OCEANS ATMOSPHERE TERRESTRIAL SPACE

NOAA Emerging Technologies Workshop II for Observations

August 22-23, 2017
College Park, MD

Prepared by Technology, Planning and Integration for Observation

Preface

The NOAA Observing Systems Council (NOSC) hosted its second workshop on Emerging Technologies for Observations (ETW) on August 22 and 23, 2017. Due to the success of the first workshop in 2016, the NOSC expanded the workshop into a two-day event and invited scientists from both within the Agency as well as NOAA's external partners in the private sector, including members of academia, industry, other governmental agencies, and affiliates to NOAA. The event was held at the NOAA Center for Weather and Climate Prediction (NCWCP) in College Park, Maryland, with 260 participants in attendance.

The 2017 ETW theme was "Technology toward a mission-effective, integrated, adaptable, and affordable observation portfolio." The workshop included seven sessions that enabled NOAA leadership to interact with researchers, analysts, and practitioners from space, atmosphere, terrestrial, and oceans observing domains. Day One consisted of four sessions in which speakers from NOAA and NOAA affiliates examined emerging technologies from each observing domain. Day Two consisted of two sessions in which speakers from the private sector focused on identifying ways to fill specific gaps in NOAA's observing system portfolio. The remaining session was a cross-cutting session discussing data management and analytics. The workshop concluded with an interagency panel session to share ideas on how to transition emerging technologies to operational use within their own agencies and organizations. The workshop featured 34 presentations and 40 poster gallery exhibits.

The workshop hosts were the Observing Systems Committee (OSC) co-chairs, Mr. Joseph Pica (National Weather Service) and Mr. Richard Edwing (National Ocean Service). This report contains summaries of the keynote speeches and main presentations, followed by a summary of the panel discussion, and recommendations for future workshops. The appendices contain the ETW agenda, conference links, and post-workshop survey results.

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Keynote Address

Dr. Stephen Volz
Assistant Administrator for Satellite and Information Services;
Acting Chair of NOAA's Observing Systems Council (NOSC); and
Acting Assistant Secretary for Environmental Observations and Prediction

The Emerging Technologies Workshop (ETW) is the key to managing, directing, advancing, and improving NOAA's breadth of observing systems and information gathering services. This responsibility is felt keenly by NOAA and all of NOAA's partners because we recognize the value of what we do, even when it is not realized by those who receive and utilize our services.

Over the past two years, NOAA has used the ETW to look at how new data and new observation systems can be productively and effectively integrated into existing structures. NOAA uses the ETW to try to determine how NOAA can not only stay fresh with current technology, but how NOAA can stay at the cutting edge of technologies for observations and predictions to maintain its position as the leader of Earth observations nationally, as well as globally. As such, one of the key challenges that NOAA and its commercial and academic partners face is determining how to enhance and expand existing observing systems.

NOAA has the responsibility to observe the whole planet. NOAA's charter is to observe the planet, understand what is observed, and to protect and inform the U.S. public so that they can make accurate and reliable decisions based on the information provided. In short, one of NOAA's goals is to provide the public with knowledgeable information that they can actually work with.

NOAA uses an incredible breadth of observing systems that span from the bottom of the ocean to the surface of the sun. Making observations that encompass the entire planet and its atmosphere is one of NOAA's greatest challenges. The first part of this challenge is simply making the observations. The second part of this challenge is making observations consistently, reliably, and productively over the long term.

For the past two years, NOAA's Observing Systems Council (NOSC) and its partners and research organizations have worked to integrate the platforms users utilize to determine how all of the observing systems can most effectively work together. NOSC has determined that it is critical that these systems be managed as a single system rather than a multitude of separate observing systems.

One of NOAA's most significant challenges is determining how older but still well-performing systems can evolve into new systems that perform just as well or better in the future. Specifically, NOAA is faced with the challenge of taking older systems that have been in place for years and evolving them so that in 10, 20, and 30 years NOAA is using the best technologies with the best capabilities. In the past, the government would likely have been able to provide solutions for each observing system; however, in the future, solutions for evolving observing systems will almost certainly not come solely from the government. Instead, new solutions will likely come from the commercial sector as well. For instance, commercial systems are already providing quality weather observations in some areas, and NOAA is working with the commercial sector to determine how the government and commercial sectors can work together to deliver new observing systems in an integrated systems architecture.

It is NOAA's role as part of the government and as the integrator of all observing systems to ensure that the products and services provided to the public are consistent and reliable so that users do not have to worry about where data comes from. NOAA and its interagency, international, and commercial partners are part of a brand defined by reliability and accuracy. As part of this, NOAA's role in the ETW is to determine how best to merge new technologies and capabilities, including through partnerships with national and commercial sectors, into existing observing systems. Successful merging of these elements will allow NOAA to retire older observing systems while simultaneously deploying new observing systems, which will provide a seamless delivery of services and information.

Currently, one of NOAA's most critical services is providing a context for its forecasts and observations. NOAA uses archival and current datasets to provide context to help determine whether an event is an anomaly or typical for a specific phenomenon. NOAA must continue to provide this context, and having the best observing systems is crucial to maintaining an observing context that allows us to see how different observations fit together. As part of this, one of the enduring ETW goals is to refresh existing observing systems. NOAA has well-performing systems, but they are ageing and are ready to be replaced or invigorated with new technology. The observing system challenge that NOAA faces is how to integrate new datasets and new capabilities into our operational systems. Often the focus is on the observing systems themselves when we should actually be focusing on why the observations are needed, who the users are, and what is the expected impact of the measurements and information. Also of importance is how NOAA provides the translation between the observing systems and the information products we provide. Ultimately, NOAA must begin with the requirements of the user community, interpret new technologies to determine if they are usable and compatible with existing and future systems, and provide the new capabilities in a sustainable and consistent way.

An example of how NOAA is replacing an older observing system with a new observing system is happening right now with the global ocean buoy system. NOAA deploys ocean buoys around the globe that provide information on sea surface conditions, salinity, temperatures, and surface weather conditions. The buoys used in NOAA's legacy buoy network, while reliable, are big, bulky, difficult to deploy, hard to re-service, and have reached the end of their service life. As such, NOAA's National Data Buoy Center developed a replacement buoy system, the Self-Contained Ocean Observations Payload or SCOOP, that is modular, more compact, less labor intensive, easier to deploy, and uses new technologies that can provide the same information. By the mid-2020s, the SCOOP system will have completely replaced the older system. NOAA's challenge, however, is not simply to replace older observing systems, but to continually refresh and replenish all existing and new observing systems whether they are buoys, aircraft measurements, satellites, or any of the other myriad observing systems that NOAA employs. The current example is one of an individual replacement, but other situations could be more significant and require architectural changes.

Ultimately, NOAA's key challenge is to determine the viability of new emerging technologies and how they can be integrated and merged into existing observing systems. Forums such as the ETWs are crucial to this endeavor because they keep us informed of current capabilities and what is on the horizon of being viable for observing systems. The ETW also provides a forum for ongoing dialog between NOAA and the commercial and research communities to discuss user needs, NOAA systems requirements and capabilities, and future plans and opportunities. Merging and integrating new technologies does not happen overnight, but NOAA is committed to identifying incremental steps and midterm projections and activities that allow us to make better informed decisions for our observing systems.

Workshop Sessions

The goal of the Emerging Technologies Workshop is to promote a broader awareness of new innovations and technologies that are on the horizon and could potentially be incorporated into NOAA's observing system portfolio. This year's workshop maintained a strong focus on the four primary domains (space, atmosphere, terrestrial, and oceans), but also expanded to include two requirements gaps sessions, a data management and analytics session, and an emerging technologies panel discussion. The theme of the workshop, "Technology toward a mission-effective, integrated, adaptable, and affordable observation portfolio," was integral to all of the sessions.

The Emerging Technologies Workshop is part of an important effort to establish more forums for sharing ideas, technologies, challenges, and encouraging greater collaboration among different sectors and fields. The workshop is instrumental in helping to determine where synergies might occur among different sectors, and forging meaningful partnerships for collaboration.

This year's ETW included two Request for Information (RFI) requirements gaps sessions, the "Oceans Requirements Gaps Session" and the "Land-Atmosphere Requirements Gaps Session," that were intended to address unfulfilled high priority requirements that are limiting the performance of NOAA due to lowered performance of highly relevant products associated with requirements. The products and technologies included in the two RFI requirements gaps sessions were solicited through an Acquisition of Grants Office (AGO) RFI that targeted commercial vendors with proven technical capabilities appropriate for fulfilling information gaps. To identify which specific products to include in the ETW, NOAA employed a gap analysis methodology to determine which products, if improved, would yield appreciable "top-node" improvements (~33%) at the mission and NOAA level, and which products had room for improvement and were highly relevant and impactful to NOAA. Additional and more in-depth criteria were also utilized to identify the most appropriate and relevant products.

This year's workshop also included a new session on Data Management and Analytics. The Data Management and Analytics Session was added to address the growing importance of data in observing systems. Fully utilizing data and analytics is critical for maximizing the capabilities and potential of observing systems. The inclusion of a Data Management and Analytics Session highlights the importance of data, data management, and data analytics in observing systems, and provides a platform for sharing information on how to integrate, manage, and maximize data capabilities.

Appendix 2 contains links to all of the conference materials. The session write-ups include summaries of the presentations. Each workshop session concluded with a question and answer session in which audience members used the smartphone app "Slido" to submit questions to the panel moderator. The Slido app is specifically designed to facilitate audience interaction. Use of the app streamlined the question and answer sessions, and allowed all members of the audience to submit their questions for possible discussion.

