

CMTS

4th *Biennial Conference:*
Research and Development

U.S. Committee on the Marine Transportation System



From Sail to Satellite



Delivering Solutions for Tomorrow's Marine Transportation Systems



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U.S. Committee on the Marine Transportation System Conference Summary
of the 4th Biennial Research and Development Conference

*This conference was organized with the Transportation Research Board (TRB).
However, this summary document is not a report of the TRB or the
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subjected to its official review procedures and processes.*

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I. Conference Recap

Overview

The U.S. Committee on the Marine Transportation System (CMTS) worked with the Transportation Research Board (TRB) to hold their fourth biennial research and development conference, “From Sail to Satellite: Delivering Solutions for Tomorrow’s Marine Transportation System,” in Washington, DC at the National Academy of Sciences on June 21-23, 2016. The forum examined emerging and innovative technologies and practices in marine transportation and waterways management, bringing together approximately 130 attendees from government, industry, academia, and beyond. These participants made the event the largest marine transportation system (MTS) research and development (R&D) conference yet, with 19 breakout sessions, 3 plenary sessions, 3 keynote addresses, a student honors panel, and the closing summary session.

The sessions not only discussed the latest innovative technologies and practices in marine transportation and waterways management, but also strove to contemplate the MTS of the next 100 years and the R&D needed to successfully get there. Participants from students to keynote speakers to research experts championed the need to continually adapt and innovate to tackle ever-changing challenges.

This summary details the key takeaways from the conference in order to inform the broader strategy for MTS-related research and development over upcoming years. The following presents the notable Keynote thoughts and visions, a synopsis of each of the panel discussions, and the major points discussed in the many Technical Breakout Sessions. The document then identifies the specific gaps and needs the MTS should be addressing in order to inform future research prioritization.

Keynotes and Plenary Vision

Keynotes – The MTS Vision Looking Forward

Vice Admiral Manson Brown (USCG ret), Assistant Secretary of Commerce for Environmental Observation & Prediction and NOAA Deputy Administrator called attention to the need to build on the MTS legacy as it transitions to the next stage in leadership. He reminded the audience that a broad array of maritime observation data are absolutely critical to the success of the MTS as maritime freight flow is forecasted to triple over the next 20 years. Federal data must be provided to the mariner where it is needed most – on the ship’s bridge. The emerging practice of converting data and observations into information and notices to mariners is going in the right direction. These emerging technologies will affect everything from inland navigation to managing the MTS with regard to climate change. The MTS must also recognize the importance of effectively leveraging storytelling around these R&D issues as it attempts to move the needle forward on the big picture issues facing the nation and driving the MTS of the future.

IHS Maritime & Trade Group’s Mr. William Cassidy inspired thoughts about the ability of technology to better connect our MTS and inland supply chains. Freight fluidity analytics show supply chain bottlenecks, but solutions have been principally impeded by siloed thinking, the

lack of long-term infrastructure investment and planning, and the greater likelihood for problems alongside increasingly complex, diverse supply chains. These fluidity challenges may be overcome through innovative approaches to the way technologies are adopted, generating significant improvements through the automation of manual processes and the replacement of past inefficiencies.

Conference Keynote presenter, Air Force General Darren W. McDew, Commander, US Transportation Command (TRANSCOM), further championed the need to innovate and respond to disruptive influences, challenging the nation and our MTS to not fall behind in the same way. As an example, he noted that Blockbuster video rental failed to foresee their eclipse by Netflix's application of technology. This readiness to adapt requires addressing those developing vulnerabilities such as cyber security in both our military and commercial systems. As we automate further, we need to keep training our nation's manpower to utilize these technologies to their full potential.

