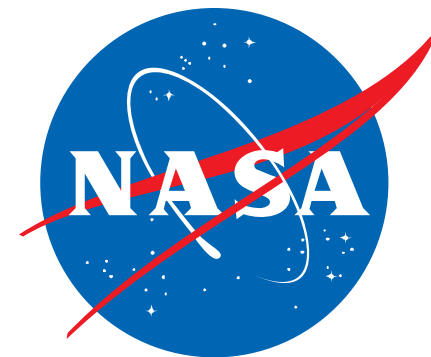




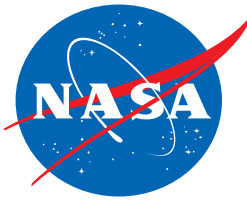
Guidance for Implementation of a Single Event Effect Criticality Analysis (SEECA)

Michael J. Campola

NASA Goddard Space Flight Center (GSFC)

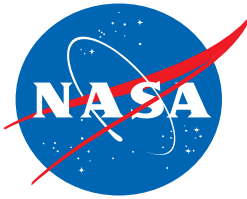
NASA Electronic Parts and Packaging (NEPP) Program

Acronyms

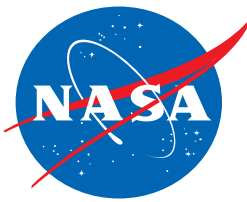


MEAL	Mission Environment Application and Lifetime
GSN	Goal Structuring Notation
LET	Linear Energy Transfer
SEFI	Single Event Functional Interrupt
SEECA	Single Event Effects Criticality Analysis
SEE	Single Event Effects
ConOps	Concept of Operations
RHA	Radiation Hardness Assurance

Background Information

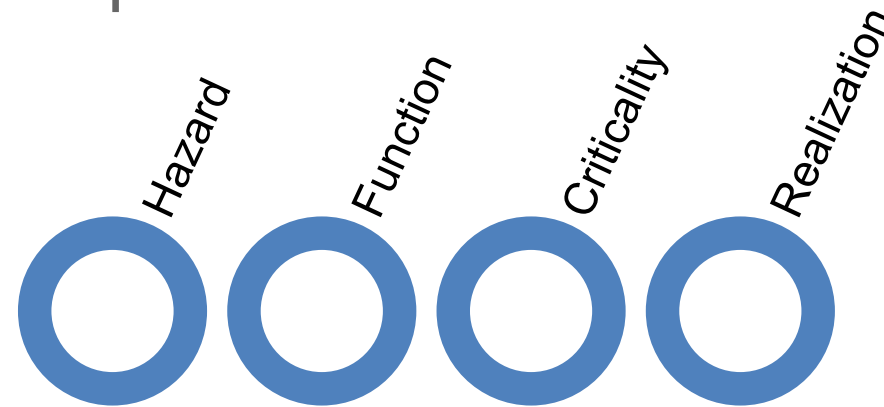


- First presented at SEE Symposium!
 - NASA HQ Sponsored study – GSFC Lead
 - » Gates, Michele and LaBel, Kenneth, "A Systems Engineering Approach to the Design of Survivable Electronics for the Natural Space Ionizing Radiation Environment," AIAA paper 95-0843, Jan. 1995.
 - » LaBel, K. and Gates, M., "Single Event Effect Mitigation from a System Perspective," IEEE Transactions on Nuclear Science Special Edition, 1996.
 - Original still lives here:
<https://radhome.gsfc.nasa.gov/radhome/papers/seecai.htm>
- Still holds up to this day, some topics that need more detail or revamping:
 - New technologies
 - Prevalence of SEFIs



