Introduction to Project Scheduling

2 DAY CLASS

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INTRODUCTION PROJECT SCHEDULING

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Objectives of the Seminar

- Provide an overview of proven scheduling concepts and practices that have been successfully applied on projects.
- Describe the steps needed to develop, status, and control meaningful project schedules.
- Promote an awareness of the benefits of proper project planning & scheduling.

Acknowledgements

This presentation is organized within the framework of "*A Guide to the Project Management Body of Knowledge*" (PMBOK Guide), 2000 edition, published by the Project Management Institute.*

The PMBOK is gaining acceptance as the de facto global standard for project management. It has been formally accepted as the project management standard by the:

- American National Standards Institute
- Institute of Electrical and Electronic Engineers

The PMBOK Guide is available from the PMI website at: www.pmi.org

*Project Management Institute, A Guide to the Project Management Body of Knowledge (PMBOK® Guide)- 2000 Edition, Project Management Institute, Inc., 2000.

Seminar Outline *(1 of 2)*

Seminar Outline *(2 of 2)*

Before We Continue…

The project scheduling concepts and techniques presented in this seminar are "generally accepted."

"Generally accepted means that the knowledge and practices described are applicable to most projects most of the time, and that there is widespread consensus about their value and usefulness.

Generally accepted does not mean that the knowledge and practices described are or should be applied uniformly on all projects; the project management team is always responsible for determining what is appropriate for any given project."

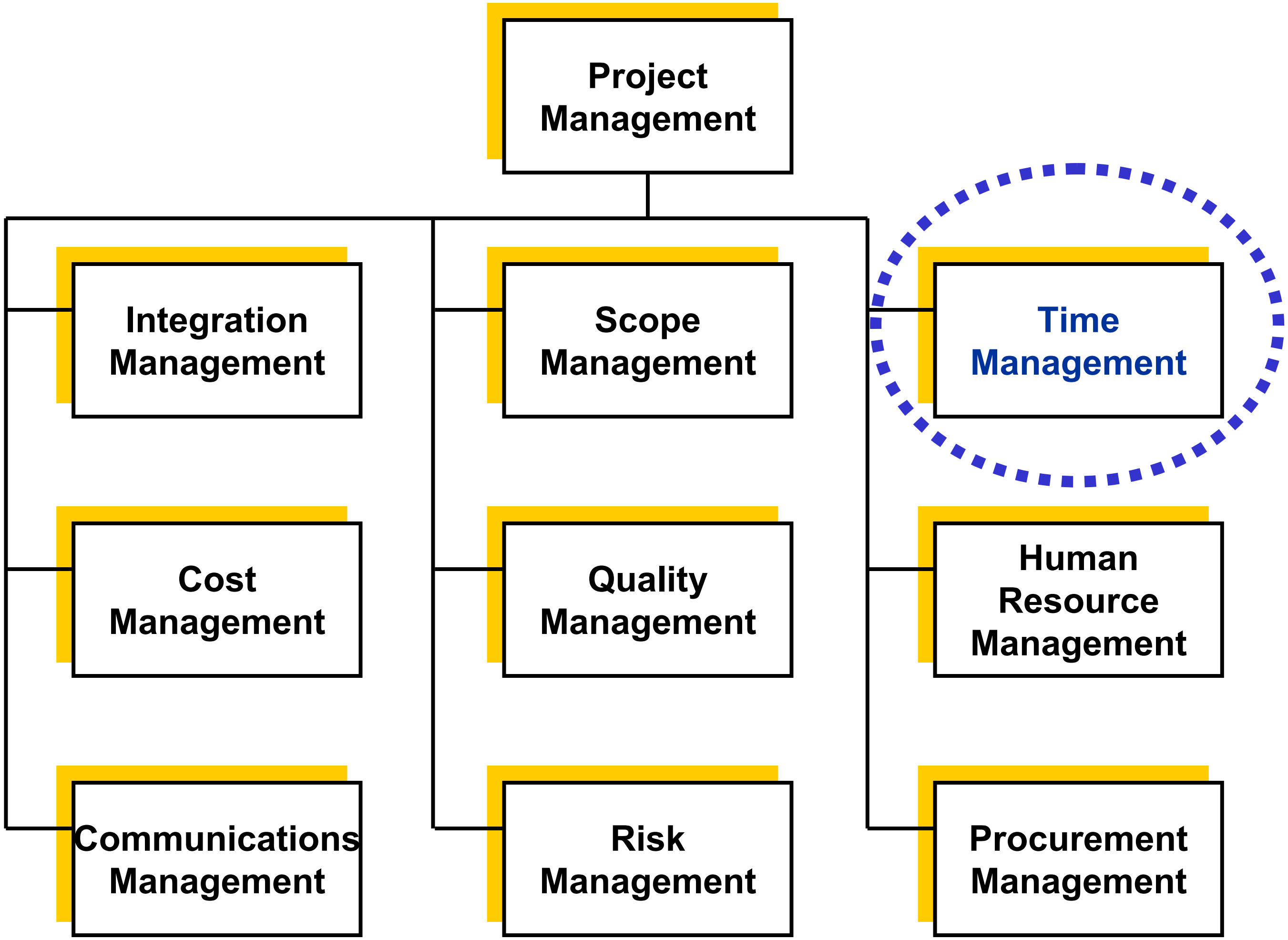
SOURCE: *Project Management Institute, A Guide to the Project Management Body of Knowledge (PMBOK® Guide)-2000 Edition, Project Management Institute, Inc., 2000.

1.0

Introduction to the Project Scheduling Process

– Project Management Knowledge Areas
– Purpose and Benefits of the Project
– Schedule Scheduling Terminology
– Role of the Project Planner/Schedule Analyst

PMI's Project Management Knowledge Areas & Processes



Time/Schedule Management

Project Schedule Management consists of the processes required to ensure timely completion of the project:

- **Activity Definition - what needs to be done**
- **Activity Sequencing - the order things need to occur**
- **Activity Duration Estimating - the number of work periods needed to accomplish an activity**
- **Schedule Development - creating the roadmap**
- **Cost/Schedule Integration - time is money**
- **Schedule Status Accounting - getting the facts**
- **Schedule Analysis - what is the schedule telling us**
- **Schedule Performance Reporting - how are we doing and where are we going**
- **Schedule Control - managing change**

Project Scheduling is the application of these processes

Purpose and Benefits of the Project Schedule

The purpose of a schedule is to provide a tool that supports planning, directing, and controlling a project in order to ensure its timely completion.

The schedule aids in:

- Integrating the project's activities into a logical flow
- Providing a roadmap for achieving a project's objectives
- Establishing a time-phased budget
- Measuring performance
- Identifying potential problems early
- Forecasting completion dates and the impact of changes
- Projecting how long it will take in order to finish the project
- Preparing "what-if" analysis and "workaround" plans

Scheduling Terminology (1 of 8)

Project - A temporary endeavor undertaken to create a unique product or service . . . every project has a definite beginning and a definite end.

Schedule - A time-based chronology of the events, activities and milestones necessary to achieve an objective.

Activity - A task or step that needs to be performed.

> ***Task-driven*** **-** Activity takes a fixed amount of time to complete regardless of amount of resources assigned.
>
> ***Resource-driven*** **-** Duration is dependent upon the amount of resources assigned or available.

Resource - People, equipment, facilities, etc. needed to accomplish an activity.

Scheduling Terminology *(2 of 8)*

Milestone - An event which identifies significant, measurable progress.

Event - An occurrence at a point in time.

Work - Amount of effort, such as number of hours, needed to accomplish an activity.

Duration - Number of periods or length of time needed to perform the work. (Can be dependent upon amount of resources applied or available.)

Logic Network - A schematic display of a project's activities and their logical relationship.

Scheduling Terminology *(3 of 8)*

Calendars - Specified periods when work can and cannot be performed.

Base Calendar - Defines the standard working period for all of the project's activities

Modified Base Calendar(s) - Define alternative working periods for selected project activities

Resource Calendar(s) - Defines the working period for a specific resource

Dependency - Relationship or logical sequence among activities; can be mandatory, discretionary, or external.

- Finish-To-Start
- Start-To-Start
- Finish-To-Finish

Scheduling Terminology *(4 of 8)*

Lead - An overlap in dependencies between two activities that will shorten their combined duration.

Lag - A delay or gap in dependencies between two activities that will lengthen their combined duration.

Constraints - Restrictions, deadlines or limitations on an activity's start or finish dates:

- *ASAP* - As Soon As Possible
- *ALAP* - As Late As Possible
- *FNET* - Finish Not Earlier Than
- *SNET* - Start Not Earlier Than
- *FNLT* - Finish Not Later Than
- *SNLT* - Start Not Later Than
- *MSO* - Must Start On
- *MFO* - Must Finish On

Scheduling Terminology *(5 of 8)*

Assumptions - Factors that are uncertain, but for scheduling purposes are considered to be true, real or certain.

Early Start/Early Finish - Earliest date an activity can start or finish.

Late Start/Late Finish - Latest date an activity can start or finish without delaying the project's planned completion.

Time Analysis - The automatic calculation of the early start/finish dates ("forward pass") and latest start/finish dates ("backward pass") using project management software tools.

Scheduling Terminology *(6 of 8)*

Slack/Float - The difference between the early and late dates of activities; the "spare" time available.

> ***Free Slack -*** The amount of time an activity can be delayed before it impacts the early start of the succeeding activity.
>
> ***Total Slack -*** The amount of time an activity can be delayed from it's early finish without delaying the planned completion or end date of the project. Can be positive, zero, or negative.

Critical Path - The longest sequential path through a logic network, from beginning to end, that defines the earliest a project can finish.

- Path with the longest overall duration
- Path with the least amount of total slack

Scheduling Terminology *(7 of 8)*

Secondary Path(s) - Next most longest path(s) through a logic network (also called near-critical path).

Schedule Reserve/Contingency - A pre-planned amount of schedule duration incorporated into the project schedule at critical points and/or prior to the completion point ("dummy activity" in logic network).

Acts as a buffer or cushion to absorb unanticipated problems with in-scope work

Baseline - A record, benchmark, target, or snapshot of the schedule at a given point in time (i.e.,"the plan").

- The project team's schedule commitment; its original plan
- Needed to compare with actual performance/current forecast
- Can be modified for changes (e.g., new scope)

Scheduling Terminology (8 of 8)

Forecast - An estimate or prediction of when activities will start and/or finish such as:

- When an activity that has already started is expected to finish
- Amount of duration remaining in an activity already underway
- When an activity that has not yet started is expected to begin
- Increase or decrease in duration, based on new information, of a future activity that has not yet started

Variance - The difference between the baseline schedule and actual schedule performance. (Can also, the difference between the baseline schedule and the current or forecast schedule.)

Role of the Project Planner/Schedule Analyst *(1 of 3)*

Primary Responsibilities: **Leads project planning by:**

- Integrating all elements of the project schedule
- Facilitating the planning and control needed to ensure the schedule supports the project's objectives

Planning Focus: **Coordinate with the project team to:**

- Define project requirements and schedule objectives
- Identify the activities that need to be performed and determine their sequence or flow
- Estimate the duration of activities
- Develop the project schedule using project management software tools and techniques
- Collect status and update the project schedule database
- Help ensure schedules are integrated with cost planning

Role of the Project Planner/Schedule Analyst *(2 of 3)*

Analysis Focus - **Provide insight to the project team by:**

- **Assessing schedule progress**
- **Reporting schedule performance, variances and forecasts**
- **Evaluating the affect of risks, problems and changes on the project schedule**
- **Performing "what-if" schedule analysis**

Control Focus - **Assisting the project team to manage change by:**

- **Incorporating new scope changes into the project schedule**
- **Maintaining an accurate baseline schedule**
- **Coordinating with the project team in replanning and the development of workaround alternatives to schedule problems and risks**

Role of the Project Planner/Schedule Analyst *(3 of 3)*

Skill Requirements - The project planner/schedule analyst must:

- Communicate effectively (orally and in writing)
- Have up-to-date computer skills
- Think logically
- See the "big picture" as well as the details
- Have the ability to coordinate with all members of the project team, including outside contractors
- Possess initiative and a proactive approach to problem solving

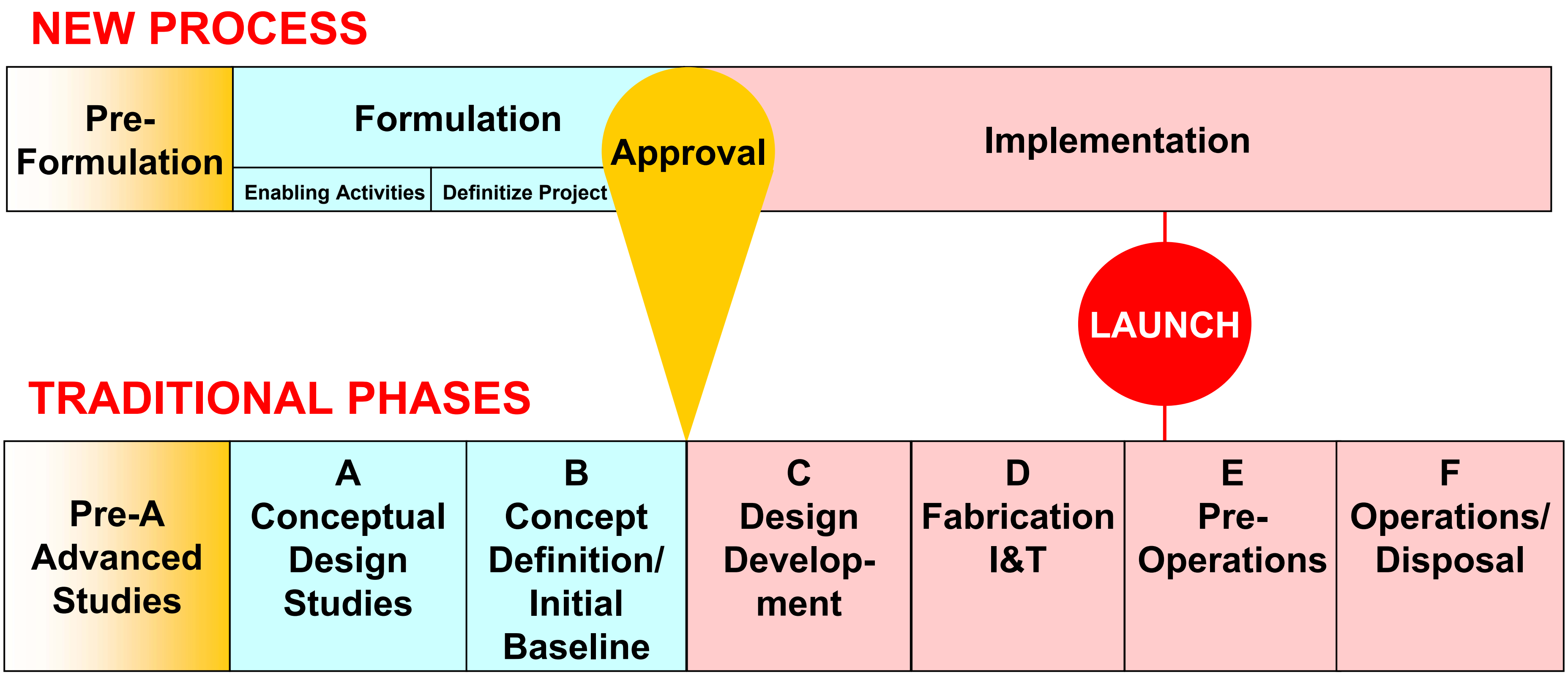
The schedule is the roadmap and the Project Planner/Schedule Analyst is the navigator.

