Effective Meetings
**Effective Meetings**

1. There is no such thing as just an individual/Teams are made up of individuals
2. 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)

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-F17-P5-001 (Action Item-Fall 2017-Project 5-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 Status – give the current status of the AI: OPEN, CLOSED, or WITHDRAWN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>
<tr>
<td>SSR-ECF-32</td>
<td>SRR</td>
<td>a) Check GSD of imaging system</td>
<td>Byron</td>
<td>Dec. 16</td>
<td>Done for PDR</td>
<td>CLOSED</td>
</tr>
</tbody>
</table>
| SSR-ECF-36 | SRR      | b) 79 deg. FOV is very wide, especially given 1024 x 1024 pixels  
| 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  | Team Meeting Minutes (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 Al 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 into 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 telecon 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. | Jason    | 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?
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 bunch 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 activities having one goal or purpose and that must be completed by a specific time, within budget, and according to 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
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)

### MANAGEMENT TASKS

- Complete the Project Plan
- Develop and document a *preliminary* Management Baseline for all work to be performed by the project
- Identify any risk drivers and proposed mitigation plan for each
- Develop list of descope options
- Conduct PDR
- Prepare and finalize any Phase C & D work agreements (but do not execute pending approval)
- Develop, document, and maintain a project Management Baseline for all work performed by the project

### TECHNICAL TASKS

- Implement the *preliminary* Project Plan
- Baseline system-level requirements and develop the subsystem and lower level technical requirements leading to the PDR baseline
- Develop a set of system subsystem preliminary designs, including interface definitions, and document this work in a preliminary design report
- Develop and document a baseline mission operations concept
- Complete development of mission-critical or enabling technology, as needed
- Plan and execute long-lead procurements in accordance with Acquisition Plan
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) 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

<table>
<thead>
<tr>
<th>MANAGEMENT TASKS</th>
<th>TECHNICAL TASKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Support the development of Project Plan revisions</td>
<td>• Execute the mission in accordance with the Mission Operations Plan and document this work in a Mission Report</td>
</tr>
<tr>
<td>• Prepare and document a baseline Systems Decommissioning/Disposal Plan</td>
<td>• 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</td>
</tr>
<tr>
<td>• Prepare or update work agreements for Phase F</td>
<td>• Provide sustaining engineering, as appropriate, to the mission to enhance efficiency, safety, and accommodate obsolescence</td>
</tr>
</tbody>
</table>

• Capture and archive mission results, including engineering data on system and subsystem performance
**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.
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
- Adaptive
- Extreme

What’s Needed?
- Clearly Defined
- Not Clearly Defined

How to get it?
- Clearly Defined
- Not Clearly Defined

- TPM
- APP
- N/A
- XPM

ME 481/482
Traditional Project Management
Stages of Project Management

Stage 1: Definition
Stage 2: Planning
Stage 3: Implementation
Stage 4: Termination

Difficult
Project Management of Project Life Cycle

NASA Model

Stage 1
DEFINITION

Stage 2
PLANNING

Stage 3
IMPLEMENTATION

Stage 4
TERMINATION

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

FORMULATION

IMPLEMENTATION

APPROVAL FOR IMPLEMENTATION
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

POS

PDS
Definition Stage

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.
HawaiiSat-1 MISSION STATEMENT

To demonstrate HSFL's ability to design, launch, and operate a versatile small satellite. In support of the demonstration, the mission shall provide an on-orbit platform for the CRATEX, THI, and HIP payloads.
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 PR) 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

HawaiiSat-1 Example

• Primary Objectives

1. Develop, launch, and operate a small, low-cost, low-earth-orbit experimental satellite.
2. Support the C-Band Radar Transponder Experiment (CRATEX) payload for a minimum of two (2) years.
3. Demonstrate capability of the thermal hyperspectral imager (THI) payload.
4. Demonstrate the suitability of the Hawai’iSat-1 spacecraft to test technologies suitable for missile detection and tracking.

