

Exploring the Moon: Preserving the Legacy Through Spacesuit Knowledge Capture and Strategic Communication

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NASA is returning to the Moon to stay. To establish a sustained lunar presence, astronauts will pack spacesuits, surface-mobility tools, rovers, and decades' worth of knowledge. The U.S. Spacesuit Knowledge Capture (SKC) and Strategic Communications (Strat Comm) team is specialized in capturing, preserving, and sharing space-related knowledge with NASA scientists, technicians, engineers, vendors, and the public to support space exploration. Since the SKC Program's 2007 inception, its focus has been to capture and share valuable spacesuit-related knowledge with the NASA community. As the program evolved, its notoriety, funding, scope, and staffing expanded from a one-person, part-time, unfunded operation to a small-team, funded entity. Currently, this team has been formulated with a diverse skillset to meet the requirements of its stakeholders. The SKC and Strat Comm team has used its skills to produce over 260 recorded knowledge captures of subject-matter experts (SMEs) and photoshoots. These knowledge captures are in the form of photographs, lectures, workshops, vignettes, videos, and interviews containing essential space-related knowledge. To help educate the space community and public, this trove of information (e.g., videos of world-class facilities, photographs, and SME lectures), produced inside NASA Johnson Space Center, can be obtained through various sources. During Fiscal Year 2024, the SKC and Strat Comm team will focus on several initiatives. Examples of initiatives include the following: 1) share lessons learned during NASA's internal venues such as Safety & Health Day and Day of Remembrance; 2) share knowledge with the public, educators, and students through a media production titled *Exploring the Moon*; and 3) highlight NASA's unique capabilities and expertise in a video series titled *What's Behind This Door?* This paper discusses the team's approach, unique capture capability, initiatives, and much more.

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Nomenclature

<i>ARGOS</i>	= Active Response Gravity Offload System
<i>AX3S</i>	= Active Response Gravity Offload System (ARGOS) exploration extravehicular activity (EVA) Simulator
<i>COVID-19</i>	= coronavirus disease 2019
<i>EA</i>	= Engineering Directorate
<i>EC</i>	= Crew and Thermal Systems Division
<i>EC5</i>	= Space Suit and Crew Survival Systems Branch
<i>EHP</i>	= Extravehicular Activity and Human Surface Mobility Program
<i>EVA</i>	= extravehicular activity
<i>FY</i>	= fiscal year
<i>GTU</i>	= ground test unit
<i>IO</i>	= Imagery Online
<i>JSC</i>	= Johnson Space Center
<i>LTV</i>	= Lunar Terrain Vehicle
<i>NESC</i>	= NASA Engineering and Safety Center
<i>NTR</i>	= new technology report
<i>OSTEM</i>	= Office of Science, Technology, Engineering and Math
<i>PAO</i>	= Public Affairs Office
<i>SBIR</i>	= Small Business Innovative Research
<i>SKC</i>	= U.S. Spacesuit Knowledge Capture
<i>SME</i>	= subject-matter expert
<i>STEM</i>	= science, technology, engineering, and math
<i>Strat Comm</i>	= Strategic Communications
<i>STRIVES</i>	= Scientific, Technical and Research Information DiscoVERY System
<i>TVAC</i>	= Thermal Vacuum Chamber
<i>xEMU</i>	= Exploration Extravehicular Mobility Unit
<i>xEVA</i>	= exploration extravehicular activity
<i>xEVAS</i>	= exploration extravehicular activity (xEVA) services

I. Introduction

NASA'S Artemis generation is going to the Moon to stay, and the U.S. Spacesuit Knowledge Capture (SKC) and Strategic Communications (Strat Comm) team is helping to equip space engineers, technicians, and scientists with a collection of knowledge needed to accomplish this mission. Over 50 years ago, the Apollo Program safely launched humans to the Moon using collective knowledge and teamwork. For humans to return and have a sustained presence on the Moon, incremental knowledge, as well as the collaboration of many people, will be required. To make this human lunar endeavor possible, partnerships between NASA, industry, and international space agencies must be formed.¹

To borrow essential historically documented space-related knowledge and experience needed to meet NASA's mission, the SKC and Strat Comm team has a robust library built from the SKC Program's (logo shown in Figure 1) knowledge collected from subject-matter experts (SMEs) since its inception. The team continues to capture, curate, and share this knowledge through lectures, interviews, workshops, and vignettes to educate and stimulate the curiosity of current and future space enthusiasts and anyone supporting NASA's mission.



Figure 1. U.S. Spacesuit Knowledge Capture Program logo. (Image by NASA)

In 2007, the SKC Program was formed as a grassroots effort seeking to augment the education of NASA's spacesuit community, fill knowledge gaps, and secure knowledge from those retiring or anticipating retirement. It continues its efforts and achieves this by identifying, collating, and preserving valuable spacesuit-related knowledge and making it accessible to customers who apply it to support NASA's mission.² The program's function continues to align with the 2008 Johnson Space Center (JSC) Policy Directive that encourages JSC organizations to promote knowledge transfer, collaborative sharing, and required learning for successful missions.³

Initially, the SKC Program was maintained solely by the SKC Program manager, without funding. As it gained exposure, demand to capture essential spacesuit knowledge increased, resulting in the expansion of its staff size and funding. As the SKC Program continues to evolve, it adapts to meet the needs of its customers and has survived through various funding source fluctuations.

