National Aeronautics and Space Administration

Soft Factors & Space Mission Failures

Quantifying the Effect of Management Decisions

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Where Did We Start?

- Command File Errors
  - Formal Definition:
    - One of the following regardless of the effect on the spacecraft:
      - An error in a command file that was sent to the spacecraft
      - An error in the approval, processing, or unlinking of a command file that was sent to the spacecraft
      - The omission of a command file that should have been sent to the spacecraft
- Management's Influence in Errors
  - Lack of knowledge of trajectory uncertainty
  - Led to decision to cancel final maneuver

Why?

Several instances of root cause analysis for the reasons that operators make mistakes or slips led us to management and organizational factors

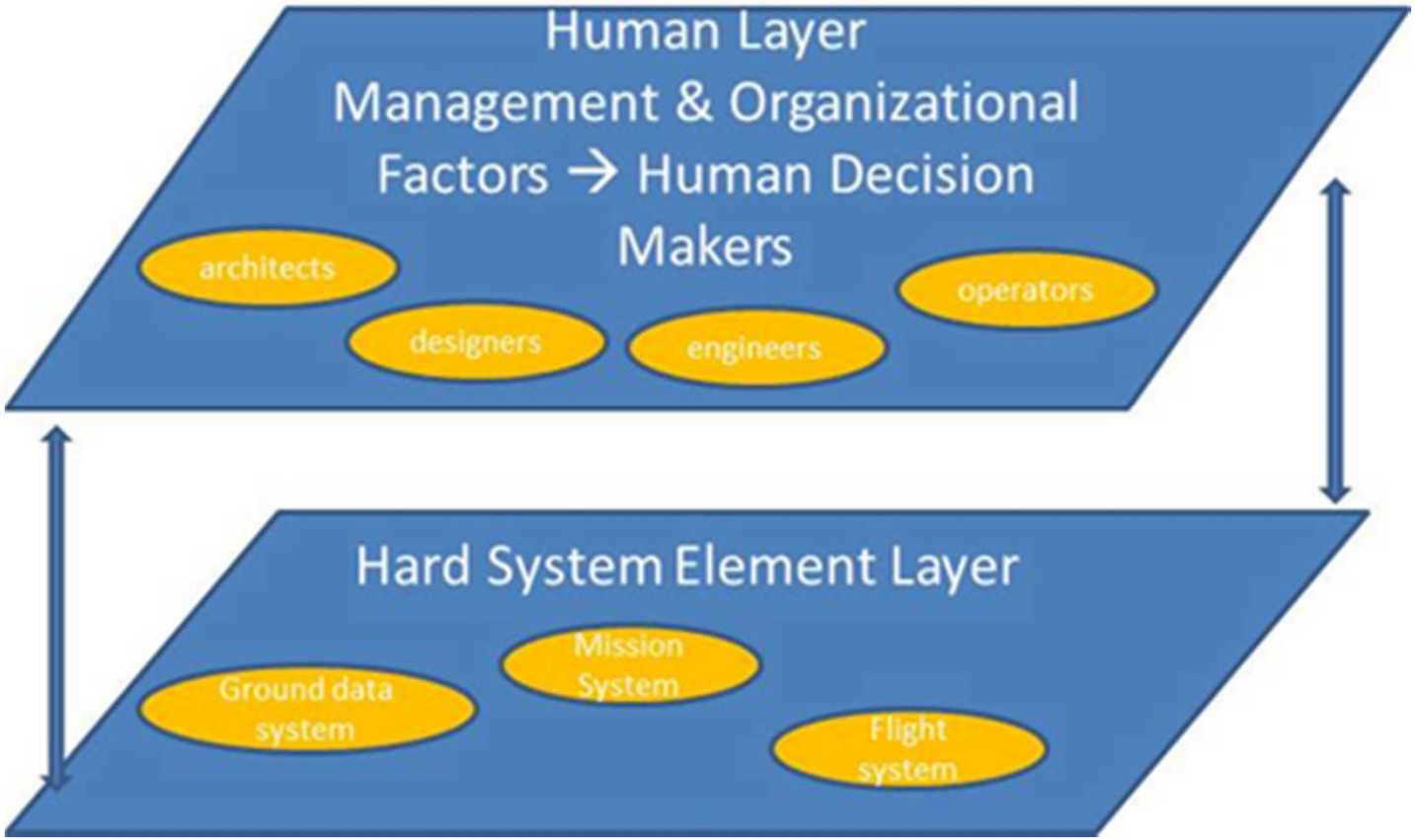
- Decisions regarding the infrastructure in which the command files are generated and radiated
- Factors that affect the choices of operators and their state of mind and levels of stress

