U.S. DEPARTMENT OF COMMERCE

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

HYDROGRAPHIC SERVICES REVIEW PANEL

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PUBLIC MEETING

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MONDAY,
SEPTEMBER 11, 2017

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The Hydrographic Services Review Panel met in the Prescott Ballroom, Sheraton Portsmouth Hotel, 250 Market Street, Portsmouth, New Hampshire, at 8:30 a.m., William Hanson, Chair, presiding.

MEMBERS PRESENT:

WILLIAM HANSON, HSRP Chair
JOYCE E. MILLER, HSRP Vice Chair
DR. LARRY ATKINSON
DR. LAWSON W. BRIGHAM
LINDSAY GEE*
KIM HALL
EDWARD J. KELLY
CAROL LOCKHART
DR. DAVID MAUNE
ANNE MCINTYRE
EDWARD J. SAADE
SUSAN SHINGLEDECKER
GARY THOMPSON*

NON-VOTING MEMBERS:

ANDY ARMSTRONG, Co-Director, NOAA/University of New Hampshire Joint Hydrographic Center
JULIANA BLACKWELL, Director, National Geodetic Survey, NOS
RICH EDWING, Director, Center for Operational Oceanographic Products and Services, NOS
DR. LARRY MAYER, Co-Director, NOAA/University of New Hampshire Joint Hydrographic Center

STAFF PRESENT:

REAR ADMIRAL SHEP SMITH, HSRP Designated Federal Official; Director, Office of Coast Survey
DR. PAUL DOREMUS, Acting Assistant Secretary for Conservation and Management
GLENN BOLEDOVICH, Policy Director, NOS PCAD
CAPTAIN RICK BRENNAN, Chief, Hydrographic Surveys Division
ASHLEY CHAPPELL, IWG-OCM
DR. GREG DUSEK, CO-OPS
CARL KAMMERER, NOS OCS
LYNNE MERSFELDER-LEWIS, HSRP Coordinator
JIM RICE, NOS PCAD
ERICA TOWLE, NOS OCS
E.J. VAN DEN AMEELE, Chief, Coast Survey Development Laboratory
LT DAVID VEJAR, NOS OCS

ALSO PRESENT:

PATRICK CARROLL, Office of Representative Carol Shea-Porter (New Hampshire)
THOMAS CHANCE, Chief Executive Officer, ASV Global
KERRY HOLMES, Office of Senator Maggie Hassan (New Hampshire)
DOUG LOCKHART, Vice President and General Manager, Teledyne CARIS Inc.

BONITA POTHIER, Office of Senator Angus King (Maine)
REBECCA T. QUINTAL, Hydrographic Survey and Data Solutions Manager, Leidos
ELIZABETH WESTER, Office of Senator Jeanne Shaheen (New Hampshire)

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P-R-O-C-E-E-D-I-N-G-S

(8:33 a.m.)

CHAIRMAN HANSON: All right, if everybody can take a last shift there and get ready for -- start. I think we're online and so let me go ahead and do the honors here. Go ahead and call the meeting to order here.

Good morning, I'm Bill Hanson, chair of the Hydrographic Surveys Review Panel. And to my right, is Joyce Miller, my co-chair -- the co-chair. Both call to order and welcome all to the panel's fall meeting.

It is great to be in New England and the great city of Portsmouth. We're looking forward to hearing more from the UNH Joint Hydrographic Center and Center for Coastal and Ocean Mapping over the next -- course of next couple of days.

My thanks to the panel members and staff for putting together a robust program including presentations by NOAA leadership, Dr. Paul Doremus, Glen Boledovich, and speakers from prominent organizations focusing on R&D, technology and highlighting the importance of navigation services contribution to the backbone and infrastructure of the U.S. including the Corp of Engineers, the National Geospatial-Intelligence Administration, otherwise known as NGA, and others.

We obviously a lot going on in the country right now. We want to send our thoughts to the folks recovering from Hurricane Harvey, in Texas, and those still feeling the impacts from Hurricane Irma. And our thanks go to National Survey and NOAA for fulfilling a very important emergency response mission when needed, as they are now.

Folks who withstood Harvey have a long recovery and those also just now being impacted by Irma with effects to be still be felt. And NOS has personnel who have been playing a vital role in preparation and as well as in response.

We want to especially give a shout out to National Geodetic Survey and Julianna

Blackwell's staff who are busy with imagery and remote sensing to CO-OPS whose sensors are 24/7 in the water and on land and being mentioned on The Weather Channel -- so you've hit the big time -- congratulations.

Thanks to the NRTs who were positioned to swoop into to the ports to help survey and reopen the ports. Again, a lot of that's in Houston and a lot of it's ongoing now in Florida as well up the East Coast and in the Gulf -- a very big storm.

NOS, NAV Services data, products, and services are absolutely essential in such emergency. We are in New England and not far from the Wells National Estuarine Research Reserve. Joyce, you want to say a couple words?

VICE CHAIR MILLER: Yes, when I joined the panel -- and I believe Susan was on and couple of others -- there was a wonderful woman, Dr. Michele Dionne, who was in charge of the National Estuarine Research Reserve and she passed away four years ago, I believe.

And so while we're in her territory, I just wanted to say she was a real addition to the panel.

CHAIRMAN HANSON: Thank you, Joyce. And we're also mindful that today is 9/11 and I know that everybody's mind and thoughts immediately race to where you were and the impacts on all of us. Andy Armstrong, would you say, you know, a couple of thoughts on 9/11?

CAPT ARMSTRONG: Yes. Thank you, Bill. I think, as you say, we all remember where we were and what we were doing on that day when our nation was attacked. And I think, particularly in light of what's going on now, it's good for us to thank our first responders for their work then and now and also remember the victims of 9/11.

And I think if we could have a moment of silence for the victims at this point, that would be nice.

(Moment of Silence)

Thank you.

CHAIRMAN HANSON: And thank you, Andy. But, back to the meeting here. We'll do our best to stay on schedule. I've got a very small little hammer here so I'll try to be loud with it, yet recognizing everybody wants to contribute and have questions to ask.

We've been a very interactive panel in recent meetings and would encourage that to stay the same for this meeting. Members, please feel free to call on the experts in the room for questions and clarification of points throughout the meeting.

As a point of order, all comments from non-members will be held to the designated public comment period of the meeting. Your comments can also be sent by the webinar or by email to the HSRP mailbox and to Lynne Mersfelder.

You know, one of the things I don't recall us doing -- and I think we've done it in past meetings -- is do a quick introduction of who the members are.

Is that appropriate just real quick

who we are with affiliation just so members of the panel and public remember just how diverse a group this is? Carol, do you mind starting off?

MEMBER LOCKHART: There we go. So I'm Carol Lockhart. I run a woman-owned small business called Geomatics Data Solutions. So we're -- my expertise is in hydrographic lidar and hydrographic multibeam service.

MEMBER BRIGHAM: Lawson Brigham. I'm a professor at the University of Alaska Fairbanks and retired Coast Guard Officer.

MEMBER McINTYRE: Anne McIntyre. I'm a Maritime Pilot with the Columbia River Pilots.

MEMBER SHINGLEDECKER: Susan Shingledecker, Vice-president of BoatUS Foundation. I work with recreational boaters around the country.

MEMBER KELLY: Ed Kelly. I'm the Executive Director of the Maritime Association in the port in New York and New Jersey.

MEMBER ATKINSON: Larry Atkinson, Old Dominion University.

MEMBER EDWING: Rich Edwing, Director of the Ocean Service Center for Operational Oceanographic Products and Services.

MEMBER MAUNE: Dave Maune from Dewberry. I'm a specialist in digital elevation models and cost-benefit analysis that I'm going to do for the 3D Nation study for NOAA.

MEMBER SAADE: Ed Saade with Fugro. I'm the President of Fugro USA and the Regional Director for the Marine Division.

MEMBER HALL: Hi, I'm Kim Hall. I'm the principal consultant and founder for a woman-owned small business as well named Brizo Maritime Consulting, and I specialize in maritime security and nautical operations.

MS. BLACKWELL: Julianna Blackwell, Director of NOAA's National Geodetic Survey.

CAPT ARMSTRONG: Andrew Armstrong. I'm the NOAA Co-director of the NOAA University of New Hampshire Joint Hydrographic Center.

DR. MAYER: If Andy says Andrew, I'll say, Lawrence Mayer, Center for Coastal Ocean

Mapping, University of New Hampshire and Joint Hydrographic Center.

RDML SMITH: Shep Smith, the director of the Office of Coast Survey at NOAA.

CHAIRMAN HANSON: I'm Bill Hanson, chair of HSRP and with Great Lakes Dredge and Dock Company.

VICE CHAIR MILLER: Joyce Miller, I'm semi-retired from the University of Hawaii. I worked in multibeam pretty much my entire career.

DR. DOREMUS: Paul Doremus. I'm the Acting Assistant Secretary for Conservation and Management at NOAA.

CHAIRMAN HANSON: While we're on a roll, we're going to go ahead and ask the audience as well just so -- again, these meetings always draw a diverse group of folks and it's important to kind of know who's in a room just so you can call in that expertise. So Captain, if you don't --

CAPT VAN DEN AMEELE: Good morning, E.J. Van Den Ameele, Chief of the Coast Survey

Development Lab and --

CHAIRMAN HANSON: Public meeting, so we have to have that microphone.

VICE CHAIR MILLER: That's fine. So just, again, always talk with the mic, please.

CAPT VAN DEN AMEELE: Morning, E.J. Van Den Ameele, Chief of the Coast Survey Development Laboratory and Office of Coast Survey.

MR. LOCKHART: Good morning, I'm Doug Lockhart. I'm with Teledyne Technologies. I'm currently VP and General Manager of Teledyne CARIS.

MR. CHANCE: Hi, my name is Thomas Chance. I'm CEO of ASV Global, unmanned boat company.

MS. QUINTAL: I'm Rebecca Quintal, the Hydrographics Surveys Manager at Leidos.

MS. CHERRY: Good morning. I'm Kristine Cherry. I'm the Advisor to the ASEM at NOAA.

MR. RICE: Jim Rice, NOS Policy.

MR. DUSEK: Greg Dusek, Chief

Scientist for the Center for Operational Oceanographic Products and Services, NOS.

MR. VEJAR: My name is David Vejar. I'm the Navigation Manager in New York, New Jersey, and New England.

MR. KAMMERER: I'm Carl Kammerer. I'm with CO-OPS also, but I also sit at the University of New Hampshire at the JHC.

MS. CHAPPELL: This is Ashley Chappell, NOAA Integrated Ocean and Coastal Mapping.

MR. FERGUSON: Scott Ferguson, interested public.

MR. NOLL: Guy Noll, former NOAA Corps and now with ISRI at Maritime Lead Consultant.

RDML GLANG: Good morning, Gerd Glang, retired from NOAA and now with IIC Technologies.

CHAIRMAN HANSON: Sorry, Admiral Glang. We just were commenting on your witness protection program disguise there. So I've been doing this for -- did we get everybody?

MR. COLE: We've got the other side

here.

CHAIRMAN HANSON: Oh, I'm sorry.

MR. COLE: Hi, I'm Eric Cole. I'm here as a public attendee.

MS. POTHIER: My name is Bonita Pothier I work with U.S. Senator Angus King's office.

MR. MADDOCK: Hi, I'm Dave Maddock. I'm Technical Director for programming for HYPACK.

MR. ORLINSKY: And last, I'm -- good morning, Harold Orlinsky, general manager for HYPACK and ex-NOAA Corps as well.

CHAIRMAN HANSON: Thank you.

VICE CHAIR MILLER: Glen, did you introduce yourself?

MR. BOLEDOVICH: Glen Boledovich. I'm the policy director for NOAA's National Ocean Service.

MS. MERSFELDER-LEWIS: I'm Lynne Mersfelder-Lewis, I'm the -- I'm HSRP program manager.

MS. TOWLE: Thank you. Erica Towle. I'm Coast Survey front office staff.

CHAIRMAN HANSON: I think we were going to introduce you guys later, but if you want to go ahead and do it now, thanks.

MS. WESTER: Liz Wester, Office of Senator Jeanne Shaheen.

MS. HOLMES: Kerry Holmes, Office of Senator Maggie Hassan.

MR. CARROLL: I'm Patrick Carroll from Congresswoman Shea-Porter's office.

CHAIRMAN HANSON: And thank you very much for being here. Thanks for everyone else for the introductions. It just helps to set the tone, so appreciate that.

So I've been doing this for eight years and which means this is my last meeting. So as we had a little administrative session this morning and talked about new leadership.

And so I want to announce that the new chair of HRSP and congratulate Joyce Miller on -- who will serve as the new chair and Ed Saade who will serve as the co-chair. So thank you for your willingness to serve. And, Joyce, it's been a treat to working with you over these last many, many years now -- so congratulations on that.

Kim Hall will also serve as co-chair of the Planning and Engagement Working Group. Thanks, Kim. So if we can give them a round of applause for their willingness.

Plans for our 2018 meetings are tentatively scheduled for Miami in April to coincide with the Miami Ports system dedication. And in August, potentially in Alaska.

They're tentative dates and obviously subject to change, don't -- but go ahead and put them on your calendars as possible.

And now I'd like to introduce Rear Admiral Shep Smith, our federal designated officer and director of NOAA's Office of Coast Survey. During his 23-year NOAA career, he has advanced in State of Art in hydrography and cartography commanded several NOAA vessels.

His full biography and all speaker

member bios are in your meeting materials, handouts at the sign-in table, and also available on the HSRP web site.

Admiral Smith, thank you for taking the time to be with us this morning. We know you've got a lot of going on, but as we said in the past, it's very critical to have leadership participate in these FACA meetings, and it says a lot to have you here, so thank you.

RDML SMITH: Thank you, Bill. I -- and we need to update the boiler point language there because I hit 24 this year, so just cutting you a break.

Welcome to the -- to this meeting of NOAA's Hydrographic Services Review Panel. First a few book -- housekeeping announcements. Exit doors are clearly marked. Restrooms are right here behind the -- back in this corner. And we don't expect any drills or any other emergencies, but we understand from the hotel that they'll be announcements and bells and that sort of thing.

So congratulations to Ed Kelly --

where's Ed there -- and to Sal Rasello, who couldn't join us here who have been sort of reappointed for second four-year terms -- so thank you for offering to continue to serve. We appreciate the continuity of leadership.

In addition this year, we will be welcoming three new members -- Sean Duffy, Jr., who is the executive director of the Big River Coalition; Julie Thomas, who's a senior advisor for IOOS at SCRIPPS; and Ed Page, the executive director of the Marine Exchange of Alaska.

I do want to just make a quick side comment that, you know, this panel is -- has this range of expertise in geographic scope not by accident, but by design, and we're really pleased to have found such great new panelists to fill the roles of some of our departing panelists, so we're really excited for the future of the panel as well.

Joyce, Ed, Kim, and Dave, thanks for agreeing to serve in your new HSRP positions for 2018. And this is Bill's eighth on the HSRP and, along with Lawson and Brigham and Scott Perkins, this will be their last meeting so I want to help go out with a bang and do my best to ensure that this meeting is productive, strategic and useful for your last meeting.

We're honored to have such a robust group of experts assembled in the room and partners at the -- from the University of New Hampshire. For the Center of Coastal Ocean Mapping and the UNH NOAA Joint and Hydrographic Center. I'm honored to welcome the speakers.

I'm really -- this agenda this week I just want to -- I'm diverting from my script here for a minute -- but the -- this -- the agenda for this week has taken a lot of work and a lot of great creativity to put it together and I'm really excited about and particularly the unmanned systems focus.

The UNH folks have a -- have been building experience and will have a demo for us this week and we have a fabulous panel to walk us through sort of what the state-of-the-art is and where the pain points and opportunity points are going forward -- so I'm really looking forward to that deep dive.

So in that unmanned systems sessions, we have Thomas Chance, Doug Lockhart, and Rebecca Quintal, and Captain E.J. Van Den Ameele, who will all be speaking. And thank you, Carol, for moderating that session.

So -- oh, and I -- Lyndsay Gee was really one of the primary leaders in putting this session together and he is, unfortunately, not able to join us, but you -- his efforts for putting this together will certainly be felt at the meeting.

So in addition, I want to recognize subject matter experts NOAA's staff here with us. And, Bill and Joyce, and other members, please feel free to call on them during the meeting.

The last thing we want to do is have a disconnect between what the panels thinking and what -- and what's already happening within the agencies so let's try to get those -- it's a good opportunity to get synced up as we go along. And they've already introduced themselves.

So I do want to call out the regional NOS staff, Carl Kammerer from CO-OPS, who introduced himself, Lieutenant David Vejar from Coast Surveys, the NAV manager for the Northeast Region. And we're just starting that role this year and so this is -- he's spinning up quickly, but it's a big part of our regional presence to have the -- that NAV manager at all the meetings in the region. So he puts a lot of miles on the suburban getting around.

For -- Dr. Greg Dusek introduced himself for -- from CO-OPs. From NOS headquarters, Glen Boledovich, who has been with HSRP from the beginning, I believe, and really he knows all the history of these discussions and is a real process expert as well in how to make our thoughts felt effectively -- so please use Glen.

From Coast Survey, I sort of apologize because we usually have a bigger footprint here, but we -- there's a hurricane going on and we thinned down our present --- our presence here for the folks that are directly involved in the hurricane response preparation.

So but we do have Captain Rick Brennan, who I think is stepped out to -- for the hurricane call, Captain E.J. Van Den Ameele, Ashley Chappell from IOCM, let's see, Christie Vandell couldn't make it. Erica Towle, as her first HSRP, has been a great addition to the Coast Survey front office and picks things up really quickly -- so glad to have her here as well.

And, of course, none of this would happen at all even these words that I'm reading without Lynne Mersfelder-Lewis, who organizes and orchestrates this whole enterprise -- so thank you, Lynne.

And I really can't -- we already outed Admiral Glang back there in the back, but I did want to call out and thank him for his presence here as well. Not representing NOAA anymore, but his depth of experience and commitment to this panel and to the hydrographic enterprise has been decades and decades long -- so thank you. I'm really happy to have you here, Gerd.

With that, I think it's back to you, Bill.

