



WITHOUT THE PRODUCT, THERE IS NO PROCESS!



2012

Jan

Feb

Mar

Apr

May

Jun

Jul

Aug

Sep

Oct

Nov

Dec

# Combined Resources Forum

**Presents:**

## Planning and Scheduling for the Resources Analyst

November 2012

## Project Cost and Schedule Visibility

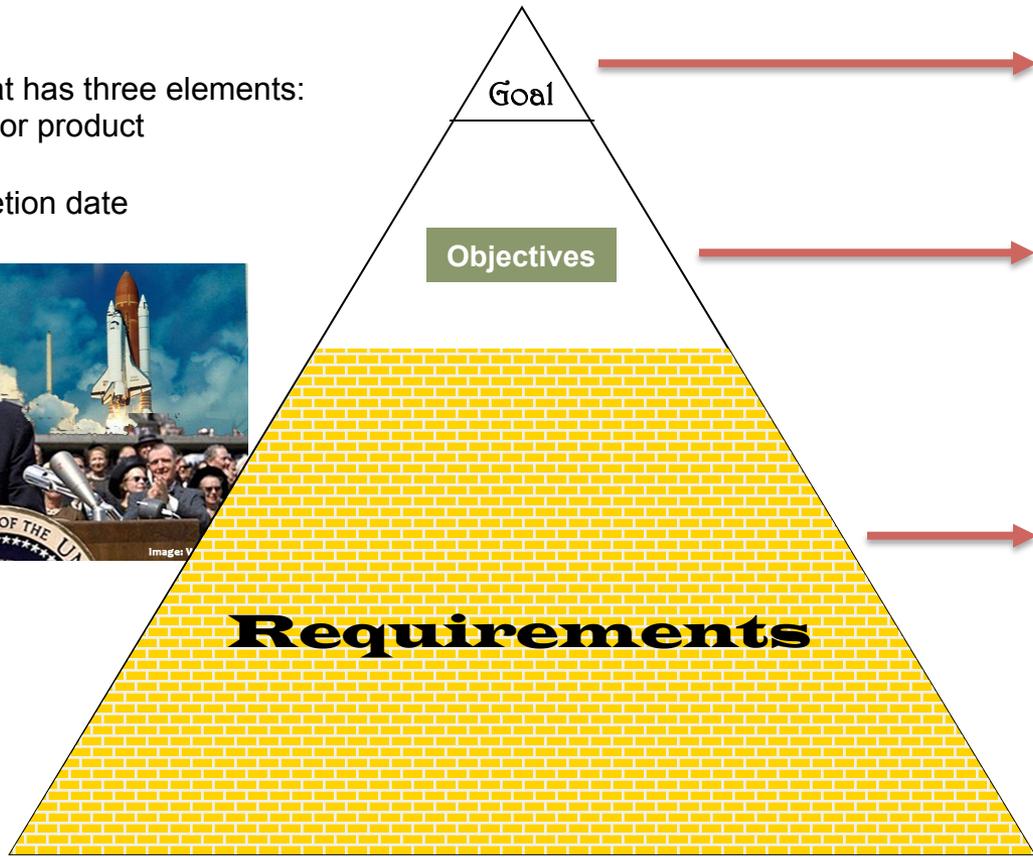
### Why are cost and schedule more visible than ever before?

- Watchdogs: Standing Review Board (SRB), IPAO, NASA HQ Office of Evaluation (OE), OMB, GAO and Congress
  - NASA makes the formal Agency Baseline Commitment at Key Decision Point-C (KDP-C)
  - Not fulfilling these commitments will result in increased scrutiny and criticism and may impact the project's ability to proceed
- More difficult/limited budgetary environment
- Grassroots budgets and schedule flows are supported by independent analyses, probabilistic risk assessments, and parametric cost models ((Independent Cost Estimates (ICE), Earned Value Management (EVM), and Joint Confidence Level Estimates (JCL))

# Requirement Definition

A "Goal" is a statement that has three elements:

- 1) the end result and/or product
- 2) the budget
- 3) the desired completion date



Build a satellite to study the sun for \$X and launch in 2014

S/C, Instruments, Science, Lifecycle, Product Realization, etc.

All supporting details

Requirements define the goal and objectives

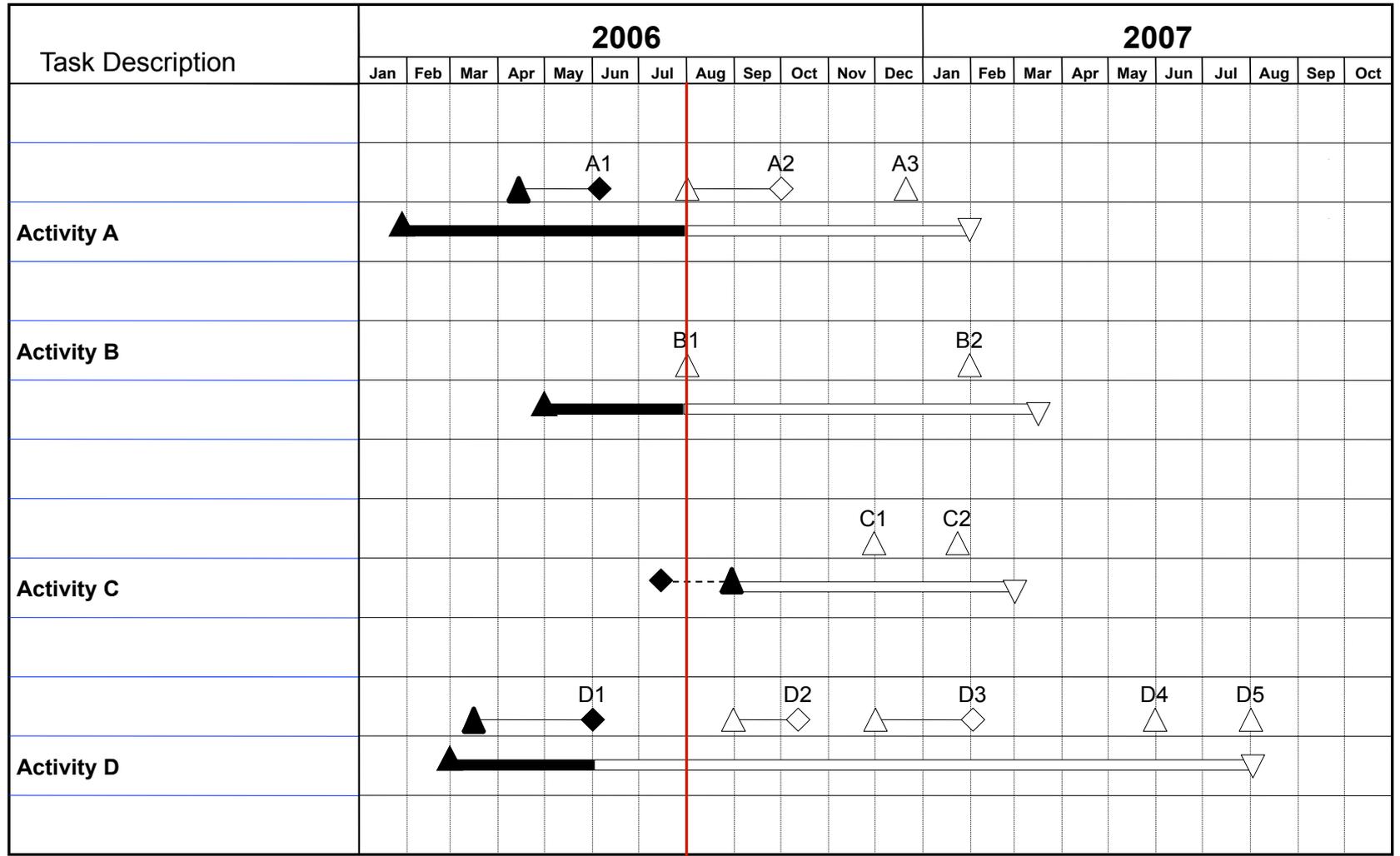
## What is a Schedule?

A **SCHEDULE** may be a “picture” of an entire project or a magnification of any part or level thereof.

It can establish the sequence of activities; indicate future work loads; identify key events; visually indicate the critical path; and be used to highlight the distribution of resources necessary to support the project.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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# Gantt/Bar Chart Schedule example



- △ Event/Milestone Planned Start
- ▲ Event/Milestone Actual Start
- ◇ Anticipated Slip
- ▽ Event/Milestone Planned Complete
- ▼ Event/Milestone Actual Complete
- ◇ Anticipated Slip
- ▬ Planned Activity
- ▬ Actual Activity
- ◆ Actual Slip

## Ownership of the plan or schedule belongs to....

**... those responsible for accomplishing its task.**

**The scheduler “represents” or “models” the data and information until it reflects the reality of the plan. Then they provide the status versus the plan for the owner and other managers.**

**A scheduler must be flexible and always ready to modify the plan for any changes.**

## What Scheduling Does

- **Plans, monitors and provides controls for the entire project:**
  - Measures performance against the baseline
  - Identifies potential risks
  - Performs “what-if” scenarios
  - Analyzes work-around options if delays occur
  - Forecasts start and completion dates (early or late)

This enables accurate, time-phased, budgets

## Why Should an RA Care about Schedules?

- Resources Analysts are the financial backbone supporting Research and Development, the building of Spacecraft, Instruments, Balloons, Mission Operations, Facilities, et cetera
- An RA may be assigned a Project element such as an instrument on a spacecraft or a ground system.
- All of the work for this element must be planned over a period of time or “scheduled.”
- Both schedule and cost performance must be tracked, managed and forecasted.
- The Financial Manager (FM) and Deputy Project Manager for Resources (DPMR) must understand cost plans and schedules for all Project elements.

## A Delicate Balance



Schedule, Cost and Scope are traded off to achieve an optimal balance.

The RA is in a key position to observe and support the tradeoff discussions.

