ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FIVE

INSTRUCTIONAL GUIDE

SECTION 1

EO C540.01 – REFLECT ON CANADA'S CONTRIBUTION TO AEROSPACE TECHNOLOGY

Total Time: 90 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-805/PG-001, *Proficiency Level Five Qualification Standard and Plan*, Chapter 4. Specific uses for said resources are identified throughout the self-study package within the section for which they are required.

Self-study packages are intended to be completed by the cadet independently. More information about self-study packages can be found in the foreword and preface.

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

Photocopy the self-study package located at Attachment A for each cadet.

Photocopy the answer key located at Attachment B but **do not** provide it to the cadets.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

A self study was chosen for this lesson as it allows the cadet to reflect in greater detail on Canada's contribution to aerospace technology at their own pace. This encourages the cadet to become more self-reliant and independent by focusing on their own learning instead of learning directed by the instructor.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall have reflected on Canada's contribution to aerospace technology.

IMPORTANCE

It is important for cadets to recognize the contribution Canadian researchers, scientists and technicians have made to the development of aerospace technology, not only for Canada but the world. Canadian technical knowledge has assisted aerospace development to create global advances within the space program and aircraft development.

SELF-STUDY PACKAGE INSTRUCTIONS

OBJECTIVE

The objective of this self-study package is to have the cadet reflect on Canada's contribution to aerospace technology.

RESOURCES

- Self-study package, and
- Pen / pencil.

ACTIVITIY LAYOUT

Provide the cadet with a classroom or training area suitable to complete the self-study package.

ACTIVITY INSTRUCTIONS

1. Provide the cadet with a copy of the self-study package located at Attachment A and a pen / pencil.
2. Allow the cadet 90 minutes to complete the self-study package.
3. Provide assistance as required to the cadet.
4. Collect the self-study package once the cadet has finished.
5. Correct the self-study package with the self-study package answer key located at Attachment B.
6. Provide feedback to the cadet and indicate whether or not they have completed the Enabling Objective (EO).
7. Return the completed self-study package to the cadet for their future reference.
8. Record the result in the cadet's logbook and Cadet Training Record.

SAFETY

Nil.

END OF LESSON CONFIRMATION

The cadet's participation in reflecting on Canada's contribution to aerospace technology will serve as the confirmation of this lesson.

REFERENCES

C3-346 ISBN 978-1-55002-940-6 Melady, J. (2009). *Canadians in space: The forever frontier*. Toronto, ON: Dundurn Press.

C3-347 Aerospace and Defence. (2008). *Canada's evolving position in the aerospace environment*. Retrieved October 23, 2009, from http://www.ic.gc.ca/eic/site/ad-ad.nsf/eng/ad03879.html

C3-356 Centennial of Flight (2009). *Avro Canada*. Retrieved December 4, 2009 from http://www.centennialofflight.ca/airforce/hist/history_Avro_Canada_e.php

C3-357 page.interlog.com (2004). *Avrodemo timeline*. Copyright 1998–2004 by Art and Industry/20th Century Limited. Retrieved December 4, 2009 from http://pages.interlog.com/~urbanism/adrodemo.html

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Reflect on Canada's Contribution to Aerospace Technology

SECTION 1: ACCOMPLISHMENTS UP TO THE CANCELLATION OF THE AVRO CANADA CF-105 ARROW PROJECT

SECTION 2: THE ACCOMPLISHMENTS OF FORMER AVRO CANADA LIMITED PERSONNEL

SECTION 3: CANADA'S CONTRIBUTION TO THE SPACE PROGRAM

SECTION 4: CANADA'S CONTRIBUTION TO AIRCRAFT DEVELOPMENT

SECTION 1
THE ACCOMPLISHMENTS UP TO THE CANCELLATION OF THE AVRO CANADA CF-105 ARROW PROJECT

Canada's interest in space began well before we were a country. The first astronomical observatory was located in the French colony in Louisbourg on the coast of Cape Breton Island. As the country grew, observatories were developed in Quebec, in Quebec City and Montreal, and in Ontario, in Kingston and Toronto.

Did you know?

The first recognized Department of Astronomy was formed at the University of Toronto in 1904.

With the interest in the north magnetic pole and its affect on ratio waves, further examination of the sky was conducted with telescopes and weather balloons. Communication during World War II (WWII) became increasingly important. Scientists found that signal strength rises and falls depending on how high on a promontory or how low in a valley you are.