• Secondary Objectives

1. Demonstrate the ability of the University of Hawai’i to use its facilities and infrastructure to support the development and operation of satellites.
2. Demonstrate the accuracy of the Super Strypi launch vehicle in deploying satellites into a specific orbit.
3. Obtain color images of the Hawaiian Islands from space.
4. Develop a spacecraft bus that will be easily adaptable for use in future missions.
Definition Stage

**Step 4: Identify the Success Criteria**

– *Success criteria* map directly to objectives and may specify different levels of success for each objective
HawaiiSat-1 Success Criteria

• Primary Success Criteria

1. Spacecraft is:
   a. Placed into orbit
   b. Transmits signal to Earth
   c. Receives uplink signal
   d. Controlled by HMOC (HSFL Mission Operations Center)
   e. Able to provide data for orbit determination to a 5-meter accuracy.

2. CRATEX payload provides operational C-band transponder for radar calibration activities for two years.

3. THI obtains images sufficient to characterize its on-orbit performance.

4. Technologies suitable for missile tracking are successfully tested.
HawaiiSat-1 Success Criteria

**Secondary Success Criteria**

1. UH facilities and infrastructure are used to support the design, fabrication, integration, testing, and operations, of the Hawai’iSat-1 mission.
2. Super Strypi launch vehicle deploys the satellite into orbit.
3. Downlink color image(s) of Hawaiian Islands to HMOC.
4. Use of standard interfaces with payloads.
Definition Stage

**Step 5: List principal players, assumptions, risks, and obstacles**

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

  **HawaiiSat-1 Example**

  - Primary Customer: **DOD/ORS**
  - Secondary Customer: **UHM**
  - Operator: **HSFL**
  - End User: **Government Tracking Stations**
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
• 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

Project Avionics Engineer
Jason Akagi
  - Graduate Assistant (Lim-6/09) [Byron Wolfe]
  - C&DH Lead Engineer
    - Jason Akagi
  - EPS Lead Engineer
    - (Jason Akagi)
  - Telecom Lead Engineer
    - Byron Wolfe
      - Wayne Shiroma* [Jason Akagi]
      - Jason Akagi
      - Undergraduates

Project Mechanical Engineer
Carole Hude

Project Software Engineer
Eric Pilger

Flight Software Lead Engineer
Eric Pilger

Ops Software Lead Engineer
Mark Wood

Operations Manager
(Trevor Sorensen)

Payloads Manager
Byron Wolfe

Ground Network Lead Engineer
(Byron Wolfe) [Byron Wolfe]

Mission Planning Lead Engineer
(Trevor Sorensen) [Byron Wolfe]

S/C Engineering Lead Engineer
(Trevor Sorensen) [Byron Wolfe]

Data Management Lead Engineer
Eric Pilger [Byron Wolfe]

Orbit Analyst
Moriba Jah [Byron Wolfe]

I&T Manager
(Byron Wolfe) [Byron Wolfe]

I&T Mechanicals
Carole Hude [Byron Wolfe]

I&T Avionics
Jason Akagi [Byron Wolfe]

Testbed/Simulator
(Byron Wolfe) [Byron Wolfe]

Graduate Assistant (Gregory-8/09)
Postdoc (Nikolai)

Undergraduates

* Faculty Member

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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.
Planning Stage

Example Architectures – DataLynx

Honeywell

DataLynx System Architecture

Ground Network System
Mission Operations
DOC Facilities

Low Data Rate Customers

NASA BDS

Remote Sensing High Data Rate

GEO Communications

High Data Rate Customers

DataLynx Operations Center (DOC) Includes GNCC and MOps

DataLynx Planning Stage
Planning Stage

Example Architectures – LEO-1

- S/C Design, Build, I&T S/C+PAD I&T
- Project Management
- Ground Station
- HMOC Mission Ops
- HSFL (Manoa)

Launch Support GS
- To LEO (SSO 600km)

CubeSats
- Students & Support
- Training & Prestige

SPARK I
- Satellites w/ Integrated PL Adapter
- Launcher Dev Oversight
- Launch Support

B/U MOC
- B/U MOC
- PAD
- Integrated P-Pods

ARC
- CubeSats

NASA
- CubeSats

HSFL (Manoa)
- CubeSat(s)

CubeSats
- Students & Support
- Training & Prestige

LEO-1
- C-Band
- UHF Doppler

DoD Ground Stations
- Requirements
- GFE
- Reports
- C-Band
- Transponders
- CERTO Beacon
- Tasking
- Schedule
- Orbit Data
- Images
- Outreach
- Support

