System Design

What is system design?

- High-level design identifying the system processes, functional components, and their interfaces
- Derived from system requirements
- Provides an overview of the project
  - Define the components that are needed
  - Establish how components “communicate” with other components
  - Determine how to modularize the project into discrete work packages
  - Identify critical interfaces that must be well defined
- Used to provide initial cost, schedule & resource estimates
- Little or few implementation details
  - As system design is refined, and lower-level subsystems are included, implementation issues may need to be addressed

System design steps

- Define project goal and objectives
- Develop the project system requirements
- Identify the major system components that satisfy the system requirements
- Identify the major system interfaces
- Refine the system design
  - Define subsystems making up each component
  - Specify interfaces between subsystems
- Establish management controls for the system interfaces

Traceability Matrix

- Shows the relationship between requirements and the components that satisfy these requirements
  - Commonly used in software engineering, but has application to hardware as well
  - Used to ensure that the system design properly addresses the project needs and does not incorporate any unnecessary components
- Format of the matrix can vary widely, but generally includes the following for each requirement
  - Identification number
  - Description of the requirement
  - Description of the component that satisfies the requirement
  - Description of proof that verifies a components or system satisfies the requirement

Sample NASA Flight Mission Traceability Matrix

Science Goals	Science Objectives	Scientific Measurement Requirements		Instrument Requirements		Projected Performance	Mission Requirements (Top Level)
		Observables	Physical parameters				
Goal 1		Absorption line	Column density of absorber	Alt. Range	XX km	ZZ km	Observing strategies: requires yaw and elevation maneuvers
Goal 2		Emission line	Density and temperature of emitter				Launch window: to meet nadir and limb overlap requirement. Window applies day to day
Etc.	Objective 1		Size of features	Vert. Resol.	XX km	ZZ km	Need AA seasons to trace evolution of phenomena
		Morphological feature		Horiz. Resol.	XX deg x XX lat x XX long	ZZ deg x ZZ lat x ZZ long	
			Rise time of eruptive phenomenon	Temp. Resol.	XX min	ZZ min.	Need AA months of observation to observe variability of phenomena
				Precision	XX K	ZZ K	
		Rate of change of observable phenomenon		Accuracy	XX K	ZZ K	
	Objective 2 to N			Repeat above categories			

System design steps

- Define project goal and objectives
- Develop the project system requirements
- Identify the major system components that satisfy the system requirements (Initial System)
- Identify the major system interfaces (Initial System)
- Refine the system design
  - Define subsystems making up each component
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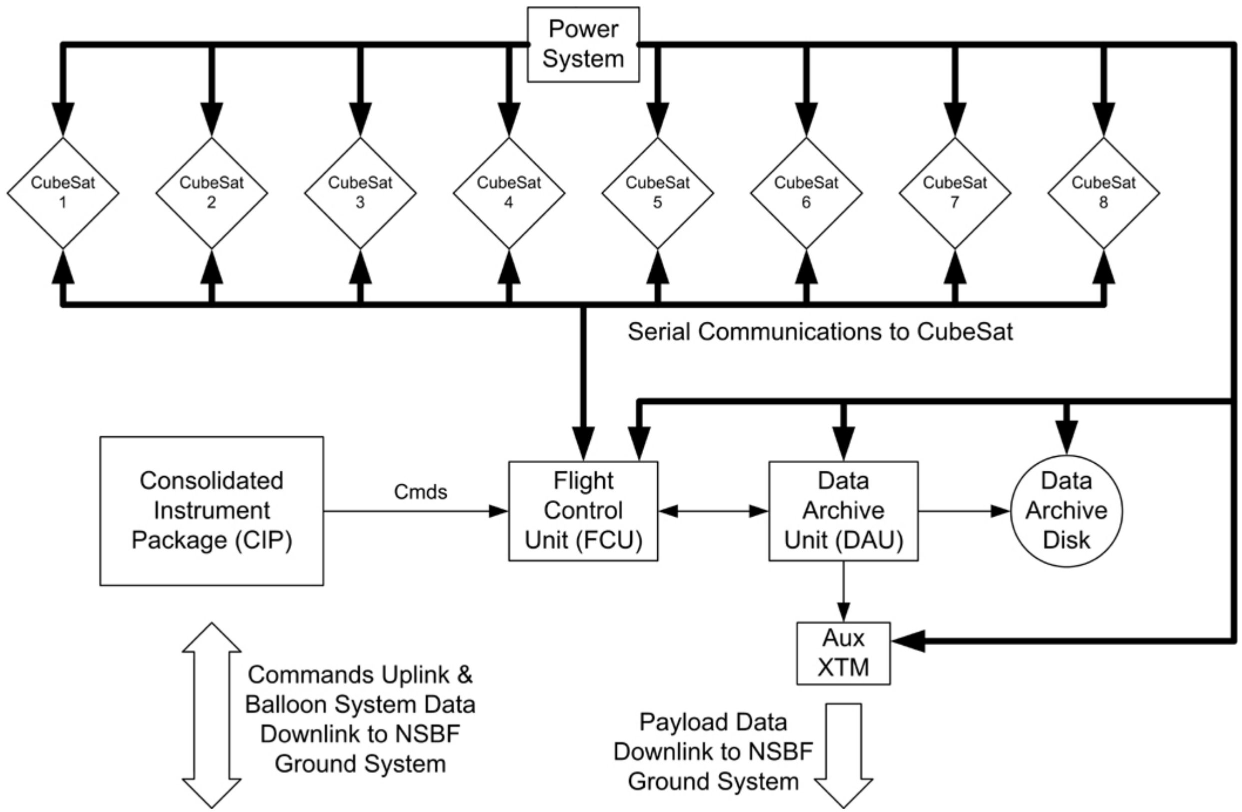
Initial System Design

