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Electrical Tactical Humanitarian Operations Response (eThOR) Final Report

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ADMINISTRATIVE INFORMATION

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EXECUTIVE SUMMARY

OBJECTIVE

The Electrical Tactical Humanitarian Operations Response (eTHOR) project aimed to demonstrate the viability of the eTHOR concept. The project includes two primary capabilities: providing mobile electrical power in various real-world scenarios and providing edge compute and communications in a compact, efficient form. Figure ES-1 shows a graphic from an eTHOR presentation summarizing the approach.

eTHOR is a prototype system-of-systems consisting entirely of commercial off-the-shelf equipment, designed for real-world environment demonstrations (Figure ES-2). eTHOR integrates a remotely or human-operated mobile power station (MPS) provided by DD DANNAR, LLC, with a communications and computation payload called the Innovation, Connectivity & Experimentation (ICE) payload from Amazon Web Services (AWS).

- Image courtesy of CANA LLC.

Figure ES-1. eTHOR Conceptual Graphic.

Figure ES-2. DANNAR MPS powering the deployed AWS ICE payload during testing at Camp Pendleton.

PROJECT TIMELINE

Over two years, eTHOR evolved from conceptual design to multiple live demonstrations. This rapid timeline was possible due to the extensive use of commercially available equipment and agile development methods designed by the eTHOR team and internal stakeholders.

In 2023, eTHOR combined demonstration, testing, and evaluation over three events:

- A NavalX SoCal Tech Bridge demonstration in July at Marine Corps Base (MCB) Camp Pendleton.
- The Marine Corps Air Station (MCAS) Miramar Air Show in September.
- The International Climate and Energy Security Forum (ICESF) in November, also at MCB Camp Pendleton.

Each event showcased the equipment in an operationally relevant environments. Live data capture measured power usage and digital data transmission over networks, particularly the eTHOR private 5G wireless network. CANA, LLC and the Naval Information Warfare Center (NIWC) Pacific analyzed the data. CANA also performed simulation and further analysis.

CONCLUSIONS

eTHOR was an atypical Department of Defense (DoD) research and development project. Instead of focusing on a narrow capability advancement, it combined multiple innovative technologies into a comprehensive system of systems for running a Tactical Operations Center (TOC). Key technologies include:

1. Electric Vehicles (EVs)
2. High-capacity mobile electric power storage
3. Expeditionary 5G private networking
4. Cloud compute, including edge compute
5. Internet of Things (IoT) power monitoring

None of these alone are new. The innovation of the eTHOR project combined them into one system to create a flexible, efficient TOC of the future. Significant data was collected, and simulations and analysis were performed, some of which are discussed in this report. The successful demonstration and testing have generated significant interest among Warfighters, leading to several follow-on efforts focused on various aspects of the eTHOR concept. These follow-on efforts are detailed in the Transition Efforts section. A technical data package supplements this report and is available upon request.

ACRONYMS

AWS	Amazon Web Services
BoSEC	Balance of Systems Edge Compute
C2	command and control
COC	Command Operations Center
CONOPS	Concepts of Operation
CONUS	continental United States
CRADA	Cooperative Research and Development Agreements
DFT	Digital Force Technologies
DIU	Defense Innovation Unit
DoD	Department of Defense
EDSI	Extended Duration Storage for Installations
eTHOR	Electrical Tactical Humanitarian Operations Response
e-SIM	embedded subscriber identity module
EV	electric vehicle
eVTOL	electric vertical take-off and landing
ICESF	International Climate and Energy Security Forum
ICE	Innovation, Connectivity & Experimentation
IoT	Internet of Things
ISR	Intelligence, Surveillance, and Reconnaissance
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCI West	Marine Corps Installation West
MCTSSA	Marine Corps Tactical Systems Support Activity
MLR	Marine Littoral Regiment
MOS	Military Operational Specialty
MOU	Memorandum Of Understanding
MPS	Mobile Power Station
NIWC Pacific	Naval Information Warfare Center Pacific
NSWC Crane	Naval Surface Warfare Center Crane
SWaP	size, weight, and power
TOC	Tactical Operations Center
USAF	United States Air Force

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CONTENTS

FIGURES

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1. INTRODUCTION

1.1 OBJECTIVES AND NEEDS

The overarching objective of Electrical Tactical Humanitarian Operations Response (eTHOR) is to modernize and enhance the Department of Defense (DoD) operational energy capability.

One key method to achieve this is by improving installation resilience. DOD directive 4715.21 defines resilience as the "ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions." The ability of our installations, along with the equipment and personnel they support, has become a focal point of the military after years of inadequate support and resources. Installations must be more than just a place for the military to park its equipment and personnel.

Another improvement is in battlefield electrification, addressing the increase demand for electricity on the battlefield. This demand is driven by technology—the growing capabilities powered by electricity, such as the emergence of electric-powered tactical vehicles. The DoD must remain competitive with adversaries in efficiently distributing and storing energy.

Reducing the DoD's reliance on fossil fuels can result in significant cost savings and reduce its impact on climate change. The DoD's Climate Adaption Plan is outlined in the 2023 Plan to Reduce Greenhouse Gas Emissions and the 2022 U.S. DoD Sustainability Plan.

Optimizing energy use involves efficient and modern computational and communication systems, including cloud computing and modern communications architectures, like 5G. The DoD's Cloud Implementation Strategy outlines the potential tactical and logistical benefits of cloud computing (DoD, 2018). The security benefits of communication technologies like 5G are detailed in the DoD 5G Strategy Implementation Plan (DoD, 2020).

eTHOR addresses vital parts of these objectives through mutually beneficial technological advancements. One advantage of cloud computing is energy efficiency. Furthermore, mobile electrical power allows cloud computing to be deployed in tactical domains, where it can be more capable and power-efficient than current practices. These broad objectives are detailed in Cichy and Berry, 2024.

1.1.1 Live Demonstration in Relevant Environments

A key objective of eTHOR was rapid live demonstration and testing in realistic environments. This was achieved with the first live demonstration in the project's first year. Warfighter feedback from across the spectrum of military positions—from enlisted personnel with Military Operational Specialties (MOS) in power distribution or communications technologies to senior officers involved in policy and Concepts of Operation (CONOPS) development—contributed to the design and vignettes.

1.1.2 End-to-End Independent Electrification

Another key objective was complete end-to-end grid-independent electrification of every aspect of the eTHOR concept for the duration of demonstration and testing events. All equipment, including vehicles, remote sensors, Tactical Operations Center (TOC) apparatus, was electric. No generators or grid power were used. Extensive data collection on the electrification effort was performed, as described in section 3. This was also the subject of extensive analysis and modelling, as introduced in section 5.

