Risk Management of Student-run, Small Satellite Programs

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Overview

- What is Risk Management?
- Motivation
- My Preliminary Goal
- Risk Items Unique to Small Satellites
- Suggestions to Reduce Risk
- Master Logic Diagram
- Future Plans

What is Risk Management?

- Risk
  - "A factor, thing, element, or course involving uncertain danger; a hazard."[1]
- Risk Management Process
  - Identify issues that may be potential pitfalls
  - Create and implement a plan to mitigate risks
  - Monitor and update risks and risk status

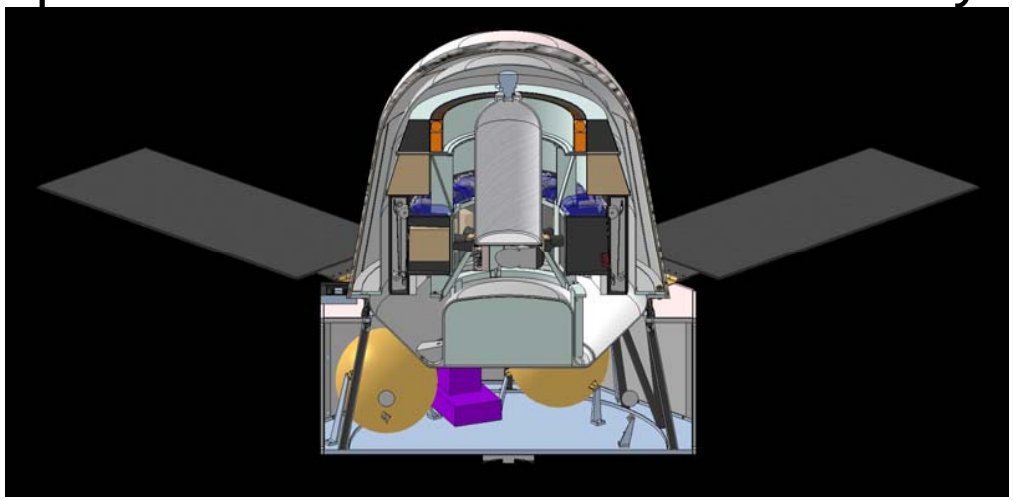
Why Use Risk Management?

- Focus on mission success and safety
- Identify problems early -> design changes, better allocation of resources
- Teach all steps of the engineering process
- Learn to resolve technical & managerial problems

http://www.sondrenorheim.com/images2/E03.jpg

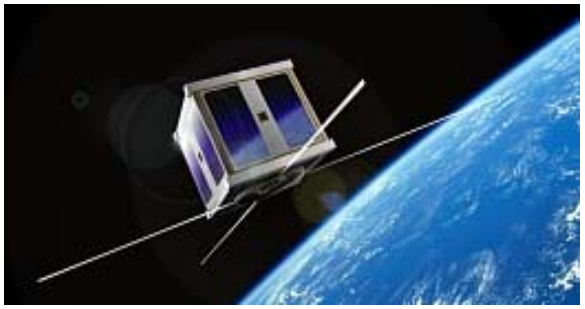
Motivation

- Asked by Mars Gravity Biosatellite to do risk management
- Started with bad end states and worked from there
- Noticed process was time consuming and not necessarily complete
- Tried looking through industry and university examples
- Realized no consistent way
  - Many people interested in a more uniform way to identify risk



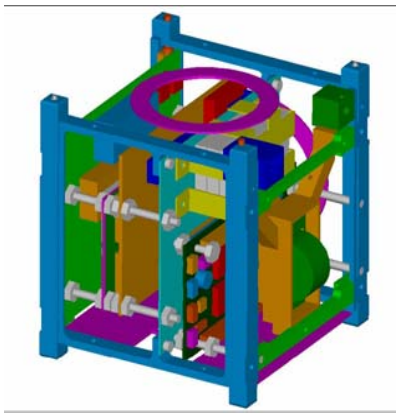
Risk Management for Student-run, Small Satellite Programs

