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USC ARTEMIS Project: Maximum Impact(MAXIM) Moon Mission Tribute to Apollo

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"*....it is the stated policy of this administration and the United States of America to return American astronauts to the Moon within the next five years."* – Remarks by Vice President Mike Pence at the Fifth Meeting of the National Space Council, Marshall Spaceflight Center, Huntsville, Alabama, March 26, 2019

Abstract

The current US administration has laid out a series of Space Policy Directives intended to reaffirm American preeminence in space in general and human space activity in particular. The directives provide a clear mandate to NASA to quickly return humans to the Moon with the clear intent to gain vital know-how to execute a long duration, endurance-class Mars expedition in the 2030s timeframe. Long duration interplanetary transit requires closing several critical knowledge gaps and retiring many risks involved with both crew safety and human factors as well as long duration vehicle systems engineering for deep space operations. NASA's lunar orbiting Gateway project evolved from these directives in order to create an architecture to eventually support interplanetary spaceflight.

In March 2019, the space policy of the US administration advanced the timeline for execution, directing NASA to land a woman and a man on the Moon by 2024. In response, NASA initiated Project Artemis in May. NASA has been targeting the south polar region for such a mission and studying options to integrate lunar landing options in the Gateway program. Through a creative collaboration with small private space companies with innovative ideas, the Commercial Lunar Payload Services(CLPS) program is designed to fly robotic precursor missions to provide NASA with lunar information ahead of astronaut activity.

In 2019, on the 50th anniversary of the historic Apollo 11 Moon landing, the studio chose to look for fresh, new ideas that support policy, while drawing attention to new and age-old customs and sensitivities our species seem to resonate with, that were not within the traditional domain of the scientific and engineering communities, at least not until recently. As scientific and engineering methods are employed to better appreciate and shape outcomes of those soft, anthropological, sociological, cultural and behavioral science disciplines, human spaceflight could pioneer the use of these values and tools to enhance human spaceflight projects, create a globally compelling and wholesome narrative, and promote developments in other hard technological arenas of endeavor as well.

Following the 2018 USC ADAM project that was presented at the 2019 IAC in Washington DC., the 2019 USC ARTEMIS Maximum Impact Moon(MAXIM) Mission Project chose to pay tribute to a unique group of high-achieving engineers and scientists and astronaut explorers who created and executed the Apollo program with such daring and precision. They went on to repeat the feat over and over, even succeeding in the face of peril, and in the process, caught the awe of the whole world, while paving the way to making us a truly space faring species.

Great civilizations and cultures of the world actively seek to preserve and protect their heritage. Preserving human space culture, especially the first excursions of our species on an extraterrestrial surface, is very important for our youthful nation as it must be for all humanity who cherish and yearn for freedom of thought and expression around the world since the vastness and resources of outer space presents the ultimate arena for it. As a step toward that goal, this USC ARTEMIS Project chose to examine, study and deploy methods to protect those Apollo sites on our Moon visited by Apollo astronauts, and to preserve the Apollo artifacts on our Moon, from natural degradation, and protect them from present and future artificial agents, for posterity.

Synopses of topics chosen by the 2019 Fall Graduate Space Concepts Studio follow the theme above and are presented as sections in the following programmatic report of this USC ARTEMIS: Maximum Impact Moon(MAXIM) Moon mission proposes a wholesome, globally acceptable program in a speedy lunar return of humans to the Moon, that pays tribute to the heroes of the Apollo era who put the first humans on the Moon.

Keywords: Return to the Moon, White House Policy SPD#1, Mars Forward Agenda, Gateway Project, Commerce

1. Introduction

The current US administration has laid out a series of Space Policy Directives intended to reaffirm American preeminence in space in general and human space activity in particular. The directives provide a clear mandate to NASA to quickly return humans to the Moon with the clear intent to gain vital know-how to execute a long duration, endurance-class Mars expedition in the 2030s timeframe. Long duration interplanetary transit requires closing several critical knowledge gaps and retiring many risks involved with both crew safety and human factors as well as long duration vehicle systems engineering for deep space operations. NASA's lunar orbiting Gateway project evolved from these directives in order to create an architecture to eventually support interplanetary spaceflight.

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Great civilizations and cultures of the world actively seek to preserve and protect their heritage. Preserving human space culture, especially the first excursions of our species on an extraterrestrial surface, is very important for our youthful nation as it must be for all humanity who cherish and yearn for freedom of thought and expression around the world, since the vastness and resources of outer space presents the ultimate arena for it. As a step toward that goal, this USC ARTEMIS Project chose to examine, study and deploy methods to protect those Apollo sites on our Moon visited by Apollo astronauts, and to preserve Apollo artifacts on our Moon, from natural degradation, and protect them from present and future artificial agents, for posterity.

The USC ARTEMIS Project chose to present a case to do this quickly, by the 50th anniversary of the last human to visit the Moon, starting the mission by 2022, concluding by 2024 latest, as mandated by the administration. The Apollo-type equatorial free-return mission profile was selected for a seven Earth-day daylight lunar surface traverse mission. A daylight rover traverse mission on mare terrain offers several safety advantages over a polar mission, especially for the first few lunar visits, five decades after Apollo. A phased approach to incrementally complex mission operations as executed by the Apollo program is proposed. The USC MAXIM mission will help to prepare both astronaut crew and allied space systems for more challenging operations in the lunar polar regions. Such human lunar surface activity would also remind all about US preeminence in human space activity, make maximum impact on national space policy, and help further strengthen a global coalition to engage in peaceful, progressive, cooperative and collaborative human space activity.

As American vision and largesse in supporting the International Space Station program is being extended beyond international partners now to make a truly global coalition with all nations participating to promote, preserve, protect and share the space cultural heritage our of species, we thought it fitting and proper that Americans pay tribute to the scientists, the engineers and the Apollo astronaut explorers who walked, drove, sang, prayed and played golf, and safely came home. We thought it important to remind the world and show a whole new generation where we had been fifty years ago, and what we did there. As some of the heros have departed and others age gracefully, it is time past to honor those very brave and unique corps of astronauts and their support team who showed what is possible for our species, if only we set our collective will and minds and hearts to do.

This USC ARTEMIS:MAXIM Moon Mission Tribute to Apollo team project is evolving a globally compelling narrative that evokes nostalgia in the Apollo generation, stirs awe and excitement into a new generation of explorers and adventurers all in the arena of human spaceflight, that weaves the human condition

and yearnings into the fabric of a hard, leading-edge applied science and advanced technology endeavour.

The following sections 2-8 are synopses of various concepts presented on December 17th, 2019.

Figure 1. USC Artemis Maximum Impact Moon Mission(MAXIM) Tribute to Apollo project logo

Work expands so as to fill the time available for its completion. – C.N.Parkinson 1955

2. Cislunar Transport and Communications Architecture

With accelerated plans to return humans to the Moon by 2024, alternative pathways and infrastructure must to be explored and proposed. To circumvent the reliance on the Space Launch System (SLS), a complex project with several schedule slips to date, this Artemis 2.0 MAXIM proposal presents the case for heritage and commercial launch vehicles and capsules that can be modified and utilized to expedite and decrease the reliance on a single system, the SLS, for transporting humans and cargo to create infrastructure on the Moon.

