Global Maritime Forum 2019

REPORT ON THE WORKSHOP

held at the University of Liverpool, Liverpool, United Kingdom

Unifying Unmanned Systems to Enhance Maritime Security: Building Networks to Solve Unique Challenges

National Maritime Information Centre

U.S. National Maritime Intelligence-Integration Office
U.K. National Maritime Information Centre

NMIO Science and Technology Initiatives

For eight years, National Maritime Intelligence-Integration Office (NMIO) Science and Technology (S&T) initiatives have offered organizers and participants alike outreach opportunities to connect with subject matter experts from across the Global Maritime Community of Interest (GMCOI). Participants have come from government, academia, think tanks, private industry, and non-government organizations. S&T collaboration leverages the skills of experts to harness emerging maritime security innovations and develop strategies to counter emerging threats in and to the maritime environment.

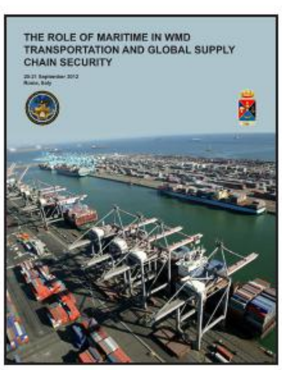
One of the most rewarding of such initiatives is the Global Maritime Forum (GMF). This NMIO-led activity creates new engagements with members of the GMCOI, aiding participants to identify and develop technologies, road maps and policy recommendations to enhance security and counter threats.

In past years, NMIO has partnered with university and government co-sponsors such as the University of Washington Applied Physics Laboratory, NASA, and the Italian Naval War College. This year NMIO, in partnership with the United Kingdom's National Maritime Information Centre (NMIC), held the GMF at the University of Liverpool. Working closely with cosponsors enables NMIO to leverage expertise and interest in the GMF thematic focus areas. Based on this expertise, GMF has convened in Italy, Singapore, the United Kingdom, and the states of California and Washington in the United States, allowing GMF participants a personal connection to focus on the issues they have gathered to discuss.

Each GMF is an opportunity to create action plans and projects through guided working group sessions, which are organized after keynote and panel discussions. Specific action plans stemming from GMF working groups have provided new capability for threat mitigation and defeat. The 2015 GMF led directly to a worldwide two-phased Maritime Data Challenge, where data scientists from around the world were asked to create an algorithm capable of identifying and detecting fishing activity. The Maritime Data Challenge was co-sponsored by NMIO, NASA, DOD, DHS, NRL, and Harvard University. The results of this crowd-sourcing challenge provided law enforcement and international security officials with greater insight to determine where Illegal, Unregulated, and Unreported (IUU) fishing is occurring, helping authorities preserve scarce resources by avoiding the need for patrols "in the dark." The next year, actionable results from the 2016 GMF initiated co-funded basic research projects with the Naval Postgraduate School.

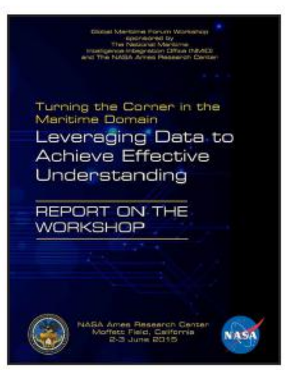
Another important initiative, the Technical Bulletin, is a key vehicle to promote enhanced maritime domain awareness, information sharing, and create S&T public-private-academic-international partnerships and cooperation. The Technical Bulletin is published once per year on topics aligned with the thematic focus area of the GMF with articles received from institutions such as Stanford University, University of California, Georgetown University and several international universities in Australia and Japan. Previous Bulletin themes have addressed space-based capabilities for the maritime domain, exploring Arctic research and forecasts on the great technological advancements of the future. Improved productivity resulting from technology innovation continues to be a major driver for economic growth, changing the way we live in astonishing ways. Science Technology Engineering and Math (STEM) education has a wide-range of disciplines and is often regarded as a platform for tackling maritime challenges.

Thank you to all who have supported the GMF and NMIO Technical Bulletin. Please find on page 31 of this report a display of Technical Bulletin editions. We welcome your readership and the continued contributions of your articles. We are currently planning the 2020 GMF and the next edition of the Technical Bulletin. It is an exciting time for us to be soliciting ideas from across the GMCOI to focus on your interests in these NMIO S&T initiatives.

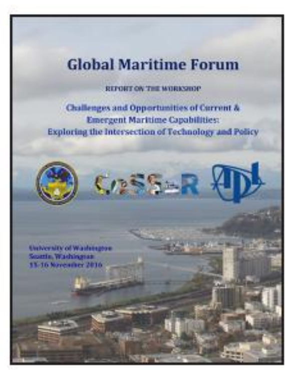


2012
Rome, Italy

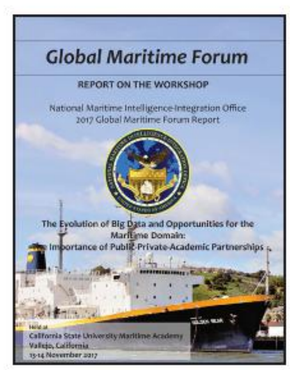
2014
Venice, Italy



2015
Moffett Field, California



2016
Seattle, Washington



2017
Vallejo, California

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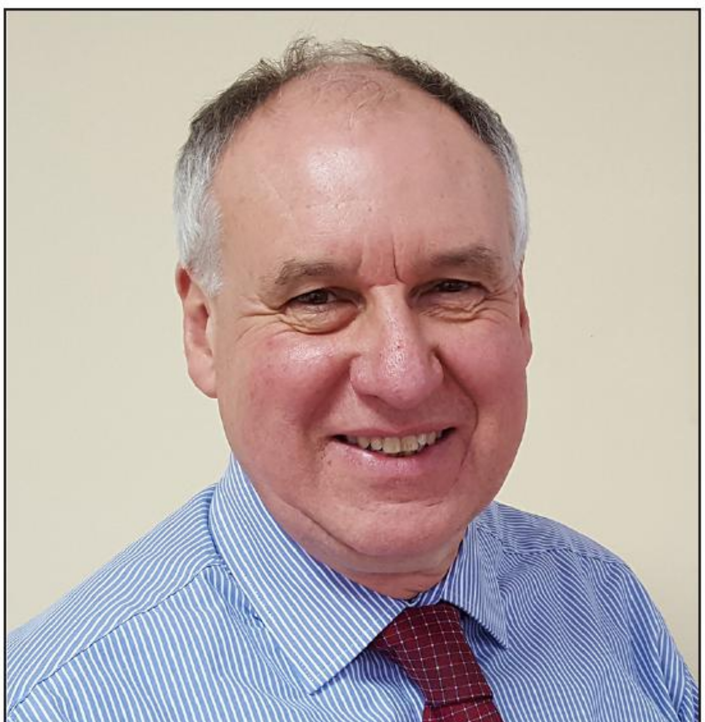
This Final Report summarizes the presentations of the Global Maritime Forum (GMF) workshop as interpreted by Ms. Mekisha Marshall, Chief Science and Technology Advisor, National Maritime Intelligence-Integration Office and Mr. Neil Palmer, Science Advisor, National Maritime Information Centre. The conference adheres to a variation of the Chatham House Rule. Accordingly, beyond the points expressed in the presentations, no attributions have been included in this conference report. This report represents the views and opinions of the panel participants and does not represent official government policies or positions. The Final Report explores ideas found across the maritime community and is an unclassified record made available to all.

Foreword

Rear Admiral Gene Price, Director of the United States' National Maritime Intelligence-Integration Office (NMIO) and Mr. Malcolm Brown, Director of the United Kingdom's National Maritime Information Centre (NMIC) co-hosted the 8th annual Global Maritime Forum (GMF) at the University of Liverpool in Liverpool, United Kingdom. This forum, entitled *Unifying Unmanned Systems to Enhance Maritime Security: Building Networks to Solve Unique Challenges*, brought together senior science and technology (S&T) representatives from across the Global Maritime Community of Interest (GMCOI) to seek ways to improve information sharing and technology advancements of unmanned systems, and thereby develop a better understanding of a significant emerging technology for improving maritime security.

RDML Gene Price, Director of the U.S. National Maritime Intelligence-Integration Office (NMIO)

The GMF offers a whole-of-nation and cross-government collaborative model for S&T experts seeking an opportunity to work with others in government, industry, and non-governmental organizations (NGOs). GMF panels embrace new ideas about data mining, predictive analytics, and data visualization, and they test those ideas against objectives including transparency, interdiction, safety, and securing the global supply chain. This year, expert insights focused mainly on up-to-date analytic methods and technology advances related to unmanned vehicle (UxV) systems for maritime security.



Mr. Malcolm Brown, Director of National Maritime Information Centre (NMIC)

On behalf of a long-standing commitment by both NMIO and NMIC to international cooperation on maritime security technologies, Admiral Price and Mr. Brown convened the 2019 GMF in Liverpool to advance technology solutions for emerging unmanned undersea technologies. The driving force in co-hosting this forum is a unity of effort commitment to exploring technologies "of the future." It is noteworthy that since 2018, when this GMF was first announced, some of the "emerging technologies" that had been selected for study were already advancing past the development stage and were being deployed successfully. Therefore, with this in mind, the co-hosts updated the program a week before this GMF to include the absolute latest "emerging technologies" on the runway for deployment in 2020, and beyond.

