CTMA CONNECTOR

Digitizing the F100 Engine and Researching Parts for Additive Manufacturing

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NATIONAL CENTER FOR MANUFACTURING SCIENCES

CTMA Connector

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UPCOMING EVENTS

July 17–18, 2023
NCMS Technology Showcase: Tinker Air Force Base
Oklahoma City, OK

July 18-19, 2023
Additive Manufacturing for Maintenance Operations (AMMO) 2023 Advanced Manufacturing Workshop
Bethesda, MD

August 14-17, 2023
DOD Corrosion Prevention Technology and Innovation Symposium
Tucson, AZ

August 15-17, 2023
Ground Vehicle Systems Engineering & Technology Symposium (GVSETS) & Modernization Update
Novi, MI

September 26-28, 2023
NCMS Technology Showcase, Puget Sound Naval Shipyard
Bremerton, WA

December 18–21, 2023
DOD Maintenance Symposium
San Diego, CA

Due to ongoing travel uncertainties, some NCMS events might get rescheduled. Please check the NCMSEvents Page for the latest updates. Don't hesitate to email eventsupport@ncms.org with any questions.

About NCMS

The National Center for Manufacturing Sciences (NCMS) is a cross-industry technology development consortium, dedicated to improving the competitiveness and strength of the US industrial base. As a member-based organization, it leverages its network of industry, government, and academic partners to develop, demonstrate, and transition innovative technologies efficiently, with less risk and lower cost.

About CTMA

The Commercial Technologies for Maintenance Activities (CTMA) Program offers a unique contracting vehicle for industry, academia, and the DOD sustainment community to work collaboratively. Through these efforts they promote the demonstration, evaluation, and validation of new and innovative technologies that enhance warfighter readiness at optimal value and lowest risk. This non-FAR based contracting vehicle is the only DOD-wide program focused solely on maintenance and sustainment.

An HH-60W Jolly Green II helicopter from the 66th Rescue Squadron taxis at Nellis Air Force Base, Nevada. A recent CTMA project has brought together the US Air Force, the Defense Logistics Agency, and Andromeda Systems Incorporated to conduct a gap analysis on repair processes for the US Air Force's HH-60Ws. (US Air Force photo by Staff Sgt. Alex Stephens.)

Collaboration Seeks to Reduce Air Force Maintenance Costs

The US Department of Defense's most versatile helicopter, the Black Hawk, and its close cousins, other H-60 variants, perform multiple missions: delivering and rescuing warfighters in combat zones, protecting aircraft during armed assault missions, providing aerial firefighting, patrolling borders, bringing critical supplies to civilians during natural disasters, and transporting dignitaries.

With more than 5,000 in service worldwide, the Black Hawk primarily serves the US Army, but it is also used by other services including the Air Force. To complete timely repairs, the DOD needs to solve numerous logistical challenges including ensuring the accuracy of forecasting methodologies, standardizing work practices, clearly defining capacity constraints, and quickly identifying alternate sources for repair parts.

A current CTMA collaboration, Modeling Repair Activities, is demonstrating a methodology designed to help overcome these challenges.

Launched in April 2022, the project brings together the US Air Force, the Defense Logistics Agency, and industry partner Andromeda Systems Incorporated (ASI). The objective of this initiative is to conduct a gap analysis at two DOD repair locations: Warner Robins Air Logistics Complex at Robins Air Force Base in Georgia and Ogden Air Logistics Complex at Hill Air Force Base in Utah.

Gap analyses are used by both public and private-sector organizations to assess the performance of a business or business unit to determine whether business requirements or objectives are being met and, if not, what steps should be taken to meet them.

This team is conducting a gap analysis on repair processes for the US Air Force's Black Hawk variant, the HH-60W Jolly Green II, which is a combat rescue helicopter.

"There's a lot of opportunity for synergy within the Black Hawk community across the enterprise," said Greg Hutson, ASI's Air Force Program Manager. "Our goal is to see where this helicopter is being repaired, at different locations throughout the DOD, to avoid duplicative maintenance. Identifying the repair capabilities

that already exist within the DOD can help to reduce maintenance costs."

This gap analysis will assist the HH-60W Program Office, which requires a comprehensive assessment of current line-replaceable units (LRUs)—an essential support item that can be removed and replaced at the field level to restore the end item to an operational ready condition, as defined in MIL-PRF-49506. LRUs are designed to be replaced within a short time, without the need for specialized tools, so they are particularly useful because the aircraft can quickly return to service while the failed LRU is being tested and repaired.

"The Air Force designated 30 components of the HH-60Ws as a core workload," said Hutson. "The vast majority of these are avionics, and all are LRUs. According to the '50-50 Rule', the Air Force needs to have 50 percent of their workload that is organic to maintain the depot capability. The Air Force wants to assess the repair capabilities for these 30 components at the Georgia and Utah sites."

> **"The Air Force designated 30 components of the HH-60Ws as a core workload. [It] wants to assess the repair capabilities for these 30 components at the Georgia and Utah sites."**
>
> *– Greg Hutson, ASI*

The project is proceeding in several steps. First, the team is reviewing the processes, skills, and resources currently in use, or planned, to complete repairs. Next, they are identifying the support and requirements needed such as test equipment, tooling, spares and repair parts, staffing, training, technical documentation, facilities (unique power/heating/cooling requirements and quality assurance). This step is also considering the packaging, handling, storage, and transportation (PHS&T) needed to activate the designated repair capabilities.

Then, the team is developing an estimated number of repairs based on the number of failures per flight hour. These estimates will be based on actual failures that have occurred, along with projected failures in the future. Finally, the team is producing repair time estimates, which will include the amount of time needed to diagnose, repair, and return the LRUs back to service. Part numbers and descriptions of relevant repair-related documentation will be provided. This includes, but is not limited to, acceptance test procedures (ATP), diagnostic test procedures (DTP), and repair procedures.

The project's final deliverable will be a depot gap analysis report that will identify the gaps between the current depot capabilities and those required to support the sample set of new LRUs to help establish the depot source of repair (DSOR). This project's report will assist DOD decision-makers with the process of determining when to in-source, and when to outsource LRUs to improve throughput.

