PROJECT MANAGEMENT - II

ME 481 Senior Design

Fall 2020

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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

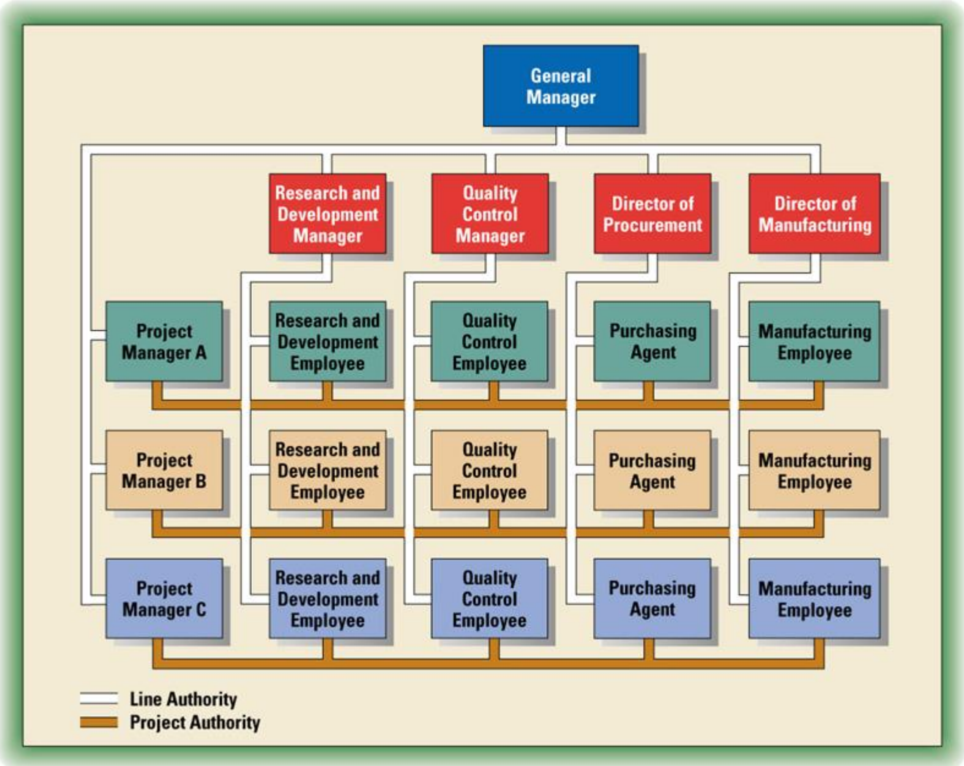
Planning Stage

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

Matrix Structural Organization

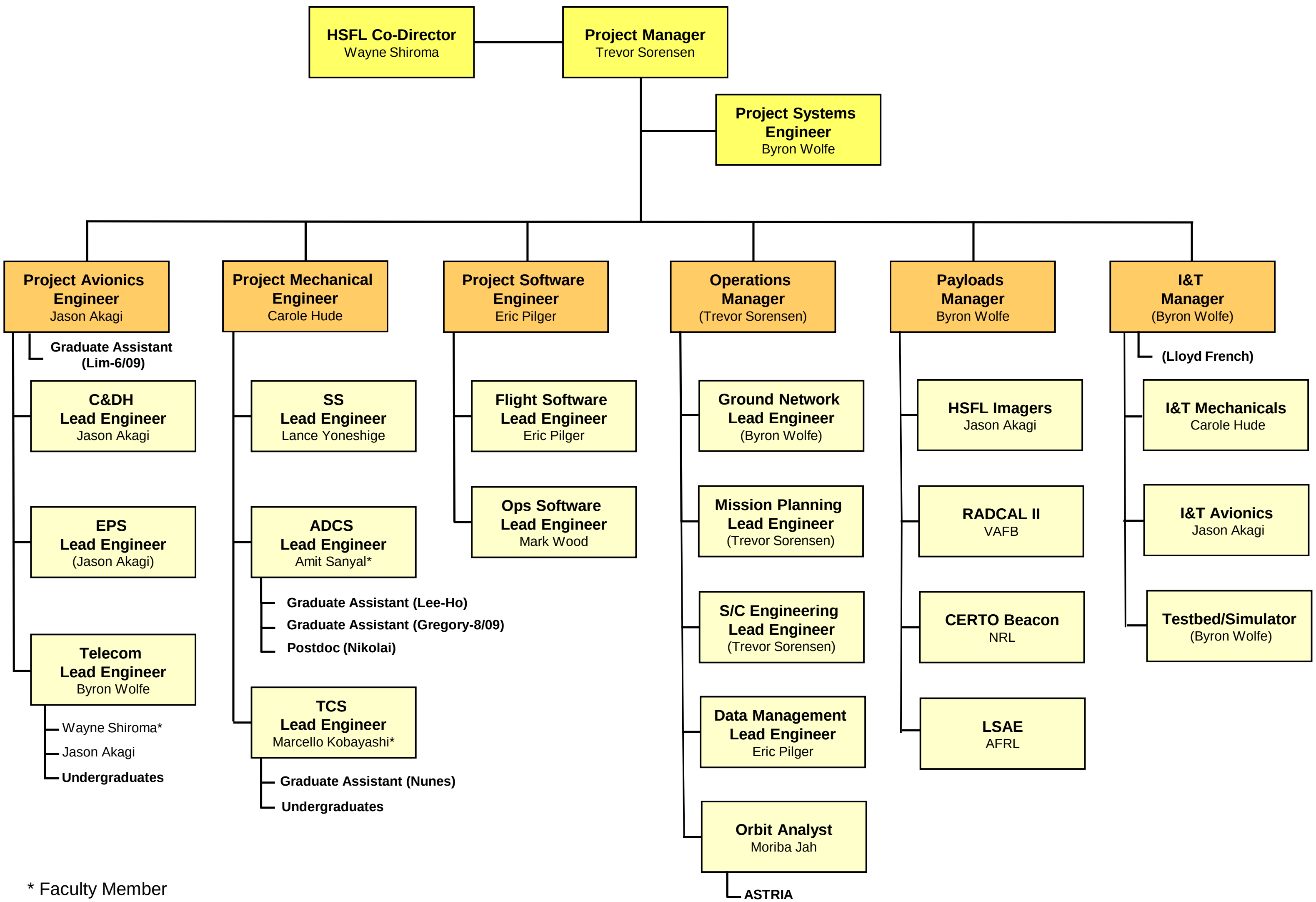
- Type of organizational structure in which people with similar skills are pooled for work assignments, resulting in more than one manager per person



https://xreferat.com/60/425-1-matrix-organization-structure-advantages-and-disadvantages.html