Obtaining crew rating certification on newly developed launch vehicles has proven to be an extremely challenging task. With the Orion, Dragon 2 and Starliner capsules close to their crew rating certification, a mission architecture is proposed that can leverage these spacecrafts for cislunar operations, atop already developed and human rated launch vehicles in operation today.

Furthermore, to support and document return mission, a communication architecture capable of live, near real-time communication in 4K is proposed. Using existing technology and platforms infrastructure and communication equipment can be placed in orbit around and on the surface of the Moon. [Figure 2a,b].

The successful Lunar Laser Communication Demonstration (LLCD) experiment has proven the capability to advance broadband Earth-Moon communication links and will provide many options for efficient lunar surface communication as well.[F

Small, low power satellite constellations in lunar orbit and terminals on the lunar surface may be networked to provide Earth- Moon broadband links with continuous mission coverage with ample redundancies.

Figure 2a. Cislunar communications constellation architecture concept with small low-power satellites

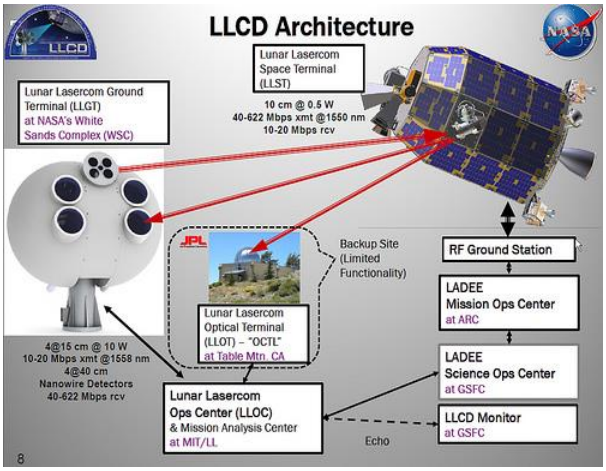

Figure 2b. Lunar Laser Communication Demonstration (LLCD) experiment has proven the capability for fault tolerant high bandwidth Earth-Moon communication.

If it ain't broke, don't fix it – Bert Lance colloquial heuristic

3. Fly Me to the Moon: The Common Descent Vehicle

The current US administration has laid out documents that direct NASA to refocus its efforts to put men and women on the Moon sustainably. Using that experience, and partnering with private industry, NASA will then work towards Mars missions. Other administrations have made similar charges, but the push to the Moon has never followed quite as earnestly as it has this time. Vice President Mike Pence also challenged NASA to double their efforts by shortening their timeline from 2028 to 2024, giving NASA only five years to land the first woman and the next man on the Lunar South Polar Region. The response to these directives and challenges is the Artemis program.

The Common Descent Vehicle (CDV) landing system is a proposal to get us back to the Moon in five years with a design that has real, proven flight heritage, a high success and safety rate, and a nostalgic element that will win public support. The Common Descent Vehicle (CDV), heavily based on the Apollo LM, could be used to ferry crew and cargo to the Lunar surface. The basic design would remain the same - the only redesign would be upgrades to avionics, ECLSS, and flight software, upgrades to new materials that would increase performance or reduce cost, and added capability for remote and limited autonomous operation. The hypergolic, deep throttling propulsion system has proven reliability and is best suited for this accelerated mission schedule with minimal upgrades. This CDV would also feature a standard payload interface that could be used to carry specialized crew or cargo modules. That element is key to the CDV design.

This standard payload interface, much like a launch vehicle has for its payloads, will make the CDV available for commercial use by virtually any customer. Interest and support from commercial partners could reduce development costs and program risk, enabling lunar missions to be profitable, as well as inspiring and scientifically important. Apart from the obvious scientific and exploration uses, possible business cases span from buying payload space on test missions to a fleet of cargo vehicles with space available for purchase to transport payloads to the Moon. The many business cases for CDV ensure that the next move into space by humans will be accompanied by tangible economic growth and the initial development of a true space economy.

The rationale behind this design choice is that the timeline for developing hardware for the Artemis landings is incredibly short. Even Apollo' aggressive development timeline was seven years from the LM RFP to the first Moon landing. Thus, a design strategy to use an incredibly successful and well-designed predecessor as a starting point was chosen to streamline the development process as most of the design, test and crew flightworthy certification work on the lander chassis has already been done. The development of a single descent stage for a variety of uses, both crewed and uncrewed, also saves initial development time and cost. Human rating a system is a long and tedious process, and starting from a human-rated system whose safety record is proven is an enormous advantage. The theme of this design is to upgrade and modify, not develop from scratch. [Figure 3].

4. LRadS: Lunar Radiation Studies, Apollo11 Site Preservation & Solar Activity Record Extraction

NASA's Artemis mission aims to land one woman and one man on the Moon's south pole by 2024 and take steps towards establishing a permanent human presence on the lunar surface. Instead, we propose a 2022 landing, 50 years after the last crewed lunar landing, in Mare Tranquillitatis as a tribute to NASA's Apollo program. Artemis will serve to inspire a new age of exploration and reaffirm a global love for human spaceflight. Meeting this compressed timeline will require NASA to form new international alliances, revamp existing methodologies, and forge new partnerships with private companies.

Astronauts will conduct radiation experiments to gain vital information for the health of long-term lunar inhabitants. First, they will drill into the lunar surface to learn how radiation dosage scales with regolith thickness and will then use the Caltech Axel Rover to explore and assess the environment inside a lunar lava tube.

Next, astronauts will pay tribute to the Apollo program by using state-of-the-art Lunar Roving Vehicles on their journey to the Apollo 11 landing site. There, they can digitally preserve the landing site using advanced technologies, including 360-degree cameras mounted onto extendable booms; allowing the scene to be virtually

