Project Management, Lifecycle, and Documentation

What is a project?

- A project is a complex, non-routine, one-time effort limited by time, budget, resources, and performance specifications designed to meet specific needs.
  - Examples include the construction of a chemistry department building, holding a teacher development workshop, or creating a new French dining experience
- Projects generally have a particular set of characteristics in common
  - A clearly stated objective
  - A specific life span with a beginning and an end
  - Multiple departments or people working together
  - Must be done within specific time, cost, and performance requirements

Why manage a project?

- Accomplish objectives of the project within constraints
- Balancing trade-offs between time, cost, and performance
  - These three constraints can be mutually exclusive
  - An effective balance is necessary for project success
- Anticipating, identifying, and handling the unexpected
  - Unexpected events will happen throughout a project (Murphy's Law)
  - Risk planning is an essential component to project management
- Taking into account unique project features
  - As project complexity increases, coordination and risk also increase
  - New technology development is usually associated with increased risk and complexity

Project Team Structure

- Dedicated project team structure
  - Create independent team composed of specialists to focus exclusively on project
- Project team management structure
  - Maximum cohesion and focus provides fast response
  - Resistance to “outsiders” and constrained staff expertise
  - Appropriate for complex or organizations with many projects
- You should establish a “Team Contract” to define your organization and interaction as a team

Stages of Team Development

- Forming: Get acquainted stage when ground rules, roles, and interpersonal relations are established
- Storming: Conflict stage when group control, decision making, group & project constraints are contested
- Norming: Stage when close relationships develop, and the group demonstrates cohesiveness
- Performing: Established expectations of how to work together and the group begins channeling energy into achieving project goals
- Adjourning: Attention is focused on completing the project and could include conflicting emotions

Building a Project Team

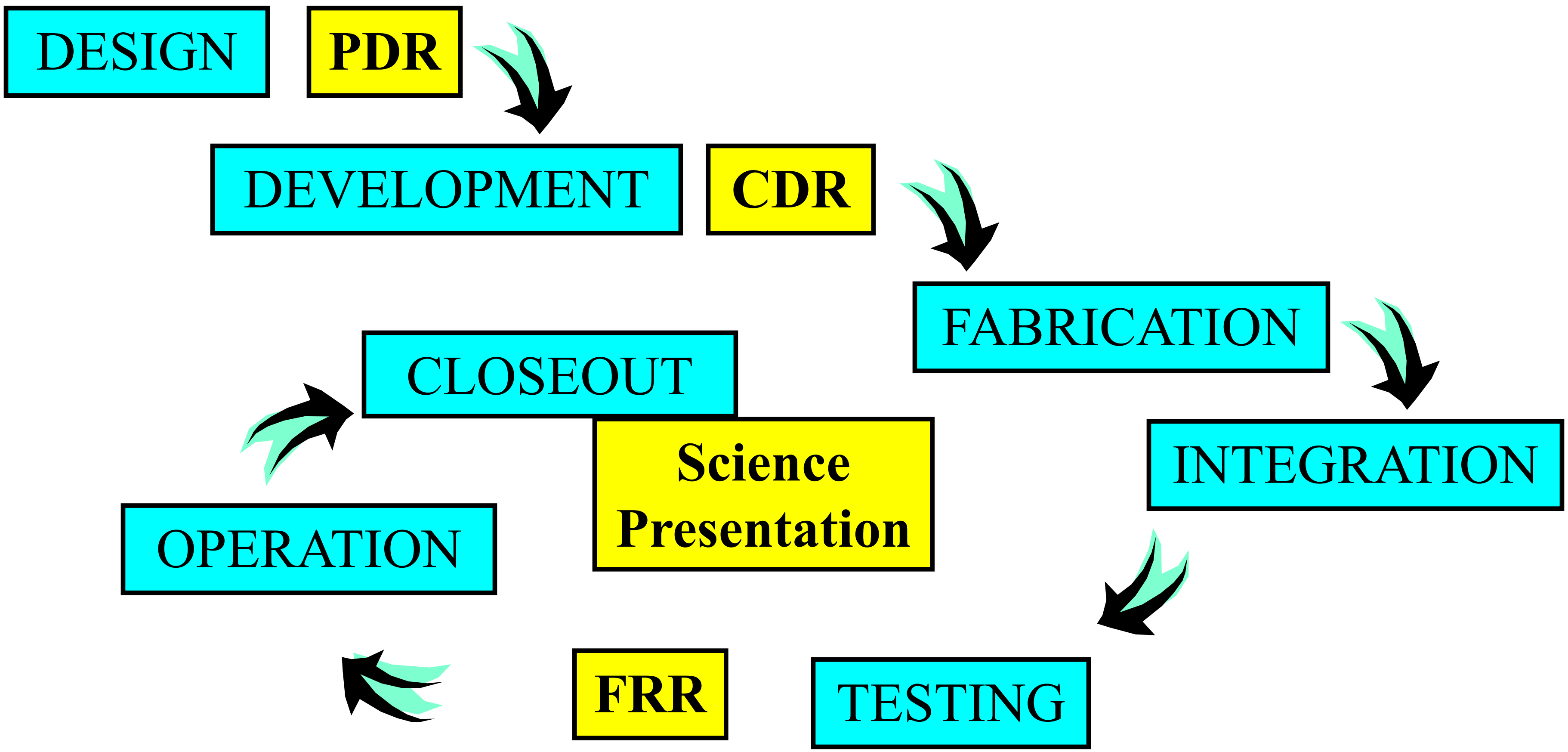
- Early on establish ground rules such as the following
  - How will the project be planned?
  - What will be the specific roles and responsibilities?
  - How will progress be assessed and tracked?
  - How will project changes be documented and instituted?
  - How, when and where will meetings be scheduled and run?
- Conduct project meetings that are regular, crisp, have a focused agenda and are time constrained
- Establish a team identity and create a shared vision
- Facilitate group decisions by identifying underlying problems, generating alternate solutions, fostering a consensus, and following-up on solution implementation
- Accepting, managing, and encouraging functional conflict