2.0

Space Mission Overview

– NASA Project Lifecycle
– Typical Space Mission Hierarchy
– Example System Operations Overview
– Flight Hardware Overview

Project Life Cycle Relationship



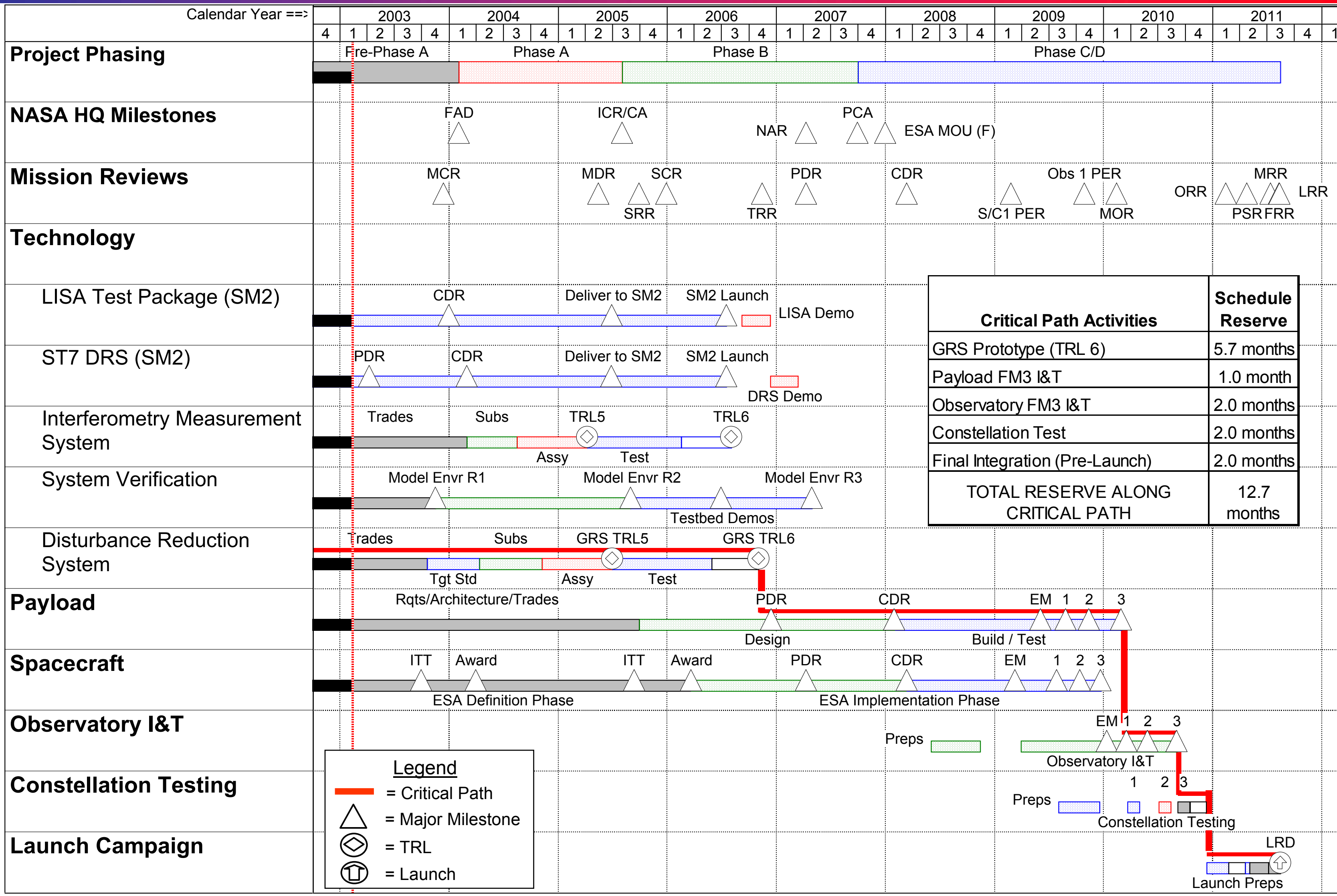
The NASA Project Life Cycle

NPG 7120.5B replaces the hard lines of Phases A, B, C, D & E with a realistic, flexible and concurrent process-oriented approach:

- **Pre-Formulation:** Includes advanced feasibility studies, measurement options and long-term technology development.
- **Formulation*:** Defines an affordable program concept and plan to meet mission objectives or technology goals.
- **Approval*:** Determines whether a program is ready to proceed from the formulation process to the implementation process.
- **Implementation*:** Implements the approved program requirements and plans.
- **Operations:** Launch, initial checkout, acquisition & distribution of data products and system maintenance.

* NPG 7120.5A

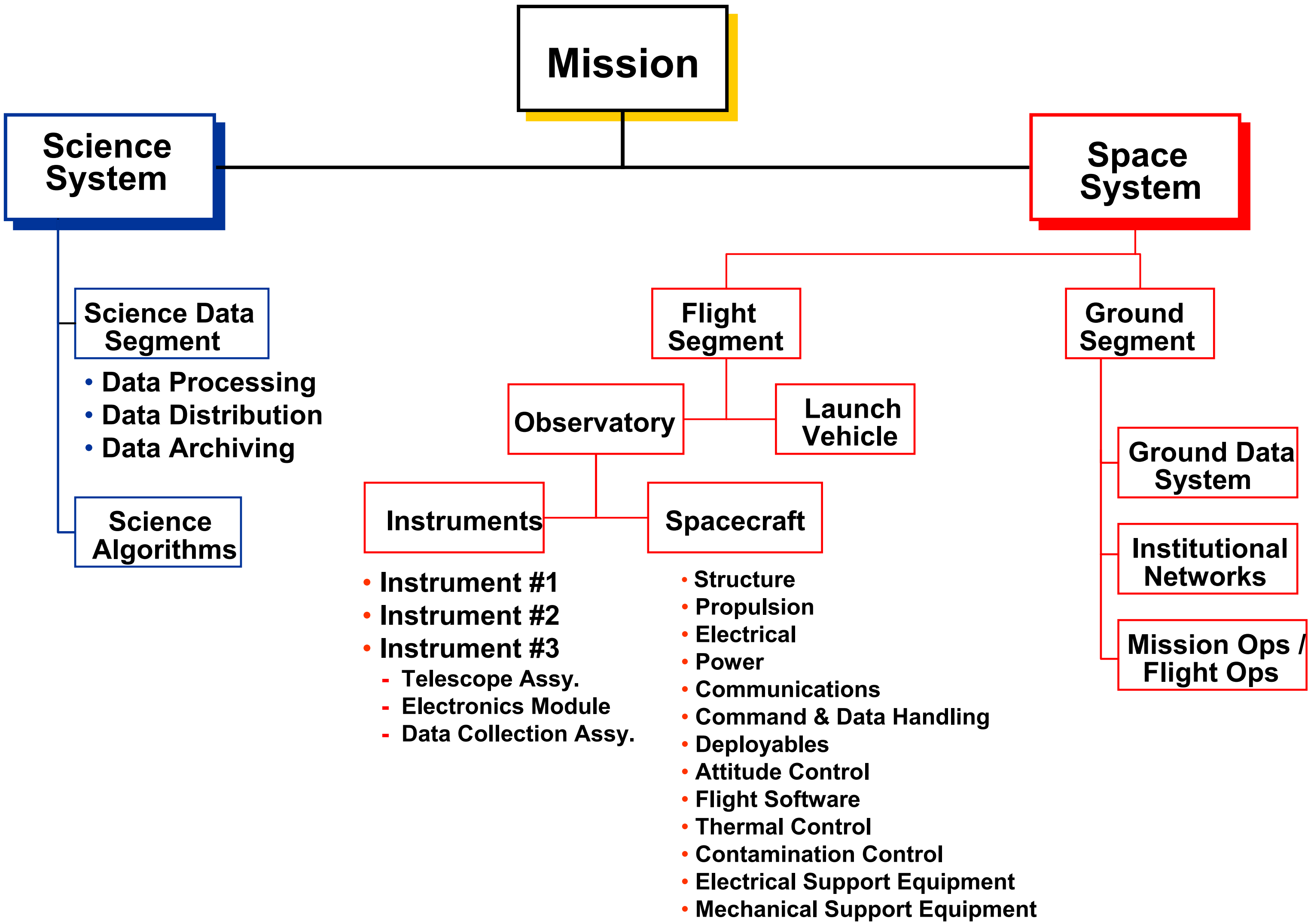
Example Master Schedule



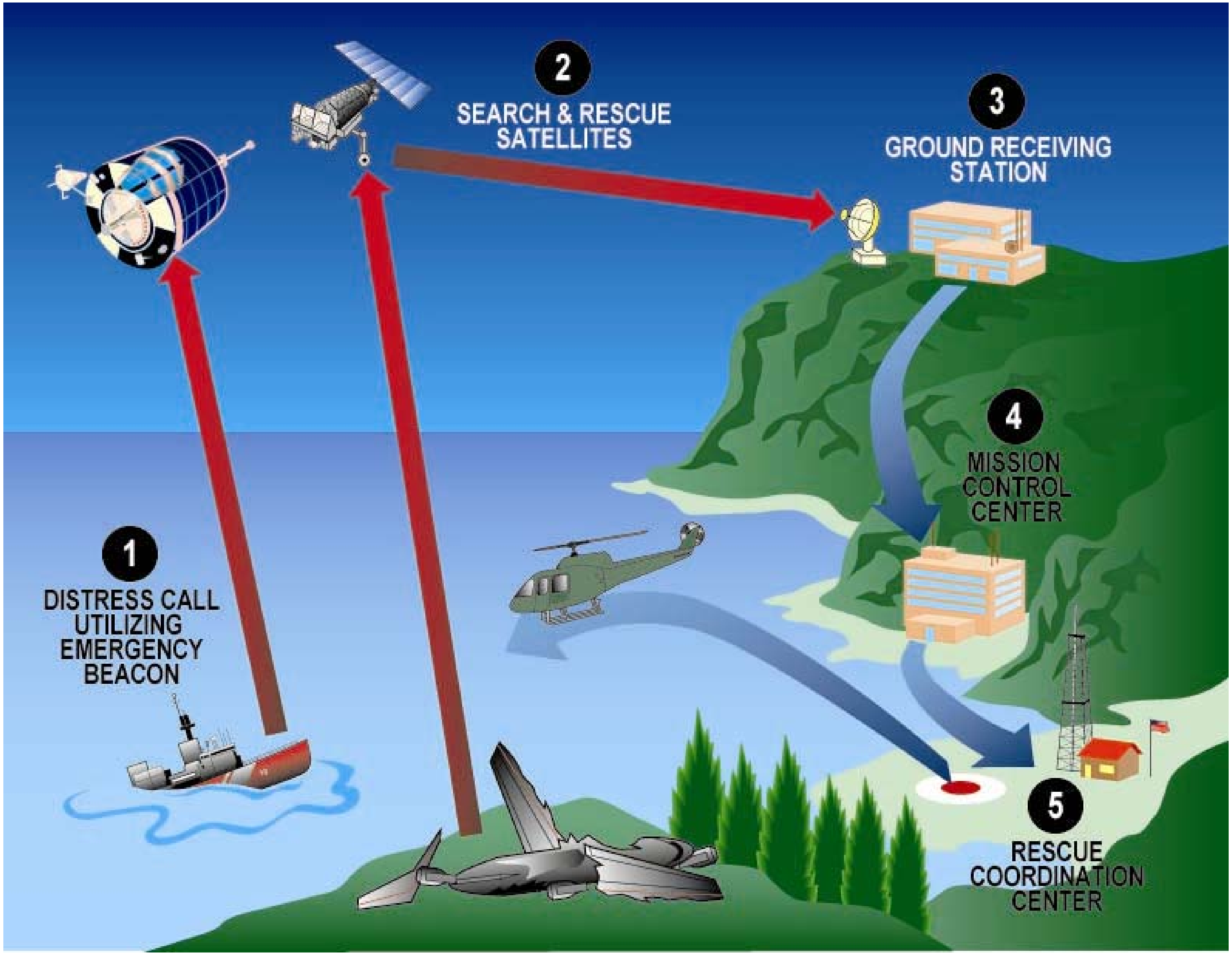
Critical Path Activities	Schedule Reserve
GRS Prototype (TRL 6)	5.7 months
Payload FM3 I&T	1.0 month
Observatory FM3 I&T	2.0 months
Constellation Test	2.0 months
Final Integration (Pre-Launch)	2.0 months
TOTAL RESERVE ALONG CRITICAL PATH	12.7 months

REV: TRIP Report_03Feb'03

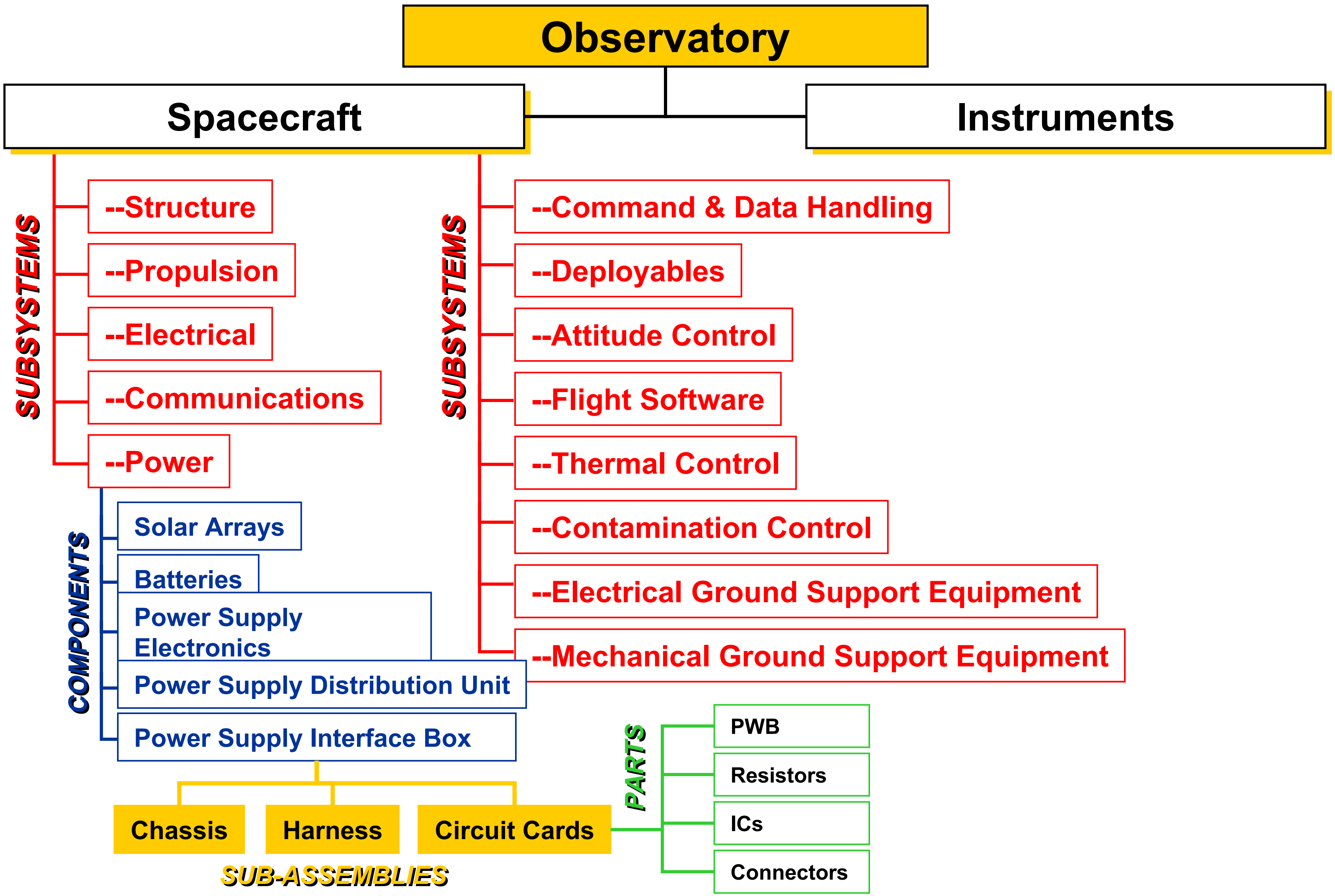
Typical Space Mission Hierarchy



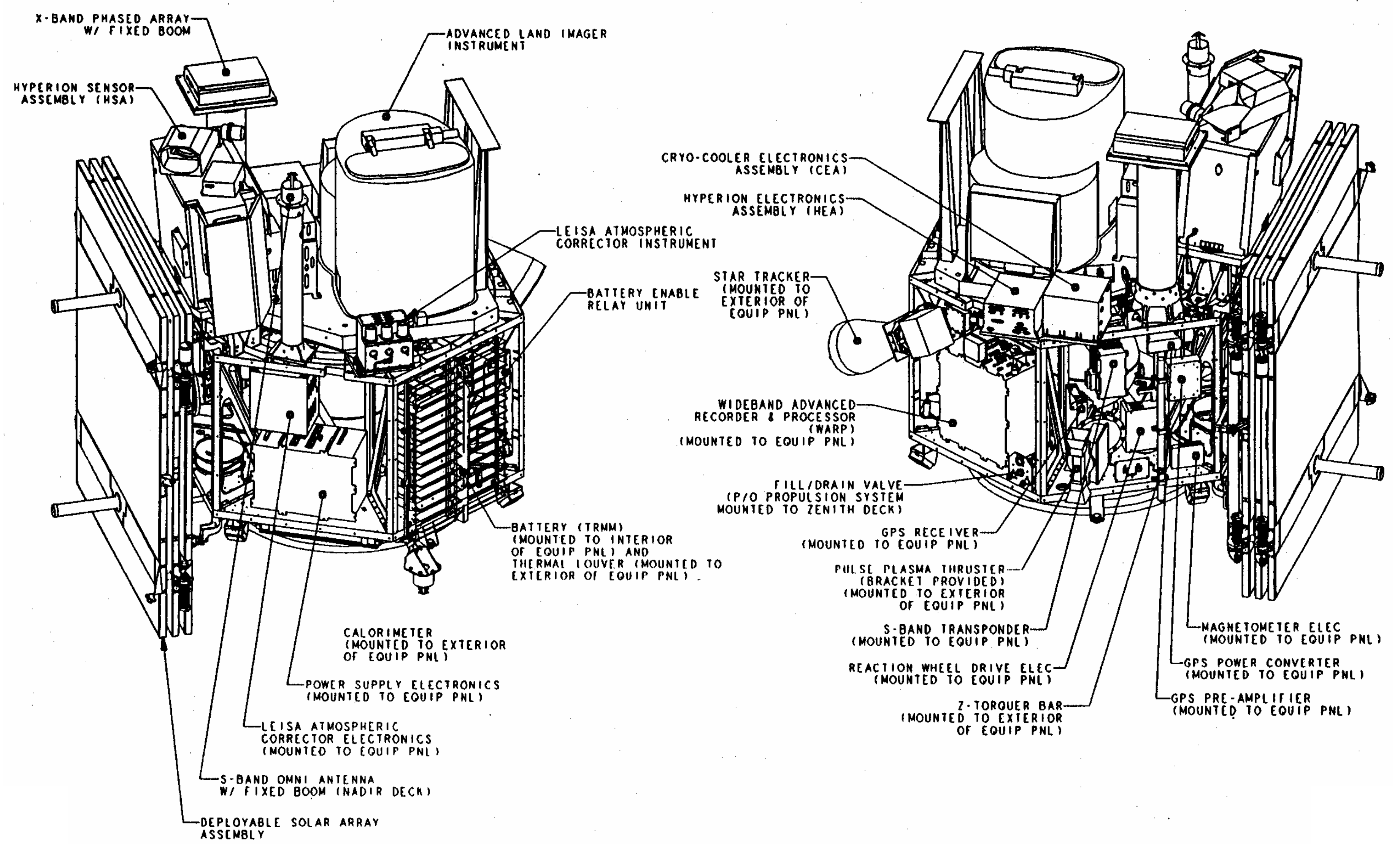
Example System Overview: Search & Rescue



