Future Space System Support to U.S. Military Operations in an Ice-Free Arctic:

Broadband Satellite Communications Considerations

Patrick L. Smith[1], Leslie A. Wickman[2] and Inki A. Min[3]
The Aerospace Corporation, El Segundo, California, 90245

Significant increases in shipping traffic and resource exploration/exploitation activities are occurring in the Arctic region. The U.S. Navy, Coast Guard and other military services have begun to plan for increased operations in the region, which could start ramping up as early as about 2013 if recent climate model predictions for Arctic melting prove accurate. The polar region is a very different arena for space system operations compared to lower latitudes, and supporting increased U.S. military activities in the Arctic may require new satellite systems and user terminals. U.S. weather, navigation and surveillance satellites in polar orbits already cover the Arctic region, but current military satellite communications capabilities in the region are quite limited and existing passive satellite imagery (for ice monitoring and other types of surveillance) is hampered by persistent cloud cover and seasonal darkness. Given the high costs and long lead times (up to 10 years or more) to develop new space systems, the U.S. military could face a shortage of communications and possibly other space-based support capabilities during a period when nations are intensely jockeying for influence and resource claims in the region. Canada and Russia are developing new satellite programs to support their countries' increased Arctic activities. The potential need for new space-based support capabilities in the Arctic region is certainly well within the U.S. military's current planning horizon. This paper focuses on the military's future requirements and options for broadband satellite communications in the Arctic region. Getting a head start on defining the requirements analysis and procurement options will help to expedite the space-system acquisition process when, perhaps in the very near future, the timeline for Arctic melting and increased military activities in the region becomes better established.

Nomenclature

AEHF = Advanced Extremely High Frequency
AVHRR = Advanced Very High Resolution Radiometer
C4ISR = Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
DoD = Department of Defense
DSCS = Defense Satellite Communications System
DMSP = Defense Meteorological Satellite Program
EELV = Evolved Expendable Launch Vehicle
EHF = Extremely High Frequency
EPS = Enhanced Polar System
Gbps = gigabits per second
GEO = Geosynchronous Earth Orbit
GIG = Global Information Grid
GPS = Global Positioning System
HEO = High Earth Orbit
IPS = Interim Polar System

[1] Principal Director, Retired, Vandenberg Air Force Base.
[2] Sr. Engineering Specialist, Space Architecture Department, M4-940, AIAA Lifetime Member.
[3] Department Director, Space Architecture Department, M4-940.

LEO = Low Earth Orbit
LLC = Limited Liability Corporation
Mbps = megabits per second
MEO = Medium Earth Orbit
Milstar = Milstar Satellite Communications System
MUOS = Mobile User Objective System
NASA = National Aeronautics and Space Administration
NATO = North Atlantic Treaty Organization
NOAA = National Oceanic and Atmospheric Administration
NSS = National Security Space
PCW = Polar Communications and Weather
R&D = Research and Development
ROM = Rough Order of Magnitude
SAR = Synthetic Aperture Radar
SHF = Super High Frequency
SS = Sun Synchronous
SSM/I = Special Sensor Microwave/Image
TDRSS = Tracking and Data Relay Satellite System
TSAT = Transformational Satellite Communications System
UAV = Unmanned Aerial Vehicle
UHF = Ultra High Frequency Satellite
UNCLOS = United Nations Convention on the Law of the Sea
USGS = United States Geological Survey
WGS = Wideband Global SATCOM System
XDR = Extended Data Rate

I. Introduction

In 2007 the U.S. Congress enacted the Global Climate Change Security Oversight Act, directing the defense and intelligence communities to report on potential threats to U.S. security due to global warming.[i] More recently, in January 2009 a National Security Presidential Directive was issued that calls on the Secretaries of State, Defense, and Homeland to "…develop greater capabilities and capacity, as necessary, to protect United States air, land, and sea borders in the Arctic region…"[ii]

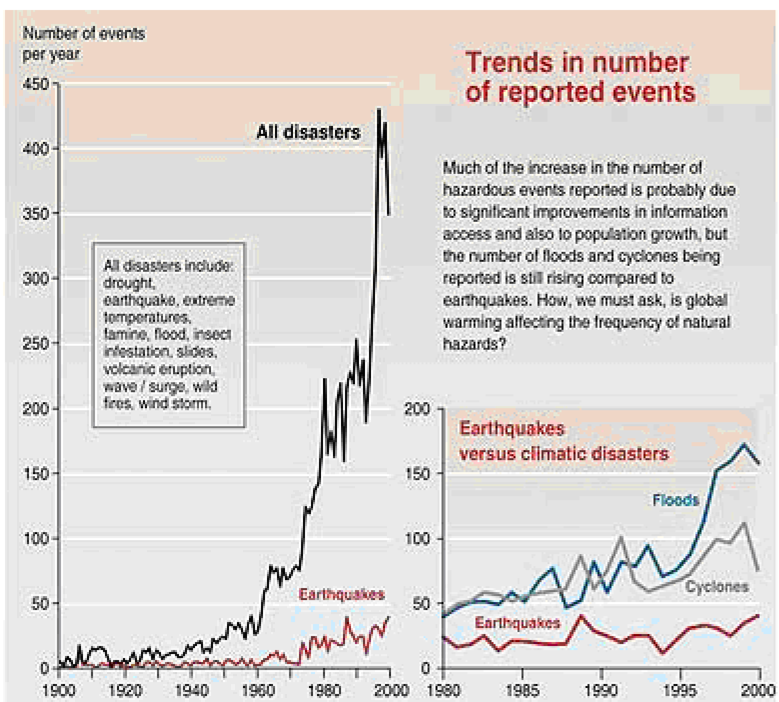
The purpose of our paper is to draw attention to potential new National Security Space (NSS) missions that will be needed to support increased U.S. and allied military operations in the Arctic region. We focus primarily on the future need and options for broadband communications in the region, but other new space missions such as enhanced ice surveillance and ship tracking may be needed as well.

