U.S. Spacesuit Knowledge Capture Accomplishments in Fiscal Years 2012 and 2013

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The NASA U.S. Spacesuit Knowledge Capture (KC) program has existed since the beginning of 2008. The program was designed to augment engineers and other technical team members with historical spacesuit information to add to their understanding of the spacesuit, its evolution, its limitations, and its capabilities. Over 40 seminars have captured spacesuit history and knowledge over the last six years of the program's existence. Subject matter experts have provided lectures and some were interviewed to help bring the spacesuit to life so that lessons learned will never be lost. As well, the program concentrated in reaching out to the public and industry by making the recorded events part of the public domain through the NASA technical library through YouTube media. The U.S. Spacesuit KC topics have included lessons learned from some of the most prominent spacesuit experts and spacesuit users including current and former astronauts. The events have enriched the spacesuit legacy knowledge from Gemini, Apollo, Skylab, Space Shuttle and International Space Station Programs. As well, expert engineers and scientists have shared their challenges and successes to be remembered. Based on evidence by the thousands of people who have viewed the recordings online, the last few years have been some of the most successful years of the KC program's life with numerous digital recordings and public releases. This paper reviews the events accomplished and archived over Fiscal Years 2012 and 2013 and highlights a few of the most memorable ones. This paper also communicates ways to access the events that are available internally on the NASA domain as well as those released on the public domain.

Nomenclature

AES	=	Advanced Exploration Systems (Program)
APPL	=	Academy of Program and Project Leadership
ASTP	=	Apollo-Soyuz Test Project
CAMRAS	=	carbon dioxide and moisture removal amine swing bed
CASI	=	Center for AeroSpace Information
EMU	=	Extravehicular Mobility Unit
EVA	=	extravehicular activity
ICES	=	International Conference on Environmental Systems
ISS	=	International Space Station
JSC	=	Johnson Space Center
KC	=	knowledge capture
KM	=	knowledge management
KSC	=	Kennedy Space Center
MD	=	medical doctor
MOD	=	Mission Operations Directorate
NA&SD	=	NASA Aeronautics and Space Database
NASM	=	National Air and Space Museum
NEO	=	near-Earth object
NESC	=	NASA Engineering and Safety Center
NTRS	=	NASA Technical Reports Server
PLSS	=	Portable Life Support System

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SATERN	= System for Administration, Training, and Education Resources for NASA
SME	= subject matter expert
STI	= Scientific and Technical Information
STS	= Space Transportation System
SWME	= Suit Water Membrane Evaporator
TPS	= Thermal Protection System

I. Introduction

WITH the current NASA administrative mission to explore deep space and harness an asteroid as a steppingstone to venture to Mars, the U.S. spacesuit remains a priority for NASA. NASA's Fiscal Year (FY) 2012 Performance Plan cites this as a goal: "Develop advanced spacesuits to improve the ability of astronauts to conduct Extravehicular Activity (EVA) operations in space including assembly and service of in-space systems and exploration of surfaces of the Moon, Mars, near-Earth objects (NEO), and other small bodies."[2]

NASA developed an advanced spacesuit to meet this performance goal using past spacesuits and improving them to meet current and future needs. The Space Shuttle Extravehicular Mobility Unit (EMU) was the last spacesuit that NASA developed over 30 years ago. Engineers will need to use the knowledge gained from Mercury, Gemini, Apollo, Skylab, Space Shuttle, and International Space Station (ISS) lessons learned to develop a more advanced spacesuit. Knowledge from the Constellation Program, Exploration Technology Development Program, Enabling Technology Development Demonstration Program, and Office of Chief Technology have stimulated the initiation of a new, advanced spacesuit.[3] These programs have influenced the progress of technology over the last seven years. Now the Advanced Exploration Systems (AES) Program has the responsibility to develop an advanced spacesuit for exploration. Additionally, new programs such as the Space Technology Mission Directorate has been instrumental in the development of critical components the new, advanced spacesuit.

