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,

Gregory Hamilton
President
Aviation Week Network

Acknowledged, agreed, and submitted by

Tonya Ladwig _____ 5/31/23

Nominee's Signature Date

Nominee's Name (please print): Tonya Ladwig_____

Title (please print): Vice President for Human Space Exploration & Orion Program Manager _____

Company (please print): Lockheed Martin _____

NOMINATION FORM

Name of Program: Orion Program

Name of Program Leader: Tonya Ladwig

Phone Number: 720.381.7809

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Postal Address: 6415 Business Center Drive, Highlands Ranch, CO 80130

☒ Customer Approved

- Date: 5/25/2023
- Customer Contact (name/title/organization/phone): Paul Marshall, Assistant Program Manager, Orion Program, NASA

☒ Supplier Approved (if named in this nomination form)

- Date: 5/30/2023
- Supplier Contact (name/title/organization/phone): Numerous named – Michael Eddy is the LM POC for supplier approved inclusion in this document

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?

Lockheed Martin is the prime contractor building the Orion spacecraft for NASA's Artemis program missions to the Moon. Through Artemis, NASA will use what it learns from working and living on and around the Moon to send humans deeper into the solar system and Orion is the spacecraft making it possible. Because Orion achieved many "firsts" in the history of human space exploration, it reveals the unique characteristics of the program while overcoming challenges and opportunities associated with unknown deeper space exploration.

Orion surpassed the distance record for a spacecraft designed to carry humans and safely return them to Earth, traveling 268,593 miles from Earth on November 28, 2022, and breaking the record set during the Apollo 13 mission in 1970.

Orion was the first to enter a Distant Retrograde Orbit (DRO), a highly stable orbit around the Moon where little fuel is required to maintain trajectory. The orbit was used to test Orion's systems far from Earth, including achieving better understanding of its propulsion system by performing precision flybys of the Moon and entering and exiting lunar orbit. Orion's flight trajectory performance on Artemis I was so precise in the DRO that a planned orbital maintenance burn for Flight Day 13 was deemed unnecessary.

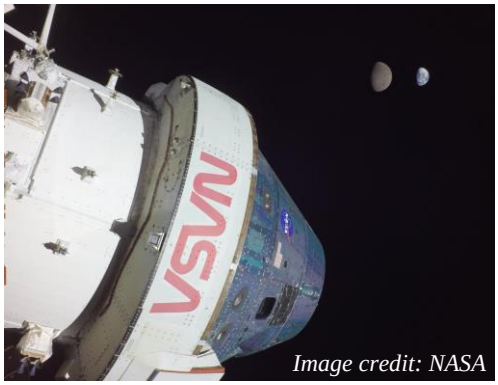


Image credit: NASA

Orion is also the first human rated spacecraft to return using an unprecedented skip-entry technique that helps to dissipate atmospheric entry temperatures exceeding 5,000 degrees F and velocities of nearly 7 miles per second (or 25,000 mph). This technique safely allows the vehicle to reject some of the heat back out into space before dipping back into the Earth's atmosphere and it also allows Orion to hit a far more precise landing target, by "skipping" longer or shorter distances to a closer, pre-determined landing sight, decreasing recovery time in the Pacific Ocean.

Orion was so successful in its performance that the mission team executed 21 additional test objectives on orbit, beyond the initial 124 planned at launch, before returning to Earth. Examples of the added on-orbit maneuvers included conducting two propellant tank slosh tests to measure the effect propellant sloshing has on spacecraft orientation and trajectory, and certifying the optical navigation system that provides dissimilar redundancy to Orion's primary navigation sensors, increasing crew safety margin.

The Orion spacecraft is paving the way to establish a long-term lunar presence and eventual presence on Mars and its flawless execution during the mission allowed it to accomplish so many firsts in human space exploration while exceeding all test objectives. It is a testament to the excellence in engineering design, build and test, and mission execution that the Orion program is worthy of consideration for this award.

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**

Artemis I was the latest in a series of four major flight tests of the Orion spacecraft, and the last uncrewed mission before NASA sends astronauts back to the Moon for the first time in over 50 years on Artemis II. The terabytes of data collected during the flight test, which Lockheed Martin is currently analyzing, will help ensure the safety of Orion's crewed missions to the Moon and beyond beginning with Artemis II. It is impossible to quantify the personal investments of all those employees that have been a literal part of space exploration history for decades as they pave the way for future deep-space exploration.