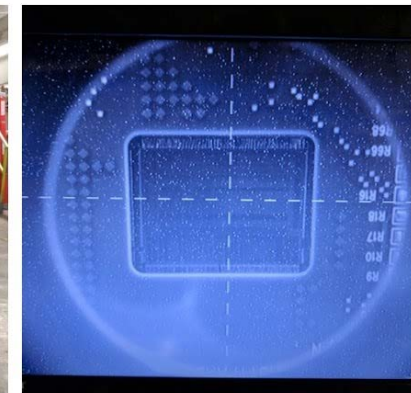
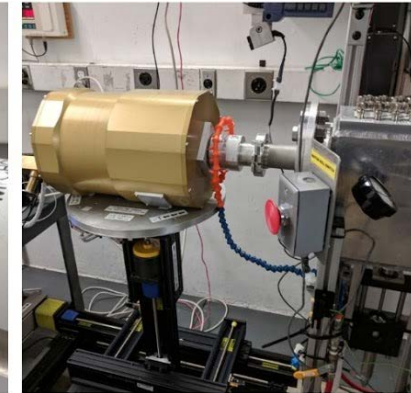
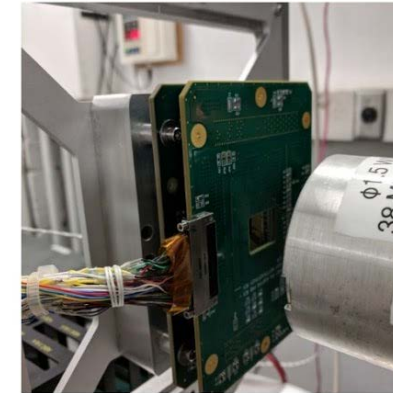
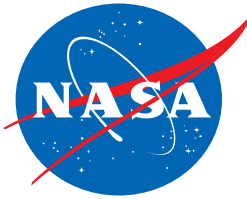
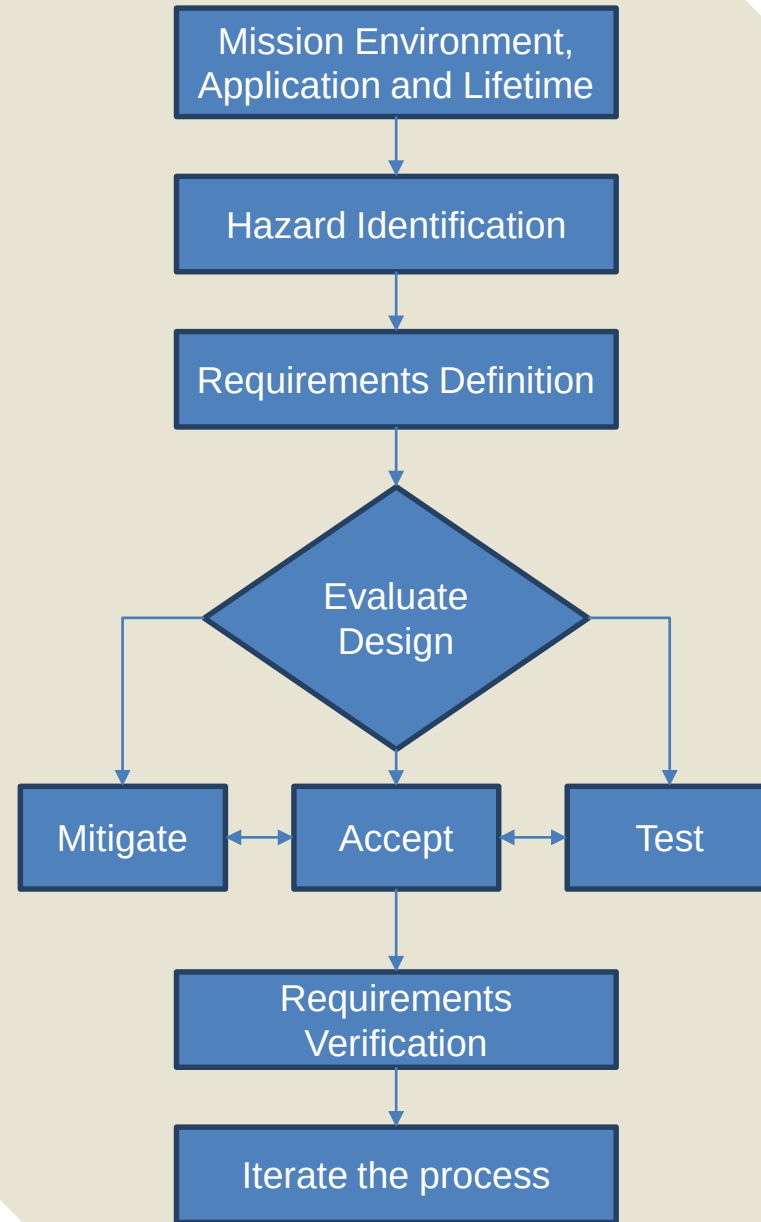
What is a SEECA?

- Failure Modes and Effects Analysis
 - Similar, but tools don't fit the bill
- An analysis of a specific set of failure modes with respect to radiation effects engineering and their severity
- Codified procedure for identifying Single Event Effect (SEE) risks with respect to the system design
- Some simplified principles:

