

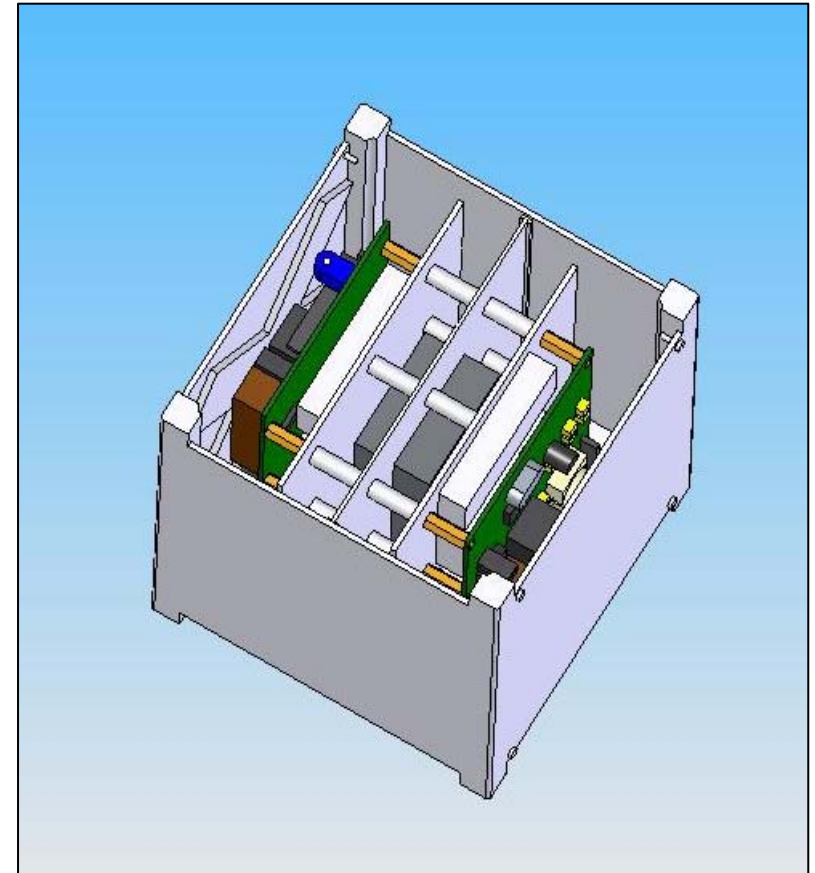


Applying Practical Systems Engineering & Project Management to University Small Satellites