With an annual federal budget of $1.4B for the Orion spacecraft and a contract for eight Artemis missions, the Orion Program has employed thousands of bright and skilled people since program inception. Building a vehicle that can sustain human life in deep space beyond the protection of the Earth's magnetosphere is a complex feat that provides unique engineering challenges to conquer. Solving these unique challenges make the Orion program a potent recruitment and retention tool for the corporation.

Orion is one of Lockheed Martin's largest and most visible programs with the unprecedented challenge of sending humans farther into the solar system than any have ever traveled, making it one of our flagship programs. When so many other Lockheed Martin programs are defense based and proprietary in nature, space is that inspirational and uniting story for the corporation that is very open and inclusive, inviting all to experience the wonders of our solar system as we learn and bring new benefits back to life on Earth.

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

There are three foundational tenets to safely support NASA's long-term human exploration goals that the Orion program helps foster - get to flight, enable exploration and make it sustainable.

In order to meet these tenets and the needs of the Artemis architecture and lunar Gateway platform, Lockheed Martin established strong sustainability and producibility initiatives that have provided significant savings and cost avoidances across the program. Orion program leadership drove the

evolution of this program from a Design, Development, Test & Evaluation (DDT&E) program to a streamlined, firm-fixed price model under the Orion Production Operations Contract (OPOC), which manages Orion spacecraft production for Artemis missions III – VIII and that will ultimately allow us to produce more vehicles for more flights, support NASA's Mars-forward vision and bring production costs down. Some specific examples of innovative actions include:

- Exploring new approaches to cost reduction such as in the Orion docking control. This Lockheed Martin-led initiative resulted in over $10M in cost reductions by putting our docking control into a Compact Flight Computer (CFC), rather than adding capability to existing hardware and software.
- Creating commercial partnerships to advance new technologies for human space exploration. Lockheed Martin partnered with two innovative giants – Amazon Alexa and Webex by Cisco – to create the Callisto Technology Demonstration payload on Artemis I. This demonstration enabled us to test new crew interfaces using commercial-off-the-shelf (COTS) hardware to provide new and lower cost utility that can improve crew efficiency, safety and morale. This demonstration also captured attention and inspired millions through online content, media and STEM engagements from Mission Control.
- Reducing the costs on Orion by 50 percent per vehicle on Artemis III through Artemis V, under OPOC compared to vehicles built during the design and development phase. The vehicles built for Artemis VI, VII and VIII will see an additional 30 percent cost reduction.

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

The feeling of completion and the sense of accomplishment for over a thousand Lockheed Martin employees that have worked on the first Orion vehicle since the program's initial contract award in 2006 cannot be underestimated. Orion made history during the Artemis I mission flying 268,563 miles away from the Earth, the furthest a human-rated spacecraft has ever traveled. To have played a part in that historical milestone, it is easy to understand why tears were shed as friends, family and colleagues watched Orion safely return to Earth on Dec 11, 2022.

Not only is Orion one of Lockheed Martin's most visible and important programs, it is building the primary foundational element for long-duration, deep space human exploration missions that will pave the way for further exploring our solar system, with Mars as the next potential destination after the Moon. This program is of paramount importance to maintain our nation's leadership in space and foster global collaboration for the future of humanity, putting our employees front and center of "history in the making."

The Artemis story is about sustaining humanity – on Earth and in deep space. Those who make this journey possible come from around the globe, contributing diverse thinking and ideas. Every state in America has put its mark on Artemis, with large and small companies providing goods and services that will help establish a long-term human presence at the Moon. NASA and its prime contractors—Aerojet Rocketdyne, Boeing, Jacobs, Lockheed Martin, and Northrop Grumman—currently have more than 3,200 suppliers contributing to Artemis. The European Space Agency (ESA) and its prime contractor, Airbus, enlist 26 European companies in 11 countries to build the European Service Module, ESA's contribution

to NASA's Orion spacecraft. Space exploration is a global endeavor contributing to trust and diplomacy between nations and it is inspiring to be part of a global effort.

