AVIATION WEEK NETWORK

# 2020 Program Excellence Awards

## NOMINATION FORM

Name of Program: Exoatmospheric Kill Vehicle (EKV)

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☒ Customer Approved

- Date: 16 July 2020
- Contact (name/title/organization/phone): Ryan Orlinski, Supply Chain Contracts Manager, The Boeing Company, 256.772.1112

☐ Supplier Approved (if named in this nomination form)

- Date: _____
- Contact (name/title/organization/phone): _____

## CATEGORY ENTERED

Refer to definitions in the document "2020 Program Excellence Directions." You must choose one category that most accurately reflects the work described in this application**. The Evaluation Team reserves the right to move this program to a different category if your program better fits a different category.**

**Check one**

- ☐ Special Projects
- ☐ OEM/Prime Contractor Systems Design and Development
- ☐ OEM/Prime Contractor Production
- ☐ OEM/Prime Contractor Sustainment
- ☒ Supplier System Design and Development
- ☐ Supplier System Production
- ☐ Supplier System Sustainment

The views expressed are those of Raytheon and do not constitute an endorsement by the Missile Defense Agency (MDA) or The Boeing Company (Boeing).

## Point Distribution

| Executive Summary: Make the Case for Excellence (15 pts) | | |
|---|---|---|
| **Metrics**<br><br>**10 pts**<br><br>Predictive Metrics (10) | **Program Volatility/ Uncertainty/Complexity/ Ambiguity**<br>**25 pts**<br><br>Describe overall VUCA (10)<br><br>Cite examples of team response (15) | **Organizational Best Practices & Team Leadership**<br>**40 pts**<br><br>Innovative Tools and Systems (15)<br><br>Unique Innovative Processes for People Development/Knowledge Transfer (15)<br><br>Unique Practice es for Customer Engagement (10) |
| **Value Creation (10 pts)** | | |

## Abstract

In 150 words or less, why is this program excellent in terms of execution?
*(12 pt. Times Roman)*

In 2019, the Ground-based Midcourse Defense Flight Test 11 (FTG-11) containing, key Exoatmospheric Kill Vehicle (EKV) objectives, was the first salvo engagement of a threat-representative Intercontinental Ballistic Missile (ICBM) target by two Ground Based Interceptors (GBI), and was the first real-life scenario where launching more than one interceptor ensured destruction of the threat away from population centers. The EKV Team demonstrated Raytheon Missiles & Defense's (RMD) excellence as the leader in Kill Vehicle (KV) technology for missile defense.

Program excellence is seen across all areas of the EKV Program; the Software Development Team's use of Agile development to optimize velocity and meet requirements; the Space Systems Operations (SSO) Team delivery of advanced KV technologies using state of the art production techniques; the Flight Test Execution Team's use of innovation to solve complex infrastructure challenges and the Leadership Team's unique approach to customer engagement. These enabled rapid decision making during the execution of this historic event.

## Purpose

Provide a 150-word description of the purpose of this program, spelling out all acronyms and correct acronyms *(12 pt. Times Roman)*

The Ground-based Midcourse Defense (GMD) System defends the United States against current and future ballistic missiles by destroying them while they are still in space. As part of the complex GMD System, the EKV is the kinetic-force component of the GBI, for which Boeing is the Prime Contractor.

When the GMD System tracks a threat using land, sea or space sensors, it launches a GBI, which uses its three-stage solid rocket booster to fly out of the Earth's atmosphere at near-hypersonic speeds. Once it has exited the atmosphere, the Kill Vehicle's job begins.

The EKV seeks out its target using multi-color sensors, a cutting-edge, onboard computer, and a rocket motor that helps it steer in space. It guides to the target and, with pinpoint precision, destroys it using nothing more than the force of a massive collision. No traditional warhead is necessary.

**Executive Summary: Make the Case for Excellence** *(Value: 15 pts)*

*What is the vision for this program/project? What unique characteristics and properties qualify this program for consideration? (12 pt. Times New Roman)*

The vision for the EKV Program is to leverage the Raytheon Missiles & Defense world-class sensor, discrimination and production technologies into a sustainable Ballistic Missile Defense (BMD) System with the most noble of purposes – the defense of the United States homeland against an attack.

Raytheon Missiles & Defense recently completed delivery of its 65$^{th}$ EKV Payload from its Kill Vehicle (KV) Space Systems Operations (SSO) Factory in Tucson, Arizona. This culminated a production run that stretches back to the 1990's, and has supplied the cornerstone KV technology for the 44 GBIs on station at Fort Greely, AK and Vandenberg AFB, CA.

The EKV has been through intense flight tests as part of the GMD Flight Test Program, with a 77% flight test success over the life of the program and 100% flight test success with the most current EKV Block configuration. This flight test program culminated with the 2019 FTG-11 salvo test, which was 20 years in the making, and employed a threat representative scenario. Raytheon Missiles & Defense has supported each of the crucial flight test milestones with a knowledgeable and experienced team of Subject Matter Experts (SMEs), adept at adjusting to changing test conditions, with the leadership experience necessary to make the important, time critical decisions as a key part of the government/industry team. In addition, the RMD EKV Team's early delivery of the FTG-11 software and production payload increased the available field integration time, thus allowing for reduced the integration risk to the broader industry and government team.