1.1.3 Edge Compute and Agile Communication Architecture

All computation and communications for the demonstrations were achieved using Amazon Web Services' (AWS) Innovation, Connectivity & Experimentation (ICE) infrastructure—a power-efficient, compact system that replaces a typical suite of independent compute and communications systems. The ICE system uses a cohesive architecture that provides the benefits of cloud computing and communication while allowing seamless integration with existing tactical communication systems. This architecture was also the subject of data collection and analysis. The AWS ICE system is discussed in multiple sections below.

1.1.4 Requirements Analysis

eTHOR documented the implications of the testing and analysis for DoD requirements generation. This is intended to assist DoD Program Offices in integrating eTHOR technologies into existing and future programs. The CANA LCC report on requirement analysis comprises eTHOR's requirements analysis (Cichy and Berry, 2024).

1.1.5 Technology Transition

While the eTHOR project has been completed, the component technologies are the subject of several new-start and ongoing projects. The goals of these projects include developing CONOPS for using new technology with Warfighter feedback, converting commercial equipment to military standards, and continuing requirements development. Section 7 details the follow-up efforts underway as of the writing of this report.

2. PERFORMERS AND STAKEHOLDERS

2.1 PROJECT SPONSORSHIP

eTHOR's primary sponsor was the Office of the Undersecretary of Defense (OUSD) Operational Energy Capability Improvement Fund (OECIF). The sponsor's mandate was to rapidly produce, demonstrate, and test a working prototype of the eTHOR concept.

2.2 CONTRACT AND TECHNICAL OVERSIGHT

The NavalX SoCal Tech Bridge and the Naval Information Warfare Center (NIWC) Pacific provided contractual and technical oversight. The DoD-supported initiative NavalX fosters collaboration among leaders in industry, academia, and government. Marissa Brand of NIWC Pacific was the program manager.

2.3 PROJECT MANAGER AND MS&A PERFORMER

CANA provided overall project management, including organizing technical work, scheduling testing and demonstrations, and handling project logistics. CANA was also responsible for conducting strategic analysis and generating documentation. These documents are discussed in section 5.

2.4 PRIMARY TECHNICAL PERFORMERS

2.4.1 DD DANNAR, LLC

DD DANNAR is the designer and manufacturer of the DANNAR mobile power station (MPS) vehicle, the primary mobility and power provider for eTHOR. The DANNAR MPS is discussed throughout this report. Detailed information about the DANNAR MPS is available in section 6.

2.4.2 AWS

AWS provided the AWS ICE system: a compact edge compute and communications architecture demonstrated throughout the eTHOR project. The AWS team personnel provided tremendous input on military and disaster response CONOPS and use cases, drawing from the broad military and disaster response background of the AWS team leaders, including Jeffrey Schweitzer.

2.5 SECONDARY PERFORMERS

The secondary performers were largely AWS subcontractors or provided services at their request.

2.5.1 Moxion Power

Moxion provided a compact trailer with the MP-75 power system and a 75 kWh battery. This system offered additional energy storage during the eTHOR tests and demonstrations, showcasing the potential for various form factors in mobile electrical power. Figure 1 illustrates the Moxion MP-75 trailer at the Marine Corps Tactical Systems Support Activity (MCTSSA) field at Camp Pendleton, with Digital Force Technologies (DFT) surveillance towers.

Figure 1. Moxion Power MP-75 Trailer and DFT towers.

2.5.2 DFT Remote Sensing

DFT provided remote sensing abilities for the eTHOR experiment. They offered a realistic example of the power demand for a command and control (C2) Intelligence, Surveillance, and Reconnaissance (ISR) deployment. Moreover, they demonstrated real-time data and threat identification and classification to the TOC, which was the demo's focal point.

2.5.3 Volcon

Volcon provides rugged, off-road, tactical-ready electric motorcycles and side-by-sides. These vehicles were present at eTHOR tests and demonstrations. They offered a real-world demonstration of the power storage system's ability to charge electric vehicles in a realistic environment. This enabled a simulated rapid response to threat events and demonstrated the eTHOR communications network's ability to communicate across several square kilometers. Figure 2 shows the DANNAR MPS charging a Volcon tactical electric vehicle (EV).

Figure 2. The DANNAR MPS charging a Volcon tactical EV.

2.5.4 Athonet

Athonet, owned by Hewlett Packard, provided private 5G cores and the Radio Access Network for the eTHOR program. The compact and flexible 5G setup was crucial in demonstrating eTHOR'S 5G power. An example of this flexibility occurred when the author of this report had trouble with commercial 4G access at Camp Pendleton. Athonet personnel provided an embedded subscriber identity module (e-SIM) to the phone, providing access to the StarLink internet connection within a minute. This ease and rapid deployment exemplify the eTHOR concept. Figure 3 presents a similar setup used by the eTHOR project.

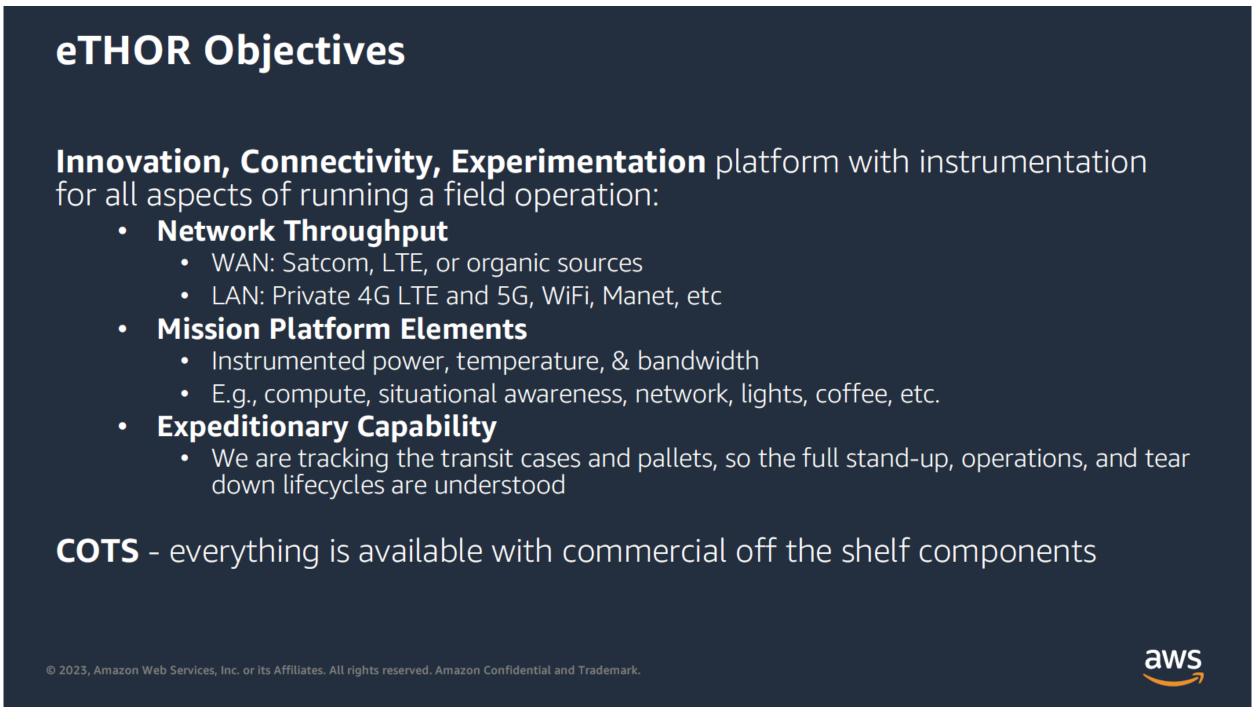
- Image courtesy of Athonet.

