# SAFETY & MISSION ASSURANCE (SMA) ACTIVITIES IN SUPPORT OF ARTEMIS I AND PLANS FOR ARTEMIS II

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## ABSTRACT

The Artemis I mission in 2022 accomplished humanity's first venture beyond Low-Earth Orbit (LEO) with a human-rated spacecraft in over fifty years. Artemis comprises several key Program elements – Multi-Purpose Crew Vehicle (MPCV) Orion Crew Module, Service Module, Launch Abort System; the Space Launch System (SLS) and the Exploration Ground System (EGS). Much of our human spaceflight experience with crewed lunar missions is captured in historical program documents, but first-hand knowledge is limited to a few spaceflight veterans. Missions to LEO have offered the opportunity of direct, near-instantaneous communications and assistance, and the ability to return to Earth within a matter of hours in case of emergency. Outward-bound missions do not have these features and will require a more autonomous and reliable spacecraft.

The assessment of compliance with applicable safety requirements and adequacy of hazard controls and verifications is the responsibility of the MPCV Safety and Engineering Review Panel (MSERP), along with a Joint [NASA/ESA] Safety and Engineering Review Panel (JSERP) for the review of the European Service Module (ESM). The MSERP has two features that are relatively unique amongst NASA safety panels. First, NASA Engineering was added as a Panel co-chair, which enhanced the Engineering organization's engagement and level of understanding of hazard analysis methodology and results. The MSERP has representation from each office, including Flight Operations Directorate (FOD) and Health and Medical Technical Authority, supporting the Orion Program in addition to the Engineering and Safety Technical Authority co-chairs. Second, the JSERP has a second set of co-chairs from ESA Engineering and ESA Product Assurance and Safety organizations, which recognizes the international arrangement as one of partnership.

This paper will focus on SMA processes, activities, and plans for the Orion element and explore unique challenges associated with Artemis II as we approach the flight of the first crewed Orion vehicle.

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## 1. INTRODUCTION

The Orion Spacecraft completed its first integrated flight test with the Space Launch System (SLS) and Exploration Ground Systems (EGS) in 2022, launching atop the SLS on November 16, 2022, from Kennedy Space Center LC-39B and splashing down on December 11, 2022, in the Pacific Ocean off Baja California.

During Artemis I, Orion's performance demonstrated the technical capabilities of the spacecraft by completing a 1.4-million-mile journey from Earth to the Moon, entering a Distant Retrograde Orbit of the Moon where it achieved a max distance of 268,563 miles from Earth, and then returning to Earth with a mission duration of 25.5 days.

The Orion Safety & Mission Assurance (S&MA) Team supported the Orion Program throughout the spacecraft development, test, production, launch and operations through a rigorous set of processes defined in the MPCV Orion S&MA Plan. The Artemis I uncrewed test flight provided a valuable opportunity to exercise the processes leading to flight and the ground support teams operating and monitoring the spacecraft during the mission from pre-launch through splashdown and recovery. During the mission, the Orion S&MA Team supported the Orion Mission Evaluation Room (MER), Common Exploration Systems Directorate (CESD) Safety Console, Anomaly Resolution Teams (ARTs), and the CESD Artemis I Mission S&MA Backroom. As the Orion Program completes its final assessment and report for the Artemis I mission, the Program now turns its focus to Artemis II and the flight of the first crewed mission to the moon in over fifty years. At the core of every activity the Program executes in preparation for this next historic mission are the fundamental core values of safety and quality.

*Figure 1. Artemis I – Orion Outbound Powered Flyby (OPF) Flight Day 6, Nov. 21, 2022.*

## 2. EXECUTING THE ARTEMIS I MISSION

No space mission is without risk due to the inherent hazardous nature of space systems, the unforgiving operational environments, complexity of the systems and interfaces involved, challenges with testing every system and component exactly to flight configuration and environments, and new technologies being flown and demonstrated for the first time. As the Space Shuttle Program demonstrated twice, even with many successful flights, disaster can strike at any time with space systems and components thought to be safe for flight and the personnel involved. Artemis I presented unique risks associated with being the first flight of SLS and Orion together and the first test flight of Orion beyond LEO with many systems and configurations not present during the 2014 Orion Exploration Flight Test (EFT-1).

