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Acknowledged, agreed, and submitted by

Nominee's Signature ______________________ 31 May 2022
Date

Nominee's Name (please print): Michael J Molohon

Title (please print): Senior Principal, Program Management

Company (please print): L3Harris

NOMINATION FORM

Name of Program: Advanced Low Cost Munitions Ordnance (ALaMO)

Name of Program Leader: Michael Molohon

Phone Number: 972-359-2358

Email: michael.molohon@l3harris.com

Postal Address: L3Harris, 6900 Avenue K, Plano, TX 75034

☒ Customer Approved

- Date: 27 May 2022 ______________________________

Contact (name/title/organization/phone): Rory O'Connor / Director, Office of Corporate Communication / Naval Sea Systems Command / 202-781-2975

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

EXECUTIVE SUMMARY: Make the Case for Excellence *(Value: 10 pts)*
What is the vision for this program/project? What unique characteristics and properties qualify this program for consideration?
(12 pt. Times New Roman) LIMIT YOUR NARRATIVE TO THIS PAGE.

The vision of the ALaMO program is to provide the U.S. Navy with a new capability to defeat threats of asymmetric swarming small boats and unmanned aircraft systems (UASs). ALaMO solves a key Anti-Surface Warfare mission problem statement to eliminate the swarm prior to the threats reaching their effective weapon range. The ALaMO Integrated Product Team (IPT) combined the unique abilities of L3Harris to develop a compact, accurate but highly survivable and affordable radar solution leveraging the experience of NSWCDD in developing, testing and qualifying Navy munitions. This partnership was guided by the leadership of Integrated Warfare Systems (IWS) as the Program Executive Office.

L3Harris's creative approach to the ALaMO program delivers a unique set of enabling capabilities: 1) a thermal battery that is activated at launch, 2) a radar sensor that can track multiple targets in angle, range, and range rate, 3) a divert section that releases masses in one rotation to eliminate weapon system errors, and 4) guidance integrated fuzing to fuze the warhead. In addition to these capabilities, the L3Harris program team had to ensure the survivability of these unique technical capabilities during the harsh gun launch environment.


ALaMO Guided Projectile

The U.S. Navy is receiving production ALaMO cartridges today because of the L3Harris engineering team's focus on key development drivers. First, ALaMO had to be designed to **SURVIVE** the very harsh gun environment that has significant acceleration, base pressure and projectile spin rates.

Second, engineering needed to **SIMULATE** performance to reduce development cycle time. Extensive high-fidelity simulations were developed for guidance algorithms, lethality assessment, and gun survivability. This model-based systems engineering method, an early example of Knowledge-Based
Product Development, together with a disciplined Failure Review Board process enabled the growth of a learning organization that rapidly and successfully progressed the design.

Third, the L3Harris program team worked as a **PARTNER** with the U.S. Navy to leverage existing Test & Evaluation and range telemetry capabilities at NSWCDD. This customer partnership reduced the total development cost, development time and test cycle time. It also provided value to the customer as the prior 57mm round was a non-developmental item without a government-owned technical data package. The close collaboration of the U.S. Navy Dahlgren team with L3Harris during development enabled the government to own the final technical data package, providing it increased flexibility in procurement.

Finally, a low Size, Weight, Power and Cost **(SWAP-C)** radar that could detect small boats and provide adequate measurements for guidance had to be developed. The joint contractor – government engineering team traded dBs of performance for dollars of cost. Cost of the ALaMO cartridge is a Key Performance Parameter and a focus of the engineering development. The ALaMO program promoted heavy use of Commercial Off the Shelf electronic components within the design, with only one custom part resident in the entire solution. Design for Manufacturability and Reliability principles were center stage early in the implementation, with the bulk of the Preliminary Design Review to Critical Design Review evolution driven by affordability trade studies.

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.