- Objective:
  - Identify unique risks
  - Develop a risk identification approach for university-affiliated, small satellite programs
- Outcome:
  - Created Master Logic Diagram (MLD) for small satellites
    - Helps identify all potential levels of failures



www.cubesat.auc.dk/

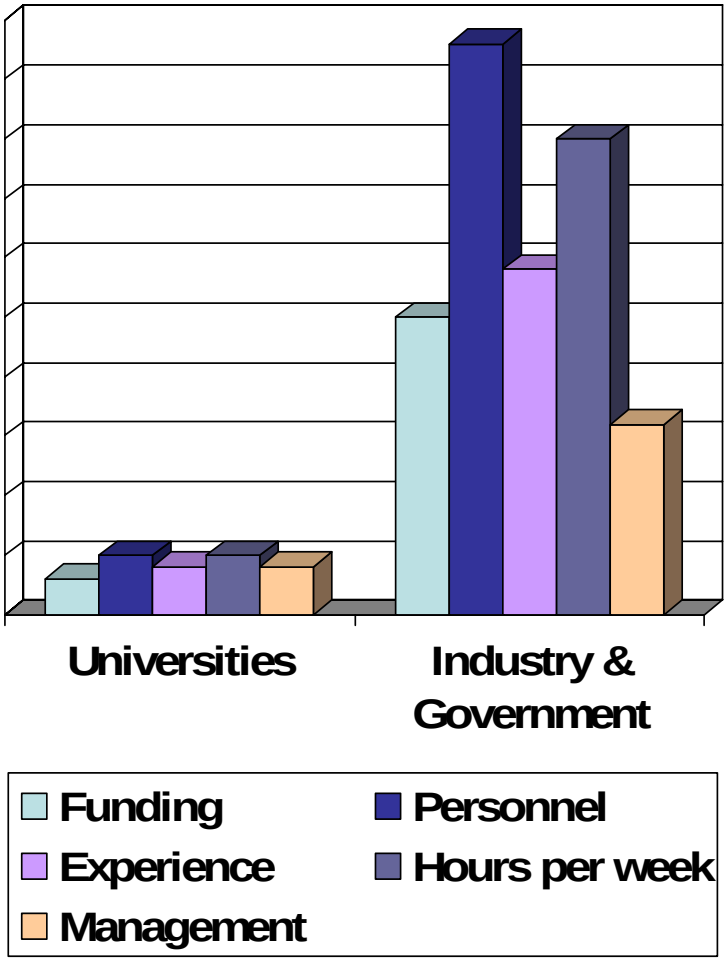
http://www.daviddarling.info/



http://www.mae.cornell.edu/cubesat

Risk Items Unique to Small Satellites

- Fundamental elements of satellite programs at commercial businesses or government programs are similar to those found at universities
- Universities normally have “less” of all major resources
- Risk poses different threats to university-based programs than to industry projects



Risk Items, cont'd

- Obtaining Support
  - Little to no money to pay staff
  - Funding needed to attract graduate students
  - Funding affects every aspect of satellite design

- Competition Against Non-Universities
  - Must have sufficient risk mitigation strategies in place to give better-than-expected results
  - New satellite programs have higher risk

- Funding Affects Schedule
  - Many are secondary payloads on a launch vehicle
    - Ties development to that of the available primary object launches

