Canadian Space Agency
SDC Joint Project Team

SAR Data Continuity
Harmonized User Needs Document

Rev B.1

July 05, 2018

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REVISION HISTORY

Rev.	Description	Initials	Date
Draft 0	Initial draft version of the document.	ML	March 31, 2017
Draft 0.1	Second draft version revised following individual feedback from departments and discussions at harmonization meeting (April 26).	ML	May 11, 2017
Rev A	First Release Version	ML	May 26, 2017
Rev B	Added the possibility of additional classified needs in Section 4.5 and corrected a typo in DEM posting for [LAN-910] and [LAN-920].	ML	May 31, 2017
Rev B.1	Version for public consultations. Also minor updates for MAR-320, MAR-330, MAR-340, MAR-350 and MAR-360.4.	ML	July 05, 2018

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1 INTRODUCTION

This Harmonized User Needs Document summarizes the Government of Canada (GC) main user needs in the context of the SAR Data Continuity (SDC) initiative.

1.1 PURPOSE AND SCOPE

The purpose of this document is to record the user needs of the Government of Canada departments for the provision of SAR information after the end of the design life of the RADARSAT Constellation Mission (RCM) in 2025. Although the focus of this document is on SAR-related needs, the document also gives an overview of some non SAR space-based Earth Observation needs that are expected, in some cases, to enhance the SAR information. This list of broader EO needs is not complete and will be the object of a future exercise outside the SDC initiative. The scope of this document is limited to maritime/marine and terrestrial needs.

1.2 APPLICABLE AND REFERENCE DOCUMENTS

1.2.1 Applicable Documents

There is no applicable document.

1.2.2 Reference Documents

There is no reference document.

2 CONSULTATION BACKGROUND

The third generation of RADARSAT-brand satellite systems, the three-satellite RADARSAT Constellation Mission (RCM), is scheduled to be launched in 2018 and is expected to operate until at least 2025. This system will provide Canada with continued and independent access to SAR data, a critical Earth observation capability that supports a wide range of Government operations.

Given the significant planning and financial investments required to deliver a major satellite project, the Canadian Space Agency (CSA) and key federal partners are beginning planning for the next generation of SAR Earth Observation systems in order to ensure that Canada is able to seamlessly maintain this capability and enhance the operational services beyond 2025.

To this end, the CSA have consulted key federal partners to gather inputs on Canada's future Earth Observation needs, with a focus on the SAR data needs, with the objective to provide the recommendations on the way forward to ensure SAR Data Continuity for Canada.

3 SUMMARY OF GOVERNMENT OF CANADA USER NEEDS

This section provides an overview of the Government of Canada main user needs that will be described in more detail in the next section.

TABLE 3-1 – SUMMARY OF GC USER NEEDS IN THE CONTEXT OF SDC

ID	*Name*	*Expected Contribution from SAR*			*Stage of Maturity*[1]		
		Mostly SAR	*Benefit from SAR*	*Not SAR*	*1-Operational*	*2-Pre-Operatinal*	*3-Emerging*
[MAR-100]	**Ice Monitoring (including Sea Ice and Iceberg)**	x			x		
[MAR-110]	**Ice Data Assimilation**	x				x	
[MAR-120]	**Oil Pollution Monitoring**	x			x		
[MAR-130]	**Marine Winds**	x			x		
[MAR-140]	**Wind Data Assimilation**	x				x	
[MAR-150]	**Ice Dynamics**	x				x	
[MAR-200]	**North America & Arctic Maritime Surveillance**	x			x		
[MAR-210]	**Global Maritime Surveillance**	x			x		
[MAR-220]	**Monitoring of Global Maritime Static Facilities**	x				x	
[MAR-230]	**Naval Task Group (TG) Surveillance**	x					x
[MAR-300]	**Coastal Altimetry**	x[2]			x		
[MAR-310]	**Marine Turbulence**		x			x	
[MAR-320]	**Satellite Derived Bathymetry**		x		x		

[1] **Stage of Maturity in the context of SDC:**

1- Operational: currently operational need for which the absence of data will directly impact the department capacity to deliver its mandate in 2025.
2- Pre-operational: need that is expected to become operational and improve the department capacity to deliver its mandate in 2025.
3- Emerging: need that is emerging and for which there is uncertainty on its eventual operational use by the department to deliver its mandate.

[2] Satellite altimetry is used (SWOT SAR interferometric altimeter will be used: non-traditional SAR).

[MAR-330]	**Shoreline/Intertidal Zone Extraction**		x		x		
[MAR-340]	**Change Detection**		x		x		
[MAR-350]	**3 Dimensional Shoreline extraction and Depth Estimation**		x			x	
[MAR-360.1]	**Oceanographic monitoring and ecosystem assessment – Temperature, Salinity & Turbidity**			x	x		x
[MAR-360.2]	**Oceanographic monitoring and ecosystem assessment – Currents**	x[3]			x		
[MAR-360.3]	**Oceanographic monitoring and ecosystem assessment - Waves**	x			x		
[MAR-360.4]	**Oceanographic monitoring and ecosystem assessment – Sea Ice Characterization**		x		x	x	
[MAR-360.5]	**Oceanographic monitoring and ecosystem assessment - Harmful Algal Bloom**			x		x	
[MAR-360.6]	**Oceanographic monitoring and ecosystem assessment – Ocean Color**			x	x		
[MAR-360.7]	**Oceanographic monitoring and ecosystem assessment - Phytoplankton**			x			x
[MAR-360.8]	**Oceanographic monitoring and ecosystem assessment - Bottom Type**		x				x
[MAR-370]	**Changes in marine / estuary fish habitat & vegetation**		x			x	
[LAN-100]	**Lake Ice Monitoring**	x			x		
[LAN-110]	**Lake Ice Monitoring and Thickness**		x			x	
[LAN-120]	**River Ice Monitoring**		x		x		
[LAN-130]	**Monitoring of ice formation in the Great Lakes connecting river channels**	x					x
[LAN-200]	**Permafrost Landscape Characterization**		x		x		x
[LAN-210]	**Glaciology - Iceberg Discharge**	x				x	
[LAN-220]	**Glaciology - Mass Balance**	x[4]			x		
[LAN-300]	**Snow water equivalent retrievals**	x[5]					x
[LAN-310]	**Estimating snow cover extent**			x	x		
[LAN-400]	**Ecosystem Monitoring – Wetlands and coastline**		x		x		
[LAN-410]	**Northern Ecosystem Monitoring**		x			x[6]	
[LAN-420]	**Remote Sensing of Freshwater Environments**			x			x
[LAN-430]	**Surface Water Mapping**	x			x		

[3] Satellite altimetry is used (SWOT SAR interferometric altimeter will be used: non-traditional SAR).
[4] Radar altimetry is used (Cryosat SAR interferometer: non-traditional SAR).
[5] On-going studies to determine best approach to derive SWE. Could be SAR, but at higher frequencies than C-band (e.g. Ku/Ka).
[6] Pre-operational for radar data, operational for optical data.

[LAN-440]	**Flood Mapping and Flood Risk**	x			x		
[LAN-500]	**Soil Moisture Data Assimilation**		x				x
[LAN-510]	**Soil Moisture for Agriculture**	x[7]				x	
[LAN-600]	**Land cover / Land Use Classification**		x		x		
[LAN-610.1]	**Crop Condition Assessment - Vegetation biophysical monitoring**		x			x[8]	x
[LAN-610.2]	**Crop Condition Assessment - Vegetation biochemical monitoring**			x			x
[LAN-620.1]	**Grassland and Rangeland Condition Assessment – Mapping grassland and rangeland extent**		x		x		
[LAN-620.2]	**Grassland and Rangeland Condition Assessment – Estimating grassland and rangeland health**		x			x[9]	
[LAN-620.3]	**Grassland and Rangeland Condition Assessment – Estimating grassland and rangeland health – invasive plant**		x				x
[LAN-630.1]	**Land Management- Tillage and crop residue mapping**		x				x
[LAN-630.2]	**Land Management- Estimation of soil properties**		x				x
[LAN-630.3]	**Land Management- Prescription mapping for variable management of agricultural inputs and crop yield**	x					x
[LAN-700]	**Forest canopy height mapping and monitoring**	x[10]					x
[LAN-710]	**Biomass mapping and monitoring**		x			x	
[LAN-720]	**Active wildfire mapping and fuel consumption monitoring**	x[11]					x
[LAN-800]	**Infrastructure Integrity Monitoring**	x			x		
[LAN-810]	**Infrastructure Damage Assessment**	x				x	
[LAN-820]	**Monitoring Seismically Active Areas and Volcanoes**	x				x	
[LAN-830]	**Rapid Earthquake Characterization**	x			x		
[LAN-840]	**Assessing Induced Surface Deformation**	x			x		
[LAN-900]	**Domestic and Arctic Land Surveillance**	x[12]			x		
[LAN-910]	**Expeditionary Land Surveillance - Strategic**	x			x		
[LAN-920]	**Expeditionary Land Surveillance - Tactical**	x			x		

[7] Also done operationally at coarser resolution using passive microwave.
[8] Operational for optical data.
[9] Operational for optical data.
[10] Single-pass tandem radar interferometry is needed (e.g. Tandem-X).
[11] C-band only for wetland or open forest. L-band needed for dense forest.
[12] For [LAN-9xx], also a need for visible, IR, and hyperspectral imagery to complement the SAR.

4 GOVERNMENT OF CANADA NEEDS

In this section, the detailed needs of the GC are presented. Section 4.1 summarizes the maritime needs and Section 0 summarizes the land needs, including inland waters. The focus is on the measurement performance, areas of interest, revisit/coverage frequency and latencies. Section 4.3 includes needs related to data availability and continuity, data access and use, security and network.

4.1 GOVERNMENT OF CANADA MARITIME NEEDS

This section contains the maritime/marine needs of the Government of Canada. While the term « maritime » is used in this section for simplicity, both marine (e.g. organisms, ecosystems dynamics, ocean currents, etc.) and maritime (e.g. human related activity centered on ocean resources) needs are included. Inland waters are covered in Section 0.

It is assumed that those needs must be met simultaneously when applicable and that compromise beam modes can only be used if they allow satisfaction of all the applicable needs. This applies also to the land needs of the following section.

TABLE 4-1 –GC MARITIME NEEDS IN THE CONTEXT OF SDC

ID	*Name*	*Purpose and Rationale*	*Stage of Maturity*	*Needed measurement(s)*	*Measurement Performance (T: Threshold; G: Goal)*	*Area of Interest & Revisit/Coverage Frequency (T: Threshold; G: Goal)*	*Data Latency[13] & Fast-tasking (T: Threshold; G: Goal)*
[MAR-100]	**Ice Monitoring** (including Sea Ice and Iceberg)	Operational monitoring of Canada's navigable waters to support safe and efficient	1 - Operational	Sea ice type and extent Ice thickness (G)	Data/image quality to enable multiple ice typing, texture and structure, floe size and shape and icebergs. **Polarization:** HH/HV & VV/HH dual polarization and Compact Polarimetry (T)	**Areas of interest:** Ice Monitoring Can AOI (ref. Section 5.1) (T) North Pole (ref. Section 5.1) (G)	**Data latency:** 30 min (T) 10 min (G) On-board processing

[13] **Data Latency:** time between data acquisition and product delivery.

		maritime operations.			Fully polarimetric at swath widths of 200-500 km (G) **Spatial resolution:** 50 m (T) 1-10 m (G) with swath widths of 500km or greater (G). **Noise floor:** <-28 dB (T) <-30 dB (G) **Other considerations:** • Simultaneous (or near-simultaneous e.g. min) multi-frequency/wavelength data is highly desirable; C-band (for continuity) and longer wavelength (e.g. L-Band) would be desirable. For example, L-band SAR would be useful for better classification of ice types (first-year and multi-year) during both dry and wet periods and for improved identification of floe boundaries and ridges throughout the melt season; C- and X-Band combination not desirable as interaction with ice cover is too similar. • High resolution optical imagery (VIS/IR) would be a complementary source of data for this application. • Ice thickness information is highly desirable and a complementary source of data for this application.	**Coverage Frequency:** Ice Monitoring Can AOI: Twice daily (T) North Pole: Daily Morning acquisitions are critical.	for target (ship vs iceberg detection) of interest IF false alarm rate can be minimized and detection accuracy maximized. **Fast-tasking:** 6 hours (G) for emergency situations.
[MAR-110]	**Ice Data Assimilation**	Operational regional and global sea ice analyses in support of operations and environmental predictions.	2 – Pre-operational (while NWP data assimilation is operational, the use of	Ice concentration, thickness and motion	**Polarization:** full polarimetric mode <u>if it can be implemented with large swaths</u> (~500 km). If there is a choice between full polarimetric mode on narrow swaths and wide swath C-band and dual-polarization (HH-HV) dual-frequency (C- and L-band), wide swath is preferred.	**Areas of interest:** Similar to Ice Monitoring and Ice Dynamics but on a <u>global domain</u> (ice on entire globe).	**Data latency:** 30 min (T)

