched by the Shuttle.

STARLAB

STARLAB is a proposed 1-metre diameter, high resolution, wide field of view space telescope which is being discussed as a joint Canada-USA-Australia project. The telescope would be placed in LEO by the Shuttle, as one facility on board a U.S. platform. It would remain in orbit for periods of 6-12 months and then be retrieved for instrumentation changes. The earliest launch date would be 1990. The present discussions involve two focal plane instruments consisting of one wide field camera operating from 900-10000 A using CCD imaging devices, and one spectrograph covering the range 900-40000 A.

Reflights of Spacelab Instruments

The project definitions for the Canadian Spacelab instruments described earlier (WISP/HF, EIMS and WAMDII) included the intention to modify, refurbish and refly all three as components of a continuing scientific facility. No formal discussions have taken place, and no funding has been provided, but the intention still remains to use Shuttle/Spacelab for this purpose.

LDEF Reflight

Interest has been expressed within Canada in participating in the LDEF-2 mission in orbits between LEO and geostationary orbit. One of the great advantages of the use of composites is the ability to tailor the mechanical properties of the material by properly engineering the fabrication process. It is necessary to know what effects space radiation will have upon these engineered properties. A fully-active experiment is proposed, in which specimens of composite materials would be loaded mechanically while exposed to the ambient conditions of deep space. During this long exposure, changes due to thermal fatigue, as well as changes in damping parameters exhibited by the specimens, would be monitored.

Active Experiment Satellite

This program (AES) would involve a satellite in LEO containing a number of chemical canisters and dedicated to a series of chemical release experiments in the high-latitude (auroral) ionosphere. The program would likely be carried out in collaboration with other countries. A barium thermite release would produce visible ion and neutral clouds for studying convection

patterns in the high-latitude ionosphere. Injection of lithium ions into the auroral ionosphere as a tracer would provide a unique tool with which to study energization and transport processes in the magnetosphere. The release of water vapour in the F-region ionosphere would produce a region of plasma depletion; the response of the auroral ionosphere to such a depletion would provide unique information on the energization mechanism of auroral particles. Neutral gases would be injected into the atmosphere at orbital velocities to study the critical velocity phenomenon in space plasma. Depending on the collaborating country, AES could be a potential Shuttle launch.

Microgravity Experiments

Discussions have recently begun in Canada on possible programs that could be pursued in the field of microgravity using the Shuttle/Spacelab facility. Attention is being directed to materials processing and to biosciences.

Materials Processing. This is an area that lends itself to collaboration with other countries, several of which are planning significant programs. A number of researchers in government and university laboratories, as well as several Canadian industries, have expressed interest in crystal growth and thin film experiments under low gravity conditions. It is proposed to better define Canadian interests and expertise in this area with a view to identifying specific projects.

Biosciences. Again, this field is one of broad global interest, although Canadian participation has been slow to develop. Some very preliminary discussions have taken place concerning experiments with microbiota and pharmaceutical production.

Any follow-on to the human vestibular function studies described above would be a future user of Shuttle/Spacelab, and should be mentioned under this heading. No detailed plans exist at the present time, and further developments in this program will depend to a large extent on the findings of the first three missions (Spacelab 1, D-1 and 4), and on the future direction of the manned spacecraft program.

LONG TERM POSSIBILITIES

The final section of this paper will briefly discuss some possible future uses of the Space Shuttle which have been recently suggested. None have received any significant funding support. Some proposals have been formally discussed, while others are simply the ideas of individuals.

Direct broadcasting to individual home receivers has emerged as a dominant new application of satellite technology for the 1980's. Canada was the first country to demonstrate this technology in 1976, using the high powered HERMES satellite, in a cooperative program with the USA. Field trials are continuing using the lower powered ANIK-B communications satellite. Canada has now commenced a comprehensive, multi-disciplinary study program designed to provide the information necessary for making decisions on the implementation of a direct broadcasting satellite (DBS) service in Canada. If it were decided to undertake such a DBS service, the large spacecraft required would be a logical candidate for launch using the Shuttle.

One proposal that has only been discussed in a preliminary way would result in the availability of standardized bus facilities designed to support a range of small space science experiment packages. Participating scientists would be able to design and construct their instruments in their own laboratories, and then have them integrated into the bus structure by an industrial contractor, whose responsibilities would include ensuring that Shuttle interface requirements were satisfied. Such a standard bus might take the form of a spinning free-flying satellite to be released by the Shuttle in LEO and later retrieved. Another possibility would be to provide an instrument support package that would remain attached to a Spacelab pallet during flight. It has been suggested that the provision of such a standard bus would permit substantial reductions in the cost of individual small experiment packages.

A major area of potential Shuttle use is as a versatile test bed for trying out new concepts that cannot be verified except by actually operating a system in space. One example might be the testing of remote sensing devices. As a short term test facility, intermediate between aircraft and a free-flying satellite, the Shuttle would be an ideal vehicle. Canada is presently developing a Fluorescence Line Imager (FLI) for mapping productive areas of the ocean by observing changes in the colour of the water. The device would make use of Canadian experience in solid state imaging to allow measurement of the natural fluorescence signal from chlorophyll-A found in phytoplankton, as well as to give improved sensitivity for measurements based on absorption. Because of the strong international interest in this type of data, it is planned to carry out experimental surveys from a variety of high-flying aircraft, with the possibility of a Shuttle test flight using the Spacelab facility.

A second potential type of test that could be carried out with the Shuttle would be the launch and check-out in LEO of structures or sub-structures designed to be used in space and therefore incapable of proper operation under normal gravity conditions. Critical components of a larger assembly could be individually tested in orbit and then integrated back on earth for subsequent re-launch and final deployment in space.

The Space Operations Center (SOC), a permanently-manned space station in LEO, is presently considered to be the next major program in the development of space systems from which, amongst others, construction, manufacturing and servicing tasks will be undertaken. Several areas of such development are well-suited to the present capability of Canadian industry: the solar power array extension booms, the closed cabin cherry picker manipulator, and the articulated construction facility, as well as other major space mechanisms. Canada will continue to review its contribution, not only to the development of such basic equipment, but also to the manufacturing processes that will result from their use in SOC's as space becomes technologically exploited.

ACKNOWLEDGEMENT

Many colleagues in government, industry and the universities have provided material for this paper, either verbally or through earlier documentation. The author wishes to thank them all for their contributions.