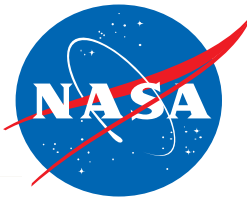


RHA Flow

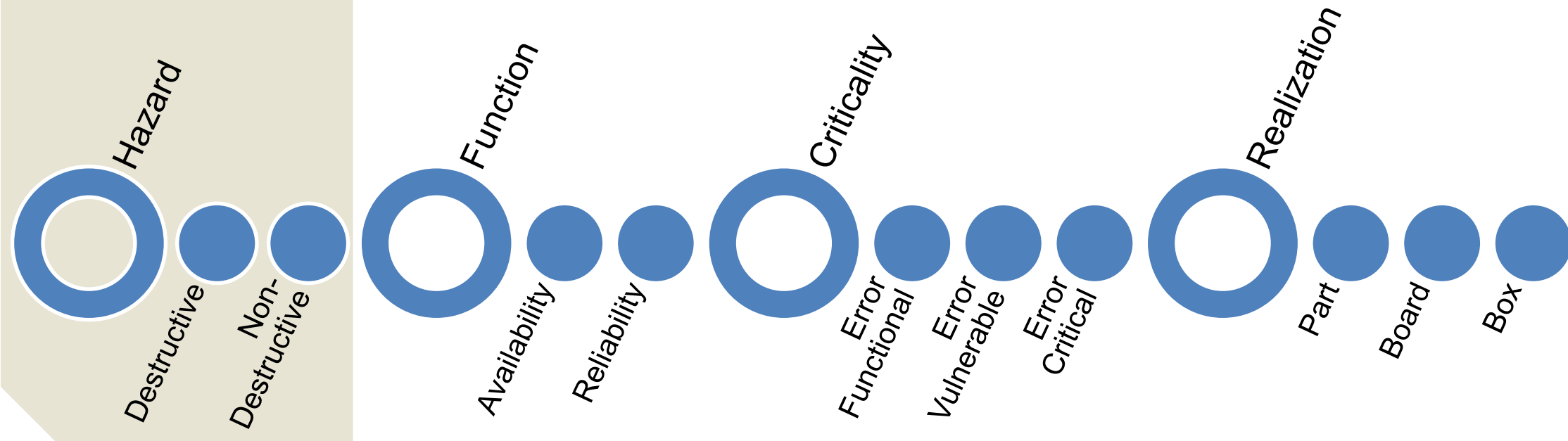
- Addresses all radiation effects
 - Total Ionizing Dose
 - Total Non-Ionizing Dose / Displacement Damage
 - Single Event Effects
- Holistic approach to capturing risk and requirements verification
 - SEECA plays a crucial role within the entire RHA context



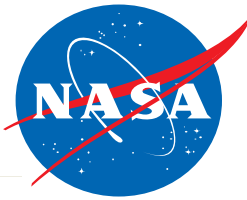
System-Level Thinking



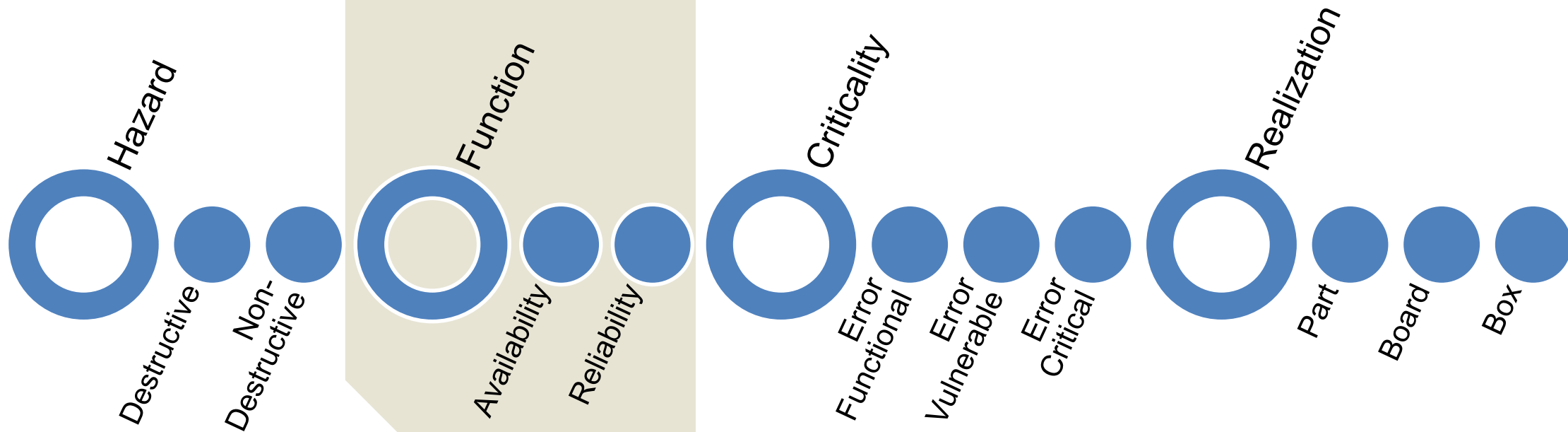
- Determined by Technology – The possibility of the effect as well as the Mission Environment, Application & Lifetime (MEAL)
- Usually requires the expertise of a radiation engineer
- Can be modified by part selection