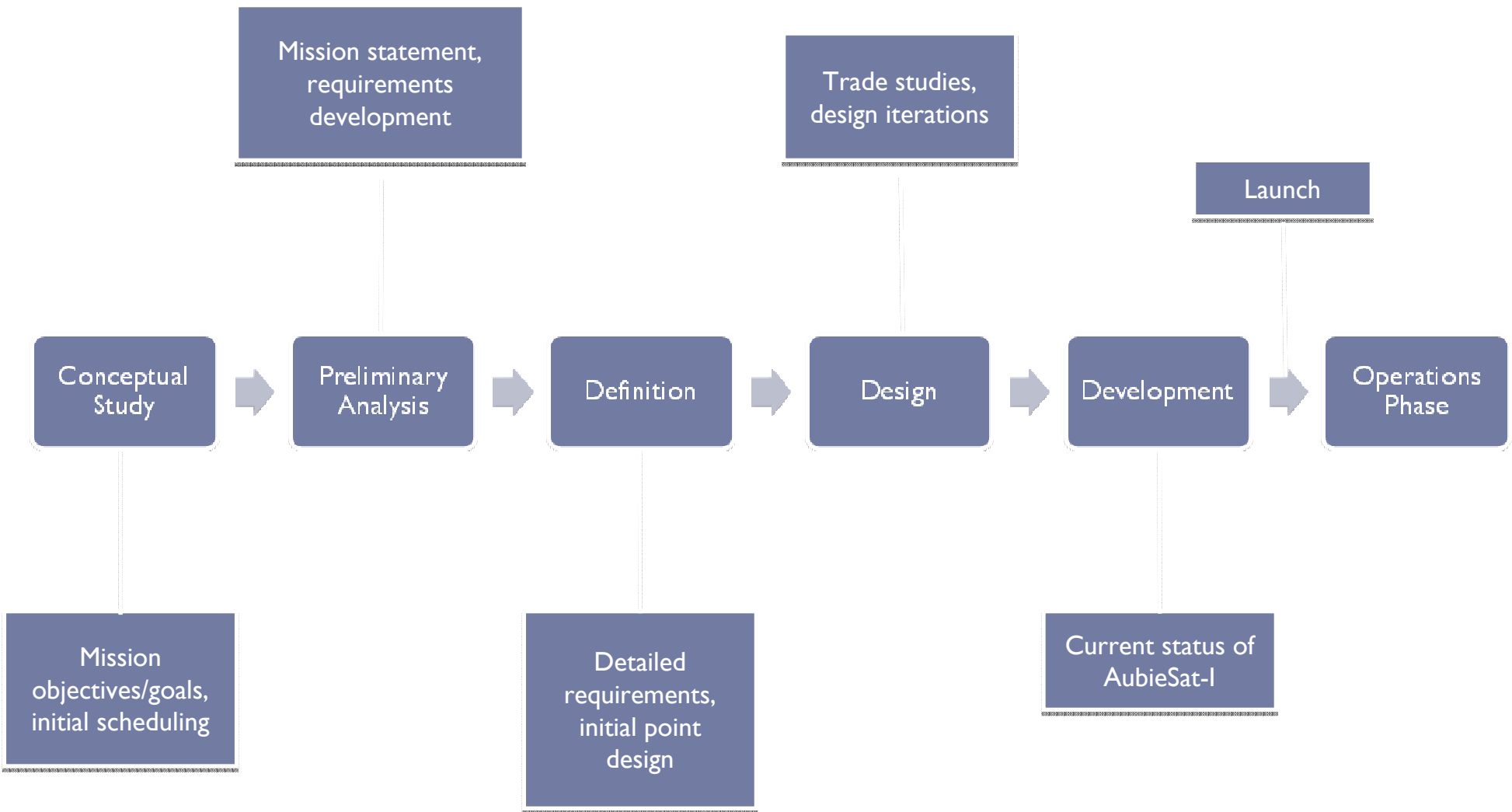
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Presentation Topics

- ▶ Project overview
- ▶ Management
- ▶ Requirements
- ▶ Work breakdown structure
- ▶ Scheduling
- ▶ Trade studies
- ▶ Reviews
- ▶ Documentation