The SKC Program’s most recent major change in financial support came in 2022, when the Extravehicular Activity and Human Surface Mobility Program (EHP) (logo shown in Figure 2) began funding it. As a result, the SKC Program expanded its knowledge capture scope to support EHP’s mission and began to include strategic communications. Since then, the combined SKC and Strat Comm team has captured the spacesuit and many other pertinent human space-flight topics (e.g., Lunar Terrain Vehicle (LTV) and extravehicular activity (EVA) tools). Additionally, the team is subsidized by the NASA Engineering and Safety Center (NESC). The NESC Academy is the current repository of the SKC archives.

During the SKC Program’s infancy and formative years, its knowledge capture focused on spacesuits and ancillary topics delivered by SMEs, mainly through in-person classroom courses, to gain historical knowledge and foster discussions around lessons learned. Beginning in early 2020, learning to navigate through the spatial restrictions of the coronavirus disease 2019 (COVID-19) resulted in sharing knowledge using videoconferencing software. During that time, the SKC Program also seized the unique opportunity to capture and preserve the Exploration Extravehicular Mobility Unit (xEMU) buildup at JSC — the government reference spacesuit for human lunar exploration. This knowledge capture produced videography and imagery that revealed intricate technical details of the buildup and invited the xEMU community to virtually enter JSC laboratories where spacesuit components were being tested and integrated into the xEMU. For a compilation of the SKC Program’s history, refer to prior published SKC Program ICES papers.^{2,4-14}

As the SKC and Strat Comm team’s scope continues to evolve and expand, it is working to make captured knowledge more readily accessible and evident to its users. Simultaneously, opportunities increase for the SKC and Strat Comm team to capture and share important space-related knowledge. During the past two years, the Crew and Thermal Systems Division (EC), which is the home organization of the SKC and Strat Comm team, has requested that the team secure SMEs to share pertinent lessons learned during NASA’s Safety & Health Day and Day of Remembrance. These events emphasize the value of sharing and applying lessons learned to prevent repeating past mistakes. As NASA prepares to return humans to the Moon, these lessons are even more vital.

It has been over half a century since humans visited the Moon. NASA employees and contractors continue to be inspired by space-related experiences and lessons learned. However, most people outside the space community have not experienced the excitement that existed within NASA during the Apollo Program. To generate more public awareness, interest, and appreciation for space exploration, the SKC and Strat Comm team is expanding its reach and collaborating with NASA’s human space exploration contributors and supporters. The team is preparing to debut its *Exploring the Moon* media production — an in-depth look at NASA’s journey to the lunar surface. *Exploring the Moon* brings experts and astronauts together to uncover the spacesuits, tools, and other innovations that the Artemis missions will rely on for success. For anyone who wants to peek behind the scenes at JSC and learn more about NASA’s unique capabilities, the SKC and Strat Comm team began launching its *What’s Behind This Door?* videos on NASA social media platforms in March 2024.

The following sections elaborate on these endeavors and on the team’s knowledge capture approach, new initiatives, and plans for fiscal year (FY) 2024.

II. Approach

The SKC and Strat Comm team continues to set and achieve ambitious knowledge capture goals to collect, preserve, and disseminate space-related knowledge to the widest extent possible, as appropriate. The SKC and Strat Comm team plans to continue to capture knowledge, archive it, and disseminate it in a manner that supports the goals of its NASA stakeholders. The stakeholders include EHP, NESC, Engineering Directorate (EA), EC, and Space Suit and Crew Survival Systems Branch (EC5). EHP has emphasized external communication, including the promotion of



Figure 2. Extravehicular Activity and Human Surface Mobility Program logo.
(Image by NASA)

knowledge transfer across the EHP community and Exploration Extravehicular Activity Services (xEVAS) vendors,* ensuring the availability of relevant captured knowledge, and facilitating education through documenting technical progress, successes, and lessons learned. The NESC, EA, EC and EC5 have emphasized internal knowledge transfer to ensure that knowledge captured and lessons learned are rightly transferred to the next generation of engineers. Leveraging organizational position and access to immense subject matter capabilities, the SKC and Strat Comm team has an unprecedented variety of mechanisms to accomplish successful knowledge capture and dissemination to serve its stakeholders.

A. Unique Embedded Capabilities

Although the SKC and Strat Comm team has fewer than 10 members, it is rich in skills. The team has over 100 years of combined NASA experience, much of which is directly related to knowledge capture. The SKC and Strat Comm team is organizationally embedded within the JSC technical community, giving it a unique knowledge capture capability and the tools to help NASA achieve its mission.

Because the SKC and Strat Comm team understands NASA's organizational structure and processes, they know how to identify and encourage the experts to share pertinent knowledge and explain how it contributes to NASA's mission. Over the past 16 years, the SKC and Strat Comm team has developed strong relationships with technical experts and leaders at JSC. The SKC and Strat Comm team has proved its capability to direct camera crews through JSC laboratories to highlight the essential elements of the SME's story and communicate them to the appropriate audience. The technical community's trust and appreciation for the SKC and Strat Comm team allow the team unique access and insight. The team uses their expertise to network within and outside the space industry to deliver their products internally and to audiences worldwide, to increase the education of the space industry and broaden public interest in space exploration.

