Mission Lifetime Model

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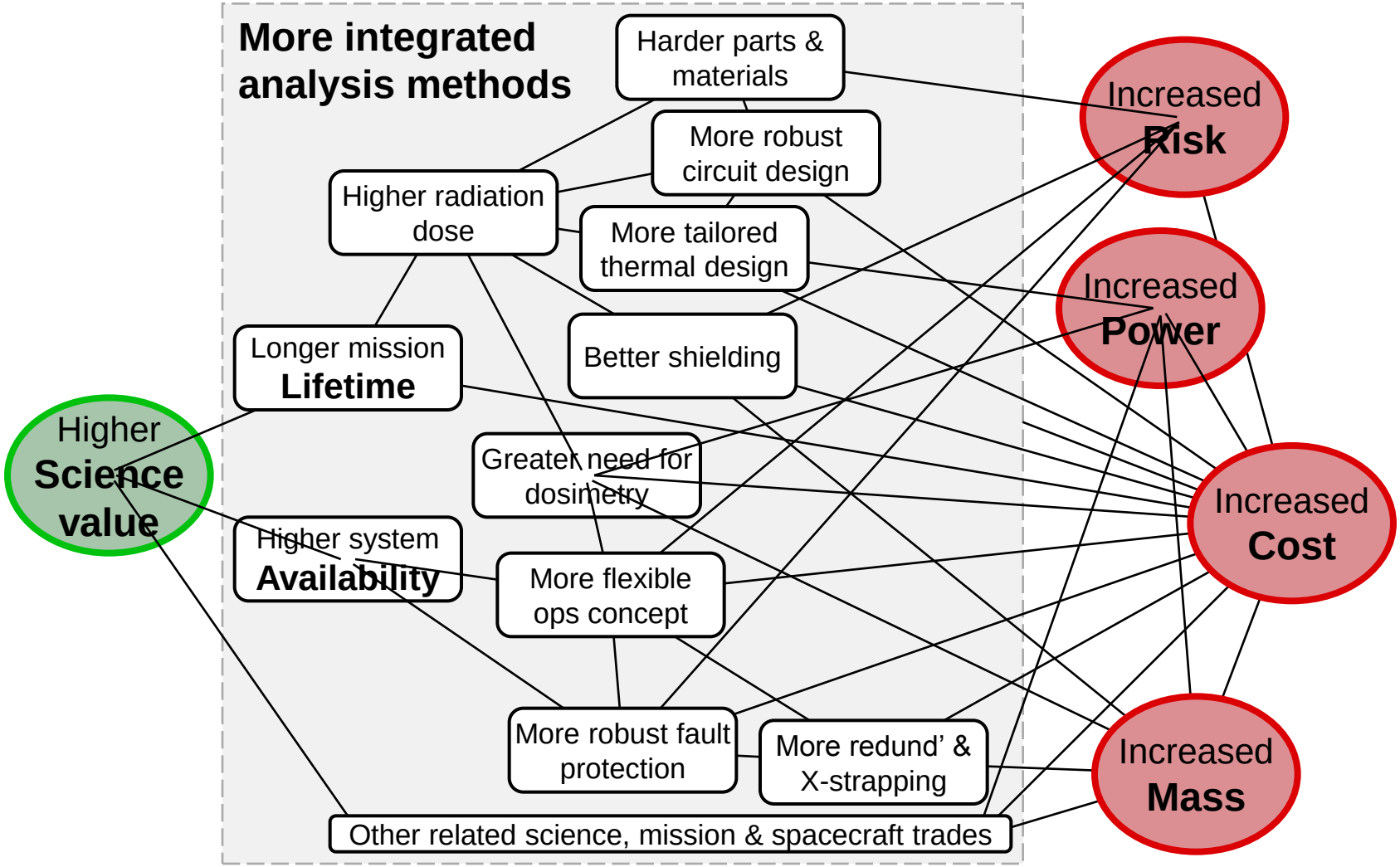
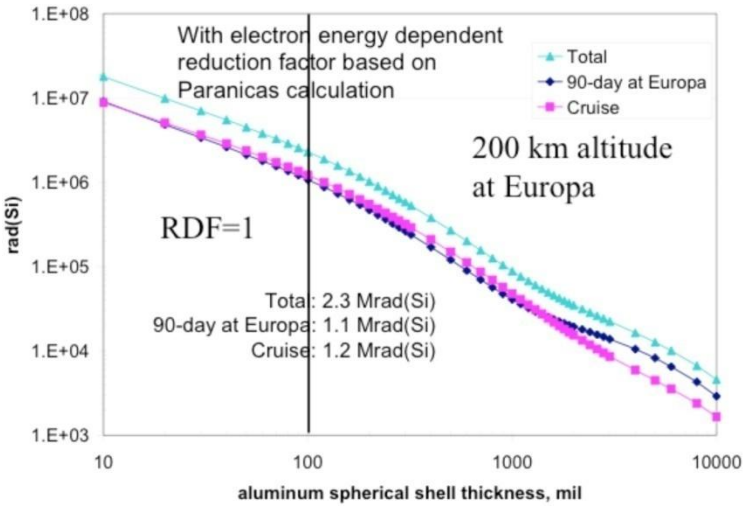
image credit: John Spencer, SwRI