*Figure 2. Artemis I – Wet Dress Rehearsal, Kennedy Space Center (KSC), June 14, 2022*

The challenge for S&MA is to analyse these complex systems and environments over the course of the development, test, and evaluation campaign to ensure a complete hazard control approach is implemented and verified through defined processes that involve review from many cross-discipline stakeholders and that the system meets an acceptable level of risk before the vehicle is certified for flight. Additionally, S&MA is responsible for ensuring that the development, production, assembly, integration, and test has been conducted to the NASA standards and requirements for human spacecraft through its Quality Assurance function and the suppliers' Quality Management System (QMS). Through an understanding of the unique hazards associated with the system design, the system and component reliability, and environment, along with assuring adherence throughout the entire lifecycle to quality requirements, S&MA can analyze the residual risk inherent in the system to inform decisions makers such as Program Managers, Mission Managers and Mission Management Teams (MMT) who are responsible for accepting that risk to authorize the flight operation of the system.

To inform the Orion Program Manager and MPCV Program Control Board (MPCB) of the residual risk the program would have to accept for Artemis I, the MSERP reviewed the system safety analysis and hazard analysis provided by the Prime Contractor (Lockheed Martin Space Systems) and Government Furnished Equipment (GFE) providers for flight hardware/software to ensure compliance with the MPCV Program's system safety requirements and assess the adequacy of hazard controls and verifications. These reviews were conducted in Phase Reviews that followed the subsystem and component development both for Prime Contractor furnished and GFE furnished projects. The Phase Reviews (Table 1) set expectations of completeness and maturity of the hazard controls, verification methods and verification closure with the specific lifecycle phase of the project. The final phase review (Phase 3) was conducted by the MSERP to provide final verification that requirements had been met or approved to be transferred to the Verification Tracking Log (VTL). The MSERP Co-chairs reported to the MPCB regularly to inform Program leadership of significant findings during Safety Reviews. After the Phase 3, the hazard reports were brought to the MPCB in groups for final risk acceptance with a summary of the causes, controls, and verifications, with more detailed rationale for causes with elevated levels of risk. Hazard causes with elevated risk were presented to the Exploration Systems Directorate (ESD) Control Board for acceptance (ref. Figure 3). For Hazard Reports that involve the ESM, the JSERP reviewed and approved Hazard Reports. This methodology provided the Program confidence that the system had been analyzed and reviewed to deem it acceptably safe to fly.

| Phase Review | Lifecycle Phase | Purpose |
|---|---|---|
| Phase 0 | SRR<br>SDR | Phase 0 is used for Projects unfamiliar with Safety Review Process. |
| Phase 0/1 | PDR | Identification of hazards and causes, as well as discussion of hazard |

| | | |
|---|---|---|
| | | control strategy. |
| Phase 2 | CDR | Identification of hazard controls and verification type (E.g., test, analysis, inspection). |
| Phase 3 | SAR/DCR | Focus on verification closure. |

*Table 1. Orion Safety Review Process*

The completion of required Safety Reviews for the Orion system is a success criteria for Program PDR, CDR and System Acceptance Review (SAR)/Design Critical Review (DCR) for each mission including Artemis I and plays a key role in establishing the Certification of Flight Readiness (CoFR) where key stakeholders across the Program and Technical Authorities endorse and certify the safety and operational readiness of flight hardware/software, mission critical support equipment and software, hazardous facilities/operations, and high energy ground-based systems.

One of the challenges that faced the Orion Program and Enterprise leading to the Artemis I launch was the introduction of new risks after the completion of the Safety Reviews, SAR/DCR, and CoFR leading up to and even after the Flight Readiness Review (FRR). For example, lightning strikes, pad stay exceedance, and pad winds due to tropical weather events resulting in minor fairing Thermal Protection System (TPS) loss at KSC introduced new risks that required analysis to determine if the issue presented any change to the baseline hazard report risk score. For these issues, the Program Management Team (PMT) evaluated the risk with Orion S&MA providing the Phase 3 baseline risk for the hazard and along with engineering and contractor teams, performing an assessment increase in risk score from the baseline. This joint analysis was presented to the PMT to make a risk-informed decision on the flight worthiness of the Orion system and any associated impacts to the residual risk already accepted by the Program and/or MMT.