Figure 1 provides an overview of the evidence that climates around the world are changing. Figure 2 suggests a possible connection between global warming and the increase in reported weather-related natural disasters.

Evidence of Global Climate Change:

- increasing average global air and ocean temperatures
- widespread melting of snow and ice
- decreasing average annual Arctic sea ice extent over the last 30 years by:
  - 2.7% per decade in winter
  - 7.4% per decade in summer
- decreasing mountain glaciers and snow cover in both hemispheres
- rising average global sea levels
  - at an average rate of 1.8 mm/year since 1961
- widespread increasing temperatures
  - greatest at higher northern latitudes
  - warming of land regions faster than oceans
- increasing intense tropical cyclone activity in the North Atlantic since 1970

Figure 1. Brief Summary of Evidence of Global Climate Change [iii]



(c) United Nations Environment Programme / GRID-Arendal

Figure 2. Trends in Reported Natural Disasters [iv]

II. Background

In the past 23 years, 41% of the perennial Arctic ice has melted. Between 2004 and 2005 alone, 14% was lost.[v] The volume of ice in the Arctic at the peak of 2009's annual freeze was the lowest on record - and only 30 percent of that was thick, slower melting multiyear ice.[vi]

Up until a few years ago, climate models were predicting that the Arctic would not be ice-free during summers until the end of the century. But revised model predictions presented at the 2007 meeting of the American Geophysical Union indicate that ice-free Arctic summers might start occurring as early as 2013.[vii] The Arctic Ocean may soon start to resemble the Baltic Sea, which is covered by seasonal ice only in the winter, but is fully navigable year-round.

The Northwest Passage (shown in Figure 3) briefly opened for the first time in human memory in 2007. Once the opening becomes predictable, it would soon become a preferred navigation route since it cuts about 7,000 km from the current shipping routes between Asia and Europe. Canada currently claims the Northwest Passage as internal waters, whereas the United States asserts the route is through international waters where free passage is permitted.

A preliminary assessment by the US Geological Survey (USGS) suggests the Arctic seabed may hold as much as 25 per cent of the world's undiscovered oil and natural gas reserves. Sovereign rights to energy resources in the Arctic seabed are still largely undetermined under international law. Recent articles in Jane's Defense Weekly (16 January 2008)[viii] and Foreign Affairs (March 2008)[ix] describe the increasing competition among nations to claim parts of the Arctic seabed. The United Nations Convention of the Law of the Sea (UNCLOS) provides a general legal framework to govern uses of the world's oceans and resources, but major players in the Arctic must still gather evidence to bolster their particular claims under the treaty, which has not yet been ratified by the U.S. The Russians raised the stakes in 2007 by claiming the North Pole and the resources underlying it.[x] None of these issues are likely to be resolved soon.