Project Team Pitfalls

- Project teams and managers need to be aware of various pitfalls that can lead to poor decisions.
- A team can become convinced that its decisions are infallible.
- Fail to examine alternate solutions and problems that might arise from the current plan.
- Stereotype outsiders negatively so that external concerns, issues or solutions remain unconsidered.
- Opposition by a member to a particular direction or solution might be repressed by the team.

The Project Phases

All projects complete roughly the same phases from inception to completion



The Design Phase

"Paper" study of all issues to establish major concepts and plans

- Little to no hardware testing or prototyping
- Define mission **goals** and science **objectives** and top level **requirements**
- System level design (ie, Block Diagram – subject of a later lecture)
  - System requirements derived from goals and objectives
  - Identify major subsystems and interfaces
- Concept hardware and software design
  - Derived from system requirements and constraints
  - Identify parts, costs, & availability
- Establish tasks, schedule, resource needs, and plans for the remaining phases of the life-cycle
- Develop preliminary risk assessment & management plan
- Phase terminates with Preliminary Design Review (PDR)

Goals vs Objectives vs Requirements

- GOAL
  - A broad, high-level statement telling what the payload should accomplish
  - This should be a one-sentence high-level statement: Why do we care about this payload?
  - Not measurable or quantifiable
- OBJECTIVE
  - Specific tasks needed to be accomplished by the payload to meet its goal
  - Should be specific, measurable, and tie into the data generated by the payload
    - The collected results, not an individual measurement – e.g. Temperature Altitude Plot
  - What outputs does the payload need to produce, **but not** how it is going to produce them
- REQUIREMENT
  - Multilevel with lower levels, adding specifics to and flowing from higher-level requirements
  - The lowest level should give specific capabilities of components, sensors, or instruments
    - Individual data points - e.g. a temperature measurement and it's error bars

Requirements: Science Vs Technical

- Science Requirements
  - These are the specific observables and the physical parameters measured to accomplish the objectives
  - Each of these should tie back into one of the objectives
  - But these should not be the hardware performance requirements
- Technical Requirements
  - These are the specific hardware performance requirements needed to meet the science requirements
  - This is also where mission operation and constraints should be addressed – i.e. adequate power, adequate storage, operating in the flight environment

Example House

(adapted from Pugel, 2019 https://smd-cms.nasa.gov/wp-content/uploads/2023/04/2019_546_Pugel_Final_WhatAreRequirements.pdf)

- GOAL: Provide shelter and housing
- Objective: The project will build a house
- Requirements: (Notice the numbering structure used)
  - Level 1: 1. The project shall build a house for two adults, 3 children, and two dogs
    - Level 2: 1.1 The house shall have one master bathroom
      - Level 3: 1.1.1 The master bathroom shall have a sink
        - Level 4: 1.1.1.1 The sink shall be deliver water at temperatures from 10-60C