NMIC and NMIO recognize partners who have shaped the 2019 GMF by specific technological contributions to improve information sharing services. Moderators and panelists featured in the following pages mitigate real-world problems faced by the maritime community. They "connect the dots" and leverage their expertise to advance maritime security missions around the globe. Their names are found throughout this report, and their work forms the basis of the 2019 GMF. It is important to recognize the contributions offered by Dr. Deji Coker of the Office of Naval Research Global - London Office, and Dr. John Mittleman of the U.S. Naval Research Laboratory. Their annual commitment and guidance to this forum, particularly as part of this year's workshops aimed at mitigating technical obstacles, is a significant catalyst for new ideas.

Contributing this year's first Key Note Presenter was Nick Lambert, Director, NLA International. He shared his insights on emerging maritime capabilities, specifically, networked unmanned systems. Another particularly important contributor, and our other Key Note Presenter, was Dr. Sandro Carniel, Head of Research at North Atlantic Treaty Organization's (NATO) Science and Technology Organization Center for Maritime Research and Experimentation. Dr. Carniel described his work on advancing unmanned systems to inspire new ideas for mitigating obstacles encountered in the Arctic.

This event would not have been successful without the staff and facilities of the Foresight Centre, a historic landmark on the campus of the University of Liverpool. The Foresight Centre offered an ideal environment for participants from across the GMCOI to gather for sharing ideas and innovative strategies on scientific and technological advances. The staff of the Foresight Centre welcomed all GMF participants by providing audio visual support for our presentations and break out working groups and hospitality for meals and coffee breaks. Finally, for administrative contributions to this report, NMIC and NMIO wish to thank the 2019 GMF notetakers: Mr. James Wright, Mr. Lyudmil Z. Vladimirov, Ms. Annabel Turner, and Mr. Benjamin Millman.

The Director of National Intelligence, in cooperation with Navy and Coast Guard, created NMIO in 2009 to advance governmental collaboration and unity of effort as outlined in the 9/11 Commission Report, the Intelligence Reform and Terrorism Prevention Act of 2004, and the National Strategy for Maritime Security. NMIO facilitates information sharing and collaboration across the Global Maritime Community of Interest, which consists of U.S. federal, state, local, tribal, and territorial governments; maritime industry; academia; and our international partners. Learn more about NMIO online at http://nmio.ise.gov/index.html.

National Maritime Information Centre

The NMIC was established under UK Strategic Defence and Security Review 2010 as an independent cross-government body tasked with developing the maritime picture around the UK as part of the national security arrangements for the London Olympics in 2012. The NMIC's role was formalised in 2013 by the Maritime Security Oversight Group, (succeeded by the National Maritime Security Committee (Officials) group (NMSCIO) the same year), and further endorsed in 2014 with the publication of the National Strategy for Maritime Security. This defined the NMIC as the UK centre for maritime situational awareness and thereby the lead for the cross-government understanding of activity within the maritime domain around the UK and in areas of UK interest around the globe. Learn more about NMIC online at www.nmic.org.uk.

Executive Summary

The The 8th Annual Global Maritime Forum (GMF), co-hosted by Rear Admiral (RDML) Gene Price, Director of the United States' National Maritime Intelligence-Integration Office (NMIO) and Mr. Malcolm Brown, Director of the United Kingdom's National Maritime Information Centre (NMIC), convened from April 30 to May 1, 2019, at the historic University of Liverpool, Liverpool, United Kingdom. The GMF attracted more than 100 participants from across the Global Maritime Community of Interest (GMCOI) to focus on the theme Unifying Unmanned Systems to Enhance Maritime Security: Building Networks to Solve Unique Challenges.

Government officials, researchers, and entrepreneurs from eight nations (Canada, Chile, Denmark, Italy, Japan, Norway, United Kingdom, and the United States), collaborated on technical panels and working groups on the development, deployment, and operation of unmanned vehicles (UxV), and the challenges associated with networked UxV systems.

The GMF co-hosts set the tone by highlighting their nations' commitment to leveraging research initiatives with partners throughout the GMCOI to overcome technical barriers. Building upon existing partnerships, and creating new partnerships, is key to developing a unified unmanned networked system to benefit all GMCOI partners. This GMF is designed to capitalize on actionable, predictive information to advance a more fully automated, unified unmanned security network in the maritime domain.

On the first day, each panel discussed recent impressions of maritime unmanned undersea vehicles (UUV) applications to collect, store, and analyze massive amounts of data. The main take-away of these panels was that these applications are not only "at hand," but they are maturing rapidly. Enabled by a new generation of tools for data integration and analysis, decision makers in the commercial world spoke about the use of UxV (including satellites) on a global-scale, with the new applications being adapted for security, law enforcement, and environmental challenges. For example, new applications of software for multispectral imaging will make possible at least three impacts: improving operational and cost effectiveness; expanding the role of maritime data in our national architecture; and, creating an explosion of information on security risks and Anti-Access, Area Denial (A2AD) strategies.

RADM (Royal Navy, Ret.) Nick Lambert and Dr. Sandro Carniel were keynote speakers. They both shared personal experiences on how to navigate public-private maritime research initiatives. RADM (Royal Navy, Ret.) Nick Lambert spoke of the man-machine interface, specifically about empowering analysis by using UxVs to capture economic data from the ocean. Elaborating on the theme of this GMF, RADM Lambert described how networked unmanned systems will use data to advance maritime security efforts in the future. Following RADM Lambert's keynote was robust discussion that forecast a higher degree of UxV autonomy and greater reliance on artificial intelligence.

Dr. Carniel, from NATO's Centre for Maritime Research and Experimentation (CMRE), presented a wide range of technological challenges found in Arctic regions -- particularly how physical barriers posed by the Arctic's harsh environment can be successfully managed to allow maritime information sharing between UxVs capable of operating in settings so extreme that manned scientific activities face prohibitively high costs and risk to human safety.

Panel One, chaired by Dr. John Mittleman of the U.S. Naval Research Laboratory, focused on adaptations in marine settings that are currently operational and as envisioned for future autonomous systems. The discussion noted particular autonomous capabilities of networked UUV, to increase connectivity and to reduce error. Panelists elaborated on the future of UxV technology, stressing the advantages of "cloud" computing capabilities.

Panel Two, moderated by Ms. Gina Fiore of the Pew Charitable Trust, delved into how to determine observables and object attributes with autonomous systems. The panel elaborated on new trends related to data sharing in the maritime domain, highlighting the expansion of sensor types and social media sources. Participants forecast "crowd sourcing" as one of several potential ways to counter illicit activity.

Panels Three and Four, led by Dr. Ayodeji Coker of the U.S. Office of Naval Research-Global in London, and by Dr. Simon Maskell of the University of Liverpool, looked closely at research discussed by both previous panels. Experts elaborated on tools currently deployed to achieve unmanned network integration and security. Specifically, panelists offered solutions for verification, data provenance, data-origin record keeping, deployment, and for determining legal and regulatory compliance. Each panelist described first-hand their approaches to overcoming the hurdles associated with developing and maintaining interoperability between systems.

On the second day of the GMF, panelists offered a deep-dive on how to expand the operation of UUVs on a network scale, addressing a wider range of data types to derive effective understanding and mission advantage. By encouraging futuristic analytic approaches,

Foresight Centre

attendees explored solutions from commercial, NGO, and academic sectors applied to technical obstacles associated with maritime security.

Panel Five, the last of the panels, was led by Dr. Paul Shapiro of National Defense University. Dr. Shapiro introduced examples of emerging artificial intelligence (AI) and machine learning (ML) capabilities. Questions explored by this panel included: what impact might AI and ML have on monitoring fishing activities on a global scale? and, how might governments use the data and analytic capabilities of the future to tackle other illicit activities?

Following the presentations, the GMF organized participants into small working groups to focus on solving specific challenges associated with building UxV networks. After a few hours of collaboration, each working group presented the results of their work to the assembled participants. The outbriefs highlighted one or more obstacles identified as the most difficult to overcome when working through a project from initial concept to successful deployment.

At the conclusion of the workshop out-briefs, the NMIC and NMIO co-hosts closed the forum with remarks inspired by their interaction with participants during the two-day event. Both hosts agreed that the potential impacts of the 2019 GMF will be measured by efforts to harness the new ideas generated from collaboration by all participants.