The SKC and Strat Comm team reveals its unique knowledge capture capability in its video recordings of SMEs' lessons learned, JSC testing facilities, and the buildup, assembly, and testing of hardware that is unique to NASA. In October 2023, the SKC and Strat Comm team captured imagery to document the thermal vacuum (TVAC) testing of the government reference xEMU (Figure 3). This test represented a major milestone for the project and provided valuable insight regarding how the suit would perform in the vacuum of space and in extreme thermal conditions. On April 3, 2024, NASA awarded contracts¹⁵ to Intuitive Machines, Lunar Outpost, and Venturi Astrolab to build the next LTV



Figure 3. Setup of the government reference xEMU TVAC test. (Image by NASA)

* For information on xEVAS, see: NASA Press Release 22-055, "NASA Partners with Industry for New Spacewalking, Moonwalking Services," June 1, 2022, URL: <https://www.nasa.gov/news-release/nasa-partners-with-industry-for-new-spacewalking-moonwalking-services/> [cited 11 March 2024].

See also: O'Shea, Claire A., NASA Press Release 23-075, "NASA Expands Options for Spacewalking, Moonwalking Suits, Services," July 10, 2023.

(sometimes called a Moon buggy) (Figure 4).^{*†} In parallel, engineers at JSC are building a ground test unit (GTU) to identify and understand necessary capabilities and requirements, as well as new technologies and materials that are being developed. The SKC and Strat Comm team is capturing imagery of this buildup for technical documentation and public awareness. The team has also captured multiple spacesuit runs of the Active Response Gravity Offload System (ARGOS) (Figure 5) and the buildup of the ARGOS Exploration EVA Simulator (AX3S), documenting this system’s unique capabilities (Figure 6). Capturing hardware imagery such as the TVAC testing, GTU rover buildup, ARGOS, and the AX3S provides current and future technical teams with useful reference images and a visual record.

B. Mechanisms and Functions

Collaborating with technical teams and SMEs provides the SKC and Strat Comm team with countless opportunities for knowledge capture. The team’s adaptability and variety of knowledge sharing mechanisms allow it to maximize the benefit of this access.

The SME presentations, courses, interviews, and vignettes that make up the traditional knowledge capture approach continue to engage and educate the technical space community. The team has expanded many of these offerings to include virtual attendance options and increase accessibility. For an in-depth description of the program’s traditional knowledge capture methods, refer to prior published SKC Program ICES papers.^{2, 4-14}

SKC events are only one method that the SKC and Strat Comm team uses to capture and disseminate space-related knowledge. As the team inherits legacy knowledge (e.g., reports, drawings, and schematics) from currently employed and retired SMEs, it will continue to digitize this knowledge and offer it to the space community. To ensure the preservation of institutional knowledge, the team maintains a database of photographs and videos, a collection of digitized historical files, and an inventory of historical spacesuit hardware. Photographs and videos are housed on Imagery Online (IO), JSC’s online application for archiving institutional imagery.

The SKC and Strat Comm team’s mechanisms to integrate strategic communications and knowledge capture include special-event videography and photography services, high-speed video production, editing, and full production of videos, including small vignettes that can be assembled into a documentary or design series. These include photoshoots of relevant space-related hardware and laboratories, video recordings of test operations and hardware assembly, and interviews. Archived photography and videography may be used as well. A selection of the numerous functions performed to prepare multimedia content and assemble a rich compilation of knowledge is described below:

- 1) Develop strategic plans to implement events, provide multimedia expertise, and lead coordination of all participants and resources for each event.

^{*} “Lunar Terrain Vehicle Services (LTVS) Contract,” JSC Office of Procurement, <https://www.nasa.gov/johnson/jsc-procurement/ltps/>, [cited 8 January 2023].

[†] “NASA Selects Companies to Advance Moon Mobility for Artemis Missions” NASA Headquarters, <https://www.nasa.gov/news-release/nasa-selects-companies-to-advance-moon-mobility-for-artemis-missions/>, 3 April 2024.

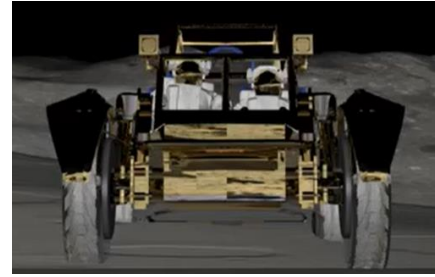


Figure 4. Animated ground test unit rover. (Image by NASA)



Figure 5. An ARGOS familiarization run. (Image by NASA)

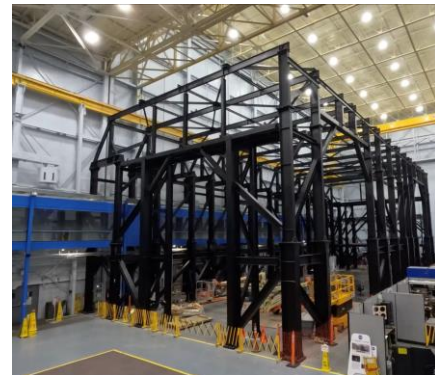


Figure 6. Image from a timelapse video of the AX3S buildup. (Image by NASA)

- 2) Collaborate and coordinate with personnel across the NASA agency to record and permanently archive events.
- 3) Produce special-event videography, direct set creation, and coordinate media production for events.
- 4) Participate in and lead the recording and editing productions, assist in quality reviews of event content, and edit final products for potential public release.
- 5) Participate in video field productions of onsite laboratories and support onsite photoshoots and video shoots, as needed.
- 6) Capture, review, and edit photographs and videos of facilities, components, spacesuit systems and subsystems, human surface mobility systems, and associated test environments.
- 7) Develop and archive multimedia content that facilitates knowledge transfer across the EVA and surface mobility community.