- 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

Project Line Organization – LEO-1 Example



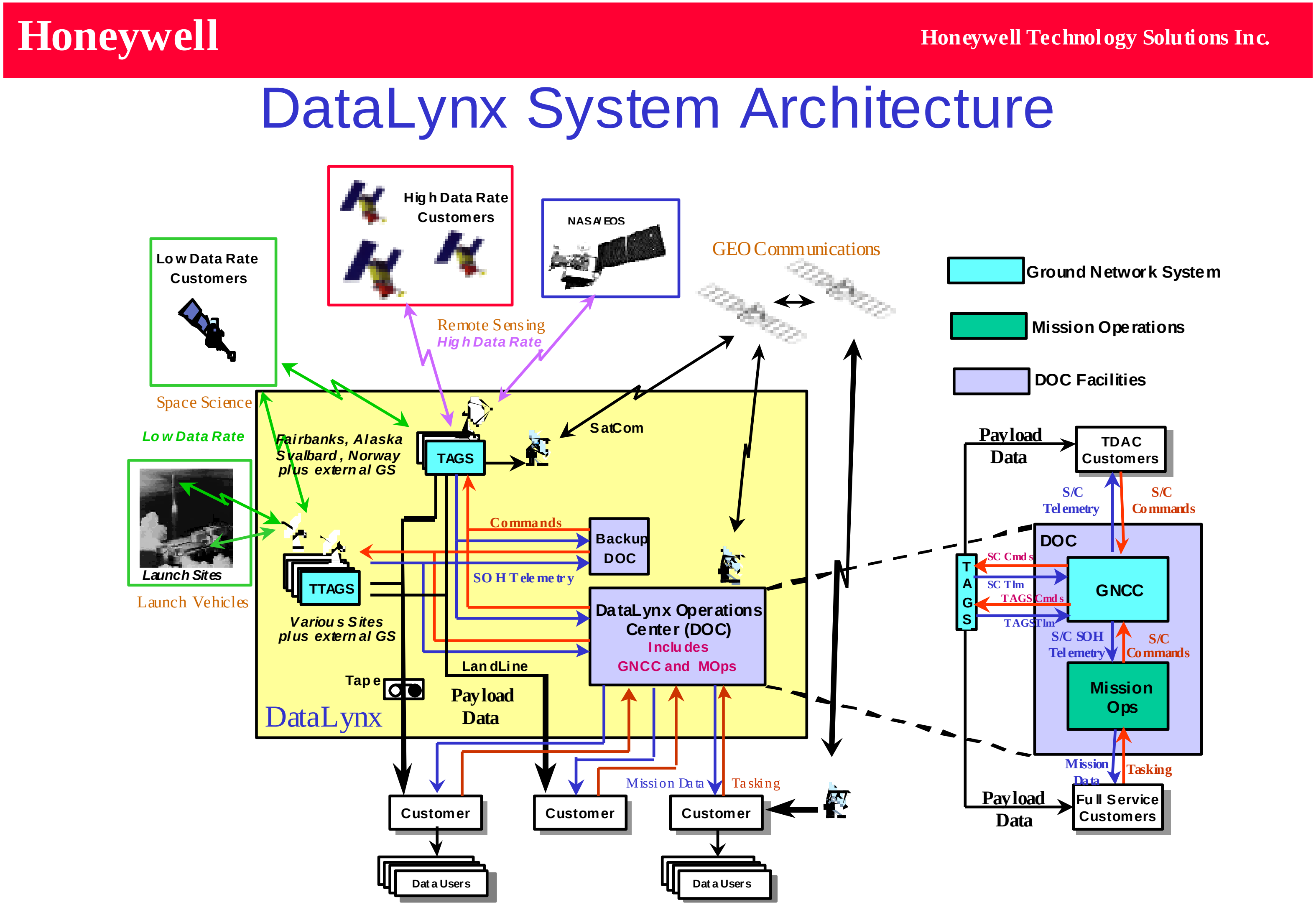
Planning Stage

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



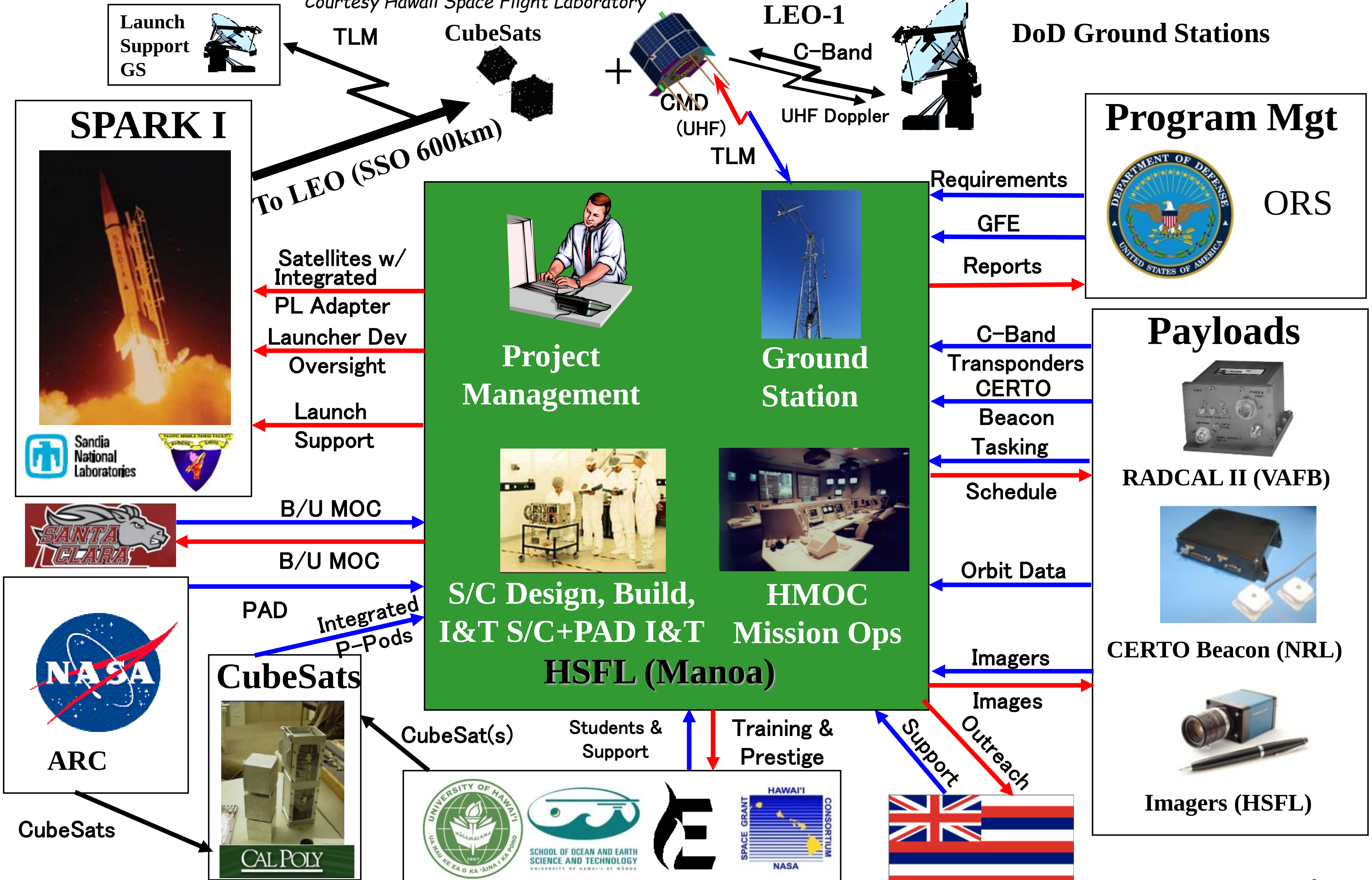
Courtesy Honeywell Technology Solutions Corporation

IAA-L-0806

Planning Stage

Example Architectures – LEO-1

Courtesy Hawaii Space Flight Laboratory



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

Task is Verb-Noun

- 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

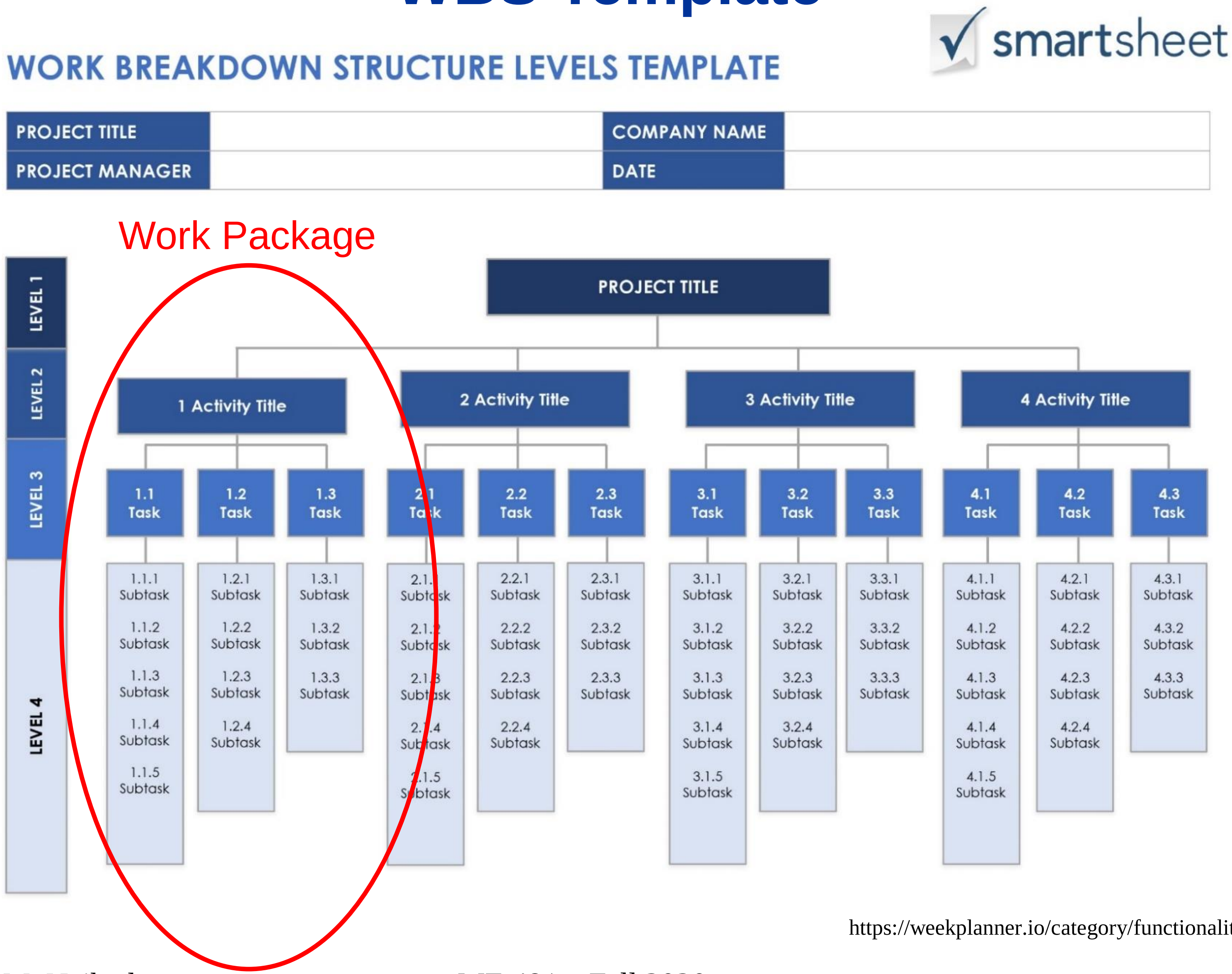
Planning Stage

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 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 acitivity 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



https://weekplanner.io/category/functionality/

Work Package Description Form

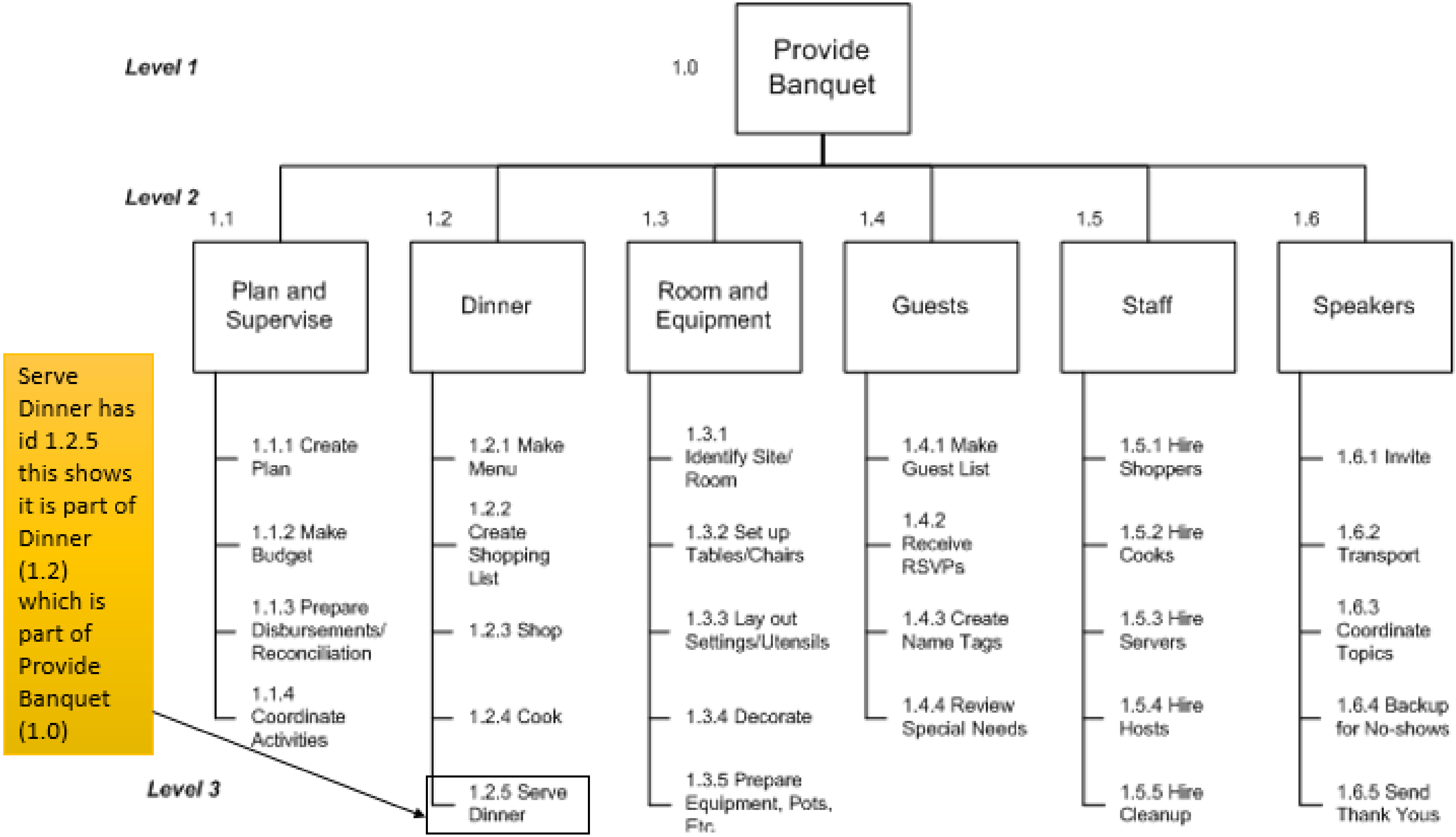
WORK PACKAGE DESCRIPTION	Project Name		Project No.	Project Manager	
Work Package Name	Work Package No.	Work Package Manager		Contact Info.	Date
Start Date	End Date	Critical Path Y N	Predecessor Work Package(s)	Successor Work Package(s)	

TASK					
No.	Name	Description	Time (days)	Responsibility	Contact Info.

