PROJECT MANAGEMENT

ME 481 Senior Design
Fall 2022

Dr. Trevor C. Sorensen
Effective Meetings
There is no such thing as just an individual as a team, but teams are made up of individuals.

Any design process must make the best use of resources: individuals and teams:

- Give individuals pride of ownership:
  - Privately (think & create on their own, AND constructively evaluate the work of others)

- Maximize the efficiency and effectiveness of teams and reduce apathy:
  - Do not have brainstorming meetings unless everyone is PREPared
  - Individuals must have thought of ideas and reviewed each other’s ideas beforehand
  - Peer pressure will help correct non-performers and nay-sayers and reduce apathy
Effective Meetings

Safety Tip

Purpose

Agenda (allocate duration for each item)

Code of Conduct

Expectations

Roles:
  Facilitator (meeting leader)
  Recorder (records notes for minutes)
  Observer (ensures SPACER followed)
  Scribe (writes notes on board)
  Timekeeper (checks time vs allocations)
Effective Meetings

Safety Tip

Purpose

Agenda (allocate duration for each item)

Minutes must be produced and published for every meeting. Copies should be sent to all attendees and to management (project manager, system engineer, etc.)

Roles:

 Facilitator (meeting leader)
 Recorder (records notes for minutes)
 Observer (ensures SPACER followed)
 Scribe (writes notes on board)
 Timekeeper (checks time vs allocations)
Effective Meetings

Action Items

• All important decisions and rationale made during the project should be recorded. Include concepts that were considered but discarded with rationale.

• Action items (AIs) are unresolved items identified during a meeting that need to be resolved after the meeting. List all AIs, which are assigned a unique Action Item tracking number and tracked with the following information:

1. Tracking Number, e.g.,
   AI-F20-P2-001 (Action Item-Fall 2022-Project 2-number 1)
2. Source – where did the AI originate, e.g., TM03 for team meeting #3, or PDR for Preliminary Design Review
3. Assignee – to whom is the AI assigned (team leader if to a team)
4. Date Due
5. Resolution – state how the AI was resolved
6. Status – give the current status of the AI: OPEN, CLOSED, or WITHDRAWN

• The team leader is the owner the Action Item list for the team
# Effective Meetings

## Action Items List Example – LEO-1

<table>
<thead>
<tr>
<th>Tracking #</th>
<th>Source</th>
<th>Action</th>
<th>Assignee</th>
<th>Due</th>
<th>Resolution</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSR-ECF-12</td>
<td>SRR</td>
<td>Check where more GS antennas are needed to have contact with LEO-1 in its first orbit</td>
<td>Trevor</td>
<td>7/15/2009</td>
<td></td>
<td>OPEN</td>
</tr>
<tr>
<td>SSR-ECF-14</td>
<td>SRR</td>
<td>Need to describe techniques LEO-1 will use to mitigate radiation effects (SEE) or RAM &amp; memory (i.e., EDACS or equivalent)</td>
<td>Byron</td>
<td>7/15/2009</td>
<td></td>
<td>OPEN</td>
</tr>
<tr>
<td>SSR-ECF-30</td>
<td>SRR</td>
<td>Quadrifilar antennas require holes in ground plane. What is the requirement on mounting that plate on the S/C structure? Might have leakage back into the internal S/C structure.</td>
<td>Jason</td>
<td>7/15/2009</td>
<td>Mark Franz determined it’s not needed because our payloads are not downlinking data through the Telecom</td>
<td>OPEN</td>
</tr>
<tr>
<td>SSR-ECF-31</td>
<td>SRR</td>
<td>Clarify requirements for encryption of DoD payloads (Mark Franz says DoD payloads require encryption - software encryption not allowed by NSA)</td>
<td>Byron</td>
<td>Dec. 16</td>
<td></td>
<td>CLOSED</td>
</tr>
</tbody>
</table>
| SSR-ECF-32  | SRR    | a) Check GSD of imaging system  
b) 79 deg. FOV is very wide, especially given 1024 x 1024 pixels                                                                                                         | Byron    | Dec. 16   | Done for PDR                                                                                                        | CLOSED |
| SSR-ECF-36  | SRR    | Check integration time of camera versus movement of S/C                                                                                                                                                  | Jason    | Dec. 16   | Done for PDR                                                                                                        | CLOSED |
| SSR-ECF-41  | SRR    | The schedule is very aggressive for a new development and most likely not achievable                                                                                                                  | Trevor   | Before PDR |                                                                                                                    | OPEN   |
| AI-09-001   | TMM-01 | Revisit lens to be used on the cameras and report at the team meeting.                                                                                                                                   | Jason    | 2/11/2009 | Report made at 2/11/09 team meeting                                                                               | CLOSED |
| AI-09-002   | TMM-01 | a) Calculate the shielding provided by the avionics boxes for different thicknesses of aluminum and b) provide a recommendation.                                                                     | Byron    | 2/25/2009 | a) Report on shielding made 2/25/09 team meeting b) use 3.175mm AI as baseline                                    | CLOSED |
| AI-09-003   | TMM-01 | Set up an RDAQ Working Group that contains all of the subsystem leads that will be interfacing with RDAQs including Flight Software.                                                            | Jason    | 2/4/2009  | Incorporated in the new Interfaces Working Group                                                                | CLOSED |
| AI-09-004   | TMM-01 | Determine your development schedule and ability to meet milestones.                                                                                                                                    | Lead Engineers | 2/4/2009  |                                                                                                                    | CLOSED |
| AI-09-005   | TMM-01 | Provide a list of the deliverables needed for PDR and plan to complete them (schedule and resources).                                                                                                    | Lead Engineers | 2/4/2009  |                                                                                                                    | CLOSED |
| AI-09-006   | TMM-01 | Contact NASA Ames about getting the specifications, blueprints, and schematics for their CheapSat reaction wheel and controller.                                                                        | Trevor   | 2/4/2009  | Trevor, lloyd & Carole held telecom with Stevan Spremo on 2/5/09 and he provided information about their RW | CLOSED |
| AI-09-007   | TMM-02 | Combine the relevant action items from the SRR with the AIs resulting from these minutes into a definitive project action item list.                                                                  | Trevor   | 2/11/2009 | This document                                                                                                     | CLOSED |
| AI-09-008   | TMM-02 | Perform and present the results of analysis of the nadir and zenith imagers considering such factors as focal length, integration time, orbit speed, FOV, obstructions, etc. | Trevor   | 2/11/2009 | Replaced by other Action Items                                                                                     | WITHDRAWN |
| AI-09-009   | TMM-02 | Develop a set of derived requirements (including the one above) to help specify the equipment required by the imagers (e.g., lens) and their performance.                                                | Jason    | Pre-PDR   | Done for PDR                                                                                                       | CLOSED |
Project vs Program?
Project vs Program

A project has a start as well as a well-defined end and produces well-defined deliverables or outputs.

On the other hand, program is a often a number of projects with no definite end and is more concerned with outcomes and benefits.
Project Definition
A project is an organization of people dedicated to a specific purpose or objective. Projects generally involve large, expensive, unique, or high risk undertakings which have to be completed by a certain date, for a certain amount of money, within some expected level of performance. At a minimum, all projects need to have well-defined objectives and sufficient resources to carry out the required tasks.
A project is a combination of human and nonhuman resources pulled together in a temporary organization to achieve a specified purpose.
A project is a sequence of unique, complex, and connected \textit{activities} having one goal or \textit{purpose} and that must be completed by a \textit{specific time}, within \textit{budget}, and according to \textit{specification}. 
Characteristics of a Project

- Goal oriented
- Coordinated undertaking of interrelated activities
- Of finite duration
- To a degree, unique

Constraints that operate on every project:

1. Scope
2. Quality (performance)
3. Cost
4. Time
5. Resources
6. Risk
Project Life Cycle
Project Life Cycle

NASA Model

Pre-Phase A
Concept Studies

Phase A
Concept & Technology Development

Phase B
Preliminary Design & Technology Completion

Phase C
Final Design & Fabrication

Phase D
System Assembly, I & T, Launch

Phase E
Operations & Sustainment

Phase F
Termination/Closeout

Project Definition Input
MS, Obj & Const, SC, TL Req.

