VIRTUAL

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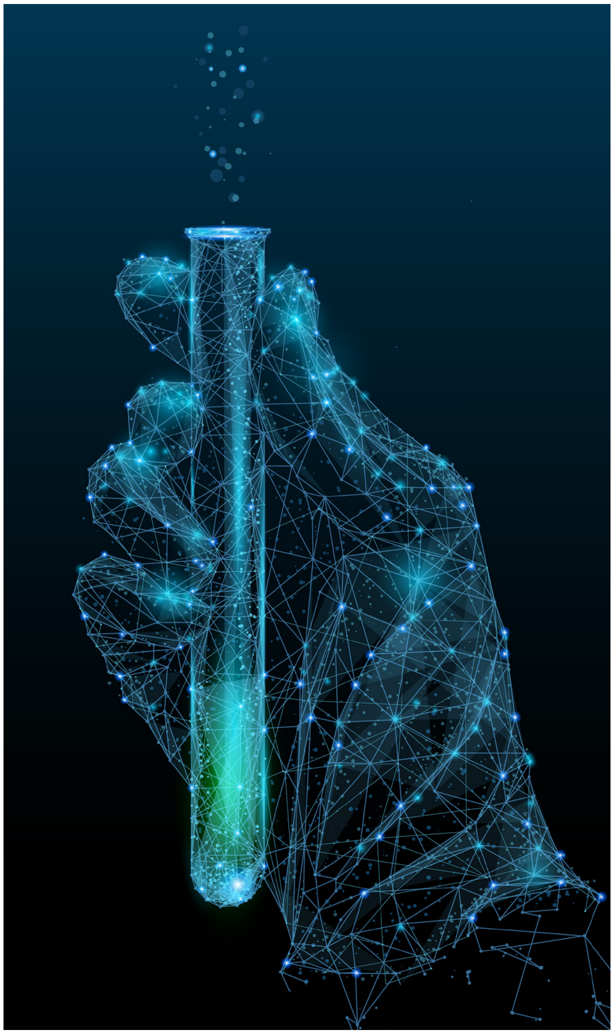
Adaptive Research and Technologies from Biological and Chemical Engineering



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ABSTRACT BOOK

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Identifying Cost Effective Radiation Shielding Using Super Computers.

Timothy Nisi

Indiana University, Indianapolis, IN

The IU School of Medicine Department of Radiation Oncology currently makes patient specific radiation shielding devices called "bolus." The shape and thickness of the bolus is defined by dosimetrists, medical physicists, and radiation oncologists using Monte-Carlo simulations that trace the trajectory of radiation produced by hospital machines. We are using the same state of the art technology and expertise used for treating cancer to identify and manufacture radiation shielding for astronauts.

Active Magnetic Radiation Shielding for Long-Duration Human Spaceflight.

Kristine Ferrone

The Aerospace Corporation, Houston, TX

Interplanetary space radiation presents significant hazards to astronaut health and survival because it can cause both acute and chronic health effects including carcinogenesis. Mitigation of space radiation risks remains critical for enabling human missions beyond Earth orbit. Currently available options for space radiation shielding, such as water shielding, may not be sufficient at reducing space radiation dose and cancer risk to within current regulatory limits. Active magnetic shielding using superconductors has consistently been identified for further study due to its high potential benefit. In response, we have developed Monte Carlo models to determine the effectiveness of several of the latest magnetic shielding concepts, along with current passive shielding techniques, in terms of risk of exposure induced death. This was done for various Mars flyby mission profiles according to current space agency risk tolerance limits. Our study found that few shielding options were able to meet current risk tolerance limits without relying on astronauts of advanced age (>60 years). However, all of the magnetic shielding configurations provided substantial benefit in reducing space radiation cancer risk given high magnetic field strength (7 Tesla). With this information, space agencies can move towards engineering assessments of magnetic shielding technology and begin to advance the concept into a solution enabling interplanetary travel.

Space and Thin Film Technology Utilizing Atomic Layer Deposition for NASA Line of Business Science Discoveries.