			SAR in this process is pre-operational)		**Spatial resolution:** < 50 m (T) **Noise floor:** < -30 dB (G) **Other considerations:** • C- and L-band imagery available simultaneously (highly desirable for sea ice mapping, especially in summer season (breaks, wet ice) to remove ambiguities). • RCM Interferometric capabilities should be maintained (i.e. 4-day Coherent Change Detection). • An instrument on board that would be quite valuable for NWP is a GNSS receiver for radio-occultation (RO). Small instrument with significant impact on forecasts.	**Coverage Frequency:** 4 times daily (6 hours) (G) Twice daily (T)	
[MAR-120]	**Oil Pollution Monitoring**	Monitoring to encourage compliance with Canada's laws and International Conventions that seek to minimize oil pollution.	1 – Operational	Oil spill extent over marine areas	**Spatial resolution:** 10 m (T) 3 m (G) with swath widths of 300-500 km, or greater (G) **Noise floor:** < -28 dB (T) < -30 dB (G) **Other considerations:** • C-band preferred but X-band could also be used. • High Resolution optical (VIS/IR) imagery would be a complementary source of data for this application.	**Areas of interest:** Oil Pollution Can AOI (ref. Section 5.2). **Coverage Frequency:** Three times daily (G) Twice daily (T) Local acquisition time other than dawn/dusk would also be desirable.	**Data latency:** 15 min (T) 5 min (G) On-board processing for anomaly "first-guess" detection is of interest is accuracy can be maximized. **Fast-tasking:** For emergency and/or "re-look" at higher

							resolution [G].
[MAR-130]	**Marine Winds**	To support the operational marine forecasting program.	1 – Operational	Marine surface wind speed and direction	**Accuracy:** 2 m/s at 500 m resolution (T) Better accuracy than current SAR capability (G) **Polarization:** Optimal VV-VH; Compact Polarimetry. **Other considerations:** • C-band best but X-band could also be used. • Over 85% of the data used by this application is "re-used" from primary application orders (e.g. ice, oil).	**Areas of interest:** Greatest spatial coverage possible over marine areas. Focus on coastal areas and shared AOI with much of the ice monitoring and oil (ISTOP) needs. Potential "global" marine wind products in future if coverage allows – see Wind Assimilation. **Coverage Frequency:** 3-4 times daily	**Data latency:** <3 h (T) <10 min (G)
[MAR-140]	**Wind Data Assimilation**	To support regional and global numerical weather prediction (NWP) data assimilation over oceans.	2 – Pre-operational	Marine surface wind speeds	Coverage is more important than the resolution of the data. Hence, data over a 500 km swath would be required. **Other considerations:** • To complement scatterometers data providing two wind components at about 50 km horizontal resolution. • An instrument on board that would be quite valuable for NWP is a GNSS receiver for radio-occultation (RO). Small instrument with significant impact on forecasts.	Global oceans **Coverage Frequency:** Global coverage 4x daily (G)	**Data latency:** 6 h (T) 0.5 - 1.5 h (G)

[MAR-150]	**Ice Dynamics**	Ice motion products are required to assess the state of the Arctic sea ice cover which supports strategic operational and policy decision making, national and international research initiatives, and infrastructure design. Ice motion information is also used to constrain estimates from seasonal forecast models.	2 – Pre-operational	Sea ice speed and direction	**Polarization:** HH **Other considerations:** • L, X and Ku-band imagery could be used in addition to C-band to increase coverage. L-band could find additional utility during the melt season for determining additional vectors. • Pre-processing of imagery to ingest into the ice drift tracking algorithm would be beneficial to ease the transition to fully operational. Large data volume is an issue.	**Areas of Interest:** pan-Arctic (ref. Section 5.3) **Coverage Frequency:** 1-3 day Application expected to grow with increasing capabilities of SAR, including higher temporal and spatial coverage.	
[MAR-200]	**North America & Arctic Maritime Surveillance**	GC requirements to detect and track all vessels in the Maritime approaches to Canada; GC is required to generate Maritime Domain Awareness (MDA) in its entirety for the North American and Arctic Maritime AOIs in support of operational requirements.	1-Operational [2-Pre-operational for ship/ice discrimination and CMT]	Automatic detection, classification, identification, and tracking of vessels, day and night, in all weather conditions.	**Vessel detection performance:** Automatically detect vessels of 15 meters length or larger with a 90% probability of detection and a very low false alarm rate, in all weather conditions up to and including sea state 5 Beaufort Wind Scale 6 and in all atmospheric conditions (day/night, cloud cover, fog etc.). The required probability of false-alarm for 15m vessel detection, including image artifacts like range ambiguities, is less than 2.5×10^{-9} over a resolution cell of 50 m by 50 m. Ship detection performance must be maintained for areas where icebergs are present and where ships may be breaking ice.	**Areas of Interest:** North America & Arctic Maritime Surveillance AOIs (maritime regions of Section 5.4). **Coverage Frequency:** Region-dependent (from once every 3 days to 4 times daily – ref Section 5.4). For the higher resolution detection (5m),	**Data latency:** - Within a domestic ground-station mask: less than 5 min (incl. association with AIS/CMT); - Globally: less than 15 min (30 min when including association with AIS/CMT);

					Vessel classification performance: Need to exploit all aspects of the imagery (e.g. MTI and ship wakes) to derive vessel characteristics: vessel or not and confidence level, length within 5 meters, width within 3 meters, orientation/course within 5°, speed within 2 knots, error estimates/confidence levels. Need to identify and highlight vessel behavioural information such as: Polluting/pumping bilges and Jamming, blinding or attempting to deceive the space-based sensor. **Common Maritime Transmissions (CMT)[14]:** Concurrent active wide-area surveillance vessel detection and CMT (AIS and others) detection and independent geolocation (with greatest possible accuracy) are needed. Need to exploit transmission information in order to verify the compliancy (i.e. spoofing detection). **AIS Detection Performance:** Correctly process at least one AIS message (both class A & B) from a transmitting vessel with a minimum detection rate of 90% under the following conditions: a. An absence of in-band and adjacent VHF interference; b. The vessel is within the instantaneous field of view for 5 minutes; and	the stated frequency is for access rather than coverage. It is desired to have equally-spaced temporal coverage (e.g., 4 times daily suggests an image roughly every 6 hours). For AIS & CMT: near continuous receiver operation (multiple times a day).	**Fast-tasking:** Half orbit (~50 min)

[14] Other maritime transmission systems for geolocation may include:
- New AIS channels & protocols;
- VHF Data Exchange System (VDES);
- Navigation Data (NAVDAT) in the 500kHz band;
- Long Range Identification and Tracking (LRIT);
- Maritime Radars; and
- Any other EM transmission that could enable the geolocation of ships at sea.

					c. There are no more than 2,200 transmitting vessels within the instantaneous field of view. **Vessel detection performance for narrow AOIs/smaller ships:** Also a need to automatically detect vessels of 5 meters in length or larger up to an including sea-state 4 Beaufort Wind Scale 5 for all Maritime AOIs except arctic.		
[MAR-210]	**Global Maritime Surveillance**	GC maintains operational interest in, and has obligations to, AOI's that extend to international waters.	1-Operational [2-Pre-operational for ship/ice discriminati on and CMT]	Automatic detection, classification, identification, and tracking of vessels, day and night, in all weather conditions.	Refer to North America & Arctic Maritime Surveillance performance [MAR-200].	**Area of Interest:** Described in Section 5.5. **Coverage Frequency:** Twice daily It is desired to have equally-spaced temporal coverage. Contiguous SAR swath coverage at the equator. A minimum of 50% growth of the specified Global AOIs is expected. For AIS & CMT: all the globe (near continuous receiver operation).	**Data latency:** Less than 15 min (30 min when including association with AIS/CMT); **Fast-tasking:** Half orbit (~50 min)
[MAR-220]	**Monitoring of Global Maritime**	GC often has intelligence requirements to understand the	2-Pre-operational	Imaging and monitoring harbours and ports that an	**Spatial Resolution:** 5 m (20 km swath) This implies:	**Areas of Interest:** 200 ports worldwide	**Data latency:** 15 min

	Static Facilities	disposition of adversarial forces. This requirement helps determine force size & location, capability, readiness, order of battle, pattern of life etc.).		RCN ship may visit and other locations of strategic interest for Canada.	• The need for semi-automatic ship detection close to land, in harbours and ports; and • The need for high resolution imagery close to regions where active wide-area surveillance is also required, necessitating a capability of rapid switching from high resolution narrow swath to lower resolution wide swath.	roughly distributed on the coastal areas of the following continents: 125 Asia, 25 South America, 50 Africa (classified AOIs). Global Access is needed (exclusion of lat<-80° is acceptable). **Coverage Frequency:** Twice daily Coherent change detection (CCD) revisit capability of no more than 4 days.	**Fast-tasking:** Half orbit (~50 min)
[MAR-230]	**Naval Task Group (TG) Surveillance**	The ability to provide global space-based surveillance supports Canadian and Allied Naval Expeditionary operations.	3-Emerging	Active wide-area surveillance overhead/over-the-horizon view of the moving AOI surrounding a Naval TG(s)	Vessel detection performance may range from large (> 25 m) to small (~5 m). Automatically detect vessels of 5 meters in length or larger up to an including sea-state 4 Beaufort Wind Scale 5 (wave height 1 to 2 m).	**Areas of Interest:** Up to 5 ad-hoc AOIs located anywhere in the world centered on a moving point with a radius of 400 nm. Global Access is needed (exclusion of lat<-80° is acceptable).	**Data Latency:** <5 min (incl. association with AIS/CMT) – information provided to the ship. Line-of-sight communication between the satellite and the ship

						Coverage Frequency: 4 times daily	is needed (can take the form of VHF and/or UHF). **Fast-tasking:** Half orbit (~50 min) Low latency ordering capability from a ship within the TG is needed.
[MAR-300]	**Coastal Altimetry**	To build satellite altimetry data for GC's long-term and operational monitoring of canadian waters.	1-Operational	Coastal Altimetry/ Sea Level	**Accuracy:** 0.5 cm **Spatial resolution:** 1 km **Other considerations:** • Satellite Altimeter. This technology is currently operational and advancements are expected with the launch of SWOT (first 2-D altimeter). • The technology will grow over the coming decades. • Current satellites: Jason 2 (NASA/CNES), Sentinel-3 SARL (ESA), AltiKa (ISRO).	**Area of Interest:** All Canadian waters **Coverage Frequency:** TBD	**Data latency:** 11 days (T) 2-3 days (G)

[MAR-310]	**Marine Turbulence**	Marine forecast and to monitor the physical environment.	2-Pre-operational (derived from SAR data)	Surfactants crude oil natural oil seeps macroalgae on ocean surface	**Accuracy**: 5 km/h **Spatial resolution:** 1 km **Other considerations:** • SAR backscatter (RADARSAT-2) and Ocean Color satellites are currently used. • Relate the radar signal backscatter to turbulent mixing intensity based on the hypothesis that more waves generates more backscatter as well as more turbulence.	**Area of Interest:** All Canadian waters (EEZ) **Coverage Frequency:** 2-3 days (T) Daily (G)	**Data latency:** 1-2 days
[MAR-320]	**Satellite Derived Bathymetry**	Derive water depths to support extension of hydrographic surveys to wider geographical areas. Increase the amount of depth information presented within shallow areas onhydrographic charts.	1-Operational (optical) 3- Emerging (radar and hyperspectral)	Water Depth	**Spatial resolution:** 0.5-2 m (G) 30 m (optical and hyperspectral) 50 m (radar) (T) **Other considerations:** • Cloud and ice free imagery critical • Optical (e.g. DigitalGlobe, RapidEye, Sentinel-2 and Landsat) and Radar (RADARSAT-2, RCM, possibly TerraSAR-X) data can be used. • Optical gaps: recent coverage; SAR gaps: Regular high resolution coverage within coastal areas. Radar will function best in areas where optical satellite derived bathymetry is not possible (e.g. strong current areas). • Impact of technology change: optical: could impact accuracy of depth estimates; radar: could require significant modifications to depth estimation methods; hyperspectral: minimal impact as satellite methods not yet developed. • Growth expected to be greatest during the 2025-2030 timeframe for optical, and during the 2030/2035-2040 timeframe for radar.	**Area of Interest:** Canadian coastal waters and major inland waterways (e.g. St. Lawrence River). Also the Great Lakes for optical data. **Coverage Frequency:** Monthly (T) Weekly (G)	**Data latency:** 3 days

[MAR-330]	**Shoreline/Intertidal Zone Extraction**	Identify shorelines and intertidal zones from optical and SAR imagery for use as source data for hydrographic charts. Detailed shorelines are required for aquatic species habitat modelling. Accurate assessment of shoreline modifications requiring Fisheries Act and or Species at Risk Act permits.	1-Operational	Shoreline and intertidal zone locations	**Spatial resolution:** 30 m (T) 1-2 m (G) **Other considerations:** • For optical, cloud free optical imagery is critical. • For SAR, multi-polarization SAR observations (e.g. HH+HV, quad pol, CP) are beneficial. • DigitalGlobe, RapidEye, Sentinel-2, Landsat and RADARSAT-2 are currently used. • Optical gaps: recent coverage; SAR gaps: Regular high resolution coverage within coastal areas. • Technological change impact medium. Methods for shoreline extraction would need to be updated. • Growth expected to be greatest during the 2025-2030 timeframe.	**Area of Interest:** Canadian coastal waters and major inland waterways, including the Great Lakes. **Coverage Frequency:** Monthly (T) Weekly (G)	**Data latency:** 3 days
[MAR-340]	**Change Detection**	Identify changes in Canadian coastal waters to support hydrographic chart production planning activities. Measuring and monitoring impacts of works near water.	1-Operational	Areas of change indicators (vector, raster).	**Spatial resolution:** 10 m (T) 1-2 m (G) **Other considerations:** • Cloud free optical imagery critical. • Multi-polarization SAR observations beneficial. • DigitalGlobe, RapidEye, Sentinel-2, Landsat and RADARSAT-2 are currently used. • Optical gaps: recent coverage; SAR gaps: regular high resolution coverage within coastal areas. • Technological change impact medium. Some changes to methods would be required. • Growth expected to be greatest during the 2025-2030 timeframe.	**Area of Interest:** Canadian coastal waters and major inland waterways. **Coverage Frequency:** Bi-weekly (T) Weekly (G)	**Data latency:** 3 days For emergency: 1h (G) 3h (T) **Fast-tasking:** May be requested for emergency situations.