The American taxpayers (and ultimate stakeholders in the success of NASA missions) also have the right to access information that NASA’s export control has approved for public release. Because it is important to share this knowledge to the widest extent possible, the SKC and Strat Comm team possesses and applies expertise in NASA’s export control processes. Export control scrutinizes SKC and Strat Comm knowledge shared with the public before it is released. Vetting captured knowledge through export control has allowed the team’s reach to expand to commercial vendors, academic institutions, community partners, and the public.

These mechanisms and capabilities have led the SKC and Strat Comm team to many accomplishments and will continue to facilitate knowledge sharing in the human spaceflight community.

C. Program Accomplishments

Since the SKC Program’s existence, it has had hundreds of successes. Table 1 reveals some of these achievements. To date, the team has captured 261 recorded products, 74 of which are available to the public. There are 24 recordings that contain sensitive information and can be made available to NASA employees and contractors with the consent of the SKC program manager. The team recorded 69 video modules related to the xEMU buildup. The completed modules were made available to the xEMU community on IO and through internal distribution. There are 34 products that are undergoing review and editing before submission into the Scientific, Technical, and Research Information DiscoVery System (STRIVES). NASA uses the STRIVES system to review products for export control release.

In addition to traditional knowledge capture events, the Strat Comm component of the team engages in a variety of photoshoots and video shoots. The resulting photographs and video footage are often used for multiple projects or are combined to create professionally edited media content such as the *Exploring the Moon* production and others. In FY 2023, the team had 43 photo and video shoots, resulting in 46 photo and video products for use in media productions or as stand-alone content. Currently, in FY 2024, they have had 14 photo and video shoots.

Table 1. Total SKC Products

Product Category	Number of Products
Available- Public	74
Available- Restricted	102
<i>Includes 69 xEMU modules*</i>	
By request only	24
<i>Includes 18 Spacesuit Spotlights**</i>	
Not yet available †	49
<i>Includes 1 xEMU module*</i>	
Will not be distributed † †	12
<i>Includes 1 xEMU module*</i>	
Total Products	261
Strat Comm Photo and Video Shoots ‡	57

* xEMU modules are not planned for agency-wide release.

** Spacesuit Spotlights are planned for NASA internal use only.

† 15 products have been approved in STRIVES for public or restricted release but are not yet available on the NESC Academy website. The remaining products have not yet been submitted to STRIVES.

†† These products will not be distributed due to sensitive personal information, students present in the video, etc.

‡ This includes photo shoots and video shoots from FY 2023 and FY 2024.

III. Challenges and Initiatives

As a response to NASA's progress toward a sustained presence in space, the SKC and Strat Comm team is adapting its focus to support the next generation of space exploration. From recording the technical details necessary for successful space exploration, to telling the human-centered stories of ingenuity, failure, and triumph, the SKC and Strat Comm team stands prepared to preserve and promote the monumental legacy of human spaceflight.

In the past, the SKC Program has focused heavily on capturing knowledge and creating a knowledge base. The team is now taking advantage of increased staffing to pursue several new initiatives with an added focus on knowledge sharing and application. To continue its work in cultivating a culture of learning at JSC and beyond, the SKC and Strat Comm team is also focusing on increased collaboration and visibility. The SKC and Strat Comm team is developing internal partnerships, identifying new concept areas for knowledge capture, updating content delivery methods, and expanding the program's presence in the human spaceflight community.

The efforts outlined in this section, aligned with EHP, NESC, EA, EC, and EC5 objectives, are simultaneously aimed at supporting a technically robust workforce and engaging the public. These initiatives are also intended to help mitigate and resolve some existing challenges, described in Section III A.

A. Challenges

To meet NASA's missions, part of JSC's policy is to promote required knowledge transfer, collaborative sharing, and learning.³ The SKC and Strat Comm team aligns with this policy and encourages the sharing of its captured knowledge to the widest extent possible. This work is not without challenges. The sheer volume of products, the time and labor required to process products through export control, and the absence of a single archive location are some of the difficulties the team faces in making content easily accessible.

The SKC and Strat Comm team has produced over 280 recordings that include SME presentations, narrative vignettes, interviews, training modules, hardware buildup, and products such as *Exploring the Moon* and *What's Behind This Door?* In addition to video content, the team has produced thousands of still photographs — ranging from documentation of technical components to team portraits and event photographs. These assets constitute an incredibly valuable record of the SMEs, technology, experiences, culture, innovation, lessons, and legacy of human space exploration. However, storage and distribution of these products presents some challenges.

As the SKC and Strat Comm team's scope has expanded, so has the need for more electronic storage. The type, purpose, and sensitivity of the knowledge contained within a digital file can determine where it is stored. For example, content intended to enhance the education of spacesuit professionals is stored separately from content intended to inform the public about the history and status of space-related knowledge. Some of the legacy knowledge that the team inherits is stored with similar preexisting knowledge, sometimes requiring special credentials to access it. The more places knowledge is archived, the more challenging it is for developers to inventory it and users to locate it. Content that is archived on platforms maintained by other NASA organizations runs the risk of being digitally "lost" if the platforms change or go defunct. This creates significant work for the SKC and Strat Comm team in maintaining an accurate catalog of content and responding to requests from users.