Spacecraft Subsystem Hardware Overview

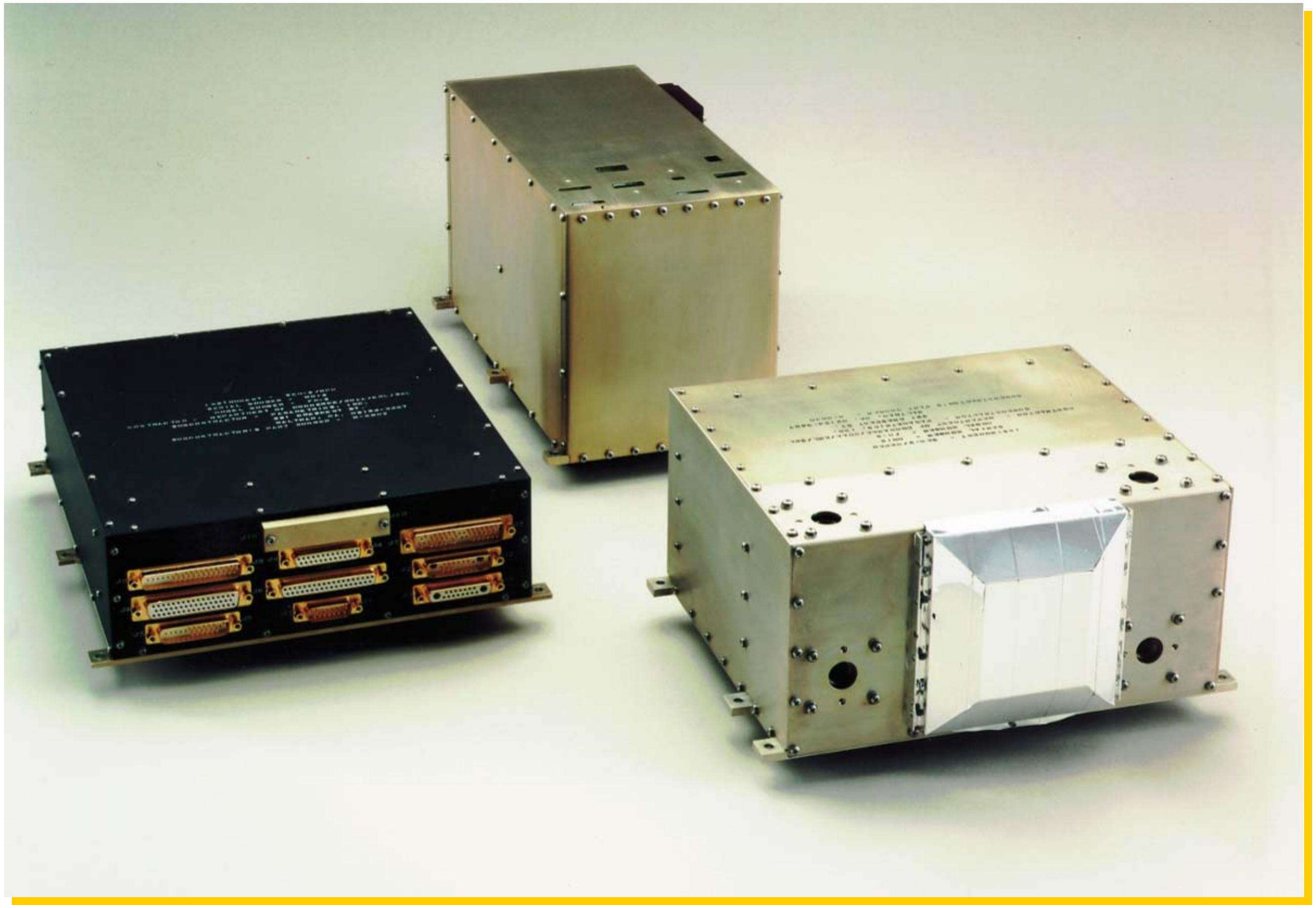


Example Observatory Equipment Layout



Example Instrument:

Space Environmental Monitor (SEM)



Hardware Definitions *(1 of 2)*

Prototype Unit - Hardware of a new design to be subjected to qualification testing and not intended for space flight.

Protoflight Unit - Hardware of a new design to be subjected to both qualification testing and flight acceptance testing and intended for flight.

Qualification Unit - Hardware of a new or existing design to be subjected to qualification testing only.

Flight Unit - Hardware intended for space flight with a design qualified as a prototype or protoflight and is subjected to flight acceptance testing.

Brassboard - A high-fidelity replication of the flight design that is built with flight hardware to flight standards and is used for development and/or life testing.

Hardware Definitions *(2 of 2)*

Engineering Development Unit (EDU) - Test hardware built with non-flight parts to non-flight standards and is used for "proof-of-concept" (breadboard).

Engineering Test Unit (ETU) - Same as EDU, but subjected to full range of verification testing.

Mass Model - A physical representation of a hardware element that simulates its mass; used during spacecraft mechanical testing usually when flight hardware is unavailable.

Engineering Model - Same as ETU.

Flight Software - Software incorporated into flight hardware and actually flown in space.

We Need A Project !

To "Understand the Project Scheduling Process" . . .

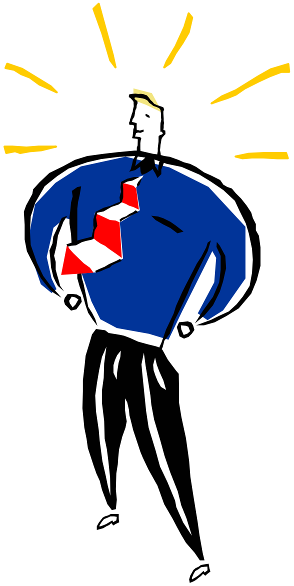
. . . We need a project!

The NBT Project

("Next Big Thing")

Congratulations!

Assume it is August 15, 2001 and you have been selected as the NBT Project Manager.



The NBT Project
(“Next Big Thing”)

- NBT is a new “in-house” mission at GSFC
- NBT will monitor shoreline erosion along the Gulf coast
- GSFC is the “system integrator” for the NBT mission and will:
  - Procure the spacecraft bus
  - Procure one science instrument
  - Develop one science instrument in-house
  - Perform observatory integration & test in-house
  - Conduct launch site operations in coordination with the Kennedy Space Center (KSC)

NBT Statement of Work

Flight Assurance

Environmental Testing

Instruments

Spacecraft

Statement of Work for the Next Big Thing (NBT) Project

1.0 Scope

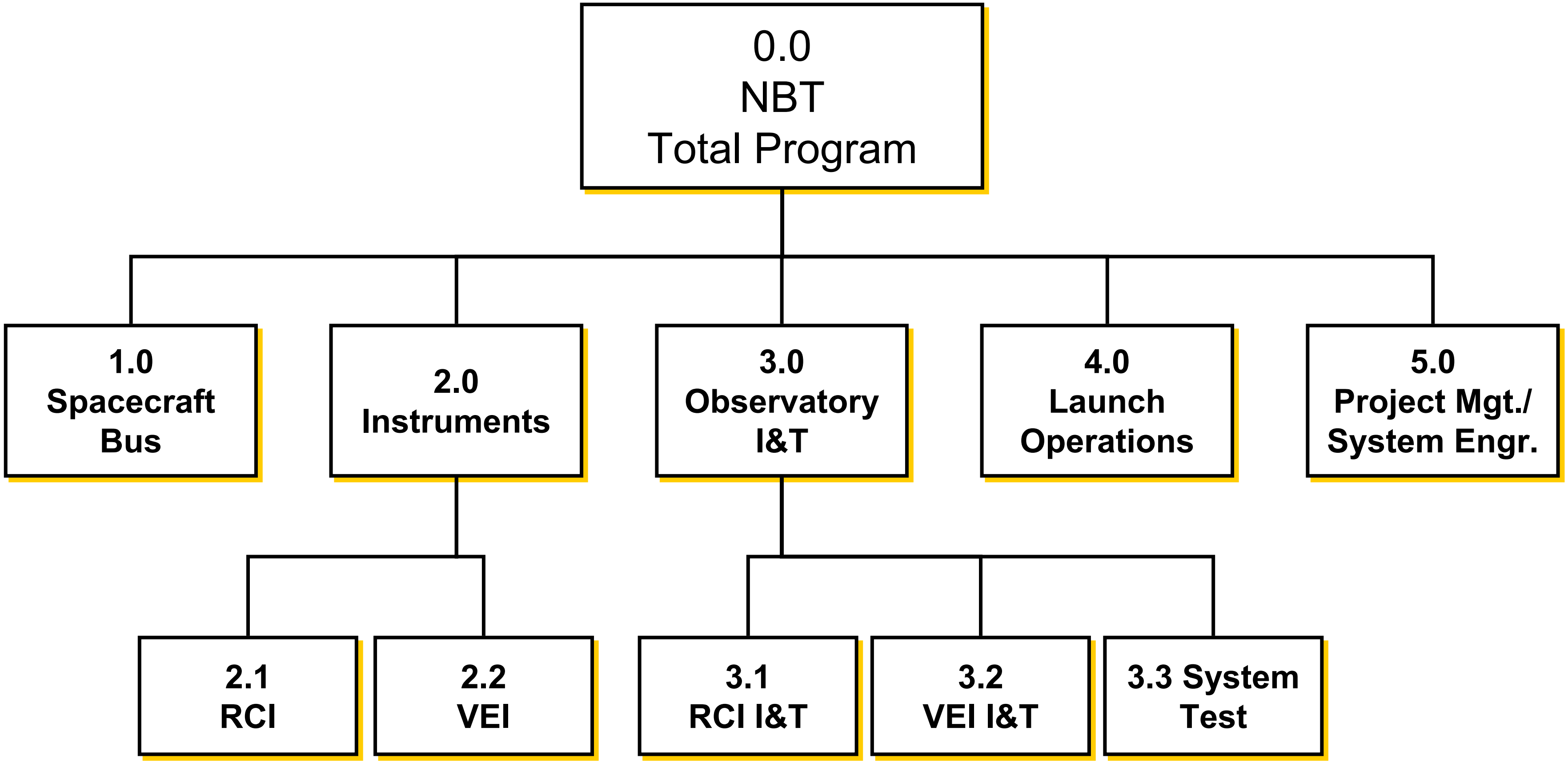
GSFC will design and develop an Observatory capable of meeting the requirements set forth in NBT Performance Specification 1.2.3.

The NBT observatory will support Sensors capable of measuring the

Statement of Work:

A narrative description of products and services to be provided or supplied.

NBT Work Breakdown Structure



Work Breakdown Structure:

A deliverable-oriented grouping of project elements that organizes and defines the total work scope of the project. Each descending level represents an increasingly detailed definition of project work.

NBT Spacecraft Bus Procurement

- GSFC has selected Ultra Corporation to supply the spacecraft bus
- The contract is already negotiated and work can start as soon as funding is available
  - Funding will be available for Ultra Corporation five work days after NASA HQ authorizes NBT funding to GSFC
- Lead time is 200 work days from award of contract
- Ultra operates on a five-day work week, Monday - Friday

NBT VEI Procurement

("Very Expensive Instrument")

- GSFC has selected Acme Instrument, Inc. to supply the VEI instrument
- VEI proposal negotiations are underway and contract award is projected for 12/3/01
  - Funding will be available for Acme Instrument, Inc. five work days after NASA HQ authorizes NBT funding to GSFC
- Lead time is 220 work days from award of contract
- Acme operates on a five-day work week, Monday - Friday

NBT RCI Development

("Really Cool Instrument")

- GSFC will develop the RCI instrument in-house
  - Complexity and heritage indicate the RCI will take 20% more time to develop than similar instruments which averaged 200 work days
  - GSFC operates on a five-day work week, Monday - Friday
- Development work on the RCI can begin five work days after funding is authorized by NASA HQ

NBT Observatory I&T

- **I&T engineers have performed a detailed analysis and have determined:**
  - **Five work days each are needed to integrate the VEI and RCI to the spacecraft**
  - **The RCI must be integrated with the spacecraft before the VEI can be integrated**
- **Observatory system testing is estimated at 120 work days based on historic data from similar test programs**
  - **A five-day work week is planned**
  - **GSFC's system test area is unavailable due to maintenance between 1/1/02 and 3/31/02**

NBT Launch Site Operations

- GSFC will coordinate launch operations with KSC for the NBT launch
- NBT will be launched on a Delta launch vehicle
- The normal launch site operations sequence for a mission like NBT is 60 work days
  - Work is planned for seven days per week
- NBT must be ready to launch by 8/1/03 or the mission may be cancelled

NBT Schedule Reserve

- According to standard GSFC planning practices, one month of schedule reserve/contingency is needed for each year between time-now and launch
- NBT schedule reserve is designated for unknown problems that may occur during observatory testing
  - The entire seven-day work week is available for schedule contingency

Can NBT Launch On Time?

- The science community desperately needs NBT in orbit by late summer of 2003.
- NASA HQ has targeted a 8/1/03 NBT launch
- As the NBT Project Manager, it is your job to make it happen
- Can NBT launch on time? Let's find out!

The Next Four Sections Will Address:

- Activity Definition
- Activity Sequencing
- Activity Duration Estimating
- Schedule Development

3.0
Activity Definition

Activity Definition

Activity Definition is the process of identifying the activities which must be performed in order to produce the project's deliverables and meet it's objectives.

INPUT

- WBS
- SOW
- CDRLs
- MOU, PCA
- Historic Data
- Similar schedules
- Responsibility Assignments
- Drawing trees
- Constraints
- Assumptions

PROCESS

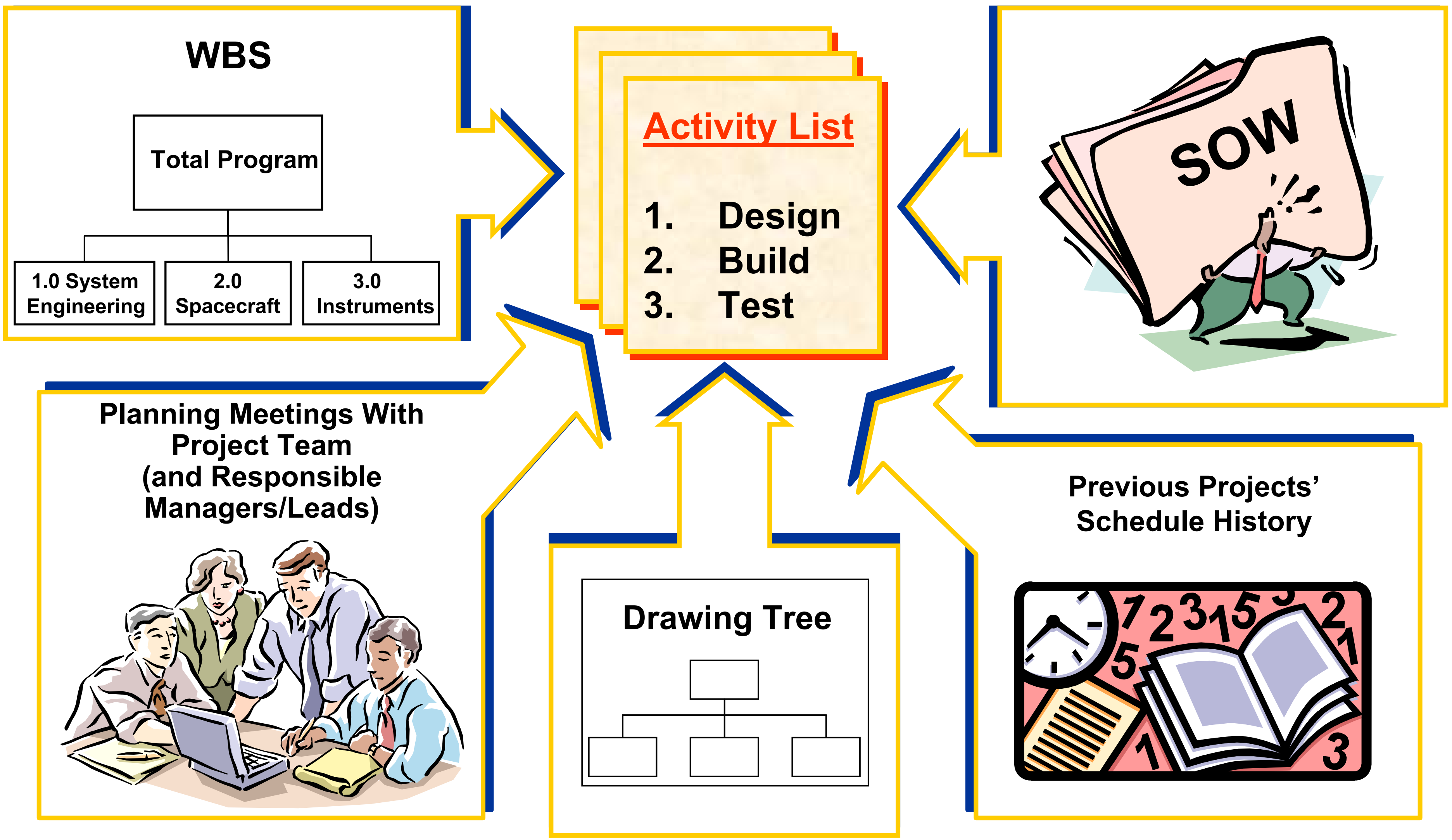
Decomposition

Subdivide the project work into smaller, more manageable components

OUTPUT

- Activity list
- Documented constraints & assumptions

Identify the Project's Activities



SOW Example

NAS5-30355
CONTRACT ATTACHMENT A

Statement of Work
Solar Backscatter Ultraviolet Radiometer (SBUV/2)
November 1998

I. Scope

The Contractor shall provide for the fabrication, qualification, storage, storage testing, delivery, post delivery bench testing, and other necessary field support of four flight SBUV/2 instruments, Flight Models 5, 6, 7, and 8 starting with BASD Model No. IN021A, Part No. 67901-509 which meets the requirements of GSFC Specification S-480-31, for incorporation on the L, M, N, and N' series of Advanced Tiros-N (ATN) spacecraft.