Agile software development, operations excellence, a highly experienced Flight Test Execution Team, and strong Customer partnerships makes for a stronger program. These attributes, in addition to the lessons learned during the extensive GBI flight test program and knowledge of the evolving nation-state capabilities, make for a better BMD System. The EKV Program continues to develop and field software and algorithm solutions to remain many steps ahead of the threat. Raytheon Missiles & Defense world-class expertise in sensing technology, discrimination, and software development has allowed the Missile Defense Agency (MDA) to devise and implement solutions to defeat advances made by adversaries of the United States.

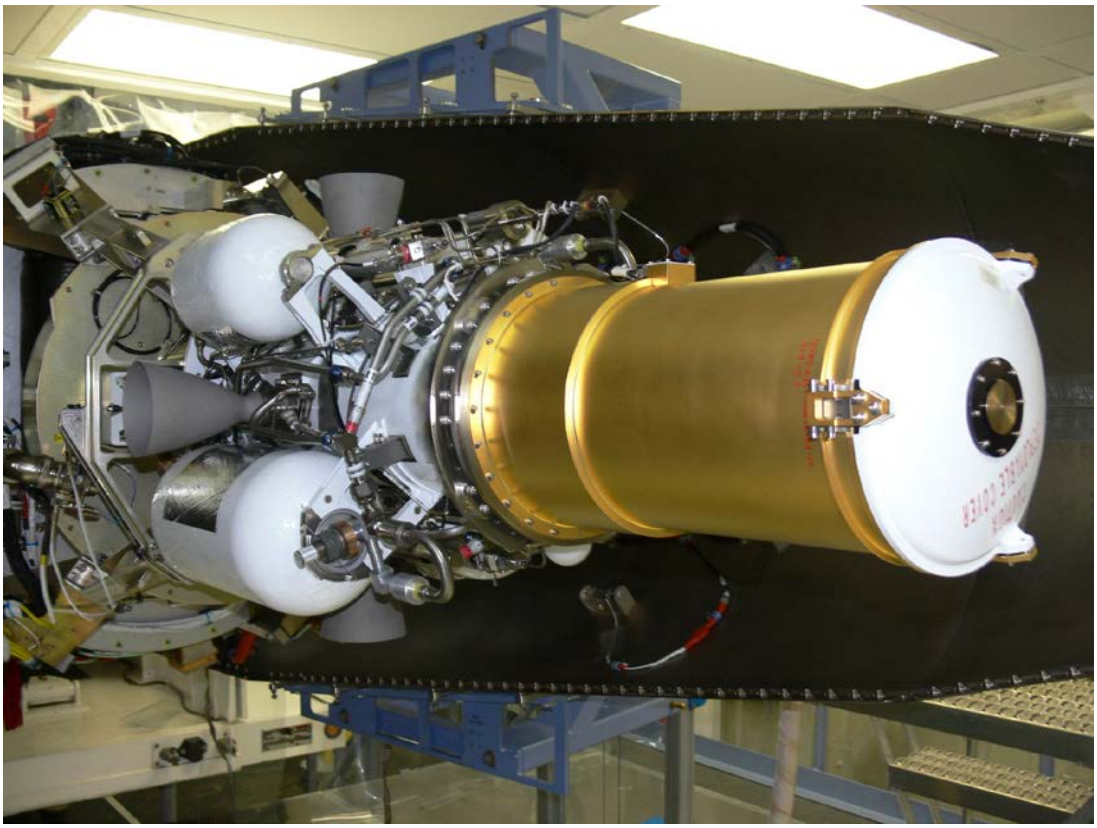
Raytheon Missiles & Defense business is widely considered the world leader in KV Engineering design and analysis as well as manufacturing technologies, processes and personnel. The RMD Tucson SSO Factory

boasts a state of the art facility with patented clean room processing capabilities and disciplines while leveraging advanced manufacturing technology, resulting in superior product quality.

As the GMD System, which the EKV is a key element, stands watch over the United States nearing 16 years, efforts are underway to modernize and improve this fundamental capability. Raytheon Missiles & Defense has evaluated a number of opportunities to improve the reliability, service life and performance of the EKV System. The RMD Team is collaborating with Boeing and the MDA to identify and prioritize growth opportunities for this critical system.

Along this journey of designing, producing, supporting and evolving the missile defense system lifecycle, RMD has emerged as the pre-eminent company for BMD KVs. The sensing and discrimination technology, BMD experience and knowledge, and the KV manufacturing expertise are unparalleled.

The EKV Program has taken a concept that, previously, was denounced as an impossibility and evolved it into a key element of the GMD weapon system, demonstrating the United States' defense against nuclear attack is in place, operational, and ever improving.



**Production of EKV in SSO Factory**

(Do not exceed 10 pages in responding to the following four descriptions; allocate those 10 pages as you deem appropriate, but it is important that you respond to all four sections.)

