A Ten-Year Prioritization of Infrastructure Needs in the U.S. Arctic

National Strategy for the Arctic Region Implementation Plan Task 1.1.2

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Prepared By

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For the

U.S. Department of Transportation

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- U.S. Coast Guard
- Maritime Administration
- U.S. Department of Transportation, Office of the Secretary
- Department of State
- Environmental Protection Agency
- U.S. Army Corps of Engineers
- U.S. Navy
- National Maritime Intelligence Integration Office
- Department of Energy
- Bureau of Ocean Energy Management
- Bureau of Safety and Environmental Enforcement
- U.S. Transportation Command
- Executive Office of the President, Office of Science and Technology Policy
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EXECUTIVE SUMMARY

This document, "A Ten-Year Prioritization of Infrastructure Needs in the U.S. Arctic" (Prioritization Framework), presents a framework to address Arctic infrastructure gaps by identifying needs that are considered to be critical requirements for a safe and secure U.S. Arctic Marine Transportation System (MTS) over the next decade.

This report by the U.S. Committee on the Marine Transportation System (CMTS) fulfills directive 1.1.2 under the White House National Strategy for the Arctic Region (NSAR) 2014 Implementation Plan objective to "Prepare for Increased Activity in the Maritime Domain." The deliverable for 1.1.2 is to "Deliver a 10-year prioritization framework to coordinate the phased development of Federal infrastructure through Department and Agency validated needs assessment by the end of 2016." Transportation Secretary Anthony Foxx tasked this action to the CMTS in a May 2014 memorandum.

Using the CMTS 2013 report U.S. Arctic Marine Transportation System: Overview and Priorities for Action (CMTS 2013 Arctic Report) definitions, this Prioritization Framework organizes the U.S. Arctic MTS into five core components:[1]

- *Navigable Waterways*
- *Physical Infrastructure*
- *Information Infrastructure*
- *Response Services*
- *Vessels*

The recommendations set forth for consideration in this report are grouped into three categories under each of the five primary components: (1) infrastructure considerations that require both near-term planning and implementation; (2) infrastructure considerations requiring near term planning for mid- to long-term implementation; and (3) infrastructure considerations requiring long-term planning and implementation. This categorization facilitates the discussion of many coordinated infrastructure needs while acknowledging planning and funding requirements and limitations.

Over the past five years, with the continuing trend in diminishing Arctic sea ice, discussions and projections for the Arctic as a new international trade route have increased. Some vessels, particularly smaller recreational vessels, currently operating in the Arctic are neither designed

[1] U.S. Committee on the Marine Transportation System (2013). U.S. Arctic Marine Transportation System: Overview and Priorities for Action. A Report to the President. Available at: http://www.cmts.gov/downloads/CMTS%20U%20S%20%20Arctic%20MTS%20Report%20%2007-30-13.pdf as of December 2015.

nor equipped for hazardous Arctic conditions.[2] As sea ice retreats, the lack of U.S. Arctic infrastructure to support increased maritime activity grows more apparent. Limited nautical charts, aids to navigation, communication, emergency response, and rescue capabilities make operations difficult and potentially dangerous. Other elements contributing to accident risks in the Arctic include inadequate maritime infrastructure and environmental and economic uncertainties, all major challenges identified in the CMTS 2013 Arctic Report.

To address some of these risks, a number of studies have examined the gaps and potential infrastructure needs of the U.S. Arctic MTS. These needs include not only physical infrastructure such as ports, support vessels, and communication networks, but also the informational infrastructure enabling mariners to operate safely, such as nautical charts and electronic aids to navigation. The NSAR Implementation Plan (IP) identifies separate actions related to Arctic communications and aviation infrastructure [Objectives 1.2 Sustain and Support Evolving Aviation Requirements; and 1.3 Develop Communication Infrastructure in the Arctic]. This report synthesizes existing information on Arctic MTS infrastructure and gaps in order to distill requirements for future infrastructure needs over the next decade.

There are 43 recommendations put forward in this report for necessary elements of a comprehensive Arctic MTS. This framework necessarily involves elements of the traditional definition of infrastructure, but also includes communication, planning, management, environmental policies, regulatory implementation, and the human element, all of which are required for safe, secure, and successful maritime transportation.

Of the total list of recommendations, 25 are near-term recommendations to address the current gaps in U.S. Arctic infrastructure.

[2] Mooney, C. (April 8, 2015). *The Arctic has lost so much ice that now people want to race yachts through it.* The Washington Post. Available at: https://www.washingtonpost.com/news/energy-environment/wp/2015/04/08/the-arctic-has-melted-so-much-that-people-want-to-race-yachts-through-the-northwest-passage/ as of February 2016.

Near-Term Recommendations	
Navigable Waterways	Designate Port Clarence as an Arctic Maritime Place of Refuge.
	Review Port Clarence facilities to assess whether adequate support facilities are available at Port Clarence or in the region for a ship in need of assistance.
	Support Arctic Waterways Safety Committee efforts to bring stakeholders together
	Leverage existing data-sharing frameworks, such as Data.gov, the Alaska Regional Response Team, and Alaska Ocean Observing System, to facilitate waterways planning and response to environmental emergencies.
	Leverage international partnerships supporting waterways coordination.
	Work with stakeholders to coordinate research efforts to de-conflict research within commercial and subsistence use areas.
	Designate M-5 Alaska Marine Highway Connector to connect the Arctic Ocean and the western section of the Northwest Passage.
Physical Infrastructure	Prioritize the need for Arctic port reception facilities to support international regulatory needs and future growth.
	Expand Arctic coastal and river water-level observations to support flood and storm-surge warnings.
	Review U.S. Arctic maritime commercial activities to identifying major infrastructure gaps that should be addressed to promote safe and sustainable Arctic communities.
	Co-locate new Continuously Operating Reference Stations and National Water Level Observation Network stations to significantly improve the Arctic geospatial framework with precise positioning and water levels.
Information Infrastructure	Improve weather, water, and climate predictions to an equivalent level of service as is provided to the rest of the nation.
	Implement short-range, sea-ice forecasting capability.
	Place hydrography and charting of the U.S. maritime Arctic among the highest priority requirements for agency execution.
	Advance Arctic communication networks to ensure vessel safety.
	Finalize the Port Access Route Study for the Bering Strait and continue efforts to provide routes for vessel traffic in the U.S. Arctic.
	Expand partnerships to provide new satellite Automatic Identification System (AIS) capabilities for offshore activity information.
MTS Response Services	Continue collaboration with State and local authorities to ensure readiness of Arctic maritime and aviation infrastructure for emergency response and Search and Rescue (SAR).
	Continue coordination through international fora to provide significant opportunities for engagement across the Federal Government and the international Arctic response community.
	Support Pan-Arctic response equipment database development, best practices recommendations, and information sharing for continued development of guidelines for oil spill response in the Arctic.

	Develop a plan to transport critical response equipment from the contiguous U.S. into the Arctic area in the event of a catastrophic event.
	Evaluate facilities currently available on the North Slope for use as seasonal staging areas by those engaged in readiness exercises or research.
Vessel Operations	Expand U.S. icebreaking capacity to adequately meet mission demands in the high latitudes.
	Update domestic law to implement the mandatory provisions of the Polar Code and the Convention on Standards of Training, Certification and Watchkeeping for Seafarers.
	Examine existing training and safety standards applicable to the U.S. fishing fleet with respect to the new Polar Code requirements.

The CMTS recommendations in this report cover the five core MTS components and provide a path for Federal activities needed to preserve the mobility and safe navigation of U.S. military and civilian vessels throughout U.S. Arctic waters.

As sea ice retreats, the United States must recognize the importance of providing infrastructure to support increased domestic and international maritime activity. The current limitations in nautical charts, aids to navigation, communication, emergency response, and rescue capabilities make operations difficult and potentially dangerous, hindering U.S. maritime activities in the Arctic. The priorities and recommendations presented in this document create an actionable framework to improve the U.S. Arctic MTS and facilitate responsible activity and growth in the region for a safe and secure Arctic over the next decade and beyond.

INTRODUCTION

The U.S. Committee on the Marine Transportation System (CMTS) is a Federal Cabinet-level, inter-departmental committee chaired by the Secretary of Transportation. The purpose of the CMTS is to create a partnership of Federal departments and agencies with responsibility for the Marine Transportation System (MTS). In 2010, the CMTS was directed by statute to coordinate transportation policy in the US Arctic for Safety and Security. The National Strategy for the Arctic Region (NSAR) Implementation Plan (IP) directs the U.S. Department of Transportation to execute the tasks under the objective Prepare for Increased Activity in the Maritime Domain. These tasks were delegated to the CMTS by the Office of the Secretary in 2014.

This report by the CMTS fulfills directive 1.1.2 under the NSAR IP 2014 objective to "Prepare for Increased Activity in the Maritime Domain." The deliverable for 1.1.2 is to "deliver a 10-year prioritization framework to coordinate the phased development of Federal infrastructure through Department and Agency validated needs assessment by the end of 2016."

The CMTS completed its first deliverable under NSAR Line of Effort 1 with the delivery of a report, *10-Year Projection of Maritime Activity in the U.S. Arctic,* to the White House National Security Council in December of 2014 (Action 1.1.1).[3] The CMTS is also charged with developing recommendations for pursuing Federal public-private partnerships in support of the needs assessment and identifying prioritized activities (1.1.3) planned for delivery later in 2016.

This 10-year prioritization framework to coordinate the phased development of Federal infrastructure under 1.1.2 builds on the 2013 CMTS Report to the President, *U.S. Arctic Marine Transportation System: Overview and Priorities for Action*, which produced scenario based projections of potential U.S. Arctic maritime activity in 2025.[4] Action 1.1.2 is the next step in making recommendations for developing, improving, and maintaining infrastructure in support of Federal maritime Arctic activities, national security, navigation safety, and stewardship of natural resources.

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[3] Azzara, A. J., Wang, H., Rutherford, D., Hurley, B., and Stephenson, S. (2015). *A 10-year Projection of Maritime Activity in the U.S. Arctic Region.* A Report to the President. U.S. Committee on the Marine Transportation System, Integrated Action Team on the Arctic, Washington, D.C., 73 p. Available at: http://www.cmts.gov/downloads/CMTS_10-Year_Arctic_Vessel_Projection_Report_1.1.15.pdf as of December 2015.

[4] Committee on the Marine Transportation System (2013). *U.S. Arctic Marine Transportation System: Overview and Priorities for Action.* A Report to the President. Available at: http://www.cmts.gov/downloads/CMTS%20U%20S%20%20Arctic%20MTS%20Report%20%2007-30-13.pdf as of December 2015.

Using the CMTS 2013 Arctic Report definitions, this 2016 report organizes the U.S. Arctic Marine Transportation System (MTS) into five core components:

- Navigable Waterways
- Physical Infrastructure
- Information Infrastructure
- MTS Response Services
- Vessels

The recommendations set forth for consideration in this report are grouped into three categories under each of the five primary components: (1) infrastructure considerations that require both near-term planning and near-term implementation; (2) infrastructure considerations requiring near-term planning for mid- to long-term implementation; and (3) infrastructure considerations requiring long-term planning and implementation. This categorization facilitates the discussion of many coordinated infrastructure needs while acknowledging planning and funding requirements and limitations.

BACKGROUND

The United States is an Arctic Nation, with 33,900 miles of shoreline in Alaska, including the Aleutian Islands.[5] [6] Three Arctic seas bound the State of Alaska: the Bering, the Chukchi, and the Beaufort (Figure 1). Historically, these seas are frozen for more than half the year. The general Arctic maritime season typically lasts only from June through October, and unaided navigation occurs within a more limited time frame. However, this pattern appears to be rapidly changing as ice-diminished conditions become more extensive during the summer months. On September 16, 2012, Arctic sea ice reached its lowest coverage extent ever recorded, paving the way for the longest Arctic navigation season on record.[7] In the 2015 Arctic Report Card, the September 2015 Arctic sea ice minimum extent was the fourth lowest value in the satellite record (1979-2015) and January 2016 was a new record low for winter ice extent in the Arctic.[8] [9] While loss of sea ice may increase the time available for navigation in the Arctic, marine transportation

[5] This report uses the U.S. Arctic Research Policy Act of 1984 to define the Arctic, including all waters subject to U.S. jurisdiction: The U.S. Exclusive Economic Zone, U.S. territorial sea, and internal navigable waters in Alaska.
[6] Facts about Alaska, Official State of Alaska Website. Available at: http://alaska.gov/kids/learn/facts.htm as of January 2016.
[7] McGrath, Matt (2012). Gas tanker Ob River attempts first winter Arctic crossing, BBC News. Available at: http://www.bbc.co.uk/news/science-environment-20454757.
[8] M. O. Jeffries, J. Richter-Menge, and J. E. Overland, Eds., (2015): Arctic Report Card 2015, Available at: http://www.arctic.noaa.gov/reportcard as of February 2016.
[9] National Snow and Ice Data Center, Arctic Sea Ice News and Analysis available at: http://nsidc.org/arcticseaicenews/ as of February 2016.

in the region will continue to be challenging and potentially hazardous, particularly due to variability of sea ice from year to year. Although transiting across Arctic waters has greatly improved due to increasing summer ice retreat, there are still unpredictable ice floes, inclement weather (e.g., extreme cold, heavy fog, severe storms), and seasonal accessibility based on variation in ice location.[10]