Vivek Dwivedi[1], *Raymond A. Adomaitis*[2], *and Henry de Groh*[3]

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ALD is a cost-effective nanoadditive-manufacturing technique that allows for the conformal coating of substrates with atomic control. Utilizing this tool applications for NASA lines of buisness are presented. The optical and physical properties of spacecraft radiator coatings are dictated by orbital environmental conditions. Current dissipation techniques include depositing a layer of ITO (indium tin oxide) on the radiator surface. A method has been demonstrated for the ALD of In_2O_3 and films on a variety of substrates specifically Z93P pigments resulting in a direct spaceflight application recently launched to the international space station, ISS. Stray light optics for space platform instruments require components of the optical bench to be coated with a material that suppresses light reflectance allowing for the imaging of extremely dimmed objects. Coronagraphs are key heliophysics instruments because they image coronal mass ejections (CMEs), which are the most energetic phenomena on the Sun. CMEs have wide-ranging impact on the heliosphere, from interplanetary spacecraft to astronaut safety—in short, they are major drivers of space weather. Coronagraphs reveal the structure and speed of CMEs when they are near the Sun and provide essential input to predictive space weather models. In a typical space-based coronagraph, an external occulter blocks light from the disk of the Sun so that the corona can be imaged. A promising advance in stray light control is the application of carbon nanotubes. CNTs have shown to be 10 to 100 times blacker than anodized black from the Near UV to Far Infrared, it will be demonstrated that the utilization of ALD to deposit a catalytic layer of Ni can result in the growth of CNTs with enhanced reflectance properties. Large telescopes that could be used for detecting and analyzing Earth-like planets in orbit around other stars or for peering back in time to observe the very early universe may not necessarily have to be built and assembled on the ground. In the future, NASA could construct them in space. We present a selected opportunity for an "ALD in Space" concept that will fly a football-sized ALD chamber aboard a Blue Origin New Shepard rocket.

Forging the Future: The Impact of Multi-Material Additive Manufacturing on the Future of Space Exploration.

Matt Napoli

Made In Space, Inc., Moffett Field, CA

Made In Space, Inc. (MIS) is the industry leader for space manufacturing technologies, delivering next-generation capabilities in orbit to support space exploration objectives and national security priorities. MIS is developing the orbital economy by leveraging unique properties of the microgravity environment and focusing on advanced materials engineering, ultimately expanding the utilization of ISS into new product areas not previously investigated. This presentation discusses the valuable enabling technologies that integrate flight-proven microgravity process controls and payload support systems to sustain long-duration human spaceflight operations that MIS is pioneering.

Bioreactor Development for CO2-Based in Situ Resource Utilization Manufacturing.

Benjamin Alva[1,2], *John A. Hogan*[2], *Jonathan M. Galazka*[2], *Michael Dougherty*[2], *and Aditya Hindupur*[2]

(1)Biomedical Engineering, University of Minnesota Twin-Cities, Minneapolis, MN, (2)NASA Ames Research Center, Mountain View, CA

Sustainable long-duration manned missions on both the Moon and Mars will require in situ resource utilization (ISRU). Carbon dioxide (CO_2) has great potential as a harvestable resource, making up 95% of the atmosphere on Mars and being produced as respiratory waste in spacecraft and future planetary habitats. Through ISRU, biomanufacturing has the capability to produce a near limitless array of products from local space resources. Here, a CO_2-based ISRU recombinant protein producing bioreactor and associated biomanufacturing organisms were designed to produce a highly stable carbonic anhydrase (CA). Candidate organisms were selected by growth characterization on acetate and formic acid, carbon substrates that are synthesized via electrochemical conversion of CO_2. To improve growth on the CO_2 producing substrate formic acid and for direct integration of ISRU CO_2, a synthetic Calvin-Benson-Bassam cycle was designed for use in *Escherichia coli*. Multiplex genetic modification in *E. coli* was facilitated by a tailored CRISPR/Cas9 and λ red recombineering two-vector system. For expression of CA, a blue light regulated T7 promoter was employed for dynamic and small molecule free induction. Efficient bioproduction through a fed-batch exponential feeding strategy was determined via mass balance analysis from ISRU substrates to biomass and CA yield. Flux balance analysis was used to model ISRU substrate metabolism and metabolic pathway engineering in candidate organisms under cultivation strategy conditions for both metabolism reconstruction and pathway design optimization. Finally, a small-scale, disposable bag bioreactor for use in the NASA Bioculture System infrastructure was designed to enable CO_2-based CA biomanufacturing in reduced-gravity environments.