**VALUE CREATION** *(Value: 10 pts)*
**Please respond to the following prompt:**

- **Clearly define the value of this program/project for the corporation beyond profit and revenue**
- **Clearly define the value of this program/project to your customer**
- **Clearly define the value of this program/project to members of your team**
- **Clearly define the contribution of this program/project to the greater good (society, security, etc.)**

*(12 pt. Times Roman)*

The EKV System is the hit-to-kill component of the GMD System, and designed to detect, identify, and intercept ballistic missiles in the midcourse phase of flight. With interceptors deployed since 2004, the GMD System has the primary responsibility for defense of the United States homeland against ballistic missile threats. The Program is led by Boeing, with RMD and Northrop Grumman providing the payload and booster components, respectively. During the over 20 year history of EKV development and deployment, both the performance and reliability delivered to the Warfighter have continued to improve, culminating in the fielding of the most advanced generation of Kill Vehicles with the current EKV Block configuration.

Within RMD, the EKV Program is a cornerstone of the extensive missile defense portfolio, enabling the Business to develop extensive knowledge and expertise in hit-to-kill technology. The advanced technologies and production techniques developed under the EKV Program have applied to other programs, including the Standard Missile-3® (SM-3®) family of interceptors. This sharing of engineering and production expertise and lessons learned, combined with world class production facilities has been of immense benefit to both the individual programs as well as serving to increase the overall knowledge level within this complex mission space. The knowledge sharing spans not only across RMD KV programs, but also sensor and command and control programs, allowing RMD to provide a holistic, system of systems approach and understanding to their Missile Defense solutions.

**FTG-11 GBI Launch**

However, more importantly is the value the EKV Program brings to the MDA and their noble mission to "defend against all threats, at all ranges, in all phases of flight." The Program has ably demonstrated hit-to-kill technology and the ability to "hit a bullet with a bullet" many times over against threats of ever-increasing complexity. In over two decades of development and testing, the EKV Program has demonstrated countless firsts, including the most recent FTG-11 Flight Test in March 2019. This flight test was 20 years in the making and the first GMD flight test to use salvo doctrine (multiple interceptors engaging one target). The system performed exactly as designed. The first Kill Vehicle correctly identified the simulated lethal object and successfully intercepted it, while the trailing Kill Vehicle identified the next-most lethal object in the scene and successfully intercepted it. The significance of this accomplishment cannot be overstated: the successful salvo

engagement demonstrated to the Country and its adversaries that the United States possesses a credible Missile Defense System that works as designed. Furthermore, this achievement represents another step toward the realization of Ronald Reagan's Strategic Defensive Initiative (SDI) vision of rendering an adversary's ballistic missile threat ineffective and obsolete.

According to MDA Director Air Force Lt. Gen. Samuel A. Greaves, "This was the first GBI salvo intercept of a complex, threat-representative ICBM target, and it was a critical milestone. The system worked exactly as it was designed to do, and the results of this test provided evidence of the practicable use of the salvo doctrine within missile defense." Through this success, RMD secured growth opportunities and furthered its competitive advantage within Missile Defense.

**Government / Industry FTG-11 Team**

Through the flawless execution in accomplishing the FTG-11 objectives, the EKV Program signaled to the world the system's operational capability against real world threats in the protection of the United States. For the RMD Team, FTG-11 demonstrated that EKV performs as designed against a complex adversary and confirmed the technology growth roadmap is sound. For the FTG-11 EKV Flight Test Team, there is nothing like knowing that all of the hard work and tireless hours have paid off, and for the United States, EKV is a ready and able system.

**METRICS** *(Value: 10 pts)*
**Please respond to the following prompt:**

- **How do your predictive metrics drive action toward program excellence?**

*(12 pt. Times Roman)*

**Software Development Team - Agile Development to Meet Time Critical Customer Needs**

Agile software development enabled the EKV Software Development Team to react to Customer needs quickly and priorities with improved team efficiency. Through Agile development, the Team focused on addressing the most critical capability enhancements and software improvements, solving difficult problems through incremental solutions, continuously tested against evolving threats. Additionally, by using Agile predictive metrics, such as Team Velocity, Story Point Burn-up and Cumulative Value Flow, the Team was able to increase productivity by identifying and removing roadblocks and inefficiencies.

Another part of the Agile continuous integration process that is used by EKV Software Development Team is the execution of tens of thousands of test cases in the simulation environment as part of a regression test suite. This set of scenarios is carried over from build to build and updated, as the threat evolves. For each incremental build, this test suite is executed and compared to the previous known set to ensure unintended behaviors have not been introduced, and that new capability enhancements do not negatively affect performance against existing threats.