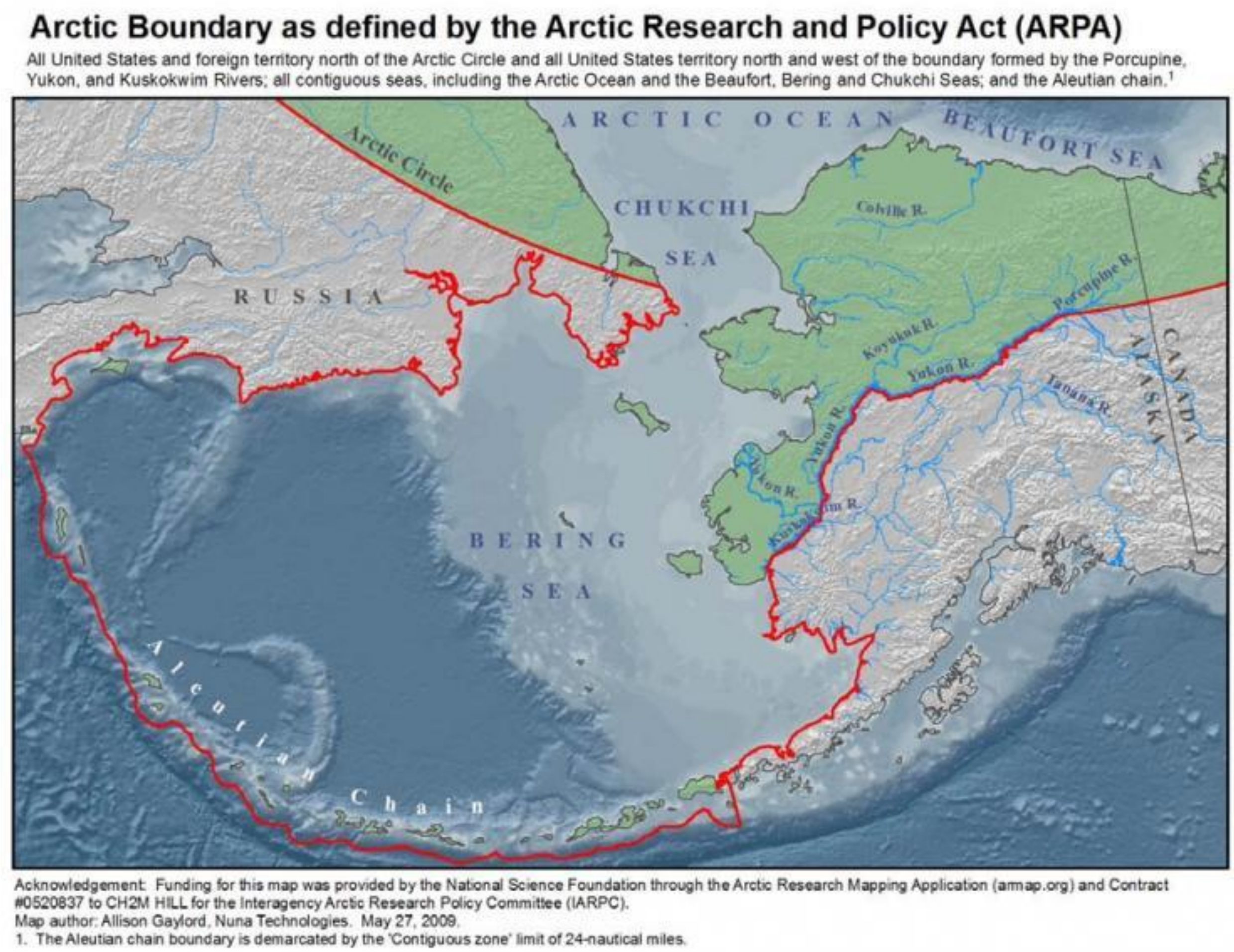

Figure 1. The geographic area covered by this report consists of all U.S. territory north of the Arctic Circle and all U.S. territory north and west of the boundary formed by the Porcupine, Yukon, and Kuskokwim Rivers; all contiguous seas including the Arctic Ocean and the Beaufort, Bering, Chukchi Seas and the Aleutian Island chain, as defined in § 112 of the Arctic Research and Policy Act of 1984 (ARPA). Source: U.S. Arctic Research Commission.

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[10] Committee on the Marine Transportation System (2013). *U.S. Arctic Marine Transportation System: Overview and Priorities for Action*. A Report to the President. Available at: http://www.cmts.gov/downloads/CMTS%20U%20S%20%20Arctic%20MTS%20Report%20%2007-30-13.pdf as of December 2015.

As sea ice retreats, the lack of U.S. Arctic MTS infrastructure to support increased maritime activity in shipping, mining, oil and gas exploration, fishing, and tourism grows more apparent. Limited nautical charts, aids to navigation, communication, emergency response, and rescue capabilities further challenge these difficult and potentially dangerous operations. Currently, the U.S. Government has surveyed and charted less than two percent of navigationally significant U.S. Arctic waters to modern standards for accurate water depths and hazards to navigation.[11]

Over the past five years, with the continuing trend in diminishing Arctic sea ice, discussions and projections for the Arctic as a new international trade route have increased. Between 2011 and 2013, transits through the Bering Strait increased from 410 to 440, and transits through the Northern Sea Route increased from 36 to 71, as compared to only 4 in 2010. Despite a dip in activity in 2014, Russia's Northern Sea Route Administration granted more than 650 permits to transit the Northern Sea Route in 2015, demonstrating sustained interest in the region.[12] [13] Transit statistics for the 2015 season support this continued interest with 300 unique vessels and 540 vessel transits through the Bering Strait, an increase over 2012 activity (Figure 2).

Despite this quantifiable growth in vessel traffic, some vessels currently operating in the Arctic are neither designed nor equipped for the ice conditions that they could potentially encounter. Other elements contributing to risk of accident in the Arctic include inadequate maritime infrastructure and environmental and economic uncertainties, all major challenges identified in the CMTS 2013 Arctic Report, and in risk reports such as *Arctic Openings: Opportunity and Risk in the High North*, published in 2012 by Lloyd's and Chatham House.[14]

To address some of these challenges, a number of studies have examined the gaps and potential infrastructure needs of the U.S. Arctic MTS. These needs include not only physical infrastructure such as ports, support vessels, and communication networks, but also the informational infrastructure enabling mariners to operate safely, such as nautical charts and electronic aids to navigation.

[11] Committee on the Marine Transportation System (2013). U.S. Arctic Marine Transportation System: Overview and Priorities for Action. A Report to the President. Available at: http://www.cmts.gov/downloads/CMTS%20U%20S%20%20Arctic%20MTS%20Report%20%2007-30-13.pdf as of December 2015.

[12] The Northern Sea Route spans the Arctic waters between the Barents Sea and the Kara Sea, along the northern Russian coast.

[13] Northern Sea Route Information Office, transit statistics. Available at: http://www.arctic-lio.com/nsr_transits as of December 2015.

[14] Lloyd's and Chatham House (2012). *Arctic Opening: Opportunity and Risk in the High North*. Available at: http://www.chathamhouse.org/publications/papers/view/182839 as of December 2015.

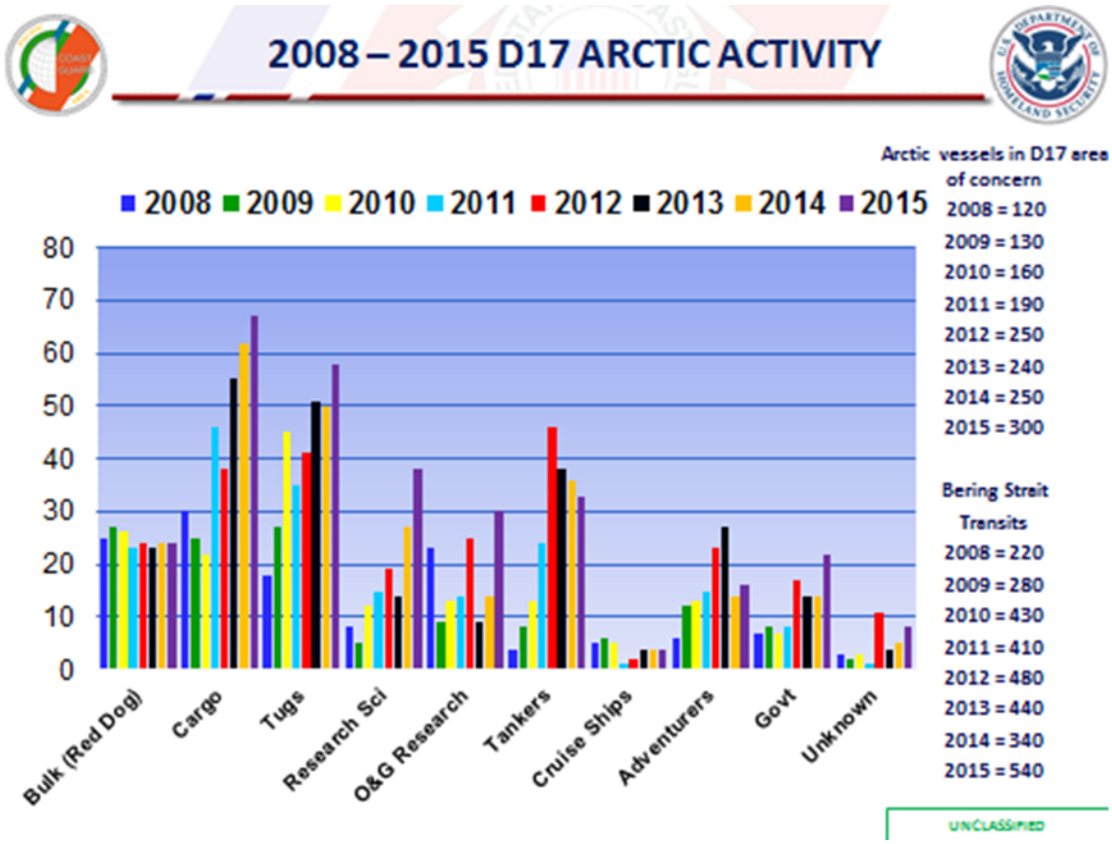

Figure 2. Arctic traffic in the USCG District 17 area of concern and transits of the Bering Strait, 2008 to 2015.

As part of the first CMTS deliverable for the NSAR IP, projection scenarios for vessel activity in the U.S. Arctic were developed. The vessel activity projections are separated into three general categories of growth reflecting (1) estimated growth in global trade; (2) the assumption that some international vessel traffic will divert from the Suez and Panama Canals in favor of Arctic shipping routes; and (3) various oil and gas exploration and production scenarios for the next decade. For each type of growth, scenarios were explored. The scenarios span a range (i.e. low, medium, and high) of intentionally conservative assumptions to less conservative development patterns with higher rates of vessel diversion enabled by increased accessibility to the Arctic. A conservative estimate of the number of unique vessels operating in the Bering Strait and U.S. Arctic in 2025 is 420, resulting in approximately 877 transits through the Bering Strait, or a doubling over 2013 transit levels. These conservative estimates assume no increase in oil and gas activity over 2011 levels. The transit statistics from 2015 support the general projections in the report and showed an increase of 50 unique vessels over the 2012 numbers. The various growth possibilities developed by the projections helped to inform the range of infrastructure needs evaluated in the current report.

This report synthesizes existing information on Arctic MTS infrastructure (Table 1) and gaps in order to distill requirements for future infrastructure needs over the next decade.

PREVIOUS WORK IDENTIFYING INFRASTRUCTURE NEEDS

In 2009, the Arctic Council's Protection of the Arctic Marine Environment Working Group published the *Arctic Marine Shipping Assessment* (AMSA).[15] This report detailed 17 recommendations for maritime safety and marine environmental protection in the Arctic. The AMSA report addressed the infrastructure deficit for supporting Arctic maritime safety, environmental protection, and sustainable development. AMSA recommendations specifically noted the need for Arctic states to support continued development of a comprehensive Arctic marine traffic awareness system, as well as to invest in hydrographic, meteorological, and oceanographic data to support safe navigation and voyage planning.

The May 2013 NSAR and subsequent January 2014 Implementation Plan (IP) elevated the national conversation about the U.S. Arctic, placing specific agencies in charge of assessing the current state of Arctic infrastructure and its future needs. The IP reflects the reality of a changing Arctic environment and the desire to promote national interests for safety, security, and environmental protection.

The CMTS 2013 Arctic Report highlighted the risks and opportunities of increasing maritime activity. It presented a vision of a U.S. Arctic MTS capable of meeting the safety, security, and environmental protection needs of present and future Arctic stakeholders. The report included sixteen issue papers discussing elements of the U.S. Arctic MTS, including gaps currently inhibiting safe U.S. Arctic marine transportation and necessary physical and informational infrastructure improvements to support U.S. Arctic commerce and security. Table 1 is drawn from the CMTS 2013 Arctic Report. Updated for 2016, Table 1 illustrates the current state of U.S. Arctic MTS infrastructure. The subsequent sections in this report are intended to identify significant gaps and provide recommendations to address national interests for safety, security, and environmental protection in the U.S. Arctic.

[15] Arctic Marine Shipping Assessment (2009). *Protection of the Arctic Marine Environment Working Group, Arctic Council*. Available at: http://www.arctic.noaa.gov/detect/documents/AMSA_2009_Report_2nd_print.pdf as of December 2015.

Additional reports published by a variety of sources continue to highlight the need to address various MTS infrastructure issues in the Arctic.[16] These include the 2014 U.S. Government Accountability Office report, *Maritime Infrastructure: Key Issues Related to Commercial Activity in the U.S. Arctic over the Next Decade*. In January 2015, the Alaska Arctic Policy Commission published a strategy and implementation plan using similar language and priorities to the NSAR for safe and secure navigation and development in the Arctic.