Figure 3. A promotional example of Athonet's compact private 5G system.

3. AWS DATA CAPTURE

3.1 OBJECTIVES

Data collection efforts in the eTHOR program (see Figure 4) aimed to capture granular information on nearly every recordable metric, down to the individual device level. This high level of transparency and introspection into a complex system was an innovative aspect of eTHOR. As noted in the CANA reports, while data exists on device size, weight, and power (SWaP), specification sheets are not always the best way to determine real-world performance. Some spec sheets specify maximum rather than normal steady-state power, and devices are often used periodically rather than continuously during simulated mission scenarios. AWS provided a summary presentation on data collection methodology (AWS, 2023), outlining the breadth and depth of data collection across a mission lifecycle, including stand-up and shutdown phases.

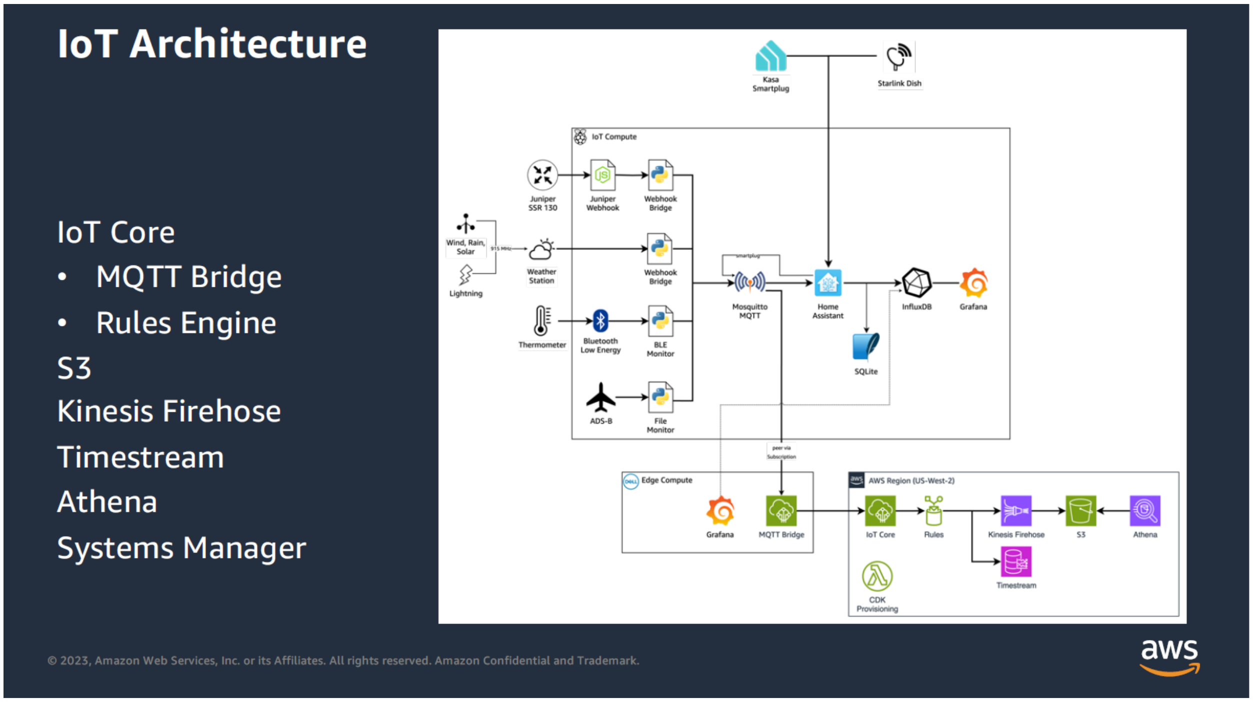


- Image courtesy of AWS.

Figure 4. eTHOR data collection objectives.

3.2 METHODS

Figure 5 illustrates AWS' cloud resources during data collection, including AWS-supported databases, real-time data processing, and storage solutions.



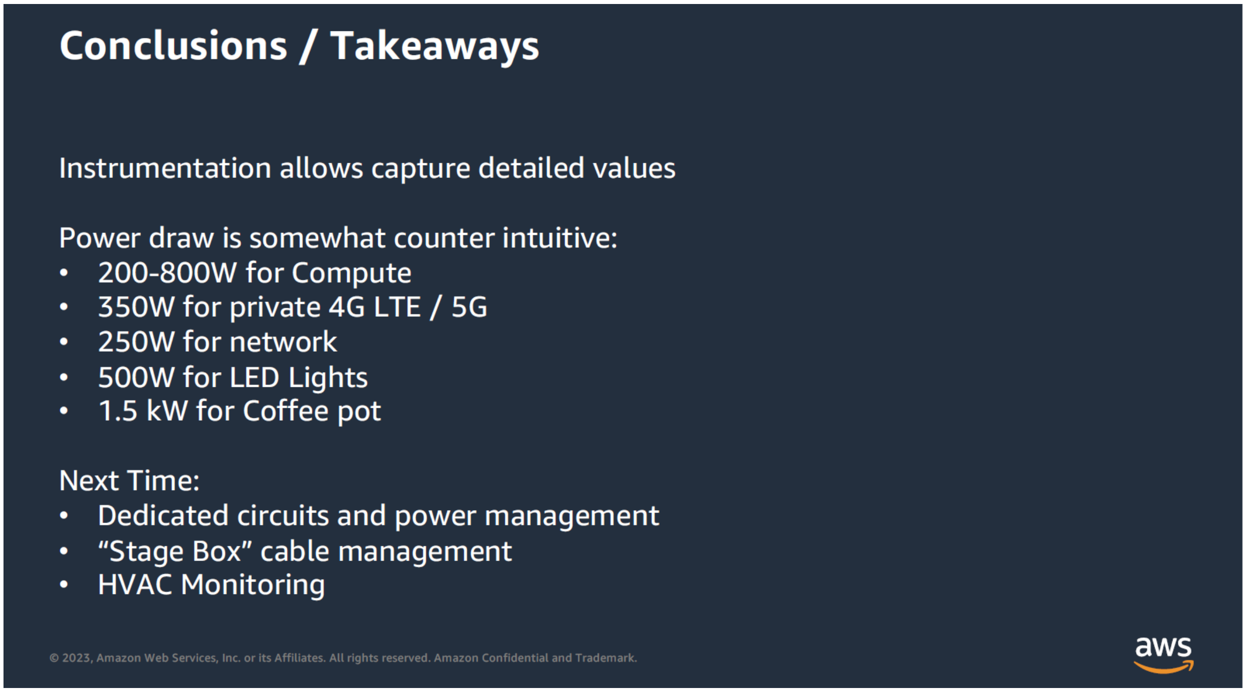
- Image courtesy of AWS.