[MAR-350]	**3Dimensional Shoreline Extraction and Depth Estimation**	Use of stereo optical and/or SAR measurements to derive elevations of coastal areas. Allows for precise mapping of high/low water lines and intertidal zones. Can support validation of tidal predictions.	2-Pre-operational	Shoreline locations and water depths	**Spatial resolution :** 10 m (T) 1-2 m (G) **Other considerations:** • Cloud and ice free optical imagery critical. • Ice free SAR data critical. • DigitalGlobe and TerraSAR-X currently used. • Gap: stereo data availability over coastal waters. • RCM expected to be very useful. • Technological change impact may be high if data characteristics change significantly. • Growth expected to be greatest during the 2030/2035-2040 timeframe.	**Area of Interest:** Canadian coastal waters and major inland waterways. **Coverage Frequency:** Weekly (G); Annual (T).	**Data latency:** 3 days For emergency: 1h (G) 3h (T) **Fast-tasking:** May be requested for emergency situations.
[MAR-360.1]	**Oceanographic monitoring and ecosystem assessment – Temperature, Salinity & Turbidity**	Monitor the physical environment, detect and quantify changes that may affect the entire marine ecosystem. EO products needed to integrate and complement in situ and field-based monitoring activities in support of regional assessments of oceanographic conditions in marine areas.	1-Operational (Temp.) 3-Emerging (Salinity)	Temperature Salinity Turbidity	**Accuracy:** <0.1% **Other considerations:** • Various platforms, including ships (flow through and direct samples), autonomous vehicles (argo-floats and gliders) and moorings and satellites. • Technology will grow over the coming decades, which may provide opportunities to expand the types of measurements that can be derived for EO systems. Current satellites: *Temperature:* • MODIS (NASA) • AVHRR (NOAA/EUMETSAT) • SLSTR (ESA/EUMETSAT) *Salinity*: • SMOS for global coverage (ESA) Ocean Colour satellite for river mouth (correlation of salinity with CDOM absorption)	**Area of Interest:** All Canadian waters (EEZ) **Coverage Frequency:** Needed at various temporal (daily, weekly, monthly, seasonally, annually).	**Data latency:** 24 to 48 h

[MAR-360.2]	**Oceanographic monitoring and ecosystem assessment – Currents**	Monitor the physical environment, detect and quantify changes that may affect the entire physical oceanography and marine ecosystem.	1-Operational	Current velocity and direction coastal currents mesoscale/ sub-mesoscale features and eddies	**Accuracy:** <0.1% **Spatial resolution:** ~1km **Other considerations:** Satellite Altimeter. This technology is currently operational and advancements are expected with the launch of SWOT (first 2-D altimeter). The technology will grow over the coming decades. Current satellites: • Jason 2 (NASA/CNES) • Sentinel-3 SARL (ESA) • AltiKa (ISRO)	**Area of Interest:** All Canadian waters (EEZ) **Coverage Frequency:** weekly (T) daily (G)	**Data latency:** 1 week
[MAR-360.3]	**Oceanographic monitoring and ecosystem assessment - Waves**	Monitor the physical environment, detect and quantify changes that may affect the entire physical oceanography and marine ecosystem.	1-Operational	Wave height mean directions 1-d and 2-d wave spectra period swell	**Accuracy:** 5 cm **Spatial resolution:** 1km **Polarization:** SAR Compact polarization offers new opportunities for retrieving wave information. **Other considerations:** Current satellites: RADARSAT-2, Sentinel-1. Moorings, wave gliders and RCM to come. Gap: low revisiting frequency	**Area of Interest:** All Canadian waters (EEZ) **Coverage Frequency:** 2-3 days (T) daily (G)	**Data latency:** 1-2 days
[MAR-360.4]	**Oceanographic monitoring and ecosystem assessment – Sea Ice Characterization**	Marine Forecast, marine safety, and to monitor the physical environment	1-Operational for some products and 2-Pre-operational for others (e.g., melt pond, ice type).	Sea-ice floe-size distributions concentration thickness melt ponds ice type	**Spatial resolution:** 100 m **Other considerations:** **[Similar to Ice Monitoring: MAR-100]** Current satellites: Radarsat-2, Ocean Colour/Visible RCM to come	**Area of Interest:** Arctic and subarctic waters **Coverage Frequency:** 2-3 days (T) daily (G)	**Data latency:** 1-2 days

[MAR-360.5]	**Oceanographic monitoring and ecosystem assessment - Harmful Algal Bloom**	Detection of Harmful algal bloom	2-Pre-operational	Cell abundance of harmful algae and bacteria	**Other considerations:** Use of satellite ocean color to derive biomass indices or rely on proxies. Current satellites: OLCI (ESA), MODIS and VIRS (NASA)	**Area of Interest:** All Canadian waters (e.g., ocean, coastal, inland waterbodies and waterways). **Coverage Frequency:** 2-3 days (T) daily (G)	**Data latency:** 1-2 days
[MAR-360.6]	**Oceanographic monitoring and ecosystem assessment – Ocean Color**	Monitor the biological environment, detect and quantify changes that may affect the entire marine ecosystem.	1-Operational (2-Pre-operational and 3-Emerging for sensors that will be launch in the near future with extra spectral, temporal and spatial capacity)	Ocean Color (chl, cdom, primary production and more)	**Other considerations:** Various platforms, including ships, autonomous vehicles (argo floats and gliders) and moorings. Current satellites: OLCI (ESA), MODIS and VIRS (NASA). Gap: coastal areas are not monitored, need for high resolution (< 250m) satellite with multi- or hyperspectral capacity (COCI-type). PACE (NASA) expected to be launched in 2020, need to support effort to ingest hyperspectral data in processing chain. Technology will grow over the coming decades.	**Area of Interest:** All Canadian waters (EEZ) **Coverage Frequency:** Needed at various temporal (daily, weekly, monthly, seasonally, annually).	**Data Latency:** 2-3 days (G)
[MAR-360.7]	**Oceanographic monitoring and ecosystem assessment - Phytoplankton**	Monitor the biological environment, detect and quantify changes that may affect the entire marine ecosystem.	3-Emerging	Phytoplankton vertical profile	**Other considerations:** Shipboard and satellite LIDAR (e.g., Calipso satellite LiDAR, 2006-current).	**Area of Interest:** All Canadian waters (EEZ) **Coverage Frequency:** 2-3 days (G) 2 weeks (T)	**Data Latency:** 24 – 48 h

[MAR-360.8]	**Oceanographic monitoring and ecosystem assessment - Bottom Type**	Identify and monitor habitat and habitat suitability in oceans, inland, and coastal waters (e.g., Great Lakes, Lake Winnipeg), and inland waterways (e.g. St. Lawrence River).	3-Emerging	Bottom type classification, state of the ecosystem	**Other considerations:** With RCM and possibly COCI, technology will grow over the coming decades. Current Satellites: • Landsat, Sentinel-2 • Radarsat-2 • OLCI, MODIS, and VIRS	**Area of Interest:** All Canadian coastal waters **Coverage Frequency:** 2-3 days (G) 10 days (T)	**Data latency:** 1-2 days
[MAR-370]	**Changes in marine / estuary fish habitat & Vegetation**	Identify and track changes in nearshore marine and estuary habitat & vegetation (eelgrass, kelp, etc.) that are important for fish.	2- Pre-operational	Bottom type classification	**Spatial Resolution:** 5 - 250m **Other considerations:** • Potentially from existing satellite imagery resources, but would require further investigation.	**Area of Interest:** BC coastal waters **Coverage Frequency:** Annually (T)	**Data Latency:** 6 months

4.2 GOVERNMENT OF CANADA LAND NEEDS

This section contains the land needs of the Government of Canada, including the inland waters. It is assumed that those needs must be met simultaneously when applicable and that compromise beam modes can only be used if they allow satisfaction of all the applicable needs. This applies also to the maritime needs of the previous section.

TABLE 4-2 –GC LAND NEEDS IN THE CONTEXT OF SDC (INCLUDING INLAND WATER)

ID	*Name*	*Purpose and Rationale*	*Stage of Maturity*	*Needed measurement(s)*	*Measurement Performance (T: Threshold; G: Goal)*	*Area of Interest and Revisit/Coverage Frequency (T: Threshold; G: Goal)*	*Data Latency & Fast-tasking (T: Threshold; G: Goal)*
[LAN-100]	**Lake Ice Monitoring**	Monitoring of lake ice coverage for heat flux input estimates to improve weather forecast accuracy.	1 - Operational	Lake ice type and extent Lake ice vs. water extent Ice thickness (G)	Similar to Ice Monitoring [MAR-100]. **Other considerations:** • High resolution optical imagery (VIS/IR) would be a complementary source of data for this application. • Ice thickness information is highly desirable and a complementary source of data for this application.	**Areas of interest:** National inland lakes (ref. Section 5.6) **Coverage Frequency:** Weekly (T) Twice weekly (G)	**Data latency:** 30 min (T) 10 min (G)
[LAN-110]	**Lake Ice Monitoring and Thickness**	Measure presence and condition of ice lakes in support of public safety (e.g. EGS) and climate change studies.	2- Pre-Operational	Ice / No Ice Ice Conditions Ice Thickness	Consistent separation of ice and rough open water Consistent separation of wet snow and flooded ice and open water Identification of cracks, ridges and ice types (e.g. snow/ice, thermal ice) Estimation of ice thickness (+/- 10 cm) **Spatial Resolution:** 10 m over 350 km (T) 3-5 m over 350 km (G)	**Areas of interest:** National inland lakes **Coverage Frequency:** Twice a week (T)	**Data Latency:** 24h

					Noise floor: <-28 dB (T) <-30 dB (G) **Other considerations:** • Lake ice detection and conditions operationally possible with C-band single, multi-pole and polarimetric data (incl. compact-polarization) • Ice thickness not possible with RCM. Preferred approach is L-band sensor in a bi-static tandem mission with large baseline. • Reliable separation of ice from open water is an outstanding requirement. L-band, concurrent optical data or bistatic SAR could assist.		
[LAN-120]	**River Ice Monitoring**	Measure presence and condition of river ice in support of public safety (e.g. EGS).	1- Operational 2- Pre-operational for Ice Thickness	Ice / No Ice Ice Roughness Ice Thickness	Consistent separation of ice and rough open water Consistent separation of wet snow and flooded ice and open water Identification of ice types (e.g. smooth and rough-ice jams) Estimation of ice thickness (+/- 10 cm) **Spatial Resolution:** 5 m over 350 km (T) 1 m over 100 km (G) **Noise floor:** <-30 dB (T) <-35 dB (G) **Other considerations:** • River ice detection and conditions operationally today with C-band single channel HH • Ice thickness not possible with RCM. Preferred approach is L-band sensor in a bi-static tandem mission with large baseline. • Reliable separation of ice from open water is an outstanding requirement. L-band,	**Areas of interest:** National scale **Coverage Frequency:** Twice daily (T)	

					concurrent optical data or bistatic SAR could assist. • Maximize river coverage in individual frames		
[LAN-130]	**Monitoring of ice formation in the Great Lakes connecting river channels**	Monitoring of river ice formation to support regulatory operations and water balance monitoring	3 - Emerging	Monitoring of ice formation in the Great Lakes connecting river channels	Similar to ice monitoring [MAR-100]. **Other considerations:** • High resolution optical imagery (VIS/IR) would be a complementary source of data for this application.	**Areas of interest:** Great Lakes connecting river channels **Coverage Frequency:** Daily (T) From December through to April.	
[LAN-200]	**Permafrost Landscape Characterization**	Detect and map the presence and impacts of frozen soils and ground ice	1- Operational for ground deformation 3-Emerging for spatial distribution	3-D Ground deformation related to ice growth, melt Spatial distribution of permafrost and ground ice	**Spatial Resolution:** 5 m for 3D terrain displacement **Polarization:** Polarimetric (or compact-pol) data required to support PolInSAR methods **Noise floor:** <-30 dB (T) <-35 dB (G) **Other considerations:** • For spatial distribution: direct measurements of the presence of permafrost and other types of ground ice are required over large areas. Currently cannot observe sub-surface ice directly. Vegetation and deformation used as proxy for its presence. • For ground deformation: InSAR approach used: vertical surface deformation required (mm accuracy). 3-D deformation desirable.	**Area of Interest:** Continuous and Discontinuous Permafrost Regions of Canada **Coverage Frequency:** Daily through summer period.	

