Risk Management of Student-run, Small Satellite Programs

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August 16, 2006

What is Risk Management?

- Risk
  - "A factor, thing, element, or course involving uncertain danger; a hazard." (m-w.com)
- 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

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

Risk Items Unique to Small Satellites

Overall

- Fundamental elements of satellite programs in industry ~= those found at universities
  - Universities normally have "less" of all major resources
- Risk poses different threats to university-based programs than to industry projects

Experience

- Little experience to:
  - Design well
  - Identify risks
  - Suggest mitigation strategies

Schedule

- Schedules linked to money, personnel, and resources

Follow-Through

- Plan handover of information

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Risk Items, cont'd

Funding

- Obtaining support
- Competition against non-universities
- Funding affects schedule

Staff

- Students are students
  - Other obligations
  - Learning curve
- Turnover
- Single-string workers
  - Delay if a person leaves unexpectedly
- Class projects
  - Short class timeframes lead to one of the following:
    - Short development & production time
    - Handover to entirely new workforce
    - Unfinished project

Learning Curve

Knowledge vs. Time (Years)
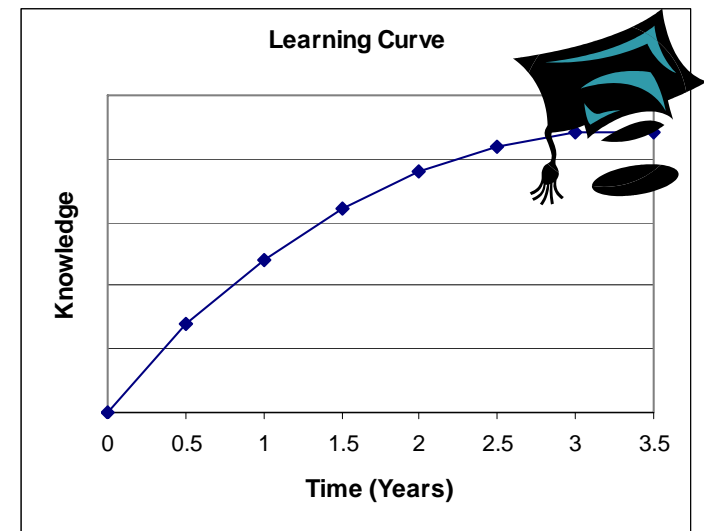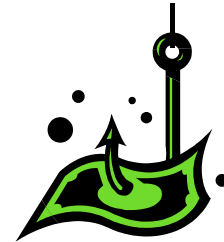
Risk Management for Student-run, Small Satellite Programs

- Main objective:
  - Develop an approach to identify failure modes in university-affiliated, small satellite programs

- Outcome:
  - Created Master Logic Diagram (MLD) for small satellites
   - Helps identify all potential levels of failures

I wish I knew the potential failure modes here!
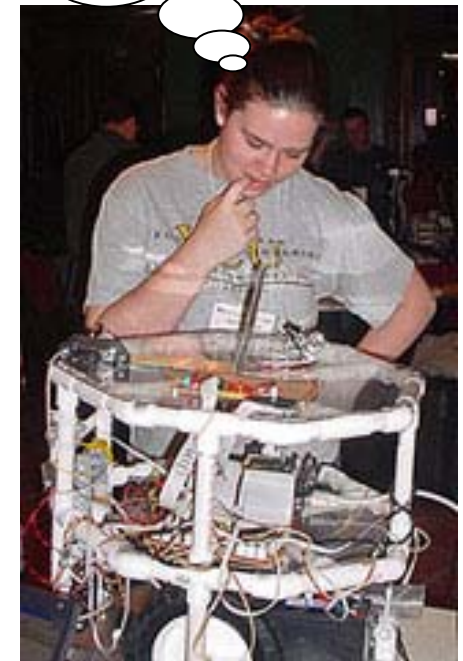
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Master Logic Diagram Overview