Figure 5. Internet of Things (IoT) architecture.

Standard open file and data formats made subsequent analysis by CANA and NIWC Pacific efficient. Data could be graphed and processed on-site during the event, contrasting with some DoD programs where data is proprietary and cumbersome.

AWS provided a basic summary analysis in Figure 6. The low-power consumption, relative to legacy DoD TOC operations, is corroborated by more detailed analysis by NIWC Pacific and CANA. All eTHOR data is available upon request from the author of this report.

3.2.1 Analysis



- Image courtesy of AWS.

Figure 6. Summary takeaways from the Miramar event.

Some analysis by NIWC Pacific is shown in the discussion of individual events. Analysis by CANA is documented in the 2024 eTHOR Requirements Analysis Report, the Final and Modeling Simulation & Analysis (MS&A) Report.

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4. DEMONSTRATION AND TEST EVENTS

4.1 JUNE 2023: MCTSSA CAMP PENDLETON EVENT

4.1.1 Overview

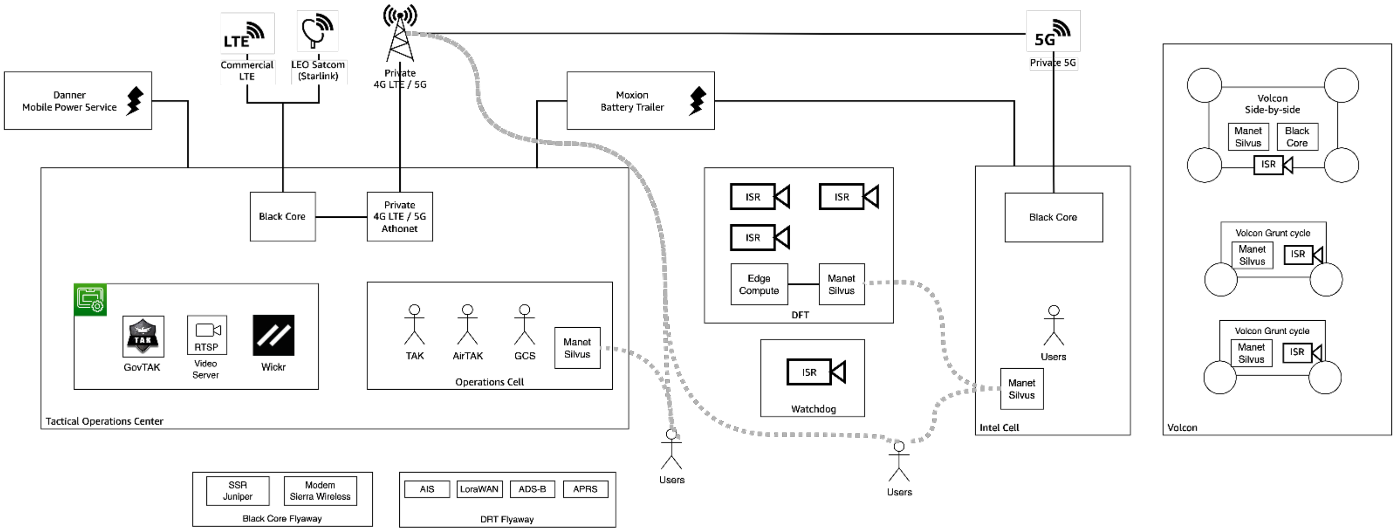
On June 23, 2023, MCTSSA conducted its first complete demonstration and test during the *eTHOR STRIKE 2023*. The use case involved powering a simulated next-generation Command Operations Center (COC) using the DANNAR MPS and Moxion Power MP-75 trailer. The AWS ICE was installed in a deployable tent (see Figure 7), providing edge computing and various wireless communication options, including Wi-Fi, 4G, LTE, 5G, StarLink, tactical radio networks. The ICE system served as a routing mesh to link these communications. Inside the COC, consoles connected in real-time to sensor data from the DFT towers and C2 information worldwide (Figure 8). After a local, private 5G network on the Citizens Broadband Radio Service was configured, e-SIM cards were distributed to cell phones, and other 5G devices, enabling independent internet access without commercial 4G or 5G networks.

Figure 7. COC Tent at MCTSSA Camp Pendleton.

Figure 8. TOC screens in operation.