Space Session

Day 1 – August 22, 9:00 – 10:20

Session Chair: Dr. Frank Gallagher, NESDIS

Panel Members:
Dr. Jim Yoe for Dr. R. Michael Hardesty, OAR/ESRL
Dr. Cinzia Zuffada, Cal Tech/JPL
Dr. Alejandro Egido, NESDIS STAR
Dr. Dennis Socker, NRL
Mr. Daniel St. Jean, NESDIS

The panelists answered questions from the audience in an open question and answer period at the end of the Space Session. Topics included the challenges of assimilating lidar-based wind measurements, current observations from next generation environmental space remote sensing instruments, the next phase for next generation environmental space remote sensing instruments, the goals of commercial weather data, obtaining bathymetry data from altimetry, steps taken to prevent infrastructure damage after a CME (coronal mass ejection) has been identified, a timeframe for when the U.S will have a 3D wind mission, using assistive data to improve bathymetry, and from where the requirements for next generation environmental space remote sensing instruments are coming. Summaries of the discussions are provided below.

Even with advancements in technology, challenges always remain. Dr. Yoe answered questions on the challenges of assimilating lidar-based wind measurements. Dr. Yoe explained that Observing System Simulation Experiments (OSSEs) have been essential for providing critical information for establishing a strategy.

Understanding the types of observations every observing system makes is critical to a successful observing systems portfolio. Dr. Zuffada answered questions on the types of observations provided by next generation environmental space remote sensing instruments. Dr. Zuffada explained that some of the observation abilities in the trade-space are variable. Dr. Zuffada further explained that the observations provide steady-state architectures with a constellation of capabilities. Dr. Zuffada noted that constellations have been eliminated in the trade-space, and that the remaining constellations are now a subset of the original constellations.

Discussing the future direction and potential of new technologies is critical to advancing future research directions. Dr. Zuffada answered questions on the next phase of the instruments catalogue. Dr. Zuffada explained that the technology is a development roadmap. Dr. Zuffada noted that developments are intertwined and require close cooperation for coordinated development. How data is used is as important as the data itself. Mr. St. Jean explained that it is not their goal to have their data used in the Big Data Initiative. Mr. St. Jean further explained that the data from the first pilot is restricted to the NOAA community and related third parties. Mr. St. Jean noted that the data from the second pilot will be open to NOAA core partners (EUMETSAT). Mr. St. Jean stated that cloud implementation is outside the scope of the project.

Exploring the capabilities of technologies is essential for establishing their uses. Dr. Egido answered questions on whether it is possible to obtain bathymetry data from altimetry. Dr. Egido explained that the resolution needed to map the bottom of the ocean depends on the processing technique. Dr. Egido further explained that the process could potentially result in significant

improvements in bathymetry measurements. Dr. Egido noted that CYGNSS is very sensitive to wetlands and soil moisture.

Technology's ability to predict, identify, and help prevent damage is crucial. Dr. Socker answered questions on the compact coronagraph's ability to identify a CME and subsequent steps taken to prevent infrastructure damage. Dr. Socker explained that once a CME is identified, a notification indicating a potential event is triggered. Dr. Socker further explained that assets at L1 help produce a 45-minute alert.

Advances in technology implementations are sometimes hindered by factors other than a lack of technology itself. Dr. Yoe answered questions on a potential timeframe for when the U.S will have a 3D wind mission. Dr. Yoe expressed his opinion that it is a matter of will. Dr. Yoe clarified that the U.S is close to having the technology required to undertake a 3D mission, but the lack of commitment to such a mission is preventing its realization.

Data collaboration is more crucial than ever, especially in terms of producing information rather than just data. Dr. Egido answered questions on whether they have reached out to better-equipped communities to collect assistive data in terms of bathymetry. Dr. Egido explained that they have reached out to other communities, and that it is an ongoing process that they hope to continue.

Requirements can come from many factions and have a significant impact on the resulting technologies and capabilities of those technologies. Dr. Zuffada answered questions on whether requirements for instruments and technology were coming from users. Dr. Zuffada explained that the NWS has worked to make requirements mission-driven. Dr. Zuffada further explained that they used the Satellite Needs Working Group (SNWG) to create a set of environmental data models that produced a set of capabilities that they then reverse-engineered to develop constellations.

Atmosphere Session

Day 1 – August 22, 10:50 – 12:10

Session Chair: Dr. James O'Sullivan, NWS

Panel Members:
Dr. Jamie Dyer, Mississippi State University
Dr. Vijay Tallapragada, NWS/NCEP
Ms. Lisa Bucci, OAR/AOML
Dr. Joseph Cione, OAR/AOML
Dr. Changyong Cao, NESDIS/STAR

The panelists answered questions from the audience in an open question and answer period at the end of the Atmosphere Session. Topics included FAA and commercial regulations that limit deployments, biases and errors in UAV measurements, interest in developing a 100-meter profiler for the ocean, the restrictions of small sample sizes in smartphone GPS capabilities testing, using smartphones to measure pressure and temperature, the wavelength at which airborne wind liars operate, improving observations to reduce errors in hurricane intensification, other potential uses of the UAS platform, the use of shear probes and fast thermistors in UASs, the uses of data for rawinsondes, phasing out XBTs, using large data systems to correct data, and societal fears concerning geolocation tracking and its impact on smartphone GPS capabilities research. Summaries of the discussions are provided below.

FAA and commercial regulations can limit the deployment and utility of observing aircraft. Dr. Dryer answered questions concerning the regulations affecting UASs. Dr. Dryer explained that FAA requirements necessitate the need for both a certified pilot and observer, and that UASs must be flown below 400 feet.

Biases and errors are an issue in data analysis. The panelists answered questions concerning unexpected biases and errors in UAVs. The panelists explained that the biggest problems result from radiation shielding, and that these biases are minimized by using alternating mounting scenarios. The panelists further explained that it is necessary mount multiple sensors on the same UAV to see if the measurements correlate. The panelists stated that another significant issue with UAV measurements is how you mount the sensors because differences in mounting can yield several different answers. The panelists stressed that it is difficult to find a correct sensor mounting location because the measurements cannot be compared to other measurements.

New capabilities are often not developed if they are not explicitly requested. Dr. Cione answered questions on whether there is currently interest in developing a 100-meter ocean profiler. Dr. Cione explained that there is a Small Business Innovation Research (SBIR) group that is looking into a scaled down version of the AXBT. Dr. Cione further explained AXBTs are bulky and take up an inordinate amount of space that limits the amount of personnel for missions. Dr. Cione noted that the SBIR is looking to combine the dropsonde with a mini-ABXT, and that the cost would be approximately 1.5 times less than the cost of a dropsonde. Dr. Cione mentioned that the combination dropsonde and mini-AXBT would have the additional ability to provide profiles.

Small sample sizes are often problematic for researchers. Dr. Cao answered questions on how the poor dissemination of the newest Android software updates and the resulting small sample size affected his research on the GPS capabilities of smartphones. Dr. Cao explained that a larger

number of observations are needed for analysis because every cell phone can potentially be affected by a clock bias, which is an issue that must be addressed. Dr. Cao further explained that they are currently comparing the results from cell phones to the results from base stations. Dr. Cao noted that a significant challenge is that even when the carrier phase is available, many cell phones use duty cycling which provides only a portion of the data that is needed.

Expanding the capabilities of existing technologies is critical to every observing system. Dr. Cao addressed questions on whether smartphones, in addition to providing measurements for integrated precipitable water, could also provide measurements for pressure and temperature. Dr. Cao explained that by using radio occultation smartphones can provide measurements for pressure and temperature, but that it is limited to use on mountaintops when GPS satellites are either rising or setting. Dr. Cao noted that this is a significant limitation, but that it can be done. Dr. Cao also stated that there is existing software that can provide these measurements.

Knowing the precise operational requirements necessary for observing systems is crucial for ascertaining product utility and viability. Ms. Bucci answered questions on the wavelength requirements for airborne Doppler wind lidar. Ms. Bucci explained that the airborne Doppler wind LIDAR operates on a wavelength of 1.6 photons, and that it has a very low energy of 1 MJ.

Real-time data observations are often challenging for observing systems. Ms. Bucci fielded questions on the computer systems and processors being explored for real-time data measurements in the airborne Doppler wind lidar. Ms. Bucci explained that currently they are exploring using an FTP website, but that they would like to have a website that automatically updates plane location, recent satellite images, and the profile of the data collected.

Improving measurement capabilities and reducing errors is critical to observing systems. The panelists answered questions concerning the most critical ocean observations needed to reduce errors in hurricane intensification. The panelists explained that in situ observations, especially for sub-surface cooling, are essential and available in XBT data. The panelists noted that similar data may be available from emerging gliders. The panelists stressed that the most important factor is improving existing models. The panelists explained that improvements in the models will allow users to take better advantage of observations, as well as data assimilation techniques. The panelists also noted that a better understanding of the underlying physics and processes is necessary, which means there is a need for more samples. The panelists emphasized that having a better understanding of the physics and processes will create more accurate models.

Fully utilizing existing technology includes determining all of its potential applications. Dr. Dyer addressed other potential applications of the UAS platform. Dr. Dyer explained that the UAS could be used for determining crop health, growing cycles, and soil moisture. Dr. Dyer further explained that agricultural meteorology is one of the primary applications of the technology. Dr. Dyer noted that the UAS could also be used to study sea breeze formations and small-scale circulations in rivers and lakes. Dr. Dyer stated that the current maximum altitude of the UAS is 1,000 feet.

The applicability of specific products and processes vary for every type of technology. The panelists answered questions on whether shear probes or fast thermistors can be used for measuring speed and stress in UASs. The panelists explained that they do not use shear probes or fast thermistors. The panelists further explained that they use low-cost sensors because they have the best instrument response time. The panelists noted that sensor response is a critical issue in UASs. The panelists stressed that advancements in sensor response time are needed.