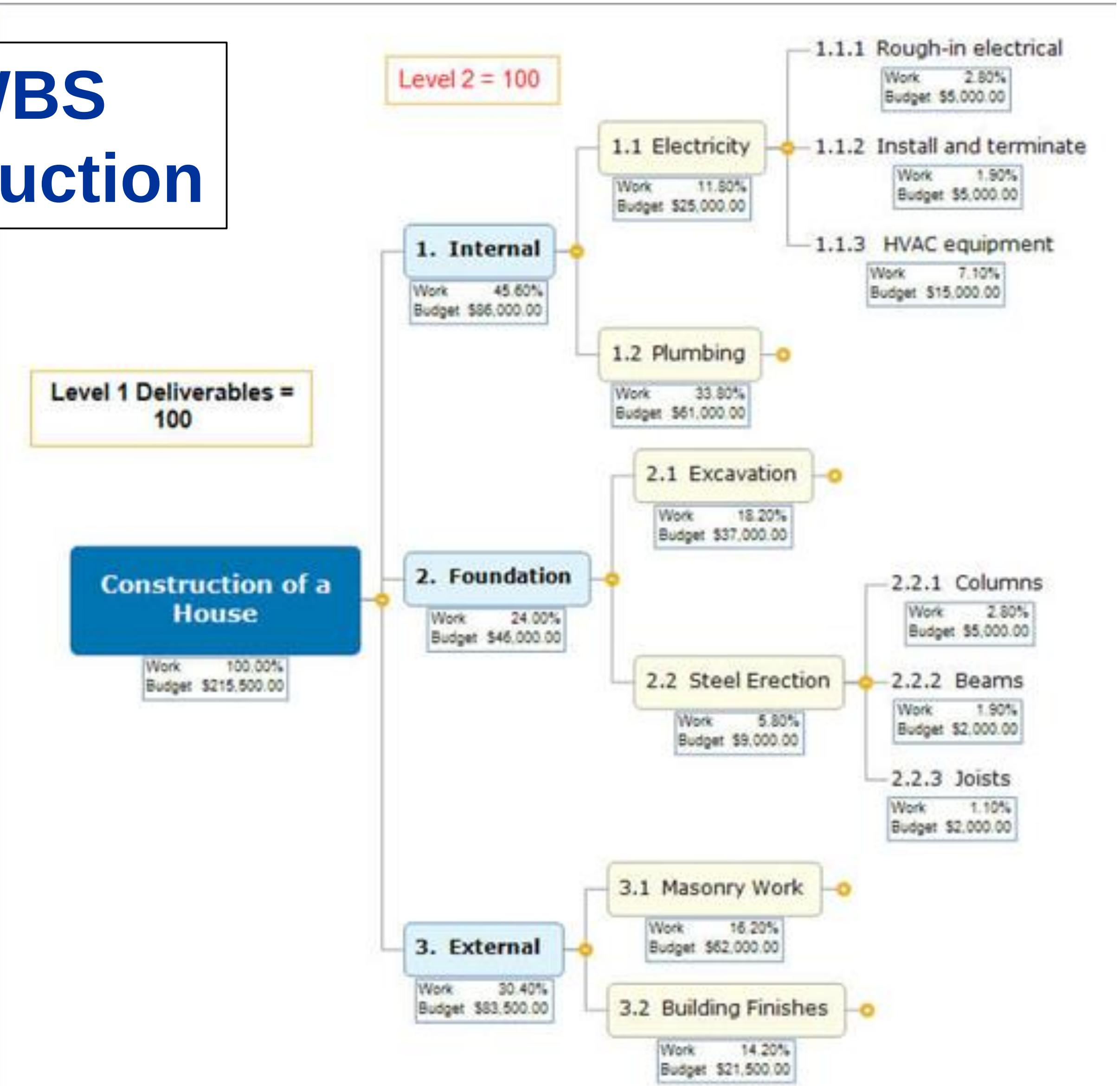
Prepared by	Date	Approved by	Date	Sheet 1 of 1

Planning Stage

Example WBS - Simple



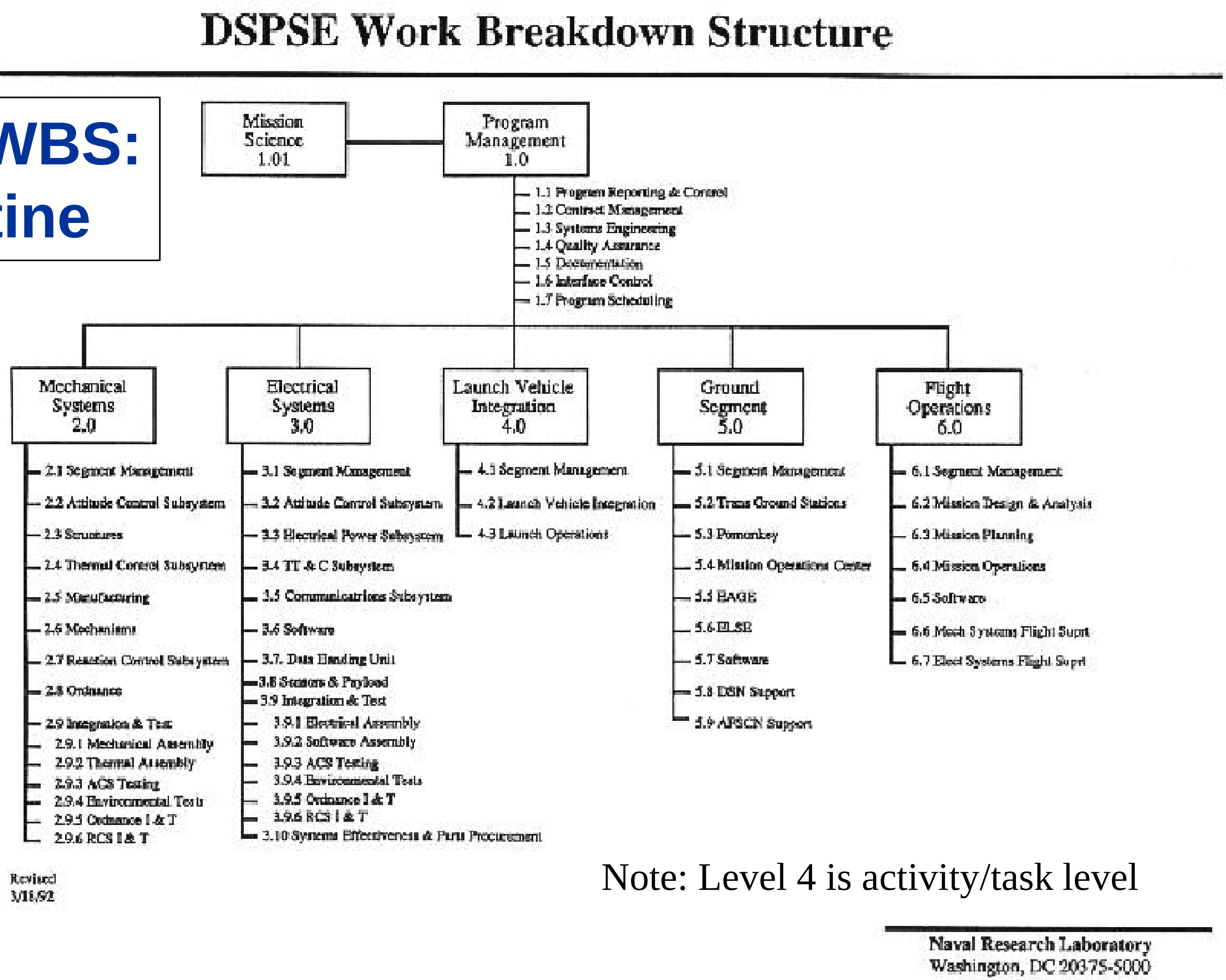
Example WBS House Construction



https://www.workbreakdownstructurewbs.com/

Planning Stage

Example WBS: Clementine



Note: Level 4 is activity/task level

Step 4: Identify Milestones

https://commons.wikimedia.org/wiki/File:A350_Milestone.JPG

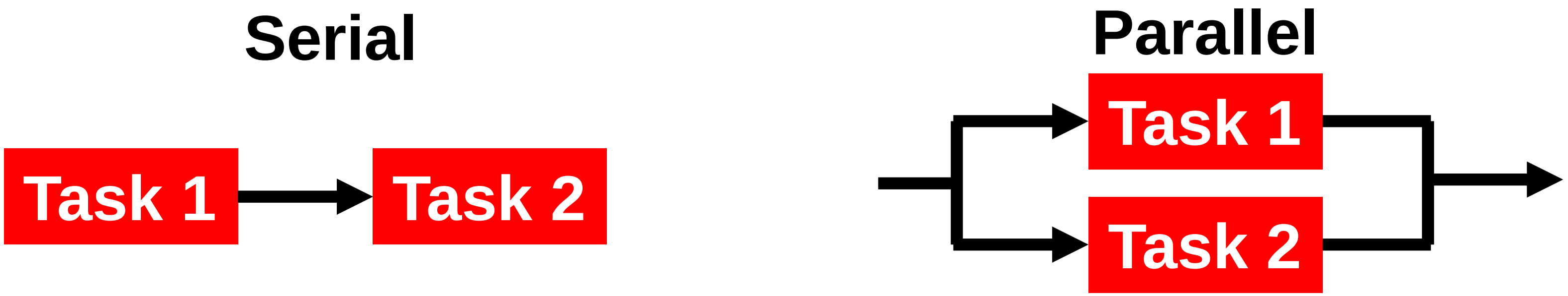
- Types of milestones
  - Provide tangible interim goals
  - Demonstrate progress
  - Enforce schedule
- State each milestone by "noun-verb" or “noun” form