					• Research underway to assess longer wavelength polarimetric SARs (e.g. L-band, P-band) to detect ice directly • Inclusion of concurrent optical data can assist through mapping of related landscape features and change. • See suggestions for Infrastructure Integrity Monitoring [LAN-800].		
[LAN-210]	**Glaciology - Iceberg Discharge**	To enhance our understanding of climate change and its impacts.	2- Pre-Operational	Glacier ice motion - seasonal	**Spatial resolution:** 5-10 m **Other considerations:** • Current data source: RADARSAT-2 • L-band would improve velocity mapping capabilities in summer months • Integration with optical data (May to October) would be valuable	**Areas of interest:** Terrestrial ice masses (150,000km2) within the Canadian Arctic Archipelago **Coverage Frequency:** 1-2 day	
[LAN-220]	**Glaciology - Mass Balance**	To enhance our understanding of climate change and its impacts.	1- Operational	Glacier ice thickness change	**Spatial resolution:** 5-10 m **Other considerations:** • Interferometric SAR (Ku Band) mode: current source – CryoSat-2	**Areas of interest:** Include land ice masses across the Canadian Arctic Archipelago and Western / Northern Cordillera of Canada **Coverage Frequency:** 1-2 day	

[LAN-300]	**Estimating Snow Water Equivalent**	Radar retrievals of snow water equivalent are required to support land surface data assimilation for numerical weather prediction and hydrological forecasting. Coarser resolution (i.e. passive microwave) can be used for weekly mapping SWE across Canada's agricultural extent for inputs to hydrological models and bio-geochemical (yield) models.	3 - Emerging	Snow Water Equivalent (SWE)	**Spatial resolution:** 1 km (T) 500 m (G) **Accuracy:** 30 mm (T) 10 mm (G) **Other considerations:** • C-band measurements are not appropriate for snow water equivalent retrieval - higher frequency (Ku; Ka) measurements are required. • Current concept studies and analysis of experimental data focused on identifying ideal frequency or frequencies, retrieval algorithm development, and data assimilation. • For Agriculture, best available resolution from passive microwave might be sufficient, but desirable to have high level "canned" products.	**Area of interest:** Land regions with seasonal snow cover (Northern hemisphere (T), globally (G)). Agricultural Region of Canada **Coverage Frequency:** 1-3 days [weekly in fall and spring for Agriculture]	**Data Latency:** 6-12 hrs for operational data assimilation [72h for Agriculture]
[LAN-310]	**Estimating Snow Cover Extent**	Weekly mapping snow cover extent across Canada's agricultural extent. Data used to map the extent of snow cover to help define start of growing season.	1. Operational (As part of CALMS)	Extent of snow cover	**Spatial Resolution** (Sub-field level): 30 m (T) 10 m (G) **Other considerations:** Optical: NIR and SWIR critical (or "canned" product); Wide swath (AWiFS-type); Daily MODIS MOD10A1 L-2 Product currently used (daily but coarse resolution at 250m); Gaps over cloudy regions; Dependencies on USGS LP-DAAC archive that does not ensure timely delivery (<48 h) of data. Concerns over MODIS life-span and effort to transition to new sensor.	**Area of Interest:** Agricultural region of Canada. **Coverage Frequency:** Weekly (T) Daily (G) Limited to spring (possibly fall).	**Data Latency:** 72 hours (T)

[LAN-400]	**Ecosystem Monitoring – Wetlands and Coastline**	Ecosystem habitat monitoring, assessment and mapping, Arctic coastline sensitivity mapping	2 – Pre-operational	Wetland mapping, habitat monitoring, coastal mapping	**Polarization:** Continuity of polarimetric data for wetlands (Compact-Pol and Quad-pol) **Spatial Resolution:** Higher resolution (5m), larger swath widths towards improved operationalization **Other considerations:** • L-band would be beneficial for wetland vegetation penetration. • SAR complimentary data source with other space-based EO sources and sensor types including optical data.	**Areas of interest:** Wetland sites and coastal erosion sites (ref. Section 5.7). **Coverage Frequency:** Higher re-visit times and coherent change detection (~daily) are expected to improve ecosystem monitoring.	
[LAN-410]	**Northern Ecosystem Monitoring**	Land-based ecosystem management decision support and monitoring. Data is needed to detect and monitor inland (lake) development, especially in the north where there is limited physical access to sites.	1-Operational for optical data 2-Pre-Operational for radar data	Data for the analysis of the cumulative impacts of human activities (e.g. mines, dams, etc.) and natural causes are required.	**Spatial Resolution:** High resolution (exact value not a high priority) **Other considerations:** • This data could come in the form of optical and radar data. • Current source: LANDSAT.	**Area of Interest:** Focus on Canada's north (inland and coastal). **Coverage Frequency:** Annual (T)	
[LAN-420]	**Remote Sensing of Freshwater Environments**	To inform assessments, research programs, and management of	3-Emerging	Water Depth Temperature Turbidity	**Spatial Resolution:** 5 m **Other considerations:** • Potentially from satellite imagery, in situ platforms, acoustic profilers, drones.	**Area of Interest:** Pacific Region (BC and Yukon)	**Data Latency:** 30 days

		anadromous fish species. To assess impacts of land-use changes on salmon habitat and population dynamics.		Stream flow velocity and volume. Trophic status Riparian vegetation and stream cover vegetation characteristics.	• Additional investigation of emerging technologies is required.	rivers, lakes and wetlands **Coverage Frequency:** Monthly (T) weekly (G)	
[LAN-430]	**Surface Water Mapping**	Across Canada's agricultural extent, data used to: (a) map areas of flooding; (b) excessive wetness; (c) land that is too-wet-to-seed. Surface water seen to have multiple uses with other applications (e.g. ecosystems). Map inland lakes and rivers in support of National Hydro Network.	1-Operational	Locations of surface standing water over agricultural land. Terrestrial water body extent, incl. ephemeral areas (e.g. wetlands), relative and absolute water levels and seasonal change detection	**Spatial Resolution** (Sub-field & Dugout level): 10 m (T) 5m (G) over large as possible swaths **Polarization:** Polarimetric data needed for wetland (incl. peatlands) classification. **Noise floor:** <-28 dB (T) <-32 dB (G) Repeat pass imagery and phase preservation required for water level dynamics via coherence and InSAR methods. **Other considerations:** • C & L Band, RADARSAT-2 currently used; Gaps if confliction with OGDs, especially in spring. • L-band could assist detecting flooded vegetation • High resolution cloud-free optical imagery would be a valuable complementary source of data for this application (too-wet-to-seed maps could even be produced with optical data alone with lower classification	**Area of interest:** Surface waters in Canada, including the entire agricultural region of Canada and all Canadian Prairies. Entire BC, MB, ON, NB, NS, PEI, NFLD&LAB at lower frequency. **Coverage Frequency:** Weekly & on-demand when needed. Annually for BC, MB, ON, NB, NS, PEI,	**Data Latency:** 24 h (T)

					accuracies and less reliability).Possible extension to mapping on-farm water resources (dug-outs). Would be considered an Emerging R&D priority.	NFLD&LAB. Seasonal (March – November)	
[LAN-440]	**Flood Mapping and Flood Risk**	Measure inundated areas in support of emergency geomatic services and assessing flood risk	1- Operational for water extent 2- Pre-Operational for water level	Surface water extent Surface water level	**Spatial Resolution:** 10 m over 350 km swath (T) 5 m over 350 km swath (G) **Polarization:** HH/HV & CP (T) Fully Polarimetric (G) **Noise floor:** <-28 dB (T) <-32 dB (G) Repeat pass imagery and phase preservation required for water level estimation via coherence and InSAR methods. **Other considerations:** • Consistent detection between dry land and flooded land independent of acquisition geometry and environmental conditions. • Detection of flooded areas under vegetation canopies and of flooded urban areas required. • Current data sources: RADARSAT-2, Sentinel-1 • Frequency: C+L or C+S: S & L-band could assist detecting flooded forests, vegetation • Integration of concurrent optical data would be valuable (resolution up to 3m in a visible spectrum).	**Area of interest:** Varies annually **Coverage Frequency:** 3-4 times daily	**Data Latency:** 30 min
[LAN-500]	**Soil Moisture Data Assimilation**	For inclusion in GC's land data assimilation system, in order to provide	3 - Emerging	Soil moisture, numerical modeling	**Other considerations:** • SAR data currently a complementary source of information for assimilation into numerical weather modeling. It is not used	**Areas of Interest:** Canada's agriculture regions	**Data latency:** 12 h (T) 2 h (G)

		analyses for environmental applications including weather, hydrology, agriculture, and forest fires.			yet operationally for soil moisture. First implementation would be with RCM, but the value of C-band active measurements would increase with increased temporal and spatial coverage. • An instrument on board that would be quite valuable for NWP is a GNSS receiver for radio-occultation (RO). Small instrument with significant impact on forecasts.	(prairies, southern Ontario and southern Quebec) (T). Eventually national, continental, and even global coverage (G). **Coverage Frequency:** 1-3 days	
[LAN-510]	**Soil Moisture for Agriculture**	Mapping of surface soil moisture during the growing season.	2-Pre-Operational for SAR 1. Operational for Passive Microwave	Volumetric surface soil moisture content over agricultural land.	**Spatial Resolution** for Agriculture Region of Canada: (Sub-field level): 30 m (T) 10-20 m (G) Coarser (e.g. best resolution of passive microwave) for entire Canada terrestrial landmass. **Other considerations:** • Both SAR and passive microwave are needed for this application. • SAR: C & L band, RADARSAT-2, Wide Fine Quad-Pol currently used; Gaps if confliction with OGDs. • Passive Microwave**:** L-Band, SMAP currently used.	**Areas of interest:** Agricultural region of Canada / Specific regions at high resolution (i.e. radar). Ref. Section 5.8. Canada terrestrial landmass at lower resolution (i.e. passive microwave). **Coverage Frequency:** Weekly & on-demand	**Data Latency:** 24 h (T)

						when needed (May – September).	
[LAN-600]	**Land Cover / Land Use Classification**	The Annual Space-Based Crop Inventory (ACI) maps crop type at the field level annually across Canada's agricultural extent.	1. Operational	Agricultural and non-agricultural land use and land cover.	**Spatial Resolution** (Sub-field level): 30 m (T) 10-20 m (G) **Other considerations:** • Optical: R, NIR & SWIR bands critical, Landsat-8 currently used, AwiFS-type swath; Gaps over cloudy regions; • SAR: C-Band (Multi-Pol), though Multi-Frequency desired, RADARSAT-2 currently used, ScanSAR Wide-type swath; Gaps if confliction with OGDs. • Without optical data ACI cannot be generated. Without SAR, the ACI could still be produced with optical data, but would lead to lower overall classification accuracies (accuracies of 5-15% less in places).	**Area of interest:** Agricultural region of Canada and international sites (JECAM experiments). (Ref. Section 5.9) **Coverage Frequency:** >3 overpasses per growing season (April – Nov)	**Data Latency:** 1 week (T)
[LAN-610.1]	**Crop Condition Assessment - Vegetation biophysical monitoring**	Weekly mapping of vegetation biophysical condition using Canadian Ag-Land Monitoring System (CALMS). Used to identify areas of poor and high plant productivity to help target various GC programs.	1-Operational (Optical) 3-Emerging / 2-Pre-Operational (SAR)	Vegetation biophysical variables over agricultural land.	**Spatial resolution** (Sub-field level): 30 m (T), 80 m (T) for TIR 5 m (G) **Other considerations:** • Optical data is currently essential. • Optical: R, NIR & SWIR bands critical. B, G, Y bands desirable; Two bands within "red edge" preferable; TIR (critical for ET). MODIS currently used; Dependencies on USGS LP-DAAC does not ensure timely data delivery (<48 h). Effort to transition to new sensor post-MODIS. • SAR: C-band (RADARSAT-2, Fine Quad-Pol Mode currently used); Gaps if confliction with OGDs.	**Areas of Interest:** Agricultural region of Canada / Specific regions. **Coverage Frequency:** Weekly (March – October).	**Data Latency:** 24 h (T)

					• Needed measurements includes: NDVI; LAI; Yield; Above-ground Biomass; Evapotranspiration; Surface Temp.		
[LAN-610.2]	**Crop Condition Assessment - Vegetation biochemical monitoring**	Weekly mapping of vegetation biochemical condition across Canada's agricultural extent.	3. Emerging	Vegetation Biochemical variables over agricultural land	**Spatial resolution** (Sub-field level): 30 m (T) 10 m (G) **Other considerations:** • Optical: Definition of "red edge" critical; Two bands within "red edge" preferable. • Wide swath (AWiFS-type). • Needed measurements includes: Leaf chlorophyll; leaf N; PRI; other Photo-chemical Indices].	**Areas of Interest:** Agricultural region of Canada / Specific regions. **Coverage Frequency:** Weekly	**Data Latency:** 72 h (T)
[LAN-620.1]	**Grassland and Rangeland Condition Assessment - Mapping grassland and rangeland extent**	The Annual Space-Based Crop Inventory (ACI) maps grassland and range-land annually across Canada's ag extent. The ACI grassland and range-land extents are used to: (a) calculate acreage under these types; (b) track spatio-temporal changes in ag-related land use; (c) create Agri-Environmental Indicators (AEIs) for reporting purposes.	1. Operational (as part of the ACI)	Extent of grassland, rangeland and pasture.	**Spatial resolution** (Sub-field level): 30 m (T) 10 m (G) **Other considerations:** • Optical: R, NIR and SWIR; Wide swath (AWiFS-type); Landsat-8 currently used; Gaps over cloudy regions. • SAR: C-Band ScanSAR-type swaths; RADARSAT-2 Wide Mode currently used; Gaps if confliction with OGDs. • Without optical data ACI cannot be generated; without SAR, ACI would be produced with optical data with lower classification accuracies.	**Areas of Interest:** Agricultural region of Canada (western provs.) **Coverage Frequency:** Monthly, during growing season (May – Sept).	**Data Latency:** 1 week (T)