UNIVERSITY OF LIVERPOOL

GMF 2019 Program Committee

Rear Admiral Gene Price (USN), Director of NMIO
Mr. Malcolm Brown, Director, NMIC
Commander Phil Ponsford, Deputy Director, NMIC
Mr. Lyston Lea, Principal Advisor, NMIO
Ms. Mekisha Marshall, Chief Science and Technology Advisor, NMIO
Mr. Neil Palmer, Science Advisor, NMIC
Professor Simon Maskell, University of Liverpool
Professor Matthew Palmer, National Oceanography Centre
Mr. Darrick McNeill, Deputy Science and Technology Advisor, NMIO
Ms. Honey Elias, Public-Private Partnerships, NMIO
Ms. Faith MacDonald, GMF Coordinator, NMIO

AGENDA

Tuesday, 30 April 2019

Time	Event
0730-0800	**Registration & Morning Coffee**
0800–0815	**Welcome Remarks/Administrative Notes** The 2019 GMF is an unclassified setting governed by a variation of the Chatham House Rule. **Mr. Neil Palmer**, Science Advisor, United Kingdom National Maritime Information Centre; **Ms. Mekisha Marshall**, Science & Technology Advisor, National Maritime Intelligence-Integration Office
0815-0830	**Opening Remarks and Keynote Introduction** Co-hosts welcomed all to explore technical solutions to influence the future security for the Global Maritime Community of Interest. **Mr. Malcolm Brown**, Director, United Kingdom National Maritime Information Centre; **Rear Admiral Gene Price**, Director, National Maritime Intelligence-Integration Office; Commander, Office of Naval Intelligence
0830-0915	**Day One Keynote** In the era of autonomy, S&T advances contribute to greater alignment of international maritime initiatives in unmanned systems. **Rear Admiral (Ret.) Nick Lambert,** Director, NLA International
0915-0945	**Break**
0945-1115	**Panel Session I: Unmanned Platforms: Space, Air, Surface & Sub-Surface** Discuss the platforms to understand what they can and can not do. Propose practical mitigations for design challenges. **Chair - Dr. John Mittleman**, Senior Research Engineer, U.S. Naval Research Laboratory **Panelists: Dr. Tim Barton**, VP/Solution Architect/Technical Fellow, Leidos; **Ms. Whitney Million**, CEO, Aquabotix; **Vice Admiral (Ret.) Mike Connor**, President and CEO, ThayerMahan, in association with Riptide; **Mr. Chris DeMay**, CTO & Founder, Hawkeye 360
1115-1215	**Lunch**
1215-1400	**Panel Session II: Determining Observables/Object Attributes** Build on insights about platform capabilities. Explore what data should be gathered to learn and perform various missions. **Chair - Ms. Gina Fiore,** Senior Associate, Enabling Illegal Fishing Project, The Pew Charitable Trusts **Panelists: Dr. John Mittleman**, Senior Research Engineer and Advisor, Maritime Domain Awareness, U.S. Naval Research Laboratory; **Ms. Ebony Mullins**, Science and Technology Lead, Intelligence Systems Integration Branch Head, Naval Information Warfare Command-Pacific (NICW-P); **Mr. Brion Thomas**, NICW-P; **Mr. Steve Pokotylo**, Counter Terrorism Information Officer (CTIO) Royal Canadian Mounted Police

AGENDA

Tuesday, 30 April 2019 (cont.)

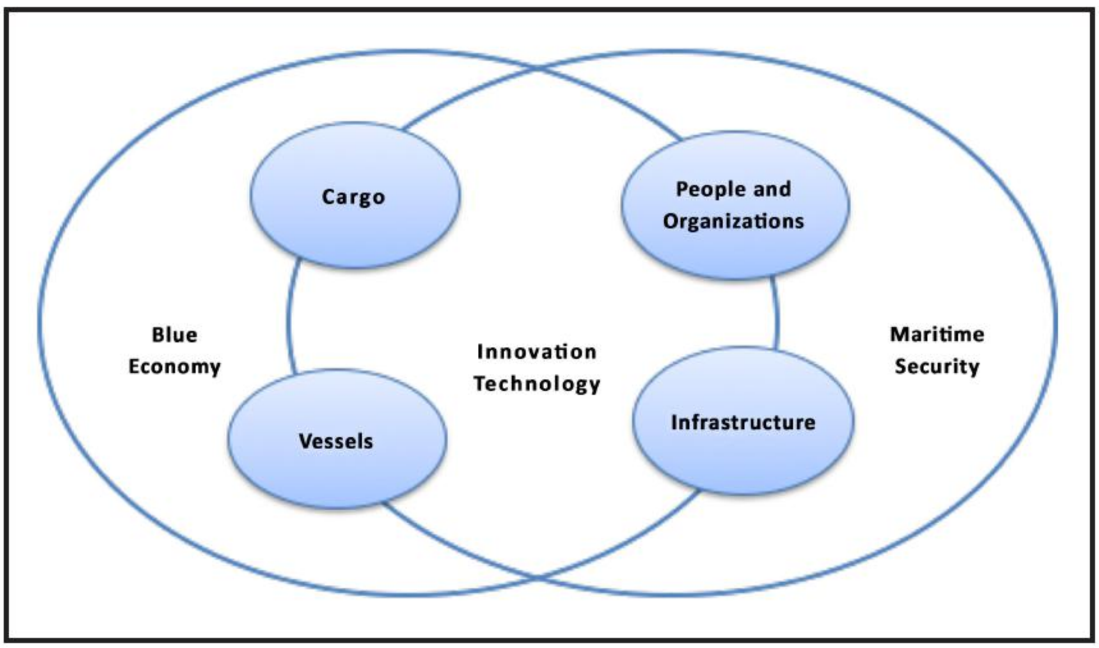
Time	Event
1400-1530	**Panel Session III: Network Integration and Security** Once the data has been collected, focus shifts to how the platforms are interconnected to share data for analysis. **Chair: Dr. Ayodeji Coker**, Science Director, Officer of Naval Research Global; **Panelists: Dr. Alex Bordetsky**, Director, Center for Network Innovation and Experimentation (CENETIX); **Mr. Henry Mottesheard**, Chief, Naval Warfare Branch, Future Warfare Systems - National Geospatial-Intellligence Agency; **Mr. Alan T. Dunn**, Director of Operations, Stephenson's National Center for Security Research & Training; Transformation Technologies; Cyber Research Center at Louisiana State University
1530-1545	**Conference Photo & Break**
1545-1700	**Panel Session IV: Big Data Analytics** Explore the best ways to organize, analyze, and understand data. Discuss the tradeoff between "Big data in a big pot" and "Big data on identified persons, places, things, and events." **Chair - Dr. Simon Maskell**, Director, Liverpool Big Data Network, Professor Autonomous Systems **Panelists: Dr. Luc Moreau**, Head of Department of Informatics, King's College London; **Dr. Alexandra Kokkinaki**, Senior Data Scientist, British Oceanographic Data Centre, National Oceanographic Centre, United Kingdom; **Mr. Richard Schgallis**, Vice President, Technical Strategy and Solutions, Airbus Defense and Space Government Solutions, Inc.
1800-2000	**Social Event** The Mayor of Liverpool and Mersey Maritime hosted an evening at the Cunard Building. Guests were invited to tour the British Music Experience and enjoy interactive exhibits.

Colleagues attend the social event at the Cunard Building.

AGENDA

Wednesday, 1 May 2019

Time	Event
0730-0800	**Morning Coffee**
0800-0815	**Recap and Keynote Introduction**
0815-0900	**Day Two Keynote** First-hand insights on how to mitigate and resolve technical barriers found in the Arctic to successfully enable an autonomous, networked maritime information sharing apparatus. **Dr. Sandro Carniel**, Head of Research, STO CMRE, NATO, La Spezia, Italy
0900-1030	**Panel Session V: Emerging Artificial Intelligence and Machine Learning Capabilities** Compare and contrast machine learning algorithms and how to configure them to achieve multiple missions. **Chair: Dr. Paul Shapiro**, Professor at the National Defense University **Panelists: Dr. Tonje Nanette Hannevik**, Senior Scientist, Norwegian Defence Research Est. (FFI); **Mr. Bradley Soule**, Director, OceanMind; **LT Andrew McGuire**, U. S. Coast Guard
1030-1115	**Explanation of Working Group Topics**
1115-1230	**Assembly of Working Groups and Lunch**
1230-1445	**Working Group Collaboration**
1445-1645	**Working Group Recommendations**



Keynote Speaker: Rear Admiral (Ret.) Nick Lambert

RADM Nick Lambert (Ret.) offered a keynote presentation on the man-machine interface and how UxV technology advances impact efforts to ensure a more secure marine domain.

RADM (Royal Navy, Ret.) Nick Lambert presented a keynote address setting the tone for the 2019 GMF, providing attendees with insights on how the man-machine interface is empowering analysis by using networked, unmanned systems to enhance maritime security.

Describing current and future advances involving a higher degree of autonomy and greater exploitation of data, RADM Lambert posited that "the technology is here already; it's just not evenly distributed." (He expressed apologies for a play on William Gibson's 'the future is already here, it's just not evenly distributed.').

Examining the man-machine interface (human/device interface and human/data interface), RADM Lambert explored new capabilities and limitations of current systems as a persistent ability to track what is going on in a specific, known marine setting. Ultimately, he argued, this is a human interpretation, no matter how good technology gets.

Using one of his company's projects as an example, RADM Lambert noted that producing "Smart Port Cites" is not entirely about perfecting the platform; it is also about perfecting the sensors on those platforms and the analytics that bring a wide variety of data sources together. He suggested that the outcome creates valuable information services that can be used to ensure best return on investment decisions.

Calling the new sensors "the game changers," RADM Lambert described how autonomous sensor platforms are being perfected to collect data, but that the "value added" process still relies heavily on human elements to help analyze and interpret the data that the sensors collect. From this perspective, the object is not to exclude the human; rather, the goal is to make the human analyst better equipped to work more efficiently, and giving that analyst better, more persistent data with which to work.