- 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
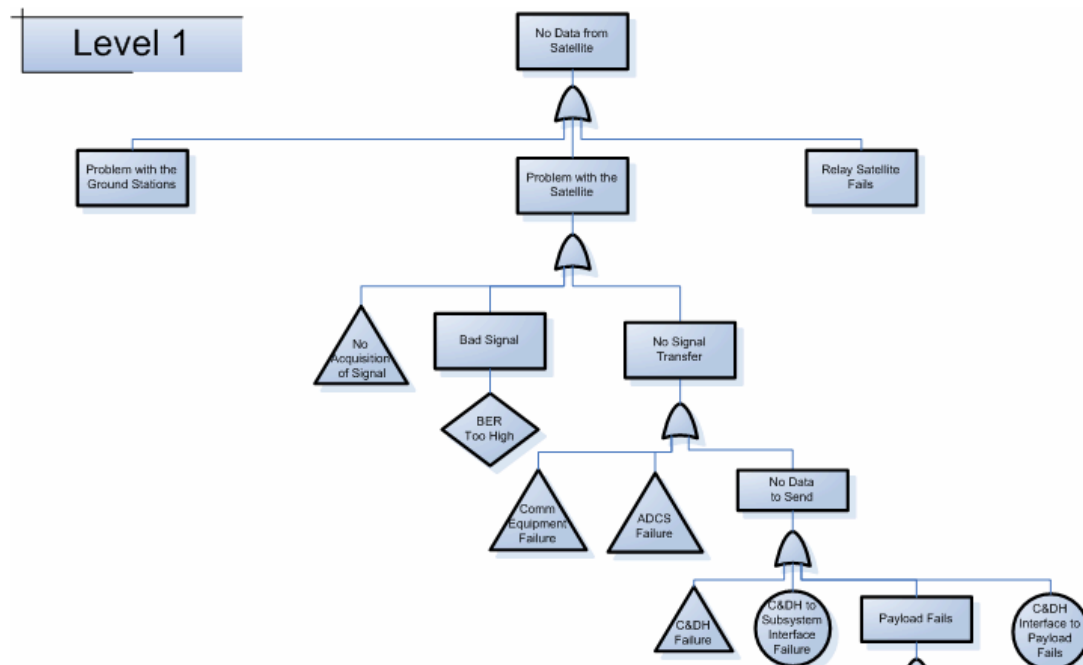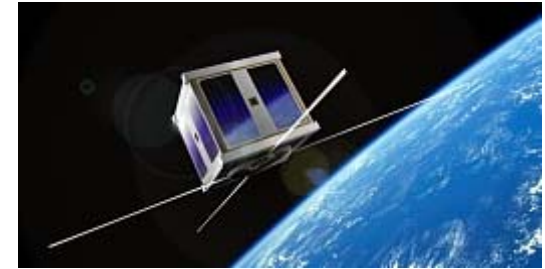
Development of an MLD for Small Satellites

- Why an MLD?
  - Student-run small satellite programs need more guidance
- 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
  - Teaching Tool

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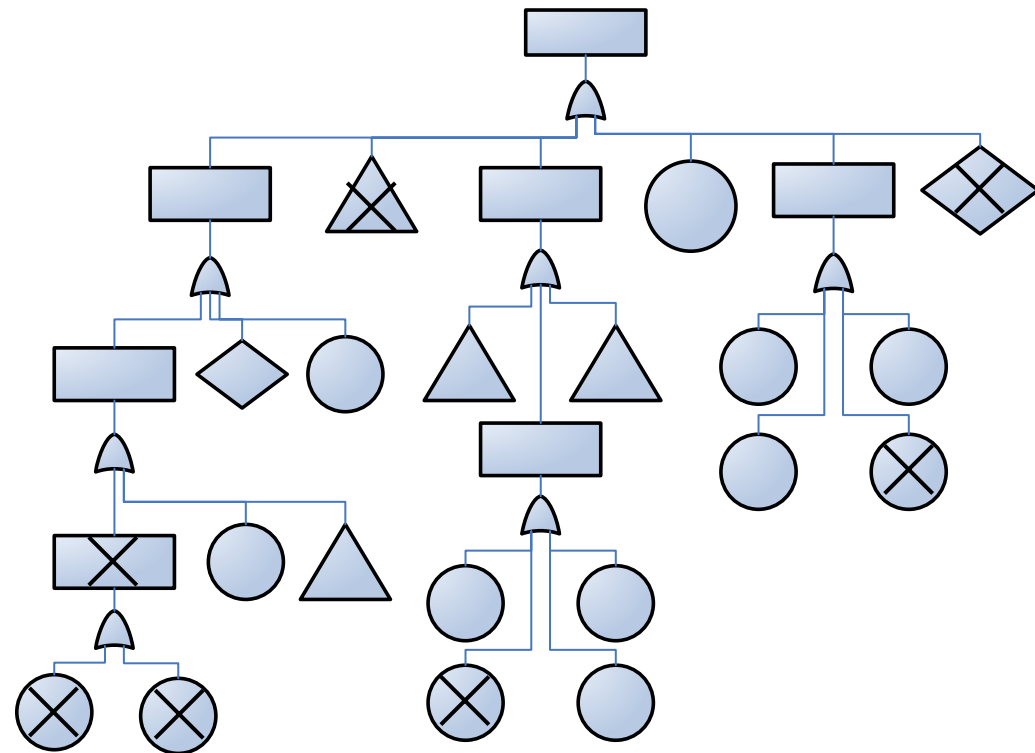
Benefits of Using the MLD