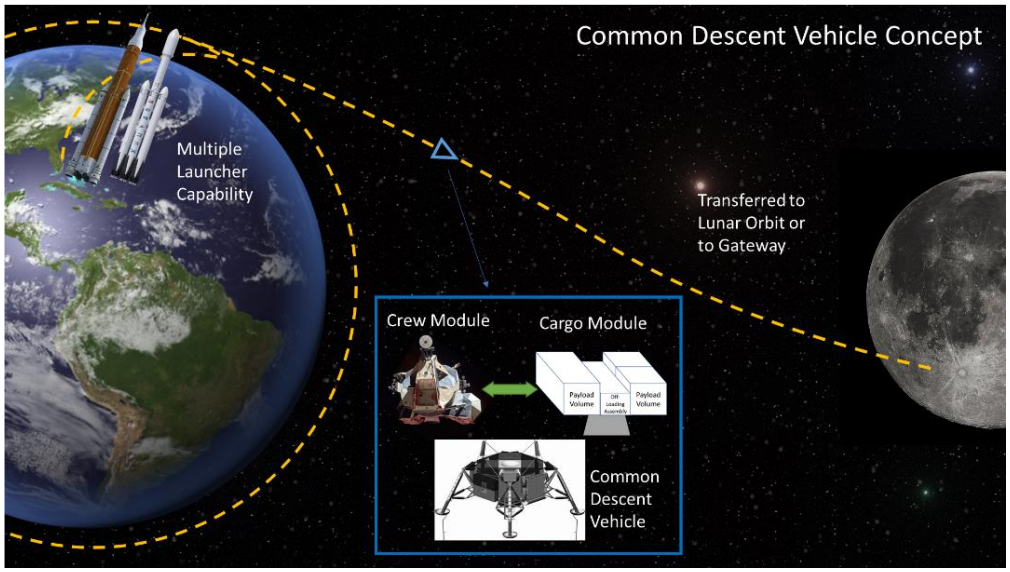

Figure 3. Common descent vehicle based on the Apollo lunar module(LM) and transit architecture

explored by the public. Additionally, they will retrieve the waste collection bags(jett bags) left by the Apollo 11 crew; these bags can give us a glimpse into the effects of the deep-space environment on the human microbiome. Additionally, the state of the bags will allow engineers to know if the waste management system needs to be redesigned for future Mars missions.

Carefully extracted cores, drilled from various sites along the traverse are proposed to be brought back to Earth to help build a reliable solar activity record spanning geological time. Such events are thought to be imprinted and preserved in the lunar regolith on our dormant Moon, that is undisturbed by dynamic tectonics or atmospheric weathering we see on Earth or other planetary bodies. Such a solar activity record would be invaluable to predict solar dynamics and help to understand and create accurate climate change models.

The Artemis missions will lay down the foundation for a permanent human presence on the Moon and yield hard data critical for Mars missions. Additionally, they will inspire a new generation of scientists and engineers to expand our reach further out into the solar system. Most of all, visiting the Apollo 11 site would serve as a tribute to the first explorers to set foot on an extraterrestrial surface and of America's historic achievements in space exploration. [Figure 4].

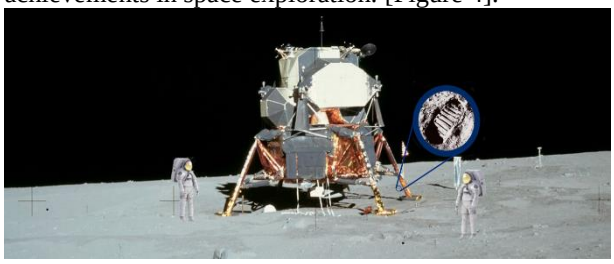

Figure 4. LRadS operations near the historic Apollo 11 landing site include site investigation & preservation

5. Mowing the Lune: Agriculture to the Lunar Ecosystem

This year marked the half-century anniversary of Apollo 11, the first successful manned mission to the Moon. And in recognition of the long hiatus from manned missions, Project Artemis was commissioned by the current administration to get astronauts back to the lunar surface by 2024. However, it is not enough to simply re-enact what we have done before. And while there is a clear outline for USC Project Artemis: Tribute to Apollo to visit the Sea of Tranquility and the original Apollo 11 landing site, to study the effects of weathering on Apollo artifacts exposed to the harsh lunar surface environment over fifty years since the historic touchdown, we need to not only catalog the past but also make strides toward the future. Toward that end, instead of having a mission that only visits old sites, collects samples, and returns, it is important to pioneer new technologies upon lunar landing. One of the most forward-looking ways to do this is with lunar agriculture that is critical to any permanent extraterrestrial settlement plans.Lunar agriculture presents a few challenges, all of which are critical to future space exploration: mechanics, chemistry/biological resources, and the time and money intensive research to overcome these challenges. The mechanics of plant growth will be different on the Moon due to new environmental conditions and altered gravity force. The chemistry of the lunar regolith is also different from that of soil on Earth as are the energy and water resources available. And – as an added challenge – the USC Project Artemis mission will last only about 14 days, which is not a lot of time for even a single seed-to-seed cycle of most plants. To handle these challenges, genetic modification of plants can be attempted, construction of radiation and micrometeor-safe infrastructure can be done, and studies on the effect of differing light and gravitational force on plant growth can be conducted on test plant specimens sent with the 2024 mission crew for transplantation on the lunar surface. Furthermore, to increase the probability that the plants sent to the Moon will survive, a series of experiments can be done on Earth simulating the harsher environmental conditions of the Moon to monitor plant response.

While this is a tall order to make of NASA alone, fortunately the space administration collaborates with the space initiatives of many other countries. Thus, this proposal seeks that NASA team up with global partners whom already have made headway in lunar agriculture to hone and build upon recent experiments and pre-existing ideas, make them space ready, and send plants to the Moon in 2024. Fig5a shows NASA-ESA effort underway in the Antarctica for fresh produce. There will be a goal of altering a handful of plants to have a shorter seed-to-seed cycle, proving that seed-to-seed viability during the mission, and comparing a series of controls to one another to determine the factors of the lunar environment that most affect plant growth and survival. At the conclusion of the manned mission, the vegetation can be left behind for monitoring over time, and the results of this on-site experiment can be extrapolated for future iterations to make lunar agriculture (and eventually agriculture on Mars) a sooner reality than previously thought possible.[Figure 5b].

Figure 5a. Fresh produce at the EDEN ISS experimental agriculture module in Antarctica.[credit ESA]

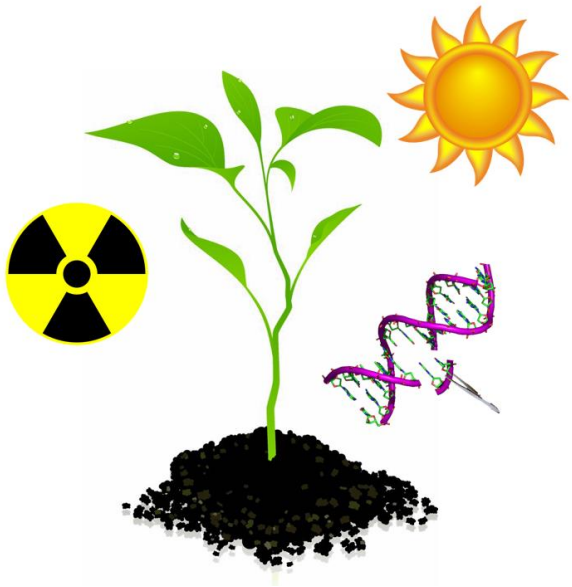

Figure 5b. Moon crops genetically engineered to thrive in the challenging lunar soil and radiation environment

6. All Access Lunar Exploration Camera Suite - ACCESS

The Trump administration mandated NASA to return humans to the Moon by 2024. State-of-the-art technologies exist to record and broadcast this historic mission in real time for the whole world to watch in crisp visual detail.

