U.S. Spacesuit Knowledge Capture Series

Catalog

Crew and Thermal Systems Division

September 28, 2012

CTSD–SS–3487

Revision: Baseline

National Aeronautics and Space Administration
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Change Log

Effective Date	Version	Description	Author
09/28/2012	Baseline	N/A	Rose Bitterly

Purpose

The National Aeronautics and Space Administration (NASA) and other organizations have been performing U.S. Spacesuit Knowledge Capture (USSKC) since the beginning of space exploration through published reports, conference presentations, specialized seminars, and classes instructed by veterans in the field. The close physical interaction between spacesuit systems and human beings makes them among the most personally evocative pieces of space hardware. Consequently, spacesuit systems have required nearly constant engineering refinements to do their jobs without impinging on human activity.

Since 2008, spacesuit knowledge capture has occurred through video recording, engaging both current and former specialists presenting technical scope specifically to educate individuals and preserve knowledge. These archives of spacesuit legacy reflect its rich history and will provide knowledge that will enhance the chances for the success of future and more ambitious spacesuit system programs. The scope and topics of USSKC have included lessons learned in spacesuit technology; experience from the Gemini, Apollo, Skylab, and Shuttle Programs; the process of hardware certification, design, development, and other program components; spacesuit evolution and experience; failure analysis and resolution; and aspects of program management.

USSKC activities have progressed to a level where NASA, the National Air and Space Museum (NASM), Hamilton Sundstrand (HS) and the spacesuit community are now working together to provide a comprehensive way to organize and archive intra-agency information related to the development of spacesuit systems. These video recordings are currently being reviewed for public release using NASA export control processes. After a decision is made for either public or non-public release (internal NASA only), the videos and presentations will be available through the NASA Johnson Space Center Engineering Directorate (EA) Engineering Academy, the NASA Technical Reports Server (NTRS), the NASA Aeronautics & Space Database (NA&SD), or NASA YouTube. Event availability is duly noted in this catalog.

EA Engineering Academy - Internal NASA only

http://ea.jsc.nasa.gov/Ea_web/html/emplsrv/academy/index.asp

NTRS - Publicly available

http://ntrs.nasa.gov

NA&SD - Internal NASA only

https://www2.sti.nasa.gov

NASA CASI (Center for AeroSpace Information) YouTube

http://www.youtube.com/playlist?list=PL30B1C44470174A66&feature=plcp

For further information:

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Acronyms

0-g	zero gravity
acfm	actual cubic feet per minute
AEMU	Advanced Extravehicular Mobility Unit
AES	Advanced Exploration Systems
AEVA	Advanced Extravehicular Activity
ARES	Astromaterials Research and Exploration Science
ASTP	Apollo-Soyuz Test Project
C3I	communications, command, control, and information
CASI	Center for AeroSpace Information
CEIT	Crew Equipment Interface Test
CETA	Crew and Equipment Translation Aid
CFD	Computational Fluid Dynamics
CI	co-investigator
CO_2	Carbon Oxide
CS	Crew Survival
C-SAFE	Constellation Space Suit Accommodations for Exploration
CSSE	Constellation Spacesuit Element
CTSD	Crew and Thermal Systems Division – EC5 – JSC
CxP	Constellation Program – JSC
DoD	Department of Defense
EA	Engineering Directorate – JSC
EC	Crew and Thermal Systems Division
EC5	Space Suit Systems Branch – CTSD – JSC
EMU	Extravehicular Mobility Unit
ESCG	Engineering and Science Contract Group – JSC
EVA	Extravehicular Activity
GSAB	General Support Aviation Battalion
HoFi	Hollow Fiber SWME
HS	Hamilton Sundstrand
HSIR	Human Systems Integration Requirements
HTV	H-II Transfer Vehicle

HUT	hard upper torso
IR	ionizing radiation
ISS	International Space Station
IVA	Intravehicular Activity
IVT	Integrated Vehicle Test
JSC	Johnson Space Center
KC	knowledge capture
KSC	Kennedy Space Center
LEA	Launch, Entry, and Abort
LEO	low Earth orbit
mmHg	millimeters of mercury
MMU	Manned Maneuvering Unit
MOD	Mission Operations Directorate
NASA	National Aeronautics and Space Administration
NASM	National Air and Space Museum
NA&SD	NASA Aeronautics & Space Database
NBL	Neutral Buoyancy Laboratory
NIOSH	National Institute of Occupational Safety and Health
NTRS	NASA Technical Reports Server
PABF	precision air-bearing floor
PAS	Power, Avionics, and Software
PGS	Pressure Garment Subsystem
Ph.D.	doctor of philosophy
PI	principal investigator
PLSS	Portable Life Support System
RATS	Research and Technology Studies
RCA	Rapid Cycle Amine
RCC	Reinforced Carbon-Carbon
RF	radio frequency
SaM	Sheet Membrane SWME
SCM	Single Crew Module
SEAT	Science, Engineering, Analysis, and Test Contract

SE&I	Systems Engineering and Integration
SMAC	Spacecraft Maximum Allowable Concentration
SRAG	Space Radiation Analysis Group
STS	Shuttle Transportation System
SWME	Spacesuit Water Membrane Evaporator
TCCS	Trace Contaminant Control System
TPS	Thermal Protection System
U.S.	United States
USSKC	U.S. Spacesuit Knowledge Capture
WETF	Weightless Environment Training Facility
WORF	Window Observational Research Facility – ISS
XA	EVA Project Office – JSC

1.0 Fiscal Year 2008

The following subsections summarize the fiscal year 2008 U.S. Spacesuit Knowledge Capture (USSKC) Series presentations.

1.1 The Apollo Experience Lessons Learned for Constellation Lunar Dust Management

Sandra Wagner presented “The Apollo Experience Lessons Learned for Constellation Lunar Dust Management” on January 17, 2008.

In 2008, the National Aeronautics and Space Administration (NASA) embarked on its exploration vision knowing they would encounter many technical challenges. For lunar exploration missions, learning to manage lunar dust was one challenge. References to problems associated with lunar dust during the Apollo Program were on many pages of the mission reports and technical debriefs. All engineers designing hardware that would contact lunar dust had to mitigate its effects in the design.

Availability: by request

1.2 Implications of Operational Pressure

G. Ryan Lee presented “Implications of Operational Pressure” on February 14, 2008.

The Constellation Spacesuit Element (CSSE) was required to support Crew Survival (CS); Launch, Entry, and Abort (LEA) scenarios; zero gravity (0-g) Extravehicular Activity (EVA) (both unscheduled and contingency); and planetary EVA. Operation of the CSSE in all of these capacities required a Pressure Garment Subsystem (PGS) that would operate efficiently through various pressure profiles. The PGS team initiated a study to determine the appropriate operational pressure profile of the CSSE and to determine how this selection would affect the design of the CSSE PGS. This study included an extensive review of historical PGS operational pressure selection and the operational effects of those pressures, the presentation of four possible pressure paradigm options for use by the CSSE, the risks and design impacts of these options, and the down-selected pressure option.

Availability: by request

1.3 Gen Y Perspectives

Garret Fitzpatrick presented “Gen Y Perspectives” on February 22, 2008.

Are you familiar with the famed Generation Y, or "Gen Yers?" Generation Y is projected to be 47 percent of the workforce by 2014. They were born roughly between 1977 and 2000, but that is definitely not their only defining factor.

But who is this group, and what do they have to do with the future of the space program and the Johnson Space Center (JSC)?

During 2007, a group of Gen Yers at JSC participated on a committee to address the NASA Headquarters strategic communications plan. Fitzpatrick, along with his co-authors, created a presentation to share the Gen Yers' perspective on their generation in conjunction with the strategic communications strategy released. This knowledge capture (KC) event is that presentation.

Availability: by request

1.4 Baseline CxP PLSS Schematic Functions and Operational Modes

Bruce Conger presented "Baseline CxP PLSS Schematic Functions and Operational Modes" on February 28, 2008.

Conger presented the operations and functions of the baseline Constellation Program (CxP) Portable Life Support System (PLSS) schematic and key development technologies. He explained the functional descriptions of the schematic components in the fluid systems of the PLSS for multiple operational scenarios. PLSS subsystems include the oxygen subsystem, the ventilation subsystem, and the thermal subsystem. He also presented the operational PLSS modes: Nominal EVA mode, Umbilical – no recharge mode, Umbilical – with recharge mode, BENDS mode, BUDDY mode, Secondary oxygen mode, and the PLSS-removed umbilical mode.

Availability: by request

1.5 Arizona Geology Field Trip

Gretchen A. Thomas and Amy J. Ross presented "Arizona Geology Field Trip" on March 27, 2008.

A variety of hardware developers, crew, mission planners, and headquarters personnel traveled to Gila Bend, Arizona, in February 2008 for a CxP Lunar Surface Systems Team geology experience.

