

This Directed Acyclic Graph and write-up is an excerpt from a larger NASA document.

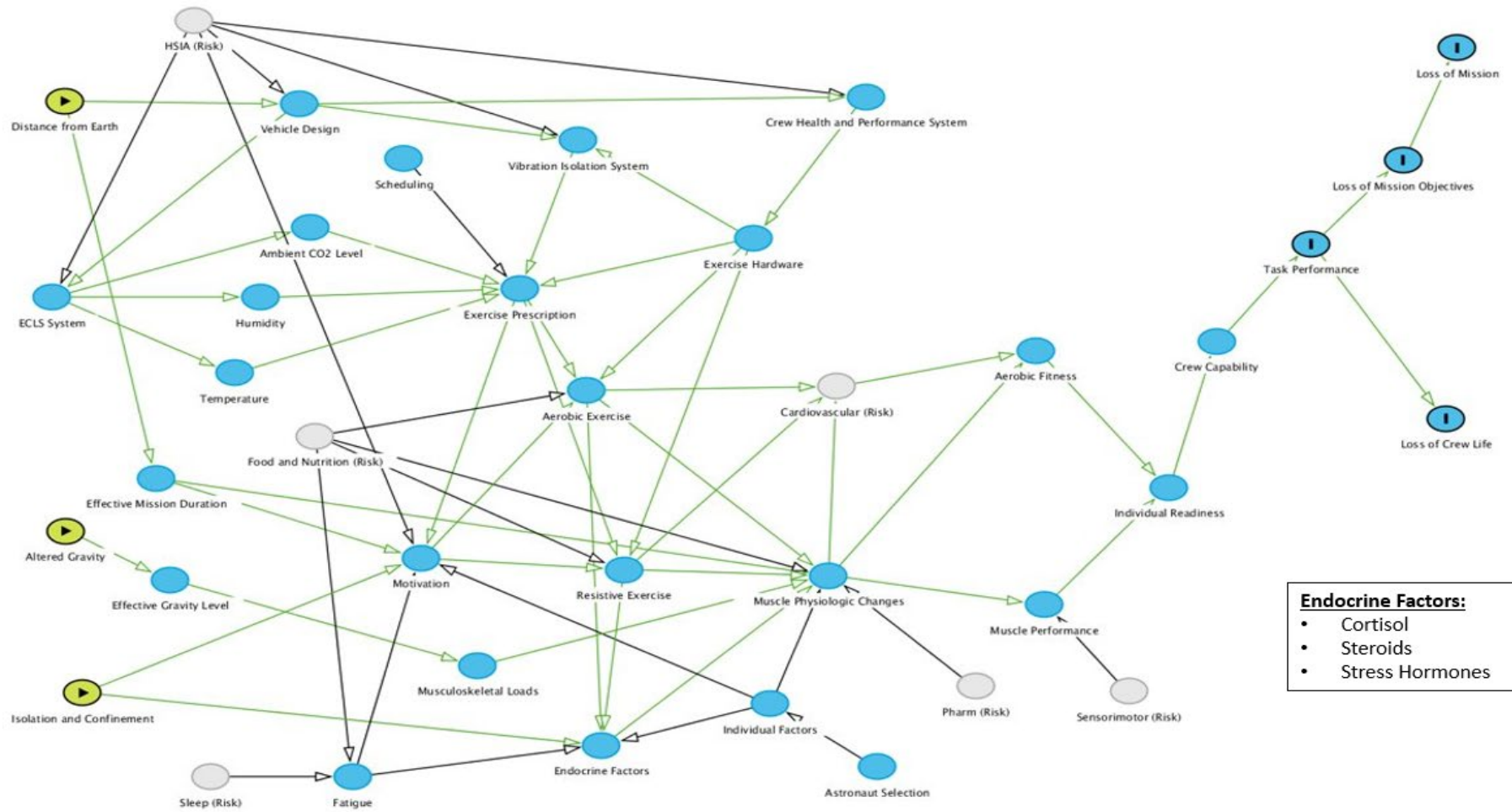
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**Directed Acyclic Graphs: A Tool for Understanding the NASA
Spaceflight Human System Risks**

Human System Risk Board

October 2022

Risk of Impaired Performance Due to Reduced Muscle Size, Strength, and Endurance (Muscle Risk) and Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity (Aerobic Risk)



Muscle and Aerobic Risks DAG Narrative

- **Altered Gravity** across all DRMs includes microgravity, lunar gravity, Mars gravity and Earth Gravity. This affects **Effective Gravity Level** experienced by crew and through that **Musculoskeletal Loads**.
- **Isolation and Confinement**, especially over long **Effective Mission Durations** can induce monotony and anhedonia affecting the **Motivation** to perform needed exercise.
- **Distance from Earth** determines the mass and volume allocations for **Vehicle Design** and **Suit Design** and affects the **Effective Mission Duration**.
- The central focus of the Muscle and Aerobic Risk DAG is on **Aerobic Fitness** and **Muscle Performance** levels being adequate for crew to do the tasks that are expected of them (**Task Performance**). These directly influence **Individual Readiness** and crew readiness or fitness for duty (**Crew Capability**).
- When these nodes are negatively affected, the performance of EVAs - **EVA (Risk)** - and the performance of post-landing tasks – **Crew Egress (Risk)** may be threatened.
- **Aerobic Fitness** and **Muscle Performance** are directly affected by the **Muscle Physiologic Changes** that occur at the level of cardiac, smooth, and skeletal muscle throughout the body as a result of the duration of exposure to the spaceflight environment. **Aerobic Fitness** is also directly dependent on the functionality of the Cardiovascular system (**Cardiovascular Risk**).
- These **Physiologic Changes** are the result of several contributing factors:
 - **Musculoskeletal Unloading** that occurs as a result of the **Altered Gravity** Environment.
 - Endocrine Factors that are related to the Isolation and Confinement experienced.
- Countermeasures to these include:
 - Resistive Exercise.
 - Aerobic Exercise.
 - Medications - Pharm (Risk).
 - Nutrients - Food and Nutrition (Risk).
- Other contributing factors can include the **Motivation** to exercise which is impacted by **Fatigue** through the **Sleep (Risk)** and **Food and Nutrition (Risk)**, **Effective Mission Duration** that can induce monotony, design and maintenance challenges from the **HSIA (Risk)**.
- The exercise capability that protects **Aerobic Fitness** and **Muscle Performance** is the result of the **Vehicle Design** process, the **HSIA (Risk)**, and the fielded **Crew Health and Performance System**. These define and limit the presence and reliability of the **Exercise Hardware** that is available in a mission. The **Exercise Prescription** that can be accomplished by crew is limited by the **Schedule**, **Vibration Isolation System**, **Previous Injury**, and environmental factors such as **Temperature**, **Humidity**, and **CO2 (Risk)** that are a function of the **ECLS System**.