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

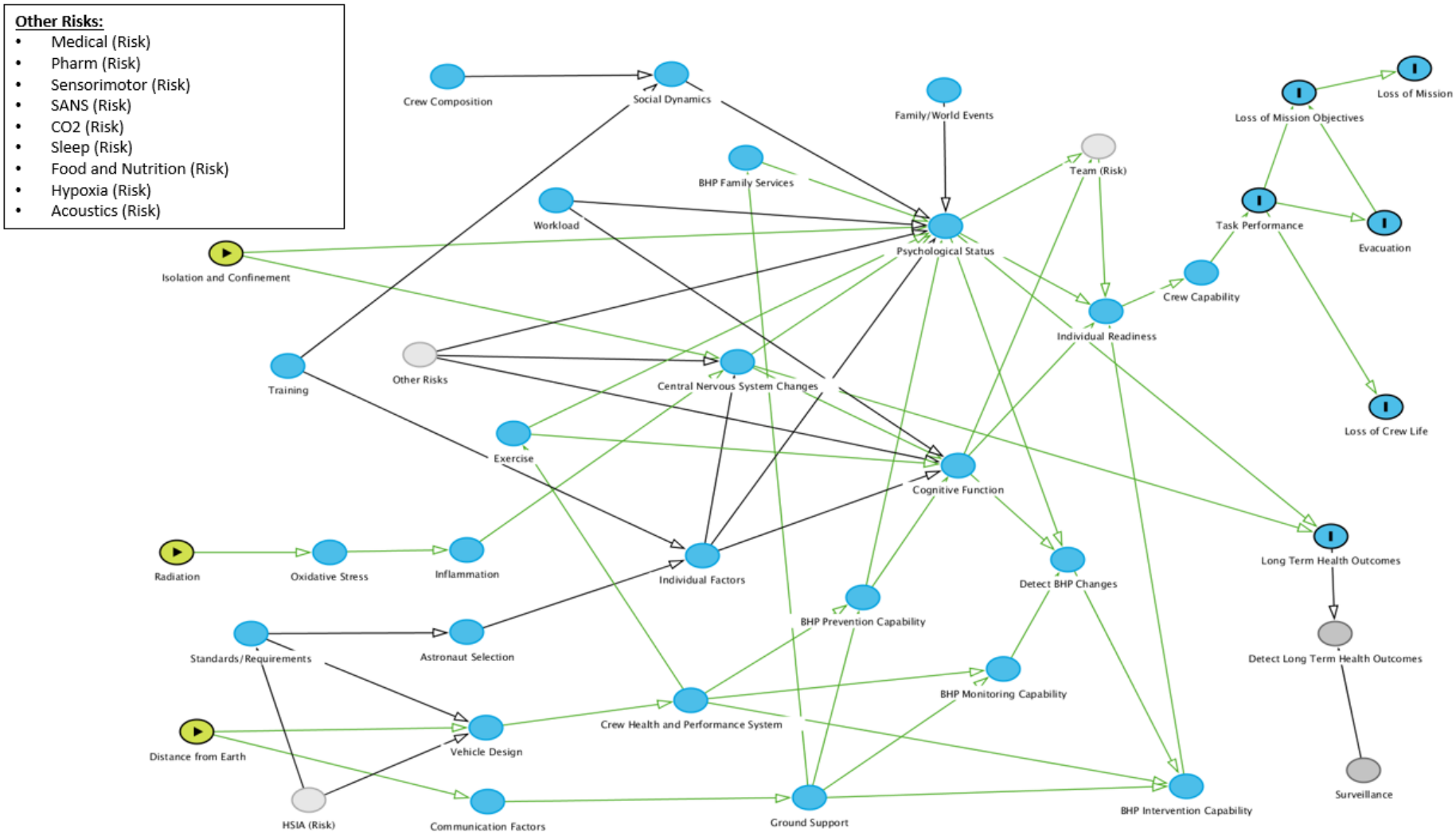
NASA/TP-20220015709

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

Human System Risk Board

October 2022

Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders (Behavioral Med. Risk)