Data is critically important, but it cannot always be assimilated into existing models due to a lag in technological capabilities. The panelists answered questions on the utility of data collected from

UAVs for rawinsondes that cannot be assimilated into existing models. The panelists acknowledged that while all of the data from UAVs cannot be assimilated into models, the data itself is still essential to exploring multiple factors, such as small-scale processes over varied terrain and turbulence flexes. The panelists stressed that it is important to separate data assimilation issues from model improvement issues.

As technologies age, they are often phased out and replaced by new technologies with more or improved capabilities. Dr. Cione answered questions on why XBTs are being phased out, especially when other observation platforms struggle to reproduce its spatial sampling from instruments deployed from aircraft. Dr. Cione explained that XBTs were first built in the 1980s and that there are very few XBTs in existence. Dr. Cione further explained that XBTs are excessively large and heavy, and the amount of space available for personnel has to be restricted to accommodate the size of XBTs. Dr. Cione also noted that when deployed, XBTs require a lot of resources in terms of the number of XBTs needed and the number of days necessary for sampling. Dr. Cione stressed that XBTs are no longer practical.

Data systems are often used to correct data. Dr. Cao answered questions on specific types of large data systems used to correct data. Dr. Cao explained that having a lot of users creates a large dataset, and that each input can potentially be biased or otherwise have problems that cannot be corrected on the user's side, which requires correction from a centralized location that uses smart algorithms to determine which inputs are biased. Dr. Cao noted that they are exploring architecture systems that can make corrections, but their explorations are in the preliminary stage.

Utilizing and tracking geolocations has created societal fears over privacy rights. Dr. Cao answered questions on whether he utilizes geolocations in his research on the GPS capabilities of smartphones. Dr. Cao acknowledged that geolocations have definitely sparked fears within society, and that Google's decision to enable such a feature is a larger issue. Dr. Cao noted that, from a research point of view, knowing the geolocation of smartphones is useful for making higher quality weather measurements with the aid of small devices attached to the back of the smartphones.

Terrestrial Session

Day 1 – August 22, 13:40 – 15:00

Session Chair: Dr. Hernan Garcia, NESDIS

Panel Members:
Dr. Siwei Li, Howard University/NOAA Center of Atmospheric Science and Meteorology
Dr. Manoj Nair, NESDIS/NCEI CIRES
Mr. Mark Miller, NWS/OBS
Dr. Jonathan Munoz-Barreto, University of Puerto Rico
Dr. Belay Demoz, UMBC

The panelists answered questions from the audience in an open question and answer period at the end of the Terrestrial Session. Topics included the power requirements of the radiosonde auto launcher, correcting magnetic offsets from different phones in CrowdMag (an App to see if digital magnetometers built in smart phones can be used as scientific instruments), ownership of shared data from the CrowdMag App, and the Automated Surface Observing Systems (ASOS) National Lidar Network and how it should be cited, research observations of NOAA's CrowdMag Project, citizen sourcing of CrowdMag data used by high school students or commercial industries, whether CrowdMag can be used for mapping in coastal environments, new technology on the horizon for the ASOS program, estimates of forecast improvements in radiosonde auto launchers deployed to remote areas to fill data gaps, issues preventing ASOS from receiving data every 15 seconds, gaps that remain across all sectors in government, academia, and commercial sectors in the development of new technologies, ongoing testing of radiosonde auto launchers in ocean environments, and how long sondes can be kept in storage before the balloons and sondes degrade. Summaries of the discussions are provided below.

Determining technologies' power requirements is essential for establishing overall capabilities and potential uses. Mr. Miller answered questions concerning the power requirements of the radiosonde auto launcher. Mr. Miller explained that the power requirements for the radiosonde auto launcher can be configured for 220 or 110 volts, and that testing in the United States is focusing on 110. Mr. Miller noted that there are currently two vendors that provide packages with 24 or 12 radiosondes, with work being done to increase these numbers.

Technologies' ability to correct for myriad issues that arise during use is critical for usability and viability. Dr. Nair answered questions on whether CrowdMag has the ability to correct for magnetic offsets from different phones. Dr. Nair explained that currently CrowdMag cannot correct for magnetic offsets from different phones, in part because different manufacturers have different offsets that they cannot access. Dr. Nair noted that they are tracking 800 different phones in the hopes that tracking more phones will yield a normal distribution of the different offsets. Dr. Nair stressed that they are currently working on a program to improve calibration.

Determining ownership and proper citation of shared data can be difficult. The panelists addressed questions on who owns shared data from the CrowdMag App and the ASOS National Lidar Network and how it should be cited. The panelists explained that CrowdMag data are owned by NOAA, stored securely in a database, and protected by access privileges so that few people have access to it. The panelists further explained that the CrowdMag application protects the privacy of phones by not independently identifying individual phones, accessing any information on those phones, or collecting emails and other Personally Identifiable Information (PII). The

panelists noted that they have not had an instance where the data has needed to be cited because the data collected are completely anonymous. The panelists stressed that NOAA owns all data collected from the National Lidar Network and it would be cited accordingly in published papers.

Observations are critical for directing research initiatives. The panelists addressed questions concerning the research observations of NOAA's CrowdMag Project. The panelists explained that their research observations have improved the model and enhanced the model's predictions regarding aerosols and air quality. The panelists further explained that, similar to climate modeling, it is necessary to compare the model output to actual observations that allow you to ground truth model predictions and make adjustments to the model for more accurate runs later. The panelists noted that more observations allow for the development of a better understanding of the physics behind the model.

Providing data to the public is essential for highlighting the capabilities and importance of observing systems. The panelists answered questions on citizen sourcing of CrowdMag data used by high school students or commercial industries. The panelists explained that the CrowdMag project is working on making an external sensor for cell phones for use by high school students so that they can better understand the properties of magnetic fields generated from atmospheric interference. The panelists further explained that CrowdMag can be used to create urban magnetic maps, and that it can potentially be used to supplement GPS positioning. The panelists noted that there are no current cases of CrowdMag being used commercially, but that there are potential commercial uses.

Coastal mapping is more important than ever in light of severe weather and rising water levels eroding coasts. The panelists answered questions on whether CrowdMag could be used for mapping in coastal environment by collecting data from marine environments. The panelists explained that CrowdMag is not suitable for coastal mapping because it is hard to get a location fix in areas where there is not adequate coverage from cell tower connections. The panelists further explained that some NOAA ships have provided magnetic data to the program, but so far that has been rare.

Being aware of new technologies on the horizon is critical, and is the rationale behind the ETW. Dr. Demoz answered questions on new technologies that are on the horizon for the ASOS program. Dr. Demoz explained that the ASOS program is currently undergoing service life extension programs, including essential updates. Dr. Demoz further explained that the communication system is transitioning to an Internet Protocol (IP) communication mode to be followed by standard sensor replacement. Dr. Demoz noted that due to the preoccupation with service life extension programs they are not aware of new technologies on the horizon.

Eliminating data gaps is crucial to having complete datasets. Mr. Miller answered questions on whether there is an estimate of forecast improvement for radiosonde auto launchers deployed to remote areas to fill data gaps. Mr. Miller explained that currently they are not considering putting radiosonde auto launchers in remote areas. Mr. Miller further explained that they have been looking into putting stations in areas where no stations currently exist, such as the four corners area or locations in Kentucky. Mr. Miller clarified that the goal of their study is not to find gaps that can be filled by radiosonde auto launchers, but to identify gaps and then determine how to best fill them using the entire observation portfolio so that the best system(s) are used.

Consistent data observations are crucial for observation systems and creating datasets. Dr. Demoz answered questions on what has been preventing the ASOS from obtaining data at set 15 second intervals. Dr. Demoz explained that recent updates to the old communications and operating system are preventing this function, and that they have vendors addressing the issue.

Dr. Demoz clarified that it is a case of the system sensors infrastructure requiring updates to meet network connection capabilities.

Gaps in data affect all sectors involved in observing systems. The panelists answered questions on gaps that remain in government, academia, and commercial sectors, and how developing new technologies can address these gaps. The panelists explained that utilizing new instruments, and using new technologies that are low cost will reduce redundant efforts as well as facilitate local stakeholder use and use by other downstream institutions. The panelists stressed that determining exactly how new technologies will be used is essential for bridging gaps. The panelists further explained that much of the technology they need already exists, and that it is a matter of identifying and applying these existing technologies to facilitate data needs through coordination between the government, academia, and the commercial sector. The panelists stressed that creating a common data format and a data policy for crowd sourced data are critical steps in establishing improved collaboration between all of the sectors.

Testing is essential for establishing the exact uses of new technologies. Mr. Miller answered questions on whether radiosonde auto launchers are being tested in ocean environments. Mr. Miller explained that while other countries are exploring this idea, NOAA is not testing for that capability. Mr. Miller noted that while it is not currently being investigated, prototyping is possible in the future.

Knowing the shelf life of products can be critical for successfully completing missions. Mr. Miller answered questions on how long a sonde can be kept in storage before the balloon and sonde degrade. Mr. Miller explained that while there is no set term for how long sondes can be kept in storage, they do know that the possibility of degradation increases with the amount of time radiosondes sit in the launcher before they are used, especially in terms of handling the balloon.

Oceans Session

Day 1 – August 22, 15:30 – 16:50

Session Chair: Mr. Charles Alexander, OMAO, for Mr. John McDonough, OAR

Panel Members:
Capt. Edward J. Van Den Ameele, NOS/OCS
Ms. Elizabeth Lobecker, OAR/OER
Dr. Ruhul Amin, NMFS/PIFSC
Dr. Gustavo Goni, OAR/AOML
Dr. Gijs de Boer, OAR/ESRL

The panelists answered questions from the audience in an open question and answer period at the end of the Oceans Session. Topics included air deployed micro buoys, differences in required sea time between traditional mapping and telepresence mapping, running multiple Autonomous Surface Vehicles (ASVs) simultaneously from a single mothership, the maximum sea stay for unmanned surveys, the different sampling strategies of gliders and Airborne eXpendable Bathy Thermographs (AXBTs), and how theoretical increases in funding would affect the panelists' fields. Summaries of the discussions are provided below.