VALUE CREATION *(Value: 15 pts)*
Please respond to the following prompt:

- Clearly define the value of this program/project for the corporation
- 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)

Program Value to Corporation Beyond Profit and Revenue

The L3Harris Precision Engagement Systems Sector has a key organization goal to accelerate innovation and demonstrate its competency in advanced missile systems tactical design. Critical to achieving these goals is to mature the organization's capabilities in digital engineering and model-based systems engineering using knowledge-based product development to create solutions utilizing open system architectures. The ALaMO program enabled each of these capabilities to be matured. With this maturity came success in other innovative weapon system designs as the learnings of the ALaMO program team spread throughout the L3Harris division, a key innovation incubator within L3Harris.

Program Value to the United States Navy

L3Harris has defined its purpose, in part, to 'serve our customers with technology solutions that protect our nation…' This service-oriented culture enabled the close collaboration between the L3Harris design team, the Naval Surface Warfare Center intermediate caliber weapons subject matter experts, and the Integrated Warfare Systems program office. This collaboration resulted in a completely new capability for the U.S. Surface Navy – the first guided projectile with a Hit-to-Kill capability. The government ownership of the technical data package provides procurement flexibility in addition to the mission flexibility provided by the ALaMO solution.

Program Value to Members of the L3Harris Team

The system-level nature of the ALaMO program enabled the program team members to move beyond their existing sensor development capabilities and develop key new competencies across a broad set of engineering disciplines. Algorithm engineering competencies were enhanced with the development of full mission profile simulations. Mechanical modeling capabilities were developed to enable simulation of the harsh gun environment. With ALaMO rounds directly impacting the target following successful track and divert performance, the confidence of the engineering team soared, and this success orientation has permeated the organization. With simulation capabilities developed that support requirements development, lethality assessment, survivability characteristics, and sensor performance, a complete digital engineering suite is available for use across the business unit by engineers who are well-versed in digital engineering design methods.

Program Contribution to the Greater Good

The United States upholds freedom of navigation as a principle and the U.S. Navy is charged with enforcing this principle. Under international law as reflected in the Law of the Sea Convention, the ships of all nations enjoy the right of innocent passage through the territorial sea. Certain adversaries of the United States seek to challenge freedom of navigation and U.S. Navy efforts to maintain it. They do so by aggressive right of way intrusions against U.S. Navy warships and non-combatants that reduce the security of our ships and sailors. As a precision weapon in the ship's arsenal, ALaMO provides a unique capability for defense as part of the anti-surface warfare mission. As budget pressures mount for the U.S. Navy and our Allies, ALaMO provides a cost effective way of ensuring open access to vital sea lanes globally.

METRICS (Value: 15 pts)
Please respond to the following prompt:

- What are your predictive metrics?
- How did you perform against these metrics?
- How do your predictive metrics drive action toward program excellence? Please provide examples.

(12 pt. Times Roman)

The ALaMO program maintained an end-to-end set of metrics of predictive metrics that drove action and decisions resulting in program excellence. With the primary objective of a program leader to create value for the customer, customer involvement in the definition of what constitutes program excellence is key to achieving such excellence. The L3Harris – U.S. Navy program team jointly agreed on the trades between cost, schedule, requirements, and risks and the metrics that predict performance in these trade spaces. Transparent and open communications enabled alignment of objectives.

With a strong focus on digital engineering and model-based systems engineering, nearly every aspect of the ALaMO guidance section was simulated in the design phase. Design metrics and Technical Performance Measurements were reviewed at quarterly program reviews and design decisions confirmed at the Critical Design Review. Simulation results and key parameters were tracked and became part of the predictive model for total system performance. From insertion loss modeling of the radome, through gain and bandwidth of the antenna, through a full system simulation of the radio frequency module, and simulation of the frequency stability of the radar, metrics-based decisions could be made from the front to the back of guidance section. These predictive metrics could then be confirmed at the system level and the system simulations tuned appropriately.

