RELIABILITY ANALYSIS AND CATEGORIZING ANOMALY DATA IN SOARS DATABASE

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- Reliability Analysis
- Fault/Success Tree Analysis
- Bayesian Analysis
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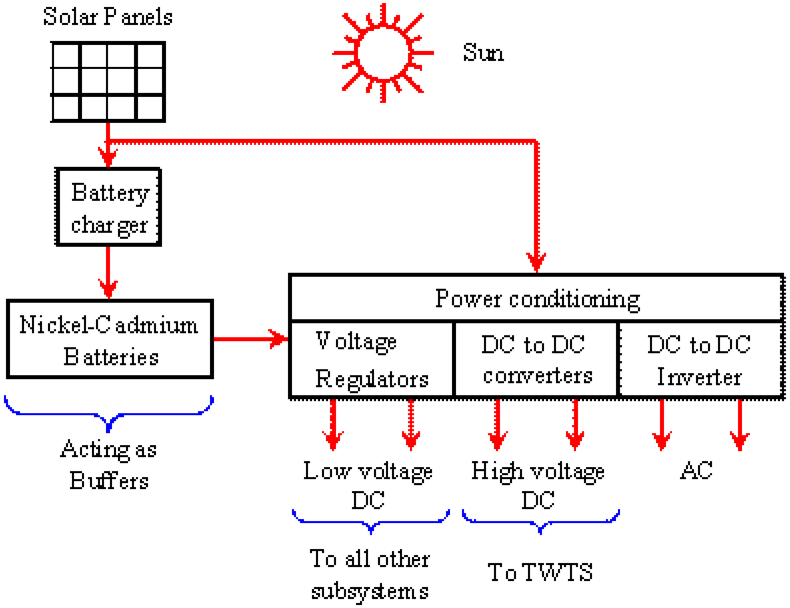
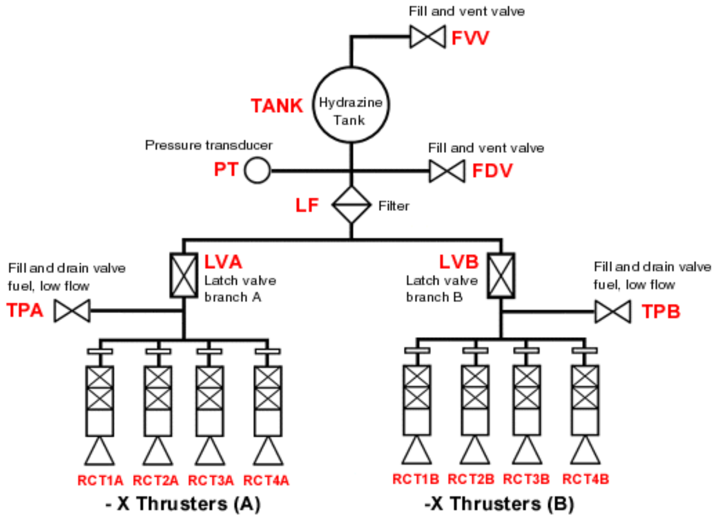
Project Background

- Due to various unsuccessful space missions, reliability analysis has become critically important.
- GSFC has recorded all spacecraft anomalies since 1972 in its Spacecraft Orbital Anomaly Report System (SOARS) database.
- Reliability and risk analysis can be enhanced by appropriately categorizing the data in the SOARS database.