During the Artemis I mission, Orion S&MA provided support to both the CESD S&MA Backroom, the MER Safety Console, and MER-led ARTs. Like activities leading up to and prior to the launch, the baseline Hazard Reports played a key role in determining the risk to the vehicle and mission as issues arose. As flight anomalies were recorded by the Flight Operations Team and MER, the CESD S&MA Backroom would log these items into the Flight Safety Office and Risk Database (FSOARD) to document the anomaly, the remaining failure tolerance in the system, potential mission impacts because of the failure, and the criticality that was used to inform the Mission Risk Matrix (MRM). The process of entering FSOARDs and completing the MRM each flight day relied heavily on complete and thorough Failure Mode Analysis and Effects (FMEA)/Critical Items List (CIL) and Hazard Reports. Orion S&MA is staffed with a Vehicle Safety Engineers (VSEs) for each major subsystem of the spacecraft elements, including the CM, ESM, and LAS (Launch Abort System).

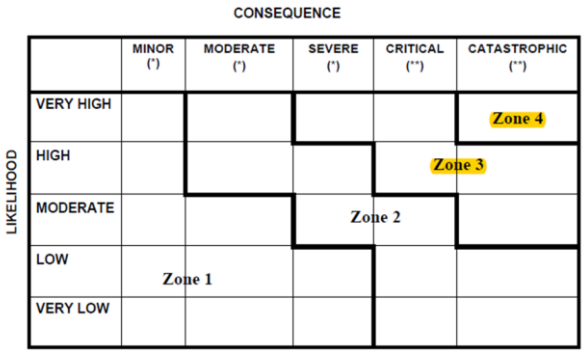


FIGURE 5.5-1 RESIDUAL RISK ACCEPTANCE AUTHORITY

Notes:
Zone 4 - NASA Administrator
Zone 3 - ESD Control Board
Zone 2 - MPCV Program Control Board

*Figure 3. MPCV Orion Program Hazard Risk Acceptance and Approval*

TABLE 5.3.4-1 HAZARD LIKELIHOOD AND SEVERITY

| Description | Hazard Likelihood Definitions |
|---|---|
| Very Low | **Qualitative**: Extremely remote possibility that it will happen. Strong controls in place. **Quantitative**: ~P ≤ 1/100,000 |
| Low | **Qualitative**: Not expected to happen. Controls have minor limitations or uncertainties. **Quantitative**: ~1/100,000 < P ≤ 1/10,000 |
| Moderate | **Qualitative**: Not likely to happen. Controls exist, with some limitations or uncertainties **Quantitative**: ~1/10,000 < P ≤ 1/1000 |
| High | **Qualitative**: Likely to happen. Controls have significant limitations or uncertainties. **Quantitative**: ~1/1000 < P ≤ 1/200 |
| Very High | **Qualitative**: Very likely to happen. Controls are insufficient. **Quantitative**: ~1/200 < P |

| Description | Hazard Severity Definitions |
|---|---|
| (*) Minor | **Personnel**: Minor injury not requiring first aid treatment, minor crew discomfort **Facilities, equipment, assets**: Minor damage to non-essential flight/ground assets |
| (*) Moderate | **Personnel**: Injury requiring first aid treatment, moderate crew discomfort **Facilities, equipment, assets**: Major Damage to Non-essential flight/ground assets |
| (*) Severe | **Personnel**: Injury or occupational illness requiring medical treatment **Facilities, equipment, assets**: Damage to significant flight/ground assets |
| (**) Critical | **Personnel**: Injury or occupational illness requiring definitive/specialty hospital/medical treatment resulting in loss of mission **Facilities, equipment, assets**: Loss of mission, condition that requires safe haven, or major damage to essential flight/ground assets |
| (**) Catastrophic | **Personnel**: Loss of life or permanently disabling injury **Facilities, equipment, assets**: Loss of vehicle prior to completing its mission, or loss of essential flight/ground assets |