Predictive metrics were also utilized in setting product cost targets, enabling effective affordability trades to be conducted with demonstrable results, including: a 61% reduction in process steps, and 86% reduction in fasteners, an 82% reduction in mechanical part quantities, and a 70% reduction in mechanical part numbers to mention only a few of the measures. The joint contractor – government engineering team traded dBs of performance for dollars of cost. Cost of the ALaMO cartridge is a Key Performance Parameter and a focus of the engineering development. The ALaMO program promoted heavy use of Commercial Off the Shelf electronic components within the design, with only one custom part resident in the entire solution. Design for Manufacturability and Reliability principles were center stage early in the implementation, with the bulk of the Preliminary Design Review to Critical Design Review evolution driven by affordability trade studies.

DFM/A Attribute	PDR		CDR	Reduction %
Mechanical Assy Part Count	87	➔	26	- 70%
Mechanical Assy Part Qty	277	➔	49	- 82%
Fastener Qty	84	➔	12	- 86%
Wire/Lead Qty	76	➔	8	- 89%
Process Steps	82	➔	32	- 61%

DFM/DFA Metrics

In addition to product cost, program cost measures were developed to account for the volatility of funding and the multiple contract vehicles in place. Specific scope and phase-gate exit criteria were developed for each contract duration. Flexible rolling wave forecasts of future remaining work that could be sized based on funding levels and estimated in duration using Monte Carlo schedule risk assessment techniques were prepared. This enabled a fully funded development and qualification program with a reduction in risk that was deemed sufficient to enable low rate initial production orders.

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

Please respond to the following prompts:

- *10 pts:* Describe areas of VUCA faced by your program and why.
- *15 pts:* Explain how your team responded to these challenges.

(12 pt. Times Roman)

Volatility, Uncertainty, Complexity, and Ambiguity Experienced by the ALaMO Team

The volatility, uncertainty, complexity, and ambiguity faced by the L3Harris ALaMO program team required disciplined, rigorous program management and fully transparent communications with the customer that could adapt to multiple contracting actions during the engineering development. With multiple incremental contracts, the program needed to efficiently plan upcoming contractual sprints using rolling wave planning techniques while maintaining a contract-independent Estimate at Complete to ensure the total development and qualification scope was understood and able to be funded.

As prime contractor, L3Harris understood that volatility, uncertainty, complexity, and ambiguity would generate challenges that the joint contractor – government program team would have to mitigate. Risk management strategies were employed to deal with each of these elements, with appropriately different strategies for each. Understanding that each element requires a different mitigation strategy is the first step toward achieving program excellence in the response.

For instance, the mitigation strategy for volatility is a strong vision regarding the required outcome. The ALaMO team experienced volatility in the design of a thermal battery that would meet both performance and safety requirements. One part of the solution was to engage multiple battery suppliers to give more design alternatives rather than continue with a single supplier that might not have yielded a solution.

The mitigation strategy for uncertainty is understanding. Despite a lack of complete information, a task's basic cause and effect can be learned. Rigorous root cause and corrective actions that resulted from L3Harris' disciplined failure review board activities increased learning effectiveness during each design cycle. Creation and utilization of effective models and simulations during the systems engineering and design phase also increased understanding.

The mitigation strategy for complexity is clarity, obtained by disciplined decomposition of requirements to ensure linkage to and prioritization of Key Performance Parameters. Though there may be several interconnected aspects to the design or program milestone, some information is known. Areas that are unknown can be addressed when identified by engaging external subject matter experts, leveraging the greater L3Harris talent resources when necessary or by broadening your simulation or experimentation activities. Key divert module failures initially ascribed to connector design were ultimately resolved when external sneak circuit analysis experts evaluated the design and identified a ground bounce behavior.

Finally, the mitigation strategy for ambiguity is agility. Planning in short sprints enabled rapid decision making at the end of a sprint and direction adjustments as appropriate and incremental validations of assumptions and performance. This planning method was continually required due to the multiple contractual actions experienced by the program, with occasional funding breaks. Key exit criteria often required adjustment when a progress milestone deemed critical needed to be achieved within a certain period of performance. Experimentation and understanding cause and effect enables lessons learned to be quickly applied.