- Development of the initial system design can, at times, go hand-in-hand with refinement of the system requirements
  - Functions needed to satisfy the science requirements define the initial system
- For example, to perform any payload will probably need these functions
  - You will need a sensor (detector system)
  - You will need to power the sensor (power system)
  - You will need to read data from the sensor (data acquisition system)
  - You will need to store the data (data archive system)
  - You will need to control the sensor, readout, and storage (control system)
  - You will need to analyze the data (ground data system)
- As the design develops, you will determine specific detailed requirements for the above systems
  - For example, the power system will need to supply volts & milliamps to the sensor, data acquisition, archive and control systems

Major System Interfaces

- An interface describes the linkage between major subsystems or processes
- There are multiple types of interfaces
  - Mechanical: How systems physically fit together
  - Power: What voltage and current flows between the systems
  - Electronic: The characteristics of electrical signals between systems
  - Data: Format and content of information transferred between systems
  - Thermal: How does heat flow between systems
  - Software: How modules communicate with other modules or hardware
- The type and characteristics of all interfaces need to be identified and defined

System Level Drawing Example



- High-level overview of a balloon platform that could carry eight Cubesat payloads
    - Primary subsystems are identified (Power, CubeSats, FCU, etc.)
    - Directionality and content of major interfaces are identified

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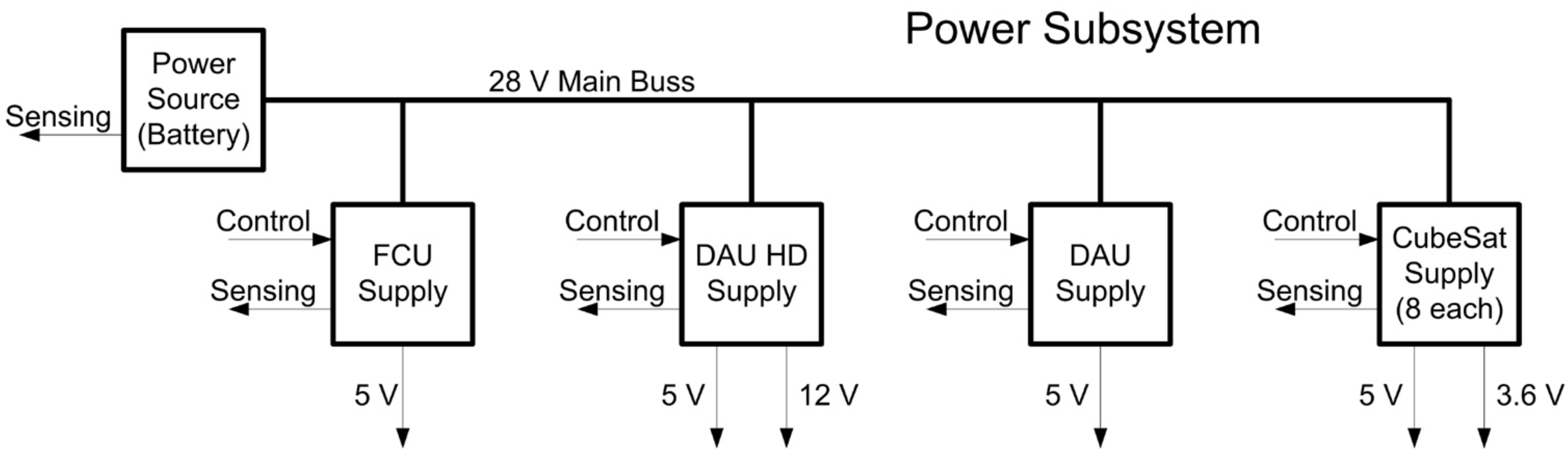
Refining the System Design

- After the major systems and interfaces are identified, the subsystems are described
  - The process is repeated for each of the subsystems (i.e. the boxes of the system diagram) defined in the top-level system design
- For example, the Power Subsystem in the previous slide requires the following components
  - A source that supplies the energy for the entire platform
  - Separate supplies to convert the source power to the proper voltage and current required by the other systems (FCU, DAU, etc.)
- Each of the subsystem interfaces is given a more detailed specification
  - How many and what kind of interfaces do the subsystems need?
  - What are the details (Voltage, current, logic levels, etc.) of the interface