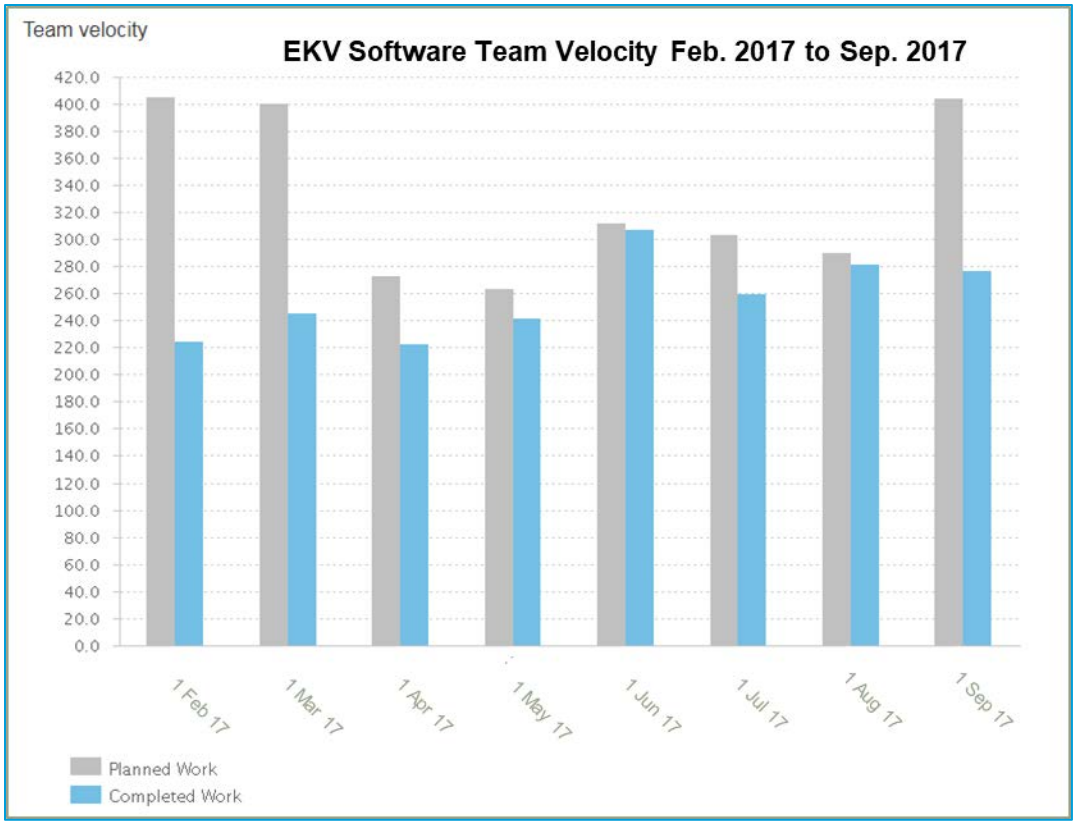
Within the Agile software development framework, a Sprint is a time-boxed iteration of a continuous development cycle. Within a Sprint, a planned amount of work is completed by the team and made available for review by stakeholders. This approach to development allowed the Software Development Team the

ability to make updates and changes to code in a more proactive manner, with Customer engagement. The capability developed during a Sprint is measured in User Stories, which contain a description of a software feature the end-user or product expects to see and Story Points, which estimates the difficulty of implementing a given User Story.

The following details the EKV Software Development Team's use of these predictive metrics during the Agile software development of EKV embedded software build that was flown in FTG-11.

**Team Velocity**

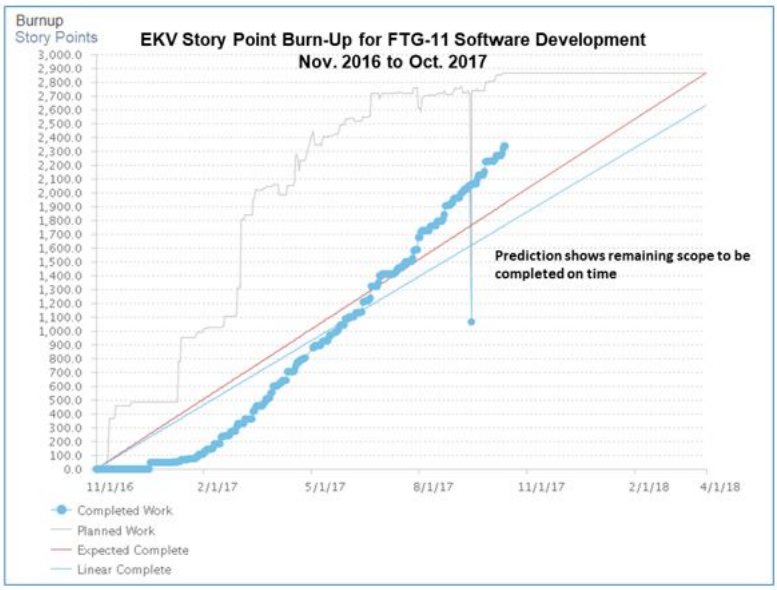
Team Velocity, measures how many User Stories, on average, the team completed in previous Sprints. Using prior month's data, Team Velocity predicts how much work the team is able to accomplish in the future months. It is critical to maintain some level of backlog, or work not completed at the end of each month, in case the team completes some planned work more quickly than expected. Each User Story is assigned a number, based on a scale established by the Development Team, to indicate the difficulty of each User Story. This is how the scale on the y-axis in the plot above is developed. Throughout the development cycle for the FTG-11 software build, the Software Development Team progressively increased their Team Velocity, as indicated by the metrics shown above. In February and March of 2017, the backlog was greater than it should be, indicating that the plan was too great for the Team Velocity being achieved. Through a team assessment of this metric, it was determined the team was not as efficient as planned. As part of the Sprint retrospective, lessons learned were documented and incorporated into future development activities, with the plan revised to align with the predicted Team Velocity. In April through August, the Team achieved the expected velocity and managed to an appropriate backlog. Management of the software development using Team Velocity enabled the Software Development Team to increase efficiency and accelerate their development process, allowing time for one additional Sprint, for additional capability development and debugging, prior to entering the software qualification phase.