The U.S. spacesuit has become an international icon for NASA and is one of the national treasures of the space industry. Without spacesuits, humans could not have ventured into space, explored the moon, constructed space stations, or maintained and upgraded the Hubble Space Telescope that has provided millions of images that have amazed and educated humankind.[1] The legacy of the spacesuit is beautifully depicted in Ron Woods painting of the spacesuits, "Hanging Around" in Fig.1.

Capturing knowledge through experience gained over the years becomes even more important for engineers to develop a new, more sophisticated spacesuit. Knowledge has been "captured" through lessons learned and a multitude of venues documented in published reports (failure and scientific), conference presentations, briefings, specialized seminars, photographs, analyses, audio and visual media, logs, and memories of veterans in the field. NASA must strive to preserve the rich history of its spacesuit program so that this trove of design information, procedural knowledge, and lessons learned can inform future spaceflight engineers and historians. This paper focuses on the status and progress of the U.S. Spacesuit Knowledge Capture program over FY12 and FY13.

II. U.S. Spacesuit Knowledge Capture Program Background

The U.S. Spacesuit Knowledge Capture (KC) program was formed in 2007 as a result of a Johnson Space Center (JSC) center-wide KM assessment that was completed in May 2007. The 2008 JSC Policy Directive related to KM encouraging JSC organizations to promote knowledge transfer, collaborative sharing, and learning required for the success of the NASA missions also spurred the KC program.[A] The program focuses on capturing the historical knowledge of spacesuits, their associated technologies, and peripheral topics that enhance an engineer's performance in developing spacesuits. The Space Suit & Crew Survival Systems Branch at NASA's Johnson Space Center in Houston, Texas manages the program. Knowledge is collected through recollections, lessons learned, and recommendations of subject matter experts and preserved in written, video, and audio formats. The KC events are digitally recorded during lectures, courses, and interviews. They are archived electronically and made available to the NASA community and to the public through the NASA Scientific and Technical Information (STI) Center's YouTube site. KC also reviews collaborative partners, and identifies new initiatives introduced to augment the development of our nation's next-generation spacesuit.[A]

U.S. Spacesuit Knowledge Capture Status and Initiatives paper reviews NASA's U.S Spacesuit KC program from inception through a portion of FY12.

III. U.S. Spacesuit Knowledge Capture Program's Essential Elements

Perhaps the essence and purpose of KC is best summarized in this quote from Winston Churchill: "The farther backward you can look the farther forward you can see.". KC makes it possible for scientist, engineers, and other members of the spacesuit community to look into the past, capture recorded past lessons learned, and use them to achieve more advanced technical designs for spacesuits.

A major goal for NASA's human spaceflight program is to send astronauts to near-Earth asteroids (NEA) in the coming decades. To achieve this mission, future spacesuits must be advanced to shield astronauts from the extreme environments of space. The five KC program tenets offer support to this mission:

- **To collect and preserve the oral history of spacesuits is to keep future manned space exploration alive.**
  The U.S. Spacesuit Knowledge Capture collects and preserves the oral history of spacesuits to educate its audience and enhance the chances for the success of future and more ambitious spacesuit system programs. These activities identify and collect the information that exists in areas across the agency and the processes help to efficiently manage the agency's knowledge resources. The knowledge capture team develops techniques and tools to enable teams and communities to collaborate across the barriers of time and space.

- **Without the spacesuit, Extravehicular Activities (EVA) are impossible.**
  To advance human space flight, spacesuits must be advanced to shield humans from the extreme environments of space. Preserving and sharing spacesuit-related information increases the opportunity for advanced future manned space exploration.

- **Retaining and sharing the successes and failures of past lessons learned helps continually build knowledge for more advanced future results.**
  The main sources of information captured in this forum include recollections, conclusions, and recommendations of experts; information in written, video, and audio formats; and hardware items representing not only flight items and flight configuration items, but also mock-ups, advanced prototypes, and training hardware.

