Polar Communication and Weather Mission

Canada Plans National Solutions for the Arctic Area

The polar area does not have the same satellite coverage as the more central parts of the world, mainly because much of the services the satellites provide are based on use of geostationary satellites. Due to the orbit geometry, parts of the Canadian territory cannot be covered at all by the GEO satellites.

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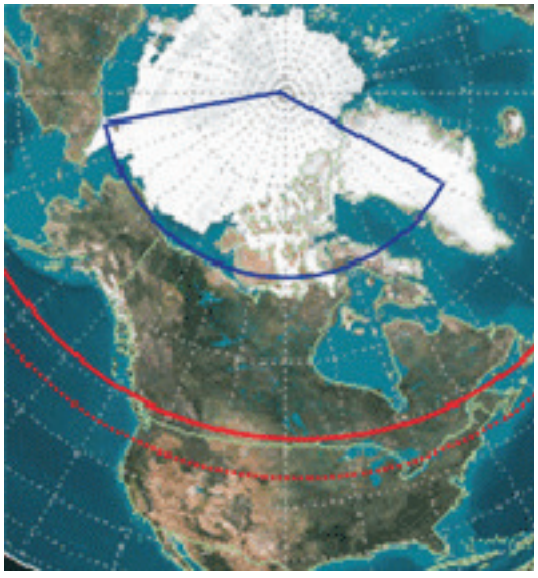


Areas of Interest
Meteorological: 50o north latitude (in red)
Communications: 72o north latitude (in blue)

(Credit: Canadian Space Agency)

By using two satellites in highly elliptical orbits the Canadian Government will be in position to ensure the northern society the same service that the people in more central areas enjoy. The PCW (Polar Communication and Weather) satellites are designed to give 24/7 hour (continuous) coverage over the Arctic and the North Canada when they become operational in 2017. In addition, the scientific instrument package, called Polar Highly Elliptical Molniya Orbital Science for PWC, will provide essential Arctic weather, climate and air quality data from the PWC satellite.

Canada Near the Border for Golden Standard Services

Communication

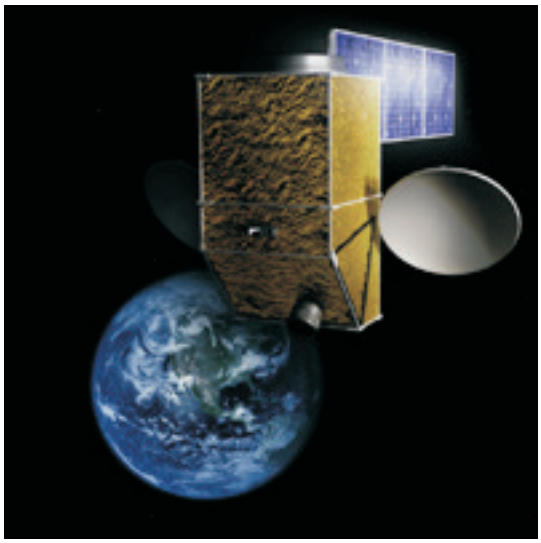
Communication satellites over equator have very low elevation when one stay in areas north or south of seventy degrees and even small terrain hindrances can disturb the signals. Therefore, there are

several limitations to what GEO satellites can offer in the High Arctic, particularly for mobile services such as ships, planes and other mobile services. That leaves a part of the Canadian territory in the Arctic region without access to secure, highly reliable and high capacity telecommunication solutions.

Weather Forecasting

Weather forecasting is also to some degree based on the geostationary satellites, and statistically, it is essential lesser accuracy at forecasting for the polar areas than for the lower areas. Already at sixty degrees the spatial resolution of the satellite pictures degrades due to the Earth curvature and geostationary satellites lose much of their capacity, a capacity polar orbiting weather satellite cannot fully replace.

At present, the data for the Numerical Weather Prediction models is collected by GEO and Low Earth Orbit (LEO) polar orbiting satellites operated by other nations (GOES and POES (NOAA); MSG and MetOp (EUMETSAT)). GEO satellites provide an image of the Earth disc every 15 minutes, from 60° South to 60° North at 0.5-2.0 km spatial resolution. That is a "golden standard" in modern state-of-the-art meteorology. However, the spatial resolution rapidly degrades above 60°, due to the Earth curvature, leaving Polar Regions without coverage from GEO. LEO polar orbiting satellites are capable of providing much better spatial resolution over high latitudes, but on a narrow swath. Thus, they are unable to cover the whole circumpolar area at once, and it might take up to 6 hours before the satellite is able to image the same target area.



Artist's rendering of PCW.
(Credit: Canadian Space Agency)

Global Climate Change

Global climate change and renewed worldwide interest in the vast natural resources in the Arctic represent new challenges and opportunities for Canada. To profit from the natural resources in the North and to respond to the challenges of sovereignty and security in this region, Canada needs better communications, weather prediction, and climate and environment monitoring capabilities in the North.

Navigation

Navigation systems based on satellites also have lower reliability at the high latitudes, and other systems must complete the satellite systems, something that occurs regarding search and rescue operations in the near arctic areas. Due to the lack of services for huge parts of its country, Canada has made plans of its own satellite system to supply some of the needs and to improve the services for the Canadians that live in the more sparsely populated areas. .