Complicated Relationships



Europa Drivers

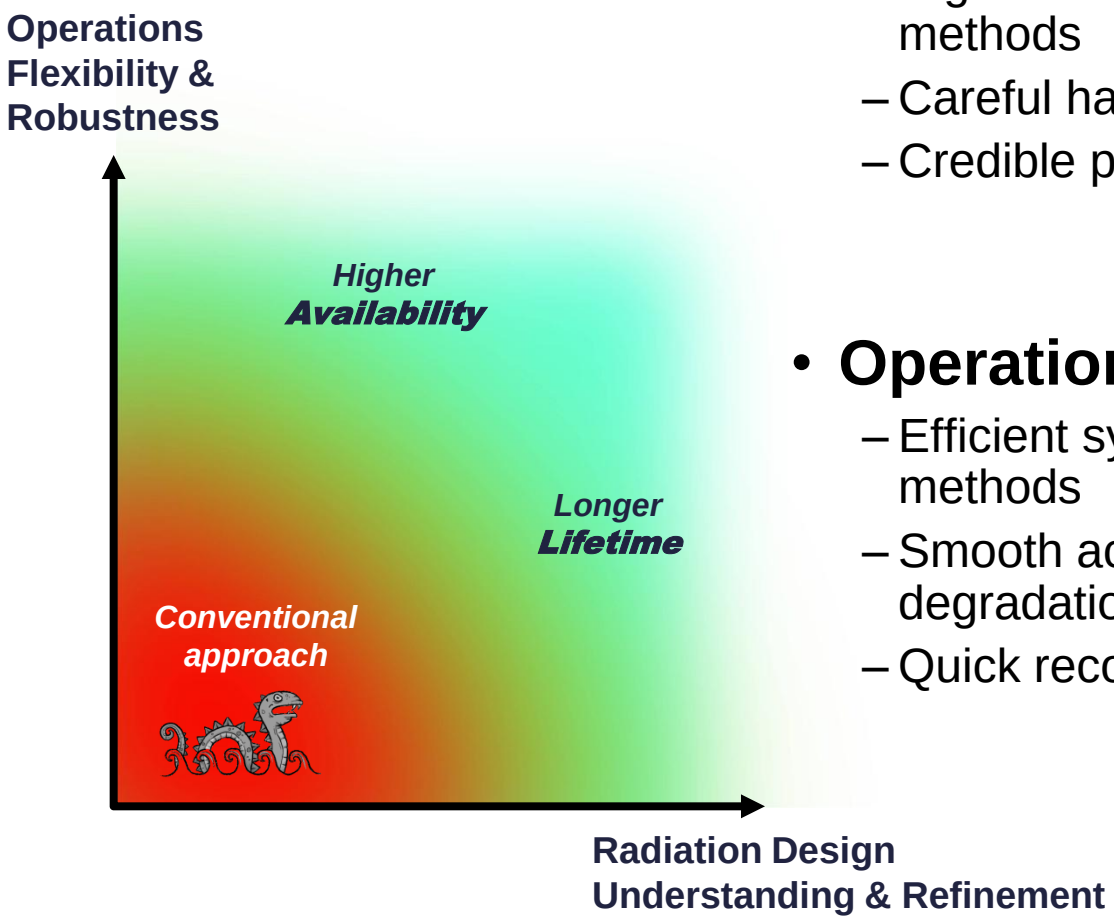
- High radiation dose rate
  - Before Europa orbit, dose would already have exceeded 1 M-rad (100 mils Al)
  - Thereafter, radiation damage accumulates at ~85 k-rad / week
  - Past the conventional design point, degradation is likely to accumulate over an extended period prior to failure



