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.

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Thank you for participating,

G H Hamilton

Gregory Hamilton
President
Aviation Week Network

Acknowledged, agreed, and submitted by

Daniel T Dyring — May 30, 2023
Nominee's Signature — Date

Nominee's Name (please print): Daniel T. Dyring

Title (please print): Program Director

Company (please print): Raytheon Missiles & Defense (RMD)

NOMINATION FORM

Name of Program: SDPE Air Base Air Defense Experiment

Name of Program Leader: Daniel T. Dyring

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☒ Customer Approved

- Date: May 4, 2023
- Customer Contact (name/title/organization/phone): Bryan Ripple / Media Lead / AFRL Public Affairs / 937.469.1728

☒ Supplier Approved (if named in this nomination form)

- Date: May 30, 2023
- Supplier Contact (name/title/organization/phone): Trond Inge Olsen / Director / KDA / 571.363.8052

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

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?

[LIMIT YOUR NARRATIVE TO THIS PAGE.]

The US Air Force (USAF) Strategic Development, Planning, and Experimentation (SDPE) Air Base Air Defense (ABAD) Experiment Trident Elding 2022 (TE22) informs strategic investment decisions through evaluation of low-cost, high technology readiness level (TRL) capabilities that could provide near term ABAD capability for USAF. US air bases outside the continental United States currently have no air and cruise missile defense capability and are therefore vulnerable to adversary attack of platforms and infrastructure on the ground.

Raytheon Missiles & Defense (RMD) and Kongsberg Defense & Aerospace (KDA), in partnership with United States Air Force (USAF) Strategic Development Planning & Experimentation (SDPE), and in collaboration with the Norwegian Government, conducted a first-of-its-kind air defense demonstration, integrating National Advanced Surface-to-Air Missile System (NASAMS™) with AIM-9X® Sidewinder®, AIM-120 AMRAAM®, AMRAAM-ER, U.S. Army AN/MPQ-64 Sentinel radars, and the BattleSpace Command and Control Center (BC3).

The joint Raytheon, Kongsberg, and United State Government (USG) team executed against a short, dynamic schedule to prove ready-now capability to USAF through a novel approach of blending programmatic and technical metric management. The execution of this effort was accomplished through collaboration across three services within the US military – US Navy, US Army, US Air Force – and across two contintents – US and Europe – to meet the challenge.

The Raytheon-led team architected, integrated, tested, and shipped OCONUS to a Norwegian range via military airlift, and executed the demonstration within nine (9) months. The team established an integrated master schedule and a weekly cadence assessing progress, risks, mitigations, and opportunities. The team conducted multiple demonstration planning conferences and held monthly technical executive communication meetings.

“We demonstrated how integrated defense solutions enable the warfighter to deploy the right effector at the right time and at the right target,” said Wes Kremer, president of Raytheon Missiles & Defense. “Using fielded systems, our goal is to provide customers the quickest, most effective way to protect their people and critical infrastructure with layered cruise missile defense.”

The team collaborated on a list of “firsts” for this effort, i.e. a list of capabilities, software, hardware, and concepts that would be executed for the first time during the SDPE ABAD TE22 Experiment. Due to the dynamic schedule and the maturity of the systems involved, this program implemented a “Form of Firsts” tracking as a technical metric to work towards the capstone flight test event. This was a novel way to manage areas with the potential for technical risk with a metric-based approach.

Throughout execution of the USAF SDPE ABAD Experiment Program, the RMD/KDA team learned to collaborate with, plan and execute a joint exercise across the Air Force, Army and Navy. The multi-disciplined and cross-functional team from multiple Raytheon Mission Areas quickly learned the criticality of effective and consistent communication, risk management and effective planning.