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

Lockheed Martin's vision for Orion is to be the centerpiece for sustained lunar presence and beyond. The Orion program mission is to expand the reach of humanity and to accelerate discoveries that will ultimately benefit life. The Artemis program and Orion spacecraft are important strategically from a national positioning stance and on a global protection front as it provides advancements in technology to sustain the Earth and its inhabitants. Understanding human biology during long duration spaceflight, and under multiple gravity conditions to keep crew safe and healthy throughout future missions, will lead to new breakthroughs in medicine and health that will benefit humanity for decades to come.

Orion is integral to the success of the Artemis missions and plays an important role in engaging the public, allowing all to follow along as we explore the cosmos and inspire future explorers around the world. The Callisto Technology Demonstration alone allowed us to engage over 100,000 STEM students through an online tour through our partnership with Amazon Future Engineers. In a post survey tour, these same students showed an improved score in the "intent to pursue STEM careers" category, highlighting how impactful space travel is in inspiring the next generation of students.

Lockheed Martin continues to support NASA and industry Small Business (SB) priorities. Lockheed Martin relies heavily on embedded SB technical support personnel throughout the contract life cycle and major events. The Orion program has offered Lockheed Martin the opportunity to develop a comprehensive and innovative strategy to ensure the achievement of NASA goals while strengthening the US economy. Small businesses in every state of our union, as well as Puerto Rico and Washington, D.C., contributed to the Orion program. These include women-, minority-, and veteran-owned businesses in Historically Underutilized Business Zones (HUB Zones) bringing their highly skilled, highly technical, and great-paying jobs to underserved parts of many communities throughout the country. We continue to recognize and reward SB through our Orion SB Awards Program, distributing dozens of Nebula and subcontractor of the year awards to the embedded subcontract personnel. Lockheed Martin supports NASA SB outreach events and nominates Orion SB for NASA Industry Awards.

ORGANIZATIONAL BEST PRACTICES AND TEAM LEADERSHIP

Value: 35 points
Use 12 pt. Times Roman typeface

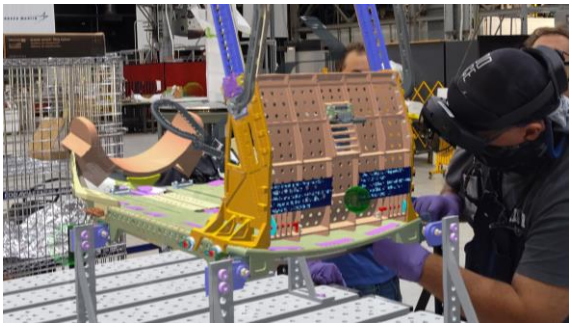
Please respond to the following prompts:

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

Lockheed Martin opened the Spacecraft Test, Assembly & Resource (STAR) Center near Kennedy Space Center to expand and streamline Orion spacecraft production operations for multiple missions. Program leadership implemented new technologies and systems to enhance both program operations and stakeholder involvement and support. Lockheed Martin's manufacturing facilities connect to our Intelligent Factory Framework (IFF), which is an edge computing platform that secures, scales and standardizes device connectivity through internet of things (IoT) practices. This streamlines production and provides agility across production operations by automatic performance monitoring and maintenance eliminating the need for manual reviews. For the Orion program, the STAR Center supports:

- Assembly and testing of the Orion aeroshell heat shield and backshell panels, including thermal protection system installation
- Fabrication and testing of the crew module and crew module adapter wire harness
- Assembly and testing of the propulsion and environmental control and life support systems
- Production of the electrical ground support equipment

In addition, by treating data as a strategic asset, the team is actively connecting devices and machines. That interconnectivity gives team members at both Kennedy Space Center facilities (STAR Center and Operations and Checkout building) real-time access to valuable data to enhance efficiency, manage capacity and monitor workflows, systems and equipment.



Lockheed Martin production facilities integrate other smart tools including virtual reality (VR) and augmented reality (AR). By utilizing smart tools, the production team is able to maximize the effectiveness of new tools across the product lifecycle. This expansion of digital transformation technologies, along with our existing expertise in production and machine shop capabilities, allows us to scale Orion spacecraft production to deliver faster and drive down costs.