Spacecraft Subsystems

- Power: Includes all energy source and storage mechanism on the spacecraft

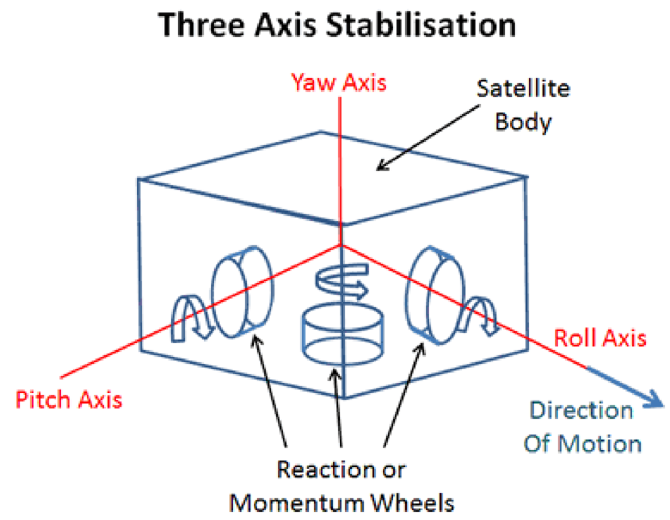




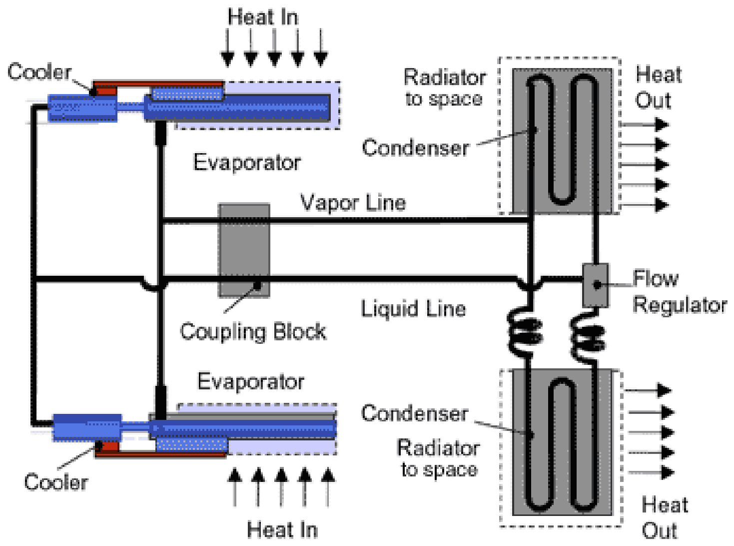
- Propulsion: Consists of the main propulsion motor (kick motor), and the propellant

Spacecraft Subsystems (cont.)

- Stabilization and Attitude Control: Ensures that the satellite does not get destabilized from its orbit and that it always points in the right direction

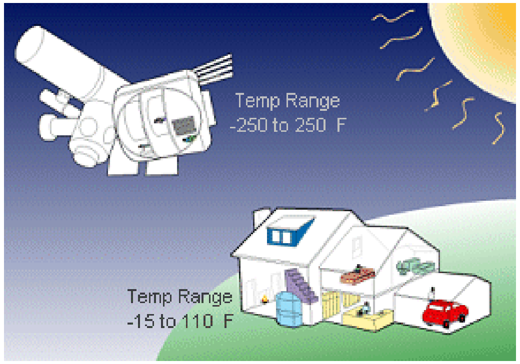


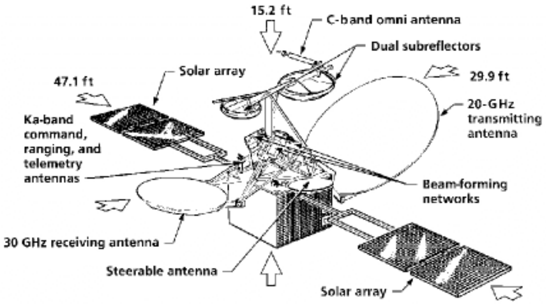
- Thermal Control: Ensures that components of satellite does not become too hot or too cold.

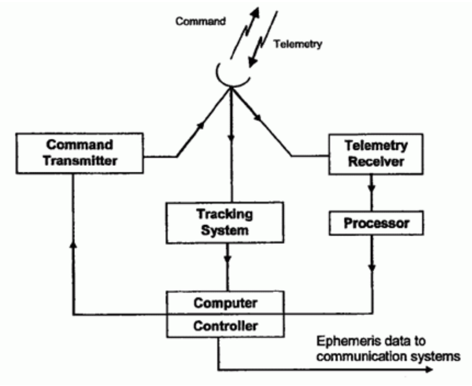


Spacecraft Subsystems (cont.)

- Environmental Control: Controls air quality, humidity, temperature, and other factors essential for survival of astronauts
- Communications: Consists of transmitters and receivers to relay data to Earth
- Telemetry, Tracking, & Command: Used to monitor and control the satellite.