Did you know?

By the mid 1950s, the ideas of man-made satellites were being discussed. To launch a satellite was the problem.

Experimentation with rockets was mainly being conducted near Churchill, Manitoba jointly between Americans and Canadians. Research was being conducted by the Bristol Aerospace Company in Winnipeg, Manitoba in conjunction with the Ottawa-based Defence Research Board.

Many well known scientists worked on the development of rockets, including a little known Canadian, Dr. John Chapman. Dr. Chapman's contribution to space flight and space flight technology is unparalleled in our country.

Did you know?

The Canadian Space Agency headquarters site at Longueuil, Quebec is named The John H. Chapman Space Centre after Dr. Chapman.

As a Royal Canadian Air Force (RCAF) officer, Dr. Chapman learned and worked in the developing field of radar. After the war, he returned to Canada, received his doctorate in physics and became involved in ever-increasing leadership roles at the Defence Research Telecommunication Establishment.

When the Russians launched Sputnik in 1957, the Russian-American rivalry began. The Defence Research Telecommunication Establishment was among the first to detect and monitor the sounds of the satellite.

Figure A-1 Sputnik

Note. From "About.com". *Sputnik 1 Mockup*. Retrieved December 4, 2009, from http://www.space.about.com/od/sputnik/ig/Sputnik-a-Pictures-Gallery/Sputnik-a-Mockup.htm

With the Russian success, and the successful launch of Explorer 1 in 1958 by the Americans, Canada realized that they too could have a satellite in space. The team in Ottawa, Ontario lead by Dr. Chapman started working on this problem. If they could develop a satellite for Canada, perhaps the Americans would launch the satellite.

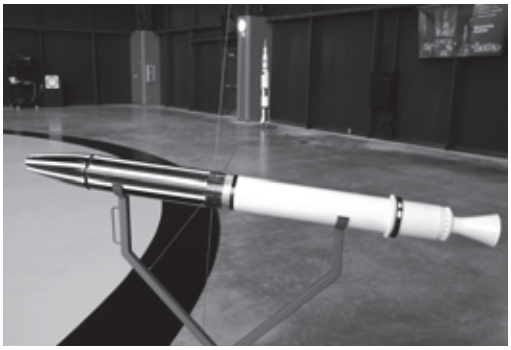

Figure A-2 Explorer 1

Note. From "U.S. Space & Rocket Center", 2009, *U.S. Space & Rocket Center Official Gallery-Interior/Explorer 1–8*. Copyright 2009 by U.S. Space & Rocket Center. Retrieved December 2, 2009, from http://www.spacecamp.com/gallery/displayimage.php?album=36&pos=1

Did you know?

When the National Aeronautic and Space Administration (NASA) was formed, they started examining American achievements including Canadian successes with space research. NASA started as a bureaucracy to keep track of space-related advances and to lend cohesion to the progress that was being made in the space field.

In 1959, NASA agreed to launch the Canadian satellite built by Dr. Chapman and his team with the understanding that any information would be shared with other countries.

The Americans already had close connections with the Canadian capabilities and resourcefulness. The Storable Tubular Extendible Member (STEM) antenna was invented by George Klein, an engineer with the National Research Council (NRC) and built by Spar Aerospace Limited (Ltd.). It was used on all early American–manned space flights, including John Glenn's (first American astronaut) launch into space.

If you want to read more about NRC engineer George Klein, you can go to http://www.nrc-enrc.gc.ca/eng/education/innovations/discoveries/stem.html

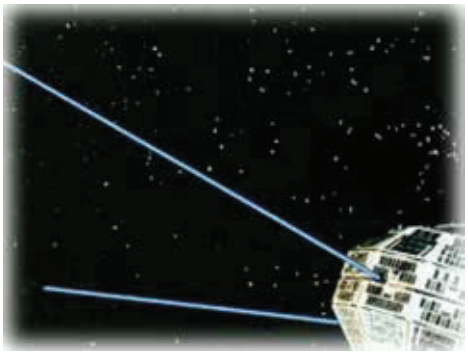

Figure A-3 STEM Protruding from Alouette

Note. From "Canada Science and Technology Museum", 2009, *Background Information for Canada in Space*. Copyright 2009 by Canada Science and Technology Museum. Retrieved December 4, 2009, from http://www.sciencetech.technomuses.ca/English/schoolzone/Info_Space.cfm

A STEM antenna, a flat strip of steel, unrolls when the satellite reaches its orbit and remains rigid when it is deployed.