## Story Point Burn-Up

A Burn-Up Chart is a visual representation of a team's work progress, plotting Story Point completion over time. This chart depicts the scope of a project and work completed. As part of FTG-11 software development, the EKV Team was able track their progress as they worked towards completion.

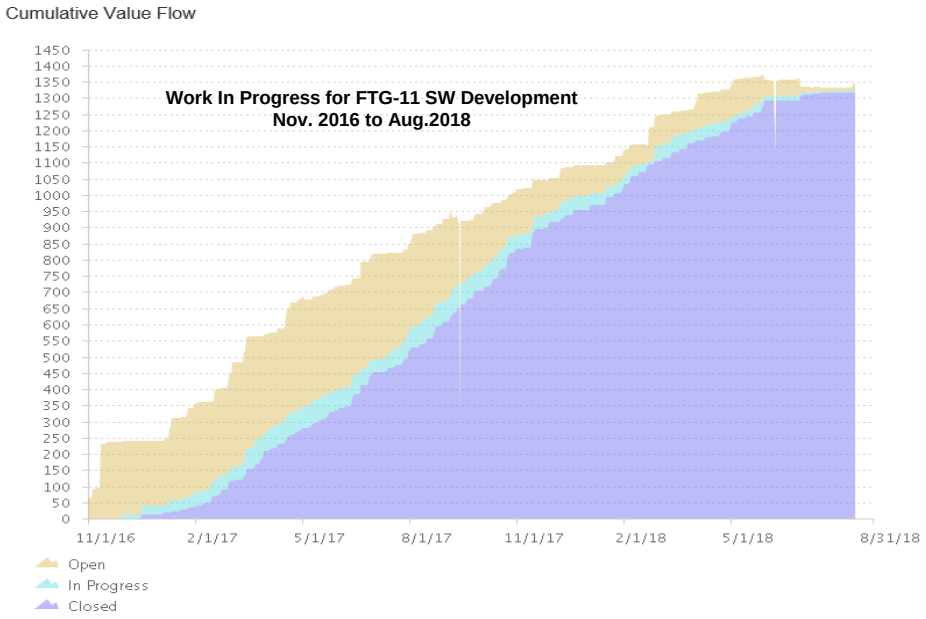
The chart to the right shows a transition from a period during the software development cycle when the EKV Software Development Team was not completing tasks quickly enough to meet the overall build schedule due to external influences, such as work on completion of software builds not related to FTG-11.




Using this information, the EKV Software Development Team was able to use the Story Point Burn-Up data, along with the Team Velocity data described above, to be proactive in its planning and assignment of software developers to the tasks that were falling behind. These adjustments allowed the EKV Software Development Team to recover from the slow start, support the overall program schedule, and complete development and qualification of the software flown in FTG-11 ahead of schedule.

## Cumulative Value Flow

The Cumulative Value Flow, also known as Work In Progress (WIP), shows the number of work items started but not finished (see light blue in chart below). The goal of the WIP chart is to measure and guide the team in knowing how to reduce the number of actual tasks in progress. The number of WIP tasks staying low means the team was working efficiently by focusing on tasks to complete User Stories. The greater the number of User Stories completed, the greater the Team Velocity. The Cumulative Value Flow chart is an advanced version of the Point Burn-Up chart and, again, is used as a proactive workflow management tool through the software development cycle. The EKV Software Development Team used the chart to the right as a part of their sprint retrospective. Similar to the Team Velocity data, the Team incorporated this data into their lessons learned and incorporated into future development activities to increase efficiency and accelerate their development process.



**Space Systems Operations (SSO) Factory - Defects Per Unit (DPU)**

In addition to the Agile development metrics utilized throughout the software build, the EKV Operations Team utilized metrics associated with the hardware manufacturing of the payloads. Defects Per Unit (DPU) is an important metric to drive efficiency, quality, and effectiveness in a positive direction. After many years of production, lessons learned and applied continuous improvement initiatives, the SSO Factory was able to predict areas of vulnerability and mitigate risks with a DPU efficiency gain of 91%. This increase in efficiency enabled the Operations Team to complete and deliver the outstanding FTG-11 payload 11months ahead of schedule.