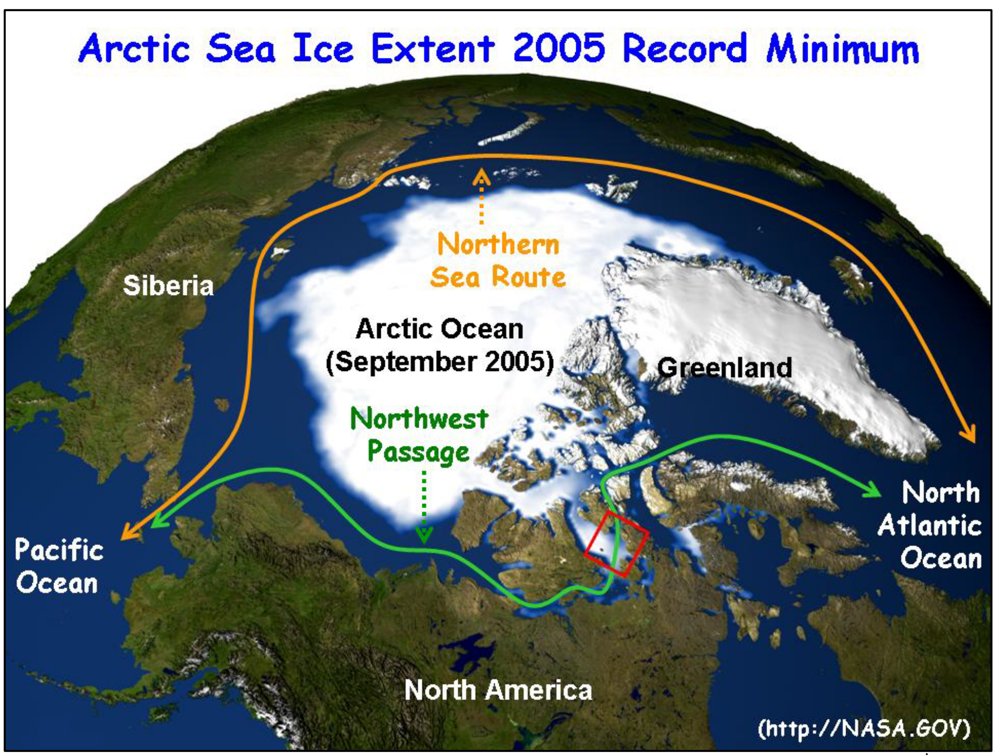


Figure 3. Arctic Sea Ice 2005 Record Minimum (reprinted courtesy of NASA)[xi]

III. Future Military Activities in the Arctic

Unlike Antarctica, there is no ban on weapons in the Arctic and nations surrounding the region are starting to increase their military presence in the area.[xii,xiii,xiv,xv,xvi,xvii] Canada, Russia and the U.S. have started deploying additional surveillance assets and conducting more Arctic military exercises, flights and exploration missions using icebreakers.[xviii,xix,xx] Yet at present no country has clear legal authority to conduct maritime interdictions, ensure safe transit of commercial shippers or conduct routine surveillance of maritime traffic.

The opening of Arctic sea routes threatens to complicate relations among the stakeholder nations (including China) competing for oil and gas in the region. Strategic choke points in the region include the Bering Strait, Canada's Queen Elizabeth Islands in the Northwest Passage, and Russia's Severnaya Zemlya and New Siberian Islands in the Northern Sea Route (see Figure 3). These narrow passages are vulnerable to control or blockade, which would significantly disrupt potential commercial shipping and oil transport. If melting of the permafrost damages ice roads and disrupts the Alaskan oil and the Mackenzie Valley gas pipelines, then maritime alternatives for shipping oil and other resources would become even more critical.[xxi,xxii,xxiii]

The U.S. has many national interests in the region, including roughly 1,000 miles of Alaskan coastline.[xxiv] According to Rear Admiral David Gove, the U.S. Navy will soon be called upon to monitor activities related to early warning/missile defense; maritime presence and security; and freedom of navigation and over-flight.[xxv] Admiral Thad Allen is quoted as saying that the U.S. should consider establishing forward operating bases in the Arctic to support search and rescue, pollution response, security patrols and crises in the region. "… As we look at maritime strategy on a global basis, we can't ignore the future of the Arctic, the implications and access to the Arctic," he said.[xxvi]

A future ice-free Arctic Ocean has been the topic of two National Oceanic and Atmospheric Administration (NOAA)/National Ice Center-sponsored conferences: "Naval Operations in an Ice Free Arctic" (April 2001), and "Impact Of An Ice-Diminishing Arctic on Naval and Maritime Operations," (July, 2007). The 2001 NOAA conference brought together the U.S. Navy and Coast Guard, members of the scientific community, Canadian armed forces and research representatives, and officers from the Royal Navy to discuss potential requirements for future naval operations in the altered Arctic environment. Papers in the conference proceedings suggest that the melting trend in the Arctic creates new national security concerns along with increasing interest in border protection, new shipping routes and increased fossil fuel exploitation. One paper concludes that… "polar C4ISR infrastructure appears to be a limiting factor. A dedicated polar space support concept of operations is required to provide network centric warfare capability for polar operations. Ice reconnaissance should be a key component."[xxvii]

IV. Satellite Coverage of the Arctic Region

Many military planners may not appreciate that the Arctic region is a very different arena for space systems compared to lower latitudes. High latitude communications satellites require different types of orbits, satellite designs, ground-station connectivity, and user terminals. Figure 4 is a summary of the characteristics of different types of constellations that provide coverage north of the Arctic Circle.

Current weather and surveillance satellites in polar orbits cover the Arctic region, though not continuously. In addition, visible and infrared satellite imagery is hampered by persistent cloud cover and seasonal darkness.

Satellites in 12-hour Molniya orbits provide hours-long periods of polar viewing around apogee, which is about as distant from Earth as geostationary satellites. Two satellites in phased Molniya orbits can provide essentially continuous Arctic coverage, however terminal antennas must be able to continuously track the satellite and switch between satellites as they move in and out of view.

