# A Panel on the Future of Long Duration Maritime Autonomy

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***Abstract*— We present a summary of a panel on long-duration maritime autonomy (LDMA) taking place at *IEEE OCEANS 2015*, Washington, DC. The panelists include Drs. Jason Stack and Theresa Paluszkiewicz of the Office of Naval Research, Dr. Geoffery Hollinger of Oregon State University, Rafael Rodriguez of the Naval Surface Warfare Center, Panama City Division, and Clayton Jones of Teledyne Webb Research. The panelists come from key stakeholders within the maritime autonomy domain: academia, government, and industry. These differing points of view will give unique insights into the history and future of long-duration maritime autonomy.**

## I. INTRODUCTION

The use of autonomous and unmanned systems for complex operations spanning several days to months is becoming increasingly prevalent in the maritime domain [1], [2]. The systems are motivating research in long-term observation, acoustic sensing, and even field experiments in trans-Atlantic autonomous navigation [3]–[5]. Additionally, long-duration autonomy is a key component to several current and former Office of Naval Research (ONR) programs [6]–[9]. We have organized a panel session for *OCEANS 2015* on long-duration maritime autonomy. The panelists will discuss the current status of long-duration maritime autonomy, and the future as seen from their perspective. The panelists come from four of the primary stakeholders in maritime autonomy research: government sponsor, academia, government laboratory, and industry. Additionally, the panelists bring differing levels of experience within the maritime autonomy domain, from junior faculty instilled with the latest cutting-edge research techniques to senior government personnel with decades of experience within research, development, test and evaluation (RDT&E) and acquisition programs involving autonomy. These differing points of view will give unique insights into the history and future of long-duration maritime autonomy. The panel is expected to last for a one-hour technical session, and will consist of a combination of pre-constructed questions, audience questions, and open discussion amongst the panelists.

## II. MAJOR SUBTOPICS OF LONG-DURATION MARITIME AUTONOMY

The panel will discuss key topics of relevance to the main subject of long-duration maritime autonomy. These topics range from current technical challenges to broader impacts of a world where long-duration maritime autonomy capabilities are commonplace.

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### A. Need for Long-Duration Maritime Autonomy

With the current limited capability for subsea communication, coupled with an uncertain and potentially hostile environment, the ocean is implicitly conducive to the need for vehicles that can react autonomously to changing, uncertain situations. The panel will discuss current and anticipated use cases for long-duration autonomy in the maritime domain. While areas such as ocean sampling, subsea survey, and naval applications are early proponents of LDMA, as the technology and operator trust matures, future needs by the ocean technology and maritime community may increase the use cases considerably [10]. The panel will discuss other conceivable applications that could require LDMA technology in the future based on their knowledge of current research and drivers.

### B. Current Technical Challenges

While significant advances in the capabilities of unmanned maritime systems have been made over the past decade to accomplish autonomous operations over great distances, considerable challenges remain. The panel will discuss what they view as the most difficult technical challenges that must be addressed before long-duration autonomous operations become a standard practice in maritime settings.

### C. Current Non-technical Challenges

In addition to technical challenges, non-technical issues could limit the prevalence of autonomous vehicles performing long-duration maritime operations [11], [12]. The panel will discuss what they view as the most pressing non-technical issues to LDMA becoming a commonplace tool for the maritime community.

### D. Verification and Validation

A topic of increasing interest and visibility in the broader robotics research community is the verification and validation (V&V) of autonomous systems [13]–[15]. Autonomous systems, by their nature, are difficult assets on which to perform V&V. When the task profile of the system is increased from the short-term (minutes to hours), to the long-term (days to months), the difficulties and potentially required test cases increase exponentially. Yet V&V is a key component to gaining user trust. The panel will provide their insights into the current V&V research efforts and their views on the path with which V&V of autonomous maritime systems to perform long-duration operations can become a reality.

### E. Commercial Benefits

In addition to the current scientific and naval applications that are widely anticipated to use LDMA technology in the future, there is the potential for significant commercial benefits as well. Could an Uber of the Sea come into existence in the next twenty years? The panel will discuss their views on where they see commercial opportunities taking place to make use of autonomous systems over long-duration tasks.

## III. Panelists

The following panelists have graciously volunteered to participate in the panel on long-duration maritime autonomy.

### A. Dr. Jason Stack, Office of Naval Research

Dr. Jason Stack is a Program Officer at the Office of Naval Research (ONR) in the Ocean Battlespace Sensing department and serves as the Team Lead for the Mine Warfare (MIW) and Ocean Engineering programs. He directly manages a portfolio in the research areas of machine learning, autonomy, and sensor development for the underwater domain. As Team Lead, his responsibilities include coordinating ONRs overall portfolio in MIW, Explosive Ordnance Disposal, Naval Special Warfare, and Ocean Engineering. He is currently appointed as the US National Lead for The Technical Cooperation Program (TTCP), Maritime Group, TP-13 (MIW); the US Member-at-Large in autonomy for the NATO Systems, Concepts, and Integration panel; and the US lead for a NATO Joint Research Project on machine intelligence and autonomy for mine countermeasures. Dr. Stack holds the B.S.E. degree in electrical engineering from Mercer University, the M.S.E. and Ph.D. degrees in electrical engineering from the Georgia Institute of Technology, and the MBA degree from the Massachusetts Institute of Technology.