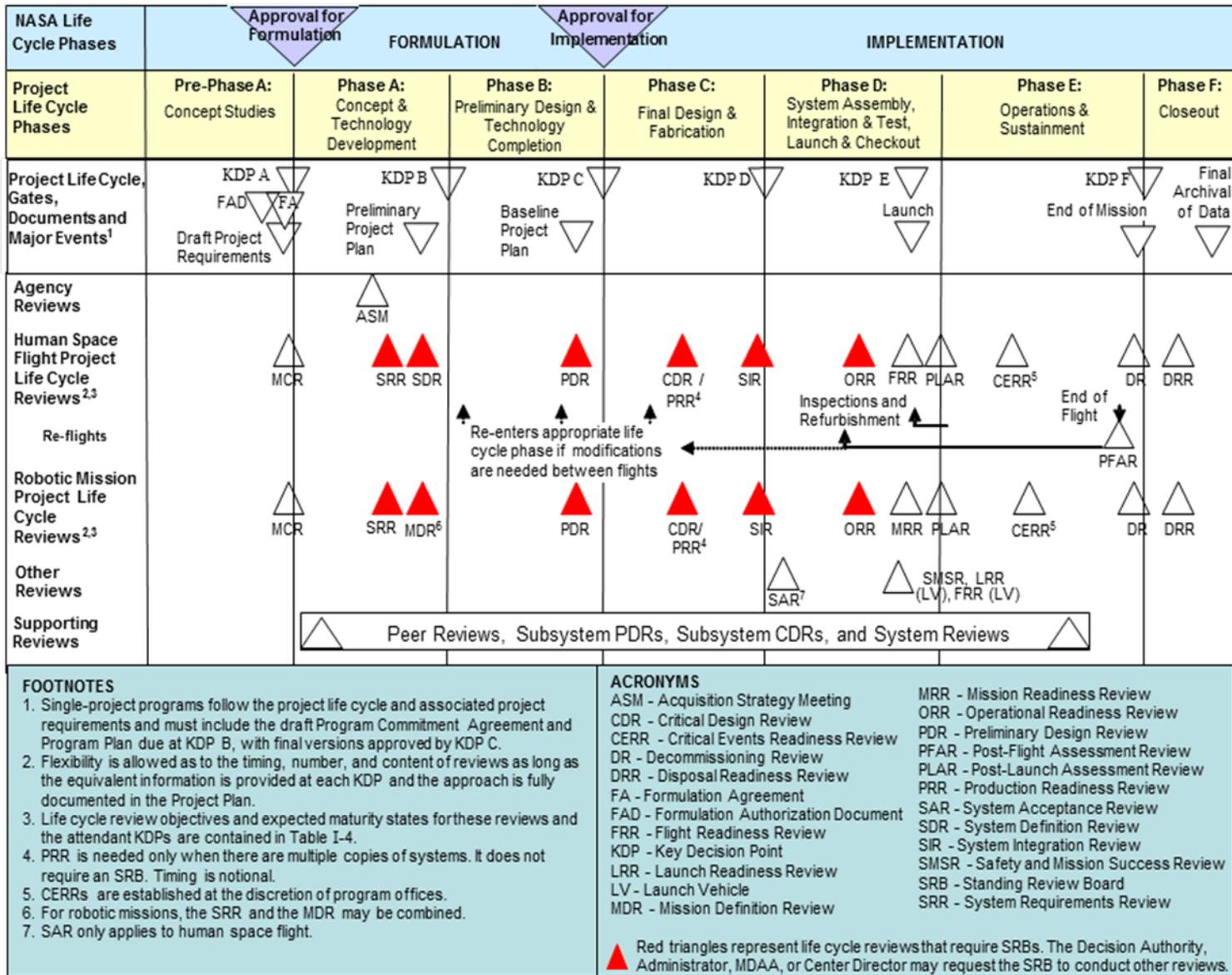
## Developing Schedules

- Before schedules are developed and utilized, a project must:
  - Understand the NASA Project Lifecycle (NPR 7120.5)
  - Know basic scheduling practices
  - Have requirements defined
  - Have a WBS structure to reflect those requirements and products
- An RA must be aware of each step and understand how schedules work. Schedules and budgets are closely connected.

Knowing how schedules are developed and where you can influence better scheduling --- will result in better budgeting.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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# NASA Project Lifecycle: From NPR 7120.5



# Project Phases

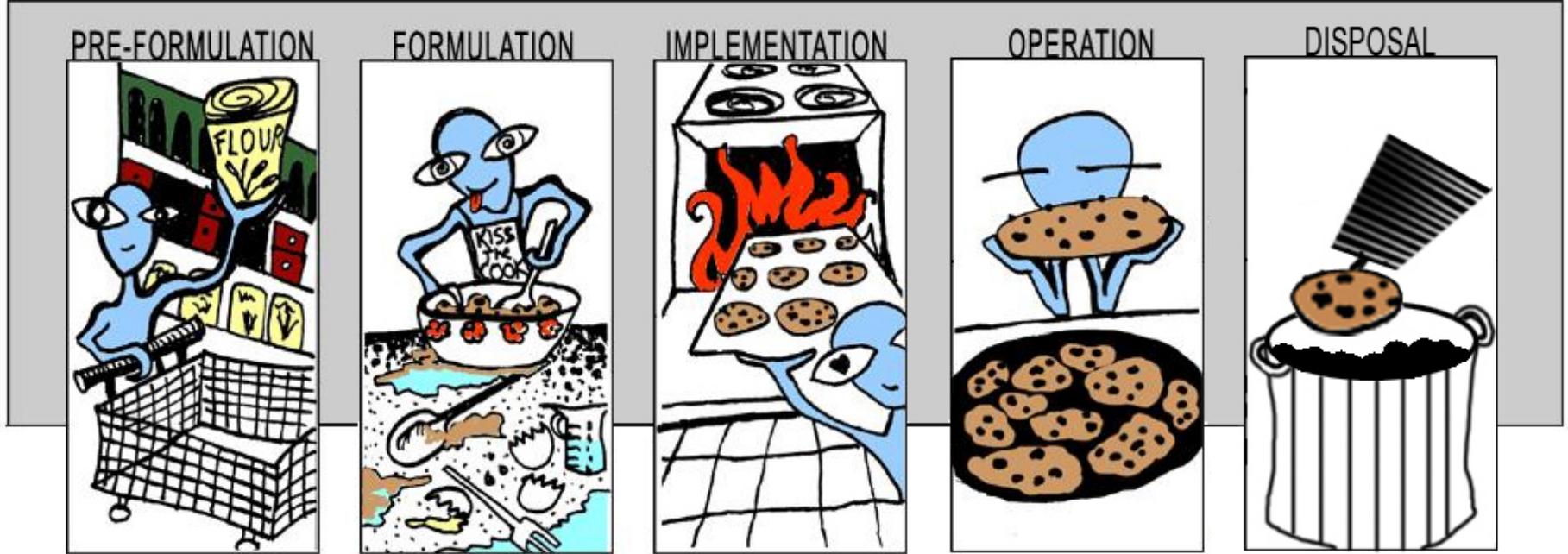
Pre-A

A/B

C/D

E

F



## Resources Emphasis by Phase

- Phase A:** Understanding new technology and requirements can make scheduling and budgeting challenging. Expect many changes and replans as available resources and scope change.
- Phase B:** Costs and Schedule are baselined (approved at the end of Phase B). Early development activities can be in flux and are risky. However, the planning portion of budgets and schedule should become firm.
- Phase C/D:** As flight hardware is procured, integrated and tested, problems are uncovered. Make sure sufficient cost and schedule reserves exist to cover for an unknown risks and additional testing (if required).
- Phase E/F:** Level of effort costs should be well understood with little variation for mission operations (little cost reserves needed). Costs of shutdown/disposal (e.g. safe reentry).

Each Phase has unique activities that can impact schedule and cost

# NASA Work Breakdown Structure – NPR 7120

## G.4 Space Flight Project WBS Standard Elements (NPR7120.5)

**Standard Level 2 WBS elements for space flight projects** are shown in Figure G.4-1. The standard WBS template below assumes a typical spacecraft flight development project with relatively minor ground or mission operations elements. For major launch or mission operations ground development activities which are viewed as projects unto themselves, the WBS may be modified. For example, the spacecraft element may be changed to reflect the ground project major deliverable product (such as a facility). The elements such as payload, launch vehicle/services, ground system(s), and mission operations (system) that are not applicable may be deleted.

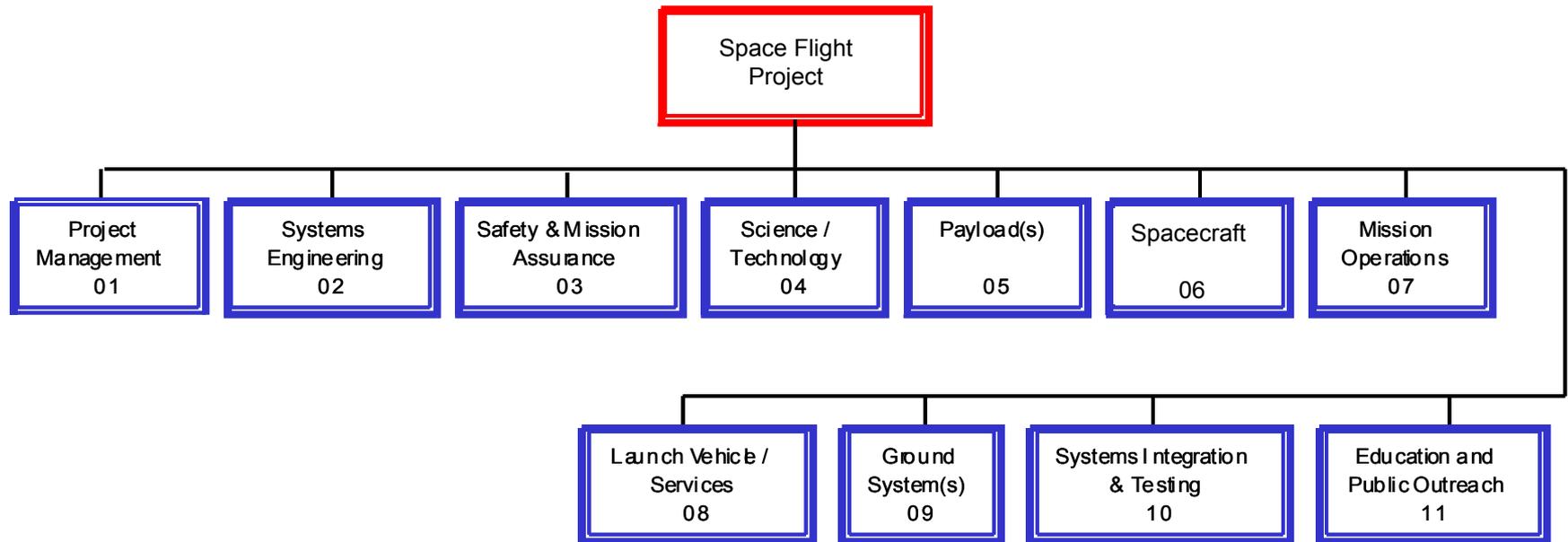
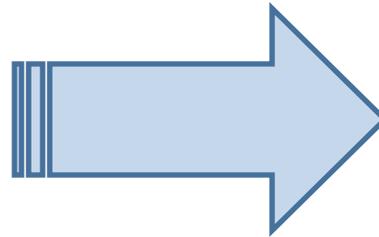
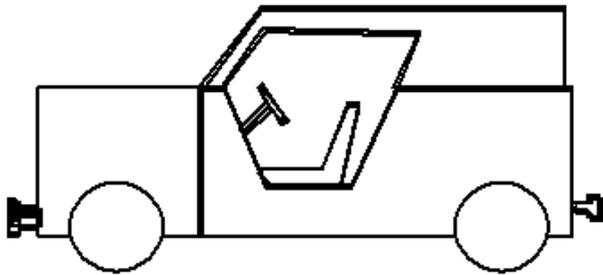


Figure G.4-1 Standard Level 2 WBS Elements for Space Flight Projects

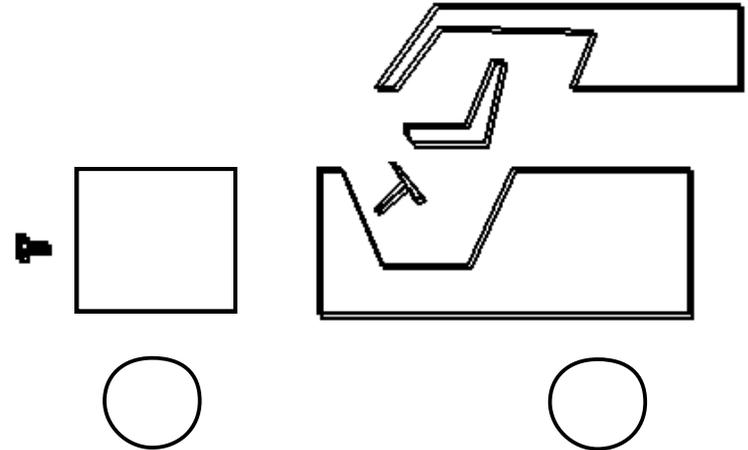
# What is a WBS?

