Directed Acyclic Graph – DAG (Narrative)

The primary spaceflight hazard associated with the EVA Risk is the **Hostile Closed Environment** in which crewmembers don protective spacesuits and journey outside the vehicle to perform mission-related tasks. Activity involving rovers or other planetary surface exploration vehicles is excluded from this risk; the Dynamic Loads Risk covers these injuries. Secondary hazards include **Distance from Earth** and **Altered Gravity** that impact EVA design and crewmembers' health and performance support. All hazards, including **Radiation** exposure and **Isolation and Confinement**, can result in cognitive function decrements or injury to crewmembers.

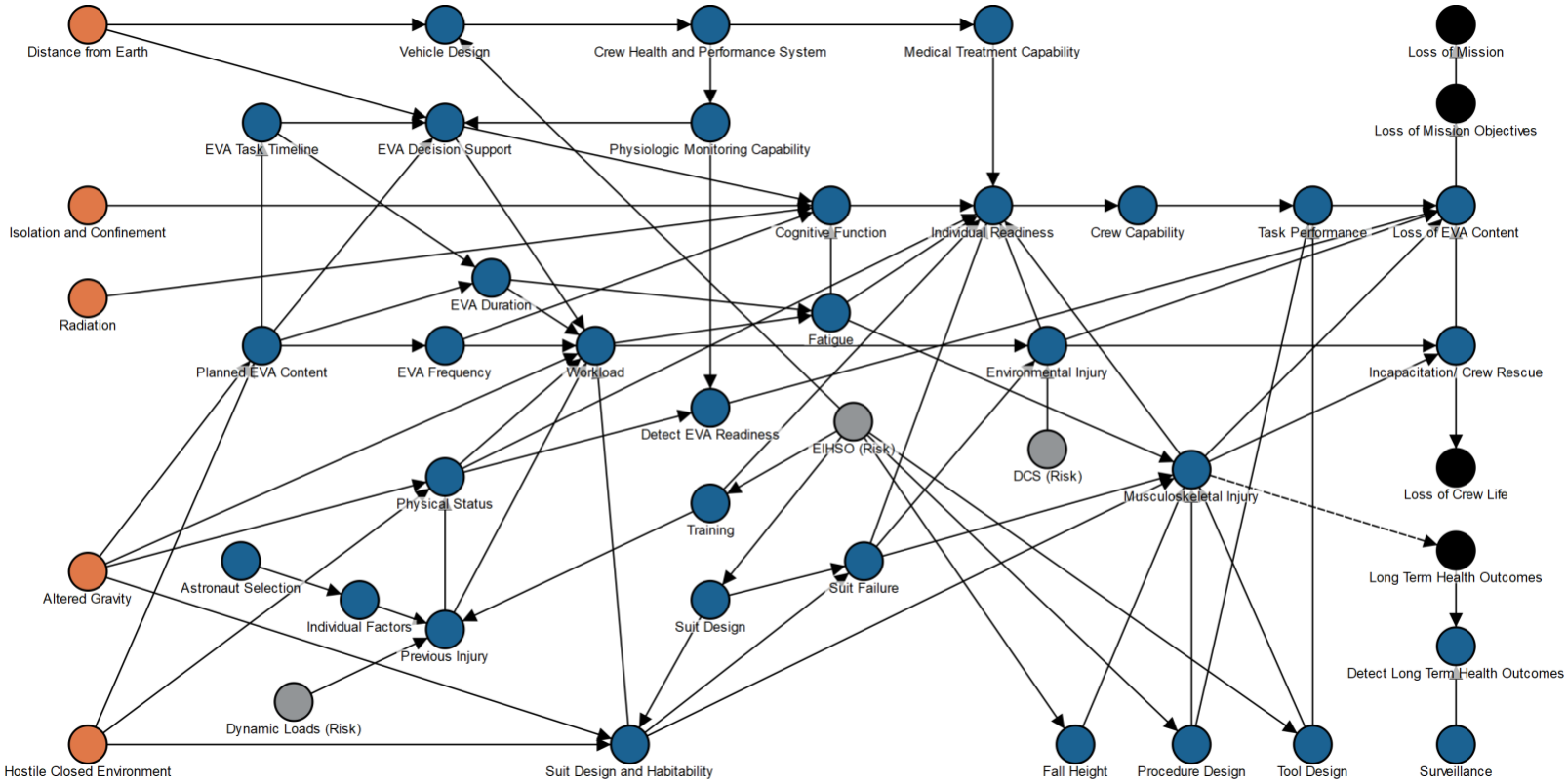
- The central issues in the EVA Risk are **Environmental Injury**, **Musculoskeletal Injury**, and **Task Performance**. The numbers, types, and severities of injuries that occur during EVA affect **Individual Readiness** and **Crew Capability** by introducing functional impairments that can affect **Task Performance**. These injury categories are explicit in the Medical Risk DAG, and **Medical Treatment Capability** determines the extent to which the consequences of these injuries can be mitigated in mission.
- Contributing factors to **Environmental Injury** include **Suit Failure** and Decompression Sickness – **DCS (Risk)**, which incorporates the occurrence of ebullism and arterial gas embolism.
- Contributing factors to **Musculoskeletal Injury** include **Suit Failure**, **Fall Height** (either from poor vehicle design or mission task attributes), **Tool Design** (such as in Apollo missions where many astronauts complained of hand injuries), and **Procedure Design**. There is a weak level of evidence supporting the association between **Musculoskeletal Injury** and **Long-Term Health Outcomes**, which is also associated with **Surveillance** programs and the ability to **Detect Long Term Health Outcomes**.
- When severe, these injuries can lead to **Loss of EVA Content**, which increases the likelihood of **Loss of Mission Objectives** and **Loss of Mission**, especially in short-duration missions. Additionally, they can lead to **Incapacitation/Crew Rescue** during an EVA, which increases the likelihood of **Loss of Crew Life**.
- **Individual Readiness** and **Crew Capability** are also affected by design and operational decisions and their consequences. **Cognitive Function** and **Fatigue** are dependent on
  - EVA Operations:
    - **Planned EVA Content** and **EVA Task Timeline**. Are they feasible and appropriate?
    - **EVA Duration.** How long do they last?
    - **EVA Frequency.** How many and how often?
    - **EVA Decision Support.** Is decision support effective at cognitive unloading?
  - All components of **EVA Operations**, **Altered Gravity** environment (microgravity, lunar, or Martian), **Hostile Closed Environment**, crewmembers' **Physical Status, Previous Injury** – either old or incurred during prior EVAs, and **Suit Habitability** contribute to the **Workload** that crews experience during their EVAs**.**
  - **Cognitive Function** is also associated with **Isolation and Confinement** and **Radiation** issues such as solar particle events.