This project will benefit not only the Air Force but also the DOD, enterprise wide. Lessons learned from this initiative can be applied across all DOD maintenance organizations, with the potential for adoption by managers of ground vehicle fleets, engineering equipment, power generation, ship repair, and a multitude of other applications. This project's framework will help to facilitate more effective resource allocation and provide the DOD with more accurate forecasts for its operation and maintenance (O&M) budgets, greater fidelity when developing contract requirements and deliverables, and improved accuracy when reporting these publicly owned assets on financial statements and audits.

Additional benefits to the DOD include improved collaboration between engineering and logistics providers across the enterprise; optimized sustainment policies and practices at the program office, field repair activities, and field supporting agencies; decreased turnaround times and maintenance costs for organizational, intermediate, and depot-level repair activities; and increased mission capable/full mission capable weapons systems available to the warfighter.

The project is scheduled to be completed with the delivery of the final technical report and research items this July.

"We have appreciated the customer's flexibility. The HH-60 Program Office has been very flexible and thoughtful about working with the various stakeholders—the OEMs and Air Logistics Complexes," said Hutson. ■

Optimizing the Manufacturing and Assembly of T-38 Aircraft Wings

The Air Force trains new pilots on the Northrop T-38 Talon, leading to significant wear and tear on the aircraft, and in particular the wings. Presently, production of replacement wings and associated repairs takes a lengthy amount of time due to outdated part designs and processes, so the Air Force is looking to optimize wing manufacturing and assembly.

The CTMA Program has stepped in to fill this need by launching a collaboration between the Air Force and the National Institute for Aviation Research (NIAR): Wing Optimization for Manufacturability.

Tina McClane, a T-38 Talon aircraft structural mechanic, works on the wing of a T-38 at Holloman Air Force Base, NM. (US Air Force photo by Daniel E. Liddicoet.)

"A key Air Force challenge is getting wings often enough," explained Allison Bonitati, NIAR's Director of Programs and Finance. "This is a full-scale wing redesign. Our team is comprised of about 400 engineers, and we have a full MRO team that does manufacturing and modification of aircraft."

"Our goal is to be able to use our expertise to analyze all the options, newer technologies, and processes to provide a solution to the Air Force to support their needs for the T-38 wing replacements," added Amber Delong, who is managing the project for NIAR.

There was a redesign of the T-38 wings around 2000, so the team is working from that design, but some of the components are from the original aircraft, which is over 60 years old. The team is investigating the current manufacturing and assembly process to increase efficiency. They are researching various options such as part consolidation and finding alternative materials that are more readily available and require less manufacturing time.

"We're primarily looking at castings, forgings, and extrusions that have been used historically but can be improved with modern machine capabilities," said Delong.

"The modern machine technologies allow us to make an equivalent strength part in less time," added Bonitati.

The team is currently in the first phase of what will be a multi-phase project. In this first phase, the collaborators are reviewing the data to determine the necessary trade studies to conduct. For example, one trade study will perform calculations to see if parts can be switched to a different material without invalidating the integrity of the wing. This trade study will require weight and strength comparisons between the original and proposed replacement materials.

"Another trade study we'll need to do is on the airworthiness approach for certification of the wing," explained Delong. The trade studies will provide a formal cost-benefit analysis, where different options are weighed against each other, along with a decision matrix formalizing all the information, for Air Force decision-makers.

The next steps will be to share the findings with the Air Force, then move into concept design review, where the team will preliminarily lay out the engineering and study stress, fatigue, parts, materials, and certification. The project will utilize the Design for Manufacture and Assembly (DfMA) approach, which is focused on optimizing the design to reduce manufacturing and assembly time to increase the production rate. The initiative will culminate in the production of a prototype T-38 wing.

"Supply chain has been challenging for everyone," said Bonitati. "The redesign might alleviate supply chain issues because we can identify materials that are more common, readily available, and machined in more than one location."

The project is scheduled to be completed in December 2024. ■

A Royal Air Force (RAF) Airman of the 48th Fighter Wing inspects a Pratt & Whitney F100 engine at RAF Lakenheath in England. (US Air Force photo by Tech. Sg

Digitizing the F100 Engine and Parts for Additive Manufactur

The CTMA Program is collaborating to improve the maintenance and sustainment of aircraft engines through a partnership with the National Institute for Aviation Research (NIAR) and the Air Force Life Cycle Management Center by creating a digital twin engine along with the Workbench for Additive Materials.

"The Air Force's Propulsion Directorate is a recognized leader in the implementation of innovative technologies. Our partnership with the NIAR on the F100 Digital Twin and the Workbench for Additive Materials (WAM) [database] will accelerate the adoption of 3D metal printing and foster competition. Both are instrumental for resolving pervasive material shortages impacting legacy propulsion readiness," said Beth Dittmer, USAF Propulsion Integration and Innovation Division Chief.

This initiative—Digitization of Jet Engines to Improve Maintenance—is using the F100 engine as a testbed, utilizing digital twin technology to improve engine sustainment across the DOD. The project's research into additive manufacturing is also expected to benefit the commercial aircraft industry.

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The F100 engine is a mainstay for the US Air Force, logging more than 30 million engine flight hours since it powered its first F-15 in 1972. The F100 series remains in use, with more than 3,800 in service, and it will continue to be an important engine far into the 21st century.

To advance F100 engine repair, the team is creating a digital twin of the F100 engine. A digital twin is a digital replica of the physical engine that links the virtual and physical environments. Both operational and maintenance data associated with the physical engine system are supplied to the virtual environment to update the virtual model in the digital twin. The digital twin becomes a precise and up-to-date representation of the physical system that also reflects the operational context of the physical twin, making it possible to track the performance and maintenance history of each physical twin over time, detect and report anomalous behavior, and recommend maintenance.

To create the digital twin, the team is using digital engineering principles, including a model-based systems engineering (MBSE) road map and strategy. MBSE is the formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases.

The team is creating a level 1 digital twin of the F100 engine (modules, components, and parts) from government-furnished technical documents and physical assets. Digital twin maturity models typically delineate five levels, with level 1 being a 2D map/system or a 3D model, object-based, with no metadata. The highest level, Level 5, enables automatic asset control, operation, and maintenance.

Along with creating a digital twin of the F100 engine, the initiative is concurrently creating the WAM database that will be a repository for material specifications, material allowables, and the associated pedigree information for additively producing parts, which is imperative to improving asset readiness and is a high priority across the DOD.