	Orbit Type	3 Polar GEO	2 Polar GEO	4 Incl GEO	3 Incl GEO	3 Tundra GEO	2 Molniya HEO	4 Magic MEO	3 Magic MEO	20 SS LEO	16 SS LEO	5 SS LEO	3 SS LEO
	# Orbit Planes	1	1	4	3	3	2	4 (2)	3	2	2	5	3
	Orbit Period (hr)	24	24	24	24	24	12	3	3	1.7	1.7	1.7	1.7
Elev > 10 deg	Time in View (%)	100	75	>95	<75	100	100	100 (99)	95	90	75	>25	<25
Elev > 10 deg	Avg Revisit Time (min)	0	180	<60	>360	0	0	0 (1)	5	10	15	20	60
Elev > 10 deg	Max Revisit Time (min)	0	>210	<60	>360	0	0	0 (1)	7	20	25	70	60
Elev > 20 deg	Time in View (%)	99	60	>50	<50	~100	100	99 (85)	75	50	50	<25	<25
Elev > 20 deg	Avg Revisit Time (min)	15	>210	360	>720	~0	0	5 (15)	25	15	20	30	60
Elev > 20 deg	Max Revisit Time (min)	30	>210	360	>720	~0	0	10 (20)	35	30	30	80	120

Figure 4. Constellations Providing Coverage of the Arctic Circle
(green = excellent coverage; yellow = moderately good coverage; red = poor coverage)

The key characteristics of a satellite constellation are 1) the percent of time a point on the earth or region is in view of a satellite; 2) the average revisit time; and 3) the maximum revisit time. The upper three shaded rows of specifications in Figure 4 are for communication coverage (requiring line of sight about 10 degrees elevation above the horizon); the lower three shaded rows are for weather and other sensor coverage (requiring line of sight about 20 degrees above the horizon).

High earth (HEO) Molniya orbits are highly elliptical with 12-hour periods and inclination angles of 63.4 degrees. Polar geosynchronous orbits have 24-hour periods and are inclined 90 degrees with respect to the equator. Sun synchronous (SS) orbits are circular with an altitude of 845 km and an inclination of 98.8 degrees. The medium altitude elliptical orbits (loosely referred to as "Magic" in Figure 4) are 520 x 7843 km with 3-hour periods and an inclination angle of 63.4 degrees. We also looked at both polar and 35 degree inclined geosynchronous constellations, which require at least three satellites in separate orbital planes to provide continuous coverage. Inclined geosynchronous orbits were originally proposed for Milstar, but geostationary (equatorial) orbits were eventually chosen instead. Finally, we looked at "Tundra" elliptical 63.4 degree inclined geosynchronous orbits with apogees at the northernmost point in the ground track. The coverage with a constellation of three Tundra GEO satellites is essentially equivalent to the previously mentioned two Molniya HEO constellation, as well as the three Polar GEO, or four "Magic" MEO constellations.

Current weather satellite and imaging sensors have excellent coverage of the Arctic region because inclined sun synchronous orbits are in view on every orbital pass. However, heavy clouds and darkness are more prevalent above the Arctic Circle, which can hamper the performance of some types of sensors.

GPS (Global Positioning System) provides navigation coverage in the Polar Regions, though the low elevation angles to the satellites reduce altitude-determination accuracy somewhat and there are increased ionospheric effects.

Communication satellites in geostationary orbits are below the 10 degree elevation constraint and therefore not accessible from Polar Regions. All dedicated U.S. military communication satellites are in geostationary orbits, which appear stationary to terminals on the ground and can be easily moved around to shift coverage from one place to another. For example, if a geostationary satellite fails over an important region another satellite in the constellation can be shifted to take its place.

It appears that the most efficient coverage option for dedicated Arctic communications is a phased two-satellite Molniya constellation. (As mentioned above, Polar and Tundra geosynchronous, as well as "Magic" constellations can also provide good coverage of the Arctic region and beyond, but all of these other types of orbits require more than two satellites to do so.) To provide continuous coverage requires the two Molniya satellites to be in different orbital planes. Since it is too costly to maintain a spare satellite in each orbital plane, a satellite failure will result in a periodic gap in Arctic coverage since there is no other satellite that can be moved over to take its place. Another disadvantage of Molniya orbits is that user terminal antennas must track the satellites as they move across the sky.

V. Future Space Missions for the Arctic Region

Given the long lead time to develop a new military space system it is clearly prudent to begin coordinating future communication and other requirements should the Arctic continue to melt at its current (or possibly accelerated) rate. Improved space-based weather and climate monitoring will also be needed.

U.S. fleet operations in the Arctic will require substantial communications bandwidth for imagery and bulk data transmissions. UAVs, for example, which are increasingly used by the U.S. military and intelligence agencies, require wide swaths of bandwidth. The requirements and options for Arctic broadband communications are discussed in more detail in Sections 6 and 7.

Increased naval operations will also require timely and very detailed information on ice pack drift and forecasts. Ice-strengthened naval vessels operating within the icepack will be able to take advantage of more precise information on the distribution and age of ice and on pack motion to avoid high pressure ridges and identify navigable leads. At the 2008 First Workshop on Satellite Imaging of the Arctic (Copenhagen, Denmark)[xxviii] requirements for improved ice monitoring in support of shipping and activities in the Arctic were discussed and a recent U.S. Coast Guard report defined specific requirements for satellite-based imagery for tracking ice flows.[xxix] Basically, the extent of ice surveillance must be sufficient to cover several days' passage with sufficient resolution to delineate routes permitting safe and efficient navigation.