When Lockheed Martin began assembling the crew seats for Orion for Artemis I, a new process was implemented using Microsoft's HoloLens 2 device. Everything required – from animations of how pieces fit together, to engineering drawings, to torque values for tightening bolts – was all done in mixed reality. These headsets allow hands-free access to data to allow for the manual manipulation of hardware. Voice commands were used to guide through every step, and holographic instructions were overlaid on relevant parts of the four seats. The holographic instructions alone helped technicians finish the repetitive tasks 90 percent faster, making it an invaluable tool, especially when marking locations for hundreds of fasteners that require a lot of precise measuring by hand.

The teams responsible for structural testing of the Artemis thermal protection systems are regularly using AR to place instrumentation on the composite panels of the capsule. Due to the complex shape of the panels and structure, determining exact location by manual measurement is a very time-consuming process prone to error. AR has enabled Lockheed Martin to create scenes where technicians are able to visually see where instrumentation is to be installed or where load application points need to be placed without the need for physical measurements. The simplicity of using the tools and the obvious time savings that can be achieved with them, have led to rapid adoption in all instances where the AR tolerance requirements are sufficient to meet the placement requirements.

Orion's Integrated Test Lab (ITL) is the highest fidelity test environment outside of the actual vehicle and supports two shifts a day, seven days a week to integrate and test Orion's complex Crew Module and Service Module Avionics, Power and Wiring (APW); Guidance, Navigation and Control (GN&C); and Flight Software subsystems which enable Lockheed Martin, NASA, and ESA users to simulate a flight vehicle configuration. The ITL team completed the transition that allows them to efficiently switch between the Artemis I, II and III configurations and have successfully demonstrated that capability multiple times. By leveraging the experience gained and lessons learned on Artemis I, the ITL is well positioned to adjust its integration to support Artemis program mission needs.

Prior to the launch of Artemis I, a near-identical Orion vehicle test structure, called the Structural Test Article (STA), underwent punishing tests that deliberately took the vehicle's structure to the limits of its design. The tests simulated the raucous launch and harsh space environments that physically affect the structures of the Orion spacecraft. At Lockheed Martin Space in Denver, teams worked around-the-clock for days at a time to prepare the tests, execute, tear down then reconfigure the STA for the next test, culminating in 330 actual days of testing. During some test phases, engineers pushed expected pressures, mechanical loads, vibration and shock conditions up to 40 percent beyond the most severe conditions anticipated during the mission, analyzing data to confirm the spacecraft structures can withstand the extreme environments of space.

Post Artemis I, the Orion Crew Module continues its mission now on the ground as an Environmental Test Article (ETA). It will validate the models on Earth, and test new hardware needed for the Artemis II mission that were not present on Artemis I, such as the Docking Module. The Structural Test Article, "Orion's Twin", will also once again be used for continued testing on a ground-based qualification unit of the Docking Module design.

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

Lockheed Martin could not produce great engineering products like Orion without investing back in its greatest asset, its employees. Below are just a few ways in which Lockheed Martin helps to develop, lead and manage our workforce on the Orion program.

Every Wednesday morning, the program office hosts a 25-minute webcast, "Orion Sunrise", for subject matter experts to talk about the Artemis missions and various subsystems and production progress. This allows for increased awareness among the workforce and provides opportunities for employees to engage on aspects of Orion they might not touch otherwise.

In addition to the webcast, Orion 101 is a series of presentations that educate employees program wide on the spacecraft's technical subsystems, enabling cross functional knowledge on technical aspects of future missions. In addition to explaining technical details, Orion 101 also educates employees on some of the engineering and design changes needed to perform mission requirements so there is more comprehensive knowledge of the vehicle.

The Orion "Chat with the Chiefs" program is another way Lockheed Martin leads and develops people. This monthly initiative is led by the chief engineers office and is a forum to connect the engineering staff with engineering leadership so they have the opportunity to voice concerns, discuss opportunities for growth, and drive more effective change.

Hearing from each level of the workforce is so critical to Orion's success that Orion program leadership implemented the Production Process Verification (PPV) platform. This gives the factory floor workers a voice back into the program so leadership can be responsive to their needs. This has led to the development and adoption of clearer instructions and engineering enhancements that have increased efficiency and improved cost effectiveness.

Given the program shift from a design/development mindset to a production and sustainment mindset, Lockheed Martin has created five required workshops under the Accelerate Exploration Culture Transformation that helps change the cultural behavior of the workforce. These required workshops provide training and guidance to help the team understand the differences between the two contracts as well as how to prioritize work scope when conflicts arise between the different missions. This sets expectations of performance to achieve contractually desired results.