Program Mgt
- ORS

Payloads
- RADCAL II (VAFB)
- CERTO Beacon (NRL)
- Imagers (HSFL)

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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
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 to 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

<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>COMPANY NAME</th>
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<tbody>
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<table>
<thead>
<tr>
<th>PROJECT MANAGER</th>
<th>DATE</th>
</tr>
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</tbody>
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Work Package
## 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>
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<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>
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### 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>
</table>

Prepared by

Date

Approved by

Date

Sheet 1 of 1
Planning Stage

Example WBS - Simple

Provide Banquet

Level 1

1.0

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

1.3

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

1.4

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)
Example WBS
House Construction

Planning Stage

Level 1 Deliverables = 100

1. Internal
   Work 45.60%
   Budget $56,000.00

2. Foundation
   Work 24.00%
   Budget $46,000.00

3. External
   Work 30.40%
   Budget $63,500.00

1.1 Electricity
   Work 11.80%
   Budget $25,000.00

1.1.1 Rough-in electrical
   Work 2.80%
   Budget $5,000.00

1.1.2 Install and terminate
   Work 1.90%
   Budget $5,000.00

1.1.3 HVAC equipment
   Work 7.10%
   Budget $15,000.00

2.1 Excavation
   Work 18.20%
   Budget $37,000.00

2.2 Steel Erection
   Work 5.80%
   Budget $9,000.00

   2.2.1 Columns
       Work 2.80%
       Budget $5,000.00

   2.2.2 Beams
       Work 1.90%
       Budget $2,000.00

   2.2.3 Joists
       Work 1.10%
       Budget $2,000.00

3.1 Masonry Work
   Work 16.20%
   Budget $62,000.00

3.2 Building Finishes
   Work 14.20%
   Budget $21,500.00
Planning Stage

Example WBS: Clementine

Note: Level 4 is activity/task level
Planning Stage

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

**Using Microsoft Excel**

<table>
<thead>
<tr>
<th>Phase A - Study (Concept Definition &amp; Costing)</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
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</thead>
<tbody>
<tr>
<td>Milestone</td>
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<td>System Requirements Review (SRR)</td>
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<td>Preliminary Design Review (PDR)</td>
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<td>Critical Design Review (CDR)</td>
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<td>Test Readiness Review (TRR)</td>
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<tr>
<td>Mission Readiness Review (MRR)</td>
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<tr>
<td>Pre-Ship Review (PSR)</td>
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<td>Milestone</td>
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<td>J</td>
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<td>System Design; ICD; I&amp;T Concepts</td>
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<td>Proof of Concept Development</td>
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<td>J</td>
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<tr>
<td>EM Payloads Due</td>
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<td>FlatSat Development; FlatSat I&amp;T</td>
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<td>Ground System and Ops Integration</td>
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<td>J</td>
<td>J</td>
<td>J</td>
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<td>Transition FlatSat to EM; EM I&amp;T</td>
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<tr>
<td>FM Payloads Due</td>
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<td>FM Development; System I&amp;T</td>
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<td>Spacecraft System I&amp;T</td>
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<td>Launch Support</td>
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<td>J</td>
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<td>IOC (EE&amp;CO)</td>
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<tr>
<td>Mission Ops</td>
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</table>

### Milestone Schedule

<table>
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<tr>
<th>Milestone</th>
<th>Date</th>
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</thead>
<tbody>
<tr>
<td>System Requirements Review (SRR)</td>
<td>Jan, 2010</td>
</tr>
<tr>
<td>Preliminary Design Review (PDR)</td>
<td>June, 2010</td>
</tr>
<tr>
<td>Test Readiness Review (TRR)</td>
<td>June, 2011</td>
</tr>
<tr>
<td>Mission Readiness Review (MRR)</td>
<td>Sept, 2011</td>
</tr>
<tr>
<td>Pre-Ship Review (PSR)</td>
<td>Dec, 2011</td>
</tr>
</tbody>
</table>
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.
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

TODAY
## Planning Stage

### Gantt Chart Tracking Example

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

![Gantt Chart](image)

- **behind schedule**
- **ahead of schedule**
Planning Stage

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/CPM 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.
Planning Stage