4.1.2 Network and Power Architecture

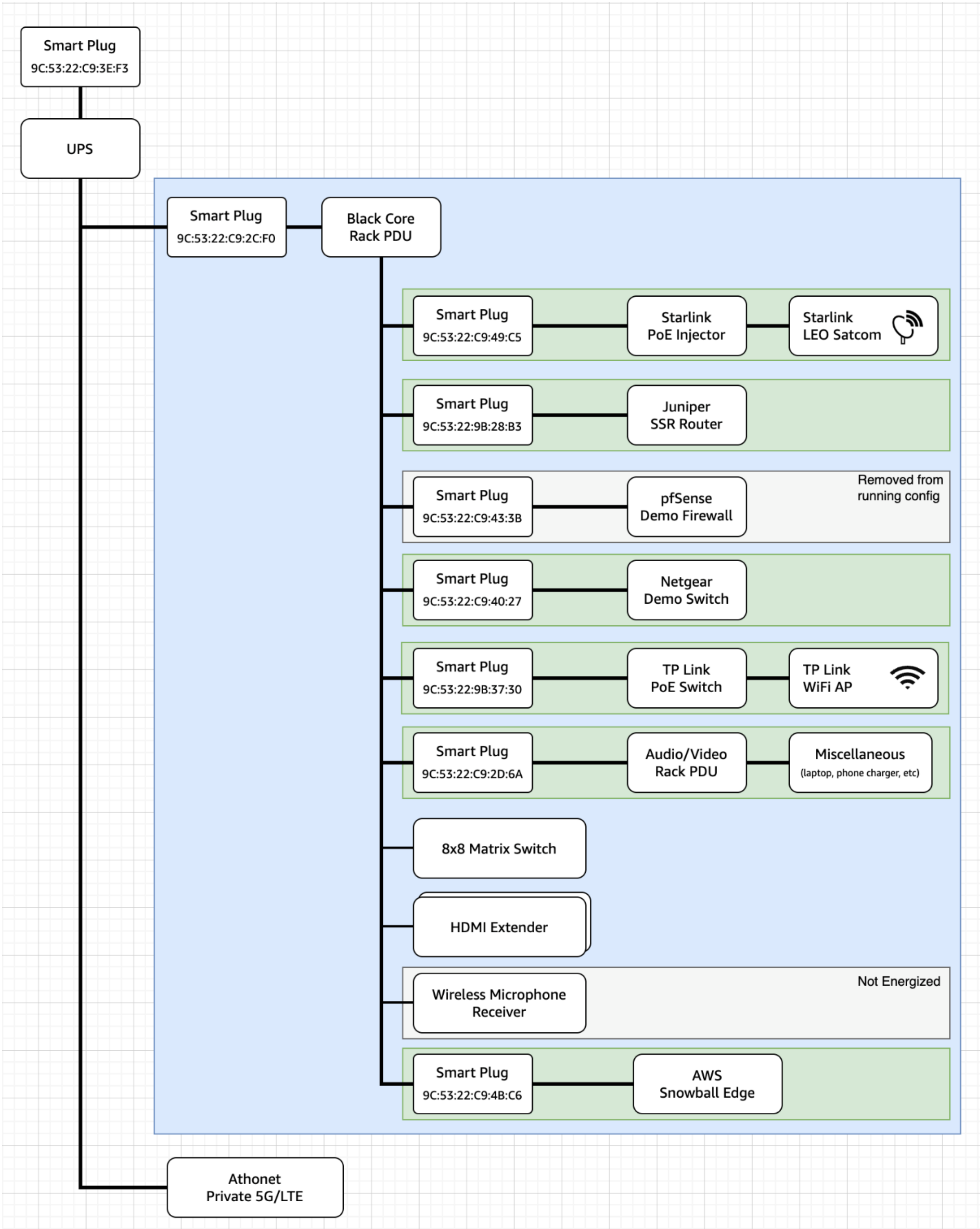
While visually impressive, the true innovation with the eTHOR project lies in the power, computational, and networking architecture. Figure 9 sets out the C2 use case and ISR mission, which verifies how the COC or TOC connects to all the mission assets.



- Image courtesy of AWS.

Figure 9. Mission CONOPS.

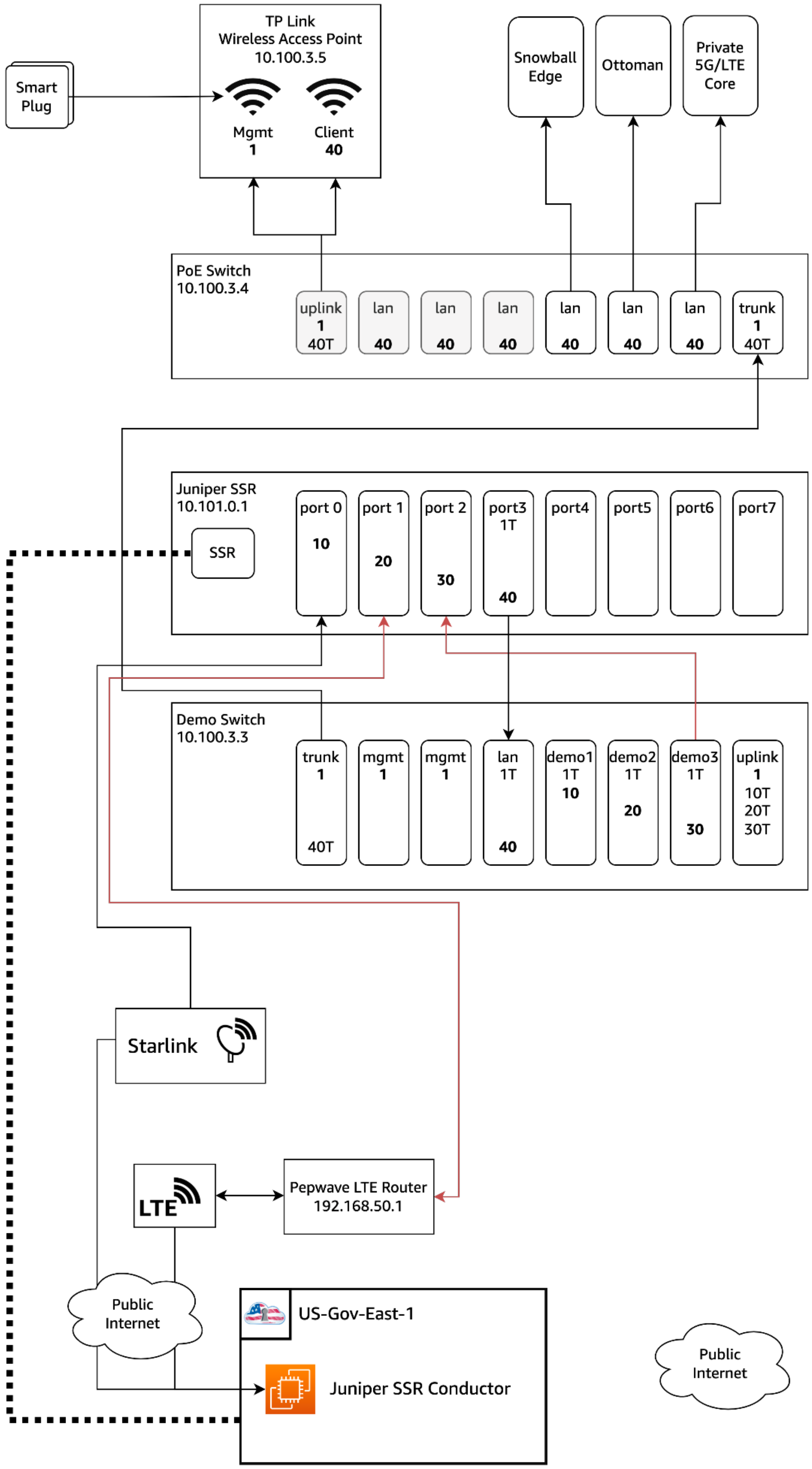
Figure 10 reveals the power architecture for the COC. This illustrates the first implementation of the AWS IOT data collection architecture, described further in Data Collection. The key aspects are the highly granular collection of power data down to the individual device level using smart plugs and other power collection devices. This allows for detailed analysis and deep characterization of the power used during testing and demonstration.