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

With suppliers representing multiple industries from traditional aerospace to automotive, medical and even entertainment industries and coming from all 50 states, Puerto Rico and Washington, D.C. – the design, development and test of the Orion spacecraft system leveraged the knowledge and expertise of an extensive, diverse national supply chain. More than half the contract value is redirected into Orion's supply chain. Half of that amount ($2.1B) is sent to small businesses. Major partners and even small businesses made investments of their own to make Orion a reality. Given the breadth of our suppliers, we have included examples of leveraging their skills on three core aspects of Orion: the pressure vessel panels, the windows, and the Environmental Control and Life Support System (ECLSS).

The Orion program underwent major improvements in producibility and production efficiency, partly enabled by rebalancing our flow of manufacturing hardware upstream to our suppliers, reducing overall complexity and risk at the subsystem assembly level. One of the first successes in this realm was to streamline the overall weld process of the Crew Module pressure vessel design by reducing the total number of parts from 32 down to the seven parts that comprise the design today. The conical section of the pressure vessel was among the more complex, costly and time consuming sections because of the 12 parts all welded to the geometrically complex precision needed for Orion. The design of the conical section was changed to reduce total parts down to three which were then welded into the final conical assembly. However, this required the sub tier fabricator of the parts to successfully build the much larger conical segment parts which demanded a much more capable machine shop tooling and operator skill than the simpler parts the original design required. By shifting this work to AMRO Fabricating Corp., we were able shift the production complexity from the pressure vessel weld assembly level to the lower machine shop parts fabrication level leveraging the expertise and capabilities inherent in AMRO's machine shop operations, making the process highly repeatable and more efficient.

The Orion windows team leveraged the optical glass manufacturing experience of Rayotek Scientific Inc in San Diego, CA, to reduce the cost of manufacturing high optical quality window panes needed for human spaceflight. Rayotek's ability to work with multiple materials allowed for a one-stop approach for all pane manufacturing reducing overall costs. Additionally, their on-site capabilities such as water-jet cutting, flame polishing and testing reduced the amount of travel and handling of the panes, reducing the possibility for damage to occur.

ECLSS plays a vital role in sustaining the crew onboard Orion, so Lockheed Martin leveraged expertise for the ECLSS system from Collins Aerospace who has developed life support systems since the Apollo missions. Collins provided the initial architecture for the active thermal control and air

revitalization systems based on their knowledge of thermodynamics, fluid physics in microgravity, and gas separation techniques.

When NASA had concerns with the development of one of their vendor's Composite Overwrapped Pressure Vessel (COPV) components on the Artemis I Service Module, Lockheed Martin was asked to initiate a backup development effort to have a "drop in" ready in 6 months. Given standard COPV procurement time is 36 months, Lockheed Martin approached supplier ARDE Inc. given their expertise in COPV development. Using forgings and other long-lead components from their existing supply, ARDE was able to construct a solution in less than half the time it normally takes. It not only helped avoid a major delay to NASA's schedule, but it also performed flawlessly during the mission.

Adel Wiggins GRC (AWG) is another outstanding example of supplier performance and collaboration. From their West Coast engineering and manufacturing division, AWG worked tirelessly to develop and deliver a series of valves that needed to be modified to human spaceflight requirements. These requirements include the ability to have manual operations that can be used by crew if the need ever arises to introduce critical nitrogen and oxygen flow into the cabin in the event of an emergency.

When the last legacy space shuttle era Positive Pressure Relief Valve Assembly (PPRA) was used on Orion for Artemis I, Lockheed Martin worked with the Eaton Corporation to develop a new Positive Pressure Relief Valve for the Orion Artemis II crew module. Eaton engineers worked diligently from archival proprietary data on the PPRA to design and develop a new valve. Leveraging the same heritage principles, they were able to use modern tools and manufacturing techniques to deliver a robust precision valve.

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.)**

The Orion program faced many challenges regarding Volatility, Uncertainty, Complexity and Ambiguity including competing priorities within supply chain, an ever-changing launch schedule, working with international and commercial partners, and a customer driven initiative to drive costs down to a more sustainable level.

Volatility: When it comes to supply chain, demand is much higher than the market can supply on a per-year basis, especially for spaceflight-rated hardware. In some instances, the customer dictates which suppliers we can use, which often have competing priorities with our competitors and even within our own contracts, making it difficult to pivot if issues arise. Department of Defense projects add another layer of unpredictability as they generally take higher priority, further affecting timelines.