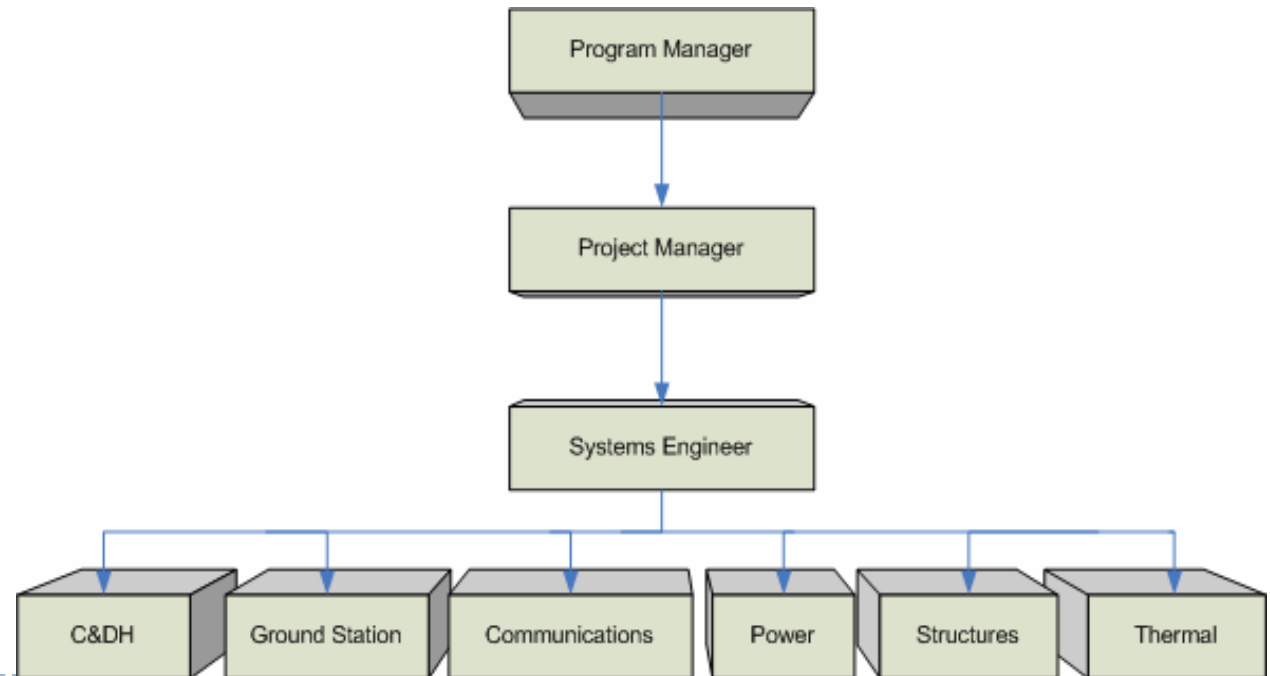
Project Overview



Project Management



- ▶ Students enroll in upper-level Physics course
- ▶ 2 official group meetings per week
- ▶ Students graded on attendance, deliverables & documentation



Requirements



- ▶ All design choices SHOULD be made by what satisfies requirements – and accomplishes mission goals
- ▶ Requirements Excel document kept up to date
- ▶ Re-evaluate at the beginning of every semester
- ▶ Started with Cal Poly / P-POD requirements

Requirement	Rational
EPS shall provide two deployment switches per CalPoly specifications	Keeps power system deactivated during launch
EPS shall provide a remove before flight (RBF) pin per CalPoly specifications	Keeps power system deactivated during transit
EPS shall provide appropriate power to all other subsystems	
EPS shall be capable of operating with a rechargeable battery source	
EPS shall be capable of providing margin in solar cell area	
EPS shall provide transient protection	
EPS shall provide C&DH with a means to measure voltages	Housekeeping
EPS shall provide cabling for all interconnections between subsystems	
ADC shall be capable of maintaining orientation such that a communication link can be maintained with ground station	
ADC shall be capable of providing proper solar cell orientation	
C&DH shall be capable of processing and formatting science data	
C&DH shall be capable of processing and formatting housekeeping data	
C&DH shall be capable of executing commands	
C&DH shall be capable of successfully performing several duty cycles	
C&DH shall provide a documented programmer's interface for the Ground Station	
C&DH shall be capable of controlling all other functions of the satellite	
COMM shall be capable of receiving a transmitter shutdown command	FCC regulation
COMM shall enter low power transmit mode (LPTM) no earlier than 15 minutes after ejection from P-POD	Limiting interference with other payloads
COMM shall enter high power transmit mode (HPTM) no earlier than 30 minutes after ejection from P-POD	
COMM shall be capable of receiving commands from the ground	
COMM shall be capable of transmitting data to the ground	
COMM shall be capable of sending a beacon	
COMM shall be capable of receiving data from C&DH	
COMM shall provide redundancy in transceivers	
All deployables shall be internally constrained	P-POD can't be used to deploy (CalPoly)
MECH shall not deploy large booms earlier than 30 minutes after ejection from the P-POD	Limiting interference with other payloads