A method to achieve Logical Decomposition of a large/complex thing:

**The Whole**



**Its Pieces**

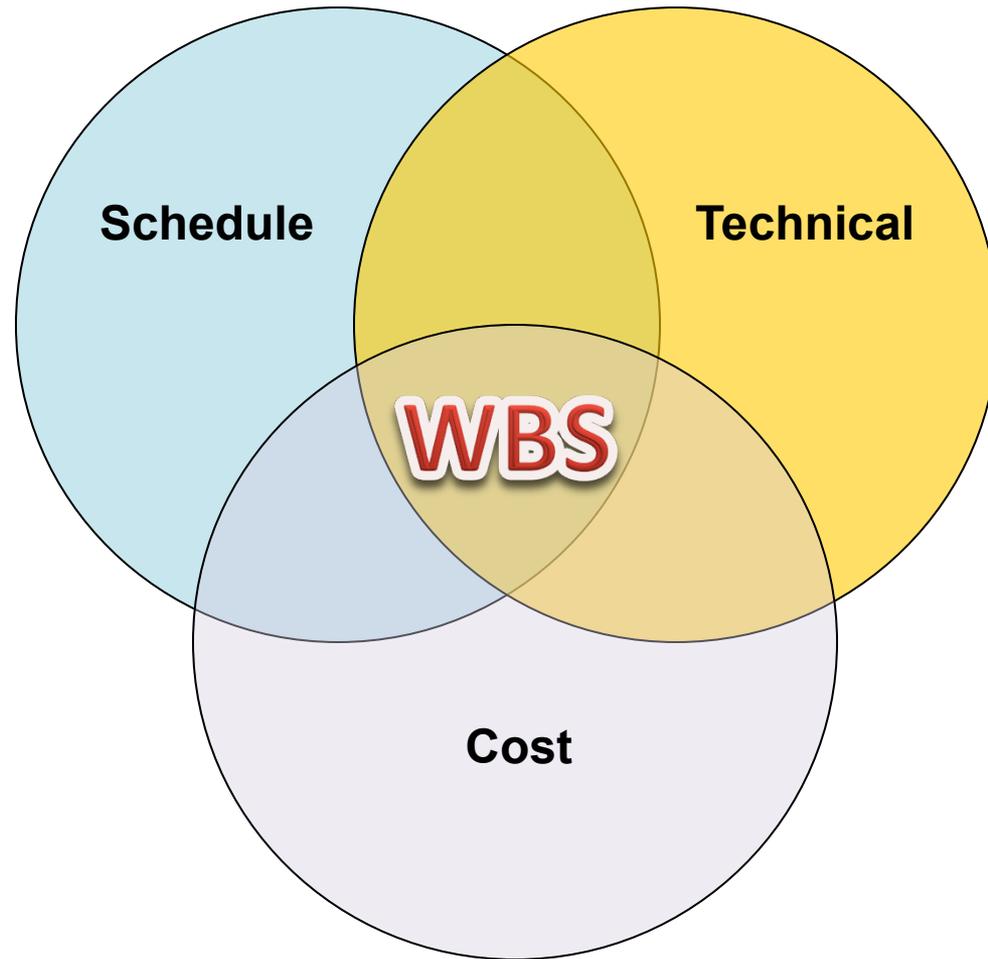


The whole is successively decomposed into smaller pieces until each piece is a manageable size.

## Purpose of a WBS

- **To provide a common logical approach for planning & managing a project.**
  - *Project planning and control start with the definition of what is to be done; the when (schedule); how much (the cost); and, who is responsible.*
  
- **To identify & match requirements to products and services.**
  - *The purpose of the WBS is to define, successively lower levels, what is to be delivered or performed. The depth will differ on each project or program depending on complexity, length and cost.*
  
- **To break the total project into accomplishable & controllable work elements.**
  - *The WBS structure parallels a decomposition of the project into a tree of elements. Each level of detail breaks out an element of the higher level into more detail. All elements 'tree' back to a single source at the top.*

# Work Breakdown Structure (WBS) Relationship



## RA Take-Away

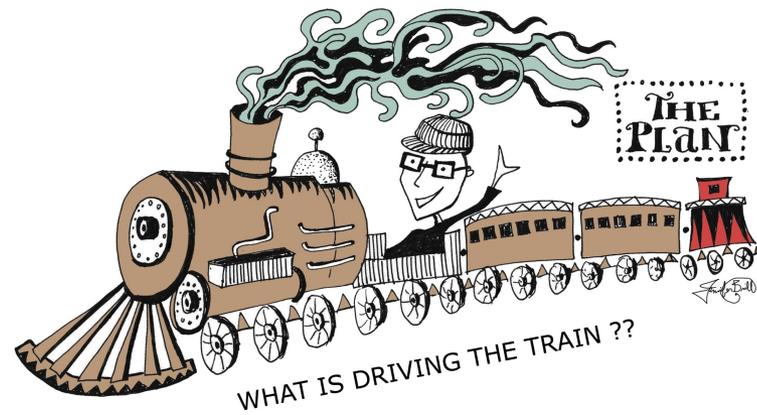
- A well defined WBS is important to establish the link between the technical, scope, schedule and budget
  - Integrates all elements of a project as a function of logic and time
  - Helps with executing Earned Value Management
  - Provides a common communication base
  - Identifies the scope of work
  - Helps with time phasing and resource loading budgets
  - Balances time with budget availability

Having the technical lead, scheduler and RA connected with a common and aligned WBS helps bring it all together

# The Planning Process

... is not all about the dollars - it is about mission success!

- The planner does not decide the plan - he or she “represents” it and then iterates and manages it with instructions from the project.
  - The plan is never done until the product is completed.
- Time is money: most of the cost of project overruns are from delayed funding on the front end and a marching army on the back end.
- Proper planning prevents poor performance!



# Schedule Realism



**YOU WANT IT WHEN?!**

We need to be realistic in our planning. An overly optimistic schedule, one used to “sell” a project to NASA HQ or partners, or a schedule without any margin just creates problems later in the project lifecycle.

## Frequently Used Terms

- **Milestone:** A specified event in the plan used to measure progress. Defined as beginning or ends of activities. A milestone is visually depicted on a schedule chart as triangle.
- **Activity:** An activity is an identifiable work element; finite, discrete task. Its start and finish date are measureable.
- **Duration:** The duration is the estimated amount of time necessary to accomplish a task in “work units” (e.g. days).
- **Early Start/Early Finish:** These are the earliest dates a given activity can start or finish on without impacting its successor activity.
- **Late Start/Late Finish:** These are the latest dates a given activity can start or finish on without slipping the schedule.
- **Schedule Baseline:** When the schedule is approved by the PM it is baselined to lock in the planned working dates. The baseline start and finish dates are the dates the project agrees to start and finish their activities on. Progress is measured against these dates.
- **Critical Path:** The longest path per the time available through a project, or the path through the project with the least amount of float.

# Standard Schedule Symbology



Major Milestone



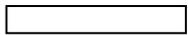
Planned Start Milestone



Planned Finish Milestone



Reschedule



Span of Activity



Progress of Activity



Changed Milestone w/# slips



Completed Start Milestone



Completed Finish Milestone



Completed Reschedule



Milestone



Reschedule #



Complete



Major Milestone



Reschedule #



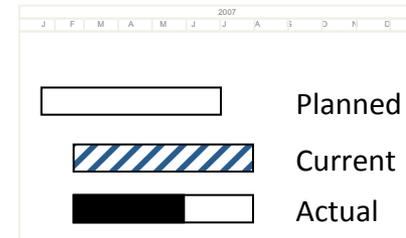
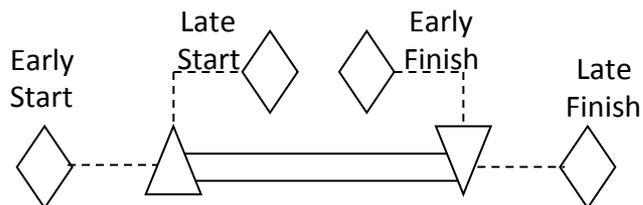
Complete



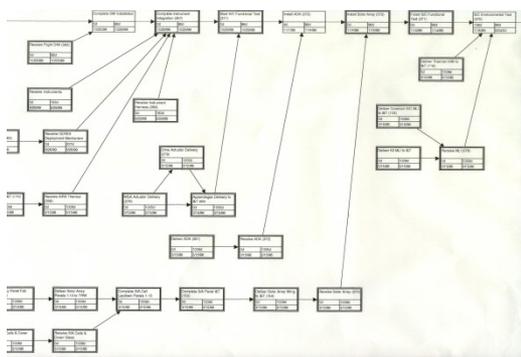
Reschedule #



Complete



# Schedules: Vertical Traceability



Computer may not have enough memory to open the image, or the image may have been corrupted. Restart your computer, and then open the file again. If the red x still appears, you may have to delete the image and then

### Detailed milestones & networks (e.g. spacecraft assemblies)

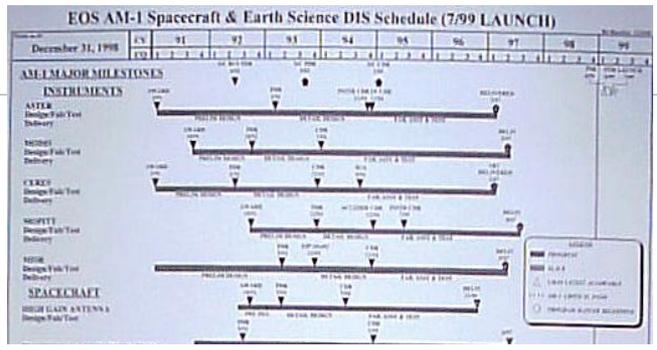
GODDARD SPACE FLIGHT CENTER		MASTER SCHEDULE		ORIG. APPL. 08/30/93	
APPROVAL V. WEYERS		EOS AM-1 SPACECRAFT		LAST CHANGE 10/31/96	
ACCOMP. C. SCOLESE		Page 2 of 2		STATUS AS OF 10/31/96	
MILESTONES	Calendar Year	Quarter			
		91	92	93	94
		1	2	3	4
1 EOS AM-1 INSTRUMENTS:					
2 MODIS		AWD	PDR	CDR	
3					
4 ASTER		AWD	PDR	INSTR	CDR
5 SWIR DES, FAB, ASSY & TEST			PDR	CDR	
6 TIR DES, FAB, ASSY & TEST			PDR	CDR	
7 VNIR DES, FAB, ASSY & TEST			PDR	CDR	
8 SYSTEM INTEGRATION & TEST					
9					
10 MOPITT		AWD	PDR	A CD	CDR
11					
12 CERES		AWD	PDR	CDR	WA
13				EP (draft)	
14 MISR			PDR	CDR	
15					
16				ARV	ARV
17 SCIENCE ALG. DEV/MAINT (PRELIM)			POS TOOL-KIT	ARV	ARV
18					
19 EOS ESDIS MAJOR MILESTONE				ETE REVIEW	
20					

