National Aeronautics and Space Administration

OFFICE OF THE CHIEF HEALTH AND MEDICAL OFFICER

Ensuring The Health of Exploration

YEAR 2024 IN REVIEW

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MESSAGE FROM THE CHIEF HEALTH AND MEDICAL OFFICER

Dr. James D. “JD” Polk

DO, EdD, MS, MMM, CPE, FACOEP, FAsMA, FEWM

In this annual report, it is incumbent upon me, as the Chief Health and Medical Officer of NASA, to convey with the utmost fidelity and lucidity the dedication and unwavering resolve of our workforce in the Office of the Chief Health and Medical Officer and Health and Medical Technical Authority. For it is they who, with their unshakable spirit and tireless efforts, have allowed us to execute the human-rated spaceflight missions this past year and keep our workforce healthy. Our missions are manifold, and they encompass the highest degree of technical authority and medical expertise. We are at the intersection of human health, human research, human factors, and human systems integration for spaceflight missions. It is within the realms of these pillars that the safety, well-being, and success of our astronauts and missions are enshrined.

As we navigate the challenges and transitions that lie ahead, it is the confluence of our technical authority and medical acumen that allows our expertise and contributions to propel us forward. We are in the midst of critical commercial crew missions, safely completing the missions and phenomenal research legacy of the International Space Station, transitioning low Earth orbit operations to the commercial sector, developing new vehicles for the Moon and Mars, and developing new aircraft to further aviation. It’s an incredibly busy and exciting time to be at NASA.

In the spirit of earnest endeavor and with a profound sense of responsibility, I invite you to peruse the pages that follow, wherein the accomplishments, aspirations, and unwavering dedication of our office are chronicled.

We are a small team with a big impact.

OVERVIEW AND STRUCTURE

NG-20 Cygnus Spacecraft named the S.S. Patricia “Patty” Hilliard Robertson. The vehicle launched in January 2024 and is named in remembrance and celebration of former flight surgeon and astronaut Dr. Patricia “Patty” Robertson.

The Office of the Chief Health and Medical Officer (OCHMO) is the principal office responsible for the administration of health and medical policy and oversight of related activities. We provide guidance through effective and efficient policies, procedural requirements, technical standards, and programs to ensure the safety, health, and productivity of humans and animals in the global spaceflight and NASA community.

MISSION STATEMENT

Providing for health and wellness on Earth and in space, discovering new insights into medicine, educating the next generation, and innovating for the benefit of space exploration and humanity.

VISION STATEMENT

To expand the frontiers of health and wellness on Earth and in space.

CORE VALUES

NASA is committed to maintaining an environment of trust, built upon honesty, ethical behavior, respect, and candor.

OCHMO actively seeks to ensure the health and wellness of those working toward the exploration of air and space.

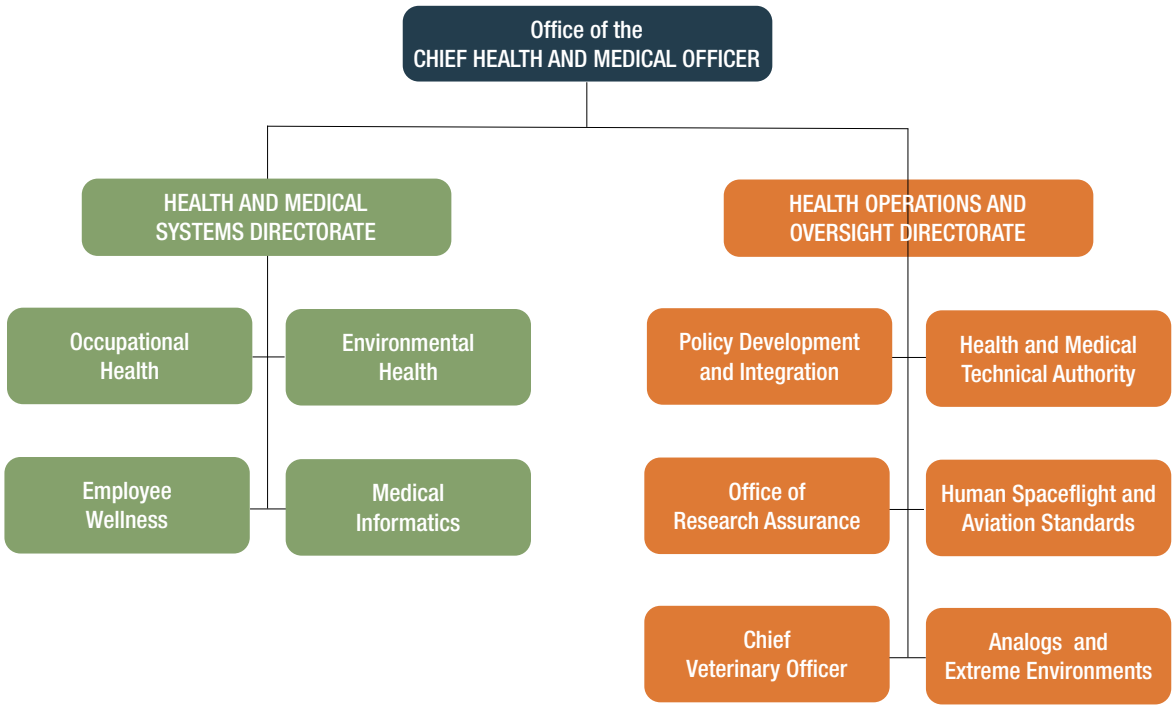
NASA's constant attention to safety is the cornerstone upon which we build mission success.

To achieve the highest standards in engineering, research, operations, and management in support of mission success, NASA is committed to nurturing an organizational culture in which individuals make full use of their time, talent, and opportunities to pursue excellence in conducting all agency efforts.

OCHMO fosters curiosity to enable personal growth, encourage innovation, and enable discovery.

Organization Structure

The OCHMO is composed of three divisions: (1) Health and Medical Systems, and (2) Health Operations and Oversight. Each division plays a key role in promoting, developing, maintaining, and advocating the best health and medical operations, practices, and standards for NASA and oversees and implements a variety of projects, programs, and initiatives at NASA Headquarters, centers, and facilities around the country.



Executive Leadership and Administrative Team

James "JD" Polk,
Chief Health and Medical Officer

Vincent Michaud,
Deputy Chief Health and Medical Officer

Jade Spurgeon,
Director, Health and Medical Systems

Mark Weyland,
Director, Health Operations and Oversight

Meredith Hawkins,
Administrative Officer and Project Management Specialist

Samantha Harvey,
Executive Assistant, NASA Headquarters

Sara Frahlman,
Executive Assistant, Johnson Space Center

2024 Operational Health Update. OCHMO staff from left to right: Dr. Azhar Rafiq, Jennifer Ensley Gorshe, Lesley Lee, Dr. Marisa Covington, Dr. Vince Michaud, Daniel Newfang, Mark Weyland, Dr. JD Polk, Dr. Jade Spurgeon, Angel Plaza.

Team Leads

Health and Medical Systems

Olga Emgushov,
Senior Medical Officer

Angel Plaza,
Senior Environmental Health Officer, Environmental Health

Daniel Newfang,
Deputy Senior Environmental Health Officer

Azhar Rafiq,
Director, Medical Informatics

Policy Development and Integration

Lesley Lee,
Manager, Policy Development and Integration

Health and Medical Technical Authority (HMTA)

Neal Zapp,
Manager, HMTA, and Chief Health and Performance Officer, Space Operations Mission Directorate (SOMD) and Exploration Systems Development Mission Directorate (ESDMD)

Debra Berdich,
Deputy Manager, HTMA, and Deputy Chief Health and Performance Officer, SOMD and ESDMD

Office of Research Assurance (OORA)

Marisa Covington,
Director, OORA, and Chair, NASA Institutional Review Board

Victor Schneider,
Research Liaison

Human Spaceflight and Aviation Standards

Dave Francisco,
Manager, NASA Technical Fellow for Health, Medical and Performance Spaceflight Standards

Office of the Chief Veterinary Officer

Chad Foster,
Chief Veterinary Officer

Mary Lou James,
Flight Institutional Animal Care and Use Committee (FIACUC) Chair

Laura Lewis,
Management Officer

Analogs and Extreme Environments

Marc Shepanek,
Program Lead

ISS MMPB. OCHMO staff from left to right: Dave Francisco, Debra "Debbie" Berdich, and Dr. J.D. Polk.

Jade and Lesley take part in an Eagle Horizon exercise.

Support Staff

Health and Medical Systems
Hanna Bogner
Matty Budesa
Regina Chisholm
Kaye Cole
Nancy Eckhardt
Erin Jensen
Bart Geyer
Justin Gilman
Jamie Gurney
Layzamarie Irizarry-Colon
Robert McIntosh
Michael Mcpherson
Papiya Ray
William Wilson

Health and Medical Technical Authority
Courtney Barringer
Paula Evans
Yamil Garcia
Sascha Henderson
Travis Houser
Tanya Paine
Dave Rubin

Office of Research Assurance
Sara Asgar
Arturo Garza
Jennifer Ensley Gorshe
Jennie Green
Jessica Kisenwether
Kirkland Ntow
Cyndi Roman

Human Spaceflight and Aviation Standards
Laura Bostick
Kristin Coffey
Doug Ebert
Emma Hwang
Kim Lowe
Imene Mechkene
Harrison Otto
Sarah Taoufik

Office of the Chief Veterinary Officer
Russell Higbee
Elaine Kim
Julia Kissling

Internship Spotlight

Dr. Samantha King,
Health and Medical Systems
Resident Intern, Summer 2024

Dr. King is a second-year resident in Aerospace Medicine at the University of Texas Medical Branch. She previously completed Emergency Medicine residency and Ultrasound fellowship, during which she completed the Aerospace Medicine clerkship at NASA Johnson Space Center.

During her rotation, Dr. King gained exposure to various aspects of regulation and policy within OCHMO. She worked on the update revision of NASA Procedural Requirements (NPR) 1850.1, Quality Assurance of NASA Medical Care. In addition to this project, she also contributed toward the creation of privileging checklists and the collation of roles and responsibilities in OCHMO policies, drafted language for OCHMO-related policy clarifications, and attended meetings related to Occupational Health and Aerospace Medicine at NASA. Dr. King also attended the Annual Operational Update in at Glenn Research Center in Cleveland, OH, participating in the Credentialing and Privileging small group section.

Joanna Kaouk,
Human Spaceflight and Aviation
Standards Intern, Summer 2024

Ms. Kaouk is a recent graduate of Louisiana State University, where she received her BS degree in biology. During her internship, Ms. Kaouk worked on the intervertebral disc technical brief, 100.1; drafted a trace from the International Space Station (ISS) Medical Operations Requirements Document (MORD) to NASA Standard 3001; and drafted a publication on the history of suited carbon dioxide testing. Ms. Kaouk was offered and accepted a full-time position with the Standards team and transitioned to full-time employment in fall 2024. In her spare time, she enjoys making sourdough bread for her coworkers, friends, and family.

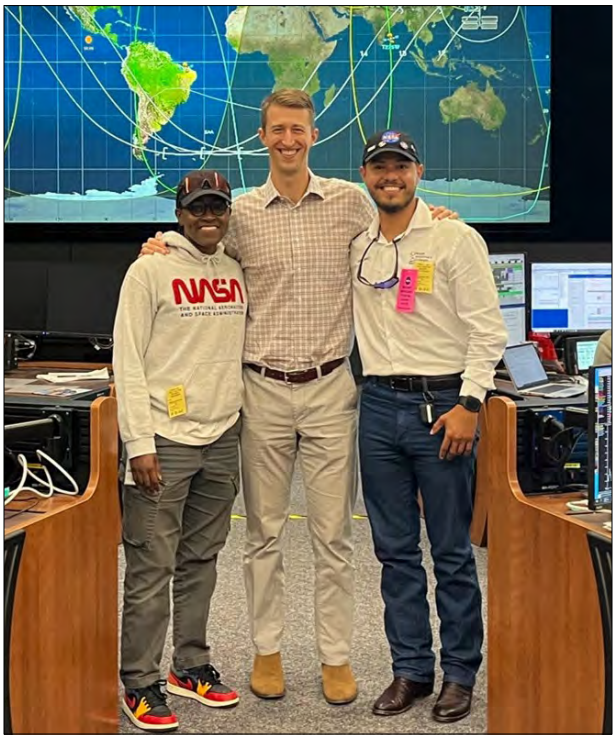
Ian Alexander Alvarez Acosta,
Office of the Chief Veterinary
Officer Extern, Summer 2024

Mr. Alvarez is a third-year veterinary student at the Royal Veterinary College in London. He is passionate about orthopedics and aims to achieve board certification from the American College of Veterinary Surgeons in Small Animals after completing his DVM degree.

During his externship, Mr. Alvarez designed the Mouse Health Check Form for rodents on the ISS; helped draft a statement of response for NASA's ethical and responsible use of lab animals; and worked on various rodent research projects, such as RR26, RR27, and MHU9, in which he collaborated with the astronauts for Crew 9. Additionally, he designed a final draft of the "Mouse Anesthetic, Reversal Agent and Analgesic Formulary Guidelines" for the Veterinary Verification and Consultation (VVC) at Kennedy Space Center. Lastly, Mr. Alvarez accompanied the Chief Veterinary Officer (CVO) to meetings with key stakeholders in NASA's animal operations, wildlife management, and musculoskeletal research.

Mr. Alvarez plans to apply for a seat in the Aerospace Medical Clerkship next year, aiming to one day pursue a veterinary career with NASA.

Internship Spotlight



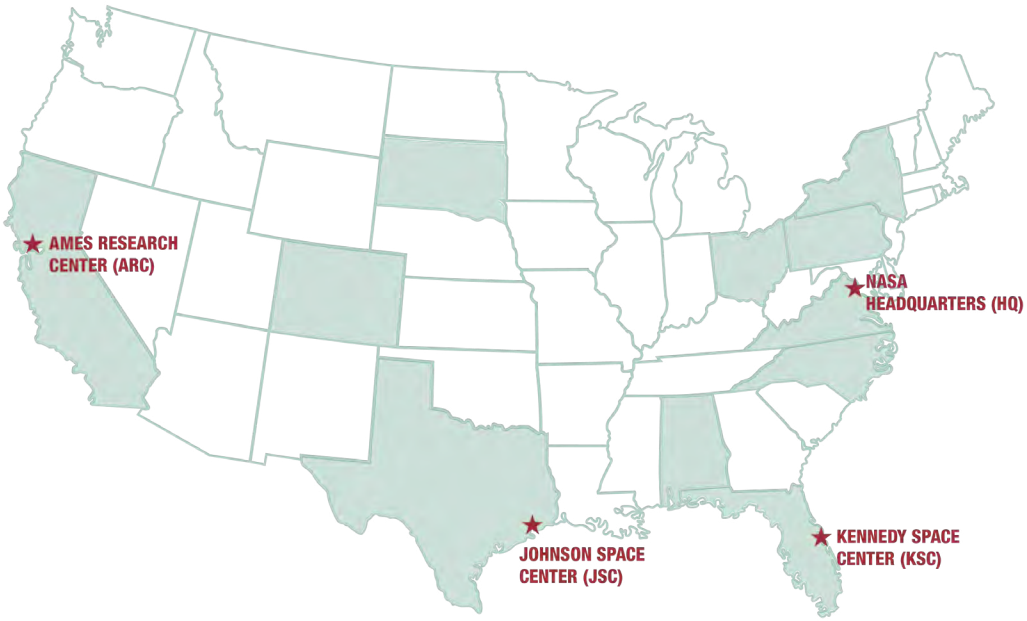
At Mission Control Center Ground, Johnson Space Center, are Dr. Kristen Peagler (left, former CVO intern), Garrett Hehn (middle, Flight Director), and Ian Alvarez (right).