- Intense science
  - Short mapping campaign of a few months*
    - Science data collection requires sustained high data rates during the mapping campaign
    - Adequate mapping coverage requires accounting for probable outages
  - Focused science after mapping is complete
    - More detailed, targeted observation of features of interest
    - Requires more versatile operations

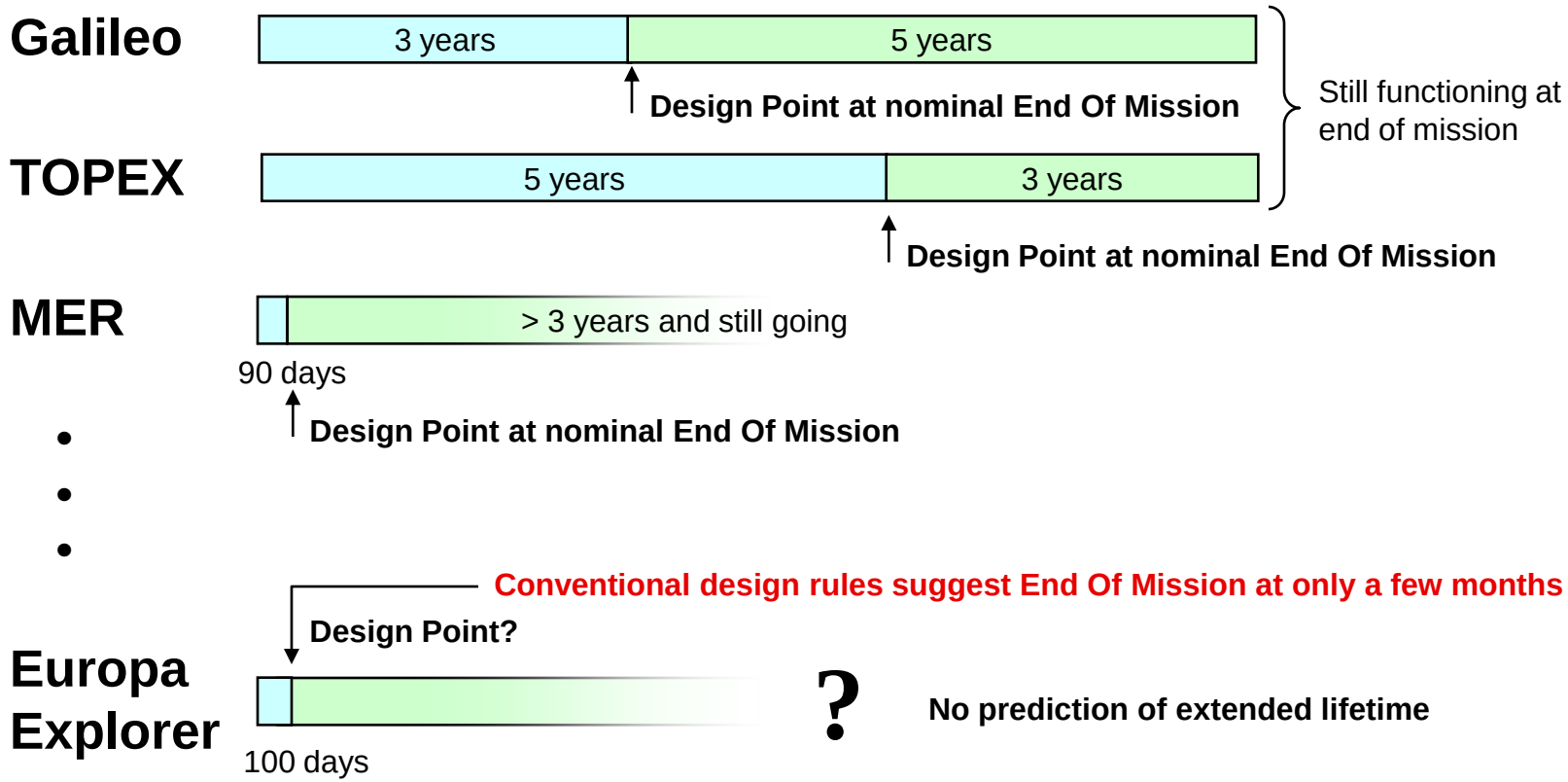
* Varies, but presently 100 days

Two Basic Concerns

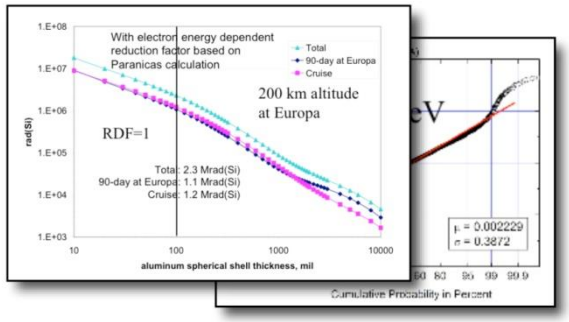


- **Radiation Design**
  - Rigorous application of hardening methods
  - Careful harvesting of excess margin