MTS 2100 – Our Next Century Transportation System

The first plenary panel session of the conference highlighted the likelihood of blurring of transportation mode function and governance. The future of marine transportation is rapidly approaching as the world looks to move safer, faster, and more efficiently. The MTS must work beyond the waterways and consider the entire multimodal transportation system, involving everything from terminal throughput efficiency to the maintenance of the right labor force. Future logistics likely will continue to consolidate, even as financing fragments, with the private sector likely to become an increasingly large player in managing port and waterway activity and services.

The MTS must work harder to optimize the flow of information, freight flow at terminal peak capacity, and freight allocation into ports. Significant levels of research have and will continue to improve our technology over the years – we will have to ensure that our policies continue to match these developments. The MTS will need to be part of a world with shared needs and new alignments that will require new perspectives for marine transportation. Overall the path to the future demands thinking globally, coordinating regionally, and acting locally.

Technology Innovations for a Next Generation Marine Transportation System

The second plenary panel session discussed how the MTS continues to technologically evolve, transitioning from single application vessel instruments to those that support multi-purposed integrated systems. Mature, commercially available technology has allowed for bold approaches to change the way the MTS conducts business in the digital age. The same public-private partnerships that have led to advancements in hydrogen fuel use and other fuel alternatives should also support other technology areas within the MTS. At the same time, old instruments should not simply be forgotten, as reliability, redundancy and simplicity have their benefits (including costs). Data technologies do demand significant data harmonization efforts to take full advantage of their potential. Information naturally wants to be free beyond its original singular purpose – while security and propriety information are important in particular cases, restrictions should be removed where possible. Technology often moves too fast to manage its application

and data sharing through the current regulatory framework. Therefore, alternative approaches must be considered to mandate proper technology incorporation and associated data access.

It has become increasingly apparent that approaches, such as structural health monitoring, are necessary to help maintain the wide array of MTS infrastructure. Taking the next technological steps will require R&D programs that consider the cost-benefit analyses of tool application, non-regulatory solutions, the human element, data integration, and stakeholder outreach.

Data Requirements for a Next Generation MTS

The third plenary panel session targeted the data that continue to support more strategic MTS operations, including approaches that may inform MTS users real-time and provide managers with MTS use data. The biggest future data driven opportunities will come in sensors that measure granular network status in real time, big data repositories that digest sensor data, and intelligent data system designs. Game changing opportunities may arise as vessel pilots might make key choices involving determination of speed, route, and departure decisions. While specific improvements may be required, the MTS should not let perfection get in the way of improvement.

Potential changes in port and MTS user governance and ownership may impact port data collection and our ability to share and access data. The MTS must develop new approaches to data that may be proprietary and not public domain. While technology enhances our ability to supply and combine data, MTS managers must avoid the potential of information overload to overwhelm our decision-making ability. Metadata must be prioritized to facilitate data discovery. Proper data integration is absolutely critical to generating applicable knowledge.

Technical Breakout Sessions

This year's conference engaged a wide variety of leading MTS R&D experts in several areas and their discussions were captured in 16 Technical Breakout Sessions summarized below:

Arctic Marine Transportation – Speakers emphasized that MTS Arctic operations must consider the non-state actors along with official governance to both respond to and manage the polar environment. R&D can better inform Arctic risk forecasting, navigation tools, and the handling of incidents in extreme conditions (e.g. oil spill dynamics). More must also be done to explore the changing risks and economic factors that accompany an opening Arctic. Given the region's remoteness and more limited response capacity, research must be translated into effective training that supports competent Arctic safety practices and operations.

Asset Management – Asset Management strategies at the port level have had mixed results – they should be kept simple, with clear measures of progress. Data collection must be integrated within a framework that reflects measurement goals. The MTS can improve long-term planning through better evaluation of current societal trends that can inform the likelihood of future scenarios. While the proliferation of new, disruptive technologies can rapidly alter society's interaction with the MTS, the same technologies are enabling quantitative rigor for Asset Management (e.g. Structural Health Monitoring and system models).