Priority areas identified in U.S. reports include acquiring new heavy icebreakers, improved nautical charts and communications capabilities, better weather forecasting and modeling, construction of a deep-draft U.S. Arctic port(s), and developing community and regional emergency response networks in preparation for vessel and aircraft accidents and environmental damage related to increased ship traffic and industry.

[16] For a more comprehensive discussion of Arctic reports, please see Table 1: *Arctic Policies and Recommendations Reviewed for MTS Focus or Investment. U.S. Committee on the Marine Transportation System* (2013). U.S. Arctic Marine Transportation System: Overview and Priorities for Action. A Report to the President. Available at: http://www.cmts.gov/downloads/CMTS%20U%20S%20%20Arctic%20MTS%20Report%20%2007-30-13.pdf as of December 2015.

Table 1. Current Status of U.S. Arctic MTS Infrastructure

MTS Components	MTS Element	Current Status for the U.S. Arctic
Navigable Waterways	Places of Refuge for Ships	- Currently no official Maritime Place of Refuge in the U.S. Arctic - State of Alaska has identified 13 sites along the North Slope as potential places of refuge - Sufficient number of ports and natural harbors available in the Aleutian Island Chain - Areas near the Bering Strait being studied by U.S. Army Corps of Engineers include Savoonga, Gamble, Cape Darby, and Port Clarence
	Areas of Heightened Ecological Significance	- Currently three areas identified: St. Lawrence Island, portions of the Bering Strait and the Chukchi Beaufort Coast - May 2015 Subarea Contingency Plan for the Aleutian Islands was completed by the Federal/State Alaska Regional Response Team, including maps showing environmentally sensitive areas. Subarea Contingency plans for other Arctic areas are scheduled for cyclic updating: North Slope (2017), Northwest Alaska (2016), Western Alaska (2018) and Bristol Bay (2018) - Biological Important Areas for Cetaceans have been developed for Gulf of Alaska, Aleutian Island and Bering Sea Region, and the Arctic Region
Physical Infrastructure	Ports and Associated Facilities	- Ten U.S. port facilities exist south of the Bering Strait: Port of Nome, St. Michael Harbor, Port of Bethel, St. Paul, St. George, Dillingham, Port of Bristol Bay, Dutch Harbor/Unalaska, Adak, and King Cove - One U.S. port facility exists north of the Bering Strait: Port of Kotzebue
	Geospatial Infrastructure	- Ten National Oceanic and Atmospheric Administration (NOAA) Continuously Operating Reference Stations (CORS) Network sites along the Aleutian Chain - Ten CORS Network sites in Arctic coastal areas of the Bering Sea - Three CORS Network sites near two North Slope coastal areas
MTS Information Infrastructure	Hydrographic Surveys	- 4330 square nautical miles (nm^2)of 42,400 nm^2 identified by NOAA as navigationally significant waters - Two 48-year old ice-strengthened hydrographic survey vessels, *Rainier* and *Fairweather*
	Shoreline Mapping	- 33,900 official shoreline miles of Arctic Alaskan coastline (measured by NOAA from 1:80,000 scale), only 12,882 of which have been mapped since 1988 using contemporary methods
	Aids to Navigation (ATON)	- 222 ATONs located throughout the Bering Sea and Aleutian Islands - Eight ATONs, mostly in Kotzebue Sound

MTS Components	MTS Element	Current Status for the U.S. Arctic
MTS Information Infrastructure		- Eleven privately maintained aids along the North Coast (near oil and gas facilities at Prudhoe Bay)
	Communications	- Line of Sight (LOS) and satellite communications (SATCOM) architecture sufficient to support voice and data communication needs in the Bering Sea - Limited LOS communications above 65°N - Limited SATCOM above 70°N
	Marine Weather and Sea Ice Forecasts	- The NOAA National Weather Service (NWS) Alaska Sea Ice Program provides a 5-day sea ice forecast every Monday, Wednesday, and Friday throughout the year in both a text and graphical format. The sea ice forecasts focus on changes to the main ice pack, marginal ice zone, shorefast ice, and sea-ice free waters. - NWS operates three Weather Forecast Offices (WFOs) in Anchorage, Fairbanks, and Juneau, which operate 24-hours-a-day, 7-days-a-week, 365-days-a-year. The WFOs produce daily wind, wave, freezing spray, and swell (both direction and height) forecasts in support of marine activities. The forecasts are available in text and graphical formats. - NOAA's National Centers for Environmental Prediction provides forecast guidance from operational atmosphere, ocean, and wave model four times daily. NCEP also provides forecast guidance for sea-ice motion, daily to day 16. The global operational Real-Time Ocean Forecast System is run once per day. The National Ice Center (NIC) provides year-round Arctic-wide sea ice analysis, seasonal sea ice outlooks, and special product support for USG vessels operating near or within the sea ice. - The U.S. Navy operational Arctic Cap Nowcast/Forecast System, transitioning to their Global Ocean Forecast System v3.1, provides1-7 day forecasts of Arctic ice concentration, ice thickness, ice velocity, sea surface temperature, sea surface salinity, and sea surface velocities used operationally by the NIC.
	Real-Time Oceanographic Information	- Nine NOAA National Water Level Observation Network (NWLON) tidal stations located at Unalaska, Nikolski, Atka, Adak, Port Moller, Village Cove, Nome, Red Dog, and Prudhoe; 21 gaps identified
	Automatic Identification System (AIS)	- 36 land-based AIS receiving stations operated by the Marine Exchange of Alaska; 11 are north of the Bering Strait
MTS Response Services	Federal Icebreaking and Emergency Response Assets	- USCG/National Science Foundation vessels are used primarily to support science missions and emergency response (SAR, Oil Spill Federal on Scene Coordinator, etc.) - USCGC *Polar Star* – Heavy Icebreaker (60,000 HP); Currently used in the Antarctic

MTS Components	MTS Element	Current Status for the U.S. Arctic
MTS Response Services (cont.)	Federal Icebreaking and Emergency Response Assets	- USCGC *Healy* – Medium Icebreaker (30,000 HP); Currently used in the Arctic - USCG vessels and aircraft have historically operated in the Bering Sea year round. Operation Arctic Shield extends operational area farther north during ice free summer months to test capabilities. - *Nathaniel B. Palmer* – National Science Foundation leased science support vessel (Light Icebreaker - 12,720 HP)
	Environmental Response Management	- All federally permitted oil and gas activities require operators to have approved oil spill contingency plans, which includes tank and non-tank vessel response plans requiring owner/operators to maintain oil spill response equipment and trained personnel both on-site and able to respond within specified timeframes based upon their operating environment and proximity to land. Closest Oil Spill Removal organizations (pollution response contractors) capable of responding to a pollution event are Dutch Harbor, Kodiak, and Anchorage (1000, 820, and 635 nautical miles away from Alaska's Northern Slope, respectively) - Aerial Dispersant Delivery System (ADDS) staged in Anchorage - U.S. Navy spill response equipment (SUPSALV) staged in Anchorage - State of Alaska has seven response equipment sites south of the Bering Strait (Nome, Unalakleet, Toksook Bay, Bethel, Dillingham, King Cove, and Dutch Harbor) and one north in Kotzebue. Two Emergency Towing Systems (ETS), located at Dutch Harbor and Cold Bay - USCG District 17 maintains four Spilled Oil Recovery Systems (SORS) equipped on 225' buoy tenders home-ported in Alaska (*Spar*, *Maple*, *Sycamore* and *Hickory*), and one Vessel of Opportunity Skimming System (VOSS) split between Anchorage and Ketchikan - USCG District 17 maintains 51 caches of Coast Guard-owned response equipment in 18 cities/ villages throughout Alaska. Ten of these caches are in C-130 compatible containers, located near Anchorage, for deployment to Arctic locations. In addition, three of the caches are located in the Alaskan Arctic towns of St. Paul, Unalaska, and King Cove. - Arctic Environmental Response Management Application (ERMA) GIS for common operating picture in event of incident (web version and stand-alone version) - All four Oil Spill Response Organizations that service the North Slope, Western Alaska, and the Aleutian Islands have only a little or no open-ocean capability, very limited wildlife response equipment and limited experience responding to Arctic spills
		- Limited SAR infrastructure and air support in the region

MTS Components	MTS Element	Current Status for the U.S. Arctic
MTS Response Services (cont.)	Search & Rescue (SAR)/ Emergency Response	- USCG forward deploys surface and aviation assets to Arctic regions based on activity levels (commonly highest during the summer season) - The nearest USCG air station is in Kodiak, 820 nautical miles from Point Barrow (northernmost point of land) - The 11th Air Force has three rescue squadrons capable of providing refuelable H-60s, C-130s, and pararescuemen throughout Alaska - The closest refueling site to Alaska's North Slope for vessels is Dutch Harbor, which is 1,000 nm away - USCG currently forward deploys helicopters from Air Station Kodiak to Cold Bay, and to St. Paul Island, in support of the red king crab and opilio crab fisheries, respectively, to ensure adequate SAR response - USCG maintains seasonal forward operating locations for H-60 helicopters on the North Slope: Barrow in 2014, Deadhorse in 2015, and Kotzebue is planned for 2016 - NOAA Search and Rescue Satellite Aided Tracking satellites relaying distress signals from emergency beacon contributions appear satisfactory - The North Slope Borough Search and Rescue Department has a Critical Care Air Ambulance Service performing medevac, SAR and emergency missions throughout the North Slope Region - All federally permitted oil and gas activities require operators to have approved contingency plans and maintain capabilities for emergency response, including SAR
Vessels	Mandatory Polar Code/Voluntary Polar Guidelines	- International Maritime Organization (IMO) has adopted an International Code for Ships Operating in Polar Waters (Polar Code) that includes mandatory and voluntary provisions that will enter into force January 1, 2017 through amendments to the International Convention for the Safety of Life at Sea and the International Convention for the Prevention of Pollution from Ships - The Polar Code builds upon previous IMO recommended guidelines including “Guidelines for ships operating in Arctic ice-covered waters” (2002) and “Polar Waters” (2009), which are available for vessels not subject to the Polar Code - The International Standards Organization Technical Committee 67 has developed design and materials standards for offshore oil and gas structures in ice-covered waters
	Crew Standards/	- Crew standards and training are found in the IMO’s International Convention on Standards of

MTS Components	MTS Element	Current Status for the U.S. Arctic
	Training	Training, Certification and Watchkeeping for Seafarers (STCW) - The United States has worked closely with U.S. industry through the Merchant Marine Personnel Advisory Committee and with other IMO Member States to develop amendments to the STCW that provide for a standardized training regime for personnel employed on vessels subject to the Polar Code - These amendments will be adopted in May 2016 and will enter into force on January 1, 2018 - USCG plans to promulgate an interim policy letter in 2016 and regulations in the future to implement these STCW amendments into the U.S. domestic credentialing regime

FORWARD-LOOKING U.S. ARCTIC MTS REQUIREMENTS: THE NEXT 10 YEARS

This section of the report presents U.S. Arctic MTS infrastructure requirements over the next 10 years. Using the CMTS 2013 Arctic Report definitions, this section discusses the U.S. Arctic MTS in five primary components: Navigable Waterways, Physical Infrastructure, Information Infrastructure, MTS Response Services, and Vessel Operations.

For each of these components, recommendations for consideration will be made within three categories:

1) *Near-Term (2016-2018):* Includes recommendations suited for near-term planning and near-term implementation such as specific infrastructure needs that have been identified as mission critical for safe navigation in Arctic waters and require immediate investment and action.
2) *Mid-Term (2018-2022):* Includes recommendations suited for near-term planning for mid-term implementation such as infrastructure needs that require longer planning stages and the potential for multiple budget cycles to secure funding through some combination of Federal appropriations and/or the establishment of partnerships to secure the necessary funding, permits, or other critical components. Although these recommendations will require longer periods of time to complete and implement, it is imperative that planning begin as soon as possible.
3) *Long-Term (2018-2025):* Includes recommendations suited for long-term planning such as infrastructure elements requiring extensive financial planning or that include cooperative planning and coordination of efforts. In addition to physical infrastructure, these elements form the stakeholder engagement, communication, and cooperative planning frameworks needed to support the physical infrastructure components of an Arctic MTS.

The ordering of infrastructure in this report is not intended to create a hierarchy of most to least important, but rather to demonstrate the necessary sequence to create the strongest foundation for U.S. Arctic infrastructure supporting current and future needs. By categorizing based on near-, mid-, and long-term needs, we can recognize interdependencies (e.g., to have accurate charts, we must first have good geodetic control and tidal data, along with accurate shoreline mapping and hydrographic survey data), and break critical infrastructure projects into components. These components, if integrated over time, support the establishment of a stronger, more resilient U.S. Arctic MTS.

Navigable Waterways

In the Arctic, diminishing ice has led to the seasonal opening of navigable waterways that are sufficiently deep and wide for vessels to pass. In the U.S. Arctic, this means additional traffic through the Bering Strait and along the North Slope of Alaska, driven by potential maritime traffic increases along the Northern Sea Routes and Northwest Passage (Figure 3).

These Arctic navigable waterways are used to transport mineral, agricultural and bulk products, as well as other trade goods and passengers to, from, and within the United States. They connect the U.S. Arctic region to the rest of the Nation and contribute to the movement of global commerce.