II. General Requirements

The Contractor shall provide for the personnel, material, and facilities necessary to design, fabricate, qualify, test, and calibrate four SBUV/2 flight units. These SBUV/2 flight units shall be fabricated, tested, and calibrated in accordance with all existing, approved SBUV/2 Integration, Functional, and Acceptance Test Procedures and all of the above shall be in accordance with the requirements of GSFC Specification S-480-31.

III. Functional Tasks

WBS Dictionary Example

WBS Dictionary

Contract Work Breakdown Structure Dictionary		Program Integrated AMSU-A	RFP No.: 5-16372/433 Contract No.: NAS5-32314	Date: July 1997 (March 1997, revised)
Level of CWBS	**CWBS Element**	**CWBS Definition**		
4	3.2.2	ELECTRONICS – CONSOLIDATED FAB The fabrication and assembly of electronic components and assemblies including assembly labor, bargaining unit supervision, inspection labor, manufacturing engineering support, shop order preparation, production control support, design engineering support, test engineering support, and test technician support for the consolidated fabrication, assembly and test of sufficient hardware to deliver the following quantities of EOS and METSAT electronic hardware: 1) 301 Circuit card assemblies of 23 part numbers 2) 12 Detector Pre-Amp assemblies 3) 141 Thermistor component assemblies 4) 48 I/O interface boards 5) 12 Transistor/diode assemblies 6) 18 Card cage assemblies 7) 12 Signal processor assemblies 8) 78 Cable assemblies 9) 2 Power control monitor assemblies 10) 10 Power relay assemblies 11) 420 PRT Terminal boards Included in each item above is all hardware ECN incorporation and all rework and retest. SOW Ref: Para 1.1 – EOS Scope; Para 1.2 – METSAT Scope Para 2.3 – EOS Protoflight Model; Para 2.4 – METSAT Flight Model 7 Para 2.5 – METSAT Flight Model 3; Para 2.6 – METSAT Flight Model 4 Para 2.7 – METSAT Flight Model 5; Para 2.8 – METSAT Flight Model 6		

Class Discussion

PLEASE DON'T TURN THE PAGE !

What are the NBT project's:

- Activities?
- Assumptions?
- Constraints?

NBT Activity Listing

- Authorize funding (from HQ)
- Procure spacecraft bus from Ultra
- Procure VEI from Acme
- Develop RCI at GSFC
- Integrate RCI to spacecraft
- Integrate VEI to spacecraft
- Observatory test at GSFC
- Schedule contingency
- Launch site operations
- Launch

NBT Activity Constraints and Project Assumptions

1. Acme contract award not earlier than 12/3/01
2. GSFC I&T facility unavailable 1/1/02 – 3/31/02
3. No funding until 10/1/01 (FY 2002)
4. Must launch by 8/1/03
5. S/C bus, VEI and RCI work cannot start until funding is authorized
6. GSFC will allocate funds five working days after funding is authorized by NASA HQ

Activities Become "Nodes" in Logic Network Diagram

Authorize Funding

Procure Spacecraft Bus

Procure VEI

Develop RCI

Integrate VEI to S/C

Integrate RCI to S/C

Observ. Testing

Schedule Contin-gency

Launch Site Ops

Launch

4.0

Activity Sequencing

Activity Sequencing

Activity Sequencing is the process of identifying dependencies and relationships among the project's activities.

INPUT

- Activity List
- Dependencies
  - Mandatory
  - Discretionary
  - External
- Constraints
- Assumptions

PROCESS

Precedence Diagramming Method (PDM)

Construct a network diagram showing activities as nodes and dependencies as lines/arrows.

OUTPUT

- Project Logic Network Diagram
- Reports

Determine the Project's Activity Sequence

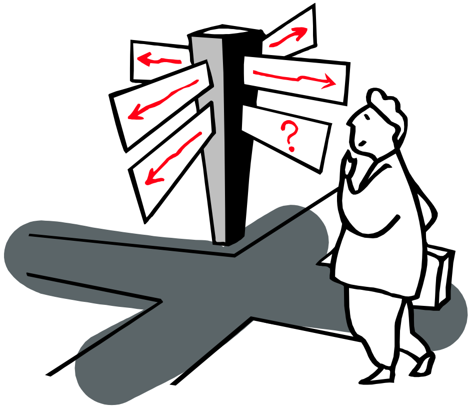
Activity List

1. Procure Bus
2. Procure VEI
3. Develop RCI
4. Observ. Test

Constraints
"Launch by 8/1/03"

Assumptions
"Schedule reserve for observatory test"

Mandatory Dependencies
"Install RCI before VEI"



External Dependencies
"Funding From HQ"

Leads/Lags
"5 Days to Allocate Funding"

Class Discussion

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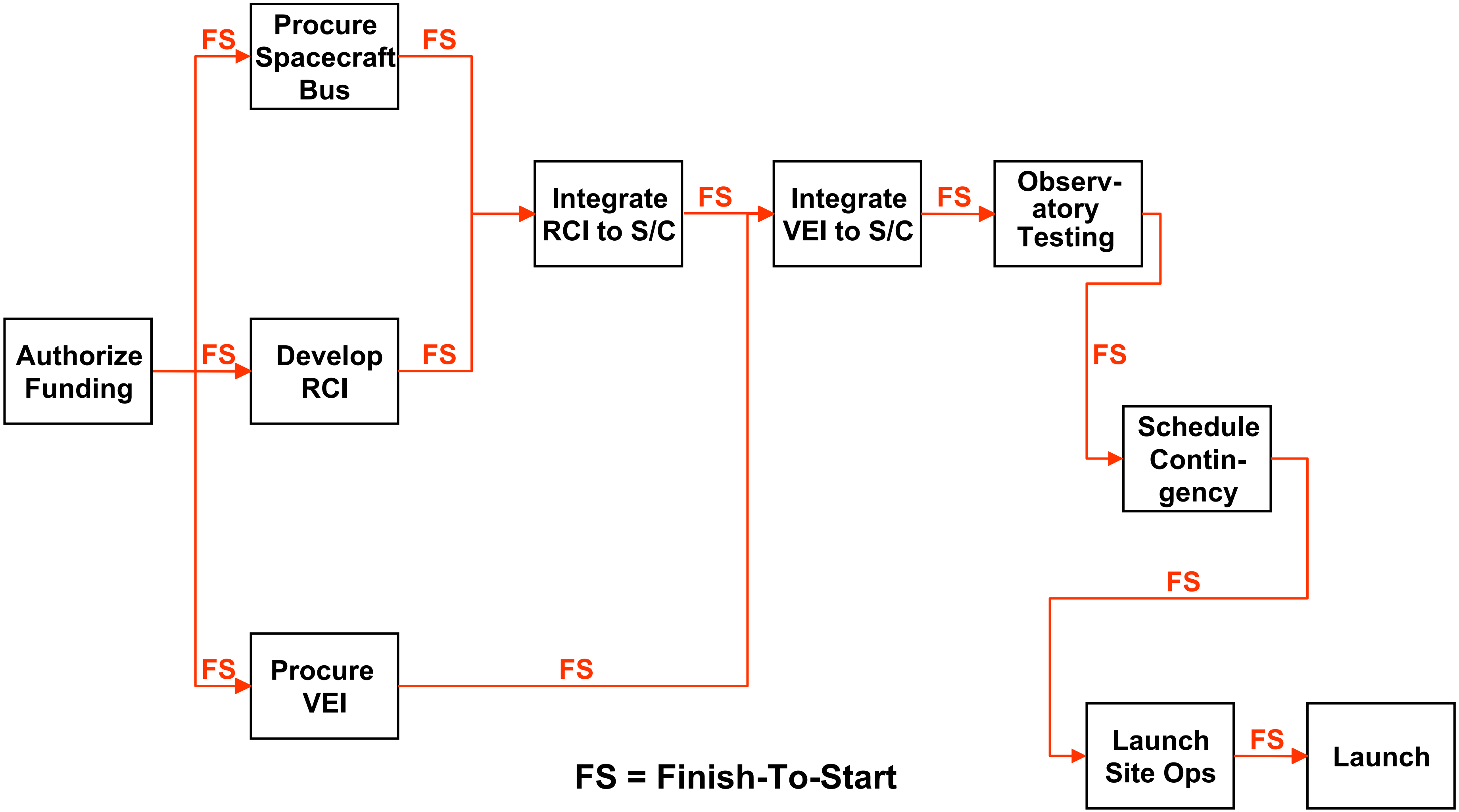
What are the NBT project's:

- Dependencies or relationships among the activities?

Arrows/Lines Show Dependencies Between Activities



FS = Finish-To-Start

5.0

Activity Duration Estimating

Activity Duration Estimating

Activity Duration Estimating is the process of determining the <u>realistic</u> number of work periods required to complete each activity.

INPUT

- Activity List
- Constraints
- Assumptions
- Historic Data
- Resources
- BOEs

PROCESS

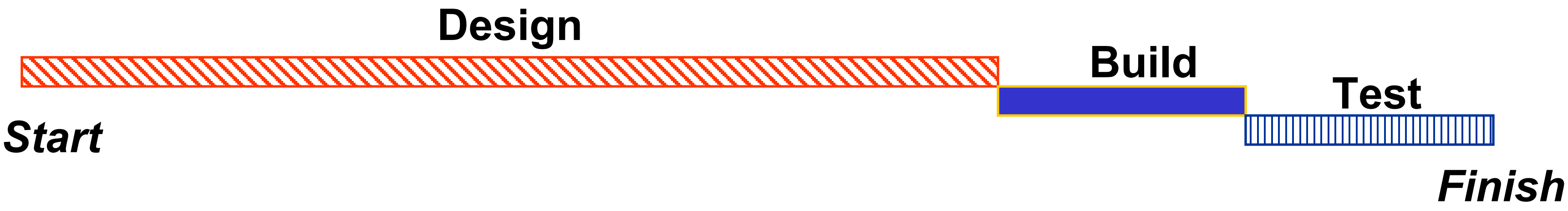
- Expert judgment
- Top-down/ analogous
- Bottoms-up
- Standards
- Brainstorming
- Historic data
  - Prior projects
  - GSFC RAO

OUTPUT

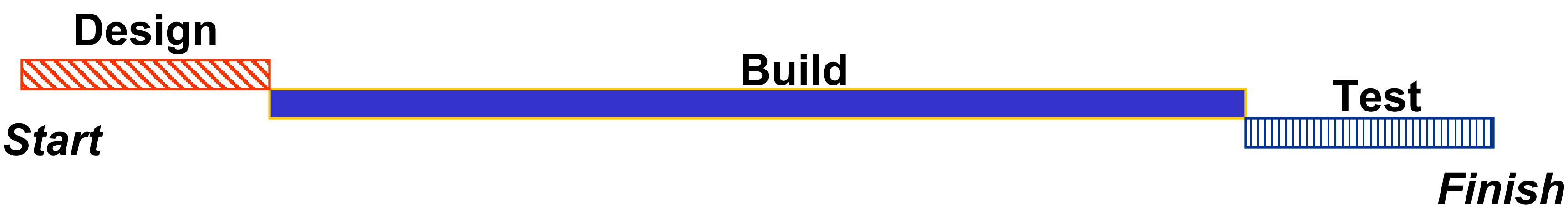
- Planned duration estimates for each activity

Realistic Activity Durations Are Important

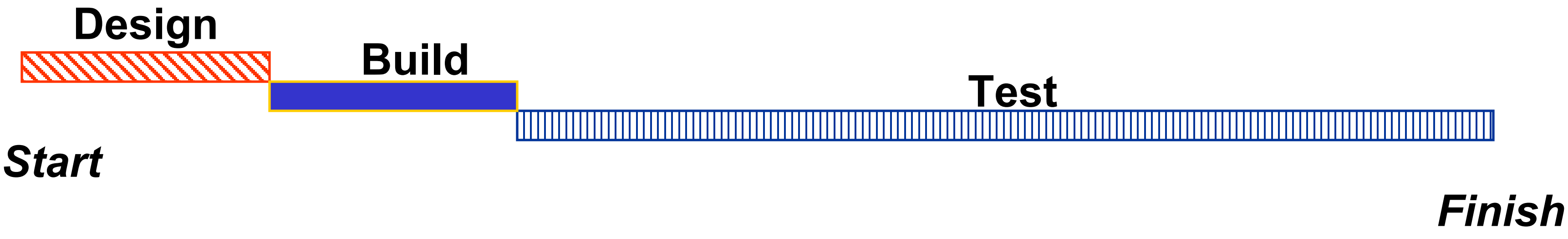
The Schedule According to Engineering



The Schedule According to Manufacturing



The Schedule According to System Test



Basis Of Estimate Example

BASIS OF ESTIMATE

Bid Title:

CCR 1743 SDDS Structural Modifications

Task Description (Statement of Work):

ASAN Instrument Teardown/Rebuild Subassys.
Disassemble top level instrument, modify piece parts and subassemblies, rebuild/test subassemblies.

Bid No.: 6141162
WBS No.: 9.3.1.2
Dept. No. 8252
Date: 7/20/00
Prepared by: G. Jones

		Func.	Hrs.	Material $
1	Instrument–Technician touch labor to disassemble instrument. Based on mfg. eng. estimate.	3125	23	
2	Preamp enclosures–Technician touch labor to disassemble and reassemble Ebox Preamp. Based on mfg. eng. est.	3125	23	
3	Electronics Box–Technician touch labor to disassemble and reassemble Ebox. Based on mfg. eng. est.	3125	40	
4	Model shop time for modifying Ebox. Based on mfg. eng. estimate.	3085	6	
5	Relay Optics–Technician touch labor to modify relay optics. Based on mfg. eng. estimate.	3125	20	
6	Scanner–Tech. touch labor to disassemble/reassemble scan assembly. Based on 60% of actuals for H304 & H305 scanners.	3125	150	
7	Model shop support to drill and pin scanner. Based on experience with previous instruments.	3085	8	
8	Filter wheel-Technician touch labor to remove, disassemble and assemble filter chopper assembly. Based on actual builds. Pickup arm is 30 hrs and chopper assembly disassembly and reassembly is 50 hrs. (30 + 50 = 80).	3125	80	
9	Outside model shop support to tailor filter wheel clamp.	5200		$ 500
10	Model shop time for machining filter wheel housing. Based on mfg. estimate.	3085	8	
11	Baseplate-Technician touch labor to build a new baseplate assembly. Based on mfg. estimate.	3125	50	
12	Model shop time for machining baseplate feet and grounding locations.	3085	8	
13	Helicoils-Technician touch labor to install helicoils and paint new panels. Estimate 25 build packages at 2 hours = 50 hours.	3125	50	
14	Technician touch labor to disassemble H306 radiant cooler, clean up parts, bag and tag parts, scrap unusable parts.	3125	30	
15	Technician touch labor to reassemble H306 radiant cooler. Based on 100% of actuals for H305 and H306.	3125	300	
16	Mechanical engineer review work instructions. 41 new/revised work instructions x 2 hours each = 82 hours.	3050	82	
17	The preceding tech (3125) touch labor hrs are based on past actuals using experienced techs. A learning curve is being added to these tasks as contingency in case the current exp. techs. are not available when the work begins. Estimate an extra 20% of normal touch labor (1000 total touch hrs x .20 = 200 hrs.) Additional hrs not needed if exp. techs are avail.	3125	200	
18	16% of mfg. touch labor for inspection of parts as removed and reassembled, and also set up verification and data review/ approval of subsystem test efforts. (1200 hrs. x 16% = 192 hrs.)	3015	192	
19	FRACAS assume 3 IRs @ 28 hrs. each for Admin. Support.	3015	84	
		TOTAL:	**1,354**	**$ 500**

GSFC Resource Analysis Office

- RAO has historical schedule data for many (but not all) NASA projects in two primary documents:
  - Project Schedule Data Base (PSDB): contains milestone data for 68 projects, both in-house and contracted (Feb '95)
  - Project Cross-Referencing System (PCRS): contains milestone, cost and technical data for the 68 projects + 28 more recent projects
- RAO's schedule data includes milestone data on:
  - Authority-To-Proceed
  - Pre-Environmental Reviews
  - (No ground system data)
  - Start and delivery of spacecraft and instruments developments
  - Wiring Harness Installation
  - Launch
  - Preliminary & Critical Design Reviews
- The Spacecraft Equipment Cost Model (SPECM) contains start and delivery dates for components (e.g., solar arrays)

(As of May 2000)

Class Discussion

PLEASE DON'T TURN THE PAGE !