The ability to monitor the full radio frequency spectrum from space is RADM Lambert's fourth satellite-based data service (complementing earth observation, satellite communications and global navigation satellite systems). This comprises a sort of "Automatic Number Plate Recognition" identification capability for ships and other maritime platforms. He argued that the ability to passively detect and analyze transmissions from all over the planet is a game changer, arguing that it is to our advantage that very few people, including "bad actors," are willing, or able, to be separated from communications technology for long. He noted that we are always connected and transmitting on countless systems, from phones through radios to radars; advances are making it easier for us to consider the use of radio frequencies to detect any activity.

Providing detail on enforcement and legislation, Admiral Lambert observed that "maritime policing is very easy to talk about, but harder to do." It requires professionals, persistence, and focus. But, he noted, policing with the use of UxV technologies can be done, and it can be done today. Admiral Lambert suggested that oversight would probably be best achieved regionally through the sharing of resources and information. From the perspective of coastal states, the notion of establishing a common Economic Exclusion Zone (EEZ), as a monitoring zone, between them makes sense, given that "bad actors" move freely between EEZs and territorial waters. The future is about inter-state cooperation for the benefit of the many.

On the question of bringing the commercial, military, and academic spheres together, Admiral Lambert observed that sharing government sonar data dates back to the Cold War. This practice evolved much later in history to sharing that data with industry. Wondering, "why don't we share that data today" led to a discussion on why warships and commercial ships seem to not gather and share information on weather more freely. RADM Lambert questioned:

- what if every ship began sharing meta-data on weather conditions and patterns?;
- what would we learn and how might the additional datapoints over our seas and oceans improve our weather forecasting?;
- would this lead to enabling better preparation of our economies and infrastructure for storms?

Slowly but surely the culture is changing. People in the academic, commercial, and defense sectors are more willing to talk to each other and share information than they have been in the past. We need to be bringing together people from all maritime sectors, and beyond, to cooperate and collaborate, creating new skillsets, professions, and institutions that will maximize the benefits of new datasets information services.

When asked whether it is important to combine the maritime security side with support for the blue economy, RADM Lambert answered,

"We're hoping to combine security and commercial interests down the road. It is up to governments whether or not to participate in joint approaches. By definition, the blue economy embraces any activity that derives socio-economic benefit from our seas and oceans. So, the resultant military and security challenges naturally involve government partners, who can exploit maritime data for both spheres.

What can we do to bring people together? I really find the answer in the purposes behind this GMF conference. This GMF promotes bringing together blue economy interests and government interests to build a more secure marine domain. The question for the GMF is: "what can we do now to gather and share data, and to build these relationships further?"

Panel I, Left to Right –VADM (Ret.) Mike Connor, President and CEO, ThayerMahan, in association with Riptide, Ms. Whitney Million, CEO, Aquabotix, Dr. Tim Barton, VP/ Solution Architect/Technical Fellow, Leidos, in association with Riptide, Mr. Chris DeMay, CTO & Founder, Hawkeye 360.

Panel I: Unmanned Platforms

Unmanned vehicles (UxV), sometimes known as drones, are able to operate without a human occupant. Today's cutting-edge technologies expand the capability to develop maritime domain awareness and challenge government and non-government actors to advance technology to make the best use of these innovations.

Panel One, chaired by Dr. John Mittleman of the Naval Research Laboratory, focused on the physical settings (space, air, surface and sub-surface) for autonomous systems. This panel discussed unmanned and autonomous platforms, coupled with new analytic methods and artificial intelligence capabilities, as part of next-level opportunities/missions, liabilities, and vulnerabilities. In particular, Mr. Chris DeMay, of the company Hawkeye 360, briefed participants on commercial radio frequency (RF) satellite monitoring capabilities, while Dr. Tim Barton, of the company Leidos, discussed the capabilities of the Sea Hunter Unmanned surface vessel. Ms. Whitney Million, of the company Aquabotix, gave a presentation on the autonomous capabilities of networked UUV swarm vehicles, emphasizing the need to improve AI incorporation in order to reduce operator strain and error. Completing the Panel One presentations, VADM (ret) Mike Connor, President and CEO, ThayerMahan, in association with Riptide, looked to the future of UxV technology, stressing the advantages of cloud computing capabilities and Machine Learning in teaching machines to do the jobs better and faster.

UUV systems linking sensors and related data processing components are becoming common in deep-water conditions. Innovations to drones and wireless networks are being adapted and deployed in marine settings at an accelerated rate. The speed with which new marine technologies advance UUVs highlights not only interest by governments and the private sector but also the accommodating nature of deep-sea

FAIR Data Principles in Brief

- **To be Findable:**
  - (meta)data are assigned globally unique and persistent identifiers
  - data are described with rich metadata
  - metadata clearly and explicitly include the identifiers of the data it describes
  - (meta)data are registered or indexed in a searchable resource
- **To be Accessible:**
  - (meta)data are retrievable by their identifier using a standardized communications protocol
  - the protocol is open, free, and universally implementable
  - the protocol allows for an authentication and authorization procedure, where necessary
  - medadata are accessible, even when the data are no longer available
- **To be Interoperable:**
  - (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation
  - (meta)data use vocabularies that follow FAIR principles
  - (meta)data include qualified references to other (meta)data
- **To be Reusable:**
  - meta(data) are richly described with a plurality of accurate and relevant attributes
  - (meta)data are released with a clear and accessible data usage license (meta)data are associated with detailed provenance (meta)data meet domain-relevant community standards

conditions. Some underwater conditions that are prohibitive for humans may be the very ones that accommodate UUVs. For example, a contact can be detected 'over the horizon' underwater in an area incompatible with human exploration, because sound (unlike radar waves) bends with the curvature of the earth. Using this example, sonic sensors can contribute to sub-surface exploration by unmanned technologies in more innovative and sophisticated ways than have been used in space and onshore.

The panel agreed data collected by UUVs can be better understood by machines, better utilized automatically in complex workflows, and more easily shared between intelligent sensor web nodes. Agreement existed across the panel on a key obstacle is the unresolved question: "What, if any, moral and ethical considerations may suggest boundaries for scientific and technical advancement in this field?" In a subsequent discussion (Panel 4), Dr. Alexandra Kokkinaki, Senior Data Scientist, British Oceanographic Data Centre, National Oceanographic Centre, United Kingdom, returned to this question to suggest finding an answer, which would involve recognizing data associated with UUV systems to be described as Findable, Accessible, Interoperable, and Re-usable (FAIR). This construct is explained in the graphic.

Panel II: Determining Observables and Attributes

Panel Two, moderated by Ms. Gina Fiore of the Pew Charitable Trust, focused on how to determine observables and object attributes of illicit activity with autonomous systems. Mr. Steve Pokotylo of the Royal Canadian Mounted Police (RCMP) opened the panel with a brief on the RCMP "Project MarCOS" and the future vision of processing data within satellite constellations. Ms. Ebony Mullins, Science and Technology Lead, Intelligence Systems Integration Branch Head, Naval Information Warfare Command-Pacific, offered insights on obstacles associated with remotely operated vehicles. Dr. John Mittleman, Senior Research Engineer and Advisor, Maritime Domain Awareness, U. S. Naval Research Laboratory, focused mainly on the need for data sharing to better identify and combat illicit activity in the maritime domain. Finally, recognizing the expansion of data collection, all the panelists looked to social media sources as a potential way to identify illicit activity.

Dr. Mittleman discussed how small satellites and big data are helping us understand the state of the world, how it is changing, and how we can influence that change trajectory. In a contextual

Panel II, Mr. Brion Thomas, Naval Information Warfare Command-Pacific (NIWC-P), Ms. Ebony Mullins, Science and Technology Lead, Intelligence Systems Integration Branch Head, NIWC-P, Dr. John Mittleman, Senior Research Engineer and Advisor, Maritime Domain Awareness, U. S. Naval Research Laboratory, Mr. Steve Pokotylo, Counter Terrorism Information Officer (CTIO) Royal Canadian Mounted Police.

shift, data “quantity” has become a “quality” of its own. As seen in the rise of artificial intelligence, which is enabled by computer technologies, collecting huge amounts of data makes possible extensive computational analytics. This capability leads to options for unprecedented global transparency, the ability to develop a penetrating understanding of activities and trends, and a range of abilities to disseminate it quickly and widely. The resulting “democratization” of intelligence appears to be nurturing a new “whole-of-society” response to global issues, and the emergence of new approaches to trans-national problems.

Autonomous underwater vehicles (AUVs) are capable of diving to depths of several miles without direct human control or connection to a ship, and they can remain submerged for more than 70 hours. Unique design is now allowing AUV “flight” very close to the seafloor, even over rough terrain. Missions for these instruments can involve surveying the seafloor, mapping, and collecting bathometric data. This panel focused on what makes this technology possible and how it is being improved upon for maritime security and blue economy objectives, looking at a suite of scientific instruments (sonar systems, digital cameras and sensors).

Panel members offered ideas on advantages and disadvantages associated with stand-alone vehicles. Each expert agreed vehicles can also be used in tandem with other UUVs and with human-occupied vehicles. Building on the first panel’s discussion about the platforms, this panel offered insights on what data can be collected to perform security missions in the future.