Canada was launching scientific research Black Brants rockets starting in 1959, from Churchill, Manitoba. The first rocket carried a 100–kg payload to an altitude of 99 km.

Did you know?

The first Canadian satellite, Alouette 1, was launched by an American Thor-Agena rocket on September 26, 1962 in California. Alouette 1 was designed and built in Canada and had four STEM antennas. It took 20 years before Canadians were invited to become part of NASA.

While space development was progressing, aircraft development was also achieving advancements. In 1937, Malton, Ontario was selected to house Victory Aircraft. In 1945, A. V. Roe Canada Ltd. purchased Victory Aircraft as a repair and maintenance shop for aircraft. The company became known as Avro Canada.

In 1946, Avro purchased Turbo Research Ltd. to continue working on jet engines. In 1954, the Gas Turbine Division of Avro became a separate company, Orenda Engines Ltd. The Orenda engine was to be the main focus for the CF-100, F-86 and later the CF-105, as well as other countries' aircraft.

In 1953, Avro received contracts to develop a powerful interceptor aircraft to counter the Russian development of jet-powered bombers.

Did you know?

In 1952, Avro Special Projects teams started research and development on a vertical lift flying saucer-like vehicle (Avro VZ-9-AV Avrocar) funded by the United States Air Force (USAF).

The Avro Arrow was developed and proved to be an outstanding aircraft, ahead of its time. Tests flights were started in 1958 by chief test pilot Jan Zurakowski. At the same time, the Astra fire-control and Sparrow missile program were experiencing major developmental problems and creating major cost overruns. The overall costs for the Arrow project were several million dollars and increasing.

Figure A-4 CF-105 Avro Arrow

Note. From "Military Pictures", 2006, *Avro Arrow*. Copyright by MilitaryPictures.Info. Retrieved December 3, 2009, from http://www.militarypictures.info/airplanes.avro_arrow.jpg.html

Did you know?

Engineers overcame many difficulties in aircraft design at this time, including:

- wave drag at supersonic speeds:
  - used a thicker airfoil, and
  - swept airfoil rearward at a sharp angle; and
- delta wings provided:
  - more internal room for more fuel,
  - larger surface area providing ample lift at high altitudes, and
  - difficulty with increased drag at lower speeds and altitude.

NRC studied the Arrow project and was critical of the aircraft's maneuverability at altitude and range.

On September 23, 1958, the Astra and Sparrow programs were cancelled. The government cancelled the complete Arrow program on February 20, 1959. All aircraft, engines, production tools and technical data were ordered to be destroyed.

Did you know?

The Royal Canadian Mounted Police (RCMP) feared that foreign countries were spying on the development of the Arrow for technical secrets. The Mitrokhin archives (secret notes made by Vasili Mitrokhin on the Soviet Union secret police [KGB] activities and agents while working for over 30 years in the foreign intelligence archive) proved to some extend that this was happening.

At the time, foreign interest was low and the US Air Force was developing three aircraft similar to the performance of the Arrow (F-101 Voodoo, F-102 Delta Dagger and F-102B). The NRC was not interested in the Arrow, as there would be a shortage of spare parts, maintenance and qualified pilots available.

Did you know?

The NRC was against the program from the beginning.

Avro Canada continued on for several years but by 1962, the end arrived. The site was purchased by MacDonnell Douglas of Canada in 1963 and then Boeing Canada in 1997.

Did you know?

Most of the Avro site is now part of the Greater Toronto Airport Authority as Pearson International Airport.

The greatest loss was the departure of the bright minds of Avro Canada.

***Activate Your Brain #1*:**

Name the importance for each of the following:

University of Toronto	
Dr John Chapman	
George Klein	
A. V. Roe Canada Ltd	

SECTION 2
THE ACCOMPLISHMENTS OF FORMER AVRO CANADA LIMITED (LTD.) PERSONNEL

The cancellation of both the Astra and Sparrow program and the Arrow program cost 14 000 employees their jobs.

A.V. ROE CANADA COMPANY DISPERSION

Special Projects A. V. Roe became SPAR Aerospace. Orenda Engine continued operation and is now the leading industry in the Canadian company Magellan Aerospace Group. Skilled employees with these companies assisted with future successes.