MCR: Mission Concept Review
SRR: System Requirements Review
PDR: Preliminary Design Review
CDR: Critical Design Review
SIR: System Integration Review
ORR: Operations Readiness Review

APPROVAL FOR IMPLEMENTATION

IMPLEMENTATION

FORMULATION
NASA Model

**Project Life Cycle**

**FORMULATION**

- **Pre-Phase A**
  - Concept Studies

- **Phase A**
  - Concept & Technology Development

- **Phase B**
  - Preliminary Design & Technology Completion

- **Phase C**
  - Final Design & Fabrication

**IMPLEMENTATION**

- **Phase D**
  - System Assembly, I & T, Launch

- **Phase E**
  - Operations & Sustainment

- **Phase F**
  - Termination/Closeout

**APPROVAL FOR IMPLEMENTATION**

- **Team Proposal**
- **PDR: Preliminary Design Review**
- **CDR: Critical Design Review**

**ME 481**

- Project Definition Input
  - MS, Obj & Const, SC, TL Req.

**ME 482**

- **Project Review**
- **Detailed Design/Manufacturing Review**
- **Midterm Review**
- **Most Critical Module Demo**
- **Alpha Demo**
Project Life Cycle

Pre-Phase A: Concept Studies

INPUTS FROM PROJECT DEFINITION
• Mission Statement
• Objectives & Success Criteria
• Constraints (budget, schedule, risk, etc.)
• Top-Level Requirements

MANAGEMENT TASKS
• Establish project team
• Develop & document draft Management Baseline that includes WBS, schedule, ROM cost estimate
• Assessment of potential technology needs vs current and planned TRLs
• Assessment of potential infrastructure & personnel needs

TECHNICAL TASKS
• Study a broad range of mission concepts that contribute to project goals and objectives
• Draft project-level requirements
• Develop and document preliminary mission concept(s)
• Plan, prepare for, and support the project independent life cycle reviews
Project Life Cycle

Phase A: Concept & Technology Development

PURPOSE: The project team fully develops a *baseline mission concept* and begins or assumes responsibility for the development of needed technologies. This work, along with interactions with customers and other potential stakeholders, helps with the baselining of a mission concept and the top-level requirements on the project.

**MANAGEMENT TASKS**

- Prepare and document a *preliminary* Project Plan
- Develop and document a *preliminary* Management Baseline for all work to be performed by the project that includes:
  - Work Breakdown Structure (WBS)
  - Integrated master schedule
  - Life cycle cost estimate
  - Workforce estimates
  - Technical baseline mission concept
- Obtain any necessary permits
- Conduct System Requirements Review (SRR)

**TECHNICAL TASKS**

- Develop *preliminary system-level (and lower level, as needed)* requirements
- Develop and document a *baseline mission concept* (including key risk drivers and mitigation options and mission descope options)
- Develop a *preliminary mission operations concept*
- Initiate technology developments, as required
- Plan, prepare for, and support the project independent life cycle reviews
Project Life Cycle

**Phase B: Preliminary Design & Technology Completion**

PURPOSE: The project team completes its preliminary design and technology development leading to Preliminary Design Review (PDR)

<table>
<thead>
<tr>
<th>MANAGEMENT TASKS</th>
<th>TECHNICAL TASKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete the Project Plan</td>
<td>Implement the preliminary Project Plan</td>
</tr>
<tr>
<td>Develop and document a preliminary Management Baseline for all work to be performed by the project</td>
<td>Baseline system-level requirements and develop the subsystem and lower level technical requirements leading to the PDR baseline</td>
</tr>
<tr>
<td>Identify any risk drivers and proposed mitigation plan for each</td>
<td>Develop a set of system subsystem preliminary designs, including interface definitions, and document this work in a preliminary design report</td>
</tr>
<tr>
<td>Develop list of descope options</td>
<td>Develop and document a baseline mission operations concept</td>
</tr>
<tr>
<td>Conduct PDR</td>
<td>Complete development of mission-critical or enabling technology</td>
</tr>
<tr>
<td>Prepare and finalize any Phase C &amp; D work agreements (but do not execute pending approval)</td>
<td>Plan and execute long-lead procurements in accordance with Acquisition Plan</td>
</tr>
<tr>
<td>Develop, document, and maintain a project Management Baseline for all work performed by the project</td>
<td></td>
</tr>
</tbody>
</table>

A. Trimble, T. Sorensen
Project Life Cycle

Phase C: Final Design and Fabrication

PURPOSE: The project completes the design that meets the detailed requirements and begins fabrication of test and flight article components, assemblies, and subsystems.

MANAGEMENT TASKS

• Implement the Project Plan
• Update work agreements for Phase D
• Maintain the Management Baseline under configuration management
• Mature preliminary Project Plan Control Plans
• Develop a baseline Risk Management Plan
• Conduct Critical Design Review (CDR)

TECHNICAL TASKS

• Implement the baseline Project Plan
• Develop and test all requisite engineering models (brass boards, breadboards, full-up models, prototypes) sufficiently prior to CDRs to enable test results to affect detailed designs
• Develop requisite system and subsystem test beds needed for qualification and acceptance testing of final articles
• Initiate fabrication/procurement of final article components, assemblies, and/or subsystems
• Initiate the qualification and acceptance testing of final article components, assemblies, and/or subsystems
**Project Life Cycle**

**Phase D: System Assembly, I & T, Launch**

PURPOSE: The project performs system *assembly*, *integration* and *test* (I&T) and *launches* (operates) the article being built.

**MANAGEMENT TASKS**

- Implement the Project Plan
- Prepare and finalize work agreements for Phase E
- Implement project cost and schedule control activities
- Conduct System Integration Review (SIR) and Operations Readiness Review (ORR)

**TECHNICAL TASKS**

- Implement the Project Plan
- Initiate *system assembly*, *I&T*
- Resolve all test, analysis, and inspection discrepancies
- *Prepare “as-built” and “as-deployed” hardware and software documentation, including “close-out” photographs*
- Complete all operational support and other enabling developments (e.g., facilities, equipment, and updated databases), including a baseline *Ops Handbook* to support the operations team
- Conduct ops tests and training, including normal and anomalous scenarios
Project Life Cycle

Phase E: Operations & Sustainment

PURPOSE: The project implements the Missions Operations Plan

MANAGEMENT TASKS

- Support the development of Project Plan revisions
- Prepare and document a baseline Systems Decommissioning/Disposal Plan
- Prepare or update work agreements for Phase F

TECHNICAL TASKS

- *Execute the mission* in accordance with the Mission Operations Plan and document this work in a Mission Report
- *Monitor* system incidents, problems, and anomalies, as well as system margins to ensure that deployed project systems function as intended, and investigate system behavior that is observed to exceed established operational boundaries or expected trends, and implement corrective actions, as necessary
- Provide *sustaining engineering*, as appropriate, to the mission to enhance efficiency, safety, and accommodate obsolescence
- *Capture and archive mission results*, including engineering data on system and subsystem performance
Project Life Cycle

Phase F: Termination/Closeout

PURPOSE: The project: (1) implements the Systems Decommissioning/Disposal Plan developed in Phase E, and performs analyses of the returned data, or (2) ends due to criteria set at start of project (e.g., mission success, time or cost limit reached). Final reports and documentation of the project are produced.

MANAGEMENT TASKS
- Supervise implementation of Decommissioning/Disposal Plan
- Complete Final Report

TECHNICAL TASKS
- Complete analysis and archiving of mission and science data, as well as archiving of project engineering and technical management data and documentation, and lessons learned in accordance with agreements, the Project Plan
- Implement the Systems Decommissioning/Disposal Plan and safely dispose of project systems
Types of Project Management
Project management is getting the job done on time, within budget, and according to specification.

