

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

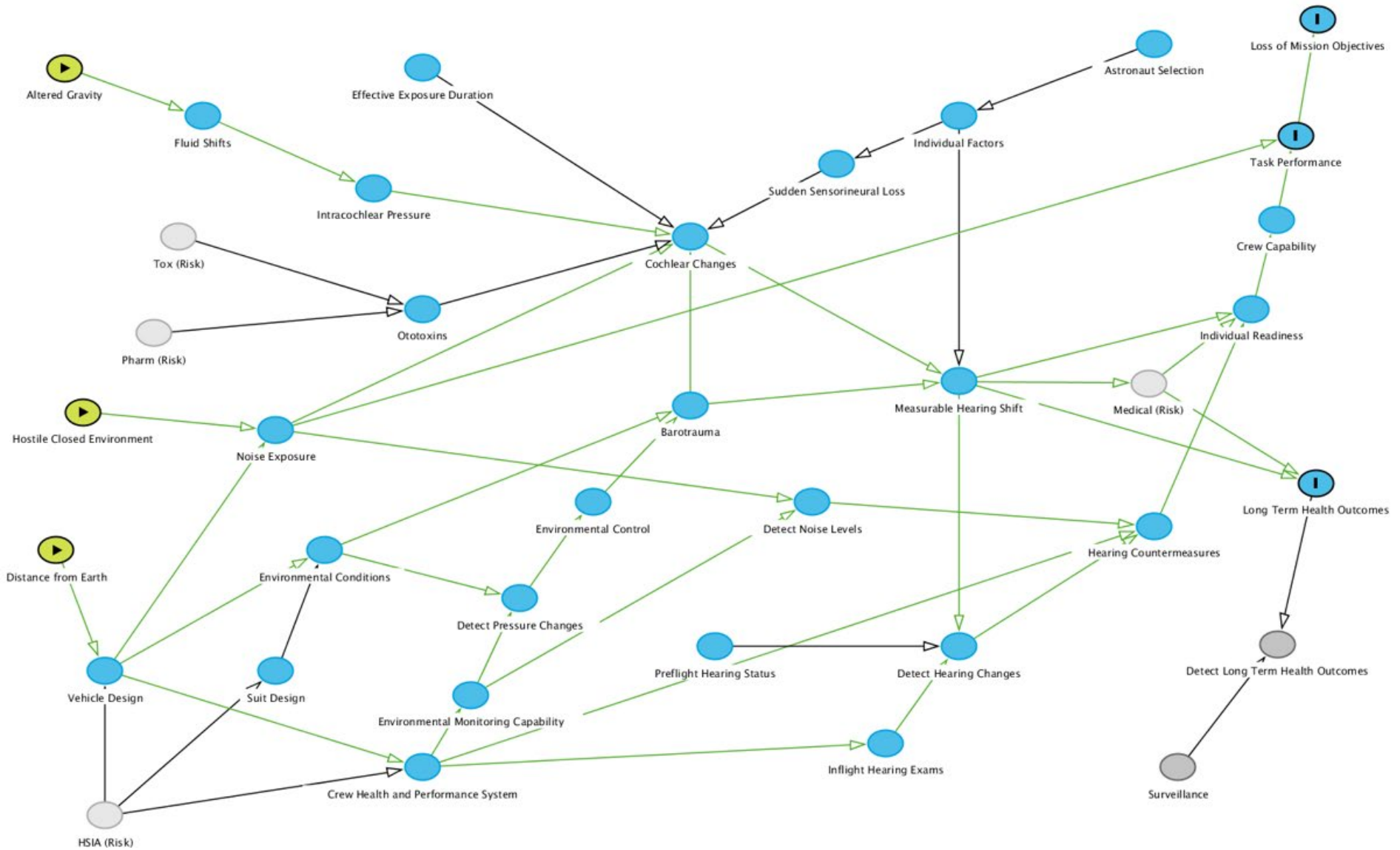
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**Directed Acyclic Graphs: A Tool for Understanding the NASA
Spaceflight Human System Risks**

Human System Risk Board

October 2022

Risk of Hearing Loss and Performance Decrements Due to Acoustics Issues in Space (Hearing Loss Risk)



Hearing Loss Risk DAG Narrative

- From a health perspective this DAG centers around **Cochlear Changes** which are changes inside the inner ear that can lead to issues with hearing. These culminate in effects on **Individual Readiness** and **Crew Capability**. This can be influenced by changes in:
 - Noise Exposure which includes Noise Intensity Level, Noise Exposure Duration, and Noise Spectrum.
 - **Ototoxins** in the environment or in medications.
 - **Sudden Sensorineural Hearing Loss** which is dependent on **Individual Factors** and has been recorded in some astronauts.
 - **Intracochlear Pressure** caused by **Fluid Shifts** in **Altered Gravity** environments. In this case the **Effective Exposure Duration** accounts for the cumulative effect that the exposure will have for different Design Reference Missions.
 - **Barotrauma** that can result from changes in pressure represented here by **Environmental Conditions**. This can result in Inner Ear Barotrauma that affects **Cochlear Changes** or Middle Ear Barotrauma that affects **Measurable Hearing Shifts** without affecting the cochlea. This is affected by **Suit Design**.
- From a performance perspective, **Noise Exposure** leads directly to **Task Performance** showing that the noise environment can affect performance by impacting effective communications without degrading astronaut health.
- Vehicle Design and the Crew Health and Performance System enable Noise Monitoring and In-Flight Hearing Exams if these are designed into the system. When designed into the system, they enable Detect Noise Levels and Detect Hearing Changes. Inflight Hearing Exams must be coupled with Pre-Flight Hearing Status to enable detection of changes. Detection of either inappropriate Noise Levels or actual hearing changes can prompt crews to use Hearing Countermeasures such as hearing protection, which must also be designed into the Crew Health and Performance System to enable risk mitigation.
- From the **Barotrauma** perspective, **Environmental Monitoring Capability** enables us to **Detect Pressure Changes**. Standards require that crew have **Environmental Control** over the rate of depressurization that can minimize the likelihood of experiencing **Barotrauma**.
- Measurable Hearing Shifts and Hearing Countermeasures both affect Individual Readiness and Crew Capability. In some cases, Measurable Hearing Shifts can lead to medical problems like Hearing Loss both In-Mission as well as Long Term Health Conditions.