As part of the University of Southern California's 2024 Tribute to Artemis human Moon landing mission, the All Access Lunar Exploration Camera Suite-ACCESS proposal suggests placing a suite of robotic optical observatories on the lunar surface as part of this primary mission. Cameras, optical sensors and allied robotic technologies have dramatically improved over the past five decades. Telescopes and cameras will be mounted on all the landers and deployed in a sequence of operations that is detailed and choreographed in this concept architecture.

A primary payload on this mission is the Earth Observation Telescope that will be deployed near the lander. Using Lunar Laser Communication Demonstration- LLCD heritage, the camera will use a 10W laser to continually beam the Earth disc directly to receivers on Earth. Algorithms are used to track the Earth disc to compensate for lunar libration.

The spacecraft will host telescopes and a number of live streaming cameras for people on Earth to follow the progress of this mission even during cislunar transit. Cameras will also be mounted on the crew and service modules for the public to view the Moon and Earth as the mission progresses toward lunar orbit and touchdown. Using state-of-the-art technology, it is possible to record and relay in real time, the entire manifest of this mission, in the highest quality possible - 4K or better.

This facility will offer humanity a high-resolution live stream image of the Earth disc. Such a concept has been proposed as the first payload by the Moon Village Association, an international organization that is helping to coordinate the various space agencies to collaborate and follow best practices while planning and executing upcoming lunar missions. Redundant optical systems are employed both at the Tx and Rx end to support this architecture. The space qualified Kilopower system is augmented with the RTG power system to provide continuous, uninterrupted power for the Earth Observation Telescope during the long lunar night. Proposed mission design life for ACCESS is 50 years from commission date, with provision for service for anomaly resolution as needed.

In a phased approach over time, using interferometry, a very large telescope array can be built and commissioned on the Moon using two or more lander descent stages equipped with deployable radio telescopes. The radio telescopes, phase-locked with other Earth based antennae would employ long base Interferometry to observe deep space objects in the radio region of the EM spectrum, and attempt to probe the deep interior of the Milky Way galaxy among other deep space observations. It would serve as a technology demonstration for future augmentation with NRO ALMA and other Earth based radio observatories to create a very high-resolution Earth-Moon Radio observatory network, eventually including other similar descent stage dishes on Moon's far side. [Figure 6a,b]

Figure 6a. Earthrise from the Moon. A spectacular mosaic imaged by Lunar Reconnaissance Orbiter(LRO) offers a panoptic view of the Earth disc that appeals to the global public.[credit NASA LRO]

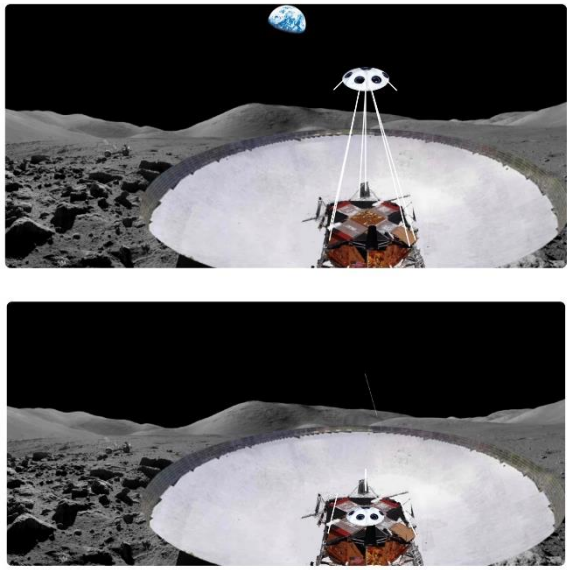

Figure 6: ACCESS lunar surface space observatory suite will also carry a high resolution Earth-facing camera to continually relay the live Earth disc image

7. Next Gen Rover and Landing Architecture

With the hopes of returning humans to the moon and eventually to Mars, NASA administration has been challenged with the goal of returning a man and woman to the moon by 2024. In an effort to achieve this goal, it is crucial to utilize existing proven technologies as much as possible. Rather than proposing a lunar mission to the south pole of moon, this mission would be a seven daylight mission to Mare Tranquillitatis Pit (MTP) to understand the viability of the pit being used as a natural infrastructure for a future human base on the lunar surface following up with traverse back in time to the first Apollo 11 landing site. Given the proposed mission, crew will need a new generation rover and landing architecture.

This concept focuses on the rover that the crew will operate as well as the landing architecture needed to land crew and cargo (rover) and safely transport crew back to Low Lunar Orbit (LLO) after mission is complete. LM1 will be an unmanned evolved Apollo lunar lander that will land autonomously near Apollo 11 site as a precursor mission in 2022. LM2 will follow in 2023 which will be an unmanned lunar cargo lander carrying rover vehicle that will land autonomously near MTP site but rather than landing vertically, will land horizontally. LM2 will utilize flight proven Apollo descent engine attached to cylindrical vessel (shown above) which will house the rover vehicle as well as telerobotic rovers that will scout the area and MTP before crew arrives. The rover vehicle be a variant of NASA's Multi Mission Space Exploration Vehicle(MMSEV) called Lunar Electric Rover(LER) (Pressurized) with modifications to simplify rover by using high Technical Readiness Level (TRL) systems. The rover will utilize solar panels on top of vehicle for power generation and larger battery pack to prepare for the approximate 400-500km traverse to Apollo 11 site. Crew can cover approximately 80-90km per day (8-9 hour drive time) assuming rover vehicle will be capable of 10km/hr and have crew reach Apollo 11 destination in five days. The rover vehicle will have the ability to be tele-operated by crew so that upon crew landing, vehicle will be commanded to reverse out of cylindrical vessel and down an extendable ramp to lunar surface.

LM3 will be an evolved Apollo lander carrying the crew in 2024 down from LLO to lunar surface, except this lander will contain an extendable docking port that can attach onto rover vehicle docking port. This is where the tele-operation of the rover vehicle comes into play, allowing crew to control the vehicle to attach onto LM3 docking port, eliminating the need for crew to don space suits and go outside of their pressurized capsule. Although planned mission will be for crew to ascend back to LLO utilizing LM1 ascent stage after their traverse to Apollo 11 site, if crew safety is comprised either shortly after landing at MTP site or shortly after traversing from MTP site, they can return back to LM3 and ascend into LLO.

