Defining the Project Tasks, Cost and Schedule

L24.01

Cost & Schedule Estimates

- The principal measures of a project are cost, time (schedule) and performance
- For a given project one or more of these measures may be constrained
  - For LaACES your launch opportunity has a fixed date and you must have a payload ready by this date
- Initial estimates on cost and schedule are essential to determine if your plan is realistic
  - May need to plan for (or implement) trade-offs according to established priorities
- Cost and schedule needs to be monitored throughout the project life-cycle

Steps to defining the project tasks

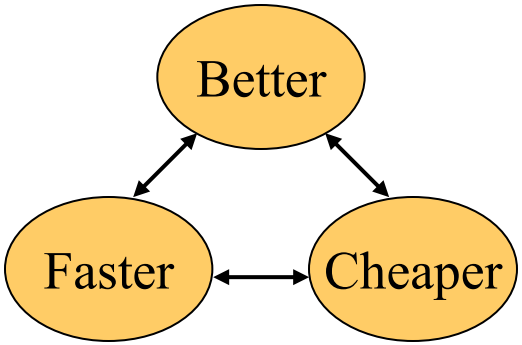
- Determine the primary characteristics of the project
  - Establish the project scope
  - Establish the project priorities
- Determine how best to organize the project tasks
  - Organization by deliverable
  - Organization by process
  - Combination of two
- Create the Work Breakdown Structure (WBS)
  - Establish highest level, most general tasks
  - Establish “tree structure” of lower level tasks
  - Lowest level used to identify “work packages

Determining the project scope

- Defining the project scope is a necessary precursor to developing an effective project plan.
- Determining the scope includes addressing the following questions:
  - What are the major objectives for the project?
  - What are the major deliverables or outputs over the life of the project and when are they due?
  - What are the significant events or milestones that will happen during the project?
  - What technical requirements must be satisfied?
  - What are the project constraints or limits that must be taken into account?
- This effort goes hand-in-hand with development of the system requirements.

Determining the project priorities

- The primary measures of a project are in terms of cost, schedule and performance
- Usually very difficult (impossible ?) to enhance or optimize all three of these measures at the same time
- Establishing the priorities at project start provides guidance for trade-offs



Pick two

(ancient engineering wisdom)

  - Required to stay fixed or constrained? (e.g. fixed budget or schedule)
  - Allowed or desired to be enhanced? (e.g. better or cheaper)
  - Acceptable to exceed? (e.g. increased cost, schedule slip, downsized)
- All three priority types should be used when ranking the primary measures of cost, time and performance
- Priorities can change, so these need to be reviewed at times

Organizing the project tasks

- Are tasks focused on producing a tangible result?
  - Project and tasks are structured by concrete products or deliverables (e.g. building a hydroelectric dam)
  - Task definitions breakdown into subdeliverables, further sub-deliverables and work packages
  - Can be run in a highly parallel fashion
- Are tasks focused on processes or phases?
  - Project evolves over time where results from one phase affect tasks in subsequent phases
  - Tasks and "deliverables" defined as outputs needed to move to next phase
- Many aerospace projects are actually a combination of these two structures
  - Phases allow new innovations to be defined and developed
  - Tangible results (e.g. spacecraft) occur during the project

The Work Breakdown Structure

- NASA definition of the WBS
  - A family tree subdivision of effort to achieve an end objective
  - Developed by starting with the end objective required and successively subdividing it into manageable components in terms of size and complexity
  - Product or task oriented and should include all the effort necessary to achieve the end objective
- MIL-HDBK-881 definition of the WBS
  - Product-oriented family tree composed of hardware, software, services, data, and facilities. A WBS displays and defines the product, or products, to be developed and/or produced.
  - Relates the elements of work to be accomplished to each other and to the end product
  - Expressed down to any level of interest. However the top three levels are as far as any program or contract need go unless the items identified are high cost or high risk.

Why use a WBS?

- Identifies the tasks, subtasks and units of work necessary to complete the project
- Identifies the relationships between tasks
- Increases the probability that every requirement will be accounted
- Organize areas of responsibility and authority
- Used to estimate project cost and schedule
- Can be used to track the costs of each element
- Can be used to monitor progress by completion of tasks

WBS Structure

- The WBS has a hierarchical structure
  - Most general units at the highest level
  - Most specific units at the lowest level
- Use a "tree structure" to provide task details

1.0 Major Task A
    1.1 Sub Task A
    1.2 Sub Task B
        1.2.1 Sub Unit A
        1.2.2 Sub Unit B
2.0 Major Task B
3.0 Major Task C

  - Split each top level general unit into subunits (level 2)
  - Split each subunit into further subunits (level 3)
- For most projects it is unlikely to need to split subunits to below level 4
- Each unit should have an identifier code representing the hierarchical, tree structure (e.g. see figure)

