

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

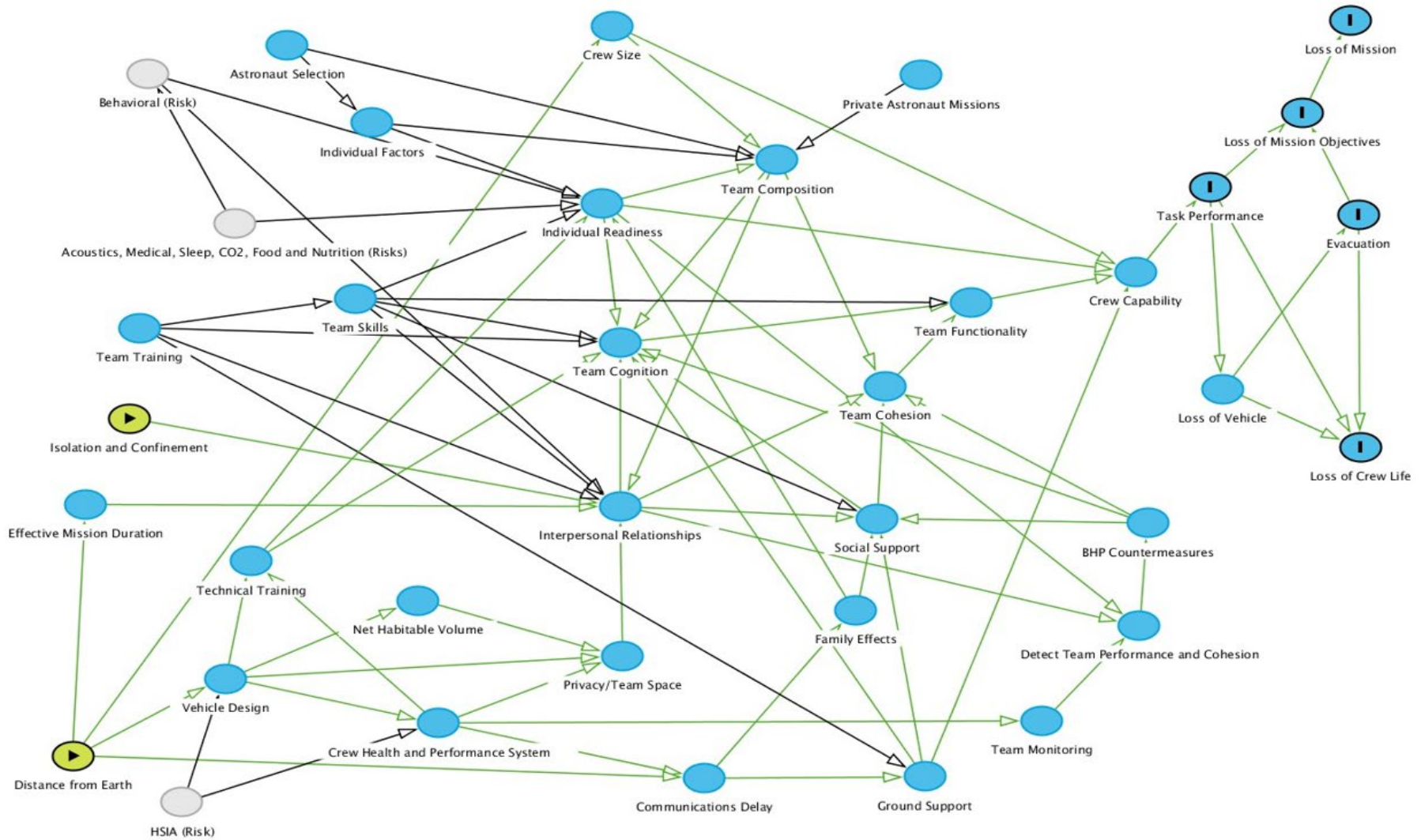
NASA/TP-20220015709

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

Human System Risk Board

October 2022

Risk of Performance and Behavioral Health Decrements Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team (Team Risk)