DIRECTIONS

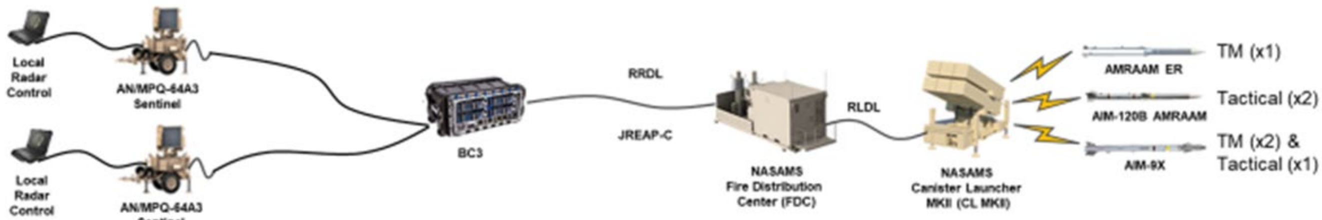
- **Do not exceed 10 pages in responding to the following four descriptions**.
  - Allocate these 10 pages as you deem appropriate, but it is important that you respond to all four sections.
- DO NOT REMOVE THE GUIDANCE PROVIDED FOR EACH SECTION.
- Use 12 pt. Times Roman typeface throughout.
- Include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

VALUE CREATION
Value: 15 points

Please respond to the following prompt:

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

Raytheon Missiles & Defense is the world's leading defense integrator. We bring together the best minds, systems and capabilities across domains to create next-level solutions that are smarter, faster and better than previously possible. Together, we break through traditional defense industry boundaries, combining the very best of our capabilities, systems and ourselves to help our customers achieve their missions and return home safely.



This program presented exceptional challenges from the beginning, including an aggressive 9-month schedule and changing customer requirements. Successfully demonstrating several live fires is proving to be incredibly valuable to the corporation. Throughout execution of the SDPE ABAD Experiment Program, the RMD/KDA team demonstrated the ability to collaborate on, plan and execute a joint exercise across the Air Force, Army and Navy. The multi-disciplined and cross-functional team from multiple Mission Areas demonstrated its ability to effectively and consistently communicate risk management, planning, and execution.

Effective communication came in numerous forms. Initially, the RMD team established internal company collaboration via Executive Communication (EXCOM) engagements with multiple Mission Area Presidents and the Chief Engineering VP to keep them informed and gain support when help was needed to overcome roadblocks. Additionally, the RMD/KDA team quickly established a cadence of communication with the USAF customer and foreign partners that proved to be critical. Due to the aggressive schedule, coupled with numerous unexpected challenges, weekly engagements with the customer allowed for out-of-the-box collaboration to mitigate risks, as well as increase the customer's confidence in the RMD team.

Demonstrating the RMD/KDA team's ability to provide an integrated, mission-focused System of Systems to our customers is invaluable to both RTX and KDA's future.

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

The experiment assessed the operational utility of the next generation NASAMS, which is capable of firing three missile variants, while integrated with operationally fielded USAF command and control (C2) capability. US Army AN/MPQ-64 A3 Sentinel radars provided the tracks the USAF C2, which enabled threat evaluation and weapon assignment recommendations to the NASAMS Fire Distribution Center (FDC). The FDC operator then closed the kill chain by selecting the most appropriate missile and executed the live fire engagements. The experiment proved that NASAMS is a robust, reliable, and ready-now GBAD system could quickly be adoped by USAF for Air Base Air Defense and Critical Infrastructure Protection. Jim Simonds, SDPE ABAD Experimentation program manager, U.S. Air Force, summarized the value by saying "Our intent was to inform strategic investment decisions through the evaluation of low-cost, high-technology readiness level capabilities that could provide near-term air base air defense capability. This layered defense solution can provide immediate defensive capability at a fraction of the price of currently fielded systems."

Trident Elding demonstrated key customer objectives:

- Integrate an AF Command and Control (C2) system into NASAMS kill chain to composite external sensors and provide quality radar tracks to FDC
- Evaluate layered defense capability to engage multiple targets using a variety of effector options

The multi-missile configuration expands upon current NASAMS single missile capability by adding cost-per-shot options, engagement envelope expansion, and seeker capability diversity. The SDPE ABAD Experiment successfully integrated USAF C2 and defeated small raids of cruise missile surrogate targets with the multi-missile NASAMS configuration. Trident Elding demonstrated that a layered defense solution will provide immediate defensive capability for USAF critical infrastructure.