Dinner with the team and astronaut Kjell Lindgren: Dr. Kristen Peagler (back left, former CVO intern), Mellodee White (middle left), Ian Alvarez (front left), Jenna Comella (back right), Dr. Chad Foster (middle right, CVO), and Kjell Lindgren (front right, astronaut).

Dr. Samantha King outside the Mary W. Jackson building, NASA Headquarters, in Washington, DC.

In front of the Vehicle Assembly Building, Kennedy Space Center, are Dr. Russell Higbee (left, Flight Attending Veterinarian) and Ian Alvarez (right).

Work Locations



Disciplines, Certifications, and Specialties

The OCHMO workforce is composed of multiple disciplines and talented staff who have an array of unique and diverse educational training, hold certifications and designations at high skill levels, and possess an assortment of expertise.

Below is a highlight of OCHMO educational background and work focus areas.

MEDICAL DEGREES AND BOARD CERTIFICATIONS

Adult Education, Aerospace Medicine, Doctor of Medicine, Endocrinology, Emergency Medicine, Internal Medicine, Neurobiology, Occupational Medicine, Osteopathic Medicine, Pediatrics, Preventive Medicine, Psychiatry, Veterinary Medicine

BACHELOR'S AND MASTER'S DEGREES

Applied Physics, Biology, Biomedical Engineering, Biomedical Ethics, Business Management, Chemistry, Education, Electrical Engineering, Environmental Health, Health Physics, Kinesiology, Kinesiology/Cardiac Rehabilitation, Mathematics, Medical Management, Military Art and Science, Nuclear Engineering, Physics, Public Health, Radiological Health Engineering, Space Studies

ADVANCED/ DOCTORATE DEGREES

Aviation and Space, Health Physics, Particle Physics, Public Health, Toxicology

PROFESSIONAL CERTIFICATIONS AND DESIGNATIONS

Aerospace Medical Association (AsMA) Fellow, American College of Laboratory Animal Medicine (ACLAM) Diplomate, American College of Occupational and Environmental Medicine (ACOEM) Fellow, American College of Osteopathic Emergency Physicians (ACOEP) Fellow, Certified Chief Flight Surgeon, Certified Industrial Hygienist (CIH), Certified IRB Professional (CIP), Certified Safety Professional (CSP), Extreme and Wilderness Medicine Fellow, Federal Aviation Administration (FAA) Medical Examiner

NASA Awards

The NASA Agency Honor Awards (AHAs) are the most prestigious honor awards given to staff. The awards are for individuals and groups who made outstanding contributions to the agency's mission. OCHMO received several AHAs in various categories highlighting the work efforts of both its federal and contract staff.

Agency Honor Award
Exceptional Public Service

Bart Geyer, Health and Medical Systems Industrial Hygiene

For exceptional occupational and environmental health support to all NASA employees and a distinguished career of outstanding service through inspired technical leadership.

Agency Honor Award
Exceptional Public Service

Victor Schneider, Research

For exceptional sustained innovation and leadership in human spaceflight research and research subject protection.

Human Health and Performance Crewed Flight Test Team

OCHMO recipient included on team:

Sarah Taoufik, HMTA

For outstanding support of the Boeing Crewed Flight Test (CFT) mission, including flight readiness support, the handling of multiple flight delays, and anomaly resolution.

Johnson Space Center Director's Innovative Group Achievement Award
Axiom-1 Human Research Institutional Review Board (IRB) Team

OCHMO/IRB Recipients:

Arturo Garza
Jennifer Ensley Gorshe
Jennie Green

For remarkable innovation in developing a flexible, thorough approach to accommodate a surge of Axiom-1 private astronaut missions involving human research investigations on significantly compressed timelines.

Dr. J.D. Polk, NASA Chief Health and Medical Officer, presents the International Space Station "Outpost at the Edge of the World" photo, by artist Mark Karvon, to Victor Schneider.

IRB team members receive the Johnson Space Center (JSC) Director's Innovative Group Award during an awards ceremony at JSC. From left to right are Douglas A. Terrier, JSC's Associate Director for Vision and Strategy; IRB staff (Arturo Garza, Jennifer Ensley Gorshe, and Jennie Green); and Vanessa E. Wyche, JSC's director.

Collaborations

OCHMO routinely works and collaborates with a number of external federal, independent, private, and educational institutions on health, medical, and research issues. The collaborations help NASA to achieve the highest standards in engineering, research, operations, and management in support of spaceflight missions.

FEDERAL AND MILITARY SPACE AGENCIES

Air Force Medical Service (AFMS)
Department of Energy (DOE)
Department of Health and Human Services (HHS)
Environmental Protection Agency (EPA)
Federal Aviation Administration (FAA)
Food and Drug Administration (FDA)
National Institutes of Health (NIH)
National Transportation Safety Board (NTSB)
North Atlantic Treaty Organization Special Operations Forces Command (NATO SOFCOM)
U.S. Department of Agriculture (USDA)
U.S. Department of Defense (DOD)
U.S. Department of Labor (DOL)
U.S. Department of Veterans Affairs (VA)
United States Air Force (USAF)
United States Space Command
United States Space Force (USSF)

INDEPENDENT ORGANIZATIONS

United Nations (UN)
World Health Organization (WHO)

PRIVATE ORGANIZATIONS AND EDUCATIONAL INSTITUTIONS

Aerospace Medical Association (AsMA)
American Board of Preventive Medicine (ABPM)
American College of Occupational and Environmental Medicine (ACOEM)
Institute of Electrical and Electronics Engineers (IEEE)
National Academy of Sciences (NAS)
National Sanitation Foundation (NSF)
Nuclear Regulatory Commission (NRC)
SAE International (SAE)
University of Texas Medical Branch (UTMB)

INTERNATIONAL ORGANIZATIONS AND INSTITUTIONS

Australian Space Agency (ASA)
Canadian Space Agency (CSA)
Centre National d'Études Spatiales / French Space Agency (CNES)
European Space Agency (ESA)
Indian Space Research Organisation (ISRO)
Japan Aerospace Exploration Agency (JAXA)
Russian Space Agency (RSA)
Scientific Committee on Antarctic Research (SCAR)
University of Strathclyde in Glasgow, Scotland

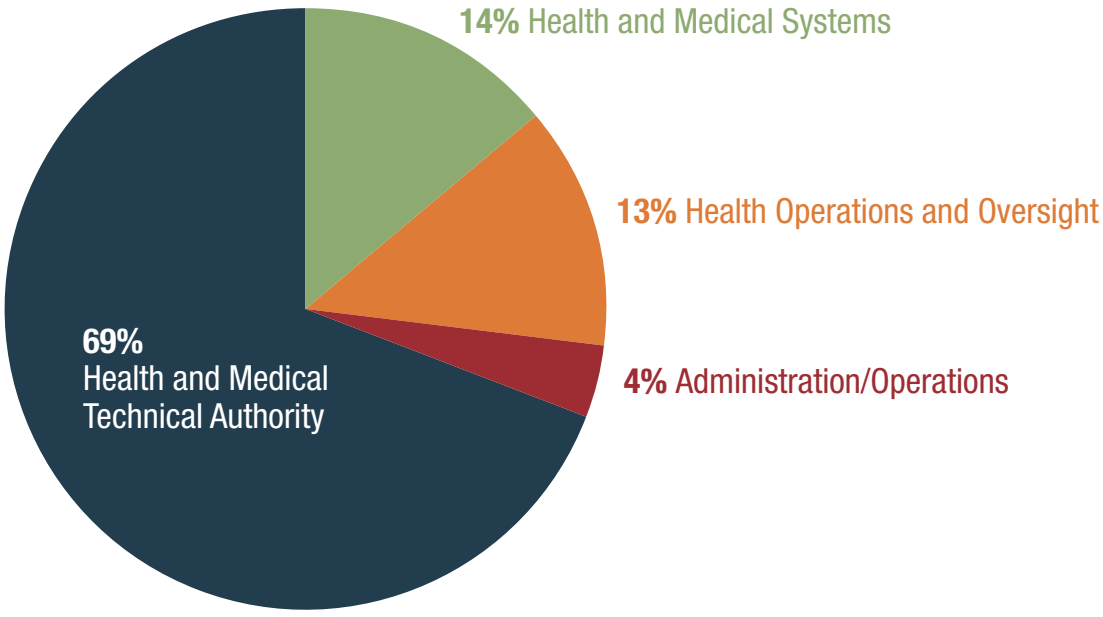
OCHMO hosted the 2024 Artemis Multilateral Medical Policy Board in Cologne, Germany. Attendees included NASA staff and international partners. From left to right are Sara Frahlman (OCHMO), Debra "Debbie" Berdich (OCHMO), Dr. Raffi Kuyumjian (CSA), Dr. Sergi Vaquer Araujo (ESA), Dr. J.D. Polk (OCHMO), and Dr. Satoshi Hayamizu (JAXA).

Financial Snapshot

The OCHMO's operations and expenditures budget for CY 2024 totaled $25.5 million. Funds were used to support a variety of programs, projects, and special initiatives and mission support activities.

CY24
Financial Total
$25.5M

Work Areas	Sum of CY 2024 Budget
Administration/ Operations	$896,853
Health and Medical Technical Authority	$17,688,639
Health Operations and Oversight	$3,345,070
Health and Medical Systems	$3,634,951
Grand Total	**$25,538,513**



HEALTH AND MEDICAL SYSTEMS

NASA stacks the first piece of the Space Launch System (SLS) rocket on the mobile launcher in preparation for the Artemis I launch.

"Occupational Health's mission is the safety and health of our employees. Our mission is not just a set of goals; it is the foundation of a future we are building every single day with our collective efforts, creativity, and passion. My team of talented and dedicated professionals continue to push the boundaries as we chart a course toward innovation and progress that will leave a lasting impact."

Jade Spurgeon, MD, MPH
Director, Health and Medical Systems

Priorities and Initiatives

- Oversees occupational health operations for all NASA work environments with an annual budget of less than $4.5 million, ensures compliance with all federal regulations, identifies workplace hazards, provides wellness and mental health support, and promotes preventive measures to avoid adverse health events for 100,000 employees. These efforts equate to an expenditure of $4.50 per employee, a tremendous return on investment (ROI) for the agency and taxpayers. This ROI can be directly appreciated by reviewing the decrease in federal workers' compensation claims paid by the agency.
- Streamlines and collaborates on processes, templates, training, and more to increase the efficiency of all Occupational Health Programs (OHPs) across the agency. The Health and Medical Systems team conducts comprehensive analysis of on-site audit procedures to identify inefficiencies and opportunities for improvement and develops and implements standardized templates to significantly streamline processes to reduce redundancy and ensure consistency across all audits. These enhancements save valuable staff time, result in measurable cost savings, and enable more effective allocation of resources. Additionally, the team cultivates relationships throughout the federal government, across industry, and internationally to bring the best, most up-to-date, evidence-based practices to NASA.
- Trains and mentors young professionals in the NASA workforce to enhance retention, improve engagement, and increase productivity, which benefits the agency and offers a variety of discipline-specific didactics from subject matter experts to the OHP workforce and no-cost Continuing Maintenance (CM) points opportunities to enhance and further the knowledge of Certified Industrial Hygienists (CIHs). This is an estimated cost savings of $250,000 within the NASA Occupational Health community.
- Upholds the highest standards of care to accelerate the health and wellbeing of NASA's workforce. Each discipline (Environmental Health, Occupational Medicine, Health Promotion, and Health Information Technology [IT]) within Health and Medical Systems works cohesively to strengthen and empower NASA's workforce so employees are prepared to face challenges and achieve extraordinary goals.

https://www.nasa.gov/ochmo/health-and-medical-systems/

ACCOMPLISHMENTS

From left to right are Bart Geyer, Angel Plaza, and Michael McPherson at the JSC White Sands Test Facility in Las Cruces, NM.

Dr. Jade Spurgeon and Kathy Cleveland Bull, keynote speaker at the 2024 Occupational Health Operational Update Meeting.

Triennial Reviews

OHP staff conducted triennial on-site reviews of the Occupational Health (OH) programs at NASA's Ames Research Center, Glenn Research Center, Marshall Space Flight Center, and Langley Research Center. The reviews consisted of interviews with employees; walkthroughs of selected areas and processes; and reviews of objective evidence such as documentation and records related to Occupational Medicine, Industrial Hygiene, Health Physics, Wellness, Health Promotion and Fitness, Food Safety, Childcare Facilities, Health Information Technology, and the Employee Assistance Program. The reviews ensured that established requirements and recommended best practices were used to implement and comply with NASA Occupational Health Program Procedures (NASA Procedural Requirements [NPR] 1800.1E).

Early-Career and Young Professionals Mentoring

The Environmental Health (EH) Team actively worked with early-career and younger professionals in NASA's EH community to foster growth and development during the post-COVID period of hybrid work. The team introduced a new mentoring platform to enhance retention, improve engagement, increase productivity, and elevate overall job satisfaction. Growing staff competency leads to quality and consistency at all NASA center EH programs and prepares employees for leadership roles as EH professionals.

Occupational Health Operational Update

OHP hosted its annual Occupational Health Operational Update meeting in August 2024 at Glenn Research Center. The 274 occupational health and safety professionals in attendance represented all NASA centers and nine professional disciplines. Overall, attendance was up nearly 20 percent from 2023. During the meeting, subject matter experts shared best practices, standardized processes, and industry updates. The OHP team took its fiscal responsibilities seriously by offering the meeting in person and virtually. This option allowed all employees access to information presented at the meeting while awarding up to 16.5 hours of continuing education credits for professional development and maintenance of industry certifications.

This meeting garnered consistent positive feedback from attendees, with 100 percent stating that the quality of this meeting was conducive to learning and valuable for enhancing participants' overall knowledge of the subject area. Statements from attendees included "This may be the best program ever put together for this meeting in 20 years," "Timely topics with great speakers," "Will bring back what I've learned to my office," "It [the meeting] allowed for building connections, networking, and relationship development for best practices agency wide," "Keynote Presentation: a perfect close to an exceptional OpUp week," and "Thanks for ending the week with a phenomenal presentation."

ACCOMPLISHMENTS

Stop the Bleed Team training.

NASA Moves! participants.

Stop the Bleed Team

The Stop the Bleed Team (STBT) continued to be instrumental in enhancing emergency preparedness and safeguarding NASA employees' health from dangers posed by an injury with associated blood loss. This team consists of multiple subject matter experts, who work diligently and collaboratively to build a coalition of stakeholders across the agency, train employees and first responders, and equip staff at NASA with lifesaving gear that can be readily deployed in cases of significant blood loss.