### B. Dr. Theresa Paluszkiewicz, Office of Naval Research

Dr. Teresa Paluszkiewicz is a program manager at the Office of Naval Research (ONR) managing basic research programs in physical oceanography and applied programs in ocean instrumentation development, the advanced use of UUVs and autonomy, and maritime domain awareness. Her present portfolio of programs includes multiple international basic research programs that feature both ocean modeling and observations, and novel autonomous technologies. Dr. Paluszkiewicz has also led applied science development programs for the US Navy. This includes programs that mature the utility of radar remote sensing from space and ships. She manages several programs in developing autonomous instrument systems and advanced autonomy for long duration UUV missions. She previously managed an Innovative Naval Prototype program on persistent UUV sensing. Dr. Paluszkiewicz holds a B.S. degree in Oceanography from Florida Institute of Technology, a M.S. degree in Physical Oceanography from the University of Alaska, and a Ph.D. in Marine Sciences from the University of Maryland. She is a Fellow of The Oceanography Society and member of AGU and IEEE.

### C. Dr. Geoffery Hollinger, Oregon State University

Dr. Geoffrey A. Hollinger is an Assistant Professor in the Robotics Program and School of Mechanical, Industrial and Manufacturing Engineering at Oregon State University. His current research interests are in adaptive information gathering, distributed coordination, and learning for autonomous aerial, marine, and ground robotic systems [16]–[18]. His past research includes networked underwater robotics at the University of Southern California, multi-robot search at Carnegie Mellon University, personal robotics at Intel Research Pittsburgh, active estimation at the University of Pennsylvania's GRASP Laboratory, and miniature inspection robots for the Space Shuttle at NASA's Marshall Space Flight Center. He received his Ph.D. (2010) and M.S. (2007) in Robotics from Carnegie Mellon University and his B.S. in General Engineering along with his B.A. in Philosophy from Swarthmore College (2005).

### D. Mr. Rafael Rodriguez, Naval Surface Warfare Center, Panama City Division

Rafael Rodriguez serves as Senior Scientist for Automation and Unmanned Vehicle Controls at the Naval Surface Warfare Center Panama City Division of the Naval Sea Systems Command. In this role he supports transitioning unmanned systems technology to Fleet service. Duties include assisting the Office of Naval Research in establishing and managing the execution of unmanned systems technology development programs for mine warfare. He also advises acquisition program officers to establish capability requirements, conduct analyses of alternatives, and develop performance specifications for system acquisition. Mr. Rodrguez earned a Bachelor of Science degree in Electrical Engineering from the University of Puerto Rico in 1982, and a Master of Science degree in Electrical Engineering from the Georgia Institute of Technology in 1983. He is the author or co-author of over 30 technical reports, project reports, and conference proceedings papers, and one patent.

### E. Mr. Clayton Jones, Teledyne Webb Research

Clayton Jones is the Senior Director of Technology at Teledyne Webb Research, part of the Teledyne Marine Systems group. Mr. Jones has been involved in the creation, design, development, and commercialization of affordable buoyancy-driven ocean instruments including ALACE, APEX, and Slocum Gliders with an emphasis on system and sensor integrations, control algorithms, and pressure tolerant antenna design. He leads a team that successfully delivers cutting-edge technologies for science and Navy programs using creative solutions to satisfy real-world timelines and in-field requirements. Since inception, Webb Research's core focus and commitment is in providing ocean observing platforms, enabling a better understanding of the world's oceans. Pioneering with innovative technologies, Teledyne Webb Research is a leader in high endurance worldwide remote sensing and data retrieval delivering low-frequency sound sources for navigation and tomography, over 8000 profiling floats, comprising the majority of the ARGO array, and over

500 Slocum Gliders, as used in the Littoral Battle Space program and Ocean Observatories Initiative. He holds a B.S. from the University of Massachusetts, Amherst (1990).

## IV. Moderator

Dr. Matthew Bays is a research engineer with the Naval Surface Warfare Center, Panama City Division. He actively performs research in autonomy and unmanned systems related to Mine Countermeasures and Mine Warfare, including optimized waterspace management of Naval assets, MCM scheduling using mathematical techniques, sensor placement, and UUV path planning. He holds a B.S. in Mechanical Engineering from Cornell University, and M.Eng. and Ph.D. degrees in Mechanical Engineering from Virginia Tech.

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