  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

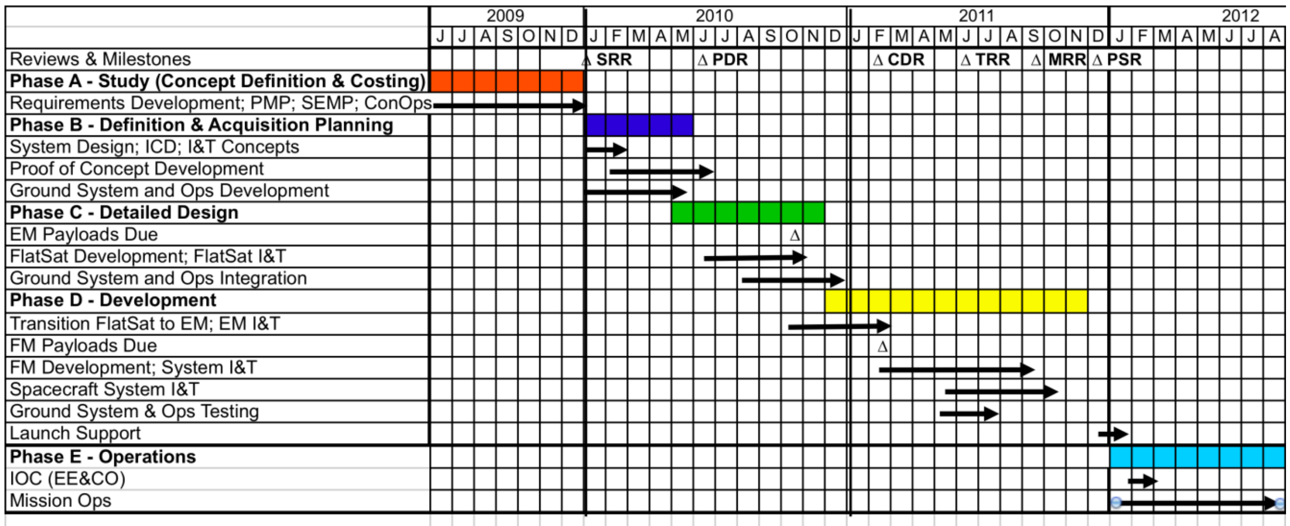


- Show WBS tasks on schedule chart
  - Simple: Carefully draw by hand or use Microsoft Excel, etc.
  - Elegant: Microsoft Project or similar tool

Planning Stage

Example Schedule - Simple

Using Microsoft Excel



Milestone	Date
System Requirements Review (SRR)	Jan, 2010
Preliminary Design Review (PDR)	June, 2010
Critical Design Review (CDR)	Feb, 2011
Test Readiness Review (TRR)	June, 2011
Mission Readiness Review (MRR)	Sept, 2011
Pre-Ship Review (PSR)	Dec, 2011