Using Highly Elliptical Orbits the Molniya Orbit

To resolve these issues and to seize the opportunities the North presents, the Canadian Space Agency, in partnership with and supported by other Government Departments, completed a Phase 0 study for the Polar Communications and Weather (PCW) project in September 2008. The outcomes of this study proved that a system of two satellites forming the Polar Communication and Weather Mission, also known as PolarSat mission, could provide broadband continuous 24/7 communications services throughout all of the Arctic and improve climate change monitoring and weather forecasting. This led

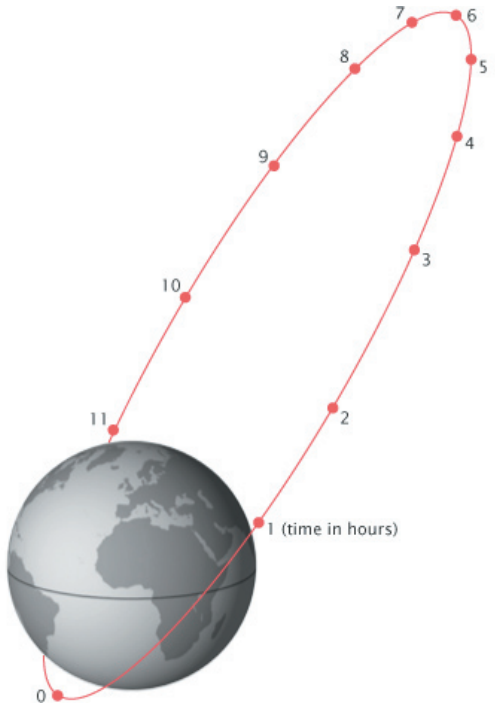


Figure 1: The Molniya orbit. Usually the period from perigee + 2 hours to perigee + 10 hours is used to transmit to the northern hemisphere. Credit: Wikipedia.

to a 12 month Phase A Mission Analysis and Concept Definition study completed in 2010.

Russia has experienced some of the same challenges as mentioned above regarding some of the areas in Siberia and they developed the Molniya type of orbits for their communication satellites. Satellites in high elliptical orbits provide good coverage for the northern areas when the satellite is in the apogees period, up to 40,000 km above the North Pole. Four pairs of satellites inclined at 90 degrees at each other ensure continuous coverage over the Northern areas. During the Cold War, American spy satellites in some cases used the same types of orbit with the aim to monitor the north areas of the then Soviet Union. Canada is now in the progress of developing a similar system for national use.

Platform

The PCW satellites will use the Canadian SmallSat Bus, to be inaugurated on the CASSIOPE spacecraft, but the structural, thermal, and power generation subsystems will be tailored to meet the specific requirements of the PCW mission.

Payloads

The main instrument for the meteorological payload will be an imaging spectroradiometer, similar to imagers being developed for the next generation of geostationary weather satellites (e.g., GOES-R and MTG). A secondary weather instrument (broadband radiometer) is also being considered.
The primary Ka-band telecommunications payload consists of a high-speed two-way system capable of providing continuous broadband services to users throughout the Arctic as far as the North Pole.
A suit of compact space weather instruments to study ionizing radiation completes the list of primary payloads.
A list of secondary scientific payloads is currently being evaluated.

Mission objectives

The PCW mission aims to support Canadian sovereignty and security, to improve quality of life and to facilitate economic development and world-class scientific research in the Arctic by providing reliable 24/7 high data rate (HDR) communications services in order to:

- Enable Canadian Forces, Canadian Coast Guard, Fisheries and Oceans Canada, Nav Canada, Transport Canada, Indian and Northern Affairs Canada and Environment Canada activities in high Arctic;
- Connect northern communities to the broadband information backbone infrastructure;
- Facilitate exploration and exploitation of natural resources;
- Enhance efficiency of the research in the Arctic;
- Ensure that Canadians are benefiting from increased air and marine traffic in the Polar region.

PCW also aims to monitor Arctic weather and climate change for the benefits of Canadians and the Global community in order to:
Significantly improve the accuracy of weather forecasting, including severe weather event warnings;
Improve the understanding of global climate change and the ability to model and predict phenomena associated with it;
Provide unique high quality operational data acquired over the entire polar region, which is currently not available from any source.

The PCW Meteorological Mission

The PCW Meteorological Imager will detect meteorological parameter like surface, clouds, aerosols, ash, wind, water quality, snow, ice, humidity etc. with imagery refresh rate at 15 – 20 minutes. The solar bands pixel resolution will be 0.5 – 1.5 kilometres while the infrared pixels resolution will be 2-3 km. Heritages instrument will include well- known sensors as ABI, MODIS, FDSHI and HIRS.

The Scientific Mission

The Polar Highly Elliptical Molniya Orbital Science for PWC (PHEMOS) will have a science instrument suite at around 50 kg. The objectives for the payload is to provide Artic data and improve meteorological data for temperature, pressure, H_2O, ice, clouds etc. The sensors will also measure gaseous species and aerosols data for ait quality improve estimates of GHG gases and sources.
The Environment Canada operational objectives for the mission is to improve accuracy of short and middle range weather forecast, improve understanding and prediction of air quality from assimilation of column species, to improve modelling of physical processes characterizing Arctic climate and monitoring and improve estimates of GHG gasses sources.

Partners

The PCW project from its inception was a close collaboration between the Canadian Space Agency (CSA), Department of National Defence (DND) and Environment Canada (EC), who recognized the gaps in the communications and observation coverage over the Arctic and jointly funded the Phase 0 of the project.
In order to respond to a wide spectrum of needs of Government Departments, a PCW Users and Science Team (U&ST) was formed in 2007, which is comprised of experts from the possible user community.
Orbit
Two PCW satellites are currently scheduled to be placed in a Highly Elliptic Orbit (HEO), Molniya-type, with a period of 12 hours, an inclination of 63.4 degrees and an apogee of approximately 39,900 km above the Northern Hemisphere. Each satellite will have a design life of six (6) years. Other orbits are being considered like the TAP (Three APogee) orbit.

PCW/PHEMOS for Arctic Weather Climate and Air Quality: www.asc-csa.gc.ca/eng/satellites/