NOTE: ARV - Algorithm Quarterly Review

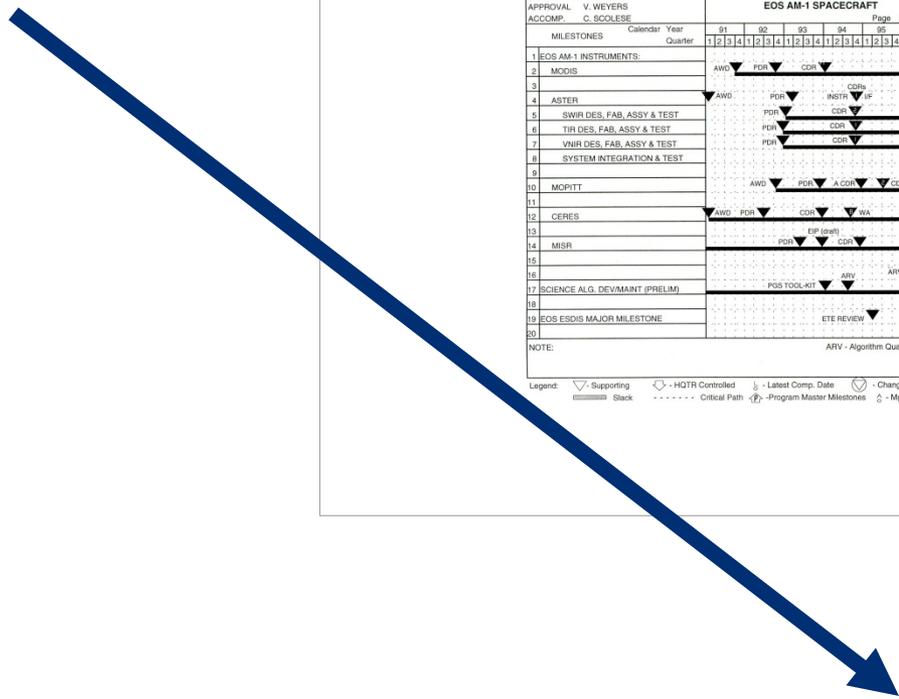
Legend:   
 ▽ Supporting   
 ◊ HSTR Controlled   
 ▽ Latest Comp. Date   
 ◊ Changed   
 █ Stack   
 - - - Critical Path   
 ◊ Program Master Milestones   
 ◊ Mgr. Assessed Comp. Date

Rebaseline Date: 11/30/93

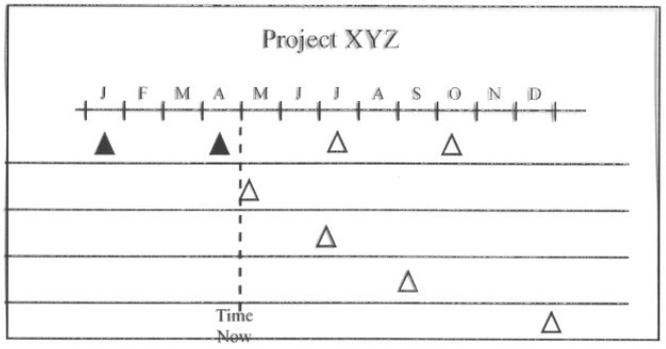
### Intermediate Schedule (e.g. spacecraft)



### Master Schedule (Mission)

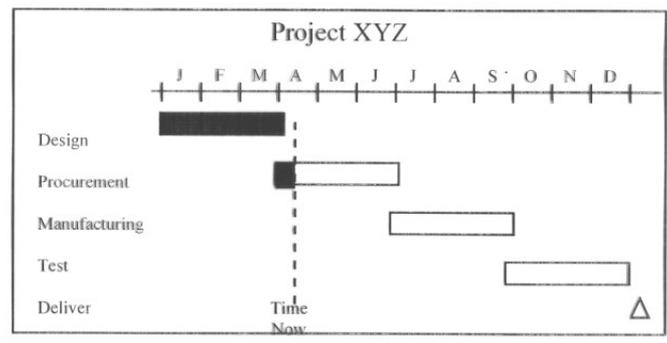


# Schedule Types



## Milestone Schedule:

Is a summary level schedule that identifies significant events (milestones) that may exist over the course of a project.

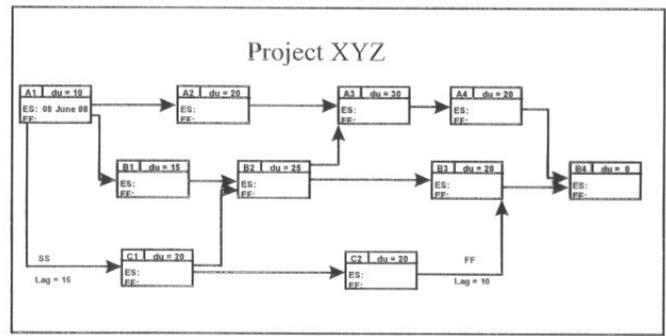


## Bar/Gantt Chart:

The left side of the chart displays the WBS, the date ribbon is placed across the top, and the activity durations are represented by horizontal bars.

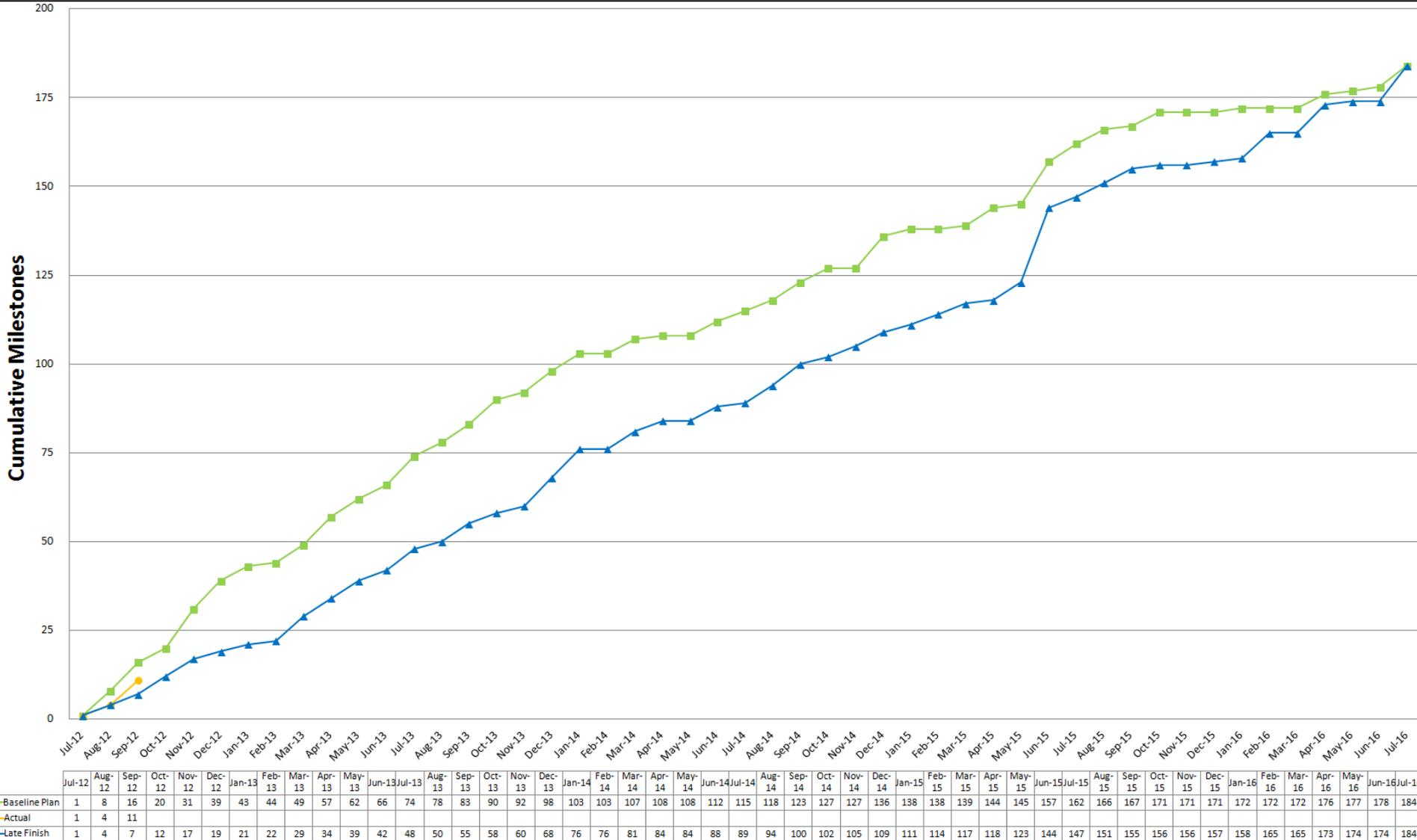
## Critical Path / Network Diagram:

Schematic of all logical relationships and activities. The network flows time-wise left to right to reflect the chronology of project work.



# ICESat-2 Monthly Schedule Book

## ICESat-2 Cumulative Milestone Chart



Status Date: 09/30/12

## The Gantt/Bar Chart as an Analytical Tool

Gantt or Bar Charts are frequently used in Monthly Status Reviews (MSR) and are easily available to RAs.

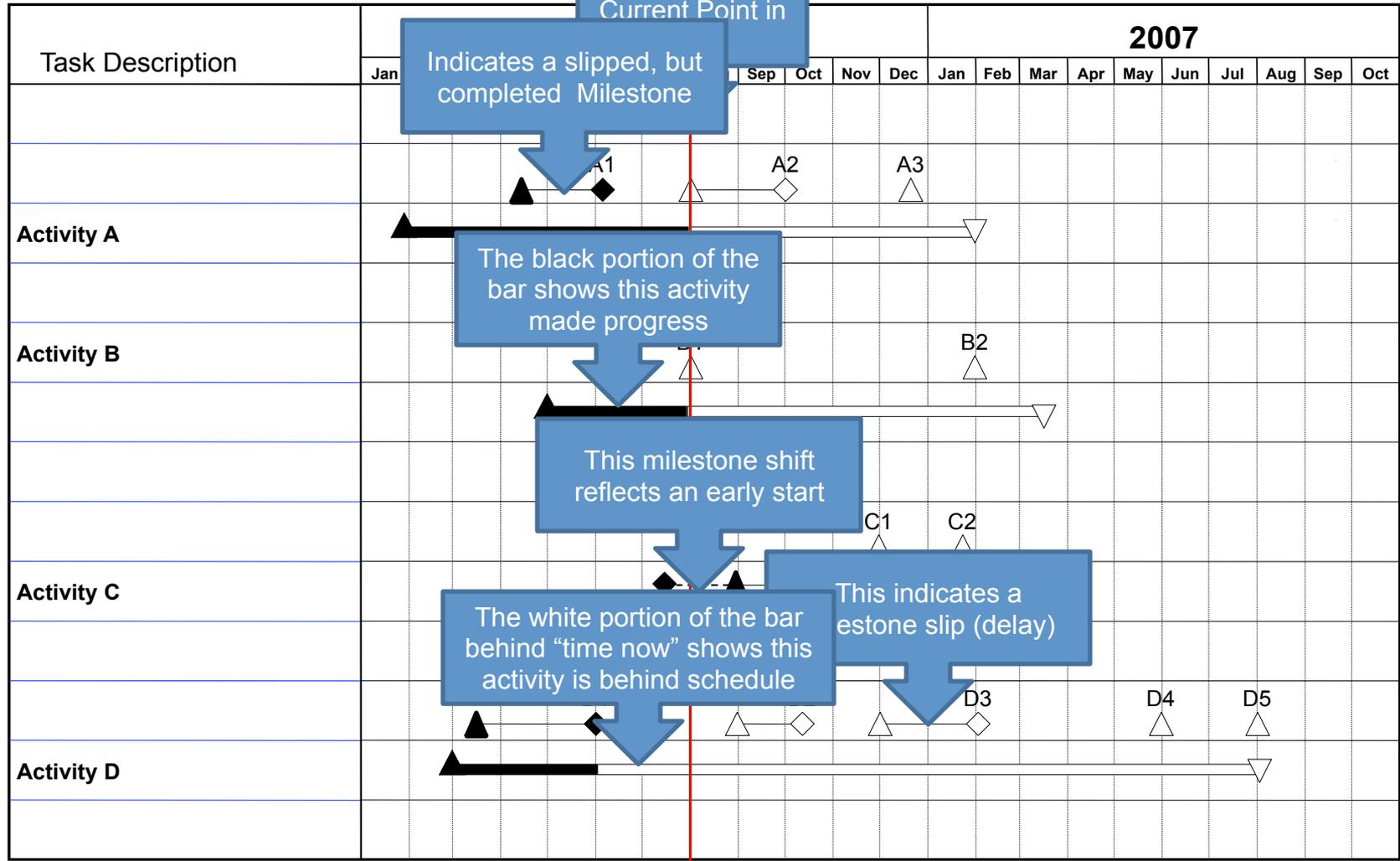
The bar chart schedule is a project tracking and control tool. It enables a project to have an overview of its performance to a baseline or original schedule and visualize what lies downstream for schedule objectives.