Work Breakdown Structures



- ▶ Created at the beginning of each semester
- ▶ Guideline for all work to be completed for the entire semester
- ▶ Developed entirely by students – guided by more experienced students

```
1. AubieSat-1 Spring 2007
  1.1 Functional Table-top Prototype of AS-1
    1.1.1 ADC
      1.1.1.1 Control Force Calculations
        1.1.1.1.1 Model aerodynamic forces.
        1.1.1.1.2 Model gravity gradient and solar pressure.
      1.1.1.2 Redundant System
        1.1.1.2.1 Risk analysis – determine chance of control system failure
        1.1.1.2.2 Trade risk vs. cost of redundancy
        1.1.1.2.3 Design redundant ADC system (if required)
      1.1.1.3 Hysteresis Rod
        1.1.1.3.1 Model Hysteresis dampening force
        1.1.1.3.2 Order Hysteresis dampener
        1.1.1.3.3 Assemble ADC system
    1.1.2 C&DH
      1.1.2.1 Planning
        1.1.2.1.1 Research newer Atmel microcontrollers
        1.1.2.1.2 Finalize Digi-key order
      1.1.2.2 Radiation Research
        1.1.2.2.1 Physical Protection
        1.1.2.2.2 Software Methods
        1.1.2.2.3 Trade Study
      1.1.2.3 Software Infrastructure Definition
        1.1.2.3.1 Conventions & Standards
        1.1.2.3.2 Documentation
        1.1.2.3.3 Human Interface
          1.1.2.3.3.1 Subsystems Functions
            1.1.2.3.3.1.1 Functions prototypes
              1.1.2.3.3.1.1.1 Stubs
              1.1.2.3.3.1.1.2 Drivers
              1.1.2.3.3.1.1.3 Header files
```

Scheduling



- ▶ Created from work breakdown structures
- ▶ Also created by students, strictly overseen by management and advisors
- ▶ Students seem to underestimate how long tasks will take

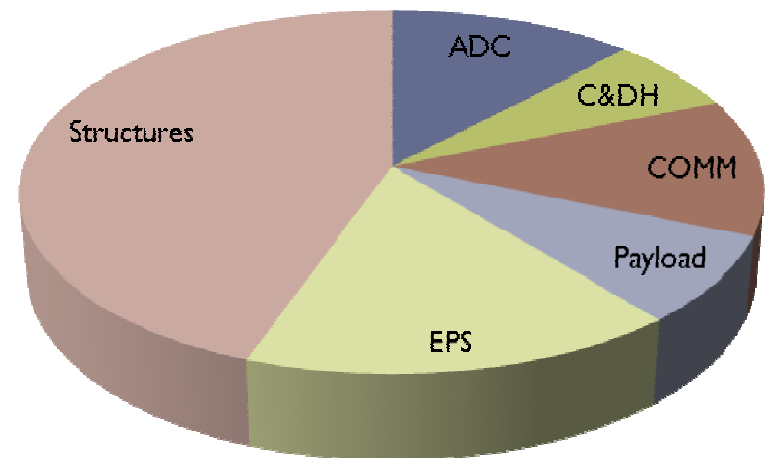
16	CONOPS	9/18/2006	9/27/2006	1.6w	
17	Functional Diagram	9/18/2006	9/27/2006	1.6w	
18	Design Review #1	9/27/2006	9/27/2006	0w	
19	Physical requirements / Trade studies	9/27/2006	10/11/2006	2.2w	
20	Pseudocode	10/16/2006	10/25/2006	1.6w	
21	Design Review #2	10/30/2006	10/30/2006	0w	
22	Prototyping	11/1/2006	11/15/2006	2.2w	
23	Design Review #3	11/29/2006	11/29/2006	0w	
24	Final Documentation	11/15/2006	12/5/2006	3w	
25					
26	Antenna Trade Studies	9/18/2006	9/25/2006	1.2w	
27	Tx Trade	9/20/2006	9/20/2006	.2w	
28	TNC Trade	9/20/2006	9/27/2006	1.2w	
29	Design Review #1	9/27/2006	9/27/2006	0w	
30	Link Budget	10/2/2006	10/9/2006	1.2w	



Trade Studies

- ▶ Used for design choices – both of the system and subsystem level
- ▶ Used several figures of merit – mass, volume, power, cost, etc
- ▶ Showed how changes in one subsystem affected the rest of the system as a whole

AS-I Mass Budget



Reviews



- ▶ Major reviews of current status at mid-semester and end of semester
- ▶ Smaller reviews with individual subsystems every few weeks
- ▶ Used as a tool to discuss problems with group and outsiders
- ▶ Gives the students plenty of opportunities to present technical data to their peers



Documentation



- ▶ Documentation is key for new students
- ▶ Created a full document of all
 - ▶ Trade studies
 - ▶ Design choices
 - ▶ General information

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Questions



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