Figure 7a. NASA Lunar Electric Rover(LER) is one variation of the multimission Space Exploration Vehicle

Figure7b, Several variations of Multi Mission Space Exploration Vehicle(MMSEV) are proposed.[NASA]

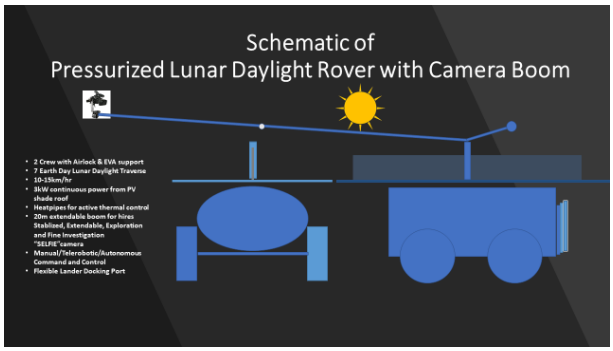

Figure 8. Lunar daylight rover with modifications to accommodate extended camera boom will allow the inspection of the Apollo 11 descent stage without disturbing the site. It will also provide closeup views of terrain features and dynamic "selfie" views of the rover and her crew during the traverse to the Apollo 11 site.

Execution is the chariot of genius.– William Blake 1795

8. Operation Hermes – Journey of USC Artemis: Tribute to Apollo

The idea behind this year's ASTE527 Studio Class outcome is about creating an alternative narrative for NASA's Artemis Mission that is fully focused on a fitting tribute to the 50th anniversary of the historic Apollo Program. The alternative mission, which is called USC Artemis, requires a crew and cargo transportation architecture from Earth surface to lunar surface, followed by a lunar surface traverse and back to Earth's surface again. The designed architecture is called "Operation Hermes" which is named after the mythological god of transportation, who is the half sibling of Artemis and Apollo. The operation could be viewed as Hermes helping his sister Artemis to get to his brother Apollo. Beside his god of transportation title, Hermes is mainly known as a divine trickster which perfectly fits the mindset of the USC Artemis Mission, the main goal being getting a woman and a man astronaut on the lunar surface by or before 2024. To be able to achieve this goal, USC Artemis Mission aims to trick the system by using mostly readily available space qualified and human rated hardware, and by relying less on any new or proposed system developments.

The current US administration's Space Policy Directives, especially SPD-1, clearly states the use of commercial and international partnerships which allows USC Artemis Mission to trick the system. Due to uncertainties posed by short timeline and cost overruns on complex transportation elements, the launch architecture of the NASA Artemis 2024 mission seems not reasonable at this point. It is for this reason Operation Hermes considered commercially available options rather than relying on NASA's Space Launch System. There are various ways to send astronauts from Earth's surface to the lunar surface but the easiest way is by using

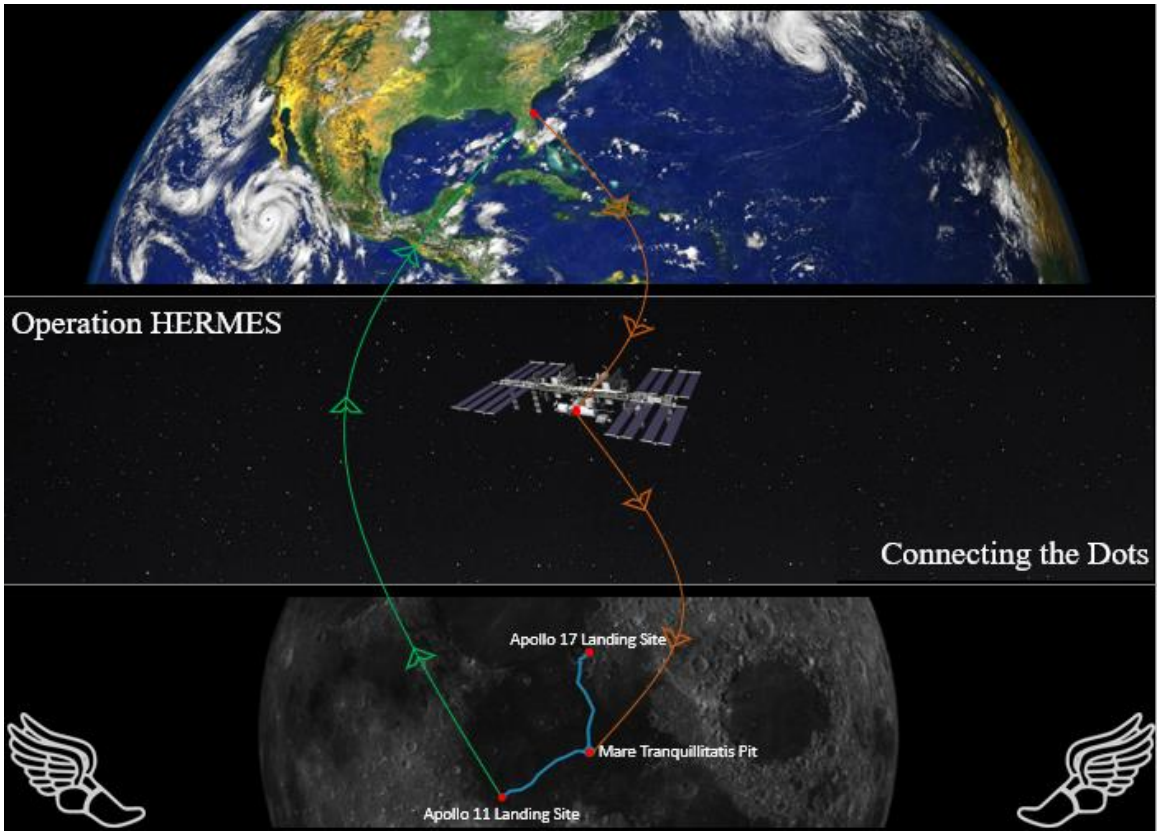

Figure 9. Operation Hermes mission schematic including International Space Station staging and lunar surface traverse from Mare Tranquillitatis Pit to Apollo 11 landing site

proven technologies that are readily available today. Currently, the most reliable way to send crew into space is via ISS operations; it has been done routinely for the last 20 years. So, instead of creating human-rated heavy-lift launchers for getting directly to Moon, astronauts could be sent to Moon via ISS by using proven launch vehicles. Though ISS is not in an inclination that supports efficient translunar injection, the precession of the ISS allows lunar departure a few times every lunar cycle. Such an option may be very attractive to lunar tourists in the future for those who wish to visit the ISS enroute to the Moon. SpaceX Falcon 9 with Dragon Capsule are already approaching human crew rating and nearly ready to send astronauts to the ISS from American soil by mid-2020. After that point, we only need an extra translunar stage and an Orion Capsule to send the astronauts from LEO to LLO. The remaining cargo payload, which also includes ascent/descent elements and roving vehicles, could be sent to the Moon using Falcon Heavy vehicles.