- Image courtesy of AWS.

Figure 10. COC Power Architecture.

Figure 11 explains the network architecture specialized to this experiment. It illustrates how AWS links multiple wireless communication methods to the broader AWS Cloud (US-Gov-East-1) and local edge devices (e.g., AWS Snowball and Ottoman devices). Each device ran various C2 and ISR applications while consuming relatively little power and maintained a compact SWaP profile.



- Image courtesy of AWS.

Figure 11. Network Architecture.

4.2 SEPTEMBER 2023: THE MARINE CORPS AIR STATION (MCAS) MIRAMAR AIR SHOW DEMONSTRATION

Figure 12 shows the MCAS Miramar Air Show demonstration from September 22-24, 2023. The event was smaller and more static than the MCTSSA demo due to venue constraints and the proximity to public viewers. The setup was a reduced version of the COC, with power supplied by the DANNAR MPS and Moxion MP-75. Detailed data collection was performed during the event.

Figure 12. MCAS Miramar Air Show display.

4.3 NOVEMBER 2023: THE INTERNATIONAL CLIMATE AND ENERGY SECURITY FORUM (ICESF) 5-EYES AT MCTSSA CAMP PENDLETON EVENT

The ICESF event was similar to the June 2023 demonstration, featuring a wide-ranging scenario simulation centered around a TOC acting as a power and information hub. This event produced the most detailed data, and some sample analysis from NIWC Pacific.

Figure 13 and 14 presents a graphical summary of the eTHOR TOC's performance with the ICE system (excluding EV recharging or power remote sensors) using the Moxion power, the DANNAR MPS, or both combined. The flat curves indicate that the 2-day event decreased available power by only a few percent, with theoretical runtime extending beyond a month. This demonstrates the potential of combining power-efficient technologies with large, mobile battery systems. Independent analysis by CANA corroborates this modeling.

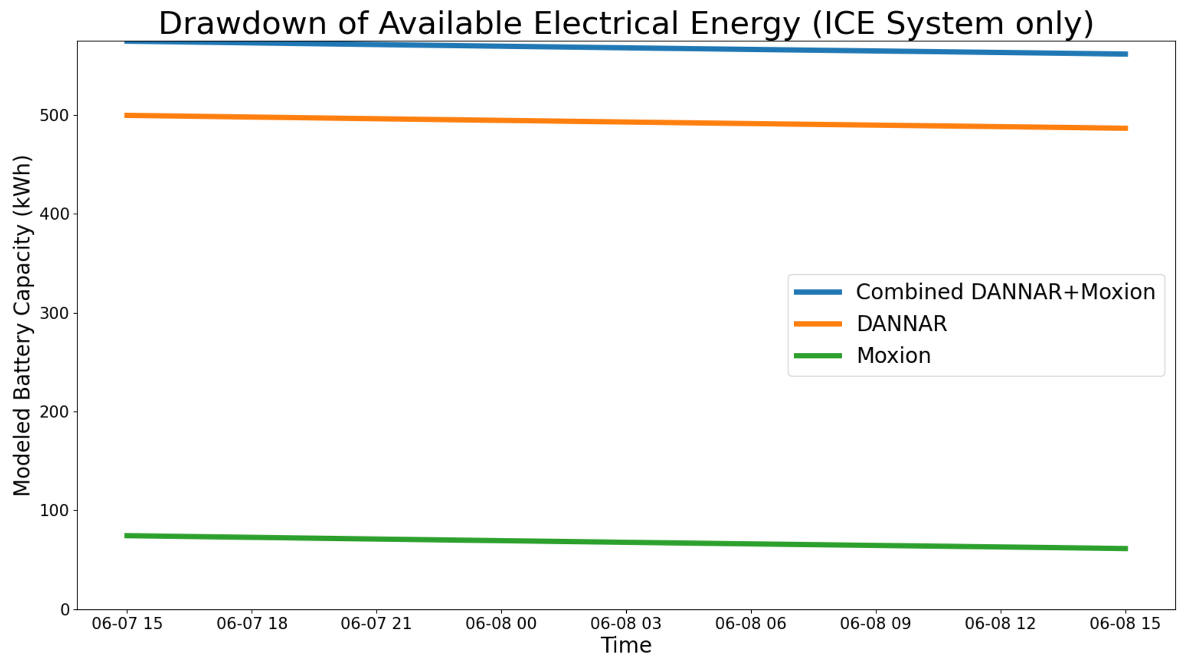
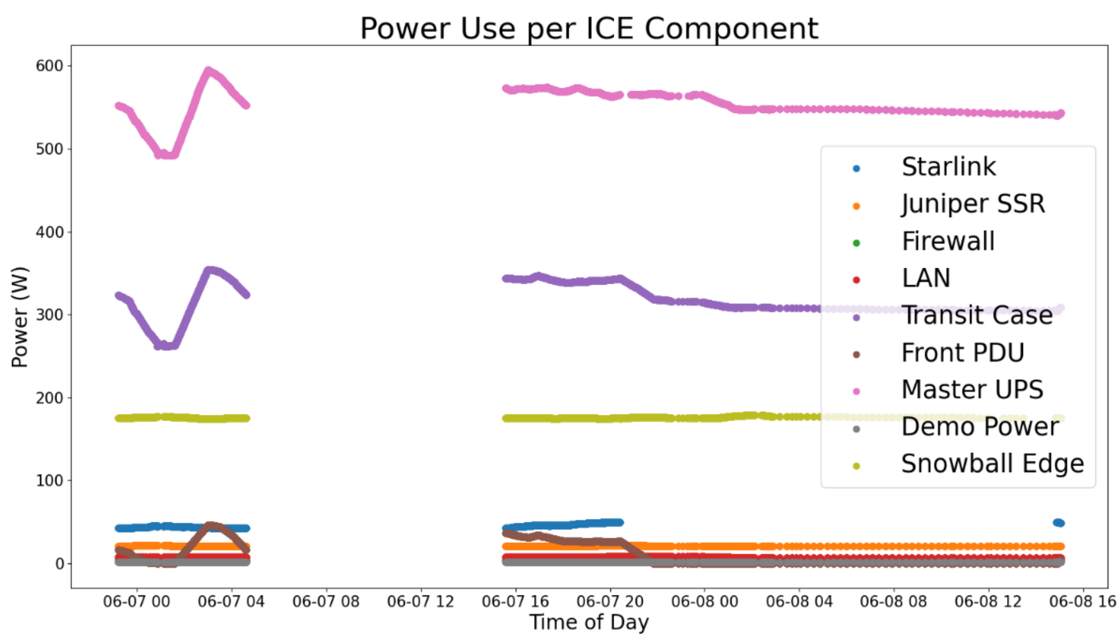


Figure 13. Modeled power drawdown.