Currently, data on additive materials is still in an early stage and is not easily accessible. This project will change that by producing a database that will contain material data to help engineers design parts using the same or different materials used on the legacy part. The idea is to be able to create parts additively to help speed up production, expand the vendor base with approved suppliers, and to build a comprehensive material specification repository for government use.

“Right now, we’re in a situation where we have to reinvent the wheel every time we want to use a new machine or a new vendor,” said Dr. Mark Benedict, Air Force Research Laboratory Additive Manufacturing Director and America Makes Chief Technology Advisor (CTA). “The hoped-for expectations are that we will reduce the generation of duplicative data and really understand the data generation needs, so we don’t

keep doing the same experiments again and again. Long term, this project will help us understand what is unique about a particular manufacturer or material process."

The WAM project is proceeding in three phases. First, the team is reviewing data sets, security requirements, servers, and software to decide on the optimal structure for the database. Next, they will release a beta version of the database to a small, select group that works with design engineers, including engineers from the Air Force and Army, and use their feedback to improve the database. In the final phase, the team will launch the working database government-wide. Access to the database will initially be for DOD agencies and other interested government agencies. In future phases, access will also be granted to specific supporting contractors who work in the field.

"If somebody wants to additively manufacture a part, this database will provide the material data to start the design work. This could include minimum allowables, machine parameters, material specifications, and pedigree information to understand which machines were used to create the data," said Polly Kipfer, USAF Program Manager for the WAM project.

"We're generating data for three different metals: aluminum F357, nickel alloy 718, and a cobalt material," said Dr. Benedict. He added that titanium data will also be included.

"The datasets include the information created by building coupons with the metals that we then run through tests such as tensile strength, porosity, hardness, etc. Having these specifications in the database will allow engineers with access to run their own analytics to see if a material will work for the part they want to build. By recording the data in the datasets, we build on work already accomplished and stop duplicating builds and tests that are both costly and time-consuming. The engineer can download the information for the material he wants to use and start analyzing and designing for his purpose," said Kipfer.

"If somebody wants to additively manufacture a part, this database will provide the material data to start the design work, [which] could include minimum allowables, machine parameters, material specifications, and pedigree information."

– Polly Kipfer, USAF

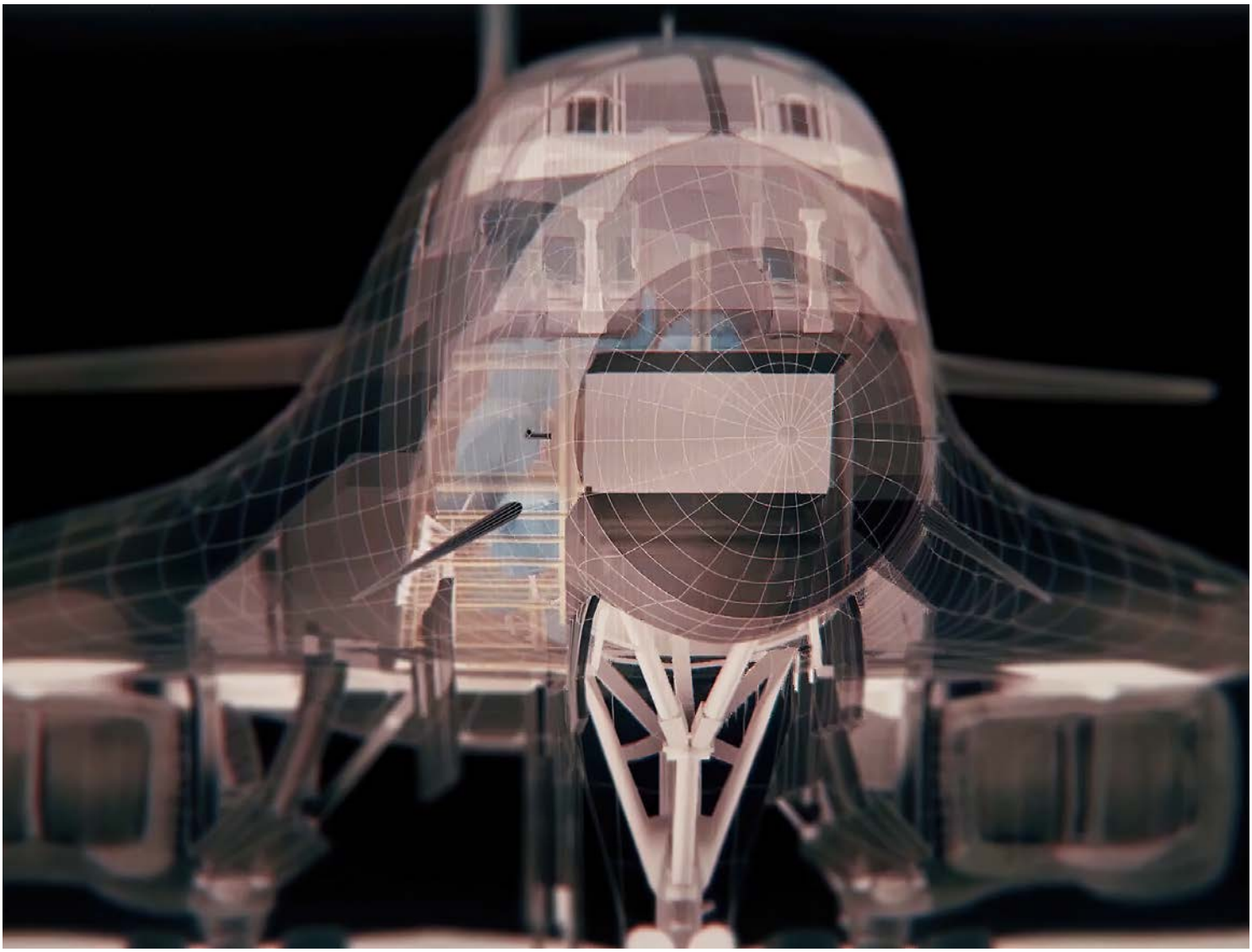
The database will do more than report data from mechanical testing.

"There's the somewhat misguided notion that we just create a database and throw in all the data and we're good," said Dr. Benedict. "The reality that we've seen and documented is that if you don't understand the specifics of how data was generated, you will not be able to draw a one-to-one comparison. These specifics are referred to as pedigree data. For example, I may have an additive printer that was working with titanium at 30-micron layers, and a different printer working with titanium at 65-microns. Each will yield different mechanical performances. If I didn't know that those two had those differences, and I just compare the outcomes, it might lead me to some very inappropriate design decisions or to take more risks than I should. So, it's really not just sharing the numbers, but sharing how those numbers were achieved, that is needed to promote confidence in the material across the whole of government."