Canadian Steel Improvement, Ltd. was the third company in the A.V. Roe Canada group. They continued development and engineering operations with a name change in 1969 to SIFCO Industries, Incorporated (Inc.). With the expertise and leadership by Charles H. Smith, SIFCO Industries, Inc. is a worldwide supplier to the developing aviation industry.

FORMER AVRO CANADA LTD PERSONNEL

Jim Floyd

Avro vice-president of engineering Jim Floyd worked with Avro technicians to find them employment with American aerospace companies such as Lockheed, Boeing, General Electric (G. E.) and Pratt & Whitney. Jim Floyd returned to Britain and worked with the Supersonic Transport studies that led to the development of the Concorde.

Jim Chamberlain

NASA had formed the Space Task Group (STG) to put astronauts in space. Engineers and scientists were recruited to work on the Mercury, Gemini and Apollo programs. Avro chief of technical design Jim Chamberlain lead the Canadians at the STG and was instrumental in the design of the Mercury capsule.

Jim Chamberlain was the head engineer of the Mercury project. He then designed the Gemini spacecraft which moved the American Space Program ahead of the Russian Space Program. He was responsible for selecting the moon orbit approach for the Apollo missions. He worked with Owen Maynard to develop the lunar module (LM) system.

Owen Maynard

Owen Maynard joined the STG and participated in the planning and development of getting astronauts to and from the lunar surface. He was instrumental as a team member with the initial designs of the Apollo command and service modules. When the accepted method of getting the astronauts to and from the moon's surface was decided, Owen Maynard's design for the LM was accepted and used. Owen Maynard was the chief of the LM engineering office. He later was promoted to the position as chief of the systems engineering division for the Apollo Spacecraft Program.

Did you know?

Thomas J. Kelly is known as the father of the LM but he acknowledges Owen Maynard as the person at NASA most responsible for the design of the LM.

Figure A-5 Lunar Module (LM-2)

Note. From "Historic Spacecraft", 2009, *Lunar Module*. Retrieved December 7, 2009, from http://www.historicspacecraft.com/Lunar_Module.html

Other ex-Avro employees went to work at NASA's Mission Control:

Christopher Kraft

Christopher Kraft became Flight Director at Mission Control and later the director of the Johnson Space Center in Houston, Texas. He and Gene Kranz were active during the Apollo 13 missions.

Jim Hodge

Jim Hodge was an original flight director at Mission Control. He, along with ex-Avro employees, Dennis Fielder, Tec Roberts and Fred Matthews, assisted in building Mission Control and the network of tracking stations that guided Mercury, Gemini and Apollo programs. He returned to NASA in the 1980s to launch the Space Station Program.

Bruce Aikenhead

Bruce Aikenhead joined NASA and worked for three years training astronauts. He returned to Canada to work with Gerry Bull and later on Canadian satellites, the Remote Manipulator System (Canadarm) and the Canadian Astronaut Program.

Did you know?

Dr. Gerry Bull, the youngest full professor appointed by McGill University, proposed launching satellites into orbit using a gun.

Thomas Louden and Ben Etkin

Within Canada, new challenges were faced by ex-Avro engineers. Thomas Louden and Ben Etkin remained in Canada and taught at the University of Toronto Institute for Aerospace Studies (UTIAS) as members of the Faculty of Applied Science and Engineering in Ontario.

***Activate Your Brain #2*:**

Who were we?

SPAR	
Magellan Aerospace Group	
SIFCO Industries, Incorporated (Inc.)	

SECTION 3
THE CANADIAN CONTRIBUTION TO THE SPACE PROGRAM

SPACE DEVELOPMENT

Aerospace and defence have become a global industries. Countries are willing to share knowledge and work collectively. Canada aerospace and defence industries have proved a valued member in these evolving industries.

Original equipment manufacturers (OEM) like Bombardier, CAE, Pratt & Whitney Canada, Bell Helicopter Textron Canada and General Dynamics Canada continue to contributed and develop new technology.

Satellite Development

Satellite development continued with Dr. Chapman with his proposal to change the development from scientific satellites to communication satellites. This lead to the joint Department of Communications (DOC) and NASA project using Hermes. Hermes had large solar panels that folded out like an accordion once the satellite reached its orbit.

Did you know?

Hermes was the first high powered satellite in orbit which led to present day satellites used to broadcast television directly to individual homes using small low-tech satellite dish antennas.