Figure 3. Northern Sea Routes and Northwest Passage. Source: Office of Naval Intelligence

Harbors of Refuge

An integral part of waterways and marine transportation system management is the availability of places of refuge for ships transiting U.S. waters. A "Harbor of Refuge" is defined as "a port, inlet, or other body of water normally sheltered from heavy seas by land and in which a vessel can navigate and safely moor." [17] Port Clarence, just south of the Bering Strait, is a known port of refuge on the Alaskan coast, has historically been used as such by fishing and whaling vessels, and is often used as such by commercial and government vessels. Section 5.1.2.2 of the United States Army Corps of Engineers' 2015 *Alaska Deep Draft Port System Draft Integrated Feasibility Report and Environmental Assessment* states, in the analysis of Port Clarence, that the location would be used as a deep-water anchorage during storms or other inclement weather.[18] While Port Clarence is situated near deep water at Point Spencer, it would require a significant amount of upland development in order to adequately support the range of maritime missions required of a commercial port. Currently, there are no navigation improvements planned for the area to address this gap in facilities support, although the Coast Guard Authorization Act of 2015 included language that transfers real property ownership to the local stakeholders, which could

[17] Under 46 CFR 175.400.

[18] United States Army Corps of Engineers' Alaska Deep Draft Port System: Draft Integrated Feasibility Report and Environmental Assessment (2015). Alaska District, Pacific Ocean Division, February 2015. Available at: http://www.poa.usace.army.mil/Portals/34/docs/civilworks/arcticdeepdraft/ADDMainReportwithoutappendixes.pdf as of March 2016.

potentially spur planning for future private investment and development particularly given the proximity of Point Spencer to Teller and Nome (approximately 70 miles by road).[19] The CMTS recommends that Port Clarence be designated an Arctic Maritime Place of Refuge and that a review of the port's capabilities be undertaken to ensure adequate support exists, singularly or in coordination with other Arctic ports should a ship or other vessel require assistance.

Marine Areas of Ecological Significance

Ecologically significant marine areas also fall under navigable waterways management. The 2009 AMSA, Section II-C under the "*Protecting Arctic People and the Environment*" theme recommended "that the Arctic states should identify areas of heightened ecological and cultural significance . . . and, where appropriate, should encourage implementation of measures to protect these areas from the impacts of Arctic marine shipping . . . ."[20]

The Interagency Arctic Research Policy Committee's five-year research plan took the need for identification of Areas of Ecological Significance one step further, recommending baseline Arctic research to better understand ecosystem-level dynamics, habitats, and species populations.[21] Because the Arctic is a dynamic environment consisting of eighteen Large Marine Ecosystems, (LMEs), each of which support unique food webs as well as commerce and subsistence economies, greater research and understanding is critical.[22] Developing coherent and comprehensive management plans for Areas of Ecological Significance is imperative for successful management of the region, including waterways use. To support coordinated use and protection of the LMEs, the CMTS recommends: supporting and coordinating Federal science programs and "science of opportunity" research on National Oceanic and Atmospheric Administration (NOAA), National Science Foundation (NSF), U.S. Coast Guard (USCG) flights and icebreaker deployments, and other private or commercial vessels; collecting and sharing of observations of physical, meteorological, oceanographic, geological, and biological observations and data; leveraging existing data sharing frameworks, such as Data.gov, and the Alaska Ocean Observing System (AOOS), to facilitate interdisciplinary research and policy development; and

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[19] Coast Guard Authorization Act of 2015 (H.R. 4188). Available at: https://www.gpo.gov/fdsys/pkg/BILLS-114hr4188enr/pdf/BILLS-114hr4188enr.pdf as of February 2016.

[20] AMAP/CAFF/SDWG (2013). Identification of Arctic marine areas of heightened ecological and cultural significance: Arctic Marine Shipping Assessment (AMSA) IIc Available at: http://www.amap.no/documents/doc/identification-of-arctic-marine-areas-of-heightened-ecological-and-cultural-significance-arctic-marine-shipping-assessment-amsa-iic/869 as of January 2016.

[21] Arctic Research Plan: FY2013–2017 (2013) Executive Office of the President National Science and Technology Council. Available at: https://www.whitehouse.gov/sites/default/files/microsites/ostp/2013_arctic_research_plan.pdf as of January 2016.

[22] Large Marine Ecosystem (LMEs) of the Arctic area—Revision of the Arctic LME Map, 15th of May 2013, PAME Working Group of the Arctic Council. Available at: http://www.pame.is/index.php/projects/ecosystem-approach/arctic-large-marine-ecosystems-lme-s as of January 2016.

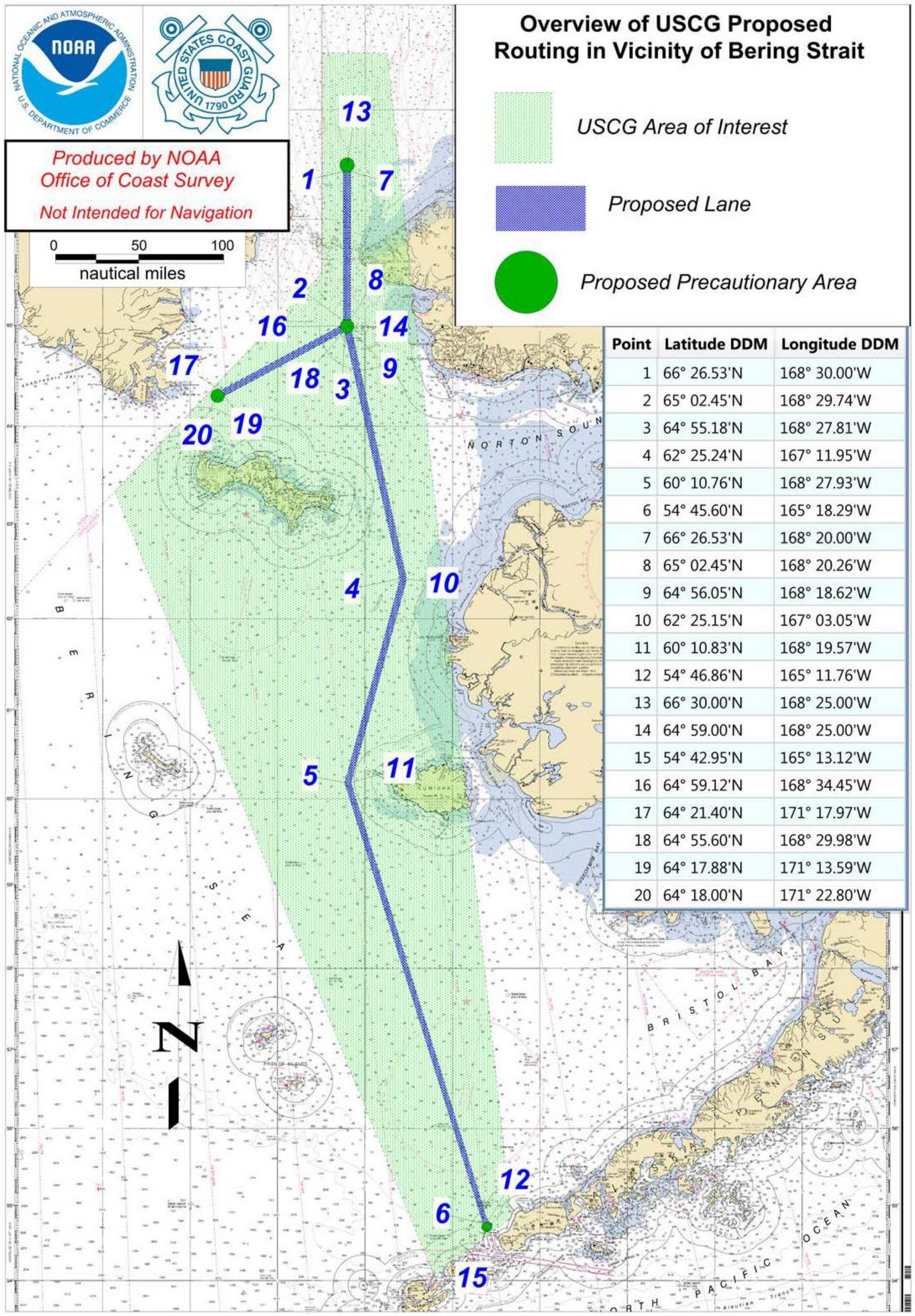
working with stakeholders to coordinate research efforts with commercial and subsistence uses within fisheries and subsistence harvest areas. These data-sharing and collaborative partnerships should directly inform policy decisions for management of the U.S. Arctic MTS, including port and waterways planning and vessel routing requirements.

Managing Arctic Waterways

In managing Arctic waterways, it is practical to develop overarching frameworks and cooperative bodies to deal with day-to-day issues as they arise. These bodies should be interdisciplinary and serve to represent issues and concerns raised by stakeholders from the maritime arena. One recent development in this area was the formation of the Arctic Waterways Safety Committee (AWSC) in October of 2014. Incorporated as a non-profit organization, AWSC has a membership that includes representation from all five subsistence co-management groups in the region, regional government, and maritime industry. The AWSC is, in essence, a "Harbor Safety Committee" under the national MTS framework. Thus the AWSC has the potential to act as a conduit to relay regional concerns to Federal MTS agencies and the CMTS.[23] In addition, consideration should be given to international waterways coordination and leveraging international partnerships, as appropriate, among Arctic States to better respond to emerging Arctic maritime and commercial requirements. These partnerships should be leveraged where possible to increase maritime domain awareness and readiness, and to protect the Arctic environment.

As an example, the USCG is engaged in a Port Access Route Study (PARS) for the Bering Strait and has published possible routing measures such as recommended two-way routes and areas to be avoided for vessel traffic in the Bering Strait (Figure 4).[24] Although these will be recommended measures and not mandatory, the United States should continue to collaborate with Russia on the Bering Strait PARS and consider appropriate IMO implementation of ship routing measures for the Bering Strait. The forward-looking action of establishing these ship routing measures in advance of any vessel collision or incident should continue to be a priority. Early identification of Arctic shipping corridors will also help to prioritize the acquisition of hydrographic survey data.

[23] The AWSC was established in October 2014 as a self-governing multi-stakeholder group focused on creating or documenting best practices to ensure a safe, efficient, and predictable operating environment for all users of the arctic waterways. Available at: http://www.arcticwaterways.org/home.html as of February 2016.
[24] Overview of USCG Proposed Routing in Vicinity of Bering Strait. USCG-2014-0941.
Supporting and Related Material. Available at: https://www.regulations.gov/#!documentDetail;D=USCG-2014-0941-0002 as of March 2015.



Point	Latitude DDM	Longitude DDM
1	66° 26.53'N	168° 30.00'W
2	65° 02.45'N	168° 29.74'W
3	64° 55.18'N	168° 27.81'W
4	62° 25.24'N	167° 11.95'W
5	60° 10.76'N	168° 27.93'W
6	54° 45.60'N	165° 18.29'W
7	66° 26.53'N	168° 20.00'W
8	65° 02.45'N	168° 20.26'W
9	64° 56.05'N	168° 18.62'W
10	62° 25.15'N	167° 03.05'W
11	60° 10.83'N	168° 19.57'W
12	54° 46.86'N	165° 11.76'W
13	66° 30.00'N	168° 25.00'W
14	64° 59.00'N	168° 25.00'W
15	54° 42.95'N	165° 13.12'W
16	64° 59.12'N	168° 34.45'W
17	64° 21.40'N	171° 17.97'W
18	64° 55.60'N	168° 29.98'W
19	64° 17.88'N	171° 13.59'W
20	64° 18.00'N	171° 22.80'W

Figure 4. Proposed Arctic Routing from Bering Strait Port Access Route Study.

Marine Highways

The America's Marine Highway (AMH) System consists of over 29,000 nautical miles of navigable waterways including rivers, bays, channels, the Great Lakes, the Saint Lawrence Seaway System, coastal, and open-ocean routes. The AMH program works to further recognize and incorporate the nation's waterways into the greater U.S. transportation system, especially where marine transportation services are the most efficient, effective, and sustainable transportation option. The AMH is not currently reflective of the commercial shipping along the Arctic areas of the west and north coasts of Alaska. The closest route is the M-5 Alaska Marine Highway Connector that currently consists of the Pacific Ocean coastal waters, including the Inside Passage. The M-5 connects commercial navigation channels, ports, and harbors from Puget Sound to Unalaska in the Aleutian Islands, spanning British Columbia, lower Alaska and connects at the Canadian border north of Bellingham, WA (Figure 5).

Adding an AMH connector to the Arctic formally recognizes the importance of the region and the increasing shipping and cargo operations. Adding an extension leg to the current M-5 Connector going north from the Aleutian Islands along the west and north coasts of Alaska would connect the Bering, Chukchi, and Beaufort Seas, and link the route to the Arctic Ocean and the western section of the Northwest Passage. This extension supports shipping and cargo movements occurring north of the Aleutians including Port Clarence, Cape Romanzof, Dillingham, Bethel, Egegik River, Port Heiden, Togiak Bay, Arctic Ocean-Off Northern Alaska, Bering Sea Off Western Alaska, Port Moller, St. Paul Island, Pribilof Islands, Hooper Bay, Nunivak Island, Nome, St. Lawrence Island, Tin City, Shishmaref, Kivalina, Point Hope, Cape Lisburne, Point Lay, Wainwright, Barrow, Kaktovik, and Prudhoe Bay. Recognizing the navigational challenges in the region, this action to designate the M-5 addition should be fully supported and is anticipated for completion in the near-term.[25]

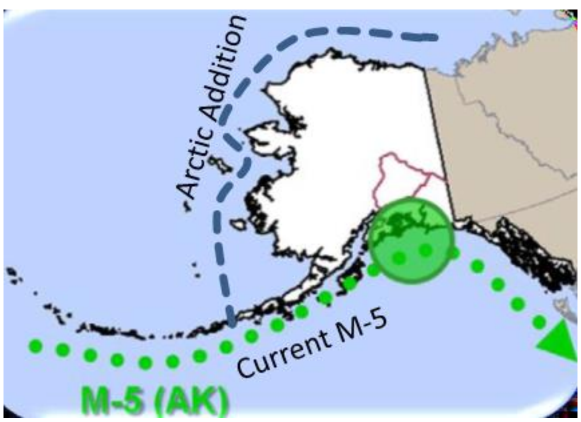


Figure 5. Current and proposed route for the extension of the M-5 Alaska Marine Highway Connector

[25] America's Marine Highway Program, U.S. Maritime Administration. Available at: http://www.marad.dot.gov/ships-and-shipping/dot-maritime-administration-americas-marine-highway-program/ as of January 2016.

