ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FOUR

INSTRUCTIONAL GUIDE

SECTION 2

EO M440.02 – DESCRIBE CANADIAN SATELLITES

Total Time:	30 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-804/PG-001, *Proficiency Level Four Qualification Standard and Plan*, Chapter 4. Specific uses for said resources are identified throughout the instructional guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Make slides of Attachments A–C.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An interactive lecture was chosen for this lesson to orient the cadets to Canadian satellites and to generate interest in the subject.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall be expected to describe selected Canadian satellites.

IMPORTANCE

It is important for cadets to be familiar with Canadian satellites so they can appreciate the Canadian space program, which is an important element of air cadet training.

Teaching Point 1 | **Identify aspects of the Alouette program.**

Time: 5 min | Method: Interactive Lecture

HISTORY

Launched on September 29, 1962, the Alouette-I scientific satellite marked Canada's entry into the space age and was seen by many as initiating the most progressive space program of that era.

Show the cadets Figures A-1 and A-2 located at Attachment A.

With the Alouette launch, Canada became the first nation after the Soviet and American superpowers, to design and build its own artificial Earth satellite.

PURPOSE

The development of Alouette-I came as a result of an American invitation, through the newly formed National Aeronautics and Space Administration (NASA) in 1958, for international collaboration in its budding satellite program. Within months, scientists at Canada's Defence and Research Telecommunications Establishment (DRTE) submitted a proposal to NASA for a Canadian satellite that could monitor the top of the ionosphere, an upper layer of the earth's atmosphere that is ionized by solar wind.

The solar wind is so hot it becomes fully ionized plasma, which means that the atoms have become separated from their electrons. This streaming plasma flows past Earth, affects the Earth's magnetic field and magnetosphere, and creates the ionosphere by removing electrons from atoms of gas in the atmosphere. The Earth's atmosphere receives a lot of energy from the sun in the form of radiation—about 1 370 watts per square metre. That is enough energy to power six desktop computers, coming from an area that would barely hold one computer.

Ground-based techniques used to study the ionosphere are similar to radar. Radio pulses are transmitted from the ground and reflected back by the ionized layer of atmosphere. The elapsed time is used to calculate the height of the layers. The equipment used to make these measurements is an ionosonde. The Canadian proposal was to integrate an ionosonde into a satellite.

The objectives were twofold, both primary and scientific:

1. Primary objectives were:
    a. to bring Canada into the space age by developing a space capability;
    b. to contribute to space engineering and technology; and
    c. to improve the capability of high frequency (HF) radio communications by studying the ionosphere from above.

2. Scientific objectives were:

   a. to measure the electron density distribution in the ionosphere at altitudes between 300 and 1 000 km;

   b. to study, for a one-year period, the variations of electron density distribution with regard to time of day and latitude under varying magnetic and auroral conditions, with particular emphasis on high latitude effects; and

   c. to determine electron densities in the vicinity of the satellite by means of galactic noise measurement and to make observations of related physical phenomena, such as the flux of energetic particles.

ACCOMPLISHMENTS

Alouette-I was a tremendous success. The conservative research approach adopted by the DRTE team paid off as the satellite eventually stretched its one-year design life into an unprecedented 10-year mission, producing more than one million images of the ionosphere.

Following the success of Alouette-I, Canada and the United States signed an agreement to launch further satellites under a new program called International Satellites for Ionospheric Studies (ISIS). Under the ISIS program, the Alouette backup model, Alouette-II, was refurbished and flown in 1965 and two new satellites, named ISIS I and ISIS II, were successfully launched in 1969 and 1970 respectively.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS:

Q1. What was the year of Alouette's first launch?

Q2. What was Alouette designed to do?

Q3. What program followed the success of Alouette?

ANTICIPATED ANSWERS:

A1. 1962.

A2. To monitor the ionosphere from above.

A3. The ISIS program.

Teaching Point 2	**Identify aspects of the Microvariability and Oscillation of Stars (MOST) mission.**
Time: 10 min	Method: Interactive Lecture

HISTORY

MOST is Canada's space telescope in orbit. It is sometimes referred to as the "Humble Space Telescope" due to its physical size, despite its effectiveness and accomplishments.

Show the cadets Figures B-1 and B-2 located at Attachment B.

The four partners who designed and created MOST are:

- Canadian Space Agency (CSA),
- University of British Columbia (UBC) (Physics and Astronomy),
- University of Toronto Institute for Aerospace Studies (UTIAS), and
- Dynacon Enterprises Limited (main contractor, mission operations).

The MOST science team includes representatives from various organizations, which include:

- University of British Columbia (UBC),
- St. Mary's University,
- L'Université de Montréal,
- University of Toronto David Dunlap Observatory (DDO),
- Harvard-Smithsonian Center, and
- University of Vienna.

MOST was carried aloft aboard a Russian three-stage rocket on June 30, 2003, from a launch site in northern Russia (Plesetsk). MOST was injected into a low-Earth polar orbit at approximately 820 km altitude with an orbital period of approximately 100 minutes in a sun-synchronous mode remaining over the Earth's terminator (the line between day and night).