Participating in this field trip were the CxP Space Suit System leads: Thomas (PLSS) and Ross (PGS), who presented the activities and findings learned from being in the field during this KC. As for the design of a new spacesuit system, this allowed the engineers to understand the demands this type of activity will have on NASA's hardware, systems, and planning efforts. The engineers also experienced the methods and tools required for lunar surface activity.

Availability: EA Engineering Academy

1.6 Rules of Thumb for Cost Estimating

Gretchen A. Thomas presented "Rules of Thumb for Cost Estimating" on April 18, 2008.

Thomas discussed best practices for estimating project costs.

Availability: EA Engineering Academy

1.7 Orlan-M Spacesuit Familiarization Class

Joey Marmolejo, Chris Estrada, Chuck Fulcher, and Bryan Peavey presented "Orlan-M Spacesuit Familiarization Class" on May 20, 2008.

This presentation provided an overview of the Russian Orlan-M spacesuit and International Space Station (ISS) support hardware. Topics included spacesuit assembly, life support system, and airlock support hardware and operations.

Marmolejo, NASA; Estrada, Hamilton Sundstrand (HS); Fulcher, HS; and Peavey, HS; presented as subject matter experts for Russian EVA systems.

Availability: by request

1.8 Gloves 101

Amy J. Ross presented "Gloves 101" on June 13, 2008.

This presentation addressed the question “What is a spacesuit glove?” – a highly specialized mobility system. It is an excellent basic tutorial on the design considerations of a spacesuit glove and the many facets of developing a glove that provides good mobility and thermal protection.

Availability: by request

2.0 Fiscal Year 2009

The following subsection summarizes the 2009 USSKC Series presentation.

2.1 Failure Recovery

Joe McMann presented “Failure Recovery” on December 1, 2008.

This two-part course was geared for engineers. The first part of the course dealt with a description of the tools and processes involved in failure recovery, and the second part was an exercise in which teams prepared and critiqued recovery plans based on sample problems. The course covered the techniques for identifying and taking necessary actions during hardware failure. Information included generating a problem resolution team, preparing fault trees, constructing an investigation plan, identifying root causes and corrective actions, and preparing a back-up plan. This class essentially covered everything that needs to be done when a failure occurs.

Availability: by request

3.0 Fiscal Year 2010

The following subsections summarize the fiscal year 2010 USSKC Series presentations.

3.1 Chinese Spacesuit Analysis

Lewis Croog presented “Chinese Spacesuit Analysis” on February 17, 2010.

In 2008, China became only the third nation to perform an EVA from a spacecraft. An overview of the Chinese spacesuit and life support system were assessed from video downlinks during their EVA; from those assessments, spacesuit characteristics were identified. Croog compared the spacesuits against the Russian Orlan Spacesuit and the U.S. Extravehicular Mobility Unit (EMU). He also presented China’s plans for future missions.

Availability: EA Engineering Academy; CASI NTRS; CASI NASA YouTube

3.2 Interviews with Apollo Astronauts

Dr. Dean Eppler presented “Interviews with Apollo Astronauts” on February 23, 2010.

A 3-person team interviewed 8 of the 11 surviving Apollo crewmembers in a series of focused interviews to discuss their experiences on the lunar surface. Eppler presented the results of these interviews, along with recommendations for the design of future lunar surface systems.

Availability: by request

3.3 Interview with Dean Eppler

On March 15, 2010, Pica Kahn presented an “Interview with Dean Eppler.”

The interview highlighted the personal and professional influences that have impacted Dr. Eppler’s contributions to the space program.

Availability: by request

3.4 Conduct of Geologic Field Work during Planetary Exploration: Why Geology Matters

Dr. Dean Eppler presented “Conduct of Geologic Field Work during Planetary Exploration: Why Geology Matters” on March 15, 2010.

The science of field geology is the investigative process of determining the distribution of rock units and structures on a planet’s surface, and it is the first-order data set that informs all subsequent studies of a planet, such as geochemistry, geochronology, geophysics, or remote sensing. For future missions to the Moon and Mars, the surface systems deployed must support the conduct of field geology if these endeavors are to be scientifically useful. This lecture discussed what field geology is — why it is important, how it is done, how conducting field geology informs many other sciences, and how it affects the design of surface systems and the implementation of operations in the future.

Availability: EA Engineering Academy; CASI NTRS; CASI NASA YouTube

3.5 EMU Certification Workshop

Joe McMann and Mike Rouen presented “EMU Certification Workshop” on May 20, 2010.

This workshop focused on historical EMU flight certification, drawing upon experiences of the Gemini, Apollo, Skylab, Space Shuttle, and ISS Programs. The shuttle EMU history of design, development, certification, and flight use was used as the backdrop for the workshop, with relevant experience from the Gemini, Apollo, and Skylab Programs interwoven to show how lessons were or were not learned. The historical meaning and purpose of certification, from component to integrated manned testing, was explored in depth, particularly the definition and imposition of requirements and the relationship of development to certification.

Availability: by request

3.6 The Size of the Universe and Where Will We Go?

B. Mike Lawson presented “The Size of the Universe and Where Will We Go?” on June 25, 2010.

As an avid engineer and amateur astronomer, Lawson presented a perspective on the size of the universe and asked the question, “Where will we go?” This was an entry-level overview for the average space worker who really wants to understand the size of stars and the distance between objects in space. Lawson provided information about familiar orbital objects and elaborated more on galaxies during the discussion. He also explored where humans can go in space and the physical limitations of going there.

Availability: EA Engineering Academy; CASI NTRS; CASI NASA YouTube

3.7 CO_2 Washout

Philip Augustine presented “CO_2 Washout” on July 23, 2010.

During design development for NASA’s CxP, conflicting requirements arose between the volume of air flow that the new manned space vehicle was allocated to provide to the suited crewmember and the amount of air required to achieve Carbon Oxide (CO_2) washout in a spacesuit. Historically, spacesuits received 6.0 actual cubic feet per minute (acfm) of air flow, which adequately washed out CO_2 for EVAs. For the CxP, the expected acfm amount decreased; the vehicle would provide 4.5 acfm of air flow to the suit. Helmet testing was performed at the National Institute of Occupational Safety and Health (NIOSH) in Pittsburgh, Pennsylvania to provide a gross-level validation of the Computational Fluid Dynamics (CFD) models. Results indicated that although 4.5 acfm of suit inlet air flow could provide adequate CO_2 washout for suited Intravehicular Activities (IVA), it was highly dependent upon helmet geometry and ventilation routing. This presentation summarized the results of this CO_2 washout study.

Availability: by request

3.8 EMU Oxygen and Fire Hazards

Glen Lutz and Mike Rouen presented “EMU Oxygen and Fire Hazards” on August 10, 2010.

This lecture focused on the technical issues of the EMU suit design. The life-saving thought process of EVA hardware development was presented, including how to identify and think through worst-case scenarios beginning with the most critical failure. The discussion included fundamental concepts, such as hardware that is developed and designed through failures rather than successes, and the ultimate importance of not overlooking the subtleties of the design.

Availability: by request

3.9 Post-Shuttle EVA Operations on ISS

Cinda Chullen and William (Bill) West presented “Post-Shuttle EVA Operations on ISS” on August 26, 2010.

The EVA hardware used to assemble and maintain the ISS was designed with the assumption that it would be returned to Earth on the Space Shuttle for ground processing, refurbishment, or failure investigation (if necessary). With the retirement of the Space Shuttle, a new concept of operations was developed to enable EVA hardware (EMU, Airlock Systems, EVA tools, and associated support equipment and consumables) to perform ISS EVAs until 2016 and possibly beyond to 2020. Shortly after the decision to retire the Space Shuttle was announced, NASA and the One EVA contractor team jointly initiated the EVA 2010 Project. Challenges were addressed to extend the operating life and certification of EVA hardware, secure the capability to launch EVA hardware safely on alternate launch vehicles, and protect EMU hardware operability on orbit for long durations.

Availability: by request

3.10 Constellation Spacesuit PLSS Trace Contaminant Control

Mallory Jennings and Dr. Glenn Waguespack presented "Constellation Spacesuit PLSS Trace Contaminant Control" on September 8, 2010.

This presentation summarized the results of a trade study that evaluated whether trace contaminant control within the Constellation Spacesuit PLSS could be achieved without a Trace Contaminant Control System (TCCS) by relying on suit leakage, ullage loss from the carbon dioxide and humidity control system, and other factors. Jennings and Waguespack studied trace contaminant generation rates to verify that values reflected the latest designs for Constellation spacesuit system pressure garment materials and PLSS hardware. They also calculated TCCS sizing and conducted a literature survey to review the latest developments in trace contaminant technologies.