**Execution Team – Real-Time Assessments and Decision Making**

Successfully launching a GBI, collecting flight data and generating performance analysis metrics and reports requires a diverse set of engineering disciplines. The FTG-11 Flight Test required the largest and most diverse EKV Flight Test Team in the history of the GMD flight test program due to the complexity of the flight test and the unique configurations of the GBIs. The diverse EKV Flight Test Team, which was comprised of over 20 engineers, deployed to Vandenberg Air Force Base and Colorado Springs to support flight execution, metrics analysis and report generation. The Team comprised of Systems Test, Systems Design & Performance, Software, Electrical, Mechanical and Whole Life Systems Engineering disciplines. The Team deployed to the field for over a month with the mission of successfully launching and assessing the performance of the GBI System. Each engineer and discipline served as a critical piece to a much larger puzzle that comprises a flight test mission. Each team member's expertise was necessary in assessing the health and readiness of the payloads prior to flight as well as in assessing system performance during and after the flight. In addition to having a diverse set of expertise, strong, trusting relationships across the industry and government team was critical. As part of launch activities, the Team had seconds to develop a detailed set of metrics, determine the health of the payloads based on a set of predetermined criteria, and to authorize the launch of the payloads. The communication systems supported real-time communication across the local team as well as with the team members deployed to other remote sites. This system ensured that all necessary SMEs could communicate with the Execution Team for the highest quality decision making at all times, which was critical as the real time decisions the team was required to make had millions of dollars of impact. It is for this reason that a tightly coupled and diverse team is necessary in support of a GBI flight test mission.

**EKV Execution Team**

**DEALING WITH PROGRAM CHALLENGES (VOLATILITY, UNCERTAINTY, COMPLEXITY, AMBIGUITY, OR VUCA)** *(Value: 25 pts)*

**Please respond to the following prompts:**

- *10 pts:* **Describe overall VUCA faced by your project/program.**
- *15 pts:* **Cite specific example(s) and how your team responded.**

*(12 pt. Times Roman)*

Given the unprecedented salvo nature of the FTG-11 Flight Test, the EKV Software Development Team faced significant uncertainty as planning for the test began several years prior to the mission scenario's definition. With this ambiguity, the EKV Software Development Team derived requirements based on engineering judgement to ensure the system was able to function as intended under a dual salvo engagement; the first EKV would intercept the primary target while the second EKV would identify the next most lethal target and destroy that target. Through the application of Agile development techniques, the Team was able to complete the software on schedule while maintaining the flexibility as the FTG-11 mission scenario definition and requirements stabilized.

**Inspecting the KV Prior to Delivery**

One example of how the program dealt with challenges from Volatility, Uncertainty, Complexity and Ambiguity (VUCA) was the partnering of the EKV Software Development Team with the Boeing and MDA Customers to facilitate "early learning" by providing a preview of the expected scenario well over a year prior to the flight test. This early learning was indeed instructive, and enabled maturation of requirements and algorithms. Multiple iterations of early learning were performed and used in concert with the Agile development processes, ultimately allowing the Program to finalize the flight software prior to having received final FTG-11 flight test scenario inputs.

The FTG-11 Flight Test presented new and unique challenges to the execution community and infrastructure. The complexity of the flight test mission and architecture required the development of new test systems, tools and methods to enable the expected test execution and mission awareness. Throughout the planning, execution and reporting phases of the project, the EKV Team worked to overcome challenges presented by the salvo aspects of the Flight Test. The Execution Team focused on two major infrastructure challenges to enable the FTG-11 Flight Test execution. The first challenge was addressing infrastructure limitations required to support the EKV integration and test of two uniquely configured GBI test assets. The second challenge was addressing real time EKV telemetry handling of two GBI data sources in an environment designed to handle a single data source. The Team's vision to execute the FTG-11 Flight Test event in the same manner as a standard flight test was successful by overcoming major infrastructure constraints and challenges.

The first infrastructure challenge the Team needed to overcome was the ability to integrate and test the two flight test GBI assets. Leading up to a flight test, the GBI is processed by integrating the EKV Payload and three-stage booster, and executing a set of test cases to verify GBI health and functionality. The RMD

Flight Test Execution Team is responsible for developing and integrating all of the EKV Payload telemetry analysis software and tools, as well as supporting test case execution activities. The test cases are executed utilizing a test environment configuration that is customized to align with the GBI asset configuration. The FTG-11 Flight Test presented a new challenge because it was the first time two GBIs would be flight tested simultaneously. The two unique GBI assets had to simultaneously process through the integration and test flows typically allocated to process a single GBI. This challenge was driven by schedule constraints. To address this challenge, the RMD EKV Execution Team developed new modular analysis tools and test software logic, which was then integrated into the Boeing developed test station infrastructure, to enable testing both GBI configurations with one test environment configuration. This was a first for the Execution Team. The implementation of these changes allowed Boeing and RMD to process the two FTG-11 GBI assets efficiently. The RMD Team worked closely, under the direction of the Boeing Flight Test Team, to execute the test cases. The RMD Team analyzed all of the EKV Payload test data for both GBIs utilizing the newly developed tools and verified all test requirements passed. Lastly, the RMD Team performed the final EKV Payload tanking, arming and closeout operations in preparation for GBI emplacement by Boeing. This facilitated the Boeing Execution Team to meet both technical and schedule requirements in support of the FTG-11 Flight Test mission.

The second infrastructure challenge the Execution Team faced was the capability to handle the real time telemetry from both GBI test assets, simultaneously. As part of a standard flight test, the GBI test asset telemeters data to receiving support equipment, which collects, processes and displays the data for real time monitoring. The telemetered data is critical during flight test execution, as it provides the ability for the Execution Team to make imperative, real-time decisions and it provides the capability for the team to perform an initial assessment of mission success. Additionally, the telemetered data is displayed real time to contractor and government leadership for mission awareness. The ability to receive, process and display the flight test data real time is a highly critical capability and function that is required in order to execute a GBI flight test.

