



System Design

L23.01



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
- Usually 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



Project goal and objectives

- The goal specifies the overall purpose of the project
 - Defines what one wishes to accomplish as a result of the project
- Objectives are discrete intended accomplishments during and resulting from the project
 - Science objectives describe the specific scientific results expected from the project
 - Technical objectives describe the specific technical accomplishments expected during the project
- Together the project goal and objectives define and constrain the project scope
 - Leads to defining the system requirements



System requirements

- A document listing the constraints imposed upon and the results necessary from the project
 - The project goal as well as the scientific and technical objectives should be reflected in the system requirements
- Time spent on detailing the system requirements is worthwhile
 - A greater understanding of what is required facilitates design and implementation and improves the chances of success
- Initially focus on developing the high level scientific and technical requirements
 - Based upon current science knowledge, what is to be measured with what resolution and accuracy?
 - What constraints impose what technical limitations on your design?



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 science measurement
 - 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, storage (control system)
 - You will need to analyze the data (ground data system)
- These functions will also need to have a set of requirements specified
 - For example, the power system will need to supply volts & milliamps to the sensor, data acquisition, archive and control systems



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 assure 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 test that verifies the components meets the requirement

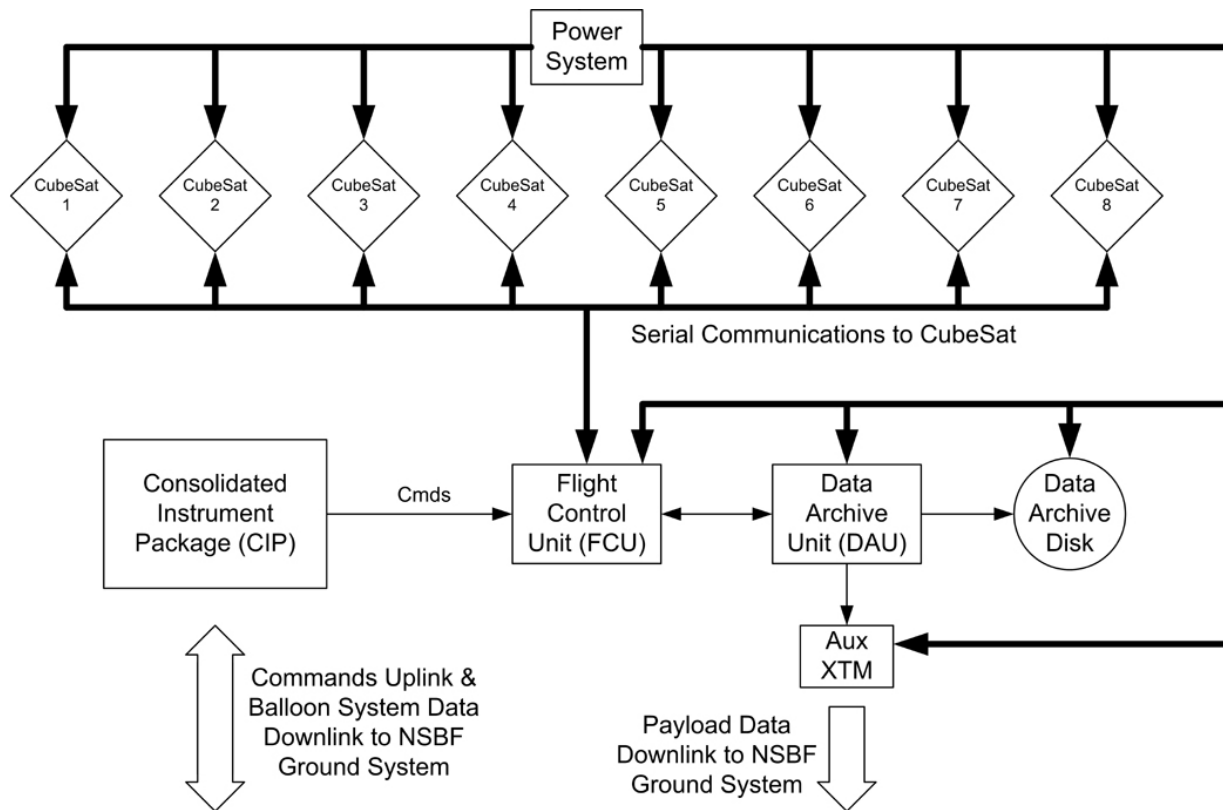


Major System Interfaces



- An interface describes the linkage between two functions or processes
- Neglecting how your systems fit together can lead to disaster
 - NASA Mars Climate Orbiter failed in 1999 because ground systems used “English” units while the flight systems used “Metric” units!
- 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 student built payloads
 - Primary subsystems are identified
 - Directionality and content of major interfaces are identified

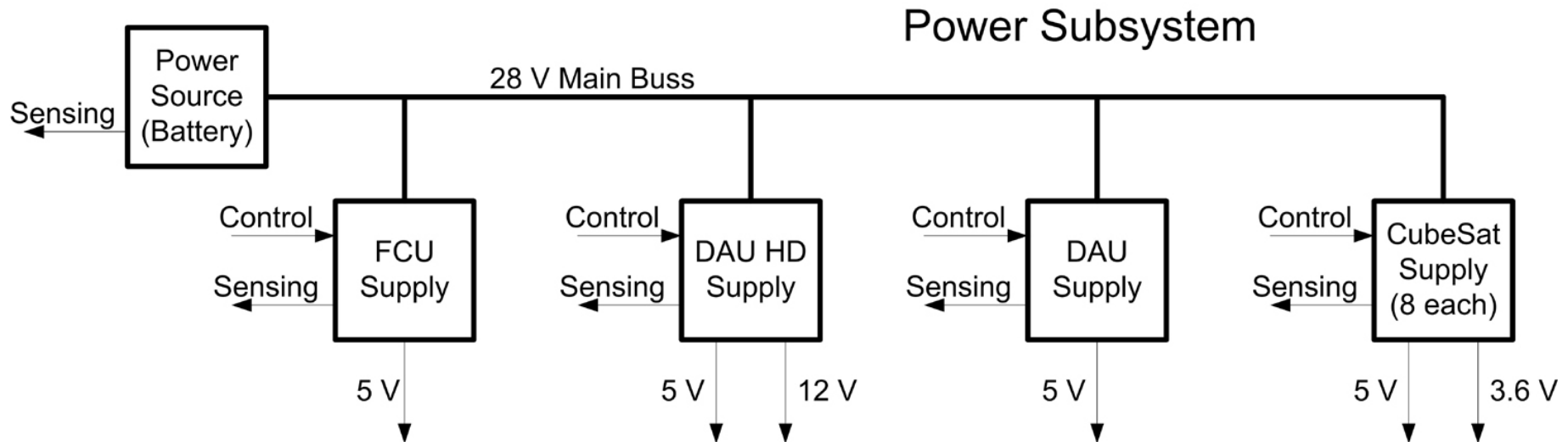


Refining the System Design



- After the major systems and interfaces are identified the subsystems are described
 - Each major function is composed of multiple activities, processes or modules each with a specific function of its own
- For example, the Power System in the previous slide has the following subsystems
 - Power source that supplies the energy for the entire platform
 - Separate supplies to convert the source power to the proper volts and amps required by the FCU, DAU, DAU Disk, Aux XTM and Cubesats
- Each of the subsystems has interfaces that need specification
 - How many of what kind of interface do the subsystems have?
 - Is the interface to another subsystem or another system?
 - What is the content of the interface?
- Traceability matrix should include these new subsystems