WBS Subunits

- Each WBS subunit is a deliverable of some kind
  - Entities necessary for exiting the current phase such as system requirements, ICD documents, test results, etc.
  - Concrete products such as power system, realtime clock software module, sensor readout system, etc.
- Lowest WBS level is defined by Work Packages
- The contents of a Work Package includes:
  - Description of the work to be done including a time schedule
  - The resources needed and the cost of the work
  - The person responsible for assuring the work is completed
- Multiple work packages may be needed for each low level WBS unit
- A sum or "roll up" of the Work Packages yields a cost and time estimate for the unit

Example WBS (Incomplete)

- Example takes one subunit down to level 4
- Many times level 3 is sufficient and level 4 defines the work package
- Each major unit has a similar level 2 list of subunits
- Each level 2 subunit has a similar level 3 list of subunits

1.0 Power System
- 1.1 Power Source
- 1.2 FCU Supply
- 1.3 DAU HD Supply
- 1.4 DAU Supply
- 1.5 CubeSat Supply
  - 1.5.1 Interface to power source
  - 1.5.2 FCU Control Interface
    - 1.5.2.1 Establish control requirements
    - 1.5.2.2 Design control interface
    - 1.5.2.3 Prototype & test design
    - 1.5.2.4 Complete design
    - 1.5.2.5 Implement & test design
  - 1.5.3 DC/DC Converters
  - 1.5.4 FCU Monitoring Interface
- 1.6 Integrate & test power system

2.0 Flight Control Unit
3.0 Data Archive Unit
4.0 Data Archive Disk
5.0 Auxiliary Transmitter
6.0 Mechanical Structure
7.0 Thermal Control
8.0 System Integration & Testing
9.0 Management

Steps to developing the estimates

- Develop the general project definition and set of tasks
- Perform a rough cost and time estimate
- Develop the detailed project definition, tasks and WBS
- Estimate the cost and time for each individual, lowest level element of the WBS
- Roll-up (add) the cost and time for each low level WBS elements to obtain the estimates for higher level elements
- Establish the project schedules
- Reconcile differences between the macro and micro estimates

Factors affecting the estimate

- Task Definition: The completeness of your project definition will determine if all tasks have been taken into account.
- People Productivity: People do not focus on a task with 100% efficiency. The difference between “calendar time” and effort must be considered.
- Project Structure: A dedicated project team will be able to focus its effort on completing the project effectively.
- Padding: People may increase estimates to take into account unknown risks and this may force an unnecessary trade-off.
- Culture: What is deemed acceptable behavior by the organization (e.g. padding vs. accuracy) will affect estimates.
- Downtime: Equipment repairs, holidays, vacations, exam schedules can all affect the time estimate.

Estimating Techniques

- Scaling: Given a cost for a previous project then an estimate for a new project can be scaled from the known cost. E.g NASA, at times, uses spacecraft weight to estimate total cost.
- Ratio: Costs for subunits of the new project would be proportional to similar subunits in a previous project. For example, if it takes 1 day to build & test a particular sensor unit, then an instrument with 10 sensors would take 2 technicians, 5 days to complete.
- Learning Curve: If the same task is repeated a number of times there will be a cost / time savings relative to the first time the task is done.
- WBS Roll-up: Times and costs associated with the lowest level WBS work packages are estimated and then these are added or rolled-up to yield the costs for higher level units.

Guidelines for Estimates

- Estimates should be done by the person most familiar with the task
- If possible obtain estimates from several people and use the variance for risk assessment
- Multiple estimates should be done independently to avoid “GroupThink”
- Base the estimates upon normal conditions.
- Use consistent units when estimating task time.
- Work package estimates should not include contingencies
- Use a separate risk assessment for estimating the affect of abnormal conditions and contingencies.

Example WBS Cost Roll-up

WBS Element			Estimated Time and Dollar Costs					
1.0 Power System							155.0d	$7560
1.1 Power Source					25.0d	$1340		
1.2 FCU Supply					20.0d	$970		
1.3 DAU HD Supply					15.0d	$530		
1.4 DAU Supply					20.0d	$970		
1.5 CubeSat Supply					45.0d	$2450		
1.5.1 Interface to power source			10.0d	$300				
1.5.2 FCU Control Interface			14.0d	$970				
1.5.2.1 Establish requirements	0.5d	$20						
1.5.2.2 Design control interface	1.5d	$50						
1.5.2.3 Prototype & test design	5.0d	$300						
1.5.2.4 Complete design	2.0d	$100						
1.5.2.5 Implement & test design	5.0d	$500						
1.5.3 DC/DC Converters			8.5d	$730				
1.5.4 FCU Monitoring Interface			12.5d	$450				
1.6 Integrate & test power system					30.0d	$1300		
2.0 Flight Control Unit							120.0d	$3000
3.0 Data Archive Unit							90.0d	$2500
4.0 Auxiliary Transmitter							35.0d	$1500
6.0 Mechanical Structure							100.0d	$3500
7.0 Thermal Control							65.0d	$1750
8.0 System Integration & Testing							55.0d	$6000
9.0 Management							90.0d	$1200
Total Project Estimate							**710.0d**	**$27010**