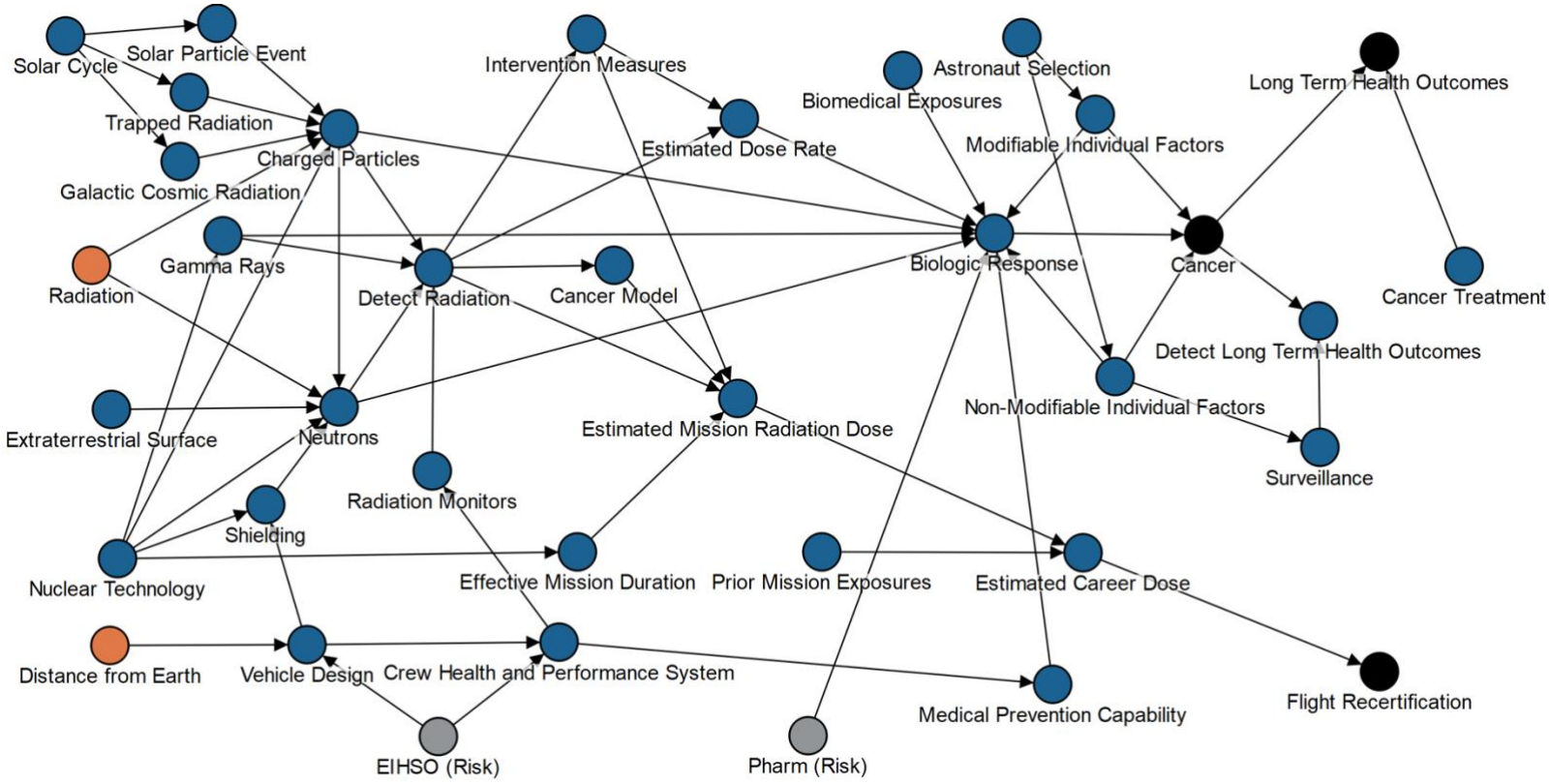
Radiation Carcinogenesis Risk DAG Narrative