In 2024, the team assembled the exact equipment and its quantity needed for each emergency versus using pre-packed options. As a result, this saved NASA approximately $600,000. The STBT successfully assembled more than 15,000 equipment packs and deployed over 960 Bleeding Control Kits, significantly improving safety capability and emergency response agencywide. In addition, the team worked with each Center, at more than 42 training events, to train individual employees and "train the trainer" on Stop the Bleed methodology and techniques. This training resulted in the education of over 500 employees on emergency equipment and procedures.

NASA Moves!

The 11th Annual NASA Moves! fitness challenge significantly enhanced the physical, mental, and emotional wellbeing of employees across all 14 NASA centers and facilities. Occupational Medicine and Health Promotion staff executed the most successful "move" challenge to date, which included an updated customer interface, a new lifestyle challenge, a no-cost digital background setting for use during virtual meetings, a free digital picture frame for social media profile photos, and the introduction of novel ways to get employees involved in various fitness challenges. Specifically, the fitness challenge enrolled 5,474 individuals, 587 teams, and 473 lifestyle challenge participants, and more than 3,000 employees completed the entire solar system trek. The total number of steps recorded by all participants was 1,032,223,469, nearly double the steps from 2023.

ENVIRONMENTAL HEALTH

Safeguarding Our Workforce and Environment

Angel Plaza, DrPH
Senior Environmental Health Officer

EH experts tackle a broad spectrum of hazards, from industrial hygiene and radiation safety to food and laser safety. Through rigorous hazard mitigation, the EH team safeguards employees and ensures that the work environment—whether on Earth or in space—remains safe and supportive. In 2024, the team led critical projects, including comprehensive laser safety reviews and significant work on the Toxic Substance Control Act (TSCA) for chemical hazard management to guarantee safety across NASA centers.

In addition, the team worked closely with NASA's Office of Safety and Mission Assurance (OSMA) to create a grassroots effort with other internal organizations and 11 other government agencies to address regulatory uncertainty for space nuclear missions, request agencies' perspective, and produce an accurate characterization of the current state of space nuclear safety regulatory matters. This effort served as a starting point for future agency-specific work and amplified the need for increased communication and clarity among agencies since NASA is operating without any precedents.

The NASA Laser Safety Review Board (LSRB) continued to be instrumental in maintaining the safety of NASA missions, NASA employees, and members of the general public from significant dangers posed by outdoor laser projects. The Board received no federal funding, despite its incredibly important role of safeguarding health and safety while minimizing operational impacts and costs. This was an extraordinary service to the agency. Members donate their time and expertise to review all outdoor laser projects and advise senior management of risks associated with the projects.

Projects reviewed in 2024 included Armstrong Flight Research Center's High Altitude Lidar for Atmospheric Sensing-Global Hawk (HALAS-GH)/ Honeywell; Goddard Space Flight Center's Multifunction Airborne Raman Lidar (MARLi) and Airborne Doppler Lidar (ADL) on the NASA Arctic Radiation-Cloud-Aerosol Surface Interaction Experiment (ARCSIX) for the NASA ARCSIX field campaign and the Space Geodesy Satellite Laser Ranging System (SGSLRS); Langley Research Center's Ekspla Tunable Laser (a.k.a. Smart Polyimide Expandable Collector to enable Investigations for Earth Science [SPECIES]) Light Detecting and Ranging (LiDAR); and Ames Research Center, the Massachusetts Institute of Technology (MIT), and the University of Florida's joint project for the CubeSat Laser Infrared Crosslink (CLICK)-B/C.

EH continued collaborations with the Office of Strategic Infrastructure (OSI) and Goddard Space Flight Center's Climate Adaptation Science Investigators (CASI) Working Group to address the growing impact of climate change on employees' health. The aim is to understand climate-related health risks due to heat stress, wildfire smoke, and the impacts to air quality. EH translates CASI data and models into practical solutions, including informed policy development, targeted educational programs, and improved operational practices at NASA sites.

Since 2022, EH has strategically focused on ensuring that NASA's EH Community is prepared to implement regulatory changes planned by the Environmental Protection Agency (EPA)'s TSCA. EPA regulations significantly increased the regulatory requirements involving the use of selected chemicals critical to NASA. Collaborating with NASA's Environmental Management Division (EMD), EH worked with each center to ensure that critical uses for chemicals were identified and characterized and corrective actions were taken if the uses were vital to NASA's mission, research, and operations. Also, EH hosted numerous meetings to prepare the centers for the new and impending regulations and developed a TSCA-focused website to aid centers in understanding and being compliant with these TSCA standards.

OCCUPATIONAL MEDICINE AND HEALTH PROMOTION

Advancing Health and Well-Being

Olga Emgushov, MD, MPH
Senior Medical Officer

Occupational Medicine (OM) focuses on proactive preventive care for a workforce of 100,000 employees and provides oversight of comprehensive occupational health and wellness services at an incredibly low cost, around $4.50 per person annually. This highly cost-effective approach to preventive care allowed staff to offer a wide range of essential services that maximized ROIs for the agency. The services offered helped employees remain healthy, safe, and productive at work, with more than 19,000 certification examinations accomplished each year in NASA's clinics. Also, effective management of the services allowed efficient allocation of resources and maintenance of exceptional quality.

OM's goal was not to just provide treatment, but to prevent adverse health events and foster a healthier, more productive workforce that drives NASA's groundbreaking achievements. NASA's extensive health and wellness program not only supported individual well-being but helped reduce absenteeism, increased productivity, mitigated long-term healthcare costs, and directly contributed to supporting human exploration and space technology.

In 2024, OM updated the credentialing and licensing requirements set forth in NASA Policy Directive (NPD)/NASA Procedural Requirements (NPR) 1850, "Quality Assurance of NASA Medical Care," to ensure that physicians and medical professionals remain highly qualified, proficient, and aligned with the latest federal standards. The updated policy, developed through a collaborative and transparent process, involved adjudicating over 500 comments and coordinating with medical professionals and leaders across the agency. This collaborative effort reflected OM's commitment to maintaining excellence in preventive care and ensuring the highest standards of competency across its workforce.

During the assembly of the Bleeding Control Kits, there was a significant mishap involving an employee experiencing severe blood loss from a leg injury. Protective Services saved the employee's life by quickly using an improvised tourniquet, as noted by the treating hospital and in the Mishap Board's report. Since OM staff had worked on the bleeding control initiative months prior to the mishap, all logistics and stakeholder buy-in had been achieved beforehand. Therefore, Mishap Board recommendations were quickly implemented. Distribution and training on the use of Bleeding Control Kits guaranteed that NASA employees were prepared to respond to emergency situations, which is a significant benefit to the agency.

OM and NASA's Health Promotion team continued to serve as advocates for the Mission: HEALTH initiative that embodies OCHMO's holistic approach to employee wellness. By aligning with national standards and promoting total worker health, more than 1,600 employees benefited from the initiative in 2024 via virtual health events.

OCHMO's Director of Health and Medical Systems managed the Federal Employees' Compensation Act (FECA) process within NASA and via collaboration with the Department of Labor (DOL). NASA carefully analyzed injuries and payout trends to identify patterns and areas of improvement. Incident analyses contributed to the development of targeted safety campaigns aimed at reducing workplace injuries and illnesses. The campaigns promoted a safer work environment and helped prevent costly claims, ultimately saving the government significant amounts in federal workers' compensation payouts. NASA's proactive approach to optimizing federal workers' compensation enhanced employee well-being, improved safety standards, and contributed to long-term cost savings across the agency.

Dr. Jade Spurgeon and Meredith Hawkins (middle of back row) participate in Headquarters breast cancer awareness activities.

As an affiliate of the National Institute for Occupational Safety and Health's (NIOSH's) Total Worker Health® (TWH) program, OM continued to prioritize employee well-being through a robust wellness and fitness outreach initiative. Collaborating with other agencies, including the National Oceanic and Atmospheric Administration (NOAA) and the United States Patent and Trademark Office (USPTO), OCHMO expanded the reach of the initiative by persuading USPTO to join as a new TWH affiliate.

OM fitness specialists developed Desk Fit, an innovative fitness program that was highlighted on National Public Radio (NPR). The program consists of 20 simple, 1-minute exercises designed to combat physical strains associated with prolonged sitting, including neck and back pain, poor posture, and ergonomic issues. In 2024, over 600 employees participated in the program.

OCHMO continued providing tailored support through its Employee Assistance Program (EAP), with 30,000+ employees and their families receiving individual counseling and assistance. Additionally, the robust outreach efforts facilitated by OCHMO throughout the agency resulted in over 300 agency- and center-specific events, each with over 600 attendees. Topics discussed at the events covered a wide range of mental health subjects, such as suicide prevention, stress, burnout, adapting to change, anxiety, election stress, and strategies for supporting employees through these challenges.

The EAP continued to demonstrate an outstanding ROI by significantly reducing the costs associated with worker stress and mental health challenges. Stress and mental health–related issues can reduce an individual's productivity by as much as 37.5 percent. This decline not only affects the individual worker but can also negatively impact team performance, with a reduction of up to 10 percent in overall team productivity.

The financial impact of stress and mental health challenges is substantial due to their effects on productivity and potential increase in federal worker's compensation costs. EAP interventions have proven highly effective in mitigating these costs. Targeted psychological support via an EAP can recoup up to 75 percent of lost productivity, equating to an impressive $11.5 million in savings for NASA centers in a single year. This impressive savings underscores the EAP's critical role in maintaining a high-performing workforce, improving employee well-being, and generating significant savings to the agency. The EAP's success is a testament to its essential role in fostering a resilient, healthy, and productive workforce and achieving NASA's mission and ambitious goals.

HEALTH INFORMATION TECHNOLOGY

Azhar Rafiq, MD
Director of Medical Informatics

The Health IT team drives innovation and transforms the management of employee health records. In 2024, the team focused on transitioning health records to a fully digitized system and consolidating decades of medical data into NASA's Electronic Health Records System (EHRS). This Health IT effort enhanced data security, streamlined workflows, safeguarded data integrity, and empowered healthcare providers with the information they need to make timely, informed decisions.

The Agency EHRS has been a seamless tool utilized by health units at 13 Centers and hazard surveillance programs across the agency for nearly 15 years. Last year, the team processed 62,000 records each week, oversaw 27,000 clinic visit records, and managed 595 exposure group protocols and 824 exam activities for medical certification exams.

In addition to resolving hundreds of Help Desk tickets every month from users across the agency; managing all software updates, patches, and fixes; supporting profile setups; handling security rights validation; and training new staff at the centers, the EHRS team worked diligently to improve the capabilities of the system. Specifically, several centers determined that maintaining an EHRS separate from the agency EHRS was no longer financially feasible. EHRS staff performed a no-cost, full business analysis of existing software users at eight centers and compared the results to the agency EHRS. Analyses showed potential cost savings of more than $1.1 million in annual software costs and more than $1 million in start-up, transfer, and consultation fees.

The EHRS Team also completed a full product development life-cycle plan, from inspection to roll out, including testing and validation of security risks. This work effort required migrating decades of medical records for more than 16,000 employees to ensure compliance with all Occupational Safety and Health Administration (OSHA) requirements.

The team spent significant time migrating EAP legacy data out of sunsetting software for six centers. Nearly 4,000 records were imported within a few weeks while meeting or exceeding all security, privacy, and accuracy metrics and delivering significant cost savings of approximately $120,000 annually for the six centers.

As NASA Fitness Centers go paperless, the EHRS has been invaluable in securely maintaining clearance documents. More than 2,032 were completed in 2024.

A significant portion of the EHRS effort focused on hazard surveillance. The team recorded nearly 700 surveillance activity records from EH, 194 Noise Sampling/Monitoring data points, 747 Hazardous Shop Survey results, and 31 new equipment entries last year. NASA is better able to protect its workers and characterize the effectiveness of hazard mitigation strategies by maintaining the integrity and security of these data.

The Director of Informatics engaged in significant collaboration efforts by participating in multiple intra-agency working groups, including the Office of the Chief Information Officer's (OCIO's) Digital Transformation Community; the Vulnerability and Asset Management Program (VAMP); the Identity, Credential, and Access Management (ICAM); the Risk Information Security Compliance System (RISCS); the JSC + Google project: AI clinical decision support project; the Inter-agency Working Groups within the Offices of National Coordinator and Health and Human Services' Federal Health IT Coordinating Council, as well as the National Coordinator and Health and Human Services' Digital Health Innovation Working Group; the General Services Administration's Technology Transformation and AI Community of Practice; and the Cybersecurity and Infrastructure Security Agency.

HEALTH OPERATIONS AND OVERSIGHT

NASA astronauts Sunita "Suni" Williams, Butch Wilmore, and Nick Hague with Russian cosmonaut Aleksandr Gorbunov aboard SpaceX Crew Dragon.

"It is a privilege to serve with such an amazing group of people within the Health Operations and Oversight Division. They never cease to amaze me with their work ethic, creativity and leadership across so many different subject matter expert disciplines as well as a diversity of programs and projects."

Mark Weyland
Director, Health Operations and Oversight

Priorities and Initiatives

- Provides oversight of the formulation and implementation of health and medical policy, including standards related to the care of spaceflight and aviation crews and the regulatory use of human and animal subjects in NASA-sponsored research; the implementation of NASA's HMTA; the study of extreme environments; and the translation of research findings into operations.
- Is composed of Policy Development and Integration, the Health and Medical Technical Authority, Human Spaceflight and Aviation Standards, the Office of Research Assurance, the Chief Veterinary Officer, and Extreme Environments and Analogs.

NASA astronaut and Expedition 72 Flight Engineer Jonny Kim installs experimental hydrogen sensors to test the advanced life-support gear for longer calibration life and improved reliability aboard the International Space Station's Destiny laboratory module.

POLICY DEVELOPMENT AND INTEGRATION

Hurricane Milton is pictured as a category 4 storm in the Gulf of Mexico in this photograph from the International Space Station. The SpaceX Dragon Freedom spacecraft is also pictured.

"People at NASA don't just work 9-to-5—it's a mission, a calling, and a privilege to be called a "NASA geek." Our OCHMO team lives their enthusiasm for space exploration through its dedication to protecting the health and well-being of our crew and workforce, including our research participants and even the tiniest animals in our care. I love learning from and collaborating with colleagues inside and outside NASA to evolve our OCHMO policies to enable the next giant leaps in space."