Availability: by request

3.11 Design and Testing of the Sheet and Hollow Fiber Spacesuit Water Membrane Evaporators

Grant Bue and Matthew Vogel presented "Design and Testing of the Sheet and Hollow Fiber Spacesuit Water Membrane Evaporators" on September 30, 2010.

Bue and Vogel presented the two types of Spacesuit Water Membrane Evaporators (SWME) that were developed based on hydrophobic microporous membranes. One type, the Sheet Membrane (SaM) SWME, is composed of six concentric Teflon sheet membranes fixed on cylindrical-supporting screens to form three concentric annular water channels. Those water channels are surrounded by vacuum passages to draw off the water vapor that passes through the membrane. The other type, the Hollow Fiber (HoFi) SWME, is composed of more than 14,000 tubes. Water flows through the tubes and water vapor passes through the tube wall to the shell side that vents to the vacuum of space. Both SWME types have undergone testing to baseline the performance at predicted operating temperatures and flow rates; the units also have been subjected to contamination testing and other conditions to test resiliency.

Availability: by request

4.0 Fiscal Year 2011

The following subsections summarize the fiscal year 2011 USSKC Series presentations.

4.1 Joint Mobility

Jennifer Matty presented “Joint Mobility” on October 28, 2010.

This joint mobility KC lecture included information from two papers, “A Method for and Issues Associated with the Determination of Space Suit Joint Requirements” and “Results and Analysis from Space Suit Joint Torque Testing,” as presented for the International Conference on Environmental Systems in 2009 and 2010, respectively. The first paper discusses historical joint torque testing methodologies and approaches that were tested in 2008 and 2009. The second paper discusses the testing that was completed in 2009 and 2010.

Availability: by request

4.2 Spacesuit System Evolution and Experience

Joe McMann and Kenneth Thomas presented “Spacesuit System Evolution and Experience” on November 4 and 5, 2010.

This two-day workshop introduced participants to the history, experience, technical characteristics, and lessons learned related to both U.S. and Russian spacesuit systems. Copies of “U.S. Spacesuits,” written by the presenters, were provided to workshop participants. The time covered the 1950s to the present, including the spectrum of all U.S. space programs, beginning with Project Mercury. McMann and Thomas also discussed recent forays by the commercial sector into the spacesuit arena. Topics included engineering, subsystem management, contract technical management, resident government representation, advanced systems planning and design, and participation as test subjects. As a special feature, McMann and Thomas described the role of the Smithsonian in preserving valuable spacesuit hardware artifacts.

Availability: by request

4.3 Mike Lawson’s Stories and More

B. Mike Lawson presented “Mike Lawson’s Stories and More” on December 16, 2010.

Lawson briefly discussed pressure drop for aerospace applications and presented short stories about adventures experienced while working at NASA and General Dynamics, including exposure to technologies like the Crew and Equipment Translation Aid (CETA) cart and the SWME.

Availability: by request

4.4 Suit 101

Amy J. Ross presented “Suit 101” on January 25, 2011.

A NASA spacesuit under the EVA Technology Domain consists of a suit system; a PLSS; and a Power, Avionics, and Software (PAS) system. Ross described the basic functions, components, and interfaces of the PLSS, which consists of oxygen, ventilation, and thermal control subsystems; electronics; and interfaces. Design challenges were reviewed from a packaging perspective. Ross also discussed the development of the PLSS over the last two decades.

Availability: by request

4.5 PLSS 101

Gretchen A. Thomas presented “PLSS 101” on March 31, 2011.

This presentation reviewed basic interfaces and considerations necessary for prototype suit hardware integration from an advanced spacesuit engineer perspective during the early design and test phases. The discussion included topics such as the human interface, suit pass-throughs, keep-out zones, hardware form factors, subjective feedback from suit tests, and electricity in the suit.

Availability: by request

4.6 PAS 101

David Irimies presented “PAS 101” on May 6, 2011.

EVA systems consist of a spacesuit or garment, a PLSS, a PAS system, and spacesuit interface hardware. The PAS system is responsible for providing power for the suit, communication of several types of data between the suit and other mission assets, avionics hardware to perform numerous data display and processing functions, and information systems that provide crewmembers data to perform their tasks with more autonomy and efficiency. Irimies discussed how technology development efforts have advanced the state-of-the-art in these areas and shared technology development challenges.

Availability: by request

4.7 An Interview with Joe McMann: His Life Lessons

Pica Kahn conducted “An Interview with Joe McMann: His Life Lessons” on May 23, 2011.

With over 40 years of experience in the aerospace industry, McMann has gained a wealth of knowledge. Many have been interested in his biography, progression of work at NASA, impact on the U.S. spacesuit, and career accomplishments. This interview highlighted the influences and decision-making methods that impacted his technical and management contributions to the space program. McMann shared information about the accomplishments and technical advances that committed individuals can make.

Availability: by request

4.8 Alternate Approaches to Exploration – The Single Crew Module Concept

Joe Chambliss presented "Alternate Approaches to Exploration – The Single Crew Module Concept" on June 30, 2011.

The CxP envisioned exploration of the Moon and Mars using an extrapolation of the Apollo approach. Chambliss provided a brief overview of the CxP approaches for lunar and Mars missions and some of the alternatives that were considered. He described an alternative approach referred to as a Single Crew Module (SCM) approach. The SCM concept employs new technologies in a way that could reduce exploration cost and possibly schedule. The presentation and discussion also included options to the approaches.

Availability: by request

4.9 An Interview with Joe McMann: Lessons Learned in Human and Hardware Behavior

Pica Kahn conducted "An Interview with Joe McMann: Lessons Learned in Human and Hardware Behavior" on August 16, 2011.

With more than 40 years of experience in the aerospace industry, McMann has gained a wealth of knowledge. This presentation focused on lessons learned in human and hardware behavior. During his many years in the industry, McMann observed that the hardware development process was intertwined with human influences, which impacted the outcome of the product.

Availability: by request

4.10 Spacecraft Charging Hazards

Dr. Steven Koontz presented "Spacecraft Charging Hazards" on August 30, 2011.

Spacecraft flight environments are characterized both by a wide range of space plasma conditions and by ionizing radiation (IR), solar ultraviolet and X-rays, magnetic fields, micrometeoroids, orbital debris, and other environmental factors, all of which can affect spacecraft performance. Koontz's lecture provided the audience with a solid foundation in the basic engineering physics of spacecraft charging and charging effects that can be applied to solving practical engineering design, verification, and spacecraft operations problems.

Availability: **by request**

4.11 Space Radiation Basics for EVA Materials and Avionics and Space Radiation Effects on EVA Materials and Avionics

Dr. Steven Koontz presented “Space Radiation Basics for EVA Materials and Avionics” on September 8, 2011 and “Space Radiation Effects on EVA Materials and Avionics” on September 14, 2011.

The space-flight IR environment is dominated by very high-kinetic energy-charged particles with relatively smaller contributions from X-rays and gamma rays and essentially no contribution from the natural radioisotope decay processes that dominate the natural Earth surface IR environment. Koontz’s lecture provided the audience with a solid foundation in the basic engineering physics of space radiation environments and how those environments can affect spacecraft materials and avionics systems, in general, with some emphasis on EVA and supporting hardware systems beyond low Earth orbit (LEO). Koontz provided the JSC Space Radiation Analysis Group (SRAG) points of contact and a summary of the process for submitting hardware designs to the SRAG for crew dose evaluations.

Availability: **by request**

5.0 Fiscal Year 2012

The following subsections summarize the fiscal year 2012 USSKC Series presentations.

5.1 Packing the PLSS

Mallory Jennings presented “Packing the PLSS” on October 20, 2011.

Jennings familiarized attendees with a new beta-version of an educational and public outreach activity on how to package the PLSS. This activity used 1/10 scale plastic and cardboard mockups to emulate the actual packaged PLSS flight hardware components. At the end of the session, the attendees could educate students on the process of packaging the PLSS and could simulate an engineering test scenario. This was a great opportunity for engineers to become educators. The activity emphasized the scientific method, center of mass, and mass calculations, and allowed students to work through engineering design methods used by NASA spacesuit life support engineers.

Availability: **by request**

5.2 PLSS 1.0 Breadboard – Schematics

Carly Watts and Bruce Conger presented "PLSS 1.0 Breadboard – Schematics" on November 29, 2011.

Watts and Conger examined the considerations that went into the design of the advanced PLSS architecture, the test development process, test stand build-up, test series, data reduction, and analysis. They focused on the PLSS architecture development that drove design changes between the Revisions B and C advanced PLSS schematics, as well as the development of the PLSS breadboard test schematic. They also discussed component specification, test system build-up, testing, test results, and the implications of test data on prototype and system-level designs.

Availability: by request

5.3 Kosmo's Farewell Advice

On December 6, 2011, Amy J. Ross interviewed Joe Kosmo during "Kosmo's Farewell Advice."