"For additive, there's definitely an emphasis on pedigree and fidelity of data that is required to make the right decisions on designs that meet the military's criteria for airworthiness," added Angel Rivera, Senior Materials Engineer for the USAF Propulsion Additive Manufacturing Team. "This database will be a location that government engineers, who are responsible for the safe flight of their systems, can easily access and become familiar with these materials and these processes."

The project is slated to wrap up in November 2025.

"This database is not solely for the Air Force," said Dr. Benedict. "This is meant to be an across-government activity—primarily, of course, for the DOD, but also for NASA, potentially the Federal Aviation Administration (FAA), the National Institute of Standards and Technology (NIST), or other parties interested in this type of data." ■



The National Institute for Aviation Research (NIAR) team has been creating a digital twin of the B-1 by stripping down an out-of-service aircraft and performing a complete scan of each part to create a virtual copy. The entire process will take about six years to complete. (Photo captured as a still frame from a 2020 video episode of "Around the Air Force"; video by Staff Sgt. Timmethy James.)

USAF Digital Twin Efforts Progress at National Institute for Aviation Research (NIAR)

As the B-1 continues its service into the 2030s, a CTMA project is assisting with the aircraft's digital engineering (DE) transformation.

The B-1 System Program Office (SPO) began its DE transformation in early 2020 by creating a structural digital twin of a single wing at the NIAR facility at Wichita State University, then expanding to the entire airframe in 2021. Last March, a CTMA collaboration between NIAR and the B-1 SPO at Tinker Air Force Base was awarded a six-year $100M follow-on contract to continue the B-1's DE transformation, integrating systems and weapons into the structural twin. The follow-on contract also focuses on utilizing the integrated digital twin for structures and weapons analysis.

The collaboration is creating a digital twin of the entire B-1 airframe of appropriate fidelity to meet the long-term objectives of the SPO, which includes the integration of data between the digital model and the physical aircraft through a digital thread that links authoritative data sources.

The digital twin will incorporate ultra-high-fidelity simulation, which could be paired with the B-1's onboard integrated vehicle health management system, maintenance history, and all available historical and

fleet data to mirror the life of its flying twin and enable unprecedented levels of safety and reliability.

The digital twin can be used to evaluate damage or changes to aircraft usage in order to repair, modify the design, change structural inspection intervals, or even reevaluate the design life of the asset. This initiative supports the DOD's efforts to create digital twins, enterprise-wide, to increase mission readiness while improving maintenance and reducing sustainment costs.

"The project has several different objectives. We're really working hard to address some parts obsolescence and diminishing manufacturing sources issues with the B-1 program," said Dr. Melinda Laubach-Hock, NIAR's Director of Sustainment. "Manufacturing teams today don't want to make parts off of 2D drawings, so the objective is to develop full 3D CAD models that have each of the detailed parts for manufacturing purposes. In addition, by using digital twins we're working toward becoming more predictive in managing the airframe and beginning to work on problems before they arise."

> **"With both these programs, we are interested in not just engineering, but also shop-floor training. We're teaming with some of the simulation teams to be able to give them higher fidelity, more accurate graphics that look like a B-1 and an F-16."**
>
> *– Dr. Melinda Laubach-Hock, NIAR*

The partnership also entails conducting analyses to ensure the viability and safety of new B-1 weapons to increase diversity in the weapons the airframe can carry.

"This requires a lot of engineering and computing time," explained Laubach-Hock. "With the digital twin, we positioned ourselves very well to be able to take some of the engineering analysis workload off the Air Force. While we're not certifying weapons, we're doing supporting analysis work."

In addition to the B-1 digital twin initiative, another CTMA collaboration with NIAR is creating a digital twin of the F-16. First flown in 1976, more than 3,000 F-16s are operating today in 25 countries.

"The F-16 is very tightly compact, so they're constantly upgrading and modifying that fleet," said Dr. Laubach-Hock. "For example, if they want to add new radar, we need to study where to locate it and how to connect the wires."

"We're also doing a lot of fault isolation detection for the F-16," Dr. Laubach-Hock continued. "For instance, if you flip a switch, there are a lot of things that have to happen right for the fuel tank to fill up. What is that process and what rules and laws govern that process from an engineering perspective? We're putting all of that into system modeling language (SysML) so we can model the way the system performs normally, then we can go in and insert little faults. For example, if there is a fuel leak, we look at what that's going to do downstream and how's it going to manifest itself as a physical symptom on the airframe."

The collaboration is also focused on training both current and next-generation maintenance professionals.

"With both these programs, we're interested in not just engineering, but also shop-floor training," said Dr. Laubach-Hock. "We've looked at digital work instructions to make sure that maintainers have digital aids to assist them in some of the complex repairs they're doing. For training, we're teaming with some of the simulation teams to be able to give them higher fidelity, more accurate graphics that look like a B-1 and an F-16."

The digital twin of the F-16 is scheduled to wrap up in August 2024, while the B-1 digital twin is slated to be completed in 2028.

"One of the unique objectives of all of these programs at NIAR is we're tied to Wichita State University, so we're an educational institute and we're training the next-generation workforce," said Dr. Laubach-Hock. "Probably greater than 50 percent of the employees performing work on these programs are students under the supervision of seasoned engineers. The students are getting great experience and going out to the real world with a resume that makes them highly competitive." ■

Soldiers of the 34th Red Bull Infantry Division conduct wash-rack operations at Camp Arifjan, Kuwait, utilizing the post's pressure washers to remove dirt, sand, chemicals, and other contaminants to prevent corrosion as well as promote longer equipment lifespan. (Photo by Spc. Samantha Petersen, 34th Red Bull Infantry Division.)

Risk-Based Corrosion Prevention Initiative to Offer Versatile Assessment Tools

Corrosion is an insidious problem across the globe, costing industries and governments billions of dollars each year to prevent and remediate while simultaneously taking critical equipment and infrastructure out of service. A CTMA collaboration is developing best-practice technical and business process solutions to effectively address corrosion throughout the life cycle of fielded equipment and infrastructure. The initiative will be useful for the Army, the DOD, and commercial industries that maintain corrosion-prone assets.