Lesley Lee
Manager, Policy Development and Integration

Priorities and Initiatives

- Ensures consistency, accountability, and excellence in the provision and oversight of OCHMO's responsibilities in aerospace, occupational, and veterinary medicine; in the ensuring of terrestrial and spaceflight crew and workforce health and safety; in the ethical conduct of human and animal research; and as the Agency Health and Medical Technical Authority (HMTA).
- Guides the development and implementation of policies that communicate specific mandatory instructions and requirements, define purpose, grant authority, and assign key responsibilities and tasks to NASA employees, organizations, and programs.
- Leverages relationships with internal and external organizations (e.g., the Office of Safety and Mission Assurance, Office of Legal Counsel, Department of Defense, or Federal Aviation Administration) to inform the development of policies and requirements within the realms of NASA and federal suborbital and orbital spaceflight.

https://www.nasa.gov/ochmo/health-operations-and-oversight/ochmo-policy1/

ACCOMPLISHMENTS

Revised Human Research Subjects' Protection Policy

NASA's human research policies and data protections must keep pace with increasingly complex and personal data, some of which may foretell specific disease risks for the research participants, as well as their family and descendants. Therefore, the OCHMO Policy and Institutional Review Board teams incorporated NPD 7170.1, "Use of Human Research Genetic Testing," into NPR 7100.1, "Protection of Human Research Subjects, Revision D." This updated policy provides comprehensive guidance on the use and protection of human research data. Specifically, it requires funding programs and investigators to fully protect participants' privacy and the confidentiality of biospecimens and all forms of data collected and generated for a study. The policy also requires consideration of genetic counseling or education of participants before obtaining informed consent and throughout the study, as appropriate, for investigations of genetic information.

Astronaut Mike Barratt stows research samples in a science freezer.

Occupational Health Requirements Updates

OCHMO Policy and Occupational Health teams worked with OSMA personnel to publish a revision to NPR 1800.1, "NASA Occupational Health Program Procedures," to support OSMA's Forklift Safety campaign in August 2024. New medical examination requirements and clarifications were added to the document's Appendix C, which contains detailed occupational surveillance exam requirements for employees and applicable contractors based on one's responsibilities, workplace environment, exposures, and health maintenance. The new requirements were applied to the exam for operators of forklifts and related equipment such as cranes, mobile elevated work platforms, and various types of trucks. These and other Appendix C examinations require periodic updates due to changes in requirements or standards within NASA or from other federal agencies (e.g., the Occupational Safety and Health Administration) or credentialing organizations.

NPD and NPR 1850.1, Quality Assurance of NASA Medical Care

OCHMO completed a thorough reorganization and rewrite of NPD and NPR 1850.1, agency medical quality assurance directives, to improve usability and clarify requirements, responsibilities, and processes. The new version of NPR 1850.1 (Revision A) incorporates NID 1850.141, "Appropriate Credentials for Flight Surgeons," and a June 2024 CHMO memo that clarified requirements for the Chief Medical Officer and Medical Director positions. These updated requirements and those of other NASA healthcare personnel are now included within the specific credentials and privileging chapters of the NPR, and processes for medical incident investigations, adverse privileging and appeal, and management of records were simplified. Through these revisions, OCHMO aims to share NASA's high medical quality expectations throughout the agency and with industry stakeholders as both healthcare and human spaceflight undergo rapid and expansive changes. These directives will be published in the first half of CY 2025.

ACCOMPLISHMENTS

Medical Risk Evaluations for Private Astronauts and NASA Suborbital Research Specialists

Following the fall 2024 publication of updates to OCHMO Standard 100.1, "NASA Space Flight Medical Selection, Recertification and Mission Evaluation Standards," the policy team worked with Space Operations Mission Directorate and suborbital stakeholders on further revisions to the OCHMO NPR regarding medical risk evaluations for private astronauts and NASA suborbital research specialists. The full, rewritten NPR will be published in CY 2025; until that time, NID 8901.144, "Private Astronaut and Sub-Orbital Spaceflight Participant Medical Procedural Requirements," remains in effect to guide medical risk evaluations for these populations.

In a related effort, the OCHMO policy team, Aerospace Medicine Board (AMB) Chair, and board members updated the AMB Charter with new responsibilities for certifying NASA suborbital flyers and the risk evaluation process for private astronauts interacting with NASA assets or the ISS. The latter process includes evaluation by the ISS Multilateral Space Medicine Board.

Astronaut Mortality Directive

OCHMO published NASA Interim Directive (NID) 8921.143, "Policy for the Handling of Mortality Related to NASA Human Spaceflight Operations," informed by the recently established OCHMO medical forensics panel to address mortality mishaps or incidents resulting in death during spaceflight activity or a mission. The NID also incorporated lessons learned from previous spaceflight mishaps that occurred when no such medical policies existed. This newly established policy, along with OSMA's NPR 8621.1(mishap and close call requirements) and OCHMO's NASA Flight Surgeon Mishap Investigation Manual, guides agency organizations' jurisdictions and responsibilities in the event of a future mishap. In calendar year (CY) 2025, this NID will be incorporated into the revision of NPR 8900.1, "Health and Medical Requirements for Human Spaceflight."

NASA astronaut Sunita "Suni" Williams during U.S. spacewalk 92.

ACCOMPLISHMENTS

Aerospace Medicine Core Competencies Report

OCHMO, in collaboration with the Potomac Institute, conducted a study to define the core competencies in aerospace medicine, a field dedicated to ensuring the health, safety, and performance of individuals engaged in air and space travel. The study highlights the evolving demands of aerospace medicine, particularly with the expansion of commercial spaceflight, NASA's Artemis Program, and the establishment of the United States Space Force. It underscores the necessity for aerospace medicine practitioners to be proficient in both aviation and space medicine, as many physiological and environmental challenges overlap between the two domains. The report also emphasizes the importance of medical evaluations for astronauts, addressing factors such as radiation exposure, toxicology, hypobaric environments, isolation, and microgravity, which significantly impact human health in space. This study serves as a foundational guide for training and equipping aerospace medicine professionals to meet the growing needs of human spaceflight and aviation.

Dr. Joe Schmid (NASA) and Dr. Satoshi Hayamizu (JAXA) monitor a mission in Mission Control.

https://www.potomacinstitute.org/index.php/featured/aerospace-medicine-core-competencies-2

Privacy Act System of Records Notice: 10 ORIS

OCHMO worked with Center Radiation Health Officers (RHOs) to update NASA's Occupational Radiation Information System (10 ORIS) for publication in the Federal Register. All data collected and analyzed from ground- and space-based dosimeters and radiation monitors were processed and held at vendor locations as well as within the agency. A thorough accounting of all electronic and legacy data locations was completed and provided for the System of Records Notice (SORN) update.

Other Policy Accomplishments

The OCHMO Policy team also made significant progress on policy development that will be published in CY 2025. These include the following:

Mission Operations—Several policies are in revision to clarify the HMTA, standards, and other operational requirements. The first of these updated policies, NPR 7120.11, "HMTA Implementation," has undergone initial internal reviews and will be placed in the NASA Online Directives Information System (NODIS) for agency-wide reviews in spring 2025.

Care and Use of Animals—While initially expected for publication in CY 2024, the policy revisions were adversely impacted by the loss of a key senior team member. The Chief Veterinary Officer has also been gathering additional inputs from stakeholder programs and payload developers.

ACCOMPLISHMENTS

Collaborations and Working Groups

In CY 2024, the Federal Trilateral Space Medicine Board (FTSMB), composed of members from NASA, the U.S. Air Force/Space Force, and the FAA, met twice to continue sharing timely information, issues, and gaps in support of human aeronautics and spaceflight. Among the key topics discussed were mishap preparedness and education, crew recovery coordination, championing aerospace medicine education, training and succession plans, and safety policies and standards for crew and controllers. Amid the explosive growth of the commercial space industry, the FTSMB enabled each agency to strengthen their respective policies, standards, and operations in support of flight and ground safety.

OCHMO Policy and Standards personnel actively collaborated with counterparts in the Offices of the Chief Safety and Mission Assurance and the Chief Engineer to ensure that the Technical Authorities' agency-level policies and directives were consistent in document cross-referencing and terminology. Staff regularly reviewed draft versions of other office and program directives for impacts to, and possible mitigations for, issues related to crew and occupational health, safety, and performance. OCHMO also worked extensively with OSMA policy staff on updates to the forthcoming revision of OSMA's NPR 8621.1, "NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping," a key document for integration of agencywide mishap preparedness and response. Lastly, OCHMO staff provided inputs to NID 7900.145, "Flight Crew Duty Day Limitations," for incorporation into OSMA's NPR 7900.3, "Aircraft Operations Management" directive.

In the development of OCHMO policies, close collaborations with experts in the Offices of General Counsel and Interagency and International Relations continue to help reinforce our best practices and ensure compliance with applicable agency, federal, and international laws, regulations, directives, and agreements.

A NASA flight surgeon attends to an astronaut during an exploration analog mission on Devon Island, Canada.

HEALTH AND MEDICAL TECHNICAL AUTHORITY

The SpaceX Dragon spacecraft carrying NASA astronaut Nick Hague and Roscosmos cosmonaut Aleksandr Gorbunov approaches the International Space Station as it orbits 259 miles above Oregon.

"I am blessed to have human spaceflight as a career, and perhaps even more so to have a truly stellar team with whom to share the journey. Their dedication to understanding and overcoming the challenges of the human system in space is truly inspiring. Their passion and tireless efforts not only enhance our capabilities in space exploration but also symbolize [the] human spirit that ultimately enables it. I deeply appreciate this exceptional team as we push the boundaries of human spaceflight and help to create tomorrow from today."

Neal Zapp
Manager, HMTA, and Chief Health and Performance Officer, Space Operations Mission Directorate (SOMD) and Exploration Systems Development Mission Directorate (ESDMD)

Debra Berdich
Deputy Manager, HTMA, and Deputy Chief Health and Performance Officer, SOMD and ESDMD

Priorities and Initiatives

- Provides for direct management of health and performance of flight crews in operations and the protection of human health.
- Administers spaceflight program support for the following programs: Gateway Program (GP), Orion, Human Landing System (HLS), Exploration Ground System (EGS), International Space Station (ISS), Commercial Crew Program (CCP), Commercial Low Earth Orbit (LEO) Development Program (CLDP), and Extravehicular Activity (EVA) and Human Surface Mobility Program (HSM). Within these programs, there are currently 32 distinct areas of programmatic content.

https://www.nasa.gov/ochmo/health-operations-and-oversight/health-and-medical-technical-authority/

ACCOMPLISHMENTS

Spaceflight Program Support

The HMTA remained actively engaged in space-flight missions, offering real-time assistance during technical launch and landing operations, as well as readiness evaluations. Crewed flights included SpaceX's Crew-7 return, Crew-8 launch and return, and Crew-9 launch; and Boeing's CFT launch and uncrewed return. In addition, HMTA oversaw the readiness assessment for Russian Soyuz rocket expeditions (70S return, 71S launch and return, and 72S launch) and Axiom Ax-3's launch and return. HMTA participated in the assessment of readiness for several uncrewed missions, including SpaceX Cargo Resupply Missions CRS-30 and CRS-31, and the launches of other exploratory spacecraft such as the Europa Clipper and the Geostationary Operational Environmental Satellite (GOES-U).

In addition, HMTA personnel also represented OCHMO on Program Standing Review Boards and provided expertise and support for many key program milestones and activities, such as ISS PrK operational risk decisions, CFT return risk trades, Multi-Purpose Habitation Mission Concept Review, Argonaut Mission Concept Review, Artemis II risk trades, Architecture Concept Review (ACR) 2024 decisions, baseline of the Moon to Mars Medical Operations Requirements Document; and Crew 8 post-landing investigation and contingency lessons learned.

NASA's Space Launch System rocket with the Orion spacecraft aboard is seen atop the mobile launcher.

Aeronautics Support

OCHMO continued supporting Aeronautics in design, development, and ongoing operations. For the X-59, OCHMO worked with the Flight Readiness Review (FRR) Board, the Airworthiness and Flight Safety Review Board (AFSRB), and NASA subject matter experts (SMEs) to assess and propose risk mitigations related to cabin pressure loss, F-15 radar exposure, and fuel tank fire hazards. OCHMO also supported the DC8 Southeast Asia Air Campaign, ensuring crew duty/rest compliance with NASA policies, and assessed the Electrified Power Demonstrator for unmitigated hazards. For the Boeing 777, OCHMO ensured proper health clearances and occupant protection. Additionally, OCHMO supported the SMD Balloon operations at the South Pole by ensuring compliance with the National Science Foundation (NSF) medical guidelines for all candidates.

Technical Interchange Meetings

OCHMO developed and presented key content for several Commercial Low Earth Orbit Development Program Technical Interchange Meetings (TIMs) with the Commercial Industry. HMTA and OCHMO personnel led a Human System Integration TIM that included human rating certification lessons learned. Experts from NASA's Space Food Systems Laboratory shared the unique requirements and conditions surrounding the formulation, production, packaging, and logistics of space food for enabling the success of commercial low Earth orbit missions. More than 50 commercial food and commercial space companies were invited to learn more about technical challenges associated with sustaining life in space as well as to share fresh ideas and explore future collaborations. Acoustic subject matter experts participated in a TIM to showcase the benefits of NASA-developed quiet fans for future commercial space stations. A Medical Operations Workshop was held with CLDP potential providers addressing topics such as astronaut selection processes; lessons learned on real-time operations for pre-, post-, and in-flight; research considerations; and much more. The Commercial Industry has welcomed NASA's frank discussion and experience base across all TIMs, and OCHMO anticipates more interchanges at the request of CLDP and ISS program.

ACCOMPLISHMENTS

International Relations

The Chief Health and Medical Officer, alongside the HMTA Manager, met with the newly appointed Chief Medical Officer for the United Arab Emirates (UAE) Space Agency, Dr. Hanan Alsuwaidi. Dr. Alsuwaidi, also the UAE appointed representative to the Gateway/Artemis Multilateral Medical Operations Policy Board and Operations Board, provided a tour of the Mohammed Bin Rashid Medical Centre. Members of the UAE ruling family, together with Centre faculty, participated in the visit at this state-of-the-art facility that provides advanced computational diagnostics and precision personalized treatment regimes.

OCHMO convened the Artemis Multilateral Medical Policy Board (AMMPB) and Artemis Multilateral Medical Operations Board (AMMOB) with CSA, ESA, and JAXA in Cologne, Germany. Charters and multi-use export control agreements were established via Gateway, allowing for streamlined international collaboration and ensuring compliance with NASA standards. In addition, the meetings included in-depth discussion on the development of the NASA mortality policy, providing our international partners with a baseline to help guide the development of policies for their respective agencies.

The ISS Multilateral Medical Policy Board was held December 5–10 in Cologne, Germany, with all international partners in attendance. Key discussions during the meeting included policy updates on Crew Certification (OCHMO-STD-100.1A, Revision A) and an assessment of current medical risks. Also discussed were an outbrief of the recent Thromboembolism Technical Interchange Meetings, progress of the ESA Fly! Project, human and animal research on the ISS, and the NASA publication *Assessment of Patent Foramen Ovale (PFO) as Related to Decompression Sickness (DCS) in the Spaceflight Environment and During Ground Testing* (SP-20240010473).

HMTA-Provided Trainings

HMTA staff were busy this year enhancing the HMTA Overview training and tailoring the content to more audiences to fulfill an increased demand. HMTA's training goal was to provide participants with in-depth knowledge about the inner workings of technical authority and highlight the reasons for HMTA's formulation and its current role in supporting NASA spaceflight missions and development programs. HMTA staff conducted six training sessions, including two executive sessions for the leadership teams of the Human Health and Performance Directorate and the Human Research Program. This year, the program also conducted training for second-year aerospace medicine residents at UTMB. New to HMTA training this year was an exclusive one-on-one interview with John Tribe, a test engineer who worked the Apollo 1 mishap, to bolster Mishap History and HMTA Formulation content. HMTA staff traveled to Kennedy Space Center to capture his story and learn from his experience working at NASA during the Apollo 1 and Challenger disasters and as a docent during the Columbia disaster. Participants in the one-day training session got to hear a first-hand account of the Apollo 1 mishap, including what the culture was like before and after the mishap and what changes were made to strengthen NASA's culture at that time. HMTA staff will continue to offer informed trainings for current and future personnel.