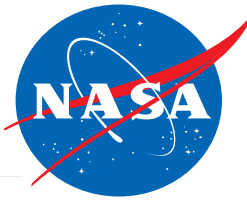
System-Level Thinking



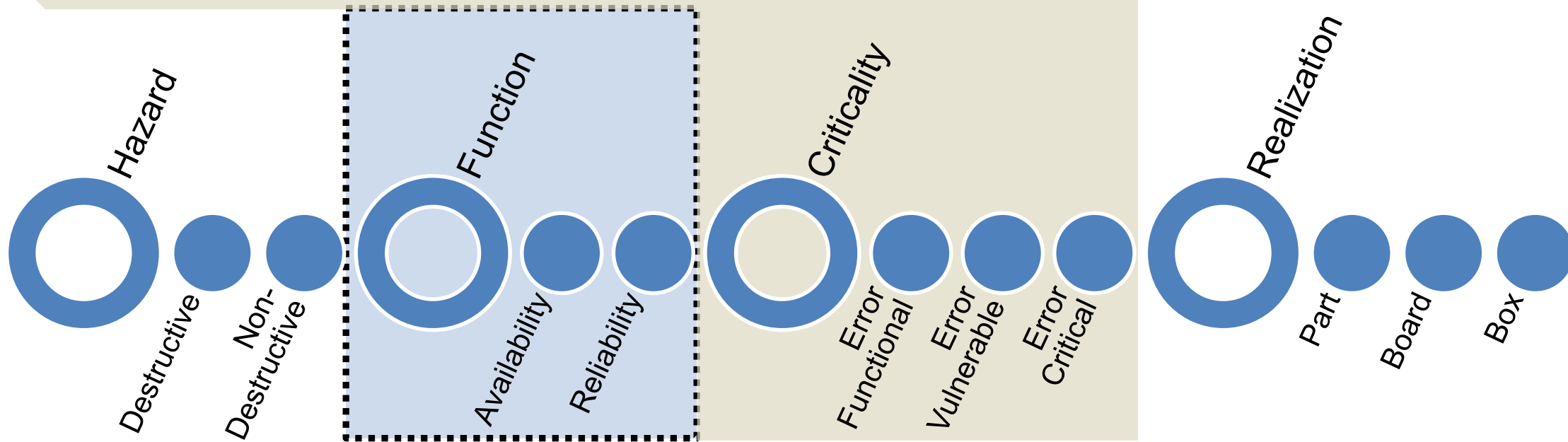
- Determined by Mission Requirements and Phases (ConOps)
- Usually requires the expertise of a systems engineer
- Can be modified by redundancy or operational constraints



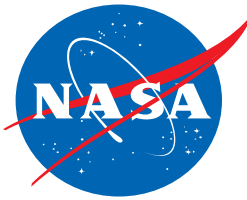
System-Level Thinking



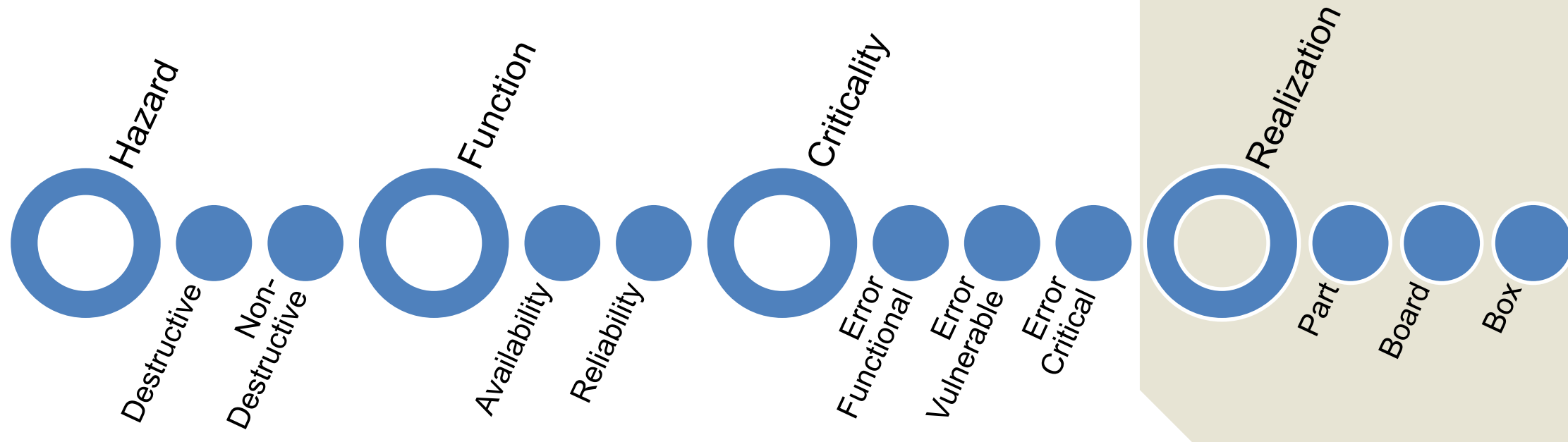
- Determined by ConOps & Function!
- Usually requires the expertise of a electrical or systems engineer
- Can be modified by redundancy, operational constraints, or mitigations