Data and Data Management – Development of authoritative standards for data transmission are critical for its effective management. With proper standards and practices, these approaches can even improve reliability of crowd-sourced data. By better displaying data (e.g. GIS), analysts may better consider how their application influences other users. The overall change in traditional algorithms and processes will continue to enable “Big data” and associated tools.

Emissions Management – Ports need to recognize the negative health and environmental impacts of maritime sourced air emissions. Collaborative, cross sector approaches should drive innovation through powerful partnerships. Regulation can only affect so much change, while market-based approaches can incentivize action through benchmarks and demands for greener shipping. These strategies may translate to smart economic decisions, with more efficient ships correlating with safer track records through time.

Environmental Stewardship – Presentations identified the need for CMTS to incorporate environmental objectives into the system. Interdisciplinary study of technological and economic motivations for freight movement may better inform environmental decision-making through visual/analytic frameworks. Operations research on MTS maintenance, particularly dredge scheduling, has also lead to potential cost savings while managing work within environmental windows. MTS energy use should address future as well as immediate goals, applying regional solutions to move forward.

Future of Navigation – Speakers called attention to new navigation technology including real-time display (Global navigation satellite system (GNSS) & Automatic identification system (AIS)) and probabilistic modeling of vessel position with critical environmental conditions. Despite the many advances, such as the USACE Lock Operations Management Application (LOMA), bureaucratic and technical barriers have prevented full application of the eNavigation concepts of electronic integration of information collection, exchange, harmonization, and application. The government cannot meet these needs on its own – more public-private outreach must increase user understanding. Data are not currently well integrated across sectors and platforms – where they are, they are not necessarily consistent in availability or quality.

Infrastructure Investment – The session highlighted the need to consider the unintended direct consequences of infrastructure investments and new technologies as well as the second order effects of such decisions due to complex economic interdependencies (e.g. freight toll impacts on business location placement). Looking back, the MTS must figure out how to more efficiency use existing infrastructure. Moving forward, the Nation must avoid overinvesting in large fixed infrastructure, as both climates and markets continue to change at accelerated rates.

Inland Resilience – Further efforts must continue to be made to enhance inland transportation system reliability. This work demands mapping the system dependencies and the interdependencies beyond first order supplies and customers. New approaches can support the optimization of responses to diversions during transit. These efforts can be best enhanced by quantifying the capacity that exists within the current system.

Innovative Materials – Two sessions detailed the considerable advances in extending the life of existing infrastructure, especially through integration of new composite materials. By applying newer materials for infrastructure repair the MTS can extend the service life of its structures, such as locks, dams, and seawalls. New materials may offer lower cost alternatives than current practices, especially with mass manufacturing, and may provide more durable, longer lasting repairs. Future work can better utilize composite properties by investigating durability issues, project failures, resistance, fatigue, and boundary condition changes.

Innovative Technologies – Speakers in two panels shined light on marine engineering technology for better data collection, further increasing ship movement and efficiency, to ultimately enhance MTS structural lifecycles through greater construction flexibility and less corrosion. Better sensor integration can especially aid efficiencies in providing predictive analytics, history, and performance monitoring. In addition to generating data, it must be done in a timely manner to actually inform decision-making.

MTS Performance Measures – Data integration is the critical step in transforming MTS data into performance metrics. While plenty of data are available as measures, they must be evaluated for universal availability, quality, consistency, and application. MTS performance can be defined through analysis of MTS user movement, especially using AIS data. Capturing delays, disruptions, and other MTS supply chain shifts (including landside processes) can quantify reliability, capacity changes, and efficiency. The real-time movement data better informs risk by capturing near-miss occurrences as well as incidents.

Resilience: Seaports and Climate – Rather than solely reacting to disruptions, the MTS needs new tools to inform proactive resilience decision-making. Gaps remain in understanding the federal-level, climate-related decisions that will need to be made for the MTS. New resilience criteria are needed for federal grant and proposal projects. Given the complexity of the US port system, more must be done to comprehend their interdependencies and ability to collaborate for overall regional and national resiliency.