- Exposure to space **Radiation** increases the likelihood that an individual will develop cancer due to interaction of **Charged Particles** and **Neutrons** with the human body. The ionizations that occur within the body lead to a **Biologic Response** that occurs on the cellular and molecular level which modifies the likelihood that an astronaut will develop **Cancer** post-mission and post-career.
    - The flux of **Charged Particles** that astronauts may receive is affected by the **Trapped Radiation**, **Galactic Cosmic Radiation** (GCR), and **Solar Particle Events** that may happen during a mission. These in turn are affected by the **Solar Cycle**.
    - The flux of **Neutrons** is affected by **Charged Particle** interactions with vehicle **Shielding** or **Extraterrestrial Surfaces** such as the Moon or Mars.
    - **Nuclear Technology**, if used in a mission for propulsion or power generation, can lead to additional **Charged Particle** exposure, **Gamma Ray** exposure, and additional **Neutron** exposure for the astronauts.
    - Other **Biomedical Exposures** such as CT scans for research or medical purposes can also affect **Biologic Response** and likelihood of developing **Cancer**.
- Besides spaceflight radiation exposures, there are other factors that modify an individual's susceptibility to developing cancer that must be considered. **Astronaut Selection** processes modify the **Individual Factors** present in the crew.
    - **Non-Modifiable Individual Factors** such as age, sex, genetic predispositions, and pre-existing medical conditions.
    - **Modifiable Individual Factors** such as smoking habits, exercise and dietary habits, alcohol habits, etc.
    - Any of these factors can modify the likelihood that Cancer will occur for a given astronaut post-career.
- **Surveillance** enables us to detect Cancer (**Detect Long Term Health Outcomes**) which can inform **Cancer Treatment.** Both the occurrence of **Cancer** and **Cancer Treatments** can affect **Long Term Health Outcomes** such as subsequent illnesses, premature death, and quality of life issues.
- **Distance from Earth** impacts the **Vehicle Design** through and volume allocations for **Shielding** and the **Crew Health and Performance System.** Inclusion of these are affected by the **EIHSO (Risk).**
- **The Crew Health and Performance System** provides allocations for:
    - **Medical Prevention Capability** which may provide medications or supplements designed to reduce overall space radiation carcinogenesis risk by modifying the biologic response to radiation. These would be affected by the **Pharm (Risk)** issues like all other medications.
    - **Radiation Monitors** on the spacecraft enable the detection of changes in **Charged Particle** or **Neutron** flux **(Detect Radiation)** that may be associated with **Solar Particle Events,** changes in **GCR, and Trapped Radiation** due to the **Solar Cycle.**
        - Monitoring can drive **Intervention Measures** in mission such as reconfiguring mass for a storm shelter, donning additional radiation protection, or early termination of EVAs.
        - Monitoring also enables **Estimated Dose Rate** and **Estimated Mission Dose** as well as informing the **Cancer Model** regarding crew exposures. The **Estimated Mission Dose** can be affected by **Effective Mission Duration** which in turn can

be modified by **Nuclear Technologies**.

- **Estimated Mission Radiation Dose** is combined with **Prior Mission Exposures** to assess an **Estimated Career Dose** for each astronaut. This information is used in conjunction with agency standards to inform **Flight Recertification** for each astronaut.


Solar Cycle
Solar Particle Event
Trapped Radiation
Galactic Cosmic Radiation
Charged Particles
Intervention Measures
Estimated Dose Rate
Biomedical Exposures
Astronaut Selection
Modifiable Individual Factors
Long Term Health Outcomes
Gamma Rays
Radiation
Detect Radiation
Cancer Model
Biologic Response
Cancer
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Detect Long Term Health Outcomes
Extraterrestrial Surface
Neutrons
Estimated Mission Radiation Dose
Non-Modifiable Individual Factors
Surveillance
Radiation Monitors
Shielding
Nuclear Technology
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EIHSO (Risk)
Pharm (Risk)