A United Launch Alliance Atlas V rocket with Boeing's CST-100 Starliner spacecraft aboard is seen illuminated by spotlights on the launch pad at Space Launch Complex 41 ahead of NASA's Boeing Crew Flight Test, Saturday, May 4, 2024, at Cape Canaveral Space Force Station in Florida.

ACCOMPLISHMENTS

Collaborations and Working Groups

OCHMO partnered with the Science Mission Directorate and Earth Sciences colleagues to represent both the agency's portfolio of space-borne scientific observational platforms and the human health and performance technologies developed to support crewed spaceflight at the United Nations Office for Outer Space Affairs (UNOOSA)/Committee on the Peaceful Uses of Outer Space (COPUOS)/World Health Organization (WHO) Symposium for Health in the Americas. This was one of several symposia aimed at better understanding the implications of the use of space assets for global health and environmental applications (e.g., wildland fires, climate resilience, and health and air quality), both operationally and for research.

HMTA personnel provided the NASA Technology Coordination and Integration Group (TCIG) with the OCHMO Top Human System Exploration Capability needs as agreed upon across the crew health and performance community of practice.

OCHMO released "Forensic Support Request for Information (RFI) 80HQTR24OCHMO-001" for industry feedback on the current state of the art with respect to medical forensic activities associated with space mishap investigations. Data gathered will be used to assess potential ideas, knowledge-sharing modes, industry state-of-the-art technologies, and investigative techniques, all to support preparedness for medical operations in mishap investigations.

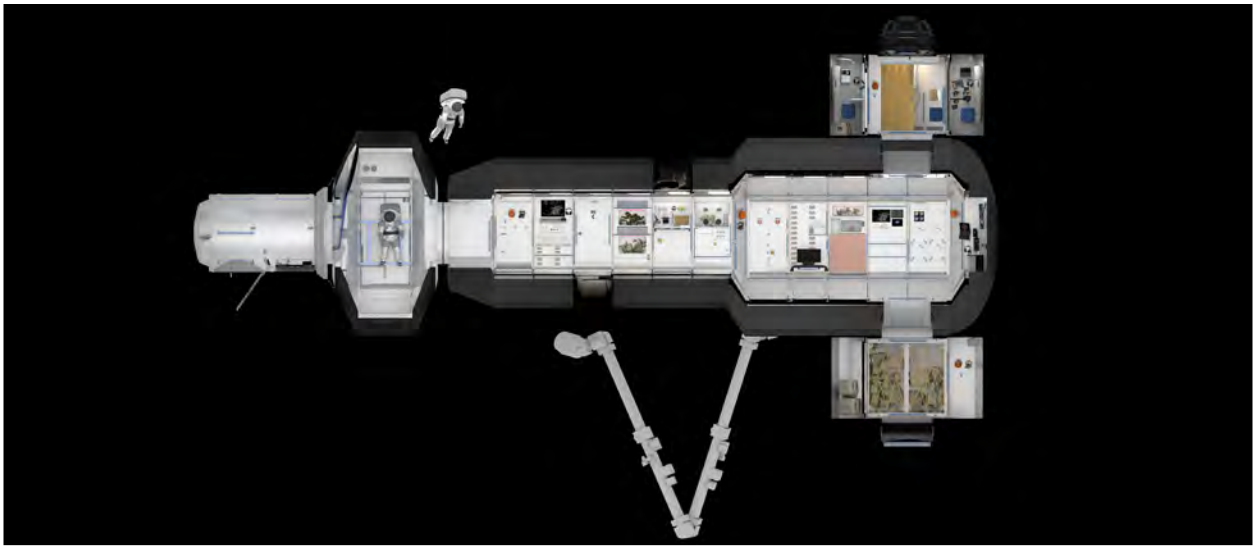
Working sessions were held with the FAA, NTSB, and DOD (Special Forces, Det 3, United States Air Force [USAF], Armed Forces Medical Examiner [AFME]) with respect to technical interchange on human risk and physiological changes in spaceflight and upon return. Future knowledge transfer sessions and plans for training are underway.

OCHMO gave a presentation on Medicolegal Death Investigation in Space to the Office of Justice Programs/Centers for Disease Control and Prevention Medicolegal Death Investigation Interagency Working Group.

OCHMO also worked closely with the Planetary Protection Officer and Administration for Strategic Preparedness and Response (ASPR) on risk mitigation strategies for backward contamination for human-rated missions.

Teams transport the agency's powerful SLS core stage to Kennedy Space Center's Vehicle Assembly Building in Florida after the completion of its journey from NASA's Michoud Assembly Facility in New Orleans aboard the Pegasus barge.

HUMAN SPACEFLIGHT AND AVIATION STANDARDS



Rendering of a mock habitat that would be derived from the NASA Spaceflight Human-System Standard.

"It is an awesome opportunity to work within OCHMO and with the dedicated Standards Team to enable human spaceflight across NASA, the commercial industry and our international partners. The Standards team is a diverse, talented and energetic team that pushes every boundary to ensure that we provide the best possible information to facilitate human spaceflight."

Dave Francisco
Technical Fellow for Health, Medical, and Performance Spaceflight Standards

Priorities and Initiatives

- Creates, reviews/validates, and adjudicates all NASA human health, medical, and performance standards, which include Human Spaceflight Standards (NASA-STD-3001), NASA Astronaut Selection Standards (OCHMO-STD-100.1), and Aviation Medical Standards (OCHMO-STD-1880.1).
- Develops the medical and technical requirements and documentation necessary to successfully implement NASA programs and the commercialization of human spaceflight.
- Collaborates with NASA, national, and international subject matter experts to ensure that best practices and data are utilized to develop new and/or update spaceflight and aviation standards according to the needs of each NASA mission.
- Performs independent assessments of NASA health, medical, and performance high risks with the goal of minimizing risk while enabling safe and efficient human exploration. Partnering with external experts and organizations is a keystone in minimizing human spaceflight risks and providing written reports to ensure that the knowledge is captured and disseminated.

https://www.nasa.gov/ochmo/hsa-standards/

ACCOMPLISHMENTS

Human Spaceflight and Aviation Standards Website

The OCHMO Human Spaceflight and Aviation Standards website captures all relevant human spaceflight medical, health, and performance information for dissemination to the public. The OCHMO Standards Team also utilized the public website to enable public comments to standards that were being updated. This process enabled transparency on NASA's activities and also engaged the public in ensuring that NASA had the best and most up-to-date requirements. Website traffic and views of technical briefs, standards, and other related articles have significantly increased over the past year due to expanding the distribution of newsletters, engaging the public in standard reviews, and further highlighting independent assessment findings. The OCHMO Standards Team will continue to highlight pertinent information and news on a rolling basis.

Medical and Technical Briefs

OCHMO Medical and Technical Briefs were developed to capture critical technical and medical data, background, and application notes to aid in the development of hardware, systems, and vehicles, as well as human needs/limitations. Technical briefs integrate content from multiple standards and serve as an integrated informative resource when working with Human Spaceflight Standards (NASA-STD-3001) and the Astronaut Selection Standard (OCHMO-STD-100.1). Eight medical and technical briefs were added to the OCHMO Standards' website in 2024:

- Design for Maintainability
- Exercise Overview
- Microbiology in Space Overview
- Crew Survivability
- Non-Ionizing Radiation
- Spaceflight Associated Neuro-Ocular Syndrome*
- Urinary Health*
- Waivered Health Conditions*

*The medical technical briefs include treatment algorithms for Spaceflight Associated Neuro-Ocular Syndrome and atrial fibrillation, amongst other conditions, which will enable commercial providers to successfully treat and care for crew in space.

NASA Medical Selection, Recertification, and Mission Medical Evaluation Standards (OCHMO-STD-100.1, Revision A)

OCHMO-STD-100.1 Standard provides both NASA programs and commercial entities with medical requirements for the selection of astronauts (NASA and commercial) and also specific medical evaluations for assignment to spaceflight missions of different durations. The latest revision provided updates for the selection process and also provided guidance for specific medical tests to be performed for different missions, including communicable disease screening, medical tests, performance testing, and occupational surveillance to ensure astronauts' mission health and performance, along with ensuring long-term health.

NASA astronaut Scott Kelly (left) assists Japan Aerospace Exploration Agency (JAXA) astronaut Kimiya Yui (right) with measurements for the ongoing Ocular Health study.

ACCOMPLISHMENTS

Independent Assessments

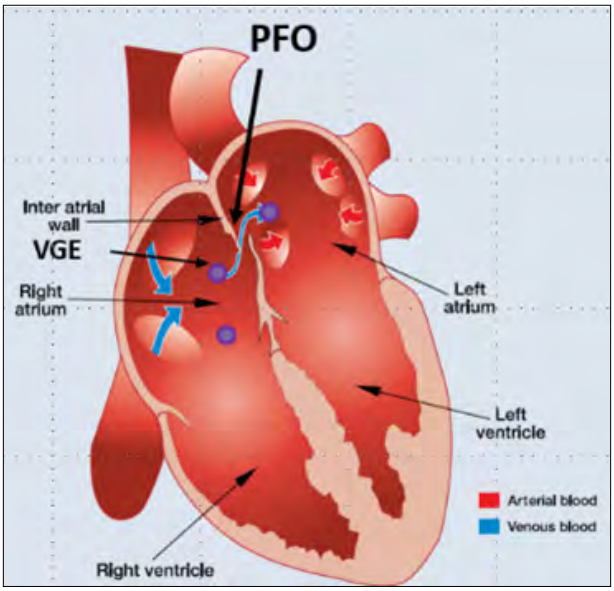
Throughout 2024, the Standards Team hosted and facilitated working groups, meetings, and panels to independently assess research and clinical activities. Attendees at these events included internal SMEs and more than 40 external expert reviewers from diverse disciplines and backgrounds, including academia, military and armed forces, physicians, commercial aerospace, and international organizations.

Patent Foramen Ovale and Decompression Sickness

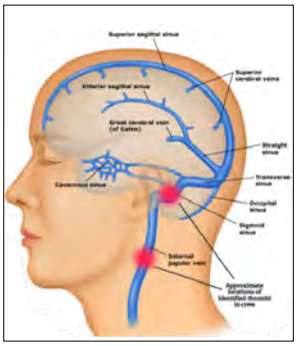
Participants: standing, left to right, are Dave Francisco, Joanne Kaouk, Dr. Richard Moon, Dr. Tony Alleman, Dr. Sean Hardy, Sarah Taoufik, Kristin Coffey, Dr. Ed Powers, Dr. Doug Ebersole, Dr. Steven Laurie, and Dr. Doug Ebert. Seated, left to right, are Dr. Alejandro Garbino, Dr. Robert Sanders, Dr. Kristi Ray, Dr. Mike Gernhardt, Dr. Joseph Dervay,and Dr. Matt Makowski. Not pictured: Dr. Caroline Fife.

OCHMO hosted this working group to review and provide analysis on the status and progress of research and clinical activities intended to mitigate decompression sickness (DCS) issues related to the patent foramen ovale (PFO) (a small opening between the two upper chambers of the heart, the right and the left atrium) during spaceflight, ground testing, and human subject studies. The working group took place over two days at Johnson Space Center, and a report was generated and posted to the Standards website.

https://www.nasa.gov/humans-in-space/assessment-of-pfo-as-related-to-dcs-in-the-spaceflight-environment-and-during-ground-testing/



ACCOMPLISHMENTS

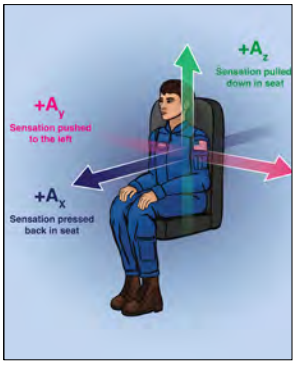


Venous Thromboembolism/Blot Clots in Spaceflight

OCHMO spearheaded this working group to review and provide analysis of the status and progress of research and clinical activities aimed to mitigate the risk of venous thromboembolism (VTE) during spaceflight. The group's efforts served as a precursor to the international partner meeting held in December 2024 at the ESA facility in Cologne, Germany. The VTE Summary Report resulting from this meeting will be posted on the Standards website in February 2025.

In-person participants: left to right, back row: Jason Lytle, Stuart Lee, Eric Bershad, Ashot Sargsyan, Aaron Everson, Philip Wells, Sergi Vaquer Araujo, Steven Grover, John A. Heit, Mehdi Shishehbor, and Laura Bostick; middle row: Sarah Taoufik, Stephan Moll, Brandon Macias, Kristin Coffey, Ann-Kathrin Vlacil, and Dave Francisco; front row: James Pavela, Doug Ebert, Kathleen McMonigal, Esther Kim, and Emma Hwang. Not pictured: Tyson Brunstetter and J. D. Polk.

Online participants: Stephen Alamo, Mark Crowther, Steven Nissen, Mark Rosenberg, Jeffrey Weitz, R. Eugene Zierler, Serena Aunon, Tina Bayuse, Laura Beachy, Becky Brocato, Daniel Buckland, Jackie Charvat, Diana Cruz Topete, Quinn Dufurrena, Robert Haddon, Joanne Kaouk, Kim Lowe, Steve Laurie, Karina Marshall-Goebel, Sara Mason, Shannan Moynihan, James Pattarini, Devan Petersen, Ruth Reitzel, Donna Roberts, Lucia Roccaro, Mike Stenger, Terry Taddeo, Gavin Travers, Mary Van Baalen, and Liz Warren.



Common XYZ Coordinate Frame for Translational Acceleration.

Acceleration and Dynamic Loads

Due to concerns that landing on the lunar surface will need further risk reduction to prevent minor injuries, the Standards Team facilitated an external group of experts to reassess existing technical requirements for landing loads. Initial evidence showed that injuries may occur during a lunar surface landing, and these injuries could impair a crew member's ability to perform EVA mission tasks. A test plan was developed and coordinated with the Human Research Program (HRP) for implementation. The results of these tests will directly enable HLS commercial providers' designs of occupant protection systems. In 2025, the team will host a panel discussion on the use of Human Body Models (HBMs) to assess a crew member's risks of injury during dynamic phases of flight for future missions. HBMs will enable virtual assessment of vehicle design, which will reduce testing costs while maintaining crew safety.

ACCOMPLISHMENTS

Suited Carbon Dioxide (CO_2) Test Methods

OCHMO collaborated with external experts to review data collected in an effort to produce testing methods that are repeatable, minimize variability, and are easily implemented for NASA's commercial providers developing future spacesuits. OCHMO supported ongoing plans for future testing to determine safe levels of inspired CO_2 in spacesuit helmets. Testing of Phases I and II of suited CO_2 washout was completed, and various stakeholders met on a regular basis to discuss the test results and create plans for Phase III. Future OCHMO work includes continued collaboration with stakeholders on the development of a new suited CO_2 contingency limit requirement. A technical bulletin was generated to update the test method.