Resilience: Tools and Needs – Real-time data, visualization, and forecasted processes need to apply to all interconnected transport modes in order to identify the next steps and costs to enhance resilience. By quantifying the benefits of adaptation approaches (e.g. reuse of dredged sediments) along with the costs, the MTS community can better quantify cost savings for future responses. The MTS should consider and evaluate social vulnerability factors alongside the physical risk factors that shape port resilience.

Security – There is a significant need for the MTS to place a higher priority on IT and cybersecurity. As a system of systems, the MTS must focus on better understanding and communicating security risks and consequences among stakeholders. Cybersecurity efforts demand considering the threats to these systems as well as how to recover cyber infrastructure and cyber dependent systems following attacks. These security concerns often come down to people – there needs to be better effort towards training a cyber-aware workforce to enhance our MTS security.

Systems Management: RSM and EWN – There is a continued need for stakeholders involved with Regional Sediment Management (RSM) and Engineering with Nature (EWN) programmatic approaches to use science and tools to provide quantifiable evidence of positive outcomes of these activities. R&D using imaging and unmanned technologies has improved manager ability to understand the complex array of variables and processes at work underwater that influence RSM and EWN implementation. Beyond illustrating these activities and benefits with R&D, more must be done to cultivate stakeholder relationships and build trust to collaborate on applying lessons learned and best practices.

Student Honor Panel – A selection of outstanding abstract submissions from the next generation of MTS leaders led to a first-ever student honor panel that tackled issues around resilience. Panelists suggested that the U.S. inland transportation systems should be included in extreme event assessment as well as applying Waterways Action Plans to shape response to such disruptions. The MTS must consider applying resilience assessment tools in order to provide simple and quick methods for ports and communities to consider their own resilience and manage future operational challenges.

II. Identified Research, Development, and Technology Needs

As the MTS continues to play a critical role in an increasingly interconnected world, it must also evolve alongside the changes these interconnections bring with them. TRB-CMTS R&D Conference speakers and participants emphatically stated the necessity to prepare the MTS to better withstand disruptions, adapt to changes, and take advantage of emerging technologies to address the challenges and other influences on the system. Strategic implementation of R&D will enable the MTS to evolve. The following subsections detail R&D needs and gaps that were identified by the conference attendees. Some of the R&D needs are specific to particular aspects of the MTS, while others, such as resilience, cross-cut different MTS elements.

Data Integration

Data collection, availability, and integration remain critical to multiple aspects of the MTS, ranging from navigational guidance to monitoring MTS structural health. This appetite for data has grown as operations become further dependent on specific information alongside a greater number of data sources. The conference identified the following data integration needs for the MTS:

- MTS entities must develop frameworks and integrated approaches for data collection tools to be more interoperable and thereby support more widespread knowledge generation.
- Better coordination requires more fully implemented data standards as well as real-time collection and sharing.
- Data communication at these levels will demand high bandwidths to deliver data streams to a wide user group.
- To enhance the relevance and proper use of data, their collection must better align with MTS geography (e.g. port borders and port tonnage).

- More Big Data analytics could successfully reveal potential connections as we also must better develop cross sector data transparency. While the proprietary nature of certain datasets is important, those restrictions should be removed as soon as possible.
- The MTS R&D community should build more long-term test beds to better understand and comprehensively validate these data
- As data become more available and reliable, they should be incorporated to enhance performance metrics. Such application includes the need for resilience metrics and considering social risks related to MTS along physical risks.
- There should be a survey of data needs and more effort to engage MTS stakeholders when deciding what data resources would be most applicable. This kind of process should also connect with more efforts and methods to enhance tech transfer and further reduce the valley of death between research and application. Such methods would also ideally lead to better technology distribution.
- Data should also be integrated with the Regional Ocean Planning processes to fully inform and leverage those efforts and represent MTS concerns there.