Based on the NBT project background material on pages 33 - 43:

- **What are the planned durations for each NBT activity?**
- **What estimating methodology was used to determine the durations?**

Duration Estimates for the NBT Project

Activities	Planned Duration	Estimating Methodology
Procure spacecraft bus	200 work days	Projection of actuals; vendor quote
Procure VEI instrument	220 work days	Top down/analogous to similar job
Develop RCI instrument	240 work days	Analogy with factor applied
Integrate RCI to S/C	5 work days	Bottoms up
Integrate VEI to S/C	5 work days	Bottoms up
Observatory Testing	120 work days	Expert judgment/historic data/analogous to similar testing
Schedule Contingency	60 calendar days	GSFC standard
Launch Site Operations	60 calendar days	Historic data

6.0 Schedule Development

- Applying Activity Durations
- Applying Leads & Lags
- Applying Constraints
- Assigning Work Calendars
- Running the Time Analysis
- Slack & Reserve
- The Critical Path
- Setting the Baseline Schedule
- The “Rolling Wave”

Schedule Development

Schedule Development is the process of determining the "early" and "late" start and finish dates for the project's activities in order to establish the project schedule.

INPUT

- Logic Network Diagram
- Activity Duration Estimates
- Resources
- Work Calendars
- Assumptions
- Constraints
- Leads & Lags
- Contingency

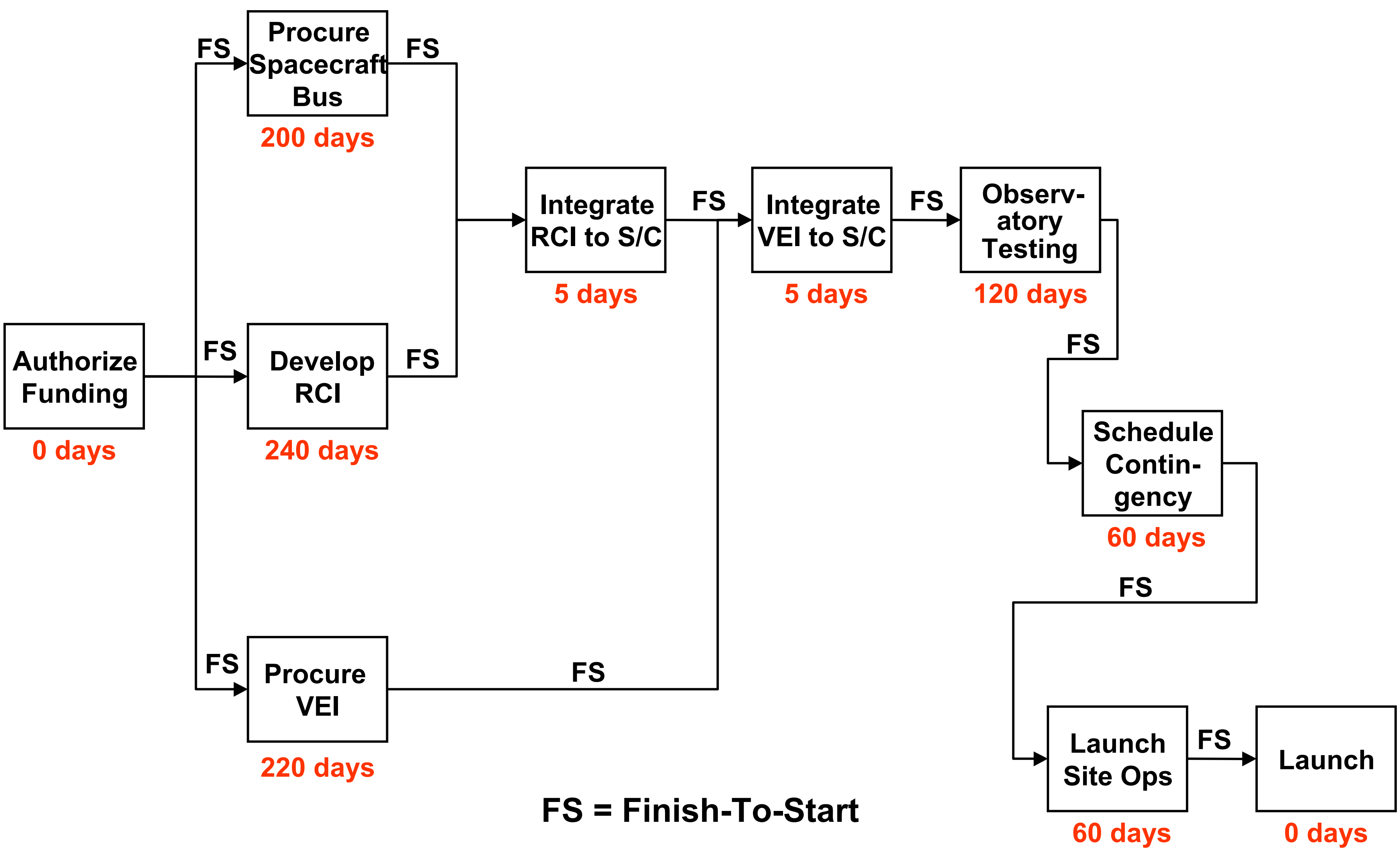
PROCESS

Computer-based Logic Networking

OUTPUT

- Baseline Schedule
- Logic Network
- Gantt/bar charts
- Reports

Estimated Durations Are Applied to Activities in Logic Network Diagram



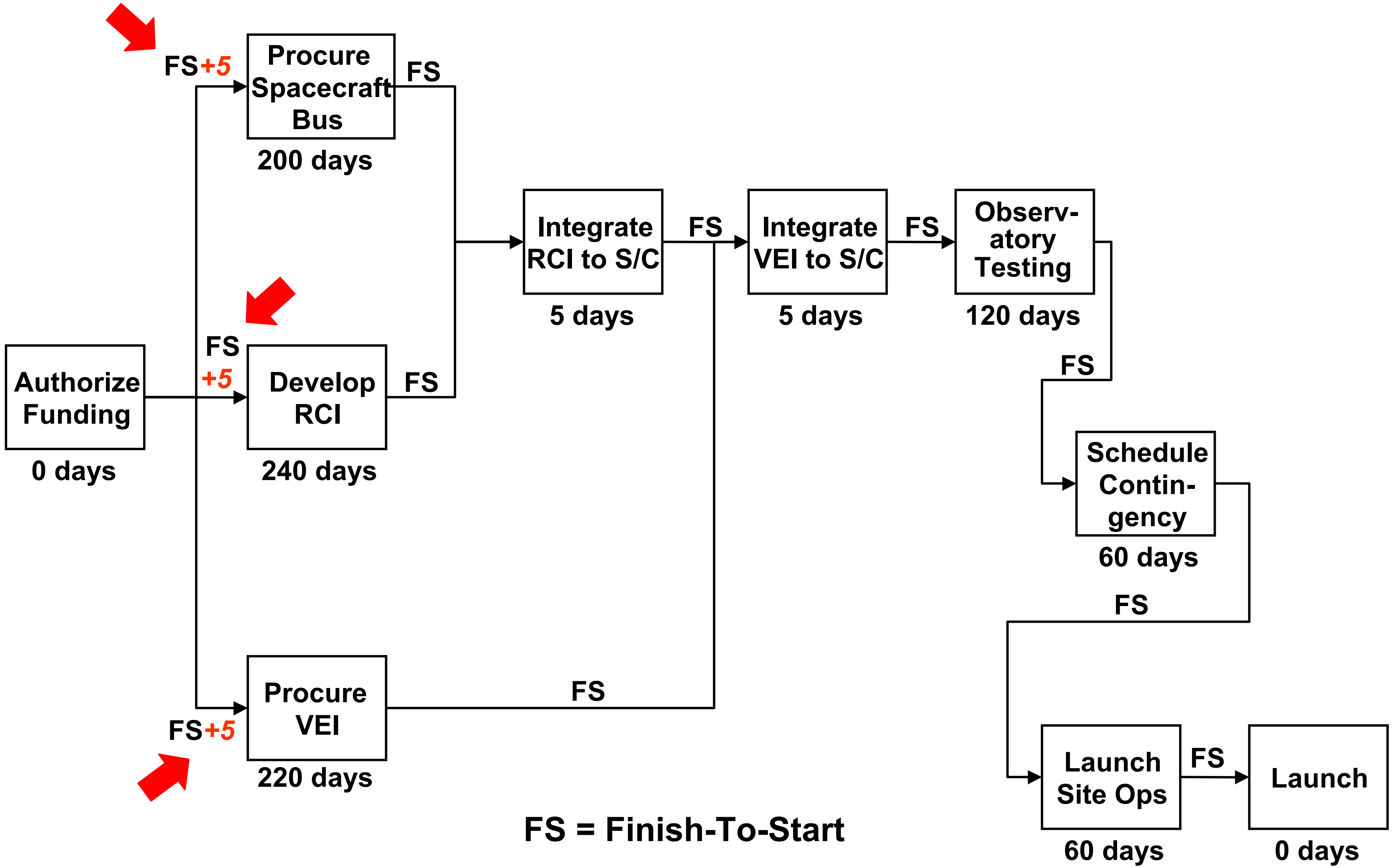
Class Discussion

PLEASE DON'T TURN THE PAGE !

Based on the NBT project background material on pages 33 - 43:

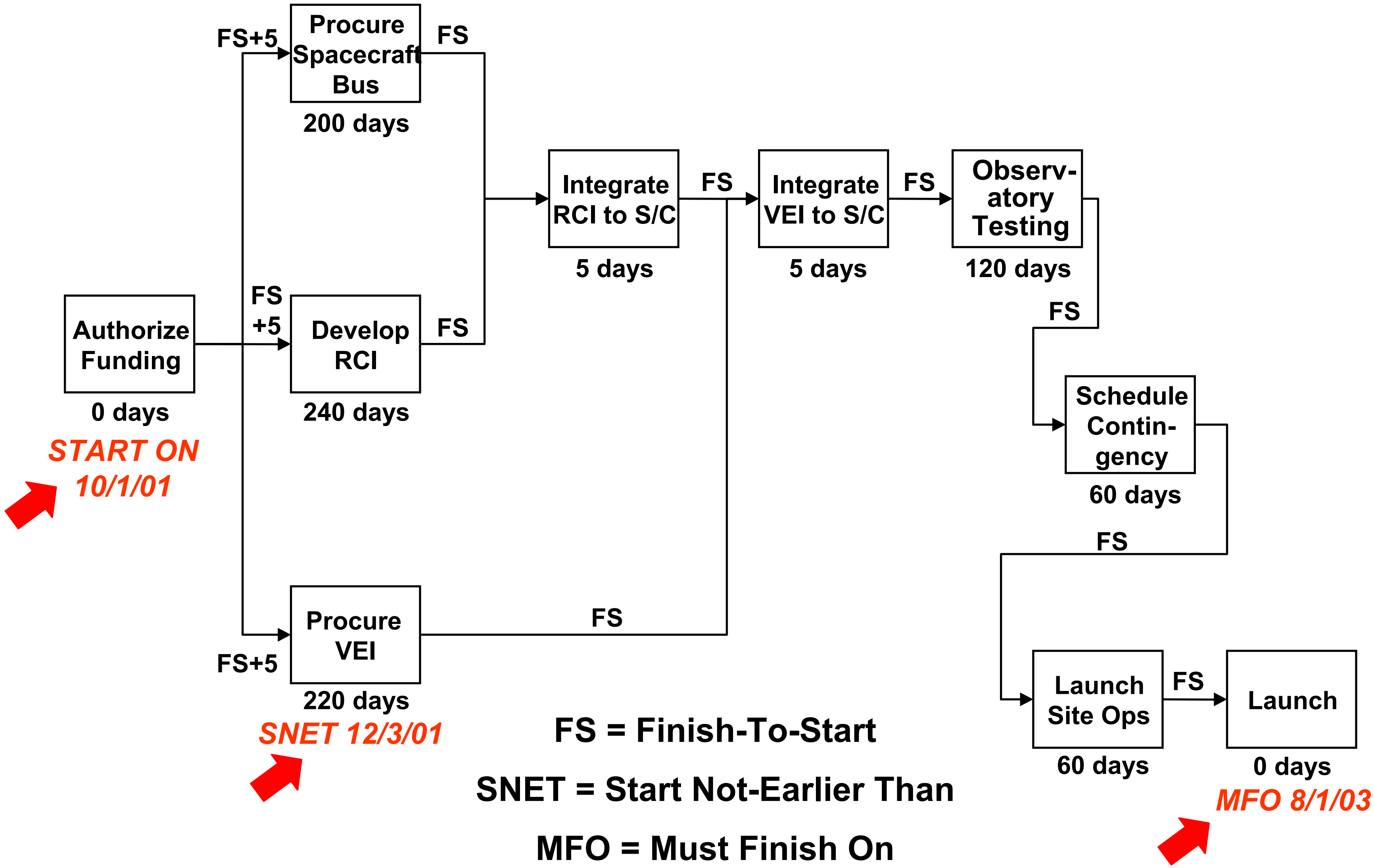
- Are there any "leads" (overlaps) between activity dependencies?
- Are there any "lags" (gaps) between activity dependencies?
- Are there any "constraints" on start or finish dates?

Leads/Lags Are Applied to the Logic Network Diagram



FS = Finish-To-Start

Constraints Are Incorporated Into the Logic Network Diagram



FS = Finish-To-Start

SNET = Start Not-Earlier Than

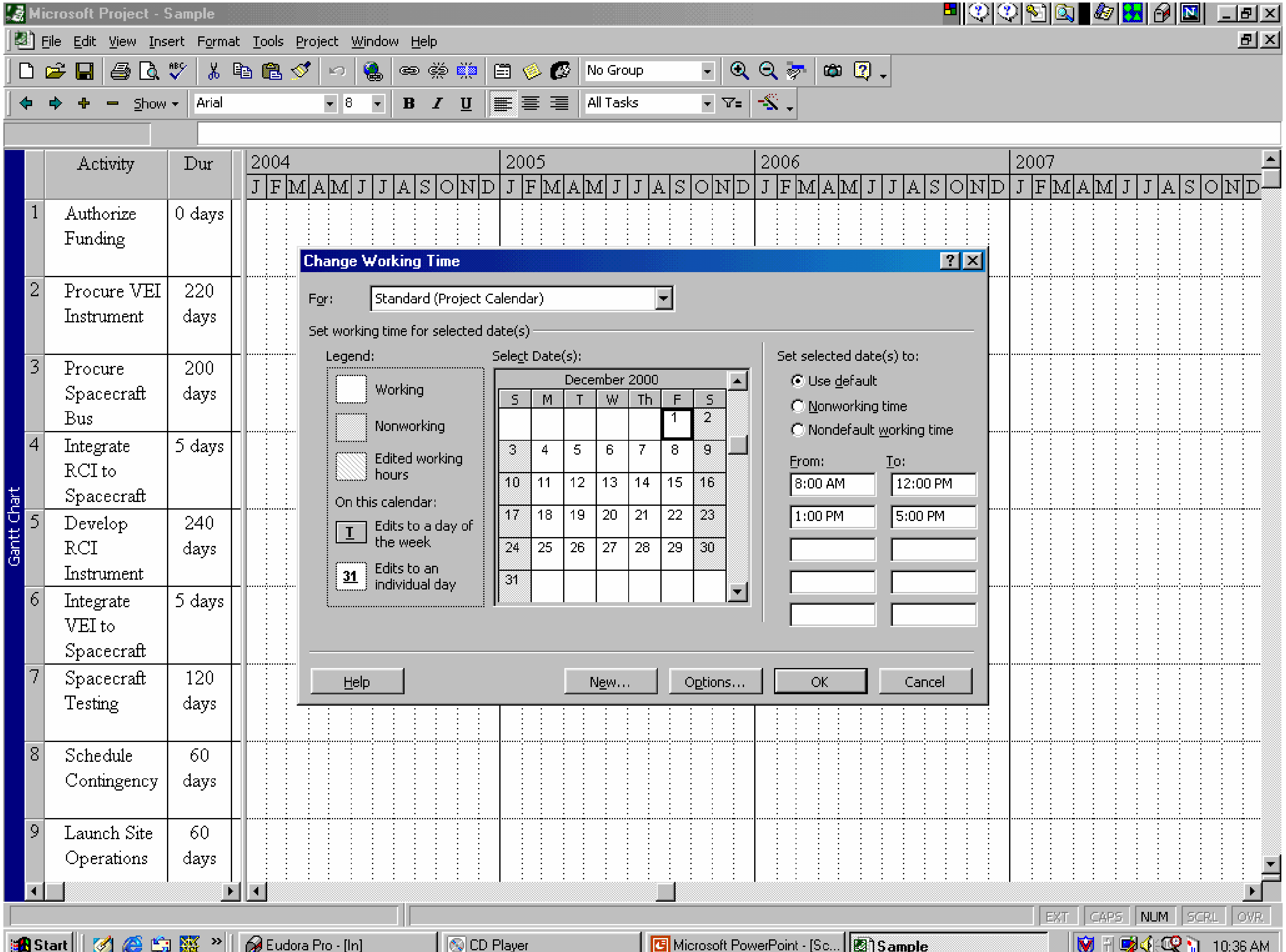
MFO = Must Finish On

Establish and Apply Work Calendars to Project Activities

- **Work Calendars**
  - Base/Standard calendar for Ultra, Acme & GSFC activities = 1-8-5 days (1 shift, 8 hrs./day, M-F)
  - GSFC System Test calendar = 1-8-5 days (1 shift, 8 hrs./day, M-F)
  - Launch site calendar = 2-8-7 (2 shifts/day, 8 hrs./shift, Sunday-Saturday)
  - No resource calendars (for this example)