When asked how to locate, identify, and track hard target vessels conducting illegal activity, the panel gave first-hand examples of patterns and activities, traits useful as building blocks for interdiction of illicit maritime activity. This panel also discussed external sources of information known as “contextual knowledge.” For example, data gathered by UxS sensors, Internet, and cloud-enabled databases (e.g., weather, commodity prices, bunker prices, shipping timetables, social media, etc.) can deliver “contextual knowledge” if they can be properly coordinated and analyzed. When asked whether there might be an underwater communications network to do this, panel members answered “Yes,” indicating the same types of technological advancements that improve undersea sensors also improve undersea connectivity. This led discussion to the next panel to demonstrate the ideas of “connectivity” and “coordination.”

Panel III: Network Integration and Security

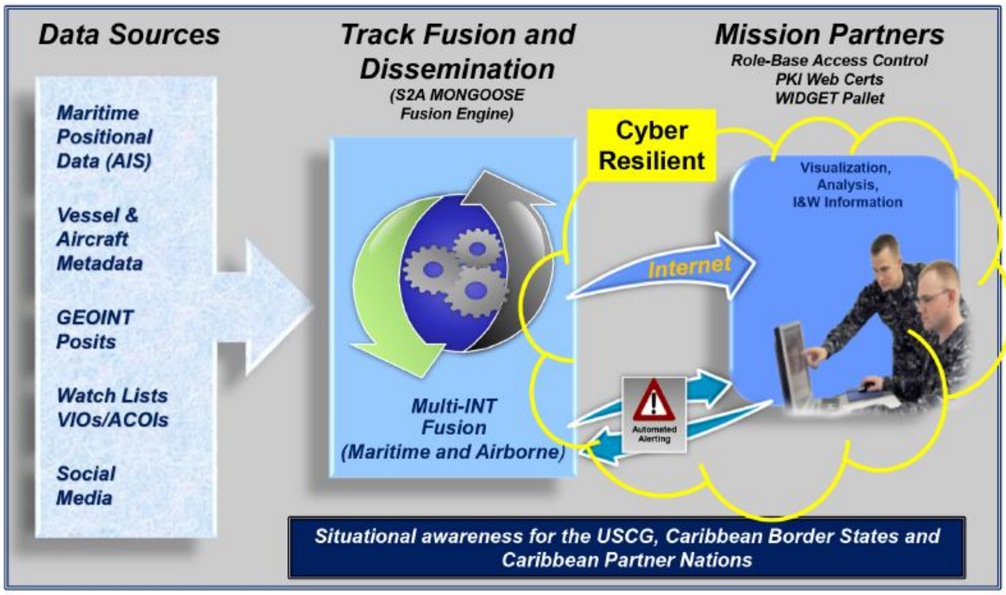
Panel Three, chaired by Dr. Ayodeji Coker of the U.S. Office of Naval Research-Global in London, combined aspects of both Panels One and Two with a discussion of unmanned network integration. Mr. Alan Dunn of the Stephenson National Center for Security Research and Training at Louisiana State University spoke of the ability to use specialized tools and filter via the use of classified algorithms to pull data securely from open sources. Mr. Henry Mottesheard of the U.S. National Geospatial-Intelligence Agency presented his vision for enabling machine learning in an upper level ontology across government, academia, and industry. Dr. Alex Bordetsky of the Naval Postgraduate School concluded the discussion of network security by providing insight into his research into self-forming mesh networks of unmanned autonomous systems.

This panel offered first-hand advice on mitigating challenges associated with system operation. To advance platform interconnectivity, panelists presented examples of future network integration and their conclusion, “the future is swarm intelligence and mesh network technologies.”

Panel III, Mr. Henry Mottesheard

"Swarm intelligence" (SI) is the collective behavior of decentralized, self-organized systems, natural or artificial. The concept is employed in work on artificial intelligence. The expression was introduced by Gerardo Beni and Jing Wang in 1989, in the context of cellular robotic systems. A "mesh network" (or simply meshnet) is a local network topology in which the infrastructure nodes (i.e. bridges, switches and other infrastructure devices) connect directly, dynamically and non-hierarchically to as many other nodes as possible and cooperate with one another to efficiently route data from/to clients. Anticipating mesh networking successes, panelists agreed innovations enabling autonomous systems would not be possible without overcoming the following barriers: inconsistent funding, difficulty processing data in a manner that can secure the data within the network, operability challenges with platforms, and control issues while data is transmitting. When questioned about how these challenges impede network innovation, panelists summarized two hurdles closely associated with mesh topology: (1) unpredictable cost of implementation, and (2) issues associated with redundant connections -- which adds to high costs and potential for reduced efficiency.

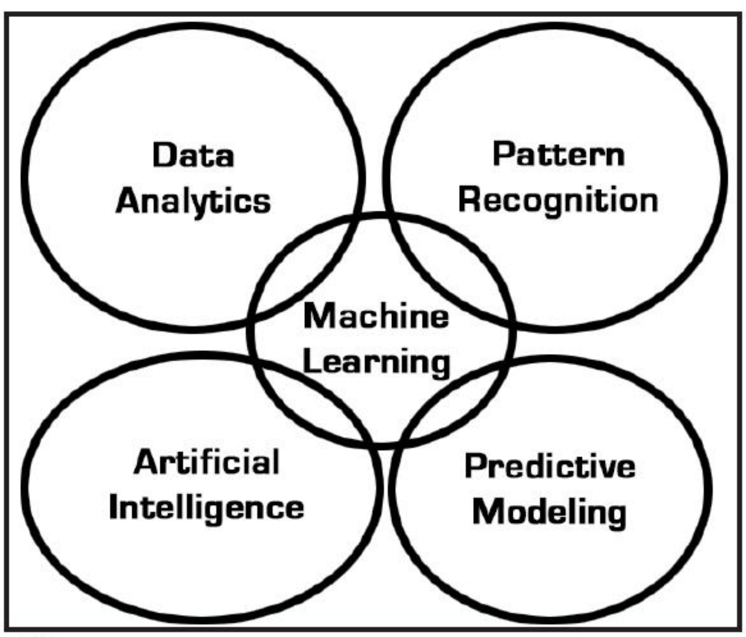
The panel elaborated on key technical challenges associated with swarm systems and AI. In particular, swarm intelligence, which stems from swarm collectives making "decisions," faces the challenge of operating in a dynamic marine environment. To succeed in a marine environment, human interaction with swarms must be effective. Guided by a round of probative questions, the panel members gave practical advice and identified future opportunities for technology partnerships with academic institutions.



Slide produced by Mr. Alan T. Dunn

the panelists underscored the potential to operate high-bandwidth datalinks underwater — albeit at shorter ranges than radio waves in air. These technologies are more valuable when operated with enough computing power at the receiving end to sort signal from noise. Undersea cables or relays deployed on the sea floor could extend the network back to land.

Elaborating on marine settings, the panel shared challenges specific to the Caribbean Collaboration Environment (CCE) Joint Capability Technology Demonstration (JCTD), a U.S. Congressionally Directed Activity aimed at providing support for U.S.-Caribbean border security. Describing the intent of JCTD, Mr. Dunn detailed efforts to integrate traditional sensor data with big data analytics. Efforts to link modern enterprise capabilities via a service-oriented architecture is ultimately to develop visualization tools to deliver decision advantage. The panel concluded by offering ideas on how to mitigate challenges associated with high-frequency sound waves and lasers. Specifically,



Panel IV: Big Data Analytics

This panel built on previous discussions of data sharing methods, to shift the focus to analyzing the data. Chaired by Dr. Simon Maskell of the University of Liverpool, the panel discussed how to mitigate challenges associated with Big Data Analytics in the maritime domain. Dr. Luc Moreau of King's College London introduced the audience to data provenance and the importance of data-origin record keeping. He emphasized the absolute importance of developing and maintaining interoperability between systems.

Dr. Alexandra Kokkinaki of the British Oceanographic Data Centre underscored the importance of ensuring data shared is accessible, interoperable, and most importantly, of sufficient fidelity. Mr. Richard Schgallis of Airbus Defense and Space Government Solutions gave a presentation on how his company maximizes data extracted from fixed sensors.

The panel agreed one way to organize data is "big data in a big pot," while another way is "big data on identified objects (persons, places, things, events)." By exploring ways to organize, analyze, and understand data by offering perspectives on obstacles, presenters shared

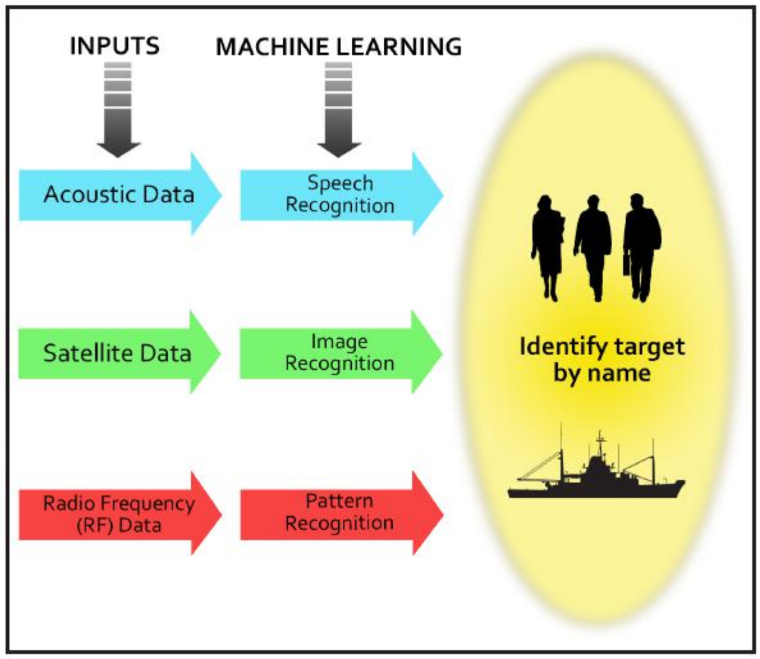
Panel IV, Mr. Richard Schgallis

the obstacles and mitigations they developed as experts in detecting "clusters" of similar attributes, activities, and patterns. The ability to infer likely future behaviors and patterns is a major step toward mitigating road blocks.