Planning Stage

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

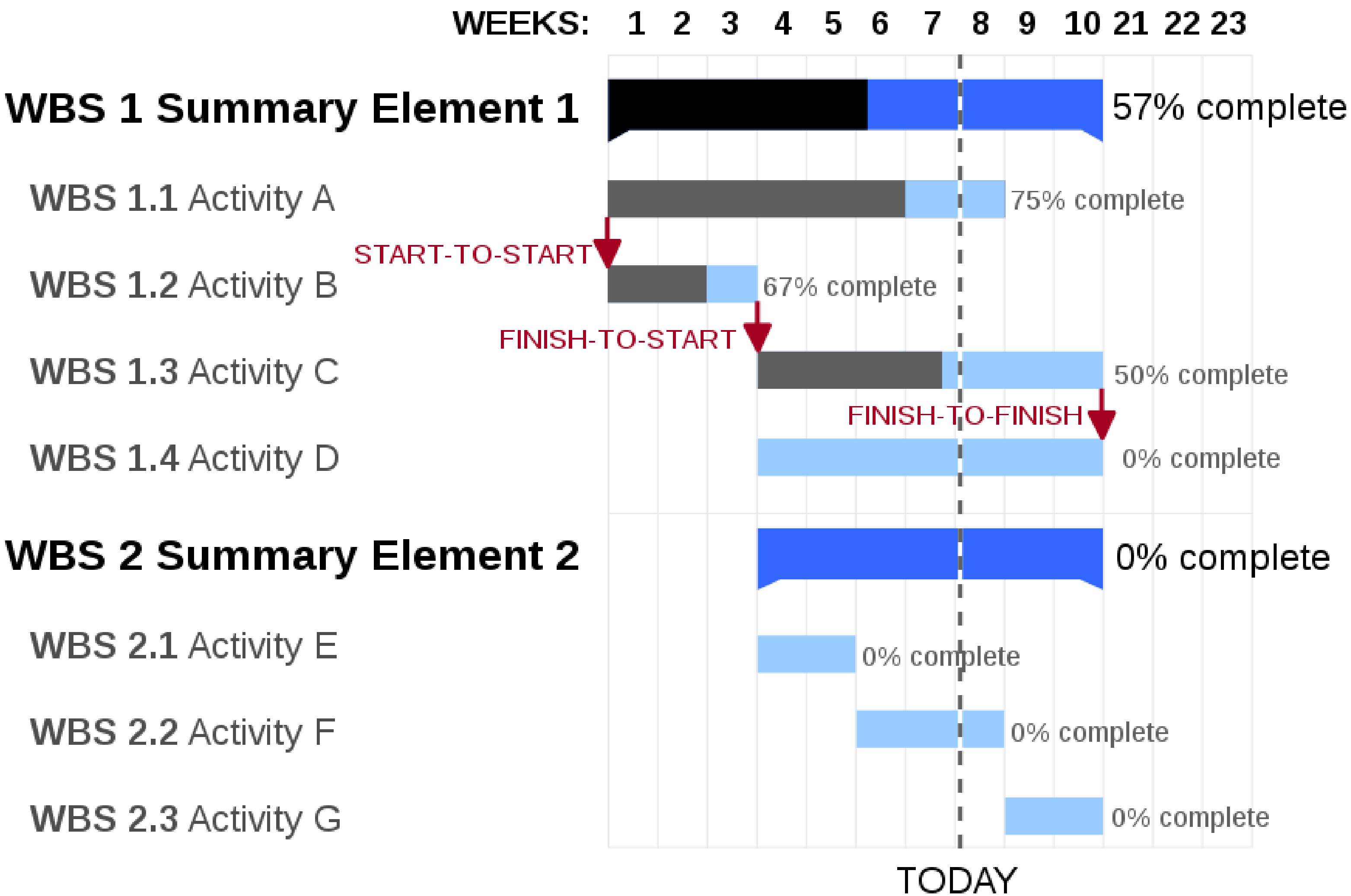
Planning Stage

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

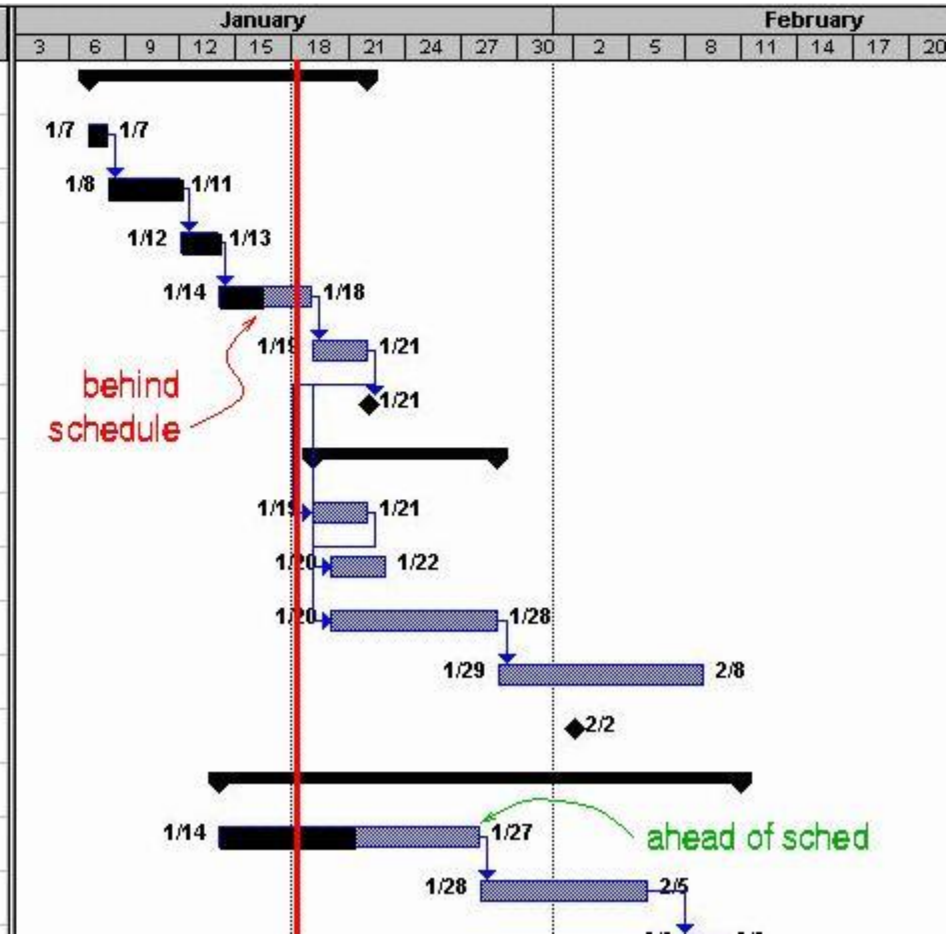
Planning Stage

Example Gantt Chart



Gantt Chart Tracking Example

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



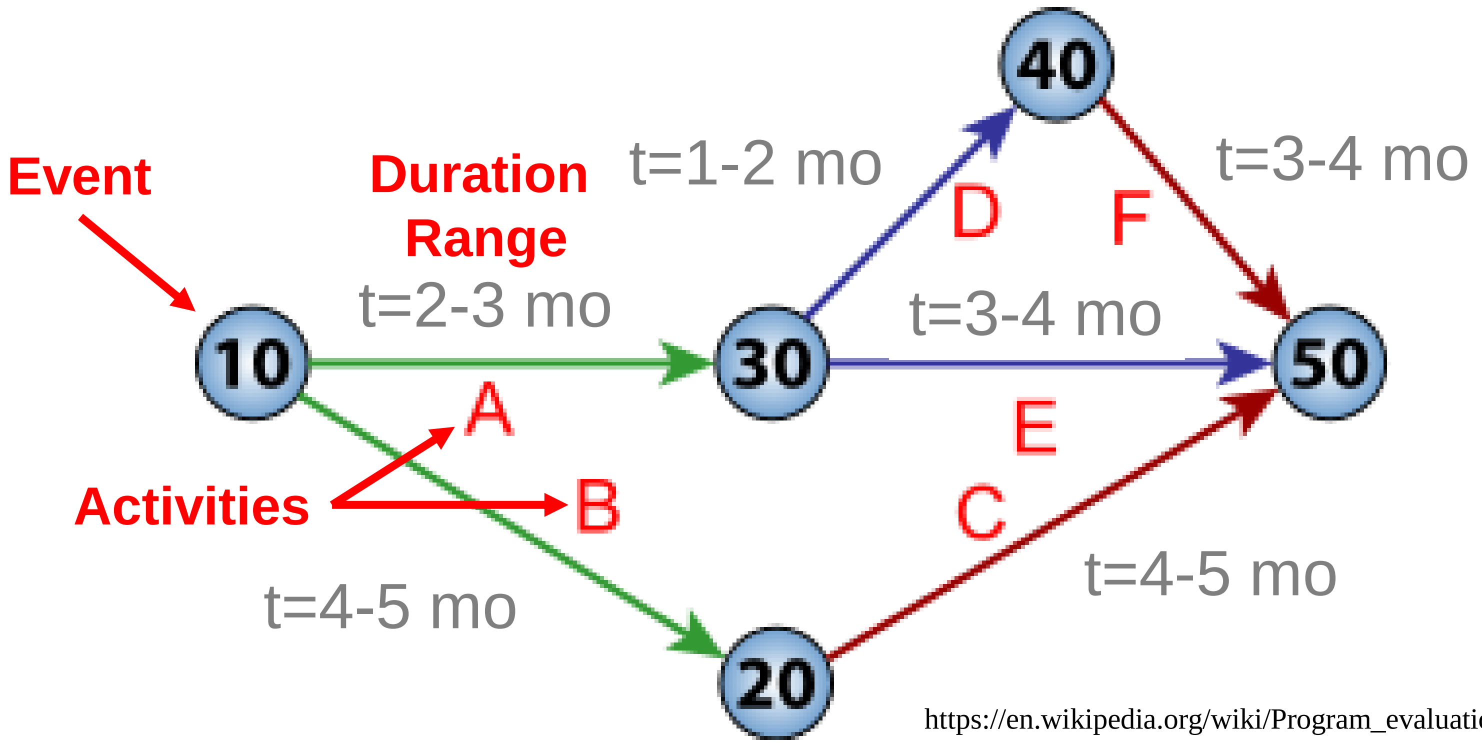
Planning Stage

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 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



https://en.wikipedia.org/wiki/Program_evaluation_and_review_technique

ACTIVITY PATH	DURATION	COMMENT
A → E	5-7 months	
B → C	10 months 8 months	Critical Path Optimistic time
A → D → F	6-9 months	

Planning Stage

Step 7: Develop Staffing Plan

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

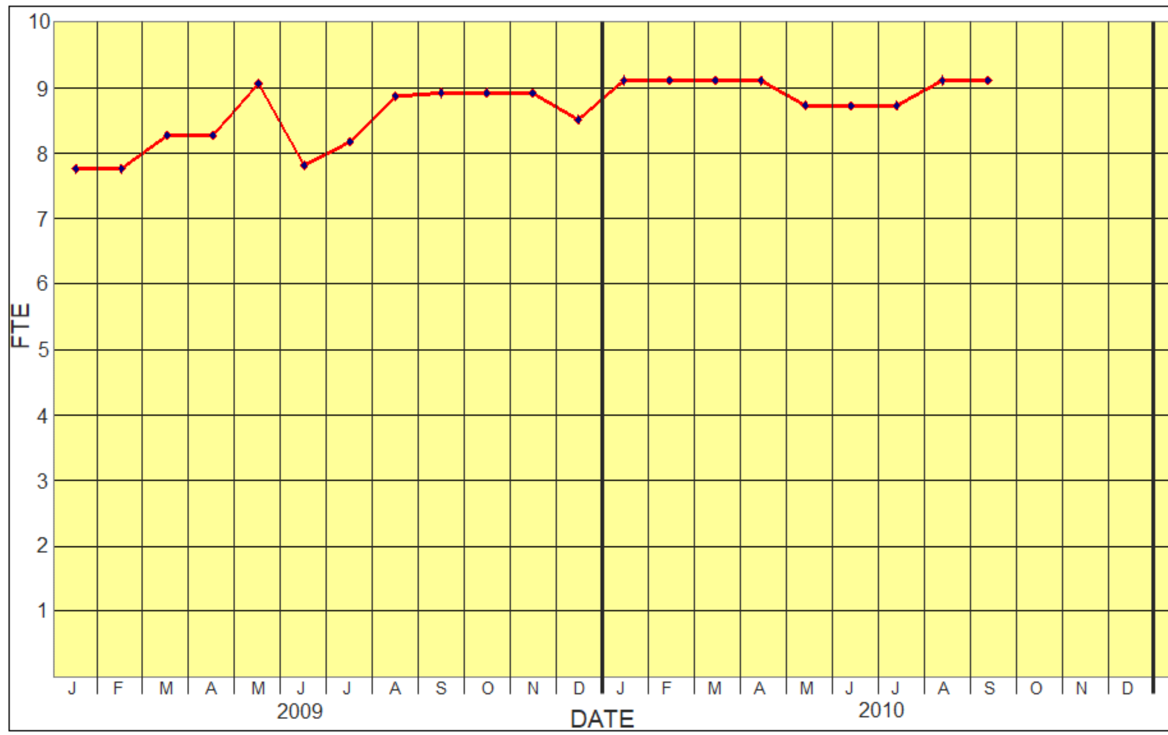
Staffing Plan Example – LEO-1

POSITION	FUNDING	J	F	M	A	M	J	J	A	S	O	N	D
Project Manager - Trevor	COE	0.6576	0.6576	0.6576	0.6576	0.6576	0.6576	0.6576	0.6576	0.6576	0.6576	0.6576	0.6576
Project Systems Engineer - Byron	Project	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
TB/Sim Graduate Assistant	Space Grant								0.5	0.5	0.5	0.5	0.5
Project Avionics Engineer - Jason	Project	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Avionics Engineer	Project								1	1	1	1	1
Avionics Graduate Assistant	Space Grant									0.5	0.5	0.5	0.5
Avionics Graduate Assistant - Toy	Space Grant						0.1	0.5	0.5	0.5	0.5	0.5	0.5
C&DH Lead Engineer - Jason	Project	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
EPS Lead Engineer - Jason	Project	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Telecom Lead Engineer - Byron	Project	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Telecom Assistants -U/G (2)	Free	0.4	0.4	0.4	0.4	0.4	0.2	0.2	0.4	0.4	0.4	0.4	0.2
Flight Software Lead Engineer - Eric	Project	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
SW Graduate Assistant	Project									0.5	0.5	0.5	0.5
Ops Software Engineer - Harold	Project	0.6	0.6	0.6	0.6								
Ops Software Engineer - Mark	HIGP					0.5	0.5	0.5	0.5	0.25	0.25	0.25	0.25
Ops Software Engineer - Mark	Project									0.25	0.25	0.25	0.25
Project Mechanical Engineer - Carole	Project	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Mech. Graduate Assistant - Michael	Project			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mech. Graduate Assistant - Elizabeth	Project								0.25	0.5	0.5	0.5	0.5
Mech. Graduate Assistant - Casey	Free							0.25	0.25	0.25	0.25	0.25	0.25
Structures Lead Engineer - Lance	Project	1	1	1	1	1	1	1	1	1	1	1	1
Structures Assistants -U/G (2)	Free												
ADCS Lead Engineer - Amit	Free + 1 month SS	0.1	0.1	0.1	0.1	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
ADCS Post Doc - Nikolij	COE	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25			
ADCS Engineer - PhD or Post Doc	Project										0.5	0.5	0.5
ADCS Graduate Assistant - Zach	Space Grant	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
TCS Lead Engineer - Marcelo	Free	0.1	0.1	0.1	0.1	0.1	0.05		0.05	0.1	0.1	0.1	0.1
TCS Graduate Assistant - Michael	Project			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
TCS Assistants -U/G (2)	Free	0.4	0.4	0.4	0.4	0.4	0.2	0.2	0.4	0.4	0.4	0.4	0.2
I&T Manager - Byron	Project	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
I&T Mechanical - Carole	Project	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
I&T Avionics - Jason	Project	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
I&T Support - Lloyd	Project?	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Mission Operations Manager - Trevor	Project	0.2424	0.2424	0.2424	0.2424	0.2424	0.2424	0.2424	0.2424	0.2424	0.2424	0.2424	0.2424
Data Management Lead - Eric	Project	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ground Network Manager - Byron	Project	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Orbital Engineer - Moriba	Free	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
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

NAME	2009	2010	COMMENTS
MANAGEMENT			
Trevor Sorensen	0.50	0.28	
SYSTEMS ENGINEERING			
Byron Wolfe	0.30	0.14	
TESTBED/SIMULATOR			
Byron Wolfe	0.15	0.18	
AVIONICS			
Jason Akagi	0.30	0.21	
Graduate Assistant (Toy Lim)	0.50	0.35	SPAC
C&DH			
Jason Akagi	0.25	0.11	
EPS			
Jason Akagi	0.25	0.11	
TELECOM			
Byron Wolfe	0.35	0.04	
Jason Akagi	0.10	0.04	
Wayne Shiroma	0.05	0.04	
Undergraduate Students (2)	0.40	0.28	
SOFTWARE			
Eric Pilger	0.49	0.25	
Harold Garbeil	0.15	0.00	
Mark Wood	0.27	0.18	
MECHANICALS			
Carole Hude	0.80	0.14	
STRUCTURES			
Lance Yoneshige	1.00	0.71	
ADCS			
Amit Sanyal	0.10	0.07	
Postdoc (Nikolai)	0.25	0.18	
Graduate Assistant (Zach Lee Ho)	0.50	0.35	SPAC
Graduate Assistant (Elizabeth Gregory)	0.17	0.12	SPAC
Graduate Assistant (Miguel Nunes)	0.21	0.15	
TCS			
Marcelo Kobayashi	0.10	0.07	
Graduate Assistant (Miguel Nunes)	0.21	0.18	
Undergraduate Students (2)	0.40	0.28	
I&T			
Byron Wolfe	0.05	0.25	
Carole Hude	0.20	0.57	
Jason Akagi	0.10	0.25	
Lloyd French	0.05	0.14	
OPS			
Ops Manager (Sorensen)	0.40	0.35	
Data Manager (Eric Pilger)	0.01	0.11	
Ground Network Manager (Byron Wolfe)	0.15	0.11	
Orbit Analysis (Moriba Jah)	0.02	0.01	
TOTAL	**8.77**	**6.23**	