Risk Items, cont'd

Experience

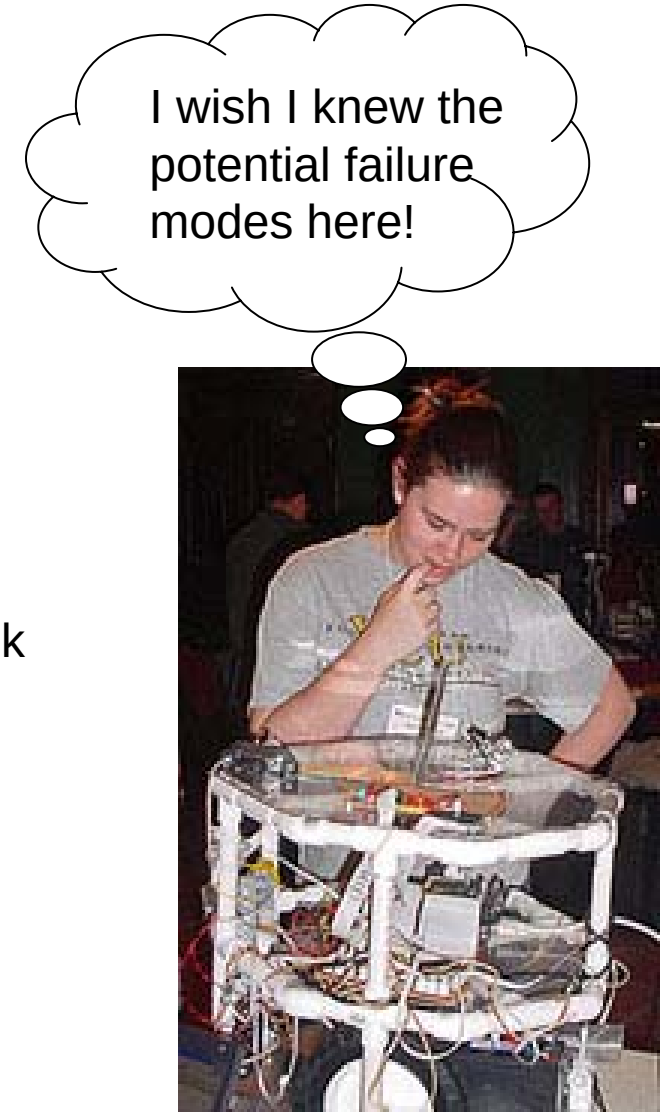
- Little experience to
  - Design well
  - Identify risks
  - Suggest mitigation strategies
- Learning curve eats a lot of time

Schedule

- Schedules linked to money, personnel, and resources
- Number of hours available to work varies each week
- Hard to determine:
  - How long it will take to complete a certain task
  - How many jobs can be done in a given amount of time

Follow-Through

- Take ownership of the entire project
- Information must be handed over
- Schedule time to maintain proper records