Welding and Repair in Space.

Yu-Hui Chiu

Busek Co Inc, Natick, MA

Busek company is developing a versatile deployable spacecraft called SOUL (Satellite On Umbilical Line). This presentation will illustrate a NASA SBIR Phase I concept to develop a semi-autonomous, teleoperated welding robot for repair or joining of external surfaces in space. The welding robot is an adaptation of SOUL with a suitable weld head attached to it.

SOUL is a nanosat-sized space vehicle hosted by and deployed from a larger mother ship (Host Space Vehicle, HSV) as needed to perform a variety of duties. SOUL was originally developed to capture large space debris (and towed by the HSV to a disposal orbit) which now includes servicing. Upon completion of its mission the SOUL is re-stowed inside the HSV in a marsupial-like manner. Unlike “free flying” robots, the SOUL communicates securely with its HSV over a fiber optic link embedded in the umbilical without the need for encryption, and in case of malfunction, does not become another uncontrolled space debris. Thus, SOUL is a low risk system that in case of malfunction, is retracted by the HSV and re-stowed. Unlike fixed robotic arms attached to large spacecraft, the low mass, low momentum of the SOUL precludes damage inducing accidental collisions that may create additional space debris. The SOUL system was awarded a US patent. When equipped with suitable welding device, SOUL can perform both micrometeoroid damage repair and join metallic surfaces by welding.

Designing Bioinks for Utilization on the International Space Station.

Eugene Boland

Techshot, Inc., Greenville, IN

Bioprinting provides the unique promise of permitting three dimensional spatial organization of biological materials. The foundation of all bioprinted constructs are the matrix materials that provide form to the fabricated 3D geometries and concurrently support the function of the incorporated cells. Paralleling physiological environments, most of these matrix materials are hydrogels, often composed of naturally occurring proteins such as collagen and fibrin. Recent efforts of the Techshot Engineering team have focused on the development and evaluation of biologically-based bioprinting-compatible inks for use in our BioFabrication Facility (BFF) currently operational onboard the International Space Station (ISS). Designing inks for this particular environment provides a number of challenges on top of those faced by typical terrestrial activities. Transport, storage, handling, mixing, and printing were all taken to new heights during our fabrication operations on-board ISS Expeditions 59 and 60.

Mechanical Counter Pressure Space Suits

Theodore Southern

Final Frontier Design, Brooklyn, NY

Traditional full pressure space suits are heavy, bulky, and restrictive, greatly reducing an astronaut's efficiency during Extra Vehicular Activity (EVA). NASA's next generation EVA space suit, the xEMU, will weigh more than 300 pounds and restrict hand motion by more than 50%. The pressurized oxygen that surrounds the astronaut's head is continuous with their arms, legs, hands, and feet, adding risk of losing breathing gas if a glove or boot is punctured.

Mechanical Counter Pressure (MCP) space suits replace a continuous full pressure suit with a pressurized helmet, neck seal, and very tight fitting compression garment. The compression garment has a goal to provide equivalent pressure to the trunk and limbs as is in the helmet (at least +3.5 psia), evenly, throughout a human's natural range of motion. This is relatively straightforward with circular-cross-section body parts, but flats and concavities are especially challenging.

The MCP space suit has the potential to greatly expand human's potential for space exploration by enabling more natural range of motion, reducing hundreds of pounds of equipment from the overall EVA system and drastically reducing overall bulk from both the enclosure and the life support system.

The MCP suit has been preliminarily tested in a lab as early as 1970, by Dr. Paul Webb, but has been stalled for decades because of a lack of sophisticated materials needed to adaptively provide very high compression against the skin while remaining elastic. MCP garments have been fabricated and tested utilizing multiple layers of elastic, as well as inflatable capstan like tubing, to increase the adaptive compression of the garment at differential pressure. Many physiological issues remain unanswered about MCP suits, including the body's capability to withstand local variations of pressure, prolonged skin exposure to vacuum, tolerance within different tissue types, and the relative effects of motion on blood flow and compression. MCP space suits have the potential to revolutionize human exploration of space with cross-discipline materials science advancements.