The collaboration—Corrosion Prevention and Control (CPC) Program Development, which brings together the Army and industry partner Jensen Hughes—is expected to be a multi-phase, multi-year project. The team completed the first phase earlier this year.

"In Phase I, we developed what we call a risk-based approach to corrosion planning during the acquisition process of weapon systems," said Patrick Taylor, who is managing the project for Jensen Hughes. "We created a tool to help acquisition managers make sure that corrosion is being addressed in the design to reduce the risk of negative consequences later in the life cycle, primarily cost overruns, performance degradation, or lack of readiness due to corrosion."

The tool the team developed is in an Excel spreadsheet format to make it universally accessible to anyone with a computer. The tool takes a logical, stepwise approach, factoring in all the considerations that may affect the corrosion-resistance properties of equipment.

"The tool asks around fifty questions," said Taylor. "Some of the questions are specific to the Army, and some are specific to the DOD, but for the most part, the questions are generic to any kind of equipment that might be exposed to corrosive environments."

The assessment questions are broken down into several major areas: environmental susceptibility, design materials, preventative maintenance, and storage.

"The environmental susceptibility questions ask how the system is going to be used from an environmental exposure perspective," explained Taylor. "For example, you can select a default of the most corrosive environment for an Army weapon system because the

equipment must operate everywhere. But for a different user who's only worried about putting equipment in a single location, they can tailor the risk assessment to just that location, and the tool will help them decide if it's corrosion-resistant enough for that local environment."

After the user has answered all the questions, the tool will generate a risk assessment.

"The tool is not quantitative, but it does tell the user where their equipment fits in terms of low, medium, or high risk," said Taylor. "And it's really up to them to decide if that's acceptable as they consider trade-offs with all the other things that they need to consider for the life of their program."

It's also up to the end user to decide when to use the tool, but Taylor believes it makes the most sense to use the tool at a specific phase of the engineering process.

"I think it would make the most sense to apply it during the preliminary design review after some of the engineering and design work has been done, but before the design has been locked in and started production," Taylor said. "In order to answer the questions most accurately, you need to have some level of design decision that has already been made. It's not necessarily going to help you design something from scratch, but it will serve as a very good check early in the design process about whether you're making sound decisions regarding corrosion."

While the project's first phase focused specifically on corrosion prevention during design of Army weapons systems, the project's later phases will address different aspects of preventing corrosion for equipment and infrastructure.

"This work is not unique to the Army," said Taylor. "Some of the other services have expressed interest in it, and it would be pretty easy to adapt to other service weapon systems as well."

The team will present their findings at the 2023 DOD Corrosion Prevention Technology and Innovation Symposium, which will be held August 14-17 in Tucson, Arizona. NCMS will have a presence at the symposium—please visit us in Booth 220. ■

NCMS Technology Showcase at Norfolk Naval Shipyard Features World-Class Exhibitors

NCMS partnered with the Norfolk Naval Shipyard (NNSY) in Portsmouth, VA, from May 9 to 11, on an NCMS Technology Showcase that featured leading-edge solutions from world-class organizations designed to help fast-track relevant maintenance, repair, and overhaul (MRO) innovation for all naval shipyards.

Working closely with the innovation leads at NNSY, NCMS identified best-in-class technologies aligned to key MRO functional areas: Advanced/Additive Manufacturing, Workload Planning, Advanced Machining, Welding, Fiber-Optics Repair, Distance Communications, Robotics, Cleaning, Software Maintenance, Business IT and Analytics, CBM+/ Predictive Maintenance, Coatings and Corrosion Prevention, Energy/Environmental/Health & Safety, Enhanced Inspection, Facilities and Industrial Process Modernization, Hardware Reliability Improvement, and Workforce Development and Visualization. Also, in alignment with NAVSEA 05T objectives, robotic maintenance capabilities were successfully demonstrated during this event, specifically for hydroblasting.

Over 1,500 personnel from key NNSY production shops, command leadership, NAVSEA engineering and sustainment, Coast Guard, USS Truman, USAF innovators, and representatives from the Navy's Repair Technologies (REPTECH) working group collaborated and shared ideas regarding how NNSY MRO operations could significantly improve through the adoption of advanced technology and sustainment processes.

Next steps include reviewing data collected during the event to extract business insights regarding the potential benefits of the workforce's most desired capabilities. Based on this feedback, NCMS stands ready to facilitate rapid technology demonstrations via the CTMA Program and technology transfer processes. NCMS Technology Showcases have become a sustainment innovation and technology transfer best practice, as the maintainers who are closest to the problems are the best source of ideas to improve MRO operations. ■

NCMS Partners with Carrier Team One for Innovation Expo, and with NavalX for Technology Exchange Workshops

Attendees at this year's Carrier Team One Innovation Expo, hosted by NCMS, view exhibitors' technology solutions. (Photo used by permission; photo by Carrier Team One.)

NCMS supported Carrier Team One (CT1) in their mission of improving the performance and availability of Navy aircraft carriers by hosting an Innovation Expo during CT1's Annual Community Event in May at the Norfolk Waterside Marriott in Norfolk, VA.

NCMS reached out to our network to seek industry partners with technologies that may help CT1 with their objectives: modernizing current carrier business processes, increasing the efficiency of their carrier deck plate processes, and providing solutions that are available to implement on aircraft carriers. Companies that met these criteria exhibited and demonstrated their technologies at the Expo.

