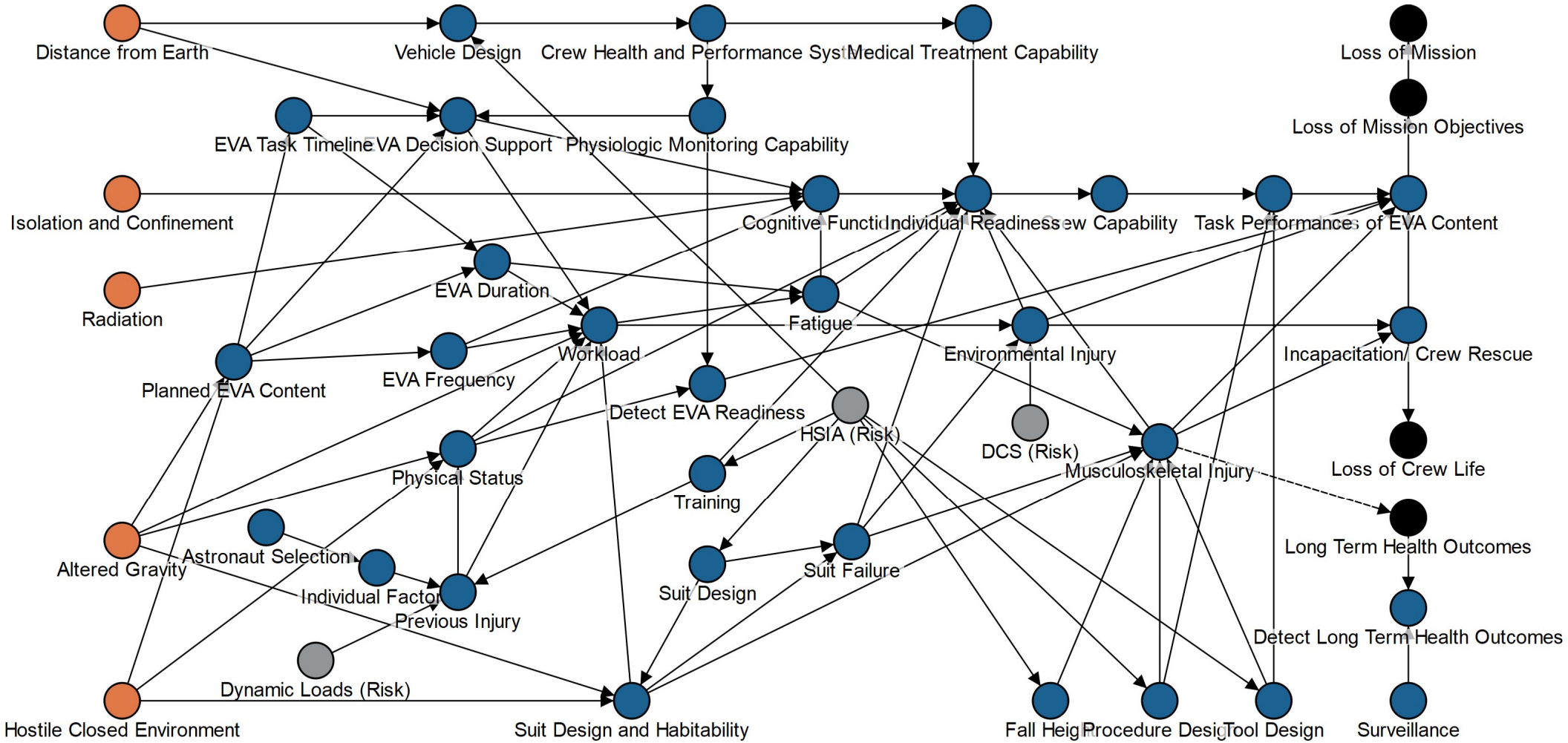
Distance from Earth
Vehicle Design
Crew Health and Performance Sys
Medical Treatment Capability
Loss of Mission
Loss of Mission Objectives
EVA Task Timeline
VA Decision Support
Physiologic Monitoring Capability
Isolation and Confinement
Cognitive Functi
Individual Readiness
ew Capability
Task Performance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

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 HSIA (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.