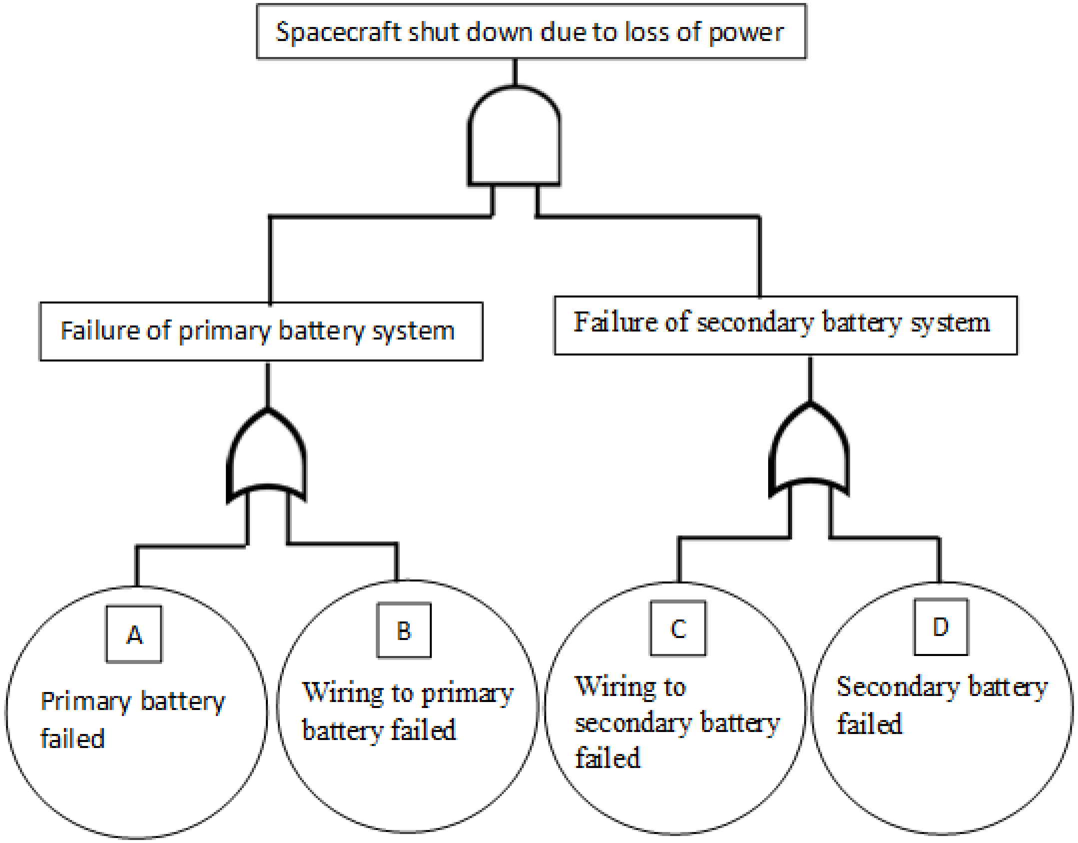


Reliability Analysis

- Used to understand how prone a spacecraft or its subsystems are to failure.
- Operational data from previous missions used to determine future performance.
- Output information used to reevaluate longevity of spacecraft and subsystems.
- Can make space missions safer and less expensive.
- Two types of reliability analysis: Fault/Success Tree Analysis and Bayesian Analysis.

Fault/Success Tree Analysis

- Enables reliability engineers to take a system failure and draw out the various events that could have led to the failure
- Provides visual representation of the method of failure, and helps determine quantitative probabilities of said failure



Bayesian Analysis

- Allows reliability analysts to determine the probability of an event happening based on observed occurrences.
- Bayes' Theorem:

Prior Probability

Likelihood of the evidence 'E' if the Hypothesis 'H' is true

$$P(H|E) = \frac{P(H) * P(E|H)}{P(E)}$$

Posterior Probability of 'H' given the evidence

Priori probability that the evidence itself is true

SOARS

- Spacecraft Orbital Anomaly Reporting System
- Spacecraft anomaly information from 1972 to present
- Details of spacecraft and anomaly as well as corrective action recorded
- Used for reliability analysis at Goddard Space Flight Center


GSFC SPACECRAFT ORBITAL ANOMALY REPORT (SOAR)

Section 1. (To be completed by originator)

1. SOAR No. B-0142

1A. PROJECT NO. (OPTIONAL)

2. SPACECRAFT 3. SUB-SYSTEM OR INSTRUMENT 4. ANOMALY DATE GMT JDAY

5. COMPONENT Name Code ID Number Serial# Manufacturer

6. ASSEMBLY Name ID Number Serial # Manufacturer

7A. REV. NO. 7B. LAT. 7C. LONG. 7D. A/D 7E. S/D 7F. LOCAL TIME 8. DAYS OPERATION (Since Launch)

9. ANOMALY DESCRIPTION:

10. ADDITIONAL COMMENTS:

11. ORIGINATOR 12. NASA/GOVERNMENT REPRESENTATIVE

SECTION 2. (To be completed by responsible person)