- **It took many people working together to design America's first spacesuit; it will take many people sharing information to develop future ones.**
  Accomplishments as skillful as EVAs take teamwork to make them successful. As part of the Johnson Space Center's (JSC) Policy Directive, this knowledge capture encourages JSC organizations to promote knowledge transfer, collaborative sharing, and learning required for the success of NASA missions.

- **It is paramount to get the right information to the right people at the right time for the recipient to use it adequately.**
  The U.S. Spacesuit Knowledge Capture helps people create knowledge and share it in ways that will measurably improve spacesuit performance. This information is available to the NASA and contractor EVA community, and events that are appropriate for public release are available to the public.

KM systems and processes have helped NASA deliver its missions in three ways:[4]

- KM retains NASA's knowledge across missions and generations by identifying and capturing existing information across the agency.
- KM manages the agency's knowledge resources by identifying, storing, organizing, and sharing existing knowledge.
- KM develops techniques, processes, and tools to enable teams and communities to share knowledge.

KM is a strategic objective for NASA. The U.S. Spacesuit KC program has proved to be vital in meeting a strategic objective for NASA. This program has provided a mechanism for retaining pertinent knowledge of the spacesuits. KC is at the forefront and is timely as a new spacesuit is being designed, assembled, and tested, and the architecture is being established. Knowledge is being shared and learning is being encouraged to help improve performance, facilitate innovation, reduce future redundant work, potentially reduce "training time," and help adapt to a changing environment in space exploration. The information being archived comes from the knowledge of those who learned before us so those who come after us can continue to explore, go beyond past boundaries, and live in space so that we can go farther, do better, and know more in the process. Perhaps the greatest challenges facing the KC system consist of ensuring that those who could benefit from it know it exists, know how to use it, and understand the importance of archiving spacesuit history so future engineers and managers can benefit from our nation's investment. The value of KC was best expressed by the parent of an elementary student: “We don’t always reach our expectations and we don’t always win; it’s the lessons from the journey that we carry with us [that] mean the most over time.”

IV. U.S Spacesuit Knowledge Capture Process

The U.S. Spacesuit KC process was initially defined by Chullen, et al. in the 2011 paper entitled, “U.S. Spacesuit Knowledge Capture”.[1] The process has been updated slightly since first published as shown in Fig. 2. In particular, two collaborators have been added to the process, namely, the JSC History Office and the NASA Scientific and Technical Information (STI) Program. The STI Program has recently expanded to include the YouTube repository for publically releasable video files. All U.S. Spacesuit KC events deemed publically releasable are planned to be archived with the STI YouTube site. The new collaborators along with the existing ones are detailed in section IV of this paper. Although not direct collaborators, the entities that remain sources of information or tools include the following: System for Administration, Training, and Education Resources for NASA (SATERN); Lessons Learned Database; Academy of Program and Project Leadership (APPL) along with the electronic journal, “ASK the Academy”; and the NASA Engineering and Safety Center (NESC). All other aspects of the U.S. Spacesuit KC process remain unchanged.

Figure 2. U.S. Spacesuit KC process, 2012 [To be Inserted].

V. U.S. Spacesuit Knowledge Capture Collaborators

The U.S. Spacesuit KC program specifically focuses on capturing the historical knowledge of spacesuits, their associated technologies, and peripheral topics that enhance an engineer’s performance in today’s environment. Several key collaborators are involved; namely, the SMEs themselves, the MOD Training Academy, the JSC History Office, the JSC Engineering Academy, the NASA STI Program, and the Smithsonian. These collaborators are detailed below:

1) SMEs – These are the experts that actually conduct the lectures for the U.S. Spacesuit KC program. These are internal NASA and contractor employees and they can be external such as NASA and contractor retirees.
2) MOD Training Academy – This team provides the recording venue and production capabilities to record the U.S. Spacesuit KC events. The services of this team are provided by the Mission Operations Directorate in conjunction with the Engineering Directorate at JSC.
3) JSC History Office –The JSC History Coordinator serves as the interviewer of the SMEs. The JSC History Office will post the transcriptions on its website [JSC History Portal: http://www.jsc.nasa.gov/history/oral_histories/oral_histories.htm] and archive the digital audio recordings in its JSC History Collection.
4) JSC Engineering Academy – All events that are not export controlled will be archived with the JSC Engineering Academy on the JSC internal website http://ea.jsc.nasa.gov/Ea_web/html/emplsrv/academy/index.asp . Also, the JSC Engineering Academy Council led by the JSC Engineering Academy Dean approves all outside SMEs. Objectives of the JSC Engineering Academy are to provide a learning environment for professional development and technical training directed at increasing the breadth and depth of engineering discipline knowledge.[6]
5) NASA Scientific and Technical Information (STI) Program - The NASA STI Program Office and its contractor-run facility, the NASA Center for AeroSpace Information (CASI), collect, organize, preserve, and distribute NASA STI worldwide. Many records are available to the public through the NASA Technical Reports Server (NTRS). Registered members of the NASA research community can access the full collection through the NASA Aeronautics and Space Database (NA&SD). Textual KC materials will be accessible through the NTRS [http://ntrs.nasa.gov] and NA&SD [http://access.sti.nasa.gov] and KC program videos will be accessible via the STI YouTube site [http://www.youtube.com/playlist?list=PL30B1C44470174A66].
6) Smithsonian Institution’s National Air and Space Museum (NASM) – As caretaker of over 1200 spacesuit artifacts of the U.S. space program, the NASM acquires, preserves and archives pressure suits and suit components of historical importance after their release from NASA programmatic use.

VI. Summary of Accomplishments and Events

When the U.S. Spacesuit KC program began in 2007, the first two full years (FY2008 and FY2009) were dedicated to getting the program up and running. The JSC Spacesuit KC Manager, Cinda Chullen, initiated the program with no funding and with limited time to accomplish the tasks, but with a great desire to see the program succeed. After meeting a life-long dream of joining the spacesuit team to help build the next generation spacesuit that had not been done in over 40 years, Cinda quickly realized there was a lot to learn about spacesuits and little time in which to do it. Therefore, she combined her former experience as the JSC Engineering Academy Dean with her desire to learn more about spacesuits. This combination resulted in the U.S. Spacesuit KC program as it is today. Also, as interest increased with the development of a new spacesuit and KM was being encouraged at JSC as well as agency-wide, funding was awarded to augment the program and the U.S. Spacesuit KC program has been off and running ever since.

To measure the success of the program, a matrix was initiated in 2010 to plan and track activity of the KC events. The matrix reveals that over 1170 NASA civil servants and contractors have participated in the events and reflects an increase in attendance each year. The participants represent a large variety of different organizations at JSC that include the Offices of External Relations, Procurement, Department of Defense Payloads, Space Shuttle Transition and Retirement, Extravehicular Activity Office, and the Chief Financial Officer. Directorates represented include the Flight Crew Operations, Mission Operations, Engineering, Information Resources, Center Operations, Astromaterials Research and Exploration Science, Safety and Mission Assurance, Space Life Sciences, and programs represented include ISS, Space Shuttle, the former Constellation Program, and the Multi-Purpose Crew Vehicle, as well as several power and avionics visitors from Glenn Research Center.

Additionally, a significant number of the attendees are the engineers focused on the development of the next generation spacesuit, the Advanced Extravehicular Mobility Unit (AEMU). It has become evident that several engineers are now reaching out to these SMEs to seek advice. One engineer working on the AEMU Project commented about Joe McMann, "As usual, you're a wealth of knowledge and I appreciate the time you've taken to share your experiences." An evaluation comment from the event with former astronaut, Scott Parazynski, M.D. revealed, "Excellent use of time."