CHAIRMAN HANSON: All right. Thank you, Admiral Smith. Again, we do appreciate you and your experts being here. They make the meetings much more productive. We also want to thank, again, the congressional staff representatives for being here as well. That means a lot to us as well.

Obviously, all the recommendations that we make are very appropriate for you folks as your advocacy and something for you to champion and to take credit for, for your support of the work that NOS does.

One of the things that I've come to appreciate over the years on the panel is just the amount of innovation and forward-thinking that goes on within NOS. And as someone who spends a lot of time advocating for infrastructure investment, certainly innovation is the way forward.

It's not going to be -- we're not going to move forward by doing things the same way that we've always done them. And this group and NOAA and NOS, particularly, embody that innovation thought process that will help drive this nation forward and so your continued support of their efforts is much appreciates.

And the more we can help articulate those points as are relevant to you and in the work you do, we very much look forward to doing that. So we've got Kerry Holmes from the Senator Hassan's office, we've got Mr. Wester from Senator Shaheen's office, and then Patrick Carroll, thanks, from Congresswoman Carol Shea-Porter's Office.

So we've also got messages -- video messages -- and even an a letter that will be read a little bit later. And Bonita, thanks for showing up as well. Appreciate that. So with that, I think we're actually going to moving forward here, sir, so --

RDML SMITH: Yes, I just want to -- may I just echo your thanks for our -- the representatives from our Washington delegation being here.

We've had a really great support from the New Hampshire delegation over the years expressed not only through support for the Joint Hydrographics Center, but for NAV services overall, and so thank you. I know that that's -- I know that level of support comes with a level of commitment. I really appreciate it.

I also want to flag representation from my home state of Maine and thank you to the -- to Senator King for making you available to join us today, so thank you.

CHAIRMAN HANSON: You want to talk about our issue papers, so.

RDML SMITH: So that's the panel to review and provide your consensus comments to NOAA on the OCS autonomous system strategy. I appreciate the work you've already done, and look forward to receiving your comments at the end of the meeting.

CHAIRMAN HANSON: Great, thank you. And so for the members of the audience, one of the things that this panel has taken on over the last few years is, rather than just sitting around and making a -- it's common for FACA is to do recommendation letters to the whatever group they're reporting to.

This group took on another level of detail and started writing issue papers to give us more of a chance to put down on paper some of our thoughts, some of the things that we've been -- we'd like to see come out of these discussions and some -- so we've done, I think, nine?

RDML SMITH: Nine.

CHAIRMAN HANSON: Nine papers to date, and we've got two more issue papers for you today that we're looking to finalize -- one on precision navigation, and the other that I'm particularly excited about -- is the R&D benefits for NOAA in the industry.

So we'll discuss and prioritize additional issue papers in the future, but we're excited to be able to complete these two at this meeting. Okay. All right. And for those who are interested, the papers that we'll be talking about and finalizing are available at the front desk as you check in.

RDML SMITH: Thank you, Bill. I just want to echo my thanks and congratulations to the panel for all of the hard work in developing all those papers. We -- as you know, it -- we are in the midst of leadership changes in Washington and have an opportunity to reintroduce our programs to folks that have not had a lot of history with them and these types of papers are really helpful to us to have some as part of our briefing to new leadership and provides a nice, independent view of our program -- so thank you.

CHAIRMAN HANSON: Great. So you're probably tired from hearing from us at this point so we'll get -- go ahead and get the staff and folks ready to geared up. If you don't mind, Kerry Holmes from Senator Hassan's Office, I believe you have a letter?

MS. HOLMES: I do, yes, thank you. So the letter to read on behalf of Senator Hassan. She regrets she couldn't be here today.

"Dear Rear Admiral Smith, I regret that I am unable to attend the Hydrographic Services Review Panel meeting in Portsmouth today, but I would like to welcome you to New Hampshire and thank all of the stakeholders and the National Oceanic and Atmospheric Administration partners for attending this important meeting.

The Hydrographic Services Review Panel meeting is an important opportunity for NOAA officials, HSRP members, NOAA partners and other marine stakeholders to come together and discuss ways to improve NOAA data products and services and recommend changes.

This work is critical to ensuring that the users of our waterways from small, recreational boaters to large, commercial vessels have the data and the tools that they need to safely and efficiently navigate our nations waterways. A well-functioning marine transportation system is critical for global commerce and our economy.

The HSRP and these meetings are important tools to ensure that we continue to improve and enhance our marine transportation system. Once again, thank you for your work. I look forward to continuing to work together on these and other important marine issues. With every good wish, Margaret Wood-Hassan, United States Senator."

CHAIRMAN HANSON: Thank you very much and please pass our appreciation as well. Liz Wester from Senator Shaheen's Office.

MS. WESTER: Yes. "Dear Rear Admiral Smith, thank you for the invitation to attend today's meeting of the Hydrographic Services Review panel. I wish I could join you, but want to pass on my appreciation to NOAA and everyone else who has made today's panel possible.

We, in New Hampshire, are always aware that the ocean are -- is one of our most important beautiful resources. Residents, tourists, and a variety of industry's all benefit from the coastline -- a fact that illustrates significance of its stewardship and sound management.

By focusing on research and the development of new hydrographic technologies, we will give scientists and researchers access to data and information that will broaden our understanding of the ocean and how it can be made safer for private and commercial travel.

Modernizing the way we survey, chart and navigate our oceans will give greater insight that will help all of us make decisions that will preserve, if not improve, our way of life in our coastal regions.

Thank you again for the invitation, I look forward to hearing from your continued successes. Sincerely, Jeanne Shaheen, United States Senator."

CHAIRMAN HANSON: Wonderful. Thank you, and please again, pass on our thanks for the participation also encouragements as well. Patrick Carroll, representing Representative Shea-Porter. Thank you for being here.

MR. CARROLL: Thank you, and good morning to everyone. On behalf of the Congresswoman at our office, welcome to the first district from the beautiful coastline up to the White Mountains. We're very proud of this district and happy to brag about it. Thank you for coming.

"Thank you for inviting me to the NOAA Hydrographic Services Review Panel Public meeting in Portsmouth, New Hampshire. I regret that I cannot be here with you in person today. I represent the first district of New Hampshire, which includes Portsmouth a port city.

As a member of the Congressional Ports caucus, I support its mission to promote the importance of our ports to the nation's economy and the need to secure them since U.S. ports support 13.3 million jobs across the country and contribute $3.15 trillion to the economy and business activity.

This means that safe and efficient maritime transportation and commerce is essential to the United States, to New England to the New Hampshire economy and even to the well-being of our citizens. For example, the primary delivery of both heating oil, LNG and salt to New England is by ship.

Marine transportation depends on accurate and up-to-date navigation services. The accuracy of navigation services is vital, but accurate depth information for nautical charts is particularly challenging in the New England region where the irregular and rocky seafloor off New Hampshire created by glaciers require surveys using modern, multibeam echo sounders.

In addition, accurate tides and currents data must be collected and updated as the Port of Portsmouth, with its critical Portsmouth naval shipyard -- one of the U.S.

Navy's four public shipyards -- has a high range of tide and very strong currents. Reliable data, tide data and tidal current predictions and the supporting observations are essential.

Finally, accurate depths and reliable tide predictions depend on a robust underlying network of geodetic positions and vertical elevations which makes accurate, modern mapping equally essential.

I also understand how catastrophic events like Hurricanes Harvey and Irma can impact its critical infrastructure and thank the navigation response teams and others including several folks who were supposed to attend this meeting, who have deployed to these areas to provide needed services.

We are fortunate in the first district of New Hampshire to be home to the Joint Hydrographic Center at the University of New Hampshire. New Hampshire is proud to have the Joint Hydrographic Center at UNH and the effective collaboration it facilities among NOAA the university, and its private sector partners.

It is a world leader in hydrographic and ocean method technology and the premier provider of advanced education in these technologies. I understand that many of the NOAA leaders in this room have graduated from the UNH program and that several of the private sector organizations of record here are industrialized partners for the center.

New Hampshire is also proud to be the home port of NOAA's most modern, hydrographic vessel, the NOAA ship, Ferdinand Hassler.

Given the need for accurate and up-to-date data to ensure port and navigational safety in general and, in particular, to ensure safety at the port of Portsmouth for national security reasons related to the Portsmouth naval shipyard, I will work hard to ensure that NOAA is adequately funded to maintain its critical navigational services.

And I hope that NOAA will continue to give strong support to the Joint Hydrographic

Center at the University of New Hampshire.

Thank you again for inviting me to share my thoughts about these important issues. Sincerely, Carol Shea-Porter, Member of Congress."

CHAIRMAN HANSON: Thank you very much, Mr. Carroll. Thanks for reading that, and please, again, pass along our thanks and congratulations for all of her support. We have another letter from Senator Collins, and allow me to go ahead and read that into the record.

"Dear Friends, I'm pleased to -- welcome me to the meeting of the Hydrographic Survey Review panel, the National Oceanographic and Atmospheric Administration. This panel plays a vital role in advising the NOAA administrator on issues related to hydrographic and shoreline surveying, nautical charting and several other areas that enhance our management of coastal and marine ecosystems.

I am confident that your work here will greatly contribute to our understanding and stewardship of America's oceans. I am pleased to join the many welcome you today and extend my appreciation for your outstanding work. Sincerely, Susan Collins, United States Senator."

And then we also have a video. Let's see, Congresswoman Chellie Pingree of Maine has provided a video message. If we can -- are we able to roll that now?

HON. PINGREE: Hello. I'm Congresswoman Chellie Pingree. Thank you for the opportunity to share a few words for the latest meeting of the Hydrographic Services Review Panel.

As someone who lives on an island in Maine's Penobscot Bay, I have a personal appreciation for the work of NOAA's navigation services.

In our community, getting out on the water is a fact of life whether it's taking the ferry to the mainland, using a lobster boat to make a living or simply sailing across the main coast.

For us and thousands of other Mainers, being on the water safely depends on having the best information possible about sea levels, current speeds, navigational routes and more. NOAA's navigation services does an exceptional job of collecting and distributing that vital information.

As a member of Congress too, I'm grateful for the broad range of services you offer. Your nautical charts are essential to our states marine economy.

And the wealth of data you collect on shorelines and water levels helps researchers, policy makers and coastal communities plan for the future of our marine resources.

The technology available today, to map and measure our oceans, is simply amazing. But the sheer amount of data it provides must be overwhelming. I truly appreciate the work of the Hydrographic Services Review Panel to help NOAA decide how to distill and distribute that information so it can be most useful for those who need it.

Thank you for lending NOAA your time and expertise. My thanks also to NOAA staff. I truly appreciate the many areas of work this agency does. As a member of the House Appropriations committee, I will continue advocating for the resources it needs to carry out its important mission. Thank you all, and take care.

CHAIRMAN HANSON: And thank you for that note -- message as well. We appreciate the letters and the videos and your participation.

One of the things at HSRP is we do travel around the country, as you've heard, and one of the messages that I think you can carry back is that a lot of the issues facing this region are not that unique.

A lot of the coastal and ocean issues, you have a lot of friends on the Hill, a lot of friends in congress that have the very same issues, no matter what side of the aisle they're on when it comes to coastal and ocean issues.

So we encourage you to continue to work not only for your region in your districts and your states, but also for the nation and looking for coalitions that help advance the very same things we're all advocating for -- so appreciate you being here. Thanks again.

It's now my pleasure to introduce NOAA's leadership representative here, Dr. Paul Doremus, performing the duties of Assistant Secretary for Conservation and Management of NOAA.

Dr. Doremus is responsible for driving NOAA's programs in areas ranging from enabling marine transportation to managing our nations fisheries and protecting and preserving coastal resources.

He also serves as a deputy assistant administrator for Operations at NOAA Fisheries where he is the Chief Operating Officer. He is responsible for the day-to-day management of the agency operations and oversees NOAA Fisheries financial and business processes, works to strategically align and improve the performance of NOAA Fisheries and ensures NOAA Fisheries has effective and efficient infrastructure for its mission ranging from fleet and facilities to information technology and workforce.

His full bio, if there could be one, is in your materials. Dr. Doremus, thanks for being where we're with us today. We know there's a lot going on. And again, look forward to your comments.

DR. DOREMUS: Thank you, Mr. Chair, it's a great pleasure to be here. And I do want to start off by thanking you and acknowledging your eight years of service on the panel and recent activities as chair.

Greatly appreciated by NOAA. And I'm extending thanks on behalf of the acting NOAA administrator, Ben Friedman, for your service -- as well, Lawson, for yours. It's been a great pleasure to have both of you serve the panel for such an extended period of time and we look forward to future collaboration with you both.

Also want to acknowledge Sal Rasello, not here, but Ed, congratulations on your reappointment and we will look forward to new members in the next meeting as has already been acknowledged.

And Julie, we're really pleased to have you step up as chair; likewise, Ed as co-chair, and look forward to working with you both in that capacity.

I also appreciate, Bill, your observations right at the outset about where we are today and a lot of our organization's focus, understandably, on events in Florida, continued events in Texas and the moment of reflection, a number of years ago, on 9/11.

These are extraordinary events, awful in their scale and their human impact. But also, rather incredible examples of how our institutions and how our society works and really comes together and meets these very stressful tests of the very fabric of society.

And it's outstanding to me and awesome

in many respects how strong, flexible, resilient, you will, that social fabric is.

And I think we're seeing that play out now throughout the Gulf of Mexico in the most extraordinary back-to-back set of extreme weather that we have seen from just phenomenal precipitation levels in Texas and extraordinary flooding to the circumstances we have with storm that's wider than the peninsula of the entire peninsula of Florida.

So we're tracking that very closely. And I think that you see in this both the entirety of the federal government, but the public sector enterprise.

Our relationships with our state and local public sector entities, the response community -- the emergency response community -- as well as our long-term restoration activities require an incredible level of collaboration not just across government, but between government, private sector, academic sector and society at large.

And we are -- we're seeing that play out now and we're going to see that in large measure in the long-term response to these incredible events. And that is, in fact, I think, at root, one of the things that I find most impressive about this advisory committee.

It is linking those communities. It's inking our federal community, our private sector community, our academic community around the programmatic areas for hydrographic services. We know how vital navigation services are.

It's interesting, at times, the smoothness and underlying reliance of the nature on a highly functioning productive efficient navigation system is. And it comes to the surface and to people's attention when it's disrupted and we're seeing that in big, big measure right now in the Gulf.

So clearing, reopening ports and waterways, incredible work that needs to be done there. And the long-term restoration of those capabilities as well as the ability of our community to maintain pace with technology and to provide these sort of capabilities, the sort of infrastructure for commerce and for exchange will be a big part of -- has been a big part of your work, your advice to us, and will be a big part of our future efforts.

And the entirety of the NOAA leadership team is very grateful for that service. And we look forward to continued work with the panel to that end.

We have seen an incredible and very productive and informative set of formal advice come from the committee. In issue papers, three special reports sets the recommendations across a variety of areas from the policy-driven domains of the U.S. Ocean Action Plan to the National Coastal Mapping strategy, Arctic Priorities and the upcoming work that you're citing in your new issue papers which we're very much looking forward to.

This has been a very impressive set of recommendations and a record of accomplishment and one that's been very influential to our thinking into our operations.

I've been working, over time, prior to my current responsibilities -- for a period of time I was essentially served as NOAA's Chief Strategy Officer and worked with virtually all of NOAA's federal advisory committees.

And I've -- from, you know, the broad, encompassing work of the Science Advisory Board through to the line of program-specific advisory committees.

And the work of this committee has been very, very valuable and an essential part of that, what I view as sort of an external board function for our public agency. And we take it very seriously and rely on it very heavily and look forward to continued collaboration along those lines.

As you indicated, we're in the middle of an extended transition. I'm serving in the capacity of assistant secretary until the administration appoints someone into this position. And as of this point in time, we have a very limited number of political appointees at NOAA.

Chris Oliver serves -- was recently appointed. He serves as the assistant administrator for NOAA Fisheries. And we had just announced, a matter of days ago, the administration's nomination of Admiral Tim Gallaudet, former oceanographer of the Navy, to be the Assistant Secretary for Earth Observations and Predictions.

Colloquially, that's the dry side assistant secretary. I'm a functioning as the wet side assistant secretary. And we are thrilled to have him come on board. Deeply knowledgeable about our organization about the, in particular, the physical infrastructure assets that we need to observe the environment in all its dimensions, many of which have been the focus of this panel and will continue to be.

And he will not only be stepping in as our assistant secretary in NOAA's organizational structure, that position is next in line and order of succession for the NOAA administrators.

Right now we have NOAA's highest ranking career executive, the Deputy Undersecretary for Operations, Ben Friedman, serving as the NOAA administrator.

We anticipate that Admiral Gallaudet will step into that capacity presuming he is confirmed by the Senate -- and so we await that entire process. But if that all plays out, as we hope, then we'll see that likely change of command there.

There's been a lot of reports in the press about the administration being prepared soon to nominate a NOAA administrator. We look forward to that. And likewise would have to go through the same steps of Senate confirmation.

And in the meantime, your faithful career executives will maintain operational continuity. That's primarily my goal, and that's been playing out in our inner agency environment as well as in response to the administration and their emerging priorities.

It's been a pleasure to meet with Secretary Ross. I think you can -- you see a lot of the dimensions -- of the Secretary's priorities and the public work, and he's got a very, very strong focus on trade.

We have used that as an opportunity to talk about the various ways in which commerce depends upon NOAA's services -- maritime infrastructure being only one of them, but a very significant one.

The Secretary has also been very focused on aspects of our trade balances on other parts of NOAA's business, particularly in fisheries, my kind of home office. There's a big focus on the seafood trade deficit and the possibility of building domestic capacity in seafood production, which could largely come through the expansion of aqua-culture activities.

And as everything in our world is connected, that comes back to understanding all kinds of activity in the ocean and coastal domain, how ocean and coastal resources are currently being used and need to be used in the future for commerce, for security, for energy, for fish production, for commerce of various sorts -- recreational activities.

It's a complex set of uses and we have to be increasingly sophisticated in our knowledge of how those uses relate and can coexist. And likewise, coexist in a manner that's conducive to long-term ecological health as well and that's fundamentally what we do and requires all of our communities to work very closely together to make that all work smoothly.