Arctic ice monitoring and forecasting services provide general information on ice type and concentration. Sparse, but sometimes useful reports of ice conditions are received from ships and weather stations in the region. Airborne coverage in the Arctic is limited and aircraft are often grounded by adverse weather. Current ice maps combine DMSP SSM/I and NOAA AVHRR measurements with SAR imagery.[xxx] SAR measures surface scattering properties (which depend on roughness and presence of melt ponds or frost flowers) and volume scattering properties (which depend on salinity and the type of and ice). Canada's recently launched Radarsat-2 satellite provides resolution down to 3 meters and swath widths up to 500 kilometers (at 100 meter resolution).[xxxi]

Recent studies within the Air Force and intelligence communities have considered how to make better use of commercial SAR imagery products and satellite technology but, as with polar broadband communications requirements, current ice surveillance requirements do not take into account increased military activities in the Arctic.

VI. Communications Satellites Covering the Arctic Region

A. U.S. Military Systems

Documented U.S. military requirements for communications support for submarines, aircraft, and other platforms and forces operating in the high northern latitudes (as in all other theaters) have increased substantially over the last twenty years, even without the recent concern of accelerated Arctic melting. Future communications requirements arising as a result of Arctic melting are not reflected in the current requirements set.

Figure 5 is a brief summary of current U.S. military communication satellite programs.

	Protected	Wideband	Mobile / Tactical	Latitude	Deployed
DSCS		yes		< 65 degrees	yes
Milstar	yes			< 65 degrees	yes
UHF			yes	< 65 degrees	yes
IPS	yes			polar	yes
TDRSS				< 65 degrees	yes
WGS		yes		< 65 degrees	yes
AEHF	yes			< 65 degrees	future
MUOS			yes	< 65 degrees	future
EPS	yes			polar	future

Figure 5. US Military Satellite Communications Systems[xxxii]

All dedicated U.S. military communication satellites are in geostationary orbits. Interim Polar System (IPS) and future Enhanced Polar System (EPS), "hosted" strategic communications payloads on other satellites, cover the Arctic region but have limited channel capacities.

The IPS program was established in 1995 when the original plan to place Milstar satellites in inclined geosynchronous orbits was scrapped. The IPS packages are basically low-data-rate Milstar payloads. The follow-on EPS is based on more capable Advanced Extremely High Frequency (AEHF) technology and the eXtended Data Rate (XDR) waveform. EPS will provide protected communications services on Super High Frequency (SHF) and Extremely High Frequency (EHF) bands and connectivity to Global Information Grid (GIG) gateways. Special terminals, which must track the EPS orbits and compensate for Doppler effects, are being procured by each service under separate contracts. The EPS Mission Control Segment will part of the Advanced EHF (AEHF) Mission Control Segment.

At lower latitudes there are several options for quickly "surging" military communications capacity, such as repositioning geosynchronous satellites, leasing commercial satellite transponders and linking to fiber networks. None of these "surge" options are feasible in the Arctic region.

B. Commercial and Non-U.S. Communications Systems

It has been reported that about 80 percent of the satellite communications capacity supporting Operation Iraqi Freedom is provided by commercial communications satellites, up from 30 percent during Operation Desert Storm.[xxxiii] The only commercial satellite communication service currently available in the Arctic region is provided by Iridium Satellite LLC. The U.S. military is the largest individual user of Iridium. Indeed, it was Iridium's large contract with the military that enabled the restructured company to emerge from bankruptcy. As mentioned previously, the Iridium satellites now in orbit are well beyond their 6.5 year original design lifetimes. Launching of replacements will almost certainly need to start in the 2010-2012 timeframe to avoid service outages as individual satellites begin to fail. (Iridium requires satellite-to-satellite crosslink connectivity in order to route calls to ground stations and therefore cannot tolerate more than a few empty slots in the 66-satellite constellation.)

Russian communication satellites in Molniya orbits provide communications to their military forces in the northern and Arctic regions. (Molniya orbits were first used by the USSR.) The first prototype Molniya satellite was launched in 1964 and reportedly there are currently 16 operational Molniya satellites that carry the Russian Orbita Television network as well as commercial, government and military communications traffic. Russia is also planning a Molniya orbit version of its Express-series of GEO communications satellites, called Express-RV, based on the 8-12 kW Express-4000 bus. Press releases indicate that Express-RV will provide internet access as well as broadcast service.[xxxiv]

VII. Future Arctic Broadband Communications

A. Summary of Options

Alternatives to the current hosted polar communications payloads have been studied by the Air Force at various times in the past. One option considered in a 2004 study, for example, considered replacing the IPS hosted payloads and ground gateways with dedicated satellites with laser cross links to the then-planned TSAT constellation. In a 2008 study, a dedicated Molniya constellation of small satellites was considered. All of these types of options were eventually rejected as too costly compared to hosted payloads, which have the advantage of getting a "free ride" on the host's satellites' launch vehicle and satellite bus.