Recommendations

Navigable Waterways	Recommendations	Implementation Timeline
Place of Refuge	Designate Port Clarence as an Arctic Maritime Place of Refuge.	Near-Term
Place of Refuge	Review Port Clarence facilities to assess whether adequate support facilities are available at Port Clarence or in the region for a ship in need of assistance.	Near-Term
Managing Arctic Waterways	Support Arctic Waterways Safety Committee efforts to bring stakeholders together.	Near-Term
Areas of Ecological Significance	Leverage existing data-sharing frameworks, such as Data.gov, the Alaska Regional Response Team Ocean.gov, and AOOS, to facilitate waterways planning and response to environmental emergencies.	Near-Term
Managing Arctic Waterways	Leverage international partnerships supporting waterways coordination.	Near-Term
Marine Highways	Designate M-5 Alaska Marine Highway Connector to connect the Arctic Ocean and the western section of the Northwest Passage.	Near-Term
Areas of Ecological Significance	Support and coordinate collection and sharing of observations and data for waterways management and vessel routing requirements.	Mid-Term
Managing Arctic Waterways	Continue to collaborate with Russia on the Bering Strait Port Access Route Study.	Mid-Term
Managing Arctic Waterways	Consider appropriate IMO implementation of ship routing measures for the Bering Strait.	Mid-Term
Place of Refuge	Explore the need for maritime infrastructure to support vessels seeking refuge to build in redundancy into Alaska's Arctic MTS infrastructure.	Long-Term
Areas of Ecological Significance	Continue to identify areas of heightened ecological and cultural significance requiring waterways management in the Arctic and western Alaska.	Long-Term

Physical Infrastructure

Shore-based marine transportation infrastructure generally includes those land-side components that allow for quick and efficient transportation of cargo and passengers. Physical infrastructure for the MTS encompasses:

- Ports
- Terminals
- Piers
- Berths
- Intermodal connections and linkages to road, rail, and airport access routes and facilities
- Cargo handling and passenger/crew facilities
- Port Reception Facilities as required by the International Convention for the Prevention of Pollution from Ships MARPOL Annexes I, II, V, and VI [and sewage as required by U.S. Environmental Protection Agency (EPA) regulations] to receive and dispose of all ship generated wastes in an environmentally sound manner, and the
- Geospatial infrastructure and Continuously Operating Global Positioning System Reference Stations supporting accurate positioning, navigation, and development.

Physical infrastructure in the U.S. Arctic MTS is critical but lacking in many areas. This is due in part to small populations scattered across the landscape, and in part to the fact that the Arctic has not needed substantial MTS infrastructure until now with the new reality of diminishing sea ice. Improving infrastructure in the Arctic is more difficult than in the contiguous United States because of the narrow seasonal windows available for field work and high mobilization costs to remote Arctic areas, particularly with new challenges associated with shorelines and grounds that were once frozen permafrost, and can now no longer support conventional construction. The majority of existing road and rail infrastructure is concentrated in the south central region of the State; 82 percent of Alaska's communities are not connected by road and residents rely, in part, on snow machine, pick-up truck, and dog sleds in the winter to travel over land and sea ice.[26] Primary modes of commercial transportation are air and barge services supported by 400 general aviation airports and a network of small ports and harbors along the north and west coasts. This makes the delivery of life-sustaining resources, such as fuel, to many Alaskan communities expensive and restricted for many months of the year.

One major infrastructure consideration is the need for an Arctic deep-draft port (or ports), and associated evaluation of possible locations that could support fishing fleets, oil and gas development, mining, natural resources development, and ports of refuge. Additionally, these

[26] Aviation-Alaska's Lifeline (2012). Federal Aviation Administration and State of Alaska Transportation and Public Facilities. Available at: http://www.alaskaasp.com/media/1013/lifeline_video_fact_sheet_2012.pdf as of January 2016.

ports will need to provide reliable and economical delivery of goods to Alaskan communities and take into consideration the sustainable energy needs of a large port isolated for much of the year.

As noted previously, the U.S. Army Corps of Engineers (USACE) undertook a study in 2011 to determine options for an Arctic deep-draft port. After considering a number of options, including Kotzebue, Teller, Prudhoe Bay, St. Paul, Cape Darby, and Barrow, the draft report released in February 2015 identified the Port of Nome, Alaska, as the most suitable location for a deep-draft Arctic port.

Nome and surrounding communities are rural and remote, located off the continental road system. They are not connected to the power grid. Nome is served by regular, scheduled jet service, as it cannot be reached by road from Anchorage or other population centers of Alaska. Nome is a hub for more than 50 communities along the western shore of Alaska. Freight is shipped to Nome where it is then shipped via smaller barges to communities, where they often offload directly onto beaches or sand spits. These communities rely on barge shipments of fuel for electrical generators, among other things. Improvements to navigation in the area, therefore, would not only contribute to the well-being and sustainability of the residents and community—58 percent of whom are Alaska Native—but also the surrounding communities.

The USACE Port of Nome expansion proposal would construct a 2,150-foot-long causeway extension and a 450-foot dock, while deepening the harbor to 28 feet mean lower low water (MLLW). The project is designed to minimize risks to both the environment and navigation over the long term, while working towards sustainable communities throughout the region. However, with the cessation of oil and gas exploration efforts in the Chukchi Sea, the Nome project, as currently configured, does not exhibit an adequate cost-benefit analysis (i.e. > 1:1). USACE analysis for implementing infrastructure projects is justified based on efficiency gains measured in monetary terms. While this benefit calculation framework works well for gauging enhancements to commercial navigation, it is much more difficult to account for benefits to other types of navigation needs, logistical support, oil spill or other disaster response, and locations of vessel refuge that are not as easily converted to monetary terms. Therefore, an alternate method of justifying infrastructure investment to Arctic ports may be required to account for non-commercial navigation needs that are known to exist but that USACE has difficulty utilizing for project justification.

To adequately address all of these non-commercial navigation needs, a depth of at least 36 feet MLLW would be required at any deep-draft port. Based on feedback from Alaska Governor William Walker, U.S Special Representative for the Arctic Admiral Robert Papp, and many other notable speakers during the Conference on Global Leadership in the Arctic: Cooperation, Innovation, Engagement and Resilience (GLACIER) in Anchorage, Alaska during August 2015, it is short-sighted to build a deep-draft port with a limiting depth of 28 feet as it would not meet

Arctic requirements to provide northernmost bases and facilities for the United States. A deep-draft port at 36 feet water depth provides a logistics port in the Arctic Region for USCG icebreakers and cutters, U.S. Navy and NOAA vessels, and any other commercial or government ships that require a minimum depth of 35 feet. The vessel currently with the deepest anticipated draft in this fleet is the USCG heavy icebreaker *Polar Star*. In discussions, USCG stated that an icebreaker requires at least a depth of 35 feet for the vessel to safely enter a harbor to anchor or moor.

A deep-draft port in the Arctic could expedite attaining and meeting goals for strengthening marine environmental protection and response and completing tasks such as hydrographic charting.

The initial focus of a deep-draft port should be to establish a viable location of logistics support or viable staging area of operations in a location that has established infrastructure, such as a hospital, fueling facilities, and airport. As this port would be primarily used to reduce risk to commercial operations, a cooperative agreement must be made with that community and industry to share the use of the port to provide a center of logistics support for Federal Government and commercial activities in the Arctic region. A deep-draft port advances U.S. security interests and reflects a commitment to stewardship of the Arctic region.

Consideration should also be given to whether future, limited MTS infrastructure would be valuable at other sites outside of Nome, not only to support vessels seeking refuge, but to build redundancy into Alaska's Arctic infrastructure and critical community supply chain network. As commercial interest in the Arctic increases, the discussion of activity and infrastructure must expand to uses other than oil and gas exploration and development. Despite announcements in the fall of 2015 related to the cessation of oil exploration in the Chukchi for the near future, the United States must focus on other commercial uses such as transshipment, mining, resupply, fisheries, and tourism—all viable enterprises. There are also additional energy sector priorities relevant to marine transportation, such as renewable energy development, expanded distribution of North Slope natural gas, and the shipment of natural gas resources through the Arctic. While energy exploration companies are required to provide much of their own support capacity, other maritime activities rely more on Federal, State, and local infrastructure for emergency response, shelter, weather forecasting, and search and rescue. These enterprises also support national and regional economic development and provide important services to Alaskan communities. Exploring the support needs of these commercial activities and identifying major infrastructure gaps is an important step in supporting continued safe and sustainable communities as prioritized by the U.S. agenda for the Arctic Council chairmanship and the priority to improve economic and living conditions in Arctic communities.[27]

International Convention for the Prevention of Pollution from Ships Port Reception Facilities at Ports Servicing Arctic Shipping

As international marine transportation in the Arctic has increased, so has the need to monitor possible environmental impacts and support voluntary and legal requirements. The International Convention for the Prevention of Pollution from Ships (MARPOL) applies in the Arctic just as it does elsewhere around the globe. Additionally, the IMO recently adopted the International Code for Ships Operating in Polar Waters (Polar Code). The Polar Code is a ship-specific set of requirements to raise the safety and environmental protection standards for ships operating in the Arctic and Antarctic. As the United States plans for Arctic deep-draft ports and increased maritime operations, consideration should be given to the infrastructure necessary to address new international pollution prevention regulations, including port reception facilities (PRF), as well as the duty to protect the Arctic from environmental disasters as a result of increased use.

U.S. ports in the Arctic such as Nome, which does have adequate reception facilities for the seasonal shipping that currently uses the port, may face additional challenges as ship traffic increases and ice-free conditions last longer. Consideration should be given to the arrival of larger cruise ships, which will also require greater capacity and use of port reception facilities.

The established near-Arctic U.S. ports (e.g., Anchorage) and U.S. ports that regularly service ships heading for Alaska (e.g., Seattle-Tacoma) have adequate port reception facilities (PRF) for MARPOL wastes and could expand capacity to receive increased shipping to and from the Arctic region. The Arctic Council's Protection of the Arctic Marine Environment Working Group has considered waste management challenges facing both ship operators and existing and potential ports that are located in Arctic waters.[28] These waste management challenges include:

- Difficulty in constructing new infrastructure due to remoteness or geological characteristics of the port
- Changing ice conditions that would prevent practical use or siting of reception facilities

[27] U.S. Chairmanship of the Arctic Council. Available at: http://www.state.gov/e/oes/ocns/opa/arc/uschair/index.htm as of January 2016.
[28] Arctic Council Protection of the Arctic Marine Environment Working Group, Technical Report—Phase I of The Assessment of existing measures for port reception facilities for ship-generated waste and cargo residues (2006). Available at: http://www.pame.is/images/02_Document_Library/Reports_to_Ministers/05_AC_Meeting/technicalreport-port-receptionfacilitiesthepameregion.pdf as of March 2016.

- Landside environmental concerns regarding waste processing and disposal facilities sited in Arctic ports located adjacent to environmentally sensitive areas, and protected habitats, designated refuges, or culturally sensitive areas; and
- PRFs in logistically challenging remote areas (seasonally or year round) or complete inability to operate at some PRFs during winter months due to seasonal ice conditions.

Accurate Positioning

An underlying aspect to physical infrastructure development is the need for accurate maritime positioning information. There are two major components to this kind of reference information: spatial reference (through geodetic datums) and vertical water-level reference (through tidal datums). Because the U.S. Arctic has been relatively inaccessible until recently, it lacks the same basic geospatial infrastructure NOAA has provided to the rest of the Nation (Figure 6). For example, elevations relative to sea level can be off by more than a meter in the Arctic, whereas the rest of the Nation benefits from centimeter-level positioning accuracies.

Meter-level positioning errors can impact infrastructure siting and construction, sea-level change data, erosion accuracy, energy development, and storm-surge modeling. To improve positioning in all three dimensions, NOAA must continue to collect gravity data and to add Continuously Operating Reference Stations (CORS) and National Water Level Observation Network (NWLON) stations. Currently there are very few CORS stations serving the Alaskan Arctic, with only ten sites along the Aleutian Chain, ten in Arctic coastal areas of the Bering Sea, and three serving the North Slope. Similarly, NOAA operates only nine long-term NWLON stations in the Arctic, with a minimum of twenty-one more stations needed. Co-locating new CORS with NWLON stations would significantly improve the extremely limited coverage in northern and western Alaska for precise positioning and water levels, thus improving the Arctic geospatial framework. This framework is critical as it not only supports physical infrastructure development, but is also the foundation for other key MTS safe navigation needs such as nautical

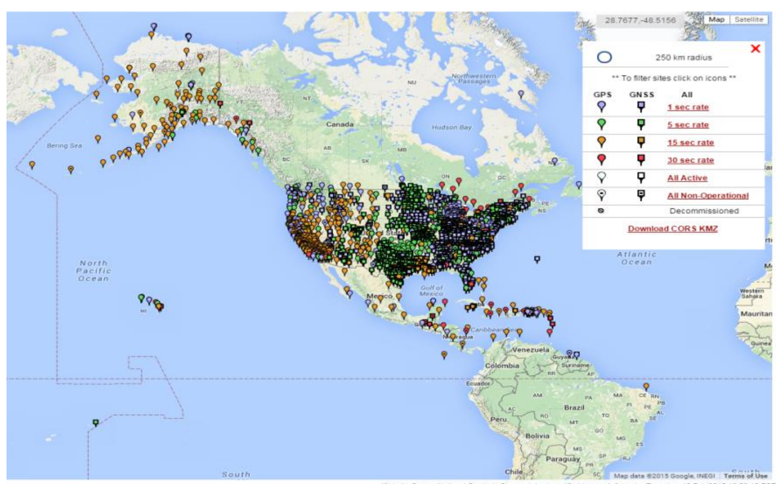


Figure 6. Map demonstrating unequal distribution of Continuously Operating Reference Stations between Alaska and the contiguous United States

charts, depths, and shoreline mapping. Additional coastal and river water-level observations also support flood and storm-surge warnings, which should be considered priorities given the rapidly changing Arctic environment and future impacts on Arctic communities.