On the next page is a generic multi-milestone barchart. It reflects the schedule and progress of certain activities and events (milestones).

No doubt there is considerable information relative to the schedule and status of the project.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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# Reading the Gantt/Bar Chart



Indicates Current Point in Time

Indicates a slipped, but completed Milestone

The black portion of the bar shows this activity made progress

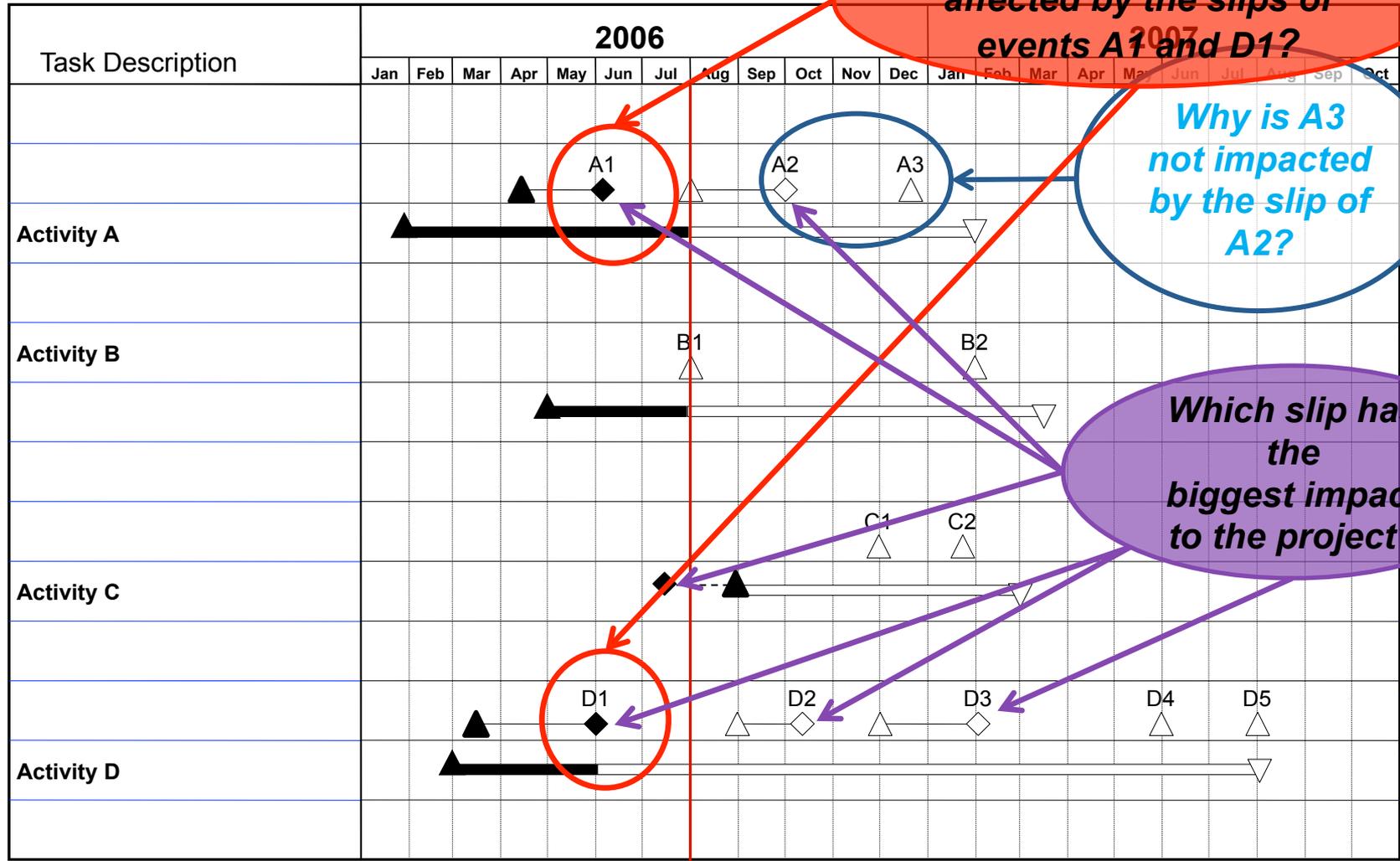
This milestone shift reflects an early start

The white portion of the bar behind "time now" shows this activity is behind schedule

This indicates a milestone slip (delay)

- △ Event/Milestone Planned Start
- ▲ Event/Milestone Actual Start
- ▬ Planned Activity
- ▬ Actual Activity
- ▽ Event/Milestone Planned Complete
- ▼ Event/Milestone Actual Complete
- ◇ Anticipated Slip
- ◆ Actual Slip

# Bar Chart Questions



**What activities were affected by the slips of events A1 and D1?**

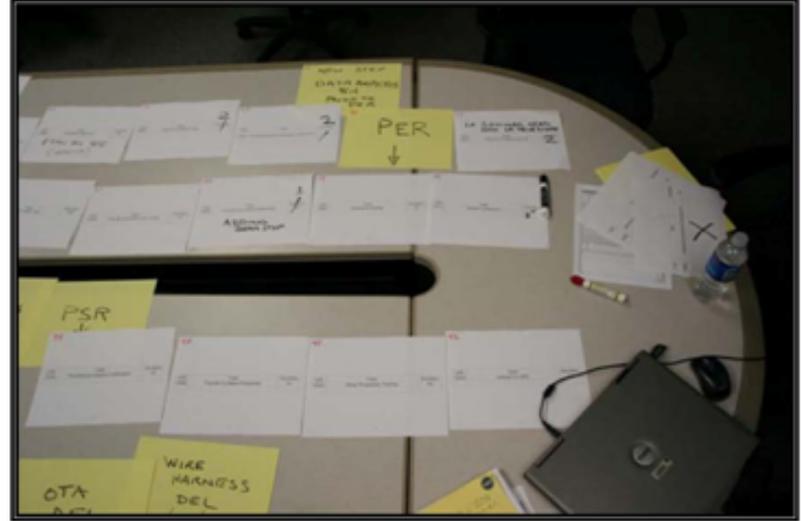
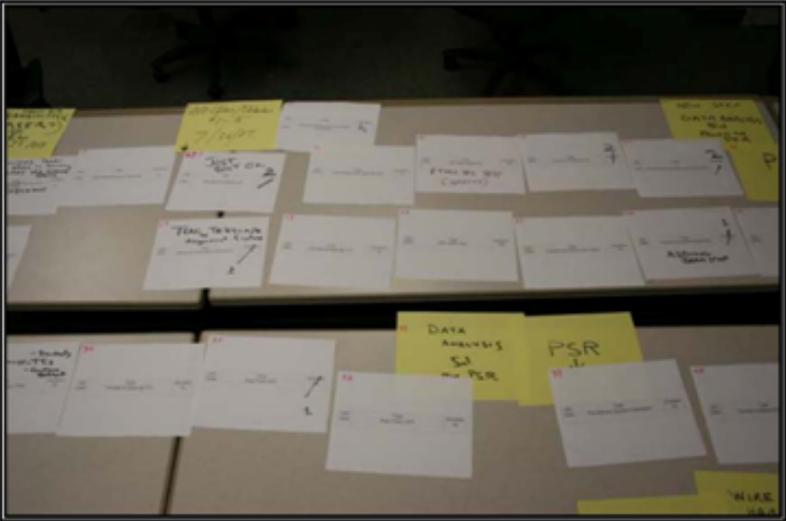
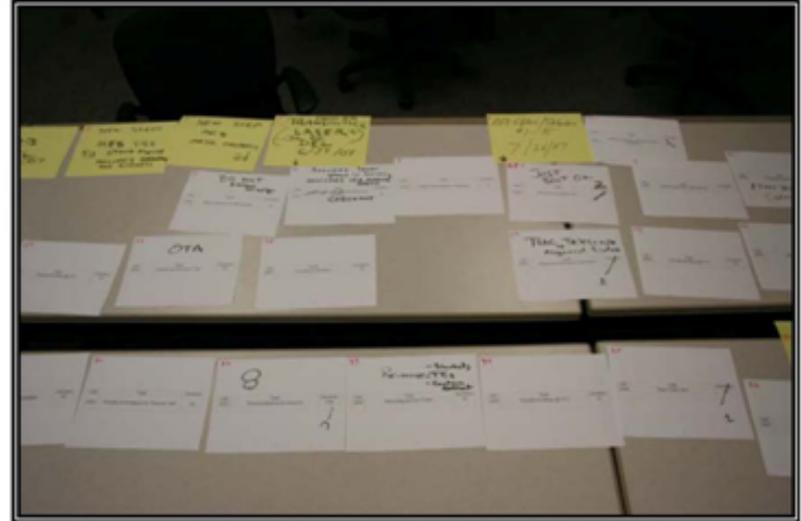
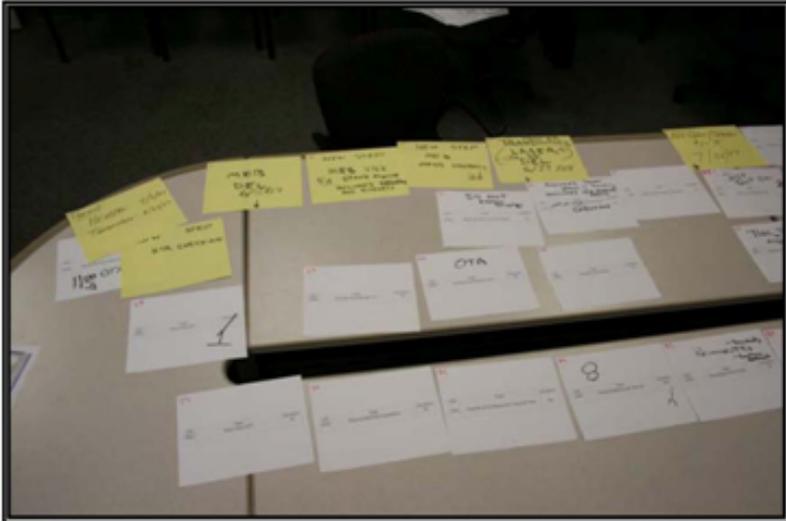
**Why is A3 not impacted by the slip of A2?**

**Which slip has the biggest impact to the project?**

- △ Event/Milestone Planned Start
- ▲ Event/Milestone Actual Start
- ◻ Planned Activity
- Actual Activity
- ▽ Event/Milestone Planned Complete
- ▼ Event/Milestone Actual Complete
- ◇ Anticipated Slip
- ◆ Actual Slip

But how did we actually  
construct the schedule?