Sun-synchronous means that, although MOST orbits Earth, it also maintains its orientation to the sun.

Show the cadets Figures B-3 to B-5 located at Attachment B. For orbit information, cadets can visit http://www.astro.ubc.ca/MOST/galleries.html#movies

From that vantage point, MOST will have a Continuous Viewing Zone (CVZ) spanning declinations from about -19 to +36 degrees, in which a selected target star will remain observable for up to 60 days without interruption.

UBC has a collection of MOST training eClips and explanations located at their MOST website at http://www.astro.ubc.ca/MOST/galleries.html#movies

PURPOSE

The stated purposes of the MOST space telescope are the detection and characterization of:

- acoustic oscillations in sun-like stars, including very old stars (metal-poor subdwarfs) and magnetic stars (roAp), to probe seismically their structures and ages;
- reflected light from giant exoplanets closely orbiting sun-like stars, to reveal their sizes and atmospheric compositions; and
- turbulent variations in massive evolved (Wolf-Rayet) stars to understand how they add gas to the interstellar medium.

MOST, therefore, is an attempt to answer important question about stars, such as:

- Can we understand our sun in the context of other stars?
- By putting a birthdate on the oldest stars in the solar neighbourhood, can we set a limit on the age of the universe?
- How do strong magnetic fields affect the physics of other stars and our own sun?
- What are mysterious planets around other stars really like?
- How did the atoms that make up our planet and our bodies escape from stars in the first place?

ACCOMPLISHMENTS

Although the MOST space telescope is often referred to as the Humble telescope because of its size next to the Hubble Space Telescope (HST), the accomplishments of MOST are anything but humble. MOST turned out to be a precocious child. The team of scientists and engineers—located from coast to coast across Canada and in Harvard and Vienna—has extended the capabilities of this "little telescope that could" to explore exoplanets (alien worlds around other stars). MOST has measured the properties of several of these planets, which are invisible even to the largest telescopes. Among the findings of MOST is a planet whose atmosphere is either so clear or so hazy that it reflects only four percent of the light it receives from its parent sun.

For information about MOST observations, visit the MOST Science website at http://www.astro.ubc.ca/MOST/science.html

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CONFIRMATION OF TEACHING POINT 2

QUESTIONS:

Q1. What year was that the MOST telescope carried aloft?

Q2. What sort of orbit does MOST have?

Q3. What viewing opportunity does MOST's orbit provide?

ANTICIPATED ANSWERS:

A1. 2003.

A2. A low-Earth polar orbit.

A3. A CVZ spanning declinations from about -19 to +36 degrees, in which a selected target star will remain observable for up to 60 days without interruption.

Teaching Point 3	**Identify aspects of the RADARSAT program.**
Time: 10 min	Method: Interactive Lecture

HISTORY

The RADARSAT program was born out of the need for effective monitoring of Canada's waters. Canada is a world leader in the operational use of space radar for sea ice monitoring. Earth-observation satellites have an advantage over aerial surveillance missions. Satellites operate day and night in all weather conditions and provide timely coverage of vast areas.

Show the cadets Figure C-1 located at Attachment C.

RADARSAT is Canada's first series of remote-sensing satellites. RADARSAT-1 was launched in 1995 and RADARSAT-2 in 2007. These satellites focus on the use of radar sensors to provide unique information about the Earth's surface through most weather conditions and darkness. A technique known as synthetic-aperture radar (SAR) is used by RADARSAT satellites to increase the resolution of images by taking advantage of the fact that the satellite's small aperture is constantly moving. The many echo waveforms received at the different antenna positions are then post-processed by a computer in order to resolve the target with high definition. Post-processing by a computer is also the technique used by Global Positioning System (GPS) receivers to eliminate location ambiguities.

PURPOSE

Marine Surveillance

Worldwide offshore resource-based operations such as fishing, oil and gas exploration and production have intensified over the past few decades. Government and industry require powerful solutions for assessing the resources and risks associated with the ocean environment. To monitor the world's oceans, Canada has provided radar data for operational applications such as ship detection, oil spill monitoring, and wind and surface-wave field estimation.

RADARSAT-2 improves ship detection with its ultra-fine beam mode, which can resolve objects down to 3 m on a side, and offers the potential for ship classification.

Disaster Management

Radar satellites are key resources in a variety of disaster management scenarios. The data has been used effectively in disaster responses such as earthquakes, tsunamis, floods, landslides, forest fires, and other natural or technological disasters such as a large oil spill in Japan. On January 2, 1997, the Nakhodka, a Russian oil tanker, broke apart during a storm 130 km (80 miles) off the coast of Japan's Shimane Prefecture.

Show the cadets Figure C-2 located at Attachment C. The inset view in Figure C-2 shows the location of the Wakasa Bay nuclear reactors.

At one point the spill threatened one of the most concentrated areas of nuclear reactors in the world. The oil slicks came close to the 15 reactors in Japan's Wakasa Bay but the cleanup effort was able to keep the oil from seeping into the reactor's intake pipes, which serve to cool the reactors with seawater. Officials stated that in the worst case, if the oil had seeped into the pipes, plant operators would simply have been forced to suspend power. RADARSAT images served to define the extent and shape of the oil spill during this disaster.