The focus for FY13 and beyond will be to facilitate the cross training of current SMEs on specific components for the AEMU project intertwined with bringing in experts knowledgeable with former systems or like systems to gain a historical knowledge base and foster discussions around lessons learned. As the AEMU project heads toward several major agency milestones, it will be critical that the current engineers are acutely knowledgeable about their hardware and the hardware with which they have to interface. Therefore, the FY13 KC events will concentrate on providing these engineers with SME experience focused on selected technical areas. Not only will the U.S Spacesuit KC program focus on spacesuit hardware topics, but also on personal development to help the spacesuit engineers do their jobs better. Spacesuit projects need professionals with a wide-field view of how to get their jobs accomplished. Evaluations of prior events have shown that the non-technical events are rated just as high as the technical events. The goal is to satisfy the interest of the spacesuit project engineer in doing their jobs. Also, additional emphasis will be placed on processing the historical KC events so that they are archived and made available to the public via the NTRS. The event entitled "Chinese Spacesuit Analysis" was the initial public release on the NTRS YouTube site with nearly 1500 viewings at the end of June 2012.

A chronological portrayal of the events held in FY12 and FY13 is summarized in this section.

FY12 & FY13 Accomplishments and Initiatives

- Engage the JSC History Office in Interviews – Rebecca Wright (JSC History Coordinator) agreed to conduct interviews for U.S. Spacesuit KC events
- In addition to archived recordings, the audio will be archived with the JSC Oral History Project and made public (vetted through legal)
- Written transcription of audio will be accomplished at no cost
- Secured Human Resource budget to augment KC events for external SMEs
- Prepared a 2012 ICES Paper entitled "U.S. Spacesuit Knowledge Capture Status and Initiatives" – Focus on accomplishments
- Designed and released a U.S. Spacesuit KC Catalog (A copy may be obtained from one of the authors)
- Continued to archive recordings with the JSC Engineering Academy [http://ea.jsc.nasa.gov/Ea_web/html/emplsrv/academy/index.asp]
- Processed KC events through Export Control process (Form 1676) – all KC information cannot be publically released without going through this process and cleared for export
- Publicly released viable recordings – NASA Technical Library
- NASA Technical Library release first U.S. Spacesuit KC event to YouTube
- FY12, the U.S. Spacesuit KC program held 22 KC events as shown in Table 1
- FY13, the U.S. Spacesuit KC program held 14 KC events as shown in Table 2 - A few of the events are featured in Section V of this paper
- Had XXX personnel attend events through September 2013

Table 1. FY12 U.S. Spacesuit KC Events

Date	Presenter	Title
10/28/2011	Mallory Jennings	Packing the PLSS
11/29/2011	Carly Watts & Bruce Conger	PLSS Breadboard Series, Part 1
12/06/2011	Joe Kosmo	Joe Kosmo's Farewell Advice
12/08/2011	Joe McMann	Fifty Years of Observing Hardware and Human Behavior
01/19/2012	McMann & Paul Shack	Shuttle Electronics-Avionics Experience
01/24/2012	Scott Parazynski, M.D.	EVA Physiology and Medical Considerations Working in a Suit
02/16/2012	Scott Parazynski, M.D.	Real-time EVA Troubleshooting
02/23/2012	Scott Parazynski, M.D.	Space Shuttle TPS Inspection and Repair
03/06/2012	Scott Parazynski, M.D.	EVA Skills Training
03/28/2012	Ron Woods	Interviewed by Rebecca Wright: Apollo, Paintbrushes, and Packaging
04/19/2012	Ron Woods	Lessons Learned & Why Not to "Ship and Shoot"
04/26/2012	Ron Woods	Road to Final Stow
05/01/2012	Joe Kosmo	Innovation Brings Results
05/10/2012	Tom Sanzone	The Good Old Days

		of Crew and Thermal Systems Division (CTSD)
05/14/2012	Cathy Lewis, Ph.D	Interviewed by Rebecca Wright: Smithsonian NASM Spacesuit Curator Dr. C. Lewis
06/19/2012	Grant Bue & Janice Makinen	PLSS Component: Suit Water Membrane Evaporator (SWME)
06/25/2012	Joe McMann	PLSS Design and Manufacturing Review Debrief
07/10/2012	Richard Scheuring, M.D.	Investigations on In-Suit Shoulder Injuries
08/14/2012	Juniper Jairala &Robert Durkin	EVA Development and Verification Testing at NASA's Neutral Buoyancy Laboratory
09/12/2012	Richard Scheuring, M.D.	Apollo Lunar Surface Operations and EVA Suit Issues
09/20/2012	John James, Ph.D.	Crew Health/Performance Improvements & Resource Impacts with Reduced CO_2 Levels
09/28/2012	James (Jim) McBarron II	Interviewed by Rebecca Wright: Personal Background Interview of Jim McBarron