NASA Project Paradigm introduced by NASA Administrator Dan Goldin in 1990s

Experience shows that it is possible to achieve 2 of these 3 qualities, but almost impossible to get all 3
Types of Project Management

• Traditional Project Management (TPM)
  – Follows very detailed plan built before any work is done on project
  – Based on assumption that the goal is clearly defined before the beginning of the project
  – Success based on correct specification of goal during project definition and initial scoping of activities
Types of Project Management

• Adaptive Project Framework (APF)
  – Follows detailed plan, but plan is not built before start of project
  – Plan built in stages at completion of each cycle that defines the project life cycle
  – Budget and time limit are specified at outset
  – At completion of each cycle, team and client review progress and adjust plan going forward
  – Planning done using just-in-time philosophy with little effort put into initial planning and scheduling components not used
  – APF project generally finished in less time and cost than a TPM project when project goals and method not well defined at outset
Types of Project Management

- Extreme Project Management (XPM)
  - Projects do not follow a plan in sense of TPM or APF projects
  - PM makes informed guesses as to the final goal (or solution), and is not very specific
  - Cycle of work planned based on assumption that the initial guess is reasonable
  - As in APF, completion of each cycle has review of what has been learned, which is factored into specification of goal and new goal definition (feedback loop)
  - Next cycle is planned based on new goal
  - Process continues until acceptable solution is reached or project is abandoned (due to lack of convergence of viable solution within acceptable expenditure of resources)
Types of Project Management

- **Traditional**: Clearly Defined
- **Adaptive**: Not Clearly Defined
- **Extreme**: Not Clearly Defined

<table>
<thead>
<tr>
<th>How to get it?</th>
<th>Clearly Defined</th>
<th>Not Clearly Defined</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XPM</td>
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</tbody>
</table>

ME 481/482
Traditional
Project
Management
Stages of Project Management

Stage 1
DEFINITION

Stage 2
PLANNING

Stage 3
IMPLEMENTATION

Stage 4
TERMINATION
A. Trimble, T. Sorensen
Definition Stage
Definition Stage

• In this stage, the customer and the project manager come to an agreement about several important aspects of the project

• The Definition Stage sets the scope of the project
  – It forms the basis for deciding if a particular function or feature is within the scope of the project
  – Anticipate and plan for *scope creep*
Definition Stage

Definition Stage must answer following questions:

1. What is the problem or opportunity to be addressed?
2. What is the goal of the project?
3. What objectives must be met to accomplish the goal?
4. How will we determine if the project has been successful?
5. Are there any assumptions, risks, or obstacles that may affect project success?
Definition Stage

1 – Identify Problem

2 – Establish Mission Statement

3 – Define Objectives & Constraints

4 – Define Success Criteria

5 – List principal players, assumptions, risks, and obstacles

6 – Define top-level system requirements

Stage 2: Planning

Project Overview Statement (POS)

Project Definition Statement (PDS)
Step 2: Define the Project Mission Statement

- Highest level succinct description of the major goal or purpose(s) of the mission (project)
- A well-fashioned Project Mission Statement allows the project team to move ahead with clarity, speed and buy-in and, if you're lucky, enthusiasm as well. It also provides customers and other stakeholders with a clear and succinct picture of the project's essence
- Defined by or with the customer (owner/funder of the mission)
- All objectives and requirements flow down from the Mission Statement
Definition Stage

Project Mission Statement

• Guidelines for a good concise project mission statement:
  
  – **Sentence 1:** The lead sentence contains three components:
    
    1. *Who* is doing the project
    2. *Purpose* of the project
    3. *What* is to be produced (i.e., output of the project)
  
  – **Sentence 2:** State the timeline or establish a stop sign, i.e., to define when the project is over, and what will happen when the project ends (outcome)
  
  **Example Concise Project Mission Statement**
  
  We aim to create a new brand of shampoo by the end of the year that is specifically targeted at hairdressers in order to gain a foot in the beauty industry.
Definition Stage

Box Farm™ MISSION STATEMENT

The Box Farm team will create an indoor autonomous hydroponics garden, Box Farm, that uses a robotic system to plant, water, transfer, monitor, and harvest vegetables in an Inflatable Lunar Mars Habitat (ILMH) greenhouse, created by the University of North Dakota, to test technologies for supporting and sustaining manned missions to the Moon, Mars, and beyond. It will reduce the amount of man hours spent tending to the greenhouse by maintaining a steady supply of vegetables. The Box Farm project will demonstrate its ability to meet its objectives at the ILMH greenhouse by May 2019.
The Box Farm team will create an indoor autonomous hydroponics garden, Box Farm, that uses a robotic system to plant, water, transfer, monitor, and harvest vegetables in an Inflatable Lunar Mars Habitat (ILMH) greenhouse, created by the University of North Dakota, to test technologies for supporting and sustaining manned missions to the Moon, Mars, and beyond. It will reduce the amount of man hours spent tending to the greenhouse by maintaining a steady supply of vegetables. The Box Farm project will demonstrate its ability to meet its objectives at the ILMH greenhouse by May 2019.
Definition Stage

Step 3: Define Project Objectives and Constraints

– Objectives are broad goals drawn from mission statement
– Objectives are usually subjective, not quantitative as are the requirements and constraints
– Objectives usually cannot be modified substantially
– Objectives can usually be classified as primary (e.g., technical or commercial) and secondary (e.g., political, hidden, or Public Relations) objectives
– Constraints are limits put onto the mission that are beyond the control of the project management (e.g., funding limits, technology to be used, specific payloads, specific launch vehicle with resultant mass, or safety limits)
Definition Stage

Box Farm™ Example

• **Primary Objectives**
  1. To create a working prototype of an autonomous hydroponic system that reduces human intervention.
  2. To develop a graphical interface to display system diagnostics and allow the user to monitor and control the system if needed.
  3. To design the system to be easily integrated with University North Dakota's Inflatable Lunar Mars Habitat greenhouse.

• **Secondary Objectives**
  1. To integrate the Comprehensive Open-architecture Solution for Mission Operations System (COSMOS) platform to establish communications with mission control.
  2. To develop strategies to reduce the complexity and dependency of system autonomy.
  3. To provide favorable publicity for the Department of Mechanical Engineering, College of Engineering, and the University of Hawaii at Manoa.
  4. To graduate in Spring 2019.
Definition Stage

**Step 4: Identify the Success Criteria**

– *Success criteria* map directly to objectives and may specify different levels of success for each objective
Primary Objectives
1. To create a working prototype of an autonomous hydroponic system that reduces human intervention.
2. To develop a graphical interface to display system diagnostics and allow the user to monitor and control the system if needed.
3. To design the system to be easily integrated with University North Dakota's Inflatable Lunar Mars Habitat greenhouse.

Primary Success Criteria
1. The system autonomously seeds and transplants for a multitude of cycles.
2. The graphical interface is user friendly and has a wide range of displayed data, and ability to control the system.
3. The system fits seamlessly into the ILMH and operates nominally.
Definition Stage

Box Farm™ Success Criteria

• Secondary Objectives
  1. To develop strategies to reduce the complexity and dependency of system autonomy.
  2. To provide favorable publicity for the Department of Mechanical Engineering, College of Engineering, and the University of Hawaii at Manoa.
  3. To graduate in Spring 2019.

• Secondary Success Criteria
  1. Able to perform remote control uplinking and diagnostic data transfer through COSMOS.
  2. The system is operationally adaptive to component failure.
  3. Favorable articles and features about Box Farm appear in media.
  4. Pass ME 481-482.
Step 5: List principal players, assumptions, risks, and obstacles

• Step 5a: List principal players
This helps to understand the who the customers are, who will be using the product/results of the project, which may affect the design and operability of the product

Box Farm™ Example

• Primary Customer: Dr. Sorensen
• Secondary Customer: Dr. Pablo del Leon
  (University of North Dakota)
• Operator: Box Farm Team/ UND
• End User: NASA?
• **Step 5b: List assumptions, risks, and obstacles**
  
  – Project Manager identifies factors that can affect the outcome of the project
  
  – The Project Management Plan (PMP) should list these factors and possible contingencies or mitigations that can help reduce the probable impacts and effects on project success
  
  – Examples of factors that can inhibit project success:
    
    • **Technological** – experience with a new technology may be lacking in the project team or a designated new technology is not fully mature. Will the technology vendor still be able to support it in the future?
    
    • **Environmental** – this usually refers to the work environment, such as does the project have the full support of higher management?; is the management and organization labor situation stable (i.e., personnel turnover)?; are the facilities adequate for the implementation of the project?
    
    • **Funding** – is the funding adequate and assured, or will it come in installments that are not certain (e.g., government annual budget)?
    