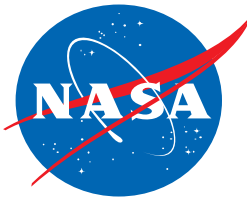
System-Level Thinking



- Determined by Design
- Usually requires the expertise of a electrical or systems engineer
- Can be modified by mitigation or redundancy



Steps for implementing SEECA: Preparation

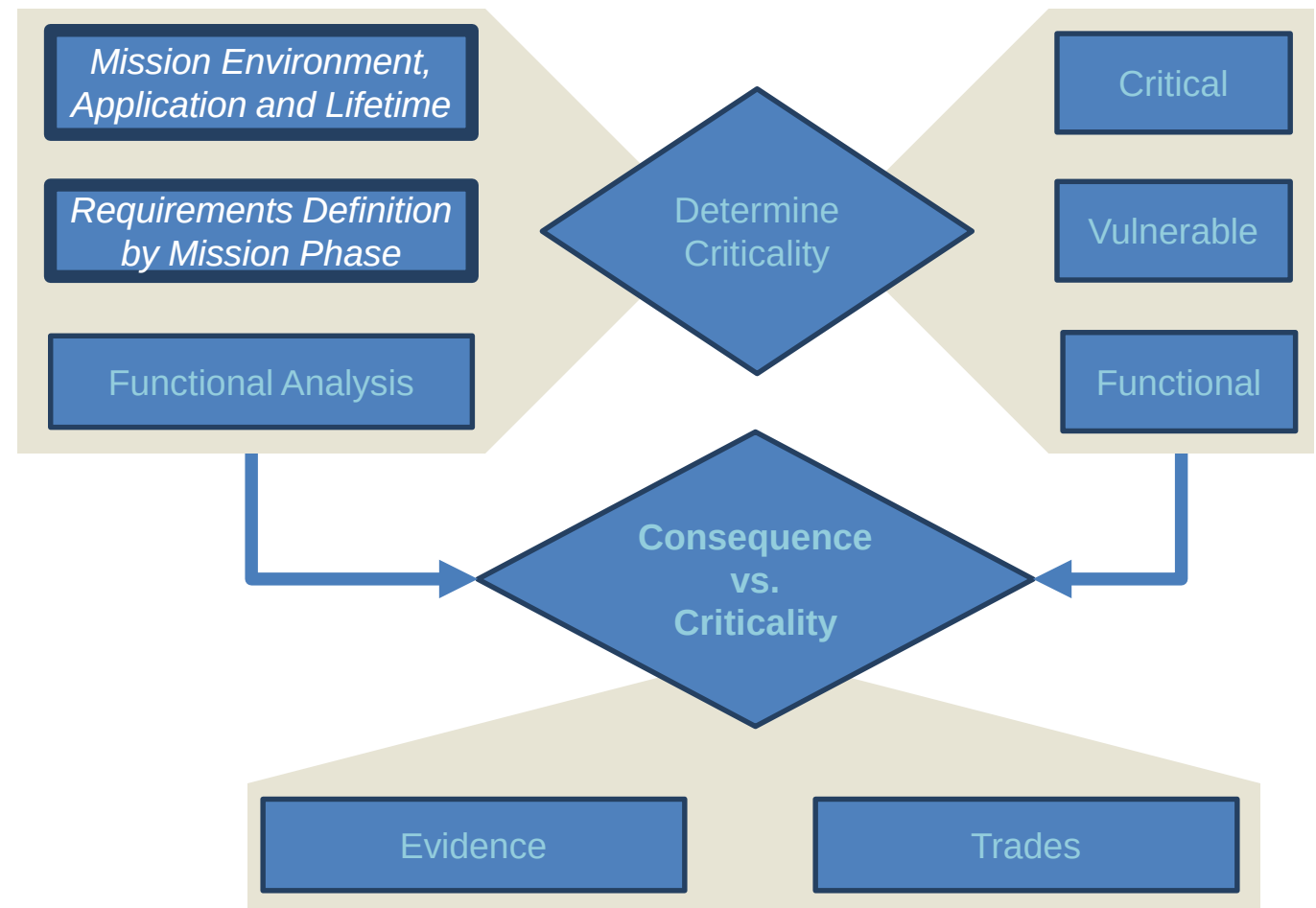


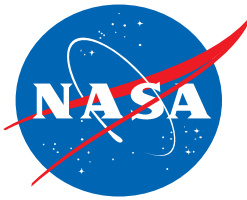
- *Environment & Lifetime Requirements*

- Translate mission requirements for radiation
 - » Reliability
 - » Availability
 - » Safety
- Requirements by phase from ConOps