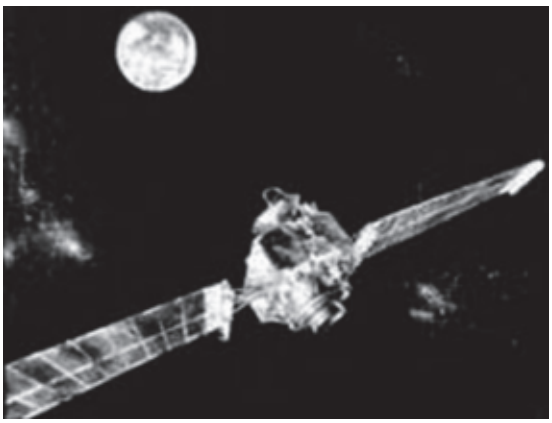

Figure A-6 Hermes Spacecraft

Note. From "Friends of CRC / Les Amis du CRC", 2001, *Hermes*. Copyright by Friends of CRC. Retrieved December 7, 2009, from http://www.friendsofcrc.ca/Projects/Hermes/hermes.html

To test a satellite before flight in a thermal vacuum chamber, the David Florida Lab (DFL) near Ottawa, Ontario was built. A satellite was tested in the Thermal Vacuum Facility which simulated the temperature and vacuum of space, cycling through hot and cold temperatures. The facility also tested the satellite in a spin machine, simulating spinning in space.

The satellite was also tested in the Vibration Test Facility, shaking the satellite to ensure that it would withstand the vibrations and shock of the launch. Radio frequency testing was also performed in the reflection-free chamber duplicating the conditions of space.

Did you know?

The DFL was named after David Florida, a Canadian space pioneer who managed the team that built the International Satellites for Ionospheric Studies.

In 1991, the Anik-E series of satellites was built by Spar Aerospace but launched by the European Space Agency. The E2 satellite was not test at the DFL due to it being too large for the facility and when in space, the antenna triggers would not release. The technicians, including DFL staff showed that satellites in space could be rescued from Earth. They received awards for the rescue of the satellite.

Did you know?

Telesat, owner / operator of the satellite, received two awards for the rescue, including:

- first ever Space Recovery Prize from La Réunion Spatiale, and
- International Space Risk Insurance Group.

Canadarm

With the development of the space shuttle program, NASA turned to Canada for the development of a lifting and placement machine. The Remote Manipulator System (Canadarm) was the result of work by Spar Aerospace.

Did you know?

Canadarm is a robotic arm that allows astronauts to work in space, to include:

- releasing and retrieving satellites in space;
- working in the cargo bay from the safety of the flight deck; and
- serving as a platform from which an astronaut outside of the cargo bay can:
  - repair satellites,
  - assemble tasks, and
  - disassemble tasks.

CANADIAN ASTRONAUTS

In 1982, Canadian astronauts were invited to train and soon fly, with the United States Space Shuttle Program. Men and women joined the Canadian Space Agency and provided specialist roles within the NASA program. Not all Canadian astronauts flew in space.

This list of Canadian astronauts is current as of 2010. Go to the Canadian Space Agency at http://www.space.gc.ca to find out about Canadians who have since become astronauts.

Marc Garneau

Marc Garneau was the first Canadian to fly in space in 1984. His role was as a Payload Specialist working on several scientific exercises that would further benefit the on-going flight and future space missions. He also was tasked with taking photographs of the aurora borealis. He flew again in 1996 as a Mission Specialist and again in 2000 when he directed three spacewalks at the International Space Station (ISS) and worked the Canadarm.

He served as the first non-American capsule communicator (CAPCOM). Marc Garneau was the Deputy-Director of the Canadian astronaut program. When he retired as an astronaut in 2000, he became president of the Canadian Space Agency (CSA).

Did you know?

Marc Garneau spoke at community gatherings on his return, showing the pictures he took. Many cadets and officers witnessed the photographic wonders taken during the first flight in the mid 1980s.

The Canadian-built IMAX camera was used on this flight.

Roberta Bondar

Roberta Bondar was the second Canadian astronaut and the first Canadian woman to fly into space with the United States Space Shuttle Program. She was a Payload Specialist and worked in a science lab call Skylab in 1992. She conducted a teleconference with 1 000 elementary school students and teachers from space at the Ontario Science Centre in Toronto, Ontario.

Did you know?

Ken Money was her backup astronaut. He never flew into space and left NASA after the Bondar flight.