After sharing personal experiences mitigating challenges to reach a specific technical and non-technical objective related to AI, ML, and Deep Learning, the panel concluded that the most successful mitigations were those that focused mainly on deductively identifying activity, recognizing patterns, and detecting changes and anomalies.

Colleagues enjoy a short break between panel discussions.

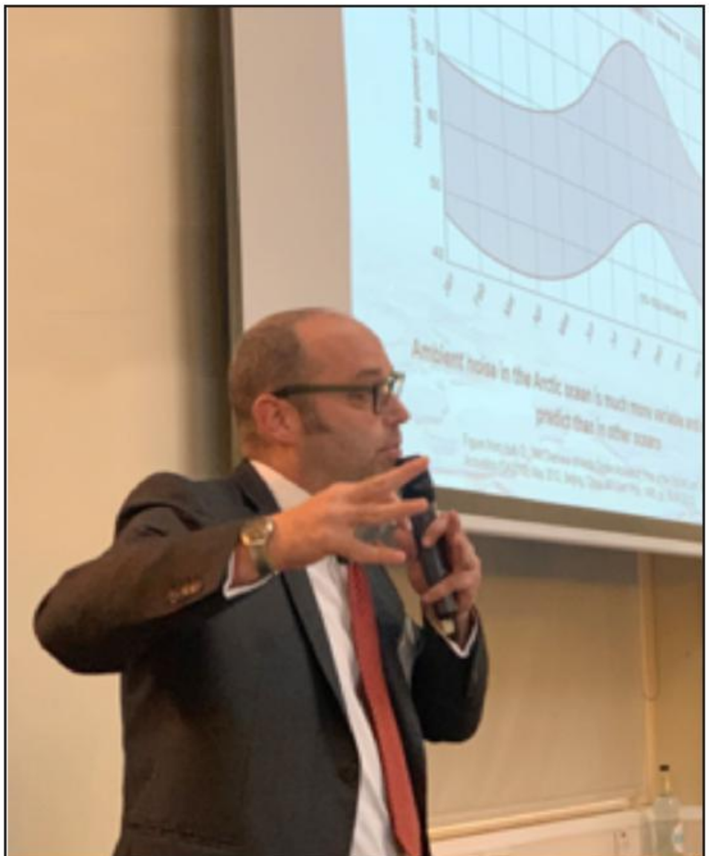
Panelists recommended overcoming challenges associated with cost, reliability, and safety, based on the twin powers of (1) unmanned systems and (2) advanced image analytics. For example, to gain cost reduction, it is important to cultivate a fundamental understanding that these technologies, taken jointly and in tandem, can form a solution. Specifically, this pairing is now producing workable systems that operate to raise warning alarms when a vital piece of equipment is at risk of failure.



Machine Learning holds the promise of more than just detecting uncooperative vessels.

A catch phrase that captures how these twin capabilities (unmanned systems and advanced image analytics) are accelerating change in the maritime security space is: "more data is not just more data." Quantity is becoming quality, mainly as UUV and data analytics mature to revolutionize government security assets such as drone usage linked with data analytics.

Keynote Speaker: Dr. Sandro Carniel



Dr. Sandro Carniel, Head of Research at NATO's Centre for Maritime Research and Experimentation, offered insights on unmanned system operations in the Arctic.

Dr. Sandro Carniel, Head of Research at the Centre for Maritime Research and Experimentation (CMRE), a scientific research and experimentation facility and executive body of NATO's Science and Technology Organization, provided the GMF's second keynote presentation, offering insights about his own experiences mitigating challenges encountered during sea trials to test unmanned system operations in the Arctic. "Advances in remotely operated and unmanned vehicles in the Arctic will be a major catalyst for future gains in research activity and collaborative ocean and atmospheric projects worldwide," he said.

In response to questions, Dr. Carniel detailed specific strategies for overcoming obstacles associated with the complexities of UxV communications and operations in harsh Arctic conditions. In addition to elaborating on how he has tackled technical barriers, such as absence of energy supply and remote, harsh physical settings, he described how to mitigate non-technical barriers such as geopolitical, diplomatic, commercial, and societal challenges. By focusing on both technical and non-technical challenges, Dr. Carniel provided a comprehensive description of efforts underway to achieve more successful information sharing between UxVs operating in the Arctic.

Dr. Carniel highlighted technical successes unique to Polar Regions, drawing attention to technical and non-technical hurdles he has encountered. The enormity of analytic and operational challenges found in the Arctic helps illustrate how each step toward developing a successful technology requires considerable collaboration, not only from scientific researchers but from regional policy makers as well.

To emphasize how essential collaboration is to technology advances in the Arctic, Dr. Carniel addressed factors that might potentially undermine stakeholder cooperation: unpredictable or diminished resources, geopolitical events that trigger regional instability, dynamic physical conditions, new and untested commercial activities in the region. He offered insights on to countering these factors by listing mitigations to help enhance technical collaboration: joint- or co-funded research, a stable governing body, academic supporters with Arctic experience, and public interest in advancing safe and environmentally sound technologies for regional application. By listing both the challenges and possible solutions, Dr. Carniel underscored the difficulty and the value of fostering collaborative partnerships. By his attempts to broaden collaborative efforts, to include those familiar with regional commercial and security decision making, he said it has been possible to enhance analytic capabilities beyond vessel tracking and other current analytic products.

When asked whether successfully deploying UUV technology in the Arctic will result in manned submarines collecting data becoming irrelevant, Dr. Carniel answered “Platforms without autonomous features are still valued. However, unmanned systems and autonomy are quickly becoming highly prized generally in the marine science and technology domains, and particularly in the Arctic.” What was once an “either/or” question of being capable of penetrating a prohibitive or inhospitable area for the explicit objective of achieving stealth, is now a discussion about achieving the most complete Maritime Domain Awareness (MDA) one can obtain for understanding the marine and coastal world. Advances associated with unmanned vessels, as compared to manned vessels, is now a question of which offers more complete MDA.

In response to questions, Dr. Carniel offered insights on overcoming the following challenges prevalent in the Arctic:

- how to neutralize ice concentration as an obstacle to testing system operation;
- how to prioritize limited energy resources for implementing place-based policing;
- how to gain “continuous awareness” by tracking movements in time and space;
- how to survive natural disasters and man-made incidents anticipated in the Arctic; and,
- how to analyze patterns of data to predict climate conditions in polar regions.

Panel V, Mr. Bradley Soule

Dr. Carniel emphasized that a useful tool in mitigating technology road-blocks is promoting collaboration among government agencies, technology industry associations, and standards development organizations. Having to solve a technical challenge tends to test how skillfully one works across organizational lines.

Dr. Carniel closed his keynote address by offering practical advice on how to conduct necessary research while avoiding negative impacts to the environment in the Arctic:

“Work together in a responsible way.” Dr. Carniel added, “We are seeing intensive international interest, with a trend toward stronger enforcement, in the Arctic. However, enforcement remains inconsistent across the region. In instances where not all countries are willing to be subject to the same rules, there can be a problem.”

Panel V: Emerging Artificial Intelligence and Machine Learning Capabilities

The last panel, led by Dr. Paul Shapiro of National Defense University, concluded the briefing portion of GMF. Dr. Shapiro guided a discussion on how to mitigate challenges associated with emerging artificial intelligence (AI) and machine learning (ML) capabilities.

While emphasizing AI is an enabler for positive, lawful activity, the focus shifted to misuse of AI for nefarious purposes. LT Andrew McGuire of the U.S. Coast Guard described emerging AI capability in law enforcement as part of a discussion on targeting “bad actors,” and on specific applications for identifying and tracking illicit shipments.

Dr. Tonje Hannevik, Senior Scientist of the Norwegian Defence Research Institute (FFI) provided a comprehensive brief on FFI’s research into the use of AI to analyze maritime imagery automatically.

Discussing Implementation of AI-based systems and ongoing research activities were Chair: Dr. Paul Shapiro, Professor at the National Defense University, LT Andrew McGuire, United States Coast Guard, Dr. Tonje Nanette Hannevik, Senior Scientist, Norwegian Defence Research Est. (FFI), Mr. Bradley Soule, Director, OceanMind,

Finally, Mr. Bradley Soule of OceanMind encouraged participants to consider what it means to put AI into practical use in the maritime domain. Effective use of AI can have positive impacts on the fishing industry when governments share information analyzed to tackle illicit fishing activities.

To answer questions about how soon emerging AI and ML capabilities might be operational for platforms to transmit and use shared data to detect illicit behavior, the panel agreed: "Now!" ML algorithms are already capable of doing what they are configured to achieve.