Air-deployed micro buoys are used for Conductivity, Temperature and Depth (CTD) sensors. The panelists addressed the current limitations of micro buoys. The panelists explained that one of the biggest limitations of micro buoys is their inability to reach deeper levels while maintaining buoyancy and strain, as well as remaining small enough in size that they can still be deployed by air. The panelists further explained that creating an electronic system for micro buoys that could reach deeper levels would be difficult because the system would need to be able to take hundreds of temperature samples at one-meter resolution which is a formidable task. The panelists mentioned that there are commercially available conductivity cells that could be of use.

Telepresence mapping uses modern computer networks and a high-bandwidth satellite connection to enable remote users to participate virtually in ocean research and exploration cruises. One of the benefits of telepresence mapping over traditional mapping is the reduced amount of time spent at sea by personnel. The panelists were able to quantify this difference by explaining that traditional mapping required at least 100 days at sea while telepresence mapping required only three weeks of sea time. The panelists related that the reduction of time spent at sea greatly improved personnel's productivity and quality of life. The panelists also stated that telepresence mapping is ultimately more productive, effective, and practical, especially in terms of fully utilizing personnel resources.

ASV surveys have great utility but multiple ASV surveys cannot currently be run simultaneously from the same mothership. The panelists explained that while creating this capability is definitely the direction they are heading in, there are challenges to accomplishing such a goal. The panelists stated the one of the major challenges is the amount of personnel currently required to monitor one ASV survey. Current monitoring requires a team of six individuals for a 24-hour period, although ideally that will be reduced to a team of three members with future advancements. The panelists also discussed how the increase in autonomous technology could potentially be used to create an autonomous system that would not have to be monitored by individuals, which could streamline the process and alleviate the reliance on personnel.

Ascertaining the maximum sea state for unmanned surveys is critical for safe operations. The panelists explained that AUVs have a maximum sea state of three, four, or five foot seas depending on the host vessel. The panelists further explained that the biggest challenge and limitation of AUVs is getting them in and out of the water. The panelists mentioned that maneuvering AUVs when they are close to the host vessel requires extreme precision and can sometimes pose difficulties. The panelists also discussed how potential enabling technologies are on the horizon and could improve the capabilities of AUVs.

Gliders and AXBTs both play an important role in observations, yet each utilizes different sampling strategies. The panelists stated that they had great appreciation for both platforms, but that AXBTs have more value because no other platform can reproduce the type of data and operations that AXBTs are capable of providing. The panelists further explained that AXBTs are unique in that they can be deployed from both ships and aircraft, and they can provide both atmospheric observations and ocean profile observations. The panelists also discussed the significant benefits and capabilities of gliders, especially the extended coverage they provide and their ability to be recovered, refurbished, and re-deployed. The panelists concluded by stating that AXBTs and gliders complement each other, as well as Argo (an international program that uses profiling floats to observe temperature, salinity, and currents).

Meager or inadequate funding is an issue that affects every field. The panelists discussed how a theoretical doubling of their funding would affect their field and capabilities. The panelists explained that a theoretical increase in funding would allow them to increase the scale of their projects and capabilities, speed up much of the work they do, and ultimately enable them to work more efficiently and productively. The panelists also stated that one of the biggest benefits of an increase in funding would be the ability to have dedicated personnel in roles that require extensive training and knowledge. The panelists explained that not having dedicated personnel for some of the more intensive technological aspects of their jobs is a significant challenge, and repeatedly having to find individuals with the technology skills and knowledge they require is time consuming and inefficient.

Oceans Requirements Gaps Session

Day 2 – August 23, 8:45 – 10:00

Session Chair: Mr. Carl Gouldman, IOOS

Panel Members:
Capt. John Kusters, General Dynamics - Applied Physics Sciences
Mr. Paul Seiffert, Maritime Applied Physics Corporation
Mr. Doug Wilson, Caribbean Wind LLC
Mr. Sebastien de Halleux, SailDrone, Inc.

The panelists answered questions from the audience in an open question and answer period at the end of Ocen Requirements Gaps Session. Topics included how the FutureWaves Wave and Vessel Motion Forecasting System compares to the wave buoy network, GARC Rapid Ocean Observing Vessel (GROOV's) ability to self-right in large waves, managing vandalism at sea, avoiding debris for unmanned surface vehicles, the geographic, seasonal, and latitudinal limits of SailDrone's solar powered instrumentation, FutureWaves' ability to resolve wind and swell waves and its sea state limitations, the challenges of working with the government, and NOAA's ability to purchase new and emerging technology given its restricted budget. Summaries of the discussions are provided below.

Comparisons between emerging technologies' capabilities and currently used technologies' capabilities are critical for ascertaining the viability of incorporating or utilizing emerging technology. Capt. Kusters responded to questions on how FutureWaves Wave and Vessel Forecasting System compares to the wave buoy network. Capt. Kusters explained that the FutureWaves system uses the same band as Coastal Data Information Program (CDIP), and that it has a 90% correlation to wave height and an 80% correlation for wave direction. Capt. Kusters also mentioned that surface currents could be a potential capability, and they are looking to work on creating that ability.

The ability for unmanned vessels to self-right at sea is a critical capability. Mr. Seiffert and Mr. Wilson explained that GROOV has an option to self-right; although they clarified that GROOV can operate in sea states of six to seven feet without needing the self-right option, which is an impressive capability.

Vandalism of unmanned vessels at sea is a continuing issue of concern. Mr. de Halleux noted that vandalism is a big problem for NOAA's infrastructure. Mr. de Halleux explained that the SailDrone Unmanned Surface Vehicle does not appear on standard charts which makes it extremely difficult for individuals to locate and vandalize. Mr. de Halleux further explained that you have to be within half a mile of the SailDrone to see it. Mr. de Halleux also noted that the SailDrone is made of composite materials so there is nothing of value that would encourage or otherwise entice vandals. Additionally, the vehicle is large which makes it difficult to steal. Mr. de Halleux pointed out the SailDrone's onboard collision avoidance and speed capabilities are also useful for preventing vandalism. Ocean debris poses issues for unmanned vessels. The panelists explained that there are currently no active features or capabilities that allow for the avoidance of ocean debris, but that operating speeds, specifically the ability to move quickly, can mitigate the problem.

Solar powered instrumentation can be limited by geography, season, and latitude. Mr. de Halleux explained that SailDrone's solar powered instrumentation can operate at 75 degrees N without

issues. Mr. de Halleux also mentioned that SailDrone is implementing small wind turbines to provide additional power.

The limitations of unmanned vessels to resolve wind and swell waves, as well as the overall sea state are critical issues. Capt. Kusters explained that FutureWaves has the capability to resolve both types of waves, and that it can operate at sea state 5 with little to no errors. Capt. Kusters also noted that, theoretically, FutureWaves could operate at a sea state 8 with a 95% resolution, but that it is limited by ground truthing.

Technologists within the marine and ocean arena have to overcome various challenges when working with the government. The panelists highlighted some of the most significant challenges they faced when working with government agencies. The panelists stated that getting sufficient operational test and evaluation time to demonstrate the technology is problematic. The panelists also noted that even when technologies are proven (TRL 8-9) it is still difficult to identify pathways for implementing and integrating the technology in operation frameworks. The panelists stated that having more in-depth discussions and forums such as the ETW would be beneficial, as would having a central website to share information on technologies that different agencies are using.

NOAA has a restricted budget that makes it difficult to purchase and incorporate new and emerging technology. Panelists stated that they are aware of NOAA's limited budget, and noted that the private sector has been working hard to reduce the costs of operations in light of that issue. The panelists also suggested that NOAA could cut costs by exploring leasing options and only paying for data streams that have a maximum impact on NOAA's mission. The panelists emphasized that a key factor in reducing costs is expressing data needs to the private sector.

Final Points of Discussion

The Oceans Requirements Gaps question and answer session wrapped up with some final observations and points of discussion, including:

- The significant efforts and work within NOAA's research sector that have resulted in robust data dissemination systems.
- The need to make assets available to multiple users within NOAA.
- The importance of collaboration and coordination, and the need to formulate plans on how to best share data and successes.
- The fact that partnership is a two-way street. The private sector recognizes the importance of NOAA's work and the complex budget situation the country is in; however, the private sector needs the support of agencies and a way to compile all of the government's needs in order to develop and improve technologies.
- The need to create a systematic process for identifying requirements so that the private sector can address those requirements.

Land-Atmosphere Requirements Gaps Session

Day 2 – August 23, 10:30 – 12:15

Session Chair: Dr. James Yoe, NWS

Panel Members:
Dr. François Smith, MDA Information Systems LLC
Mr. Keith Barr, Lockheed Martin Corp
Dr. James Carr, Carr Astronautics
Dr. Sara Tucker, Ball Aerospace
Mr. Michael Kruk, Earth Resources Technology, Inc.

The panelists answered questions from the audience in an open question and answer period at the end of Land-Atmosphere Requirements Gaps Session. Topics included the estimated maintenance cost of the WindTracer Doppler Lidar, the use of MODIS (Moderate Resolution Imaging Spectroradiometer) and VIIRS (Visible Infrared Imaging Radiometer Suite) data as ancillary datasets for land cover classification, using OAWL (Optical Autocovariance Wind Lidar) to assess moisture content as well as winds, the power required to run OAWL from space, interacting with state and local governments to bring technologies into operation, using long-term climatology to validate products, possible commonalities among the presented technologies and ways to leverage and complement existing efforts, analysis packages for analyzing data, comparisons between 2-satellite measurements and 3-satellite measurements, whether Doppler lidar winds can provide sufficient power for a 3-year mission, and land cover data usage for assimilation into NWP (Numerical Weather Prediction) models. Summaries of the discussions are provided below.