Closure, Long-Duration Life Support, and Launch Costs—a Changing Environment.

Grant Anderson

Paragon Space Development Corporation, Tucson, AZ

The goal of long-duration life support is to minimize resupply by closing the life support loop-recycling as much water and oxygen as can possibly be done with current or advanced technology. But what makes sense in an environment when launch costs are dropping and "logistics trains" are reasonably priced? This paper explores the trade-offs and advantages of the new economics of resupply and life support. Water is usually recovered from urine, feces and even the respired moisture in the air. The spacecraft then needs the ability to isolate, purify and "polish" the water for return to the potable water tank. Oxygen (O_2) is usually recovered from the expired Carbon Dioxide (CO_2) where the method of extracting the O_2 is through a Sabatier reaction ($CO_2 + 2H_2 = CH_4 + O_2$) which utilizes the "excess" hydrogen from a electrolysis system ($2H_2O = 2H_2 + O_2$) leaving a methane (CH_4) "waste" product or with complete solid-oxide electrolysis ($2CO_2$ + energy= $2CO + O_2$) where the CO is then "cracked" to $2CO = 2C + 2O_2$ to yield a total reaction of 4CO2 + energy = $4C + 4O_2$ leaving elemental Carbon as a "waste" product. Each subsystem to achieve this recycling has to have provisions for failure or repair, which also adds to the logistics train. This, then, is a difficult trade that may result in break-even analysis which is highly dependent on the "resupply" logistics, cost and risk being balanced with the "recycling" logistics, cost and risk. Launch costs, in the last 40 years have been reduced from roughly $50K/kg to $2K/kg. This makes for a very different picture of what is practical for resupply and changes both the economic question, as well as the logistical burden from both a risk and opportunity perspective. So what is the new economics and program risk considerations and how does that change the answer? And how does this manifest itself in future Mars or Moon missions?

Design of the MIT BioSuit™ Mechanical Counter Pressure Spacesuit.

***Akshay Kothakonda** and Dava Newman*

MIT Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, MA

Spacesuits will play a key role in conducting planetary surface exploration of moon and Mars in the future human spaceflight missions. The spacesuits must allow for low effort locomotion and limb movements involved in conducting scientific activities during an Extravehicular Activity (EVA). Historically, all spacesuits that have been used in EVA's apply pressure on the body using a volume of gas contained within the suit. This volume of gas imposes significant resistance to suited movements. The MIT BioSuit™ spacesuit concept is based on exerting the necessary pressure using a tensioned fabric in direct contact with skin, thus obviating the need for gas. Some of the top level requirements of the MIT BioSuit™ include exerting necessary and uniform mechanical counter pressure (MCP), minimizing mechanical work involved in joint movements under tensioned state, and easy donning and doffing of the suit. The current research effort is aimed at realizing these capabilities for the arm segment of the suit. Fulfillment of these requirements is explored through a suit design consisting of an active tensioning system implementing shape memory polymer (SMP), numerical modelling of deformation of woven fabric under pressurized movements, and implementing skin Lines of Non-Extension (LoNE's). The SMP, coupled with an elastomer, working as an actuator shall generate the required MCP in its tensioned state. The shape memory effect of the actuator would allow for modulating the circumferential tension along the arm, thereby enabling uniform pressure distribution, as well as enabling easy donning and doffing in the low tension state. A novel Finite Element Analysis (FEA) model under development shall inform patterning the fabric so as to minimize mechanical work during suited movements. Finally, LoNE's, estimated from skin Digital Image Correlation (DIC) measurements shall inform routing of inextensible cables through the suit, also to minimize mechanical work.

Bio-Electrochemical Systems for Sustainable Production of Chemicals from CO2 and Electricity.