Example NASA Mission

(adapted from Pugel, 2019 https://smd-cms.nasa.gov/wp-content/uploads/2023/04/2019_546_Pugel_Final_WhatAreRequirements.pdf)

- GOAL: The mission will improve the understanding of the formation of planets in the solar system.
- Objective: The mission will generate a topographical map of the surface of Mars
- Requirements: (Notice the numbering structure used)
  - Level 1: 1. The mission will measure 90% of the surface of MARS every 300 m at 10 m precision
    - Level 2: 1.1 The mission will make radar interferometric measurements every 10 m
      - Level 3: 1.1.1 The mission shall have an antenna capable of receiving 77 GHz
        - Level 4: 1.1.1.1 The radar antenna shall receive 77 GHz with an antenna gain of 30 dB

Preliminary Design Review (PDR)

- The primary objective for the PDR is to review results from your design phase
- At the end of the PDR you should have been able to show that you have "thought the problem through"
- There will be two parts to the PDR
- The Pre-PDR will focus on your mission goal, science background, objectives, and requirements.
  - What do you want the payload to be able to do
- During the PDR you will build on the Pre-PDR
  - Resolve issues identified in the Pre-PDR
  - Add system design, concept instrument hardware & software design, risk analysis
  - A system-level design of what subsystems you need and what they need to do

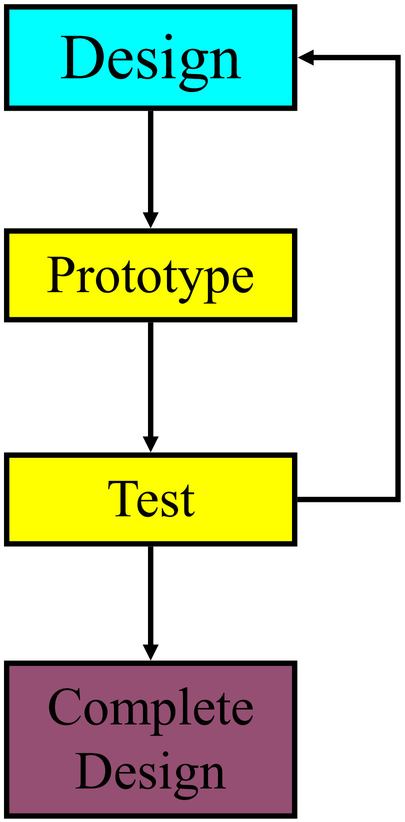
PDR Elements

- The PDR should focus on the following topics:
  - Goals and objectives 🡐 Pre-PDR
  - Science background and requirements 🡐 Pre-PDR
  - Preliminary System design
  - Concept hardware & software design
  - Tasks, schedule, resource needs, long-lead items 🡐 Pre-PDR
  - Preliminary risk assessment and management plan
- Use the document template to guide your PDR write-up
  - Similar document for CDR and FRR

The Development Phase – 1 of 2

Detailed in-depth study when all design components are finalized

- Test concepts by prototyping
  - Not building flight hardware
  - Used to gain information necessary to refine or finalize a design
  - Applies to structure, electronics, sensors and software
- Finalize hardware & software design
  - Complete system design
  - Define interfaces and develop appropriate Interface Control Documents (ICD)
  - Complete detailed design



Critical Design Review (CDR)

- The primary objective of the CDR is to review the results from your development phase
- Determines whether you are ready to begin building your payload flight hardware
- The Pre-CDR will focus on resolving PDR issues, prototype results, “proven” design, final system, and interfaces.
  - Build and test prototypes to go from block diagrams
- During the CDR you will build on the Pre-CDR
  - Resolve issues identified in the Pre-CDR

CDR Elements

- CDR should follow the same format as the PDR
  - Modify document template for CDR
  - Same oral presentation format
- CDR should emphasize the following topics:
  - Resolving issues identified during the PDR 🡐 Pre-CDR
  - Prototyping results and “proven” designs 🡐 Pre-CDR
  - Completed system design and defined interfaces 🡐 Pre-CDR
  - Finalize tasks, schedule, procedures, and costs
  - Updated risk assessment and management plan
  - Preliminary Mission Operation and Data Analysis plan (what are you going to do on flight day and after you receive your payload back)