Cost of maintenance is a critical factor in determining whether new and emerging technologies are feasible for government use. Mr. Barr addressed cost maintenance questions concerning the WindTracer Doppler lidar. Mr. Barr explained that the cost of maintenance varies tremendously depending on whether the systems were purchased outright or are being used as a data service. Mr. Barr advised that it would be more affordable for NOAA to opt for the data service plan, in which Lockheed would continue to own and operate the systems and pay for maintenance, and NOAA would make monthly payments for the data from the network.

The type of data technologies that systems use can often affect their feasibility for use in existing programs. Dr. Smith addressed questions concerning the use of MODIS and VIIRS data as ancillary datasets for land cover classification. Dr. Smith explained that they use MODIS for atmospheric correction, along with Landsat data. Dr. Smith further explained that most of the ancillary data they use are either derived from DEMS (Digital Elevation Models) or other datasets, including statistical data that are segmented from the imagery itself.

Determining the extent of new technologies' capabilities is critical for establishing their potential uses. Dr. Tucker addressed questions on whether OAWL can be used to assess moisture content as well as winds. Dr. Tucker explained that while lidar could be used to measure atmospheric moisture, the OAWL system as it is currently configured would not be optimal for that purpose. Dr. Tucker further explained that there are ways of assessing moisture content with other lidar

systems, such as differential absorption or Raman systems, but OAWL does not currently have that capability.

Determining power requirements and capabilities is essential for determining whether technologies are suitable for use in specific programs. Dr. Tucker addressed questions on the power requirements for running OAWL from space. Dr. Tucker explained that the power requirements for running OAWL from space depend on the mission requirements and the mission budget. Dr. Tucker further explained that the modules are currently limited to 500 Watts of power, which is the listed minimum power necessary for the Athena-OAWL. Dr. Tucker clarified that larger platform satellites (such as a free-flyer) could have more power availability, which would result in improved data products.

Data accessibility has long been a critical issue. The private sector often faces challenges when interacting with state and local governments in terms of bringing technologies into operation that create data accessibility. The panelists discussed some of the factors and issues of working at the microscale level. The panelists first explained that the difficulty levels of working with state and local governments vary depending on the industry. The panelists then explained that one of the greatest challenges is convincing current users that sharing data, which is a key factor in data accessibility, is advantageous. The panelists further explained that it can be difficult for state and local governments to find funding to acquire the data they want. The panelists stated that the Green Climate Fund is often crucial for small countries to be able to afford data. The panelists stressed that there are different answers for different types of systems, and that it is important to recognize that technologies work at different scales. The panelists noted that it is often easier to fund land cover products because of their more obvious utility. The panelists complimented NOAA on its Big Data Partners Initiative, which provides local governments and small operators with access to a broad spectrum of environmental data in a cloud environment. The panelists stated that the initiative was a powerful way to stimulate significant data innovation and exploitation.

Product validation is essential to assessing the viability and use of new products and technologies. Mr. Kruk addressed questions regarding the validation of products using long-term climatology. Mr. Kruk explained that they validated their product using a couple of NASA-developed interim programs, such as the NASA Develop Program. Mr. Kruk further explained that they had leveraged those resources to validate both the winds and precipitation capabilities of the product. Mr. Kruk stated that they have also used other satellites for intercomparisons, and that they collaborate with NOAA's CPC (Climate Prediction Center), but not with this product.

Collaborating across industries can often yield significant results and address important measurement gaps. The panelists addressed possible commonalities among their technologies and ways to leverage and complement each other's existing efforts. The panelists explained that no one data system can fulfill all data needs, which makes collaboration important. The panelists stated that creating a systems approach, in which all systems are seen as part of one larger system, would be highly beneficial. The panelists further explained that shifting focus to where the actual needs are and fulfilling those needs is critical.

Data analysis is becoming increasingly significant in sectors that are defined by the data and information they produce. The panelists discussed various analysis packages for analyzing data. The panelists explained that they often use several analysis packages, and that they commonly use open-source packages, in-house software engineers, R, Python, C++, GIS, and MatLAB.

Comparing new and existing technologies and products can be essential for determining whether new technologies provide sufficient benefits and value to be implemented. Dr. Carr addressed questions on comparisons between 2-satellite measurements and 3-satellite measurements. Dr.

Carr explained that currently only about half of the Earth's surface is covered by three satellites, with the other half being covered by two satellites (either GOES-East + GOES-16, or GOES-West + GOES-16). Dr. Carr further explained that most of the area covered was from two satellites for cloud top height products. Dr. Carr stated that you can get very valuable data from two satellites, but that a third satellite does provide an increased range of coverage geographically. Dr. Carr noted that the overlap between GOES-East and GOES-West does not cover the entire CONUS.

Determining whether technologies meet mission requirements is critical. Dr. Tucker addressed questions on whether Doppler lidar winds systems can be provided with sufficient power for a 3-year mission. Dr. Tucker explained that obtaining a full depth profile is dependent on how much aerosol is in atmosphere and the type of laser used for the measurement. Dr. Tucker stated that AEOLUS is a very powerful instrument with a large telescope in a 350-km orbit that can obtain profiles down to the surface. Dr. Tucker further explained that the mass for such a system would be very similar to CALIPSO in terms of a free-flyer. Dr. Tucker noted that an ISS mission would not have weight and mass concerns, but that there are constraints in how much power ISS would allocate to a system. Dr. Tucker stated that Athena was specifically designed to fit within the NASA Earth Ventures cost cap.

Data assimilation and extracting as much information as possible from data are becomingly increasingly significant issues across every sector. Dr. Smith addressed questions on land cover data usage for assimilation into NWP models. Dr. Smith explained that their land cover data is a scientific layer in many other analyses. Dr. Smith further explained that MDA Information System has its own weather group that uses the land cover data for many purposes. Dr. Smith stated that they also utilized data from the SMAP (Soil Moisture Active Passive) mission for soil moisture. Dr. Smith noted that soil moisture is one of the land cover datasets that they do at a 30-meter resolution, as opposed to the 5km resolution from SMAP. Dr. Smith emphasized that their expertise is in high-resolution land cover datasets at 30-meter resolution and below.

Data Management and Analytics Session

Day 2 – August 23, 13:45 – 15:05

Session Chair: Dr. Edward Kearns, NOAA Chief Data Officer

Panel Members:
Mr. Kyle Wilcox, Axiom Data Science
Mr. John Aviles, IBM
Dr. Manoj Nair, NESDIS/NCEI
Mr. Brian McKenna, RPS Group
Mr. George Leshkevich, OAR/GLERL

The panelists answered questions from the audience in an open question and answer period at the end of the Data Management and Analytics Session. Topics included determining community wants and needs through feedback metrics, gap assessments filled by magnetic models, how the Cloud-based Sandbox can improve modeling skills, changes in Great Lake ice over the past 20 years, data accessibility for the public, and whether current data platforms allow users to build visualizations. Summaries of the discussions are provided below.

Providing information to users is critical. Using feedback metrics to determine the specific information user communities want is crucial to that effort. The panelists explained that it is important to have a thorough understanding of your audience before you begin designing a service for them. The panelists emphasized that it is critical to have a specific definition of every customer and user base. The panelists further explained that using online surveys and questionnaires, as well as user groups are essential metrics in determining user community's wants and needs.

Filling specific gaps in data assessments is a critical issue within NOAA. The panelists addressed how magnetic models fill assessment gaps. The panelists explained that magnetic models have filled a gap by developing an API service at the request of users. The panelists further explained that magnetic models use cloud-computing services that are very cheap, so that even if the BEDI was defunded it would remain highly affordable.

Technology improvements that enhance modeling skills are important for users and necessary for advancing essential capabilities. Mr. McKenna addressed how the Cloud-based Sandbox improves model skills. Mr. McKenna explained that in many ways Sandbox is a process improvement, not necessarily a product improvement. Mr. McKenna also explained that Sandbox allows for more opportunities to explore three or four iterations rather than just one. Mr. McKenna stressed that having more iterations allows for the identification of skill.

Melting ice has been a major environmental concern for several years. Mr. Leshkevich addressed changes that have occurred in Great Lake ice over the past two decades. Mr. Leshkevich explained that while Great Lake ice has been forming as usual, the overall ice has changed dramatically. Mr. Leshkevich further explained that by plotting data going back 40 years, there is a definite downward trend in maximum ice coverage on a yearly basis. Mr. Leshkevich stressed that this downward trend has been especially notable since the severe El Nino year of 1998, which appears to have been a tipping point for ice becoming more variable and sporadic. Mr. Leshkevich provided examples to highlight this variability: The maximum ice reach was 34% in 2015 and 16%

in 2016, whereas it was 94.5% in 2014. Mr. Leshkevich explained that this large year-to-year variability has never been seen before.

Data accessibility for the general public, as well as for educational purposes has become more important over the years. The panelists explained that while data accessibility is an ongoing effort, their data is currently open to the public. The panelists further explained that their data is available through websites in a variety of formats, and that they are working to formalize, catalog, and otherwise make it more accessible and user-friendly for the public.

Data visualization is becoming increasingly important and necessary to both understand and convey information. The panelists explained that while their platforms do not currently provide direct visualizations, they are heading in that direction and working on building visualization and interactive capabilities. The panelists stressed that their information is currently available for direct download, which allows users to create visualizations using their own systems.