13. CAUSE OF ANOMALY:

14. CORRECTIVE ACTION

15. MISSION EFFECT 16. ANOMALY EFFECT 17. FAILURE CATEGORY 18. TYPE OF ANOMALY

19. ACTION TO BE TAKEN ON FOLLOW-ON S/C

20. REFERENCE DOCUMENT(S) ID:

21. RESPONSIBLE PERSON 22. NASA/GOVERNMENT REPRESENTATIVE

23. FAM OR SOAR SYSTEM MGR. 24. CLOSE-OUT: ENTER CLOSURE DATE

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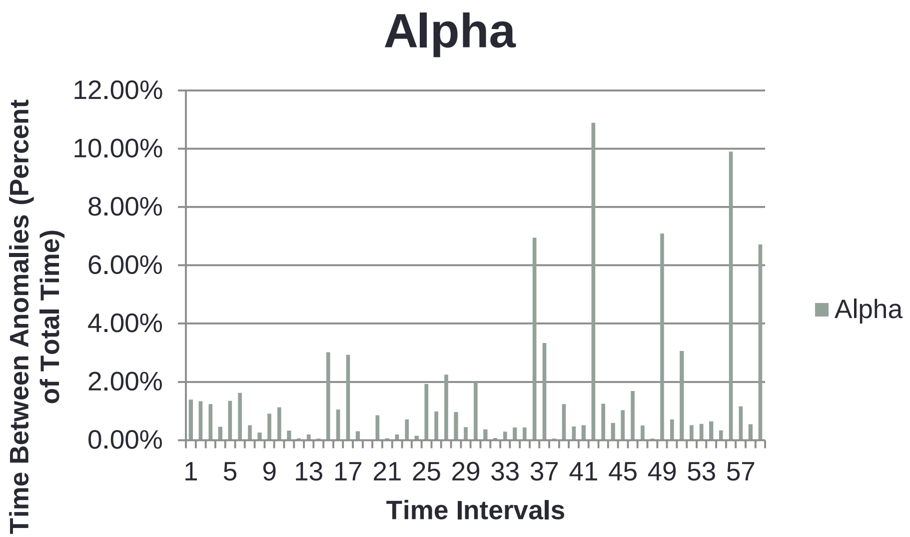
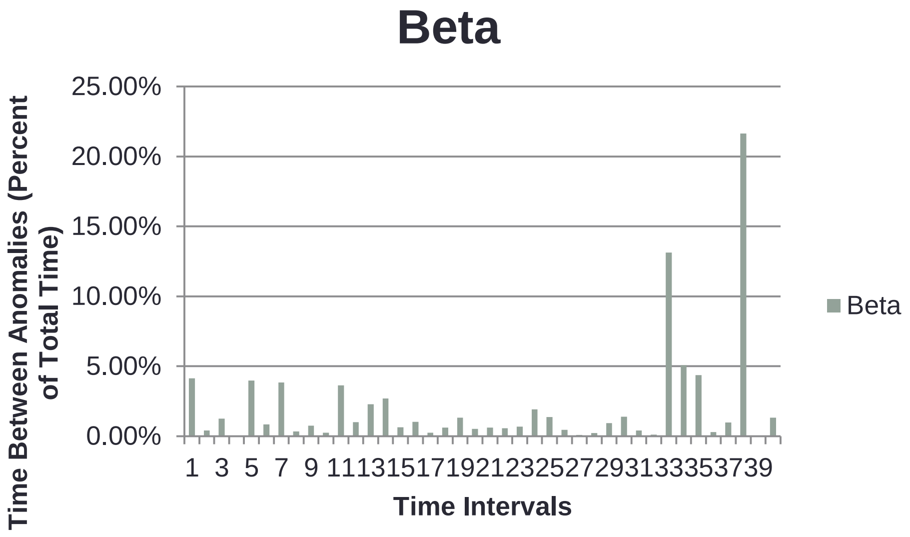
Research Project