Behavioral Med. Risk DAG Narrative

- The primary spaceflight hazard for the Behavioral Risk is exposure to the **Isolation and Confinement** of spaceflight which can result in decrements in cognitive and behavioral functioning centered around two nodes, **Psychological Status** and **Cognitive Function;** secondary Hazards include **Distance from Earth** and **Radiation**.
- **Psychological Status** refers to the mood and psychological state of the crew at any given time during a mission. These factors can directly affect **Individual Readiness**, **Crew Capability** by decreasing an individual's readiness for **Task Performance** if crew are distracted, preoccupied, dysregulated, unmotivated, or uncooperative. This also affects the **Team (Risk).**
  - The equilibrium that is present in **Psychological Status** for an individual astronaut is affected by:
    - **Family/World Events** that can occur while an astronaut is on a long mission. These can include deaths and loss that provoke grief and affect mood and motivation for example.
    - **Social Dynamics** with the rest of the crew are dependent on **Crew Composition**. NASA typically does not select crews for their compatibility, but this may be required in longer duration exploration missions.
    - Central Nervous System Changes that can occur as a result of Isolation and Confinement or can occur because of Other Risks including Medical (Risk), Pharm (Risk), Food and Nutrition (Risk), Sensorimotor (Risk), SANS (Risk), Sleep (Risk), CO2 (Risk), Hypoxia (Risk), Immune (Risk), and Acoustics (Risk) changes. This can also be affected by Oxidative Stress and Inflammation as a result of Radiation and other causes.
    - **Individual Factors** including Age, Sex, Genetic Predispositions and more affect the resilience of individual astronauts and the magnitude of impact to **Psychological Status** that may occur.
- **Cognitive Function** refers to the astronaut's attributes like planning, reasoning/decision-making, attention, memory, cognitive speed, and other thought processes that can be affected by a variety of factors in the spaceflight environment. Disruption in **Cognitive Function** can also directly affect **Crew Capability** and decrease readiness for **Task Performance** required for a variety of mission objectives. This can affect the **Team (Risk)** by requiring other team members to compensate for the individual's deficits.
  - The equilibrium that is present in **Cognitive Function** for an individual astronaut is affected by:
    - Central Nervous System Changes as described above can affect Cognitive Function.
    - **Workload** can affect ability to focus and general cognitive function.
    - **Individual Factors** including Age, Sex, Genetic Predispositions and more affect the resilience of individual astronauts and the magnitude of impact to **Cognitive Function** that may occur.
- Countermeasures to issues with **Psychological Status** and **Cognitive Function** can occur pre-flight or in-mission and in some cases must be included in **Vehicle Design** allocations and the **Crew Health and Performance System** in order to realize risk reduction. These include:
  - **Selection** of crew who are resilient to decrements in **Psychological Status** and **Cognitive Function**.
  - **Training** historically has occurred pre-flight and enables crews to develop individual resilience as well as team cohesion. This may need to be included in-flight as well in future missions.
  - **Exercise** has a strong connection with mood and motivation of the crew affecting both **Psychological Status** and **Cognitive Function** in positive ways.

  - **BHP Prevention Capability** could include **Exercise** as above, but there are other preventive measures that are performed including care packages, family conferences, private psychological conferences, and more.
  - **BHP Monitoring Capability** enables the crew to identify when there are changes to **Psychological Status** or **Cognitive Function** and determine appropriate times to implement **BHP Intervention Capability**. This includes regular assessments of **Cognitive Function** and evaluations during **Private Medical Conferences** as well as **Private Psychological Conferences**.
  - **BHP Intervention Capability** includes as clinically indicated Private Psychological Conferences, Private Family conferences, and ground-based family support services. Intervention by other crewmembers, and other BHP interventions that may include medications if warranted.
- Most of the current countermeasures are dependent on real-time communication and resupply. As **Communication Factors** change with **Distance from Earth**, access to **Ground Support** that enables successful **BHP Monitoring Capability** and **BHP Intervention Capability** becomes strained or non-existent.
- **Central Nervous System Changes** and **Psychological Status** of an individual astronaut throughout a mission both have the possibility of causing **Long Term Health Outcomes**. **Surveillance** post-flight and post-career enables us to **Detect Long Term Health Outcomes** of interest and better characterize the long-term risk to astronauts.