    • **Personnel** – does the project have adequate staffing and personnel of the required experience and skill sets?
Definition Stage

The results of the Definition Stage are often captured in a:

• Project Overview Statement (POS) or
• Project Definition Statement (PDS)

which can be issued as standalone documents, but are incorporated in the Project Management Plan (PMP), which is the end product of the Planning Stage
Planning Stage
Planning Stage

• Develop the project plan
  1. Establish basic project team and organization
  2. Develop mission architecture and concept
  3. Define tasks and resources
     - Estimate task duration
     - Determine resource requirements
     - Develop Work Breakdown Structure
  4. Determine milestones
  5. Define schedule
  6. Construct/analyze the project network
  7. Prepare staffing plan
  8. Estimate cost and formulate preliminary budget

• Prepare the project plan (proposal) for customer review
Planning Stage

Step 1: Project Team and Organization

• Break overall project into major elements and subsystems to set preliminary organization
  – Typically hierarchical organization, but not always
  – May match parent organization’s structure or a unique structure based on the nature of the project
  – Two basic types of organizations for project
    • *Line* organization sets unique hierarchical organization for the project
    • *Matrix* organization taps personnel from departments to form temporary project organization, but personnel are still part of their original department
Planning Stage

Matrix Structural Organization

• Type of organizational structure in which people with similar skills are pooled for work assignments, resulting in more than one manager per person

- Advantages:
  – Individuals can be chosen according to needs of the project.
  – Use of a project team that is dynamic and able to view problems in a different way as specialists have been brought together in a new environment
  – Project managers are directly responsible for completing the project within a specific deadline and budget

- Disadvantages:
  – Conflict of loyalty between line managers and project managers over the allocation of resources
  – Projects can be difficult to monitor if teams have a lot of independence
  – Organizational efficiencies are very difficult to identify because benchmarking headcount against revenue (or output) is not possible due to the scattered nature of the supporting functions

Planning Stage

Project Line Organization – LEO-1 Example

HSFL Co-Director
Wayne Shiroma

Project Manager
Trevor Sorensen

Project Systems Engineer
Byron Wolfe

Operations Manager
(Trevor Sorensen)

Payloads Manager
Byron Wolfe

I&T Manager
(Byron Wolfe)

* Faculty Member
Planning Stage

Step 2: Develop Mission Architecture & Concept

- This is a product of the project design process, but requires project management participation and guidance.
- The baseline mission architecture should show all the major elements of the project including the operations concept.
- You should be able to describe the project concept using the architecture diagram – for this reason it is advantageous to use icons and images instead of just text boxes.
DataLynx System Architecture

- **Mission Operations**
- **DataLynx Operations Center (DOC) Includes GNCC and MOps**
- **TAGS**
- **Payload Data**
- **Customer**
- **Data Users**
- **GNCC**
- **SC Telemetry**
- **S/C Commands**
- **TDAC Customers**
- **Payload Data**
- **Full Service Customers**
- **Launch Sites**
- **Low Data Rate Customers**
- **Space Science**
- **Low Data Rate**
- **Fairbanks, Alaska**
- **Svalbard, Norway**
- **Payload Data**
- **Mission Data**
- **Tasking**

**Example Architectures – DataLynx**

Planning Stage

Courtesy Honeywell Technology Solutions Corporation

Honeywell Technology Solutions Inc.
Planning Stage

Step 3: Identify Tasks & Resources

- Break overall project into tasks & sub-tasks
- State each task using “verb-noun” form

*Examples:*
- Design motor test stand
- Build motor test stand
- Plot torque vs. speed

- Appropriate level of detail
  - *Function*, not *form*, known at start of project
  - Example: “Build concept demonstration prototype”

- Make each task significant
  - e.g., “Identify competitive products” rather than “Go to library”

- Estimate duration of each task
- Estimate resources (persons) for each task
Work Breakdown Structure (WBS)

- The *Work Breakdown Structure (WBS)* is a hierarchical description of the work that must be done to complete the project.
- It is often structured using nouns for upper level organization (e.g., systems and subsystems), but at the lowest level tasks should be in the task (verb-noun) form to show work.
- *Activity* can be interchangeable with *task*, but usually an activity is a collection of tasks that make up a *work package*, which is a complete description of how the tasks that make up that activity will actually be done.
- Breaking down work into hierarchy of activities, tasks, and work packages, is called *decomposition*.
- The WBS is a key product. It is the foundation for project planning, cost estimation, schedule and budget formulation, specifications, progress status reporting, and problem analysis.
Planning Stage

WBS Template

WORK BREAKDOWN STRUCTURE LEVELS TEMPLATE

[Diagram of WBS Template with highlighted Work Package]

https://weekplanner.io/category/functionality/
# Planning Stage

## Work Package Description Form

<table>
<thead>
<tr>
<th>Work Package Description</th>
<th>Project Name</th>
<th>Project No.</th>
<th>Project Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Package Name</td>
<td>Work Package No.</td>
<td>Work Package Manager</td>
<td>Contact Info.</td>
</tr>
<tr>
<td>Start Date</td>
<td>End Date</td>
<td>Critical Path</td>
<td>Predecessor Work Package(s)</td>
</tr>
</tbody>
</table>

### TASK

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Description</th>
<th>Time (days)</th>
<th>Responsibility</th>
<th>Contact Info.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Prepared by

Date

Approved by

Date

Sheet 1 of 1
Planning Stage

Example WBS - Simple

- **Level 1:**
  - Provide Banquet

- **Level 2:**
  - 1.1 Plan and Supervise
    - 1.1.1 Create Plan
    - 1.1.2 Make Budget
    - 1.1.3 Prepare Disbursements/Reconciliation
    - 1.1.4 Coordinate Activities
  - 1.2 Dinner
    - 1.2.1 Make Menu
    - 1.2.2 Create Shopping List
    - 1.2.3 Shop
    - 1.2.4 Cook
    - 1.2.5 Serve Dinner
  - 1.3 Room and Equipment
    - 1.3.1 Identify Site/Room
    - 1.3.2 Set up Tables/Chairs
    - 1.3.3 Lay out Settings/Utensils
    - 1.3.4 Decorate
    - 1.3.5 Prepare Equipment, Pots, Pans
  - 1.4 Guests
    - 1.4.1 Make Guest List
    - 1.4.2 Receive RSVPs
    - 1.4.3 Create Name Tags
    - 1.4.4 Review Special Needs
  - 1.5 Staff
    - 1.5.1 Hire Shoppers
    - 1.5.2 Hire Cooks
    - 1.5.3 Hire Servers
    - 1.5.4 Hire Hosts
    - 1.5.5 Hire Cleanup
  - 1.6 Speakers
    - 1.6.1 Invite
    - 1.6.2 Transport
    - 1.6.3 Coordinate Topics
    - 1.6.4 Backup for No-shows
    - 1.6.5 Send Thank Yous

Serve Dinner has id 1.2.5 this shows it is part of Dinner (1.2) which is part of Provide Banquet (1.0)
Planning Stage

Example WBS
House Construction

https://www.workbreakdownstructurewbs.com/
Planning Stage

DSPSE Work Breakdown Structure

Example WBS: Clementine

Note: Level 4 is activity/task level
Step 4: Identify Milestones

- Types of milestones
  - Provide tangible interim goals
  - Demonstrate progress
  - Enforce schedule

- State each milestone by "noun-verb" or “noun” form

  Examples
  - Mission defined
  - Preliminary Design Review (PDR)
  - Prototype completed

- Probably about 4-10 milestones is appropriate for 12 week project
Planning Stage

Step 5: Define Schedule

• Define start & end dates for each WBS task
  - Serial tasks: Dependent
  - Parallel tasks: Independent

• Show WBS tasks on schedule chart
  - Simple: Carefully draw by hand or use Microsoft Excel, etc.
  - Elegant: Microsoft Project or similar tool
# Planning Stage