Table 2. FY12 U.S. Spacesuit KC Events

DATE	PRESENTER	TITLE
10/02/2012	Jason Norcross	CO2 Washout Testing of NASA Space Suits
10/16/ 2012	Joe Chambliss	The Single Habitat Module Concept – A Streamlined Way to Explore
11/06/2012	Jim McBarron	Spacesuit Development and Qualification for Project Mercury

12/04/2012	Jim McBarron	Spacesuit Development and Qualification for Project Gemini
01/29/2013	Jim McBarron	Apollo Block I Spacesuit Development and Apollo Block II Spacesuit Competition
04/10/2013	Kenneth Thomas	Launch, Entry & Abort, Intra-Vehicular Spacesuits
05/06/2013	Dr. Stan Love	Antarctica EVA
06/18/2013	David Leestma	STS-41G EVA
07/25/2013	Dr. Paul Abell	Human Exploration of Near-Earth Asteroids
07/31/2013	Dr. Stan Love	Near-Earth Asteroids: Threats and Opportunities
08/21/2013	Dr. John Charles	Origins and Early History of Underwater Neutral Buoyancy Simulation of Weightlessness for EVA Procedures Development and Training – From 'Below Dignity' to 'Above It All
09/10/2013	Dr. John Charles	Origins and Early History of Underwater Neutral Buoyancy Simulation of Weightlessness for EVA Procedures Development and Training – Winnowing and Regrowth
09/17/2013	Dr. Jonathan B. Clark	Overview of Spacesuits for Survival and Escape

VII. Featured U.S. Spacesuit Knowledge Capture Events

The U.S. Spacesuit KC program shares information through various techniques: lunch-and-learns, training courses, lectures by experts, workshops, and formal interviews. To educate future spacesuit designers, scientists, engineers, spacesuit academia, and, when appropriate, the space community, these KC events are electronically recorded and archived with the NTRS. These recorded series include the verbal presentation along with questions that attendees posed during the event. These events that are not export controlled will be available for public consumption. Spacesuit designers will be able to view the archived KC spacesuit events when necessary. The U.S. Spacesuit Knowledge Capture Series Catalog Revision A CTSD–SS–3487documents all the KC events that occurred since the program's inception and includes the event's topic, presenter, synopsis, and each presenter's biography. The catalog will be made available through the NTRS YouTube site [http://www.youtube.com/playlist?list=PL30B1C44470174A66]. Two prominent FY13 events that emulate the administration's current mission are described below.

Event Topic: Human Exploration of Near-Earth Asteroids
Presenter: Dr. Paul Abell

Synopsis: A major goal for NASA's human spaceflight program is to send astronauts to near-Earth asteroids (NEA) in the coming decades. Missions to NEAs would undoubtedly provide a great deal of technical and engineering data on spacecraft operations for future human space exploration while conducting in-depth scientific examinations of these primitive objects. However, before sending human explorers to NEAs, robotic investigations of these bodies would be required to maximize operational efficiency and reduce mission risk. These precursor missions to NEAs would fill crucial strategic knowledge gaps concerning their physical characteristics that are relevant for human exploration of these relatively unknown destinations. Abell discussed some of the physical characteristics of near-Earth objects (NEO) that will be relevant for EVA considerations, reviewed the current data from previous NEA missions (e.g., Near-Earth Asteroid Rendezvous (NEAR) Shoemaker and Hayabusa), and discussed why future robotic and human missions to NEAs are important from space exploration and planetary defense perspectives.

Biography: Abell is the lead scientist for Planetary Small Bodies assigned to the Astromaterials Research and Exploration Science (ARES) Directorate at NASA JSC in Houston, Texas.

