AVIATION WEEK PROGRAM EXCELLENCE AWARDS — 20 YEARS

INTELLECTUAL PROPERTY

(This section must be signed)

Individuals **outside your company**, including the companies listed above and other third parties, potentially including your competitors and others in your industry, may receive and/or review award submissions. All information submitted should address the program's management, leadership, and processes in a manner that you are comfortable sharing with third parties freely and without restriction, and may not include any classified or proprietary information or materials. Do not include any materials marked Confidential or Proprietary or bearing any similar legend. All responses and other submissions, whether in whole or in part ("Submissions"), shall be deemed not to be confidential, proprietary, and/or nonpublic information of any sort for any purpose.

Without limiting the foregoing, you hereby grant to Aviation Week Network, an Informa business, a perpetual, irrevocable, royalty-free, full paid-up, worldwide license to copy, reproduce, distribute, display, publicly perform, publish, republish, post, transmit, disseminate, edit, modify, and create compilations and/or derivative works of the Submissions (or any portion or excerpt thereof) in connection with its or any of its affiliates' business(es). Aviation Week Network agrees not to edit the Submissions in any way that materially alters their overall substantive meaning. Aviation Week Network may freely assign, license, transfer, and/or otherwise convey any or all of the rights and licenses granted hereunder.

Thank you for participating,

[signature]

Gregory Hamilton
President
Aviation Week Network

Acknowledged, agreed, and submitted by

Matthew M. Borschke — 7/10/2024

Nominee's Signature — Date

Nominee's Name (please print): Matthew Borschke

Title (please print): Program Manager

Company (please print): Raytheon

NOMINATION FORM

Name of Program: CHIMERA

Name of Program Leader: Matthew Borschke

Phone Number: 520-848-5032

Email: Matt.Borschke@rtx.com

Postal Address: 1151 E Hermans Road, Tucson, AZ 85756

☒ Customer Approved

- Date: July 9, 2024
- Customer Contact (name/title/organization/phone): Kevin Sparks / Program Manager / Air Force Research Lab / 505-301-0985

☐ Supplier Approved (if named in this nomination form)

- Date: ____
- Supplier Contact (name/title/organization/phone): ____

PLEASE REFER TO PROGRAM EXCELLENCE DIRECTIONS AS YOU COMPLETE THIS FORM.

SECTION 1: EXECUTIVE SUMMARY

Make the Case for Excellence

Value: 10 points

Use 12 pt. Times Roman typeface.

What is the vision for this program/project? What unique characteristics and properties qualify this program for consideration?

Directed Energy (DE) systems provide a reliable and low-cost additional layer of defense for high value ground assets against a variety of advanced aerial threats. High Power Microwave (HPM) is one form of DE that offers an all-weather solution with an unlimited magazine and low cost per engagement. CHIMERA represents a one-of-a-kind HPM test bed designed and fabricated after many years of Science & Technology (S&T) investment by the Air Force Research Laboratory (AFRL) and Raytheon. The CHIMERA program aims to accelerate use of high-power microwave systems in US defense architectures. The nominated program took this prototype system to White Sands Missile Range (WSMR) and executed a test to successfully gain critical knowledge toward that goal.

The Raytheon HPM team is a highly capable group of scientists and engineers working closely with AFRL out of Albuquerque, NM. The scope was to begin the process of integrating a standalone HPM system into a system of systems through a network of sensors, driven by Command and Control (C2) and Fire Control (FC) to engage and protect against a variety of aerial threats. The system utilized required significant repairs, maintenance, and upgrades on a constrained budget to successfully execute the test.

Adapting to Change on the Fly

The scope of the program and contract were updated several times throughout the Period of Performance (PoP). One of these updates involved the Risk Reduction Test (RRT) event that was initially planned to be a checkout of CHIMERA against a static target early in the contract. Due to the availability of range time and an unplanned component failure while testing in Tucson, Raytheon worked with the Government to adjust the plan and remove the Risk Reduction Test from the contract. The program achieved the needed knowledge points through component testing and analysis at the Raytheon facility. The program initially planned to use a third-party sensor to aim the system at dynamic targets. Raytheon identified a potential cost savings by implementing a mature Multispectral Targeting Sensor (MTS) camera. Raytheon’s MTS systems already had much of the sensing and tracking software available needed for the program to be successful at future test event(s). After this sensor was confirmed, Raytheon coordinated with the government to borrow 2 MTS-A units which were later loaned and utilized for the duration of the contract. These are just two of the numerous changes the team worked through during the duration of the contract.