We are acutely aware, as are you, of shortcomings in a nation's infrastructure and we are looking forward to collaboration with the administration on that front. There's been much said about the potential for an infrastructure initiative.

A couple of dimensions on that front. One is looking very hard, and the administration has issued executive orders along these lines, at the legal regulatory environment around infrastructure investments and trying to streamline those processes, environmental reviews, in particular, as much as possible.

And then also looking at highest priority needs for investment in our infrastructure assets. And in that respect, I think we have a great national challenge of thinking through and responding to that very question, what are the most critical and most effective investments. And I command the work of the panel for drawing everybody's attention to the infrastructure dimensions that our Hydrographic Survey enterprise broadly construed -- contributes to -- in terms of our ports, our waterways, overall viability of the maritime industry in both commercial and recreational dimensions.

We also are very appreciative of the focus that the panel has taken on our physical observing assets, our fleet -- our fleet modernization plan. We are pleased to be interacting with Congress over the reinvestment requirements there and anticipate, as well, our aircraft recapitalization plan coming forward very soon.

So I will, you know, note as we look ahead here that -- and again, this is consonant with your work, it's consonant with the focus of your technical advisory papers that are coming forward. We are deeply committed to investments and the adoption of new technologies and innovative ways of getting our work done.

You don't need me to point out the difficult fiscal environment that we're in, and I don't think that will change. And we don't need to be, and always are, extraordinarily committed to getting best value for or the public's investment in our services. And technological investments have a great promise in that category.

Seeing a lot of progress -- I couldn't begin to reference all of them. Certainly, things like the digital elevation model. We now have a kind of a standard geospatial approach that can play into all sorts of applications from inundation modeling, sea level change, coastal management.

These types of infrastructure resources and that's sort of technical backbone are relied very heavily. And we're also looking to extend the pilot in Long Beach, which is very successful, and I think a great example of what precision navigation can do. I'm sure that's likely to be a focal point of one of your papers.

And we hope to be working in the Gulf of Mexico to do the same type of high resolution mapping work and harmonizing vertical data and some -- among other improvements. And it is, as we know, a very complex port structure. And I think given all the disruptions in recent weeks, the nation's sensitivity to that and the sort of infrastructure assets to make it operate effectively will come to the fore.

I'm really looking forward today to the focus on use of unmanned systems and I'm also looking particularly looking forward to the opportunity this afternoon to tour the Joint Hydrographic Center.

Again, a Class A example of the type of partnership strategy we need to be successful in this domain and has been a major contributor to our advancement for years now. And I'm looking forward to the opportunity to see current thinking and current collaborative work that we're engaged with over there.

So thank you, ultimately, for your service as a panel -- also, each of you individually. There are all kinds of significant ways that you contribute not just to our operations, but to the public's understanding and to our Congressional members' understanding of the value of our services and the ways in which we work and collaborate with the private sector and the academic sector to deliver that value.

And both as a committee and as individuals, communicating that in an environment of a great deal of noise -- it's a very loud system -- and a lot of competition for resources and your clear voice and a very businesslike and programmatic focus on economic value is extraordinarily helpful.

So thank you, Mr. Chair, and again, many thanks for your service.

CHAIRMAN HANSON: Well, thank you, Dr. Doremus. Appreciate you being here and I also appreciate you sticking around this afternoon. I know you've got some things to get back to tonight, but Andy had me come up several years ago to visit the UNH facilities and it's quite impressive.

It's also interesting because we do a lot of work with academics on other coastal engineering type issues around the country. And in a place and a time when coastal engineering laboratories are closing or underfunded or just lack of focus, to see the focus and the innovation that comes out of UNH, it's very impressive -- so glad you could join us.

DR. DOREMUS: Absolutely.

CHAIRMAN HANSON: Speaking of UNH, where's Dr. Mayer?

DR. DOREMUS: He's getting mic'd.

CHAIRMAN HANSON: Good timing. Okay, great, great. I can go ahead and introduce him while he's mic'd. It's my pleasure to introduce one of the world's premiere hydrographic experts, Dr. Larry Mayer, Director of the University of New Hampshire's Joint Hydrographic Center and Center for Coastal and Ocean Mapping.

I felt like we got to have some background music going on right now, don't you think?

MALE PARTICIPANT: Boom, boom, boom.

CHAIRMAN HANSON: Boom, boom, exactly. We're very fortunate that he serves as a non-voting member of the HSRP. CCOM/JHC provides NOAA, other federal agencies, industry and the mapping community valuable research and development for hydrographic services and has spun many private sector technology projects.

You may recall his intriguing

visualization of the Chart of the Future at our last meeting in Seattle. The panel will be visiting the center this afternoon, and we look forward to learning more about the novel work being conducted at your facility, Dr. Mayer.

DR. MAYER: Well, thank you thank you very much, Bill, and -- is that loud enough? Can you hear it? Can you hear that? Great, thanks.

VICE CHAIR MILLER: Sir, it's not on.

DR. MAYER: It's not on. So you -- Gerd can hear it, but you can't.

VICE CHAIR MILLER: As long as the court reporter can.

DR. MAYER: Okay. You're okay? Okay, thanks. First of all, I want to welcome everybody to New Hampshire. As Patrick said, we're very proud of the region and I mostly want to walk you through your visit this afternoon and then a tour again on Tuesday, I think --

CHAIRMAN HANSON: Pier.

DR. MAYER: -- at the facilities -- at the pier facilities -- to the center and to the

University of New Hampshire, in general. And I have to apologize that I actually have to leave at about noon today. I've had a long scheduled and unmovable commitment in Stockholm that I have to get to and so I really -- I'm sorry that I'll miss that.

A couple of meetings ago, I presented an overview of activities of the center. And as Bill mentioned, last meeting we took a much closer look at one aspect of that and that's our work on the Chart of the Future.

And I'm really thrilled that this afternoon you get to be able to see firsthand some of the products that are part of that effort. What I'm going to do today is something that maybe a little strange, but I think is actually very relevant.

I'm going to be a little retrospective, and I hope that what I'm going to talk about is going to epitomize the kind of things that Paul mentioned and Bill mentioned also.

I'm going to tell the story that I don't think has been talked about much at the HSRP -- I don't remember it being discussed -- and that's the activities of our lab, the activities of the Office of Coastal Survey including some people sitting right next to me, and our industrial partners in the Deepwater Horizon oil spill.

And I do that at this time of Harvey and Irma and who knows what's going to happen next because I want to remind us that sometimes the research that we do has many unexpected applications, particularly in times of national crisis.

Also want to point out, you know, I think it should be very clear, but I want to emphasize that the Office of Coastal Survey has played and will continue to play a critical role as the nation's ocean mapping experts often well beyond issues of safety and navigation.

I'm going to be self-serving and hopefully this will point out also that the collaboration between NOAA and the academic community can play -- pay off in often unexpected ways and I also help will set the scene for Ed's discussion of his working groups activities in terms of the technology that they'll talk about because this will give some of the background for where that technology came from -- and that's about as much as I can sit down.

I don't think I -- it's not going to work. I was going to try, but it's just not going to work. I got to get going here. So I'm going to start many, many years ago in, again, kind of an academic dream world when multibeam sonars first kind of were being delivered and some of us thought that, well, gee, that's wonderful how we can map the sea floor, but there's information in the water column too and why can't we extract that?

And it turns out when the sonar manufacturers built those sonar's, they built them very, very specifically to maintain the record of the bottom and not look at the water column. It was an engineering issue.

And so we worked very hard with one of the manufacturers, Kongsberg Simrad, at that time, to try to produce a one-off sonar for us that led us to look at the water column. And our effort there was, again, to expand the value -- oh, I can see just fine. Where can I stand? I keep wanting to --

VICE CHAIR MILLLER: There is good.

DR. MAYER: This is better. To expand the value of the sonar and the focus was on fisheries. Could we use these amazing sonars that showed us why there's -- to look at fisheries?

Well, it took a long time. We started to do some stuff -- that's Herring in 1994 -- but it took a very long time for the sonar manufacturers to turn around and actually start building sonars that would do that as their standard equipment.

But they did, and again as we involved with the senator hear, the focus on that value added was really fisheries -- fisheries issues.

We tried to find hydrographic applications for that water column work, and there clearly were. There were hazards in the water column. There's lease depths on wrecks. And so there were indeed value-added from a hydrographic perspective, but in our mind the application was really fisheries, and that was until the first deep water system was delivered to NOAA on the Okeanos Explorer.

And on its very first test trip, on the acceptance -- the seagoing acceptance trial for the vessel -- steaming back into the port in San Francisco, it was running along with its water column data. And I showed you this at the last meeting what did we see but a mile-high plume of gas coming out of the sea floor.

Now we shouldn't have been surprised. Gas is an amazing acoustic target, but we said, wow, you know, there's another application here and that's -- we can see gas in the water column. And we started tuning some of the fish tools to also be able to extract gas.

And here we see, we came back after that first pass to see if it was still there and it was and there were a whole series of these gas flumes -- these natural gas seeps -- coming out of an area that that is a -- it's a hydrocarbon material.

So again, it wasn't surprising. We were just surprised with the ability of the sonar to extract that information. Well this test took place about two, three months before Deepwater Horizon -- April 20th, 2010. And I think, it's -- I -- in this room I don't have to remind any of you about Deepwater Horizon.

It's really interesting now, as I talk to students sometime, many of them have no idea what I'm talking about. It's, you know, seven years ago. They were ten-years-old or 15-years-old or something.

And it's scary, but I think, again, we here remember how catastrophic the event was -- the loss of life, the remarkable size of this spill, and equally remarkable response in terms of vessels, responders, aircraft -- all kinds of dispersant issues which are still being talked about -- so lots of lessons learned in retrospect.

I think the first lesson learned is that if you're a Coast Guard Admiral, you might not want to listen to the owners of the well to find out whether it was leaking. The first reports for several days came out that there was no leak associated with the explosion.

And finally, it took about four days to realize that there was a leak -- or for it to be acknowledged that there was a leak. And at that time, the way the leak, of course, was discovered was with ROV's down below. We saw these remarkable pictures.

And I have to give credit to Coast Guard Admiral Allen who, when he saw this as the Incident Commander, insisted that this feed be kept up on the web 24 hours a day.

And it was a constant reminder about

what was going on there, but it also allowed, again, many members in the academic community to start looking at this feed and to start to try to calculate what the flow rate was.

And it took a while, but there were several estimates what that flow rate was and that flow rate was absolutely incompatible with the slick on the surface. And finally, again, it was about two, three weeks that it took, but there was a recognition that they couldn't account for all the oil on the surface, something must be going on below and the idea that there was a giant flume forming below -- and this was the real challenge.

We really had never experienced a leak at this depth. The wellhead was at about 1,5000 meters, 2,000 meters or so depth. And somewhere in the water column, a lot of the unaccounted oil had to be sitting.

And so this was a challenge. So on the 18th of May, just a couple of days after the reports came out, the White House actually called a meeting, invited a small group of academics.

The meeting was hosted by the President's Science Advisor, had the Secretary of Interior there, the EPA Administrator, the Assistant Secretary for Oceans and Atmosphere at the time, I think, the same day the NOAA administrator was testifying, so she couldn't make it. The USGS director. So it was a fairly high-level meeting.

And what they basically said is, help us try to find us this deep plume. They really didn't have the capability. And they asked each of us -- or allowed each of us --- to show three slides for how you'd approach trying to find the three flumes.

So I showed that picture. I said, look, we can find gas. I'm not sure we can find oil, but we can find gas and always with the oil there's gas associated with -- in a leak like this.

And I also showed an experiment that the Norwegians did where they intentionally set off a spill in a thousand meters of water and basically were seeing if they could trace it -- a controlled spill. They were like able to shut it off too -- and they were acoustically.

They were able to use sonars. And I don't have a pointer, but I guess right here. They were able to see the oil coming from the wellhead -- oil and gas and what they might be seeing is just the gas.

Again, this is a question, can you see oil? You can see gas. And they got very excited about this. And they said -- John Holdren said, do we have that equipment? And I said, yes, yes, NOAA has the perfect system. This was 38 kilohertz.

But we had a brand new -- that system we had just tested 30 kilohertz multibeam sonar on the Okeanos Explorer. But at that time the Okeanos Explorer was heading to Indonesia.

And actually, the comment was made that, this will all be over by the time we get it back. So the Okeanos Explorer was not recalled, unfortunately, at the time, because I don't think anybody realized how long this would go on.

But we said, do we have other devices? Said, well, the Norwegians had used fisheries echo sounders and perhaps we can do that. You'll see the tradeoff in a minute why we'd much rather have had the multibeam, but they said, okay, can you do that?

And I think it was Steve Murawski from NOAA there who said, yes, you know, we can -- we have some of these, we can start diverting the ship. But who went onboard? and here's, again, Sam Greenaway, NOAA Corps officer who was also a student with us at time. I'm not sure of the timing.

Tom Weber, a professor in our lab gets sent on the NOAA Fisheries vessel with extra equipment for what we call the CTD, a device you can lower down and try to actually detect a deep plume with an instrument called the fluorometer, looking at the fluorescence of the water.

That was on the Gunter. There was

another ship, the Thomas Jefferson. I think, you were sitting in Galveston at the time and my phone starts ringing, and -- was it Captain or Commander at the time -- Commander Smith's calling.

He said, oh, this is a terrible national crisis. We have to get going. Had to put an EK60. There wasn't one of these sounders on the -- you had this, yes, you had put the electronics onboard the ship, again, get devices lowered down.

And Admiral Smith is saying, he says, I got to get going. I said, well, have you got permission yet? Ah -- and I don't know -- and we spent many, many weeks out there and I don't know how many times I said to him, you're either going to get fired, or you're going to become the admiral. So.

And then the ships got there. But this what was going on. And all the effort was focused on trying to the cap the wells and drill -- already starting to drill the relief wells.

And so this idea of getting over the wellhead with the sonar was not terribly feasible, but, you know, their priority, and rightly so, was cap the well. And you see how crowded it was out there. And so at first they kept us very, very far, far away.

They were very, very nervous about our sonar systems interfering with their ROV navigation. But I think as they gained confidence, we started being -- kept 20 miles away and then 10 miles away and then 5 miles away.

So, but we were out there surveying. But when you start so far away, that's not the experiment that we proposed. We proposed of getting on top of it and tracing the plume from the wellhead. You're kind of fishing in the dark there.

And we were using kind of the standard techniques that people were using with the CTD and these instruments to try to find things. So you dip a instrument in the water and if there's no oil, you don't see any kick in fluorescence and the oxygen levels behave like a normal ocean column, this is zero to 1,600 meters to 700 meters depth.

But if there is the oil plume, and where it was it was always at 1,150 meters -- very consistent -- you get this big kick in this fluorescence, an indicator of organic material in the water, and a decrease in oxygen as the microbes are starting to eat the oil. They utilize the oxygen.

And so that's what many vessels were doing, not just the vessels with the sonar systems but everybody just kind of blindly dipping.

And this afternoon when you go to the lab, you'll see a tool that we developed after the fact that I so wish we had there that takes a look at the 4D flow. And you put on stereo glasses and you can see the 4-dimensional flow in the water column and you can put a tracer in the water at any level and it'll show you where, at least the models -- the updated models are showing it's going.

Had we had it at that time, it would've been very helpful and kind of, you know, not just randomly having ships around doing dips, but we could've really been focused on where, at least the models were saying, the deep flow -- the flow at that level should be going.

So we tried to look at this acoustically. Here's an area where there was nothing in the water column. This what you see up here is what we call the scattering layer -- these, little organisms that the Fisheries sonars look at -- the sea floor -- and you don't see much in there.

But here's a place where we do have -- did have a kick again -- 1,150 meters -- the big kick -- and I was always convinced that I could see a little layer, a bottom following layer, here.

Here's the CTD. You guys can see the CTD come through it. My acoustics colleagues were not as convinced, but it was -- there are only a few of these opportunities where we actually hit it and saw a target like that.

But what we did do is see lots of gas seeps -- gas seeps everywhere. And this is, again, not unusual in the Gulf of Mexico. These are natural seeps for the most part, although we saw some unnatural ones -- I'll talk about that in a moment.

And what we were doing -- and this is part of the collaboration with our industrial partners, too, at the time -- is we're onboard collecting this data using whatever software products we had and having the software updated and updated and updated, sending it back and forth from shore.

We actually didn't have all that much bandwidth, but it was certainly enough to get updated sets of code and really developing tools to look at these seeps and extract them and try to locate them very precisely and develop tools for visualizing as much as we could in the region.

Oh, thank you, that's great. Now I'm dangerous. Everybody have sunglasses on? Because I'll starting waving around. We finally got within a mile of the spill, at that point, in the surface slick.

And with a high frequency, a echo sound there could easily see -- this is a series, as we were driving in through, a series of -- as go in circles, a series of profiles of the water column acoustically. And each one of these is the spill itself coming up in the oil. That's at high frequency.

And, Shep, I think this is where you probably had the most difficulty in terms of the -- and that was not comfortable in the slick itself and the vessel was -- had to come and be washed and things like that. I think the air was not so comfortable either.

But so certainly if we can get right on top of it, we could see directly the oil, at least at high frequency. What we really wanted to do, though, was get right on top of the well.

And the reason I wanted to use that multibeam originally is here's where all the kinds of tracks we were running many different ships over much time. To see it with that Fisheries echosounder at which looks straight down, we'd have to get right on top of it and then start tracing the gas and oil and plume away.

With a multibeam, we could've sat as much as two and a half, three kilometers away outside of the traffic and all the effort over the wellhead and still see the slick and start tracing things. So that was the original reason for use a multibeam, but, I said, unfortunately it was off deployed somewhere else.

Finally, on the 15tht of July, I got what was probably the scariest phone call of my entire academic career -- or any career. I had, for weeks, been serving on the Secretary of Energy's review panel. They met every eight hours -- 24 hours a day, every eight hours, his review panel with BP.

And the government would present their concerns, BP would present their responses and the next eight hours they'd discuss it again. And I got a call out of the eight-hour cycle from the Secretary.

And I should say, in terms of lessons, the biggest lesson learned to me was if you're going to have a Secretary to Energy it doesn't hurt to have a Nobel Laureate in Physics.