Recordings that have been approved by export control for public release are archived on the NESC Academy's website. Subscriptions to NESC Academy emails, which advertise real-time webcasts that the NESC Academy broadcasts, as well as a monthly newsletter, are available to NASA employees and contractors and the public.* Though over 95 knowledge capture products are publicly available on the NESC Academy platform,[†] still more of the SKC and Strat Comm team's knowledge base is spread across multiple platforms and storage locations, making it difficult to maintain an accurate inventory of available resources. Many existing products have been approved by export control for public or internal distribution but are not easily discovered by potential users. Users who are not already familiar with the SKC resources may not realize how much knowledge is available to them. This points to a need for a centralized library and for effective promotion to engage potential audiences.

B. Knowledge Centralization Initiatives

A major initiative will be the creation and curation of an online hub connecting all the program's products, resources, and content in a centralized library. To help organize and locate captured space-related knowledge, the SKC and Strat Comm team intends to develop a platform that will serve as the primary resource for information about spacesuits, tools, rovers, and other human surface mobility topics. Though this hub is still in the early ideation phase,

* <https://nescacademy.nasa.gov/subscribe>

† <https://nescacademy.nasa.gov/catalogs/spacesuit>

the potential assets (i.e., high-quality content, a wealth of internal and publicly available products, and direct access to the technical teams driving exploration) point to agency-wide value. The SKC and Strat Comm team has identified several key needs that will inform its scope and development. Many of these needs are echoed in the SKC Program key tenets.¹³ Though the SKC and Strat Comm team is equipped to meet these needs, a learning hub will greatly increase its ability to facilitate knowledge sharing, support innovation and mission success, and inspire curiosity about space exploration.

The NASA technical workforce needs easy and timely access to relevant knowledge for effective use. A searchable library would decrease the time and effort involved in retrieving this knowledge. As a new generation of technical space professionals joins the NASA and contractor workforce, there is a significant need for specialized orientation to the unique technology those professionals will encounter and capabilities they will use. Many of the SKC and Strat Comm knowledge capture products provide baseline education that would benefit new employees' education on spacesuits, rovers, tools, important lessons learned, and historical context for the development of these technologies. Consolidating captured knowledge into one location will make that content more accessible and would complement the onboarding resources available from EHP, NESC, EA, EC Wiki, EC5 Wiki and the EA Academy. Users of a knowledge capture learning hub would have access to a wide variety of topics and content formats. They may discover pertinent knowledge that they would not have otherwise known to seek. Centralizing resources on the hub and incorporating SKC and Strat Comm products into new employee onboarding will keep the program visible for technical professionals.

Beyond its benefits to JSC's engineers, technicians, and scientists, there is demand for SKC and Strat Comm content from multiple markets, including the agency-wide technical community, commercial partners, academia, community organizations, and the public. A learning hub with leveled access restrictions could serve as a venue for both internal and external users to discover appropriate and targeted knowledge. Creating a single landing page where the public can also browse available content would simplify distribution and use for a wide range of audiences.

A knowledge capture hub also has the potential to streamline the SKC and Strat Comm team's workflow and increase its impact. Centralizing all content in one location could minimize processing time by standardizing the workflow for archiving captured knowledge. It would also reduce time spent on maintaining records, storage locations, and organization systems and responding to user requests for help finding legacy content. The hub could serve as an example and roadmap for similar programs, as well as becoming a connection point to promote additional knowledge sharing efforts. Other offices and programs within NASA would have access to current products and an overview of the capture and production capabilities of the SKC and Strat Comm team, driving collaboration.

C. Collaboration and Knowledge Sharing Initiatives

The effort to improve access to knowledge capture resources has support from other JSC entities. The SKC and Strat Comm team has benefitted greatly from an initiative undertaken by Tom Reuland, an xEVAS collaboration systems engineer and key partner in the effort to centralize the SKC Program's knowledge capture products. Mr. Reuland has developed an internal database of lessons learned extracted from many SKC videos. This database can be included on existing department Wiki pages. Further description and discussion of this project can be found in his 2024 ICES paper.¹⁶

The SKC and Strat Comm team has also initiated a collaborative partnership with the team behind EC5 internal wiki page. This wiki provides onboarding, technical, and institutional resources to employees in EC5. The SKC and Strat Comm team's collection of captured spacesuit-related knowledge is a useful resource to these employees. The team intends to guide users to available content (and eventually to a centralized hub) through links on the wiki page. Both Mr. Reuland's work and the EC5 Wiki collaboration represent important resources and scaffolding toward the development of a consolidated, searchable learning hub. They are essential partnerships in the dissemination and accessibility of the SKC and Strat Comm team's knowledge within the organization.

Because the SKC and Strat Comm team is embedded with the technical teams, it is a valuable resource for providing content to public-facing offices. NASA and JSC organizations need high-quality educational material, and the SKC and Strat Comm team has a wide range of documented knowledge and products to share with them. To maximize the reach and impact of its knowledge, the SKC and Strat Comm team has initiated collaborations with JSC's Office of Science, Technology, Engineering and Math (STEM) (OSTEM) and Public Affairs Office (PAO). These offices have expertise in outreach; existing content delivery and social media channels; and networks that include schools, universities, camps, and other community partners. The SKC and Strat Comm team has partnered with OSTEM and PAO to provide engaging educational content that they can build on, distribute, and integrate into their lineup.

To build these partnerships, the SKC and Strat Comm team is undertaking several initiatives aimed at providing content for internal and external sharing. Building upon previous efforts, the team has developed a major media production titled *Exploring the Moon* and is working on its distribution. The team has also created a collection of behind-the-scenes *What's Behind This Door?* videos. The SKC and Strat Comm team has solicited input and feedback from OSTEM and PAO on the *Exploring the Moon* and *What's Behind This Door?* productions and has discussed pairing existing OSTEM content with these new offerings. These two productions are described in greater detail in Section IV.C.