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

The opportunity for team members to work across a complex, system of systems program and across all mission areas within RMD was tremendous. The USAF SDPE-layered defense experiment contract was awarded to the Raytheon Naval Power (NP) Mission Area due to the ongoing integration of AIM-9X, a missile acquired exclusively by the Navy for all users, into NASAMS through other contracts. The Air Power (AP) Mission Area provides the AMRAAM, a missile acquired exclusively by the US Air Force for all users, and is also leading development of the AMRAAM-ER. Land Warfare and Air Defense (LW&AD) provides core components of NASAMS, a medium-range ground-based air defense system, to include computers and SW modules and the Sentinel A3 radar. LW&AD also holds the relationship with KDA, a Norwegian defense company that produces additional core components of NASAMS, such as the Canister Launcher, known as the MK II, and the FDC. Strategic Missiles and Defense (SMD) provides the BC3, a C2 system that is in use by multiple US Air Force bases to provide a common air picture. In addition, contributing organizations to the USAF SDPE ABAD Experiment included US Air Forces Europe (USAFE), US Transportation Command Military Air (TRANSCOM), US Army Program Executive Office (PEO) Missiles and Space, the Norwegian Ministry of Defence, and the Royal Norwegian Air Force.

Every member of the joint team gained invaluable technical, programmatic and leadership experience through defining the architecture, designing the experiment and conducting integration through the challenge of ever-changing requirements with limited hardware availability.

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

US airbases inside and outside the continental United States currently have no air and cruise missile defense capability. This ABAD Experiment demonstrated a modular short and medium range layered defense capability that could be integrated immediately with existing air base command and control and improved rapidly to address a changing threat environment. Air and cruise missile defense of air bases is critical to ensure US and allied cability to flow forces as necessary. Ground-based air and cruise missile defense of an air base also enables fighter platforms that might be performing own base, and nearby base, defensive counter air for cruise missile defense to also project air power forward.

The demonstration was witnessed by representatives from foreign countries including Taiwan and Ukraine. Shortly after the demonstration was complete, it was announced by the US government that NASAMS, integrated with AMRAAM, would be provided to Ukraine. Since deployment to Ukraine, NASAMS has been touted as an extremely successful air defense system that is ready now to defend air bases.

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**

The program and technical leadership for SDPE ABAD TE22 established a technical baseline for the experiment and conducted a technical baseline maturity assessment (TBMA) as part of the early work leading up to contract award. The TBMA revealed potential areas of risk to the effort based on the maturity of the architecture. Risks mitigations were identified through a series of internal Raytheon gates, as shown in the TBMA figure.

Firsts are generally identified early on in an effort like this in order to determine areas that are the most likely source of technical risk. Due to the dynamic schedule and the maturity of the systems involved, this program implemented a “Form of Firsts” tracking as a technical metric to work towards the capstone flight test event. This was a novel way to manage areas with the potential for technical risk with a metric-based approach.

Firsts burndown was treated similar to a Knowledge Point Plan or Knowledge Management plan, where milestones on a program can be partially developed based on knowledge that needs to be gained throughout development. Firsts and their burndown were briefed regularly to RMD technical leadership and the USG as a metric to show technical progress throughout the effort.