He received an artium baccalaureus in astronomy and physics from Colgate University, a master of science in space studies with a minor in geology from the University of North Dakota, and a doctor of philosophy (Ph.D.) in geology from Rensselaer Polytechnic Institute.

His main areas of interest are physical characterization of NEO through ground-based and spacecraft observations, examination of NEOs for future robotic and human exploration, and identification of potential resources within the NEO population for future resource use. Abell has been studying potentially hazardous asteroids and NEOs for over 15 years. He was a telemetry officer for the NEAR spacecraft Near-Infrared Spectrometer team and was a science team member on the Japan Aerospace Exploration Agency (JAXA) Hayabusa NEA sample-return mission. Abell was also a member of the Hayabusa contingency recovery team and participated in the successful recovery of the spacecraft‘s sample return capsule, which returned to Woomera, Australia in June 2010.

Since 2006, Abell has been a member of an internal NASA team that is examining the possibility of sending astronauts to NEOs for long duration human missions circa 2025 and is currently the lead committee member of the Small Bodies Assessment Group chartered with identifying Human Exploration Opportunities for NEOs. In 2009, he became a science team member of the Large Synoptic Survey Telescope (LSST) Solar System Collaboration tasked with identifying NEOs for future robotic and human space missions, and is also the science lead for NEO analog activities and operations of the NASA Extreme Environment Mission Operations (NEEMO) and Research and Technology Studies (RATS) projects. Asteroid 8139 (1980 UM1) is named Paulabell in recognition of Abell's contributions to NEO research and exploration studies.

Event Topic: Near-Earth Asteroids: Threats and Opportunities
Presenter: Dr. Stan Love

Synopsis: Love's presentation reviewed the basics of NEAs: how many there are, how likely they are to hit the Earth, ways to prevent a threatening asteroid from hitting us, and some thoughts on human exploration of these interesting objects.

Biography: Love is a NASA astronaut at JSC. He served as a crew member and spacewalker on Space Shuttle flight STS-122 in 2008 and worked as a Capcom for many Shuttle and ISS missions. He has participated in numerous terrestrial spaceflight analog expeditions, including two Antarctic field seasons with ANSMET. He previously worked as a spacecraft engineer at Jet Propulsion Laboratory and as a postdoctoral researcher in planetary science at Caltech and at the University of Hawaii. He holds a bachelor's degree in physics from Harvey Mudd College, and a master's and doctorate in astronomy from the University of Washington.

VIII. Conclusion

KM is a strategic objective for NASA. The U.S. Spacesuit KC program has proven to be vital in meeting this strategic objective. This program has provided a mechanism for retaining pertinent knowledge of the spacesuits and is especially timely as a new spacesuit is currently being designed, assembled, and tested. Knowledge is being shared and learning is being encouraged to help improve performance, facilitate innovation, eliminate redundant work, potentially reduce "training time," and help adapt to a changing environment in space exploration. The knowledge being archived comes from the knowledge of those who learned before us so those who come after us can continue to explore, push the envelope, and live in space so that we can go farther, do better, and know more in the process. This paper provides a status and reveals initiatives associated with the program so that the information is communicated and preserved. Perhaps the greatest challenges facing our KC system consist of first making sure that those who could benefit from it know of its existence, second, that they know how to use it, and third, that they understand the importance of archiving spacesuit history so that future engineers and managers can benefit from our nation's investment. The value of KC was best expressed by the parent of an elementary student: "We don't always reach our expectations and we don't always win; it's the lessons from the journey that we carry with us [that] mean the most over time."

Acknowledgments

The authors of this paper would like to thank Glenn Lutz for his commitment to spacesuit knowledge capture, Raul Blanco for his support and encouragement and Rebecca Wright for her dedication in preserving NASA's history. We would like to thank those behind the scenes who provide incredible service in recording knowledge capture events; namely, Jim Hansen and Matthew Mcgee. Additionally, we thank Jason Nelson and Zeeaa Quadri for their continued support and commitment.

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