D. Future Initiatives

Beyond the push for more effective knowledge centralization and knowledge sharing, the SKC and Strat Comm team is laying the groundwork and planning for future initiatives.

The SKC and Strat Comm team is discussing the creation and implementation of a curriculum-based knowledge capture framework for new hires (e.g., “Spacesuit 101”). This framework could be developed and accessed via a learning hub. Anecdotal data suggests that some new members of the JSC technical community are using SKC and Strat Comm products in this way. The team has randomly interviewed several new spacesuit engineering interns who indicated that they have used the team’s content to accelerate their spacesuit knowledge. Currently, there is not enough data to know the extent of how engineers might be using the captured knowledge as a tutorial. However, this is an area that the team would like to formalize, potentially with a user survey.

There has also been discussion about implementation and distribution for “Andi the Astronaut,” a cartoon character mascot that the SKC and Strat Comm team designed to engage and educate younger audiences about human surface mobility. “Andi the Astronaut” will give children a tool to create their own stories about lunar exploration and see themselves as part of the Artemis team. The intended accompanying materials, still in early development, may include coloring books, puzzles, and other age-appropriate activities. With this initiative, the team hopes to encourage problem solving, creativity, and storytelling while inspiring the next generation of space professionals and enthusiasts. “Andi the Astronaut” highlights the value of diverse skillsets and emphasizes that there is a place for a diverse culture at NASA.

Further consideration will determine the feasibility and merit of these potential future initiatives. The SKC and Strat Comm’s strong legacy and focus areas for FY 2024 will position the team to continue improving the impact and accessibility of their products.

IV. Focus for Fiscal Year 2024

The SKC and Strat Comm team has worked to identify relevant and high-interest topics, develop collaborative relationships with technical experts, and facilitate knowledge transfer through a variety of mechanisms. Building on past successes and incorporating new initiatives, the SKC and Strat Comm team has determined several areas of focus for FY 2024. In addition to facilitating knowledge sharing events, capturing technical processes, and creating new educational content, the SKC and Strat Comm team is planning for the future of the program. There has been an effort to document and standardize processes within the team to ensure the longevity and continuity of the program's activities. Though several of the team’s new initiatives are in early stages, they establish a direction for continued growth. The preparation and work on these initiatives in FY 2024 will allow the SKC and Strat Comm team to better meet the needs of its customers, stakeholders, and audience.

A. Knowledge Capture Events

To enrich the knowledge of the space community, events as presented by the historical SKC Program will remain an integral part of the team’s activities. In FY 2024, the events will expand to not only include spacesuits, but tools, rovers, and other human surface mobility topics as well. Collaboration between the SKC and Strat Comm team and SMEs will provide valuable content and expertise, delivered in the form of courses, interviews, workshops, and vignettes. The team will continue to facilitate knowledge capture events for its stakeholders EHP, NESC, EA, EC, and EC5. In-person, virtual, and hybrid (combined online and in-person) events are video recorded for preservation and future viewing. Following the STRIVES review process, the SKC and Strat Comm team works to make these recordings available to the widest appropriate audience.

By using an online video conferencing platform, the SKC and Strat Comm team has made many knowledge capture events accessible and convenient to a wider audience than a classroom can accommodate. The first lecture of FY 2024, titled "Lunar Dust Mitigation 101" (Figure 7), exemplified the demand for knowledge capture offerings, both at JSC and throughout the human spaceflight community. The hour-long class drew 324 attendees, 305 (approximately 94%) of whom attended virtually. Learners from 47 JSC divisions, at least 8 NASA centers, and several external partner organizations were present. Survey responses from this event expressed the value of its lessons shared and the importance of sharing them with those who need them most. "This was incredibly interesting. I hope commercial providers are paying attention to this." Respondents also realized that important lessons learned are valuable and useful only if they are delivered to the right people at the right time. "This is a very timely and important subject. This information needs to get out to help the wide community that is getting humans back to the Moon...." "This course had a lot of great information which needs to be distributed to the space community." Other responses indicated a desire to attend more such events, to see more frequent events offered, and an appreciation for the option of attending virtually or in person. The SKC and Strat Comm team continues to seek feedback on its events and has adapted procedures to improve the classroom experience and meet the needs of the NASA workforce.



Figure 7. Dr. Kristen John presents “Lunar Dust Mitigation 101” to a hybrid audience. (Image by NASA)

On November 8, 2023, the SKC and Strat Comm team facilitated a three-part course on capillary fluidics. With 3 hours of in-depth content, the “Avoiding Plumbing Failures in Space” course was longer than most knowledge capture events. The speaker, an accomplished SME brought in as part of a Small Business Innovative Research (SBIR) contract, covered the unexpected phenomena that occur with liquids in microgravity, a historical overview of the study of liquid behavior in space, and applications to the EVA 80 water-in-the-helmet incident.* Though the course was offered only in person, it drew nearly 70 attendees. In the week following the event, the SKC and Strat Comm team received many requests for the video recording of the lecture. There were also many requests from the JSC technical community for the course to be offered again in a virtual format for those who were unable to attend the in-person offering. A plan is underway to offer the course virtually.

B. Lessons Learned

The team’s unique position as a long-standing, embedded knowledge capture group allows it to make meaningful contributions to agency- and center-wide initiatives. In FY 2024, the team will continue to support EA by sharing lessons learned during NASA’s Safety & Health Day and Day of Remembrance, hosting lectures, interviews, and workshops for NASA employees and contractors and educational outreach events for academia.