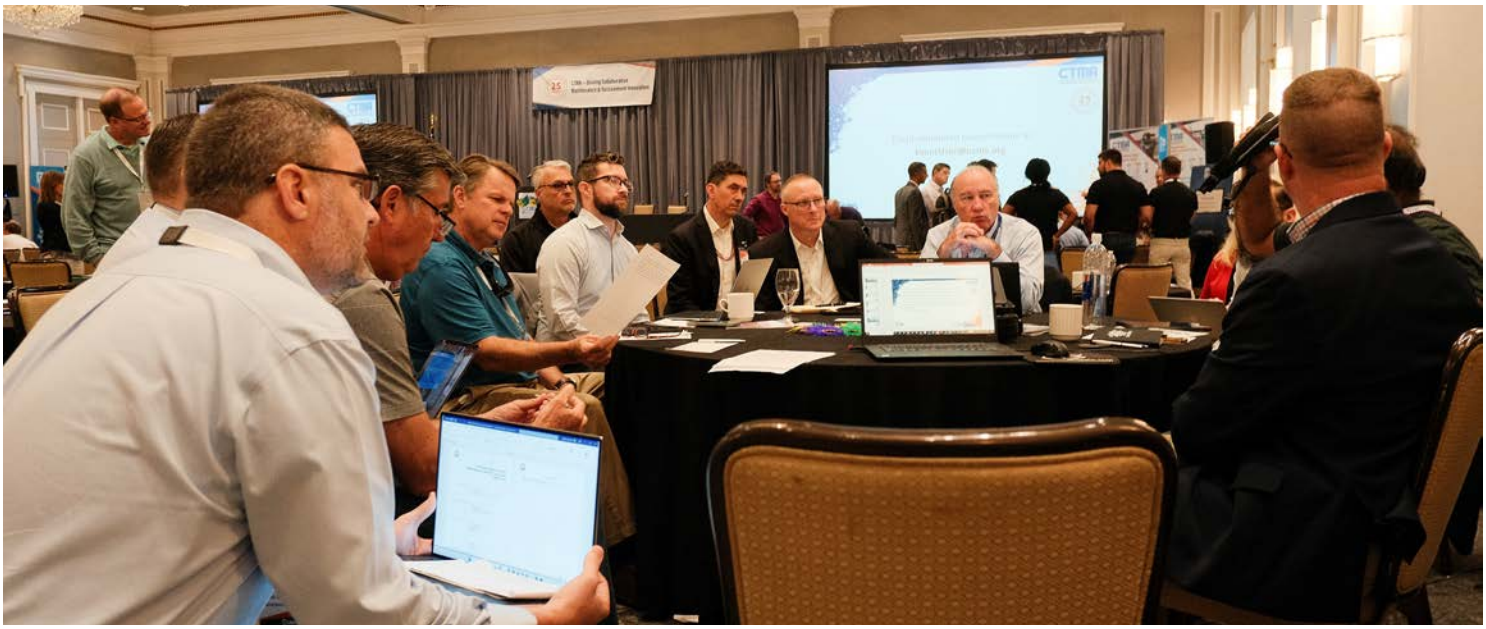
After the Innovation Expo ended, NCMS partnered with the NavalX Mid-Atlantic Tech Bridge to create two days of workshops with industry and subject matter experts (SMEs) to further discuss solutions and ways to engage. Held at NCMS's Norfolk office, workshops with SMEs enabled participants to learn about opportunities for collaboration and knowledge sharing among leading technology experts who serve the Navy's aircraft carrier maintenance community.

A morning panel on challenges in sustainment and repair was followed by four afternoon panels. Brian Shipley, SBIR/STTR Commercialization Director, led a panel on Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR). This panel included an overview of these programs, an explanation of how Navy SBIR is used to fill gaps, and how the program is leveraged to transition R&D to meet those needs. The second panel, run by Arveice Washington, DoN Small Business Director, focused on DoN small business opportunities, lessons learned, and how to participate.

A panel led by David Schiff from the National Security Innovation Network (NSIN) Transition Cell provided an overview of the NSIN, what the Transition Cell can help with, and how to connect. Finally, Julie Stark, Science & Technology Manager for Combatant Craft at NSWC Carderock, gave an overview of NavalX Tech Bridges and provided opportunities for organizations to connect with the network of 18 Tech Bridges located throughout the US as well as the UK and Japan.

Finally, in partnership with innovation leadership at NNSY, CT1, NAVSEA 05T, and the Mid-Atlantic Tech Bridge, NCMS organized, facilitated, and co-hosted maintenance capability gap assessments aboard the USS Harry S Truman and the USS Dwight D Eisenhower (Ike). Forty best-in-class companies toured the dockside aircraft carriers and gained firsthand knowledge of three sustainment challenges: valve seat inspection and repair, tank and void inspection, and condenser tube inspection and repair. Engaging with stakeholders from ship's company, NNSY, and NAVSEA, these companies had the opportunity to provide fresh ideas regarding the application of their existing and emerging capabilities to address maintenance challenges.

NCMS will continue to work with Navy stakeholders and industry to develop proposals that integrate and demonstrate the use of new technology-based capabilities aboard the Truman and the Ike needed to better sustain these critical assets. It is possible that the CTMA cooperative agreement could be leveraged to rapidly execute these innovations and position the Navy to broadly adopt much needed modern maintenance and sustainment capabilities. ■



The first-ever "Show Us Your Technology Workshop" brought together nearly 100 attendees at the 2023 CTMA Partners Meeting to compete in teams developing solutions for one of four proposed scenarios. (Photo by NCMS Staff.)

2023 CTMA Partners Meeting and NCMS Technology Showcase Ignites Innovation and Collaboration

The 2023 CTMA Partners Meeting and NCMS Technology Showcase were exceptionally productive events. Along with hosting the Joint Robotics Organization for Building Organic Technologies (JROBOT) Summit VI and determining the 2023 CTMA Technology Competition winners, this year's Partners Meeting featured the first-ever "Show Us Your Technology Workshop," where participants collaborated on solutions to pressing DOD maintenance and sustainment needs. What's more, attendees marked the 25th anniversary of the CTMA Program.

From June 6 to 8, nearly 200 NCMS members and partners gathered in New Orleans, with dozens of exhibitors demonstrating their maintenance and sustainment solutions each day in the NCMS Technology Showcase.

Stellar Speakers

NCMS was honored to feature three speakers: Dr. Vic Ramdass, Deputy Assistant Secretary of Defense for Materiel Readiness, who keynoted the event; Steve McKee, Director, Enterprise Maintenance Technologies, Office of the Deputy Assistant Secretary of Defense for Material Readiness (ODASD-MR); and Mike Kelly, Sustainment Director, Advanced Development Programs (Skunk Works®), Lockheed Martin Aeronautics Company.

In his keynote address, Dr. Ramdass defined success in materiel readiness. "Success is getting capabilities into the hands of the warfighter, and seeing them used," he said. "CTMA is doing that...that's why forums like this are absolutely where we need to continue to go."

He emphasized the importance of integrated deterrence in order to operationalize the national defense strategy. Further, he highlighted current materiel readiness opportunities in data analytics, tele-maintenance, quantum information science, blockchain for supply chains, technology insertion, digital twins, robotics, automation, cold spray, and more.