PERT Diagram

### Activity Path Table

<table>
<thead>
<tr>
<th>Activity Path</th>
<th>Duration</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>A → E</td>
<td>5-7 months</td>
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</tr>
<tr>
<td>B → C</td>
<td>10 months, 8 months</td>
<td>Critical Path, 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.
## 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>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
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**Total FTEs:**

7.82 | 7.82 | 8.32 | 8.32 | 9.12 | 7.87 | 8.47 | 10.67 | 11.97 | 12.22 | 12.22 | 11.82
## Planning Stage

### Staffing Plan Example – LEO-1

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<td>Orbit Analysis (Moriba Jah)</td>
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<td><strong>TOTAL</strong></td>
<td>8.77</td>
<td>6.23</td>
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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

![Diagram showing the cost curve over design life. The graph illustrates the cost breakdown into Payload Cost, Bus Cost, Launch Cost, Operations Cost, and Total Cost. The y-axis represents Cost ($M) and the x-axis represents Design Life (years). The graph peaks at around 50 Cost/year with Total Cost, Payload Cost, and Operations Cost showing distinct curves. The diagram highlights the importance of considering costs throughout the life cycle.]
HawaiiSat-1 Hardware Budget

Spacecraft H/W Cost Est. ($K)

Note WBS element identification
## LEO-1 Project Costs

### Hardware Costs

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<th>SUBSYSTEM</th>
<th>FM</th>
<th>EM</th>
<th>FlatSat</th>
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<td>CDH</td>
<td>$65,500</td>
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<td><strong>BUS TOTAL</strong></td>
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<td><strong>SC TOTAL</strong></td>
<td><strong>$274,341</strong></td>
<td><strong>$150,448</strong></td>
<td><strong>$50,050</strong></td>
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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

**PDR: FM + EM = $424,789**

**SRR: FM + EM = $456,150**

**TOTAL COST FROM PDR**

- **Post-PDR** = $1,628,006
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%
- Avionics: $246,218, 20%
- Software: $200,004, 17%
- Ops & Data Mgt: $0, 0%

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%

SysEng $24,940, 9%

TCS $6,000, 2%

Margin $1,900, 1%
Planning Stage

LEO-1 Spending Profile (Hardware)

Timeline

Expenditures

$250,000
$200,000
$150,000
$100,000
$50,000
$-

2Q 3Q 4Q 1Q 2Q 3Q

2009 2010

A. Trimble, T. Sorensen, Z. Song

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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 Architecture
- Top Level Requirements & Constraints
- Mission Success Criteria
- Mission Operations Plan
- System Requirements Document (SRD)
- Interface Control Documents (ICDs)
- Subsystem Specifications (Derived Requirements)
- Functional Flow Block Diagram (FFBD)
- WBS
- Detailed Design, Analysis & Validation

- Specifications, Parts List, Cost, I&T Plan, Ops Procedures, Staffing Plan
- Reports
- NEXT PHASE

- Orbit Analysis
- Mass, Power & Volume Budgets

Legend:
- Completed
- Partially Completed or In-work
- Not Started

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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
## Planning Stage

### Risk Management Approach Summary

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

1. Risk Mitigation Strategies
   – RMT decides which risks should be assumed and which avoided
   – 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 EPScO)  
- 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 |
| 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 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 CDH architecture which 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 s/c tumble  
- Include redundant IMU and GPS units  
- Reduced attitude modes  
- Disable magtorquers and allow s/c to tumble |
| ADCS magtorquers 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 |

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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
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

• 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.
Project Manager

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?
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
Definition Stage

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.

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## 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)
  - 2.1.6.6 Integration & Testing (System Level)

### 2.1.7 Integration & Testing (System Level)

### 2.2 Mechanical Systems

### 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)

### 2.2.4 Attitude Determination & Control Subsystem (ADCS)
- 2.2.4.1 Task Management
- 2.2.4.2 Requirements Analysis
- 2.2.4.3 Subsystem Design
- 2.2.4.4 Procurement/Vendor Monitoring
- 2.2.4.5 Fabrication
- 2.2.4.6 Testing (SS Level)
- 2.2.4.7 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)

### 2.2.6 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)