*Figure 4. MPCV Orion Program Hazard Likelihood and Severity Descriptions*

The Orion S&MA VSEs, counterparts to NASA Engineering System Managers and Lockheed Certified Project Engineers (CPE), understood the technical details of the systems and were able to assess the failure tolerance and impacts of the anomaly and the likelihood of future in-flight occurrences and their impacts due to

the timing and mission phase. Some Items for Investigation (IFI) or In-flight Anomalies (IFAs) required the Orion MER to form a special ART to work the issue to determine root cause and any operational impacts or workarounds quickly. Orion S&MA VSEs participated in important ARTs during the mission that heavily influenced the Orion PMT and MMT's determination of mission risk. Again, much of the residual risk with IFI/IFA during flight was anchored by the risk identified in the baseline Hazard Report for the system or component and the likelihood and consequence of a failure.

As the Artemis I flight progressed and systems were better understood with observed performance exceeding expectations in many cases, the Flight Operations Team posed the idea of stressing certain systems further than planned to obtain more flight data to better inform the teams about the vehicle for future, more demanding flights. An Orion Program team was formed to develop and plan additional Flight Test Objectives (FTO) to implement during the mission. Orion S&MA evaluated these additional FTOs for impact to risks to the vehicle and mission success and were part of the signature loop for the mission action requests. These FTOs provided invaluable data to the Orion Program and Lockheed teams on the performance and capabilities of the Orion spacecraft ahead of Artemis II, but more importantly, ahead of longer, more complex missions. Specifically, for Artemis III and Artemis IV, Orion will expand its capabilities to provide key functions to the Artemis enterprise such as 33 day+ missions and delivering Gateway module elements to Near-Rectilinear Halo Orbit (NRHO) as Co-Manifested Payloads (CPL) requiring power transfer from Orion in flight along with commanding of the CPL International Berthing & Docking Mechanism (IBDM).

With the gentle landing of the Orion CM under its three main parachutes in the Pacific Ocean on December 11, 2022, the activities related to Artemis I for the Orion S&MA team did not conclude. The Orion spacecraft was moved by the recovery team to the U.S. Navy's USS Portland and initially inspected bringing forth imagery of Orion's backshell and heatshield. After arrival back at KSC in late 2022, all the Orion flight and instrumentation data was downloaded for engineering teams to assess. Additional IFIs were identified post-landing that required support from Orion S&MA. For Artemis I and future Orion missions, Orion S&MA is responsible for tracking the closure of all non-conformances with the Orion vehicle leading up to (post-delivery to EGS) and during the mission and assessing the need for corrective action.

*Figure 5. Artemis I – Orion Earth return and splashdown, Flight Day 26, December 11, 2022*

The Artemis I mission was highly successful in demonstrating the 161 intended FTOs for Orion including 21 test objectives added during the mission. The Orion spacecraft traveled 1.4 million miles, generated 22% more power than predicted, consumed 25% less power than predicted, received ~38,000 uplinked commands, downlinked ~155 GB of data and splashed down 2.4 miles from the target.

*Figure 6. Artemis I – Orion Crew Module recovery, Flight Day 26, December 11, 2022*

## 3. PREPARING FOR ARTEMIS II+ MISSIONS

Artemis II will be a second flight test of the SLS and Orion spacecraft and the first flight with human crew by executing a 10-day mission that includes a flyby of the Moon and return to Earth. The mission will serve to confirm all of the spacecraft's systems operate as-designed and intended with crew on board and operating in deep space. The mission will also demonstrate Proximity Operations with the SLS Interim Cryogenic Propulsion Stage (ICPS) to provide performance data and operational experience with both the crew and ground personnel ahead of dockings with the Human Landing System (HLS) and CPL and Gateway on Artemis IV+ missions.