Emerging Technologies Panel Discussion

Day 2 – August 23, 15:20 – 16:20

Panel Chair: Dr. Stephen Volz, Acting Chair of the Observing Systems Council

Panel Members:
Dr. Mario Tamburri, Director for the Alliance of Coastal Technologies (ACT) and Professor at the University of Maryland Center of Environmental Science
Dr. Fred Carr, past President of the American Meteorological Society & Professor, School of Meteorology, University of Oklahoma
Dr. Mark Landers, Chief, Federal Interagency Sedimentation Project, Office of Surface Water, United States Geological Survey
Dr. Pamela McDowell, Chief Scientist, Commander, Naval Meteorology and Oceanography Command (CNMOC)
Mr. George Komar, Associate Director in the Earth's Science Division and Program Manager for the Earth Science Technology Office, NASA

The workshop concluded with a panel of external NOAA experts. Each of the five panelists gave five-minute presentations on their individual organizations and described the various technologies they currently use in their fields and their processes for identifying, developing, implementing, and merging new and emerging technologies. The workshop proved to be a valuable forum for sharing ideas, technologies, challenges, and encouraging greater collaboration among different sectors and fields. The workshop was also instrumental in igniting conversations, sharing perspectives, and determining where synergies might occur.

Workshop Reflections

During their presentations, the panelists discussed issues raised in the workshop and the challenges of identifying and integrating emerging technologies, including:

- Identifying areas of unmet need within every field and trying to meet those needs.
- Forging a community consensus on how to go forward with new technologies.
- Monitoring and promoting greater awareness of new and emerging technologies.
- Improving the lines of communication between NOAA, other Federal agencies, users, and the private sector providing the technologies. These connections need to be more robust.
- Improving the transition between emerging technologies and operational technologies to make the process more rapid and effective, and to see a greater return on investment.
- Having more workshops and conferences like the ETW because they are important forums for capacity and consensus building.
- Using challenges to identify large cross-cutting issues and encouraging collaboration across different sectors and fields that share or are affected by similar issues.
- Getting information out as quickly as possible in a consistent format.
- Identifying user and community needs and fine-tuning data to meet those needs.

- Turning data into information, this is essential.
- Encouraging competition between sectors to get the best technology providers.
- Actively managing emerging technologies to make sure investments are not being wasted or misallocated.
- Ensuring that technologies have been verified and demonstrated so that their actual operational use is not in question.
- Making data more user-friendly so that the end users know how to interact and utilize the data.
- Investing in technology to enable and improve the future, and to create more capabilities.
- Investigating the use of machine learning to address the large volume of collected and generated data to provide better data and information to users.

Question and Answer Session

The panelists answered questions from the audience in an open question and answer period at the end of the workshop. The session addressed shared challenges that NOAA and other agencies and sectors face. Topics included gap assessments, prioritization of different measurement capabilities, the changing relationship between government and non-government agencies in terms of using and managing observing systems, the limitations posed by the acquisition process, and the need to provide information instead of data and whether that ability should be an internal skill and capability. Summaries of the discussions are provided below.

A topic of discussion at the ETW was NOAA's gap assessment abilities and how to identify and prioritize the most important measures. The panelists explained that prioritization in their fields is often based on abilities and assets, but that they rely heavily on input from their communities and users to drive their measures and priorities. The panelists encouraged NOAA to get as much input as possible from their community through surveys or other forums. The panelists cautioned that it is not just a matter of identifying gaps; it is also a matter of identifying solutions to those gaps in terms of an emerging technology perspective. The panelists recommended that prioritization processes should be as transparent as possible so that everyone can feel comfortable with how decisions are being made.

Observations are critical to NOAA and attendees of the ETW. A shared matter of concern is how much weight should be given to Observation System Simulation Experiments (OSSEs), especially in terms of the prioritization of different measurement capabilities. The panelists expressed some concerns about the weight given to OSSEs, and how advantages can be created by not including a sufficient amount of other measurements. The panelists also pointed out that OSSEs are expensive, intensive, and lack automation. The panelists did agree, however, that OSSEs are an important first step in what is ultimately a long process, and that OSSEs are significant to the scientific process.

In the future, a changing relationship between government and non-government agencies may be necessary because non-government agencies often provide the observing systems that government agencies rely on. The panelists agreed that a more robust relationship between government and non-government agencies would be beneficial and that there are definitely drivers for it in terms of making the best use of information and budget sharing, but that they are not certain such a change is on the horizon. Problems such as restrictions in what data can be

shared and with whom it can be shared are major obstacles. The panelists recommended improving the balance between different groups in the private sector to naturally offset each group's' strengths and limitations to create a more productive and effective observing systems network.

Procurement and acquisition policies involve lengthy processes that some see as inhibiting rather than enabling emerging technology development. The panelists agreed that while rules and policies are there for a reason, certain policies and rules can make it excessively difficult to acquire and advance technologies, which allows other industries to surpass agencies that face these restrictions and limitations. The panelists advocated for using legal techniques and innovations to circumvent some of the more time consuming and limiting processes.

In recent years, there has been a push for agencies to provide more information rather than just data. Providing information requires more processing and analysis, which is challenging because sponsors often do not want to fund anything other than data. Implementing different ways of doing data management, data archiving, and data of access seems like an increasingly important internal skill for NOAA. The panelists agreed that having the internal capabilities to analyze and produce information is critical. The panelists cautioned that it is important to devote sufficient resources to integrating information and data structures, and that it is essential for the information process to be holistic rather than piecemeal efforts.

Closing Comments from Dr. Volz

The success of this workshop will be measured by the continued conversations attendees have after they depart the ETW. Hopefully, these conversations will include insights into how observations used in one community could also be used in another. NOAA's goal is to work towards an integrated observing system, and while we are not there yet, we are branching across different communities and finding new opportunities to use data in different ways, such as ocean surface data that can lead to improved wind and weather modeling.

NOAA is constantly trying to enhance and facilitate collaboration by increasing communication and coordination across different disciplines and agencies. NOAA is exploring ways to harmonize data collections and utilizations in ways that maximize capabilities. A major take-away from this workshop is to explore how to measure nutrient pollution from space.

After leaving the ETW, it is critical to continue to reflect on how business and research success is measured, whether it is by citations, publications, or user feedback. Ultimately, it is essential to take these measurements and communications and feed them back into planning processes to ensure success and advancement.

The ETW would not be possible without the participation and contributions of the presenters, panelists, and everyone else involved in putting the workshop together. We value your feedback and comments, and hope you participate in future ETWs.

Findings and Recommendations

1. There was very positive reinforcement on the value of NOAA holding periodic ETWs and to continually reassess and evolve the workshop to help identify promising new technologies for transition by NOAA observing systems.

    - Conduct a post workshop assessment to review the frequency, venue, structure, availability of resources, and engagement of the ETW to align with NOAA processes and external drivers and opportunities. The assessment will inform the timing and design of the next ETW.

    - Capture best practices and guidelines in NOAA Administrative Order 212-16 Handbook.

2. There was clear recognition of the benefits of more fully engaging the private sector, academia and other federal agencies toward infusing new observing system technologies and data management capabilities.

    - Improve communication of NOAA's observing system requirements with external organizations, and expand interface with industry and collaboration with the broader community.

    - Build and improve the existing methodology for identifying observation requirements gaps at NOAA to highlight more gaps, and develop strategies to encourage more participation from industry and academia.

    - NOAA will explore available acquisition options such as leasing that can accelerate transition to operations of new technologies.

3. Cross over technologies and autonomous platforms to acquire observations across all observing domains were broadly recognized as promising opportunities to significantly expand capabilities while reducing costs.

    - Encourage cross NOAA collaboration to identify cross over opportunities and align research and development activities leveraging autonomous platforms and similarly common technologies.

    - Facilitate coordination and linkage with Research to Transition Program (RTAP) through collaboration with NOAA Research Council.

    - Continue to identify and leverage other large cross cutting issues.

4. Big data and data visualization capabilities provide exciting new opportunities to force multiply the application and value of observing systems.

    - Coordinate activities with NOAA's Chief Data Officer to continue exploring and leveraging these capabilities.

NOAA is committed to continuing the workshop as a critical tool for observing systems management. NOAA will continue to enhance the workshop to include topical subjects and themes, and maximize engagement with external partners such as other federal agencies, the private sector, and cooperative institutes.

Appendices

Appendix 1: Agenda

NOAA Center for Weather and Climate Prediction (NCWCP)

College Park, Maryland, **August 22-23, 2017**

Topic: Technology toward a mission-effective, integrated, adaptable, and affordable observation portfolio

Day 1 - August 22

08:45 - 09:00 Welcome and Opening Remarks

- Observing System Committee (OSC) Co-Chairs, Richard Edwing and Joseph Pica
- Agenda overview, ground rules, and logistics

09:00 - 10:20 Space Session

09:00 - 09:05 Introduction - Frank Gallagher, Session Chair (NESDIS)

09:05 - 09:15 Lidar-Measured Global Wind Profiles, James Yoe for R. Michael Hardesty (OAR/ESRL)

09:15 - 09:25 Next Generation Instruments for Environmental Space Remote Sensing, Cinzia Zuffada (Caltech/JPL)

9:25 - 09:35 Advanced Data Processing Methods for Enhanced Microwave Ocean Measurements, Alejandro Egido (NESDIS/STAR)

09:35 - 09:45 Compact Coronagraph, Dennis Socker (NRL)

09:45 - 09:55 NOAA's Commercial Weather Data Pilot, Daniel St. Jean (NESDIS/OSAAP)

09:55 - 10:20 Panel Q&A

10:20 - 10:50 Break & Posters

10:50 - 12:10 Atmosphere Session

10:50 - 10:55 Introduction - James O'Sullivan, Session Chair (NWS)

10:55 - 11:05 Small UAS Platform for Observation of Lower Atmospheric Characteristics, Jamie Dyer (Mississippi State University)