You know, he was absolutely remarkable. He really was. Challenging BP, making them read papers, challenging their calculations. It was really impressive. But I got a call and was told that they think they finally have a solution to the capping the well. This is by July. Now remember, this started in April.

And the modeling of the bore hole itself showed some concern over the integrity of the bore hole. And the concern was that if the cap worked, there'd be a side wall blowout and there's no stopping that until the well is depleted or they have the safety wells drilled which wouldn't be until October.

But if they caught it early, they can uncap the well and go back to -- and his question was, can you guarantee -- the models all show that if this is going to be a blowout, it's going to be gas first, it's going to be coming within, they said, 500 meters of the water hole -- can you guarantee you can see gas?

And I thought we could, but guarantee is -- that's not a word that scientists like to use, ever. And so I got all our acoustics experts, you know, and we all said, yes, yes, we -- so we said, yes. And they said, okay, and they started capping the well and he did some pounding on the table, but had us drive right through there.

And, you know, really kudos to the NOAA boat drivers because that's what they had to do, drive through. That's from the window of the survey vessel as we were going by other vessels. But over the wellhead, and what did we see but gas coming out of the capped well.

And so there was a panic, as there should've been, and BP said, no, no, no, you're just totally wrong, it's -- you're just totally misinterpreting this. See, there's no way that can be -- you're -- there's lots of infrastructure down there, and you're misinterpreting the infrastructure for gas leaking.

And we came back and said, no, no, we recognize the infrastructure. That's a riser. That's the wreck of the Deepwater Horizon with 9 ROVs still around it. That's another riser. But this, which is what I plotted there as a single pass, is three passes over gas rising up.

So they scrambled and they come back and say, oh, yes, yes, well, it's gas, but it's not methane, it's really nitrogen exuding from the cement.

And we came back and said, no, because we had been looking at gas seeps -- methane seeps -- for months now and every one of them comes up to about 400, 500 meters and then disappears. And that's because the gas is surrounded by an ice coating and that's what keeps from going into solution -- is something we call a hydrate -- and then when it gets to 400, 500 meters depth, that ice coating goes away and the methane goes into solution and this is exactly how this was behaving.

And so then, finally, they came back and said, oh, yes, yes -- and they found the leak and that's all it was. It was a scratch on a metal-to-metal flange, and it was just a few bubbles a second, but that few bubbles a second leads to a target like that. That's how sensitive the sonar is to gas bubbles which resonates, so.

And it turned out that BP just had to keep an eye out on it. All the engineers said there wouldn't be an issue, keep an eye on it, and they did for the next ten months and nothing ever changed with that, and so that was not a big deal.

But here I should -- what I want to

mention here was -- this here is a -- that gas hydrate stained by oil -- some of that frozen gas. And every once in a while a piece would break off and we can just trace the piece coming right up. So again, how accurate that sonar could be.

And then all we did for the next -- and you talk about boring, we did this on kind of two-week shifts on different vessels for the next three months until the relief wells were finally drilled and the well was cemented in. Just went back three times a day back and forth and back and forth, making sure that nothing changed.

And so we would just rotate people down doing that every couple of weeks. Finally, in the following year, we got the multibeam sonars to the Gulf of Mexico, as we had wanted to do, and started to look at the amazing distribution of these natural gas seeps. Also, some unnatural ones.

This is just -- the blue dots are all gas seeps we mapped around the -- this is the

Deepwater Horizon site. The yellow is the infrastructure -- pipelines and wellheads and things like that. Wherever there is a blue dot on the infrastructure, it indicates that it's a leaky wellhead or leaky pipe.

And they're not serious leaks. They're all little tiny leaks like that, but each one we would contact MMS at the time and they have an obligation to go and try to find what was going on.

But as we were now bringing the multibeam in, we started to really fine-tune the tools to make sure that we could really find this seep quite accurately because if you want to go and look at it with an ROV you have to know where it is within about 30 meters or so.

So we worked all that out, kind of georeferencing it, and really got to the point of being able to precisely locate it. And this is where the software started to become useful for folks like Ed Saade and Fugro, who were working on exploration in the Gulf of Mexico.

And these tools became very, very -- and that's the kind of stuff you read about -- very, very helpful to Ed and to Exxon and to other players in the area in terms of helping locate both hazards, but also using it as a tool for exploration.

And so this is part of this technology transfer that started in a totally different world looking at Fisheries research, but has come around to being something that's very, very useful. And Ed, in his paper, talks about some of the ramifications of that.

But we don't stop there. We want to say, well, we can find the seeps, can we now measure how much it's coming out? And so that's now turned around into a new research program that's not funded necessarily by NOAA, it's funded by NSF and DOE and other folks where we're now actually looking at trying to be quantitative about the rate at which the oil is coming out. And that really depends on understanding the size of the bubbles.

We started with some just primitive, little experiments sending down a -- the Okeanos Explorer with its little submersible or ROV, I should say, and just trying to measure the rate to get some groundtruth and capture some gas so we can see bubbles quite nicely with high definition cameras. You can see those -- but they make those amazing targets.

We just took a little grid behind it so we can actually see the size of bubbles and write some software to track them and measure their rise rate and their size, estimate it from that. Estimate it from the acoustics, compare our estimates.

We are estimating our rate of .003 liters per second from the acoustics. And then go out and try to do the ultimate groundtruth in terms of what the flux is, put a bucket over it, and we do. And, again, you can capture it. It's going to turn into this hydrate, into this frozen gas, right away as soon as it comes there.

The frozen gas will expand so when we

bring it up and we get to about that kind of 400 meter -- I don't know if we have the time to watch it. It all expand into, back into free gas when it -- well, you'll see a little bit starting to happen here.

That's, I think we have -- you okay? We're okay, with time, Joyce? I only have one more slide, I think, after this and then I think we're okay. So, it's because it's fun to watch this disassociate. At least it's fun for me. I don't know.

I guess we each have our own. Here we go. It's starting. It's going to be at about -- and all of a sudden, it'll reach this what we call the hydrate stability zone. And there it goes, boom.

And so we get two measurements. We get measurement of the frozen gas volume and the free gas volume. So this gives us, for seven minutes we know how -- what the volume is. And so ours meant, there it was .0024 -- so versus the .003 -- so we were pretty happy about that.

And so when we went -- again this is funded now by the National Science Foundation. Again, so NOAA, the Center, became a seed for something that really took off in terms of going to a place in the Eastern Siberian Arctic where there's supposedly a lot of gas and now using a new really broadband -- so really broad range of frequency sonar -- to really try to get down to the size of the bubbles.

And so we upgraded the sonar on a Swedish ice breaker. And this is looking at individual, what they thought were individual targets, with the expanded Fisheries sonar, but when you use the broadband one you see -- you really were seeing clumps of them.

And now we can get down to the individuals. And with this we've now got a graduate student who's actually measuring individual bubbles and being able to trace individual bubbles coming up and measure their rise rate and measure their size. And I think that's the very last slide.

We just go through a bunch of pictures. But the bottom line is we now are making estimates of flux. And I just want, again, I just want to tell this story -- an old story -- but I think it has lots of resonant messages that you never know where the research is going to go.

We start off thinking about fish and end up something that's helping Ed in the industry tremendously, that helped in Deepwater Horizon. And it's really, in these national crises, who knows what will involve from the work that NOAA will go out and start doing after the hurricanes.

That the collaboration, again, between the academic and industry and NOAA, I think, has been fruitful; that, again, it was OCS that was called upon.

I mean, none of this would've happened without the Corps officers, the OCS folks who are trained as the mappers, who, again, went off for a different application, but that amazing expertise that spreads to wide national needs and then finally something that may even have an industrial payoff -- a big industrial.

You've given the numbers. They're huge numbers in terms of the industrial payoff. So I thank you all. And I guess I'm even finished early, so that's --

VICE CHAIR MILLER: Questions. Questions.

DR. MAYER: Questions? No, that wasn't in the contract. Questions. I'm happy to answer questions, but maybe now I'll sit down.

Questions for Paul. It's much better, questions for Paul than for me.

CHAIRMAN HANSON: I'm going to open for questions for either Dr. Mayer or Dr. Doremus or the panel? Observations, Dave? Okay.

MEMBER MAUNE: Oh, I guess I was supposed to -- no, no, this just -- and I'm going to turn it over to Andy because we were supposed to have breakfast, give a little -- since we have a moment or two, just to -- about this afternoon. Is that --

VICE CHAIR MILLER: It'd be great. But Paul is only here with us today. So if you have questions -- and Larry is only here with us today. Take that time and use that time.

MEMBER MAUNE: Okay. Well, I'll do that, but they didn't seem to have questions.

CHAIRMAN HANSON: Okay. Well, we're going to go ahead and if there are no others questions, we'll go ahead and take a -- go ahead and do our break. Certainly, Larry, we've got you until noon, until you go to Stockholm, Texas or where you going?

DR. MAYER: I'm not going to say, I wish.

CHAIRMAN HANSON: And so got a few minutes to grab them at the break or -- and then, Paul, you'll be with us for the rest of the day, so appreciate that. And I'm sure there's -- be some questions that will come up. All right, let's go ahead and take a break. We'll come back at 10:15 for unmanned systems for hydrographic surveying.

DR. MAYER: Thank you.

(Whereupon, the above-entitled matter went off the record at 9:56 a.m. and resumed at 10:19 a.m.)

CHAIR HANSON: All right. Now we're reconvened here. We've got our first panel, and I'm going to go ahead and turn the mic over to Carol Lockhart as the moderator. Carol is a working hydrographer, a small business owner, a member of the HSRP. And it's also our Technology Working Group.

Thanks, Carol.

MEMBER LOCKHART: Thanks, Bill.

So I was going to do a brief introduction of everybody's bios and things. But I think we have a short amount of time, and everyone is really interested to see what the panel has to say.

We have some great presenters here today. Most of you already know Captain E.J. Van Den Ameele. He served with NOAA for 23 years, and he's currently the director of the Coast

Survey Development Lab. He's going to give us an introduction or overview of autonomous vessels as they pertain to hydrographic survey, show us some examples of vessels NOAA has used, and describe NOAA's involvement in the industry and some of the lessons learned so far.

We're then going to move on to Thomas Chance, who probably needs no introduction to anybody that's been working in the hydrographic survey industry. He was the CEO of C&C Technologies. They did a wealth of surveying with AUVs, but more recently, he's now the founder of ASV Global which he started back in 2010. And I'm sure he'll talk about ASV Global during his presentation. He's going to talk about their experiences and go into details of the vessels they've designed and built. So I'm sure in 30 minutes here you guys will be in engineering heaven.

Doug Lockhart is the vice president and general manager of Teledyne CARIS, and he's going to talk about how autonomy applies to hydrographic surveying with an analysis of the potential cost benefits as we introduce various levels of autonomy.

And then we're going to move on to Rebecca Quintal who is the Hydrographic Survey Data Solutions Manager for Maritime Systems Division of Leidos. And she's going to talk about the research and development of the Sea Hunter, which is a longer endurance ocean-going autonomous vessel -- so a little bit different from the initial presentations -- and talk about the kind of technology involved in making something like that happen.

So hopefully, we'll give you a broad overview. There are some things we recognize may be missing from this presentation. We're probably pretty light on the processing side of autonomy. That was recognized when we set this panel up. But hopefully, we'll have time to actually have some good questions and panel discussions so we can talk a little bit more about some of the things we may have missed as we go through it.

So without further ado, I'm going to hand over to E.J. here.

CAPT VAN DEN AMEELE: Great. Thank you very much, Carol. And good morning, everyone. It's a pleasure to be here to talk about the Autonomous Systems Strategy that the Office of Coast Survey has developed. And in doing so, this morning, I hope to somewhat set the stage for the further discussion on the panel.

Coast Survey has about over a dozen years or so of experience with unmanned and autonomous systems. And based on that experience, we did develop the strategy, and we certainly look to not only our internal resources but our academic and industrial partners as well to help us fulfill some of the objections of the strategy. So hopefully, this introduction to our strategy will help set the stage for further discussion on the panel, and I look forward to the other three presentations from my colleagues here as well.

So as mentioned and I think has been distributed to the panel and others, we have, I guess, we still consider it a draft, pending final comments and review. But of the Office of Coast Survey's Autonomous Systems Strategy, we both developed a longer version, which is about a seven or eight-pager -- which I know many of you have reviewed -- as well as a more flashy one-pager that we've distributed as well.

So this was briefed out to the HSRP Technology Working Group back in early August. We had some very good discussions based on that, and we've received some great comments back. So we certainly appreciate the feedback that we received back from the working group and the panel as well, as we look to finalize those and use that input to update our strategy. So thank you for that.

So Admiral Smith has spoken to this before. I believe he spoke to it back at the meeting in April and may speak to it again at this meeting as well: The new sort of Coast Survey focus areas, particular with regards to our data acquisition efforts for hydrographic survey as well as updating our charts. And I just wanted to mention these again briefly, because as we look to the use of autonomous systems for our mission, we look how we can apply these in these three kind of key focus areas.

The first being the critical under-keel clearance and ports. These are the high-risk areas with deep draft, large volume traffic where very high resolution and high accurate hydrographic surveys are necessary to ensure safe and efficient transportation.

A renewed focus on reserving and cleaning up chart discrepancies. These are the many things that get put on the chart that are very difficult to remove from the chart, whether it's a vessel that sank -- but you don't know quite exactly where it was -- to somebody found a shoal sounding and reported it and now it stays on the chart as a reported sounding or a position approximate and those sorts of things.

So I think our current inventory of those of recent count was over 10,000 on NOAA's 1,000-plus charts. So we need to go ahead and look those up. And do we have a role for autonomous systems in being able to help fulfill that need as well as a more broad interdisciplinary seafloor mapping?

So this is beyond the routine shallow water coastal harbors and approaches work to really mapping out the full U.S. EEZ and beyond, as we even look to things like Seabed 2030 and how do unmanned systems fulfill a role in potentially that application.

And then the fourth one that isn't listed here but I often like to mention in regards to this talk is the Arctic as well. That's a priority, and I think there's a role for these types of systems in fulfilling our need.

The Arctic is a big area that, as everyone knows, is opening up to commerce and transportation. There's lots of white areas up there on the charts that don't have a lot of soundings and getting that mapped is no small feat. And how do we do that? And there's probably a role, and we've done a little bit of work to date with that as well.

So those are kind of the key focus areas I ask everyone to maybe think about as well as the panel as we look at how we can best apply the use of these systems in those priority mission areas.

So just a quick synopsis on our unmanned work to date, particularly within Coast Survey and the hydrographic survey program. As I mentioned, we first got into this about a little over a dozen years ago, probably around 2004 or so. And our initial work was to see how we can use the force multiplier concept with regards to unmanned systems.

So these ships are very expensive, and they're tough to get station and on location. So when they're there, you want to maximize your data acquisition and your cost benefit. So can you get as many sensors in the water as possible? And sometimes, maybe that wasn't always carrying big boats or large ships but a smaller platform like the AUV, the one in the upper left-hand corner, that particular one.

So that was the first one we acquired. That was a Hydroid REMUS 100, as you can see, deployable by a couple of people over the side of a boat and didn't really require any sort of specialized handling equipment. Get it into the water and get it out of the water. And this one in particular was equipped with side scan sonars, so the equipment used to locate obstructions on the seafloor which are hazardous to navigation.

And after several years of that, we were very successful. We did transition that type of vehicle to operations. We found that we can acquire at least seafloor imagery data and detect obstructions on the seafloor with the same bit of accuracy that we could we the tradition tow systems which we would typically tow behind a vessel.

And so that system is operational now. What you see in particular right there is primarily used these days for emergency response work, such as we have ongoing right now with the current hurricanes. And that one may, in fact, deploy down to Florida as part of the result.

So based on our successes on those types of vehicles, we then wanted to move up and solve the next question. So we next acquired a larger vehicle, the one in the bottom left-hand corner, which was the same manufacturer, Hydroid REMUS, but as I mentioned, a larger vehicle.

And we had a couple of objectives with this in particular. The first was, can we now acquire very accurate bathymetry data that would meet our nautical charting standards and IHO standards with a multibeam echo sounder on board? And the second area that we were trying to address was, can we increase the endurance of the vehicles that we're operating?

So initially, that top one, we could run for about seven or eight hours. So a typical kind of day operations before we run out of juice and have to bring it back and download the data and recharge it.

So our goal with the larger vehicle there was to see if we can get 24 hours. So can we run a full day out at sea and bring it back and do the same type of thing: Offload the data, put in a new set of batteries in it while we recharge the ones that were in there, and get it right back out on a mission?

So with those particular objectives, after again, several years of development, we were very successful. However, we found that some of the logistical challenges made it, perhaps, not necessarily the best vehicle for a typical sort of hydrographic survey work for a few reasons.

One was, as you can kind of see from this picture there, getting it in and out of the water was, at that point, much more difficult. And if you were to, say, deploy it on a vessel of opportunity, they might not have that specialized handling equipment, launch or recovery system. So then you're kind of adapting what you do have on board in terms of A-frames or cranes or things like that.

So that certainly becomes a challenge, and someone starts to limit the sea state that you can especially recover these types of vehicles. And so that was a limiting factor.

The second factor was, unlike the side scan sonar AUV -- which you like to get down below the surface at a certain depth for its maximum effectiveness -- when you're talking about acquiring bathymetry data from a multibeam sonar, you want to be high above the seafloor as you can because that maximizes your data acquisition.

But where we're operating these types of vehicles, again, in more highly trafficked areas, you've got to get them down low to not be a hazard to navigation or for that collision risk. So it was far less effective in at least multibeam bathymetry data than we were able to get from a surface vehicle.

So we then later asked the question, well, is it worthwhile for us to hang onto this if it doesn't suit our primary mission objective? But it still is -- we found it certainly can collect very good, high resolution bathymetry of the seafloor, just not as efficiently as a surface vessel.

So it has a large application to a whole other range of seafloor mapping missions within NOAA and beyond the agency as well. So we've decided to hang onto that one right now and kind of have it as a gun for hire, so to speak, for potential other mapping missions within the agency.

So based on that experience, with a larger vehicle, we then said, okay, well, it looks like maybe we need to start investigating the surface vessel aspect because of the lessons we learned with our underwater vessel. So we first turned to the smaller ones, like the Z-boats that you see in the upper right-hand corner there, the Teledyne Z-boat.

