Human Spaceflight Challenges: Human Performance and Countermeasures

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Human spaceflight is a very challenging endeavor and extremely demanding for astronauts. Decrements in human performance in such a difficult environment are operationally relevant and can lead to mission failure. My research interests focus on understanding and quantifying human performance in aerospace environments, and developing countermeasures and technologies to improve astronaut performance, health, and safety. In this presentation, I will discuss my latest research advancements in two areas: the use of artificial gravity in space and human-spacesuit interaction.

In the first part of the talk, I will discuss human performance in altered-gravity environments. Astronauts and pilots experience multiple gravitational environments or G-levels (e.g. microgravity, hypo-gravity on the moon or Mars, or hyper-gravity during an aircraft coordinated turn), and it is critical to understand how these altered-gravity environments affect their ability to perform their tasks safely and successfully. In particular, extended microgravity exposure results in physiological deconditioning including, but not limited to, musculoskeletal, cardiovascular, sensorimotor, cerebrovascular, and ocular changes. Artificial gravity has often been proposed as an integrated multi-system countermeasure to mitigate many of these negative effects. However, many design considerations still remain unanswered, including centrifuge configuration, optimal gravity level, and use/intensity of exercise among others. In this presentation, I will specifically discuss my research efforts to investigate the short-term physiological effects of ergometer exercise combined with short-radius centrifugation. Methods include the use of both human experiments and computational modeling approaches.

In the second part of the talk, I will discuss human performance within a spacesuit. Extravehicular activity (EVA) is one of the most challenging activities that astronauts need to perform in space, and maintaining health and comfort inside the spacesuit is critical. The current gas-pressurized US spacesuit provides limited mobility and has led to minor (and some major) musculoskeletal injuries and discomfort that could affect astronauts’ performance in a space mission. I will describe a new musculoskeletal modeling framework to analyze human-spacesuit interaction and musculoskeletal performance during EVA, and I will discuss initial results from “suited” and “unsuited” conditions. This analysis provides new insight into human performance in “suited” conditions, and contributes to the assessment of astronaut health and safety, informing flight surgeons, EVA operation teams, researchers, and spacesuit designers.

Dr. Ana Diaz Artiles is a lecturer and research associate at the Sibley School for Mechanical & Aerospace Engineering at Cornell University. Her interests focus on the biomedical and human factors aspects of space exploration, including artificial gravity, extravehicular activity, biomechanics, exercise physiology, cardiovascular modeling, sensorimotor adaptation, human health countermeasures, and space mission design. At Cornell, she has created and leads the senior/graduate course: “Bioastronautics and Human Performance”, and she directs the “Bioastronautics and Human Performance” research lab.

She received her Ph.D from the Massachusetts Institute of Technology in 2015, where she studied artificial gravity combined with exercise as a countermeasure for spaceflight-related physiological deconditioning. Prior to MIT, Ana worked for five years in Kourou (French Guiana) as a member of the Ariane 5 launch team. Dr. Diaz Artiles has a background in aeronautical engineering from Universidad Politécnica de Madrid (Spain), and SUPAERO in Toulouse (France). She is a 2011 Fulbright fellow and a 2014 Amelia Earhart Fellowship recipient.