***Frauke Kracke**, Jörg S. Deutzmann, and Alfred M. Spormann*

Civil and Environmental Engineering, Stanford University, Stanford, CA

A variety of microorganisms are known to be able to exchange electrons with solid state electrodes. This fundamental principle of utilizing electrodes as electron donors or acceptors for metabolic pathways gives rise to a variety of technological applications that are useful here on Earth and may also be adapted for biotechnological in-situ resource utilization at destinations across the solar system. In particular, **microbial electrosynthesis** enables the sustainable production of chemicals from CO_2 and electricity using microbes as catalysts. While the concept is known for decades, its application remains limited due to low volumetric production rates, energy losses at the cathode, as well as the unknown physiology of the microbes in an electrochemical reactor.

Here, we present a bio-electrochemical hybrid system that significantly increases the productivity of microbial electrosynthesis via highly efficient, electrochemical production of hydrogen. The direct integration of non-precious metal cathodes with microbial cultures enables the selective production of chemicals from CO_2, electricity, and water as sole process inputs.

We demonstrate the efficient production of liquid, multi-carbon compounds such as acetate, as well as the production of gaseous methane, which presents an attractive solution for energy storage problems. Our system achieves electron recovery in product of >90%, while operating stably for several weeks. Further, we performed a first in-depth characterization of the microbial catalyst during this long-term operation, which revealed robustly-growing cells with nearly identical protein expression patterns to gas-fed controls.

Synthetic Carotenoid-Rich Plant Organelles for Space and Earth Nutrition.

Briardo Llorente

Macquarie University and CSIRO, Sydney, NSW, Australia

When humans venture to Mars and return to the Moon for extended periods, a critical necessity will be the supply of sufficient and healthy food. Poor nutrition can cause detrimental effects on health and adversely affect physical and cognitive performance. Because of payload mass limitations and the enormous costs of resupplying resources from Earth, the best approach would be to produce food on-site. Carotenoids are natural antioxidant pigments essential to human health and the main source of Vitamin A. However, humans cannot produce carotenoids and need to obtain them primarily through plant-based foods. We have developed a novel and generalizable approach that enables the synthetic conversion of plant chloroplasts into carotenoid-rich plastids. This approach has enabled us to substantially enhance the nutritional value of green vegetables with relatively low carotenoid content like lettuce, which otherwise has advantageous traits for supporting human space missions (e.g., high harvest indices, small plant size, rapid growth). This work lays the foundation for developing more nutritious crops to combat Vitamin A deficiency on Earth and support the human exploration of space.

Sunlight-Driven Electrochemical Conversion of CO2 to Useful Products in Space.

*Richard Jones[1], Ferenc Darvas[1,2], and **Csaba Janáky**[1,3]*

(1)ThalesNano Energy, Budapest, Hungary, (2)InnoStudio, Budapest, Hungary, (3)Department of Phys. Chem. Mater. Sci., University of Szeged, Szeged, Hungary

Increasing public and private interest in deep-space exploration begs the question: how do we undertake long-duration space flights with the limited resources that can be carried on such flights? Although we believe that many of these challenges can be solved using synthetic chemistry, there has been surprisingly little focus on chemistry R&D in space research (in contrast to efforts in biology and physics). The internationally growing efforts and in fact, needs for the development of efficient in-situ resource utilization technologies are expected to open the way to chemical solutions to be adapted and applied routinely in space. One of such specific challenges is to convert the waste materials that are generated during the voyage and/or the natural resources of alien planets into usable chemicals to sustain human life or to further exploration. Considering the composition of the Martian atmosphere (96% CO_2), the most important source of oxygen and any carbon-based chemicals (fuels, food, etc.) is CO_2. Sunlight is available (with a significant of UV-component), therefore solar panels can provide electricity, or sunlight can even be directly used in photoelectrochemical cells. Such systems allow the electrochemical recovery of O_2 from CO_2, as well as the generation of other basic building blocks to enable chemical transformations to more complex molecules.

In this talk I am going to highlight the recent progress related to chemical engineering solutions for space research and applications made within our company group, focusing on some aspects regarding the transformation of CO_2 to useful products (e.g., oxygen and hydrocarbons) in space (specifically on the International Space Station and Mars). I will discuss our recently developed ultralightweight electrochemical cell, together with the micro/nano-engineered membrane electrode assembly. These developments allow the energy efficient conversion of CO_2 to ethylene under mild conditions, using the electricity provided by the solar panels. Furthermore, our approach avoids the use of any toxic or corrosive chemicals in the process. The produced ethylene can be further converted into polyethylene, which then can be employed as raw material for 3D printing. Our efforts and results in this latter direction will also be presented.