Technical Baseline Maturity Assessment (TBMA) Customer Mission & CONOPS Understanding				
Maturity Artifact(s)	**Gate 0/1 Artifact(s)**	**Gate 2 Artifact(s)**	**Gate 3 Artifact(s)**	**Gate 4 Artifact(s)**
Customer Mission & Mission Environment Comprehension	Initial	Updated	Final	**Final**
Customer Mission Drivers (Red vs. Blue Fight) Knowledge	Initial	Updated	Final	**Final**
Customer's Value Proposition (Key Discriminators) Insights	Initial	Updated	Final	**Final**
Customer Mission Drivers Translated Into MoP/MoE	Concept	Initial	Confirmed	**Final**
Defined M&S Strategy Employment CONOPS	Concept	Initial	Updated	**Final**
Solution Architecture				
Maturity Artifact(s)	**Gate 0/1 Artifact(s)**	**Gate 2 Artifact(s)**	**Gate 3 Artifact(s)**	**Gate 4 Artifact(s)**
System Drivers are Identified and Documented	None	Initial	Draft	**Final**
Enterprise Understanding is Sufficient (REAP Activity I)	None	Draft	Final	**Deltas Captured**
Architecture Planning is Sufficient (REAP Activity II)	None	Draft	Final	**Deltas Captured**
Mission Architecting is Sufficient (REAP Activity III)	None	None	Final	**Deltas Captured**
Technical Architecture is Sufficient (REAP Activity IV)	None	None	Draft	**Final**
Analysis Supports Gate Review Objectives (i.e. Decision)	None	Draft	Final	**Deltas Captured**
Technical Baseline				
Maturity Artifact(s)	**Gate 0/1 Artifact(s)**	**Gate 2 Artifact(s)**	**Gate 3 Artifact(s)**	**Gate 4 Artifact(s)**
Technical Baseline is defined at a level of completeness / maturity that it can be bid	None	Concept	Final	**Deltas Captured**
Technical Baseline meets the customer key mission needs and requirements	None	Concept	Final	**Deltas Captured**
Leveraged design reuse and IRAD need dates, requirements, and handoffs are partnered	None	Identified	Final	**Deltas Captured**
Proposed solution is within the customer's acceptable price range	None	Initial	Draft	**Final**
Technical risk of the proposed solution has been characterized	None	Initial	Draft	**Final**

#	First	Risk	Steps
14	AIM-9X telemetry at ASD First collection of AIM-9X telemetry at ASD	1) None	1) Lessons learned from AMRAAM-ER 2) Follow the ER example of TM data collection / transmission, PMA-259 has signed off on the 9X plan to date a) TM will be captured and monitored real-time during the flight test b) TM will only be available post-launch (no pre-launch on-the-rail TM available) c) Data will be stored on HDDs and transported by USAF to be evaluated in Tucson after the flight 3) PMA-259 Attended Mid-Planning Conference (MPC) at ASD, 22 April 4) All TM weapons verify comms prior to launch during cold pass / TM check
15	AMRAAM TM c-band transponder First use of transponder to cue the Monopulse 774 missile tracking radar at ASD	1) Tracking a high speed, maneuvering target	1) Transponder information provided to ASD range (complete, March 2022) 2) Additional transponder plan to test with handheld transponder developed a) Confirmed availability of the ASD range to conduct test (complete, April 2022) b) All required authorizations received; team prepared to depart c) Transponder test at ASD, (Complete 20 May) i. Monopulse 774 Tracking radar blind range determined ii. Moving target (Avis rental car) tracked successfully iii. New radar site has been selected following integration test 3) Pre-flight checkouts will be conducted once ER missile and radar are on-site, ECD 19 August

Examples of firsts are shown in the above table. Note some of the mitigations that went into firsts were not necessarily technical in nature; rather, some steps taken on planning, or arrangements made with the government, allowed the team to make progress towards burning down risk.

#	Description	Pelham + ROF	M&S / Analysis	ASD Walk-Up		ASD LFX 1v1	ASD LFX 2v2, 3v3
1	SDPE 3-on-3 Engagement	Partial	Full	Full			Full
2	3-Missile NASAMS configuration	Full	Full	Full			Full
3	AIM-9X, AMRAAM, & AMRAAM-ER launch from single NASAMS CL MKII	Partial	Partial	Partial		Partial	Full
4	Interface between Sentinel A3 and BC3	Full		Full			Full
5	"Virtual Radar" RRDL interface between BC3 to FDC	Full		Full			Full
6	BC3 to provide Fire Direction to FDC	Full		Full			Full
7	WEZ to recommend engagement solution for AMRAAM-ER, AMRAAM, and AIM-9X	Full		Full			Full
8	Supplying uplinks to in-flight missiles simultaneously using Zenith element	Partial	Full				Full
9	Sentinel A3 radar as track source for AIM-9X	Partial	Partial	Full			Full
10	AIM-9X OFS 9.15X live fire from NASAMS	Partial				Full	Full
11	AIM-9X launch from NASAMS with missile uplinks in flight	Partial	Full			Full	Full
12	AMRAAM-ER to demonstrate end-game performance		Partial				Full
13	Airbus DoDT45 target for Sentinel A3 and AIM-9X	Partial	Partial	Full		Full	Full
14	AMRAAM TM c-band transponder to cue the Monopulse 774 missile tracking radar at ASD	Partial		Partial			Full

The table above shows the firsts associated with this effort as well as where they were mitigated. Pelham Radar Operations Facility (ROF) events refer to integration testing that took place at the Raytheon facility in Pelham, NH and the ROF at Redstone, AL.