Joe Kosmo shared some final words and advice for his teammates in the Spacesuit and Crew Survival Systems Branch (EC5) and the Crew and Thermal Systems Division (CTSD (EC)). He knew nothing about spacesuits when he started working for NASA in 1961, but neither did anyone else. He summed up the best lessons learned during his 50 years of developing U.S. spacesuits and encouraged the next generation's space industry workers to challenge what they hear and decide what is right.

Availability: by request

5.4 Fifty Years of Observing Hardware and Human Behavior

Joe McMann presented "Fifty Years of Observing Hardware and Human Behavior" on December 8, 2011.

During this half-day workshop, McMann presented the lessons learned during his 50 years of experience in both industry and government, which included all U.S. manned space programs, from Mercury to the ISS. He shared his thoughts about hardware and people and what he has learned from first-hand experience. Included were such topics as design, testing, design changes, development, failures, crew expectations, hardware, requirements, and meetings.

Availability: by request

5.5 Shuttle EMU Electronics/Avionics Development Experience as Related to Advanced EMU Development

Joe McMann and Paul Shack presented “Shuttle EMU Electronics/Avionics Development Experience as Related to Advanced EMU Development” on January 19, 2012.

This seminar was a recap of significant developmental problems and solutions in the area of electronics and avionics that McMann experienced during his years at NASA. His experience covered the shuttle EMU programs as a Life Support System manager, an EMU Subsystem manager, and an EMU technical manager. McMann offered lessons learned to the next generation of EMU electronics and avionics system designers. Subject matter focused on power generation and supply systems, caution and warning systems, and sensors. McMann also covered radio frequency (RF) equipment, extravehicular lighting and video, flammability, suit noise, and the criticalities of assemblies.

Availability: by request

5.6 EVA Physiology & Medical Considerations Working in a Spacesuit

Dr. Scott Parazynski presented “EVA Physiology & Medical Considerations Working in a Spacesuit” on January 24, 2012.

Parazynski covered several topics related to the medical implications and physiological effects of suited operations in space from the perspective of a physician with considerable first-hand EVA experience. Key themes included EVA physiology – working in a pressure suit in the vacuum of space, basic EVA life support and work support, Thermal Protection System (TPS) inspections and repairs, and discussions of the physical challenges of an EVA. He covered the common injuries and significant risks during EVA, as well as physical training required to prepare for EVAs. He also shared overall suit physiological and medical knowledge with the next generation of EMU system designers.

Availability: by request

5.7 Real-Time EVA Troubleshooting

Dr. Scott Parazynski presented “Real-Time EVA Troubleshooting” on February 16, 2012.

Parazynski focused on the STS-120 Solar Array Repair EVA with personal anecdotes and then spoke about what it takes to have a successful EVA, what types of problems can occur during an EVA, particularly with the spacesuit and the safety of the crew, and how to resolve these quickly, safely, and efficiently. He also described the participants and the types of decisions and actions each had to take to ensure success. He described “Team 4,” in Houston and on orbit, as well as anecdotes from his STS-86 and STS-100 missions. Parazynski provided a retrospective on the EVA tools and procedures NASA used in the aftermath of Columbia for shuttle TPS inspection and repair. He described his role as the lead astronaut during this effort, and covered the Neutral Buoyancy Laboratory (NBL), KC-135, precision air-bearing floor (PABF), vacuum chamber, and 1-G testing performed to develop the tools and techniques that were flown. Parazynski discussed how the EVA community worked together to resolve a huge safety issue, and how his work in the spacesuit was critical to overcoming a design limitation of the Space Shuttle.

Availability: by request

5.8 TPS Inspection and Repair

Dr. Scott Parazynski presented “TPS Inspection and Repair” on February 23, 2012.

Where necessity drives out-of-the-box thinking, Parazynski discussed a retrospective on the EVA tools and procedures efforts NASA went through in the aftermath of Columbia for the Space Shuttle TPS inspection and repair. He was the lead astronaut on this effort and participated in all the NBL, KC-135, PABF activities, and in vacuum chamber and 1-G testing. He led the crew consensus reporting and helped develop the tools and techniques that were flown. Parazynski described how the EVA community worked together to resolve a huge safety issue (how to conduct EVA repairs on the Space Shuttle) and how work in the spacesuit was critical in overcoming a design limitation of the Space Shuttle.

Availability: by request

5.9 EVA Skills Training

Dr. Scott Parazynski presented “EVA Skills Training” on March 6, 2012.

Parazynski and a colleague from EVA, Robotics, & Crew Systems Operations (DX) worked closely to build the EVA Skills Training Program, and for the first time, defined the gold standards of EVA performance, allowing crewmembers to increase their performance significantly. As part of the program, individuals had the opportunity to learn at their own rate, taking additional water time as required, to achieve that level of performance. This focus on training to one's strengths and weaknesses to bolster them enabled the Crew Office and DX to field a much larger group of spacewalkers for the daunting “wall of EVA” required for the building and maintenance of the ISS. Parazynski also stressed the need for designers to understand the capabilities and the limitations of a human in a spacesuit, as well as opportunities to improve future generations of space. He shared lessons learned (how the Crew Office engaged in these endeavors) and illustrated the need to work as a team to develop these complex systems.

Availability: by request

5.10 Apollo, Paintbrushes, and Packaging: An Interview with 40-year Spacesuit Veteran Ron Woods

Ron Woods was interviewed by Rebecca Wright during the presentation of "Apollo, Paintbrushes, and Packaging: An Interview with 40-year Spacesuit Veteran Ron Woods" on March 28, 2012.

Woods exhibits a wealth of knowledge gathered in more than 40 years of experience with NASA and spacesuits. Many people are interested in his biography, progression of work at NASA, impact on the U.S. Spacesuit, and career accomplishments. Wright, from the JSC History Office, conducted this personal background interview with Woods. The interview highlighted the influences and decision-making methods that impacted his technical and management contributions to the space program.

Availability: by request

5.11 Lessons Learned From a Ship-and-Shoot Philosophy

Ron Woods presented "Lessons Learned From a Ship-and-Shoot Philosophy" on April 19, 2012.

Woods shared incredibly valuable insights gained during his 28 years at the Kennedy Space Center (KSC) packaging Flight Crew Equipment for shuttle and ISS missions. In particular, Woods shared anecdotes and photos from various processing events. The moral of these stories and the main focus of this discussion were the additional processing efforts and effects related to a "ship-and-shoot" philosophy toward flight hardware.

Availability: by request

5.12 The Road to Final Stow

Ron Woods presented "The Road to Final Stow" on April 26, 2012.

Woods shared an overview of the STS-135 Flight Crew Equipment processing at KSC. The processes included Integrated Vehicle Tests (IVT), Crew Equipment Interface Tests (CEIT) in the Orbiter Processing Facility, the Terminal Countdown Test (S0017) at the launch pad, and Launch Countdown Stowage (S0007) at the launch pad.

Availability: by request

5.13 Innovation Brings Results

Joe Kosmo presented "Innovation Brings Results" on May 3, 2012.

This presentation was primarily based on Kosmo's overview of the various aspects that affect, drive, and support a proper environment that is conducive toward fostering innovation and thinking outside the box.

Availability: by request

5.14 The Good Old Days of CTSD

Tom Sanzone presented "The Good Old Days of CTSD" on May 10, 2012.

Sanzone shared his personal experiences of working in the CTSD, starting in 1968, and focused on the Apollo era when astronauts had as many as three custom-made EVA suits sporting their names and the empowerment of youth within NASA was strong – the average age of the Apollo 11 flight controllers was 26. He also mentioned the shuttle and station. The majority of the discussion was anecdotal, storytelling, covering four decades.

Availability: by request

5.15 Interview with Smithsonian NASM Spacesuit Curator Dr. Cathleen Lewis

Dr. Cathleen Lewis was interviewed by Rebecca Wright during the presentation of an "Interview with Smithsonian NASM Spacesuit Curator Dr. Cathleen Lewis" on May 14, 2012.

Topics included the care, size, and history of the spacesuit collection at the Smithsonian and the recent move to the state-of-the-art permanent storage facility at the Udvar-Hazy facility in Virginia.

Availability: by request

5.16 SWME Development and Testing for the Advanced Spacesuit

Grant Bue and Janice Makinen presented "SWME Development and Testing for the Advanced Spacesuit" on June 19, 2012.

Bue and Makinen presented the recent design, hardware development, and testing on the PLSS SWME. The SWME provides cooling to the spacesuit liquid cooling garment and PLSS electronics by evaporating water across a membrane into the vacuum of space. As the water turns to vapor and is vented into space, the liquid is cooled and re-circulated through the cooling loop.

Availability: by request

5.17 Investigations on In-Suit Shoulder Injuries

Dr. Richard Scheuring presented “Investigations on In-Suit Shoulder Injuries” on July 10, 2012.