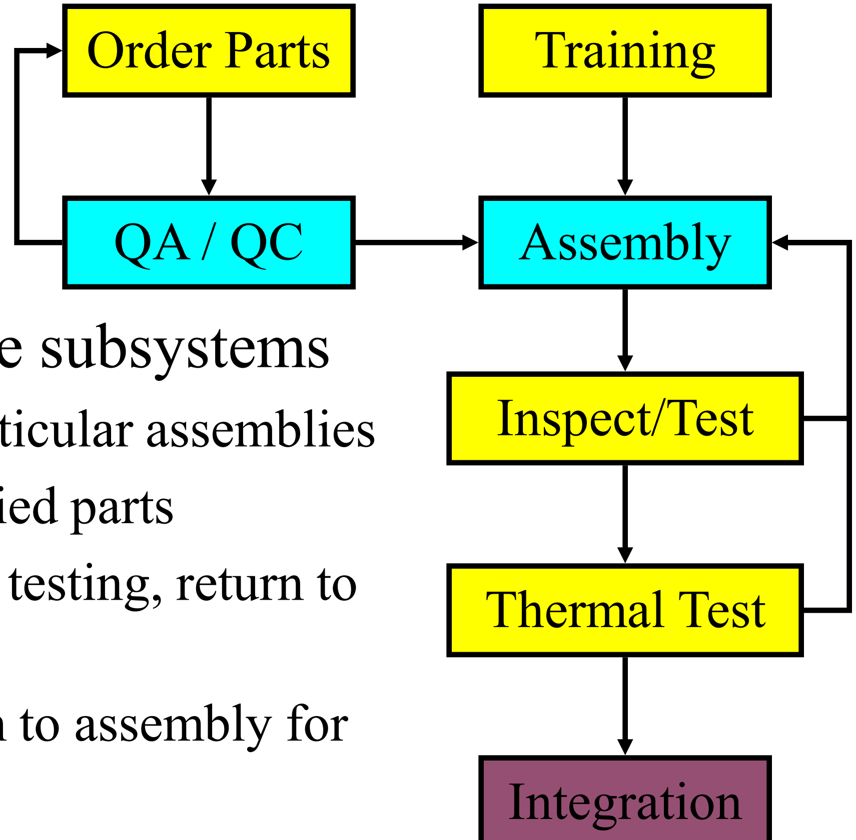
The Development Phase – 2 of 2

- Purchase long lead items (identified at PDR)
- Finalize plans for pre-flight phases
  - Fabrication, integration, calibration, and testing
  - Tasks, schedule, procedures, resource needs, costs
- Update risk assessment & management plan
  - Preliminary plan should already be in use for tracking and mitigating risks during development
- Develop preliminary mission operations & data analysis plan
- Phase terminates with Critical Design Review (CDR)

The Fabrication Phase

Implement construction of flight components

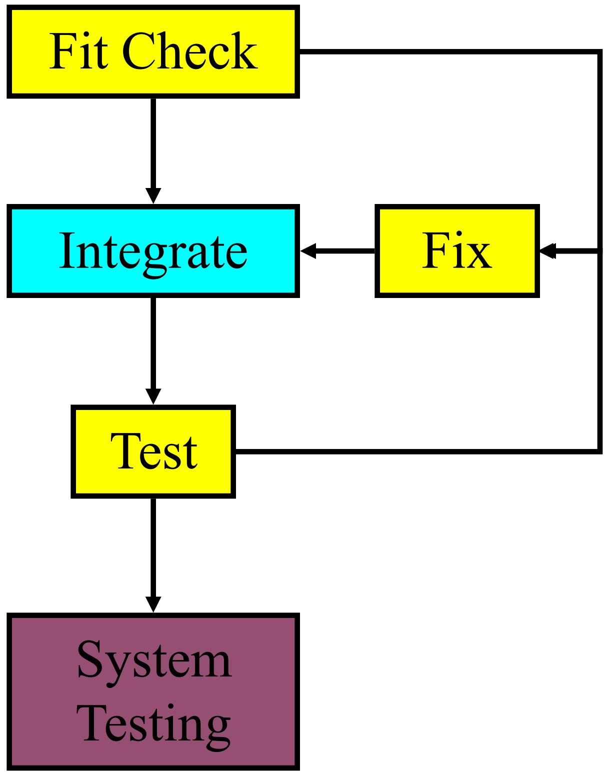
- Parts procurement
  - Test that parts satisfy flight requirements before assembly
- Assemble hardware & software subsystems
  - Training may be required for particular assemblies
  - Fabricate component with qualified parts
  - If part fails initial inspection and testing, return to assembly for rework / fixing
  - If part fails thermal testing return to assembly for rework / fixing
- Once complete move to integration



