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

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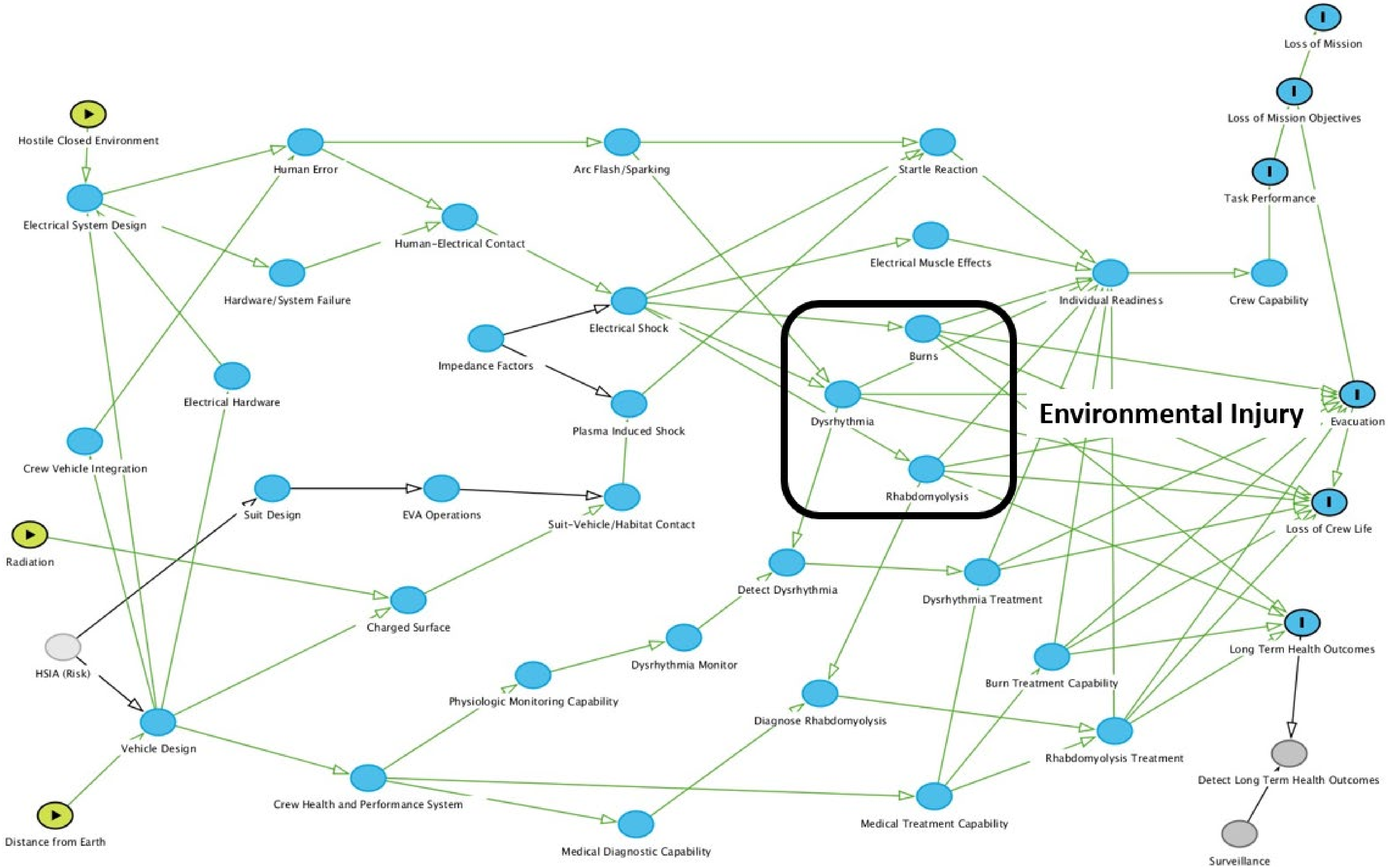
Directed Acyclic Graphs: A Tool for Understanding the NASA Spaceflight Human System Risks

Human System Risk Board

October 2022

Risk to Crew Health Due Electrical Shock (Electrical Shock Risk)



Electrical Shock Risk DAG Narrative

- The Hostile Closed Environment feeds directly into Electrical System Design which is impacted by Vehicle Design and Electrical Hardware.
- **Electrical Shock** centers around three nodes:
  - **Arc Flash/Sparking** occurs when there is a voltage difference between hardware inside the spacecraft and either a crewmember or other hardware. When a spark jumps to a crewmember this can lead to a **Dysrhythmia** or a **Startle Reaction**.
  - **Electrical Shock** describes when **Human-Electrical Contact** occurs inside the spacecraft and may occur without sparking. Small current can result in **Startle Reaction** or **Electrical Muscle Effects** such as tetany. Higher current passing through crewmembers can result in **Burns**, **Dysrhythmia**, or damage to muscles leading to **Rhabdomyolysis**. In rare circumstances, **Dysrhythmia** could lead to **Loss of Crew Life.**
  - **Plasma Induced Shock** can occur during **EVA Operations. Radiation** impacts on the spacecraft can result in **Charged Surfaces** and if there is **Suit-Vehicle/Habitat Contact** then a shock may occur. The expected current levels suggest mainly **Startle Reaction** as the likely result which can affect crew operations during the EVA.

- Crew Capability is affected by the severity of the shock that occurs in all three of the above categories. Consequences can range from minor annoyance to severe disease that results in functional impairments of the crew.
  - The severity of **Electrical Shock** and **Plasma Induced Shock** both depend on **Impedance Factors** that can include insulation of clothing and shoes as well as amount of sweat on the body.
- **Human Electrical Contact** may occur for several reasons:
  - **Electrical System Design** can be done well or poorly. Poor design can result in **Hardware/System Failure**. Poor **Crew-Vehicle Integration** can result in increased likelihood of **Human Errors** that result in inadvertent contact with charged hardware and is influenced by the **HSIA (Risk).**
  - Electrical System Design is dependent on the needed Electrical Hardware and Vehicle Design and is influenced by the HSIA (Risk).
  - Likewise, **Suit Design** influences the **EVA Operations** including timeline and likelihood of **Suit-Vehicle/Habitat Contact** and is influenced by the **HSIA (Risk)**.
- The **Crew Health and Performance System** provides monitoring and treatment capabilities needed to respond to an injury that occurs.
  - Physiologic Monitoring Capability includes Dysrhythmia Monitors required to Detect Dysrhythmias and provide Dysrhythmia Treatment when appropriate.
  - **Medical Diagnostic Capability** includes appropriate laboratory testing to **Diagnose Rhabdomyolysis** and initiate **Rhabdomyolysis Treatment** such as IV Fluids when appropriate.

    - The Medical Treatment Capability that is fielded must consider whether to include treatments such as Dysrhythmia Treatment, Rhabdomyolysis Treatment, or Burn Treatment Capability to respond to these Environmental Injuries.
- Lack of appropriate **Monitoring**, **Diagnostic**, and **Treatment Capabilities** can lead to impacts to **Crew Capability**, **Evacuation** for injured crewmembers, or **Loss of Crew Life**. In the cases of **Burns** and **Rhabdomyolysis**, failure to treat in mission can result in **Long Term Health Outcomes** including skin constrictions and kidney failure. **Surveillance** performed post-mission and post career can **Detect Long Term Health Outcomes** and better characterize the magnitude of risk.