That was initially equipped with a single beam sonar and a positioning system that would operate concurrently with both a large mother vessel -- in this case, the NOAA Ship Thomas Jefferson -- but also some of their smaller survey launches.

So this was looking to kind of expand the mission profile a little bit. It could operate in very shallow water on shore where we still had a need for collecting sounding data for the chart. But maybe we wouldn't be sending our 30-foot survey launches or even larger ships just because it was shallow. So in this case, it was kind of acting as that force multiplier and expanding into a more nearshore region.

And we also wanted to look to large vessels. So can we then start performing the mission of a typical hydrographic survey launch or a ship even with an unmanned vessel? So last fall, we -- and realizing a difficult -- I should mention one thing and up to date, this would've all been when we were acquiring these vehicles ourselves.

I'm not sure if anybody has been through the government acquisition process before. It can be very challenging and lengthy, and maybe it could take you a couple of years by the time you get through a budget cycle and then an acquisition cycle to get your equipment on board. And certainly, you're not doing a lot of innovation and development while you're working through that.

So in this case, to hasten or speed the research and development of the larger USVs, we did a lease with Mr. Chance's company here last fall. So he'll talk to it.

Not to steal your thunder too much, but that's a C-Worker 5, which is a five-and-a-half-meter vessel that we deployed on the NOAA Ship Nancy Foster for a couple of weeks in September of last year off of the Carolinas. And this was a multi-disciplinary mapping mission where it was just not strictly for nautical charting, but it was also a habitat mission for fisheries and it was sort of a map once, many times. And I've got a couple more slides coming up on that.

So that's our unmanned work to date, kind of a brief synopsis over the last 12 years or so. And again, I'll speak to how our lessons learned informed how we developed our strategy moving forward and where we see the best application of the technology and as it matures and develops.

So again, this is just some more images and a brief on the lease of the C-Worker 5 last year. So this was a little bit of a -- I personally wasn't there, but I've certainly gotten the stories from our folks who were. So we had to, again, as usual, adapt to the infrastructure that was aboard the ship, the Nancy Foster in particular. It didn't have a very talented deck crew who are used to putting boats in and out of the water all the time.

But you take a person off of that

boat, and it ramps up the challenge a little bit when you don't have somebody physically on the thing that you're putting in the water and taking it out. So we adapted to there, and I think you built a particular type of handling cradle for it as well to adapt to the knuckle boom crane that the ship had.

So again, the objective of this test was to evaluate the shipboard infrastructure requirements. What kind of staffing needs do you need? What are the manpower requirements? What are the technical capabilities? Can we acquire just as good data with an unmanned system as we can with a manned platform? And start to develop what the operational concept would look for deploying a high endurance USV.

And just a couple stats on the vehicle itself. I think it was deployed with the same speed of survey equipment that we would have on one of our manned boats. So a multibeam sonar for high resolution bathymetry, the POS MV for high accurate position, and the HYPACK data acquisition system. So the same things that our vessels with folks on board have them.

In this case, the vehicle has endurance up to five days. And I think you'll talk about your full range of offerings in your presentation, so I won't go too much further into that.

So some of the synopsis of the survey operation. So as I mentioned, it was over the course of about two weeks, a full five days of acquisition. Even though it was two weeks, some of that was a little bit weather based where they had some down days.

Some of it was just because they had to transit back and forth between the particular survey area. So it wasn't one contiguous area. It was kind of a little bit here and then they had to transit 20 miles or so to the next survey area. So that was a factor as well.

And again, that was the reason for the longest deployment. So as you saw on the previous slide, these vessels have an endurance of, potentially, up to five days. But in this case, the longest deployment was 26 hours. That wasn't a limitation of the vessel itself. It was just more because of the nature of the mission and the spread out areas that needed to get addressed.

So the other thing of note is in this case -- as we like to kind of joke about a little bit -- we had six people working on an unmanned systems mission on board the ship. So that was three ASV Global engineers that came along in support of the mission as well as three of our own survey watchstanders.

So on a typical 24-hour period, there were three eight-hour watches. We had a vessel operator or engineer that was ready to take control of the vessel, if needed, to maneuver or help avoid traffic or bring it alongside and it need to be recovered and that sort of thing. And then we also had a watchstander for our survey data acquisition.

So you can see that in the photo on

the lower right-hand side there where the person in the foreground there, he's both operating, I think, the HYPACK software as well as the multibeam data acquisition software, just albeit remotely through high bandwidth communications between the host vessel and the unmanned vessel. And then in the background is the vessel operator as well.

And in this particular case, the bridge crew on the ship were the ones that were providing the situational awareness and the lookout as well for the vessel. So they would always -- they'd keep it in line of sight so they knew where it was. It has an AIS on board, so you can track it electronically.

And other vessels have that awareness too with the AIS. But anytime there was a potential traffic situation, the bridge crew would get on the radio and try to hail the other vessel as well as relaying back to the operator back in the vessel's plot room as to stop it or have it alter course to 90 degrees, or whatever the case may be, to help avoid with that vessel type of situation.

So we think we could get that potentially down to three people perhaps. And that would be just one watchstander who maybe could do both functions once they had enough skill and experience and training in the systems they needed to. But again, at least in this particular case on this crew is that we at least needed those resources to maintain the situational awareness for the vessel and avoid any kind of situation.

And again, just some more photos of the operation here. So not too much of a -- or I wouldn't say too much of a challenge, but it was reasonable to accomplish when you had a very nice sea state and calm conditions, as you see in these couple of photos here.

And again, some more recovery. So in this case, there's a belly pack that the operator has that when you bring the ship to a stop and then you go down and take over control of the vehicle from the deck right there. As you bring it in, your deck crew, in this case, tries to get the whip from the crane down to the cradle on the vehicle as you're bringing it alongside, and then you make the recovery.

And as you can see here, there's quite a number of folks on deck -- about five or six in this particular case -- on a good day to -- again, if we were adapting the ship's capabilities along with what we had to try to make it work, there are particular dedicated launch and recovery systems that are made for these that might that a bit easier. But again, the challenge of getting in and out of the water, even on a good day, was tough.

And then this was, I think, about the best -- the highest sea state that we could hope to operate that vehicle with this particular crew. Again, because of the launch recovery, the data we got from the vessel was just fine in these conditions and was good as we would've gotten on one of our boats.

But in this case, you can kind of see in the lower right-hand corner, as it's rocking back and forth up against the hull of the Nancy Foster. And they're trying, again, get the hook to the cradle and get it on board, it became a particular challenge. And I think we banged up a couple of antennas on the vehicle in that particular case there.

And you've got a tender as well. You can see the rib there with the coxswain and folks in the boat, just ensuring everything goes well. And just highlighting one of the challenges, they then brought that boat back on board the ship with a little bit less challenges because you have folks on board that are able to do that. So one of the challenges and obstacles to be further developed and overcome in operating these systems.

So some of the key findings from this particular mission, which I've touched on, again, the launch and recovery is a challenge. A lot of these, whether it's AUVs or USVs, do have dedicated and well-developed launch and recovery systems that you can deploy; that can be, again, if you're on a vessel of opportunity, integrating those with the vessel that you have can be a challenge versus having a fixed instillation on a dedicated ship.

Staffing in this particular case, so we were just getting started and it's new. But it was, in this case, consistent with a manned survey launch, and it can certainly require new skill sets from what we're typically used to having.

The autonomy and situational awareness is somewhat rudimentary and certainly a point open for discussion -- I think, a good, lively discussion. But in this case, required supervision from a manned platform and that ability to take over, as needed.

And then communications, I should touch on. The one slide I didn't mention. So we were limited not only because of the lookout and the visual lookout that we wanted to maintain for the vessel, but also to be able to do the sonar operation and even potentially recover -- retrieve the data from the vehicle.

It requires a very high bandwidth communications, and those are very much range limited. In this case, I think the max was about seven or eight kilometers that they could operate, so not even close to over the horizon in this particular case. And so we need to further develop that technology to further enable these systems.

So we had last summer as well -- and the key point here, as I've mentioned, whether through ASV Global, we also have some of our contract survey partners who had began to employ unmanned systems in their work. And this was from a survey done by TerraSond last summer up in Etolin Strait and Nunavik Island and kind of the northeast reaches of the Bering Sea last summer.

And they utilize an ASV Global system in kind of the same way that it was done on the NOAA Ship Nancy Foster was. We call it kind of a mother duck and baby duck configuration. So basically, we were able to get another platform in the water and double their data acquisition on many days and really get a lot more effect in this and bang for their buck.

This is a video. I don't know how to run the video from -- if there's a way, if you can just click on the -- do you have the master? No?

PARTICIPANT: Sorry, we don't have the video.

CAPT VAN DEN AMEELE: Okay. It was embedded in the slide. If you just click on the image, it might play. If that doesn't work, that's fine. There you go, yes.

So you can see the TerraSond's main survey vessel in the background there near the horizon as they operated the C-Worker from afar, I believe, in very much the same sort of operational scenarios we did on the Nancy Foster. In this particular one, which we did not have, but I believe this one also had a winch on board it, which they used to tow a side scan sonar as part of their survey operations.

And I think the one thing that we were told was that this certainly wasn't anywhere the limit of the sea state that the vessel could operate in. But it was close in limit of what the drone that they used to capture the aerial footage could handle on that particular day.

And again, we're trying to advance this technology. Certainly, nowhere near on our own, but as I showed, through our commercial partners, through our contract partners, as well as our academic partners. And I know that I don't want to -- you'll certainly see a lot more of this over the next couple of days from UNH, from CCOM, and JHC here as well as on the water vessel demonstration. So I'm very much looking forward to that myself.

So we're working, obviously, as close as we can with our partners here at UNH. And more recently, we have a new grant with the University of Southern Mississippi, their School of Hydrographic Science. And they're going to be performing some work with us as well, particularly on the unmanned surface vessels as well. So we work very closely with our industrial, contract, and academic partners in helping to advance our goals here and our strategy.

But can it work everywhere? There's some places where this just might not be the best took for the job. And you look at a busy port like this where there's a lot of traffic going in and out, and I'd mentioned on one of the first slides how the port areas with minimal under-keel clearance are one of our focus areas. But applying that technology in an area like this is certainly challenging. So obviously, you have to pick and choose where it's the best took for the job.

And one thing that we track and look to -- three minutes, okay, thank you -- is the state of autonomy. And as I mentioned before, certainly, I think we have some pretty good discussions on where we are on the spectrum.

But just briefly, the way we look at the state of technology is on a five-scale level where Level 1 is just basic remote piloting. There's an operator who's remotely operating the vessel at all times, and they've got their eye on it.

To Level 2, which is basic autonomy, which is essentially executing a preprogrammed mission.

So you have a set of lines and waypoints and things that you need to do. And the vehicle goes out and executes it as its preplanned but doesn't really respond or react very much to things it encounters along the way, which is the intermediate stages of autonomy.

To something that could be as simple being chart aware, so it knows where obstructions are and the shoreline and things that it shouldn't hit and it can avoid those.

To perhaps reacting to changes in the environment, whether it's the thermocline in the water column or a shoaling that wasn't unexpected or some things like that, or other vessel traffic in the area, that it knows how to properly avoid.

To the Level 5 is the full state of autonomy where you can just say, here's an area that I need worked on or data collected in, and here's some parameters that we have. And the intelligence goes out and figures out the most effective way to execute that mission while avoiding and adapting to things it encounters in the environment.

So to wrap up, some of our key findings that helped drive our strategy moving forward is that unmanned systems require the development of new technologies. And what I mean by that is not just the autonomy and the ability to go out and maneuver autonomously. But it's some of the things like the high bandwidth communications that you need to be able to both monitor your vessels as well as even get the data off, for example.

So for a vehicle that has an endurance

of five days, you don't want to wait five days to get your high resolution water column plus bathymetry off of that. You want it as quickly as possible to ensure the effectiveness of your mission. But that's voluminous data that requires very high bandwidth communications just to even extract the data from the vehicle.

Unmanned systems, we must provide new capabilities or new mission profiles so they're not a one-for-one replacement, per se, of typical traditional missions on manned boats or ships.

They require skilled personnel to operate and maintain. So as I mentioned, this is kind of a new skill set, being able to know the best way to operate these vessels, to maintain them, to have that engineering support for them. It requires a development of new human resource capability.

And they do not diminish the need for ships. So that question comes up very frequently, particularly as we look at fleet recapitalization and need more money to build new ships. It doesn't necessarily replace the need for heavy steel. They expand your mission profile, but they don't necessarily replace any kind of capability.

And they require unique in-board infrastructure. So you need the deck space, obviously, to be able to launch and recover them. You need someplace to house them on board the ship where you can maintain them and take them apart and fix them and things like that. And some of these, as you saw, can be very large. So you need that kind of space on board the ship and facilities to be able to do that.

And again, they're not fully autonomous, as we would say, where they can go out and think for themselves or react. They still require some level of supervision or monitoring as they execute their missions.

So based on that, our unmanned systems strategy, kind of four key points that were in the documents that we distributed. The first one was to continue the development of the technology and processes that enable manned operations and support -- I should say unmanned operations and unmanned systems.

So again, as I mentioned, that's the high bandwidth radios. It's the automated data acquisition, the automated processing of things that are beyond the autonomy but that enable the unmanned systems.

The next thing that we're going to do, particularly in the Office of Coast Surveys, is the standup and operational unit with expertise in unmanned systems, and the key word I focus on there is "operational".

So this won't be developing the art or the technology. This will be a group of folks with a speed of unmanned systems that are available to go perform mapping missions to support NOAA's operational requirements, whether it'd be hydrographic surveys or some of the more broad interdisciplinary ocean mapping requirements that I had mentioned.

Obviously, we'll continue to

collaborate with academic and industrial partners on developing the technology. That's why we're all here today or one of the many reasons.

And finally, one specific thing that we're going to do is to -- hopefully, we'll have an award this week, I hope, as to contract for the conversion of, hopefully, two NOAA survey launches to what we're calling a dual mode or an optionally manned capability.

So this is essentially taking the brains of an unmanned surface vehicle and putting it on board one of our traditionally manned hydrographic survey launches and then being able to operate it in a manned mode or an unmanned mode or maybe somewhere in between, both as the requirements of the mission dictate.

You might need to work in a tricky area in the morning, so you've got people on board who can monitor it. But then your afternoon requirement might be offshore, so you might not need that. But it also enables us to help develop the state of the technology while having somebody on board to hit the big red stop button when things aren't going well. So we look forward to doing that and continuing to advance the technology that way.

So briefly, some of the -- I think I'll stop here, yes. I'll think I'll stop here.

(Laughter.)

CAPT VAN DEN AMEELE: I've got a couple extra slides, but --

MEMBER LOCKHART: If we have time, we can go back.

CAPT VAN DEN AMEELE: Yes, thank you, Carol.

MEMBER LOCKHART: Thanks very much, E.J.

I'm going to hand right over to Thomas. But before I do -- yes, you can take those, feel free, get yourself ready -- I was asked to say -- we're going to hold questions to the end, by the way, so we can have more of a panel discussion.

We have a green laser pointer, and as

a green laser expert, I was asked to mention that these things are extremely powerful. So when you are switching it on, make sure it is pointing at the screen, and do not switch it on and point it around the room. Thank you very much.

Thomas?

MR. CHANCE: Okay. Am I turned on? The mic works? All right, great.

So I'm Thomas Chance. I'm president and CEO of ASV Global. It's great to be here today, great to be in front of the Hydrographic Service Review Panel. I've seen you all since, what, before you existed. And now you're here, and you've been doing stuff for many years.

And of course, to be here, to be able to see the UNH program that Larry stood up many years ago and is doing fabulous. And I will tell you, Larry, and I will tell you all here, and for the people from Washington D.C. representing the Hill, that the group at UNH is not only number one in New Hampshire, it's number one in the United States. It's, by far, number one in the world.

These guys are like head and shoulders over everybody else. And the work that NOAA has done with UNH is just really stellar and that you really lead the world in so many ways. So the synergies are just fabulous.

So it's great to be here, and I'll jump right into it. Of course, my background, I had a survey company, Hydrographic Survey, and we had done a lot of work for NOAA doing hydrographic surveys and a lot of oil and gas survey work.

A lot of AUV work, autonomous underwater vehicles, I had done that for 15, 18 years. Did about 500,000 kilometers of AUV work, which is, according to the Navy, more than they've done. So I'm really covered with scars because I've been in the unmanned business forever and ever, right?

So I sold that company, C&C Technologies, back in 2015. But back in 2010, I had started unmanned surface vehicles. So we went from autonomous underwater vehicles to autonomous surface vehicles.

A lot of advantages when you start talking about getting on the surface with an unmanned boat. Now, you can have bigger payloads. You can have more energy sources. You can have coms. You can have GPS. You can things like air, so you can have diesel engines running. You don't rely on batteries and things. So the opportunities really grow.

So if you go to the next slide -- oh, I've got the button? I'm sorry. Try that. If you go to the next slide, Thomas.

(Laughter.)

MR. CHANCE: So ASV Global designs, builds, sells, leases, and supports autonomous surface vehicles. So kind of the full nine yards, make it easy for the users, and like I said, founded the company in about 2010. We have about 110 people now. It's a U.S.-owned company. I have an office in Louisiana where our headquarters is and then an office in the UK.

Most of our work has been for the defense industry, but we have done a huge amount for the commercial industry as well. We do unmanned boats. We do optionally unmanned boats -- as E.J. had just mentioned and talked about -- where you have somebody on, if you want somebody on, or you can take the person off and let the boat run by itself. And conversions of existing boats to optionally unmanned, so I'll talk about all of these things.

We've delivered over 90 boats. In fact, we're on Hull No. 94 right now, which is for an actively propelled unmanned surface boat. It's probably ten times more than our competitor. And we've done boats up to about 42 feet in length right now. And most of them are powered by diesel, although we've done some electric and things like that.

We're operating in a supervised autonomous mode. I think it's an analogy, as you look at the driverless cars, all the driverless cars have drivers, right? So all the driverless cars have a steering wheel and a driver's seat.

And at some point, you won't have somebody in that driver seat. But for now, we're not ready to throw the kids in the backseat and have nobody at the steering wheel and have the car drive down the highway at 70 miles an hour. The world is not ready for that.