[LAN-620.2]	**Grassland and Rangeland Condition Assessment - Estimating grassland and rangeland health**	Weekly mapping of grassland condition using Canadian Ag-Land Monitoring System (CALMS). CALMS used to identify areas of poor and high plant productivity to help target various GC programs.	1. Operational (Optical, as part of CALMS) 2. Pre-Operational (SAR)	Vegetation biophysical variables over grassland, rangeland and pasture.	**Spatial resolution** (Sub-field level): 30 m (T), 80 m (T) for TIR 5 m (G) **Other considerations:** • Optical data is currently essential. • Optical: R, NIR & SWIR bands critical. B, G, Y bands desirable; Two bands within "red edge" preferable; TIR (critical for ET); Wide swath (AWiFS-type); MODIS currently used. Dependencies on USGS LP-DAAC archive that does not ensure timely delivery (<48 h) of data. Concerns over MODIS life-span and effort to transition to new sensor. • SAR: C-band; ScanSAR-type swaths; RADARSAT-2, Fine Quad-Pol currently used; Gaps if confliction with OGDs. • Needed measurements includes: Biomass production, Amounts of photosynthetic and non-photosynthetic vegetation, bare soil ground cover.	**Areas of Interest:** Agricultural region of Canada. **Coverage Frequency:** Weekly (March-Oct)	**Data Latency:** 24 h (T)
[LAN-620.3]	**Grassland and Rangeland Condition Assessment - Estimating grassland and rangeland health – invasive plant**	Weekly mapping of invasive plant species. Data used to identify invasive plant species, detect new infestations and quantify success of control programs.	3. Emerging	Invasive plant species in grassland, rangeland and pasture	**Spatial resolution** (Sub-field level): 20 m (T) 5 m (G) **Other considerations:** • Optical: Visible, NIR and SWIR; Wide swath (AWiFS-type). • SAR: C-band.	**Areas of Interest:** Agricultural region of Canada (western prov.) **Coverage Frequency:** Weekly	**Data Latency:** 1 week (T)
[LAN-630.1]	**Land Management-Tillage and crop residue mapping**	Weekly mapping of the tillage intensity of agricultural land across Canada's ag extent.	3. Emerging	Tillage intensity of agricultural land.	**Spatial resolution** (Sub-field level): 30 m (T) 10-20 m (G) **Other considerations :** • Optical: R, NIR & SWIR bands critical; Wide swath (AWiFS-type); Landsat-style	**Areas of Interest:** Agricultural region of Canada / Specific regions.	**Data Latency:** 1 week (T)

		Data used to: (a) map crop residue; and (b) characterize tillage status.			multispectral scanners currently used; Gaps over cloudy regions; Finer spatial resolution, more timely data may give more accurate estimates. • SAR: X, C & L Band (better characterization of roughness would be helpful); ScanSAR-type swaths; RADARSAT-2 currently used; Gaps if confliction with OGDs. • Needed measurements includes: crop residue cover (total and fraction of surface) and surface roughness (RMS).	**Coverage Frequency:** Weekly, but limited to fall and spring.	
[LAN-630.2]	**Land Management-Estimation of soil properties**	Weekly mapping of soil properties of agricultural land across Canada's agricultural extent. Data used to map soil physico-chemical properties.	3. Emerging	Physico-chemical soil properties over agricultural land.	**Spatial resolution** (Sub-field level): 30 m (T) 10 m (G) **Other considerations:** • Optical : NIR and SWIR; Wide swath (AWiFS-type); • SAR: X, C & L Band; ScanSAR-type swaths. • Needed measurements includes: Soil texture; organic matter; drainage; P, K, M3-Al, etc.	**Areas of Interest:** Agricultural region of Canada / Specific regions. **Coverage Frequency:** Weekly, but limited to fall and spring.	**Data Latency:** 1 week (T)
[LAN-630.3]	**Land Management-Prescription mapping for variable management of agricultural inputs and crop yield**	Prescription mapping for variable management of agricultural inputs and crop yield at field scale. Data used to map soil physico-chemical properties.	3. Emerging	Crop Yield	**Spatial resolution** (Sub-field level): 10 m (T) **Other considerations:** SAR: C-Band; ultrafine-type swaths; RADARSAT-2 Fine and Ultrafine modes currently used.	**Area of Interest:** Agricultural region of Canada / Prairie Provinces. **Coverage Frequency:** Weekly/Spring	**Data Latency:** 1 week (T)

[LAN-700]	**Forest canopy height mapping and monitoring**	Forest height is an important indicator of timber production and closely related to forest biomass in forestry.	3- Emerging	Forest canopy height	**Spatial resolution:** 10 m **Noise floor** Lower than RCM (e.g. RCM: <-25dB for 16m, <-19dB for 5m) **Other considerations:** • Single-pass tandem radar interferometry • Current data source: single-pass dual-copol/single-pol modes of TanDEM-X radar interferometry • Tandem mission critical to avoid temporal decorrelation • Wide swath and polarimetric modes • Multi-frequency preferred • Choice of different baselines	**Area of interest:** Large scale managed and non-managed forests mapping in Canada Currently R&D over sites in BC, AB, NWT and ON **Coverage Frequency:** Seasonal coverage for change detection and monitoring	
[LAN-710]	**Biomass mapping and monitoring**	Forest biomass along with related structural attributes (basal area, volume) and its dynamic is a key for national forest inventory (NFI), forest productivity assessment and bioenergy inventory.	2- Pre-operational	Live abovegroun d forest biomass	**Spatial resolution:** 25-50 m **Polarization:** Compact-pol **Other considerations:** • C-band is more useful within forests with low biomass levels or within treed wetlands. • In general, C-band datasets mostly useful when fused with L-band SAR and optical datasets • Radar modes/temporal requirements can be largely harmonized with those needed for height mapping and wildfire mapping. • Background systematic acquisitions in proper mode needed to ensure yearly multi-seasonal national coverages.	**Area of interest:** National coverage with emphasis on unmanaged northern boreal forests. **Coverage Frequency:** Multi-year, multi-seasonal	

[LAN-720]	**Active wildfire mapping and fuel consumption monitoring**	Monitoring of fire extent as well as duff and peat consumption aids in wildfire spread and smoke dispersion modelling.	3-Emerging	Forest structure change and surface deformation due to forest fire	**Spatial resolution:** 10 m **Other considerations:** • Penetration of dense forest canopy not possible with RCM C-band; L-band would provide better penetration in dense forest. • Not currently operational as RS-2 24-day repeat cycle is insufficient for InSAR approach. • RCM would provide surface deformation/ground fuel consumption only in open forest and wetlands; L-band and tandem mission would help to extend this to denser forest.	**Area of interest:** Entire forested area of Canada **Coverage Frequency:** Multi-seasonal radar interferometry monitoring for pre-burn areas and ones for post fire conditions. The first post-fire should be within 3-4 days after fire (1-2 days would be ideal)	**Data Latency:** NRT delivery for post fire
[LAN-800]	**Infrastructure Integrity Monitoring**	Monitor infrastructure and surrounding terrain to assess risk to integrity	1-Operational	3-dimensional terrain displacement Infrastructure stability Feature detection and characterization over	**Spatial Resolution:** 5 m for 3D terrain displacement 3 m for infrastructure stability **Polarization:** Polarimetric (or compact-pol) data required to support PolInSAR methods **Other considerations:** • InSAR approach used for 3D terrain displacement and infrastructure stability • Highly accurate orbital vector needed (equivalent to European missions) needed for 3D terrain displacement.	**Area of Interest:** no standard AOIs (projects dependent). **Coverage Frequency:** Daily **Coherent Change**	

				time (e.g. debris, soil)	• Measuring change in amplitude over wide range of incidence angles on a daily basis for feature detection. • Multiple viewing geometries / look directions needed to support 3-D analysis. The displacement of some terrain cannot be measured accurately via a near-polar orbit. As such, potential value in combination of data acquired by near-polar and non-near polar orbits. • Consider platforms with multiple orbital tubes to accommodate various needs (e.g. vertical structure via tomography vs. surface displacement via traditional InSAR) • Measurements required in vegetated/forested areas – L-band needed.	**Detection Revisit:** 4 days for C-band 6-8 days for L-band	
[LAN-810]	**Infrastructure Damage Assessment**	Detecting change in built infrastructure integrity (e.g. roads, rail, bridges, and buildings) due to use and hazards (e.g. earthquakes).	2-Pre-Operational	Identify post-event changes in infrastructure and surrounding environment	**Spatial Resolution:** 3 m **Polarization:** Polarimetric (or compact-pol) data required **Other considerations:** • Highly accurate orbital vector needed (equivalent to European missions) • Baseline datasets over critical infrastructure and urban areas required • Concurrent high resolution optical (incl. LiDAR) is strong complement • Multi-frequency approach (e.g. C and L) will improve target characterization and change detection	**Area of Interest:** no standard AOIs (projects dependent). **Coverage Frequency:** Daily	**Data Latency:** (<15 min) when responding to events. **Fast-tasking:** Required when responding to events.
[LAN-820]	**Monitoring Seismically Active Areas and Volcanoes**	Assessment of seismicity and source mechanisms for hazard estimation.	2-Pre-Operational	Multi-dimensional surface deformation over regional areas	**Spatial Resolution:** 5-10 m **Polarization:** Polarimetric data may improve deformation measurements through better target coherence. **Other considerations:**	**Area of Interest:** Targeted 50x50 km patches over Canada's actively seismic areas	

					• InSAR approach to measure mm-scale ground deformation • Highly accurate orbital vector needed (equivalent to European missions) • Ascending and descending passes for 2-dimensional deformation • Information informs understanding of events and improves earthquake and volcano hazard forecasts. • Non-polar orbits could be useful for 3-D deformation • Multi-frequency approach (e.g. C and L) will improve measurements due to better coherence and atmospheric correction (ionosphere). • Concurrent estimate of water vapour within imaging path would improve InSAR measurements.	(1/3rd of Canada) **Coverage Frequency:** Weekly	
[LAN-830]	**Rapid Earthquake Characterization**	Measure large scale surface deformation related to earthquakes.	1-Operational	Co-seismic surface deformation	**Spatial Resolution:** 5-10 m **Other considerations:** • InSAR approach to measure centimetre-scale ground deformation • Baseline datasets required over seismically active areas • Highly accurate orbital vector needed (equivalent to European missions) • Although currently using R-2 and Sentinel-1 data, latency is a severe limitation of current approach. • Seismic data can be combined with co-seismic InSAR deformations to obtain improved estimates of earthquake properties (operational in other countries) • Concurrent estimate of water vapour within imaging path would improve InSAR measurements.	**Area of Interest:** Specific regions (50 x 50 km) immediately after an earthquake	**Data Latency:** <15 min when responding to events. **Fast-tasking:** Required when responding to events.
[LAN-840]	**Assessing Induced Surface Deformation**	Assessment of ground deformation related to human	1-Operational	Multi-dimensional surface deformation	**Spatial Resolution:** 3 m **Polarization:**	**Area of Interest:** no standard AOIs	

		activities (e.g. oil sands steam injection, CO2 injection, water withdrawal and injection).		over regional areas	Polarimetric data may improve deformation measurements through better target coherence. **Other considerations:** • InSAR approach to measure mm-scale ground deformation measured over target areas • Highly accurate orbital vector needed (equivalent to European missions) • Ascending and descending passes for 2-dimensional deformation • Non-polar orbits could be useful for 3-D deformation • Multi-frequency approach (e.g. C and L) will improve measurements due to better coherence and atmospheric correction (ionosphere). • Concurrent estimate of water vapour within imaging path would improve InSAR measurements.	(projects dependent). **Coverage Frequency:** Weekly	
[LAN-900]	**Domestic and Arctic Land Surveillance**	Defence and security of Canada, which includes search and rescue operations. Use of SAR for imaging land in coastal areas can provide data to improve shoreline data.	1-Operational [2-Pre-Operational for low-latency cross-cueing and 3-Emerging for real-time motion of object]	Imagery for land surveillance.	**Spatial resolution:** SAR: Several imaging modes from high-resolution (1 m x 1 m) narrow swath for high-resolution imagery applications including search and rescue to medium-resolution (15 m x 15 m) wide swath to provide imagery of larger areas in case of events (e.g., flood mapping, natural disaster assistance). Also background coverage of the entire landmass at 5m resolution. There are no requirements for imagery with resolution > 50 m. Visible, IR and hyperspectral: 0.5 m **Moving Target Indication:** Detect real-time motion of objects as small as a vehicle (~3m) at velocities higher or equal to 2.8 m/s (10 km/hr). **Other considerations:** • Space-based SAR is one of the most suitable remote sensing systems for	**Area of Interest:** Canada's land mass and Arctic region. **Coverage Frequency:** For background coverage of entire landmass: yearly north of tree line, twice yearly (winter and summer) south of tree line.	**Data Latency:** 15 min **Fast tasking:** Half orbit (~50 min)

					surveillance of Canada's North: remoteness, harsh environment and extended darkness for much of the year. • There is also a need for visible, IR, and hyperspectral imagery to complement the SAR. • Low-latency cross-cueing between such sensors is needed in order to aid in the classification and the analysis of targets of interest.		
[LAN-910]	**Expeditionary Land Surveillance-Strategic**	To monitor numerous areas of the globe for defence and security purposes in support of operations such as generating intelligence products, intelligence preparation of the battlefield, humanitarian relief, disaster relief, and search and rescue. These areas can and will change depending on events.	1-Operational [2-Pre-Operational for Low-latency cross-cueing and 3-Emerging for real-time motion of object]	Monitoring and detecting changes for numerous areas of the globe.	**Spatial Resolution:** 5 m x 5 m (T) **Geolocation Accuracy:** 5 m (T) (One resolution cell) **Change Detection:** Use of change detection techniques such as Amplitude Change Detection (ACD) and Coherent Change Detection (CCD) under appropriate conditions is implied. **Moving Target Indication:** Detect real-time motion of objects as small as a vehicle (~3m) at velocities higher or equal to 2.8 m/s (10 km/hr). **Digital Elevation Models (DEMs):** Accuracy: +/- 50 cm with post spacing of 50 cm. **Other considerations:** • Day/night and all weather surveillance dictate that a radar surveillance capability is required to support this mandate. • Visible, IR and hyperspectral data are highly complementary to SAR data. • Low-latency cross-cueing between such sensors is needed in order to aid in the classification and the analysis of targets of interest.	**Areas of interest:** Up to 100 AOIs up to 125 km x 125 km (classified AOIs). **Coverage Frequency:** 50 AOIs: daily, 50 AOIs: twice a week. Global Access is needed (exclusion of lat<-80° is acceptable). Ad-hoc requirements based on geo-political events will require additional imaging capacity.	**Data Latency:** 15 min **Fast tasking:** Half orbit (~50 min)