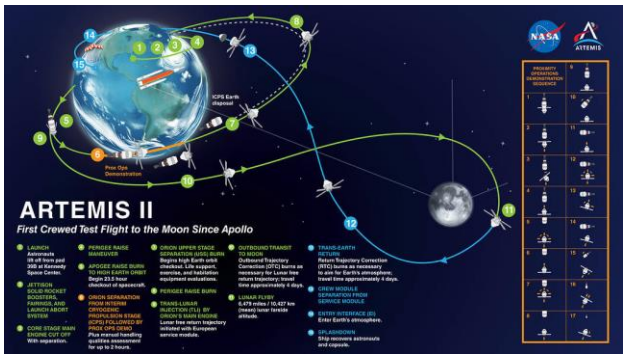


*Figure 7. Artemis II Mission Map*
Artemis II Map | NASA

The Orion S&MA activities in support of Artemis II will be like those of Artemis I and verify the system has met Orion Program system safety requirements ahead of the Artemis II vehicle SAR/DCR. For the most part, the Artemis II vehicle is the same as Artemis I, however there are added systems that were not flown on Artemis II, such as the complete Environmental Control and Life Support System (ECLSS), flight crew equipment and interfaces through the Displays and Controls subsystem, and a fully functional and armed LAS. Orion S&MA will concentrate efforts on hazard control verifications for systems that have changed or been added since Artemis II or for any heritage verifications that have changed. Artemis I included 35 Hazard Reports with over 2,000 hazard control verifications and with new and updated systems for Artemis II, there are now 48 Hazard Reports that include ~2800 hazard control verifications. One key activity for Orion S&MA is to ensure the Hazard Reports are complete and accurate since Orion S&MA's CoFR is strongly tied to the review of safety products for completeness, accuracy, and compliance to Orion Program safety requirements. Orion S&MA VSEs will assess their systems for needed verification assessment based on if the hardware (or system) is "new" (first flight article) for Artemis II. The criteria for Artemis II hardware design being the "same" as flown on Artemis I will be based on whether additional qualification activity is needed for Artemis II and no significant changes to the hardware (or system). VSEs will review the verifications included in the Hazard Reports and compare those against open work and issues. This updated process will maximize the efficiency and concentrate Orion S&MA efforts on those items and verifications that have not previously been reviewed.

In parallel with the hazard control verifications, the Orion S&MA team participates in all Failure Review Boards (FRB) on both the ESM and Crew and Service Module to understand how any hardware/software test failures may impact hazard verifications or risk; and ensure the impacts are assessed and documented. Orion S&MA is also a voting member of all Program Material Review Boards (PMRB), where non-conformances that impact NASA requirements, interfaces, or hazard controls are reviewed for acceptance (often in advance of a variance request).

The Artemis II Orion spacecraft will include hardware that was previously flown on Artemis I and any changes to these hardware items will be assessed for before acceptance and integration activities and, if there are no changes to the hardware or its design, VSEs are not required to investigate further. Again, this is to maximize Orion S&MA resource efficiency and dedication to items that deserve the most attention. New hardware (or systems) for Artemis II will be where most of the review will be conducted by Orion S&MA. Orion S&MA VSEs will concentrate their review on the qualification of the new design or design change and the hazard control verification closures.

For Artemis III, a new opportunity has been introduced to Orion suppliers to transform the Orion Program Quality Assurance function from an oversight model to an insight model if the supplier met certain NASA quality criteria to meet challenges for both an affordable and safe exploration class spacecraft for the U.S and its International Partners. The implementation of the Orion Supplier Quality Excellence Partnership (OSQEP) seeks to better align the Quality Assurance function with operating paradigm of the Orion Production Operations Contract (OPOC) to improve cost and schedule of the Orion Program and to better hold suppliers accountable for the quality hardware/software they will provide to the Orion Program. The OSQEP is a certification program that allows qualified suppliers to operate without Government Mandatory Inspection Points (GMIP). The OSQEP criteria is defined in the MPCV Orion S&MA Plan and suppliers who meet these conditions can partner with NASA and provide acceptable preventative and detective controls for critical attributes can build and provide NASA hardware without the additional costs and schedule impacts of GMIPs. NASA Procedural Requirement (NPR) 8735.2B (revision that Orion Program currently uses) allows for exceptions based on documented risk analysis where technical analysis of risk factors indicates acceptably low probability of noncompliance. These qualified suppliers demonstrate exceptional quality assurance policy and practices and therefore present an acceptably low risk to the Orion Program and to mission success. These suppliers are allowed to operate with minimal government oversight in exchange for increased insight. The OSQEP is developed based on successful Risk Based Quality (RBQ) strategies that have been tried and tested for specific Orion hardware as well as from lessons learned from other NASA Programs including the Launch Services Program, the International Space

Station (ISS) Program, Commercial Crew Program (CCP), and the SLS Program.