MTS Infrastructure

Conference participants addressed a number of infrastructure and materials advances while also highlighting the increasing interest to investigate the potential to replace physical aspects of MTS navigation and other operations with virtual infrastructure (i.e. eNavigation). These approaches include the need to better observe the condition of existing strategic infrastructure through Structural Health Monitoring and other management approaches. Other infrastructure areas for suggested advancement include:

- Management strategies developed for implementation at ports and other MTS systems should be simply designed.
- The MTS can innovate to reduce investing in large fixed infrastructure where it is not absolutely critical, especially as environmental conditions are likely to become more variable in the future.
- Treating MTS infrastructure projects as large, real-world opportunities for prototype investigations can generate critical knowledge. Greater engagement with academia and the private sector could better infrastructure designs and reduce future issues.
- As R&D explores additional novel materials to extend infrastructure life, more work is needed to look into materials' durability, derivative failures, operation in different conditions and other fatigue issues.
- Standardized designs could decrease maintenance costs and increase reliability.
- Current gaps align with the requirement to more efficiently use our existing infrastructure and resources. More long-term planning and investment, and less thinking within silos can add to the success of these approaches.

Supply Chain Innovation

To operate an efficient MTS, the Nation should continue to make R&D investments that lead to the optimization of supply chains and associated logistics. By increasing the visibility of the interconnectedness of the national and MTS supply chain, managers should be better able to predict second order dependencies and disruption impacts, especially if they consider the following aspects of MTS supply chains:

- Comprehensive data collection should allow for a solid suite of MTS performance measures.
- States should ensure that they have incorporated MTS elements into their state freight plans in order to best integrate multimodal transportation operations and take full advantage of any advancements.
- Innovative efforts demand better understanding of new vessel and cargo technology, automation methods, and impacts. Ports should work with each other directly to facilitate the sharing of knowledge and opportunities from these advancements.
- From the national and regional perspective, better understanding of port ecosystems, intermodal connections, and quantification of MTS capacity for freight movement could assist overall supply chain optimization and response to disruptions. The improved knowledge of these elements could increase MTS resilience as well as assist the prioritization of federal MTS investments.

Environmental Conditions, Change, and Impacts to the MTS

MTS stakeholders have developed an understanding that the likelihood for changing sea-level, precipitation, storm intensity, and temperatures may potentially stress and disrupt the MTS of the future. Therefore, more research is necessary to better visualize these hazards and understand how they will influence port and waterway operation continuity and other critical aspects of the MTS, such as impacts on channels and shoaling or cleanup of oil in ice-covered waters. The MTS should address a broad array of concerns best adapt to changing conditions:

- Management of future disturbances demands tackling them proactively, looking at future trends and not solely relying on historic patterns. Research can fill the gaps in understanding of what climate-related decisions will need to be made at the federal level to increase MTS resiliency.
- More attempts must be made to incorporate technology that reduces pollution in the air and water. The best chances to implement improvements into the MTS will include market-based approaches and incentives.
- Future environmental challenges require that the MTS develops interdisciplinary teams to work efficiently, save money, and deliver the best possible, cross-cutting solutions that enhance MTS resilience.
- Research must guide better quantification of the benefits that environmental systems generate (e.g. RSM or EWN). Only when costs and benefits are identified can these efforts be fully considered in conventional solutions.

- Continued use of unmanned systems and imaging technology should continue to measure and monitor underwater processes on the same scale and resolution we measure and monitor the MTS above the water surface.

