# Microgravity Random Access Systems in NASA and Aerospace Station

Zheng (Jeremy) Li, Ph.D., Professor
Department of Mechanical Engineering, School of Engineering
University of Bridgeport, Bridgeport, CT

## Abstract

This research is to design a preliminary microgravity random access system for deep space habitat unit via 3-D modeling and computational structure analysis. This designed system can be easily accessed with corridors in small space inside space station. The built prototype can be tested to prove its flexible and proper function. It can be applied to horizontal and vertical habitat while making product lighter in weight, safer in use, cost-effective in manufacturing, and reliable in performance. This system can also be applied to some aerospace stations that require fluids, power, gases, and data. The workstations in this system can be folded away when not being used to save space in aerospace station. The expected outcome from this research is to understand the ergonomics, zero-gravity function, and efficiency of stowage racks and moving equipment. The later research will focus on improving this system via computer-aided design and analysis to verify the anti-corrosion processes and mechanisms through the investigation of nanomaterial theories, technologies, and techniques.

## Introduction

Microgravity random access system starts to be studied in recent years to support the function in aerospace station [1]. It studies neutral buoyance, understand zero-gravity ergonomics, and validate simulated mission duration usage. Computer-aided modeling and engineering design has been brought to the forefront of the scientific and technological renovation for some fields, including NASA and US aerospace frontier exploration [2]. The research of microgravity random access system seeks to conduct fundamental research with mathematical modeling, computational simulation and technical renovation in order to understand the current issues and determine future scientific and technological endeavor [3]. The engineering design methodology and prototype proposed in this research filed can be served as the fundamental element for developing of renovated science, technology and engineering research that integrates electrical engineering, mechanical engineering, material science, and manufacturing technology [4,]. The current researches address the novel engineering design and analysis techniques to understand, characterize, and identify the critical factors to facilitate microgravity random access system for analysis in a microgravity environment.

## 3-D modeling and Analysis

This research proposes the fundamental research with 3-D design modeling, computational simulation and technical renovation to understand current problems and determine future scientific and technological space endeavors. The design modeling and analytic methodology proposed in this project can be served to develop new scientific, technological and engineering research that integrates material science, mechanical engineering, and manufacturing technology. Computational simulations can also verify and determine the strength of structural system.

The following Figs. 1 and 2 show the preliminary prototype of this system and its moving mechanism. This renovated system design will build an accessible corridor with flexibility to be applied to horizontal or vertical habitats. It will also be used for workstations requiring power, data, gases, and fluids. This system can be controlled to move towards the left and right by motorized sliders to automatically adjust flexible storage spaces for different operations. In addition, to save room in limited space of aerospace station, the workstations can be folded away by moving to the back of storage/rack system when not being used.

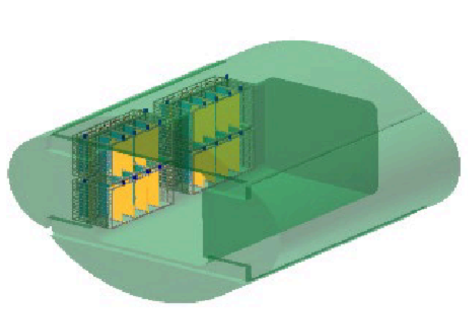

Fig. 1 Design of full system

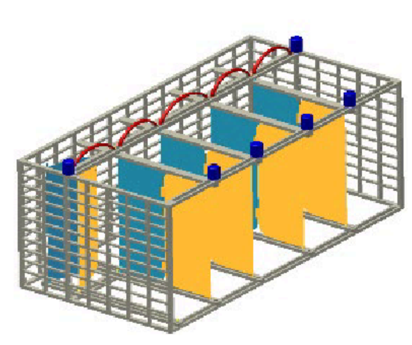

Fig. 2 Prototype of mechanism

To study this system, the functionality can be simulated and identified based on following math equations to improve the operation of mechanism in microgravity random access system [3, 4]:

1. Nernst-Planck equation: $D_i\left[\nabla^2 C_i + \frac{z_i F}{RT}\nabla(C_i \nabla \emptyset)\right] + R_i = \frac{\partial C_i}{\partial t} = 0\}$

2. Electroneutrality [∑(ZiCi)= 0]

3. Hall Petch Relationship: $\sigma_y = \sigma_o + \frac{K_y}{\sqrt{d}}$

Figs. 3 and 4 show the computational simulations on structure and deflection of this system.