Communication was one of the driving factors towards success. The integrated master schedule was reviewed at least weekly with the execution team and USG stakeholders. The general communication plan is described below:

- Due to the geographically dispersed team, the first call to action was to develop a SDPE org chart that included IPTLs from each Mission Area that participated in the SDPE effort along with their respective Mission Area Chief Engineer. In addition to Mission Area IPTLs, a SDPE Chief Engineer, SDPE Lead Systems Engineer, SDPE Systems of Systems IPTL, dedicated SDPE Supply Chain POC and SDPE Global Trade POC were assigned. This organization was established to ensure accountability across each discipline/Mission Area.
- Developed and executed a communications plan to establish a forum for technical discussion, risk assessment, status and collaboration amongst entire SDPE team:
    - Quarterly Technical Interchanage Meeting (TIM) with SDPE customer, the RMD/KDA team, and the US Army
    - Weekly cross Mission Area Integrated Product Team Lead (IPTL) meetings
    - Weekly RMD/KDA Program Management (PM)/SDPE meetings
    - Weekly RMD/KDA team meetings
    - Weekly logistics/global trade meetings
    - Monthly meetings with Engineering Leadership
    - Monthly Risk and Opportunity Review
    - Monthly Program Financial Review
    - Three planning conferences throughout PoP

- PM meetings with the Raytheon SDPE Chief Engineer and each Mission Area IPTL held each month addressed cost/schedule concerns and offered an open door to discuss current status/risk/path forward and mitigations.

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

The Raytheon program leadership team utilized executive communication (EXCOM) forums to flow challenges and help needed to the Mission Area presidents. Engagements were conducted early in the pre-contract planning phase and resulted in valuable independent reviews of the architecture, such as the Technical Baseline Maturity Assessment (TBMA).

Additionally, technical progress in the form of firsts burndown was briefed on a bi-weekly to weekly basis to the RMD Chief Engineer and technical leadership team. As the execution team approached major milestones, engineering leadership would be prepared to support the team with all challenges and details of execution.

The industry-led team implemented an approach typically used by US DOD for large exercises in the establishment of planning conferences for the capstone TE22 exercise. The conferences were attended by USAF, USN, US Army, Royal Norwegian Air Force (RNoAF), Norway Ministry of Defense (Nor MOD), Norway Defence Logistics Organisation (NDLO), Andøya Space Defence (ASD), Airbus, and led by the RMD/KDA team.

Initial, Mid, and Final Planning Conferences were held with all stakeholders and used to assess preparedness for the live fire. The Initial and Mid Planning Conferences were held in Norway at Kongsberg and Andøya Space Defence, respectively. The Final Planning Conference was held at Raytheon in Tewksbury, MA. Planning milestones related to experiment execution were established as part of the objectives for each Planning Conference. The milestones along with actions were reviewed by the joint teams in order to determine readiness to move to the next step. Implementation of planning conferences resulted in a significant increase in communication for RMD/KDA and the experiment was executed flawlessly by the ASD range and the entire team as a result. The planning conference methodology has since been adopted by follow-on efforts as a best practice.

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

Prior to developing the SDPE ABAD Experiment proposal, the RMD team hosted a Technical Interchange Meeting (TIM) with the USAF SDPE customer. The purpose of the TIM was for the customer to define their objective, which was to demonstrate layered defense capability. During the TIM which was a collaboration between RMD and USAF SDPE, the team developed a System of Systems architecture designed to meet the customer's objectives while recognizing the schedule constraints. As a result, KDA was quickly identified as a key supplier due to their expertise with the NASAMS. Additionally, Andøya Space Center (ASD) was identified as a critical supplier of resources (personnel, targets, material) and the test range where the live fires were to be conducted.