## Example Schedule - Simple

<table>
<thead>
<tr>
<th>WBS TASKS</th>
<th>MONTH</th>
<th>ΔSRR</th>
<th>ΔCDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Conduct swarm parametric study</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Run simulations for all parameters across valid ranges</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1.2 Analyze results for any unexpected behavior</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1.3 Make appropriate corrections to code base</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Develop tools for iCOSMOS-Swarm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 Convert MOST to iCOSMOS-Web</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2.2 Develop Swarm Management Tool (SMT)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2.3 Convert CEO to iCOSMOS-Web</td>
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<tr>
<td>2.4 Develop MPST for iCOSMOS-Swarm</td>
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</tr>
<tr>
<td>2.5 Convert Flight Dynamics Tool (FTD) to iCOSMOS-Web</td>
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<tr>
<td>2.6 Convert Data Management Tool (DMT) to iCOSMOS-Web</td>
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<tr>
<td>3 Enhance MAC for trajectory optimization</td>
<td></td>
<td></td>
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<tr>
<td>3.1 Define optimization objectives, variables and constraints</td>
<td></td>
<td></td>
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<tr>
<td>3.2 Derive methodology of MPC-based trajectory optimization</td>
<td></td>
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<tr>
<td>3.3 Prototype &amp; test trajectory optimization algorithms in Python</td>
<td></td>
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<tr>
<td>3.4 Port algorithms from Python to C++</td>
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<tr>
<td>3.5 Integrate trajectory optimization with MAC</td>
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<tr>
<td>4 Expand multi-node attitude planning</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>4.1 Define requirements for multi-node attitude planning</td>
<td></td>
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<tr>
<td>4.2 Develop methodology for multi-node attitude planning</td>
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<tr>
<td>4.3 Prototype and test attitude planning algorithms in Python</td>
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<tr>
<td>4.4 Port to C++ and test</td>
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<tr>
<td>5 Implement and expand HCL</td>
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<tr>
<td>5.1 Add support for adaptive covariance</td>
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</tr>
<tr>
<td>5.2 Develop methodology for attitude estimation</td>
<td></td>
<td></td>
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<tr>
<td>5.3 Implement attitude estimation in C++</td>
<td></td>
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<tr>
<td>5.4 Develop theories for navigation system FDIR</td>
<td></td>
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<tr>
<td>5.5 Implement navigation system FDIR in C++</td>
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<tr>
<td>6 Improve autonomy of nodal assets</td>
<td></td>
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<tr>
<td>6.1 Explore decision space for attitude &amp; position adjustments</td>
<td></td>
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<tr>
<td>6.2 Identify key information required to make decisions in 6.1</td>
<td></td>
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<tr>
<td>6.3 Define mechanisms for acquiring information in 6.2</td>
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<tr>
<td>6.4 Develop framework for applying mechanisms in 6.3</td>
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<tr>
<td>6.5 Develop algorithms for Swarm Autonomous Behavior</td>
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<tr>
<td>6.6 Develop algorithms for Self Autonomous Behavior</td>
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<tr>
<td>6.7 Implement and test system</td>
<td></td>
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<tr>
<td>7 Develop conceptual design of MotherShip and ChildSat</td>
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</tr>
<tr>
<td>7.1 Define requirements for MotherShip and ChildSat</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>7.2 Design study for mothership</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>7.3 Design study for childSats #1-#4</td>
<td></td>
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</tr>
<tr>
<td>7.4 Update/Iterate designs</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>8 Develop hardware-in-the-loop (HIL) simulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.1 Parts procurement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.2 Software implementation for CubeSpace HIL spoofing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.3 Assembly and Integration of MotherShip and ChildSats</td>
<td></td>
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</tr>
<tr>
<td>8.4 FlatSat configuration for HIL configuration</td>
<td></td>
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</tr>
<tr>
<td>8.5 FlatSat checkout of HIL with simulation algorithms</td>
<td></td>
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</tr>
<tr>
<td>9 Run full simulations for iCOSMOS-Swarm validation</td>
<td></td>
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</tr>
<tr>
<td>9.1 Run Monte Carlo simulations</td>
<td></td>
<td></td>
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<tr>
<td>9.2 Run multi pass HIL simulation using best scenario from 9.1</td>
<td></td>
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</tr>
<tr>
<td>9.3 Run simulations using MODVOLC for target generation</td>
<td></td>
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</tr>
<tr>
<td>10 Analyze results and write Final Report</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.1 Analyze results of iCOSMOS-Swarm validation simulations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.2 Write Final Report</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

*Using Microsoft Excel*
Step 6: Construct/analyze Project Network

- For complex project with many interdependencies it is best to construct a *project network diagram (PND)*, which is a pictorial representation of the sequence in which the project work must be done with and should show the following information:
  - Interdependencies of tasks
  - Start and end times of tasks
  - Resource allocation and expenditure
  - Milestones
  - Progress of tasks (% completion)
  - Critical path to completion

- Most commonly used tools for constructing a PND are the Gantt Chart and the Activity-on-the-Arrow (AOA) method
Planning Stage

Gantt Chart

• A Gantt chart is a type of bar chart devised by Henry Gantt in 1910s that illustrates a project schedule
  - Start and finish dates of task element
  - Can show dependency, relationship between elements, progress to date, etc.

• List WBS tasks on left; draw time line on right

• Tracking Progress:
  - Each bar in the Gantt chart time line represents percentage of task complete
  - Continuously update bars (a marking pen will do)
  - Draw red vertical line at current date to show schedule discrepancies
Planning Stage

Example Gantt Chart

WBS 1 Summary
- Element 1
  - WBS 1.1 Activity A: START-TO-START, 75% complete
  - WBS 1.2 Activity B: FINISH-TO-START, 67% complete
  - WBS 1.3 Activity C: FINISH-TO-FINISH, 50% complete
  - WBS 1.4 Activity D: 0% complete

WBS 2 Summary
- Element 2
  - WBS 2.1 Activity E: 0% complete
  - WBS 2.2 Activity F: 0% complete
  - WBS 2.3 Activity G: 0% complete
### Planning Stage

#### Gantt Chart Tracking Example

<table>
<thead>
<tr>
<th>WBS</th>
<th>Task Name</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Define specifications</td>
<td>January - February</td>
</tr>
<tr>
<td>1.1</td>
<td>Identify customers</td>
<td>1/7</td>
</tr>
<tr>
<td>1.2</td>
<td>Interview 10 customers</td>
<td>1/8</td>
</tr>
<tr>
<td>1.3</td>
<td>Interpret requirements</td>
<td>1/11</td>
</tr>
<tr>
<td>1.4</td>
<td>Benchmark products</td>
<td>1/13</td>
</tr>
<tr>
<td>1.5</td>
<td>Define target PDS</td>
<td>1/14</td>
</tr>
<tr>
<td>1.6</td>
<td>Target PDS Released</td>
<td>1/18</td>
</tr>
<tr>
<td>2</td>
<td>Generate concepts</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Review comp products</td>
<td>1/19</td>
</tr>
<tr>
<td>2.2</td>
<td>Search patents</td>
<td>1/20</td>
</tr>
<tr>
<td>2.3</td>
<td>Brainstorm concepts</td>
<td>1/21</td>
</tr>
<tr>
<td>3</td>
<td>Select top 2 concepts</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>MQ Presented</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Profile motor power</td>
<td></td>
</tr>
<tr>
<td>5.1</td>
<td>Design test stand</td>
<td>1/22</td>
</tr>
<tr>
<td>5.2</td>
<td>Build test stand</td>
<td>1/28</td>
</tr>
</tbody>
</table>

*behind schedule*

*ahead of sched*
Program Evaluation and Review Technique

- The *Program Evaluation and Review Technique (PERT)* is an AOA method that was developed and used for the Polaris Missile Program in the 1950s (completed in time and under budget).
- PERT is a method of analyzing the tasks involved in completing a given project, especially the time needed to complete each task.
- Event oriented and used mostly in projects where time is major factor rather than cost (GANTT better for cost).
- PERT is a management tool where on an arrow and node diagram, arrows represent activities and nodes represent events (completed activities or milestones).
- Using PERT with the time estimates for the different activities, you can estimate the total time of project completion and the critical path to achieve it, which is called **Critical Path Management (CPM)**.
Planning Stage

PERT Diagram

<table>
<thead>
<tr>
<th>ACTIVITY PATH</th>
<th>DURATION</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>A → E</td>
<td>5-7 months</td>
<td></td>
</tr>
<tr>
<td>B → C</td>
<td>10 months</td>
<td>Critical Path</td>
</tr>
<tr>
<td></td>
<td>8 months</td>
<td>Optimistic time</td>
</tr>
<tr>
<td>A → D → F</td>
<td>6-9 months</td>
<td></td>
</tr>
</tbody>
</table>
Step 7: Develop Staffing Plan

- Based on the project WBS, schedule, and project network diagram, the personnel needs can be estimated based on the progress of the project.

- It is usual to express the work effort and staffing in full time equivalent (FTE) units.
  - Somebody who works 8 hours a day, 5 days a week is considered to be 1 FTE. If a person works half time, then they are 0.5 FTE.

- This accounts for personnel who may only be working this project part-time (e.g., as part of a matrix organization) or are being shared among multiple projects or are not full-time members (e.g., university students).

- Staffing plan is direct input to cost estimate.
## Planning Stage

### Staffing Plan Example – LEO-1

<table>
<thead>
<tr>
<th>POSITION</th>
<th>FUNDING</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Manager - Trevor</td>
<td>COE</td>
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<td>0.6576</td>
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<tr>
<td>TB/Sim Graduate Assistant</td>
<td>Space Grant</td>
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<td>Project Avionics Engineer - Jason</td>
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<tr>
<td>C&amp;DH Lead Engineer - Jason</td>
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<td>EPS Lead Engineer - Jason</td>
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<td>Telecom Lead Engineer - Byron</td>
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<tr>
<td>Telecom Assistants - U/G (2)</td>
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<tr>
<td>Flight Software Lead Engineer - Eric</td>
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<td>SW Graduate Assistant</td>
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<td>Ops Software Engineer - Harold</td>
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## Planning Stage

### Staffing Plan Example – LEO-1

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Planning Stage

Step 8: Estimate Cost & Preliminary Budget

• Two primary methods used to estimate project costs:

  1. *Bottoms-up* or *Detailed Cost Estimating*. This uses costs of materials, parts, and components to be used by the project (*Bill of Materials*), and a description of development, production, and operations activities by labor classification.
    – This method is used later in the project when the design is mature, but is usually not suitable during the early stages unless it is a simple project.

