RESILIENCE FOR PERMANENT EXTRATERRESTRIAL HABITATS

A. Maghareh[1*], D. Gomez[1], S. J. Dyke[1,2], A. Bobet[1], J. Ramirez[1], H. J. Melosh[3], A. Modiriasari[1], and A. Theinat[1]

[1,*]Lyles School of Civil Eng., Purdue University, [2]School of Mechanical Eng., Purdue University, and [3]Department of Earth, Atmospheric, and Planetary Sciences, Purdue University

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The 49th Lunar and Planetary Science Conference March 19-23, 2018 (No. 2860)

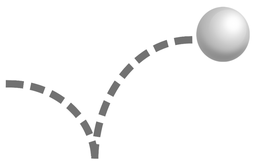
Introduction

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.

Approach

Civil Engineering

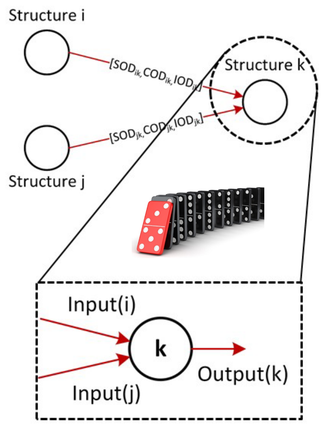
The ***civil engineering*** community has learned from past natural disasters and the impacts of failures driven by ***interdependencies among infrastructure sectors*** (Hurricane Katrina and Fukushima nuclear disaster).

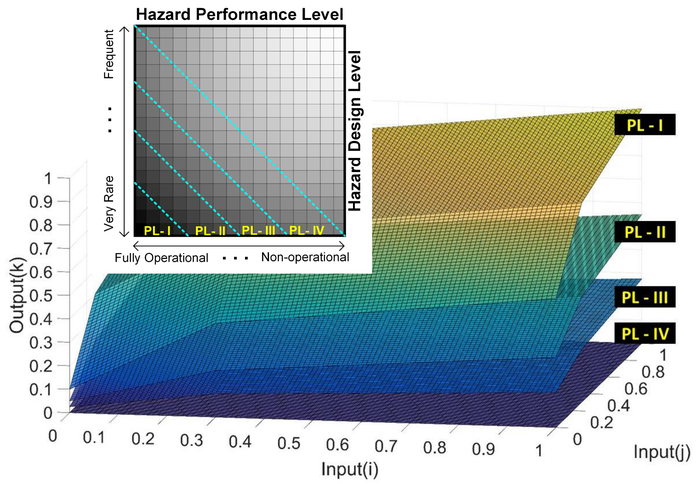
The design for structures has evolved/matured, leading to

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

Systems Engineering

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.





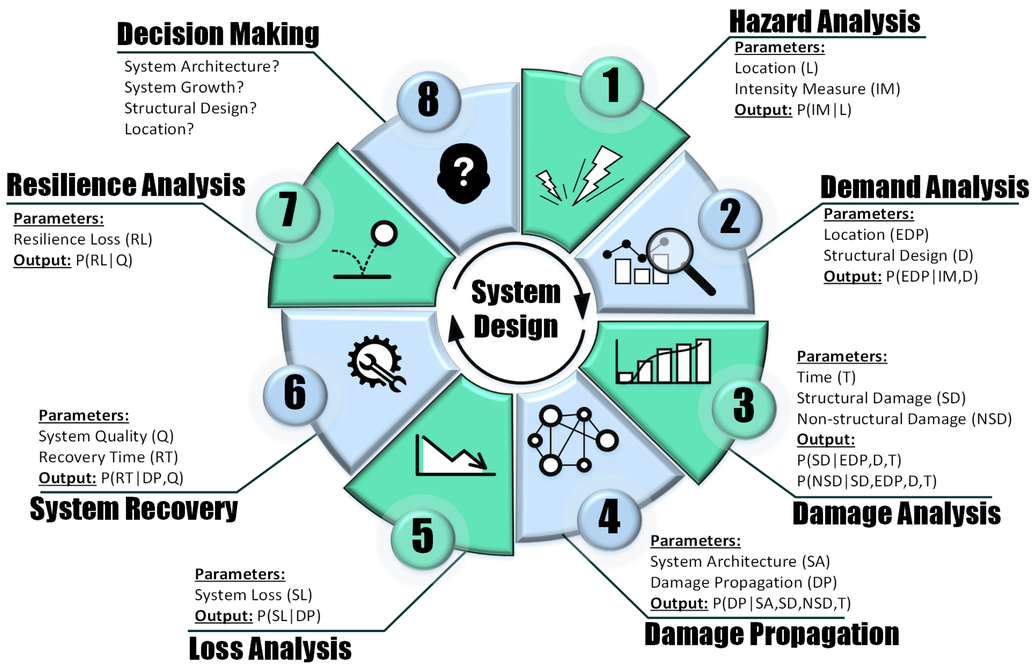
Aerospace Engineering

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.

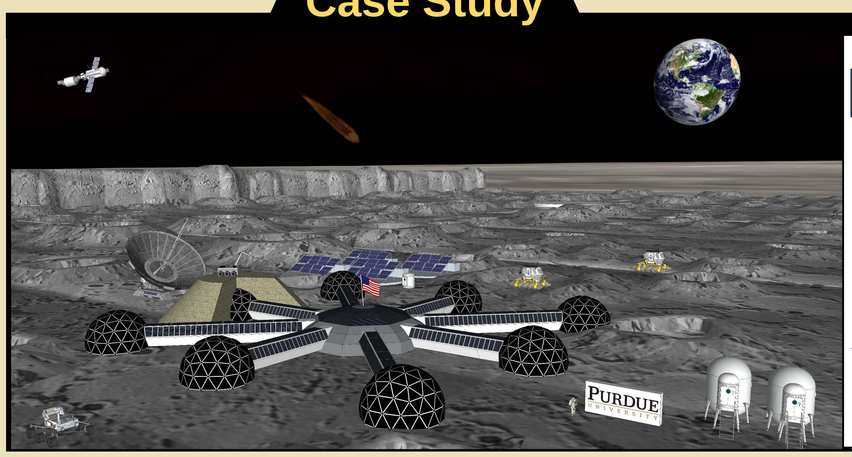
Our framework considers not only the identification of potentially major accidents and their causes but also the habitat system's

- ***response***
- ***performance level***
- ***loss***
- ***recovery***

System Resilience Framework

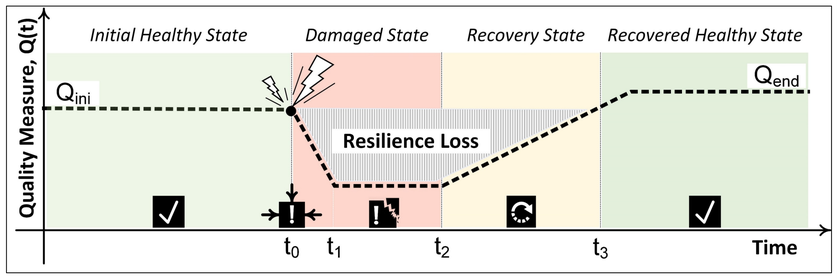


Case Study



System Resilience Framework

Civil Engineering (CBD and PBD)	*Aerospace Engineering* (PRA)	*Systems Engineering* (SODA)



Initial Design → Analysis → Evaluation → Decision → Design Iteration