Steve MacLean

In 1992, Steve MacLean flew as a Payload Specialist and on his second flight in 2006, he was a Mission Specialist. Steve MacLean's primary duty on the first mission was to operate the prototype of the Canadian Space Vision System (SVS). He was one of three Canadian astronauts who participated in a spacewalk. He became the first Canadian to operate the Canadarm2 in space.

In 2008, Steve MacLean was appointed head of the CSA.

Did you know?

SVS links computers with television cameras, shooting targets on satellites or other vehicles to provide real-time computer images of where the Canadarm is in relationship to the object it needs to grasp.

With the SVS, the Canadarm operators are able to see what they are doing, even if the arm is manoeuvring something that cannot be seen from the flight deck.

Chris Hadfield

Chris Hadfield flew in 1995 and was the only Canadian to visit the Russian Space Station Mir. He also was the first Canadian Mission Specialist to fly during the 1995 shuttle flight. He was the senior member of three men, with the same qualifications. He continued his flight of firsts as the first Canadian to operate the Canadarm in space. His 2001 flight carried the new Canadarm2 to be installed to the ISS. He was one of three Canadian astronauts who participated in a spacewalk.

Chris Hadfield worked as a CAPCOM.

Did you know?

Chris Hadfield started his flying as an air cadet with 820 Squadron, Milton, Ontario. He trained at the Central Region Gliding School, at Canadian Forces Detachment Mountainview, Ontario.

He joined the Canadian Forces and graduated from Royal Military College (RMC) located in Kingston, Ontario.

He left the Air Force as a colonel and during his career, was the U.S. Navy Test Pilot of the Year in 1992.

Robert (Bob) Thirsk

Bob Thirsk was the backup astronaut for Marc Garneau. He filled the role as CAPCOM in the space station control room. He flew in the shuttle in 1996 and with Soyuz in 2009 when he became the first Canadian to live and work on the International Space Station (ISS).

Dave Williams

Dave Williams flew in 1998, as a Mission Specialist and again in 2007. He made three spacewalks, and was the manager of the Missions and Space Medicine Group in the Canadian Astronaut Program. After completing his first flight, he was appointed as the first non-American director of the Space and Life Sciences Directorate at the Johnson Space Center. He was commander for NASA Extreme Environment Mission Operations (NEEMO) for an 18-day mission.

Did you know?

The NASA research facility called NEEMO simulates weightlessness for astronauts in an underwater setting. Astronauts prepare and train for duty in the ISS.

Bjarni Tryggvason

Bjarni Tryggvason was the backup astronaut of Roberta Bondar in 1992. He flew as a Payload Specialist in 1997. His primary role was performing fluid science experiments, the background work largely a Canadian experiment.

Did you know?

Bjarni Tryggvason was born in Iceland and had not seen an aircraft as a young boy. He and his family came to Canada when he was 14 years old. He became a Canadian citizen as a youngster and was a member of the Air Reserve as a teenager when his family settled in British Columbia.

Julie Payette

Julie Payette first flew in 1999, as the first Canadian to participate on the assembling of the ISS. Her second flight was in 2009, as a Mission Specialist.

Drew Feustel

Drew Feustel flew into space in 2009. He was a member of the last flight to the Hubble Telescope. He completed three spacewalks during the space flight.

The space flights continue with Canadian astronauts flying with the Shuttle and the Soyuz programs to the ISS. Their stay at the ISS may be long or short.

Did you know?

Canada contributes to space and aeronautical developments with NASA and also Russia, the European Space Agency, Japan and other countries.

Canadian technological contributions to the space shuttles, the ISS and the unmanned space program are numerous, including:

- Canadarm,
- Canadarm2,
- Special Purpose Manipulator (Dextre),
- weather station on the Phoenix Mars Lander,
- Radarsat-2 satellite which is monitoring the Northwest Passage, and
- communications, such as:
    - television,
    - radio,
    - cell phones, and
    - Internet.

Did you know?

The Radarsat-2 satellite was the only satellite to spot a US submarine sailing through the Northwest Passage.

***Activate Your Brain #3*:**

When did they go into space?

Marc Garneau	
Roberta Bondar	
Steve MacLean	
Chris Hadfield	
Bob Thirsk	
Dave Williams	
Bjarni Tryggvason	
Julie Payette	
Drew Feustel	

SECTION 4
THE CANADIAN CONTRIBUTION TO AIRCRAFT DEVELOPMENT

Aircraft development depended on OEMs for Canadian design and built aerospace and defence products for airlines, such as Boeing, Airbus, Lockheed Martin and Raytheon. The Canadian industry has had a close relationship with the US market.