- The gap is due to a planned system shutdown.

Figure 14. Power per ICE device.

5. CANA REPORTS

CANA acted as the lead system integrator for the eTHOR project and performed most of the technical analysis. Three primary CANA reports are summarized here and available upon request from the author of this report.

5.1 FINAL REPORT

The CANA Final Report is a detailed account of the eTHOR project's technical, integration, and demonstration activities. It includes scheduling, contracts, and financial information (Cichy and Berry, 2024).

5.2 MODELLING AND SIMULATION REPORT

The CANA Modelling and Simulation report details the tools, methods, and results of the modeling and simulation efforts. The live demonstration and testing done with eTHOR could only cover a small range of the potential applications for eTHOR technologies. The Modelling and Simulation Report expands upon what was demonstrated in live events. It examines the implications of eTHOR capabilities scaled to much broader CONOPS and use cases than was possible to establish (Cichy and Berry, 2024).

5.3 REQUIREMENTS ANALYSIS

The CANA LLC Requirements Analysis examines how eTHOR capabilities could influence existing DoD program requirements or generate new ones. The report details a full range of requirements including communications, electrical power, cybersecurity, and cloud computing (Cichy and Berry, 2024).

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6. DATA AND DOCUMENTATION PRODUCTS

Data products from eTHOR, including project documentation, raw data collected during experimentation, reporting, and media are owned by the Government and available for distribution to appropriate requestors. Detailed technical data on component subsystems, such as the DANNAR MPS battery system, is also available. Information on transition efforts, described below, is also available upon request.

A summary of documentation products and data includes:

1. Raw data collected during test events (mostly in CSV format)
2. CANA LLC intermediate and final technical reports
3. Event media (e.g., video and still photography)
4. Technical manuals
5. User manuals
6. Technical presentations

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7. TRANSITION EFFORTS

This section outlines the projects that are direct and indirect follow-on efforts to eTHOR. While eTHOR demonstrated a broad "art of the possible" with multiple innovative systems working in concert, most follow-on efforts target increasing the maturity of specific applications initially demonstrated under eTHOR. Figure 15 shows NIWC Pacific's work towards automated recharging of electric vertical take-off and landing (eVTOL) aircraft with a DANNAR MPS. Figure 16 is the military transporting the DANNAR MPS before testing.

Figure 15. Advancements towards electronic unmanned aerial vehicle recharging.

Figure 16. Military transport.

7.1 DEFENSE INNOVATION UNIT CONTRACTS

Two contracts have been awarded through the Defense Innovation Unit (DIU) to advance the DoD's energy resilience capabilities—in continental United States (CONUS) installations and contested logistics environments.

7.1.1 Extended Duration Storage for Installations (EDSI)

The DIU press release (DIU, 2023) outlines the high-level details of EDSI. Three innovative energy storage and distribution systems, including the DANNAR MPC, will be evaluated against standard core performance requirements in field trials. NIWC Pacific will manage the program through Program Manager Marissa Brand.

DANNAR MPS will deploy four vehicles to investigate eVTOL operations at two United States Air Force (USAF) locations and three Navy and Marine Corps sites.

This effort will advance the CONOPS and deployment requirements for using large-battery power systems like the DANNAR MPS. Four MPS will be deployed to the USAF, NIWC Pacific, and the Naval Surface Warfare Center (NSWC) Crane.

The USAF will use the vehicles to explore their use in eVTOL operations, including basic recharging, mobile recharging, and creating microgrids to support continuous flight operations in remote or disaster-affected areas.

7.1.2 DANNAR's Purchase: USAF, NIWC Pacific and the 3rd Marine Littoral Regiment (MLR)

Some project details are available in the project Statement of Work (NIWC Pacific, 2023). This project will deliver four MPS to the USAF, NIWC Pacific, and NSWC Crane. The NIWC Pacific vehicle will be used for the Balance of Systems Edge Compute (BoSEC) project, explained below. The NSWC Crane MPS will be a mobile recharging station for hybrid and electric ground vehicle development efforts, such as the Light Expeditionary Energy Agile Platform and the electric Ground Mobility Vehicle.

7.2 THE BOSEC PROJECT

BoSEC, a project underway at NIWC Pacific, transitions three eTHOR performers: DANNAR, DFT, and AWS. The DANNAR MPS vehicle's contribution is described in the DIU contracts section. BoSEC will provide a DANNAR vehicle to a 3rd MLR unit for testing in various use-cases. The MPS' ability to distribute electric energy can be evaluated in multiple contexts, such as supplying power to remote locations or emergency relief sites, where conventional power infrastructure may be unavailable or damaged. Acting as an MPS, it can provide electricity to critical systems and equipment, enhancing operational readiness. The MPS' capacity to store electric energy is crucial for operations in remote or off-grid areas. The vehicle can be charged during periods of excess energy production and later deploy that stored energy when needed, ensuring uninterrupted power supply during mission-critical tasks and resilience against climate-related challenges.

The DFT technology provides power-efficient, long-duration surveillance and communications infrastructure that can be rapidly deployed in tactical environments. More details about DFT are included in the eTHOR Performer section of his report.

AWS contributes to BoSEC while also serving as a standalone, persistent capability. The details for AWS's role in both BoSEC and as a standalone system are described in the next section.

7.3 3RD MLR C2-IN-A-BOX

The 3rd MLR C2-in-a-box effort provides edge compute and communications resources through the AWS Deployable Operations Cell. This cell offers power-efficient, secure, and resilient communications at tactical sites and across AWS' global presence. AWS will provide two deployable operations cells: a medium 8u transit case rack and a small 6u rack. This form factor aims to replace the space occupied by a High Mobility Multipurpose Wheeled Vehicle or more with legacy technology, offering a cohesive mesh of computational and communications resources instead of multiple independent stovepipe systems. Details of the AWS Deployable Operations Cell are documented in an AWS whitepaper delivered to NIWC Pacific (AWS, 2024).