Specific examples of VUCA and How the ALaMO Team Responded

Previously we described the key development drivers that required focus by the joint program team. First was that ALaMO must be designed to **SURVIVE** the very harsh gun environment. The magnitude of the challenge (acceleration, pressure, and spin) could be modeled at some level, however all the causal relationships were not clear and hence ambiguity existed. It was clear that the best test vehicle was to 'go to the gun.' However, the program could not afford the cost and cycle time of verifying every design parameter with test shots on the Dahlgren range.

PACS Test Setup

Ambiguity required agility in solution development. Other stressing test methods were required and developed, often jointly with input from NSWC-Dahlgren experts. They included PACS (Pressurized Air Catch System), air guns, spin tubs, drop/axial shock, vibe tables, bolt firing, and temperature chambers. Many design alternatives were verified using these alternatives to gun tests, enabling gun launches to be reserved more for verification of design choices rather than an evaluation of each design alternative.

Also described was the need to **SIMULATE** performance to reduce development cycle time. The effect of the high-fidelity ALaMOsim simulation suite was to mitigate uncertainty in the program. The simulation is an investment in information, which is a mitigation strategy for uncertainty and an example of the model-based systems engineering method implemented early in the design life cycle. The initial requirements set for ALaMO, rather than being developed from a Cooperative Research and Development Agreement arose from a customer capability gap assessment in countering the swarming boat threat. These requirements were refined and reinforced through ALaMOsim and lethality models and formalized in the government System Specification and other documents. This allowed ALaMO to evolve from a Technical Demonstration program to a Program of Record. The simulations were evolved and tuned throughout the development life cycle based upon design changes and gun test events.

The program was also faced with the complexity inherent in monitoring the operation of the guided projectile throughout the launch and flight and collecting telemetry data to verify operation and further tune the simulations. This relates to the earlier key design objective, namely the need to **PARTNER** with the U.S. Navy to leverage existing Test & Evaluation and range telemetry capabilities at NSWCDD as well as their technical expertise to reduce the complexity of the test and evaluation program. Software capabilities were built into the guidance section enabling broadcast of telemetry data to eliminate the need to develop a separate telemetry section that the program could not afford in either time or cost. The program leveraged existing Dahlgren telemetry receivers and structured test events such that the guidance section radar could interleave telemetry data reporting as well as perform target acquisition and tracking reducing total program cost and improving the execution of test events.

The SWAP-C challenges of integrating complex functionality into a small caliber munition drove decisions in functional partitioning and supplier selection. While such physical constraints typically dictate a highly-coupled approach without modularity, the design team followed the principles of Open Systems Architectures to clearly partition and define the physical, logical and functional boundaries and requirements of each subsystem component. This enabled unambiguous performance traceability, simplified component testing and competitive supplier selection.

Uncertainty in the robustness of design alternatives from different suppliers was mitigated by rigorous competitive assessments of key components. One example of ALaMO's unique approach to supply chain is in the radome. A small, agile company was able to repurpose their expertise in textile braiding into volume production of a radome using composite materials to encapsulate a fiber weave, providing both the mechanical strength and electrical properties required. Another key supply chain effort involved competing designs for the energetic bolt, which must deliver microsecond level predictability in devices that typically deliver millisecond level performance. The chosen supplier delivered a reliable design that met the timing requirements with margin. The thermal battery also required competition, as the thermal battery once occupied the number one risk position on the program. A fly-off, aided by the gun-hardened telemetry system developed by NSWCDD, provided a clear decision on a design that has proven highly reliable in the field.

ORGANIZATIONAL BEST PRACTICES AND TEAM LEADERSHIP *(Value: 35 pts)*
Please respond to the following prompts

- *15 pts:* Describe the innovative tools and systems used by your team
- *10 pts:* Define how you developed, led and managed people
- *10 pts:* How did you leverage skills and technologies of your suppliers?

(12 pt. Times Roman)

Unique and innovative practices, tools and systems enabling ALaMO program excellence

The ALaMO IPT embraced techniques of Knowledge-Based Product Development and became early adopters of simulation-based engineering methods that later evolved into Digital Engineering. Simulation capabilities were implemented that captured design, test and key component parameters to support assessments from the system-level requirements down to specific component characteristics. These simulation models drove design trade studies and were continually refined and improved with component and system test data. Structural simulations modeled both mechanical and electrical components to assess survivability in the severe environment of gun launch and free flight.