NASA's SpaceX Crew-7 crew members with new spacesuits.

Communication Delay

The Standards team met with subject matter experts at Ames Research Center (ARC) to initiate preliminary testing of 5-second communication latencies that may occur during hardware maintenance tasks. The goal of the testing was to assess the communication delay that may be experienced during lunar operations. The testing was done at ARC, and results, which indicated that more time was needed to accomplish the tasks, were summarized in a report issued and disseminated to the HLS program. The results also discussed countermeasures to minimize communication errors with latencies. Additional follow-on studies were undertaken by HRP.

Significant Presentations

Standards team members Dave Francisco and Sarah Taoufik led a presentation and conducted a workshop at the 2024 International Association for the Advancement of Space Safety (IAASS) Conference in Prague, Czech Republic. The IAASS Conference focuses on furthering international cooperation and scientific advancement in the field of space systems safety.

Mrs. Taoufik presented "NASA's Agency-Level Space Flight Human System Standards" during the Human Performance educational session on updates and the importance of human spaceflight standards and supporting documentation for the facilitation of safe human spaceflight in current and future missions. Additionally, she and Mr. Francisco successfully cohosted a workshop titled "Autonomous Operations: Performance Monitoring and Critical Awareness Maintenance," which focused on important topics related to future spaceflight missions where communication with ground support will be limited. They presented "Earth Independent Operations/Autonomy: NASA's Agency-level Space Flight Human System Standards," which provided an overview of the relevant technical requirements from NASA-STD-3001 to ensure successful future autonomous spaceflight missions. As missions become more automated, it is important to ensure that the vehicles are designed to enable the crew to operate the vehicle without continuous ground control. Over 30 industry professionals attended both the educational session and workshop.

Standards team member Kim Lowe attended the 2024 Annual National Sanitation Foundation Committee Meeting hosted by the National Sanitation Foundation (NSF) and the Food and Drug Administration. She shared information on how NASA-STD-3001, "Human Spaceflight Standards," is influenced by industry standards, including those established by NSF for food equipment and other practices. More than 60 attendees heard and praised Ms. Lowe's presentation. Her collaborative efforts with NSF served as a key step to further OCHMO's participation in commercial spaceflight industry growth.

OFFICE OF RESEARCH ASSURANCE

The SpaceX Dragon spacecraft docked to the International Spaces Station.

"Daily, I am amazed by the team members of the Office of Research Assurance. Their hard work and dedication facilitates research in support of NASA's mission and ensures the protection of participants' rights and welfare through education and collaboration. I am grateful to have such a great team."

Marisa Covington
Director, OORA, and Chair, NASA Institutional Review Board

Priorities and Initiatives

- Contributes to research integrity through oversight of the protection of human subjects and animal research across NASA centers and on the International Space Station (ISS).
- Manages the structure and activities of the Bioethics Advisory Panel (BAP), Human Research Multilateral Review Board (HRMRB), Gateway Human Research International Board (GHRIB), and NASA Institutional Review Board (IRB), including the use of eIRB, an electronic processing system.
- Establishes human subject and animal research policies and guidelines to address regulatory needs and operational and ethical concerns, including the delivery of informational and educational materials to researchers; members of the IRB, HRMRB, GHRIB, Flight Institutional Animal Care and Use Committee (FIACUC), and Animal Policy Review Board (APRB); and other NASA stakeholders.
- Ensures agency compliance with federal and state laws and regulations, as well as institutional policies, and promotes ethical guidelines governing human and animal research protection.
- Focuses on subject matters such as the protection of human subjects; animal welfare research; and education about and compliance with research ethics and regulatory practices for staff, investigators, and research volunteers; also serves as research liaison to other NASA and external organizations that perform exploration or fundamental life sciences.

https://www.nasa.gov/ochmo/health-operations-and-oversight/hsa-standards/

ACCOMPLISHMENTS

Bioethics Advisory Panel

At the request of OORA, the BAP, which is composed of internal and external experts, provided recommendations on ethical issues surrounding mortality during human spaceflight and animal research.

The BAP recommended that, when warranted, surviving crew members should not have the option to gather biological samples or perform an autopsy despite any added trauma that may come from completing these tasks. They also indicated that all religions offer exceptions that will allow these procedures during spaceflight. OORA agreed with the Panel's recommendation and acknowledged that education and training on mortality issues during spaceflight should be conducted with JSC's Flight Operations Directorate.

OORA also asked the BAP to provide thoughts on whether it is reasonable to consider a crew member's comfort with research procedures, moral stance regarding use of animals in research, and proficiency when conducting animal research. The BAP advised that while it is acceptable to consider these things, the expectation of performing tasks that generate data and science still exists.

The next meeting is scheduled for January 2025.

Audit

A routine inspection conducted by the Food and Drug Administration, Center for Drug Evaluation and Research, and Office of Scientific Investigations occurred in November. The purpose of the audit was to ensure the IRB's compliance with FDA regulations governing human research subjects. The final Inspection Report has been issued; written findings indicated no objectionable conditions (a "no action indicated" classification).

NASA Gateway Board

OORA led efforts to charter a Gateway Program board with representation from International Partners (IPs) that are directly involved in Gateway activities, similar to the HRMRB, for human subject research within the Gateway Program. The first board meeting was held in the fall with the goal of developing and finalizing the charter.

Human Research Multilateral Review Board

The HRMRB ensures that research on the ISS involving human subjects is safe, ethical, and coordinated between NASA and its IPs.

In 2024, the HRMRB reviewed 154 submissions and developed six guidance documents to ensure consistency in review. In addition, OORA worked with ESA an in effort to streamline processes through the development of a consent template to be used across international agencies. Future collaborations with ESA regarding efficiencies are ongoing.

Human Subject Compliance and Quality Improvement Program

OORA implemented a Human Subject Compliance and Quality Improvement (CQI) program to facilitate verification of research and support compliance with relevant federal regulations, NASA policies, and IRB-approved protocols. Six post-approval verification (PAV) visits were completed. These initial visits yielded minimal findings and provided an opportunity for continued education, relationship building, and improved communication with the researchers.

Collaboration

OORA continues to regularly participate in the Common Rule Working Group monthly meetings. Additionally, the office provided revisions to update the Declaration of Helsinki and the National Privacy Research Strategy. Lastly, the Associate Director of OORA also served as a member of the Clinical Trials Registration and Results Reporting National Taskforce and The Consortium to Advance Effective Research Ethics Oversight to provide insight in compliance with regulations.

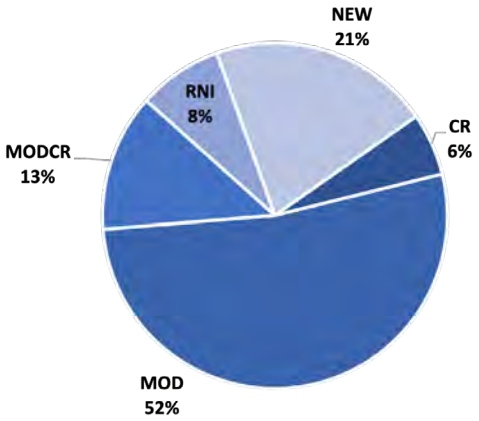
ACCOMPLISHMENTS

NASA Institutional Review Board

The NASA IRB facilitates research in support of the agency's mission by ensuring the protection of participants' rights and welfare.

During 2024, the NASA IRB held 12 board meetings and processed 636 submissions, including full-committee, exempt, expedited, not-human-subjects research, reportable events, modifications, and continuing-review submissions for mission-critical human research studies.

2024 Submissions by Application Type



The number of submissions increased by 17 percent (541 in 2023); this is likely due to an increase in commercial and Gateway human research efforts. The number of submissions is expected to continue to increase over 2025 for the same reasons.

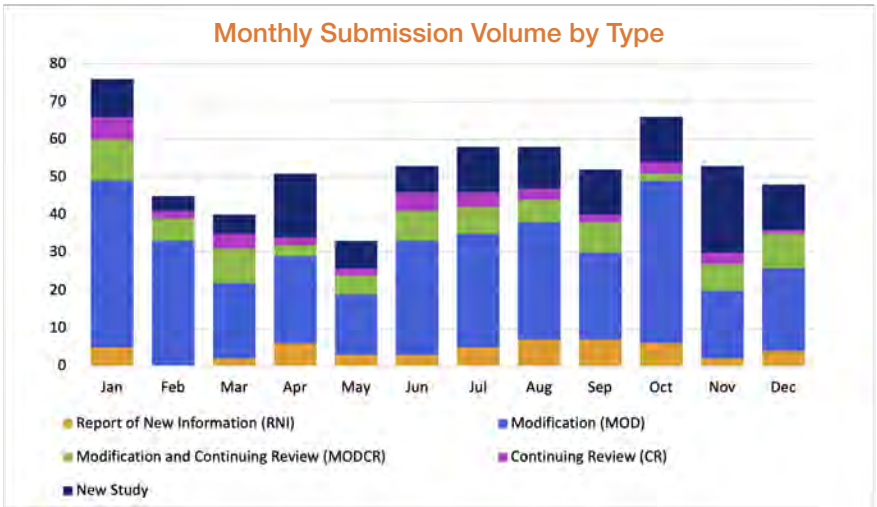
In November 2024, the NASA IRB received 23 new studies, which is the highest number of new study submissions to date. Previously, in April, the IRB recorded its second-highest-ever new study volume with 17 new submissions.

Additionally, eight new Standard Operating Procedures (SOPs) and three new guidance documents were implemented to continue to promote ethical and compliant research and foster collaboration with the research community. The SOPs addressed important health and compliance topics, such as return of research results and incidental findings, and outlined review processes to promote consistency and transparency. Guidance documents focused on relevant, rapidly growing research topics such as artificial intelligence.

In support of building relationships and encouraging dialogue with the research community, in April 2024, the IRB office implemented weekly virtual IRB office hours to provide the NASA research community with an opportunity to have walk-in conversations with IRB staff where they can receive quick answers to general research questions including IRB submission processes, navigating eIRB, status of submissions, and discussions of IRB review types.

The NASA IRB continued collaboration with Axiom providing oversight of human subject research conducted on the International Space Station. Axiom collaborations primarily included investigators from ESA, Poland, and Hungary. The NASA IRB also provided eight educational sessions to Axiom, targeting research implementation and guidance to navigate the NASA IRB processes.

Monthly Submission Volume by Type



OFFICE OF THE CHIEF VETERINARY OFFICER

NASA astronauts Jessica Meir and Drew Morgan work with the mice in the Life Sciences Glovebox onboard the ISS.

"It is a true honor to work side-by-side with the innovative and committed team members within the Office of Research Assurance who passionately dedicate themselves to facilitating the cutting-edge research that will help take humanity safely to the moon, Mars, and beyond…and back!!"

Dr. Chad D. Foster, DVM
Chief Veterinary Officer (CVO), OCVO

Priorities and Initiatives

- Serves as NASA's Subject Matter Expert on regulated animal activities; protects agency interests related to the care and use of animals in research; facilitates cutting-edge science; and ensures public confidence by guaranteeing that the highest standards of animal welfare are maintained in the design and execution of research.
- Establishes agency-level policy on use and care of animals; provides strategic direction for NASA animal care and use programs; advises the International Space Station (ISS) Program, NASA Flight Institutional Animal Care and Use Committee (FIACUC), Center IACUCs, and Research Sponsors (ISS National Laboratory (ISSNL), Biological and Physical Sciences (BPS) Division, Human Research Program (HRP), Innovative Advanced Concepts (NIAC) Program, etc.); and engages a wide range of stakeholders and collaborators through CVO Technical Interchange Meetings (TIMs).
- Partners with OORA to provide regulatory oversight of animal care programs and research funded or supported by NASA; confirms compliance with NASA policy and standards; investigates noncompliance with federal and state regulations; and addresses concerns regarding animal welfare.
- Develops agency standards and requirements for spaceflight hardware related to the care and use of animals; validates hardware verification testing before use in space missions; and develops agency standards for the care and use of animals in spaceflight. Provides education and consultation to internal and external stakeholders regarding NASA's animal programs and animal-related concerns or impacts.
- Provides education and consultation to internal and external stakeholders regarding NASA's animal care and use programs, and other animal-related activities.

https://www.nasa.gov/ochmo/health-operations-and-oversight/chief-veterinary-officer/

ACCOMPLISHMENTS

Mission Success Tiger Team

In 2024, the CVO continued to serve as Co-Chair of the Research Mission Success Tiger Team, whose efforts include identifying and addressing concerns related to planning, coordinating, and executing complex research operations on the ISS. The team evaluated all aspects of Low Earth Orbit (LEO) research operations; however, five major focus areas emerged and resulted in the creation of splinter teams: mission execution; crew training; IACUC protocol review and post-approval monitoring; research program development and implementation; and other complex payload operations.

While the Tiger Team work is ongoing, numerous processes and policies have been implemented and resulted in significant improvements in the execution of complex research operations on the ISS. These improvements include:

- Conducting baseline crew pre-briefs and de-briefs on orbit for complex research days.
- Expanding provision of animal care and use briefings by CVO to all stakeholder groups, including Flight Operations Division, Payload Operations Integration, and Crew Office.
- Creating a dedicated "Vet Coordination Loop" within Internet Voice Distribution System to use during on-orbit rodent research operations. The loop significantly improved post-approval monitoring capability for the Flight IACUC.
- Using paper simulations prior to execution of complex orbital research operations.
- Implementing joint animal care and use briefings to all assigned crew members prior to starting rodent skills training. These briefings performed provided by the CVO in conjunction with JSC attending veterinarian and the ISS (Flight) attending veterinarian provide the crew a thorough understanding of rodent research operations reducing the impacts on crew increment training timeline.
- Improving crew training curricula by implementing a process for transparent crew feedback following training and usage of a standardized scale to evaluate proficiency.
- Using a comment resolution matrix to document identification and disposition of animal use protocol review comments and revisions and to ensure accurate versions control of protocols throughout the review process.

Flight IACUC

The NASA Flight IACUC collaborated with the Kennedy Space Center IACUC to complete implementation of the newly streamlined Animal Use Protocol review process. The new process was used to successfully review, modify, and/or approve five research studies and ensure consistency in operational execution and regulatory compliance of flight and ground components of research. Also, the Flight IACUC launched a new system for conducting federally mandated, semi-annual facility inspections and program reviews to reduce risk of noncompliance with regulatory requirements.

Collaboration

Throughout the year, the Office of the Chief Veterinary Officer (OCVO) continuously worked with external stakeholders on animal research matters. For example, the CVO served as a subject matter expert for animal research roundtables, working groups, and councils; conducted educational webinars for IACUCS, research sponsors, and program personnel. OCVO teamwork efforts involved collaborating the Northwest Association for Biomedical Research Conference and National Parks Service and several universities to give lectures, attend conferences and meetings, and participate in annual research events. Most notably, the CVO was the first guest lecturer for the FDA's "Foundations of Preclinical Review Medical Countermeasures" lecture series.