WSMR Test Event

The culmination of the program was a 6-week test event at WSMR. Prior to shipping the system to WSMR, Raytheon performed various tests in Tucson using a Cessna aircraft to improve open and closed loop tracking methods with the antenna against a slow-moving dynamic target. Prior to the test event, the AFRL and Raytheon teams worked together to adapt to changing test range schedules and target availability to achieve a successful test. The static testing portion of the test was extremely successful with results following all predictions. The dynamic tracking exercise was also very successful, tracking a target throughout its entire flight. The success of this program was due to the technical acumen of the team, the close tracking of finances, open communication with the customer, and the ability to pivot and adapt as issues arose.

DIRECTIONS

- **Do not exceed 10 pages in responding to the following four descriptions**.
    - Allocate these 10 pages as you deem appropriate, but it is important that you respond to all four sections.
- DO NOT REMOVE THE GUIDANCE PROVIDED FOR EACH SECTION.
- Use 12 pt. Times Roman typeface throughout.
- Include graphics and photos if appropriate; do not change margins.

SECTION 2: VALUE CREATION

Value: 15 points

Please respond to the following prompt:

➢ **Clearly define the value of this program/project for the corporation; quantify appropriately**

High Power Microwave technology is a critical development for layered defense systems. As a system-of-systems provider, Raytheon is dedicated to developing and fielding these programs to the warfighter. The successful execution of the CHIMERA test at WSMR was considered a critical "must win" at Raytheon. While this program had multiple technical challenges and objectives along the way it was equally important to prove to the government team the technology was viable, particularly after the failed test on a prior contract. Raytheon has invested a significant amount of funding in technology and infrastructure to drive success in HPM.

Figure 1: CHIMERA Transportainer and Antenna Assembled

➢ **Clearly define the value of this program/project to your customer**

The AFRL directed energy division in Albuquerque, NM has invested for many years in HPM systems and technology with the goal of transitioning the technology to a program of record. This program was critical to increasing the Technology Readiness Level (TRL) and showing the larger DoD community that it is ready for integration and further development.

- **Clearly define the value of this program/project to members of your team; quantify if possible**

The Raytheon HPM team has invested significant energy into the development of the technology. The team believes in the technology and is excited for its place in the battlespace. When HPM team isn't in the office progressing programs, they are developing white papers and patents, experimenting in the garage, and running simulations on weekends. As with all at Raytheon, the HPM team has a profound respect for the warfighter and what they do to keep the country and world safe. Supplementing the kinetic battlespace with non-kinetic HPM technologies will further protect the warfighters and allow them to do their jobs and come home safely. Being a part of innovative early development is exciting as Raytheon works with government customers to embrace the challenges to get future systems out of the experimental realm and into production.

- **Clearly define the contribution of this program/project to the greater good (society, security, etc.)**

Due to several current threats, this program is important to the safety of the warfighter and the country. As a supplement to kinetics, CHIMERA (and future HPM systems) offer a low cost per shot with a nearly unlimited magazine depth to protect against incoming threats. Kinetic interceptors will remain critical in the battlespace, but they are limited in numbers, expensive, and require extensive logistics trails for resupply. A robust, low-cost DE solution augments these effectors in future systems. As HPM systems grow in TRL and MRL, Raytheon will progress more readily transportable and ruggedized systems; this program was an important precursor to these next developments.

SECTION 3: ORGANIZATIONAL BEST PRACTICES AND TEAM LEADERSHIP

Value: 35 points
Use 12 pt. Times Roman typeface

Please respond to the following prompts:

- *15 points:* **Describe the innovative tools and systems used by your team, how they contributed to performance and why**

To successfully execute this contract, Raytheon implemented the Integrated Master Schedule (IMS), high nail chart, stoplight chart, and financial tracking via a program generated status sheet. These tools were tailored to the level needed to succeed on this program based on schedule and funding. An established weekly cadence was critically important; these tools were embedded in the standing cadence of the program to keep the team moving forward.