The ability to deliver data in near-real time is essential for relief operations to map and monitor damage and for assessing impact.

RADARSAT-2 reduces planning lead times for data acquisition and, because it can look both right and left, provides more revisits and up-to-date data than its predecessor.

There are unlimited uses for RADARSAT image data. An example is the use of RADARSAT images by Research Institute for Advanced Mechanics (RIAM) of the Kyushu University Dynamics Simulation Research Center to develop a computer model of the Nakhodka oil spill.

Show the cadets Figure C-3 located at Attachment C.

RADARSAT images, such as the ones seen in Figure C-3, were used in creating computer programs that simulate the spreading of spilled oil.

Show the cadets Figure C-4 located at Attachment C.

Dated images of the computer program output are shown in Figure C-4. Computer analysis is now available to predict the effects of future oil spills and assist with environmental cleanup.

Hydrology

Water is one of Earth's most precious and widely used resources. RADARSAT-2 enhances soil moisture measurement, and snow pack monitoring and analysis, while improving the potential for SAR in wetland mapping and discrimination. This will benefit mapping applications involving coastlines, tidal and near-shore terrestrial areas, and near-shore bathymetry (depth measurements).

Mapping

Mapping covers a broad range of activities, including the creation of Digital Elevation Models (DEMs), the detection and mapping of centimetre-scale movements at the Earth's surface (InSAR), and the extraction and identification of features to support environment management and security.

RADARSAT-2's advanced technology provides improved capabilities for mapping. Highly accurate positional information and control over the RADARSAT-2 orbit ensures absolute quality for end products, such as DEMs and InSAR.

Geology

Satellite radar data is very useful in geological exploration and mapping activities for petroleum and mineral resources. Canadian radar data is used for both onshore and offshore exploration and mapping and to monitor and detect oil seeps, which reduces the risk and cost of drilling. The Southern African Institute of Mining and Metallurgy reports the use of remote sensing by diamond mining companies in South Africa, listing RADARSAT images as among the most useful.

Agriculture

Abundant harvests and crop yields partly depend on soil dynamics that fluctuate throughout the growing season. Satellite imagery is an efficient method for mapping crop characteristics over large spatial areas and tracking temporal changes in soil and crop conditions.

Built into RADARSAT-2 are several powerful features that respond directly to the needs of the agricultural sector. Valuable crop information can be extracted from one RADARSAT-2 image and there is no need for image data acquisition over several dates. RADARSAT provides important information about climate change.

Forestry

With more than 30 percent of the Earth's total land area covered in forests, it is no small feat to assess and monitor forest resources. Satellite imagery is the most efficient method for coverage of forested areas.

Several applications in forestry have benefited from Canadian radar data, in particular clear-cut mapping. High-resolution data from RADARSAT-2 may improve forest-type mapping using textural analysis.

ACCOMPLISHMENTS

The RADARSAT Program continues Canada's tradition of providing world leadership in advancing Earth-observation technologies and techniques. Natural Resources Canada—one of RADARSAT's main customers—observes that RADARSAT's unparalleled operational flexibility and reliable delivery provides high quality and cost-effective data to researchers and environmental professionals world-wide.

CONFIRMATION OF TEACHING POINT 3

QUESTIONS:

Q1. What kind of satellites are RADARSAT satellites?

Q2. In what year was the first RADARSAT launch?

Q3. What are three purposes of the RADARSAT program?

ANTICIPATED ANSWERS:

A1. Earth-observation satellites.

A2. RADARSAT-1 was launched in 1995.

A3. Any three chosen from: marine surveillance, disaster management, hydrology, mapping, geology, agriculture and / or forestry.

END OF LESSON CONFIRMATION

QUESTIONS:

Q1. What job was Alouette designed to do?

Q2. What does MOST's orbit provide?

Q3. What are three purposes of the RADARSAT program?

ANTICIPATED ANSWERS:

A1. To monitor the ionosphere from above.

A2. A CVZ spanning declinations from about -19 to +36 degrees, in which a selected target star will remain observable for up to 60 days without interruption.

A3. Any three chosen from: marine surveillance, disaster management, hydrology, mapping, geology, agriculture and / or forestry.

CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

Nil.

CLOSING STATEMENT

Canadian space missions affect many aspects of life, from telecommunications to environmental protection and pure science. Intended and unintended applications of Canada's space research continue to benefit other industries.

INSTRUCTOR NOTES / REMARKS

Cadets who are qualified Advanced Aerospace may assist with this instruction.

REFERENCES

C3-253 Canadian Space Agency. (2008). *Alouette I and II*. Retrieved September 29, 2008, from http://www.space.gc.ca/asc/eng/satellites/alouette.asp

C3-254 University of British Columbia. (2008). *MOST: Canada's first space telescope*. Retrieved September 29, 2008, from http://www.astro.ubc.ca/MOST/overview.html#glance

C3-255 Natural Resources Canada. (2008). *Canada centre for remote sensing: RADARSAT*. Retrieved September 29, 2008, from http://www.ccrs.nrcan.gc.ca/radar/spaceborne/radarsat1/index_e.php

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