ACCOMPLISHMENTS

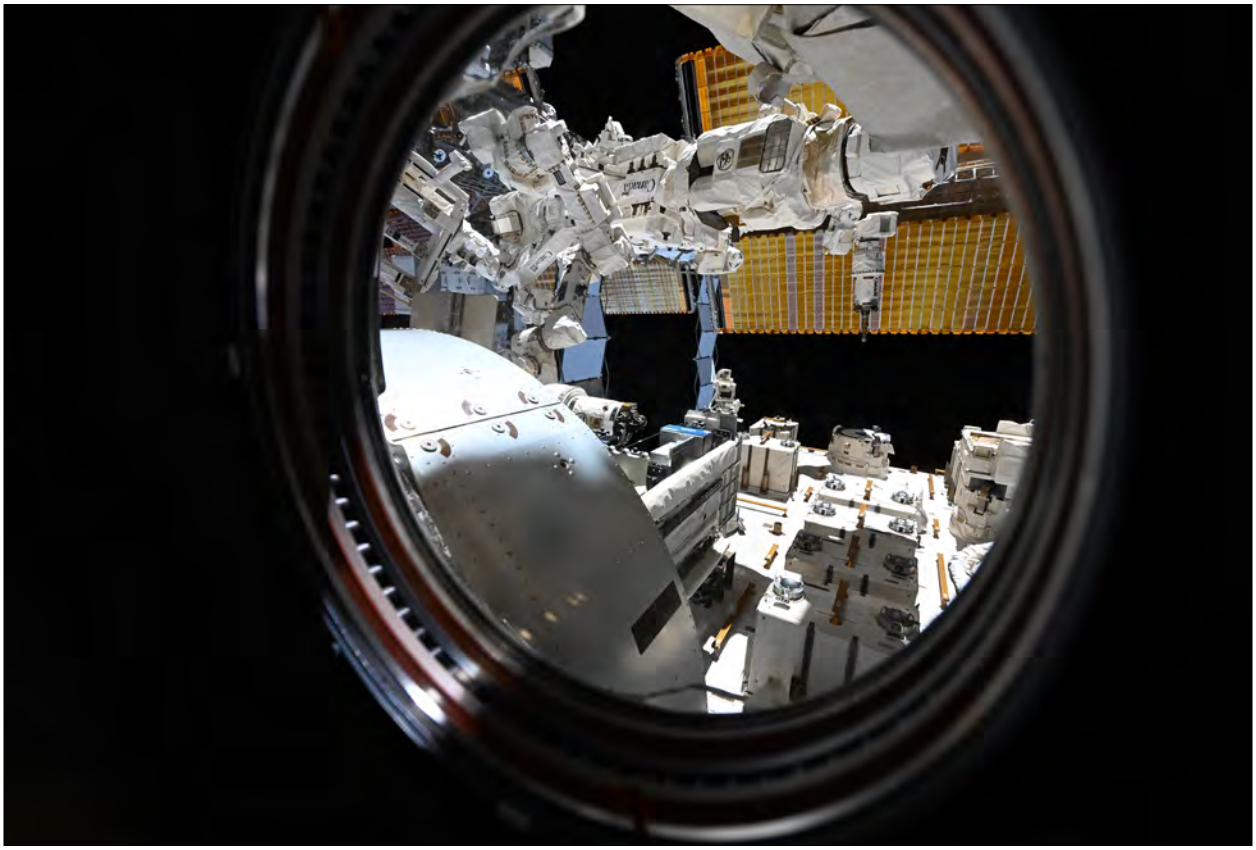
Support teams work around the SpaceX Dragon spacecraft after it lands off the coast of Florida.

CVO Technical Interchange Meetings

OCHMO dissolved the Animal Policy Review Board and the OCVO implemented CVO-led technical interchange meetings (TIMs) to ensure appropriate stakeholder involvement in and awareness of operational and strategic initiatives related to animal activities at NASA. The TIM provide greater flexibility in selecting appropriate individuals to address key tasks and/or issues and serve as the mechanism that allows the ISS Complex Research Operations Tiger Team to continue working beyond its charter. The CVO hosted two TIMs:

- A three-day TIM was held at Ames Research Center in March 2024. This meeting included a USDA Animal Welfare Information Center workshop on how to conduct quality literature searches and a presentation on the results from the MHU-8 research study co-sponsored by the BPA and JAXA.
- A two-day TIM featuring multiple topics was held at Kennedy Space Center in October 2024. The technical topics discussed included: policy updates, animal research implications of FAA's change to a Pacific Splashdown for SpaceX Cargo Dragon (Commercial Resupply Missions); archiving and releasing of animal videos from flight research; and potential role of animal research in the development of forensic medicine capability for use in spaceflight. In addition, the meeting included a webinar on the execution and results of the MHU-8 research project and overviews of ongoing NASA wildlife conservation and natural resource management programs and OCVO collaborations with the Natural Resource Council.

ACCOMPLISHMENTS



JAXA Japanese Experiment Module–Exposed Facility.

Direct Crew Support

The OCVO provided on-orbit support and training to ISS crew, NASA astronauts and JAXA members. Specifically, the CVO:

- Provided direct on-orbit support and consultation to three ISS crew members who sought guidance related to animal activities on ISS. The support given utilized the newly established Crew Branch, Flight Operations Directorate and Payload Operations Integration (POI) endorsed communication channels that allowed ISS crew members direct access to the CVO and Flight AV in real-time. Delivered live virtual on-orbit training to NASA astronauts Butch Wilmore and Sunita "Suni" Williams to ensure full regulatory compliance and execution of JAXA's MHU-9 animal research study.
- Worked with the NASA Crew Training Office to implement provisions of a joint animal care and use brief for all flight-assigned crew members prior to their rodent skills training. This effort, created in conjunction with JSC's attending veterinarian, provided participants with an in-depth understanding of rodent research operations.
- Traveled to Japan with Crew 9 astronauts to assist with the execution of MHU-9 on the ISS by providing direct training support to crewmembers, JAXA trainers, and JAXA console operators. This effort helped facilitate successful completion of the MHU-9 mission in November 2024.
- Advised on development MHU-10 by counseling on regulatory considerations, crew training and internal flight animal research operations.

ACCOMPLISHMENTS

Regulatory Compliance and Oversight

A major focus of the OCVO is improving and enhancing regulatory compliance and oversight of animal research, animal-use protocols and other animal related activities. Recent achievements included:

- Identifying significant Agency risks associated with insufficient oversight of extramural animal research performed by external partners and organizations and collaborating with the National Institute of Health (NIH) Office of Laboratory Animal Welfare (OLAW) to establish requirements for reviewing and approving animal research and activities to ensure compliance with federal regulations and NASA directives and policies.
- Teaming with NASA's HRP, BPS Division, and NIAC Program to develop standardized requirements and review processes to assure appropriate animal welfare and oversight of 40 plus animal research studies each year.
- Leading collaborative efforts between the ISS Research Integration Office, BPS, ISS National Laboratory (ISSNL), and NASA ISS (Flight) IACUC to develop an effective and efficient plan for returning live animals from the ISS following implementation of the Pacific Splashdown.
- Working with OCHMO's Policy Development and Integration Manager and key representatives to finalize and execute the JPL Care and Use of Animals Implementation Plan and to enable addition of NPD and NPR 8910.1, Care and Use of Animals, to the JPL prime contract.
- Continuing collaboration with NIH OLAW to revise and renew the Interagency Agreement that authorizes OLAW to negotiate PHS assurances with awardees who perform or teach animal research activities using NASA funds.
- Identified strategic risks associated with having the CVO serve as both NASA's Chief Veterinary Officer and Flight Attending Veterinarian (AV). As a result, the duties and responsibilities for the positions were separated. The new Flight AV position is aligned with the ISS Program to provide improved regulatory compliance and oversight.

Internship Program

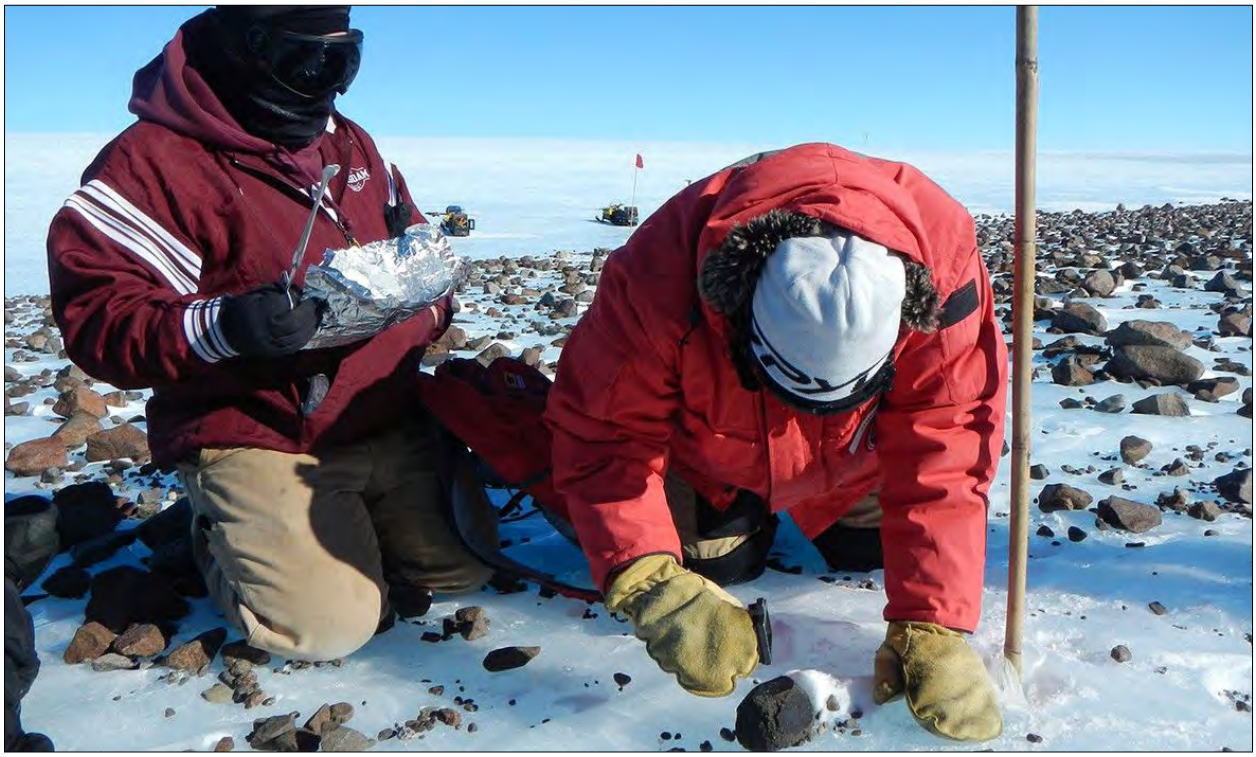
The OCVO expanded its internship program to students currently enrolled in veterinary school at the Royal College of Veterinary Medicine in London. The customized internship is designed to provide a broad working understanding of the unique structure and function of the complex NASA animal research programs and ISS research operations. Interns have opportunities to participate in meetings alongside OCVO leadership, support the ISS Research Integration Office, work with research sponsors in NASA's BPS Division and US National Labs, and spend time with veteran crew members who have conducted animal research on ISS. The goal of OCVO Internship Program is to continuously nurture students interested in space medicine and biomedical research and to prepare veterinarians for potential NASA employment.

Technical Authority

At the request of the ISS Program, the OCVO provided technical requirements for live animal return from the ISS. The new requirements assisted with the FAA-directed transition to a Pacific Ocean splashdown of SpaceX Cargo Dragon during NASA commercial resupply missions. The CVO also led strategic collaborations between the ISS Research Integration Office, BPS, ISSNL, and the Flight IACUC to develop effective and efficient plans for the return of live animals following the Pacific Splashdown.

Other OCVO accomplishments involved working with the ISS Payload Program Office (OZ) and POI to ensure that the Payload Operations Managers (POMs) consult with NASA's Flight AV in off-nominal situations that may affect animal care and welfare or research outcomes; providing SME operational and strategic guidance on two complicated undock delays and numerous hardware failures and challenges; maintaining the highest possible standards of animal care/welfare; and participating in Failure Investigation Team studies related to optimal habitat resting structure to propose modifications that prevent future failures.

ANALOGS AND EXTREME ENVIRONMENTS



ANSMET is a program funded by the National Science Foundation that looks for meteorites in the Transantarctic Mountains.

"It is inspiring to work with the scientists and managers who design studies for analogs, and the amazing people who work in those analogs. They all are empowering our efforts in exploration while making the world a better place today."

Marc Shepanek
Program Lead, Analogs and Extreme Environments

Priorities and Initiatives

- Focuses on the specific challenges identified for human space missions. The data gathered from Analogs and Extreme Environments (AEE) efforts supports mission critical research, technology development, and verification of countermeasures directly related to the health, safety, and success of human space missions.
- AEE requirements are detailed in the Human Spaceflight and Aviation Standards within the Health Operations and Oversight Division.
- AEE program administers support for analog missions at Antarctic Stations, Johnson Space Flight Center via the Human Exploration Research Analog (HERA) and Crew Health And Performance Exploration Analog (CHAPEA), and the Space Center Houston via the Mission Mars Project.

https://www.nasa.gov/ochmo-extreme-environment-analogs-assessment-program/

ACCOMPLISHMENTS

In 2024, the AEE program focused on research areas such as the impact of nutrition, confined space, communications delays and individual and group dynamics in isolated, extreme environments.

The Antarctic Space Analog Program, which focuses on examining group dynamics (both social and psychological) for long-duration space missions, provided NASA the opportunity to gather data in an uncontrolled, extreme environment that paralleled the isolation and confinement of space. NASA selected NSF to perform research at McMurdo, South Pole, and Palmer stations in behavior and performance, and immunology. These research activities helped to inform mission designs. In addition, NASA flight surgeons deployed to the ice to practice medicine in these challenging environments. Their experiences helped them provide input for NASA medical care systems, pharmacies, and other resources.

Internationally, the AEE program teamed up with the Australian Antarctic Division (AAD) and Translational Research Institute for Space Health (TRISH) to complete analyses such as the testing of wearable biosensors, such as the Biosticker, to monitor temperature, heart rate, and respiration rate. These efforts highlighted the continuous partnership between AAD and TRISH to better understand human resilience and behavior in extreme environments.

The limitations of space often made the work of AEE the first input, and in some cases, the only data source available before NASA teams engaged in exploration missions. Outstanding partnerships with international partners, academia, private industry, and within NASA and other federal agencies, yielded impactful benefits for space operations. Whether supporting exploration in Antarctica or rescue missions in remote locations after the occurrence of a natural disaster, the science, technology, and training developed through AEE activities will always have an immediate impact and can be applied on Earth today.

Expandable habitat at McMurdo Station in Antarctica.

OTHER OCHMO ACHIEVEMENTS

“MISSION: All Systems GO!” Initiative

NASA astronaut Dr, Kjell Lindgren poses with a patient at the Fred Hutch Cancer Center roll-out event for NASA’s “MISSION: All Systems GO!” suite of digital products.