As described above, Operation Hermes also covers lunar surface transportation to meet the planned USC Artemis Mission objectives. Planned mission time on lunar surface, which is approximately a week, allows extraordinary surface operations opportunities for astronauts with Mare Tranquillitatis Pit (MTP) chosen as the main landing site. The main landing site not only has excellent characteristics for possible future lunar base but it is also close to the historic Apollo 11 and 17 landing sites. The smooth mare terrain allows for a swift rover traverse between them. The Journey of Hermes traverse operation is proposed to be in two phases: Phase-1 manned traverse to Apollo 11 landing site and phase-2 robotic traverse to Apollo 17 landing site. The distances between MTP and Apollo 11 and 17 are approximately 450 and 420 km respectively, allowing some margin for slopes and terrain obstacle avoidance. higher mobility of pressurized roving vehicles such as NASA-GM lunar electric rover, which has been tested extensively in NASA DRATS missions, will allow greater exploration range that is needed to meet mission objectives of phase-1. The rover, which will be designed for two crew, will be capable of both piloted and autonomous operations that would allow crew to rest during the traverse as needed. The rover design will also include an airlock and evolved Apollo lunar suits for EVA. The suit-port concept for EVA and accessories are not recommended for this proposal as more testing is required and additional safety protocols need verification before commission. Phase-2 of the traverse will be performed by the low lunar orbiting Command Module crew, teleoperating the robotic rover to the Apollo 17 landing site while supporting the Hermes traverse to Apollo 11 site. This regular two-hourly overflight and oversight feature by command module crew with the docked lunar lander throughout the surface traverse mission offers another layer of safety and supervision that is useful for the timely execution and safety of The Journey of Hermes, allowing the Hermes crew to be quickly extracted from the vehicle should the need arise for mission abort anytime during the dynamic surface traverse. [Figure 9].

9. Advantages of a lunar equatorial landing for USC Artemis:Maximum Impact Moon(MAXIM) Mission

1. Speedy lunar return of humans to the Moon while following SPD#1-4+ as guide
2. Maximum use of existing hardware, both domestic and global, to bring partners around the world together to execute the mission
3. Apollo-type free-return trajectory is safe for EM1-3+ missions while transportation and lunar landing systems are being flight tested and certified ahead of a more ambitious polar landing mission.
4. Daylight mission offers continuous solar power at high incidence angles, much better visibility of operations both for Artemis crew and mission control as well as for global public to watch the progress of the MAXIM mission in very high definition and much better and sharper depth of visual field.[Figure 12]
5. Smooth, well-lit mare terrain offers better approach and ascent characteristics and conditions for early piloted lander in preferred visual flight rules(VFR).
6. Smooth level terrain offers best testing ground for new rover mobility before attempting rugged, polar highland terrain in very poor, shallow and intermittent sunlight angles with deep shadows. [Figure 10.]
7. Proposed Mare Tranquillitatis region offers excellent science opportunities to explore pits using real time teleoperated robots.
8. Offers the whole world the opportunity to see the Apollo 11 site and for scientists and technologists to examine study and record half century lunar surface environment exposed Eagle lander descent stage hardware.
9. Study and employ strategies to preserve the first human boot prints on an extraterrestrial surface for posterity and set an example for the whole world to follow in the preservation of historical artifacts and an extremely fragile lunar environment.
10. Low lunar orbiting command module and spare lander provides additional layer of safety through continuous monitoring of mission progress during traverse, allowing much better and quicker surface mission abort and extraction of surface crew if needed. [Figure 11]
11. Satisfies all WH-SPD & NASA Artemis objectives

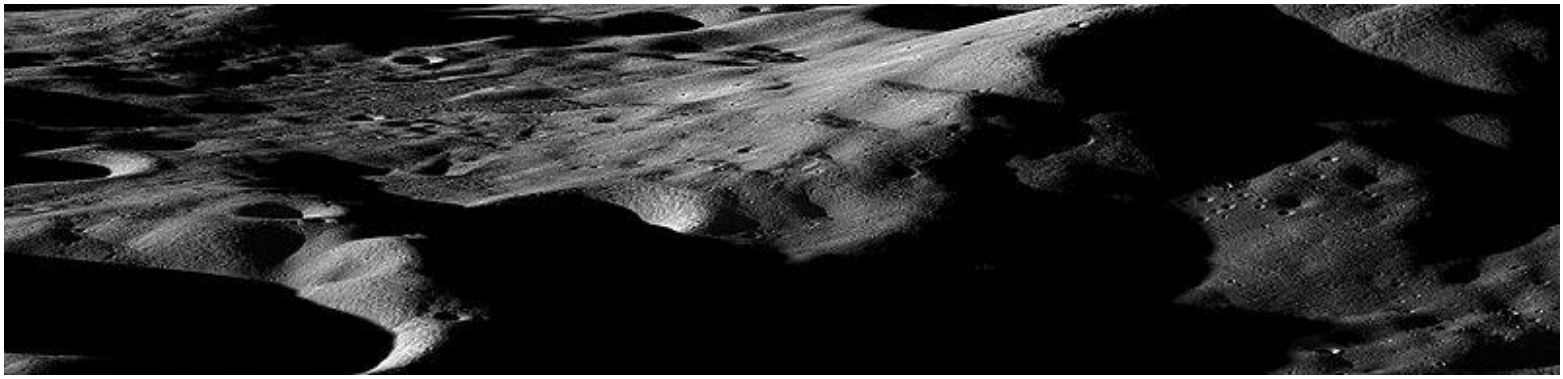

Figure 10. An oblique LRO view of the south polar region shows the rough and foreboding relief of the highland terrain. Combined with the low ambient lighting, it would be a very challenging approach for an early piloted Artemis landing. The deep & shifting shadows will not help with visual landmark identification during a surface traverse either. South polar region is better suited for early robotic operations.[credit NASA LRO]