Uncertainty: A perfect example of uncertainty on the Orion program was the ever-changing launch schedule for the Artemis I mission. Administrator Bill Nelson said it best on the September 3rd launch scrub, "We'll go when it's ready." Vehicle launches are reliant on a number of factors to mitigate risks and many are completely beyond our ability to control. The Artemis I launch repeatedly slipped, resulting

in scrubs due to Space Launch System (SLS) propellant loading issues, rollbacks to the Vehicle Assembly Building, and multiple hurricane exposures while out on the launch pad.

Complexity: The complexity of going to the Moon cannot be overstated, especially in meeting all the requirements to keep the crew safe in the harsh confines of deep space as well as through the extreme forces and temperatures they will experience upon launch and reentry. In addition, integrating Orion with multiple programs, a global network of U.S. suppliers and international partners such as ESA, Airbus and their contract companies, present a myriad of assembly, test and integration challenges.

Ambiguity: NASA's annual funding cycles drive significant priority changes in order to manage scope to budget, creating funding challenges as mission requirements evolve. Add to this the desire to implement heavy re-use of components to drive down cost and schedule amidst an environment with constant changes to future Artemis timelines and missions can make things a bit nebulous.

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

Volatility: Lockheed Martin Orion has implemented a robust supply chain outreach and engagement program which includes supplier conferences, site visits, premium payments for critical path deliveries as well as placing Lockheed Martin subject matter experts in house across the country for rapid issue resolution and engagement with our supply chain. This allows us to keep our suppliers engaged and informed on the various needs and priorities in a constantly changing and competitive landscape so we can meet Orion critical path milestones.

Uncertainty: Lockheed Martin Orion has a robust risk and opportunity management program that regularly addresses what could go wrong and creates forward looking impact points that are used to create mitigation plans (see Hardware Delivery Matrix in predictive section). Lockheed Martin was also proactive in providing Artemis I mission support despite the shifting launch timetable. The Lockheed Martin Orion thermophysics aero-sciences team made several trips to KSC to support multiple launch attempts. Additionally, several purge outages occurred which were analyzed for condensation impacts, including several hurricanes. During the rollout of the vehicle for the first launch attempt, acceleration sensors were attached to the vehicle that compromised a watertight design. Due to major rainstorms, the tape on the back shell was water-contaminated. Without hesitation nor requiring customer direction, the Lockheed Martin thermal team performed analysis to demonstrate Artemis I's space-worthy state, thus avoiding costly vehicle de-stacking for tape repair.

Complexity: Astronauts – former and current – have been an integral part of the Orion team since its design and development phase and continue to provide valued input and perspective for the Artemis II missions and beyond. With Artemis I being the final test flight before the Artemis II crewed mission, the Orion program also adheres to detailed compliance with human rating criteria which begins with strong systems engineering and integration practices, over three years of testing with the structural test article to certify it as human-rated, and the years of rigorous integrated hardware and software testing to enable the vehicle to perform and keep the crew safe. Furthermore, Orion's unique Launch Abort System design greatly increases crew safety with a proven and tested escape system in the event of an emergency during launch or ascent to orbit. The system's attitude control motor greatly improved maneuverability of the spacecraft to position it away from the launch pad or rocket to get the crew safely downrange from danger.

In regard to the challenges of working with a global network of suppliers and international partners, Lockheed Martin designated an International Integration Manager for the program team and also conducts regular leadership and program review board meetings with NASA, ESA and Airbus – domestically and in Europe – to ensure consistent communication between all parties and maintain project schedule for deliverables. In addition, NASA and Lockheed Martin hosted Artemis I post-mission recognition events at corporate and supplier sites across the U.S. and in Europe to recognize the employees and suppliers that contributed to Orion's production and mission success. Local, regional and federal elected officials as well as media attended many of these events, giving our suppliers an elevated level of recognition and appreciation in their communities around the world. These recognition events have been met with very positive feedback as evidenced by Frank Nguyen of Avatar Machine, *"Thank you so much to you and your team for the continued support of Avatar! We're exceedingly grateful and honored to receive the recognition award at Avatar. Lockheed Martin and NASA have truly enabled us to grow as a community and a stronger team as well."*