OCHMO collaborated with NASA's Space Communications and Navigation (SCaN) Program and the Fred Hutchinson Cancer Research Center in Seattle, Washington to launch and market a new multimedia program titled "MISSION: All Systems GO!" The program was developed to ease anxieties of pediatric patients facing and undergoing prolonged cancer treatments and therapies. It contains a suite of multimedia products customized with space-themed imagery likening pediatric patients' medical challenges with those of a NASA astronaut mission. Kjell Lindgren, a NASA astronaut, served as the inaugural "face" of the initiative.

Mark Weyland, Director of Health Operations and Oversight led OCHMO's participation in the program. Specifically, Mr. Weyland met with key stakeholders to ensure that resources from NASA's Cancer Moonshot initiative were incorporated into this incredible initiative. The new partnership between NASA's SCaN and Cancer Moonshot leadership further supported OCHMO's desire to continuously support the health and wellness of humanity and discovery of new medical innovations.

The "MISSION: All Systems GO!" program had a huge and positive impact on patients, their families, and caregivers. It provided patients a unique sense of comfort while they navigated their cancer treatment journey. After completing treatment, patients received a debrief from Lindgren where he expressed congratulations, offered reminders on treatment follow-ups, and presented a certificate of completion signed by him and Dr. J.D. Polk, OCHMO's Chief Health and Medical Officer.

The team of Fred Hutch Cancer Center and NASA employees involved in creating the program pose with leadership. Left to right: Ian Rice (project team), Dr. Stephanie Schaub, Robert Sweeney (NASA project team), Randall McClure (seated), Kevin Coggins, Dr. Corrie Anderson, April Clements (project team), Erin Behen (project team), Amy Walgamott (project team), NASA Astronaut Dr. Kjell Lindgren, Al Feinberg (NASA project team), Mark Weyland (seated, OCHMO Director of Health Operations and Oversight), Dr. Ralph Ermoian and Paul Massart (project team).

OCHMO Partnership with the Aerospace Medicine Residency at University of Texas Medical Branch

2024 was a year of outstanding growth and accomplishment for the Aerospace Medicine Residency Program at the University of Texas Medical Branch (UTMB). This year, UTMB completed 31 years of training for flight surgeons, most of whom work directly for and/or support NASA's space program. The 2024 class of five residents was also the largest class to date.

The Master of Science degree in the Aerospace Medicine program was initiated in early 2024 and has received substantial recognition for its practical innovations. Throughout the year, the program added new curriculum such as a dedicated systems and biomedical curriculum designed in partnership with Virgin Galactic (a leading commercial space company), a risk management curriculum taught by outstanding NASA program directors including Drs. Jeff Davis, Mary Van Baalen and Robert Mulcahy, and aerospace forensics curriculum lead by NASA's Chief Health and Medical Officer, Dr. James "J.D." Polk.

In addition to new teachings, several trainings and series were made available to residents as well. These offerings included a monthly half-day didactic series in Aerospace Medicine, an inclusive training on NASA's HMTA (administered by OCHMO staff), a Resident in Aerospace Medicine (RAM) and Star Harbor series, and on-line seminars on Aeromedicine.

Staff and students of the UTMB residency won a myriad of accolades and awards. Dr. Samantha King, OCHMO's UTMB Resident Intern, received the highest individual score in the RAM bowl at the Aerospace Medical Association (AsMA)'s annual conference. Other award recipients were Dr. Aunon-Chancellor (Louis H Bauer Founder's Award, the highest honor bestowed by AsMA), Dr. Rebecca Blue (President's Achievement Award, Space Medicine Association), Dr. Criag Kutz (Outstanding Study Award, Society of the NASA Flight Surgeons), Dr. Chough Klinker (award contributions for Aeromedical Evacuation), and Dr. Kutz (award for Wilderness Medical Expedition to the Mt. Everest Base Camp).

utmb Health®

Laura Lewis in Memoriam

Laura Lewis, Science Directorate Project Manager

Laura Lewis passed away on September 24, 2024, after a three-year fight against cancer. Laura spent her entire 34-year career at NASA. She was a member of the Science Directorate at Ames. Laura launched her career at Kennedy Space Center and later moved to Headquarters to work in the Space Life Sciences Office. She joined the Ames community in 1995.

Laura is survived by her husband and fellow Ames colleague, Bruce Yost, three children, and their three German Shepards.

A passionate animal lover, Laura found ways throughout her life to care for and advocate for animals. She had served several years leading the Ames Institutional Animal Care and Use Committee and spent the last three years on detail to OCHMO working with our Chief Veterinary Officer on strategic animal welfare initiatives and serving on [and then leading] the Flight Institutional Animal Care and Use Committee (IACUC) as well.

Laura was an invaluable advocate for animals and research, a committed civil servant, an unparalleled source of institutional knowledge, and an invaluable member of the NASA community. She will be missed dearly. We extend our condolences to her family, friends, and colleagues.

MESSAGE FROM THE DEPUTY CHIEF HEALTH AND MEDICAL OFFICER

Calendar year 2024 was an extremely productive year for the small OCHMO team, as exemplified by the exceptional summaries in this report. All our functional areas continued to remain value added by striving to not only work with all our stakeholders, but to help them optimize their functional areas. This year, the number and types of design and developmental programs and projects grew to more than 30. To cover this wide waterfront of technical challenges, our small team employed outstanding situational awareness to ensure we were always present in the important discussions.

On the occupational health front, the teams continued to ensure every employee had a safe and healthful workplace while helping to optimize performance. Going beyond occupational health, we leaned hard on getting numerous health promotion tools out, notably providing a wide range of presentations and tools for employees and supervisors on how to navigate change and remain productive.

Although our team is small in number, the value we bring to NASA is immense. Humans are involved in every program and project, and ensuring we optimize human performance while maintaining or improving our employees' well-being is our top goal.

Working with this dedicated group of exceptional professionals is a true honor.

Sincerely,
Vincent J. Michaud, MD, MPH, FAsMA

BY THE NUMBERS

Provided oversight of

19,655

MEDICAL CERTIFICATIONS

274 OCCUPATIONAL HEALTH AND SAFETY PROFESSIONALS

Attended annual Occupational Health Operational Update meeting

20% INCREASE FROM 2023

600+

EMPLOYEES

Participated in Inaugural Desk Fit Fitness Program

Hosted 11th Annual NASA Moves!

1,032,223,469

MILLION STEPS

5,470

EMPLOYEES

OCVO teamed up with NASA's HRP, BPS Division, and NIAC Program to oversee

40+ ANIMAL RESEARCH STUDIES

62,000

RECORDS

Processed Weekly in the EHRS Database

EHRS

Supported

9

SPACEFLIGHT PROGRAMS

with **32**

SWIMLANES OF CONTENT

Supported by HMTA

Standards Developed and Added

8

NEW TECHNICAL BRIEFS

to OCHMO Standards' website

30,000+

EMPLOYEES AND THEIR FAMILIES

received EAP services

+ 11.5 MILLION IN SAVINGS for NASA Centers

due to effective & efficient EAP services

Agency-Wide Policy Work

4

POLICIES WERE UPDATED AND PUBLISHED

2

NEWLY ESTABLISHED POLICIES WERE CREATED

10

POLICY CHANGES IN THE WORKS

Added

16

TECHNICAL REQUIREMENTS

to NASA Medical Selection, Recertification, and Mission Medical Evaluation Standards (OCHMO-STD-100.1, Revision A)

Stop the Bleed Team assembled

15,000

EQUIIPMENT PACKS

and Deployed

960+

BLEEDING CONTROL KITS

Worked with

30+

EXTERNAL EXPERT REVIEWERS

to conduct independent assessment working groups, meetings, and panels

Supported

7 ANALOGS

Antarctic, Arctic, Haughton Mars, Desert RATS, HERA, CHAPEA, Analogs

BY THE NUMBERS

HRMRB reviewed
154 SUBMISSIONS
and developed
6 NEW GUIDANCE DOCUMENTS

to ensure consistency in research study reviews

NASA IRB implemented

8 NEW RESEARCH SOPs and **3** NEW GUIDANCE DOCUMENTS

to improve quality of submissions to and reviews conducted by NASA IRB

OCVO welcomed
1ST INTERNATIONAL STUDENT

from the Royal College of Veterinary Medicine in London to participate in CVO internship program focused on NASA animal research programs and ISS research operations

Supported development and execution of
MORE THAN **24** RESEARCH PROTOCOLS

in behavior and performance, group dynamics, individual adaptation to isolation and confinement, viral reactivation, and nutrition in extreme environments

NASA IRB processed
636
SUBMISSIONS

= 17%
INCREASE
from 2023

CVO provided oversight and support for at least
12 ANIMAL USE PROTOCOLS at **4** AGENCY CENTER IACUCs

all of which are AAALAC accredited and PHS assured

ABBREVIATIONS

A

AAD: Australian Antarctic Division

ACLAM: American College of Laboratory Animal Medicine

ACOEM: American College of Occupational and Environmental Medicine

ACOEP: American College of Osteopathic Emergency Physicians

ACR: Architecture Concept Review

ACS: American Cancer Society

ADL: Airborne Doppler Lidar

AEE: Analogs and Extreme Environments

AFME: Armed Forces Medical Examiner

AFMS: Air Force Medical Service

AFSRB: Airworthiness and Flight Safety Review Board

AHA: Agency Honor Awards

AMB: Aerospace Medicine Board

AMMOB: Artemis Multilateral Medical Operations Board

AMMPB: Artemis Multilateral Medical Policy Board

APRB: Animal Policy Review Board

ARC: Ames Research Center

ARCSIX: Arctic Radiation-Cloud-Aerosol Surface Interaction Experiment

ASA: Australian Space Agency

AV: Attending Veterinarian

B

BAP: Bioethics Advisory Panel

BPS: Biological and Physical Sciences

C

CASI: Climate Adaptation Science Investigators

CCP: Commercial Crew Program

CFT: Crewed Flight Test

CHAPEA: Crew Health and Performance Exploration Analog

CIH: Certified Industrial Hygienist

CIP: Certified IRB Professionals

CLDP: Commercial LEO Development Program

CLICK: CubeSat Laser Infrared Crosslink

CM: Continuing Maintenance

CNES: Centre National d'Études Spatiales / French Space Agency

CO_2: Suited Carbon Dioxide

COPUS: Committee on the Peaceful Uses of Space

CQI: Human Subject Compliance and Quality Improvement program

CSA: Canadian Space Agency

CVO: Chief Veterinary Officer

CY: Calendar Year

D

DAF: Department of the U.S. Air Force

DCS: Decompression Sickness

DoD: U.S. Department of Defense

DOL: U.S. Department of Labor

E

EAP: Employee Assistance Program

ECLSS: Environmental Control and Life Support System

EGS: Exploration Ground System

EHP: Habitat Mobility Program

EHRS: Electronic Health Records System

EH: Environmental Health

EMD: Environmental Management Division

EPA: Environmental Protection Agency

ESA: European Space Agency

ESDMD: Exploration Systems Development Mission Directorate

ABBREVIATIONS

EVA: Extravehicular Activity

F

FAA: Federal Aviation Administration

FDA: Food and Drug Administration

FECA: Federal Workers' Compensation Act

FIACUC: Flight Institutional Animal Care and Use Committee

FRR: Flight Readiness Review

FTSMB: Federal Trilateral Space Medicine Board

G

GHRIB: Gateway Human Research International Board

GOES: Geostationary Operational Environmental Satellite

GP: Gateway Program

H

HALAS-GH: High Altitude Lidar for Atmospheric Sensing-Global Hawk

HBM: Human Body Models

HERA: Human Exploration Research Analog

HHS: Department of Health and Human Services

HLS: Human Landing System

HMTA: Health and Medical Technical Authority

HRMRB: Human Research Multilateral Review Board

HRP: Human Research Program

HQ: Headquarters

I

IACUC: Institutional Animal Care and Use Committees

IAASS: International Association for the Advancement of Space Safety

ICAM: Identity, Credential, and Access Management

IEEE: The Institute of Electrical and Electronics Engineers

IP: International Partners

IRB: Institutional Review Board

ISRO: Indian Space Research Organization

ISS: International Space Station

ISSNL: ISS National Laboratory

IT: Information Technology

J

JAXA: Japan Aerospace Exploration Agency

JSC: Johnson Space Center

L

LiDAR: Light Detecting and Ranging

LSRB: Laser Safety Review Board

M

MARLi: Multi-function Airborne Raman Lidar

MEDB: Mission Medical Evaluations

MIT: Massachusetts Institute of Technology

MOU: Memorandum of Understanding

N

NIAC: NASA Innovative Advanced Concepts Program

NASA: National Aeronautics and Space Administration

NID: NASA Interim Directive

NIH: National Institute Health

NIOSH: National Institute for Occupational Safety and Health

NOAA: National Oceanic and Atmospheric Administration

NODIS: NASA Online Directives Information System

NPD: NASA Policy Directive

NPR: National Public Radio

NPR: NASA Procedural Requirement

NRC: Nuclear Regulatory Commission

NSF: National Sanitation Foundation

NSF: National Science Foundation

ABBREVIATIONS

NTSB: National Transportation Safety Board

O

OCHMO: Office of Chief Health and Medical Officer

OCIO: Office of the Chief Information Officer

OCVO: Office of Chief Veterinary Officer

OH: Occupational Health

OHP: Occupational Health Program

OLAW: Office of Laboratory Animal Welfare

OM: Occupational Medicine

OORA: Office of Research Assurance

OSHA: Occupational Safety and Health Administration

OSI: Office of Strategic Infrastructure

OSMA: Office of Safety and Mission Assurance

OZ: ISS Payload Program Office

P

PAV: Post-approval Verification

PFO: Patent Foramen Ovale

POI: Payload Operations Integration

POM: Payload Operations Manager

R

RAM: Resident in Aerospace Medicine

RFI: Request for Information

RHO: Radiation Health Officer

RISCS: Risk Information Security Compliance System

ROI: Return on Investment

RSA: Russian Space Agency

S

SCaN: NASA Space Communications and Navigation Program

SGSLRS: Space Geodesy Satellite Laser Ranging System

SME: Subject Matter Expert

SOFCOM: Special Operations Forces Command

SOH: Safety and Occupational Health

SOMD: Space Operations Mission Directorate

SMD: Space Mission Directorate

SOP: Standard Operating Procedures

SORN: System of Records Notice

SPECIES: Smart Polyimide Expandable Collector to enable Investigations for Earth Science

STBT: Stop the Bleed Team

T

TCIG: Technology Coordination and Integration Group

TEN (10) ORIS: NASA's Occupational Radiation Information System

TIM: Technical Interchange Meeting

TRISH: Translational Research Institute for Space Health

TSCA: Toxic Substance Control Act

TWH: Total Worker Health®

U

UAE: United Arab Emirates

UN: United Nations

UNOOSA: United Nations Office for Outer Space Affairs

USDA: United States Department of Agriculture

USAF: United States Air Force

USPTO: United States Patent and Trademark Office

UTMB: University of Texas Medical Branch

V

VAMP: Vulnerability and Asset Management Program

VTE: Venous Thromboembolism

W

WHO: World Health Organization

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