To examine technical solutions to AI and ML challenges, the panel shared first hand experiences with Neural Networks (NNs) and Convolutional NNs as a way to achieve reinforcement learning. Other themes stemming from comparing and contrasting outcomes derived from Genetic Algorithms and Evolutionary Algorithms comprised most of the discussion among panelists.

To roll up panel views on machine learning algorithms, and address questions surrounding current and future AI capabilities, panelists observed how law enforcement authorities around the world are continually testing new technologies for interdiction and deterrence missions. For example, a governmental interest in military uses is apparent in the Barents Sea, according Dr. Hannevik, Neural Networks (NNs) and Convolutional NNs capabilities are supporting security and enforcement missions and are also advancing a range of civilian interests in marine transport, fishing, tourism, shipping, and natural resource management.

2019 Global Maritime Senior Personnel

2019 Global Maritime Forum Participants

Cunard Building

GMF Working Groups

Following the GMF presentations, workshop participants reorganized into small groups for intensive discussions addressing how to apply the theories discussed by the keynote speakers and the five panels, with the goal of identifying achievable outcomes. By drawing attention to specific impasses associated with unmanned vehicles, the following groups identified opportunities to improve maritime security.

The 2019 GMF collaborative breakout sessions are designed to identify developmental hurdles to technological innovation and offer real world solutions to those hurdles.

The following list of recommendations offers both technical and non-technical strategic advice, on topics ranging from how to set priorities to meet your goals, to how to influence maritime policymakers. Each recommendation contributes to a high-level strategic plan designed to increase policymaker's knowledge and enhance the quality of their decisions. The working groups defined their outcomes as "a systematic process of envisioning a desired outcome, and translating this vision into broadly defined goals or objectives via a sequence of practical steps." In contrast to long-term planning, (which begins with the status quo and lays down a path to meet estimated future demands), the strategic planning found below begins with the desired end (a successful new technology), and then works backward to the starting point.

Enhancing Maritime UxV Research Project Roadmaps

Recommendations:

- Prioritize cross-government collaboration.
- Identify possible public-private partnerships to act as project cohorts.
- Agree to a division of labor and formalize roles and responsibilities for project cohorts.
- Determine the range of resources potentially available for research and testing.
- Name relevant authorities and policies in the jurisdiction of interest to govern datasets, licensing, and other mutual deliverables.
- Brainstorm on collaborative actions including a timeline, milestones, and budget.
- Establish measures of effectiveness (MOE)/ success and measures of performance (MOP).
- Hold a milestone event, such as a demonstration.

Successful technology projects are particularly difficult to initiate and execute in a dynamic, uncertain, and resource-constrained environment. In some cases, success comes in phases over durations of a decade or more. By identifying successful cross-government collaboration as a primary goal during initial phases of a project, one can establish a standard approach (taxonomy) for soliciting proposals, data analysis, and tool development to achieve a higher success rate and to minimize economic loss during the collaboration.

Obstacles encountered during initial stages of a technology project can create a "valley of death" for projects. During that time, a project can face suspension or termination due to the following:

- cohort affiliations might change,
- ways to link data might become obsolete and have to be replaced by alternatives,
- related projects might unfold in a manner that displaces another project, and
- metrics for success may not align with an accepted form of evaluation.

During the initial stage of a project, these challenges can result in a team not being able to keep a project "alive" long enough to reach a future phase of planning or activity.

Mitigations for this set of challenges derive from a framework for cooperation, similar to a Cooperative Research And Development Agreement (CRADA).

Improving Data Analytics

Recommendations:

- Create well-defined standards ("make data accessible").
- Lower barriers to entry.
- Create intuitive user interfaces (UI).
- Enhance data visualization so that analytic results are clear.
- Ensure data informs decision makers.

Without the above-mentioned recommendations, interagency and international collaborations can hinder technological advances. When these conditions are gateways, not barriers, to human insights and intuition, organizations are able to collaborate outside of their own government channels across the GMCOI for creative insights and intuition regarding new analytic processes.

As with any project involving Big Data, the role of analytics is to gain decision advantage by gaining knowledge from local data collection.

The challenge for analytic processes is achieving "effective understanding" to inform decision-making. Developing mastery of non-technical maritime lexicons is a priority for sorting, organizing, and motivating outcomes in the new generation of analytics. Teaming an appreciation of non-technical data solutions with technical expertise should be a priority.

Solving problems stemming from the vastness and complexity of the data needed for advancements in UxVs requires cohorts with skill sets that are both technical and non-technical in nature. Therefore, a CRADA is essential.

Information should inform, not just provide insight, and position the decision maker to take effective action. When difficulty derives from the complexity, not just the quantity, of the data, Artificial Intelligence (AI) may allow development of actionable intelligence. Actionable intelligence addresses real-world problems in terrestrial, aerial, and marine settings. When gaps persist between "narrow" AI (where human tasks are automated), and "broad" AI (follows the path of discovery, prediction, justification) action, and learning can be difficult, especially in a maritime setting.

Targeted Development & Research Funding

Recommendations:

- Develop in-situ renewable power sources.
- Improve UxV interdiction abilities.
- Consider alternate training sources for learning network.
- Future proof the system.

Current energy storage capacities are insufficient for recharging autonomous systems. Organizations must focus on developing in-situ renewable power sources using hydroelectric and solar power development solutions. Some of these solutions are still in a research phase, and will need significant funding and development before possible deployment. The benefit will be

Dr. Alexandra Kokkinaki

significant, however, as it will reduce the need for recurring human interaction.

To improve illicit vessel interdiction, the ability to predict the behavior of a specified sub-set of vessel traffic can depend on historical data. When available, historical data can be aligned to a period and operational metrics for safety, sustainability, and security. Using a staged approach of prototyping and tool development, researchers may be able to increase the interdiction rate of success at key ports.

Exploring solutions in the marine setting by exposure to an alternate setting can overcome obstacles. For example, using Unmanned Aerial Systems (UAS) platforms and sensors can inform the development of UxV in marine settings. By studying algorithms to analyze multiple types of sensor data, it may be possible to correlate aerial solutions with marine data sources and solutions to identify, detect, and classify data.

The pace of technology advancement can sometimes be an impediment. A conscious effort should be made to incorporate "future proofing," i.e., using an open modular architecture and interoperability so that, as technology advances, it will be possible to update hardware, firmware, and software modules within systems without disrupting remaining modules. Two characteristics of "future proofing" are important to the built environment: interoperability and the ability to be adapted to future technologies as they are developed.

Providing Knowledge to Policymakers

Recommendations:

- Enhance risk assessment via in-depth computer assisted analysis.
- Examine policy options for data collection and exploitation.
- Provide transparent descriptions of system operation capabilities.

Risk aversion is an impediment to new endeavors in the advancement of automated analytic processes and cueing maritime threat operational responses. Appropriate risk assessment is required to pursue maritime research and development; otherwise, researchers may miss most or all of the important cues, data and relationships. Experience shows that tolerating some risks and risk-taking behaviors is not always associated with unsafe or costly activity. Attacking risky problems by in-depth computer-assisted analysis of individual sectors of maritime activity may make risk assessments more effective.

It is not uncommon for the public to object to technical advances based on misinformation or skepticism derived from fear of the unknown. Transparency is a useful tool to address fearful perception of successful network outputs. This mitigation can help gain confidence and trust in the ability to use machine learning for things like performing verification and validation.

To focus on transparency is to examine policy options for data collection and exploitation, as well as processing methodologies. Based on policy debates, it is possible to gain public trust. By describing to the public in clear terms how a system runs (by identifying the steps of system operation) it may be possible to limit public uncertainty about whether the resulting analysis is correct or not correct. Tracing back steps in system operation allows one to examine the process and discern any public concerns about the analysis.

Focusing on transparency is also a way to examine whether data in a system is secure and able to be shared with relevant stakeholders. “Transparency” is a tool for asking:

- Have all the necessary connections between data been made?
- Does this network capture and process all the data?
- What are the third or fourth order effects of sharing data on this system?
- Specifically for Maritime Domain Awareness (MDA) purposes, how might increasing transparency improve public perception of integrating data feeds (Air and Marine Operations Surveillance System (AMOS), Marinetraffic.org, vesselfinder.com, USCG/DHS Ship Arrival Notification System (SANS), etc.) to enhance situational awareness?

One non-technical mitigation associated with transparency would be greater MDA training in this area. Conducting training in a face-to-face classroom setting, with adequate support materials available (computers, monitors, mouse with wheel, etc.), would make it less likely for the public to object to technical advances, based on misinformation or skepticism derived from fear of the unknown.

Negative public perceptions can be associated with privacy concerns when data is derived from social media feeds. Social media training should accompany increased integration of social media data feeds (Facebook without a linked account, social media sites that contain travel records or check-ins, buy sell, and trade applications and website data feeds) to mitigate public fears and enhance social media awareness. It is best to tailor training scenarios to an organization’s operating environment.


GROUP
2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The 2019 GMF featured an evening session for all participants to extend the afternoon's collaborations in the historic Cunard Building. Participants were received in the center hall of the British Music Experience, amidst a backdrop of displays featuring the Beatles and other British bands. The reception was co-hosted by the Office of the Mayor of Liverpool and Mersey Maritime, a representative body for the Maritime Sector of the Liverpool City Region.