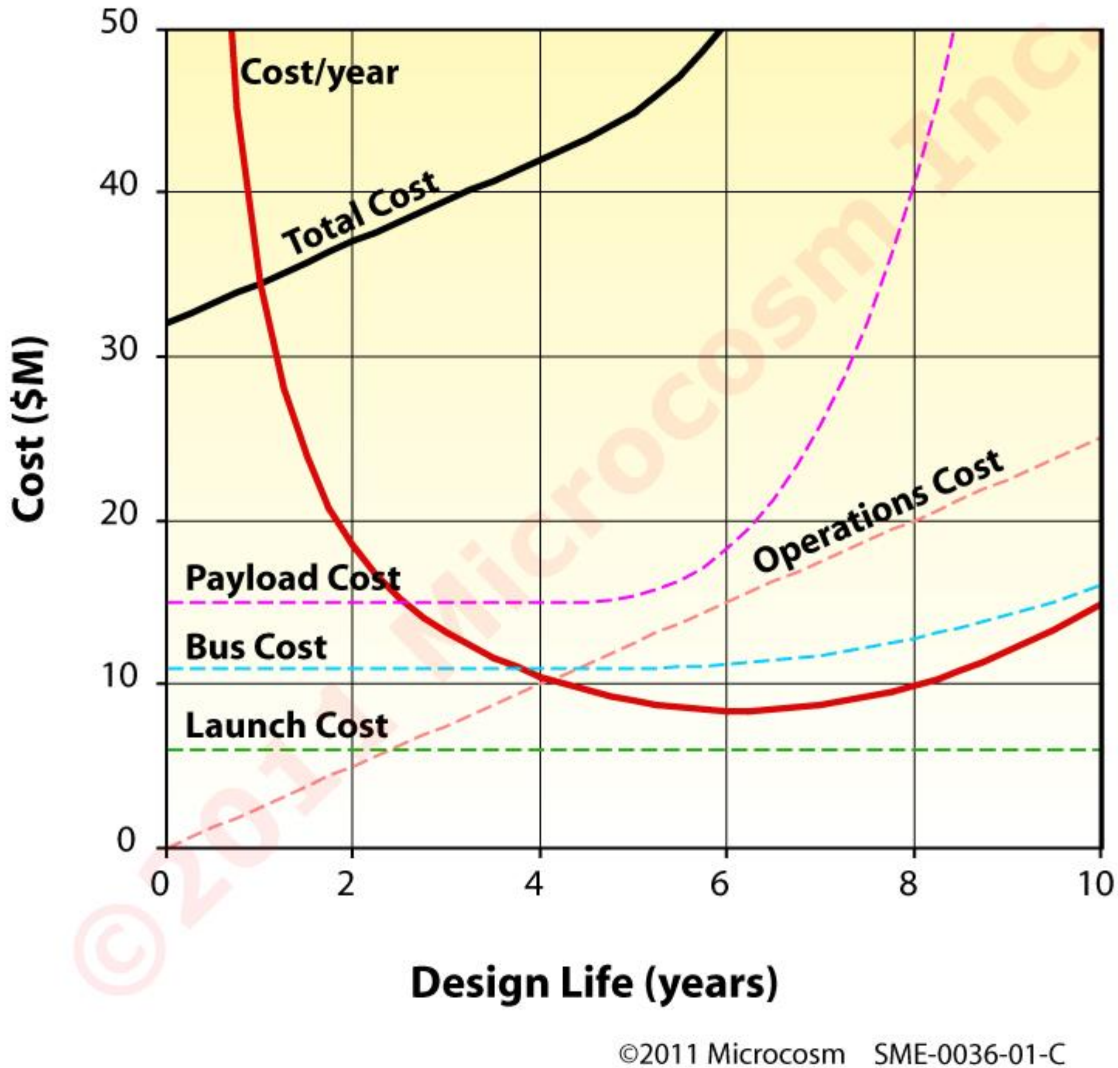
Step 8: Estimate Cost & Preliminary Budget

- 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.

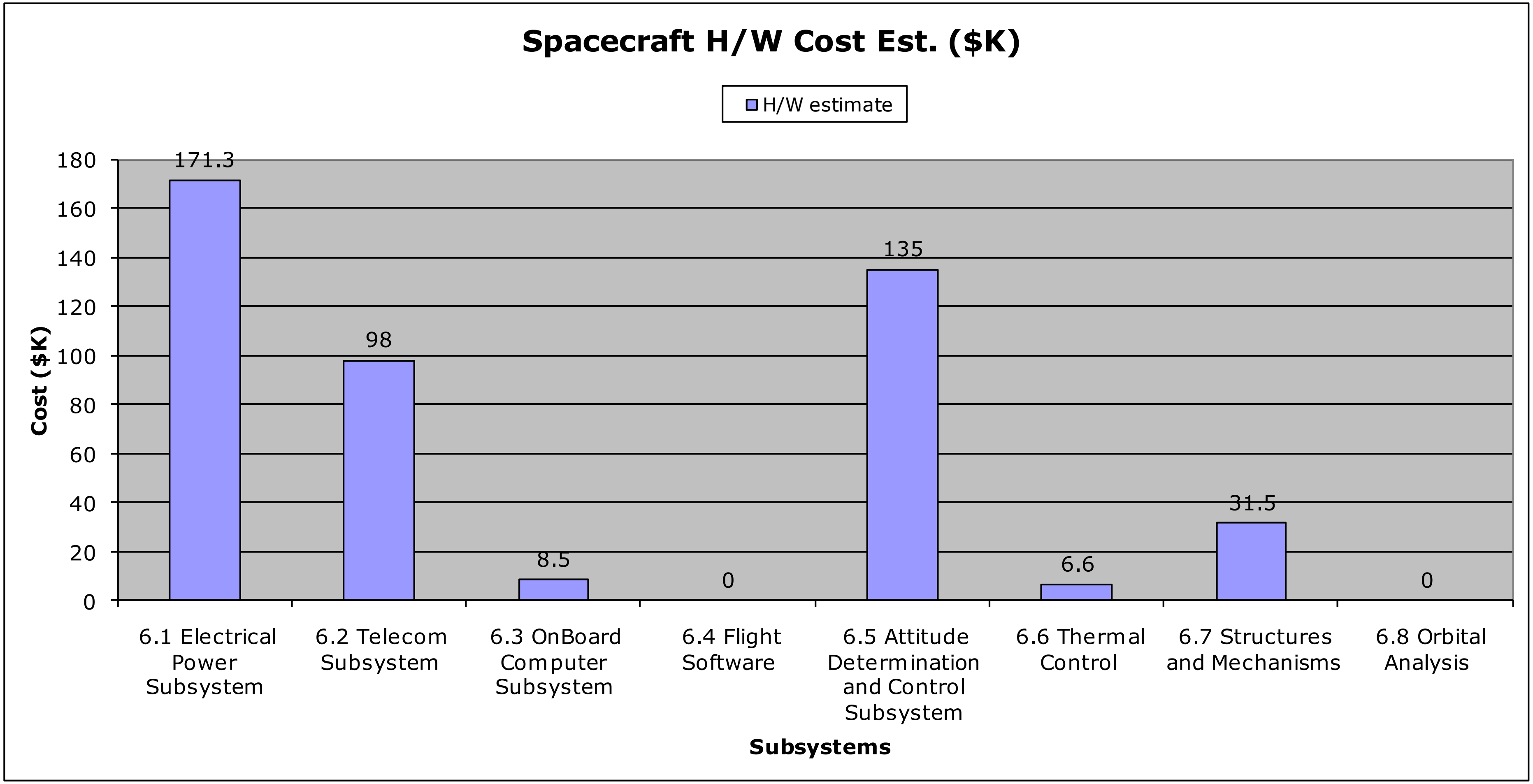
Planning Stage

Representative Curve of Cost During Life Cycle



Planning Stage

HawaiiSat-1 Hardware Budget



Note WBS element identification

LEO-1 Project Costs

Hardware Costs

SUBSYSTEM	FM	EM	FlatSat
CDH	$65,500	$9,500	$7,000
EPS	$27,500	$6,000	$9,500
Telecom	$12,900	$10,670	$5,000
Payload	$19,200	$14,100	$3,000
Structures	$34,001	$34,001	$0
ADCS	$82,400	$48,600	$18,000
TCS	$6,000	$6,000	$2,000
System	$1,900	$7,900	$1,000
BUS TOTAL	**$249,401**	**$136,771**	**$45,500**
Margin (10%)	$24,940	$13,677	$4,550
SC TOTAL	**$274,341**	**$150,448**	**$50,050**

PDR: FM + EM = $424,789
SRR: FM + EM = $456,150

Labor Costs

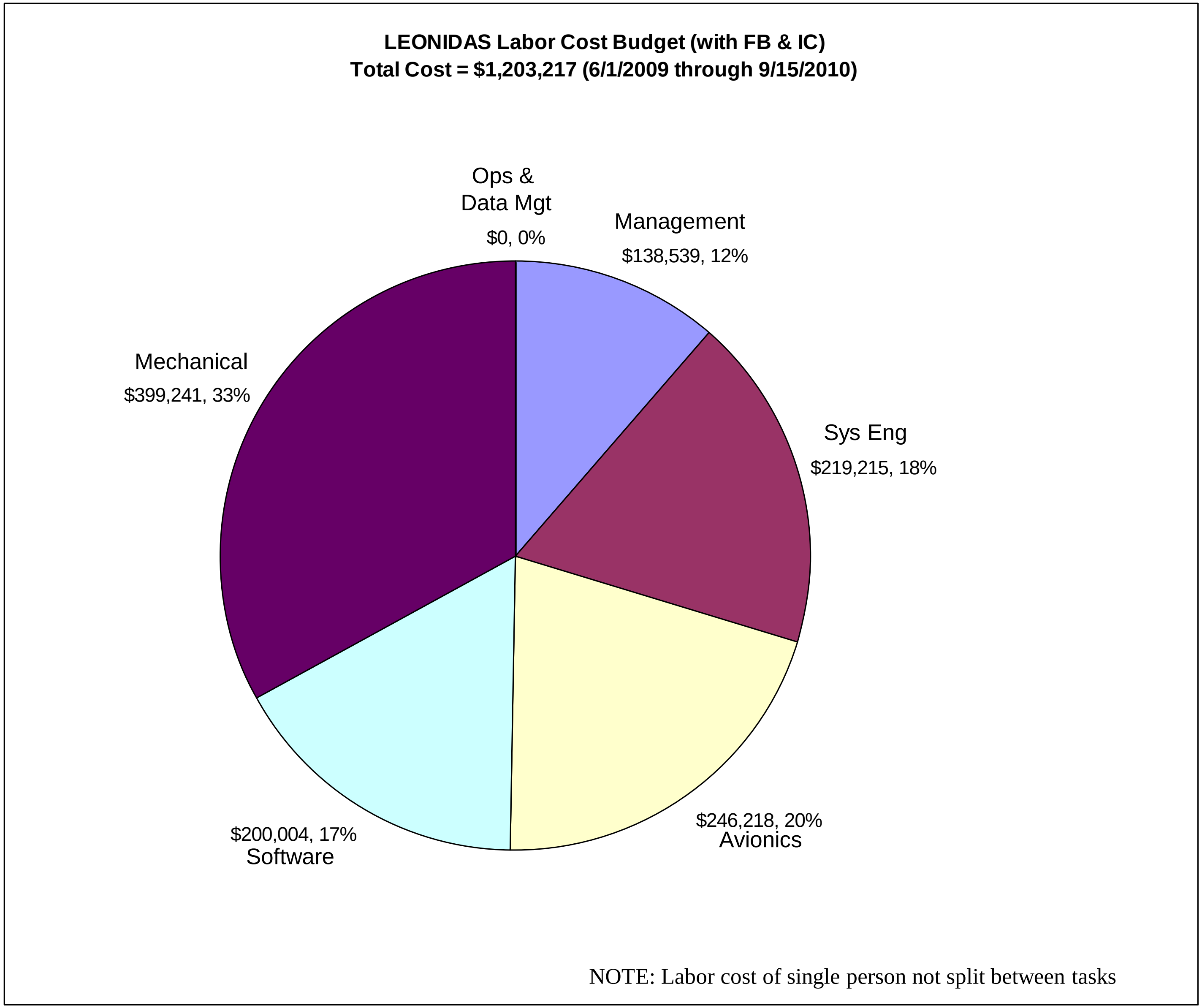
Pre PDR - $611,550
Post PDR - $1,203,217