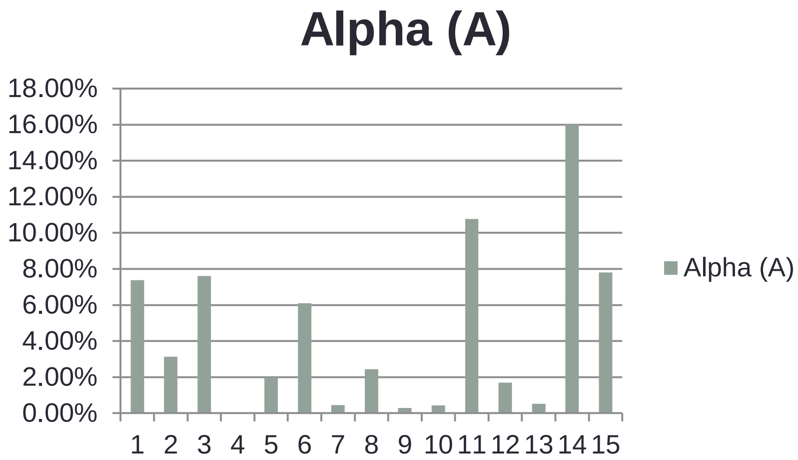
- Analyze SOARS data
- Categorize data in different ways
- Create visuals of reliability data
- Compare with expected results