The Foundation

- Theoretical Underpinnings
  - Considered models for decision making under different circumstances
  - Several human reliability analysis methods
- JPL Experiences
  - CloudSat CFE threatened power management for surviveability
  - Unanticipated interaction between two memory loads on Dawn resulted in safemode

The How

Premise: two parallel and connected layers involved in space mission design, development and operations



The How

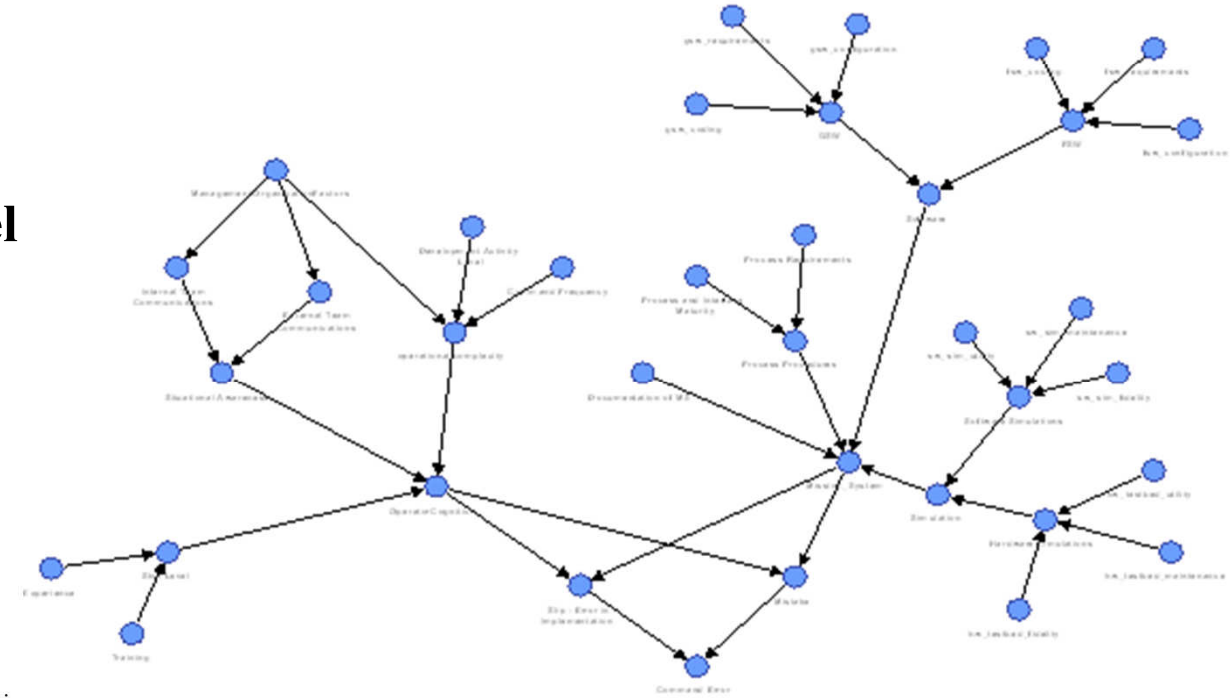
- Conducted forensic studies of reports on mission failures

Space Mission	Mission #1	Mission #2	Asteroid Mission	Orbital Mission
Status	Failed	Failed	Success	Success
Driving Factors - Soft	Inadequate staffing, inadequate team communications, inadequate training, inadequate transfer process between project phases.	Inadequate staffing; excessive overtime; insufficient systems engineering; unusual (un-tested) management processes;	Management with operational experience, good inter and intra team communication, dedicated systems engineering support,	Management with operational experience, good inter and intra team communication, dedicated systems engineering support,
Corresponding Model Elements	External Communications, Management/Organizational Factors, Skill levels, situational awareness.	External Communications; Staffing (Training, etc.), internal and external communications; situational awareness.	Management/organizational factors	Management/organizational factors
Probability of CFE	significant	significant	mostly insignificant	mostly insignificant

The How

- Causal and Probabilistic Modeling

Abstract Model



Bayesian Belief Network w/Probabilities

The Future

- Soft factors play an enormous role in mission success or failure.
- Possible to use quantitative modeling techniques to make informed decisions regarding risk related to command file errors
- Future directions:
  - Calibrate models, customize & exercise on forensic case studies to improve the CFE rates
  - enhance the management and organizational factors sub-model to account for qualities of successful management

Thank You

- Without the cooperation, involvement and support of the Dawn, Juno, MRO, and Spitzer projects, these studies and model development would not have been possible.
- The foundational work in studying and analyzing command file errors has been led for over a decade by Kyle Martin (LMSS) and Grant Faris (JPL OSMS)