Subsystem Level Example

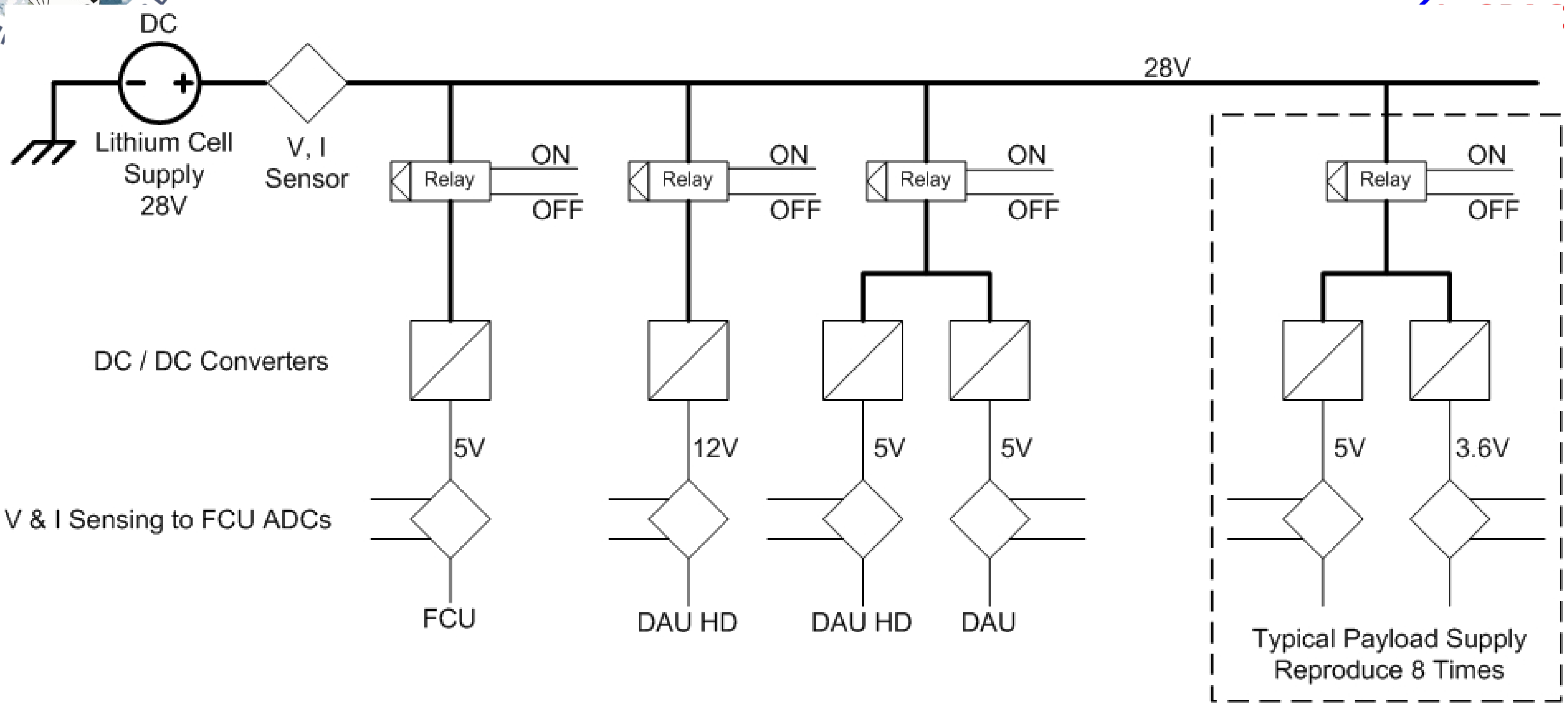


- Subsystem design provides additional details
  - Major functional components are identified and expressed
  - Shows that system requirements are satisfied
  - Most important interface details are revealed
- Still little hardware or implementation dependence

Moving to Component Specifics

- The system design refinement process continues by specifying the major components of the subsystems
- For example, the FCU supply in the power system might include the following major components
  - A relay to turn the supply on / off by computer control
  - A DC / DC converter to provide the required voltage from the source power
  - An inline sensor so that volts and amps can be monitored in real-time by the computer
- This is not a schematic drawing
  - The type of component and ratings should be identified, but not specific parts
  - I.E. You know you need a 5V/2A relay but not a specific part number

Refined Subsystem Example



- Implementation and hardware details are starting to appear
- Interfaces are close to being fully defined
- Next step would be full hardware and interface specification

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Controlling Interfaces

- Interfaces between systems need to be defined
- An ICD can be helpful during system design
  - Written description of the interface that is modified only under specific, previously defined conditions and is used by team personnel for implementation
  - Written specification of the interface
  - Obtain agreement between stakeholders on the interface characteristics
- Controlled ICDs should be used to help manage potential risks
  - When an interface error or mismatch could result in project failure
  - When stakeholders implementing the interface ends are separated in either geographic distance or time