

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

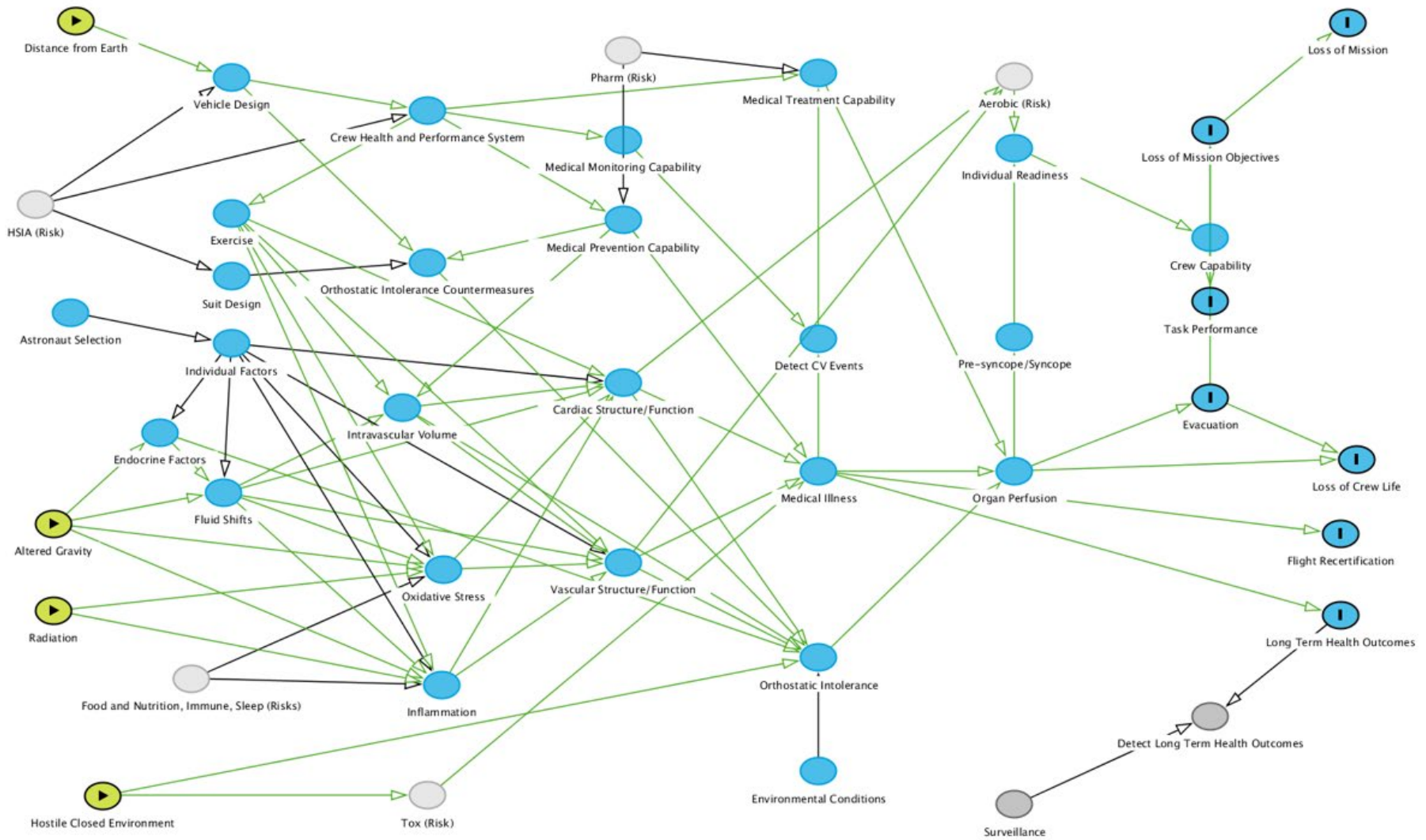
**NASA/TP-20220015709**

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

**Human System Risk Board**

**October 2022**

# Risk of Cardiovascular Adaptations Contributing to Adverse Mission Performance and Health Outcomes (Cardiovascular Risk)



## Cardiovascular Risk DAG Narrative

- The **Cardiovascular (Risk)** incorporates three former risks into a single risk to the cardiovascular system itself. The new risk is organized around the ability of the heart and blood vessels to successfully perfuse the organs (supply needed oxygen and nutrients).
- In-mission risk is dependent on aerobic fitness (captured here as the **Aerobic (Risk)**) and **Organ Perfusion**. **Aerobic Fitness** and **Pre-syncope/Syncope** (underperfusion of the brain) represent the performance pathway to affecting mission level outcomes. The health pathway is shown by **Medical Illness** which is a category node that includes a number of medical conditions including dysrhythmias (electrical system of the heart, formerly represented by the Arrhythmia Risk), myocardial infarction (damage to the pumping capability of the heart), and vascular conditions (the integrity of the pipes that deliver oxygen and nutrients from the heart).
- These are preceded by the **Cardiac** and **Vascular Structure/Function** which are both affected by **Exercise, Individual Factors, Fluid Shifts, Endocrine Factors, Intravascular Volume, Oxidative Stress, and Inflammation**. **Oxidative Stress** and **Inflammation** are in particular affected by **Radiation** (formerly part of the Radiation Risk as **Tissue Degeneration**).
- Finally, **Orthostatic Intolerance** can cause changes in **Organ Perfusion** (especially the brain) and is shown affected by multiple factors as well as **Orthostatic Intolerance** countermeasures which includes compression garments, fluid loading, salt tablets, and more.
- The **Crew Health and Performance System** design specifically includes **Exercise, Medical Prevention Capabilities** like medications, **Medical Monitoring Capabilities** like EKG and **Ultrasound**, and **Medical Treatment Capabilities** like medications and defibrillators depending on DRM needs and priorities.
- Note that if these are not designed into the vehicle, they will not be available for risk mitigation in mission.