# Network development: We often start with “cards on a wall”....



Source: Joe Krygiel/GSFC

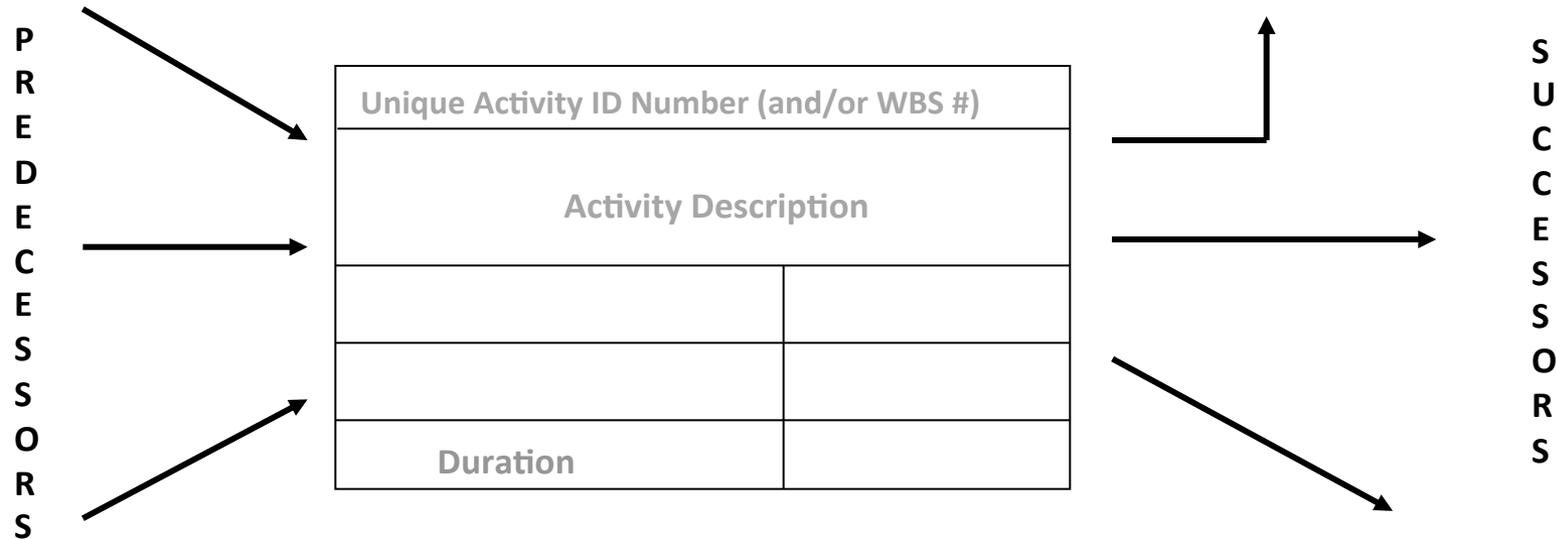
Structure Element Title	Project/WBS	WBS Level
Glory Mission	387055	.
Project Management	387055.01	WBS2
GSFC-Labor & Full Cost	387055.01.01	WBS3
GSFC-Travel	387055.01.02	WBS3
GSFC-General Support	387055.01.03	WBS3
GSFC-Fab Pool	387055.01.04	WBS3
GSFC-Test Pool	387055.01.05	WBS3
GSFC-PAAC	387055.01.06	WBS3
GSFC-Contingency	387055.01.07	WBS3
GSFC-Program Office Support	387055.01.08	WBS3
Agency Service Pool Full Cost Assessment	387055.01.20	WBS3
Agency FFS Full Cost Assessment	387055.01.25	WBS3
GSFC-GLORY FTE Supplement Labor 2007	387055.01.66	WBS3
GSFC-Code 400 Taxes -Glory	387055.01.88	WBS3
Systems Engineering	387055.02	WBS2
GSFC-MSES	387055.02.01	WBS3
GSFC-SS-1	387055.02.02	WBS3
GSFC-Other	387055.02.03	WBS3
Safety & Mission Assurance	387055.03	WBS2
GSFC-S & MA	387055.03.01	WBS3
GSFC-Mission Success	387055.03.02	WBS3
Science / Technology	387055.04	WBS2
GSFC-GISS Support	387055.04.01	WBS3
GSFC-GSFC Internal Science	387055.04.02	WBS3
GSFC-External Science Team	387055.04.03	WBS3
GSFC-DAAC	387055.04.04	WBS3
GSFC-Cal/Val	387055.04.05	WBS3
GSFC-Data Analysis	387055.04.06	WBS3

Structure Element Title	Project/WBS	WBS Level
Payload(s)	387055.05	WBS2
GSFC-TIM Instrument	387055.05.01	WBS3
GSFC-APS Instrument	387055.05.02	WBS3
GSFC-Cloud Camera	387055.05.03	WBS3
Aircraft / Spacecraft	387055.06	WBS2
GSFC-Spacecraft	387055.06.01	WBS3
JSC-ORSAT Analysis	387055.06.02	WBS3
Mission Operations	387055.07	WBS2
GSFC-Mission Operations	387055.07.01	WBS3
GSFC-TIM Mission Operations	387055.07.02	WBS3
Launch Vehicles / Services	387055.08	WBS2
KSC-Launch Vehicle	387055.08.01	WBS3
Ground Systems	387055.09	WBS2
GSFC-LASP Ground Support	387055.09.01	WBS3
GSFC-OSC Ground Support	387055.09.02	WBS3
GSFC-GSFC Ground Support	387055.09.03	WBS3
Systems Integrat	387055.10	WBS2
GSFC-Observatory I & T	387055.10.01	WBS3
Education and Public Outreach	387055.11	WBS2
GSFC-E & PO General	387055.11.01	WBS3
GSFC-E & PO Formal Education	387055.11.02	WBS3
GSFC-E & PO Informal Education	387055.11.03	WBS3
GSFC-E & PO Public Outreach	387055.11.04	WBS3
Agency Cost Assessment	387055.99	WBS2

**Make sure that the network you build follows the Project WBS.**

**Legend:**  
 **NPR 7120 Compliance**  
 Note: WBS extracted from MdM STR01

## Build the Activities Relationships\*



- Identify Preceding and Succeeding Activities

\* Also known as Constraints or Dependencies

# Constraint Template

Determining the constraint and lag relationship between two activities is as simple as filling in the blanks:

_____ Predecessor (Tail Activity #)	Must	_____ Start or Finish
At Least _____ Units Lag + or - (Constraint Delay)		
Before _____ Successor (Head Activity #)		_____ Starts or Finishes

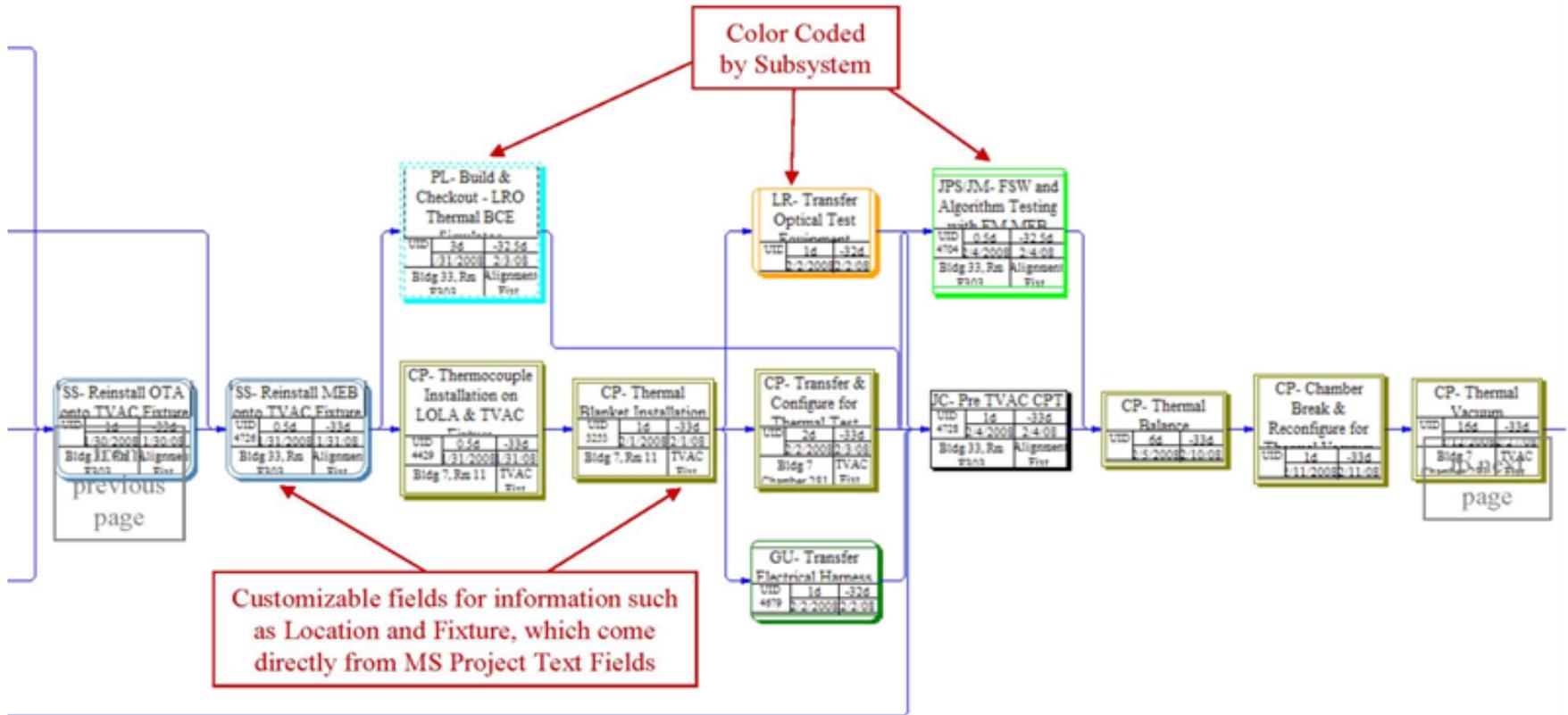
Legend:

Tail =  =Head  
(of the connecting arrow)

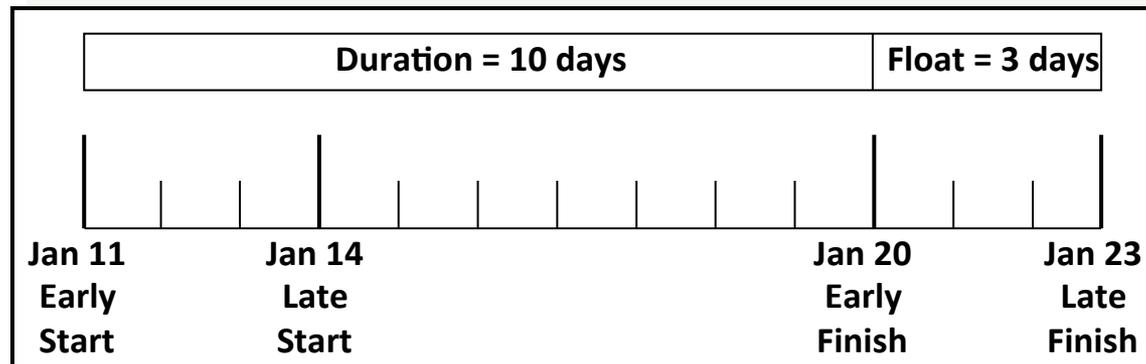
# Network Development: the end result is a logic network...