The Integration Phase

Subassemblies are put together to make the final package

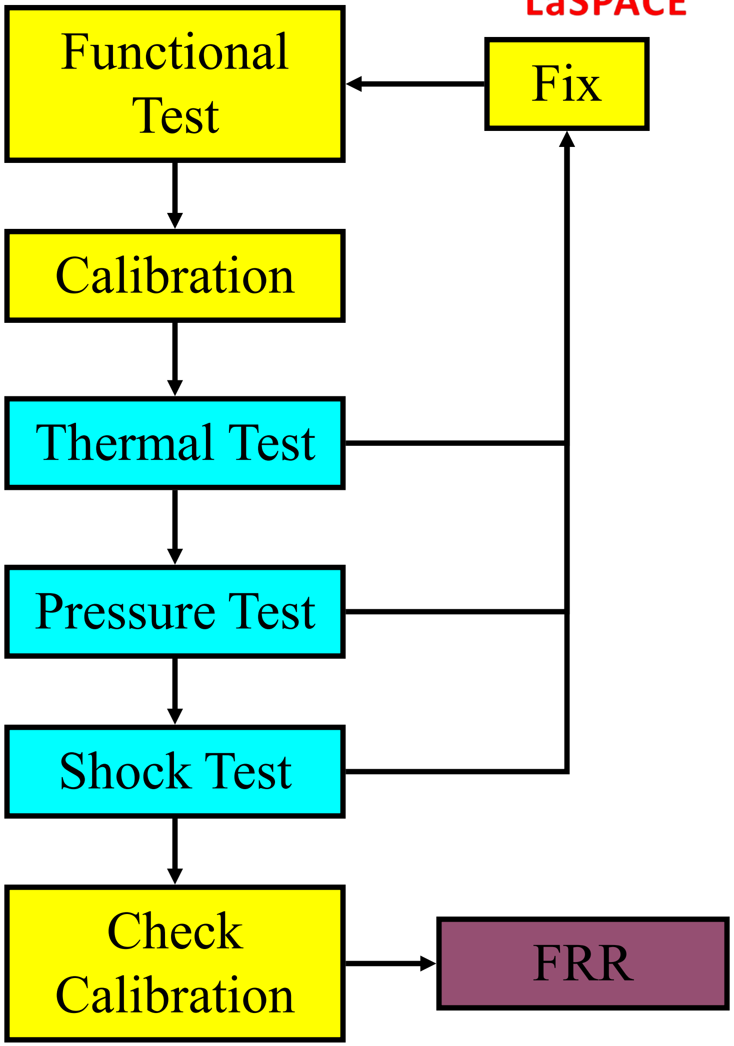
- Make sure all parts fit together, if not then rework
- Make sure power system is delivering proper voltage and current
- Connect electronics and sensors
- Install software and run
- Fix issues before proceeding to system testing



The System Testing Phase

Payload flight certification

- Integrated payload must first be fully functional
- Calibration values are determined
  - Sensors, ADC gain, timing
- Payload must function correctly during thermal, pressure & shock testing
  - If not, fix and begin again
  - If OK, then validate calibrations
- Test and test data must be documented
- Proceed to Flight Readiness Review



Flight Readiness Review (FRR)

- Determine that all issues from CDR have been resolved
- Document Experiment Readiness
    - As-built configuration
    - Environmental testing results
    - Calibrations performed
- Provide quantitative evidence that the payload:
    - Meets requirements
    - Is safe
    - Will perform properly
- Determine any impact on other payloads or the vehicle
- Describe procedures for checkout, launch integration, mission operations, and data analyssis
- There should be no outstanding issues that must be addressed before flight

Mission Operations & Data Analysis

- Mission Operations includes the following
  - Sequence of operations to prepare payload for vehicle integration
  - Sequence of operations to prepare payload for launch
  - Flight profile requirements
  - Operations, commanding, contingencies during flight
  - Recovery handling and operations
- The Data Analysis describes what happens to the flight data
  - Flight data handling, processing, and analysis sequence
  - Specify data required from the payload

Close-out: Post-Flight Science Presentation

- This where you pr
- During the launch trip, you will be required to present a report on your preliminary science results
  - PowerPoint presentation including science background, a brief description of the instrument, calibrations, analyzed data, science results, and error analysis
- You will have a full day following the flight to analyze your data and prepare your report
- Recommend the following prior to the launch trip
  - Have your presentation done except for the science results
  - Have your calibrations complete and ready to apply
  - Have your ground data handling and analysis software complete, tested, and ready to go