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

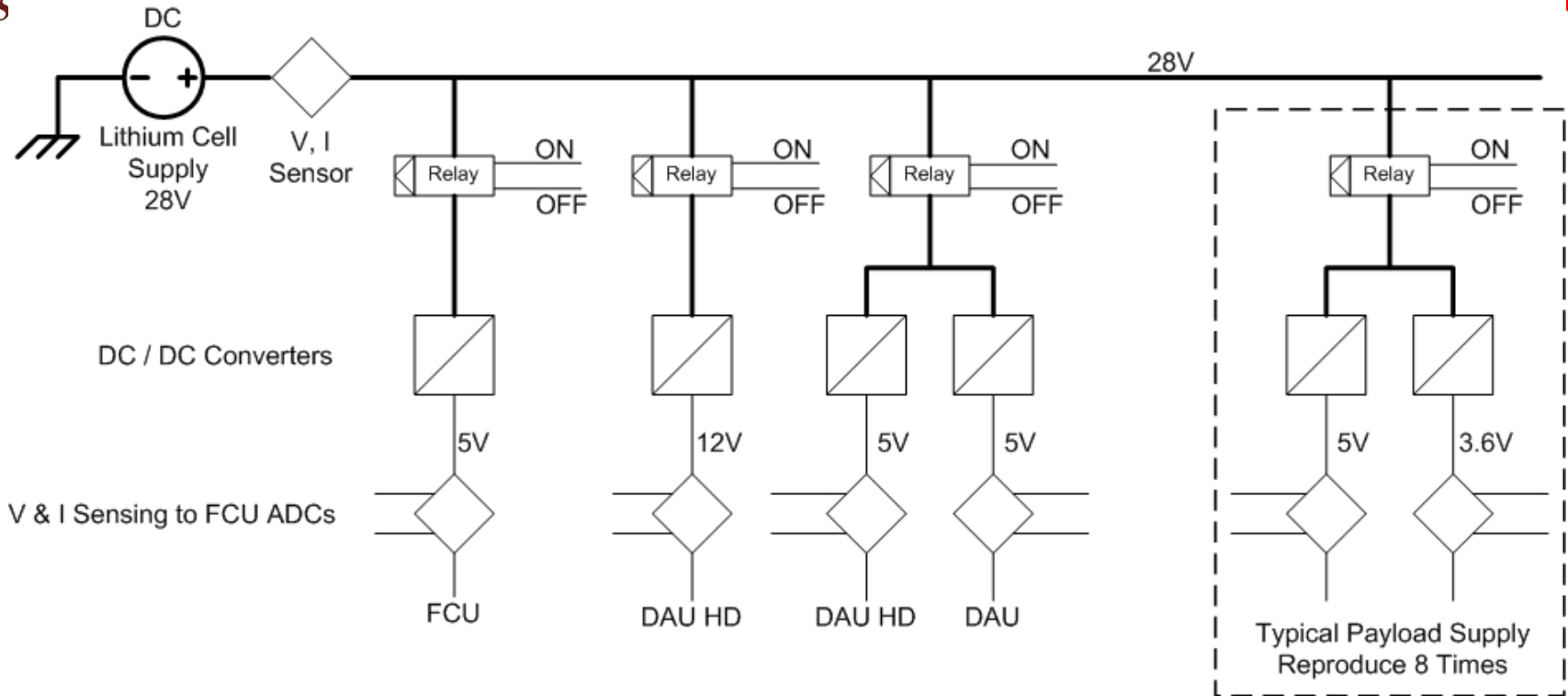


Moving to Design Specifics



- The system design refinement process continues by specifying the subsystems of the subsystems
- For example, the FCU supply in the power system might include the following sub- subsystems
 - 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
- With enough iterations the system design can evolve into an actual implementation
 - Actual components to use in the design start becoming apparent
 - Interfaces become very specific and well defined

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



Controlling Interfaces



- Critical interfaces need to be closely monitored by use of an Interface Control Document (ICD)
 - Written description of the interface that is modified only under specific, previously defined conditions and is used by team personnel for implementation
- Not all interfaces need to be controlled, but an ICD can be helpful during system design
 - 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