KDA designated a highly experienced Point of Contact (POC) that was dedicated to support the SDPE ABAD Experiment Program. The KDA POC brought years of NASAMS test experience, SMEs from within the KDA NASAMS team and lessons learned from conducting tests at ASD. KDA developed key components of the NASAMS to include the FDC display which consists of the Threat Evaluation Weapon Assignment (TEWA). TEWA was a critical component of the NASAMS operation that SDPE and USAFE funded to have US operators trained on. One of the critical risk mitigation strategies that KDA contributed was making an AN/MPQ-64F1 Sentinel radar available at ASD during the live fire as backup. Incidentally, due to some unexpected issues with a GFE Sentinel A3 and range time slipping away, the F1 radar proved to be a game changer, allowing the experiment to proceed as planned. The KDA POC assigned to the SDPE effort has a strong relationship with the Norwegian MOD which was the pivotal piece to securing the F1 as a backup resource to this engagement.

"This experiment demonstrates NASAMS' flexibility, providing the operator with enhanced firing alternatives to successfully execute complex threat scenarios employing a range of missiles," said Eirik Lie, president of Kongsberg Defence & Aerospace. Solipsys, a Raytheon wholly owned subsidiary, was subcontracted to develop Command and Control (C2) software, support integration through the live fire events. Solipsys provided tremendous expertise from previous experience working across different military branches within the C2 arena.

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.)**

Unique VUCA was encountered by the team daily due to the dependency on multiple organizations, internal and external to Raytheon, each with differing priorities, agendas and organizational goals. The team needed to achieve and maintain constant alignment amongst all to provide the hardware, software and expertise needed to create and demonstrate a layered air and cruise missile defense system before expiration of range time in mid-September 2022.

Unique volatility, uncertainty, complexity, and ambiguity encountered by the team included availability of US government furnished information, assets, and personnel. Initially, the SDPE experiment architecture included multiple additional communication protocols and link capability dependent on ongoing development in Air Force Research Laboratory (AFRL). The development status of these capabilities led to configuration uncertainty and ambiguity. The complexity of architectural changes necessary, depending on whether the government furnished the delivery occurred, or not, threatened the ability of the team to meet the schedule.

Among the many US government assets required to support the experiment were two Sentinel A3 radars. AFRL SDPE reached out to the Army and commitment was made to support AFRL SDPE with the radars and personnel necessary to operate them. However, subsequently other Army priorities resulted in late deliveries and test event relocations. The uncertainty of when, what events, and where the Army could support with radars, personnel, documentation, and analysis of results led to multiple complex test event and system architecture changes resulting in delayed data analysis and go forward decisions that needed to be made throughout the process of preparing for the experiment.

Obtaining safety releases to allow USAF personnel to operate the system during the experiment is a unique uncertainty driven by operation of a kinetic weapon system. Late in the schedule it was determined by the USAF and the NNMSB (non-nuclear munitions safety board) that no safety release precedents existed as NASAMS is not a USG Program of Record and therefore, no USAF personnel were allowed to operate it during the Live Fire.

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

The team successfully managed unique VUCA challenges by documenting firsts, identifying the associated risks, developing plans "right-sized" to be able to implement as late in the schedule as possible while still meeting the objectives of the experiment, and communcating frequently with the customer, and internally to Raytheon executive leadership. Mitigation plans were triggered at the appropriate time during the many and frequent reviews and planning sessions. The team's regular meetings with Raytheon senior technical leadership helped ensure resources were available to execute mitigations.

The AFRL communication protocol was unable to be provided when needed. The team executed a mitigation activity to updated the architecture and implemented a new and different interface to overcome this challenge. Close coordination with Solipsys in advance ensured resources were available to execute this mitigation plan and frequent communication with the AFRL development activity enabled the team to properly trigger the mitigation and meet the schedule.