The FTG-11 Flight Test presented a unique challenge, having two GBIs simultaneously telemetering data to the receiving support equipment. This Flight Test required processing twice the amount of data collected and transferred through data links and support equipment designed to handle one data stream. Constraints such as data throughput, equipment processing limitations and dual-data display requirements drove the RMD Team to develop new innovative solutions for real time data handling. In order to overcome these constraints, the RMD EKV Flight Test Team had to reinvent the way flight data was processed and transferred between stations in order to fit twice the amount of data through a constraining data link. The Team developed new data processing algorithms that reduce the amount of data transferred through the data link but would still meet the real time data monitoring objectives. These updates and changes were provided to Boeing for integration into the System-level hardware and software architecture.

The data for both GBIs was reduced to a size suitable for the data link by utilizing new algorithms, transferred through the data link and then re-processed on the receiving side of the link in order to display the data parameters real time. The FTG-11 Flight Test could not have been executed without the development and implementation of new data handling techniques.

The partnership between Boeing and RMD in the development and integration of these solutions, in almost real-time by the Execution Team, enabled the success of the FTG-11 Flight Test, facilitating the ability to overcome program VUCA challenges.

**ORGANIZATIONAL BEST PRACTICES AND TEAM LEADERSHIP** *(Value: 40 pts)*
**Please respond to the following prompts:**

- *15 pts:* **In executing the program, what unique and innovative practices, tools and systems frame your program and help you achieve program excellence**?
- *15 pts:* **What unique and innovative processes and practices are you using to develop people and transfer knowledge and how do you know they are working?**
- *10 pts:* **What unique practices are you using to engage customers and how do you know?**
  *(12 pt. Times Roman)*

The mission criticality of the EKV Program drives the need to focus on Program Engineering, Production, Execution, Management and Leadership best practices and continual improvement. These best practices are found throughout the RMD EKV Team, whether developing the next software build, building a payload in the SSO Factory, providing field maintenance support or executing a flight test.

The complexity of key components of a weapon system such as EKV requires exceptional skills and knowledge but also uncompromising processing environments and capabilities. In the SSO Factory, amongst many of the capabilities, a few are worthy of mentioning such as National Institute of Standards and Technology (NIST) recognized traceable radiometric calibration chambers, cleanroom embedded environmental test, weight and center of gravity test capabilities, and a proprietary ultra-high purity/high pressure specialty gas delivery system. The SSO Factory has been crowned by the MDA as a "World Class Factory" for the precision calibration process and patented cleanroom concepts that position the end-product at a superior state. The SSO Factory culture is unmatched with its precise Foreign Object Debris (FOD), Electrostatic Discharge (ESD), and safety protocols instilling multi-layered protection approach for its people and hardware.

Program excellence requires unique and innovative program management practices. For the RMD EKV Team, this begins with a battle rhythm that is the heartbeat of the Program. This cadence establishes discipline in everything the Program Leadership Team does, establishes open communications, and enables rapid responses to the Customer. The EKV Leadership Team operates with a daily, weekly and monthly cadence, partnered with the Boeing and MDA EKV Customers, to status, review, and make decisions on critical aspects of the Program such as program priorities, Integrated Master Schedule (IMS), scope control, earned value, risk and opportunity (R&O) management, funding and contractual actions. At the Integrated Product Team Lead (IPTL) level there is a complete understanding of scope and budget, which when combined with the trust of the Program Leadership, provides the IPTL with the empowerment to collaborate directly with their Customer counterparts. This direct collaboration not only facilitates more rapid decision-making, but it enables the program to be more nimble in the changing of execution elements. The RMD EKV bi-weekly stand-up, which is attended by the Boeing and MDA EKV Customers and cross-functional leadership, allows the Joint Leadership Team to align program priorities and provide critical program direction. The true leadership involvement and engagement, across the RMD, Boeing, and MDA EKV leaders on the day-to-day detailed execution of the Program has instilled not only the program knowledge required for rapid decision making, but has built a foundation of trust and teamwork across this integrated team. This has demonstrated, to the broader organizations, the relationships the teams are expected to build with one another.

Through the Total Employee Engagement Team Suggestions Program, the SSO Factory has developed 3D Training Video capability in concert with the RMD Immersive Design Center, allowing training to occur in a 3D simulated environment, alleviating fears of making errors and reducing risk to hardware. This Program enables people development through expedited training experiences and repetitive skill enhancement. Critical processes are captured on digital media to preserve proprietary techniques and special skills to ensure

current and future capability remain viable. The "MDA Space Culture" that took years to develop is a unique and customer trusted behavior that results in optimal efficiency and excellent product quality.

Executing a GMD flight test requires both RMD cross-functional and Customer engagement, collaboration and partnership. These partnerships are essential in the formation of a unified team working towards the planning, execution and reporting of a major flight test event. A program's ability to enable the implementation of these partnerships is the single most important attribute directly influencing the success of a flight test mission. The success of the FTG-11 Flight Test, the largest and most complex GMD mission to date, depended on the solidification of these partnerships like never before. The RMD Team's expertise and support was critical throughout the FTG-11 Flight Test for the planning of the mission scenarios, selection of flight test hardware, assembly of the payloads, development of software capabilities, integration support of flight assets, flight test execution, analysis of the flight test data, and for the overarching management of the EKV Program. The FTG-11 flight test presented unique challenges that would not have been overcome without these key partnerships.