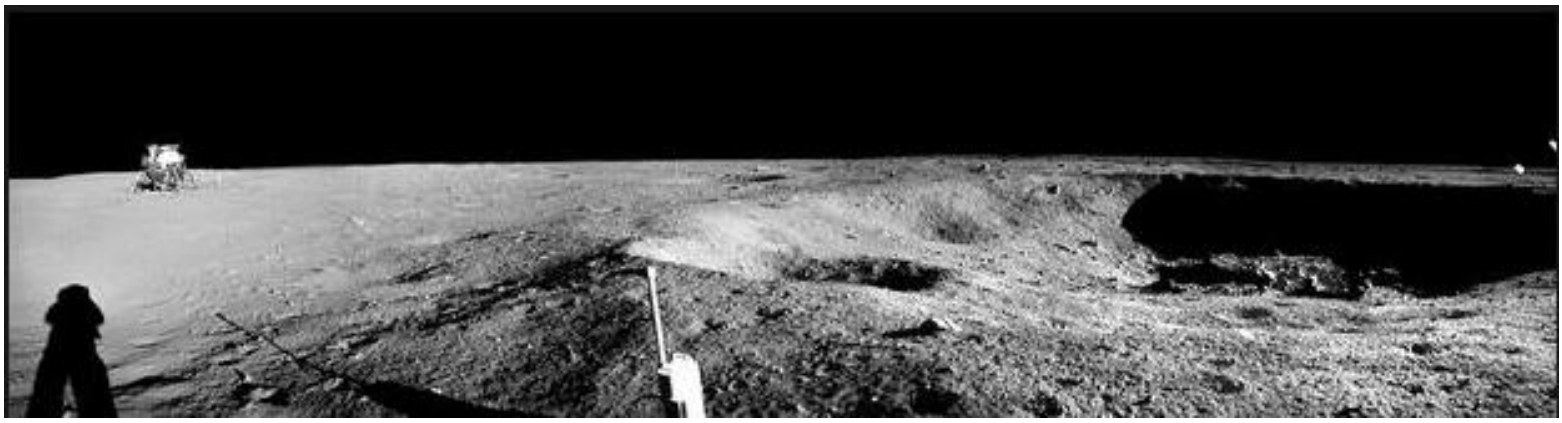

Figure 11. In comparison, equatorial mare regions like Tranquillitatis offer smooth terrain and excellent lighting for early, short duration lunar return missions and for evolving a new generation of LM-based human landing systems, as well as for long surface traverse by the lunar electric rover to explore pits using real time telerobotic agents, and to study and preserve our extraterrestrial heritage at the Apollo sites of vital interest. Such an experience proposed by the USC ARTEMIS:MAXIM Moon project is vital to gain confidence to evolve the systems and the reliability needed to explore and experiment with resources at the more challenging lunar polar regions. Such incrementally complex feedback is needed to evolve and commission systems that will enable us to build up infrastructure to "live off the land" on other planets or bodies later.[credit NASA]

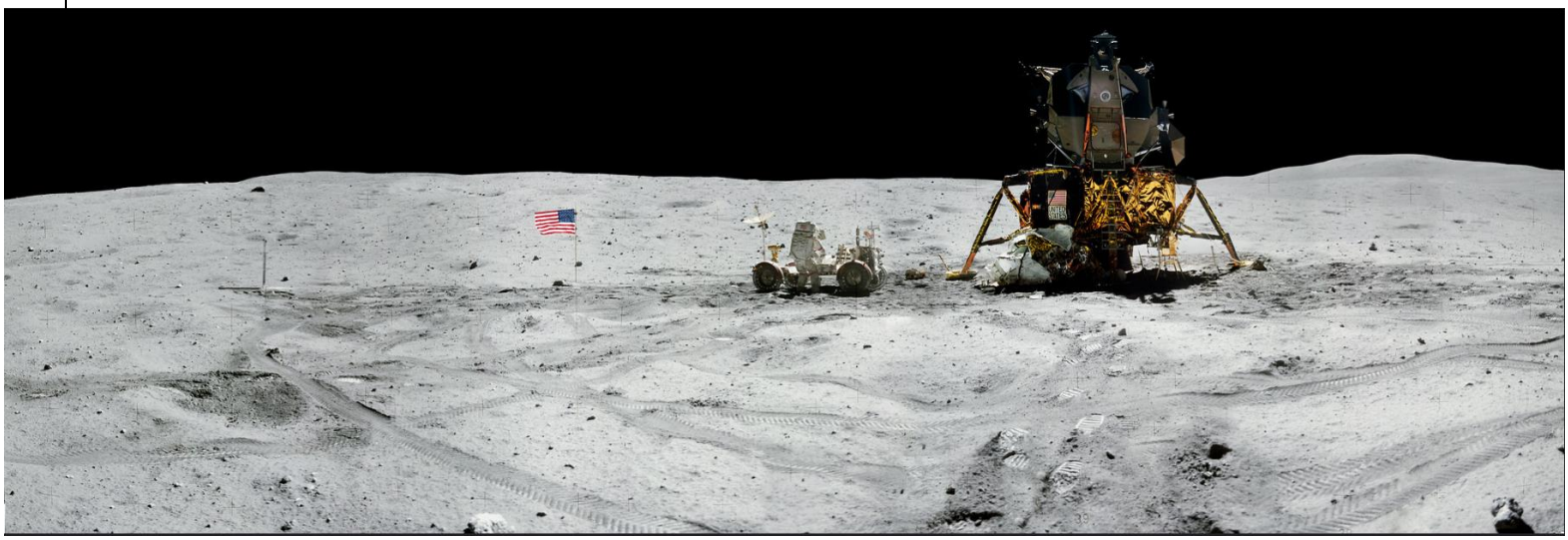

Figure 12. Solar illumination matters. Unlike the very shallow insolation angles of the south polar region that casts deep shadows that are severely compounded by lunar libration effects, uniform high elevation solar illumination on smooth rolling terrain on equatorial mares will provide ample uninterrupted photovoltaic power and also fine, sharp, deep field images of the landscape for global public to enjoy, and for astronaut activity and real time pilot navigation in particular, as the HERMES lunar surface traverse mission unfolds.[credit NASA]

10. USC Artemis: MAXIM Recommendations

- A compelling narrative for lunar return, one that inspires and educates the global public, and not focused only on advancing science and technology is needed.
- Use SPD#1-4+ and other recent documents as guide
- CLPS south polar exploration using robots is a good precursor strategy.
- Some CLPS missions could also manifest as precursors for first Artemis lunar surface missions to a le – e.g. commission beacons for precision landing, communications.
- Early lunar south pole missions better suited for robotic activity. Early human landings safer and better in lunar equatorial regions.
- The first Artemis human crew to be "daylight mission" in the equatorial region is a less risky approach for assuring mission safety and success, to make sure all systems of the Artemis architecture including cislunar cargo and crew transport, Earth-Moon communication systems, human landing systems, EVA and surface systems are all performing nominally in full sunlight .
- Mare Tranquillitatis Pits (MTP) exploration and Apollo 11 site as target landing site.
- Real time astronauts assisted telerobotic exploration of MTP
- A capable pressurized rover evolved variation of the multi mission space exploration vehicle (MMSEV) like the Lunar Electric Rover(LER) is needed for the MAXIM Mission.
- Use as much Apollo-derived and updated hardware as well as currently available commercial and global launch capability of international partners to integrate mission in LEO
- Maximum use of US commercial space companies
- Integration of lunar outbound systems in LEO allows more global participation, especially from emerging international space-faring nations
- Execute Project Artemis quickly, remind the world
- of our human spaceflight heritage, and pay homage to Apollo era heroes - 2024 timeframe

Global competition at the conceptual and design level, global cooperation and collaboration during mission manifest and execution - Buzz Aldrin @ the Hawaii Moon Conference 2018

11. How does USC ARTEMIS:MAXIM Tribute to Apollo team project help the US Human Spaceflight program ?

MAXIM paints a wholesome Artemis mission to set a woman and a man on the Moon by 2024, with a narrative that brings our entire species together, not one that only caters to the science and technology community, but one that has global appeal. MAXIM suggests speedy return of humans to the Moon, with all the capacity and capabilities of the spacefaring nations as well as those emerging. Since space activity, human space activity in particular, evokes awe and excitement among all humanity, not to mention nostalgia in the hundreds of thousands of Americans who were involved in the Apollo program, MAXIM suggests an exciting Artemis mission to the Apollo 11 site while also conducting dramatic telerobotic exploration of the Mare Tranquillitatis Pits and other experiments along the traverse route. To provide a dynamic experience, the MAXIM Hermes Rover traverse to the Apollo 11 landing site and the investigations there during the week-long surface expedition will provide the global public an experience very different from the Apollo missions, yet even more thrilling, to inspire the youth and young generation of explorers around the world.