					• Space-based surveillance technology has expeditionary surveillance applications which can aid in the defeat of camouflage, detection of explosives, tunnel detection and/or other intelligence products; • Several imaging modes of various resolutions/swaths are needed (Ref. [LAN-900]).	**Change Detection:** 4 days (T)	
[LAN-920]	**Expeditionary Land Surveillance -Tactical**	To monitor numerous areas of the globe for defence and security issues in support of operations such as generating intelligence products, intelligence preparation of the battlefield, humanitarian relief, disaster relief, and search and rescue.	1-Operational [2-Pre-Operational for Low-latency cross-cueing and 3-Emerging for real-time motion of object]	Monitoring and detecting changes for facilities of interest, including: buildings, bridges, camps, ports, airfields, and other objects/anomalies.	**Spatial Resolution:** 1 m x 1 m. **Geolocation Accuracy:** 1 m (T) (One resolution cell) **Change Detection:** Use of change detection techniques such as Amplitude Change Detection (ACD) and Coherent Change Detection (CCD) under appropriate conditions is implied. **Moving Target Indication:** Detect real-time motion of objects as small as a vehicle (~3m) at velocities higher or equal to 2.8 m/s (10 km/hr). **Digital Elevation Models (DEMs):** Accuracy: +/- 50 cm with post spacing of 50 cm. **Other considerations:** • Day/night and all weather surveillance dictate that a radar surveillance capability is required to support this mandate. • Visible, IR and hyperspectral data are highly complementary to SAR data. • Low-latency cross-cueing between such sensors is needed in order to aid in the classification and the analysis of targets of interest.	**Areas of interest:** Up to 150 AOIs up to 5 km x 5 km, worldwide (classified AOIs). Global Access is needed (exclusion of lat<-80° is acceptable). **Coverage Frequency:** Daily **Change Detection:** 4 days (T)	**Data Latency:** 15 min **Fast tasking:** Half orbit (~50 min)

4.3 GC NEEDS RELATED TO DATA AVAILABILITY AND CONTINUITY, DATA ACCESS AND USE, SECURITY AND NETWORK

Data Availability and Continuity:

[DAC-010] Continuity. There is a need to ensure SAR data continuity to avoid any gap in the operational applications.

[DAC-020] Reliability. For operational applications, it is critical to have a predictable and reliable access to near-real time data.

[DAC-030] Scalability. There is a need for the system to be scalable to allow for potential growth of the demand.

Data Access and Use:

[DAT-010] Orders Override. The capability to override other orders for purposes of health and safety of the system, emergency responses, national security events, or other urgent operations (24/7 operations) is essential.

[DAT-020] Real-Time Acquisition Planning. The capability to receive, process, and affect changes to the acquisition plan continuously in real-time is needed.

[DAT-030] Priority Schema with Feedback. There is a need for an automated priority schema with feedback in the event of conflicting acquisition requirements.

[DAT-040] Data Sharing. Data sharing with partners inside or outside the GC is essential (including other countries).

> *Note: Data sharing is specifically needed for ice monitoring (e.g. NAIS), oil pollution, lake and river ice monitoring (US shared transboundary water areas), Winds (e.g. NOAA), defense and security (may extend beyond 5-Eyes, NATO, or other Canadian partners as there may be operations where sharing with NGOs is required), and Agriculture applications. Data includes raw data, imagery and value-added products.*

[DAT-050] Archiving. Need for an archive for the data from all sensors as well as derived information products, which can be easily and efficiently exploited.

[DAT-060] Data Analysis Tools. Data analysis tools are needed to enable and simplify processing of the vast amount of information gathered by the space assets.

> *Note: This includes advanced processing to exploit other parameters of the data collected, to include as a minimum: Track history, Anomaly detection, Big data manipulation & product reports and Predictive analytics.*

[DAT-070] Efficient Data Processing, Exploitation and Dissemination. There is a need for automated, semi-automated, and manual operations for data processing, exploitation and dissemination.

> *Note: On-board processing can be explored as an option.*

[DAT-080] Extended Data Access. Access to archived data and their processing, exploitation and dissemination is needed until a point in time that there remains no further relevance or operational utility to the archived data (beyond the life of the space assets).

[DAT-090] Interoperability. For defence applications, there is a need for the system to be interoperable with other national and 5-Eyes systems within a system-of-systems operational context to the maximum extent possible.

> *Note: Factors that affect interoperability include: sovereign control of the system, data sharing, security policies and collection priorities.*

[DAT-100] Allied System Tasking. For defence applications, there is a need for the system to permit Allies to submit low-latency acquisition requests.

[DAT-110] Big Data Exploitation. There is a need for the data archive to be able to receive and exploit data from other systems and archives.

> *Note: This includes the ability to search for data and information products within operational timelines using simple tools and interfaces, which can process and analyze large volumes of data.*

[DAT-120] Data Format. There is a need for the data to be in a suitable format(s) to enable integration into other systems, including classified systems via their safe-guards.

[DAT-130] Training. There is a need for training to ensure GC stakeholders understand the potential, utility and applications associated with the system.

> *Note: This includes tailored training for different levels (from a high level understanding of the capability, to exploitation, maintenance and upgrade of the system), as well as periodic training to account for change in personnel.*

Security:

[SEC-010] Security & Protection Measures. Security and protection measures need to be in place to protect the assets from potential hostile events or accidents.

> *Note: This includes the capability to perform a maneuver in the event of a possible conjunction.*

[SEC-020] Ground Infrastructure & Network Security. The system ground infrastructure and network connectivity is required to be protected in accordance with physical, network and cyber security policies.

[SEC-030] Unclassified & Classified Operations. There is a need to support unclassified and classified (SECRET) operations for the whole process from tasking to dissemination and archival.

> *Note: Dissemination should also include TOP SECRET level (Ref. [NET-040]).*

[SEC-040] Jamming, Blinding, or Interference. Protective measures need to be in place to protect sensitive remote sensing components from being damaged in the event of jamming, blinding, or interference.

[SEC-050] Restricted Visibility. There is a need to be capable to restrict visibility into the data ordering system and the geospatial data archive.

[SEC-060] Security & Privacy of Canadians. There is a need to be capable of filtering and/or automatically censoring information (also known as minimization) on Canadians.

Network:

[NET-010] Network Connectivity for Sharing. There is a need to have network connectivity with GC and Allied systems, including DWAN, GCNet, CSNI, Stone Ghost, Enhanced Imaging, and Reporting & Exploitation System (EIRES) and Spartan.

[NET-020] Product Ordering & Delivery. There is a need to include a networked connection and interface to simplify product ordering and delivery.

[NET-030] Network Bandwidth. There is a need for a large enough bandwidth to allow for timely access (<5 minutes) and retrieval of data from the archive and allow for the full exploitation of all data generated by the system.

[NET-040] Cross-Domain Connectivity. There is a need for the system interface to be capable of real-time cross-domain connectivity, allowing automatic transfer to operational systems at all three levels of security (UNCLASS, SECRET and TOP SECRET).

4.4 CONSTRAINTS

[CON-010] Duration. The proposed solutions must ensure data continuity for a minimum duration of 15 years.

[CON-020] Compliance with GC Legislations, Directives and Policies. The proposed solution must comply with GC legislations, directives and policies, including but not limited to: Remote Sensing Space Systems Act (RSSSA), security policies and the spirit of the GC Open Data Directive (within the limitations of the applicable laws and security constraints).

4.5 OTHER CONSIDERATIONS

The proposed solution should take advantage of the existing Canadian ground infrastructures developed for the RCM to the maximum extent possible, when it is cost effective to do so. This also includes considering continuity of the RCM data format to minimize the impacts on the operations.

Also, for several applications described in this document, a technological change (e.g. different frequency band) could require substantial modifications to the current methods/algorithms, which should be taken into consideration when assessing different options.

It should also be noted that there is a possibility that additional classified needs, not covered in this document and with a TBD level of classification, may eventually be added.

5 AREAS OF INTEREST

5.1 ICE MONITORING AOIS [MAR-100]

The areas of interest for ice monitoring are season-dependent. For simplicity, the entire Ice Monitoring Canadian AOI is shown.

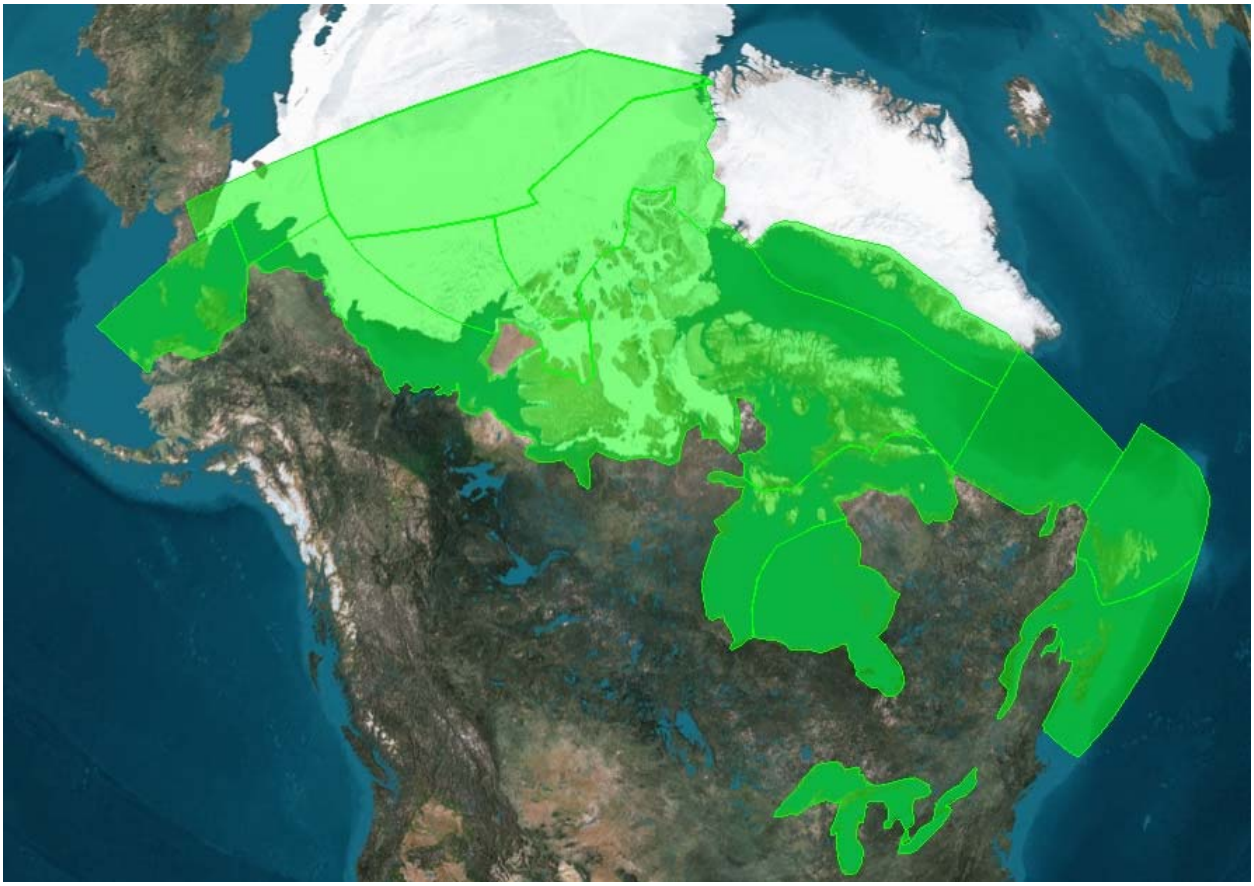

Figure 5-1: Entire Ice Monitoring Canadian AOI (seasonal dependency not shown).