To Mars and Back: 3D-Printed Construction Technologies for a Multi-Planetary Future.

Michael Bentley

AI Spacefactory, Secaucus, NJ

AI Spacefactory develops construction technologies that will enable the expansion of human life on and beyond earth. The team was awarded first prize in Nasa's Centennial 3D-Printed Habitat Challenge for their MARSHA prototype, which was printed semi-autonomously within a 30-hour construction window. The project was remarkable for its vertical, multi-story design, but also its biopolymer shell. The material is stronger than concrete, but is also renewable and recyclable. The success led to TERA, to be completed in 2021, which will allow visitors to experience a space-inspired habitat designed for earth. As TERA is adapted for various climates and evolves through each print, it advances space technologies to ultimately enable human life on the Moon and Mars.

The Main Goal of Space Architecture.

Olga Bannova

College of Engineering, University of Houston, Houston, TX

The main goal of architecture everywhere, on Earth and beyond, to serve human needs. Understanding what needs are essential for survival and what is required to maintain human lives at desired level is a fundamental knowledge for designing a habitat. Space environment creates unique challenges and opportunities for architects to find exceptional design solutions that satisfy diverse human and technological demands.

Space Architecture integrates all aspects related to designing and building human environments in space settings. Space architecture design process involves and requires all components of a common architectural practice: research, design, prototype development and testing. The design has to be validated and evaluated during manufacturing and operating of analogue of space habitats located in terrestrial environments and may go through several cycles of refinement. Space architects research how habitats influence human health, psychology, and efficiency, and define design requirements based on the "human factor." All these considerations affect the way how fabrication and construction of habitable complexes will materialize on planetary surfaces or in orbit.

NASA identified 14 space technology grand challenges that have to be addressed within next decades: economical space access, space health and medicine, telepresence in space, space colonization, affordable abundant power, space way station, space debris hazard mitigation, near-Earth object detection and mitigation, efficient in-space transportation, high-mass planetary surface access, all-access mobility, surviving extreme space environments, and new tools of discovery. Most of these challenges are connected and related technologies depend on each other success.

Space architects working on providing design ideas for several of them: space colonization, space way station, efficient in-space transportation, high-mass planetary surface access, all-access mobility, surviving extreme space environments.

New technologies such as 3D-printing yet to be advanced so they become reliable to operate autonomously. They will require abundancy of power supply and heavy and precise machinery that can operate under extreme temperatures, low gravity and pressure. That means architects have to provide design plans with development stages that would allow people to start operating as early as possible before the construction is fully complete.

Combustion Synthesis Technologies for Construction on the Moon and Mars.

Evgeny Shafirovich *and Robert E. Ferguson*

Department of Mechanical Engineering, The University of Texas at El Paso, El Paso, TX

In space applications where energy is limited, combustion synthesis technologies are a promising solution, which can make materials, join parts, and generate heat. Use of regolith for in-situ production of construction materials would decrease the amount of materials transported from Earth in missions to the Moon and Mars. One promising approach involves mixing regolith with energetic additives that can burn with the regolith, leading to the formation of ceramic materials. Here we present the results of studies on combustion of lunar and Martian regolith simulants with magnesium, conducted at the University of Texas at El Paso [1-5]. The results have shown self-sustained combustion of regolith-magnesium mixtures, explained by thermite reactions between magnesium and regolith constituents such as silica and iron oxide. We also present the results of our recent study on combustion joining of sintered regolith tiles [6, 7]. A stoichiometric mixture of aluminum and nickel powders was placed into a gap between two tiles and ignited with a laser. Propagation of the aluminum-nickel reaction produced nickel aluminide attached to one or both tiles.

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The Challenges of Medical Care Due to Distance from Earth.

Jimmy Wu

Baylor College of Medicine, Houston, TX

Humans will encounter several hazards that negatively affect health and performance during deep space flight missions. Today, there are emerging and nascent technologies that could mature into cross-cutting platforms, and when applied to human space flight, help keep humans healthy and thriving on a trip to Mars. This presentation will highlight a few of these technologies and discuss possible intersections for innovation.