Legend:

Task Description				
UID	Duration	Slack		
Start Date		Finish Date		
Location		Fixture		



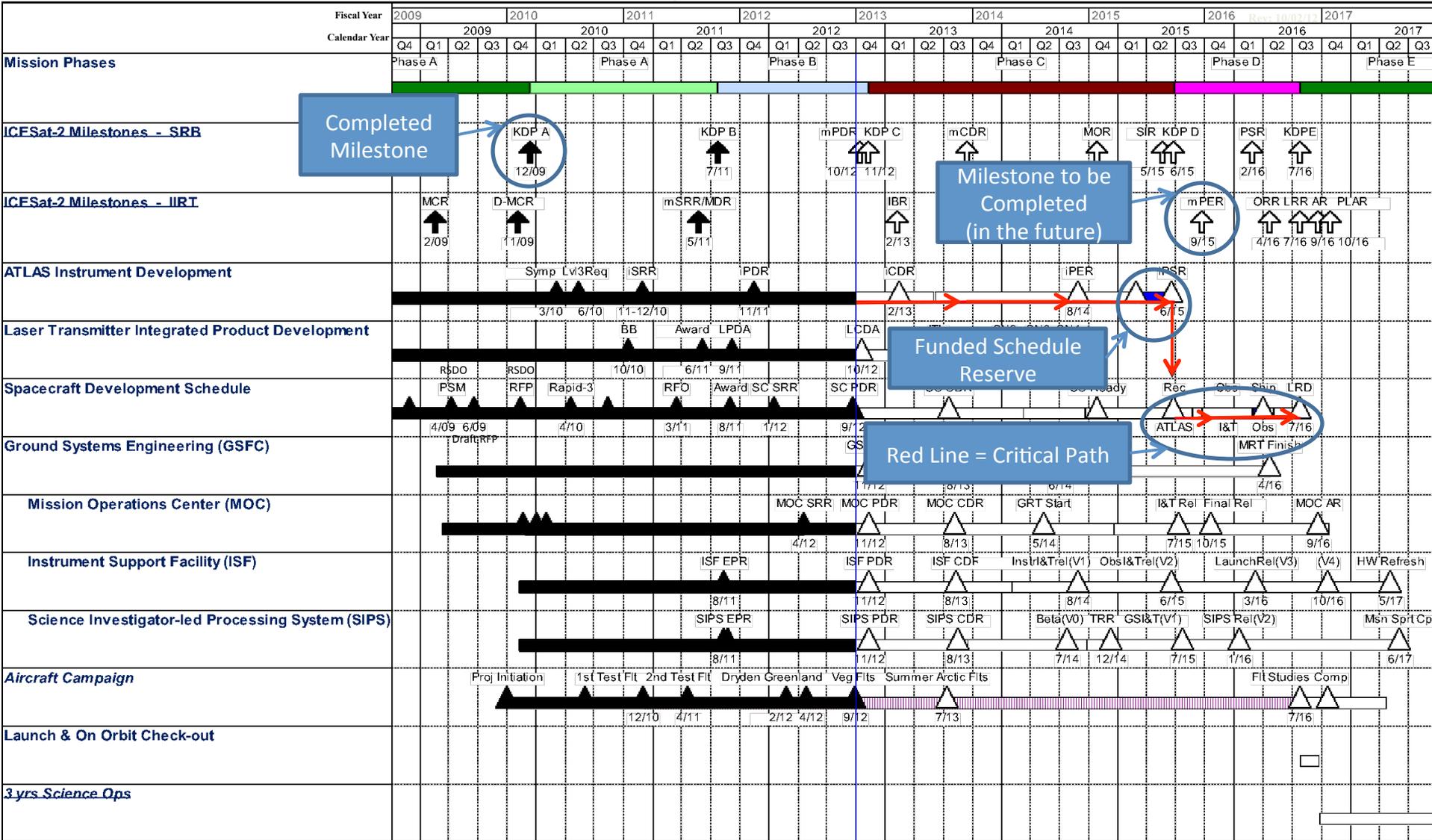
# Float/Slack



- [Total Float](#) is normally defined as:
  - The amount of time units by which activities can be delayed without delaying the completion of project or intermediate project activities.
  - The activities having the least amount of total float are on the “Critical Path” or paths.
- [Free Float](#) is the amount by which an activity can be delayed without affecting succeeding activities.
- [Calendar Float](#) is the amount of non-working time (off shifts, holidays and weekends) available to a project.

# ICESat-2 Mission Master Schedule

July 2016 LRD



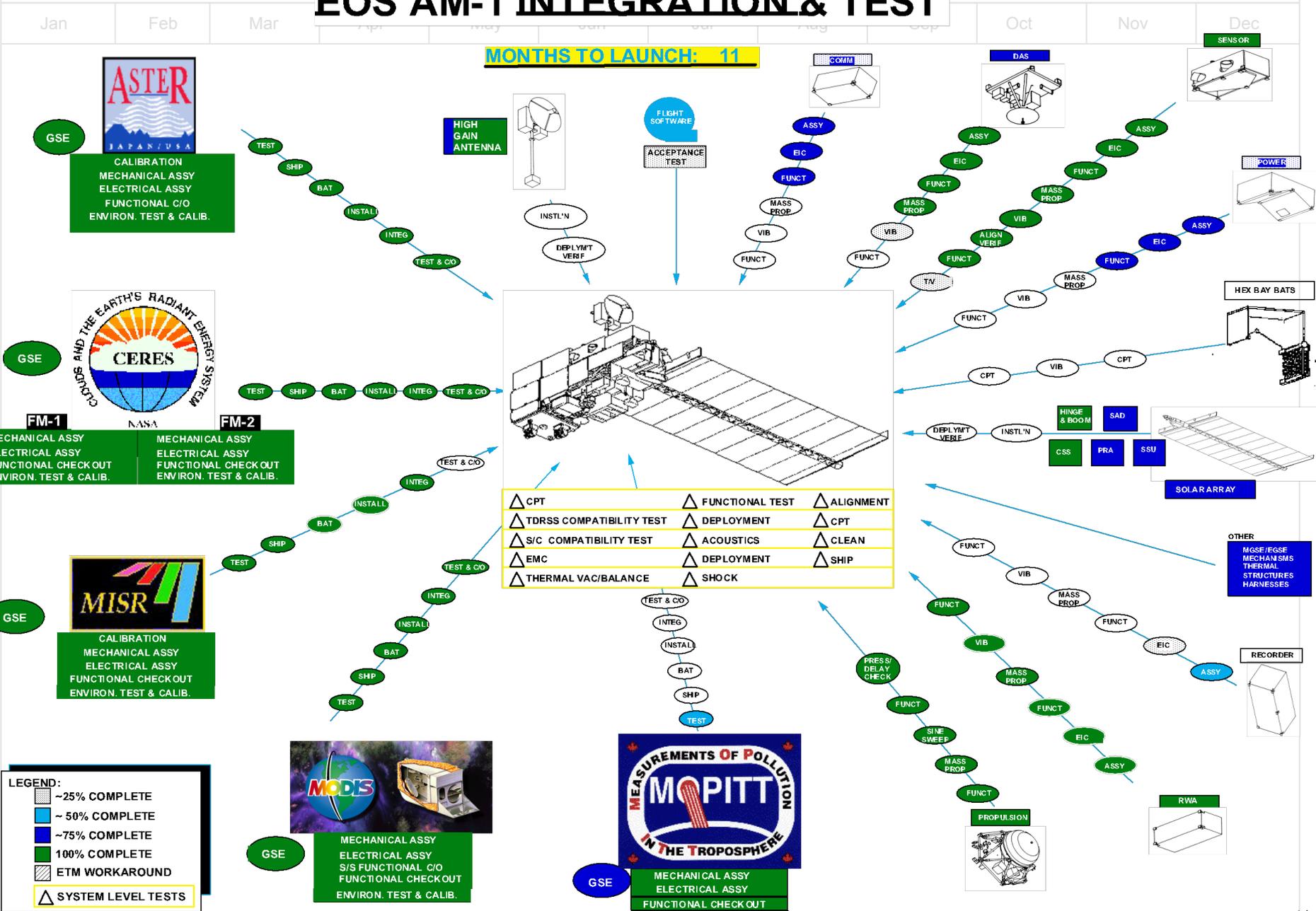
- From Confirmation to the beginning of Observatory Integration and Test (I&T): 1 month of funded schedule reserve per year
- From start of I&T to shipment to launch site (or to planned storage): 2 months of funded schedule reserve per year
- From delivery to launch site to launch: 1 week of funded schedule reserve per month

**Key:**  
→ Critical Path  
→ Funded Schedule Reserve

Status Date: 09/30/12

GPR 7120.7

# EOS AM-1 INTEGRATION & TEST



Source: C.Scolese/J.Bryson/S.Brill

## Resources

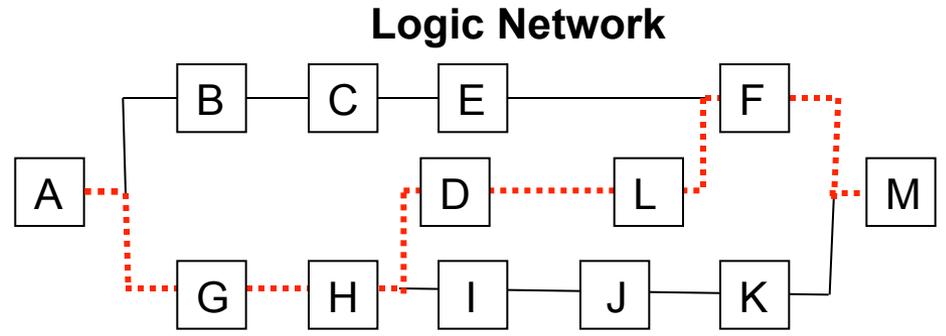
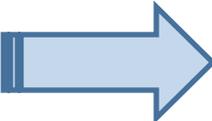
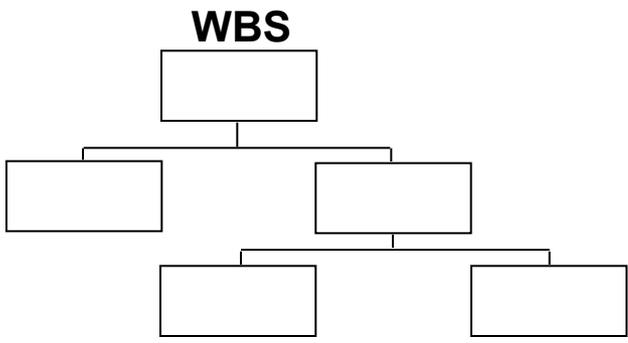
- Resources on a project will include (but certainly not be limited to):
  - Budget, time, facilities, tooling, materials, workforce, pencils and paper, etc.
  - Most resources can be replenished or refurbished.
- Replenish time and cost increases. Replenish dollars, time can remain the same.
  - The relationship between Cost and Schedule is critical project management.
  - Earned Value Management (EVM) is a well established method for establishing and reporting this relationship.

