



# **Model-Based Systems Engineering and a data challenge:**

## **How to model humans as part of a mission system?**

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# What Systems Engineering Is

From NASA Systems Engineering Handbook

## What is Systems Engineering?

- A methodical, disciplined approach for the design, realization, technical management, operations, and retirement of a system

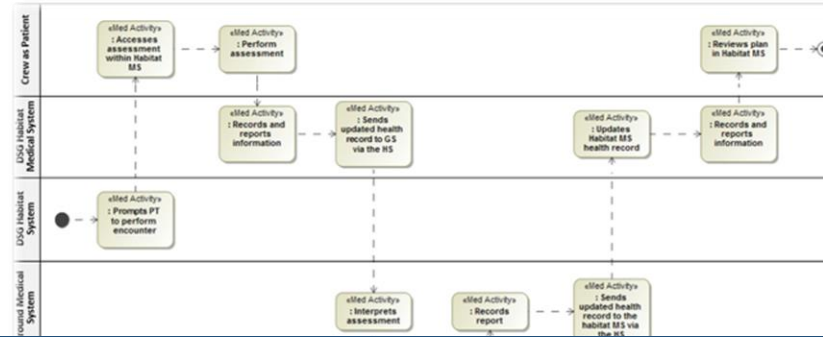
## What is a “System”?

- Collection of different elements producing results not obtainable by elements alone
  - Elements = people, hardware, software, facilities ...
- Value created by relationship among parts - how they are interconnected<sup>1</sup>



- **Systems Engineers are concerned about understanding how each part impacts every other part of a system**
  - **Weigh the technical solution options and TRADE among them**
    - **Make well-informed design decisions**

## Behavior



## Architecture

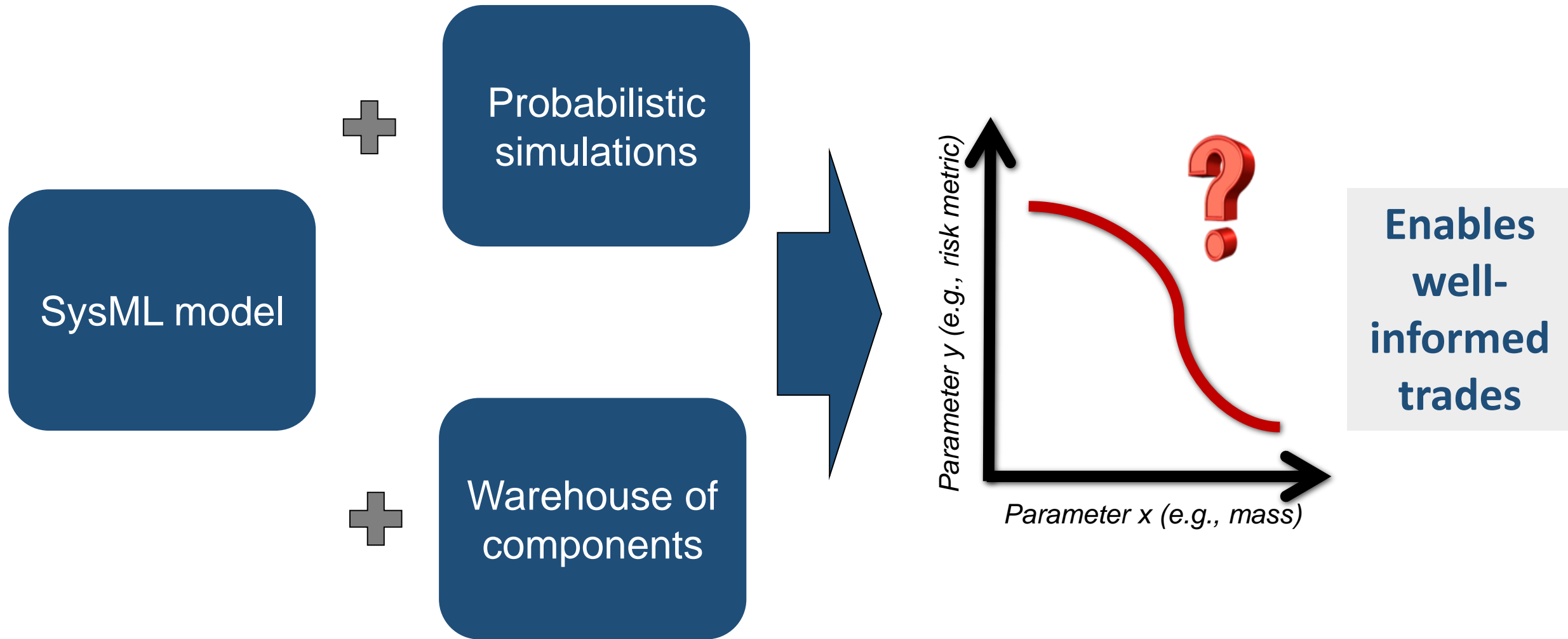


All in same model!  
Using Systems Modeling Language  
(SysML)

Analysis,  
some simulations...