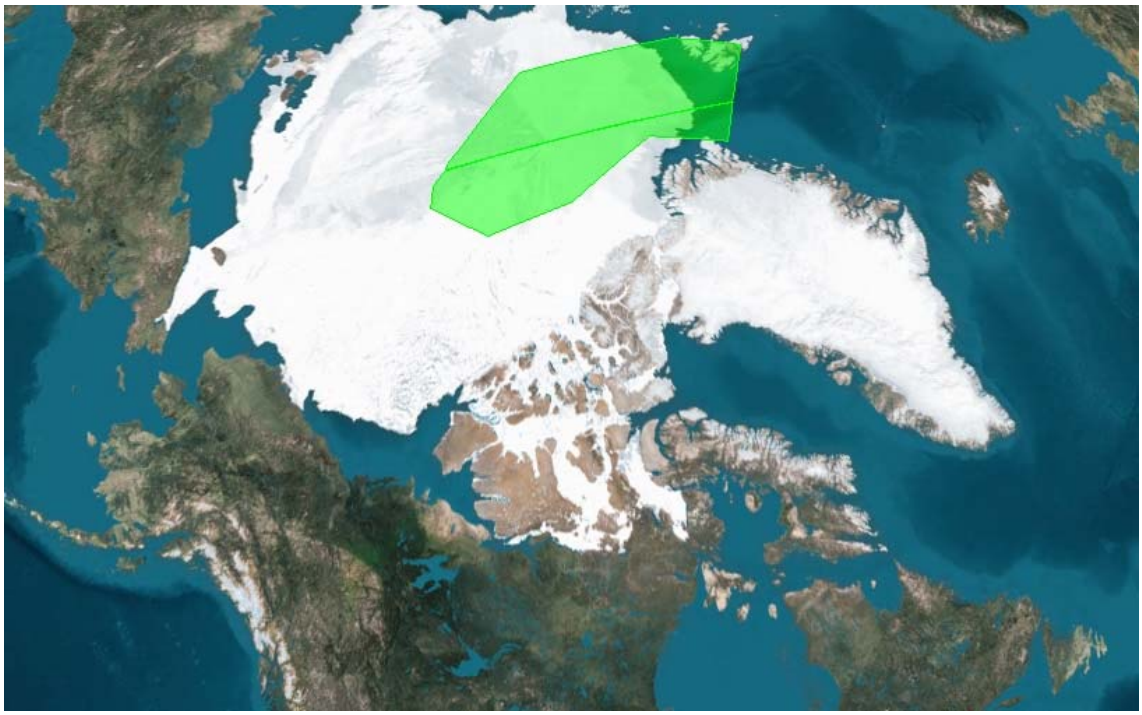

Figure 5-2: North Pole AOI for Ice Monitoring.

5.2 OIL POLLUTION (INCL. MOST OF NATIONAL SAR WINDS) AOIS [MAR-120]

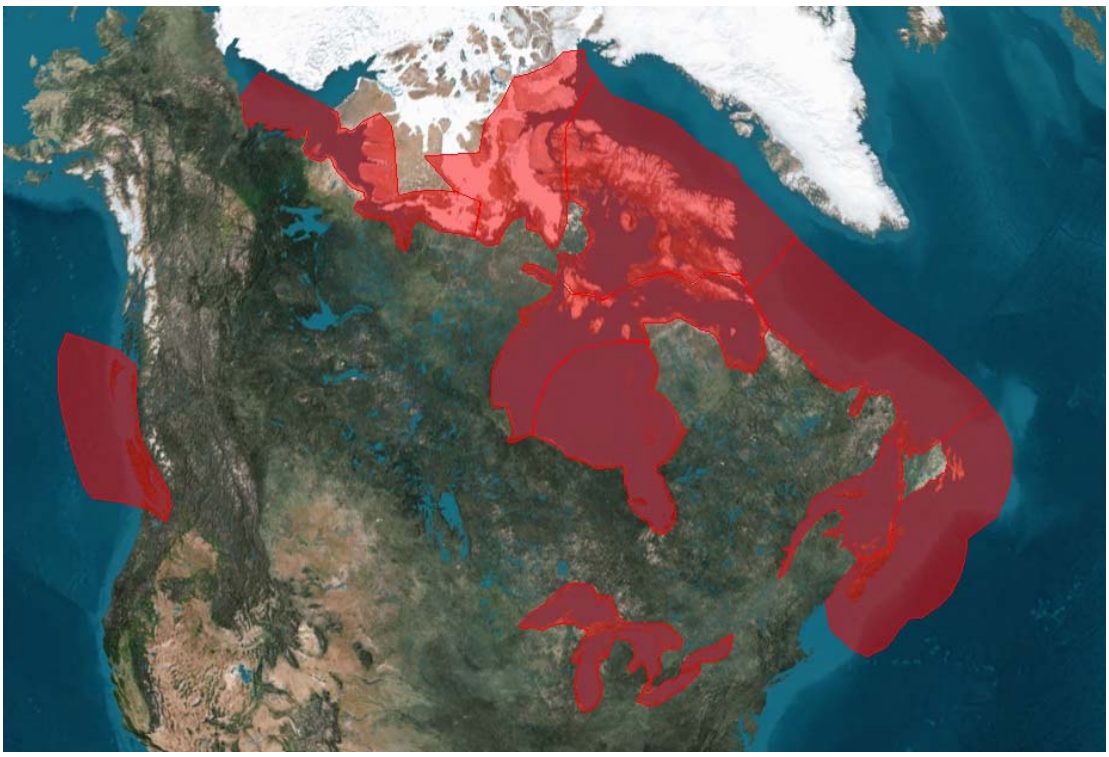

Figure 5-3: Entire Oil Pollution Canadian AOI including most part of National SAR Winds regions (seasonal dependency not shown).

5.3 ICE DYNAMICS AOIS [MAR-150]

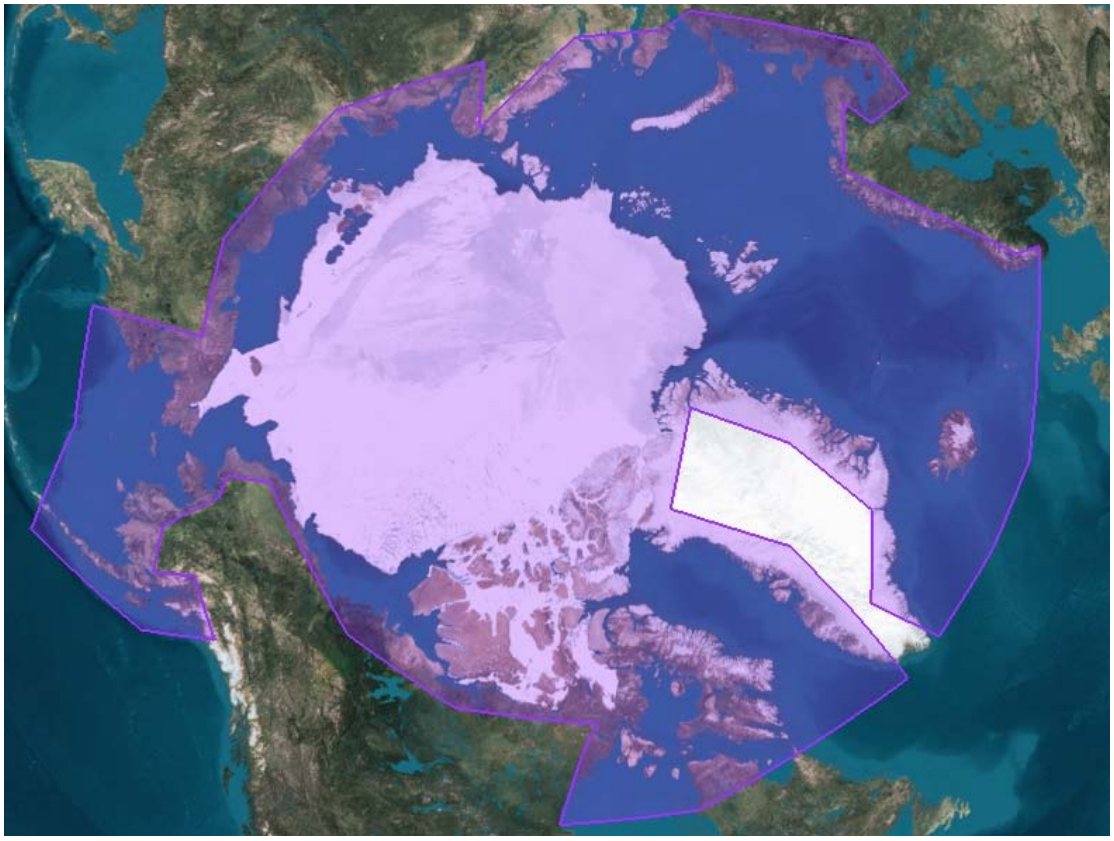

Figure 5-4: Pan-Arctic AOI for Ice Dynamics.

5.4 NORTH AMERICAN & ARCTIC MARITIME SURVEILLANCE AOIS [MAR-200]

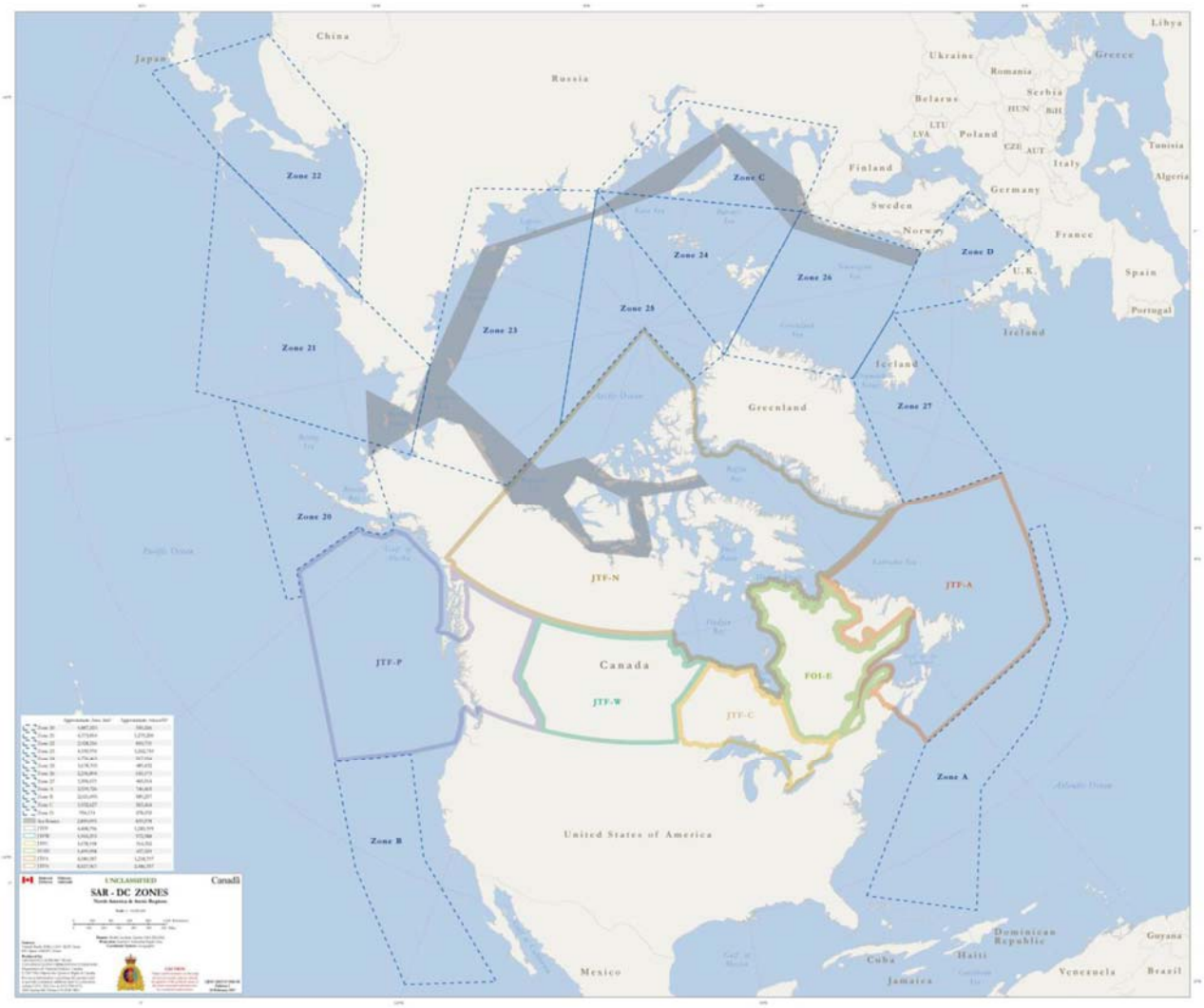

Figure 5-5: North American & Arctic AOIs.

Zone	Region	Area (nm^2)	Coverage Frequency
JTF-A	Canadian Atlantic	1,218,797	4 times daily (year round) – only maritime portion
JTF-N	Canadian North	2,486,357	4 times daily (year round) – only maritime portion
JTF-P	Canadian Pacific	1,285,399	4 times daily (year round) – only maritime portion
20	Bering Sea	550,226	Once daily (year round)
21	NW Pacific Artic	1,093,709	Once daily (year round)
22	Sea of Japan	953,261	Once every 3 days (year round)
23	E Siberian Sea	1,262,710	Once daily (year round)
24	Svalbard	523,098	Twice daily (year round)
25	S Barent Sea	489,432	Once daily (year round)

26	Norwegian Sea	634,303	Twice daily (year round)
27	W Greenland Sea	412,479	Once every 3 days (year round)
A	US Continental E	740,465	Once daily (year round)
B	US Continental W	589,257	Once daily (year round)
C	Barents Sea	563,464	Twice daily (year round)
D	North Sea	278,192	Twice daily (year round)
	Shipping Lines 1&2	822,578	4 times daily during the Jul-Sep shipping season (Indicated by grey area)

There are three ship detection applications:

1) Ice Free – West coast of Canada & East Coast, South of 45 degrees latitude. This region of the Canadian Domestic AOI requires a wide swath, high enough resolution, with sufficient sensitivity to classify a ship, but not necessarily to discriminate the ship from a false detection due to icebergs.
2) Icebergs Possible – Between 45 and 75 degrees latitude – the surveillance problem becomes a hybrid of ships in ice when frozen and ships amongst icebergs when navigable. This requires a beam mode in high enough resolution, with sufficient sensitivity, and polarizations to discriminate between ships and icebergs when navigable, and ship tracks in ice when icebreaking.
3) Ice-breaking – Above 75 degrees latitude – At this latitude, the system must be capable of detecting ships breaking through ice. This requires a beam mode in high enough resolution with sufficient sensitivity to either detect a broken ice track left by ships, or to detect the ship itself within the ice matrix.