The range of potential options for providing military higher capacity broadband satellite communications in the Arctic region include: 1) hosted payloads (as with IPS and EPS); 2) a dedicated military constellation; 3) a combined U.S. military system for all latitudes (such as inclined 24-hour synchronous orbits as originally proposed for Milstar); 4) shared or joint program with allies; and 5) leased commercial transponders (if available sometime in the future). A rough comparative assessment of the pros and cons of the different options is summarized in Figure 6.

Assessment Criteria	Hosted	Dedicated	Combined	Shared	Leased
Costs (space segment, user segment, operations)	Y	R	R	Y	G
Levels of satisfaction of various users' needs	R	G	G	Y	Y
User segment requirements & contraints	R	G	G	Y	Y
Auxiliary mission capacity (e.g., secondary payloads)	R	Y	Y	Y	R
Schedule (time required to develop & deploy)	Y	R	R	R	?
Interoperability (e.g., connection to GIG)	Y	G	G	Y	R
Flexibility (e.g., adaptable to changes in need or technology)	R	Y	R	Y	R
Sustainability (e.g., replenishment constraints)	R	G	G	Y	Y
Availability (e.g., hosted payloads are secondary)	R	G	G	G	R
Security (e.g., jamming, tamper resistance)	Y	G	G	Y	R
International participation (e.g., cost sharing)	R	Y	Y	G	G
Leveraging commercial systems (e.g., Iridium)	R	R	R	R	G
Risks (e.g., technical, cost, schedule)	Y	Y	R	Y	?

Figure 6. Assessment of Polar Broadband Communications Options
(G=excellent; Y=moderate; R=poor)

B. Hosted, Dedicated or Combined U.S. Military Broadband Polar Communication Satellites

Establishing a new military space program for broadband communications at northern latitudes will require extensive coordination among users and operators, the procurement agency, and funding authorities. Military services will first have to formally establish a ranked hierarchy of broadband communication needs in the region. The appropriate procurement agency will then need to sponsor preliminary design studies to determine the corresponding programmatic implications (cost, schedule, and risk) for a range of development options. A set of Key Performance Parameters, the overall design requirements for the proposed new system, and the budget requirements, will need to be agreed on among all parties, including Congress.[xxxv]

We used some of our R&D funds to look at orbital coverage options, and preliminary satellite concepts and costs. From Figure 4 above, a two-satellite Molniya constellation, similar to current Russian communication systems, is clearly the most efficient for broadband coverage. Figure 7 shows the typical bandwidth capacities and costs for a range of designs using current technology and launch vehicles.

Launch Vehicle Class	LEO Perf [&] (WR) kg	Molniya Perf [&] kg	S/C Wet Mass	S/C on-orbit Mass kg	Comm Capacity	LV cost * $M	# LV	SC Cost * $M	# SC	Total Cost [&&] $M	Notes
EELV Med, M+		3000 kg +	3500 kg	3500 kg	~1 Gbps	$150M	2	$350M	2	$1B	
EELV Med, M+	7000 kg +		3500 kg	1500 kg	~300 Mbps	$150M	1	$200M	2	$550M	Dual Launch [#]
Delta II/Taurus II Class	3500 kg		3500 kg	1500 kg	~300 Mbps	$80M	2	$200M	2	$560M	
Delta II/Taurus II Class	3500 kg		1900 kg	700 kg	~100 Mbps	$80M	1	$100M	2	$320M	Dual Launch [#]

* costs are ROM, for relative comparison only

** Transfer from inclined LEO to Molniya using on-board propulsion

*** Combined data rate of Ka and X band channels

[&] Performance numbers are approximate, for the class of vehicles

[&&] Does not include ground terminal or network costs

[#] Dual launch capability not available for EELV yet

Figure 7. Typical Bandwidth Capacities and Costs for Polar Comsat Options with 2 Spacecraft in Molniya Orbits.

For example, assuming typical government missions, the cost to produce and deploy an EELV-launched Molniya system providing 1 to 2 Gbps total bandwidth capacity would be nearly $1 billion plus the costs of user terminals and ground operations, which would bring the overall cost to well over $1 billion. The cost will be even higher if higher levels of protection and survivability are required. Smaller satellites would cost less, but would offer significantly less total bandwidth capacity. Much depends on the acquisition process and the degree of complexity associated with specific mission requirements.

Initiating a new hosted, dedicated or combined military space program to provide broadband communications to U.S. military forces operating in the Arctic region would be premature at this juncture, given the uncertainty of user requirements and the pace of Arctic melting, as well as tight space budgets and higher priority military needs. Hosted broadband packages might cost substantially less than dedicated satellites, but the unavailability of suitable host satellites and limits on size and power budgets for hosted packages make this option less attractive. A combined, all-latitude system (as originally planned for Milstar) might appear to be the ultimate solution, but the huge development cost (and the decades-long transition timeline) is almost certainly a showstopper.

C. Shared and Leasing Options

If we exclude a dedicated or hosted military broadband communications system, we are left with some type of joint allied or commercial approach as the only potentially viable option. The following are some possibilities to be considered.