NSWCDD developed and gun-fired instrumented 57mm projectiles that precisely characterized accelerations that the projectile would experience in the gun barrel and in flight, using a gun-hardened telemetry system to transmit data to ground receivers. Detailed radar models drove the selection of RF design parameters and modeling of signal impairments, which were characterized and updated with factory and field test data. A system level simulation (ALaMOSim) combined these radar models with aero and 6-degree-of-freedom free flight models to accurately simulate the entire mission from launch to target acquisition and track to diverting to and fuzing on the target. Results from field testing continually fed refinements into ALaMOSim, which has also undergone the rigors of Verification, Validation and Accreditation by the Navy.

The ALaMO design team capitalized on the high spin rate of the projectile, making it an advantage rather than a design barrier. In the sensor area, this philosophy enabled a radar design that measures angles to the target with only two receiver channels. To achieve divert capability without steering fins that could damage gun tubes, an innovative guidance mechanism that harvests kinetic spin energy to change the trajectory and hit the target was developed. The team was challenged to develop techniques to replicate this functionality outside of a gun launch and implemented mechanically the effects of spin in controlled environments for detailed component and system test.

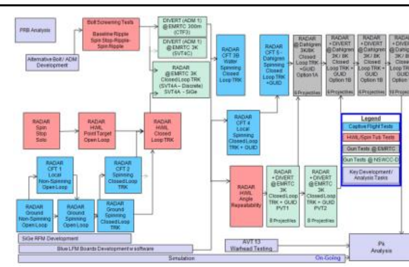
The team innovatively used spin tubs (centrifuges) typically purchased by jet engine manufacturers to test their turbines, and used them to recreate not only spin, but also the axial setback forces experienced in the gun. With rotational speeds during tests of up to 57,000 rpm, these test assets enabled early survivability testing that revealed failure modes and verified design corrections. With the ability to characterize and capture spin data, the released-mass divert physics were also validated.

VRS Test Set

The ALaMO team also needed to non-destructively decelerate a projectile and this was as important as simulating the above gun launch and free flight forces. A classic challenge faced by projectile designers is developing “soft catch” methods to recover and examine rounds after they have been fired from a gun. NSWCDD developed an innovative soft catch recovery method for this purpose – the Pressurized Air Catch System (PACS). PACS consists of a 57mm gun connected to approximately 250 feet of pressurized pipe that allows a gun-fired round to be stopped and recovered, going from zero to Mach 3 to zero in a quarter second. Using this revolutionary technique, the ALaMO program test-fired and recovered projectiles that became crucial in analyzing and correcting failure modes and verifying survivability – without the cost and time of a test range gun launch.

In addition to mechanically spinning a projectile to measure the physical forces, the ALaMO team also needed to simulate rotational velocities to electrically test the vertical reference (VRS) system. Rather than develop a test apparatus that physically rotated the projectile during test, a test jig using triaxial Helmholz coils to present a high-rate spinning (750 Hz) magnetic field was developed and utilized as both a calibration instrument and integration resource.

These specific test assets were some of the tools that formed the complete ALaMO test framework during development. The design team always considered what could be learned through simulation or hardware-in-the-loop (HWIL) testing versus what could only be learned in the gun environment. Captive flight tests were used to verify sensor performance and provide data to the ALaMOSim. HWIL and spin tub testing validated the sensor and divert electronics, with gun launch testing verifying sensor and divert performance as well as survivability.



ALaMO Test Plan

Processes and practices to develop people and transfer knowledge and how they are assessed

The ALaMO program leveraged the L3Harris corporate focus on people development to develop the talent necessary to successfully deliver the ALaMO projectile to the U.S. Navy. A key tenet of the L3Harris vision is to, in part ‘Attract, develop and retain talent…’ and the organization is focused on achieving this vision by executing the tasks supporting the key strategic pillar to ‘Build A High-Performance Culture.’ ALaMO was originally conceived in a company named Mustang Technologies, and the program leveraged a greater cultural theme that Texas began as a distinctive place and remains so. This enabled a similar program culture with a can-do attitude toward innovation and execution.