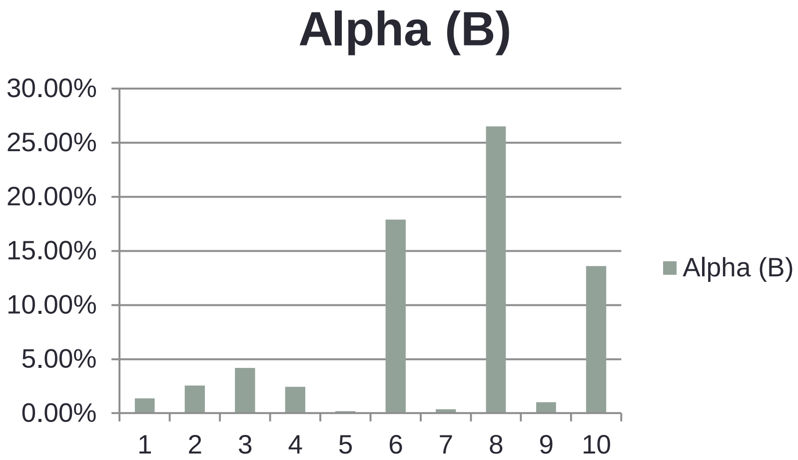
Spacecraft Anomaly

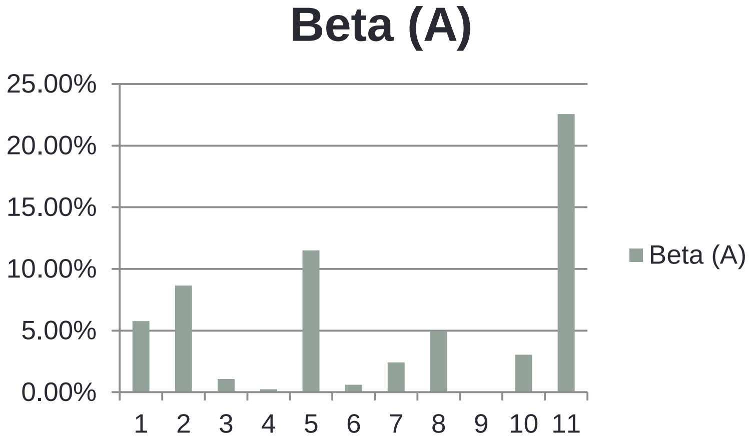


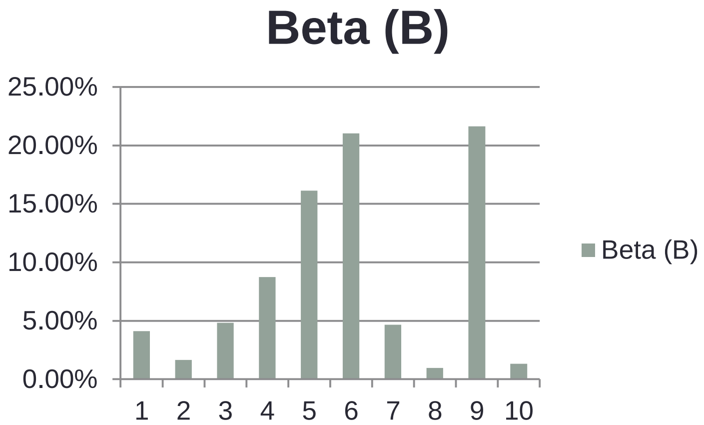


Subsystem Anomaly

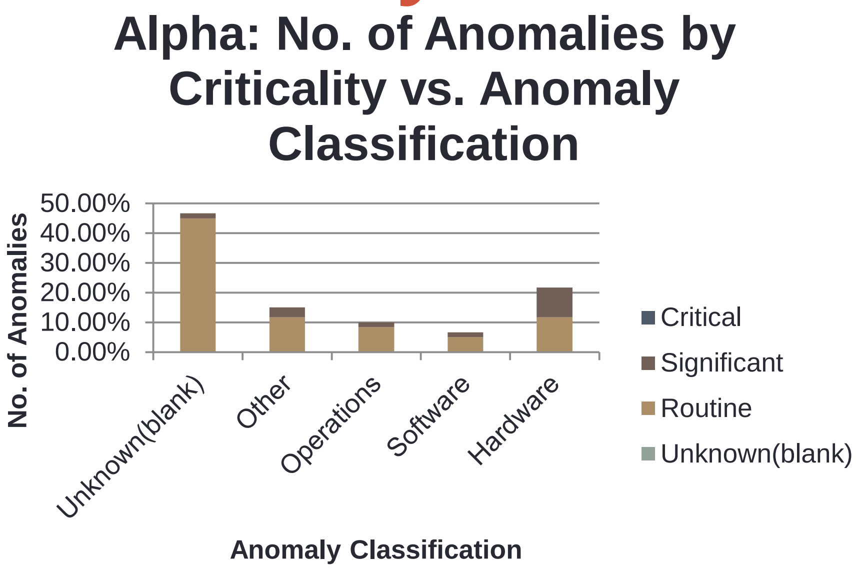


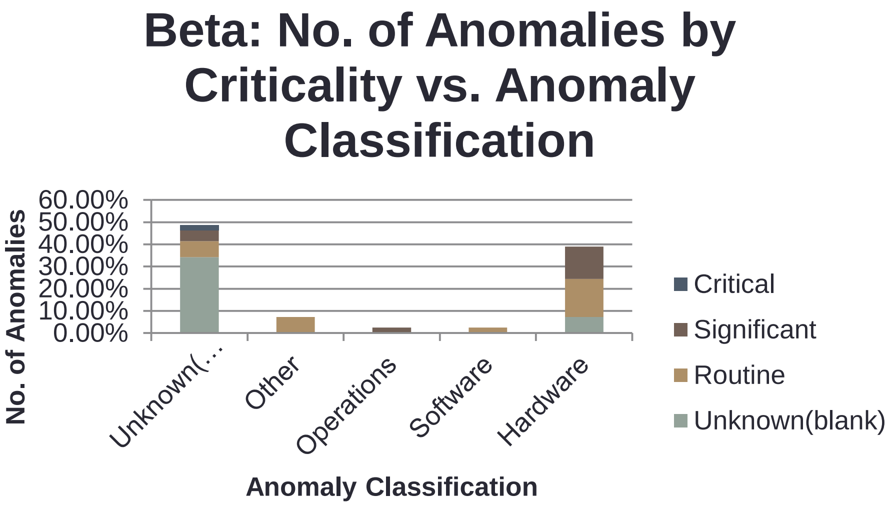




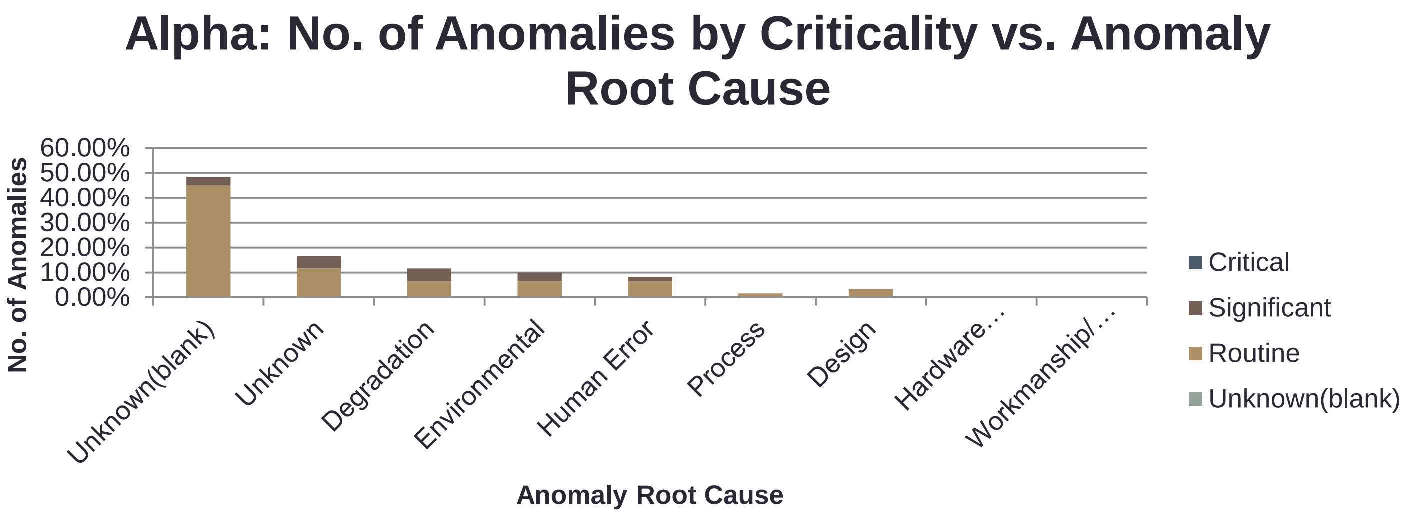