And I think that analogy is the same for the unmanned surface boat industry is that it's actually a lot more rational to think about going into open ocean at five knots in a 20-foot boat when you can see that there's nobody around for a long way. So I think it's a lot easier to try to make that work in the unmanned surface boat area. And I'll talk more about that in a bit here.

And we've done work not only over where we monitor the boats over a radio link, but we also monitor them over satellite links and have done several projects where customers have been on the other side of the world and over a satellite link, we're watching it for them or else they pick it up and watch.

I've done a lot on the payloads. Of course, it doesn't help to have an unmanned boat unless you have the payload actually doing the work, right? People don't want an unmanned boat for the sake of having an unmanned boat. They're trying to get something done, right? So we've done a lot of work with the payload integration, integrated more than 30 different payload types.

Launch and retrieval too, and E.J. talked about that a little bit, is equally as important as a force multiplier. If you can't get the thing on and off your big ship, you don't need it. So you have to take that into account.

And collision avoidance, we've done a lot of work on collision avoidance. We've done a lot of work in the military side with collision avoidance. And on the commercial side, we have very limited rollout of our collision avoidance software, but we've done a ton of work in that, everything. But we got 25 programmers just working on that. So our objective, from a collision avoidance standpoint, is going 30 knots at a moderately cluttered environment operating under the COLREG rules.

So we've done a lot on that. And now, the boat that you all had did not have that. Frankly, most of the boats that we have, we don't have our collision avoidance on because it's not publically released yet. So we need to be working on that too. Okay.

So these are some of the boats that we have put together from the small to large. And so you'll see C-Stat, the numbers after it, that indicates the length in meters, right? I'm very conscious of this screen pointer guy. So I'll talk a little bit about these different boats, more on some than the others.

So we're also, as I mentioned, doing a lot in the military. Some of these bigger boats, just like 1,000 horsepower boats that are pulling big sonars, synthetic aperture sonars, and whatnot.

So in addition to commercial and

military boats and conversion of existing boats, we do quite a bit. You can see here this is a Canadian Hydrographic Service survey launch. We're just completing the conversion of one of their vessels right now so they can operate it in an optionally manned mode.

So there's basically a little button on the boat on the bridge. So you push the button. You're in unmanned mode, and you flip it the other way and then you're back to manned.

So if they have a mission where they want people on the boat -- they're going to pick up something that's floating in the water and they want people on the boat -- they put people on the boat and go. Or if they say, hey, look, we're going to just run parallel to the mother ship for the next few weeks, so we can just watch this thing from afar. So they flip that button and then off it goes.

So what you have on the unmanned boat end is an electronics package. It's actually a bit more than that. It's not terrible, but it is a bit more than that. And so this interfaces with all the aspects of the boat, and it doesn't matter if it's a new boat. It may be a boat we built. It may be a boat somebody else built.

We interface that in to the CAN bus on an operating system in this boat. And we've got it set up where we can control if somebody has somebody has jet drives or somebody has dual direct propulsion or single drives or outboards or two outboards. I mean, it's like 16 different propulsion combinations that we've set up for so it's highly flexible.

And then on your remote supervision end, you have basically an electronic chart where you see the boat and you see other boats in the area picked up by AIS or radar overlay on it. And this is what you see, a radar overlay over an electronic chart. Thank NOAA for that. And then you have some different boats, depending on what we put on a boat.

In this one, you're looking at the picture that comes off the boat. And here, they have fore, aft, port, starboard cameras. In other situations, we have this ring of cameras where you have both daylight and thermal cameras looking 360 and getting that data back. And then you have a lot of line functions that you can run to the boat.

So at the same time, the survey operations, whether it be for multibeam -- in other words, the NOAA fuel guys, they're running with multibeam and side scan sonar, and they were using HYPACK or whatever. I mean, they're used to those instruments. They're used to running those instruments, and so we don't want to have a set up where they have to learn new instruments, right?

So when they're running those multibeam sonars or they're watching those multibeam sonars, it's just like if they were on that boat. It's the same screen. Now, they're on the mother ship, and they're looking at the same screen. They calibrate the same way. They run their multibeams the same way. They run their side scans the same way, except they're on the mother ship. They're not out there on the launch.

And as I've mentioned, the belly pack, this is so -- of course the boat will run by itself. You give a program and set a launch, and it'll run the pattern and all these kind of things. And if it has collision avoidance, it'll go around things. And we've been doing that for three years.

But when you want to bring the boat back to the mother ship and you're going to bring it back on the back deck of the mother ship, let's say. So then you take over by hand because you know your brain works better than -- we won't tell the computer guys this, but you all's brains work much better than the computers do.

When you want to say, hey, look, we're going to get that unmanned boat and we're going to put it up on that boat trailer on the boat ramp, it's easier to just do something like this. This is the Governor of Mississippi, by the way, Phil Bryant.

And then there's optional items that you have to think about. Well, do we want a boat trailer or do we want a cradle? Do we want a launch and retrieval system? All those kind of things. Do we want a lot of collision avoidance software or support when camera systems are minimal? Do we want help on payload integration? Do we want fuel support? Do we want an articulating ram that'll lower and raise a transducer? Do we want an A-frame off the stern?

This is one of the smaller boats. This is a C-Stat for stationary. So it's, like, eight-foot long, a 2.4-meter. So it just holds its position for several days, kind of, like -- it's, like, a buoy. Not really pertinent to this a whole lot, though.

This is a C-Cat 3. This is an all-electric vehicle right here, and we had built a C-Cat 2 and decided, with the lesson we learned from the C-Cat 2, a catamaran, we came up with a C-Cat 3.

And you get a little bit bigger vehicles. Now, this is the one that UNH has. This is a C-Worker 4. It's a jet drive, not a dual drive. It's a single jet drive. And you'll see that hopefully in the next -- tomorrow maybe; is that right? So they're doing development work with that. And so it's great for our technical people that work with the technical people here at UNH on that program.

A C-Cat 4, it's a little bit bigger catamaran. This is one that we sold to the Japanese. C-Worker 5, E.J. had showed you all several slides of the C-Worker 5.

We went back up to TerraSond this year. Last year, we were doing -- you see towed side scan here. So you had multibeam and towed side scan last year. This year, it was primarily multibeam work only.

This year, they did 4,700 kilometers of multibeam work next to a mother ship. So the mother ship was a 105-foot mother ship. And the TerraSond people would put the unmanned boat in, and they would run the parallel survey lines. And actually a boat like this -- we've got four of them like that right now -- it did more than the mother ship. Fifty-three percent of the survey was done by the unmanned boat. And in that case, we had two ASV people out there just to help in case there were any kind of issues.

Of course, this is an area -- they were working in Alaska again, so it's not like you're working in, like, a hugely congested, dangerous area. I mean, I think that everybody in this room understands that what we need to do is start off and be pragmatic about what we're doing. But that said, we've worked in some very congested areas. And if you're working in congested areas, whether it's a manned boat or an unmanned boat, it just takes a lot of attention so you don't get yourself in trouble.

C-Worker 6 is a bit different. It looks the same. It's another one of those yellow boats, but this one has dual diesel generators and an electric propulsion system. The payload is set up with a one-meter by one-and-a-half-meter moon pool, a hole all the way through the boat where you put a variety of payloads in there.

The other boats that I've shown you, like the C-Worker 5 on the previous slide, is set up with a hatch here where you drop -- we basically have a 19-inch rack thing. So most of that equipment, the survey equipment, is all rack-mounted.

So all that survey equipment goes in there, and it's an air conditioned area, which you probably don't need in Alaska. But most other areas of the world, you really do. You don't want to underestimate how hot the electronics get and it fails, and Murphy's Law just can't wait for you to not put an air conditioner in there. So it can knock you on your tail.

But people look at this, and they say, man, this is almost like you invented a pickup truck. In fact, you can put all kind of different things in this payload, and sure enough. And I've been in the maritime sensor business for my whole life, since I was 17 when I started surveying. And it's just amazing the number of things that people come up and say, hey, we can use this unmanned boat for this. Oh, we can use this unmanned boat. And it's like, yes, I guess. I mean, you get power and coms from the boat and off you go.

And then this is a C-Worker 7. It's a little bit bigger version. The payload in it is two-and-a-half meters by a meter. So we've done several. I'd say we've done two of these. I mean, some of these boats, we've done four and five of, and others, we've just done one.

C-Worker 8, we've actually done eight. Eight of these boats, we sold to a company in Europe. They have a bunch of unmanned underwater vehicles. They bought eight. There's too many acronyms there. It's AUVs, right? And they bought eight AUVs, and so they bought eight boats from us. They only show six in this picture because they went from six to eight.

And these boats acoustically communicate and position the AUVs and then relay that data back to the mother ship. And so then this is the real one. So it's amazing how we went from what was supposed to be to what it actually is. And you can see one of our boats there. And that's a dual diesel direct drive vessel.

You can see here these cone things. This is to help on the launch and retrieval. So because you don't have anybody on this boat, right? This is a totally unmanned boat. It's not optionally manned. So we have it set up so when you come to retrieve it from the mother ship, you have this, like, a boat hook. And you can shove this -- it's a bullet-type shaped system in on your launch and retrieval. And it goes right in there, snaps in on the bow and stern, so you can lift it up and put it on the mother ship.

C-Worker 12 is a 40-foot boat. We've

launched one like this just a few weeks ago. This is a boat that'll go about a quarter of the way around the world. It'll go about four or five knots, and then if you really gun it, you can't go that far, but it'll go about nine knots.

You see it here with a multibeam transducer, this is something that when you start doing things unmanned, it makes things a lot simpler. Okay? I mean, it's like a big boat. This is a 40-foot boat, but we're talking to people right now about 100-foot boats, 180-foot boats.

And if you make them totally unmanned, then you don't need the bunk space, and you don't need the heads, and you don't need the gallery, and you don't need the refrigerator, and you don't need the stove and washing machines and all the things that break and the hot water heaters. So this boat right here is basically diesel tanks, two diesel engines, and some computers.

Now, we've made it optionally manned just a little bit. All of the back port of this boat is open deck to put payload. You can take 4,000 pounds of payload on this boat. But here, you can put a couple of people, or you can put a few people on to test stuff out, right? We're going to try to launch these big things or pick up these big things and see.

And you can see two sat-domes on it, different frequencies and different sat-domes, and then you can have a tertiary sat-dome. So now, we're really talking about operating long periods away from the mother ship, totally independent. Not as a force multiplier but really as an independent boat.

So like I said earlier, we've done several projects like this, but this is, like, seriously doing it. And here's an image with a bigger transducer. So when you talk about mid-frequency multibeams, certainly high frequency multibeams, you can do off of this and certain mid-frequency multibeams and just go for a month or so.

This is a C-Enduro. It's an energy

harvesting type vessel. So we use and take advantage of solar panels, wind, and we do also have a baby diesel generator in there. So when mother nature doesn't cooperate -- like the sun is not shining and whatever else, wind is not blowing, waves aren't moving -- then we still need to get our job done.

But the endurance on this, you're talking about 30 days. But it's with minimum power for your payload. And realistically, if you're a 50-watt payload, that's okay. But you can't do a whole lot with it. But we've made three. We're building a fourth one right now.

Operated payloads, we've done a variety of payloads. Like, multibeam echo sounders, obviously, that's something of interest to NOAA. Kongsberg EM2040, RESON systems, multiple RESON, R2Sonic, Teledyne, EdgeTech, NORBIT, we've done those. I mean, every high frequency multibeam system, we've had on our boats, one way or the other, for multiple times, multiple missions. We've done towed side scan sonars at EdgeTech 4200, both the stainless steel and aluminum versions, the EdgeTech towed side scan and the Tritech.

So certainly, I mean, lots of other things that some of them are not really pertinent to the group here. Mid-frequency multibeam is something that we've got repeat -- a lot of interest in. Next, in the coming weeks, we're going to be putting a big, ginormous compressor in for Shell Oil in one of our boats -- in the bigger -- in the 40-foot boat to go do some seismic test.

So it's just mind boggling to think. I mean, I didn't think I would ever -- nobody would've said -- if somebody would've said, Thomas, you're going to talk about putting a seismic compressor in an unmanned survey boat. I would've said, yes, right, sure, yes, you're crazy. But it's here. Okay.

So the summary, so ASV has repeatedly demonstrated benefits in hydrography and substantial production increases. And let me just reiterate. You see a company like TerraSond. Now, TerraSond doesn't own any -- it's a survey company contracted to NOAA to help them do some work. Okay? They own some boats, but they don't own a fleet of boats. Okay?

So they have a choice, right? They have a choice of, we're going to go do this job with an unmanned boat, or we're going to use our own boat, or we're going to rent another boat, right? So they, hands down, boom. This is the third year in a row they do it.

They say they can -- this is a lump sum job for them. As a commercial entity, they want to do it as quick as they can and get the best data possible. Okay? So they're continuously coming back and saying, we want to do it with an unmanned boat because we can do it so much more efficiently.

If you have a manned launch out there -- and I've lived it, right? We had eight ships up to 250 feet long. We go out there, and not for NOAA but for other customers, we try to put a launch in the water -- a manned launch. And NOAA has to do this all the time. You have a big ship with manned launches. But it's a little rough, so you don't want to put somebody out there because you may not be able to get them back on the boat.

So we're about to put them out there. Finally, the weather has calmed down, but we think the weather is going to get bad again, so we can't put -- we've had 250-foot boats sitting for six days waiting to put the launch in so we can get the nearshore work done. It's, like, hugely inefficient. And of course, at night, you don't want them out there at night. So it's starting to get dark. You all better come in.

So now when you go unmanned, you're not worried about killing people. You're not worrying. You can run it 24-7. You can run it closer to where you wouldn't run a manned boat because you're afraid of crashing and hitting rocks and that kind of stuff.

So there's huge financial drivers on

all of this stuff. So it's exciting to be here, exciting to be in the unmanned boat business right now. So a lot of production increases. A lot of safety increases.

Until autonomy is perfected, ASVs must be supervised. You want somebody watching this, especially if it's in a very congested area. You want somebody watching it while you're running it for now.

It will certainly require some training and including some onboard training. Just like I mentioned, we have two of our guys on the TerraSond project. We have a project running in Egypt off the Nile Delta right now, all kind of sensors on it. We have a couple of people out there.

You can't eliminate the ships and personnel. This is exactly what E.J. was saying. NOAA still needs big boats and people. For as long as we can think, they're going to need that. You're not really replacing. You're augmenting and you're dramatically increasing production.

So you must account for the launch and retrieval systems, spares, upgrades, CTDs. And if you're collecting multibeam data and you don't get the water velocity profile stuff, you're wasting your time. So you have to have that on the unmanned boat as well.

So the three takeaways, I think if you take away anything from what I'm saying here today, is something like this. I mean, I'm showing our stuff, and I apologize. I know this looks really like an advertisement, and I apologize because I don't have slides on other people's stuff. And frankly, there's not a lot of other stuff out there, right?

But the C-Worker 5 is a great hydrographic survey multiplier. We've seen that time and time again. That's a second generation boat. We've built four like that, and then we already know what we're going to do to make the next one better.

The second thing I would say is that the 40-foot boat, it's an Over-the-Horizon survey vessel, ideal for working away from the mother ship.

And the third thing I'd say is that you take the existing NOAA launches and you upgrade them to optionally unmanned. That's like an open court lay-up. This is, like, that should be done.

So I think that's all I have.

MEMBER LOCKHART: Thanks very much, Thomas. We're going to move right into Doug.

MR. LOCKHART: Can you hear me all right? Sounds like it. Since I came over here, my wife ran off.

(Laughter.)

MR. LOCKHART: Fairly typical.

So my name is Doug Lockhart. I'm with Teledyne Technologies. I'm currently working with Teledyne CARIS up in Canada.

I joined Teledyne about, I guess, eight years ago or so. And every quarter with Teledyne, I go to Thousand Oaks, and I sit through a three-day quarterly review where we talk about all the technology in the company and how it's being deployed and what it is.

And in that -- what is that -- somewhere around 24 three-day meetings of this, I still cannot adequately describe the breadth and width and depth of Teledyne Technologies in the pieces of stuff they have. And I found trying to give a sort of broad brush presentation of what Teledyne does, pretty unsatisfactory for the people I'm talking to.

Trying to drill down into some of those technology pieces works a little better, but for this group, I've decided instead to try to look at sort of the business case for autonomy rather than specific technology pieces and try to understand how we can evaluate when a technology is ready for us, what it's going to do for us, almost in a businesslike sense.

I worked for Ed Saade for a number of years, and he had -- in his boardroom or his conference room -- a little piece of paper taped to the wall that said, revenue is vanity, profit is sanity, and cash flow is reality. And that distills the business down to its utter core.

And I was trying to produce something like that here, and this is sort of evidence of how, utterly, I failed at that. But at least it may give you some ideas of how we might look at this stuff.

Also, you'll find that large fonts are pretty inexpensive in Canada right now, so I've used a lot of them.

(Laughter.)

MR. LOCKHART: But we're going to look at some autonomy levels. Thank you, E.J., for starting that off. We'll take a quick look at that. Technical readiness, I know a lot of you are familiar with TRL, but we need to kind of understand that. Risk and efficiency or productivity are things that we need to understand, and then finally, cost.

And we'll try to put together a baseline for how we can sort of manage what system is preferable to another system and how we can gauge or understand when to deploy a certain suite of equipment.

So this is what E.J. was talking about. This had been all set up for the automobile industry, these levels of autonomy. So over here on the far left at Level 0, it's you and your old Ford with the stick shift and the clutch and no power steering. And on the far right over here, Level 5, you just tell that thing to go anywhere in the world and it goes there. It doesn't need to really even know the road. This is serious, figure out on the fly autonomy. And then there's everything sort of in between.

When we move to hydrography, the situation gets a little more complicated. We think we're riding around on the surface on the water, but we're really riding on the seafloor. That's our road. That's what we're trying to map. We're not a conveyance anymore. We're trying to put a sensor in position.

So all these things, all this

integration of sensor fusion starts to matter to us. That has to feed directly into the autonomy. On the surface, we have to avoid hazards and avoid targets and stuff like that. But that's how we look at boats because we're on boats ourselves. So that's our primary perspective, but that is not the primary goal of the autonomous survey launch. The goal of that vehicle is, get your sensor where you need it to be in the most efficient manner possible.