- *Weigh Part Application vs. SEE Hazard*

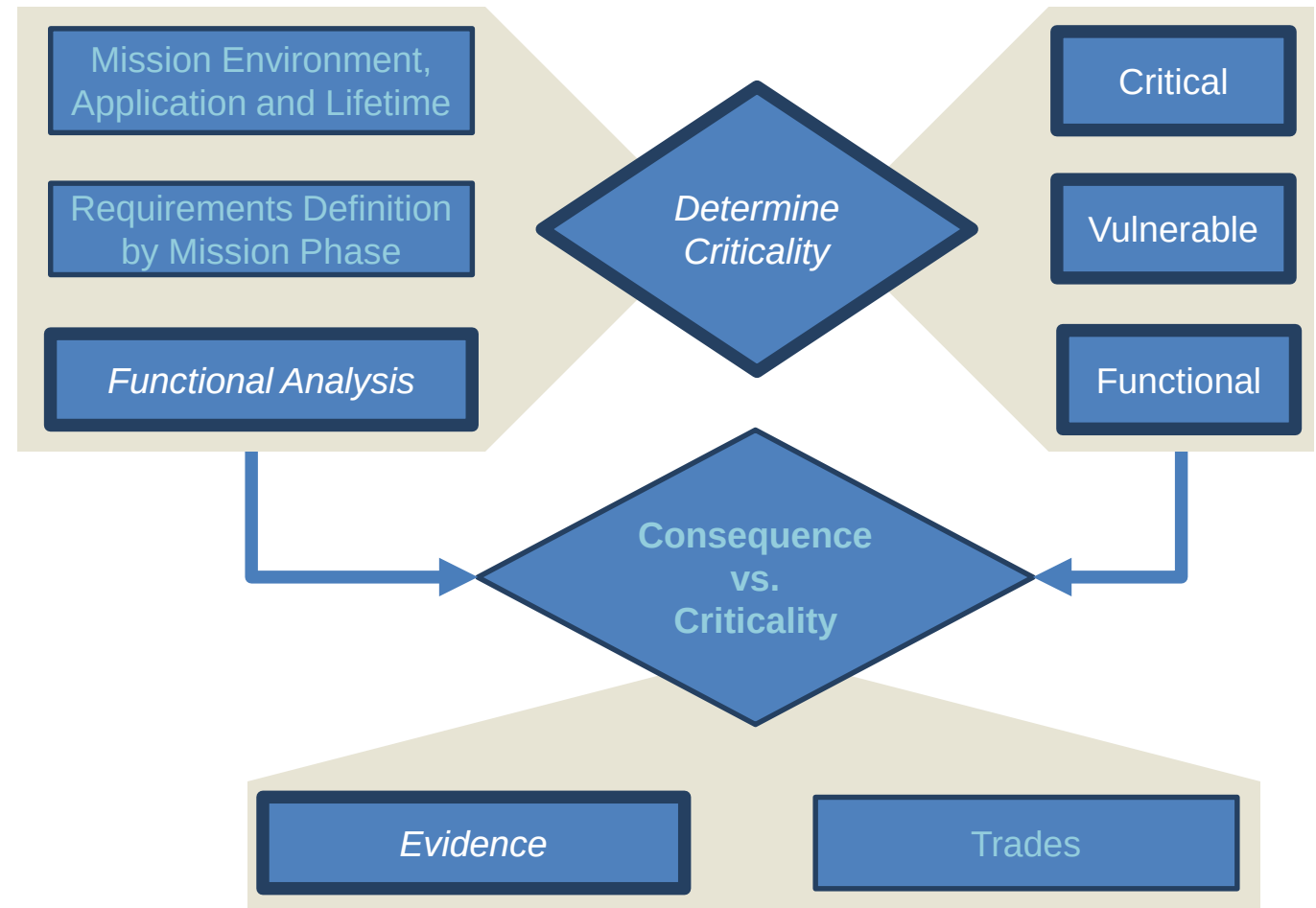
- *Knowledge of parts and failure modes*
- *Known unknowns*



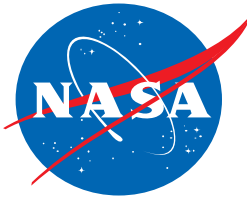


Steps for implementing SEECA: The Work

- *Functional Analysis*
 - Identify critical functions
 - Determine subsystems and components across function
- *Determine Criticality*
 - Error Critical -
 - Error Vulnerable -
 - Error Functional -
- *Evidence*
 - Test data
 - Mitigation