  - Credible prediction of lifetime
- **Operations Design**
  - Efficient system and operational methods
  - Smooth accommodation of degradation
  - Quick recovery from interruptions

A Historic Look at Lifetime



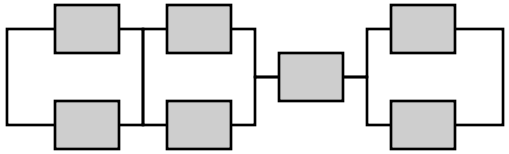
Statistical Lifetime Predictions



Environment Model

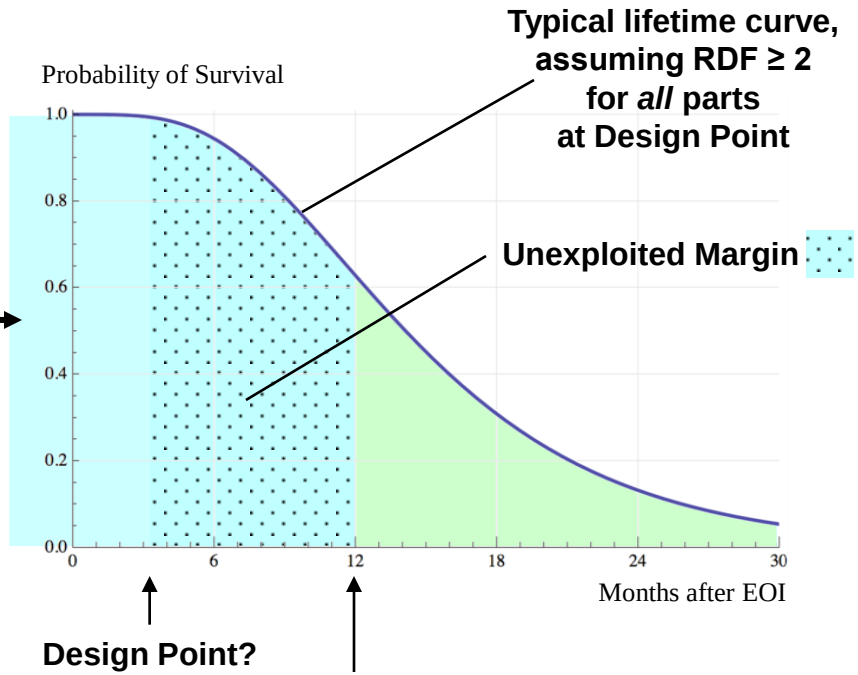
Part Category	Mean Rating, Mrad	Scaling Factor	Cov
Digital	1	3	0.15
Mem	1	2	0.15
Lin	1	2	0.15
Spec Lin	0.15	2	0.15
I/O	1	3.5	0.15
ADC	1	2	0.15
Hybrid	1	1.5	0.20
Xstor	1	3	0.15
MOSFET	0.6	1.5	0.15
Other	1	1.5	0.15
Sensors	1	2	0.15
GaAs	8	3	0.15