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

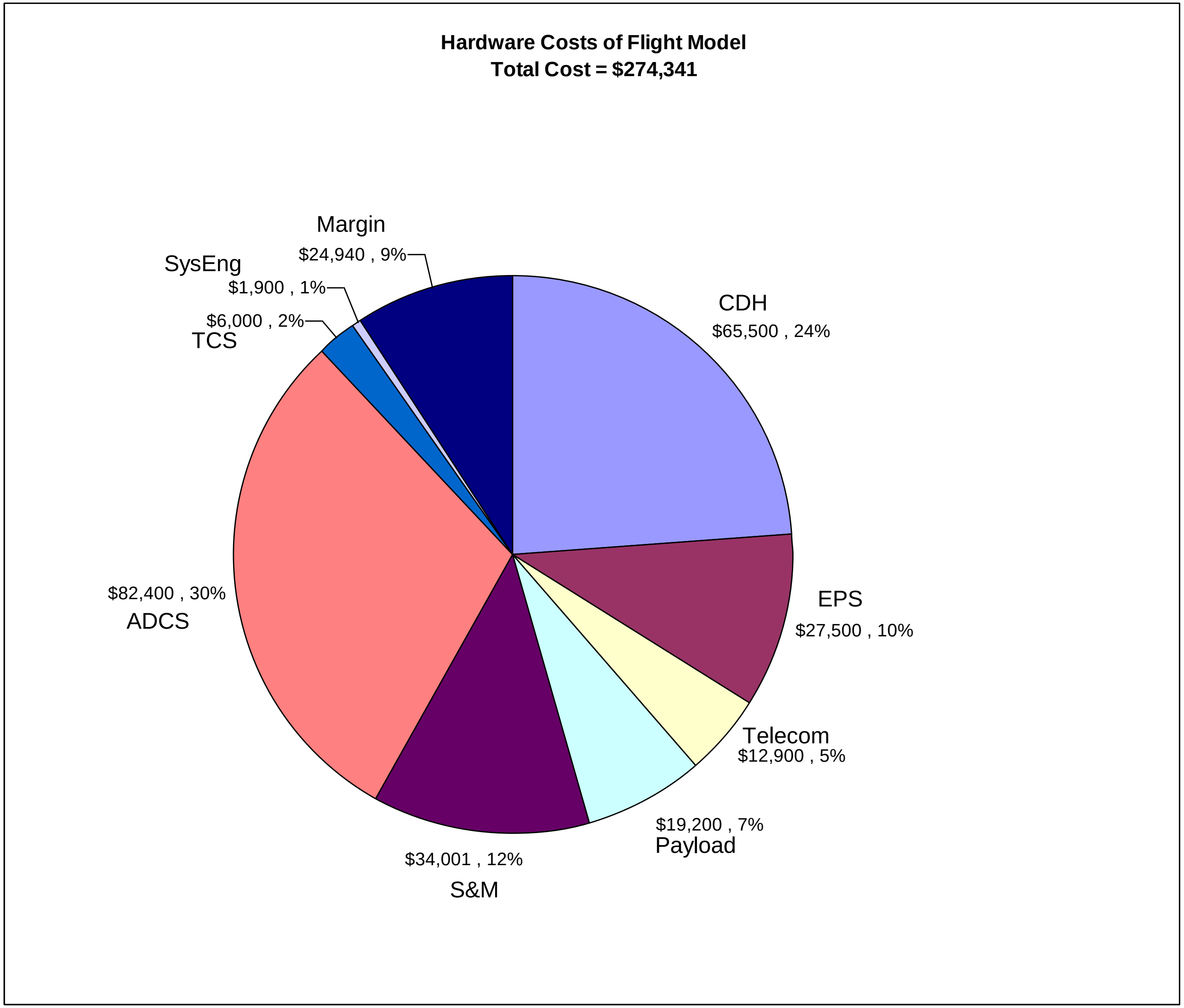
TOTAL COST FROM PDR

Post-PDR = $1,628,006

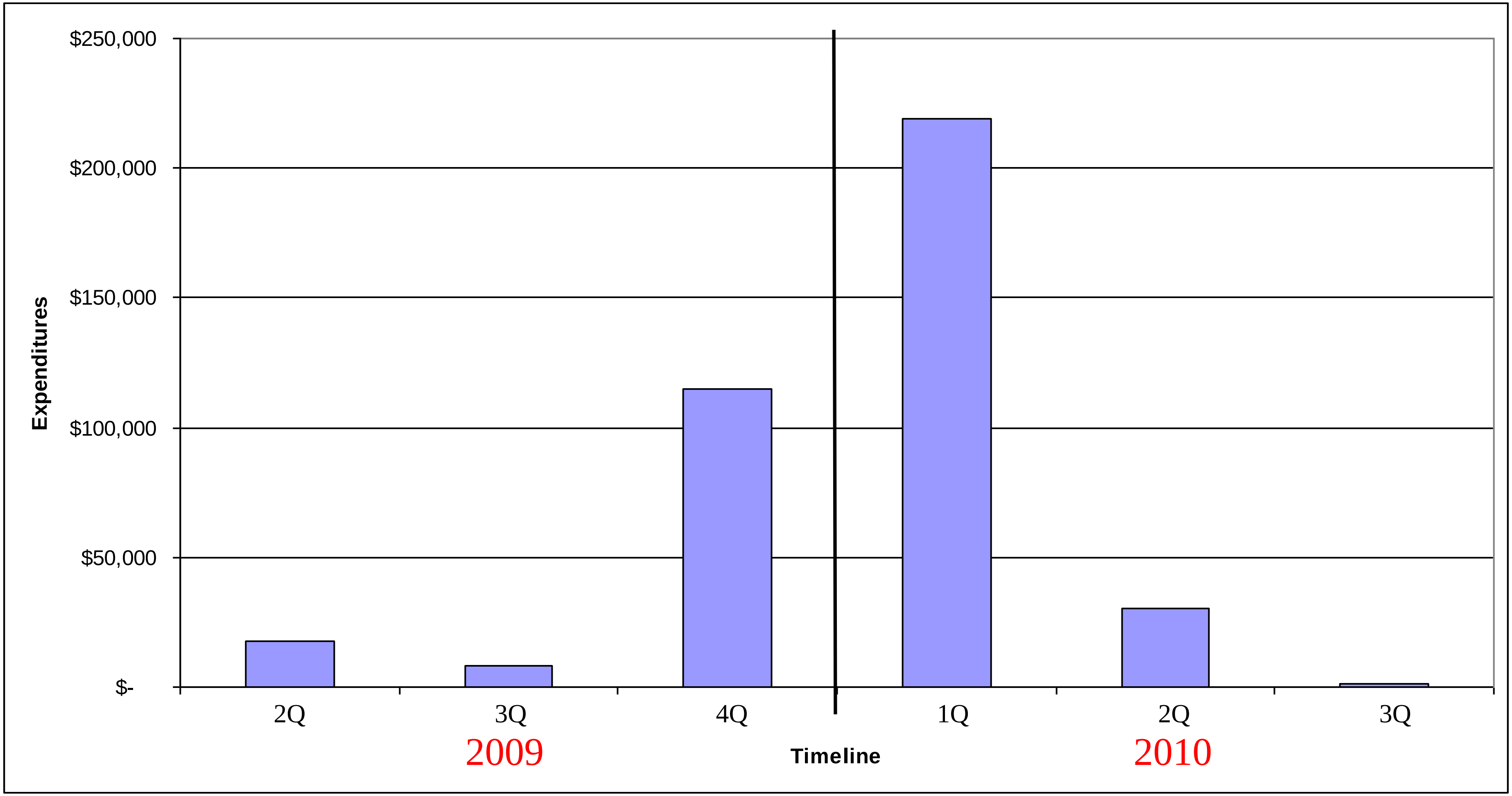
Planning Stage



Planning Stage

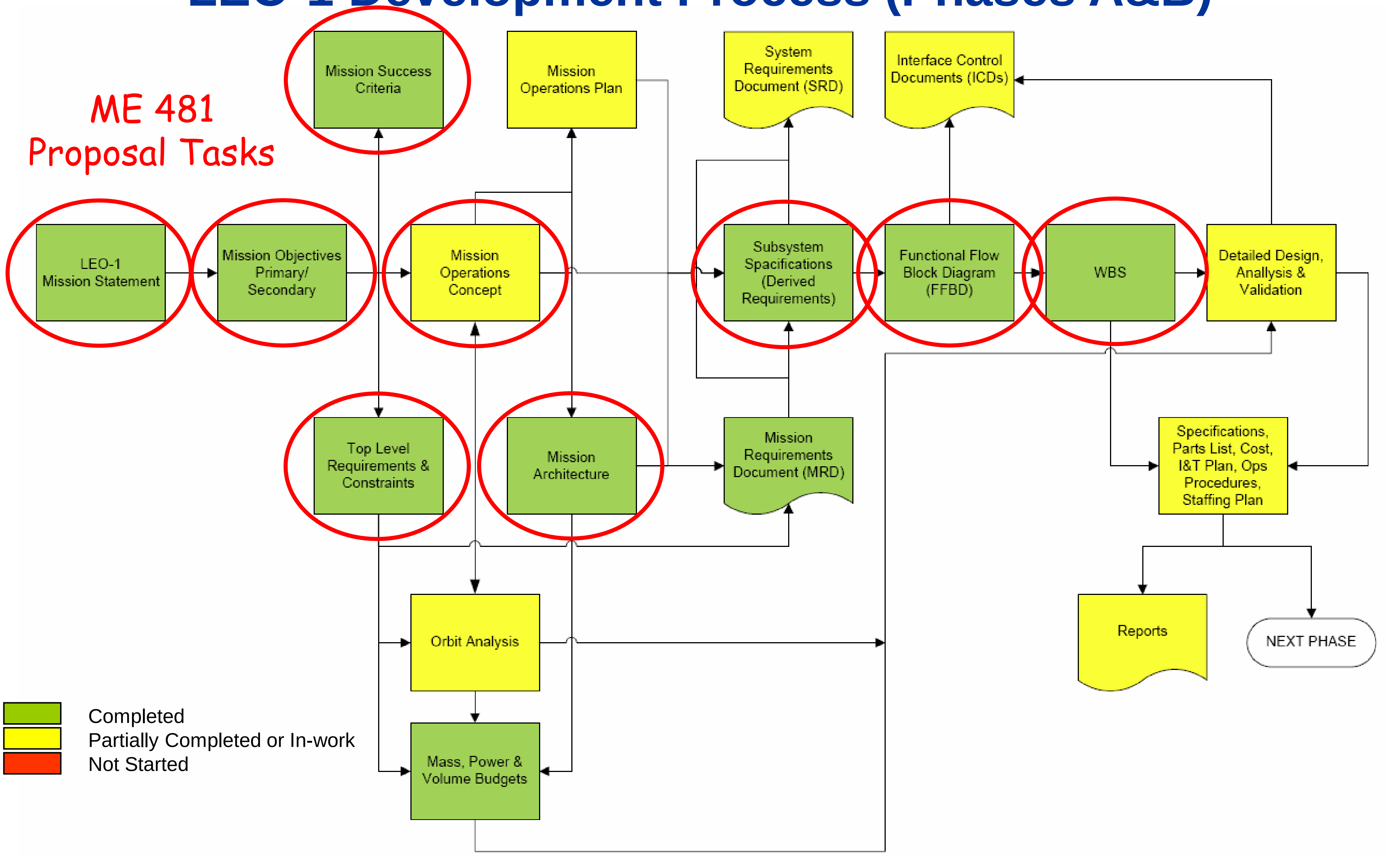


LEO-1 Spending Profile (Hardware)



Planning Stage

LEO-1 Development Process (Phases A&B)



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 Management Approach Summary

FEATURE	BENEFIT
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.