Space Medicine Capabilities and Challenges for Exploration Missions.

Moriah Thompson

Space and Occupational Medicine Branch, NASA Johnson Space Center, Houston, TX

Future exploration-class spaceflight missions will require a paradigm shift in medical operational support and capabilities. Currently, medical support of the crew on board the International Space Station (ISS) involves real-time access to flight surgeons and other ground personnel. In the event of a major medical problem, evacuation of a crewmember is possible in order to receive definitive care. A robust medical system is available on board the ISS, and resupply of medications and supplies is carried out regularly. Future long duration missions to Mars will require increasing crew autonomy and decreased reliance on ground support. Mars missions will involve notable communication delays, lack of access to evacuation or resupply, and increased medical risk. Therefore, exploration missions will require increased medical capabilities such as multifunctional integrated medical diagnostic devices, compact laboratory and imaging capabilities, autonomous diagnostic and treatment aides, and just in time training and procedural guidance. This presentation will provide an overview of the space medicine challenges for exploration-class missions, and the current efforts to address these challenges.

An Inside View of Conducting Science Investigations In Space.

Dr. Tobias Niederwieser

Research Associate, BioServe Space Technologies

BioServe Space Technologies is a research center within the University of Colorado Boulder and is committed to perform life science experiments in the space environment. Since 1987 BioServe has launched over 150 payloads on over 70 separate missions in partnership with over 125 companies which have resulted in well over 350 peer-reviewed publications. Investigations range from microbiology, over mammalian cell studies and plant studies, all the way up to rodent research missions. While BioServe also conducts research in house, the majority of investigations are conducted in partnership with pharmaceutical and biotechnology companies, universities, NIH, NASA-funded and other government agency researchers. Recent investigations have included a variety of different organisms like kidney, heart, bone, and stem cells as well as yeast, bacteria and fungi. In order to enable these investigations, BioServe has a full fleet of in-house developed scientific instruments permanently employed onboard the International Space Station but is also expanding to other platforms such as the Orion vehicle bound to fly to the Moon. These facilities include for example microscopes, temperature chambers ranging from -20.0°C to +48.0°C, carbon dioxide incubators, life support systems to support animal studies, as well as automated cell culture systems. Flight studies are accompanied over their complete life cycle from proposal writing, requirements definition, conceptual and detailed designs, simulations, safety, verification, assembly, testing, crew training, launch site late load integration, on-orbit operations, support, and live data retrieval from our Payload Operations Control Center to sample return and analysis. BioServe is looking forward to both enable future human space exploration by characterizing adaptations of biology to the space environment but also to improve life here on Earth by finding novel treatments or biomanufacturing possibilities.

Space Medicine for Exploration Class Missions.

Shawna Pandya

PoSSUM Space Medicine Group, Boulder, CO

As the international community eyes ever-distant and increasingly ambitious destinations, we must consider the challenges that come with delivering healthcare in such hostile environments. This presentation will cover the risks of the human spaceflight environment, including, but not limited to physiological changes, design constraints, the ideal standard of care, emerging challenges that come with far-off locales, and conclude by examining the novel technologies and concepts that will help overcome these challenges.

The Wolverine CubeSat Development Team: Developing Engineers of the Future.

Mili Mohanty, Rachel Nusbaum, Landon Strauss, Arnav Joseph, and ***Kevin L. Simmons***
Baylor College of Medicine, Houston, TX