The Army radars were delivered much later than originally planned. Only one radar was provided when the plan called for two, and no radar was available for one of the test events planned. The team partnered with Johns Hopkins Applied Physics Laboratory (APL) to develop a software based radar surrogate, calibrated the surrogate at the Army facility in Huntsville, Alabama, and utilized the surrogate to stand in for the Sentinels at various test events. This approach greatly reduced the uncertainty of results for when the actual radars became available. To mitigate the possible loss of radar support altogether the team leveraged the fact that Raytheon is the Sentinel A3 supplier and participates in program management reviews with the Army. The SDPE team, both AFRL and Raytheon, had communicated the SDPE experiment radar plans and requirements Raytheon and Army wide. Due to this the Sentinel Raytheon/Army PMR team was aware of the need to prioritize radar availability for SDPE. A Raytheon Sentinel team member established a Program Management Review (PMR) agenda item for the SDPE radar need real time and communicated this time slot to the Raytheon SDPE team. As a result, that same day, during the Sentinel PMR, the SDPE team was able to participate in a real time prioritization discussion with Army Sentinel Radar Program leadership and a plan to deliver and support SDPE with radars was established and met by the Army.

Although the USAF and the Non Nuclear Munitions Safety Board (NNMSB) declined safety releases for USAF personnel to operate the system an alternative to actual USAF Live Fire operation was implemented. Several people in the USAF with differing backgrounds were identified to attend a NASAMS operator training program at Kongsberg, in Norway, prior to the experiment. They were then included in tracking events prior to the live fire to execute simulated engagements against the targets during the practice flights of the actual targets. This provided invaluable feedback to USAF on the skill sets necessary to be able to operate the system successfully in the field and on the useability and maturity of the system for Air Base Air Defense.

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 yestrday'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?**

As part of their experimentation programs, USAF SDPE derived a list of Desired Learning Objectives (DLOs) for USAF Air Base Air Defense and are described in the table below. The foundation of the DLOs was the Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities and Policy (DOTmLPF-P). Trident Elding was conceved by SDPE as an experiment to demonstrate the ability of a ready now system to satisfy the required DLOs. The experiment showed that NASAMS, in the USAF architecture, met nearly all of the DLOs that USAF SDPE established for evaluating kinetic base defense solutions. Measures of success (MoS) were derived from the DLOs, which ensured program success was tied to the customer's objectives, while ensuring critical dependencies were established.

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

Post analysis assessment concluded that all three objectives were met over the course of the experiment. Some objectives were technically met prior to deployment and were re-demonstrated at the live fire. The objectives again proved that NASAMS could be integrated to operationally relevant USAF C2 and sensors, provides layered defense and is ready to deploy to air bases once adopted.

DLO #	DLO Description
1	Determine the technical performance and suitability requirements for Counter-Cruise Missile (c-CM) System of Systems (SoS), including sensors, Kinetic Energy (KE) weapons, and BMC2 systems to provide a layered base defense architecture for relevant AOR scenarios
2	Identify environmental impacts on the effectiveness of Counter-CM base defense system of systems (SoS), the sensor, weapon, data handling, and BMC2 systems - and how these systems are used – to benchmark M&S and determine how to minimize these impacts for environmental extremes
3a	Identify sensor and Battle Management / C2 requirements and techniques to rapidly acquire and address threats in relevant scenarios for specific AORs (cities, bases, FOBs, etc.) and for potential variations in adversary capabilities, counter-measures, or tactics
3b	Identify most effective/versatile existing and near-term sensor options to achieve this objective
3c	Identify Battle Management / C2 system requirements to expedite engagements, with earlier detection, reliable and accurate tracking, rapid prioritization of targets, and reduced numbers of required operators, potentially employing enhanced Common Operational Picture visualization and tactical decision aids
4	Using M&S to augment the field experiments, determine which existing CM or other threat systems can be successfully engaged by current and proposed Counter-CM SoS and identify those threats that may require more advanced Counter-CM capabilities or different mitigation strategies
5a	Identify any adverse impacts/limitations of integrating potential elements of the Counter-CM SoS (sensors, weapons, and BMC2) with current operations at relevant locations in AOR
5b	Identify CONOPS/CONEMP, training, doctrine, manpower, legal, cyber, and policy issues associated with integrating potential elements of the Counter-CM SoSs (sensors, weapons, and BMC2) into existing Air Force, Joint, and Allied Force structures in AOR
6	Identify life cycle management, field support, and maintenance requirements for elements of the Counter-CM SoS (sensors, weapons, and BMC2)
7	Identify any policy, legal, cyber, or safety issues (collateral hazards/damage, fratricide, regional risks, etc.) associated with specific KE weapons for Cruise Missile defense, and determine how to best inform/influence any required actions and requirements for future C-CM systems
8	Identify any emplacement requirements and / or CSE/PSE tools (Common Support Equipment and Peculiar Support Equipment) needed to enable the Counter-CM sensor, weapon, and BMC2 systems to transition to operational use and minimize the logistics footprint and life cycle management considerations
9a	Determine how to optimize Human System Integration (HSI) effectiveness for the Counter-CM sensor, weapon, and BMC2 systems, and for the overall SoS, potentially by employing more user-friendly operating systems, enhanced COP visualization, and tactical decision aids
9b	Identify specialized skill sets and training requirements for system operators and efficient and versatile tactical operations procedures for Counter-CM sensor, weapon,, and BMC2 systems
10	Recommend potential technology enhancements or innovative CONOPS/TTPs to use existing technologies/systems, that will be needed for current blue Counter-CM sensor, weapon, or BMC2 systems to be able to defeat adversary CMs.