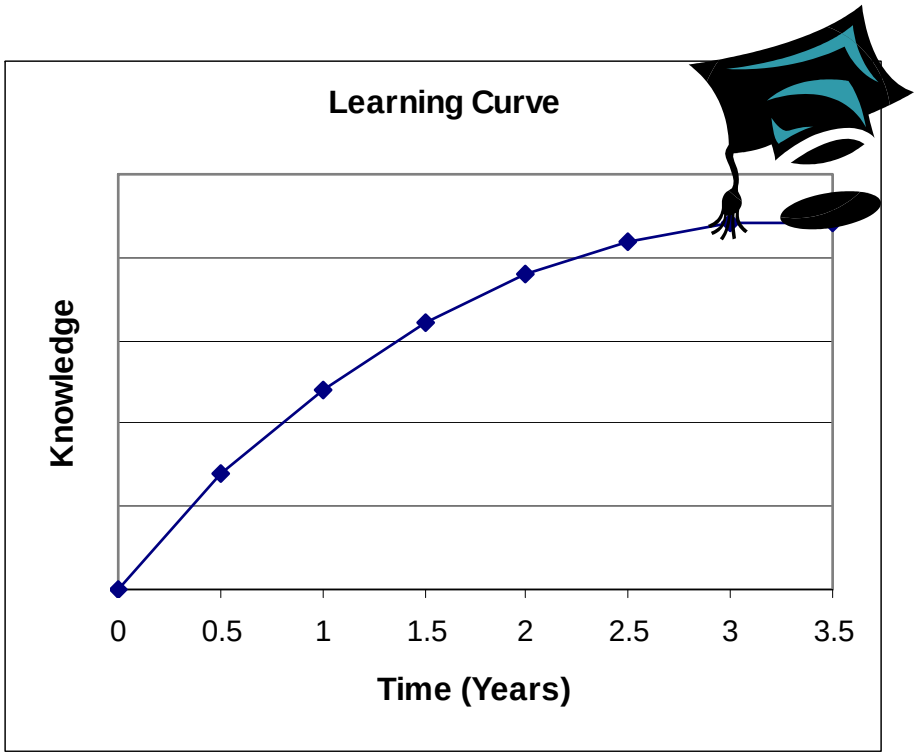


http://www.egr.vcu.edu/images/ece/announcements/ece-ieee_se_conf_sm.jpg

Risk Items, cont'd

Staff

- Students Are Students
  - Students must focus on classes
  - Hard to form a team with all the required skills
  - Difficult to find PhD students to work on small satellite projects
- Turnover
  - Difficult to keep stability in a project
  - Master learning curve close to graduation
- Single-String Workers
  - Delay if a person leaves unexpectedly
  - Large learning curve/hand-off time
- Class Projects
  - Short class timeframes lead to one of the following:
    - Short development and production time
    - Project given to an entirely new workforce
    - Unfinished project

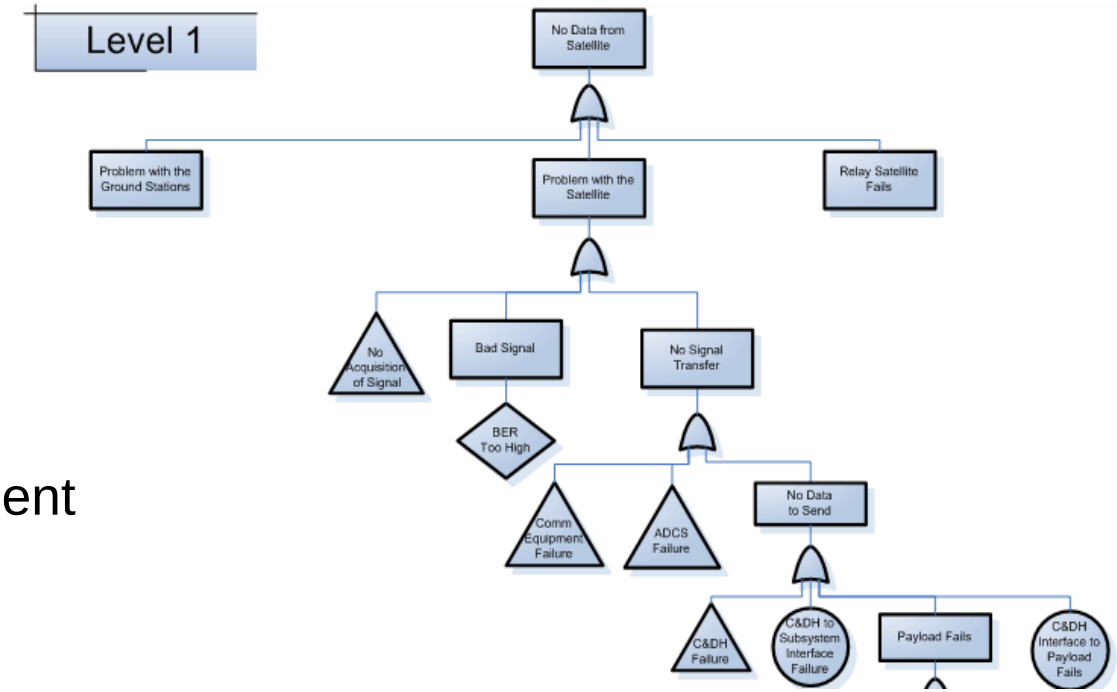


Suggestions to Reduce Risk

- Apply well-defined procedures
- Use consistent documentation
- Use configuration management
- Maintain a de-scope plan
- Focus on personnel management
  - Train and recruit new members continually
  - Hire a core group of people
  - Retain undergraduates to stay for graduate school
- Concentrate on critical items when school workload is lower
- Use hardware with flight-heritage
- Allow multiple releases based on tiered requirements
- Share information on lessons learned, probabilities of failure, high risk areas, etc.
- Focus on risks preventing the completion of a milestone
- Ensure all personnel are aware of failure modes throughout the program
- Train to Identify Risk
  - Use application-based training or academic classes
  - Create a database of failures that can serve as a reference to help identify risk