1. Iridium Next

The current Iridium Satellite LLC constellation provides 2.4 Kbps channels for voice, e-mail and low-rate data such as positions of ships on oceans.[xxxvi] U.S. government users are about 25% of the 100,000 or so current subscribers under a $36 million per year contract signed in 2000. Military applications of Iridium continue to evolve. For example, the U.S. Air Force is reportedly deploying more than 280 meteorological data terminals that report to a central processing center using the Iridium network. The U.S. government has its own Iridium gateway for continuous and secure access.

Iridium Satellite LLC has announced plans to replace its aging original constellation with a new generation of spacecraft. Iridium is reportedly seeking partners and financing for the new Iridium Next system, which the company says will cost at least $2 billion. The company's goal is to fully transition to the new system by 2016. (Current Iridium satellites are generally expected to last until about 2014, well beyond their 6.5 year design lifetime.[xxxvii]) According to a company press release, the next generation Iridium system will offer Internet Protocol (IP) broadband channels providing data transfer rates up to 10 Mbps.[xxxviii]

Auxiliary missions such as environmental monitoring, imagery and a geographic positioning system to complement GPS are also being considered. In addition, it was recently reported that the Navy may be interested in new services such as two-way messaging that would augment MUOS.[xxxix]

If Iridium Next goes forward as currently envisioned then some level of broadband communications might be available to U.S. military forces operating in the Arctic region as early as 2016. However, the bandwidth available would not support the most capable UAVs, and there may be other limitations as well. It is uncertain whether Iridium Next will be able to raise sufficient capital to stay on schedule, and there is also the risk that the aging current Iridium system will not last long enough to prevent a coverage gap. An outage experienced by current Iridium users would make it even more challenging to raise the capital needed for a follow-on system.

The potential near-term need for broadband communications in the Arctic and the fact that Iridium Next might be able to provide broadband capabilities earlier than other options are important considerations that should be taken into account by military planners.

2. Polar Communications and Weather (PCW) Initiative

The PCW system is being developed by the Canadian Space Agency and Environment Canada. The plan calls for launching two multi-mission spacecraft in Molniya orbits. One of the payloads is a Ka-band communications package. Canadian developers are seeking partners, and reportedly have had discussions with Finland, Norway, and Russia, as well as the U.S.[xl]

Like Iridium, the PCW system offers another partnership opportunity that might provide some level of broadband service to U.S. military users. The U.S. currently has Radarsat-2 data-sharing agreements, for example, which could serve as a model.

However, the multi-mission PCW Initiative is primarily a remote sensing program. If cost or weight-growth issues arise, the communications package could be downsized or dropped altogether. The development cost is also a hurdle and may not be affordable without international partners. Another consideration is that non-U.S. partnerships might restrict the U.S. military's use of the system's communications package.

3. Russian Programs

In 2010 Russia plans to start development of a satellite cluster called "Arktika" to be launched in Molniya orbits to monitor weather and ice conditions, provide broadcast communications and receive data from Arctic buoys and automatic weather stations. According to news reports, Arktika-M spacecraft will measure polar winds, cloud cover, precipitation and ice parameters; Arktika-R spacecraft will have SAR; Arktika-MS spacecraft will provide telephone communications and relay television and FM radio broadcasts to aircraft and ships.[xli]

Russia provides various communications services in the Arctic region with their Molniya systems. Some European nations, including NATO members, have reportedly expressed interest in partnering with Russia, but there is too little information available at this time to determine if this system is capable or appropriate for U.S. military needs. Though leasing channels on Russian spacecraft might not appear to be a desirable option for U.S. military planners, the feasibility of this option should perhaps be investigated further.

4. New Commercial Systems

Commercial satellite operators may see future business opportunities in providing broadband and other communication services to exploration, shipping and tourism activities, and might be interested in an "anchor tenant" leasing or other cooperative arrangement with the U.S. military. (Much of the current U.S. military satellite communications capacity is leased from commercial providers.)

The European Space Agency recently announced plans to sponsor a study of the potential future demand for communication services in the Arctic to identify possible development opportunities for the European industry.[xlii] Potential markets include Search and Rescue, Vessel Traffic Systems, Maritime Highways, in-situ sensor data collection and dissemination, and surveillance and military activities. The International Maritime Organization (IMO) and World Meteorological Organization (WMO) and other parties will be consulted as part of the study.

The market for broadband services in the Arctic could eventually be substantial, but at this point in time it is impossible to accurately predict how fast demand will increase. There is uncertainty when the ice-free summers will start occurring on a regular basis. Some are predicting as early as 2013, but it could be much later. There is also uncertainty about how rapidly activities in the region will start to pick up as the ice thins out. Finally there is uncertainty in predicting the growth of demand for broadband services for high-speed internet to airliners transiting the poles, for example, or cruise ships carrying "polar tourists". From the DoD perspective, the biggest need for broadband will be UAVs, the use of which is projected to grow substantially worldwide in the coming years.

Figure 8 is a our rough estimate of the potential growth in broadband market in the Arctic region based on fairly aggressive assumptions about how fast the ice will melt and how quickly activities in the region will increase. For example, we assume essentially continuous flights of UAVs will begin in 2013 if the supporting communications infrastructure is available. Even with very aggressive assumptions, however, the total demand does not build up very fast, reaching only about 500 Mbps in 2020. Again, this is likely an upper estimate; the actual build-up in broadband demand will probably be slower. In our view, the potential market for commercial broadband services in the Arctic is too uncertain and small for the next 10 years or so to close the business case for a commercial provider, unless the DoD helps to fund the development or leases substantial capacity as a long-term "anchor tenant".