  2. *Top-down* or *Parametric Cost Estimating*. This relies on broad design concepts and subsystem-level design parameters (cost drivers).
    – Uses cost-estimating tools, including cost estimating models, normalized historic databases, and the WBS.
    – Models are comprised of Cost Estimating Relationships (CERs), which are statistically-based cost-predicting algorithms derived from the databases.
Planning Stage

Representative Curve of Cost During Life Cycle

![Graph showing the cost of different stages during the design life of a product or system. The graph plots design life in years on the x-axis and cost (in millions of dollars) on the y-axis. The graph includes lines for total cost, cost per year, payload cost, bus cost, operations cost, and launch cost. The total cost line shows an increasing trend as the design life increases, while the operations cost line shows a decreasing trend.]
Planning Stage

HawaiSat-1 Hardware Budget

Spacecraft H/W Cost Est. ($K)

Note WBS element identification
## LEO-1 Project Costs

### Hardware Costs

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<th>FlatSat</th>
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### Labor Costs

- **Pre PDR** - $611,550
- **Post PDR** - $1,203,217

**Notes:**
- Does not include labor not charged to project (e.g., students being paid by Space Grant)
- Pre-PDR is from October, 2008 through May, 2009
- FlatSat costs need revision

**TOTAL COST FROM PDR**

- **Post-PDR** = $1,628,006
Planning Stage

LEONIDAS Labor Cost Budget (with FB & IC)
Total Cost = $1,203,217 (6/1/2009 through 9/15/2010)

- Management: $138,539, 12%
- Sys Eng: $219,215, 18%
- Mechanical: $399,241, 33%
- Ops & Data Mgt: $0, 0%
- Software: $200,004, 17%
- Avionics: $246,218, 20%

NOTE: Labor cost of single person not split between tasks
Hardware Costs of Flight Model
Total Cost = $274,341

- CDH: $65,500, 24%
- EPS: $27,500, 10%
- Telecom: $12,900, 5%
- Payload: $19,200, 7%
- S&M: $34,001, 12%
- ADCS: $82,400, 30%
- Margin: $24,940, 9%
- TCS: $6,000, 2%
- SysEng: $1,900, 1%

Planning Stage
Planning Stage

LEO-1 Spending Profile (Hardware)

Timeline Expenditures

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2010

A. Trimble, T. Sorensen
ME 481 – Fall 2022
Planning Stage

LEO-1 Development Process (Phases A&B)

ME 481 Proposal Tasks

- LEO-1 Mission Statement
- Mission Objectives (Primary/Secondary)
- Mission Operations Concept
- Mission Success Criteria
- System Requirements Document (SRD)
- Interface Control Documents (ICDs)
- Mission Operations Plan
- Subsystem Specifications (Derived Requirements)
- Functional Flow Block Diagram (FFBD)
- WBS
- Mission Architecture
- Mission Requirements Document (MRD)
- Detailed Design, Analysis, & Validation
- Specifications, Parts List, Cost, I&T Plan, Ops Procedures, Staffing Plan
- Reports
- Orbit Analysis
- Mass, Power & Volume Budgets
- Next Phase

Status colors:
- Green: Completed
- Yellow: Partially Completed or In-work
- Red: Not Started
Planning Stage

Risk Management Plan

• Risk management focuses on identifying, assessing, planning for, and dealing with areas or events having a potential for causing unwanted results

• It is an ongoing process that must be maintained throughout the life of the project

• It must be done as an applied methodology, not as a crisis response to a problem

• Risk management has multiple components, each of which is important for success, including:
  – Commitment to quality
  – Experienced project management
  – Technical understanding of the project
  – A documented risk management process
  – Risk management techniques and tools
  – Risk Retirement
# Risk Management Approach Summary

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<th>BENEFIT</th>
</tr>
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| Watch list of potential risks to the project development, staffing, and operations | • Early warning and vigilance by all concerned will allow management action to be taken to avert each risk before it becomes a problem  
• Establish the core of a tracking database to monitor problems throughout the project life cycle  
• Gives a basis for triggering farther action if necessary  
• Stimulates the identification and tracking of other risks                                                                               |
| Assessment and prioritization of each risk as it is entered on the Watch List | • Assessment helps to provide an understanding of each risk and the impact on the project  
• Ensures that the critical risks are identified and flagged early for action and continual monitoring until risk is successfully mitigated |
| Proposed mitigations for each risk on the Watch List                      | • Assurance that there are means to avert each risk  
• Given a basis for guiding further preventive action if necessary  
• Stimulates the identification, trade-off, and adoption of better risk-aversion mitigation strategies if available |
| Tracking database of risks, problems, issues, deviations from plan, and actions needed (the preliminary Watch List will form the basis of the tracking database) | • Ensures responsibility, visibility, and timely resolution of each developing problem that might hinder project development, staffing, operations and maintenance, or compromise the quality of the mission.  
• Provides a basis for assessing the completeness of LEO-1 development, operations and maintenance tasks from phase to phase of the life cycle. |
Planning Stage

Risk Assessment Process

- Risk Management Team (PM, Project Engineers) do closed-loop assessment of risks on regular basis.

- Assessment consists of three steps:

1. **Risk Identification**
   - Three types of risk in engineering projects:
     1. **Technical** – size & complexity, technology maturity, custom software/hardware, performance, logistics.
     2. **Cost** – funding availability and stability, vendors.
     3. **Schedule** – realism of schedules, resource allocation (especially personnel), changing requirements.
2. **Risk Analysis**
   - Tasks in Watch List categorized as follows:

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<tr>
<th>IMPACT</th>
<th>PROBABILITY OF OCCURENCE</th>
<th>RISK LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Medium</td>
<td>Low</td>
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<tr>
<td></td>
<td>Medium</td>
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<tr>
<td></td>
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<td>High</td>
<td>Low</td>
<td>Medium</td>
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<tr>
<td></td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

2. **Risk Prioritizing**
   - Prioritize risks (4=highest, 1=lowest) for monitoring
Planning Stage

Risk Cube

Identified Risks
1. Risk 1
2. Risk 2
3. Risk 3
4. Risk 4
5. Risk 5
6. etc.

Planning Stage

Risk Cube

Identified Risks
1. Risk 1
2. Risk 2
3. Risk 3
4. Risk 4
5. Risk 5
6. etc.

Risk Mitigation Strategy

1. Risk Mitigation Strategies
   – RMT decides which risks should be assumed and which “retired”
   – Identify proactive & reactive risk mitigation approaches and develop implementation plan
   – Identify “triggering event” for each risk

2. Mitigation Implementation
   – Implement mitigation strategies as appropriate

3. Risk Monitoring and Assessment

4. Risk Mitigation Results Evaluation

5. Risk Mitigation Replanning
   – Feedback loop of the closed-loop system

6. Risk Progress Report and Documentation
   – Provides historical trail
## Planning Stage

### Watch List for LEO-1 Risk Mitigation

<table>
<thead>
<tr>
<th>Risk Identification</th>
<th>Level</th>
<th>Risk Mitigation (blue=proactive, red=reactive)</th>
</tr>
</thead>
</table>
| HSFL has never built a spacecraft and could fail to complete the LEO-1 mission primary objectives | Medium | - Hire key personnel with space system experience
- Hire former UH students who built CubeSats
- Arrange for assistance by NASA and AFRL engineers
- Use experienced space system engineers and managers as evaluators in major project reviews
- Use COTS or flight-tested components where possible
- Build a complete Engineering Model from flight spares before the Flight Model
- Develop flat_sat using breadboards and prototypes
- Develop a testbed/simulator using the Engineering Model for the hardware
- Provide larger than normal performance margins in the design of the system (i.e., conservative design approach)
- Down scope mission objectives to allow for a smaller and cheaper spacecraft |
| Insufficient funding to complete project within schedule | High | - Arrange for alternate sources of funding (e.g., NASA EPScoR)
- Use UH undergraduate or graduate students who are paid by other sources (e.g., Hawaii Space Grant) or unpaid (e.g., for class credit or volunteer labor), as much as possible
- Use COTS rather than custom or space-qualified components where possible
- Obtain parts and services by barter or with academic discounts
- Down scope the mission's objectives to allow for a smaller and cheaper spacecraft |
| ITAR restrictions hinder development | High | - Use U.S. citizens/permanent residents whenever possible
- Arrange authorization for foreign nationals to work
- Isolation of ITAR components from foreign nationals |
| Flight software (FSW) not ready on time or unable to perform to requirements | High | - Hire software engineers with complex technical software development experience
- Develop and closely monitor a comprehensive Flight Software Plan
- Thorough FSW testing using Testbed/Simulator
- Design C&DH to accept FSW updates during flight
- FSW updates can be made during flight
- Utilize UH software engineering faculty expertise to solve specific problems |
| Operations will not be ready to support the mission | Medium | - Use experienced operations engineer as Mission Operations Manager
- Use command & telemetry lists and procedures developed from I&T during flight operations
- Provide training for operations personnel before flight
- Conduct rehearsals for nominal and non-nominal operations
- Include spacecraft engineers in Mission Operations Team after they have received training
- Design spacecraft for autonomous nominal operations and to safe the spacecraft in case of serious anomalies |