Across the Program Leadership Team, the Customer Engagement Program has paid dividends in fostering industry/customer relationships. This inclusion and transparency initiative is a collaborative effort between RMD, Boeing and the MDA to ensure genuine partnering through all aspects of execution. These partnerships have proven to be extremely effective in building trusting relationships and enabling the industry/government team to make effective, if challenging decisions, for this Nation critical Program. The Customers participate and have a voice during board reviews and the day-to-day activities, such as bi-weekly team meetings, monthly Program Management Reviews (PMRs), and Risk Review Boards. Specific to FTG-11, the industry/government EKV Team partnered in the decision making, analysis and preparation of materials for the various Readiness Reviews, presenting "one voice" to the Missile Defense community and the Director of MDA. The Customer stakeholders have repeatedly expressed their satisfaction on the candor and collaborative communications. The Customer is integrated with the RMD EKV Team, on site in Tucson, AZ, has access to the program technical databases and has full knowledge of all aspects of program execution. The RMD EKV Program Team's effectiveness and interaction with the Customer is rated on a monthly basis through a Customer quality scoring evaluation based upon established criteria.

The partnership and collaboration is found in many areas of the EKV Program, for example, in the disposition of technical risks prior to the FTG-11 Flight Test. This process required that the larger technical community (RMD, Boeing, MDA, and Aerospace Corporation) review the relevant data and concur on the statistical approach for assessment of each risk. Raytheon Missiles & Defense and Aerospace Corporation performed the analyses independently, with close collaboration between RMD and Aerospace Corporation engineers to resolve any differences. Ultimately, the risk assessments were provided to the MDA Director for final approval, with concurrence between the organizations providing the confidence necessary to execute the FTG-11 Flight Test.

A second example of exemplary Customer collaboration were the Technical Interchange Meetings (TIMs) that were established to review the development and testing of the software flown in FTG-11. These TIMs included technical and program management representatives from the Industry Team (Boeing, Northrop Grumman and RMD) and the MDA Customer. These focused on reviewing incremental design, integration and performance of each incremental software build and helped identify improvements in the mission scenario modeling as well as software design gaps before build completion. Until FTG-11, the Agile development/TIM process had not been implemented by the EKV Software Development Team. By leveraging Agile development practices, the EKV Software Development Team was able to insert an additional development Sprint. In each sprint the Software Development Team focused on short-term goals and could course correct their development activities, as needed. This approach allowed the Team to address

identified issues and conduct another TIM prior to software qualification. Through these proactive activities, the EKV Program was able to gain Customer confidence in the software leading into the FTG-11 Flight Test.

A third example in which collaboration between the RMD cross-functional team and partnership with Boeing and MDA SMEs was critical to the execution of the FTG-11 Flight Test was the disposition of an emerging flight test risk that had the potential of canceling the launch and/or impacting successful execution of launch activities. As the FTG-11 Flight Test date approached, the Operations Team in the SSO Factory identified an observation on a production asset that presented a potential risk to the FTG-11 Flight Test payloads and mission objectives. There was no way of determining whether the finding was also present in the Flight Test payloads because the units were already delivered to the field and were integrated into a higher level of assembly. Given this uncertainty, the RMD Team comprised of cross-functional personnel, as well as Boeing and MDA Customer counterparts, implemented a project to collect critical data, formulate a risk assessment and recommend a path forward for the FTG-11 Flight Test.

This Joint Team had to design and execute a unique qualification test series in an extremely short amount of time. The data collected from the test series was utilized to formulate a unified flight test recommendation that had the potential of affecting the flight test date. The only way this project could be completed in time to support the flight test date was for RMD, Boeing and MDA to collaborate as a unified team in the planning, execution and reporting of the test event. With the guidance of engineering requirements and customer input, the Operations Team assembled a production representative Unit Under Test (UUT) which was utilized in the test series. The RMD Engineering Team worked side by side with Boeing and MDA SMEs to develop test requirements. The RMD Engineering Team designed and fabricated test equipment required for the test series. Boeing and MDA SMEs, along with Leadership, participated in all informal and formal reviews leading up to this testing, including being Test Readiness Review (TRR) panel members, ensuring their integration and enabling their continued influence and co-ownership of this activity.

During test execution, the Operations and Engineering Teams worked around the clock to ensure the test completion within the schedule constraints, as both areas of expertise were critical for the test execution and UUT reconfigurations. As the Test Team encountered observations or roadblock during test execution, they consistently relied on RMD, Boeing, and MDA team members to assess the findings and determine a path forward. From planning to execution and reporting of the test series, the joint RMD/Boeing/MDA Team remained engaged and exemplified the “One Team” approach. The test series completed on time and, most importantly, enabled the Team to capture the data and knowledge necessary to assess the risk to the FTG-11 Flight Test, with a recommendation to proceed with this historic test event. The joint industry/government team engagement, collaboration and partnership was the key reason for this success.