Steve McKee discussed the second iteration of the Hermes' Sprint—the Rapid Sustainment Improvement Process (RSIP)—an integrated approach to develop, evaluate, and implement sustainment innovation ideas, products, processes, and technology to optimize weapons systems' performance and readiness. He said the objective of RSIP is to maintain a process for coordinated sustainment improvements; to rapidly implement transformative solutions; and to enable ready solutions that can impact multiple MILDEPs and agencies and incentivize them to coordinate.

McKee highlighted several RSIP examples of currently approved projects: CBM+ on the CH-47 and on USAF airframes; the application of approved coating systems onto compressor turbine blades to prevent erosion and corrosion with opportunity to increase fuel efficiency; electrical intermittent fault detection; the Naval Autonomous Data Collection System (NADACS); PLS HEMTT digitization; rapid rivet removal; and Stryker digitization.

On Day Three of the meeting, Mike Kelly, Sustainment Director, Advanced Development Programs (Skunk Works®), Lockheed Martin Aeronautics Company, discussed engineering for sustainment. He identified the four pillars of model-based sustainment: logistics support analysis (LSA), technical data presentation, visualization, and digital flight line feedback.

Kelly provided an overview of Lockheed Martin's internal MBSE strategies, then concluded with a discussion of the current composition of the M&S workforce, emphasizing the need for digitally enabled technicians.

"Every system is more complex and, in many cases, requires complex dispositions, he said. "We need to figure out how to do maintenance in a swift manner. CTMA is the kind of team that makes it happen."

Cutting-Edge Technologies

At the 2023 NCMS Technology Showcase held in conjunction with the Partners Meeting, world-class companies demonstrated how their state-of-the-art technologies and services are revolutionizing maintenance and enhancing warfighter readiness.

> **"Success is getting capabilities into the hands of the warfighter, and seeing them used—CTMA is doing that."**
>
> *– Dr. Vic Ramdass, Deputy Assistant Secretary of Defense for Materiel Readiness*

Leveraging the latest in emerging technologies, including sustainment robotics (SR), Boston Engineering, one of three meeting sponsors, demonstrated two solutions: BEEP and the Family of Sustainment Robotics. BEEP is a highly configurable multi-module platform that allows an organization to combine technologies to optimize the return on investment in workforce and operational optimization and efficiency. The Family of Sustainment Robotics is a modular robotic platform that allows the addition or reduction of add-ons to support several unique use cases while utilizing the same robotic body.

Another meeting sponsor, Naval Systems, Inc. (NSI), exhibited their Reliability Control Board (RCB) Readiness Degraders solution that accurately automates the creation of readiness degrader lists for USN and USMC aviation platforms using readily available data sources to equip maintainers with a data-driven, decision-making tool. NSI created the RCB solution via highly automated, reproducible, and fault-tolerant data pipelines and extract-load-transform (ELT) procedures.

To help solve today's supply chain and engineering design challenges, meeting sponsor Solvus Global featured three enterprises serving the aerospace, defense, and energy industries. Powders on Demand evaluates, optimizes, and qualifies highly vetted and controlled powder feedstock to expedite large AM adoption. Mammoth Metalworks provides cost-effective fabrication of large parts using AM techniques. APEX is an all-in-one workflow and data management system for cold spray to help automate the planning and execution of coating and repair projects.

Many other companies exhibited capabilities in multiple focus areas. To see the complete exhibitor directory with detailed information about each technology, visit https://www.ncms.org/wp-content/uploads/2023-PM-Showcase-Directory_FinalDraft2.pdf.

Breakthrough Initiatives

Several educational sessions covered ground-breaking initiatives through panel discussions and presentations. The event kicked off with an informational panel about the CTMA Program moderated by Debbie Lilu, Vice President, Maintenance and Sustainment, Business Development, and director of the CTMA Program.

In the panel "CTMA Success Stories/Case Studies – Keys to Technology Transition," moderated by Frank Schuster, four CTMA partners highlighted CTMA projects that have successfully transitioned into the DOD. Presenters included Rob Willis, Vice President of Andromeda Systems, who discussed the project "Leveraging Data Analytics." Next was Dr. Aaron Birt, Co-Founder and CEO of Solvus Global, who discussed the need for additive manufacturing (AM) in shipyards, along with the solution developed by several CTMA collaborations that included Solvus Global, Materials Resources LLC, Carver Pump, NAVSEA, VRC Metal Systems, DEVCOM, SPEE3D, Penn State Applied Research Laboratory, Northeastern University, and Temple University. Presenting third was Dave Davison, Chief Growth Office of Naval Systems, Inc., who discussed two CTMA projects: one delivered a low-cost maintenance scheduling and execution management system, and the second created a digital model to analyze flight line maintenance requirements and associated task training, prioritized to highest aircraft readiness degraders. Finally, Robert Appleton of R.W. Appleton, Inc., discussed the Joint Enterprise Data Interoperability (JEDI) project, which has transitioned to 21st Theater Sustainment Command, US Army, Africa and Europe (USAREUR-AF). In February 2022, at the start of Russia's invasion of Ukraine, team JEDI provided on-site support at the NATO command for the NATO Response Force, initiating data translation efforts for US force contributions. The

team began training efforts on the Logistics Functional Area Services (LOGFAS), a suite of tools supporting NATO logistics.

These initiatives show how the CTMA Program's flexibility and agility directly contributes to project success and technology transition by providing access to DOD facilities and equipment for demonstrations, reducing time between innovation and commercial production.

Award-Winning Solutions

Two previous award-winning technologies were featured in a session about the impact of technology competitions. Discussed first was Pennsylvania State University Applied Research Lab's (ARL's) Multifunctional Automated Repair System (MARS), which won the Overall Award in the 2021 CTMA Technology Competition. Dr. Tim Eden and Tony Naccarelli of Penn State's ARL, discussed MARS's robotic capabilities for inspection, preparation, and repair operations. They were followed by Perfect Point EDM Corp's E-Drill, which won the Overall Award in the 2022 DOD Maintenance Innovation Challenge. Jim Becker of Perfect Point EDM and Jared Wright of NAVAIR discussed how E-Drill uses a semi-automated, plunge-cut EDM tool to remove fasteners in seconds.