MAXIM Moon mission will help to broaden grassroots support for a space program that needs a youthful and skilled workforce for America to continue to lead the world in human space activities. Several aspects of this MAXIM Moon mission suggest the use of homegrown private space companies that is recommended by the current administration's Space Policy Directives.

12. Conclusions

Vice President Pence asked NASA to step up the return of humans to the Moon by 2024. Shortly thereafter, NASA responded by proposing the Artemis Project to put a woman and a man on the Moon by 2024. Following the directives set out by the current administration, the USC ARTEMIS:MAXIM Project chose to present an architecture to execute the mission quickly, by the 50th anniversary of the last human to visit the Moon, starting the mission by 2022, concluding by 2024 latest, as mandated by the administration. A wholesome narrative including science and technology is discussed. The Apollo-type equatorial free-return mission profile was selected for a two-week end-to-end, seven Earth-day daylight lunar surface traverse mission. A daylight rover traverse mission on mare terrain offers several safety advantages over a polar mission, especially for the first few lunar visits, five decades after Apollo. A phased approach to incrementally complex mission operations as executed by the Apollo program is proposed. The USC ARTEMIS MAXIM mission to the equatorial Apollo site will help to prepare both astronaut crew and allied space systems for more challenging operations in the lunar polar regions. Such human lunar surface activity would also remind all about US preeminence in human space activity, make maximum impact on national space policy, and help further strengthen a global coalition to engage in peaceful, progressive, cooperative and collaborative human space activity.

As American vision and largesse in supporting the International Space Station program is being recrafted and extended beyond traditional international partners now to make a truly global coalition with all nations participating to promote, preserve, protect and share the space cultural heritage our of species, we thought it fitting and proper that Americans pay tribute to the scientists, the engineers and the Apollo astronaut explorers who walked, drove, sang, prayed and played golf, and safely came home. We thought it important to remind the world and show a whole new generation where we had been fifty years ago, and what we did there.As some of the heroes have departed and others age gracefully, it is time past to honour those very brave and unique corps of astronauts and their support team who showed what is possible for our species, if only we set our collective will and minds and hearts to do.

This USC ARTEMIS:MAXIM Moon Mission Tribute to Apollo team project is evolving a globally compelling narrative that evokes nostalgia in the Apollo generation, stirs awe and excitement into a new generation of explorers and adventurers all in the arena of a hard, leading-edge science and advanced technology endeavour.

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Figure above : Apollo Mission Flight Director Gene Krantz watches on as NASA Administrator Jim Bridenstine inaugurates the fully restored and functional Apollo mission control room at Johnson Space Center. Maybe we should fire it up to fly this USC Artemis: Tribute to Apollo MAXIM mission

Nostalgia : a sentimental longing or wistful affection for the past, typically for a period or place with happy personal associations. *"I walked into that room last Monday for the first time when it was fully operational. And it was dynamite. Basically, I just, I won't say literally wept, but ... the emotional surge at that moment was incredible." Kranz said in an interview with NPR. "I walked down on the floor, and when we did the ribbon-cutting the last two days, believe it or not, I could hear the people talking in that room from 50 years ago. I could hear the controllers talking."*

– Eugene Krantz, Apollo Flight Director

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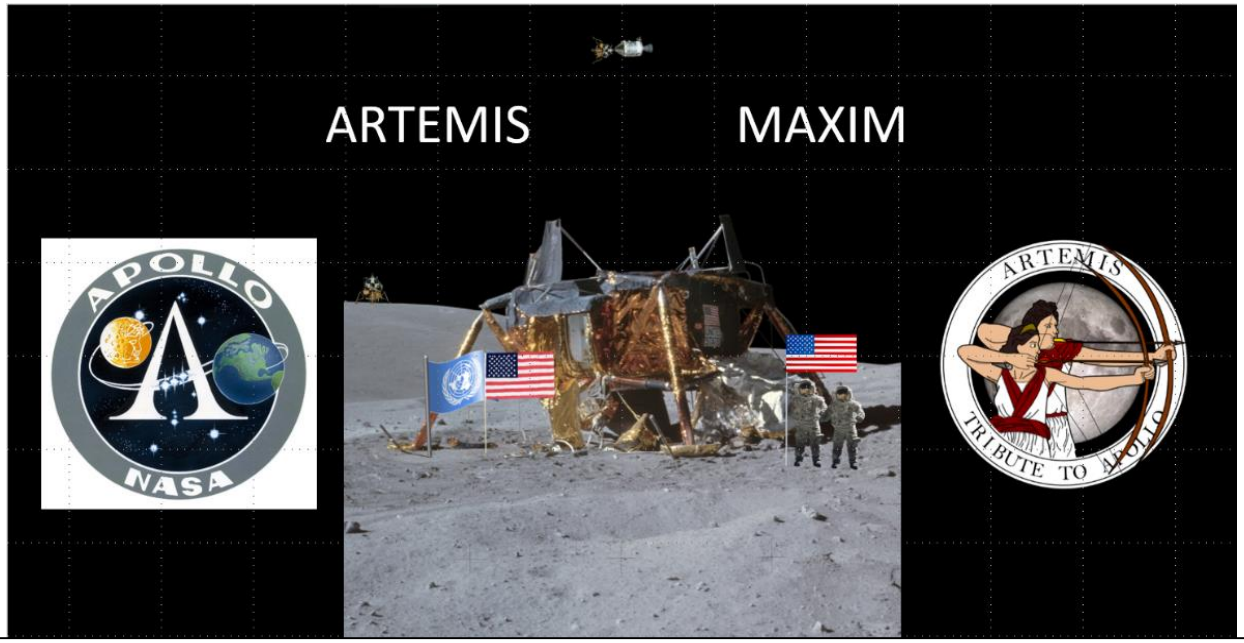

Afterword Several documents have been published by the current administration since USC ARTEMIS:MAXIM presentation in December of 2019, notably additions to the Space Policy Directives and the recent publication by the National Space Council " A New Era for Deep Space Exploration and Development". Rapid developments in the private space sector suggest a new paradigm that is less reliant on government resources is starting to dictate the future of space activity, especially in the newly shaping arena of self -sustainable human spaceflight activities. This is a healthy sign that speaks for itself. Commerce is the lifeblood of civilization, past, present and future. Commerce brings about peaceful and progressive coexistence among the rich cultures of the world to make a more vibrant, modern and pluralistic global society. Space commerce may have broken the traditional shackles of governments and have matured to become a truly self-supporting and lucrative commercial endeavour. And that is good.

E Pluribus Unum

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