Master Logic Diagram Overview

- Different tools can be used for the multiple stages of risk management
- A few common techniques
  - Event tree analysis
  - Fault tree analysis
  - Probabilistic risk assessment
  - Master logic diagrams
- An MLD ~= High-level fault tree
- The structure of the tree shows different levels of failures
  - Top Level: Critical end states (faults of the system)
  - Intermediate Levels: Subsystem failures
  - Lower Levels: Component errors & the initiating events

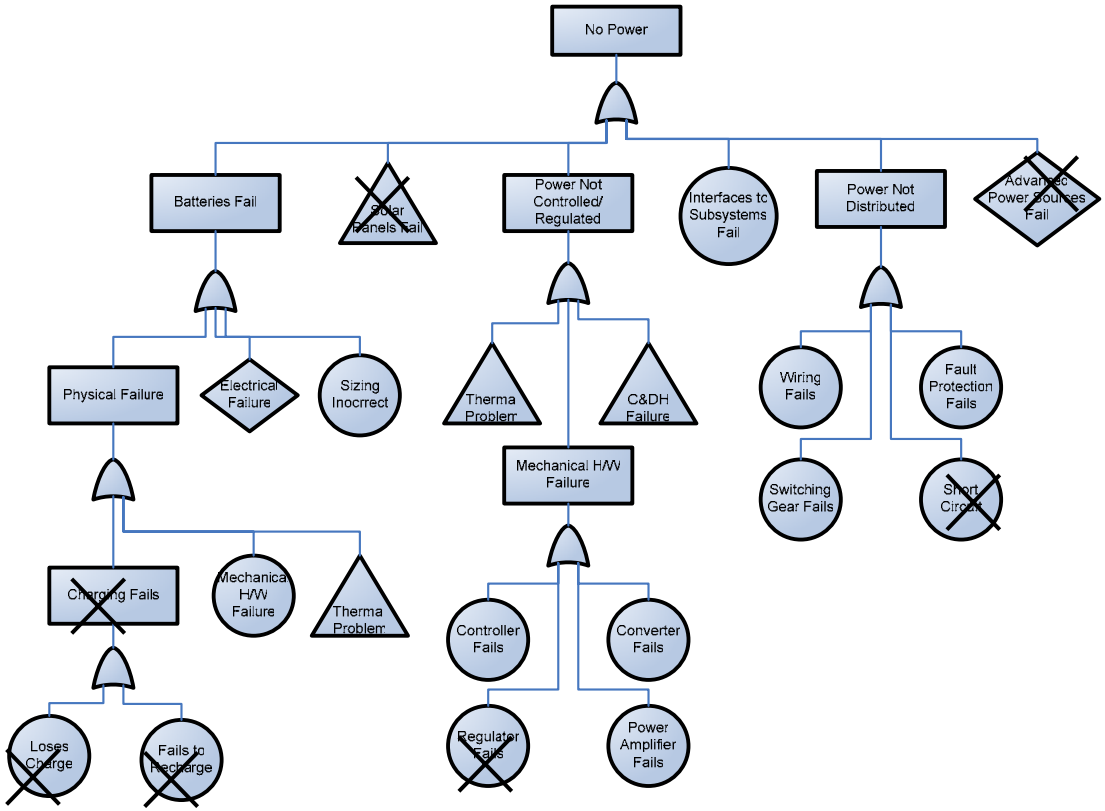


Creating an MLD

- To create the MLD, end states must be identified first
  - Ask “What could be observed?”
    - Example: Bad end state: No data from the satellite
      Observable reason: Problem with the ground station
- Outline potential reasons for the failure at the next lower level
  - Continue process, expanding the tree until basic failures identified
- MLD is complete when breaking down a component leads to the same response as the next higher level