Highlighting Day Two of the meeting were the six finalists of the 2023 CTMA Technology Competition. Following presentations by each finalist, the judges met to select the Overall Award winner. Concurrently, attendees voted to select the People's Choice Award winner. The US Air Force won the Overall Award for "Ultrasonically Activated De-Paint (UADP) Technology," which offers an environmentally friendly, aqueous-based process that completely removes top-coat and primer without damaging underlying anodized coatings. Cumulus Digital Systems won the People's Choice Award for "WeldScout™: Intelligent Welding Inspections for Critical Infrastructure," an image recognition technology that ensures quality welding by using artificial intelligence to rapidly identify defects in weld inspection scans. NCMS will provide each award winner $50,000 in CTMA project support funding. For more details about the competition, including an electronic booklet showing all entries, see: https://www.ncms.org/wp-content/uploads/2023_CTMA_CompBook_FINAL-E.pdf.

Identifying Transition-Ready Technologies

Additional panel discussion sessions highlighted some ground-breaking ways that NCMS has catalyzed the transition of technology solutions to the DOD through demonstration, evaluation, and validation initiatives. A panel discussion titled "Expeditionary Repair – REPTX and UNREP" covered the first and second runs of a new initiative called the Repair Technology Exercise (REPTX), held for two weeks in the summer of 2022 and three days in the spring of 2023. These events allowed industrial maintenance solutions to be demonstrated onboard a Navy Self Defense Test Ship. The panelists discussed the logistics of having nearly 70 organizations participating in 2022 REPTX, the steps taken to protect intellectual property, and the overall lessons learned from this initiative.

2023 CTMA Technology Competition winner Michael Froning, Technical Director for the Air Force Life Cycle Management Center, accepts his team's trophy at the CTMA Partners Meeting for the competition's Overall Award. Presenting the award is Debbie Lilu, VP, Mx and Sustainment, Business Development for NCMS. Froning's team won for their entry, "Ultrasonically Activated De-Paint (UADP) Technology." (Photo by NCMS Staff.)

"What we found with that long duration is that chance to not just validate what was there but to hone and perfect," said Janice Bryant, NAVSEA 05T1 Sustainment Technology Program Manager and moderator of the panel. "We're really not just looking at a technology. We're working on how to solve Navy problems."

Another panel featured the Airfield Autonomy Initiative (AAI), another new set of collaborative events whose purpose is to develop/demonstrate the first airfield-specific multi-agent autonomy command and control system(s), to establish a minimum viable product (MVP) of lawn mowing, Foreign Object/Debris (FOD) sweeping, and perimeter patrol systems. Dr. Al Lowas, Chief Scientist, Air Force Sustainment Center, Air Force Materiel Command, discussed how MVPs are being tested at Joint Base McGuire-Dix-Lakehurst (JB MDL) and the FAA William J. Hughes Technical Center (WJHTC). There have been two successful industry days providing a forum for partners to meet each other, to learn that none has the solution alone, and to determine how they can partner to accomplish the goals.

Additional panel discussions included "Overview of Military Service Maintenance and Sustainment Needs and

Active Initiatives to Execute Maintenance and Sustainment Innovation," which reviewed recent work of the Joint Technology Exchange Group (JTEG), and "Robotics and Automation in Maintenance and Sustainment (JROBOT)," which covered recent efforts toward the JROBOT objective: to maximize asset availability across the DOD and allied partners using robotic capabilities.

On-the-Fly Problem Solving

On the last day of the meeting, the first-ever "Show Us Your Technologies Workshop" was held to encourage collaborative solutions for maintenance challenges. Nearly 100 maintenance and sustainment (M&S) technology experts from the Department of Defense (DOD), industry, and academia broke into teams to develop solutions for one of four scenarios.

Each of the four teams had 45 minutes for a technology development and integration exercise. After collaborating on solutions, each team presented theirs to the group. Each participant was able to cast a vote for two solutions, excluding the one they helped to develop. The winning team worked on applying Condition-Based Maintenance (CBM+) and Predictive Maintenance for Marine Corps Ground Vehicles. NCMS has awarded $25,000 to this team to develop a proposal for a CTMA collaboration based on their solution. The team working to solve this scenario included experts from the USMC, Army, and Air Force, along with industry partners Andromeda Systems, Astrolabe Analytics, Edlore, and Redhorse Corporation. Be sure to see the next issue of the *CTMA Connector* for a follow-up on this new initiative.

For more information about the 2023 CTMA Partners Meeting and NCMS Technology Showcase, please visit: www.ncms.org/ctma-partners-meeting. ■

Deadline Approaches for CTMA Projects To Use FY23 Funds

The window to obligate expiring funding through CTMA's cooperative agreement will be closing soon. Funding must be received in-house no later than Monday, August 7, 2023, at 5 pm EDT to leverage this contract vehicle for funds expiring in FY23. Consider utilizing the CTMA Program to obligate your expiring funds to secure demonstrations, evaluations, and validations of maintenance and sustainment technologies.

Don't let this deadline affect your critical projects. For all CTMA-related questions please contact Frank Schuster at Frank.Schuster@ncms.org or call him at 734-995-3904. ■

MEMBER SPOTLIGHT

Meet Astrolabe Analytics

Astrolabe Analytics works to accelerate battery innovation by delivering results through battery data management and predictive analytics. The company services engineering teams in fields such as automotive and electric vehicles, aerospace, grid storage, and many more by providing solutions for battery health, safety, and predictive maintenance. Astrolabe has been funded by the US Air Force and National Science Foundation to develop best practices for operating, maintaining, and retiring battery systems in electric aircraft, and other applications where battery safety is mission critical.

Founded in 2018, the company provides solutions across the battery system life cycle. It also offers custom consulting services to help inform battery materials development, manufacturing quality control, battery vendor selection and cell validation, warranty design and analysis, end-of-life forecasting and predictive maintenance, and battery certification. Astrolabe also offers a data management product to help battery engineers streamline routine data analysis, with additional software products under development.

In 2021, Astrolabe was awarded a Small Business Innovation Research (SBIR) Direct to Phase II (D2P2) Award by the US Air Force. Because of this, Astrolabe may pursue sole-source Phase III commercialization work, greatly reducing procurement lead time with the DOD sustainment community and others concerned with battery maintenance and performance.

To learn more, visit: https://www.astrolabe-analytics.com/. ■