- 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
  - More resources -> High-risk areas
- Experience
  - Provides a bigger picture of the satellite's failure modes
    - 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

www.cubesat.auc.dk/

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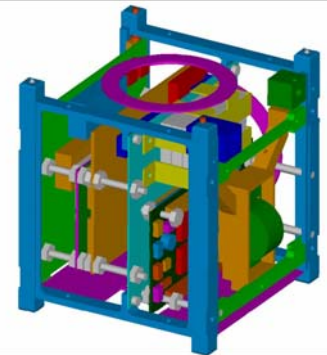
http://www.mae.cornell.edu/ cubesat

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Case Study – Before the MLD

- For MIT's Mars Gravity Biosatellite power failure modes

No power	All solar panels fail to deploy	C&DH fails
		Structures fail
	Rechargeable batteries fail	Lost charge
		Bad connection
		One battery fails
	Converter fails	
Less than max power	Fewer than all panels deploy	Structures fail
	A few panels fail	
	Voltage from panels < bus voltage	
	GNC fails	No info on eclipse
No power during	Batteries don't recharge	Solar panels don't
		Bad connection

Case Study – With the MLD

Solar panels fail	Mechanical H/W failure	Solar cells		
		Insulation between array and structure fails		
		Concentrator fails		
		Diodes fail		
		Radiation damage		
	Off-temperature			
	Panels not deployed	Structures	Unable to withstand torques	
			Unable to maintain stiffness	Off-nominal temperature
			Cannot withstand launch	See Structures
			Space environment	
		C&DH fails	See C&DH	
	Interfaces	Electrical		
		Mechanical		
	Panels not pointed to sun	ADCS fails	See ADCS	
		Structures fail	See Structures	
		Backup power fails	See Power	
		C&DH fails	See C&DH	
	Not enough power	BOL sizing incorrect		
		EOL sizing incorrect	Degradation	Space environment degradation
				Cell or array degradation
		Peak-power tracker fails		
		Shadowing on panels		
		Off-nominal satellite conditions		
		Off-nominal ground conditions		
Primary batteries fail	Mechanical H/W Failure			
	Off-nominal temp	See Thermal		
	Electrical			
	Sizing incorrect			
Secondary batteries fail	Physical	Charging fails	Loses charge	
			Fails to recharge	
		Mechanical H/W failure		
		Off-temperature		
	Electrical			
	Sizing incorrect			
Power not controlled/re	Mechanical H/W Failure	Controller fails		
		Converter fails		
		Regulator fails		
		Power amplifier fails		
	Off-temperature	See Thermal		
	C&DH fails	See C&DH		
Power not distributed	Wiring fails			
	Fault protection fails			
	Mechanical H/W Failure	Switching gear fails		

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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

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Acknowledgements

- Colonel John Keesee: MIT Advisor
- Prof. Bob Twiggs: Stanford
- Dr. Mason Peck: Cornell
- Carl Claussen, Derek Huerta, Dr. Jordi Puig-Suari, Kyle Leveque: Cal Poly San Luis Obispo
- Brian Larsen: Montana State
- Dr. Michael Swartwout: Washington University in St. Louis
- Dr. Robert Zee: University of Toronto
- Cameron Boyd: Queensland University of Technology
- Dr. Stephen Horan: New Mexico State University
- Dr. Chris Kitts: University of California at Santa Clara
- George Hunyadi: University Satellite Program
- Jason Mintz: University of Minnesota
- Dr. Hank Pernicka: University of Missouri-Rolla
- Neil Melville, and Giovanna Brizio: Student Space Exploration and Technology Initiative