11:05 - 11:15 Global Hawk Unmanned Aircraft System Operational High Impact Weather Reconnaissance Capability, Vijay Tallapragada (NWS/NCEP)

11:15 - 11:25 Airborne Doppler Wind Lidar, Lisa Bucci (OAR/AOML)

11:25 - 11:35 Infrared Sea Surface Temperature Measurements from the GPS Dropsonde Observing Platform, Joseph Cione (OAR/AOML)

11:35 - 11:45 Exploring Enhanced GPS Capabilities in Smartphones with Android N for Improved Satellite Geolocation Validation and Radio Occultation, Changyong Cao (NESDIS/STAR)

11:45 - 12:10 Panel Q&A

12:10 - 13:40 Lunch & Posters

13:40 - 15:00 Terrestrial Session

13:40 - 13:45 Introduction - Hernan Garcia, Session Chair (NESDIS)

13:45 - 13:55 Long-term Observation of Aerosols, Siwei Li (Howard University/NOAA Center for Atmospheric Science and Meteorology)

13:55 - 14:05 NOAA's CrowdMag Project - Non-traditional Observing of Earth's Magnetic Field, Manoj Nair (NESDIS/NCEI CIRES)

14:05 - 14:15 Radiosonde Autolaunchers, Mark B. Miller (NWS/OBS)

14:15 - 14:25 Coastal Ecosystem Assessment, Development and Creation of a Policy Tool using Unmanned Aerial Vehicles (UAVs): A Case Study of Western Puerto Rico Coastal Region, Jonathan Munoz-Barreto (University of Puerto Rico)

14:25 - 14:35 ASOS CL31: A National Lidar Network, Belay B. Demoz (UMBC)

14:35 - 15:00 Panel Q&A

15:00 - 15:30 Break & Posters

15:30 - 16:50 Oceans Session

15:30 - 15:35 Introduction - John McDonough, Session Chair (OAR)

15:35 - 15:45 Leveraging Autonomy - NOAA Office of Coast Survey's Autonomous Systems Strategy, Edward J Vandenameele (NOS/OCS)

15:45 - 15:55 Application of Telemetry to Telepresence Mapping on the NOAA Ship Okeanos Explorer, Elizabeth Lobecker (OAR/OER)

15:55 - 16:05 The Modular Optical Underwater Survey System (MOUSS), Ruhul Amin (NMFS/PIFSC)

16:05 - 16:15 AOML-CARICOOS Underwater Glider Observations in the Caribbean Sea and Tropical North Atlantic Ocean in Support of Tropical Cyclone Studies and Forecasts, Gustavo Goni (OAR/AOML)

16:15 - 16:25 The Air-Deployable Micro Buoy (ADMB) V2, Gijs de Boer (OAR/ESRL)

16:25 - 16:50 Panel Q&A

16:50 - 17:00 Closing Remarks and Overview of Day One (Richard Edwing and Joseph Pica)

Day 2 – August 23

08:20 - 08:30 Opening Remarks by OSC Co-Chairs, Richard Edwing and Joseph Pica

- Day 1 recap, Day 2 overview, ground rules, logistics

08:30 - 08:45 Keynote Address: Stephen Volz

08:45 - 10:00 Oceans Requirements Gaps Session

08:45 - 08:50 Introduction - Carl Gouldman, Session Chair (NOS/IOOS)

08:50 - 09:05 Measuring Ocean Surface Waves with FutureWaves™ Wave and Vessel Motion Forecasting System, John Kusters, General Dynamics - Applied Physics Sciences

09:05 - 09:20 GROOV Unmanned Surface Vessel for Ocean Observation, Paul Seiffert, Maritime Applied Physics Corporation

09:20 - 09:35 Unmanned Surface Vehicle Network for Global Ocean Data Collection, Sebastien de Halleux, SailDrone, Inc.

09:35 - 10:00 Panel Q&A

10:00 - 10:30 Break & Posters

10:30 - 12:15 Land-Atmosphere Requirements Gaps Session

10:30 - 10:35 Introduction - James Yoe, Session Chair (NWS)

10:35 - 10:50 OAWL: High TRL Doppler Wind Lidar for 3D Winds Mission Demonstration, Sara Tucker (Ball Aerospace)

10:50 - 11:05 Multi-Satellite 3D Winds, James Carr (Carr Astronautics)

11:05 - 11:20 Ocean Surface Wind Speeds via Microwave SSMI, Michael Kruk (Earth Resources Technology, Inc)

11:20 - 11:35 Automated Land Cover Updates, François Smith (MDA Information Systems LLC)

11:35 - 11:50 WindTracer® Doppler Lidar for 3D Wind Profiles, Keith Barr (Lockheed Martin Corp.)

11:50 - 12:15 Panel Q&A

12:15 - 13:45 Lunch & Posters

13:45 - 15:05 Data Management and Analytics Session

13:45 - 13:50 Introduction - Ed Kearns, Session Chair (CIO)

13:50 - 14:00 Data Infrastructure for Integrated Real-time Observations, Kyle Wilcox (Axiom Data Science)

14:00 - 14:10 High Capacity Data Distribution Capabilities for GOES-16, John Aviles (IBM)

14:10 - 14:20 Fast and Reliable Access to NOAA's High-resolution Geomagnetic Models, Manoj Nair (NESDIS/NCEI)

14:20 - 14:30 Cloud Sandbox for Ocean Circulation Models, Brian McKenna (RPS Group)

14:30 - 14:40 Operational Ice Type Classification and Water Quality Satellite Retrievals for the Great Lakes, George Leshkevich (OAR/GLERL)

14:40 - 15:05 Panel Q&A

15:05 - 15:20 Break & Posters

15:20 - 16:20 Emerging Technologies Panel Discussion

Panel Members: Dr. Stephen Volz (NOAA), Dr. Fred Carr (past President of the American Meteorological Society), Dr. Mario Tamburri (Director for Alliance for Coastal Technologies), Mark Landers (USGS), George Komar (NASA), and Pamela McDowell (US Navy)

16:20 Closing Remarks (NOSC Chair)

Appendix 2: Links to Workshop Materials

Link to the Opening Keynote Address by Dr. Stephen Volz

Session Profiles for each Emerging Technologies session provide information about the session, as well as a link to each of the presentations (available for viewing and/or download).

- **NOAA-Funded Emerging Technologies**
  - Space Session Profile
  - Atmosphere Session Profile
  - Terrestrial Session Profile
  - Oceans Session Profile
  - Data Management and Analytics Session Profile
- **Industry-Funded Requirements Gaps Emerging Technologies**
  - Oceans Requirements Gaps Session Profile
  - Land-Atmosphere Requirements Gaps Session Profile
  - Link to the TPIO's Requirements Gaps Methodology

The Abstracts for all Emerging Technologies are grouped according to their session, and can be found below. Following each abstract, the presenter offers their own response to the question, "How can this emerging technology help NOAA?"

- **NOAA-funded Emerging Technologies**
  - Space Session Abstracts
  - Atmosphere Session Abstracts
  - Terrestrial Session Abstracts
  - Oceans Session Abstracts
  - Data Management and Analytics Session Abstracts
- **Industry-funded Requirements Gaps Emerging Technologies**
  - Oceans Requirements Gaps Session Abstracts
  - Land-Atmosphere Requirements Gaps Session Abstracts

The Presentations for all Emerging Technologies are grouped according to their session, and can be found below:

- **NOAA-funded Emerging Technologies**
  - Space Session Presentations

  - Atmosphere Session Presentations
  - Terrestrial Session Presentations
  - Oceans Session Presentations
  - Data Management and Analytics Session Presentations
- **Industry-funded Requirements Gaps Emerging Technologies**
  - Oceans Requirements Gaps Session Presentations
  - Land-Atmosphere Requirements Gaps Session Presentations

Link to All Posters from the workshop's Technical Poster Session

Photographs from the 2017 NOAA Emerging Technologies Workshop

- Highlights and Candid Photos
- Panel Discussions Photos
- Poster Gallery Photos
- Individual Speaker Photos

Link to All Videos from the 2017 NOAA Emerging Technologies Workshop

Links to the **2017 ETW Workshop Dashboard:**

- ETW Dashboard Overview Tab
- ETW Dashboard Schedule Tab
- ETW Dashboard Logistics Tab

Link to the full list of Acknowledgements for the 2017 NOAA ETW

Appendix 3: Post-Workshop Survey

Following the workshop, participants responded to a number of feedback survey questions. Summaries of their responses are provided below.

1. **What strikes you as the most powerful idea for advancing NOAA's mission that you encountered at the workshop?**

Mission

- Industry will have an increasingly large role in the next decade in terms of providing new observing systems that were previously provided by the government. There needs to be thoughtful discussion across the weather, water, and climate communities in the near future about how this paradigm shift will impact data availability. Determining how the government will distribute data ingested from commercial vendors is critical.
- Cost-effective data collection that aids NOAA's observational requirements.

Data

- NOAA's Big Data Initiative and the idea of bringing users to data in the cloud are transformative.
- Cloud-based computation and data storage for scalability, reliability, and cost-effectiveness.
- The use of autonomous platforms and systems for data collection.
- NOAA needs to improve data management, dissemination, and access within the agency.
- NOAA's facilitation and use of data visualization and access.

Technology

- The use of autonomous, adaptive technologies in conjunction with NOAA's traditional missions to create highly complementary and powerful systems.
- Increased use of satellites and drone technologies.
- Cross-over technologies and deployment platforms that exploit multiple technologies and sensor capabilities.
- Low-cost autonomous vehicles making high temporal and spatial resolution measurements.
- The use of remotely sensed data to fill known needs with new types of observing systems, especially lidars on satellites that measure wind direction and wind speed.