Recommendations

Physical Infrastructure	Recommendations	Implementation Timeline
Environmental Infrastructure	Prioritize the need for Arctic port reception facilities to support international regulatory needs and future growth.	Near-Term
Accurate Positioning	Expand Arctic coastal and river water-level observations to support flood and storm-surge warnings.	Near-Term
Commercial Arctic Uses	Review U.S. Arctic maritime commercial activities to identifying major infrastructure gaps that should be addressed to promote safe and sustainable Arctic communities.	Near-Term
Accurate Positioning	Co-locate new CORS and NWLON stations to significantly improve the Arctic geospatial framework with precise positioning and water levels.	Near-Term
Arctic Deep-Draft Port	Review requirements for port investment to determine alternative methods for justifying Arctic ports to account for non-commercial navigation needs not currently utilized in USACE project justifications.	Mid-Term
Supply Chain Infrastructure	Explore additional options for limited port infrastructure to support Alaska's critical Arctic supply chain framework.	Mid-Term
Arctic Deep-Draft Port	Consider options for Federal deep-draft port facilities with cooperative agreements for dual use with local communities and facilities to meet multiple requirements.	Long-Term

Information Infrastructure

Information is an essential component of any MTS, especially in the Arctic, where conditions are often hazardous due to the harsh and changing environment. These information services require dynamic inputs and are relied on by mariners and other MTS users for situational awareness and safe, secure, and efficient marine transits. MTS information infrastructure includes, but is not limited to, the following:

- Nautical charts built on updated hydrographic and shoreline mapping, water level and geodetic positioning data
- Channel delineation and dredge data
- Aids to navigation (ATONs)
- Accurate marine weather and sea ice forecasts
- Real-time global positioning and water levels
- Automatic Identification System (AIS), and
- Communications capabilities

Automatic Identification System Framework

AIS is an automatic tracking and location system used on many vessels. The AIS device is a transponder used to communicate with other ship, shore, or satellite receivers. AIS works with vessel traffic systems to communicate critical information about vessels transiting an area such as name, identification number, speed, heading, and port of origin and destination. The system allows the ship-to-shore and ship-to-ship communication of positions that is critical for navigation and maritime situational awareness. It can also be used in a shore to ship mode to transmit information to ships from shore to make them aware of Notices to Mariners (NTM) about changes to aids to navigation, changes in charts, or other hazards that may affect their voyage.

IMO's International Convention for the Safety of Life at Sea (SOLAS) requires AIS to be carried by all international vessels 300 gross tons or larger, and by all passenger ships regardless of size including those operating in the Arctic. USCG also requires approved AIS class A devices on vessels 65 feet and longer engaged in commercial service, including towing vessels greater than 26 feet, among others.[29] [30]

[29] 33 CFR part 164.46. Available at: http://navcen.uscg.gov/?pageName=AISRequirementsRev as of March 2016.

Currently, USCG has a cooperative agreement with the non-profit Marine Exchange of Alaska (MXAK) to obtain AIS positional information from their shore-based receivers (Figure 7). Because the network is owned and operated by MXAK, the USCG is a consumer of the output of that service. It may be possible to augment the current system to track vessels operating further offshore. In addition, the existing system does not capture smaller vessel (e.g. hunting and fishing) that are not equipped with AIS capabilities.

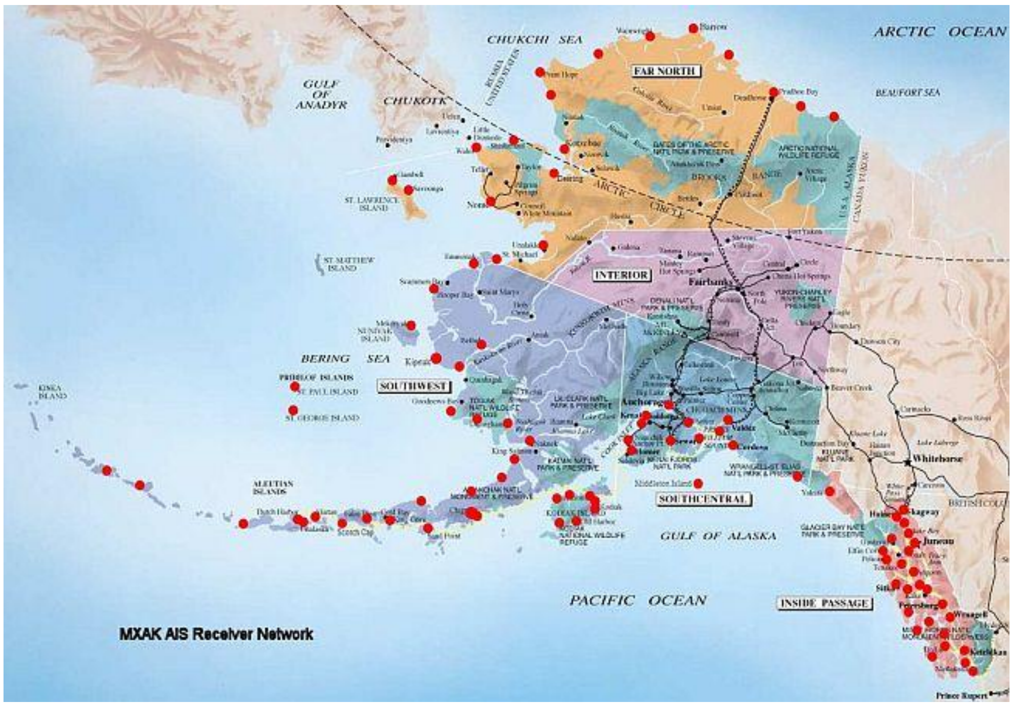


Figure 7. Marine Exchange of Alaska shore-based, Automatic Identification System receiver network.

[30] AIS class A device is shipborne mobile equipment intended to meet the performance standards and carriage requirements adopted by IMO. Class A stations report their position (message 1/2/3) autonomously every 2-10 seconds dependent on the vessel's speed and/or course changes (every three minutes or less when at anchor or moored); and the vessel's static and voyage related information (message 5) every 6 minutes. Available at http://www.navcen.uscg.gov/?pageName=typesAIS as of March 2016.

Communications

Communication in the Arctic is critical but difficult because of an inherent lack of communications architecture and the challenging polar environment. Advancements have been made to improve communications by the Federal Government and other private partners. For example, the Department of Defense's Mobile User Objective System (MUOS), a Navy-acquired narrowband, beyond-line-of-sight satellite communications system with space, ground, and waveform architectural components is scheduled to achieve full operational capability in 2016 with a 10-fold increase in capacity. Additionally, NOAA is in the process of conducting deep-water baseline assessments necessary for any fiber optic cable or other communications cables to be lain on the sea floor, and the National Telecommunications and Information Administration is assessing telecommunications services above the Arctic Circle in support of additional task items within the NSAR IP. The Arctic Council's Task Force on Arctic Telecommunications Infrastructure will also publish a comprehensive assessment of the telecommunications infrastructure needs across the circumpolar North, including in the U.S. Arctic, in 2017. The Iridium Push-to-Talk system, a commercially provided solution, uses distributed tactical communications and the Iridium constellation to provide global access. For example, Quintillion Subsea Holdings, LLC (formerly Quintillion Networks), is currently constructing a submarine cable system designed to connect Arctic Alaska, Canada, the United Kingdom, and Japan. Phase one, the Arctic Alaska portion of this project, will extend from Prudhoe Bay to Nome, with landings in the communities of Barrow, Wainwright, Point Hope, and Kotzebue. Each of these landings will have an initial capacity of 100 Gbps. This effort will provide telecommunications services to 26,000 Alaskan residents living on the North Slope and is scheduled to be operational in 2017.

Advancing communications and exchange of information is critical when sailing through such a dynamic environment, particularly when access to route, chart, weather, and ice information is critical for navigation safety and compliance. Traditional broadcast notices to mariners may not provide information in a timely enough manner to reflect changes in the Arctic, such as weather warnings.

The development of Arctic communication systems is critical to maritime safety and situational awareness. Of particular importance is the ability to communicate with ships regarding the presence of other, smaller vessels in the area or potential conflicts in use. In the Arctic, where fishing and subsistence harvesting are regular practices, the need for vessels to communicate positions and other information is paramount. An advanced communication network ensures the safety of all vessels operating in U.S. Arctic waters.

Aids to Navigation

A related communication issue is the ability to communicate specific chart or ATON information to vessels transiting the area. Timely notification of seasonal hunting and fishing areas allows vessels to take precautions while transiting the area or avoid it all together. Currently, there are no federally maintained aids along the North Slope. To assess Arctic marine traffic risks, the USCG completed a Waterway Analysis and Management System assessment in 2014 looking at the types and extent of ATON needed along the north and west coast of Alaska. Given the challenges with deploying physical ATON, the use of AIS-based Electronic Aids to Navigation (e-ATONs) may be used to augment the physical aids to navigation constellation. In addition, AIS technology can be leveraged to broadcast Enhanced Marine Safety Information (e-MSI) that will provide the mariner critical information for safe navigation. The Coast Guard is currently engaged in a Cooperative Research and Design Agreement (CRADA) with the MXAK to ensure that the ability to transmit e-ATON and e-MSI is available to the commercial industry for future implementation.

The ability to share information over the AIS data network enables rapid communication between critical agencies and vessels. Augmenting this communication using e-MSI facilitates a more situationally aware crew on the bridge. Transmitting traditional Notice To Mariners, including weather and charting information, and e-ATON changes, also relies on a robust communication network. Arctic maritime safety and enhanced situational awareness should include discussions of near-term development that can further support these types of communications.

Nautical Charting

Nautical charts based on modern hydrography and at adequate scales are essential for voyage planning, safe navigation, and safe marine operations. To illustrate, a contributing cause to the M/V *Fennica's* grounding near Dutch Harbor, Alaska, in 2015 was a shoal rock in an area last surveyed in 1933 with lead lines and sextants. Although over half of U.S. Arctic waters are classified as navigationally significant (242,000 square nautical miles), only about 4,300 square nautical miles of this navigationally significant area (less than 2 percent) has been surveyed with modern multibeam technology. In fact, most charted Arctic waters were surveyed with obsolete technology, some dating back to the eighteenth century. The incident involving the *Fennica* highlights not only current Arctic data gaps but also the need for modern hydrographic surveys to accelerate charting updates as vessel activity increases and sea bottoms change. NOAA is working to leverage Federal, State, and private partners to enhance charting capabilities. In 2015, NOAA ships *Fairweather* and *Rainier* worked with the USCG icebreaker *Healy* to acquire roughly 12,000 linear nautical miles of trackline depth measurements along the Coast Guard's proposed transit route between the Bering Strait and Dutch Harbor. The NOAA survey ships and a contractor also conducted several full bottom hydrographic survey projects, acquiring more than 500 square nautical miles of data in coastal areas along western Alaska.

The need for modern and adequate nautical charts is an urgent priority for safe navigation identified in nearly every Arctic MTS-related report since 2009. However, the total requirement to survey a minimum of 500 square nautical miles a year in U.S. Arctic waters far outweighs the resources NOAA has available and the capacities of NOAA's two 48-year old survey vessels. NOAA's Hydrographic Services Review Panel Federal Advisory Committee recommended that hydrography and charting of the U.S. maritime Arctic be among NOAA's highest priority requirements for program execution. Accurate nautical charts will also facilitate any future designation of subsistence use areas, marine protected areas, seasonal migration routes and other ecologically relevant areas. Moreover, the data supports Arctic coastal community resilience, as it feeds into storm surge models, erosion assessments, and sea level change studies.

Weather and Sea Ice Forecasting

The ability to transmit timely weather information and sea ice forecasts depends heavily on the ability to predict inclement weather and changes in currents or ice cover and extent. One side effect of an ice-diminished Arctic is a reduction in the dampening effect of ice on waves. As spring and fall storms intensify, wave action increases due to a lack of ice cover. Evidence of this is apparent in the rate of coastal erosion from the intensity of the breaking waves against the shores as well as an increase in wave conditions for vessels at sea. Thus, early warning of impending storms is that much more important, for both ships and coastal communities.[31] Loss of sea ice also changes ice floes and the speed and density of those floes. Being able to detect, track, and report locations of ice means better safety information, particularly for smaller fishing and hunting vessels most vulnerable to poor weather conditions. The NSAR IP specifically tasks the Department of Defense and NOAA with improving sea ice forecasts and predictions at a variety of spatial and temporal scales, echoing the importance of this issue.