Use Case ID	Use Case Name	Parent Use Case
Hab-MedSys-0018	Perform physical exam	
Hab-MedSys-0019	Assess vital signs	Hab-MedSys-0018
Hab-MedSys-0020	Collect vital signs	Hab-MedSys-0019
Hab-MedSys-0021	Monitor vital signs	Hab-MedSys-0020
Hab-MedSys-0022	Record vital signs	Hab-MedSys-0021
Hab-MedSys-0023	Store vital signs	Hab-MedSys-0022
Hab-MedSys-0024	Provide pharmacy	
Hab-MedSys-0025	Perform Imaging	
Hab-MedSys-0026	Perform Laboratory Analysis	
Hab-MedSys-0028	Manage physiological samples	
Hab-MedSys-0029	Perform wound care	
Hab-MedSys-0030	Perform airway procedures	

# Tool Suite



# Inside Probabilistic Simulations

Models need to include human health and performance

Probabilistic  
simulations



Influences

Influences



<https://www.sciencenews.org/blog/gory-details/how-urine-will-get-us-mars>

# Example Framework

Factor Domain

Color Key:

Operations

Vehicle Design

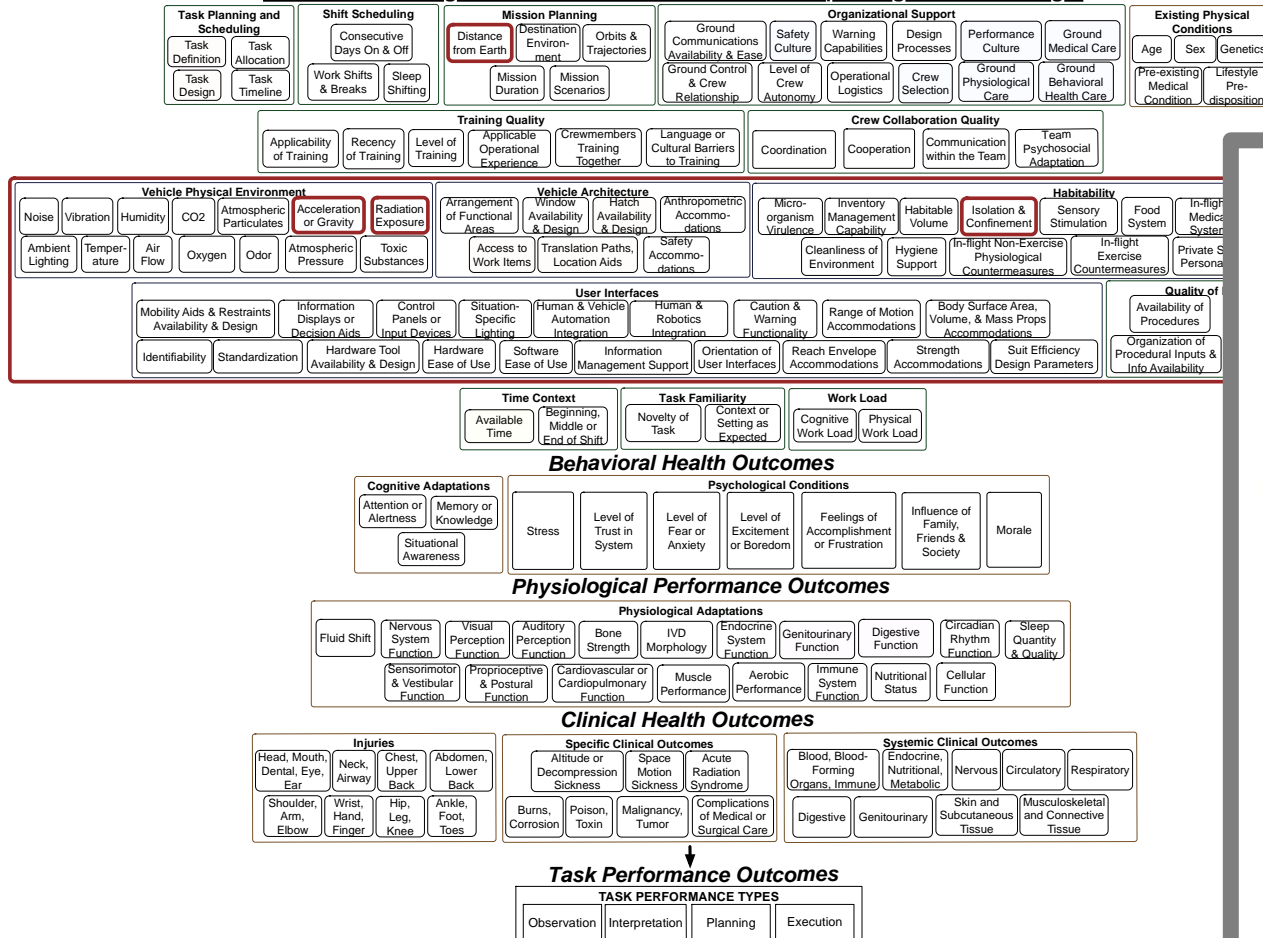
Human

HSRB Hazard:



## Contributing Factor Map

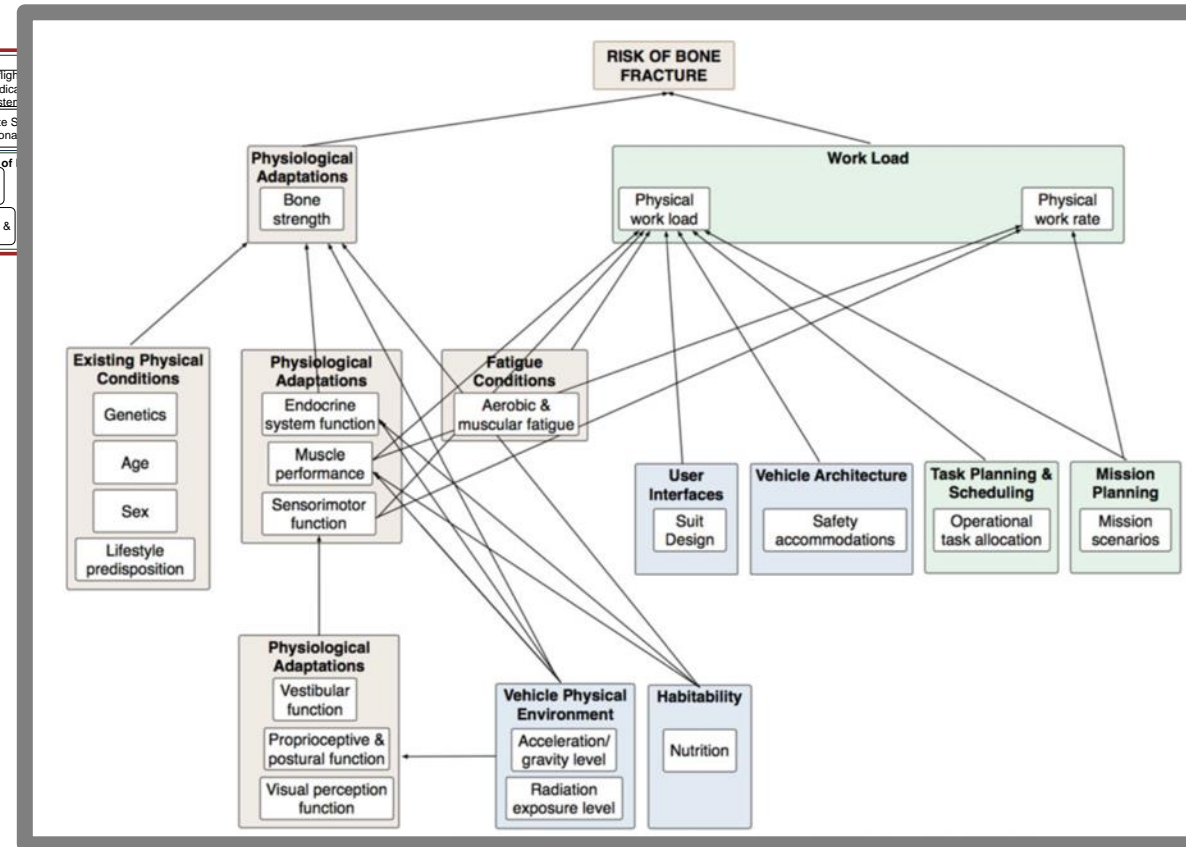
### Factors Influencing Human Health and Performance in Spaceflight and Post-Flight



Above factors and outcomes for each individual can influence overall mission outcomes

12/15/15  
WORK IN PROGRESS

## Example sub-network



Mindock, J. and Klaus, D. "Contributing Factor Map: A Taxonomy of Influences on Human Performance and Health in Space," *IEEE Transactions on Human-Machine Systems*. DOI 10.1109/THMS.2014.2328971. October 2014.



Adapted from Mindock, J. and Klaus, D. "Contributing Factor Map: A Taxonomy of Influences on Human Performance and Health in Space." *IEEE Transactions on Human-Machine Systems*, Vol. 44, No. 5, October 2014.

How do we incorporate  
terrestrial and spaceflight  
human health and performance data  
into quantitative probabilistic models  
to integrate humans as part of the  
overall system?

**Consider bi-directional influences in system TRADES!**



**Thank You**