Communication

- NOAA needs to continue to improve communicating its needs and requirements to outside organizations.
- The ability to convey scientific ideas to the public, especially how ideas are developed and defended, will ultimately be some of NOAA's greatest contributions.
- More forums that allow NOAA scientists and leaders to interact and exchanges ideas with other agencies and sectors, and provide exposure to commercial vendors.
- Collaboration with local government agencies and university partners will help test NOAA's expanding technologies, and it will put new technology in the hands of potential end users.

2. **From what you learned at the workshop, which ideas could have the greatest impact on the way you do business?**

Technologies

- The use of low cost autonomous systems.
- Innovations in buoy and ocean sensing technologies.
- Increases in observing systems, especially those related to oceans and their potential to enhance weather forecasting in the future.

Data

- The ability to leverage big data platforms to assist with analysis.
- The ability to obtain data through contracts to lower operation and maintenance costs.

Communication

- Agency efforts to coordinate and maximize data and data processing to solve joint issues.
- The interconnectivity of systems and the sharing of data, research, and technological platforms.

3. **What kinds of strategies or government processes would be most helpful for NOAA to adopt going forward in order to optimize our innovation and nimbleness?**

Mission

- NOAA needs to work with industry to craft interesting financial agreements (perhaps leasing or data service agreements) that are beneficial to both parties,

and will allow NOAA to remain nimble and allow industry to provide up-to-date capabilities that are refreshed at reasonable intervals.

- NOAA needs to be very proactive on deciding what new observations provide the greatest ROI. NOAA needs to develop a set of gap analysis tools to assess the benefits of potential new observing systems.

Communication

- Continue to interface with industry and promote community collaboration.
- NOAA needs to conduct small incubation projects in conjunction with the private industry for prototyping possible high-tech next-generation systems.
- Increase awareness of the NOAA Tech Transfer. People in field offices often have great solutions, but frequently never go beyond their own offices or neighboring sites.

Data

- Pay-as-you-go data collection that reduces costs while simultaneously meeting needs.
- The ability to obtain and use external data, which hinges on enhanced partnerships between the government and the private sector.
- NOAA would benefit from improved ingestion of high-resolution spatial and temporal observations into a standard data management approach.

Technologies

- Artificial intelligence is a ubiquitous and rapidly advancing field. NOAA needs to invest in these technologies to improve everything from weather prediction to fish identification.

Requirements

- NOAA needs to clearly define its needs and requirements to avoid redundancy in instrumentation.
- Science requirements need to drive prioritization of resources.
- Ensure that suggested avenues for satisfying requirement gaps are captured and considered in future architecture planning.

Appendix 4: NOAA Observing Systems Council (NOSC)

Leadership

Acting Chair - Assistant Secretary for Environmental Observation and Prediction	Stephen Volz	
Vice Chair (NESDIS)	Stephen Volz	Alternate: Mark Paese
Vice Chair (NWS)	Louis Uccellini	Alternate: Mary Erickson
Vice Chair (OMAO)	RADM David Score	Alternate: RDML Anita Lopez
Executive Secretary	Meredith Wagner	Alternate: Anne Kennerley

Other Voting Members	**Principal**	**Alternate Principal**
Chief Financial Officer	Mark Seiler	Tony Wilhelm
Chief Information Officer	Zack Goldstein	Doug Perry
NESDIS	Karen St. Germain	Dan St. Jean
NMFS	David Detlor	Rebecca Shuford
NOS	Richard Edwing	Colleen Roche
NWS	Joseph Pica	Kevin Schrab
OAR	Craig McLean	Gary Matlock
OMAO	Charles Alexander	Jonathan Taylor

Non-Voting Members

OSC Co-Chair	Richard Edwing
OSC Co-Chair	Joseph Pica
EDMC Chair	Jeff de la Beaujardiere
NOAA Representative, USGEO	Tom Cuff
Office of Space Commerce	Jason Kim
OFCM	William Schulz

NOSC Advisor

TPIO Director	Martin Yapur

Appendix 5: Observing Systems Committee (OSC)

Organization and Role	Representative
OSC Co-Chair (NOS)	Richard Edwing
OSC Co-Chair (NWS)	Joseph Pica
OSC Executive Secretariat	Anne Kennerley
OSC Technical Advisor	Martin Yapur
NESDIS Principal Rep	Jason Taylor
NMFS Principal Rep	Felipe Arzayus
NMFS Acting Rep	Laura Ferguson
NOS Principal Rep	Kate Anderson
NOS Alternate Rep	Colleen Roche
NWS Principal Rep	Kevin Schrab
NWS Alternate Rep	Jim O'Sullivan
OAR Principal Rep	Christopher Moses
OAR Alternate Rep	Arturo Herrera
OMAO Principal Rep	Jonathan Taylor

Appendix 6: Technology, Planning and Integration for Observation (TPIO)

Director - Martin Yapur

Technical Director / Integrated Systems Analysis Lead - David Helms

Communications Lead - Eric Miller

ETW Lead Logistician - Adam Steckel

ETW Assistant Logistician - Anne Kennerley

TPIO Webmaster - Daniel Gillespie

NOSC Executive Secretary - Meredith Wagner

Observing Systems Lead - Patricia Weir

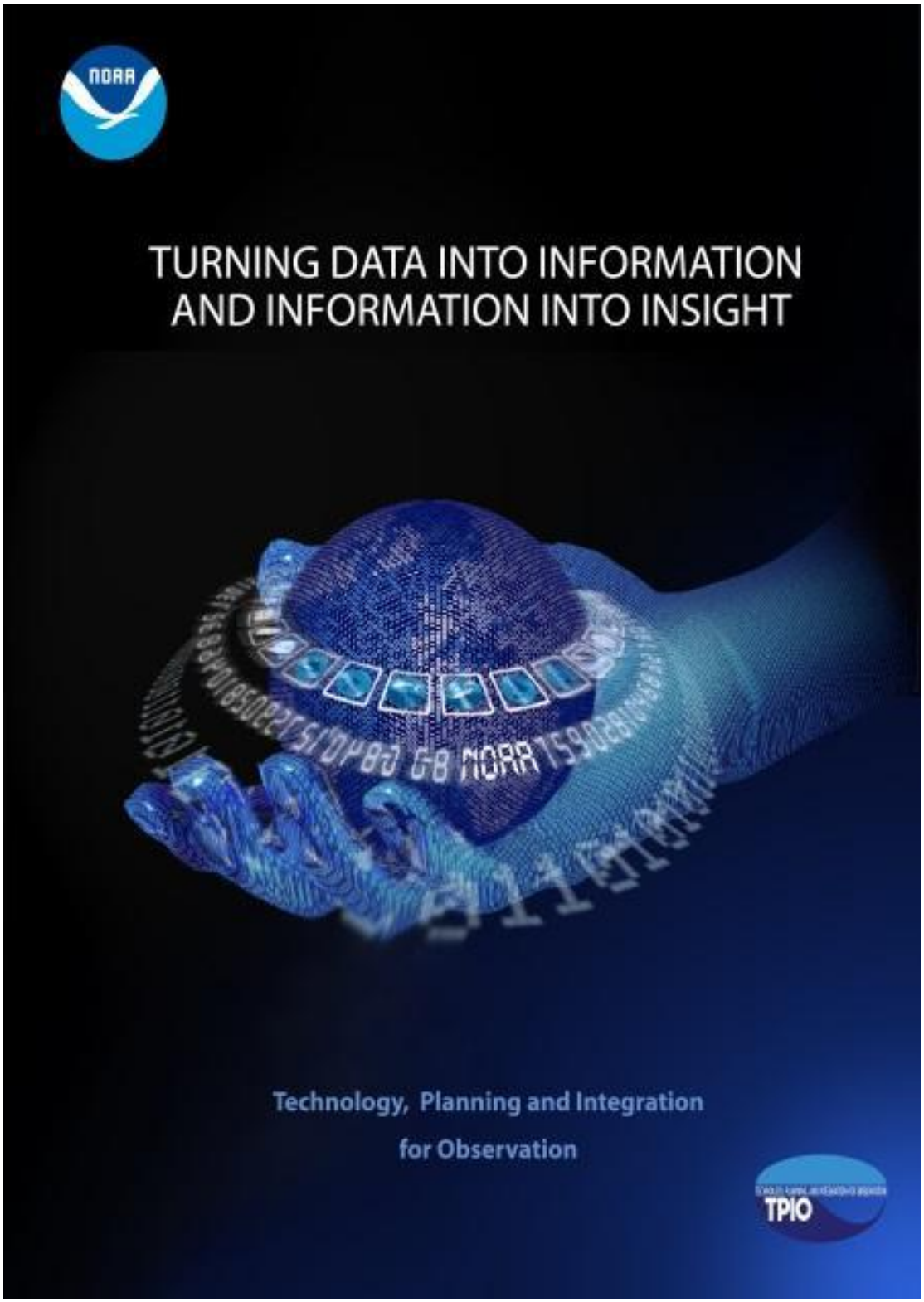
Requirements Lead - Lewis McCulloch

Visualization Lead - Matt Austin

Database Lead - Scott Smith

Additional ETW Support Staff

Aaron Pratt, Adam Neiss, Alyssa Templeton, Amanda Mitchell, Brant Priest, Brit Meredith, David Bludis, Guoxian Zhou, Itay Covaliu, Jon Corsiglia, Justin Goldstein, Katya Merezhinsky, Kennita Diggs, Lauraleen O'Connor, Louis Cantrell, Robert Reining, Sabrina Taijeron, Saiontoni Sarkar, and Thanh Vo Dinh.


NOAA
TURNING DATA INTO INFORMATION
AND INFORMATION INTO INSIGHT
Technology, Planning and Integration
for Observation
TPIO