Currently, Arctic weather forecasts and sea ice predictions are only accurate two to three days in advance, compared with five- to seven-day predictive capabilities for the rest of the United States. A key factor in the accuracy of weather model predictions is the consistency of the initial conditions. Insufficient real-time in situ meteorological observations in U.S. Arctic waters and in Alaska hamper NOAA's forecasting accuracy (e.g. spring and fall sea storms). Likewise there

[31] Sea Level Rise and Storm Surge, Sea Grant Alaska Advisory Program (2014). Available at: https://seagrant.uaf.edu/map/climate/docs/sea-level.php as of January 2016.

is a need for high spatial and temporal scale observations from satellite platforms to accurately predict weather three to seven days in the future.

At present, low-Earth orbiting weather satellites cover the entire Earth, but in the Arctic region they provide data for any given spot only a few times per day. The Joint Polar Satellite System (JPSS) will help to partially address this gap. A collaborative effort between NOAA and NASA, JPSS represents significant technological and scientific advancements in severe weather prediction and environmental monitoring. It will help advance weather, climate, environmental, and oceanographic science, including for the Arctic region. NOAA and NASA are on track for the launch of the second satellite in the JPSS program in early 2017. To supplement JPSS, the CMTS recommends reinvigorating discussions with Canada on the proposed Canadian Polar Communication and Weather (PCW) highly-elliptical orbit satellite mission to contribute needed observations for Alaskan and Arctic weather prediction. The PCW's increased spatial and temporal resolution of weather observations every five to ten minutes would enhance the consistency of initial conditions that are used in weather and climate models and will lead to improved accuracy of weather model predictions.

To increase in situ observations for better understanding and prediction of changes in Arctic sea ice and weather, a number of Federal agencies are engaged in various initiatives to address the need for greater density of meteorological and ocean observations to feed the models. For example, in 2014 the Office of Naval Research supported the deployment of nearly 100 instrumented platforms on, in, and under the sea ice to observe the marginal ice zone (MIZ), where the frozen ocean meets the open ocean in the Beaufort Sea north of Alaska. The MIZ observing array measured the weather at the ice surface; the temperature, surface characteristics, thickness and drift of the sea ice; ocean properties (salinity, temperature, and density), stratification, and mixing below the ice; and ocean surface waves and their propagation into the ice cover. The MIZ field experiment demonstrated the potential for long-duration, under-ice deployment of seagliders (unmanned underwater vehicles) to collect data supported by acoustic communications and navigation services over distances of hundreds of kilometers.

The Naval Research Laboratory, in collaboration with the National Snow and Ice Data Center and the NASA Goddard Space Flight Center, has developed a technique to blend passive microwave satellite sea ice concentration products with National Ice Center's Interactive Multisensor Snow and Ice Mapping System ice analysis for assimilation into the Navy's ice forecasting systems. These advances have provided significant improvements in the ice edge location forecast by the operational Arctic Cap Nowcast/Forecast System and pre-operational Global Ocean Forecast System, expected to be operational in 2016.[32]

NOAA's sea-ice operations have expanded to seven days per week and include detailed sea ice analysis. They provide a five-day forecast three days each week in both text and graphical formats. They also provide seasonal outlooks directed primarily at coastal communities and industry for insight into freeze-up and break-up for purposes of safe and efficient maritime operations. As part of the effort to improve sea ice forecasts, Federal agencies are involved in the development and regulation of unmanned aerial vehicles (UAV). The use of UAVs is expected to significantly increase over time, assisting in all areas of remote-sensing capabilities and other important earth observation systems used throughout the Federal Government for safety, security, and infrastructure development. The use of UAVs to assist in navigation, voyage planning, and sea ice and weather prediction for maritime shipping will continue to grow.

Increasing in situ and autonomous observations (e.g., sub-surface temperature, salinity, and ocean-current observations), along with integrated modeling throughout the Arctic, will inform and improve seasonal ice and weather forecasting and understanding of the atmosphere-ice-ocean-waves system. Such forecasting improvements are crucial for safe navigation and maritime operations in the Arctic and should be considered a high priority for near-term information infrastructure goals.

[32] The overall ice edge error in the Pan-Arctic region was reduced by 36% for a year-long time period, while a decrease of 56% occurred during the summer melt season, compared to results using ice concentration derived from the older SSMI and SSMIS satellite sensors. The results of this work are available in "The Cryosphere" (Posey et al., doi: 10.5194/tcd-9-2339-2015, http://www.the-cryosphere-discuss.net/9/2339/2015/tcd-9-2339-2015.html).

Recommendations

Information Infrastructure	Recommendations	Implementation Timeline
Weather and Sea Ice Forecasting	Improve weather, water, and climate predictions to an equivalent level of service as is provided to the rest of the nation.	Near-Term
Weather and Sea Ice Forecasting	Implement short-range, sea-ice forecasting capability.	Near-Term
Charting	Place hydrography and charting of the U.S. maritime Arctic among the highest priority requirements for agency execution.	Near-Term
Communication Systems	Advance Arctic communication networks to ensure vessel safety.	Near-Term
Vessel Routing	Finalize the Port Access Route Study for the Bering Strait and continue efforts to provide routes for vessel traffic in the U.S. Arctic.	Near-Term
Automatic Identification System	Expand partnerships to provide new satellite AIS capabilities for offshore activity information.	Near-Term
Weather and Sea Ice Forecasting	Sustain and increase in situ and autonomous observations and integrated modeling throughout the Arctic Ocean to improve seasonal ice and weather forecasting and expand Federal/international/other supporting partnerships.	Mid-Term
Charting	Survey a minimum of 500 square nautical miles a year in U.S. Arctic waters.	Mid-Term
Automatic Identification System	Explore additional requirements for private and commercial AIS transponder and networking needs (e.g. handheld devices or AIS for subsistence hunting or fishing vessels for ship-to-ship communication).	Mid-Term
Weather and Sea Ice Forecasting	Assess the expanded use of Unmanned Aerial Vehicles to assist in navigation, voyage planning and real time weather prediction, where appropriate.	Long-Term
Communication Systems	Explore the requirements for Enhanced Marine Safety Information to facilitate a safer, more aware vessel crew.	Long-Term

MTS Response Services

MTS Response Services are those services necessary to respond to marine transportation-related emergencies. These include the following services:

- Search and Rescue (SAR) to find and provide aid to people who are in distress or imminent danger;
- Environmental response management, including oil spill prevention, preparedness and response, and the response technologies and MTS capabilities (vessels, personnel, materials, and equipment) necessary to effectively plan for, prepare for, prevent, respond to, and clean up oil and other hazardous wastes spilled at sea; and
- Ice-breaking capability to free vessels beset in ice or in danger; ice-breakers also support SAR efforts, spill response, emergency marine delivery of life-sustaining resources to Alaskan communities, and research.

Emergency Response

The USCG is the primary Federal agency responsible for SAR in U.S. maritime regions. Emergency response in the Arctic is made even more difficult by the remoteness and vast distances of the region, impacts of intense and extended cold, and lack of shore infrastructure, and reliable communication networks. From the northernmost point of land at Point Barrow, Alaska, the nearest USCG air facility is at Kodiak, which is 820 nautical miles away (a 6-hour flight), and the closest refueling site for vessels is Dutch Harbor, 1,000 nautical miles away.

SOLAS, among other provisions, obligates all vessel masters to offer assistance to those in distress. In addition, on May 12, 2011, all the Arctic states signed an Arctic Search and Rescue Agreement, coordinating international SAR coverage and response in the Arctic. It establishes the area of SAR responsibility of each state party in addition to coordinating response assistance.

Over the past four summers, the USCG has set up forward operating locations in the U.S. Arctic to support Operation ARCTIC SHIELD. Through Operation ARCTIC SHIELD, the USCG is evaluating facilities and conducting research to inform future decisions for shore-side infrastructure in the region. These assets are supplemented with regional emergency response by the State of Alaska as well as private companies operating in the area. With the suspension of exploration activities, there will be a general drawdown in both the number of vessels in the region and support capacity as oil exploration campaigns dismantle response resources. This will reduce emergency response capability in the region and increase the reliance on Federal and State assets. This shift is particularly important as the cruise industry and commercial shipping prepare to sail through the Northwest Passage in the summer of 2016, and as the number of pleasure and adventure craft transiting the Northwest Passage continues to increase. Although the increase in total traffic is modest when compared with other regions, survival and response conditions in the Arctic are unlike more temperate regions. The Arctic poses unique risks and requirements for response, and with these, increased requirements for an adequate state of readiness to respond to an incident.

A state of readiness is only possible when access for emergency personnel is made available. Given the limitations of available assets at forward operating locations, such as Barrow and Deadhorse, it is important to ensure additional access by aircraft, which requires infrastructure such as runways, hangers, and refueling. Continued collaboration with State and local authorities to ensure access by air and water to necessary areas is key and should be considered a near-term requirement for Arctic infrastructure to maintain response readiness. Additional consideration should include an evaluation of the facilities currently available on the North Slope, such as those in Barrow and Wainwright that were either purpose-built by Shell or leased during exploration operations. These facilities provide lodging and kitchen facilities, and are equipped with generators and waste management systems that could be used for seasonal staging areas by USCG or other programs engaged in readiness exercises or research.

Oil Spill Response

To date, significant factors have limited commercial development in the Arctic: extreme cold, extensive ice, intense storms, and limited industrial infrastructure. These conditions also make response to and control of an oil spill or blowout more challenging than in other areas. Challenges include ice interference with mechanical, chemical, and burning response methods and potentially greater hazardous effects due to a slower emulsification rate and longer toxic component persistence.

Responding to oil spills in ice-covered waters requires a combination of tactics rarely tested in real Arctic marine and ice environments. There is currently an ongoing effort to increase preparedness and oil pollution response capabilities domestically and internationally. Established through the National Oil and Hazardous Substance Pollution Contingency Plan (40 CFR Part 300), the National Response System operates through a network of Federal agencies, through which USCG, NOAA, Fish and Wildlife and EPA oversee and enforce oil spill response. Additionally, the Federal/State Preparedness Plan for Response to Oil and Hazardous Substances Discharges and Releases (the Unified Plan), was developed jointly among the State of Alaska, USCG, and EPA. These frameworks integrate with the Alaska Incident Management System Guide for Oil and Hazardous Substance Response, which provides standardized oil spill response management guidelines to responders in Alaska.[33] The Alaska Management System coordinates with the national response frameworks (e.g., National Response System), but is specific to the State's interests.[34] The U.S. response framework intersects with other Arctic countries' authorities through the Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic.[35] This agreement's operational guidelines were developed and are maintained by the Arctic Council's Emergency Prevention, Preparedness, and Response Working Group (EPPR). EPPR facilitates exercises to test the agreement and guidelines.[36]

Continued coordination through international and interagency fora such as the EPPR, the newly established Arctic Coast Guard Forum, and others will provide significant opportunities for engagement across the Federal Government and the international Arctic response community. Future network initiatives should augment the work of the Alaska Regional Response Team (ARRT) under the Federal On-Scene Coordinator through the addition of a Pan-Arctic response equipment database, best practices recommendations built upon ongoing response exercises, and information sharing for continued development of guidelines for oil spill response in the Arctic region. Additionally, increased support for direct bi-lateral engagements (specifically with Russia and Canada) will foster existing relationships with Arctic nations through coordinated Joint Contingency Planning efforts. Improving these relationships will allow for enhancements and drills that will increase oil spill preparedness and response capabilities across the Arctic.

Response requirements should also consider the physical infrastructure needed to support oil spill clean-up and wildlife response/rehabilitation (e.g., housing, wildlife rehabilitation facilities, carcass/sample storage), as well as the manpower to undertake the operation. Consideration should also be given to whether there is sufficient upland infrastructure (e.g., landfills, incinerators, and storage tanks) with capacity to handle and dispose of spill material. Additionally, while there are guidelines to support expedited movement of people and equipment across borders, there are acknowledged challenges to transporting personnel and equipment from locations within the contiguous United States to the Arctic in the event of a catastrophic spill. Continuing support of the National Response System, and particularly ongoing spill response planning, is critical to developing the response tools and resources needed during an emergency.

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[33] Alaska Incident Management System Guide (AIMS) *For Oil and Hazardous Substance Response, Alaska Department of Environmental Conservation,* (November 2002). Available at: https://dec.alaska.gov/spar/ppr/docs/AIMS_Guide-Complete(Nov02).pdf as of December 2015.

[34] Operations, Logistics, and Coordination in an Arctic Oil Spill (2014). Transportation Research Board and National Research Council, Responding to Oil Spills in the U.S. Arctic Marine Environment. Washington, DC. The National Academies Press, doi: 10.17226/18625.

[35] Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic (2013). Available at: http://www.state.gov/r/pa/prs/ps/2013/05/209406.htm as of January 2016.

[36] Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic, Arctic Council (Revision 1: January 28, 2014). Available at: http://arctic-council.org/eppr/wp-content/uploads/2014/03/NCR-5979727-v1-OPERATIONAL_GUIDELINES_ENGLISH_FINAL_WITH_UPDATE_PROCEDURES_NO_PHONE_NR.pdf as of January 2016.

Lastly, continued scientific support for oil spill response and research is critical in developing the needed response and restoration techniques to address any future Arctic oil spill. The Interagency Coordinating Committee on Oil Pollution Research, which USCG chairs, published its *Oil Pollution Research and Technology Plan: FY2015-2021* in September 2015. This plan established 150 oil pollution research priorities in 25 standing research areas. Twenty-three priorities were specific to polar or extreme environments, in addition to many other priorities applicable to multiple environments, including the Arctic.