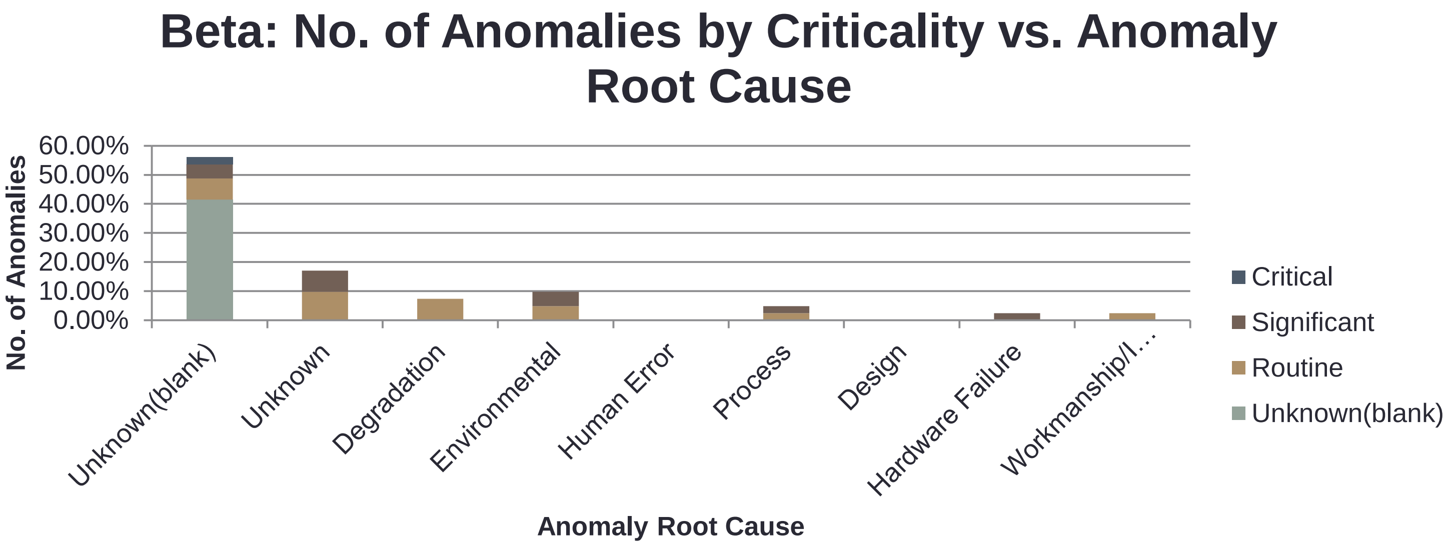
Anomaly Causes



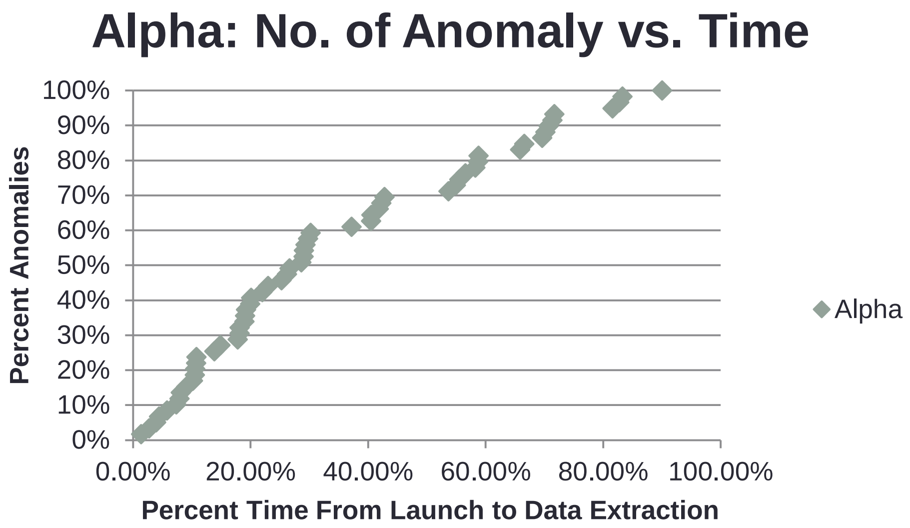


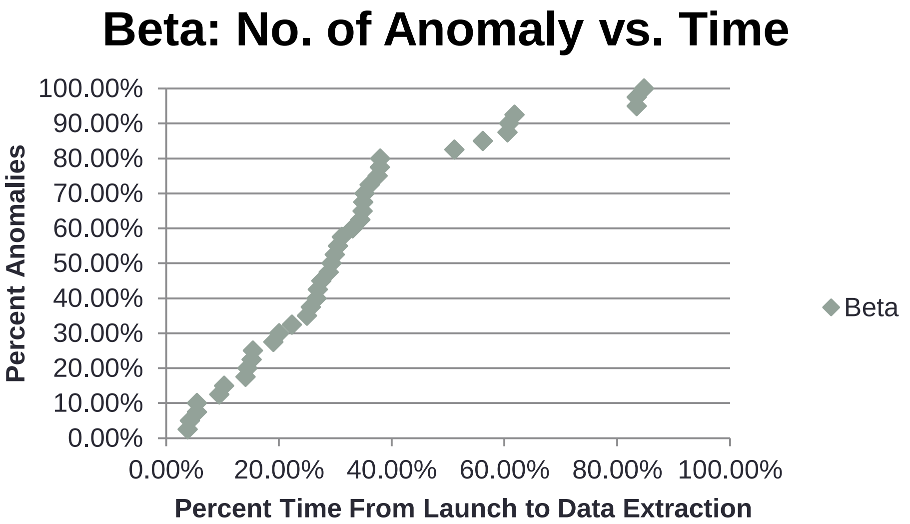
Anomaly Cause (cont.)



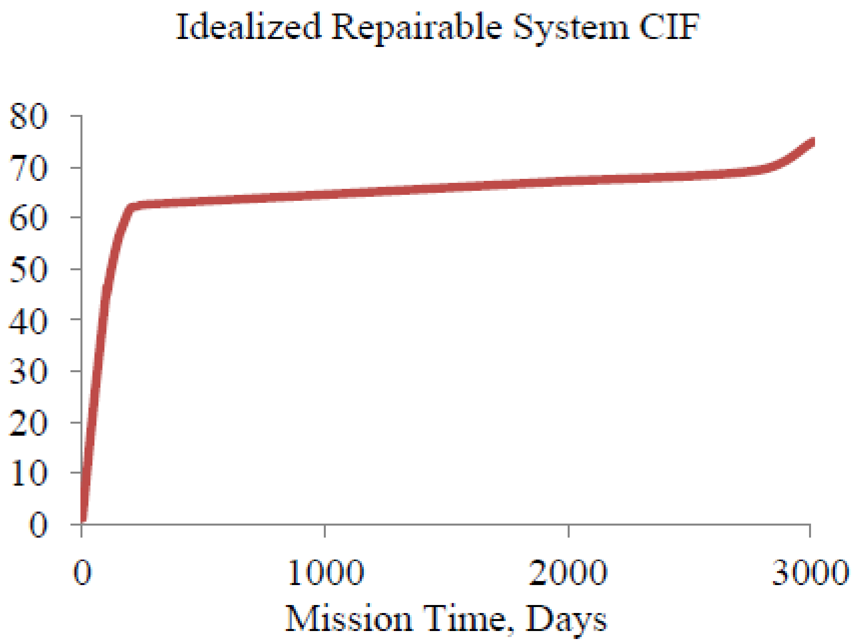


Anomaly vs. Time





Anomaly vs. Time (cont.)



Future Goals

- Investigate anomalies using Fault Tree to find reliability of individual components
- Use Bayesian Analysis to update reliability data using anomaly data in SOARS

Acknowledgment

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- Dr. Mary Bowden, UMCP

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