Team Risk DAG Narrative

- **Isolation and Confinement** affects **Interpersonal Relationships** directly and through monotony, boredom, and other possible Behavioral affects that are represented in the **Behavioral (Risk)**.
- **Distance from Earth** affects the mass and volume allocations that limit **Vehicle Design** decisions. It also affects **Communications Delays**, influences **Effective Mission Duration**, and affects **Crew Size**.
- The central issue in the Team Risk is that **Team Cohesion**, **Team Skills**, and **Team Cognition** come together to influence **Team Functionality**, and ultimately, **Crew Capability**. **Ground Support**, which will be heavily impacted by communication delays, is an important part of the spaceflight multi-team system. The Team Risk operates downstream of many other Risks, and at a higher level than the individual, but is heavily influenced by the individuals and individual-level Risks in the system.
 - **Duration** is related to distance, but not always, and it has implications for the (likely decremented) team functioning over time.
 - **Crew Size** is another potential stressor that is more loosely tied to the 5 Hazards, but has implications for the knowledge, skills and abilities, relationships, and simply # of person-hours, hands available onboard.
- **Team Functionality** is the degree of coordination, cooperation, communication, and psychosocial adaptation that enables a team to successfully complete tasks and live and work as a team. It is affected by:
 - **Team Cognition** is shared understanding among team members that is related to roles and responsibilities, team mission objectives and norms, and familiarity with team members' knowledge, skills and abilities. **Team Cognition** is supported by many factors related to **Team Composition** and **Interpersonal Relationships**, the team **Training** together, engaging in **Team Skills** and **Social Support**, **Countermeasures** (e.g., debriefs), and **Individual Readiness and Factors** (i.e., individual cognition). **Ground Support** is an important part of **Team Cognition** across the multi-team system.
 - **Team Skills** consist of information sharing, backup behaviors, leadership/followership, team care, and providing social support, among others. **Team Skills** are developed through training and supported by **Countermeasures** such debriefs and psychological support tools and experts. **Team Skills** support **Individual Readiness** to function on a team, offer social support, create and maintain shared **Team Cognition**.
 - **Team Cohesion** is tendency for a group to operate in a unified fashion while working towards a goal or to satisfy the emotional needs of its members. It is affected by **Interpersonal Relationships** that develop through shared values and complementary personalities (**Team Composition**) and **Social Support** during shared experiences.
- **Crew Capability** is the readiness of the entire crew to perform required tasks including the functional capacity as well as knowledge, skills and abilities, at both an individual and team level. Inadequate **Task Performance** during critical team tasks (e.g., EVAs for repairs or surface ops) can lead to **Loss of Vehicle** or **Loss of Mission Objectives** or **Loss of Crew Life**. This is affected by:
 - **Team Functionality** as represented above.

- **Crew Size** effects the pool of available knowledge/skills/abilities and person-hours onboard, as well as **Interpersonal Relationships** via **Team Composition**.
- **Individual Readiness** is affected by several other risks, and it affects the crew capability in a similar fashion to crew size.
- **Communication Delays** also negatively influence the real-time **Crew Capability**, particularly in time pressure situations (e.g., emergency response), by restricting timely troubleshooting by and coordination with **Ground Support**.
- **Countermeasures** and other factors influence the level of **Team Cohesion**, **Team Skills**, and **Team Cognition**. These include:
 - **Training** performed before and during a mission. This includes both technical *and* team skills training /behavioral health training. **Technical training** is dependent on **Vehicle Design** and the design of Vehicle Systems and the **Crew Health and Performance System** and can affect the **Individual Readiness** and shared understanding (**Team Cognition**) of these vehicle systems. **Team Training** affects each **Individual's Readiness** to work and live as a team, affect **Interpersonal Relationships** as they train together, and affect shared understanding (**Team Cognition**) of team norms.
 - **Astronaut Selection** creates a pool of well-qualified, highly skilled, team-oriented individuals (**Individual Factors**). A physically and psychological fit individual (**Acoustics, Medical, Sleep, CO2, Food and Nutrition (Risks), Behavioral (Risk)**), combined with **Team Skills** enhanced through **Team Training**, results in **Individual Readiness**.
 - **Team Composition** is influenced by a given DRM's **Distance from Earth** and **Crew Size**, and by the mission objectives, and the **Individual's Readiness** to meet those objectives. **Team Composition** is an ongoing consideration as different tasks occur throughout the mission, and it does not end when the crew is assigned.
 - The risk introduced by **Private Astronaut Missions** and space tourists is an unknown and may severely disruptive the entire system. Private Astronaut Missions (PAMs) will not have the same level of strategic Selection, Composition, Training, or Countermeasure support as the professional astronauts and will affect **Team Composition**.
 - The HSIA (Risk) influences Vehicle Design and systems (Crew Health and Performance System, Environmental Control), affecting the Net Habitable Volume and the availability of Privacy/Team Space. Both Privacy and shared Team Space (e.g., a dining/worktable) influences Interpersonal Relationships.
 - **Interpersonal Relationships** are affected by the mix of individuals on the mission (**Team Composition, Behavioral Risk**), the **Team Training** experienced together the **Team Skills** they use to support the relationships. **Interpersonal Relationships** particularly during longer **Effective Mission Durations** are a strong predictor of **Team Cohesion**, and how the team provides work and non-work supportive behaviors to coordinate and cooperate (**Social Support, Team Cognition**).
 - **Communication Delays** restrict the degree of **Social Support** provided by **Family Effects, Ground Support**, and psychological support (**BHP Countermeasures**) from experts on Earth. **Team Monitoring** allows experts, team members, or autonomous systems to prompt the team to engage in team-supportive countermeasures (e.g., debriefs), but these may be restricted due to **Communication Delays**.