So things like auto-tuning for survey sensors, multiple data processing streams, combined and operated, sensor fusion and data fusion on the fly, those start to matter to us as we get increasing levels of autonomy. And we'll look at it later. I think we're kind of in here, this Level 1 or Level 2 area right now. And you guys have probably a better gauge of that. It probably depends if it's your commercial or your sort of military or defense operations.

And then technology readiness levels, and Larry is probably familiar with this stuff pretty well. Basic principles was sort of when the light comes on all the way down here to number nine. It's a cost product. You can buy it shrink wrapped down at Best Buy or something like that and all the way through.

There are some key points right in here around five and six that technology validated in a relevant environment and demonstrated in a relative environment and demonstrated in an operational environment.

We are operational, and there's a lot of our technologies, things that we see as being technologies that we could use for autonomy that are way down here for vehicles and aircraft and all kinds of other things that haven't been demonstrated in our operational environment. So from our perspective, those things are at TRL Level 6 and not the TRL 9 that we kind of think of them as because we see them out there in the world all the time.

This matters because of this little action here, this thing called the Valley of

Death. And it's something that we deal with all the time as a technology business. As technology evolves, it gets to a point where the research funding push dies out and we start looking for a commercial pull. And in something like the automobile industry, that commercial pull is huge.

In the hydrographic industry, it's a lot smaller. That's why there's only one Thomas Chance up here rather Ford and GM and Elon Musk and all these other guys. There just is not that much business to pull a lot of these technologies we need across in a way that there is in the automobile industry.

We have a few of these at Teledyne. We have a way of collecting remote speed of sound without casting a probe. We can do this acoustically, and we have it at TRL Level 6. We've taken it out. We've demonstrated it. It works, and we cannot figure out how to get it into the market space.

And there's all kinds of things that

are stalled out there like that, and that's something I think this group needs to be aware of. There's a possibility of pulling things across this gap and to help ourselves out if we can identify what stalled out, what's not getting help from something else.

Risk is another thing, and Thomas started talking about this. I think it's helpful to look at automobiles first. We're all very comfortable in automobiles. We drive them around all the time. But they are, in fact, the riskiest way we can use to get from one place to another. If there was a riskier way to get around, we would replace it with the automobile, except for Carol on her motorcycle, and that's up here.

(Laughter.)

MR. LOCKHART: But yes, there's a significant amount of carnage every year on the highways. And we can kind of look and see how much there is out there with that.

So what the folks in the automobile

industry are doing, they're trying to move away from that sort of high likelihood of failure scenario. That's the whole pull. It's not that driving is that hard. It's just that it's that dangerous. So they're trying to make it less and less likely to fail.

But the fact is there's still squishy bodies in the car. So if there is an incident, the severity of failure is always going to be high. Automobiles are going to stay up at that level as long as there's people in the car. If something happens, it's bad.

For survey vessels, though, it's a different story. The first thing that happened with autonomous survey vessels is we took the squishy people out of the car or out of the vessel. That's great. It's a lot safer.

So this is exactly what Thomas was talking about here. He's coming down this curve on the bottom. So we immediately find a benefit where we start taking people out of harm's way. And this, in itself, is a pretty strong reason to just start adopting this technology because we are suddenly safer for what matters to us most. If we can take people off the boat, put them on the mother ship, or take them off the ships and put them on shore, we've suddenly made things a lot safer for ourselves.

So by the same token that an automobile is up in the upper right-hand corner, we have to assume that that's where our survey launch is as well. It is the riskiest way that we can collect hydrographic data simply by definition. It's how we do it. If I just define this new international symbol for a survey launch, running on the rocks --

(Laughter.)

MR. LOCKHART: -- endangering a sea serpent, an endangered species.

So the objective then is to move away from that curve in one direction or another. And we don't have a lot of examples out there that I have access to. We have a number with Thomas' stuff, but we have the APEX Argo floats. They're an autonomous vessel of some sort. They're out there drifting around, and we don't tell them what to do. They just drift.

We can see what their life span and what their risk is. They still have a high likelihood of failure. They're designed to fail. They're going to run up on the rocks somewhere, but there's no cost really or no severity involved when we do that.

We also have the gliders. They are a little less likely to fail but still fairly low risk. I wasn't really sure where to put ASVs on here. I didn't want to stick anything over in one of these red boxes. That just looks bad. But I think an analysis like this is sort of important when we look at this technology and try to fully understand what we want to deploy and what not to.

So now, on the cost side, I've come up with, I guess, seven different scenarios here to try and benchmark the relative productivity of having a survey boat out doing survey work or a survey boat and an autonomous vessel all the way up to Option G down here where it's two autonomous launches out there totally unsupervised.

So the one-man launch, that's typically how we go to work. But the most prevalent way of doing anything with an autonomous vessel right now requires a launch and an ASV. So I've also benchmarked two manned launches because that'll give us something to scale with directly.

And you can see here, we're doing SVP casts from the manned launch and eventually we start doing them automatically from the remote launch. And we have different numbers of operators. Right here at Level C, you can see I have three operators here now. So I think I'm undercounting by one, what they're doing at TerraSond.

And just for review, these are the levels of autonomy. So if we go back here and look, each of these say what levels of autonomy we're expecting out of the surface vehicles, the ASVs.

I had to define sort of a baseline productivity. And so I figured 30 meters depth, that's deep enough for any Panamax vessel. One hundred and fifty degrees swath, that's the most you can get out a commercial sonar right now without doing a whole lot of jumping around. Eight knots, if you go any faster than that, you'll exceed your IHO Order 1, a long track specification.

So I said a single launch surveying at eight knots in an infinite straight line, you'll get about 3.3 kilometers squared per hour. And we'll just say that's 100 percent efficient.

In an actual survey, you have overlap, you have turns, you have sound velocity casts. You have a lot of stuff that's going to diminish your efficiency. And then we have capital costs of the various pieces that we have out there.

And I just kind of made this stuff up. I bought a boat a few years ago. I figured

250,000 bucks for the boat, 300k for all the survey gear you have: Manuals, sound velocity probe, an automatic one that you don't have a to touch.

Autonomy software, I figured every time we move up a level, it's going to cost us an extra 50,000 bucks for the software once we're sort of at the coxswain level. These are fairly granular, I admit, but I needed to start somewhere. And then we have operational costs: Fuel and maintenance, operators, surveyors. And the technology lifespan I said was five years. We have to have some period of time to measure this over.

And down here, this table is a method of trying to understand what the efficiency is as we go up in autonomy level. As you go higher and higher in autonomy level, you move closer and closer to your 100 percent maximum speed. Your coxswain isn't fooling around doing other stuff. Frankly, I've been on boats where it'd be a challenge to get this sort of performance here.

But as you get more and more autonomy, you have less and less overlap. You're closer and closer to your optimal speed.

HYPACK has a piece of software now that does automatic line control or line selection, and that probably fits in out in here. And this helps work on your overlap that you're calculating on every line, reducing that and making you more efficient. So there are technology pieces that are fitting in along there as well. Five minutes? Okay. Thanks.

So as we do this, this is our single boat scenario again. So one boat surveying by itself. It looks like it's about 57 percent efficient. When you go to two boats -- I changed it to productivity because efficiency didn't really seem to fit here -- but it's about twice as productive. And over here, we have the days it takes to survey 100 square kilometers.

So you can see that starting to come down as we gain autonomy, and you can see the productivity level start to climb on up. I think

C and D are about where somewhere in there where TerraSond is trying to operate right now.

Now, for this graph here, I assumed we had a five-million-dollar budget to spend over five years. We're going to spend a million bucks a year. We're going to see how much survey we could do with that every year or what it would cost us per square kilometer to survey under those guidelines.

Again, this is our single vessel, the capital costs down here at 600,000 dollars. It costs us about 1,500 dollars a day to run, and it's costing us about 130 dollars per kilometer squared. So when we have two vessels, we're up here. Our first level autonomy comes in right here on C, and then D, I think, is where the multi-vessel --

PARTICIPANT: You have more time.

MR. LOCKHART: Oh, I have more time. Wow.

(Laughter.)

MR. LOCKHART: Yes, let me know how I

did that. I would like to repeat that later on.

(Laughter.)

MR. LOCKHART: But as you can see, right in here by C, our cost per kilometer squared starts to become advantageous and advantageous in a big way. We're going to start surveying a lot more with the same budget, with the same technology lifespan.

Conclusions, hey, I'm way ahead. So one of the things I've noticed here, we have a lot less testing in the marine environment than we've had in the automotive environment, many orders of magnitude less testing. Those guys have millions and millions of days that they wrapped up. We have probably thousands of survey days with this stuff. So we're way behind on the testing.

But this second item, the decreased severity of failure may outweigh any other financial consideration. If we have these autonomous vessels or even the shepherded vessels around, if we're using those in places that aren't near ports and harbors, that's an easy way to de-risk our operations and potentially save lives and save injury.

And again, the road is defined by our survey specification. It's not the surface of the ocean. It's the bottom of the ocean that we're mapping, and it tells us where we need to go and what we need to do. The stuff on the surface is just clutter that we need to avoid and need to deal with, but the real optimization of the survey asset is going to come through looking at the data, looking at what's on the seafloor, and directing that vessel based on what it sees on the seafloor, not necessarily what's on the surface.

And Scenario C there -- which I think is about where we are right now with Thomas' gear and TerraSond and some of these other customers -- that's already productive and making money. And actually, my little spreadsheet came out at about 55 percent, I think. I've taken productivity out when I did this. So yes, I think that sort of made sense to me.

And as we get more advanced, it'll only improve the financial aspect of this. I don't think it'll significantly de-risk it, but it'll make it more financially compelling.

So that's what I have. Thank you very much.

MEMBER LOCKHART: Okay. Thanks, Doug.

We're going to move right on to Rebecca. We are running a little behind, but I think Lynne managed to shift everything out 15 minutes. So we've got a little extra time. We're still going to be pretty short on time for questions, though.

So thanks, Rebecca.

MS. QUINTAL: Okay. Thanks. It's a great opportunity to round out this great panel. That's a preview. That's a preview.

(Laughter.)

MS. QUINTAL: They're loading up the slides. I'll start out without bringing up the slides, just saying that I'm actually presenting a subset of a slide deck that was produced by three of my colleagues. Their names are on the screen there, and the reason for that is these slides are all released for public release from the sponsor of this work which is DARPA, the Defense Advanced Research Projects Agency.

So the project was called ACTUV, which is Anti-Submarine Warfare Continuous Trail Unmanned Vessel. And what that was, was to develop a medium displacement unmanned surface vessel that needed to have ocean spanning range, have months of endurance, be able to carry a substantial payload, have enough power to support that, and demonstrate a high level of autonomy for independent operations with only sparse supervisory control.

And the idea was to demonstrate a high level of autonomy for game-changing approach to anti-submarine warfare. The idea is that this platform will be able to track and trail a quiet diesel-electric submarine. And then it needed to be able to demonstrate additional utility for

Navy missions.

One of the other priority missions that has kind of bubbled up to the surface has been hydrographic survey, which is why it's applicable to NOAA's mission and HSRP. We were, just a few weeks ago, able to demonstrate hydrographic survey as an alternate mission using the test platform for the Sea Hunter, which is a 40-foot workboat. But it has the same autonomy engine that's on board the Sea Hunter here.

And we were able to demonstrate at the Advanced Naval Technology Exercise which took place at the Naval Surface Warfare Center in Panama City, Florida and also at the Naval Undersea Warfare Center in Newport, Rhode Island. We performed an autonomous multibeam survey in Florida. We actually had the screens of the ship ported up to the tent on the pier in Newport, and we were able to control the survey from Newport.

Some of the metrics for how this program will be measured against, the platform needs to be compliant with International Maritime

Organization Rules for Preventing Collisions at Sea, or COLREGs. It needs to have propulsion and maneuvering that can outmatch a next-generation diesel-electric submarine. It needs to have an endurance greater than 70 days. And once we get to that point of getting to unit production, it needs to have a cost of less than 20 million dollars.

The image on the left was the artist's rendition what this would look like during the design phase, and the image on the right is what it looks like today. And there's two things that you can notice right away. The image on the right has a bridge, and that's because right now there is actually someone on the bridge. We're legally required to have that. And it also has a railing, and you'll see images later where there's lots of government observers that are standing on the platform. And that's for their safety.

Here's some more images of the platform, and I'll just tell you a little bit more about Sea Hunter. It's 132 feet long. It's 47 feet wide, ama to ama, which is the pontoon to pontoon. But it's just over 11 feet wide at the center hull, so it has efficient use of space there.

It has twin diesel engines. It has a fuel tank, 14,000 gallons, which gives it an endurance of over 13,000 nautical miles. What that means is it can leave San Diego, go to Guam, and back on a single tank of fuel. It was designed to operate in Sea State 5 and survive Sea State 7. It has a wave-piercing trimaran design which is important for stability. And it has five water-tight containers, any one of which can flood and the platform can still float.

This website, we're going to queue up a video here. If anyone is interested, DARPA has posted quite a few still images and videos. The video we're going to watch here is of some recent maneuvering testing that was done.

MS. QUINTAL: And it's very dramatic music.

(Video played.)

MS. QUINTAL: All right. You can probably stop it there.

(Video ends.)

MS. QUINTAL: Thank you.

So you can see there's not anywhere to sit onboard. A lot of standing. If you do want to sit, if you go inside, they do have folding camp chairs that you can sit down, and that's about it.

So where is the program now? We are currently in the tail end of year one of a two-year sea trial phase. They started out by testing the physical ship. How did the engines work? How fuel efficient are they? How's the bow thruster work? The stability of the platform, et cetera. We're moving into the COLREGs testing now, and then things like endurance testing will follow after that.

The program is currently transitioning from DARPA to ONR, which is a good thing. It means they think it's successful. And ONR's job will be to decide how best to deploy this to the fleet.

This slide has a lot going on, on it, but the idea is to talk about open system architecture which was a keystone for the development of the architecture for the system. And I'll jump to the next slide real quick, and this is a cartoon of how the different systems are segmented and the hierarchical layering of decision making that takes place.

The architecture allows for adding new sensors or systems or behavior in a simplified manner. So for example, the original ACTUV mission, while it was supposed to be able to do transoceanic voyages, never had behavior to be able to line follow like we would for a hydrographic survey. But we were able to add in that capability, which we demonstrated last month at ANTX, very simply because of this architecture.

For each of these categories, there's redundant and backup systems included. So the idea is that a single point of failure would not cause the platform to be unable to return back to its home port. It may not be able to complete its mission, or it may have to limp home, for example, if one of the engines went out but it could still get there.

In some of the areas of redundant systems, we have redundant steering and propulsion controls. We have automatically paralleling generators. The propulsion and the electricity generation are separated. We have two seawater pumps for the generators, two seawater pumps for the chillers. We have multiple radars with overlapping ranges, and they don't all have to be functional at the same time for the autonomy to work. We have 100 percent redundant computer hardware on board.

In addition to the backup systems, each component that was chosen for this vessel had to be chosen based on automated control. And you can think of that down to the most basic element of the system. You can't have anywhere on board a switch that needs someone to switch it on, a valve, even in an emergency situation, that needs someone to turn it. So you can think about, like, if a breaker trips, you can't have a breaker that needs to be toggled back on.

One of the important boxes worth mentioning is the health monitoring. The platform needs to be able to monitor itself in its own status. It needs to know what the optimal performance is for every computer on board and every software package that's running as well as the plant, the physical ship. And so there is supervisory software that's running to check that.

If it needs to, it will reboot a specific computer, shut down a specific piece of software, and restart that software if it's not functioning as its expected.

One of the other things that you need for an automated system is you can't employ any software that has pop-up boxes. It can't be waiting there for someone to say, okay, yes, really do it.

So one of the boxes, the World Model, I'm going to talk about on the next slide. So what we call the World Model is all of the information that the platform has available to it to be able to make decisions.

Some of that information, it's collecting itself: its position, sensors it has on board, radar, cameras, and AIS information from other vessels around it. And it could be some a priori information: nautical charts that are currently published, data that were previously collected in that area. It fuses all of that information together to create a World Model so that it can make decisions, and it's constantly updating and evaluating that World Model to say, now what should I do?

Two of the things I want to highlight is hazard avoidance, optical avoidance, and COLREGs compliance. For hazard avoidance, built into the system, there are exclusion zones that are user selected.

How big of an exclusion zone do you want to have around a charted wreck position approximate? How big of an exclusion zone do you want to have around shoals to have the vessel stay clear of those areas? And you may want to adjust that exclusion zone based on the particular waters that you're in, and for example, things like, what is the age of the nautical chart?

COLREGs compliance, the software is constantly looking at its environment and determining if it detects any contacts. It'll use AIS if it's available, if a contact has AIS, because that'll help it determine what the rules of the road are based on what time of vessel it is.

It will determine the risk of collision. It'll identify what Sea Hunter's role is in this situation. Is Sea Hunter supposed to stand on here or give way? It'll then take the appropriate action. And in the case that you have a noncompliant contact -- the other guy is not following the rules of the road -- it'll take action. All right.

So one of the things -- for a long duration asset when an organization is going to send that vessel over the horizon and it'll be maybe days away from the nearest human help -- you need to think about how you protect that asset. It'll be not too far in the distant future we'll have, I believe, oceanic shipping vessels. And they're going to put a lot of thought into that, how they protect those assets when they send those across the ocean.

And maybe just as important, particularly with the emerging technologies, is how do you protect the intellectual property of those technologies? And that was a big part of developing the system for Sea Hunter was including information assurance, how do you protect the data, the software, the algorithms? And also, how do you build in anti-tampering which is physically protecting the asset?

You want to know if someone has

boarded your vessel out there in the open ocean and is trying to get access to your system. That's a really important aspect, and it's not something you can layer on after the fact. It has to be built into the framework of the system.

So as a summary, we've built in COLREGs behaviors. We're currently undergoing sea trials. A lot of thought went into redundancy and cybersecurity. One thing I haven't mentioned yet is the idea of collaborative teams.

Getting back to that price point of 20 million dollars for one of these units, the idea was not to have a single Sea Hunter out there but have a fleet of Sea Hunters that could work collaboratively to perform a mission: collaboratively amongst themselves as well as other unmanned platforms and manned platforms. And so we see that as pretty exciting, going forward.