- **Assumptions**
  - GSFC System Test facility will be closed from 1/1/02 until 3/31/02

Assign Work Calendars



Run the Time Analysis

Forward Scheduling

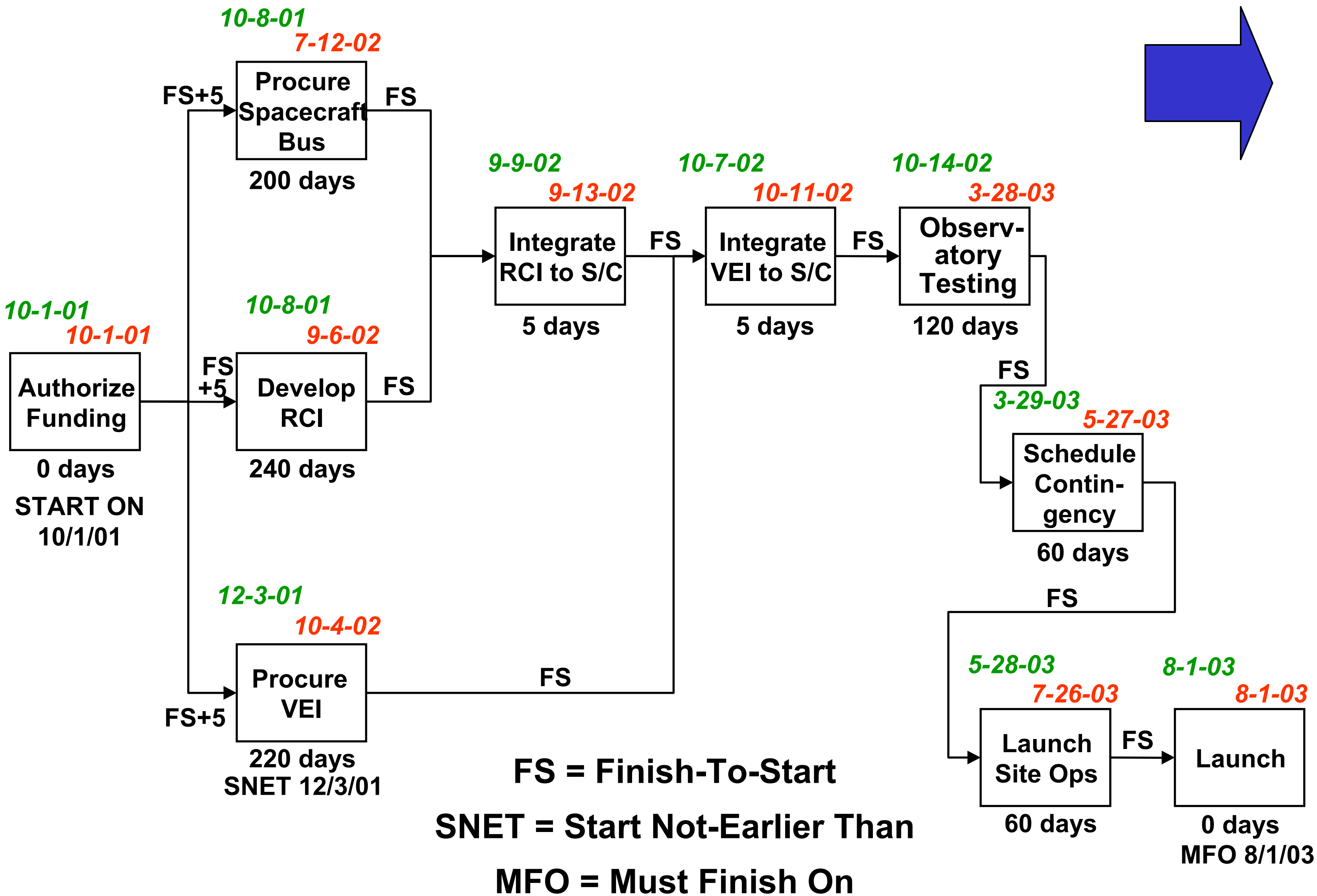
- Schedule calculated from beginning to end based on a known start date
- Earliest possible start and finish dates for each activity are computed
- The "can do" or expected schedule
- Known as the "forward pass" in logic networking

Backward Scheduling

- Schedule calculated from the end to the beginning based on a target completion date
- Latest possible start and finish dates for each activity are computed
- The "must do" or allowed schedule
- Known as the "backward pass" in logic networking

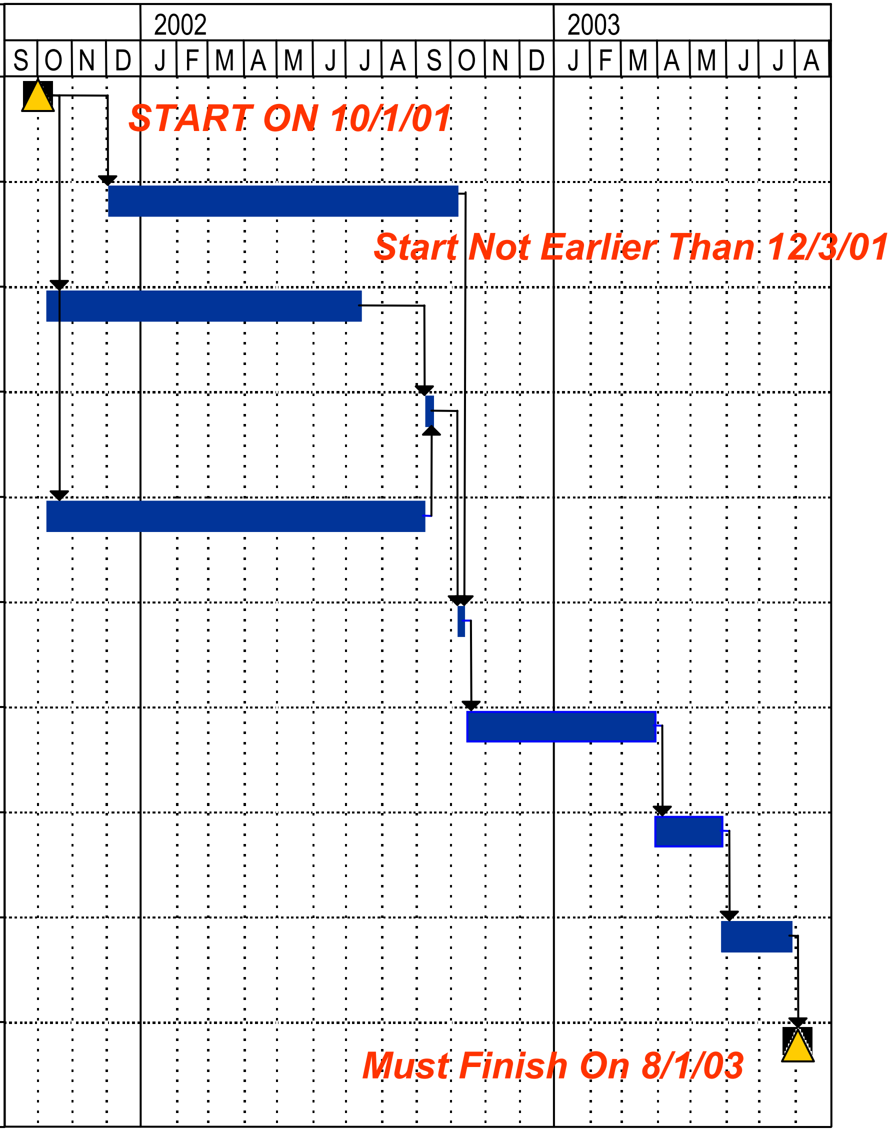
Slack is the difference between time expected and allowed

The Forward Pass: Calculates Earliest Start & Finish Dates For Each Activity

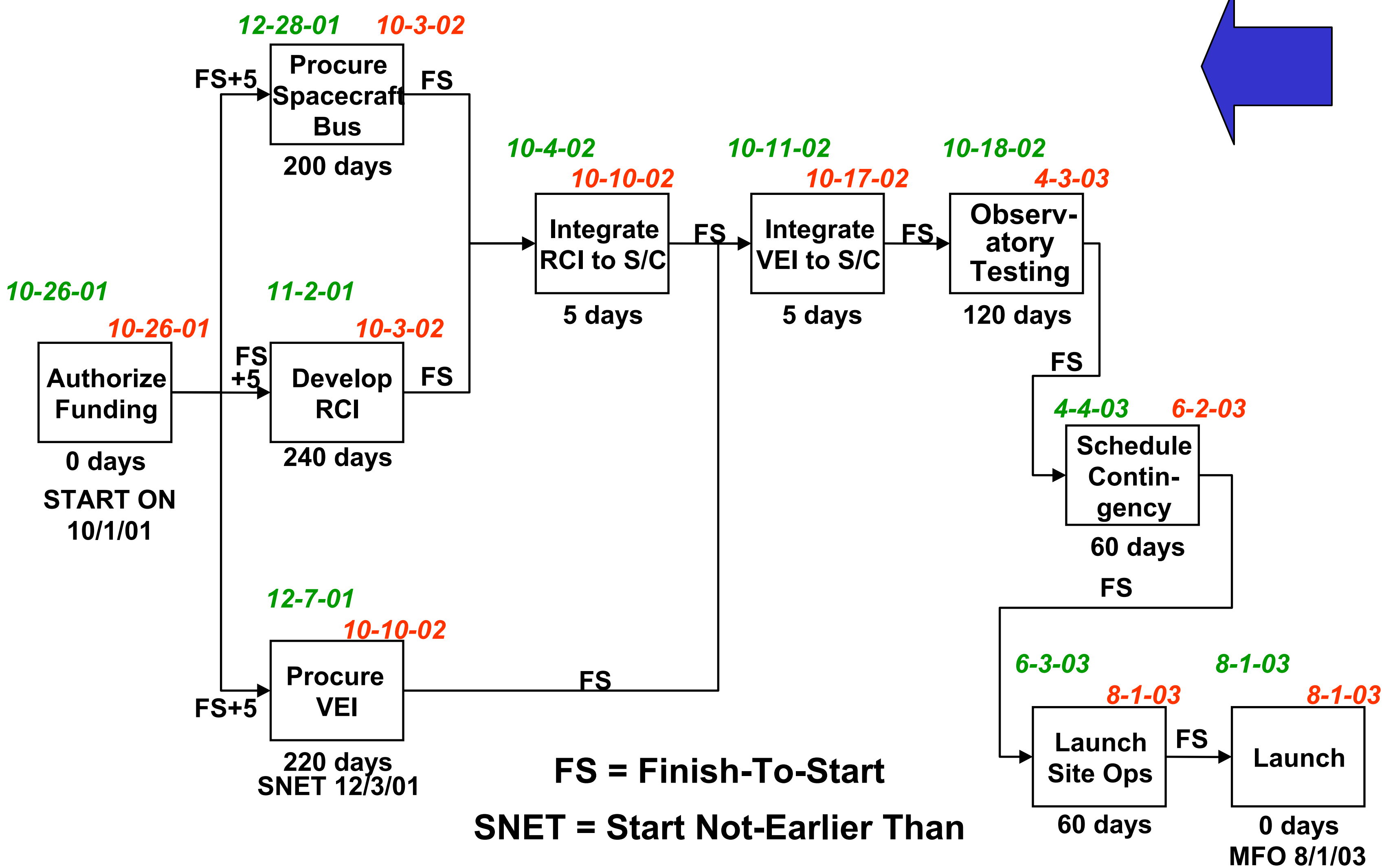


NBT Project Schedule: Early Dates

ID	Activity	Dur	Early Start	Early Finish	Calendar
1	Authorize Funding	0 days	10/1/01	10/1/01	Standard
2	Procure VEI Instrument	220 days	12/3/01	10/4/02	Standard
3	Procure Spacecraft Bus	200 days	10/8/01	7/12/02	Standard
4	Integrate RCI to Spacecraft	5 days	9/9/02	9/13/02	Standard
5	Develop RCI Instrument	240 days	10/8/01	9/6/02	Standard
6	Integrate VEI to Spacecraft	5 days	10/7/02	10/11/02	Standard
7	Observatory Testing	120 days	10/14/02	3/28/03	GSFC I+T
8	Schedule Contingency	60 days	3/29/03	5/27/03	7 Day Work Week
9	Launch Site Operations	60 days	5/28/03	7/26/03	Launch Ops
10	Launch	0 days	8/1/03	8/1/03	Launch Ops



The Backward Pass: Calculates Latest Start & Finish Dates For Each Activity



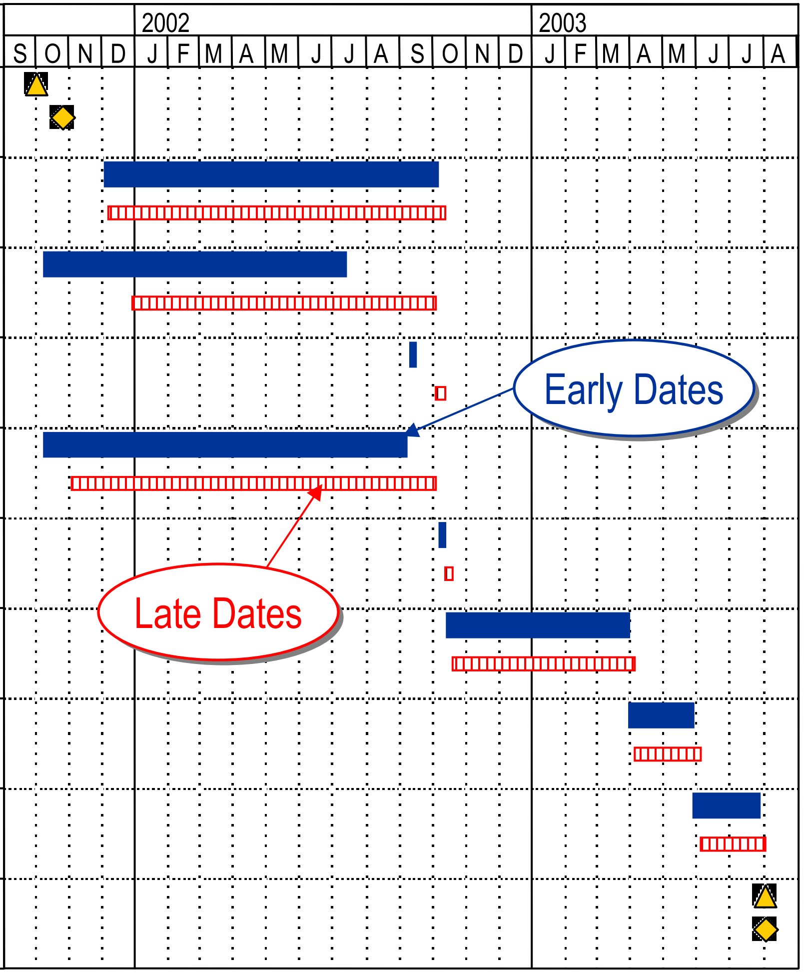
FS = Finish-To-Start

SNET = Start Not-Earlier Than

MFO = Must Finish On

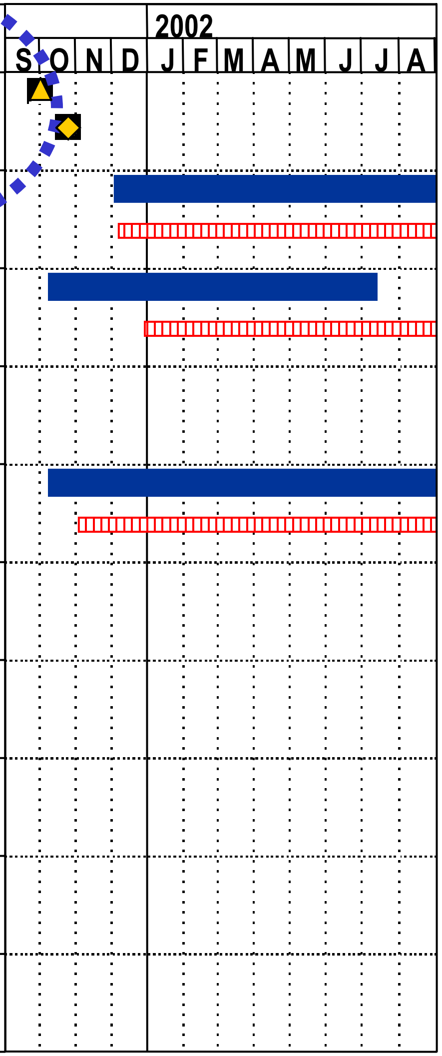
NBT Project Schedule: Early Dates Compared to Late Dates