Continuing to work with agencies and stakeholders to develop a communication structure for decision making and information sharing purposes during emergencies is critical, as is the development of a system for caching the equipment needed to implement Geographic Response Strategies and respond to oiled wildlife. By working with stakeholders to determine and fill infrastructure needs for emergency response, including wildlife response and rehabilitation, particularly through the ARRT, it is possible to strengthen relationships with U.S. Arctic neighbors to better understand how nations will collaborate during emergencies.

Given the technical and logistical challenges of responding to pollution events in the Arctic and the serious, long-term effects of possible spills, a significant focus should be placed on pollution prevention. Regulations and best practices regarding the proper use and carriage of oil and other pollutants through the Arctic should be initiated and supported by the U.S. as part of international conventions and agreements.

Recommendations

MTS Response Services	Recommendations	Implementation Timeline
Emergency Response	Continue collaboration with State and local authorities to ensure readiness of Arctic maritime and aviation infrastructure for emergency response and SAR.	Near-Term
Oil Spill Readiness	Continue coordination through international fora to provide significant opportunities for engagement across the Federal Government and the international Arctic response community.	Near-Term
Oil Spill Readiness	Support Pan-Arctic response equipment database development, best practices recommendations, and information sharing for continued development of guidelines for oil spill response in the Arctic.	Near-Term
Emergency Response	Develop a plan to transport critical response equipment from the contiguous United States into the Arctic area in the event of a catastrophic event.	Near-Term
MTS Response	Evaluate facilities currently available on the North Slope for use as seasonal staging areas by those engaged in readiness exercises or research.	Near-Term
MTS Response	Pursue increase support for direct bi-lateral engagements to foster existing response relationships with other Arctic nations.	Mid-Term
Oil Spill Readiness	Continue scientific support for oil spill response and research directives in the *Oil Pollution Act of 1990* (OPA90).	Mid-Term
Oil Spill Readiness	Develop on-shore facilities for oil spill response (e.g. hazardous/oily waste disposal, wildlife response, responder housing).	Long-Term

Vessel Operations

Vessels are the mobile platforms necessary to move goods and people throughout the MTS. In the past, there has been limited vessel activity in the U.S Arctic. With the lengthening of the open-water season due to climate change and loss of sea ice, vessel activity has increased dramatically, as has the diversity of vessels operating in the region. A variety of vessel types operate in, or transit through, the U.S. Arctic annually, including the following:

- Commercial and oceangoing vessels
- Coastal and inland vessels
- Barge vessels
- Tug boats
- Towing vessels
- Bulk carrier ships
- Container ships
- Military vessels
- Fishing boats
- Marine mammal hunting craft
- Scientific research vessels
- Recreational boats, and
- Offshore structures

U.S. Icebreaking

The current Federal fleet of Polar icebreakers consists of one medium icebreaker (USCGC *Healy*) and one heavy icebreaker (USCGC *Polar Star*). The *Polar Star* is the only active heavy icebreaker and is primarily used in the Antarctic. The *Healy* is used primarily to support science missions in the Arctic, but may also be used to support other Coast Guard statutory missions such as search and rescue or provide persistent command and control capability, as required.

It is important to note that capabilities of Coast Guard icebreakers often far exceed minimum international standards for icebreaking vessels, such as International Association for Classing Societies. These standards identify minimum power and structural survivability requirements of a single purpose vessel operating in ice infested waters. Unlike commercial vessels that are built to perform single missions with minimal crews, Coast Guard assets are multi-purpose vessels that incorporate aviation support, command and control, and additional power and endurance requirements necessary to perform all missions. The Coast Guard has assessed all available commercial icebreakers and has determined no currently operating vessel meets these critical mission and performance requirements for either a heavy or medium icebreaker. As a result, acquisition of new assets is the only viable option for obtaining additional icebreaking capacity.

The Coast Guard currently has an acquisition program that will replace the capabilities of the *Polar Star* when complete. Due to lengthy design and production and anticipated decommissioning of the *Polar Star*, the Coast Guard will not provide additional capacity within the 10-year horizon. While Coast Guard icebreaking support has been used to facilitate commerce in emergency situations, such as the 2014 fuel resupply in Nome, the Coast Guard does not intend to use these vessels to facilitate routine commercial maritime traffic or to support commercial drilling operations.

Waterway Usage Coordination

As more vessels transit U.S. Arctic waterways, planning, communication, and situational awareness will become more important to protect waterway users, the environment, and the people that live in the region. For example, subsistence-harvest activities use small vessels to access hunting grounds throughout the U.S. Arctic in and between coastal areas and islands. Though larger commercial vessels have the equipment and obligation to inform regional authorities of their plans, these smaller vessels are not bound by the same requirements. As such, maritime use and safety conflicts are serious issues for the region. The USCG Bering Strait Port Access Route Study outlines initial steps for waterways management recommendations to facilitate possible channels of communication for small- and large-vessel operators. Efforts should continue to formalize communication channels among waterways users so that all parties using the regional resources are aware of activities that may create conflicts for voyage routes or whaling and fishing activities. These efforts should utilize regional bodies like the Arctic Waterways Safety Committee to facilitate dialogue among communities and vessel operators to communicate voyage planning and waterways-use management, and to reduce conflicts that may arise from a crowded waterway during particularly sensitive times, such as marine mammal migrations and the whaling season.

This need for transparency among waterways users extends outside commercial and resource use vessels and includes activities from research vessels as well. Each summer, a number of research voyages transit the Arctic either pursuing science in U.S. waters or on routes through the region to other areas of interest. These research vessels provide a unique challenge because they, unlike commercial vessels, can spend extended periods of time within a limited area. This can create conflicts if research waters are also locations of traditional harvest or fishing for subsistence purposes. The extended presence of large research vessels creates a safety consideration for small vessels and may have consequences for marine mammal and bird populations competing for use of the same areas. The CMTS recommends the continuation of efforts to improve planning and transparency of research missions in order to include and inform Arctic communities, fostering cooperative planning that would minimize disruptions to subsistence activities while promoting scientific research in the region.

Human Element

As a result of the implementation of the Polar Code, the IMO developed training amendments to the STCW Convention, applicable to masters and deck officers serving on board vessels working in polar regions. These amendments will be adopted in May 2016 with an expected entry into force date of January 1, 2018. This common set of rules will also ensure that any increase in Arctic shipping would take place more efficiently and using the best environmental standards. Historically, at the international level, no specialized mandatory qualifications, training, or certifications existed for crews of vessels that operated in polar waters, including the Arctic. The challenge now for the United States and its international partners is implementing the Polar Code and harmonizing U.S. legislation and regulatory efforts that meet U.S. priorities for the Arctic and consider the needs of Arctic residents and other Arctic States. As with other international regulations, the Coast Guard derives its regulatory authority through implementing acts such as the *Act to Prevent Pollution from Ships* (APPS, 33 U.S.C. §§1905-1915) which implements MARPOL through domestic Coast Guard regulations. Given the expected long-term increase in shipping in the U.S. Arctic, the challenge for the Coast Guard will be considering and adapting to a potential need for increased resources for environmental response, search and rescue, and maritime domain awareness.

With respect to maritime domain awareness and Arctic governance in general, the challenges for the Arctic are two-fold; first being able to monitor vessels operating in the area despite limited capacity and second, to respond to any safety or environmental emergencies that may arise. In addition, the Coast Guard will have to monitor the many vessels transiting the Bering Strait that will not dock at a U.S. port, complicating enforcement in remote waters that include much of the U.S. Exclusive Economic Zone out to 200 nautical miles. The newly established Arctic Coast Guard Forum will address many of these response challenges. On October 30, 2015, the heads of Coast Guard-like agencies from all eight of the Arctic nations signed a joint statement establishing the Arctic Coast Guard Forum as an official mechanism for discussion and coordination of emergency response operations. The Forum's purpose is to leverage collective resources to foster safe, secure, and environmentally responsible maritime activities in the Arctic region. This construct will implement and reinforce previous agreements through the Arctic Council, such as the Search and Rescue Agreement, and may also facilitate the enforcement of new Arctic policies and regulations like the Polar Code.

As the Polar Code entry-into-force date of January 1, 2017, approaches, the United States should continue to work with international partners to evaluate the efficacy of the Polar Code, and develop the necessary interim policies and regulations to implement mandatory provisions of the Polar Code and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW). Additional work may also be needed to examine existing requirements related to training and safety standards for the U.S. fishing fleet, as commercial fishing vessels are required to comply with some, but not all, of the Polar code provisions.

Recommendations

Vessel Operations	Recommendations	Implementation timeline
Ice Breaking	Expand U.S. icebreaking capacity to adequately meet mission demands in the high latitudes.	Near-Term
Vessel Operations	Update domestic law to implement the mandatory provisions of the Polar Code and the STCW Convention.	Near-Term
Human Element	Examine existing training and safety standards applicable to the U.S. fishing fleet with respect to the new Polar Code requirements.	Near-Term
Waterway Usage Coordination	Facilitate dialogue among communities and vessel operators to communicate voyage planning, and waterways use management.	Near-Term
Waterway Usage Coordination	Continue to improve planning and transparency of research missions to include and inform Arctic communities to minimize conflicts while promoting scientific research in the region.	Mid-Term
Waterway Usage Coordination	Continue to formalize communication channels among waterways users so that all parties utilizing the regional resources are aware of activities that may create conflicts for voyage routes or harvest activities.	Long-Term

SUMMARY

The U.S. Arctic is a dynamic and rapidly evolving maritime region. The recommendations put forward in this report extend beyond the traditional definition of transportation infrastructure (the basic equipment, structures, roads and bridges that are needed for a country, region, or organization to function properly) to include a framework for the necessary elements of a comprehensive U.S. Arctic marine transportation system. This framework necessarily involves elements of the traditional definition, but also includes communication, planning, management, environmental policies, regulatory implementation, and community engagement—all of which are required for safe, secure, and environmentally sound maritime transportation.

As the recommendations in the previous sections note, there are specific near-term actions that can be taken to address the current gaps in U.S. Arctic infrastructure, such as the following:

Near-Term Recommendations	
Navigable Waterways	Designate Port Clarence as an Arctic Maritime Place of Refuge.
	Review Port Clarence facilities to assess whether adequate support facilities are available at Port Clarence or in the region for a ship in need of assistance.
	Support Arctic Waterways Safety Committee efforts to bring stakeholders together.
	Leverage existing data-sharing frameworks, such as Data.gov, the Alaska Regional Response Team, and Alaska Ocean Observing System, to facilitate waterways planning and response to environmental emergencies.
	Leverage international partnerships supporting waterways coordination.
	Work with stakeholders to coordinate research efforts to de-conflict research within commercial and subsistence use areas.
	Designate M-5 Alaska Marine Highway Connector to connect the Arctic Ocean and the western section of the Northwest Passage.
Physical Infrastructure	Prioritize the need for Arctic port reception facilities to support international regulatory needs and future growth.
	Expand Arctic coastal and river water-level observations to support flood and storm-surge warnings.
	Review U.S. Arctic maritime commercial activities to identifying major infrastructure gaps that should be addressed to promote safe and sustainable Arctic communities.
	Co-locate new Continuously Operating Reference Stations and National Water Level Observation Network stations to significantly improve the Arctic geospatial framework with precise positioning and water levels.
Information Infrastructure	Improve weather, water, and climate predictions to an equivalent level of service as is provided to the rest of the nation.
	Implement short-range, sea-ice forecasting capability.

	Place hydrography and charting of the U.S. maritime Arctic among the highest priority requirements for agency execution.
	Advance Arctic communication networks to ensure vessel safety.
	Finalize the Port Access Route Study for the Bering Strait and continue efforts to provide routes for vessel traffic in the U.S. Arctic.
	Expand partnerships to provide new satellite Automatic Identification System (AIS) capabilities for offshore activity information.
MTS Response Services	Continue collaboration with State and local authorities to ensure readiness of Arctic maritime and aviation infrastructure for emergency response and Search and Rescue (SAR).
	Continue coordination through international fora to provide significant opportunities for engagement across the Federal Government and the international Arctic response community.
	Support Pan-Arctic response equipment database development, best practices recommendations, and information sharing for continued development of guidelines for oil spill response in the Arctic.
	Develop a plan to transport critical response equipment from the contiguous U.S. into the Arctic area in the event of a catastrophic event.
	Evaluate facilities currently available on the North Slope for use as seasonal staging areas by those engaged in readiness exercises or research.
Vessel Operations	Expand U.S. icebreaking capacity to adequately meet mission demands in the high latitudes.
	Update domestic law to implement the mandatory provisions of the Polar Code and the Convention on Standards of Training, Certification and Watchkeeping for Seafarers.
	Examine existing training and safety standards applicable to the U.S. fishing fleet with respect to the new Polar Code requirements.

These 25 recommendations cover the five core MTS components for Navigable Waterways, Physical Infrastructure, Information Infrastructure, MTS Response Services, and Vessel Operations. Implementing them would provide a path for Federal activities needed to preserve the mobility and safe navigation of U.S. military and civilian vessels throughout the Arctic region.

As sea ice retreats, the United States must recognize the importance of providing infrastructure to support domestic and international industry growth in shipping, mining, oil and gas exploration, fishing, and tourism. The current limitations in nautical charts, aids to navigation, telecommunications and emergency-response and rescue capabilities make operations challenging in the U.S. Arctic. The priorities and recommendations presented in this document create an actionable framework to improve the U.S. Arctic MTS and facilitate responsible activity and growth in the region for a safe and secure U.S. Arctic over the next decade.