Integrated Master Schedule (IMS)

Prior to starting each phase, Raytheon sat down in a "war room" and planned out work packages, risks, and tasks with clearly defined handoffs and definition of done. It wasn't possible to solve all potential problems up front, so risk postures were documented weekly and shared with the customer. Planning was conducted by printing out the statement of work (SOW), Basis of Estimate (BOE), and draft IMS then placing stickered notes on a white board for linking and tasking. Each task had a name assigned to it (responsible owner) and maximum hour allocation. Going above the hour allocation required permission from the Chief Scientist (CS), Chief Engineer (CE), and Program Manager (PM). All tasks were 0/100's or 50/50's to ensure short durations to execute with the budget available. Once baselined, the IMS was taped to the wall in the "war room" to ensure everyone could see what was getting worked today, next week, and next month (30, 60, 90). The program did not require Earned Value (EV), however an implementation of EV-lite proved to be extremely agile to address new risks and opportunities quickly as an informed team.

EAC and Financial Tracking

Although the contract did not require EV, the PM utilized an excel based EV plan to track actual labor against planned and ensure the program had funding to complete. While this isn't innovative, the tracking sheet to record and plan the program was. The excel sheet to track actuals vs the plan was generated by the PM and contained approximately 250 rows of data along with multiple metrics / tables. The IMS was aligned to the EAC, and all actuals were tracked by the PM every Monday. Material and labor name runs were meticulously checked to ensure that charges were in line with expected work performed. This tracking sheet enabled the team to track and appropriately flow information to the customer and company leadership. This effort was paramount to getting to the successful end of contract with a limited amount of Management Reserve (MR).

High Nail Chart

The High Nail chart tracked open actions / concerns against the desired technical baseline and how they would or would not be addressed. When the program began, it was abundantly clear that not all issues would be fixed and many of the desired upgrades would not be possible. Prior to the start of each phase, Raytheon reviewed the SOW with technical SMEs to identify critical items, highly desired items, and nice-to-have items. As a result of the complexity and age of the system, many new findings were identified along the way. Any findings that deviated from that baseline IMS were tracked in the high nail chart similar to a scope control board. On a weekly basis the team met, added new findings, closed out open findings, and prioritized new high nail(s) to tackle for the week. Not everything could be accomplished due to time and funding, so the team prioritized the highest risk findings first. Items that couldn't be completed were documented, held as risks, and communicated to the customer and company leadership. The team executed with constant and quality communication to ensure there were zero surprises. Timelines for closure, task owner, hours to complete, description of task, and probability / consequence factors (Pf/Cf) were listed in this chart to supplement this communication.

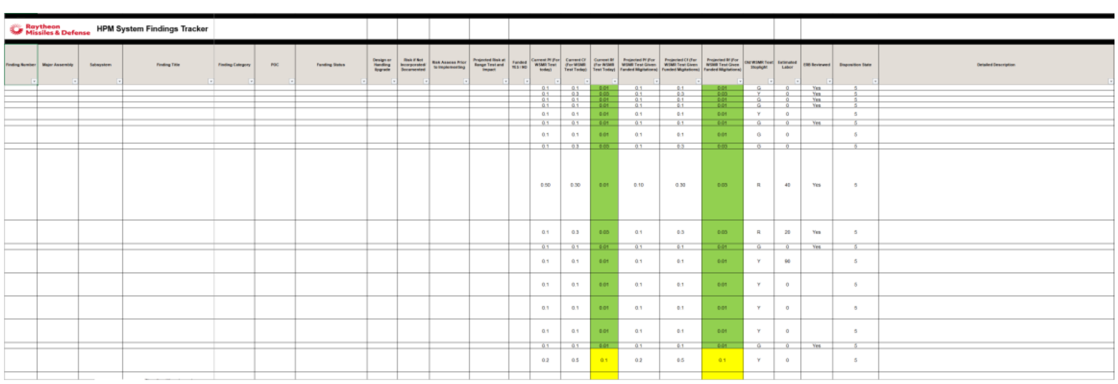


Figure 2: High Nail Chart Template

Stoplight Chart

The Stoplight Chart was created to show technical status throughout the entire system and subsystems leading up to the test event. Each section of the stop light chart had an owner responsible for getting the stop light from red to green prior to the test event. Timelines for closure to green and alignment to the high nail list were key. As the team moved closer to test, this chart proved to be an easy visual for the Test Readiness Review (TRR) to show that CHIMERA was ready to move forward with the test event.