The Wolverine CubeSat Development Team (WCDT) is composed primarily of middle school students located in and near Palm Beach Gardens, Florida. The WCDT's purpose is to design, test, build, launch, and fly CubeSats. Established in August of 2015, they started as an after-school club with a goal of launching its own CubeSat. By 2018, the WCDT launched the WeissSat-1 and is currently building a second, the CapSat-1. The WeissSat-1, tested extremophile bacteria in the harsh space environment. The CapSat-1, selected in the 2018 10th round of NASA's CubeSat Launch Initiative (CSLI), tests the practicality of a capacitors-based electrical power system. Additionally, the WCDT is working on the AMARIS Lunar Rover which seeks to mitigate dust accumulation by utilizing electrostatics. Many WCDT students gain first hand experience with the GlobalStar Network, high-altitude balloons, and organizations such as the AIAA, Aerojet Rocketdyne, and Lockheed Martin. The lead aerospace instructor, Mr. Kevin Simmons, is the founder of BLUECUBE Aerospace and the Principal Investigator of both the WeissSat-1 and CapSat-1. He actively recruits motivated middle school aged students for his team. The WCDT is the only middle school in the nation to have launched a CubeSat.
During the COVID pandemic Simmons created a new team, the Wolfpack CubeSat Development Team, composed of rising and enthusiastic 6th grade students. The Wolfpack Team's goal is to develop a successful NASA-selected CubeSat proposal. Wolverine and Wolfpack members are expected to mentor the younger students in this middle school pipeline, and teamwork within the team is esteemed above individual abilities. For several years WCDT students have written technical papers and presented at the SmallSat Conference, International Astronautical Congress, Humans to Mars Summits, etc. WCDT students take Simmons' aerospace elective at the Weiss School and enter numerous team competitions annually. As the Wolfpack team prepares to submit to the 2020 CSLI, they are also mentoring newly formed teams in North Carolina and Nebraska in an effort to help those states launch their first CubeSats.

Passive, Tunable Biocide Delivery System for Spacecraft Water Processor Assembly.

Rogelio Garcia
University of Arkansas, Ralph E. Martin Department of Chemical Engineering

A biocide dosing system has been formulated to improve the disinfection of spacecraft potable water by passivation with ionic silver. The proposed piece of equipment releases silver ions into a stream of water at levels (200ppb–400ppb) that are not only effective against microbes but also safe for consumption by humans. Experimental results and computational simulations suggest that the Passive, Tunable Biocide Delivery System (PTBDS) is capable of operating without excessive consumption of silver salt and maintenance. The silver output of the system can be autonomously tuned to the target concentrations when disturbances occur. The paper presents the technical background and preliminary results from the development of the PTBDS, which could be integrated into spacecraft potable water systems.

Dual Use Technology Development for Lunar and Terrestrial Surface Construction.

Melodie Yashar

SEArch+, Los Angeles, CA

Technology development for space has historically led to ground-breaking research instrumental to our daily lives. Commercial development of the Moon will not only incite new economic and business opportunities—through space tourism, resource mining and more—but also foster the development of game-changing technologies that radically transform how we live and operate sustainably on Earth. The needs of the United Nations Sustainable Development Goals are critical to fostering an ecosystem of shared initiatives and incentives among government, academia, and industry partners for not only revolutionizing manufacturing and construction processes here on Earth but likewise in the development of a permanent Lunar base. SEArch+ (Space Exploration Architecture) develops human supporting concepts for space exploration, and in Project Olympus is collaborating with ICON 3D and NASA Marshall to realize humanity's first off-world construction system on the Moon. ICON constructed the first permitted 3D-printed house in the United States and in collaboration with Community First has constructed low-cost 3D-printed houses for homeless communities. SEArch+ and ICON are committed to pursuing space-enabled technology development that will continue to improve life on Earth.

Microgravity Research for All - How to Run Space Experiments with a Small Budget.

Mark Kugel

YURI, Meckenbeuren, Germany

While we celebrate 20 years of continuous research this year, launching an experiment to the ISS remains a complex, expensive and manual endeavour. Defining an experiment idea, developing a suitable miniaturized bioreactor and organizing all launch logistics and paperwork can still take years and require a high six-figure investment.

In the presentation we will look at the factors that are responsible for this complexity and cost and how they can be solved. For instance, just like SpaceX drastically reduces launch cost by reusing parts of the rocket, we at YURI reduce experiment cost by offering reusable and standardized bioreactors.

At YURI, our goal is to democratize access to research in microgravity. We aim to enable many more scientists around the globe to run affordable experiments on the ISS and beyond.

The ISS projects we are currently working on and will share in our presentation is a cancer cell experiment from the University of Technology Sydney, a neural stem cell mission with UCLA in California and a protein aggregation payload for GlaxoSmithKline.

We'll give the audience insights into our projects, how we work and the typical challenges we need to overcome in launching a payload to the ISS - especially in times of Covid-19.

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