Resources can be “loaded” into your schedules (very labor-intensive and requires greater effort for re-planning) or “associated” (remains in the financial tool) but is linked through identifiers or other means.

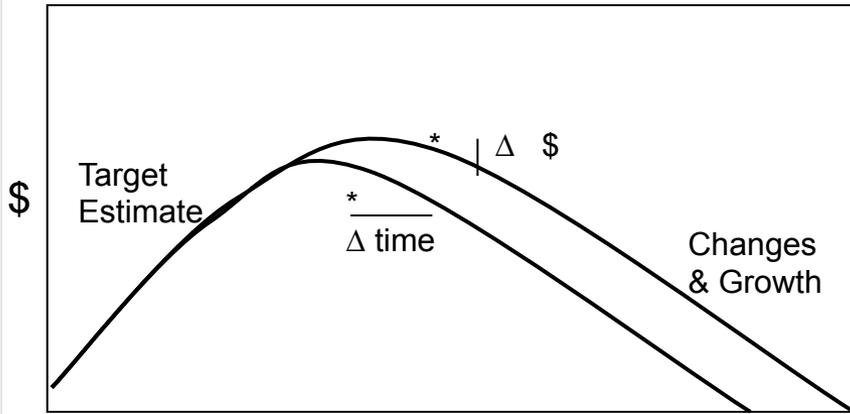
There is only one that cannot be replenished without impacting all of the others - - Time!

# Integral Tie Between WBS, Schedules, and Budgets

Schedules are the result of the planning and control process

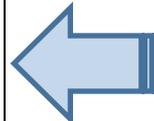


### Time Phased Budget



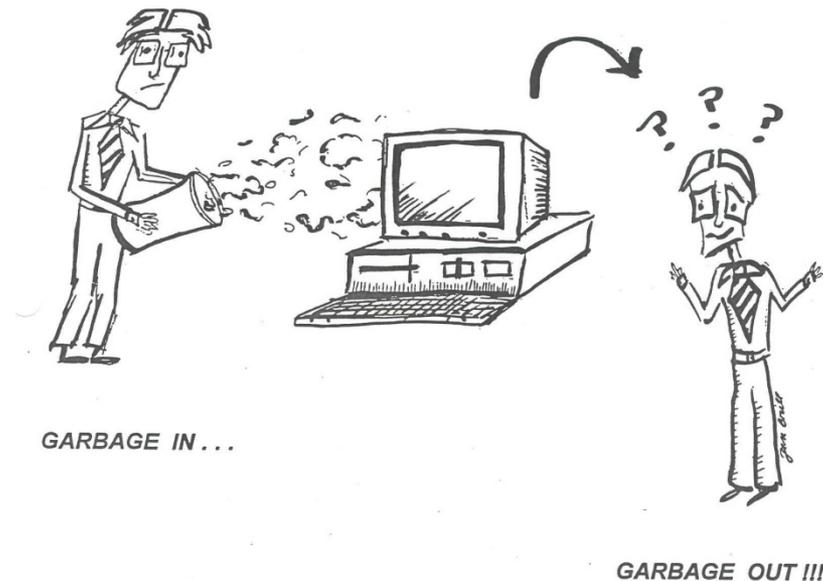
### Milestone/Bar Chart

WBS	Fiscal Year
A	Δ Δ Δ
B	Δ B Δ
C	Δ C Δ
D	Δ D Δ Δ Δ L Δ
E	Δ E Δ
F	Δ E Δ Δ M Δ
G	Δ G Δ
H	Δ H Δ
I	Δ I Δ
J	Δ J Δ
K	Δ K Δ



## Utilize Your Resources

Schedules, like budgets, are only as accurate as the information put into them. If the inputs are not realistic, then the schedules and budgets will not be realistic.



Don't accept schedules at face value. Ask questions until you understand the plan or schedule.

## Scheduling for RA's: Summary Thoughts

- Schedules are “Working Tools;” no more, no less
- Stay involved and help schedulers and technical leads remember the linkage between scope, schedule, and cost
  - The Requirements, WBS, and schedule flow needs to be as accurate as possible before a project plans thousands of activities
  - If it isn't right, don't move forward
- Have a good relationship with your project scheduler
  - Ask to spend time with them. Review your particular project/program level schedule (s)
- Talk to the technical leads and individuals performing the work:
  - Does the schedule make sense?
  - What/where are the concerns? Think of areas for budget risk
  - Visit the shop floor – see for yourself what the hardware status is

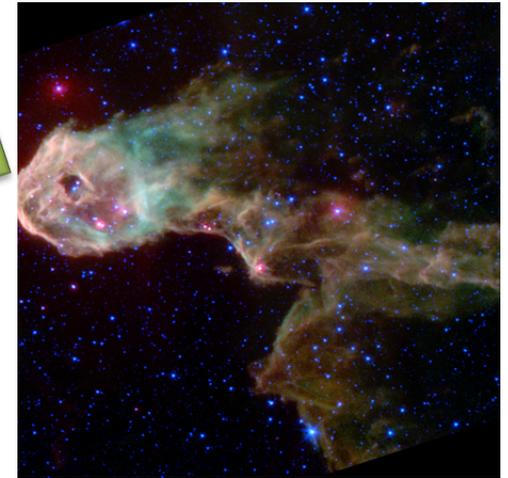
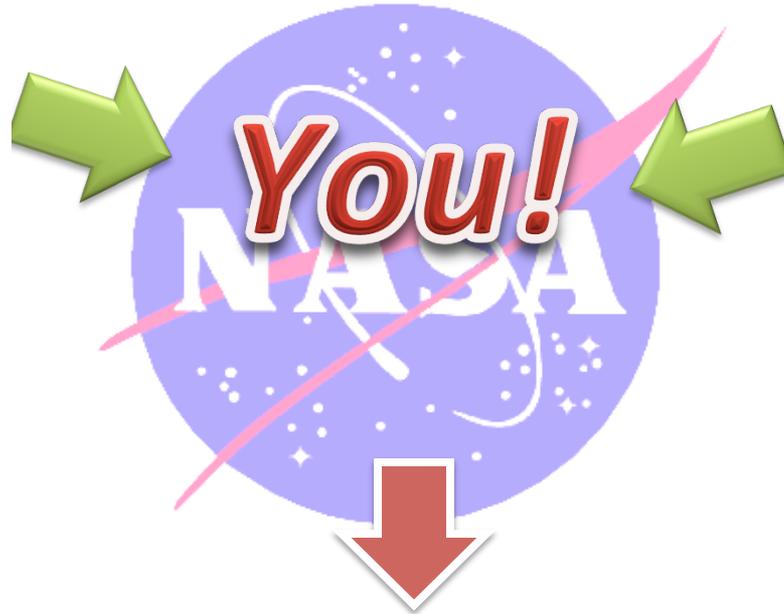
## Scheduling for RA's: Summary Thoughts

- Ownership of the Schedule goes to those responsible for accomplishing its tasks.
  - Question the owners (PDLs, engineers, scientists, managers, and others) if a schedule does not make sense
  - Coordinate meetings with them to make sure that in budget discussions, schedule is addressed too
- Check to match durations of activities with budgets.
  - If durations for specific activities or WBS numbers are longer or shorter than the allocated budget, you have a problem
- Monitor the schedule for potential problems or major changes in float/slack to identify where cost reserves are needed.

**Don't ever lose sight of the fact that you are vital links to the success of Science and Technology and what you do is important!**



**Earth**



**Space**



***NASA's Vision: "To reach for new heights and reveal the unknown so that what we do and learn will benefit all humankind."***

# Questions



## Special Thanks To...

- Chris Caldwell, Lesley Young – Combined Resources Forum co-chairs
- Code 403: Steve Brill, Matt Ritsko, Walt Majerowicz
- MMS: Bobby Miller and Mike Lilly
- GPM: Bill Paradis
- JPSS: Donna Beazley and Chris Webb
- JWST: Rich Ryan
- ICESat-2: Joe Krygiel

## Additional Resources

- NASA Scheduling Management Handbook: [www.nasa.gov/pdf/420297main\\_NASA-SP-2010-3403.pdf](http://www.nasa.gov/pdf/420297main_NASA-SP-2010-3403.pdf)
- NASA EVM:  
[www.evm.nasa.gov](http://www.evm.nasa.gov)
- Scheduling Classes:
  - APPEL – Project Scheduling: Basics and Advanced Concepts
  - APPEL – Integrating Cost and Schedule
  - APPEL – Scheduling and Cost Control
  - SATERN: Defining and Sequencing Project Activities

For additional information, contact:  
Jonathan Bryson or Lesley Young

Jan

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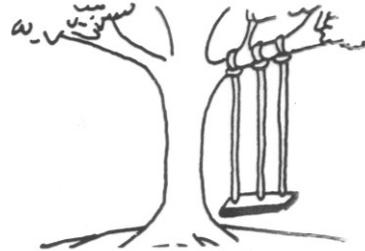
# Backup



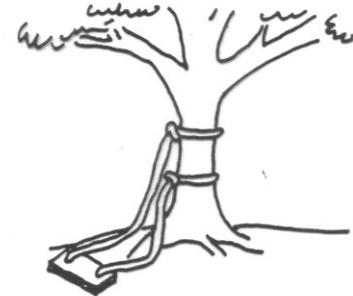
# Requirement Definition: Communicate!



1. As Marketing Requested It



2. As Procurement Ordered It



3. As Engineering Designed It



4. As Production Manufactured It



5. As Field Engineering Installed It



6. What the Customer Wanted

## Policy Context

### **NPR7120.5 NASA Space Flight Program and Project Management Requirements**

Establishes the requirements by which NASA will formulate and implement space flight programs and projects, consistent with the governance model contained in the NASA Strategic Management and Governance Handbook (NPD 1000.0).

### **NPR7123 NASA Systems Engineering Processes and Requirements**

Systems engineering is a logical systems approach performed by multidisciplinary teams to engineer and integrate NASA's systems to ensure NASA products meet customers' needs.

## Cost and Schedule Guidelines: From GPR 7120.7

- **Cost Reserves:**
  - At the time of Initial Confirmation (Key Decision Point-B [KDP-B]), flight projects should have a budget reserves level of 30% or higher through Phase D. This is a goal, not a requirement
  - At the time of Confirmation (KDP-C), flight projects shall have a budget reserves level of 25% or higher through Phase D. Deviations from this level of budget reserves shall require concurrence of the CMC at the Confirmation Readiness Review
  - At the time of delivery to the launch site, flight projects should have a budget reserves level of 10% or higher through Phase D. This is a goal, not a requirement
- **Schedule Reserves:**
  - From Confirmation to the beginning of Observatory Integration and Test (I&T): 1 month of funded schedule reserve per year
  - From start of I&T to shipment to launch site (or to planned storage): 2 months of funded schedule reserve per year
  - From delivery to launch site to launch: 1 week of funded schedule reserve per month