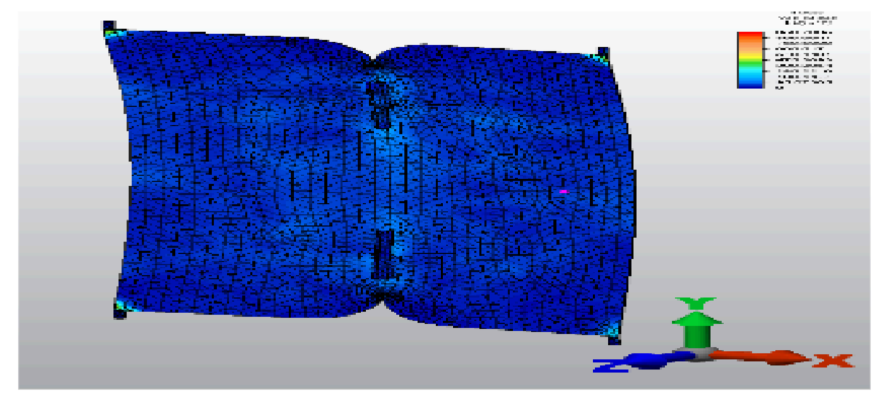

Fig. 3 Computational structure analysis on system

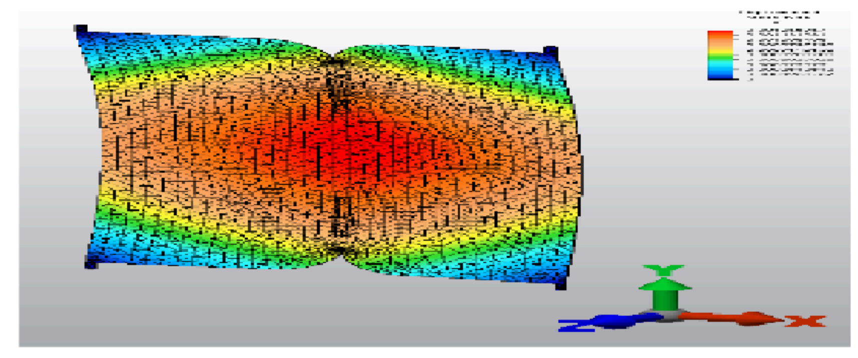

Fig. 4 Computational simulation of deflection on system

The above computational simulation and analysis validate the normal material coating process, reliable mechanical structure and good function in this preliminary microgravity random access system.

## Mechanisms for Integration

The above study and analysis will lead important theoretical findings based on current research, in which the evidence has been collected and verified to determine the dimensional geometry of this system and conditions that stabilize and enhance the structure of this system. It helps to establish the future theoretical foundation of comprehensive and fundamental restructuring of this system and aims to identify nanoscale material structure stabilization, atomic growth, improved strength and intensified strain effect, which are not well explored from a scientific and engineering perspective. There is still little understanding of all the above fundamental theories that directly influence the mechanical, electrical and thermal properties of this random-access stowage/rack system. The continuous research will use an interdisciplinary approach, integrating product design, nanotechnology, material science, mechanical engineering, manufacturing technology, and chemistry, to apply computational modeling and simulation software of COMSOL, failure mode error analysis (FMEA) and Finite Element Analysis (FEA) techniques to the NASA and aerospace products. The computer aided engineering (CAE) model is applied to design and model this system, the COMSOL model is used to analyze the nanomaterial and anti-corrosion coating performance, the FMEA model is utilized to identify the impact of process variables on nanomaterial and coating processes, and the FEA model is applied to verify the structural and functional properties of this system. These approaches can help to design this stowage/rack system, predict future performance of nanocoating operations, and verify the operation's risk or vulnerability in nanomaterial and coating processes through the FMEA analysis model.

## Conclusion

The preliminary microgravity random access system has been studied and simulated in this research. The objective of this research is to design, develop and build the 3-D model and prototype of this system for future NASA and aerospace explorer applications. The prototype of this system has been tested and the experiments show its flexible storage access and reliable function. It will help astronauts, researchers and engineers working in no-gravity space environment to perform scientific research and engineering projects. This newly proposed system can also be applied for international space workstations that require power, gases, fluid and information data. The workstations in this system is flexible to be folded away when not being used in order to give more free space in space station. This simple system design can also ease the manufacturing and maintenance processes. The expected outcome from this research is to understand the ergonomics, zero-gravity function, and efficiency of this system. The computational simulation and analysis of this system shows its reliable mechanical/structural design and normal function.

## Reference

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