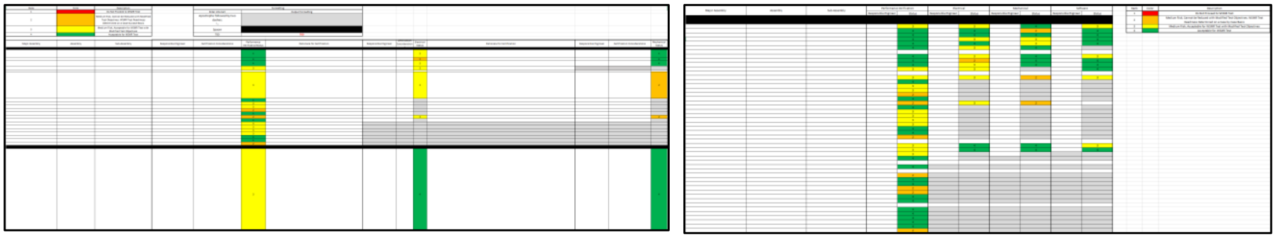


Figure 3: Stoplight Chart Template

➢ ***10 points:*** **Define the unique practices and process you used to develop, lead and manage people?**

Due to budget constraints, the program team was kept extremely lean. For example, the Chief Engineer was also the integration and test team, the program manager modeled designs in Creo, and the chief scientist turned wrenches and tested the hardware. The team remained flexible and focused on the mission of what needed to be done that week. The strength of this team was the team; everyone was bought into the culture. No one said, "that isn't my job", and everyone chipped in to ensure that work was getting done. Excessive communication, laughter, willingness to change, documentation, and accountability were all key to success. There were bad and good days on CHIMERA, but always time to laugh to cut through the stress. "Dad jokes" of the week were put up on a white board next to the IMS, High Nail List, and Stoplight Chart. The team executed by the mantra of "Semper Gumby" or "Always Flexible" due to the constant changes along the way. As the test event approached, daily standups, continued risk assessment/mitigation, and reverse planning guided the way. While there wasn't a critical chain, there was a physical white board that laid out tasks for the day, the schedule on system, and areas where help was needed. Task, owner, and completion date were all tracked on the board, so everyone knew what they had to do for a successful test event. As a result of schedule being the driving requirement, the team followed the meeting cadence and avoided excessive emails and popup meetings. Several critical "stand downs" occurred to quickly check in and make a critical schedule, cost, or technical decision to ensure alignment across the program.

➢ ***10 points:*** **How did you leverage skills and technologies of your suppliers?**

CHIMERA had been designed and built under prior contracts, therefore there weren't major suppliers involved in this program effort. There were several critical small businesses that were consulted due to their history in providing components and subcomponents under those prior contracts. Many of these suppliers answered the team's questions quickly and willingly which was key to the success. The Raytheon team recognized early in the program where there were knowledge gaps and contracted to fill those holes to meet cost and schedule.

SECTION 4: DEALING WITH PROGRAM COMPLEXITY

(VOLATILITY, UNCERTAINTY, COMPLEXITY, AMBIGUITY, or VUCA)

Value: 25 points

Use 12 pt. Times Roman typeface

Please respond to the following prompts:

➢ ***10 points:*** **Describe UNIQUE areas of VUCA faced by your program and why. (Please avoid the issues surrounding Covid-19 pandemic, which was faced by all programs.)**

This program was unique due to the lack of existing design or analysis documentation. Many of the findings on CHIMERA were addressed and solved without prior knowledge of design intent. The major issues encountered throughout the duration of the program are categorized below:

Lack of spares and obsolescence:
The CHIMERA system was designed and fabricated in Albuquerque, NM during prior S&T contracts as an advanced test bed that provided proof of principle for the technology but was never intended to be a tactical implementation. Raytheon's typical engineering practices and rigor were not fully implemented in these prior contracts due to funding limitations and the S&T nature of the effort(s). CHIMERA was not fabricated to be a fielded, ruggedized system which resulted in technical findings in the follow-on nominated program.

Due to funding, schedule, age of system, and global supply chain concerns it was challenging to get all spares that were needed to ensure continued operation. CHIMERA is a complex system with over 3,500 different parts in the Bill of Materials (BOM). Given that the system was built as a test bed with limited maintenance prior to this effort, there were numerous part failures with no spares which forced a quick reaction and adaptation of plans.

Lack of initial knowledge:
The team responsible for the success of this program is highly skilled and knowledgeable in directed energy however, almost all the team was new to this program and came in with little history of the original CHIMERA design and fabrication. The Technical Data Package (TDP) was incomplete, analysis wasn't available, documentation was lacking, and many redlines made during fabrication were never updated in the drawings. These challenges made it complex for the team to address problems as they arose.