### Risk Mitigation (blue=proactive, red=reactive)

<table>
<thead>
<tr>
<th>Risk Identification</th>
<th>Level</th>
<th>Risk Mitigation (blue=proactive, red=reactive)</th>
</tr>
</thead>
</table>
| Launch vehicle's payload environment far exceeds estimated loads. | Medium | - Be conservative in design of structure
- Test spacecraft systems to 125% of estimated launch loads. |
| STU-1 payload could be placed in significantly lower than expected and/or non-nominal orbit. | Medium | - Prepare operational procedures for non-nominal orbit scenarios with contingency data collection plans. |
| Unable to obtain required UHF frequencies in time to support mission | High | - Enlist help from AFRL/ORS or VAFB to obtain frequencies |
| Missed TT&C passes | Low | - Arrange for other ground stations to support the mission
- Have at least 48 hours of commands stored onboard at any time
- Spacecraft has sufficient autonomy for survival despite extended gaps in TT&C |
| No previous experience in building solar panels | Medium | - Have solar panels made by experienced vendor
- Arrange for tech transfer of SA capabilities |
| Using COTS instead of space-hardened parts increases chance of SEEs | Medium | - Critical avionics shielded by aluminum boxes
- Redundancy provided for critical items
- C&DH designed to recover from SEEs
- Low altitude orbit reduces chance of SEEs
- Distributed C&DH architecture allows RDAQs to control spacecraft if CPU goes down
- Robust anomaly resolution procedures
- Spacecraft goes into SAFE mode if serious problem occurs |
| ADCS failure or partial failures | Medium | - Use ADCS test bed for thorough testing before flight
- Telecom antennas and solar arrays distributed around spacecraft in case of c/s tumble
- Include redundant IMU and GPS units
- Reduced attitude modes
- Disable magtorquers and allow s/c to tumble |
| ADCS magtorquer gets into singularity | Low | - Include a reaction wheel
- Disable magtorquers and allow s/c to drift through singularity |
| Spacecraft structure heavier than budgeted | Low | - Optimize design
- Use composites |
| Power available drops below critical level | Medium | - Design EPS with plenty of margin
- Put spacecraft into Low Power modes to minimize power usage and recover positive power margin |
| Payload removed from manifest before CDR or fails to deliver on time | Medium | - Use modular design approach that allows for removal (or addition) of payloads with minimal impact
- Redo analyses and add equivalent mass ballast if required |
<table>
<thead>
<tr>
<th>Document Title</th>
<th>Document Number</th>
<th>Description</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission Requirements Document (MRD)</td>
<td></td>
<td>This document gives the mission statement, objectives, success criteria, brief description of the mission, and the top-level requirements and constraints</td>
<td>Sorensen</td>
</tr>
<tr>
<td>Project Management Plan (PMP)</td>
<td></td>
<td>This document describes how the STU-1 project will be managed. It contains background &amp; technical overview; top-level requirements; requirements analysis &amp; management; system description &amp; architecture; development &amp; implementation approach; integration &amp; testing; operations readiness preparation; sustaining &amp; maintenance engineering; WBS; schedule; risk analysis &amp; mitigation plan; project staffing &amp; organization; subcontract management plan; project control and reporting; and project support and logistics.</td>
<td>Sorensen</td>
</tr>
<tr>
<td>Systems Engineering Management Plan (SEMP)</td>
<td></td>
<td>This document is the plan governing systems engineering effort - its main role is to identify and assure quality of overall process. It includes: top level objectives &amp; requirements; system overview; FFBDs; project documentation list; configuration management; quality assurance; analysis methods; time line and scheduling analyses (Time Line Sheets); integration and test plans; and interfaces.</td>
<td>Wolfe</td>
</tr>
<tr>
<td>System Specification Document (SSD)</td>
<td></td>
<td>This document captures the top-level and derived system, subsystem, and internal and external requirements.</td>
<td>Wolfe</td>
</tr>
<tr>
<td>Operations Concept Document (OCD)</td>
<td></td>
<td>This document will be in two parts: (1) provides a high-level description of the preparation, launch of STU-1 and deployment of its payloads; (2) provides a high level description of how LEONIDAS-1 will be operated during the mission</td>
<td>Sorensen</td>
</tr>
<tr>
<td>Mission Operations Plan (MOP)</td>
<td></td>
<td>Addresses how HSFL will support LEO-1 Operations including routine, L&amp;EO, and contingency support</td>
<td>Sorensen</td>
</tr>
<tr>
<td>Conceptual Design Document (CDD)</td>
<td></td>
<td>Describes the baseline spacecraft and PAD design at the end of the Phase A study.</td>
<td>Sorensen</td>
</tr>
<tr>
<td>Phase A Cost Study Report</td>
<td></td>
<td>Describes the best cost estimates of the LEO-1 SC and PAD at the end of Phase A</td>
<td>Sorensen</td>
</tr>
<tr>
<td>Integration &amp; Test Plan (ITP)</td>
<td></td>
<td>This document is divided into two parts: (1) describes how the S/C and its subsystems will be accepted into the integration environment and the tests to be conducted as part of the integration process; (2) describes how the launch payloads will be integrated into the PAD and tested prior to integration with the launch vehicle</td>
<td>Wolfe</td>
</tr>
</tbody>
</table>
### Planning Stage

#### Documentation List Example (cont.)

<table>
<thead>
<tr>
<th>Document Title</th>
<th>Document Number</th>
<th>Description</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Acceptance Test Description (SATD)</td>
<td></td>
<td>This document describes the acceptance criteria and how the system will be tested for acceptance.</td>
<td>Wolfe</td>
</tr>
<tr>
<td>Flight Software Plan (FSP)</td>
<td></td>
<td>This document captures how the flight software will operate and function within the context of the STU-1 mission.</td>
<td>Stolper</td>
</tr>
<tr>
<td>Flight Software Description (FSD)</td>
<td></td>
<td>This document describes the specifics and functions of the flight software package.</td>
<td>Stolper</td>
</tr>
<tr>
<td>Flight Operations Handbook (FOH)</td>
<td></td>
<td>Mission specific operating procedures relating to SC bus and its subsystems, and payloads.</td>
<td>Sorenson</td>
</tr>
<tr>
<td>Operations Procedures Document (OPD)</td>
<td></td>
<td>This document captures the operations procedures required to support (1) launch operations; and (2) mission operations. This document will complement the Flight Operations Handbook, which is the reference for use by the flight controllers.</td>
<td>Sorenson</td>
</tr>
<tr>
<td>System Design Document (SDD)</td>
<td></td>
<td>Describes the baseline spacecraft and PAD design at the end of Phase C (CDR).</td>
<td>Sorenson</td>
</tr>
<tr>
<td>Training Plan (TP)</td>
<td></td>
<td>This document describes the plan to train and certify HSFL operators to support the STU-1 mission.</td>
<td>Sorenson</td>
</tr>
<tr>
<td>Subsystems Interface Control Document (SS-ICD)</td>
<td></td>
<td>This document specifies the interface requirements between subsystems within the S/C and the PAD.</td>
<td>Wolfe</td>
</tr>
<tr>
<td>Ground to Space Interface Control Document (GS-ICD)</td>
<td></td>
<td>This document specifies the interface requirements between the Ground System and the S/C.</td>
<td>Wolfe</td>
</tr>
<tr>
<td>STU-1 SRR Package</td>
<td></td>
<td>Presentation material for the System Requirements Review</td>
<td>Sorenson</td>
</tr>
<tr>
<td>STU-1 PDR Package</td>
<td></td>
<td>Presentation material for the Preliminary Design Review</td>
<td>Sorenson</td>
</tr>
<tr>
<td>STU-1 CDR Package</td>
<td></td>
<td>Presentation material for the Critical Design Review</td>
<td>Sorenson</td>
</tr>
<tr>
<td>STU-1 TRR Package</td>
<td></td>
<td>Presentation material for the Test Readiness Review</td>
<td>Wolfe</td>
</tr>
<tr>
<td>STU-1 LRR Package</td>
<td></td>
<td>Presentation material for the Launch Readiness Review</td>
<td>Sorenson</td>
</tr>
<tr>
<td>STU-1 Data Management Plan</td>
<td></td>
<td>This document describes what and how data will be collected, stored, processed, and distributed.</td>
<td>Wright</td>
</tr>
<tr>
<td>LEONIDAS-1 Final Data Package</td>
<td></td>
<td>This package includes relevant collected data and a report/impact of that data. Deliverable to customer at end of operations period.</td>
<td>Wright</td>
</tr>
<tr>
<td>STU-1 Final Report</td>
<td></td>
<td>Overall final wrap-up report of entire project, for HSFL history and delivery to customer on request.</td>
<td>Sorenson</td>
</tr>
<tr>
<td>STU-1 Integrated Master Schedule (IMS)</td>
<td></td>
<td>MS Project living schedule encompassing all activities related to STU-1.</td>
<td>Sorenson</td>
</tr>
<tr>
<td>LEONIDAS-1 Financial Spreadsheet and Tracking</td>
<td></td>
<td>MS Excel living spreadsheet that tracks on a time scale: funding, expenses (both actual and obligated), and projected spend plan based on IMS.</td>
<td>Sorenson</td>
</tr>
</tbody>
</table>
Implementation Stage
Implementation Stage