On JSC's FY 2024 Safety & Health Day, the SKC and Strat Comm team offered a lessons learned presentation led by an SME who discussed the contributing factors surrounding a past mishap. The speaker detailed key decisions that played a part in the incident, explaining how those kinds of decisions are often made in good faith and in response to competing needs. He reminded the audience consisting of technical professionals to consider controls throughout the design process and not to discount the possibility of human error. This event was held in a blended in-person and virtual format and had 77 attendees. In a feedback survey distributed after the event, 100% of respondents said that

* For further reading on this topic:

Weislogel, M. M., et al., “Excess Water in Astronaut Helmet During EVA on ISS: Mitigations with Flight Demonstrations,” 52nd International Conference on Environmental Systems, ICES-2023-402, Calgary, Canada, 16-20 July 2023.

they would be able to apply the concepts learned in this course to their job, outside work, or both. On the survey, one in-person attendee stressed the value of learning about this mishap in person: "[It] let me feel the pain the program went through." Many SKC and Strat Comm events similarly connect technical information with experience to facilitate tacit knowledge sharing and help prevent future mistakes.

In connection to NASA's annual Day of Remembrance in 2024, the SKC and Strat Comm team offered a lessons learned lecture on the EVA 23 and 80 water-in-the-helmet incidents. The hybrid event drew over 200 attendees from across the NASA agency, including personnel with first-hand knowledge of these incidents. The event provided a venue for organic and candid discussion about safety, and many participants stayed well past the scheduled end time to continue the conversation. In the feedback survey for this event, multiple respondents said they thought that the presentation should be mandatory viewing for employees. At least one manager involved in safety made this course mandatory for her employees. One attendee wrote, "It was extremely useful for my job, very informative, and impacted my career substantially."

Through involvement in events such as Safety & Health Day and Day of Remembrance, the SKC and Strat Comm team engages the NASA community in meaningful consideration of past lessons learned. These events also present an opportunity to encourage a culture of knowledge sharing, increase awareness of the program's resources and services, and establish working relationships with SMEs.

C. Media Productions

1. Summary Videos

The SKC and Strat Comm team supports EHP, NESC, EA, EC, and EC5 by combining knowledge capture and strategic communication. This work includes the technical imagery discussed in Section II, as well summary videos for EHP, EA, EC, and EC5 All-Hands meetings, as needed throughout the year.

2. Exploring the Moon

To educate and inspire the public about NASA's journey to the Moon, the SKC and Strat Comm team will debut its media production *Exploring the Moon* to the public in FY 2024 (Figure 8). This 3-hour media production will premiere on various NASA social media platforms and applications, websites, podcasts, and NASA visitor centers to target multiple audiences such as academia, summer camps, and space enthusiasts. *Exploring the Moon* will feature NASA astronauts and SMEs who give viewers a behind-the-scenes look at current preparations for NASA's return to the Moon. It will contain recorded interviews with spacesuit technicians, engineers, and astronauts who share insights and answer common questions about space exploration (Figure 9).

The *Exploring the Moon* production will help viewers understand the value of exploring the Moon and the importance of lunar spacesuits, rovers, and geology tools. It will discuss why NASA is returning to the Moon, how NASA is preparing for its Artemis missions, how the Artemis spacesuits will differ from the Extravehicular Mobility Unit, and why a different spacesuit is needed.

The SKC and Strat Comm team promoted *Exploring the Moon* during the Space Exploration Educators Conference 2024 at Space Center Houston. This conference was targeted to classroom teachers and provided them with additional tools and information to educate, engage, and inspire their students with an inside look at the many disciplines, skills, and challenges involved in space exploration.

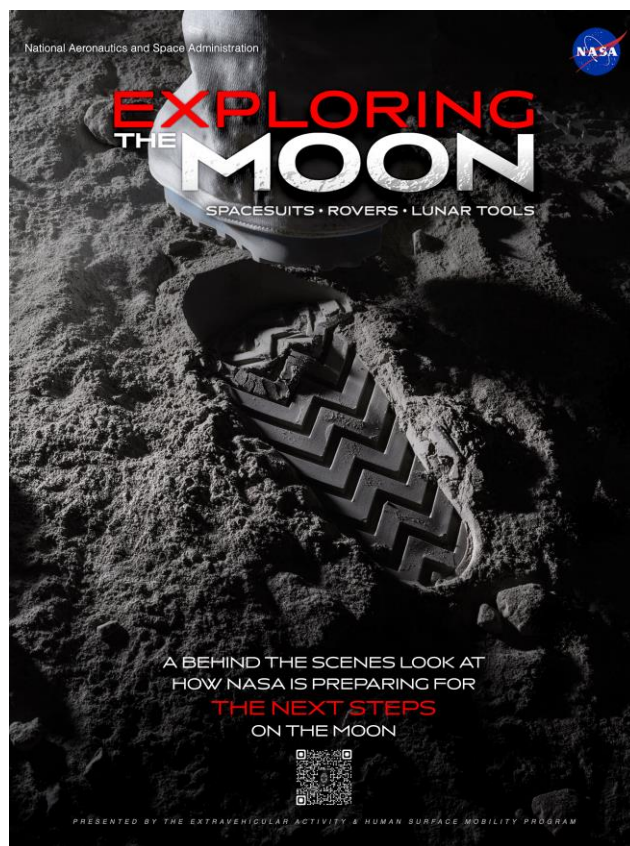


Figure 8. Promotional poster for *Exploring the Moon*. (Image by NASA)

EXPLORING THE MOON
SPACESUITS • ROVERS • LUNAR TOOLS

EPISODE 02

Artemis Spacesuits

Explore the special technologies and improvements NASA has made to its spacesuits since the International Space Station (ISS), and how they will be used to make the Artemis missions possible.