ID	Activity	Dur	Early Start	Early Finish	Late Start	Late Finish	Calendar
1	Authorize Funding	0 days	10/1/01	10/1/01	10/26/01	10/26/01	Standard
2	Procure VEI Instrument	220 days	12/3/01	10/4/02	12/7/01	10/10/02	Standard
3	Procure Spacecraft Bus	200 days	10/8/01	7/12/02	12/28/01	10/3/02	Standard
4	Integrate RCI to Spacecraft	5 days	9/9/02	9/13/02	10/4/02	10/10/02	Standard
5	Develop RCI Instrument	240 days	10/8/01	9/6/02	11/2/01	10/3/02	Standard
6	Integrate VEI to Spacecraft	5 days	10/7/02	10/11/02	10/11/02	10/17/02	Standard
7	Observatory Testing	120 days	10/14/02	3/28/03	10/18/02	4/3/03	GSFC I+T
8	Schedule Contingency	60 days	3/29/03	5/27/03	4/4/03	6/2/03	7 Day Work Week
9	Launch Site Operations	60 days	5/28/03	7/26/03	6/3/03	8/1/03	Launch Ops
10	Launch	0 days	8/1/03	8/1/03	8/1/03	8/1/03	Launch Ops



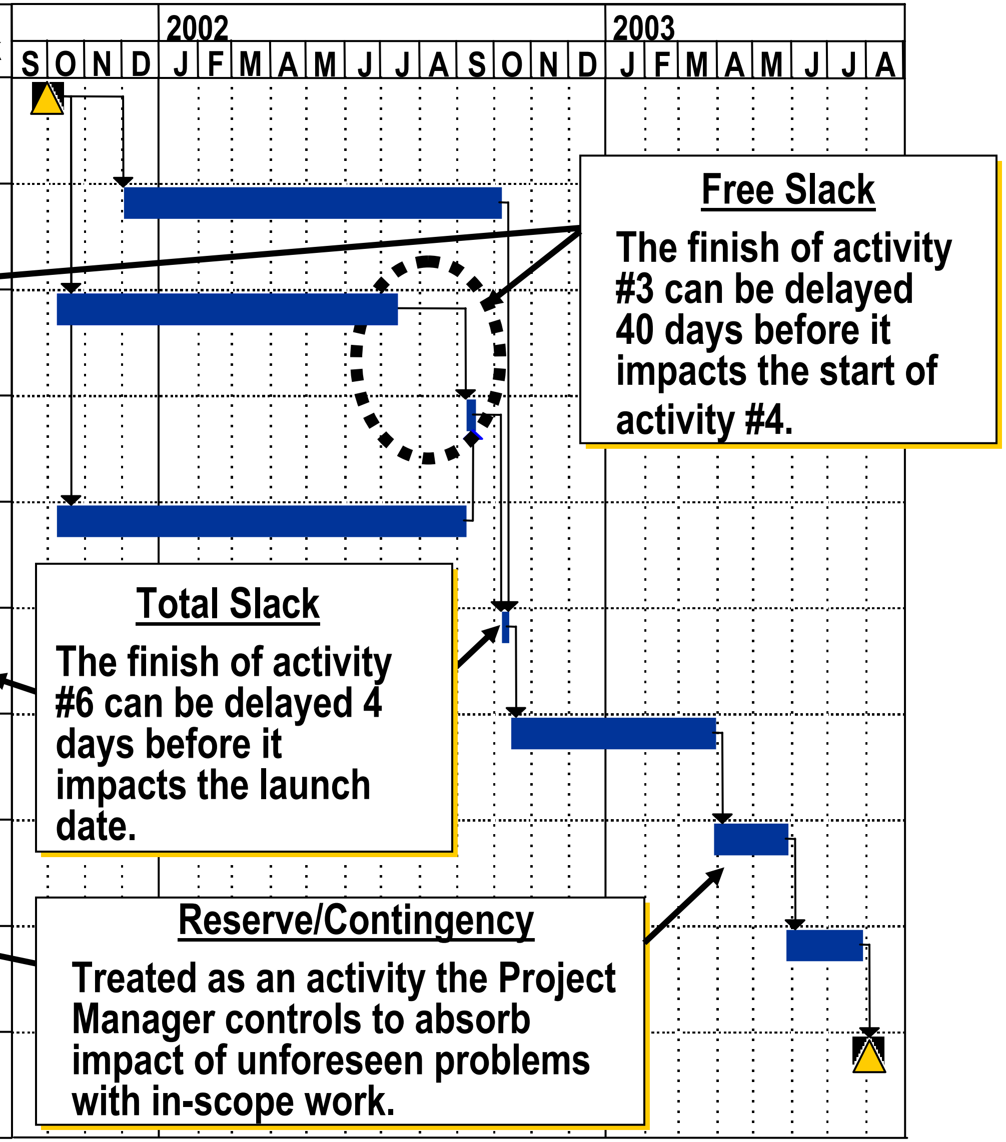
Free Slack and Total Slack

ID	Activity	Dur	Early Start	Early Finish	Late Start	Late Finish	Calendar	Free Slack	Total Slack
1	Authorize Funding	0 days	10/1/01	10/1/01	10/26/01	10/26/01	Standard	0 days	19 days
2	Procure VEI Instrument	220 days	12/3/01	10/4/02	12/7/01	10/10/02	Standard	0 days	4 days
3	Procure Spacecraft Bus	200 days	10/8/01	7/12/02	12/28/01	10/3/02	Standard	40 days	59 days
4	Integrate RCI to Spacecraft	5 days	9/9/02	9/13/02	10/4/02	10/10/02	Standard	15 days	19 days
5	Develop RCI Instrument	240 days	10/8/01	9/6/02	11/2/01	10/3/02	Standard	0 days	19 days
6	Integrate VEI to Spacecraft	5 days	10/7/02	10/11/02	10/11/02	10/17/02	Standard	0 days	4 days
7	Observatory Testing	120 days	10/14/02	3/28/03	10/18/02	4/3/03	GSFC I+T	0 days	4 days
8	Schedule Contingency	60 days	3/29/03	5/27/03	4/4/03	6/2/03	7 Day Work Week	0 days	6 days
9	Launch Site Operations	60 days	5/28/03	7/26/03	6/3/03	8/1/03	Launch Ops	5 days	6 days
10	Launch	0 days	8/1/03	8/1/03	8/1/03	8/1/03	Launch Ops	0 days	0 days



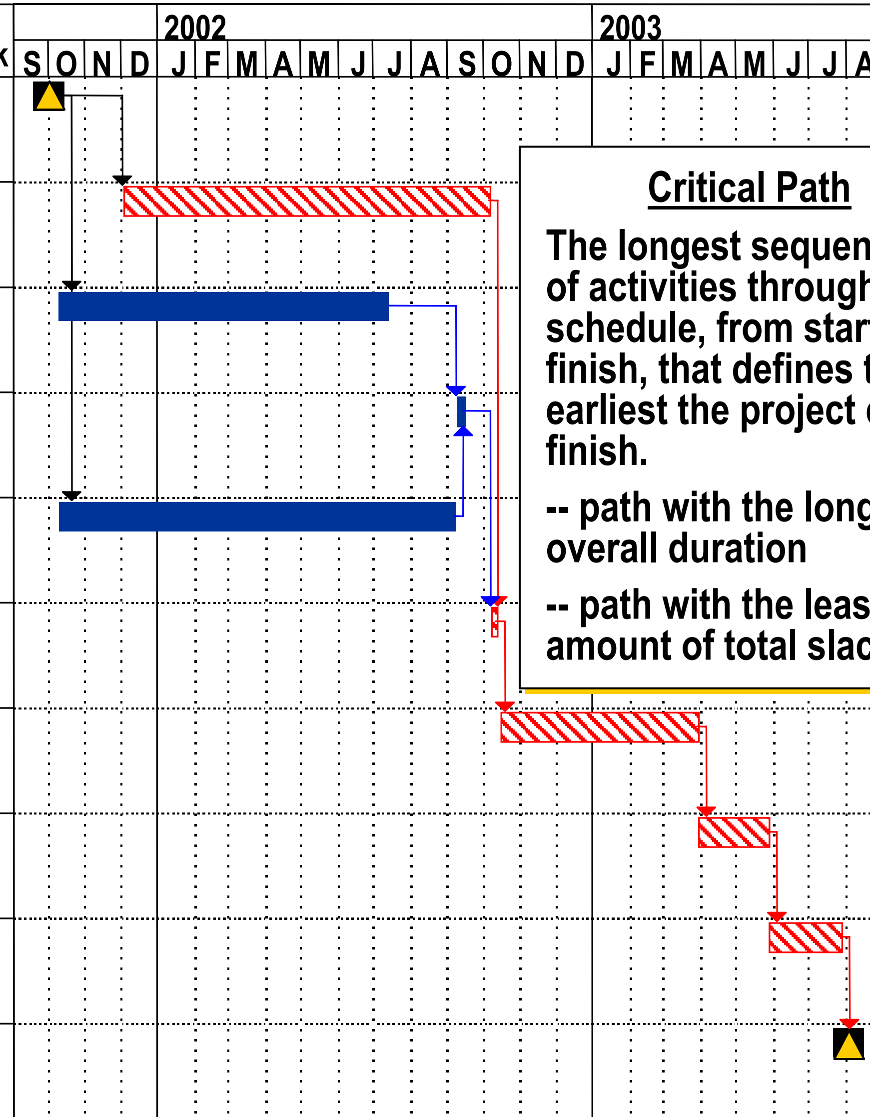
Free Slack, Total Slack & Reserve

ID	Activity	Dur	Free Slack	Total Slack
1	Authorize Funding	0 days	0 days	19 days
2	Procure VEI Instrument	220 days	0 days	4 days
3	Procure Spacecraft Bus	200 days	40 days	59 days
4	Integrate RCI to Spacecraft	5 days	15 days	19 days
5	Develop RCI Instrument	240 days	0 days	19 days
6	Integrate VEI to Spacecraft	5 days	0 days	4 days
7	Observatory Testing	120 days	0 days	4 days
8	Schedule Contingency	60 days	0 days	6 days
9	Launch Site Operations	60 days	5 days	6 days
10	Launch	0 days	0 days	0 days



NBT Project Schedule: Critical Path

ID	Activity	Dur	Early Start	Early Finish	Total Slack
1	Authorize Funding	0 days	10/1/01	10/1/01	19 days
2	Procure VEI Instrument	220 days	12/3/01	10/4/02	4 days
3	Procure Spacecraft Bus	200 days	10/8/01	7/12/02	59 days
4	Integrate RCI to Spacecraft	5 days	9/9/02	9/13/02	19 days
5	Develop RCI Instrument	240 days	10/8/01	9/6/02	19 days
6	Integrate VEI to Spacecraft	5 days	10/7/02	10/11/02	4 days
7	Observatory Testing	120 days	10/14/02	3/28/03	4 days
8	Schedule Contingency	60 days	3/29/03	5/27/03	6 days
9	Launch Site Operations	60 days	5/28/03	7/26/03	6 days
10	Launch	0 days	8/1/03	8/1/03	0 days



Critical Path

The longest sequence of activities through the schedule, from start to finish, that defines the earliest the project can finish.

-- path with the longest overall duration

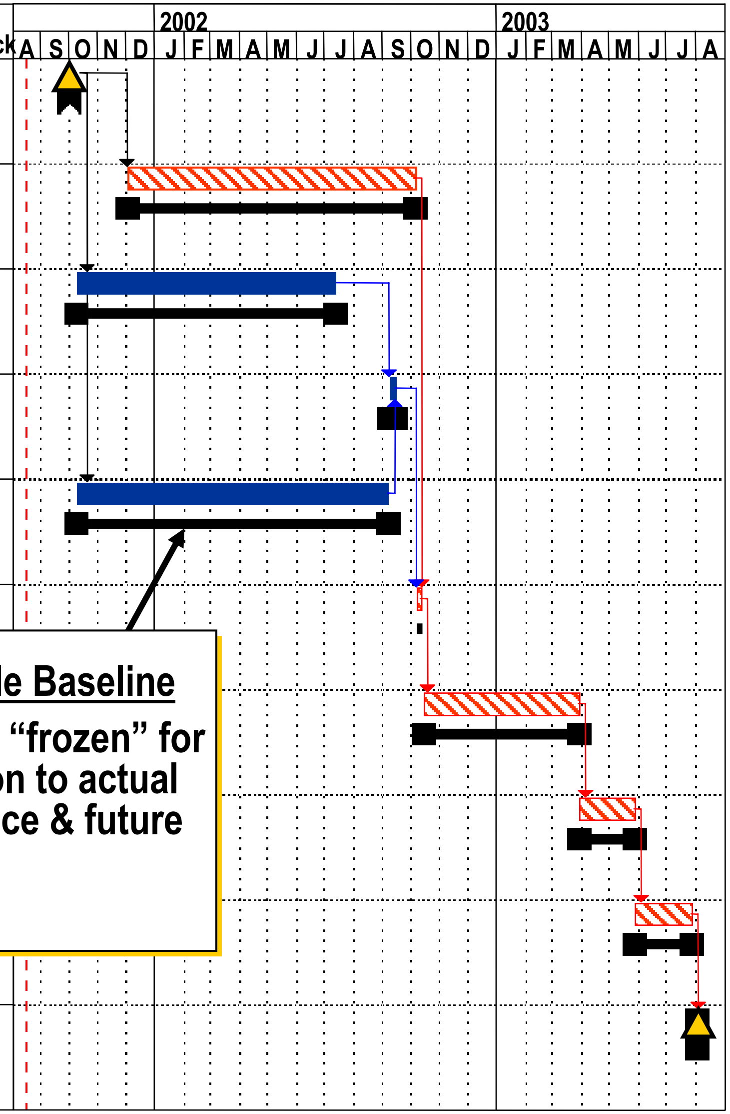
-- path with the least amount of total slack

The Baseline Schedule

- Represents the project team's schedule commitment
- Establishes target dates and planned time spans for the accomplishment of activities
- Documents the project's schedule assumptions and constraints
- "Freezes" the original plan at the completion of the initial project planning, but…
  - Will and should change over the life of the project (e.g., new scope)
  - Should not be changed to match performance
- Provides a time perspective to the project team
- Sets a benchmark against which schedule performance is measured and forecasts are projected - *in order to better determine future courses of action*
- Correlates to project's original cost estimate/budget

NBT Project Baseline Schedule

ID	Activity	Dur	Early Start	Early Finish	Baseline Start	Baseline Finish	Total Slack
1	Authorize Funding	0 days	10/1/01	10/1/01	10/1/01	10/1/01	19 days
2	Procure VEI Instrument	220 days	12/3/01	10/4/02	12/3/01	10/4/02	4 days
3	Procure Spacecraft Bus	200 days	10/8/01	7/12/02	10/8/01	7/12/02	59 days
4	Integrate RCI to Spacecraft	5 days	9/9/02	9/13/02	9/9/02	9/13/02	19 days
5	Develop RCI Instrument	240 days	10/8/01	9/6/02	10/8/01	9/6/02	19 days
6	Integrate VEI to Spacecraft	5 days	10/7/02	10/11/02	10/7/02	10/11/02	4 days
7	Observatory Testing	120 days	10/14/02	3/28/03	10/14/02	3/2	
8	Schedule Contingency	60 days	3/29/03	5/27/03	3/29/03	5/2	
9	Launch Site Operations	60 days	5/28/03	7/26/03	5/28/03	7/2	
10	Launch	0 days	8/1/03	8/1/03	8/1/03	8/1/03	0 days



Schedule Baseline

A target is "frozen" for comparison to actual performance & future forecasts.