Feedback from the 3rd MLR has been very positive, praising not only project progress but also the improvements in the day-to-day life of Marines by improving their efficiency and capability. Even small contributions, like removing cable clutter and freeing up space have been valuable. The 3rd MLR Communications Company Commander sent an informal letter of recognition to Marissa Brand, the Program Manager at NIWC Pacific, acknowledging these efforts.

7.4 AWS ICE COMMERCIALIZATION

The above BoSEC and C2-in-a-box transitions are early examples of AWS ICE technology reaching commercialized, deployable maturity. Yet, AWS personnel have outlined an unofficial roadmap to mature and convert the eTHOR component technologies into a fully productized version. This roadmap includes:

- Edge compute, storage, and networking, complete with local management for secure LAN and resilient SD-WAN.
- Basic interoperability at the edge, enabling data sharing between open architecture C2 workloads and devices.
- Persistent local C2, completely independent from a backhaul connection to cloud resources.
- The ability to generate decision advantage through hybrid cloud data sharing when cloud backhaul is available.

While an official corporate roadmap has not been released to the government, AWS intends to continue integration efforts that expand upon the eTHOR effort.

7.5 MILITARIZATION – U.S. ARMY ENGINEER RESEARCH AND DEVELOPMENT CENTER AND CONSTRUCTION ENGINEERING RESEARCH LABORATORY

While not yet funded at the time of this writing, funding is expected to be imminent for a suite of hardening and militarization efforts for the DANNAR MPS. These include:

1. Replacing commercial-standard power ports with military standard connectors. Also, modifying the internal circuitry to accommodate U.S. Army low voltage (3-phase 120/208VAC).
2. Initiating work to make the MPS compatible with the Tactical Microgrid Standard and documenting a pathway to full compatibility.
3. Evaluating MPS attachments in various Warfighter usage scenarios.
4. Exploring methods of integrating the MPS into the Advanced Medium Power Source microgrid.
5. Integrating deployable metering and monitoring systems into the MPS to allow for remote monitoring and the incorporation of MPS real-time data into the dashboard.
6. Joining the North Atlantic Treaty Organization Slave Receptable.

The results will be a more military-standard compliant vehicle along with documented pathways to full compliance.

7.6 MEMORANDUM OF UNDERSTANDING (MOU)

While an MOU is not a direct technology transition, agreements between NIWC Pacific, industry, and other DoD entities have been instrumental for eTHOR and its predecessor projects. These agreements will continue to be valuable for future transitions and new initiatives. They include Cooperative Research and Development Agreements (CRADAs) and MOUs. For example, an existing CRADA between NIWC Pacific and Verizon Wireless was crucial for the predecessor project to eTHOR.

Access to DoD facilities and ranges provides realistic environments for test and evaluation, as well as Warfighters who give feedback on technology development. eTHOR and its predecessor project have used MCAS Miramar and Camp Pendleton for test and evaluation, as documented in this report. This includes using large test ranges at both sites and accessing personnel, such as Warfighters with relevant MOS and higher-level planning and acquisition personnel from the Marine Corps Installations (MCI) West Information Technology Directorate (G-6). eTHOR engaged in vital discussions with Warfighters and civilian staff across this spectrum.

NIWC Pacific and MCI West entered a formal MOU to cement and expand their relationships. This MOU provides value to NIWC Pacific Principal Investigators and the Marine Corps. NIWC Pacific can present research ideas to the Marine Corps and they can ensure it provides current or future benefits.

Before, NIWC Pacific engaged with MCI West bases independently, with relationships subject to the relatively high-frequency turnover of senior staff (i.e., some with two-year rotations). The new MOU provides a lasting, stable mechanism for approximately 11 years, from February 2023 to October 2033.

This MOU paves the way for better communication and resource sharing between NIWC Pacific engineers, scientists, and Marine Corps Warfighters, benefiting both and improving outcomes for future projects.

7.7 MILITARY TRAINING AND DOCUMENTATION DEVELOPMENT

As these transition efforts mature, documentation and training materials related to military use must be developed in parallel. The use of the eTHOR system can fall into one of three categories.

1. Civilian-operated: This equipment is operated by government civilians and contractors for DoD use. An example is CONUS base IT and logistics operations.
2. Warfighter operation of commercial equipment: Warfighters use commercial vehicles or IT systems in non-tactical environments, such as on-base.
3. Full militarization: A DoD program office formally adopts the system for fielding tactical equipment.

eTHOR may have a role in these categories, each with different documentation sets, training, and certification requirements. Existing efforts have initiated this documentation for the DANNAR MPS. DANNAR has trained hundreds of Warfighters across multiple services on essential MPS operations. For example, they designed a training session for the Marines of the 3rd MLR at Marine Corps Base Hawaii. This accelerated training program allows Warfighters to operate MPS equipment without DANNAR personnel oversight within one day. (DANNAR, 2023)

On the second day, the Marines were trained on installing, removing, and operating attachments. That training material is available upon request by contacting the author of this report.

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8. CONCLUSION

8.1 SUMMARY

eTHOR was a unique, rapidly executed demonstration of existing commercial technology that dramatically changed DoD use of energy and information. Multiple demonstrations verified significant improvements in energy efficiency and transportation, and the handling and transmission of large amounts of data.

This technology has transitioned to existing follow-on projects and continues to be successful. CANA and NIWC Pacific have documented these improvements through strategic analysis, modelling projections, and assessment of how DoD requirements might be impacted.

8.2 RECOMMENDATIONS

The possible improvements to mission effectiveness, acquisition costs, and ultimately, Warfighter lives merit further exploration beyond the demonstrations performed by eTHOR. Some avenues for further development include:

- Introduction of component technologies to projects closer to Program Office acquisition (i.e., documented transition efforts led by NSWC Crane).
- Aligning eTHOR applications with Warfighter needs through direct communication, CONOPS development, and initial deployment (e.g., C2-in-a-box and BoSEC).
- Continuing efforts to solve long-term issues such as certifying the use and transport of large batteries and widespread adoption of charging infrastructure at the installation and expeditionary levels.

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14. ABSTRACT

The Electrical Tactical Humanitarian Operations Response (eTHOR) project leverages mobile electric power with communication and computational applications designed for the modern Warfighter. In 2023, eTHOR evolved to live testing, demonstrated at three major events. eTHOR showcased operational relevance in Tactical Operations Centers (TOC), integrating electric vehicles, mobile power storage, 5G networks, cloud and edge computing, and IoT-based power monitoring. This report presents a scalable, energy-efficient TOC of the future.

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