Part Hardness Model



System Reliability Model

Options provided by a Statistical Model

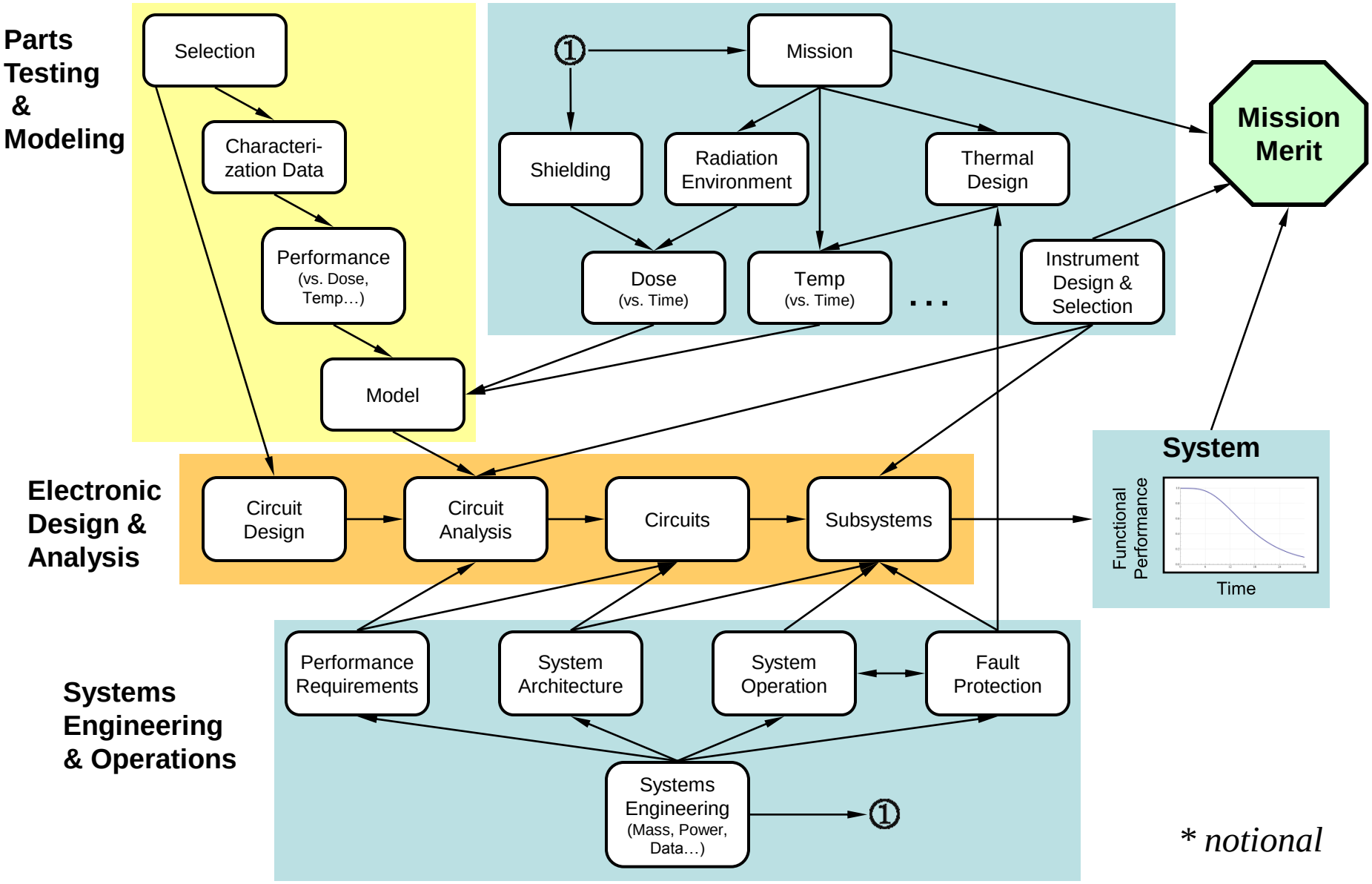


Completely dominated by weakest parts

Lifetime Prediction Challenges

- Refine environment understanding
  - Full suite of effects
  - Temporal variability and statistics
- Extend part test data
  - More parts
  - More test points — Test to failure
  - Better understanding of correlations
  - Better characterization of degradation
- Relate to circuit context
  - System failure versus part failure
  - Failure signatures
- Consolidate in system reliability model
  - Part distributions and population
  - Redundancy and fault containment
  - Operational considerations (power, temperature…)
  - Mitigation methods

System Interactions for a High Resolution Mission*



* *notional*

Good Models Will be Important

- Lifetime estimation model
  - Trade lifetime against parts, shielding, circuit and thermal design, operations concepts, and other factors
- Mission merit model
  - Relate science value to instrument selection and configuration (including radiation effects), engineering attributes, mission design…
- End-to-end data model
  - Understand relationships among RF engineering, data bandwidth and storage, data collection and management methods, single events effects on data, and weather and radiation-induced fault outages
- System parametric model
  - Keep track of all substantial system performance parameters and cross-disciplinary design relationships
- Information model
  - Tie all these modes together in such a manner that timeliness and consistency are ensured

Questions & Answers