Security

Alongside changes in the natural world, manmade threats continue to evolve. As a system of systems, MTS stakeholders need to understand all the potential vulnerabilities to it during military engagements and everyday operation. As all companies and MTS operators become technology companies to some extent, cyber attacks have become the newest disruption to the overall system. Despite this recognition, a false sense of security seems to remain. Other security issues for consideration include:

- More research must address the ability within the MTS to handle the associated risks of cyber threats to operations - the MTS must identify evolving cyber hazards and develop better protection systems against them.
- Despite advances in cyber defense, attacks will still break through. Therefore the MTS must better understand how to recover after attacks and develop post-attack contingency plans to return to functional performance levels.
- At the same time, the threat of cyber attacks should not be allowed to inhibit application of technologies that produce a safer, more efficient, and reliable MTS.
- It is not enough to simply research and model security risks – these lessons must be properly communicated and operationalized throughout the MTS to maintain proper security.

The Human Element

Despite the transition to an ever more digital, automated MTS, people remain just as critical as ever. As technology advances, the MTS requires a workforce that can manage the increasing complexity in operations and security (e.g. cyber) as well as new environments (such as the Arctic). Raising the level of workforce aptitude requires significant amounts of training as part of the effort to transfer technology and MTS-relevant research to human operation. In addition to adequately preparing the MTS of tomorrow's workforce, research must also work to better understand the adaptation of human behavior to changes associated with new MTS technologies. In particular, attendees suggested that the MTS should address several human-related issues:

- Trainings and data use procedures must be ergonomically designed to encourage acceptance and implementation.
- The need for trained merchant mariners is critical. Engagement to promote fields in maritime should start as early as possible with more outreach to K-12 students about the wide array of MTS careers available to them.
- Student engagement and workplace training can be supported among the MTS R&D community by better involving students in the TRB-CMTS R&D conferences and sponsoring more participation.

- The MTS community should take advantage of the diversity of transportation centers at universities with maritime focuses as well as looking abroad to see how the international community addresses similar R&D issues. These efforts could greatly enhance the diversity of the MTS community as well.
- By better appreciating human connections to the MTS and associated demands, MTS stakeholders should be able to better optimize system design and management.
- MTS studies must extend into the communities beyond MTS infrastructure as the value of the relationships and associated dependencies with sustainability and resilience become clear. Research must still identify how to best identify and quantify these codependent factors in order to improve the community-MTS system and linkages.

Governance

The evolution of MTS operations and technologies often will be significantly limited if federal, state, and local governments fail to support the proper environment for technological advancements to operate in. There are a number of policy challenges that prevent the optimization of freight and passenger movement, such as the list below:

- MTS stakeholders need to understand how developing technologies (and the data they generate) fit into existing authorities and regulations.
- Policies must be updated to allow for new technology integration, clarifying where potential conflicts may exist and identifying what needs to be changed.
- In certain cases, regulation can only go so far to affect change. Technology simply moves too quickly and non-regulatory ways must be increasingly considered to “mandate” proper technology use or data sharing.
- Rules shaping the travel of federal staff associated with R&D efforts should also be reevaluated, as current limitations may hold back the collaboration and facilitation necessary to push MTS R&D forward.
- Altogether, MTS progress requires less formal, more agile application of technology-based policy and new ways to work together as a community of practice.

Funding

As with any other aspect of the MTS, research and development progress comes down to the financial assets available to implement them. Even as data demands rise, the MTS must work to fund data collection under constrained resources. The federal government cannot take on guidance and implementation of all MTS relevant research, development and technology alone. The MTS R&D establishment must deal with a more fragmented logistics and finance system, and therefore should address the following challenges:

- There must be better collaboration between different federal agencies in forecasting their upcoming research plans to better enhance efficiency.
- The Federal Government must also strategically shape its criteria and definitions for grants and proposals (such as resilience factors) to better shape and guide MTS R&D application across the nation.

- Improved impact analyses detailing the potential value of R&D could better leverage funding by illustrating where investments reduce other costs as well as augment future benefits.
- Creative financing must be sought to support MTS research. Beyond the federal reach of the MTS, more non-federal champions need to stand up to help build bridges between potential R&D partners within the broader MTS.
- More innovative public-private and public-public partnerships must be implemented to better link stakeholders with compatible resources and goals.



U.S. Committee on the Marine Transportation System

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