Uncertainty leading up to and at the test event:
Leading up to the test event, Raytheon and the government worked hand in hand to get range time and align on target set. Due to the many firsts that the HPM technology brought to the test, range time and approvals were complicated. Approvals for the range and target(s) ran all the way up to days prior to the start of the actual test.

Transporting CHIMERA to the range was not trivial. Prior to Raytheon departing Tucson, a shipping and operations manual was created to guide how components would be disassembled and packaged. However, the realization of many firsts proved challenging to safely get 8 semi-trailers loaded with everything needed for the test.

- ***15 points:* Explain how your team responded to these challenges. What changes did you make, what were the results?**

Lack of spares and obsolescence:
At the start of each phase of the contract, the team laid out engineering hours then pulled from the top of the material list what was needed to ensure continuous operation of the system. There was not available budget for everything, therefore procurement decisions were based on the affect it would have on the system due to failure and the time it would take to procure new spares. Material that couldn't be procured due to schedule or cost was then documented, held as a risk, and communicated to the customer. This process was supplemented with the development of a maintenance manual which was made by reviewing off-the-shelf component specification sheets and leveraging past performance as the basis for

future success. Upon completion, the maintenance manual detailed time or shots that each piece of hardware could remain in the system prior to replacement with a new or repaired component.

Lack of initial knowledge:
With the lack of existing knowledge on the system and minimal documentation, the team created a new process to document all learning as it occurred. Every action that was completed (building, testing, hardware replacement, maintenance, etc.) was approved by the Chief Scientist (CS), Chief Engineer (CE), and Program Manager (PM) prior to being documented accordingly. Safety measures that did not exist were also documented and approved by the Engineering Safety Review Board. Within weeks of this program starting, an operation and assembly manual of more than 250 pages was created. This manual became useful throughout the duration of the contract and was kept under configuration control and revised after every new update.

Throughout the duration of the program the team conducted weekly system walks to inspect the system from tip to tail. The team checked for deviations from the available TDP, listened for off-nominal noises, and visually checked for potential concerns to be proactive vs. reactive on the maintenance of the system. Through this effort, Foreign Object Debris (FOD), frayed harnesses, un-torqued fasteners, leaks, broken parts, and ungreased mechanical components were discovered. Repairs to these findings were updated in the TDP as applicable, discussed with safety, documented, and put under configuration control.

Uncertainty leading up to and at the test event:
Due to the complexity, size, numerous firsts, and capable range of the system, a large amount of work was required to get approved on WSMR. The team worked with the customer to secure range time, align on the test plan, and receive target approvals. This process started months prior to the start of the test event but finished just days prior to packing up the system and shipping it out for test. The test plan continued to evolve as the government and Raytheon teams worked together to complete a test that met the intent of the contract and stayed within the bounds of the range and safety requirements. Excessive communication, division of work, and proactive planning kept everyone aligned. Raytheon and the government were prepared to execute the test event regardless of the scenario that was approved.

Despite efforts to document prior, learning how to package and transport the hardware largely happened as work was completed due to the numerous firsts experienced. To give an idea on size, CHIMERA’s antenna weighs 30,000 lbs. and the trailer another 100,000 lbs. Subcomponents were disassembled, packaged safely, organized, and transported to the test event. Since much of the system had not gone through structural analysis, shock or vibe, the team erred on the side of caution by disassembling all critical components and packing them safely into individual custom padded boxes. Raytheon’s machine and carpentry shops were leveraged to create a means of safe packaging on the fly to get hardware out to test. The team worked with functions like structures, safety, Engineering Health and Safety (EH and S), and SMEs to ensure processes were sound for safe transport of hardware to and from the range. Deviations from original documentation were brought to Engineering Review Board (ERB) for approvals prior to implementation to ensure alignment. The hardware was disassembled, transported, and assembled safely at the range to support the test event.

SECTION 5: METRICS

Value: 15 points
Use 12 pt. Times Roman typeface

Please respond to the following prompts, where predictive metrics indicate items that provide a view of how yesterday’s actions and today’s actions will affect the future timeline, cost or other requirement.

Provide charts/graphs that illustrate performance to these metrics:

- **What are your predictive metrics?**

Development of predictive metrics was essential throughout the duration of the effort. The majority of these metrics were communicated to the customer via the monthly technical status report. This is when the program leadership team described current issues being worked leading up to the test event, financials and risks. Finances were one of the top priorities to Raytheon and the customer, so various metrics were created by the PM to show regular performance.