For every 1 hour spent performing EVAs in space, astronauts in the U.S. space program spend approximately 6 to 10 hours training in the EVA spacesuit at NASA JSC’s NBL. In 1997, NASA introduced the planar hard upper torso (HUT) EVA spacesuit, which subsequently replaced the existing pivoted HUT. An extra joint in the pivoted shoulder allows increased mobility, but it also increased complexity. Over the next decade, numerous astronauts developed shoulder problems requiring surgical intervention, many of whom performed EVA training in the NBL. Scheuring elaborated on a study that investigated whether changing HUT designs led to shoulder injuries requiring surgical repair.

Availability: **by request**

5.18 EVA Development and Verification Testing at NASA’s Neutral Buoyancy Laboratory

Juniper Jairala and Robert Durkin presented “EVA Development and Verification Testing at NASA’s Neutral Buoyancy Laboratory” on August 14, 2012.

As an early step in preparing for future EVAs, astronauts perform neutral buoyancy testing to develop and verify EVA hardware and operations. To date, neutral buoyancy demonstrations at NASA JSC’s Sonny Carter Training Facility have primarily evaluated assembly and maintenance tasks associated with several elements of the ISS. With the retirement of the Space Shuttle, completion of ISS assembly, and introduction of commercial participants for human transportation into space, evaluations at the NBL will take on a new focus. In this session, Jairala briefly discussed the design of the NBL and, in more detail, described the requirements and process for performing a neutral buoyancy test, including typical hardware and support equipment requirements, personnel and administrative resource requirements, examples of ISS systems and operations that are evaluated, and typical operational objectives that are evaluated.

Durkin discussed the new and potential types of uses for the NBL, including those by non-NASA external customers.

Availability: **by request**

5.19 Apollo Lunar Surface Operations and EVA Suit Issues

Dr. Richard Scheuring presented “Apollo Lunar Surface Operations and EVA Suit Issues” on September 12, 2012.

The potential risk of injury to crewmembers is inherent in aggressive surface activities, whether they be Moon-, Mars-, or asteroid-based. In December 2005, the Space Medicine Division at JSC requested a study to identify Apollo mission issues that had an impact to crew health or performance or both. This talk focused on the Apollo EVA suit and lunar surface operations concerning crew health and performance. There were roughly 20 recommendations from this study of Apollo for improving these two areas for future exploration missions, a few of which were incorporated into the Human Systems Integration Requirements (HSIR). Scheuring covered these topics along with some of the analog work that has been done regarding surface operations and medical contingencies.

Availability: by request

5.20 Crew Health/Performance Improvements & Resource Impacts w/Reduced C02 Levels

Dr. John James presented "Crew Health/Performance Improvements & Resource Impacts w/Reduced $C0_2$ Levels" on September 20, 2012.

There have been a cluster of anecdotal reports that ISS crews are experiencing adverse health effects from on orbit exposure to CO_2 levels well below the current Spacecraft Maximum Allowable Concentration (SMAC), which is 5.3 mmHg for 180 days of exposure. Developing evidence that this standard should be reduced to protect crew health is not a simple process. James' team looked at the reports of headaches by the crew during private medical conferences and matched these with CO_2 levels around the time of these reports. They then compared these to CO_2 levels when there were no reports of headache. Using benchmark dose modeling, they found that the risk of headache could be predicted in concentration ranges from 2 to 5 mmHg. However, the data are incomplete because there were insufficient data when crews were exposed to concentrations below 2 mmHg. James' team also asked whether neuro-cognitive effects could be identified with CO_2 exposure levels and found that these could not be associated with CO_2 levels. Finally, they addressed the question of resource use to meet various levels of CO_2 control if the SMACs were lowered. They estimated that CO_2 restrictions approaching 2 mmHg would require substantial increases in power use and up-mass resources. They are refining their data on CO_2 and headaches, and are looking at potential interactions of intracranial pressure and CO_2 levels in eliciting ocular effects.

Availability: by request

5.21 Personal Background Interview of Jim McBarron

Rebecca Wright participated with Jim McBarron in a "Personal Background Interview of Jim McBarron" on September 28, 2012.

McBarron exhibits a wealth of knowledge gathered from more than 40 years of experience with NASA, EVA, and spacesuits. His biography, progression of work at NASA, impact on EVA and the U.S. spacesuit, and career accomplishments are of interest to many. Wright, from the JSC History Office, conducted a personal background interview with McBarron. This interview highlighted the influences and decision-making methods that impacted McBarron's technical and management contributions to the space program. Attendees gained insight on the external and internal NASA influences on career progression within the EVA and spacesuit, and the type of accomplishments and technical advances that committed individuals can make. He concluded the presentation with a question and answer period that included a brief discussion about close calls and Russian spacesuits.

Availability: by request

6.0 Biographies

A biography for each presenter of the USSKC events is provided in the following subsections.

6.1 Augustine, Philip

Philip Augustine was graduated from Texas A&M University in 2001 with a bachelor of science in biomedical engineering. His tenure with NASA began in January 2001 when he was selected as a cooperative education student to serve as a project engineer at JSC. In June 2006, Augustine became a systems engineer with the CSSE to help NASA design the next generation spacesuit system. His work concentrated on the advancement of the lunar portions of the EVA operational concepts document, wherein he led the technical team through requirements and design analysis cycles. In January 2009, Augustine joined the Constellation EVA Systems Engineering and Integration (SE&I) Architecture and Analysis group. As an analysis lead, he enabled the development of the CO_2 washout study.

6.2 Bue, Grant

Grant Bue has a bachelor of arts in biology from Harvard University and two degrees from the University of Texas at Austin: a bachelor of science in mechanical engineering and a master of science in biomedical engineering. He supported the CTSD at JSC for 15 years as a Lockheed Martin contractor and for 8 years as a civil servant in the thermal management of humans working in and around spacecraft.

6.3 Chambliss, Joe P.

Joe Chambliss has more than 37 years of experience with NASA. He began his career as a contractor before joining NASA as a civil servant in 1994. He has served as the deputy manager for Exploration in NASA's CTSD at JSC and as the system manager for the ISS Thermal Systems Development beginning in 1994. He was also the deputy manager for Advanced (originally Exploration) Life Support Technology Development. More recently he has served as deputy for Exploration in JSC's CTSD and lead for Life Support System Development for the Advanced Exploration Systems (AES) Habitation Systems Project. He has provided support to CxP, Orion, Altair, and Lunar Surface Systems projects. Chambliss received his bachelor of science in aerospace engineering from the University of Texas at Austin and two master of science degrees from Rice University: one in aerospace engineering and one in space physics and astronomy.

6.4 Chullen, Cinda

Cinda Chullen was graduated from Southern Illinois University with a bachelor of science in thermal and environmental engineering. She received her master of business administration and master of science in environmental science from the University of Houston – Clear Lake. In 1985, she joined NASA at JSC as an engineer developing environmental control and life support systems for manned spacecraft in CTSD. In 1990, Chullen became the technical manager of the Science, Engineering, Analysis, and Test (SEAT) Contract, a large high-technology contract providing research and development services to 18 different technical organizations at JSC. She continued her career in the Engineering Directorate (EA) as the manager of the Business Integration and Operations Office and as the dean of the Engineering Academy. In 2007, she rejoined CTSD in EC5 as the systems lead for the development of the PLSS for an advanced spacesuit. Since joining EC5, Chullen has served as a team lead for Systems Engineering, as a project engineer with the EMU team, as the deputy project manager of the EVA Technology Development Project, and as the team lead in the development of the PLSS Rapid Cycle Amine (RCA) component.

6.5 Conger, Bruce

Bruce Conger has worked with the Engineering and Science Contract Group (ESCG) as a technical lead for the Advanced Extravehicular Activity (AEVA) PLSS analysis activities supporting the Spacesuit and Crew Survival Systems Branch of the CTSD. He also managed life support analysis tasks supporting the Thermal Systems and Engineering Support Branch. Conger has been in the aerospace community for 27 years, including 25 years at JSC supporting life support, EVA, and thermal analysis and testing activities. He spent two years in California with Lockheed Missiles and Space performing thermal vacuum certification testing and analysis for Department of Defense (DoD) hardware.

6.6 Croog, Lewis

Lewis Croog was graduated from the University of Bridgeport, Connecticut in 1984 with two bachelor of science degrees: one in biomedical engineering and one in electrical engineering. He also entered a master of science degree program in biomedical engineering at Trinity College in Hartford, Connecticut. His career in the space industry started with HS in Connecticut, which led to a job in space life sciences with Krug International/Wyle Labs at JSC from 1988 through 2005. Projects included space motion sickness studies, cardiovascular de-conditioning studies from prolonged weightlessness, and cellular tissue changes in 0-g. Lewis served as the lead electrical designer on the ISS bioreactor project. Following the loss of Space Shuttle Columbia, he was transferred to Lockheed Martin to support work on Reinforced Carbon-Carbon (RCC) repair methods. Eventually, Croog went to work for Jacobs Technology providing support to the Spacesuit and Crew Survival Systems Branch PLSS hardware development for Constellation and performing analysis on EVA spacesuit systems.