5.5 GLOBAL MARITIME SURVEILLANCE AOIS [MAR-210]

Figure 5-6: Central & South America AOIs (year round).

Figure 5-7: Northern Europe AOIs (year round).

Figure 5-8: Southern Europe AOIs (year round).

Figure 5-9: Arabian Sea AOIs (year round).

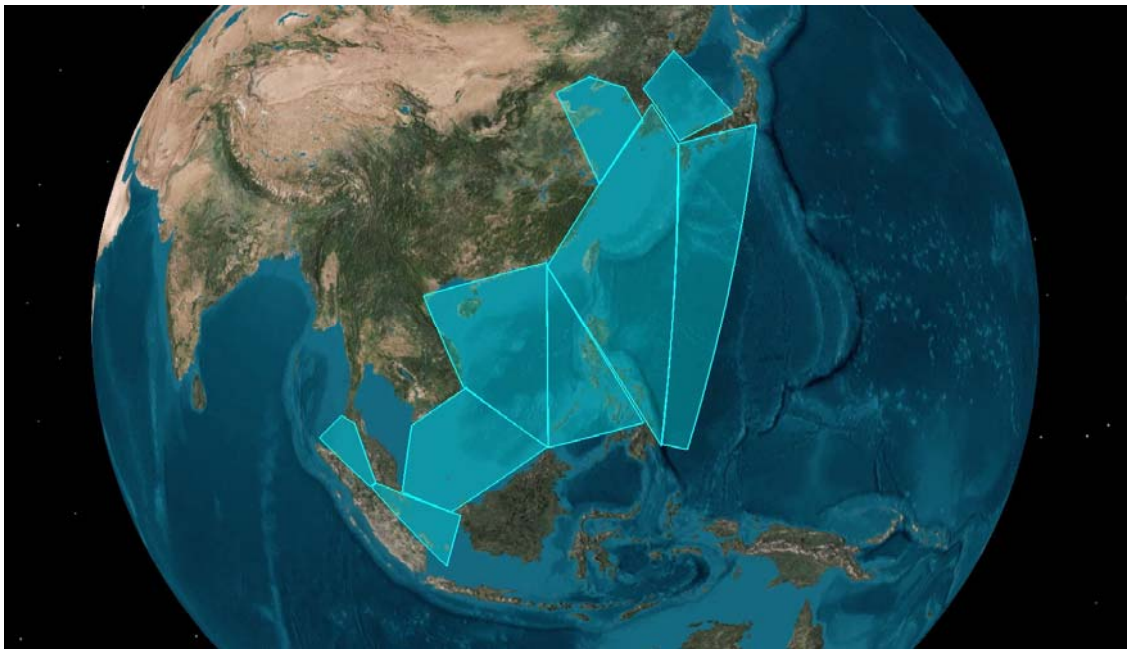

Figure 5-10: Pacific AOIs (year round).

Figure 5-11: West Africa AOIs (year round).

Figure 5-12: Central Pacific AOI (May-July only).

5.6 LAKE ICE MONITORING AOIS [LAN-100]

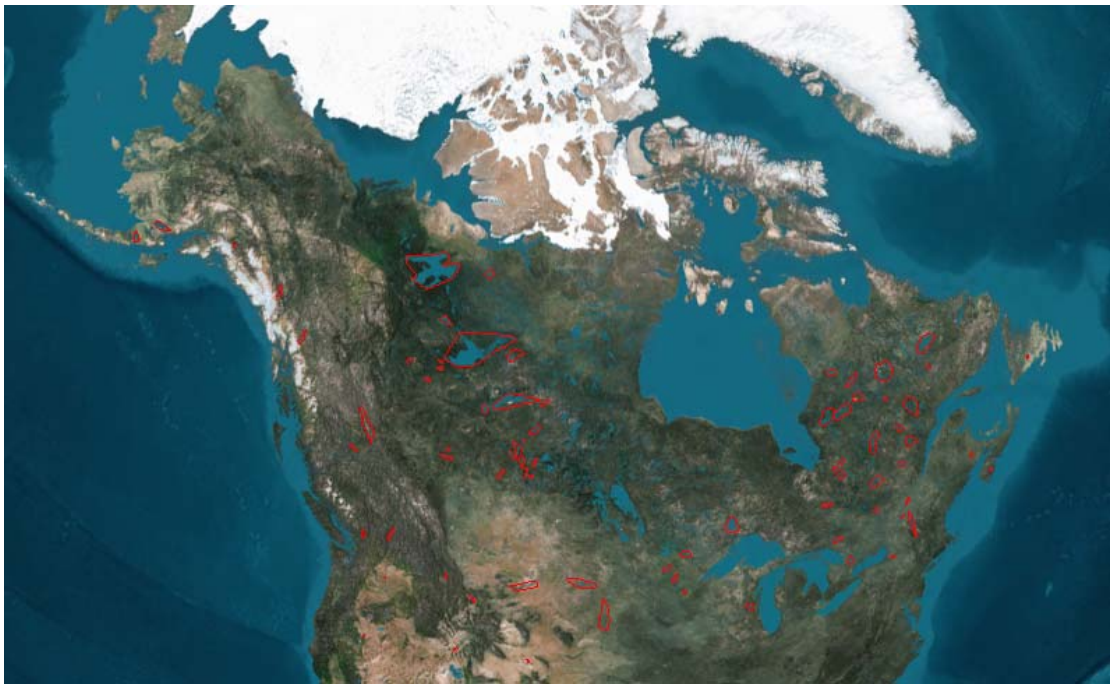

Figure 5-13: Lake Ice Monitoring AOIs (Jan-Feb).

Figure 5-14: Lake Ice Monitoring AOIs (March-April).

Figure 5-15: Lake Ice Monitoring AOIs (May-June).

Figure 5-16: Lake Ice Monitoring AOIs (July and Oct; none in Aug-Sep).

Figure 5-17: Lake Ice Monitoring AOIs (Nov-Dec).

5.7 ECOSYSTEM MONITORING AOIS [LAN-400]

These are the actual sites of interest. They are expected to evolve with time.

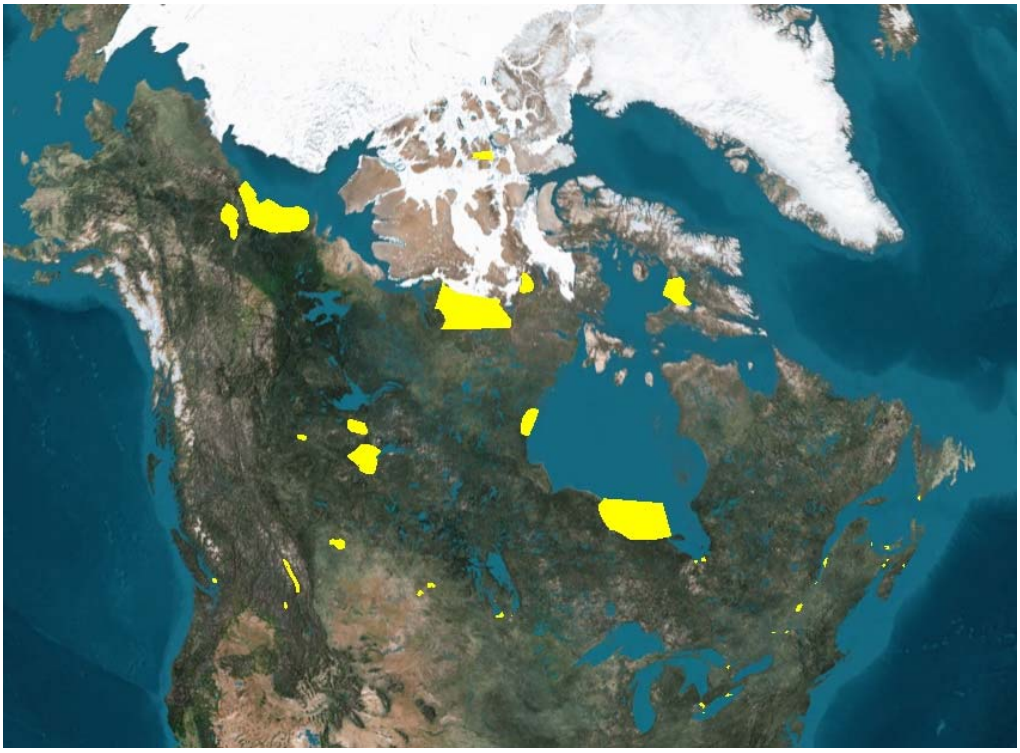

Figure 5-18: Ecosystem Monitoring actual AOIs.

5.8 SOIL MOISTURE FOR AGRICULTURE AOIS [LAN-510]

Figure 5-19: Soil Moisture AOIs.

5.9 LAND COVER AOIS [LAN-600]

Figure 5-20: Canadian Land cover AOIs.

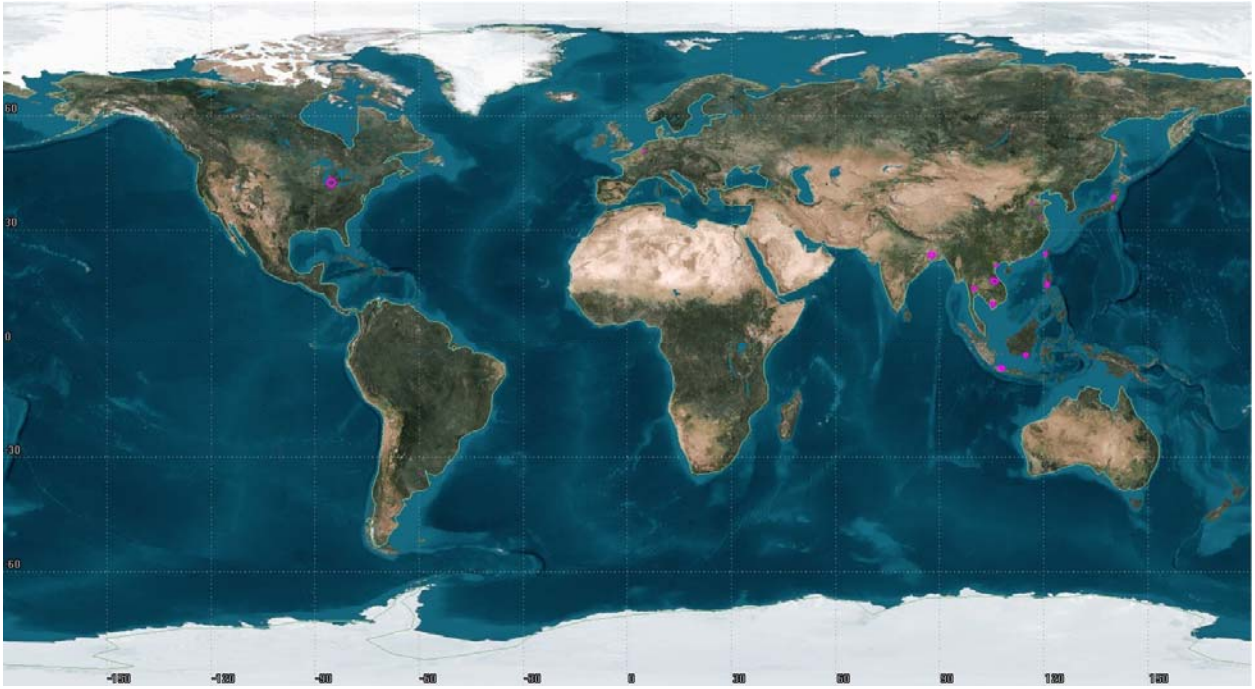

Figure 5-21: Current international land cover AOIs (JECAM).

6 ACRONYMS

The following provides a list of applicable acronyms.

Acronym	Definition
AIS	Automatic Identification System
AOI	Area of Interest
CMT	Common Maritime Transmission
COCI	Coastal Ocean Color Imager
CSA	Canadian Space Agency
CSNI	Consolidated Secret Network Infrastructure
DEM	Digital Elevation Model
DWAN	Defence Wide Area Network
EEZ	Exclusive Economic Zone
EIRES	Enhanced Imaging, Reporting & Exploitation System
EO	Earth Observation
ESA	European Space Agency
GC	Government of Canada
GCNET	Government of Canada Network
GNSS	Global Navigation Satellite System
ISTOP	Integrated Satellite Tracking Of Pollution
JECAM	Joint Experiment of Crop Assessment and Monitoring
MDA	Maritime Domain Awareness
MSOCs	Marine Security Operations Centres
MTI	Moving Target Indication
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NWP	Numerical Weather Prediction
RCM	RADARSAT Constellation Mission
RO	Radio Occultation
RSSSA	Remote Sensing Space Systems Act
SAR	Synthetic Aperture Radar
SDC	SAR Data Continuity