Mayor of Liverpool

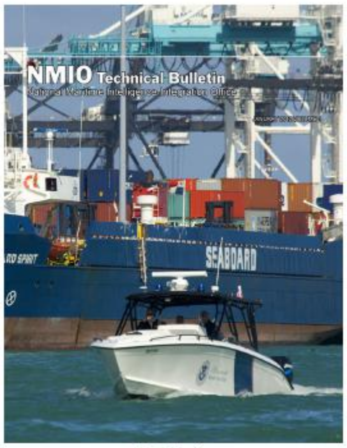
MERSEY MARITIME

british music experience

Abbreviations

A2AD	Anti-Access, Area Denial
AI	Artificial Intelligence
AIS	Automatic Identification System
AOR	Area of Responsibility
API	Application Program Interface
APG	Arctic Policy Group
BPC	Border Protection Command
BLOS	beyond line-of-sight
C4I	Command, Control, Communications, Computers, and Intelligence
CBA	Capabilities Based Assessment
CCE	Caribbean Collaboration Environment
CEED	Crowd-driven Ecosystem for Evolutionary Design
CIA	Central Intelligence Agency
CIOP-MDA	Cooperative Interagency Partnership for Maritime Domain Awareness
CMRE	Center for Maritime Research and Experimentation
CMS	Carbon Monitoring System
COA	Certificate of Authorization
COP	Common Operating Picture
CoSSAR	Center for Collaborative Systems for Security, Safety and Regional Resilience
CVISR	Consolidated Vessel Information and Security Reporting
DHS	Department of Homeland Security
DIC	data intensive computing
DoD	Department of Defense
EEZ	economic exclusion zone
ELINT	electronic intelligence
ERP	Enterprise Resource Planning
EU JRC	European Commission Joint Research Centre
FFI	Norwegian Defence Research Institute
FINRA	Financial Industry Regulatory Authority
GCCS-M	Global Command and Control System - Maritime
GIS	Geographical Information System
GMCC	Global Maritime Operational Threat Response (MOTR) Coordination Center
GMCOI	Global Maritime Community of Interest
GMF	Global Maritime Forum
GPS	Global Positioning System
GSCS	Global Supply Chain Security
HD	high definition
HPC	high performance computing
HSC	high scalability computing
HUMINT	Human Intelligence
IDA	Interagency Domain Awareness
INCSEA	Incidents at Sea
IOC	Initial Operating Capability
IR	infrared
ISR	Intelligence Reconnaissance Surveillance

IT	Information Technology
IUU	illegal, unreported, and unregulated
LRIT	long-range identification and tracking
MARAD	Maritime Administration
MCOP	Marine Common Operational Picture
MDA	Maritime Domain Awareness
ML	Machine Learning
MOC	Maritime Operational Center
MOTR	Maritime Operation Threat Response
MPA	Marine Protected Area
MSA	Maritime Situational Awareness
MSSIS	Maritime Safety and Security Information System
NAS	NASA Advanced Supercomputing or National Airspace System
NEX	NASA Earth Exchange
NGO	non-government organizations
NLA	Nick Lambert Associates
NMIC	UK National Maritime Information Centre
NMIO	National Maritime Intelligence-Integration Office
NOAA	National Oceanic and Atmospheric Administration
OSINT	Open Source Intelligence
OSV	Offshore Supply Vessel
PM-ISE	Program Manager for the Information Sharing Environment
PMAR	Piracy, Maritime Awareness and Risks
R&D	Research and Development
RCMP	Royal Canadian Mounted Police
RFP	Request for Information
RP3	Recommended Practices for Prevention of Marine Oil Pollution in the Arctic
SAP	Systems, Applications, and Products in Data Processing
SAR	synthetic aperture radar, suspicious activity reporting
SCR	Security Council Resolution
SKA	Square Kilometer Array
SOCINT	social intelligence
SRA	Systems & Resources Analysis
TOR	Terms of Reference
TREAD	Traffic Route Extraction and Anomaly Detection
TTX	Table Top Exercise
UAS	unmanned aerial system
UxS	unmanned systems
UxV	unmanned vehicles
VMS	Vessel Monitoring System
UN	United Nations
VOI	Vessel of Interest
UUV	unmanned underwater vehicle
WAM-V	Wave Adaptive Modular Vessel
WELD	Web Enabled Landsat Data



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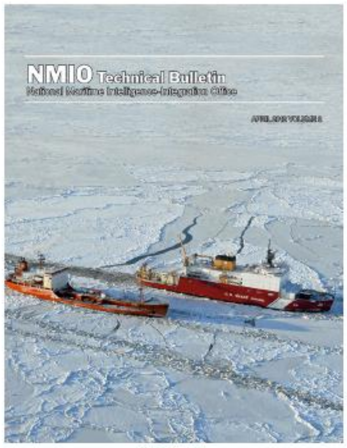

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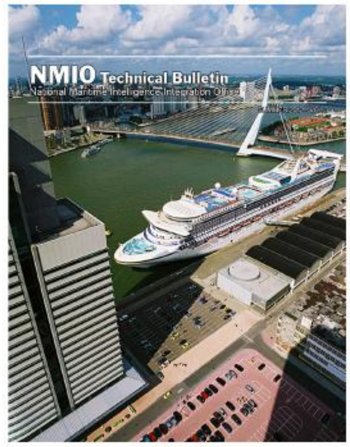

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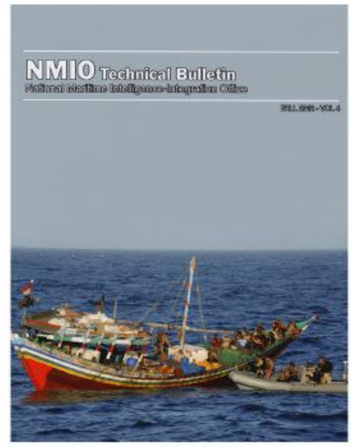

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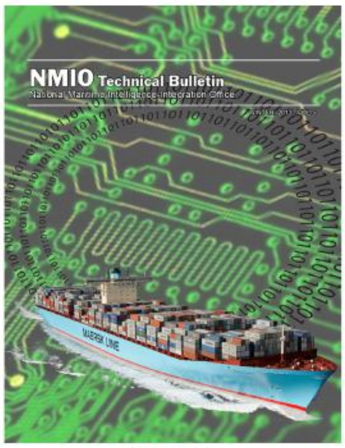

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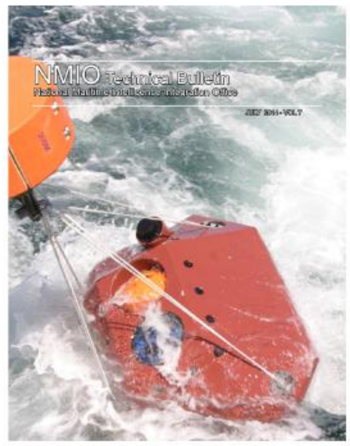

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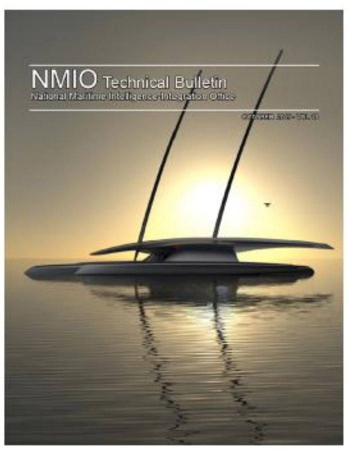

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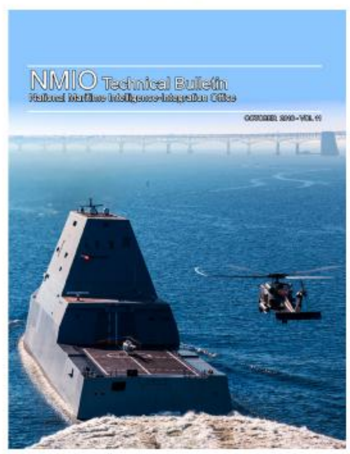

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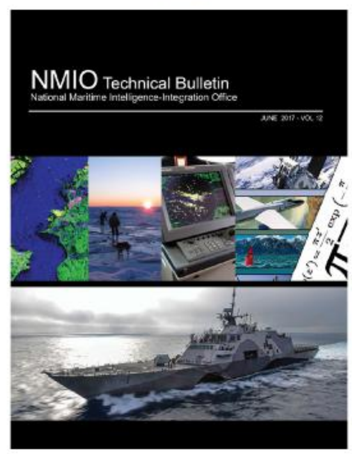

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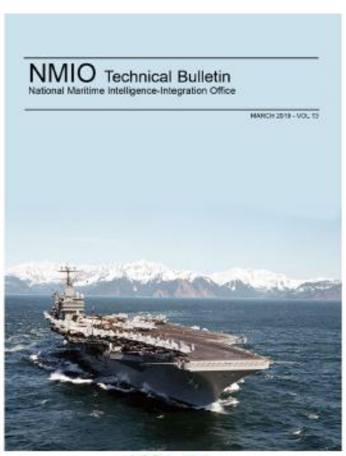

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Chief Science and Technology Advisor, NMIO: Mekisha Marshall
Deputy Science and Technology Advisor, NMIO: Darrick McNeill
Editorial Support: Faith MacDonald
Email: nmios&t.fct@navy.mil
Production: ONI Media Services
Address: 4251 Suitland Road, Washington DC 20395

Correspondence: Science and Technology Team

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