Planning Stage

2. *Risk Analysis*

- Tasks in Watch List categorized as follows:

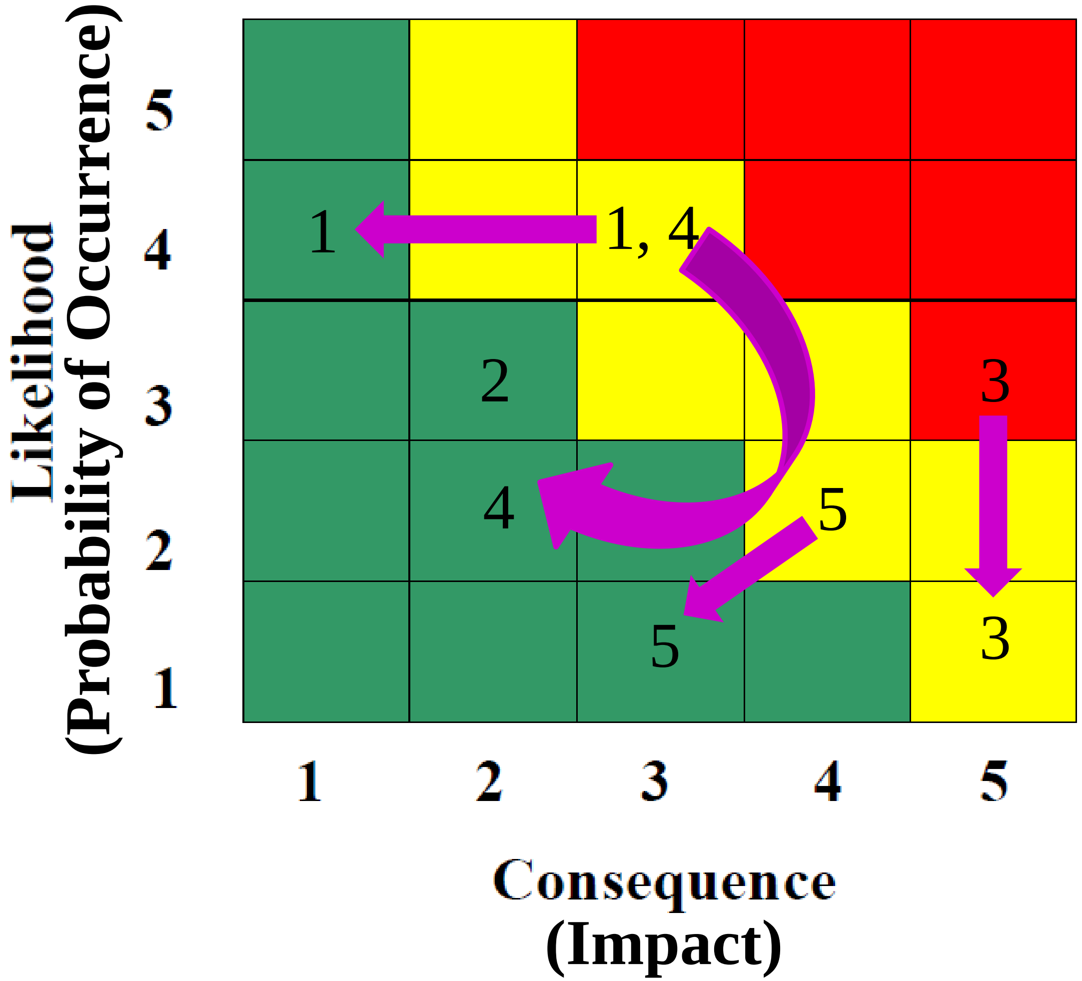
IMPACT	PROBABILITY OF OCCURENCE	RISK LEVEL
Low	Low	Low
	Medium	Low
	High	Low
Medium	Low	Low
	Medium	Medium
	High	Medium
High	Low	Medium
	Medium	High
	High	High

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.

Low
Medium
High

Source: Risk Management Guide for DOD Acquisition 6th Ed. Version 1.0

Planning Stage

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

Risk Identification	Level	Risk Mitigation (blue=proactive, red=reactive)
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 Identification	Level	Risk Mitigation (blue=proactive, red=reactive)
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 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 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

Planning Stage

Documentation List Example

Document Title	Document Number	Description	Responsibility
Mission Requirements Document (MRD)		This document gives the mission statement, objectives, success criteria, brief description of the mission, and the top-level requirements and constraints	Sorensen
Project Management Plan (PMP)		This document describes how the STU-1 project will be managed. It contains background & technical overview; top-level requirements; requirements analysis & management; system description & architecture; development & implementation approach; integration & testing; operations readiness prepartion; sustaining & maintenance engineering; WBS; schedule; risk analysis & mitigation plan; project staffing & organization; subcontract management plan; project control and reporting; and project support and logistics.	Sorensen
Systems Engineering Management Plan (SEMP)		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 & 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.	Wolfe
System Specification Document (SSD)		This document captures the top-level and derived system, subsystem, and internal and external requirements.	Wolfe
Operations Concept Document (OCD)		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	Sorensen
Mission Operations Plan (MOP)		Addresses how HSFL will support LEO-1 Operations including routine, L&EO, and contingency support	Sorensen
Conceptual Design Document (CDD)		Describes the baseline spacecraft and PAD design at the end of the Phase A study.	Sorensen
Phase A Cost Study Report		Describes the best cost estimates of the LEO-1 SC and PAD at the end of Phase A	Sorensen
Integration & Test Plan (ITP)		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	Wolfe

Planning Stage

Documentation List Example (cont.)

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

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

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

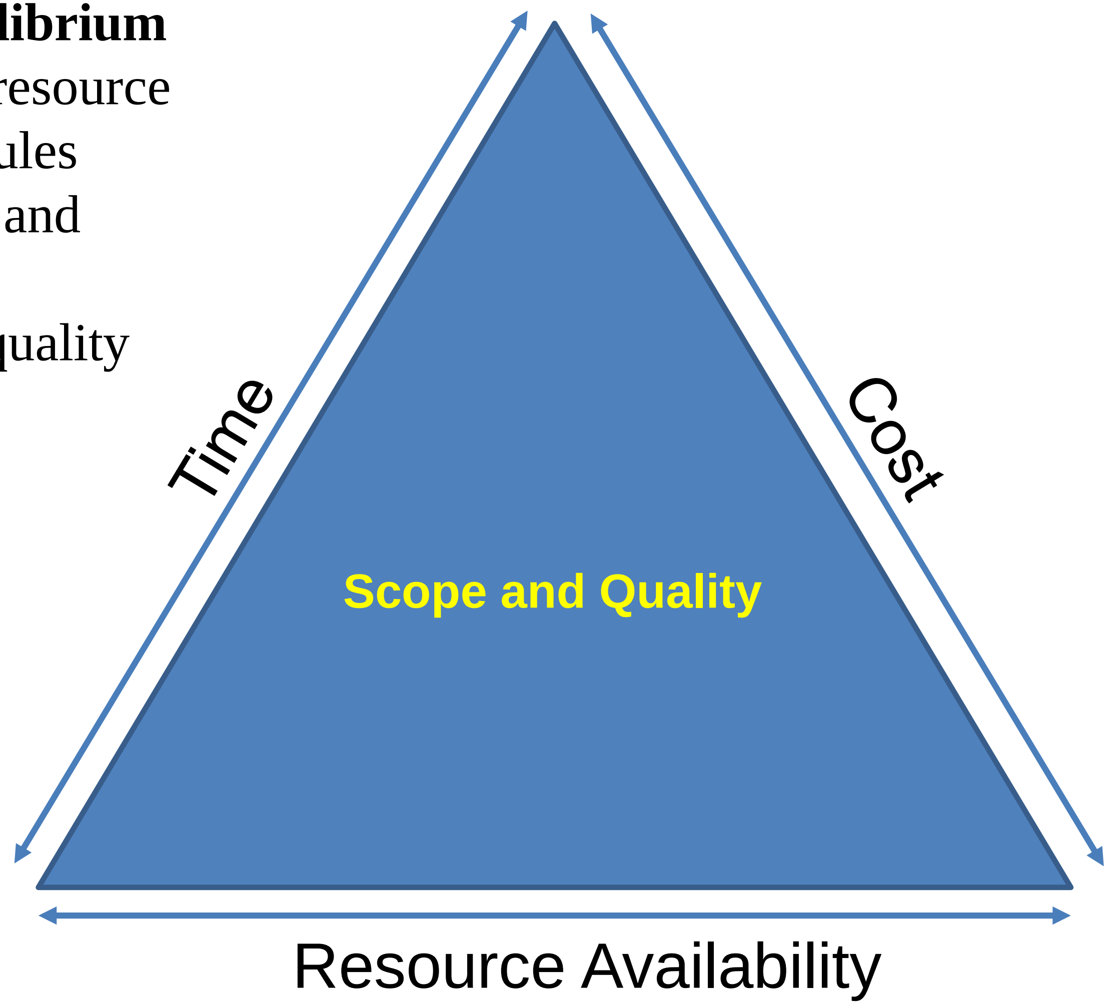
- Manager task not effectively implemented
- Work Breakdown Structure too generic to be meaningful
- Gantt chart ignored
- Poor effort estimates
- Team doesn't buy in to plan
- Documentation ignored or insufficient
- Poor communication within team or with customer
- …more?

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



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.

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 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 Segment Management
    - 2.2.2 Requirements Analysis
    - **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)