6.7 Durkin, Robert

Robert Durkin was born and raised in Herington, Kansas. He received a bachelor of science in aerospace engineering in 1993 from Wichita State University. He started his civil servant career at NASA in 1993 at the Weightless Environment Training Facility (WETF). He transitioned to the NBL in 1997 and was responsible for the Breathing Gas System and was the flight lead for STS-88, the first NASA mission trained in the NBL. In 1998, he moved to EA and was the EM division lead for Mockup Design and Fabrication. In 2001, he became the assistant to the subsystem manager for Shuttle Landing Systems. In 2002, he returned to the NBL as the facility manager and has continued to take jobs of higher responsibility in the facility. He became the chief of the NBL in August 2010.

6.8 Eppler, Dean

Dr. Dean Eppler earned a bachelor of science in geology from St. Lawrence University in 1974, a master of science in geology from the University of New Mexico in 1976, and a doctor of philosophy (Ph.D.) in geology from Arizona State University in 1984. From 1986 to 2009, he was a senior scientist with Science Applications International Corporation, which included 20 years of support to NASA at JSC. During that time, he was a lead suit test subject for advanced planetary spacesuit development and geologic field testing from 1996 to 2005; the ISS Payloads Office Program lead on development of a high-quality research window on the ISS from 1994 to 2005; the program originator and lead scientist on the ISS Window Observational Research Facility (WORF) from 1998 to 2003; and the lead for Science Operations and Logistics Concept Development for Advanced Planetary Exploration Programs, including two years in the lunar surface systems for Constellation. In 2009, he transitioned to NASA and began working in the Astromaterials Research and Exploration Science (ARES) Directorate doing science operations development for lunar missions including creating science operations concepts for Desert Research and Technology Studies (RATS) and developing and implementing the geologic training curriculum for the 2009 Astronaut Class. During his career, Eppler has published more than 30 scientific publications and has been awarded the Army Commendation Medal, the Antarctic Service Medal, and the NASA Exceptional Public Service Medal.

6.9 Fitzpatrick, Garret

Garret Fitzpatrick has served as a technical lead on NASA's Crew Protection Systems Engineering Team, and he also has served NASA as an engineer, hardware manager, and Strategic Communications/Public Outreach advocate since he began working at JSC as a cooperative education student in 2003. As an enthusiastic advocate for engaging the public with the mission of human spaceflight, he has been invited to speak at the Pentagon, the U.S. Naval Academy, Disney Imagineering, and several NASA-sponsored events.

6.10 Irimies, David

Dr. David Irimies has worked at NASA for 10 years in project management; communications, command, control, and information (C3I) software development; communication systems, including Desert RATS communications infrastructure, ground truthing, and ground station support; and aeronautics software development. His specialty areas have included communication systems engineering, network engineering, and software engineering. He has served as the PAS subsystem lead for EVA Technology Development. He has a bachelor of science in computer engineering from Purdue University and a doctor of jurisprudence from the University of Akron.

6.11 Jairala, Juniper

Juniper Jairala was born in Chicago, Illinois and was raised there, in San Diego, California, and in Quito, Ecuador. After receiving a bachelor of science in mechanical engineering from Cornell University in 1997, Jairala worked as a ride-and-show engineer building Universal Studios and Warner Brothers theme parks in Los Angeles, Japan, and Spain until 2001. Afterward, she worked at NASA Dryden in Flight Operations before earning a master of science in aerospace engineering sciences, with an emphasis in bioastronautics, at the University of Colorado Boulder in 2004. From 2005 to 2008, Jairala worked as a NASA graduate cooperative education student at JSC, continued graduate education with an emphasis in integrated physiology at UCLA, and worked as an employee of several commercial spaceflight companies (Blue Origin, X Prize, SpaceX, Andrews Space, and Zero Gravity Corporation). In 2008, she returned to JSC with Jacobs Technology, working for the CTSD as a project and test engineer on the EVA Development and Verification Test Team, where she continues to work today.

6.12 James, John

Dr. John James earned a Ph.D. in pathology from the Graduate School of the University of Maryland School of Medicine in 1981 and has been a board-certified toxicologist since 1986. He came to JSC in 1989 and serves as the agency chief toxicologist. As such, he is responsible for air quality in human-rated spacecraft. His current research interests include the pulmonary toxicity of lunar dust, the interplay between intracranial pressure and high CO_2 levels as they might affect crew health, and methods to discern health effects from exposures to mixtures of compounds.

6.13 Jennings, Mallory

Mallory Jennings was graduated from Wichita State University in 2010 with a bachelor of science in mechanical engineering. She joined NASA as a cooperative education student with the Mission Operations Directorate (MOD) at JSC in 2007. She transitioned to EC5 in 2008 and spent four semesters working various projects with the ventilation subsystem of the PLSS. Jennings later served as a technology development engineer, working with various PLSS subsystems at JSC.

6.14 Kahn, Pica

Pica Kahn is a freelance reporter and photojournalist, publishing more than 5,000 articles for the Houston Chronicle, Houston Business Journal, Texas Monthly, Galveston Daily News, Real Estate Executive Magazine, Daily Shipping Guide, Daily Court Reporter, Jewish Herald, Brides in Houston, and several European newspapers. She has lived and studied in both France and Belgium. Working in the field of television production as a producer and writer, she has been part of joint ventures between the U.S., Brazil, Australia, and the United Kingdom's BBC. Kahn is a domestic and international mediator and arbitrator, an international trainer and relocation specialist, and the author of three books, including *Soft Homes Soft Hearts – A Memoir of Life in Other Cultures* (PublishAmerica, 2006).

6.15 Koontz, Steven

Dr. Steven Koontz has worked for NASA for over 25 years, specializing in space flight environment effects on spacecraft materials and systems. He has developed specific areas of expertise, including spacecraft-plasma interactions, spacecraft charging, space radiation effects on materials and avionics systems, and spacecraft contamination. He has been the principal investigator (PI) or co-investigator (CI) on several space flight experiments aimed at quantifying space environment effects from a practical perspective. Koontz has a bachelor of science in chemistry with an emphasis in nuclear chemistry from the University of California at Berkeley and a Ph.D. in chemistry with an emphasis in analytical instrumentation from the University of Arizona at Tucson.

6.16 Kosmo, Joseph

Joseph Kosmo was graduated from Pennsylvania State University in 1961 with a bachelor of science in aeronautical engineering. In 1978, he earned a master of science in environmental management from the University of Houston – Clear Lake. In 1961, Kosmo began his career with the NASA Space Task Group at Langley, Virginia, in the Crew Systems Division, working on the Mercury Program spacesuit. During the past 45 years, he has participated in the design, development, and testing of Mercury, Gemini, Apollo, Skylab, and Space Shuttle spacesuits, as well as numerous advanced technology configuration spacesuits and EVA gloves for future mission applications. Kosmo received the American Astronautical Society's Victor A. Prather Award, the NASA Exceptional Service Medal, and the Astronaut Silver Snoopy Award. The United States Space Foundation Space Technology Hall of Fame recognized him for his work on the development of the liquid cooling garment for spacesuit and medical applications. He has pursued the development of advanced spacesuits, gloves, and ancillary EVA-supporting hardware concepts for future planetary surface exploration. For about 10 years, Kosmo has organized and led a team of engineers in a series of remote field site test activities of prototype extravehicular hardware, advanced communications systems, spacesuit mobility studies, and human and robot assistant interactive capabilities in a variety of locations, including Death Valley, the Mojave Desert, and northern Arizona. In 2011, he retired from NASA after a 50-year career in the space industry.

6.17 Lawson, B. Mike

Mike Lawson was graduated from the University of Texas with a master of science in mechanical engineering with an emphasis in heat transfer and thermodynamics. He originally worked for General Dynamics, specializing in the environmental control and heat transfer systems for the F-16 fighter aircraft. He came to work for NASA in 1980 and worked on EVA, thermal and environmental control, and life support systems. Lawson retired from NASA in December 2010.

6.18 Lee, G. Ryan

Ryan Lee has been a senior design engineer working for ESCG as part of the PGS team for CSSE. Before this position, Lee spent three years as an advanced spacesuit design engineer with ILC Dover, working on both advanced planetary spacesuits and enhanced designs for the EMU. He also worked two years with Barrios Technology, supporting MOD as an EMU systems trainer and an EVA flight controller.

6.19 Lewis, Cathleen

Dr. Cathleen Lewis is the curator of the spacesuit collection at the Smithsonian Institution, National Air and Space Museum (NASM).