Steps for implementing SEECA: The Outcomes

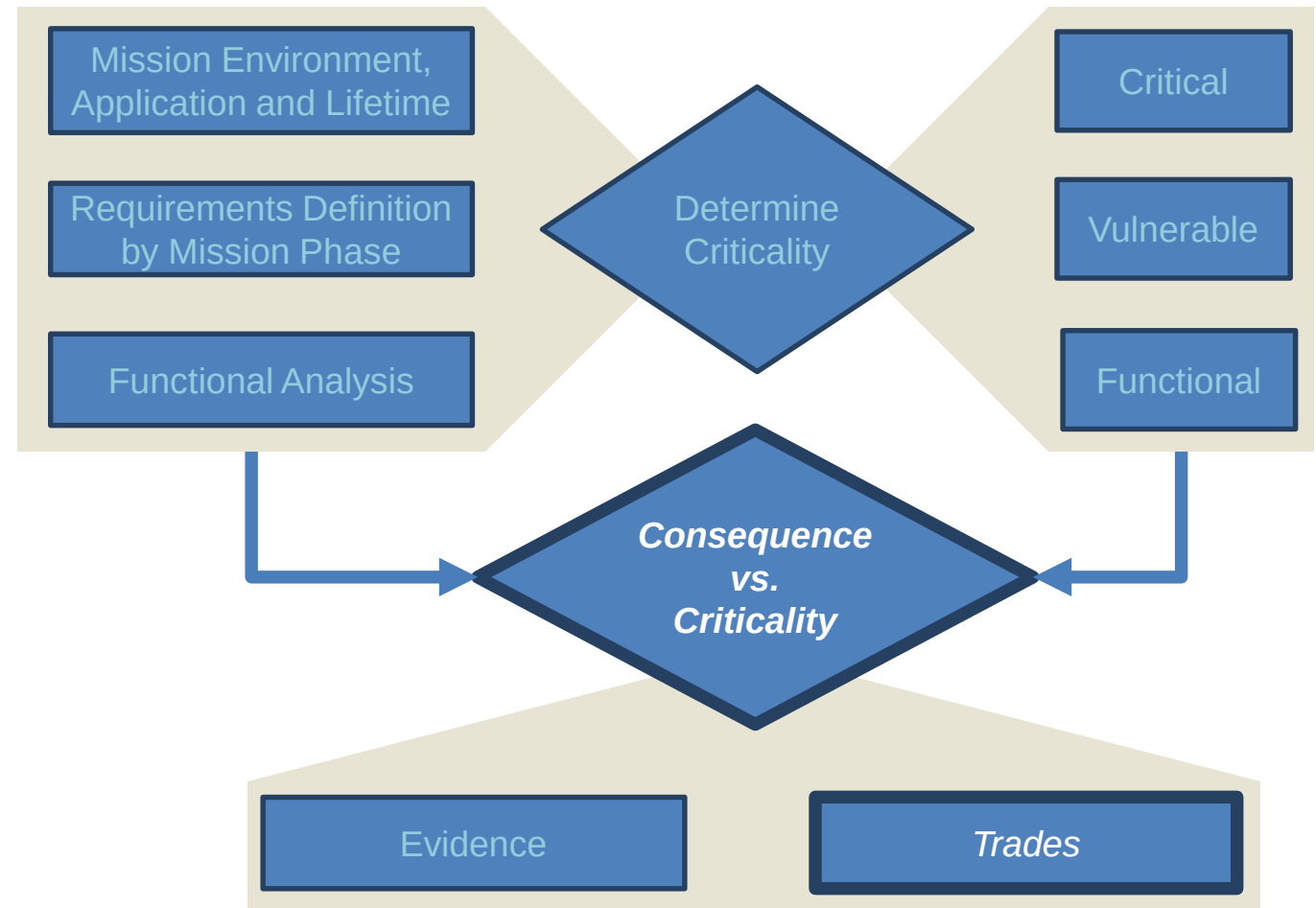


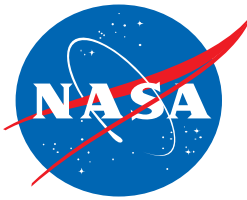
- *Consequence vs. Criticality*

- Take into account redundancy for reliability
- Assess likelihood/rate impact to availability
- Mission/Science loss
- Interventions/Interruptions
- Nuisances

- *Trades*

- Part/design change
- Accept as-is
- Mitigate
- Test





SEECA and Documentation

Analysis Requires:

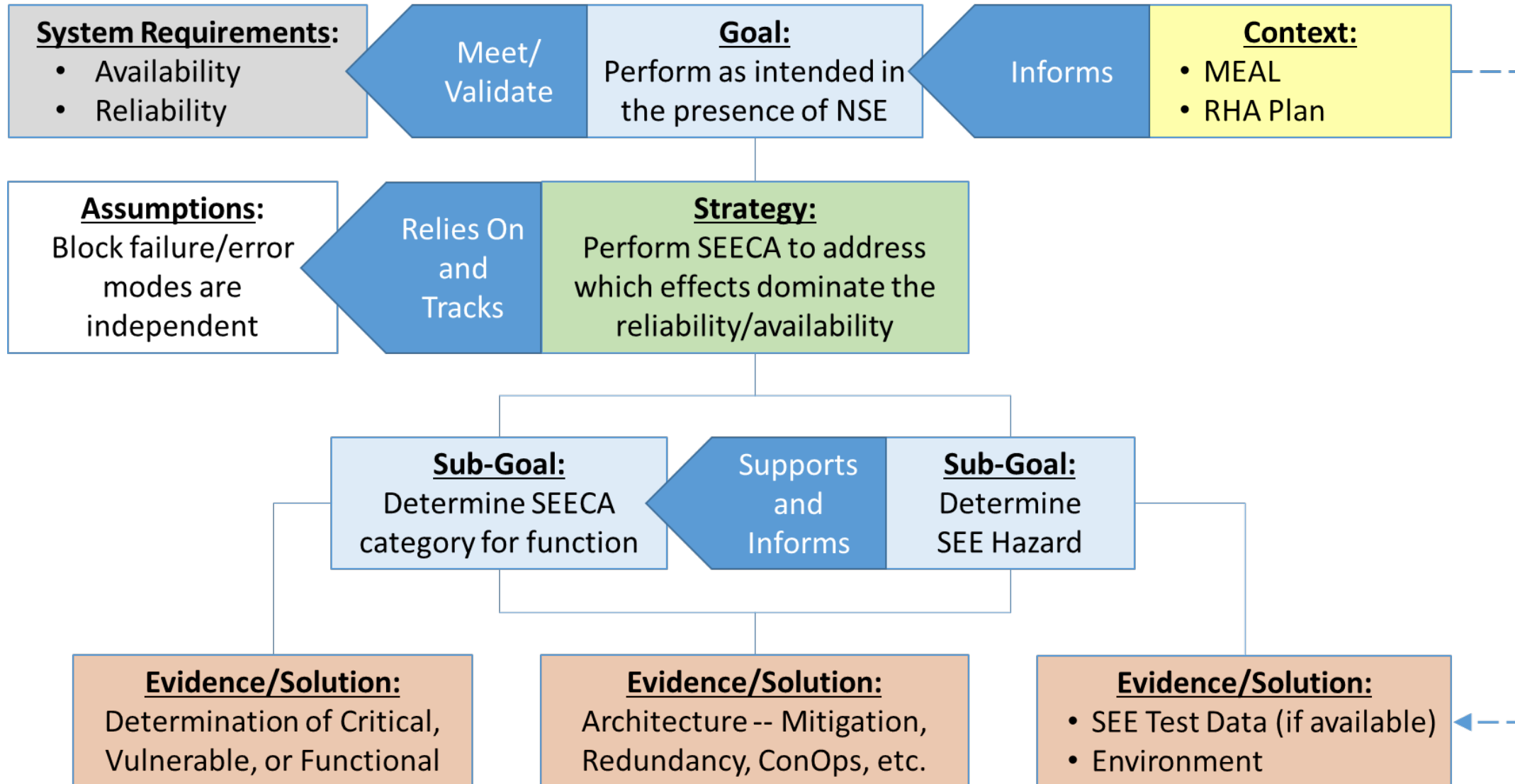
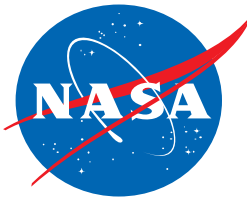
- Environment Description
 - Destination
 - Spectra
- Radiation Hardness Assurance Plan
- Concept of Operations
 - Reliability/Availability by phase
- Application information
 - Design information / Parts list
 - Worse Case Analysis

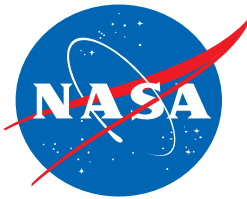
Analysis Contains:

- Categorization
 - Functional Analysis
 - Criticality vs. Consequence
- Realization
 - Rates of NDSEE where applicable
 - Likelihood of DSEE where applicable
- System-level risks

That's a lot of information to keep track of!

SEECA in the age of Goal Structuring Notation

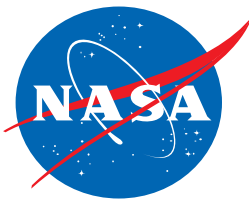




Benefits of SEECA

- Alignment with mission assurance:
 - Identifies system-level impact and dependencies
 - Tracks assumptions
- Can help translate mission requirements into radiation requirements
- Can help answer the question of “when do you *need* to test?”

Our mission goals and innovation are definitively tied to acknowledging the risks we are willing to accept



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THANK YOU