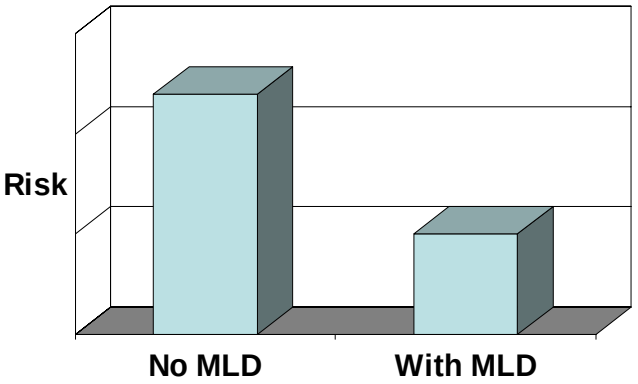
Development of an MLD for Small Satellites

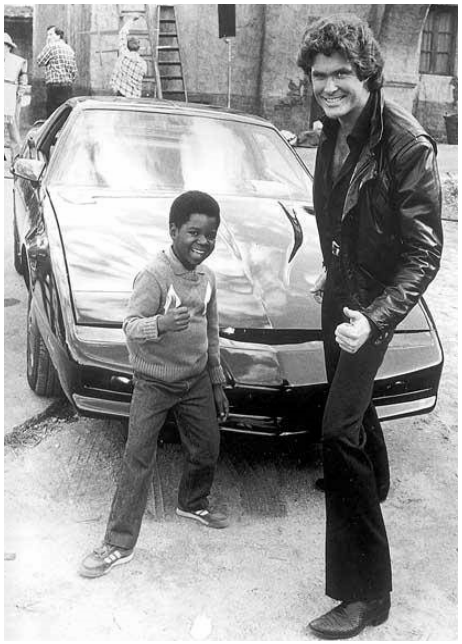
- Why an MLD?
  - Student-run small satellite programs need more guidance
  - Help from an outline of all risks relating to small satellites
- Uses of an MLD
  - Beginning a Design
    - See the types of risks
    - Plan resources
  - Working with a Design
    - Choose what parts of the MLD are needed
    - Result: MLD for the project



Benefits of Using the MLD

- Programmatic differences
  - Provides a structured risk identification format
- Funding and Schedule
  - Funding source likely requires the program to identify risks, and the MLD will help do so
  - Identify high-risk areas, and give them more resources
- Experience
  - Reduces the risk that students have less experience
  - Provides a bigger picture of the risks facing the satellite
    - Decreases students' learning curve
    - Increases knowledge of the entire system
- Follow-through
  - Gives a better way to document risk
    - Easier to communicate failure modes
  - Sharing between schools easier with a consistent layout





http://kevinremde.members.winisp.net/

Master Logic Diagram

http://web.mit.edu/edeems/www

Future Plans

Goals:

- Receive feedback from other satellite programs
  - Help make this tool more comprehensive and helpful
- Share newer versions with the entire small satellite community
  - Utilize this risk template in small satellite programs
  - Share information between schools
- Experiment to test whether this technique reduces risk

Website: http://web.mit.edu/edeems/www/

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References

1. Pickett, Joe (ed.), The American Heritage Dictionary: Fourth Edition, Houghton Mifflin Company, Boston, 2000.
2. Gilbert, M G, “A systems management approach to improving performance and reducing risks in research projects and programs,” 2002 IEEE Aerospace Conference Proceedings, vol. 7, p. 7-3469, Big Sky, MT, March 2002.
3. Michael V. Frank, “Step-by-Step Through a PRA ,” Safe, Reliable, Affordable Technology Papers, November 22, 2005, <http://www.safetyfactorassociates.com/>
4. Larson, Wiley J., and James R. Wertz, Space Mission Analysis and Design, 3rd edition, El Segundo, CA: Microcosm Press, 1999.

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Questions?

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