The OSQEP has been awarded to Lockheed Martin Space and Aerojet, with other major subcontracts in the evaluation stage currently. LM's minor suppliers are also included unless they have been jointly deemed as higher risk by NASA and LM and thus retain GMIPs. OSQEP is not applicable ESA as they are an international partner with their own Product Assurance authority. Any of the suppliers within the scope of this partnership may choose to apply to become an Orion Supplier Quality Excellence Partner. Upon application, the supplier is evaluated against the required criteria and if awarded by NASA, that supplier is allowed to operate without GMIPs except for very limited cases. Partnerships are evaluated on an annual basis and are renewed based on acceptable performance. Partnerships may be revoked at any time based on poor performance or poor adherence to the requirements defined in the MPCV Orion S&MA Plan.

*Figure 8. OSQEP Awarded to Lockheed Martin Space, November 3, 2022, Houston, TX*
*(Left to Right: Melissa Flores (NASA), Aaron Decker (NASA), Kazi Kamruzzaman (Lockheed Martin Space)*

Through these Orion S&MA efficiencies with core S&MA functions, such as ensuring the completeness and accuracy of hazard reports and the implementation of risk-based quality model transformations from oversight to insight, along with many other Orion Program affordability initiatives, NASA seeks to provide a safe, reliable, and affordable spacecraft for human deep space exploration for Artemis II and beyond.

As with Artemis I, the Orion S&MA team will support the ground operations and flight teams during the Artemis II mission. The experience and lessons learned from flying the uncrewed Orion during Artemis I will strengthen the overall support to Artemis II during its first flight with crew. The Orion S&MA team will have an even deeper understanding of the vehicle as knowledge of the system improves with each activity, review and milestone is completed.

Artemis II is not the only activity being supported by the Orion Program and Orion S&MA. Currently at the KSC Neil Armstrong Operations and Checkout (O&C) Building, along with the Artemis II CM and ESM are the Artemis III and Artemis IV CMs in production flow. To prioritize resources, Orion S&MA carefully considers the number of vehicles in flow at the O&C at one time, the mission manifest, and the unique hardware associated with that build, including reuse. Artemis III will be the first mission to land humans on the lunar surface in more than 50 years and will include the first woman and first person of color. Artemis IV will introduce Orion as the vehicle responsible for delivering Gateway module elements to NRHO and docking them with the orbiting outpost as the International Community through the Artemis Accords prepare to explore even deeper into space beyond the Earth's moon with human crew.

*Figure 9. Artemis II Crew Members*
*(Left: Mission Specialist - Christina Hammock Koch (NASA), Top Middle: Pilot – Victor Glover (NASA), Bottom Middle: Commander – Reid Wiseman (NASA), Right: Mission Specialist – Jeremy Hansen (CSA)*

## 4. CONCLUSION

The Artemis I mission demonstrated the success of the efforts across the NASA and ESA organizations and their respective contractors to design, test, and produce a spacecraft capable of flying the next humans to deep space to the moon and beyond. The success of Artemis I was enabled by a rigorous S&MA program that implemented the necessary processes and activities to prove the vehicle was acceptably safe and capable of successfully meetings its mission objectives. The Orion S&MA Team played key roles during the development and production of the Orion System, the Artemis I vehicle, and during the flight operations while the vehicle and ground teams executed the mission. Leveraging the work to verify the safety of the Orion spacecraft for Artemis I, the Orion S&MA team will gain efficiencies and focus efforts on those hardware items (or systems) that are new for Artemis II. Recently

both Lockheed Martin Space and Aeroject Rocketdyne have been awarded and certified by NASA as Orion Supplier Quality Excellent Partners that will enable an affordable path forward to produce Orion hardware while meeting the rigorous standards of building human-rated spacecraft systems. Finally, Artemis I and Artemis II are just the beginning of an exciting time at NASA and its International Partners as we return humans to explore space to better understand our moon and prove technologies that will be used to eventually explore even further into space.