Did you know?

US airlines have been a major purchaser of Canadian regional jets.

The Defence Development Sharing Arrangement Sharing Agreement allowed Canadian firms to take on cost-shared Research & Development (R&D) for the US Department of Defense requirements. This allowed Canada access to the latest technology and to initiate next-generation services for aircraft, including:

- Airbus's A-380, and
- Boeing's Sonic Cruiser.

Canadian universities and colleges provide internationally recognized programs to train:

- aerospace engineers,
- aerospace manufacturing engineers,
- aviation technicians, and
- aircraft maintenance engineers.

The Canadian Aviation Maintenance Council (CAMC) plays a role in the development of curricula and accreditation programs for universities and colleges for the aerospace maintenance sector.

The Canadian Commercial Corporation (CCC) works as Canada's international contracting agency. The CCC negotiates and executes bilateral government-to-government contracts. The CCC provides the assurance of transparency at every phase of the procurement process.

Technology Partnerships Canada (TPC) funds technology development for individual projects on a case-to-case basis. Canada's participation in the Joint Strike Fighter (JSF) program is the result of TPC funding to Canadian aerospace companies. Supplies, evaluation sites and system development by Canadian companies contribute to the development of the JSF.

Involvement in the development and manufacturing of aircraft is an ongoing part of the Canadian aircraft industry. Companies such as Goodrich and CAE have won contracts as suppliers for aircraft production, such as the A-380 program.

Canadian industry is integrated with the US and Canadian firms play a part in the global supply chain. In 2008, over 70 % of Canadian aerospace and defence output was exported to the US.

***Activate Your Brain #4*:**

Who do these acronyms represent?

OEM	
R&D	
CAMC	
CCC	
TPC	

CONCLUSION

Canada has been a country with strong ties to the aerospace and aircraft industries. From the first astronomical observatory to today's JSF and ISS participation, aerospace development continues to grow.

Each Canadian has their own ideas regarding to the continued support of aircraft development, manned and unmanned space programs and future Canadian interests in space travel. The accomplishments by individuals, like Dr. Chapman, George Klein and others have aided other countries in their quest for space travel.

Congratulations, you have completed your self-study package on EO (Reflect on Canada's Contribution to Aerospace Technology). Complete the following exercise and hand the completed package to the Training Officer / Proficiency Level Officer who will record your completion in your Proficiency Level Five logbook.

FINAL EXERCISE

The Canadian aerospace and aircraft development up to the mid 1960s showed the accomplishments Canadian scientists achieved. When the CF-105 Avro Arrow and Astra and Sparrow contracts were cancelled, history has recorded the changes in how Canadian contributions were made to both space and aircraft technology.

Reflect on the information presented in this self-study package and write your thoughts on how the cancellation of the Arrow program aided the achievements of Canadian, US, Russian and other countries.

Consider the following questions:

- Do you think the Canadian aerospace program would be different if the Arrow program was completed?
- Do you think accomplishments of the former Avro Canada Limited personnel made a significant contribution to the aerospace industry?
- Do you think Canadians played a significant role in the manned space program?
- Do you think Canadian industries and individuals played a significant role in aircraft development?

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ANSWER KEY

***Activate Your Brain #1*:**

Name the importance for each of the following:

University of Toronto	1st recognized Department of Astronomy
Dr John Chapman	Lead development of Alouette
George Klein	STEM
A. V. Roe Canada Ltd	CF-105 Avro Arrow

***Activate Your Brain #2*:**

Who were we?

SPAR	Special Projects A.V. Roe
Magellan Aerospace Group	Orenda Engine
SIFCO Industries, Incorporated (Inc.)	Canadian Steel Improvement, Ltd.

***Activate Your Brain #3*:**

When did they go into space?

Marc Garneau	1984, 1996, and 2000
Roberta Bondar	1992
Steve MacLean	1992, 2006
Chris Hadfield	1995, 2001
Bob Thirsk	1996, 2009
Dave Williams	1998, 2007
Bjarni Tryggvason	1997
Julie Payette	1999, 2009
Drew Feustel	2009

***Activate Your Brain #4*:**

Who do these acronyms represent?

OEM	Original equipment manufacturers
R&D	Research & Development
CAMC	Canadian Aviation Maintenance Council
CCC	Canadian Commercial Corporation
TPC	Technology Partnership Canada