Ambiguity: Lockheed Martin developed and managed the pioneer reuse effort from Artemis I to enable continued sustainability on subsequent flights and critical tests. Lockheed Martin's efficient and effective management of this sustainment operation led to the successful removal of Artemis I components and swift installation on Artemis II for ATLO milestone tests, including functional power-on and thermal cycle testing. In addition, Orion management employ embedded subcontractors across the Lockheed Martin Space enterprise. These subcontractors provide a ready source of surge talent as needs arise, allowing us to offset and mitigate any priority issues driven by annual funding challenges. This surge support has worked effectively in keeping Artemis II – IV production moving at pace. Lockheed Martin has also created agile processes, such as funding profile modeling tools, that allow us to work quickly with NASA to rephase scope and adjust timelines and manifests so goals can be achieved within the budget.

The approach to solving these unique challenges was always met head on with open communications, trust and teamwork which ultimately enabled Orion to have so many first-of-its-kind achievements during the Artemis I mission, with many more to come during future Artemis missions.

METRICS

Value: 15 points
Use 12 pt. Times Roman typeface

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

Provide charts/graphs that illustrate performance to these metrics:

- **What are your predictive metrics?**

Rally Flags - In sporting events, rally flags are used to draw attention and excite the crowd. On the Orion program, leadership created goals that integrate production timelines into "inchstones" that ensure critical path and mission success milestones are met on schedule. Weekly reviews with a fun game board style Tableau dashboard user interface provide frequent updates to the team to keep them on track to their goals and the schedule. The respective teams celebrate incremental milestones with team lunches, events, or other small rewards upon their rally flag completions.

Earned Value and Variance Reporting – A bi-weekly review and monthly metric that shows how the program is tracking to the initial budget and schedule created at the onset of the contract. Any change caused by elements like supply chain issues, customer timeline shifts, and even unforeseen

circumstances like the two hurricanes (Ian and Nicole) faced during different launch attempts, all get evaluated against the initial budget cost to work schedule so leadership can best determine the recovery plan of action.

Burn-Down Plans – Lockheed Martin uses burn down metrics extensively to set expectations to our teams on the scope of work and the rate by which that scope needs to be accomplished to ensure future milestones are met. This prediction allows time for recovery plans if needed in order to hold the critical path to meet over 20,000 verification requirements needed before delivering the spacecraft to NASA. One burndown metric example is used for welding operations. If 1,200 welds are required over a one-year period, the welding team's burn-down plan may include 100 welds per month. Each review of the plan would then evaluate how they are tracking towards that goal and delivery timeline.

Hardware Delivery Matrix – This is a weekly tag-up to review forward looking metrics on supplier provided hardware delivery and any potential impacts to the Orion top-level schedule based on risks and delays. Critical path hardware schedules are reviewed in comparison to non-critical path hardware schedules so leadership can divert resources to assist the suppliers through Lockheed Martin subcontract program managers.

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

The non-traditional predictive metrics like the four identified above enable program management to be more agile, given the real-time insight into the various production levels of the program. This allows leadership to focus on whatever shifting priorities are most important to meet cost and schedule parameters. As expected, with 100's of metrics, each one will vary from ahead of plan, to on plan, and a few behind plan. However, it is the Lockheed Martin response to these metrics that sets us apart. The best indicator of performing against these metrics is the cost reduction initiatives stated earlier in this document that will ultimately reduce the cost of future Orion's by 50 percent per vehicle.

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

Each of the four predictive metrics outlined above allow the Orion program to align our management methods and systems to ensure that the appropriate structures and resources are in place across the program to help us achieve the mission requirements set by NASA.

Rally flags enable leadership to focus the efforts of the workforce to meet the critical milestones needed to keep the program running, while also taking time to celebrate the team accomplishments along the way. This has brought a rich culture and sense of pride and recognition for efforts across the Orion team as we all work to the singular goal of furthering deep-space exploration.

By looking at the earned value and variance reporting and burn down plan metrics, Orion leadership is able to shift priorities and labor forces to meet the ever-changing landscape. This approach helps alleviate stress, minimize employee burnout and realign schedules to meet mission deliverables regardless of any delay challenges faced. While there is always room for continued growth and improvement, Orion strives to be a beacon of excellence any program could be proud to simulate.