## 5. BIOGRAPHY

***Paul Collier*** *received a B.S. in Computer Science from Louisiana State University – Shreveport in 2002 and holds a Master's Certificate in Systems Engineering from CalTech. He has over 20 years of experience supporting various NASA and JSC Programs and projects, most recently serving as the NASA Orion Program Safety and Mission Assurance Manager. Prior to serving as the Orion S&MA Manager, he helped lead the Orion Moon to Mars (M2M) Integration Team as the Deputy M2M Lead responsible for developing requirements, agreements, and interface control documents for integration with Gateway, Co-Manifested Payloads and the Human Landing System for Artemis lunar missions involving Orion. He is currently pursuing a M.S. in Space Systems Engineering from The Johns Hopkins University with an anticipated completion date of August 2023.*

***Michael Ciancone*** *received a B.S. in Engineering (Fluid and Thermal Sciences) and a B.A in Psychology from Case Western Reserve University (Cleveland, Ohio, USA). He worked at NASA GRC during the inception of the Space Station Freedom Program as a subsystem engineer on the Solar Dynamics and Photovoltaic Power Systems. Michael served for one year as a Technical Policy Analyst in the Office of Space Station at NASA Headquarters during Challenger Return-to-Flight. Upon his return to NASA GRC, he served as Work Package 04 Safety Manager and Lead Safety Engineer for microgravity science payloads on Microgravity Science Lab (MSL-1). Michael transferred to NASA Johnson Space Center in 1997, where he has held a number of safety-related positions, including Executive Officer for the Shuttle/ISS Payload Safety Review Panel. Michael currently serves as the Safety Lead for Orion and the alternate SMA co-Chair for the MSERP. Michael is a Fellow of the American Astronautical Society (AAS), a Member of the International Academy of Astronautics (IAA) and a Founder of the International Association for the Advancement of Space Safety.*

***Melissa Flores*** *received a B.S. in Ocean Engineering from the Massachusetts Institute of Technology (MIT) in 2002 and an M.S. in Ocean Engineering from MIT in 2003. She then served five years as an officer in the United States Navy, first aboard the U.S.S. Preble (DDG88), then as the Unmanned Underwater Vehicle (UUV) lead at the Naval Mine Warfare Command. She joined the NASA Orion S&MA organization in 2008 and has held various positions in the organization including: Systems Safety integration, Vehicle Safety Engineer for Thermal Protection Systems, Crew and Service Module Lead Safety Engineer, S&MA Manager, and currently serves as the Deputy Chief Safety Officer.*

***Kevin J. McClam*** *is the Johnson Space Center Safety and Mission Assurance (SMA) Directorate's Chief SMA Officer (CSO) for the Orion program. Mr. McClam represents NASA's Office of Safety and Mission Assurance (OSMA) at Orion Program level boards, panels, and milestone reviews. He is responsible for the disposition of all variances to OSMA owned requirements applicable to the Orion Program and is responsible for assuring the technical integrity of all S&MA products and services performed by either NASA or the prime contractor. Mr. McClam started his aerospace career by joining Science Applications International Corporation in 1996, where he worked in a variety of areas. He served as the International Space Station SMA operations lead working the ISS S&MA console and worked on the Space Shuttle Orbiter Boom Sensor System Project for SMA during the STS-114 return to flight activities. In 2007, McClam joined NASA's SMA organization as the Thermal Protection Systems SMA vehicle systems engineer for the Space Shuttle Program and, subsequently, the Orion safety analysis and requirements lead. In 2011, McClam was the NASA SMA Lead for Boeing in the Commercial Crew Program during Certification Product Contract Phases I and II. He was selected as the deputy CSO for Orion in 2014 and as the Orion CSO in 2017. Mr. McClam received his bachelor's degree from the University of Texas at Austin.*