In the context of long-term extraterrestrial habitation, **safety** and **resilience** should be given consideration early on: a planned design of habitats to consider degradation and vulnerability to disasters, and minimize disruptions affecting normal functions.

We are developing a **System Resilience Framework** to counter these challenges and design sustainable, long-term extraterrestrial habitat systems. This framework addresses the following questions:

- What can go wrong?
- What is the likelihood?
- What are the consequences?
- What should be the level of preparedness?
- What is the recovery time?

**System Resilience** ...

Resilience is the ability of a system to **adapt**, **absorb** and **recover** quickly from a disruption, expected or unexpected, without fundamental changes in function or sacrifices in safety. Resilience is an umbrella under which other factors can be found:

- reconfigurability
- robustness
- scalability
- rapidity

**System Design Criteria** ...

function, as intended, under **continuous disruptive conditions**, such as wild temperature fluctuations, galactic cosmic rays, as well as **discrete disruptive events**, such as meteoroid impacts, vibrations, solar particle events, and equipment failures; and

- meet design objectives under limited in-situ resources.

**Civil Engineering**

The **civil engineering** community has learned from past natural disasters and the impacts of failures driven by **interdependencies among infrastructure sectors** (Hurricane Katrina and Fukushima nuclear disaster).

The design for structures has evolved/matured, leading to

- **performance-based design** (PBD)
- **consequence-based design** (CBD).

**System interdependencies are modeled based on Systems Operational Dependency Analysis** (SODA). **Strength of dependency** accounts for the functional dependencies of the structures. **Criticality of dependency** and **impact of dependency** quantify the functional degradation of a structure due to failure in other structures.

**Decision Making**

- **System Architecture**
- **System Growth?**
- **Structural Design?**
- **Location?**

**Resilience Analysis**

- **Parameters:** System Quality (Q) Recovery Time (RT) Output: PPI (Q)

**Loss Analysis**

- **Parameters:** System Loss (L) Output: PES (L)

**Damage Analysis**

- **Parameters:** System Architecture (SA) Damage Propagation (DP) Output: PDP (SA,D,P,D,T)

**Case Study**

In our framework, **Probabilistic Risk Assessment** (PRA) is used to obtain the probability of a major accident as a function of the probabilities of subsystem failures.

Our framework considers not only the identification of potentially major accidents and their causes but also the habitat system's

- response
- performance level
- loss
- recovery

**Systems Engineering**

- Performance-Based Design (PBD)
- Consequence-Based Design (CBD)
- Probabilistic Risk Assessment (PRA)

**System Resilience Framework**

- Initial Design
- Analysis
- Evaluation
- Decision
- Design Iteration