- **Training** can affect the likelihood of having a **Previous Injury** as well as **Crew Capability** through a practiced understanding of movement and exertion limitations during an EVA. Both **Individual Factors**, which are commonly screened for during **Astronaut Selection**, and the **Dynamic Loads (Risk)** during a landing phase prior to EVA activity also influence the likelihood of a **Previous Injury**.

- **Distance from Earth** affects the mass, power, volume, and data bandwidth available to the **Crew Health and Performance System** that
  enables **Medical Treatment Capability** and **Physiologic Monitoring Capability** – such as ear exams done to ensure the crew can effectively clear prior to starting an EVA—and subsequently affects **EVA Decision Support** and the ability to **Detect EVA Readiness** thereby giving

crewmembers the green light to begin an EVA.

- The **EIHSO (Risk)** interfaces with many factors, including **Vehicle Design**, **Suit Design**, **Training**, **Fall Height**, **Tool Design**, and **Procedure Design**. Inadequate attention to Human System Integration at the mission, vehicle, and suit level is expected to affect EVA-related injury and performance substantially.


Distance from Earth
Vehicle Design
Crew Health and Performance System
Medical Treatment Capability
Loss of Mission
EVA Task Timeline
EVA Decision Support
Physiologic Monitoring Capability
Loss of Mission Objectives
Isolation and Confinement
Cognitive Function
Individual Readiness
Crew Capability
Task Performance
Loss of EVA Content
Radiation
EVA Duration
Fatigue
Planned EVA Content
EVA Frequency
Workload
Environmental Injury
Incapacitation/ Crew Rescue
Detect EVA Readiness
EIHSO (Risk)
DCS (Risk)
Physical Status
Musculoskeletal Injury
Loss of Crew Life
Training
Long Term Health Outcomes
Altered Gravity
Astronaut Selection
Suit Failure
Individual Factors
Suit Design
Previous Injury
Detect Long Term Health Outcomes
Dynamic Loads (Risk)
Hostile Closed Environment
Suit Design and Habitability
Fall Height
Procedure Design
Tool Design
Surveillance