The ALaMO program leadership inspired passion toward the mission and developed talent. Early members of the program team now fill 15 chief engineer and lead functional roles across the organization, transferring their knowledge to other programs. Formal student intern programs have also been successful in attracting and retaining quality new-hire talent, with 25 interns joining the organization as full-time employees since 2017.

Technical training brownbag sessions have been utilized to broaden the exposure of the engineering organization to key technology competencies necessary to make ALaMO successful. With 48 separate sessions in the last three years alone, covering topics from aerothermodynamic heating for supersonic flow fields to high speed digital simulation or radar signal processing, the organization has been successful in transferring knowledge and enhancing the ability of the integrated design teams to synthesize information across functional disciplines. A mentoring program was implemented to transfer domain knowledge from our senior technical and fellows talent to new-hire and early career employees, with 70 participants in the latest speed mentoring event held in March 2021.

The impact of these people development initiatives has been validated by the measured engagement level with the organization. During the last employee engagement survey, the team members assessed that their job is a good fit for their abilities and experience was 14 points higher than industry benchmarks, and their sense of accomplishment from their work was 10 points greater. The team delivers on its promises to successfully integrate new team members within the team, with greater than 90% engagement levels measured by new hires. During the most recent mid-year feedback survey, when the team was asked what can the organization do to better support you, the top response was that it was already doing a great job.

Recognition programs have also been successfully implemented to reward and retain people, since retention is as important as development. An individual performance program that was part of the legacy L3 Mustang organization has been retained, together with spot award programs that recognize key contributions to the program.

Knowledge transfer has also occurred as a result of design and architecture decisions taken on the ALaMO program. The lessons learned in developing ALaMO enabled a development model that opened doors in adjacent product areas by creating core platform technologies using common simulation, design and test tools. Key technologies include high-performance low-cost RF sensors, advanced signal processing algorithms, gun-hardened electronics packaging and projectile systems integration. These capabilities significantly overlap the needs of other products in the business. New programs often start with data collection experiments executed against real-world targets using derivatives of the ALaMO design, followed by development and DVT phases. Knowledge transfer and development of people have fueled the success of these programs to a large extent by leveraging, and continuously improving, simulation models, design expertise and tools developed on ALaMO, yielding an investment multiplier for other programs and the other military services.

Unique customer engagement practices and feedback mechanisms

Previously we have highlighted that one of the key development drivers was the need to PARTNER with intermediate caliber weapons experts in the U.S. Navy into the development of the ALaMO capability. Initially, a CRADA was established with NSWC-Dahlgren to enable efficient transfer of technical information. We used the CRADA to integrate the Navy team members into the program activities – and held regular Technical Interchange Meetings on the initial development activities of the risk reduction program. As part of the development agreement, the industry team delivered the high fidelity ALaMO Simulation to the Navy, allowing them to independently execute performance analyses, giving the Navy leadership confidence in the stated claims of the operational performance improvement of a guided 57mm projectile

The ALaMO program genesis was guided by a single statement of objectives: **Demonstrate The Ability Of The ALaMO Risk Reduction Hardware To <u>Survive</u> A Representative G-Hardened Launch Environment, <u>Guide</u> To A Representative Target, And Meet Probability of Kill (<u>Pk) Requirement.</u>**

To enhance the communications with the customer team and improve their confidence in our ability to achieve this statement of objective, our high fidelity simulation was shared with the government and was the accepted quantitative program tool used to bridge between our ability to guide to a target (as evidenced in gun tests at NWSC-Dahlgren), and the ability to show adherence to the Probability of Kill requirement. The ALaMO Simulation was originally used to evaluate initial tactical parameters that would achieve tactical Pk performance, taking into account initial gun weapons system and target parameters. A risk-appropriate operating point was chosen for the risk reduction configuration and then was expanded in the tactical design. With confidence that the overall system design would meet the performance objectives, then the full set of requirements could be addressed.