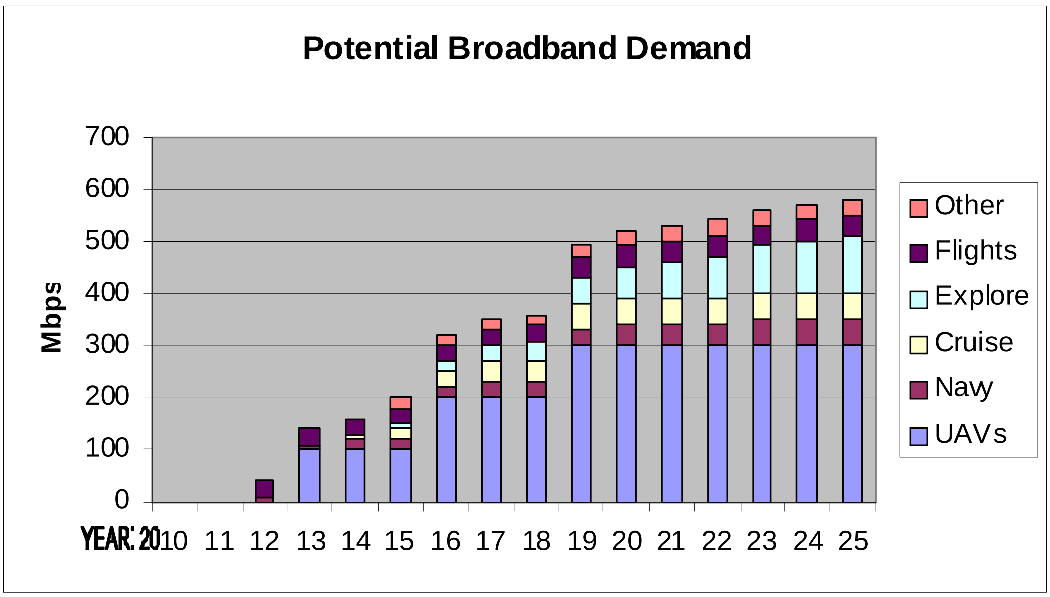


Figure 8. Potential Growth of Bandwidth Requirements in the Arctic Region over the Next 15 Years

VIII. Summary of Key Points

1. The Arctic is rapidly melting. This will lead to increased naval and other military activities in the region, possibly starting to ramp up as early as 2013, as nations, including China, begin jockeying for resources and influence in the newly accessible region.

2. Current weather and other surveillance satellites in sun synchronous orbits are in view of the polar region on every pass. However, heavy clouds and darkness prevalent above the Arctic Circle can hamper passive imaging. SAR spacecraft, such as Radarsat-2, provide the best current information on ice conditions, but more precise and timely ice information may be needed to support U.S. naval operations in marginally ice-free regions. Assuring U.S. military access to best-available ice data from existing and future commercial SAR programs should become a priority for military planners.

3. Presently there is limited U.S. military satellite communications service at high latitudes, and (unlike lower latitudes) no ability to “surge” capabilities by adjusting satellite orbits or leasing commercial transponders. This will limit the use of UAVs and other military support activities in the Arctic region.

4. Developing dedicated polar broadband communication satellites exclusively for U.S. military use in the Arctic is probably not economically feasible at least for the foreseeable future, given current budget constraints, higher priority requirements, and the current uncertainty in the timeline for increased military activities in the region.

5. Military planners should pursue joint development opportunities with other countries and commercial service providers to provide increased satellite communications capabilities in the Arctic region. Potential broadband communications options (Iridium Next or potential new polar commercial satellite services) will probably require substantial U.S. government commitment and/or investment in order to go forward, possibly necessitating changes in acquisition policy.

IX. Conclusion

Even if uncertainty remains as to whether recent accelerated Arctic melting is a long-term trend or a short-term anomaly, military space planners must begin preparing now for the possibility of an ice-free Arctic within the next decade, and the corresponding increase in U.S. military activities in the region. Broadband military communications in particular will be an important need, especially given the military’s increased reliance on UAVs. With tight space budgets, however, space planners should work with international and/or commercial partners to investigate options for developing broadband communications capabilities that can be used by U.S. military forces operating in the Arctic region. Assured access to foreign and commercial SAR imagery for ice surveillance will also become important.

In addition to the new space communications requirements discussed this paper, other impacts of climate change on space programs need to be evaluated. For example, launch system availability may be reduced due to frequent higher winds at launch sites, and the risk of flooding launch facilities at Cape Canaveral as the sea level rises, especially if hurricanes become more frequent and severe due to warming sea temperatures. Probably the most significant impacts of climate change will be anticipatory economic, social and political responses that might drastically re-order U.S. military priorities and NSS requirements well before substantial climate changes actually occur.

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