Figure 4 represents a summary of the hours worked month-to-month by the team in comparison to the plan. Months that ran over allocation were colored yellow, while months that ran under were colored green. Figure 5 is the material tracking sheet that was used to understand costs in alignment with the total program summary. The material tracking sheet was used to identify the most critical hardware to be procured in alignment with the available budget. The month-to-month predicted vs actual cost charts assessed how the program was executing. This chart gave reasonable visual representation of ability to reach complete under budget (Estimate to complete). The Full Time Equivalent(FTE) plot gave insight into workload vs time. When future workload exceeded 5-6 FTE, the team brought in support to execute. This support was then removed from the program to ensure program spending remained under budget. All four tables / plots were important metrics to track for the duration of the program for internal decision making and external communication.

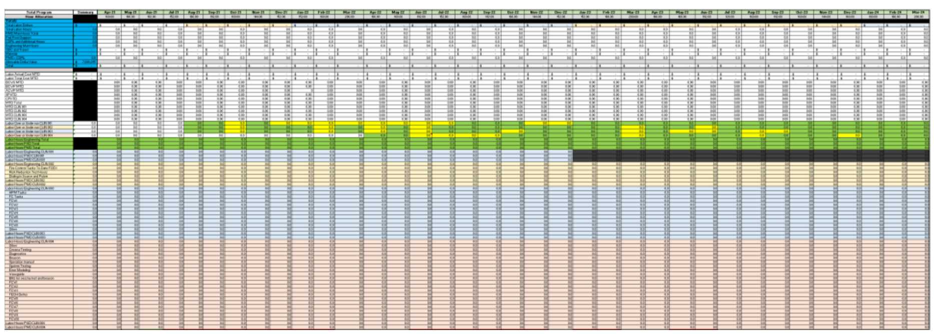
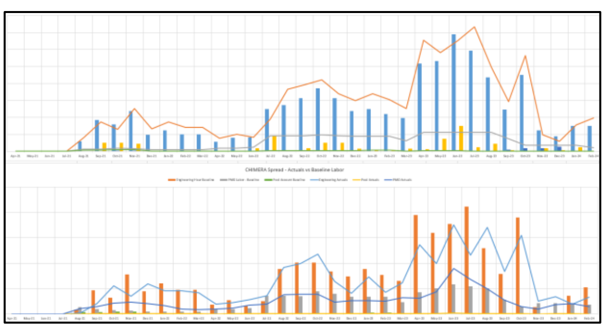


Figure 4: Financial Metrics Template



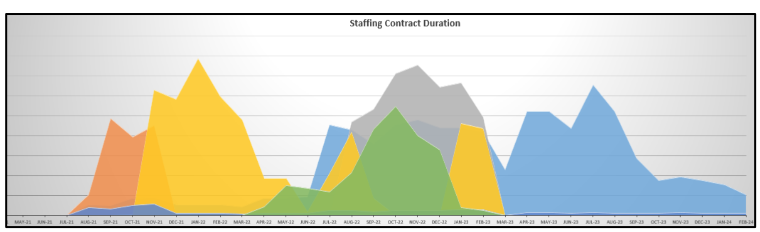


Figure 5: Month to Month Predictions vs Actuals

- **How did you perform against these metrics?**

At program inception, there was a significant amount of tailoring to fit the technical scope within the budget and schedule. The task-based IMS and financial tracking sheet were critical to the program completing with a Schedule Performance Index(SPI) of .99 and Cost Performance Index (CPI) of 1.11. The planned budget for Program Management Office (PMO) per month was very limited to allow for Management Reserve to fill technical gaps and findings as they arose. The team underran contract budget which allowed for the opportunity to work with the customer to plan and execute an additional test event at Raytheon's facility. This unplanned test was completed successfully, and further proved the capability of the technology. With program metrics and hard work, the team was able to complete a complex, ever evolving program under budget.

➢ **How do your predictive metrics drive action toward program excellence? Please provide examples.**

Some examples of successful use of the metrics above:

- Visual representation of schedule compression vs the size of the team.
- Tracking material quantity, cost, and need based on risk.
- Finding material costs not in alignment with original quotes / estimates.
- Low cost, innovative, visual based communication method for program status and health.
- Plan for the limited funding profile and communicate with the customer that the next CLIN needed funding.
- Understanding the duration of the work based on FTE and communication with the customer that funding was needed.

Figure 6: CHIMERA at Test