FEATURING



Stephanie Sipila
Series Moderator



Liana Rodriggs
Spacesuit Expert



Sunita Williams
NASA Astronaut



Carly Meginnis
Spacesuit Expert

LEARNING OUTCOMES

- Analyze how Artemis spacesuits will meet the unique challenges of lunar exploration.
- Summarize the importance and advantages of a mobile suit.
- Compare and contrast the features and uses of the ISS and Artemis Lunar spacesuits.
- Identify which parts of the body spacesuit designers prioritize.
- Evaluate the benefits of a rear-entry spacesuit.
- Discuss the value of using humans to explore the Moon.
- Explore careers in science, technology, math, and engineering.

VIDEO



PODCAST STYLE DISCUSSION

VIDEO



SPACESUIT FEATURE

Explore careers in science, technology, math, and engineering.

WEBSITE QR CODE



Figure 9. A draft fact sheet for Season 1, Episode 2 of *Exploring the Moon*. (Image by NASA)

3. *What's Behind This Door?*

The public now has a virtual opportunity to meet space experts in a collection of playful and informative videos titled *What's Behind This Door?* These short-form videos take viewers behind the doors of the JSC analogs and facilities that NASA is using to prepare for a return to the Moon. This production targets students and reveals scenes from inside JSC buildings rarely seen except by NASA employees and contractors. Each video features interviews with the experts working within these facilities, who share highlights involved in accomplishing their work.

In March, the “What’s Behind This Door? The Neutral Buoyancy Laboratory” was released on NASA social media platforms* (Figure 10). The video explores the Neutral Buoyancy Laboratory, where astronauts train underwater for space missions. At the time of writing this paper, views for this video reached over 175,000 views across multiple social media platforms.

Two more videos are complete and are planned for public release in 2024. One visits JSC’s Chamber A, a massive thermal vacuum chamber used to test hardware such as the James Webb Space Telescope. The second video features the Systems Engineering Simulator and demonstrates how it is used to simulate driving an LTV on the lunar surface. In future videos, viewers will be introduced to additional facilities such as JSC’s food laboratory, where astronauts’ food is prepared and taste-tested before being launched into space.



Figure 10. “What’s Behind This Door? The Neutral Buoyancy Laboratory” thumbnail. (Image by NASA)

4. *Spotlight Series*

To introduce the SKC and Strat Comm’s audience to the program’s nearly 120 technical knowledge contributors (e.g., SMEs), the team created Spacesuit Spotlights. Spacesuit Spotlights are 10- to 30-minute interviews of SMEs who reveal the impacts they have made to the spacesuit industry, as well as their educational background, job description, and the circumstances that led them to NASA. Eighteen interviews have been recorded and will be made available to NASA employees and contractors. Beginning in FY 2024, the SKC and Strat Comm team will expand the series to interview SMEs in other technical areas, including lunar tools, rovers, human surface mobility, and testing. The Spotlight Series will serve both as an oral history of the people involved in space exploration and as a knowledge map of NASA’s human spaceflight expertise.

V. Conclusion

NASA is returning to the Moon to drive further scientific discovery and economic benefit.¹ Though humans have made the journey before, different complexities are anticipated during the Artemis missions than those experienced during the Apollo Program. Lunar dust, radiation, and communication delays are only a few risks involved in human space exploration. The new challenges involved in returning to the Moon have inspired innovation and collaboration between NASA, industry, and academia, and have made clear the value of effective knowledge transfer.

In preparation for the Artemis missions, JSC used tacit and documented knowledge to design the government reference spacesuit. NASA’s knowledge is now available to the commercial vendors who are developing the next generation of spacesuits. When astronauts return to the lunar surface, they will be donning a new spacesuit designed for more diverse sizes than the existing spacesuit. It will have more mobility, increased performance, and hardware efficiency; and offer more protection from radiation.[†] These innovations are the result of decades of incremental learning and knowledge sharing. The spacesuit is just one part of the story. Capture, dissemination, and use of knowledge is important to every aspect of human spaceflight. Sending humans to the Moon and beyond will require a knowledge capture and transfer approach that is diverse, impactful, and embedded in the technical community it serves.

The SKC and Strat Comm team continues to capture and share space-related knowledge to enhance the success of future, more ambitious human spaceflight. The expertise, lessons learned, and experiences the team has captured provide a link between the people who pioneered human spaceflight and the generation that will embark on a new era

* “What’s Behind This Door? The Neutral Buoyancy Laboratory,” www.youtube.com/watch?v=FWVcYIYCFK8

† Building NASA’s Next Generation Spacesuit, www.youtube.com/watch?v=ug-FHsOYP5Y

of exploration. By preserving the knowledge and legacy of the gloves, suits, tools, and rovers that make space exploration possible, the SKC and Strat Comm team will support humanity's giant leap to the Moon and beyond.

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Lastly, the team thanks the users of our program's knowledge and each SME who contributes their time, expertise, and insight to help create a more knowledgeable space community.

These collaborators, supporters, and advocates empower the SKC Program to continue preserving the knowledge and legacy of human spaceflight.

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