6.20 Lutz, Glenn

Glenn Lutz was graduated with a bachelor of science in chemical engineering from Texas A&M University in 1982. He began working for NASA at JSC in 1988 as a subsystems manager for EMU in CTSD. In 1996, he became the deputy manager for EC5 and was promoted to branch manager in 1998. Two years later, Lutz transferred to the EVA office as the deputy manager. From 2005 to 2006, he completed rotations as the deputy manager for the White Sands Test Facility.

He joined the CxP EVA Systems Project Office in 2006 and accepted a position as the EVA office manager in 2008. Lutz managed the activities associated with developing NASA EVA capabilities, including development of EVA hardware, integration standards, capabilities, services, techniques, templates, and other information necessary to provide EVA services to all NASA programs. Responsibilities also included defining, developing, verifying, and integrating EVA operational capabilities to support NASA and customer requirements. He also negotiated agreements and coordinated the flow-down of these agreements to other offices within the project and JSC to produce integrated requirements, schedules, and budgets.

6.21 McBarron, James, II

In 1960, James (Jim) William McBarron II earned a bachelor of science in geology at the University of Dayton in Dayton, Ohio, and in 1983, he received a master of business administration from the University of Houston – Clear Lake in Houston, Texas. During his time in college, from 1958 to 1961, he worked part time on a University of Dayton contract with the Wright Patterson Air Force Base Aeromedical Laboratory that provided student test subjects to determine human endurance characteristics during and after exposure to extreme environmental conditions. His work as a student assistant also involved pressure suit design testing including suit hardware evaluation for the NASA Project Mercury. His career at NASA began in 1961 as an aerospace technologist with the Crew Equipment Branch, Life Sciences Division, Space Task Group, at Langley Field, Virginia. During his time with NASA, McBarron supported the Manned Spacecraft Center at JSC and worked with spacesuits for all NASA flight programs including Mercury, Gemini, Apollo, Apollo-Soyuz Test Project (ASTP), Skylab, Shuttle, and the ISS. Throughout his career he was given several prestigious awards including the American Astronautical Society Victor A. Prather Award for outstanding contribution in the field of extravehicular protection in space in 1979. He is the author and co-author of many spacesuit-related publications. Before he retired in 1999, McBarron was the CTSD chief engineer for EVA projects. In 1999, McBarron took a position with ILC Dover, Inc. as spacesuit systems manager where he reviewed advanced spacesuit technology requirements and design concepts for future manned space flight programs. In 2002, McBarron started his own consulting service to support development of advanced spacesuit technology and inflatable products for current and future manned-space missions.

6.22 McMann, Joseph

Joe McMann was graduated from the University of Notre Dame in 1959 with a bachelor of science in chemical engineering. He joined NASA in 1961 as a member of the Space Task Group. During his 35-year NASA career, he was a project engineer on the Apollo Environmental Control System; a project engineer, technical manager, and test subject on the Gemini and Skylab EVA life support systems; and a subsystem manager, test subject, and contract technical manager for the Space Shuttle EMU and Manned Maneuvering Unit (MMU). McMann has coauthored *U.S. Spacesuits* with Kenneth S. Thomas of HS (Praxis Press, 2005). He also has conducted training on failure recovery planning and practical project management and has lectured on lessons learned during more than 40 years of experience in the aerospace industry.

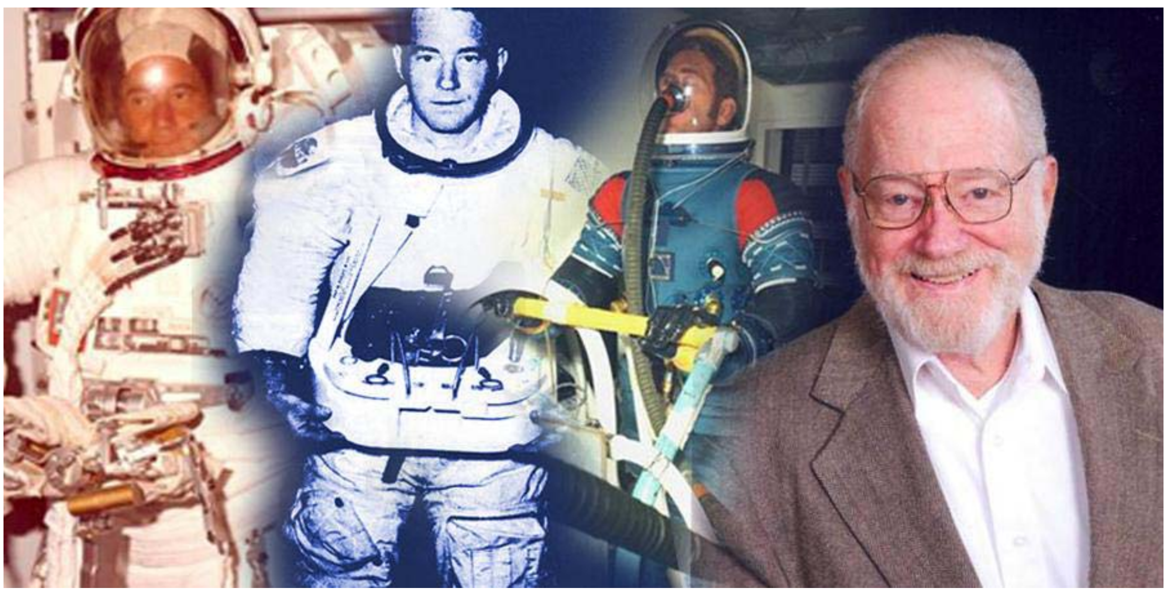

Figure 1: Images of Joe McMann throughout his career at NASA

6.23 Marmolejo, Joey

Over his 30-year career at NASA, Joey Marmolejo has become a recognized expert in the area of EVA. His project management and systems engineering background includes spacesuits, life-support systems, tools, airlocks, and airlock servicing hardware in programs such as Space Shuttle, ISS, and Constellation. He has participated in various advanced development projects, flight experiments, and cooperative projects with NASA's Russian partner. He also has extensive experience as a suited test subject in both U.S. and Russian spacesuits in vacuum, thermal and vacuum, underwater, 0-g, and air-bearing floor environments.

6.24 Makinen, Janice

Janice Makinen has a bachelor of science in biomedical engineering and a bachelor of arts in Spanish from Case Western Reserve University. Makinen began her career working in medical devices at Ortho-Pros in Santa Monica. She then joined NASA as a biomedical engineer and thermal analyst. For nearly five years Makinen has worked on many diverse projects, including smoke detection systems for the Space Shuttle and ISS Programs, lunar and ISS habitats, and developmental life support systems for the next generation of spacesuits.

6.25 Matty, Jennifer

Jennifer Matty was graduated from the University of Oklahoma in 2005 with a bachelor of science in industrial engineering. Upon graduation, she joined Jacobs Technology and the ESCG as a project engineer. She has worked with EC5 at JSC, focusing on spacesuit mobility as a Constellation spacesuit engineer.

6.26 Parazynski, Scott

Dr. Scott Parazynski is a physician and a physiologist with expertise in human adaptation to stressful environments, having been graduated from Stanford University and Stanford Medical School. He went on to train at Harvard University and in Denver in preparation for a career in emergency medicine and trauma. In 1992 he was selected to join NASA’s Astronaut Corps and eventually flew five Space Shuttle missions and conducted seven spacewalks (EVAs). In October 2007, Parazynski led the EVA team on STS-120, a highly complex space station assembly flight, during which he performed four EVAs. The fourth and final EVA is regarded by many as one of the most challenging and dangerous ever performed. In his 17 years as an astronaut, he also served in numerous senior leadership roles, including EVA branch chief and the lead astronaut for Space Shuttle Thermal Protection System Inspection & Repair (in the aftermath of the Space Shuttle Columbia tragedy). He has the distinction of being the only person to both fly in space and stand on top of the planet, the summit of 29,035-foot Mount Everest. He served as chief technology officer and chief medical officer at The Methodist Hospital Research Institute in Houston, Texas.

Figure 2: Images of Dr. Scott Parazynski from Childhood to His Stint as Chief Technology Officer and Chief Medical Officer at Methodist Hospital Research Institute

6.27   Ross, Amy J.

Amy Ross has been with NASA for over 20 years, specializing in pressure garments. She has served as the Spacesuit Team lead, Spacesuit Hardware Technology Development lead, CxP Spacesuit System PGS manager, and Space Launch Initiative Crew Escape Suit Engineering lead, with most of her experience in advanced planetary spacesuit development and testing. Past projects include the shuttle spacesuit gloves, launch and entry suit gloves, and STS-100 EVA tools. Amy earned a bachelor and master of science in mechanical engineering from Purdue University and a master of science in space studies from the University of North Dakota.