• Launch the plan
  – Recruit and organize the project team
  – Establish team operating rules
  – Level project resources
  – Schedule work packages
  – Document work packages

• Monitor/control project progress
  – Establish progress reporting system
  – Install change control tools/process
  – Define problem-escalation process
  – Monitor project progress versus plan
  – Revise project plans
Implementation Stage

Integration Plan for Team RoSE Project

Legend

IP-X  Integration Point
AT-X  Baseline Acceptance Test

Suspension Assembly → IP-1 → Core Rover Subsystem → AT-2 → IP-2 → RoSE Rover System

I&C Assembly → AT-1 → Core Rover Subsystem

Arm Subsystem → AT-3

Autonomy Subsystem → AT-4

Science Subsystem → AT-5
Termination Stage
Termination Stage

- Close out the project
  - Obtain customer acceptance
  - Install project deliverables
  - Complete project documentation
  - Complete post-implementation audit
  - Issue final project report
Project Manager
Project Manager

• The project manager is accountable for execution of the program or project, and manages overall formulation and implementation.
• Each is responsible and accountable for the safety, technical integrity, performance, and mission success of the project while also meeting programmatic (cost and schedule) commitments (constraints).
• The project manager needs not only to be able to look “down” at their project, but also be able to look “up” at the environment the project is operating under.
  - Environment is seldom static. Political and other environments can change … and the project manager must be aware of potential changes and be prepared to react to them.
Questions for Project Manager

- What is the scope of our project?
- What gets delivered for the available time, people, $? (and what won't we do?)
- What resources do we need?
- How do we tell where we are?
  - Are we on schedule?
  - Are we on budget?
- How do we communicate our plan inside & outside the team?
  - Gain team agreement
  - Gain approval of upper management
  - Communicate with customer or sponsor
Project Management

Common Problems
Project Management Common Problems

- Manager task not effectively implemented
- Work Breakdown Structure too generic to be meaningful
- Gantt chart ignored
- Poor effort estimates
- Team doesn't buy in to plan
- Documentation ignored or insufficient
- Poor communication within team or with customer
- …more?
Mahalo!

Backup Slides
The Project Scope Triangle

- **Projects are dynamic systems that must be kept in equilibrium**
- *Project Manager* controls resource utilization and work schedules
- *Management* controls cost and resource level
- *Customer* controls scope, quality and delivery dates
EXAMPLE OF LONG MISSION STATEMENT

FIRESAT II
MISSION STATEMENT

Because forest fires pose an ever-increasing threat to lives and property, have a significant impact on recreation and commerce, and also have an even higher public visibility (largely because of the ability to transmit television images from nearly anywhere in real time), the United States needs a more effective system to identify and monitor them. In addition, it would be desirable (but not required) to monitor forest fires for other nations; collect statistical data on fire outbreaks, spread, speed, and duration; and provide other forest management data. This must be done at low cost to make the system affordable to the Forest Service and not give the perception of wasting money that could be better spent on fire-fighting equipment or personnel.

Ultimately, the Forest Service’s fire-monitoring office, fire management officers in the field, and individual firefighters and rangers fighting the fire will use the data. Data flow and formats must meet the needs of all of the groups without specialized training and must allow them to respond promptly and efficiently to changing conditions.
STU-1/LEO-1 Project WBS

1.0 Project Management & Systems Engineering
  1.1 Management & Administration
  1.2 Systems Engineering
  1.3 Quality & Safety Assurance
  1.4 Configuration Management
  1.5 Documentation
  1.6 Technical Reviews
  1.7 Conferences & Presentations
  1.8 Outreach

2.0 Spacecraft Bus
  2.1 Avionics
    2.1.1 Segment Management
    2.1.2 Requirements Analysis
    2.1.3 Command & Data Handling Subsystem (C&DH)
      2.1.3.1 Task Management
      2.1.3.2 Requirements Analysis
      2.1.3.3 Subsystem Design
      2.1.3.4 Procurement/Vendor Monitoring
      2.1.3.5 Fabrication
      2.1.3.6 Testing (SS Level)
      2.1.3.7 Integration & Testing (System Level)
    2.1.4 Electrical Power Subsystem (EPS)
      2.1.4.1 Task Management
      2.1.4.2 Requirements Analysis
      2.1.4.3 Subsystem Design
      2.1.4.4 Procurement/Vendor Monitoring
      2.1.4.5 Fabrication
      2.1.4.6 Testing (SS Level)
      2.1.4.7 Integration & Testing (System Level)
    2.1.5 Telecommunications Subsystem (Telecom)
      2.1.5.1 Task Management
      2.1.5.2 Requirements Analysis
      2.1.5.3 Subsystem Design
      2.1.5.4 Procurement/Vendor Monitoring
      2.1.5.5 Fabrication
      2.1.5.6 Testing (SS Level)
      2.1.5.7 Integration & Testing (System Level)
  2.1.6 Flight Software (FSW)
    2.1.6.1 Task Management
    2.1.6.2 Requirements Analysis
    2.1.6.3 Design
    2.1.6.4 Implementation
    2.1.6.5 Integration & Testing (System Level)
    2.1.7 Integration & Testing (System Level)

2.2 Mechanical Systems
  2.2.1 Structural Analysis
    2.2.1.1 Task Management
    2.2.1.2 Requirements Analysis
    2.2.1.3 Subsystem Design
    2.2.1.4 Procurement/Vendor Monitoring
    2.2.1.5 Fabrication
    2.2.1.6 Testing (SS Level)
    2.2.1.7 Integration & Testing (System Level)

2.2.3 Structures & Mechanisms (S&M)
  2.2.3.1 Task Management
  2.2.3.2 Requirements Analysis
  2.2.3.3 Subsystem Design
  2.2.3.4 Procurement/Vendor Monitoring
  2.2.3.5 Fabrication
  2.2.3.6 Testing (SS Level)
  2.2.3.7 Integration & Testing (System Level)

2.4.4 Attitude Determination & Control Subsystem (ADCS)
  2.4.4.1 Task Management
  2.4.4.2 Requirements Analysis
  2.4.4.3 Subsystem Design
  2.4.4.4 Procurement/Vendor Monitoring
  2.4.4.5 Fabrication
  2.4.4.6 Testing (SS Level)
  2.4.4.7 Integration & Testing (System Level)

2.2.5 Thermal Control Subsystem (TCS)
  2.2.5.1 Task Management
  2.2.5.2 Requirements Analysis
  2.2.5.3 Subsystem Design
  2.2.5.4 Procurement/Vendor Monitoring
  2.2.5.5 Fabrication
  2.2.5.6 Testing (SS Level)
  2.2.5.7 Integration & Testing (System Level)

2.2.8 Integration & Testing (System Level)

2.3 Payload Systems
  2.3.1 Segment Management
  2.3.2 HSFL Imager
  2.3.3 RADCAL II
  2.3.4 CERTO Beacon
  2.3.5 GPSRO
  2.3.6 Integration & Testing (System Level)