Key Performance Parameters and Technical Performance Measures were identified and , then decomposed to sub assembly and components, and reviewed at the SRR. Hardware and software configuration items were developed against these requirements, and subjected to component level stress tests to mimic the gun environments. These were always considered necessary but not sufficient, in the context of a necessary gate to justify the cost of going to the gun tests – but the complexity of the gun environment, with all of the combined effects, can never be fully simulated. These test results were used to update the specifications and simulations, with the KPPs and TPMs tracked throughout the program. These were updated for the tactical SRR, and the ALaMO simulation continued to be the driving tool that afforded the program the opportunity to evaluate trades in performance vs. affordability.

The resulting configuration that is now in production is a reflection of the digital system engineering trades that started at the very beginning of the program, and continued throughout the life cycle, enabled by the ALaMO program's high fidelity simulation.

Typical formal reviews were held throughout the life of the program, in both the Technical Maturation/Risk Reduction Phase as well as the in the Tactical Development. A unique approach was dividing the EMD CDR into two separate and focused phases. The first phase reviewed the detailed design and the results of a number of affordability trade studies and implemented manufacturability cost reductions, while the seconds phase reviewed the manufacturing readiness of the design. This unique approach enabled the U.S. Navy to provide detailed technical and programmatic direction and helped to fully align the joint government-contractor ALaMO team as the program moved to its next phase. The program invested in a thorough FRACAS process early, allowing the team to take full advantage of U. S. Navy expertise in the key development gun survivability subject area. U.S. Navy personnel were integrated members of every FRACAS activity, and were integrated into the decisions taken on design choices, simulation approaches, test environments, and ultimately defining the successful forward path of ALaMO.

Once the tactical development began, key working groups were established across the domains of the program, to focus SME energy and expertise. The simulation team met continuously throughout, providing feedback on simulation results, and ensuring understanding of the performance results were shared between the U.S. Navy and the industry team. A lethality working group was established to ensure the lethal effects were correctly modeled, to inform the development of the requirements ahead of the System Requirements Review, and continuing through the Critical Design Review. A Program protection working group was also established at the beginning of the tactical development, ensuring the roadmap of capabilities needed was identified and agreed upon.

One of the most important activities requiring joint development was the System Safety Working Group (SSWG). The L3Harris program team was always aware that the development of ammunition required embracing the safety community's guidance, and we enlisted the counsel of the Navy's Fuze and Weapon System safety boards (the FISTRP and WSESRB). The team engaged with WSESRB and FISTRP leaders during informal Tech Assist meetings and integrated their advice into the earliest of the tactical design activities, well in advance of formal safety board briefings. The SSWG continues to meet regularly to ensure all aspects of the program's system safety requirements have been addressed ahead of the upcoming WSERSB briefing, which is an integral part of the decision to declare Initial Operational Capability.

Finally, the Program Management function held regular Program Management Reviews with the Navy Program Office, ensuring insights into the program schedule and budget were shared in an open and honest fashion. The team, throughout leadership changes, and company mergers, always upheld its pledge of sharing all data and analysis regarding schedule criticality, and necessary shifts in focus as the test program began, and FRACAS activity began to drive the program execution. The FRACAS activity of any projectile program is the make-or-break phase of the program, and has been the Achille's heel of transitioning these capabilities to the warfighter. Several programs have failed to reach the transition after significant investment of resources into the test phase – the ALaMO story is unique, as the U.S. Navy contractor joint program team partnered together to bring the first guided projectile program to the fleet. Open and honest communication was the key execution multiplier to reach this goal.

In summary, the ALaMO program has achieved the U.S. Navy vision to defeat the threat of asymmetric swarming small boats and UASs prior to the threats reaching their effective weapon range. With a strong foundation in digital engineering, key performance parameters were optimized in simulations, measured against defined predictive metrics, and validated in testing with the program's NSWCDD partners. Implementing innovative design tools and methods, the program team achieved the L3Harris vision to create a high performance culture of excellence, providing a game-changing capability to the U.S. Navy and an engineering foundation for future solution development within L3Harris.