6.28   Rouen, Michael

Michael Rouen began his NASA career as a cooperative education student in the Crew Systems Division in 1965. After being graduated with a bachelor of science degree in mechanical engineering from Lamar University, Beaumont, Texas in 1967, he joined the Apollo EMU PLSS group and became the NASA resident representative at Hamilton Standard Division to help certify the Apollo PLSS. During his 42-year NASA career, he was also an advanced technology development engineer between Apollo and Shuttle Programs. When the Shuttle Program started, he wrote the statement of work for the shuttle PLSS and became the first subsystem manager for the PLSS when NASA first formally defined that role. During the Shuttle PLSS development, he led the PLSS group from design conception through manufacture, certification, and early flight use. Afterward, Rouen led a significant glove development effort that resulted in numerous improvements in the shuttle glove including sizable fingers, custom sizing measurement techniques, reduced weight fabric for mobility increase, and design for measured human-induced loads. Rouen led the strategic planning for the newly formed EVA Project Office and served as the manager of the advanced development for two years. Upon return to CTSD, he led advanced technology development until his retirement after 42 years with NASA. Since then, he has assisted the Constellation Space Suit Accommodations for Exploration (C-SAFE) team's proposal effort and now works part time on that team.

6.29 Scheuring, Richard

Dr. Richard Scheuring grew up in Chicago, Illinois, focused on track and field, and dreamed of becoming an Olympic athlete. This drive earned him an athletic scholarship to Eastern Illinois University where he earned bachelor of arts in psychology and competed in a decathlon. But after three-and-a-half years of intense competition and an unfortunate series of devastating injuries, his dream to compete in the Olympics was over. Scheuring took his Olympic-sized desire and passion and focused on becoming a doctor of osteopathic medicine at Chicago College of Osteopathic Medicine. He then ran his own family practice, sports medicine clinic in Illinois for several years before learning of the aerospace medicine profession. Realizing he could possibly combine his childhood love for space exploration with his medical career, Scheuring completed an aerospace medicine residency and earned a master of science in aerospace medicine at Wright State University. After the September 11 attacks, Scheuring signed up to be a U.S. Army Reserve flight surgeon. He subsequently served in Iraq as a battalion flight surgeon for the 171st General Support Aviation Battalion (GSAB) in Camp Taji, just north of Baghdad where he had over 100 hours of combat flying. Later he discovered the required training for this was the final puzzle piece needed to reach his dream job, serving as a NASA flight surgeon at JSC. As of 2012, he was serving as the team lead for musculoskeletal-sports medicine and rehabilitation at NASA.

6.30 Shack, Paul

Paul Shack, after serving in the U.S. Marine Corps, was graduated from Case Western Reserve University (Cleveland, Ohio) in 1971 with a bachelor of science in electrical engineering. He spent another year at Case Western Reserve University in post-graduate studies and as research engineer in biomedical nuclear imaging.

He joined NASA in 1973, just as the Apollo lunar missions were completed. During his 34-year NASA career, he was a project engineer on SkyLab and Apollo-Soyuz audio communications and subsystem manager for the Orbiter and EMU EVA Communications system. During the post-Challenger Return-to-Flight era, he became subsystem manager for Shuttle S-Band communications. As the Avionics Division chief engineer for the Shuttle Program, he led the Space-to-Space Communications System problem resolution effort. He also served as chief engineer for EA for Orbiter and for the Space Shuttle Program before retiring in 2007.

Shack joined ATK Aerospace Systems in 2010.

6.31 Thomas, Gretchen A.

Gretchen Thomas has worked for NASA for more than 20 years in PLSS technology development and integration. She has served as the PLSS architecture and integrated testing lead for EVA technology development. Her specialty areas have included carbon dioxide removal systems, thermal control systems, and system integration and analysis. Thomas earned a bachelor of science in mechanical engineering from the University of Houston, and in 2000, she received a master of science in space studies from the University of North Dakota.

6.32 Thomas, Kenneth

Kenneth Thomas was graduated from the Central Connecticut State University in 1985 with a bachelor of science in manufacturing engineering. He had a career as a machinist, foreman, manufacturing engineer, and manager before completing his degree and joining HS as an engineer in structural composites. In 1989, he became an EMU project engineer, supporting composite parts. In that role, he contributed design features to the generation of hard upper torsos that built and support the ISS. He progressed to managing other spacesuit tasks and supported a variety of products in his career. He was the lead author of *U.S. Spacesuits* (Praxis Press, 2005) and the lead designer of three Lunar-Mars spacesuit prototypes.

6.33 Vogel, Matthew R.

Matt Vogel has a bachelor of science in aerospace engineering from Texas A&M University and a master of science in mechanical engineering from the University of Houston. He was a cooperative education student at Rockwell International in the Transportation Systems Division and later worked on the space station contract at McDonnell Douglas. He began working for Jacobs Technology in 1994, and has worked as a thermal designer and analyst at JSC for more than 18 years.

6.34 Wagner, Sandra

Sandra Wagner has been the CxP lead for Lunar Regolith Strategy and Integration. At JSC, she has worked in AEVA, habitability, space station safety, the Orbital Space Plane Project Office, and the Systems Architecture and Integration Office in EA. Before coming to JSC, she was the project manager for reengineering the wind tunnel and laboratory maintenance delivery system at Langley Research Center, and she was the program manager for characterization of low-level hazardous waste at the Rocky Flats

Nuclear Weapons Plant. Wagner earned a bachelor’s degree in physics from the University of Colorado and a master’s degree in environmental policy and management from the University of Denver.

6.35 Waguespack, Glenn

Dr. Glenn Waguespack was graduated from Louisiana State University in 1997 with a Ph.D. in mechanical engineering and a minor in physics. Subsequently, he spent six years working for Sempra Energy Solutions developing energy performance projects for commercial, government, and educational building environmental systems. He joined the NASA team in 2005 as an employee of GeoControl Systems, Inc., working on the Jacobs Technology ESC. In this position, he supported spacecraft and spacesuit thermal and environmental analysis and development efforts at JSC.

6.36 Watts, Carly

Carly Watts was graduated from Pennsylvania State University in 2009 and began working with the PLSS team to develop advanced technologies for Advanced Extravehicular Mobility Unit (AEMU). She has served as a technology development engineer in EC5 of the CTSD. Throughout 2011, Watts was the project manager for the PLSS breadboard, a development effort that accomplished the first system-level test of the advanced PLSS design.

6.37 West, William (Bill)

Bill West worked for HS as an ISS EVA increment manager in the EVA Office (XA). He was responsible for Expedition 25 ISS EVA maintenance and served as the XA representative for the Japanese H-II Transfer Vehicle (HTV). Previously, he was the ISS EVA increment manager for Expeditions 4, 6, 10, 15, 19, and 20. West has worked extensively with the Russian EVA community as part of the Joint U.S. and Russian EVA Working Group. He was graduated from Parks College of St. Louis University with a bachelor of science in aerospace engineering and received his master’s degree in space science from the University of Houston – Clear Lake. In 1988, he began working at JSC for Rockwell Shuttle Operations Company. In 1997, he joined GHG Corporation and worked in the Safety and Mission Assurance Directorate as a Space Shuttle Main Propulsion System safety engineer and in the EVA Safety Group. Beginning in 2000, West worked for HS.

6.38 Woods, Ron

Ron Woods’ career at NASA began at JSC, Crew Systems Division, as a survival technician and suit subject for the Apollo suits. Woods then supported the training and pre-flight suiting activities for Apollo, Skylab, and ASTP at KSC. During this time, he was assigned to the teams that supported the crews of Apollo 8, 11, 15, all three Skylabs, and ASTP. Post-ASTP, Woods returned to JSC to support shuttle flight crew equipment. This included the launch entry suit (ejection seat equipment) and crew-worn equipment. Woods supported the first two shuttle missions as a suit technician at KSC and three additional missions at primary and back-up landing sites, White Sands, and Dryden Flight Research Center. From 1982 to 2011, Woods worked at KSC as the JSC flight crew equipment representative for each shuttle mission and the early ISS missions. Woods' primary career and his already developing artistic skills merged into a portfolio of spacesuit paintings. As of 2012, Woods was back at JSC working launch and entry suits and crew protection systems for future human space exploration.

Figure 3: Images of Ron Woods and His Renderings of Space

6.39 Wright, Rebecca

Rebecca Wright serves as the coordinator for the NASA JSC History Office, responsible for the overall management of the office. Her duties include community outreach, history Web sites, publication efforts, oral history, research staff and resources. As an oral historian for the space agency, she has interviewed approximately 350 individuals since 1997 for numerous projects. She recently completed work as co-editor of *NASA at 50*, a book scheduled to be released later this year by the NASA Headquarters History Office. She is currently facilitating a pictorial history publication effort titled, *Johnson Space Center: The First Fifty Years*.