Objective No.	Customer Objective	Meas No.	Measure of Success	Objective First Demonstrated	Completed
1	Demonstrate BC3 capability to receive track data and provide to NASAMS FDC	1-1	BC3 Interface initializes with Sentinel A3 radar with A/B kit interface	Radar Operations Facility (ROF)	
		1-2	BC3 receives measurement level radar data from Sentinel radar via A/B kit interface, forms composite tracks and displays track data	ROF	
		1-3	FDC receives and displays track data from BC3 via V-RRDL interface	Pelham	

2	Demonstrate NASAMS FDC Threat Engagement and Weapon Assignment (TEWA) for a 3-missile type (AIM-9X, AMRAAM, AMRAAM-ER) configuration	2-1	FDC able to conduct engagements with all three effectors	Pelham	
		2-2	FDC generates a list of threat evaluations in order of priority	Pelham	
		2-3	FDC assigns a launcher/missile pair and updates target information through launch	Pelham	
3	Demonstrate layered defense capability of BC3, and 3-Missile type NASAMS to launch AIM-9X, AMRAAM, and AMRAAM-ER with sufficient cue for the missiles to guide towards target	3-1	Radar quality data provided to FDC, ie, accurate enough to allow effector to launch	Pelham	
		3-2	3-on-3 engagement executed in one scenario, with AMRAAM-ER, AMRAAM, and AIM-9X launched	Andøya	
		3-3	All effector uplink messages will be consistent with assigned targets	Andøya	

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

Deriving the measures of success was a critical first step to ensure the team had measureable milestones/objectives throughout each phase of the Program. Once the MoS was established, the team was able to develop an Integrated Master Schedule (IMS) that created the insight into, and enabled tracking, the critical paths to each major Program gate (Modeling & Simulation, C2 development, Pelham Integration, Live Fire Support and Data Review).

Monthly Risk & Opportunity Management Boards (ROMB) were held where risk mitigation plans were statused. The monthly engagement provided another venue for collaboration across all Mission Areas that supported the program. The purpose of the ROMB was to identify technical and programmatic risks that could have cost or schedule impact to the program. Risks identified throughout the ROMB process prompted program management to allocate management reserve in the event the risk was realized. Risk mitigation plans were statused during each ROMB to program management with the intent of trying to reduce the probability of the risk being realized.

Opportunities for collaboration and assessment of progress to achieving metrics were maximized by planning and executing three planning conferences and two Technical Interface Meetings (TIMs) throughout the Period of Performance (PoP). During the initial planning conference the team developed a program level action item list. The action item list was created to ensure that critical actions from each organization were documented with completion dates. Progress to mitigate risk of "firsts" and actions to demonstrate the measures of effectiveness, were all reviewed for necessary action items and updated accordingly, with all stakeholders participating including the customer, RMD, KDA and ASD, during each planning conference. Multiple planning conferences, held at least once each in the test and experimentation venues planned, together with a risk of firsts approach to demonstrate measures of effectiveness, ensured all stakeholders were aligned to the metrics and the actions necessary to demonstrate all DLOs on the timeline required to perform the experiment.