RELIABILITY ANALYSIS AND CATEGORIZING ANOMALY DATA IN SOARS DATABASE

Tousif Khan, Undergraduate Student, UMCP
Susan Hinmon, Graduate Student, MSU
Dr. Guangming Chen, PI, MSU
Outline

• Project Background
• Spacecraft Subsystems
• Reliability Analysis
• Fault/Success Tree Analysis
• Bayesian Analysis
• Spacecraft Orbital Anomaly Report System (SOARS)
• Research Project
• Graphs of Data
• Future Goals
• Acknowledgements
• References
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:

\[
P(H|E') = \frac{P(H) \times P(E|H)}{P(E)}
\]

- Prior Probability
- Likelihood of the evidence ‘E’
- if the Hypothesis ‘H’ is true
- 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
Research Project

• Analyze SOARS data
• Categorize data in different ways
• Create visuals of reliability data
• Compare with expected results
Spacecraft Anomaly

Alpha

Time Intervals

Beta

Time Intervals
Subsystem Anomaly

Alpha (A)

Beta (A)

Alpha (B)

Beta (B)
Anomaly Causes

Alpha: No. of Anomalies by Criticality vs. Anomaly Classification

Beta: No. of Anomalies by Criticality vs. Anomaly Classification
Anomaly Cause (cont.)

**Alpha: No. of Anomalies by Criticality vs. Anomaly Root Cause**

**Beta: No. of Anomalies by Criticality vs. Anomaly Root Cause**
Anomaly vs. Time

**Alpha: No. of Anomaly vs. Time**

Percent Anomalies

Percent Time From Launch to Data Extraction

**Beta: No. of Anomaly vs. Time**

Percent Anomalies

Percent Time From Launch to Data Extraction
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

• Dr. Guangming Chen – Project PI; Graduate Program Coordinator and Director of SEMI, Department of Industrial Engineering, Morgan State University (MSU)
• Mr. Luis Gallo – Project Co-PI; Aerospace Engineer, Reliability and Risk Analysis, Goddard Space Flight Center (GSFC)
• Dr. Anthony Diventi – Project Co-PI; Branch Chief, Reliability and Risk Analysis, Goddard Space Flight Center (GSFC)
• Maryland Space Grant Consortium
• Dr. Mary Bowden, UMCP
References