Thank you very much.

MEMBER LOCKHART: Thanks, Rebecca.

Thanks to everyone for presenting today, for taking the time to come up here and present. We really appreciate it.

With that said, I'm going to open it up for -- I think we have time for a few questions. So does anybody have any questions? Ed?

MEMBER SAADE: So I guess for Doug and for Thomas, one of the strategies we were considering -- and I'm curious if you think this has any validity -- forget about the mother ship. Once batteries and longevity of operation and fuel tanks are big enough, why can't we just launch them in the harbor and let them go do their thing?

MR. CHANCE: So the C-Worker 12 that I showed, the 40-foot boat, will be set up for that. Now, what we may -- I mean, it's a new boat, and you could theoretically do that. I think we haven't done it yet, but we'll probably be doing that in the next month, two months.

And it's set up so you can -- it's

optionally manned, right? So you can put people on it. What we would probably do is put people on it till we get it away from a congested area -- the dock area. And although they've got satcoms on there and things like that, in some of these port areas, you've got a lot of electrical noise, radios go down, all that kind of stuff.

So I think that's a pragmatic approach until -- but I mean, that's -- and we're already talking about people doing loop current stuff in the Gulf of Mexico with that. Just go back and forth, 40 miles this way, 40 miles back, 40 miles this way, 40 miles back. Just have it leave the dock, go out there and run for three weeks and refuel, and go back and do it again.

So I mean, we're really, really, really, really, really close, I think. So ask me in a few months and we'll know.

MEMBER SAADE: No, and I understand all this is probably years out. But that's kind of where we'd like to see the industry go, just because of, as you know, the HSE requirements for a lot of the companies that we all work for, the more humans we can get off the boat or get them out of the picture completely.

MR. CHANCE: And let me say one other thing. So the C-Worker 6 is one of the first boats that we made. It had a lot of dual redundancy on that boat, and it was set up to take a sat-dome so that we could do exactly that.

We put those boats in the water about four years ago now -- maybe five years ago. And it didn't work, and the reason why it didn't work is because the VSAT people made all kind of promises about what sat-dome stuff could -- the sat. And everybody here that's been on the boats knows the challenges of making VSAT stuff work reliably on a boat.

And we started off with it pretty small. It was a 60 centimeter type dome. So you saw the boat that I showed there has two big --

MEMBER SAADE: Yes.

MR. CHANCE: We're going with the big ones, and we're doing two. Actually, we'll have a third tertiary satcom system using Inmarsat Global Xpress -- and I'm sorry -- using Iridium NEXT, which is the next version. Your older Iridium stuff leaves a lot to be desired. Iridium NEXT has a lot more data. So that was the biggest hurdle was the satcoms because you wanted to monitor this stuff, for sure.

MEMBER SAADE: Thanks.

MEMBER MAUNE: I have a question. I was intrigued by the idea of using multibeam in an autonomous underwater vehicle where you want to go underneath the other vessels there. I'm used to using GPS for position and inertial measurement units for orientation. How do you position autonomous underwater vehicles?

MR. CHANCE: Sure. Okay. Is it on? All right.

So people have been doing multibeam on autonomous underwater vehicles since 2000. And so to position them, there usually is an ultra-short baseline acoustic positioning. And so you have a mother ship in the area that acoustically positions, and then you also have inertial nav and Doppler Velocity Log. So it's kind of like the Doppler Velocity Log is going to look at the bottom and figure out which way it's going.

Those are not absolute positioning systems, but the USBL acoustic positioning system is. Or else you have to put in an array on the bottom so it can position itself. Or else you have to come to the surface and get a GPS fix and then go back down.

The challenge with that is that your Doppler Velocity Log has to be able to see the bottom when you're all the way to the surface. And if you're in kind of deep water, that doesn't work. So then by the time you get down, you're kind of lost again.

So it's a challenge. I mean, there's a system called Nautronix NASNet which is like an underwater GPS. But I mean, it gets hugely expensive to do that. So USBL, Ultra-Short Baseline Acoustic Positioning from the mother ship, is the best, most pragmatic way.

MEMBER MAUNE: Thank you.

MR. LOCKHART: Just another quick comment on that. So I think I'm on. There we go.

So there is a bunch of technology evolving now for indoor mapping: Things called like SLAM, Simultaneous Location and Mapping, where you can send a LiDAR into a building when you're GPS denied. And using your inertial system and the cameras and the LiDAR, you can map your way around the building without any external positioning information. And that technology will come along and help this underwater navigation problem.

The environment is a little rougher. We don't have square edges and nice walls and flat surfaces. But if we're able to get some data off the bottom before we dive and we still have GPS, or right after we dive before our position degrades too much and we're able to get back there, we can use survey tools like block adjustments and things like that to pull all this data sort of back into position.

So there are methods that are coming along to help get us away from this constant need for LBL and USBL and stuff like that. They're a ways off, but again, they're being developed for another application. But we should be able to pull them across eventually.

MEMBER MAUNE: Thank you.

DR. MAYER: Okay. Let me just chime in, because I had a follow-up to Ed's question and Thomas' response. And I think that we have to -- and your question really about a very crowded port and true autonomy. And as early as we are in the stages of developing the autonomous vessels, we're even earlier in developing, I think, the infrastructure to support them.

And so I can envision -- and I think we should all be thinking about -- what sort of port infrastructure might you want to establish to truly allow, even in a crowded port, autonomous vessels to behave properly? And I think it's just something we haven't started to think about yet, but it's something we probably should.

MR. CHANCE: I'll just say real quick, Larry. From my standpoint, I would have never assumed that we could actually change anything like that. So our way is to figure out how to try to work around the existing system.

MS. QUINTAL: Well, and --

DR. MAYER: Sorry.

MS. QUINTAL: I was going to say, there's no, like, supervisory board that would, for a lack of a better word, certify when a vessel or a technology is ready to go autonomous when you can send it over the horizon now. And there's a ways to go too to update national and international maritime rules and regulations to allow for, in some cases, legal unmanned operation of these platforms. So infrastructure and rules and regulations, it all needs to be updated.

MR. LOCKHART: I think those autonomy levels give us a lot of insight into when this is going to happen. Autonomy Level 4 should support that unmanned, moving around in a port that you already know the geometry of. You may not know the traffic in the port. You may not know what's going on in there. But if you know, essentially, the physical layout of the port, Autonomy Level 4 should get you there.

Autonomy Level 5 should get you into any port anywhere in the world, whether you've been there or not. That's why those things are defined that way. So until we get to Autonomy Level 4, you're still going to need people on the boat to get you out of the port, for example. But at Level 4, it should be good to go, assuming you have some a priori understanding of what the layout of the port is.

DR. MAYER: Think about something like a realtime feed to the autonomous vessel from the vessel traffic control system.

MR. LOCKHART: Well, you shouldn't need any feed. There's no --

DR. MAYER: No?

MR. LOCKHART: -- realtime feed coming from vehicles. There isn't going to be a realtime feed from your Tesla going anywhere. When it gets to Autonomy Level 4, it's just driving.

DR. MAYER: But if it's there, why not use it?

MR. LOCKHART: Sure, yes.

VICE CHAIR MILLER: Having been at sea a fair amount, things always break. They always break. And I mean, Rebecca's -- the philosophy of dual everything is a great one. But on small vessels, that's just not possible. You can't necessarily have two generators and two air conditioners and two everything.

So I didn't see any discussion of, what happens if the vessel breaks that it can't get back to the ship and the manning necessary to repair it and so forth? So I guess I think the optimism is great, but there's some practicalities about going to sea that I haven't seen addressed here.

MS. QUINTAL: I think that there's a certain amount of risk, and you can build it into the program. You can get really fancy with a lot of things, how you deal with materials that come into the seawater intake, a foreign object. There's lots of problems that have to be addressed. And some of them, you'll do a cost benefit analysis to say, well, how risky is this? Do we need to add another level of technology to handle that or is just having redundant systems enough?

MR. CHANCE: I would say I totally and absolutely agree with you, first of all. And like I tell people, it's, like, 50 percent engineering and 50 percent is trying to figure out how Murphy's Law is not going to kick you down.

So for example, the boat that we have to go independently, all right. So I mean, first of all, we talk about the boats that are force multipliers that are working within line of sight of the mother ship. That's an easier deal, right?

But when you get to going over the horizon, you can bet Murphy's Law is going to -- I mean, there's going to be rope in front of you that your rope cutters on your props aren't going to be handle or it's going to be floating. The human eye can't see those things at night. You run over somebody's rope that fell off their boat.

And so the boat that we have, it's dual redundant throughout, but you've been there. I've been there. We'll just have to see. The easiest stuff is the force multiplier stuff. The tougher stuff is exactly what you're talking about. You take the big boat. You send it out there.

And we'll be out there. I'll be able to tell you all the bad stuff that happens, and you'll be able to tell me before it happens. I mean, what you're pointing out is a very valid thing is that you don't know where the bombs are going to come from when you're trying to do stuff like this.

VICE CHAIR MILLER: I think any cost benefit analysis has to take that into effect. I mean, I guess you have to be able to just lose the vessel. I mean, it seems like, at some point, it's halfway across the Pacific. What are you going to do with it? I mean, do you have a switch that says, boom?

(Laughter.)

MR. CHANCE: Not that I know of. But to some degree, you can drop an anchor or drop a drive line or something. But I mean, what you're saying is real. I mean, we've done designs of bigger boats where we put a heliport on there, I mean, for that very purpose. In a lot of places, you just can't get a helicopter that far out, right? So I mean, I'm not going to say what you're saying is not a valid point. You're spot on.

MEMBER SAADE: So I threw some more in there just for you to consider. We've probably had half a dozen refugee incidents over the last year globally. That's probably going to increase. What do you do when they start climbing on your autonomous vehicle?

We've had tremendous amount of vandalism on meteorological moorings. I can just imagine these folks that really like our moorings are going to really love these ASVs as well. And then the whole marine mammal observer interface that you have to deal with on a regular survey. All those things have to come into the equation.

MR. CHANCE: So as far as piracy and things and people getting on, I mean, we're not there. Obviously, we've thought about this a bunch, right? And we know these people. They just love -- not that we know them. We don't know them.

(Laughter.)

MR. CHANCE: For them to climb on board and cut off your solar panels and cut off your antennas and anything that they can take or steal a diesel and all of that sort of stuff. And there's a lot you can do with an unmanned boat when you design to try to minimize that or limit it. And then there's some things that you can do with -- what's the spray -- the pepper spray or things like that.

It's a challenge. I mean, now, they can hook on the bit on the bow of your boat and tow it to their dock. But you'll be watching them the whole time. You can have the sheriff or whoever meet them at the dock, but that'll probably be their cousin.

MS. QUINTAL: Well, I think the old adage definitely applies: Don't put anything in the water that you're not willing to lose, and I think that has to go.

And so that's one of the reasons why trying to get -- 20 million dollars is a lot of money. But to try to get that cost point down, when you talk about trying to do -- in this particular -- for Sea Hunter, it's not very much money when you're talking about how much a submarine costs. And so that'll be something that the Navy has to weigh of, at what point can you get the cost cheap enough that maybe, in some cases, they are disposable?

MEMBER MAUNE: And this just doesn't pertain to autonomous vehicles. It also pertains to manned vehicles. I remember when a -- what was it -- F-22, lost and crashed in Alaska. That plane cost 150 million dollars, and that didn't even make the news. Down here, it didn't. Maybe it did in Alaska.

MEMBER LOCKHART: Okay, Lawson, last question.

MEMBER BRIGHAM: Just a comment. It seems like the interface of smaller vehicles with your survey vessels and having the mother ship, the survey vessel. And the survey vessel being either autonomous or not but also interfacing with a smaller vehicle seems a bit more cost effective and a little less man intensive.

Kind of a combination of using these tools but tightly controlling them, particularly in the frontier areas. But maybe in a port area as well because you have tighter control. I mean, I think it seemed like in the near term, the next decade, that might be the way to pursue.

CAPT VAN DEN AMEELE: And I think one challenge or area that we're trying to realize is, how many things can we monitor at once for that maximum effectiveness, right? And now that we've done one, for example, ASV, can we go do two or three or four and monitor all them at the same time just to get more of that force multiplier effect?

So I think, yes, in the short term, while we're still under this shorter term under more supervised autonomy, that we want to continue to push that envelope to see how many things we can get in the water and still maintain some level of control over them.

MR. CHANCE: On that note, I would say that, like I showed you, the example, we have one customer that's doing eight ASVs with the one mother ship. Now, that's pushing it. So somebody has to do it.

MEMBER LOCKHART: Okay. I'd like to

thank everybody again for their presentation. If we can show them our appreciation.

(Applause.)

MEMBER LOCKHART: Sorry for going long. I'm going to hand it back to Bill. Thanks.

CHAIR HANSON: Not long at all, and thanks for that. For me, some things we've been talking about for many years now is this backlog of survey work that needs to get done. And so not only just the gee-whiz applications of this. It's also really got a real-life application to help in NOAA's mission. So appreciate all of that.

And also maybe just a recommendation, because this is such a fast-moving, fast-paced discussion, that if you had it again in six months or another year, it's probably going to change dramatically in that time frame. So you might want to keep your pulse on this issue moving forward as well. And I can do that now. I can make recommendations for future panels, right?

(Laughter.)

VICE CHAIR MILLER: Of course.

CHAIR HANSON: Make work for Joyce here. So I really appreciate the panelists and all the discussion here.

We're at a point now in our meeting where we can open for public comment. A little format there, whether you're in the audience or on the webinar. If you're in the audience, I guess you need a microphone, right? Okay. And I'll do that one. But I also want to make the announcement first.

So anybody in the audience or on the webinar, if you've got questions, please go ahead and submit those now. We do have one question that our mystery man, the most mystery man in the world, has presented.

Dr. Mayer, I don't think I need to read it to you.

DR. MAYER: Well, I had to read it. I did? Yes, and I think lessons have been learned, certainly. I think --

CHAIR HANSON: There's a question? Okay. I'll save you from that, Larry.

DR. MAYER: Thank you.

CHAIR HANSON: All right. Referring to the presentation by Dr. Larry Mayer, on the use of multibeam echo sounder technology and the response to the deepwater horizon event, how has NOAA applied the lessons learned from this incident?

Specifically, are the multibeam services, systems, and software now available aboard more NOAA ships to be effective in responding to future events where observation of oil leaking into the water column needs to be understood? Gerd Glang, Director, IIC Technologies.

DR. MAYER: Yes, I think there has been an expansion of the capability. A number of the fisheries vessels now are being equipped with kind of a hybrid type of multibeam that originally was designed only for the water column. But now, software has been developed for those systems to map both the seafloor and the water column. These are the ME70s, and so I've seen those on many of the fishery vessels.

I think most of the NOAA large ships are equipped now with multibeams. And so at that time, the Okeanos Explorer with its EM302 was really a one-off. But I think we're seeing that capability spread much further amongst the fleet, both on the fisheries vessels and certainly the hydrographic vessels.

And TJ is getting both the 710 and 2040. So we're getting multiple systems on many vessels. So I think had that situation or should a situation like that arise now, I think there are many, many more options to apply those technologies and certainly the software development has come very far.

CHAIR HANSON: Any questions from the audience? None on the webinar. Go ahead.

MR. NOLL: Larry, I noticed that you mentioned port infrastructure. And of course, we had my colleague, Marten Hogeweg, present in Seattle on that specific issue and how to maintain the assets and ensure that the port knows where everything is at.

I think it is a critical function for the HSRP to weigh in on how important the shore site infrastructure related to the ocean is, as was demonstrated over the weekend with Irma coming into shore. Many of those coastal regions may not be as well-known as they need to be.

Do you have maybe a further elucidation of where you were going with that comment?

DR. MAYER: That's a question for me?

MR. NOLL: Yes.

DR. MAYER: No, it was just a thought that as we push and develop the autonomous systems, there may be a parallel infrastructure -- a shore-based infrastructure that could really expedite and improve their efficiency and use and that it may not be an expensive infrastructure. But I don't think we've thought much at all about that, and I think it goes beyond just the autonomous vehicle question, I think, as you say, that the more that we can invest in understanding the ports, the better off we are.

MR. NOLL: Maybe just a follow-up. You mentioned -- or I think Doug mentioned during the response the Tesla example. Now, of course, the Departments of Transportation already have a framework and a data infrastructure and a data model for automobiles to travel on. And then those are augmented by the actual remote sensing that automobiles are doing in real time.

I think something similar needs to happen for the seaway, right, just like the highway. And right now, we don't have that. Certainly, hydrographic vessels participating in this drone mapping would be participants in creating that infrastructure, and maybe it's the data modeling that needs to be set up.

CHAIR HANSON: We were just chatting about all the agency opportunities to get engaged in that, not just NOAA but also Maritime

Administration, CMTS, all those groups that could be involved in that. But certainly not doing things the way we've always done them is something that these types of panels should be advocating for and can be.

So I think we're done for the morning. Do you have anything?

RDML SMITH: I don't. I just want to echo thanks to our panel. It was very thought provoking. I wish we had another half hour for discussion, because there's a bunch of threads to pull on there. But I hope at least some of you will be around for a little while, and we can continue the conversations on the side. So thank you.

CHAIR HANSON: Great.

MS. MERSFELDER-LEWIS: So the HSRP members, if you would just stay here for five minutes, Larry and Andy will talk to you about your afternoon and tomorrow afternoon. The rest of you guys, we'll see you tomorrow if you're attending. We love that you -- we had a full room. We're very happy to see who came, and thanks very much. And then we are going to go to the rooms, drop your stuff, and board the trolley as quickly as possible.

(Laughter.)

MS. MERSFELDER-LEWIS: We're in great time. Carol did a great job moderating.

(Whereupon, the above-entitled matter went off the record at 12:17 p.m.)

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C E R T I F I C A T E

This is to certify that the foregoing transcript

In the matter of: Hydrographic Services Review Panel Public Meeting

Before: National Oceanic & Atmospheric Administration

Date: 09-11-17

Place: Portsmouth, New Hampshire

was duly recorded and accurately transcribed under my direction; further, that said transcript is a true and accurate record of the proceedings.

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