REV: Baseline 8/15/01

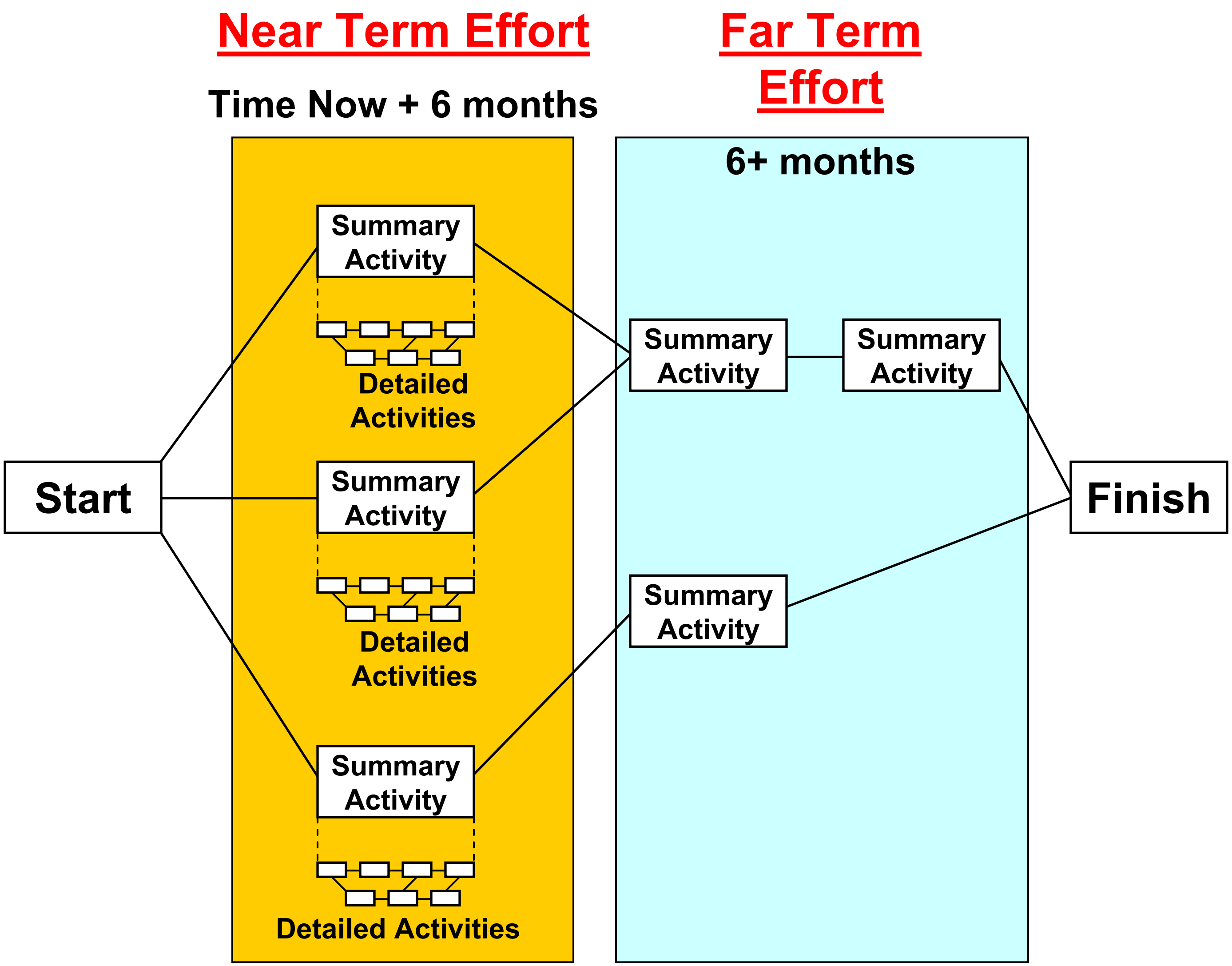
Without a Baseline Schedule:

- Projects may lose sight of their schedule objectives and commitments
- Credibility and relevance of schedule performance and forecasts are questionable
- Projects could lose schedule integration with cost plan
- Contractors may have difficulty segregating the impact (schedule & cost) of new work scope from the impact of technical or performance problems

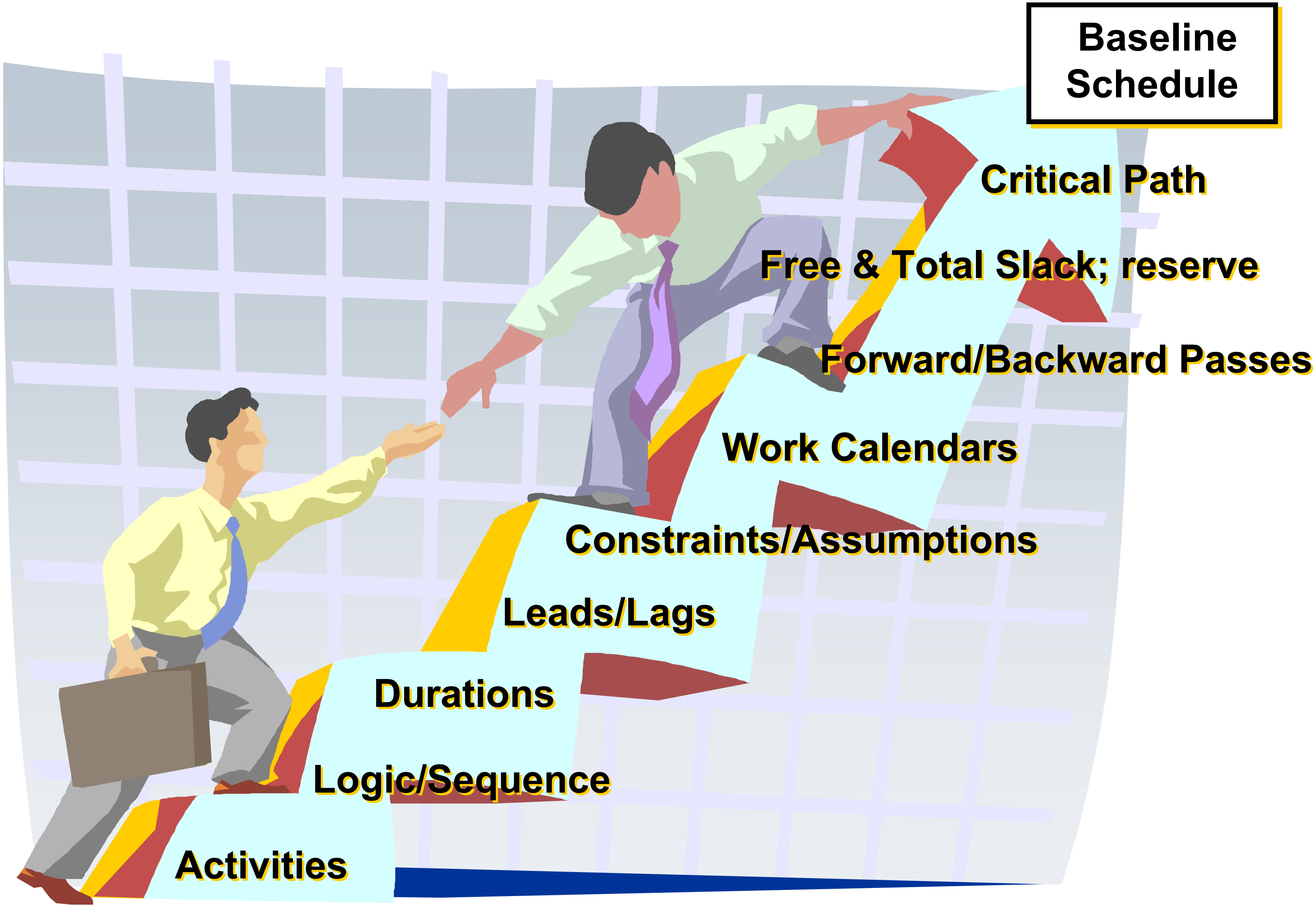
“Rolling Wave” Concept

- The “Rolling Wave” is a snapshot of the schedule planning horizon represented by:
  - Thorough and detailed scheduling of the near-term activities
  - More general top-level scheduling of longer-range activities
- It is progressively refined by the continuous subdivision of downstream activities into near-term tasks
- It is typically used on large scale, long duration projects

"Rolling Wave" Illustrated



Let's Recap
What We've Done So Far



Class Group Exercise

The Master Schedule

Class Exercise: The Master Schedule *(1 of 3)*

Background:

- You are responsible for developing a master schedule for an observatory launching on 6/1/05. The spacecraft and instrument need to be fully integrated and functionally and environmentally tested prior to observatory integration. The project manager requires no less than 4 months be held for project schedule contingency.
- There will be several mission level reviews: System Requirements Review (SRR), Preliminary Design Review (PDR), and Critical Design Review (CDR), 3, 6, and 14 months after Authorization to Proceed (ATP) respectively.
- The spacecraft contractor returned a proposal to deliver the spacecraft to spec 28 months after ATP. Their detailed schedule shows that they will need 3 months for requirements definition, 10 months for design, 10 months for box level fab, assembly and test, and another 5 months for integration and environmental testing. These activities occur in sequentially.

Class Exercise: The Master Schedule *(2 of 3)*

Background (Cont'd):

- The instrument contractor returned a proposal to deliver the instrument to spec 32 months after ATP. Their detailed schedule shows that they will need 3 months for requirements definition, 11 months for design, 13 months for box level fab, assembly and test, and another 5 months for integration and environmental testing. These activities occur in sequence.
- The spacecraft and instrument will be delivered to GSFC for observatory integration and test (I&T). Observatory I&T will take 6 months and launch site processing is another 2 months.
- The ground and science segment activities will begin at ATP and run concurrently through launch. The ground segment will conduct 3 end-to-end (ETE) tests; one each at 1, 8 and 12 months prior to launch.

Class Exercise: The Master Schedule *(3 of 3)*

Exercise:

- Develop a master schedule to include major milestones, spacecraft, instrument, and ground and science segment activities and contingency.
  - If ATP is 10/1/01, can we launch on time?
  - If so, what is the total amount of schedule contingency and where would you distribute it?
  - What is the critical path?

Assumptions:

- The launch vehicle and all facilities and personnel will be available when needed.

Class Exercise: Activity Listing Worksheet

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________

Master Schedule Worksheet

Activity	2001	2002				2003				2004				2005	
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2

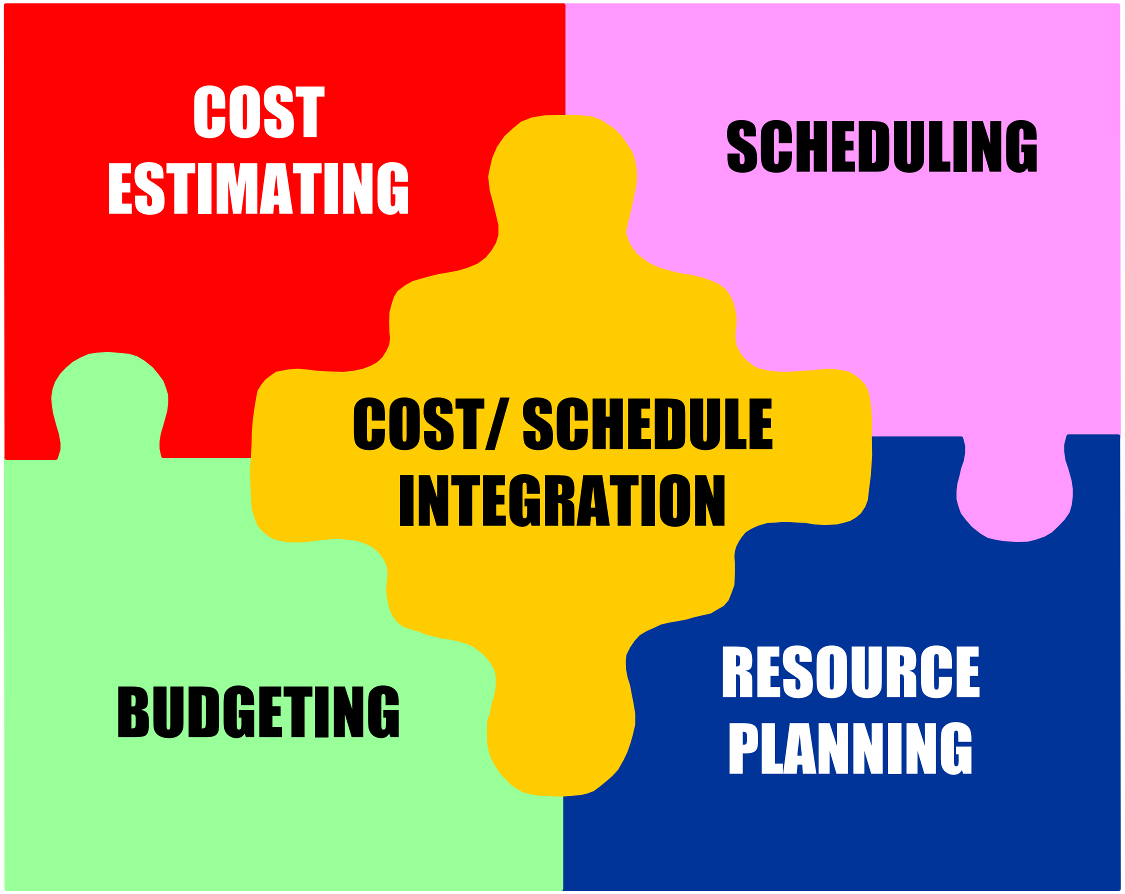
Microsoft Project Demonstration

7.0

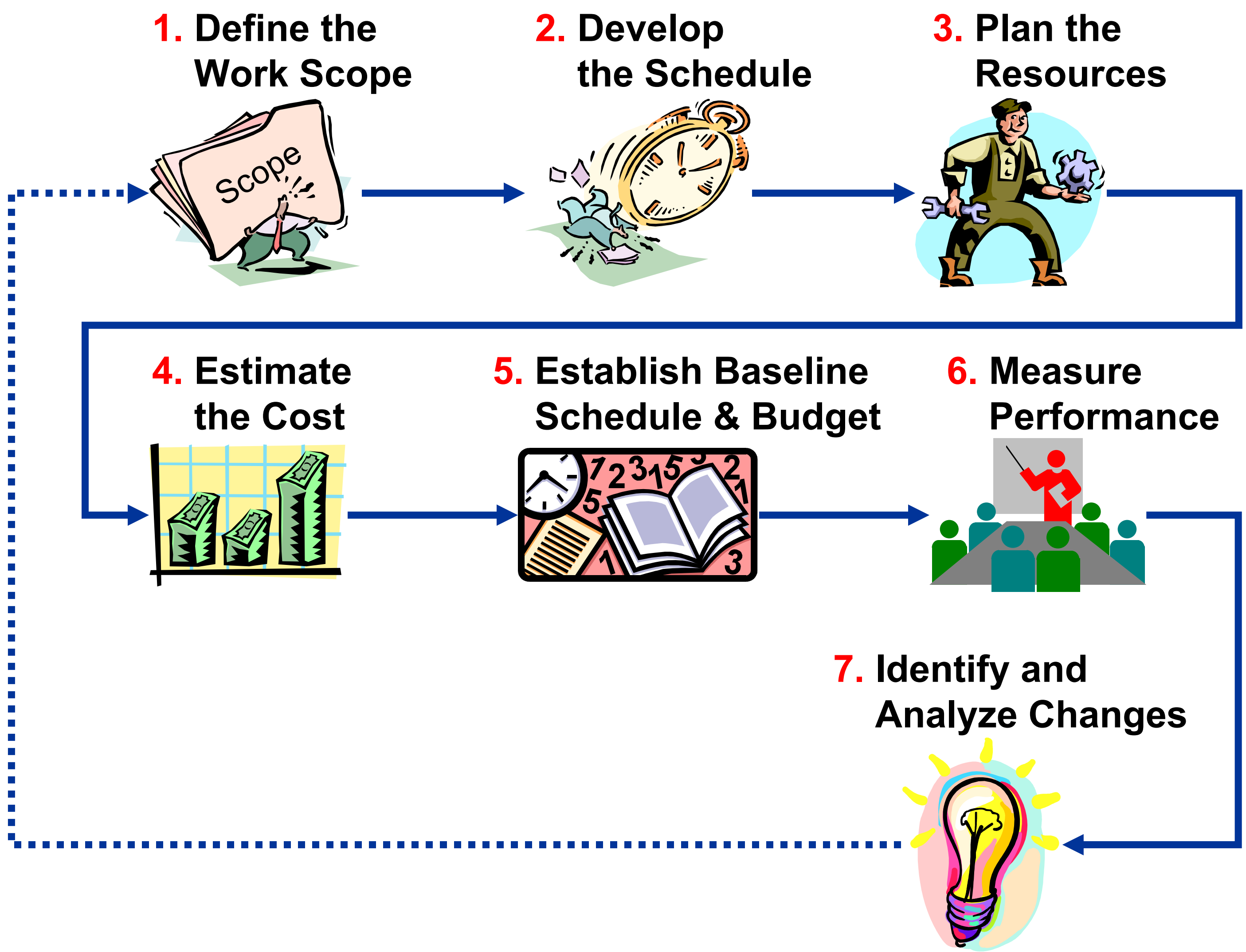
Cost/Schedule Integration

- – Overview
- – Work Definition
- – Schedule Development
- – Resource Planning
- – Cost Estimating
- – Baseline Budget/Schedule
- – Performance Measurement
- – Changes

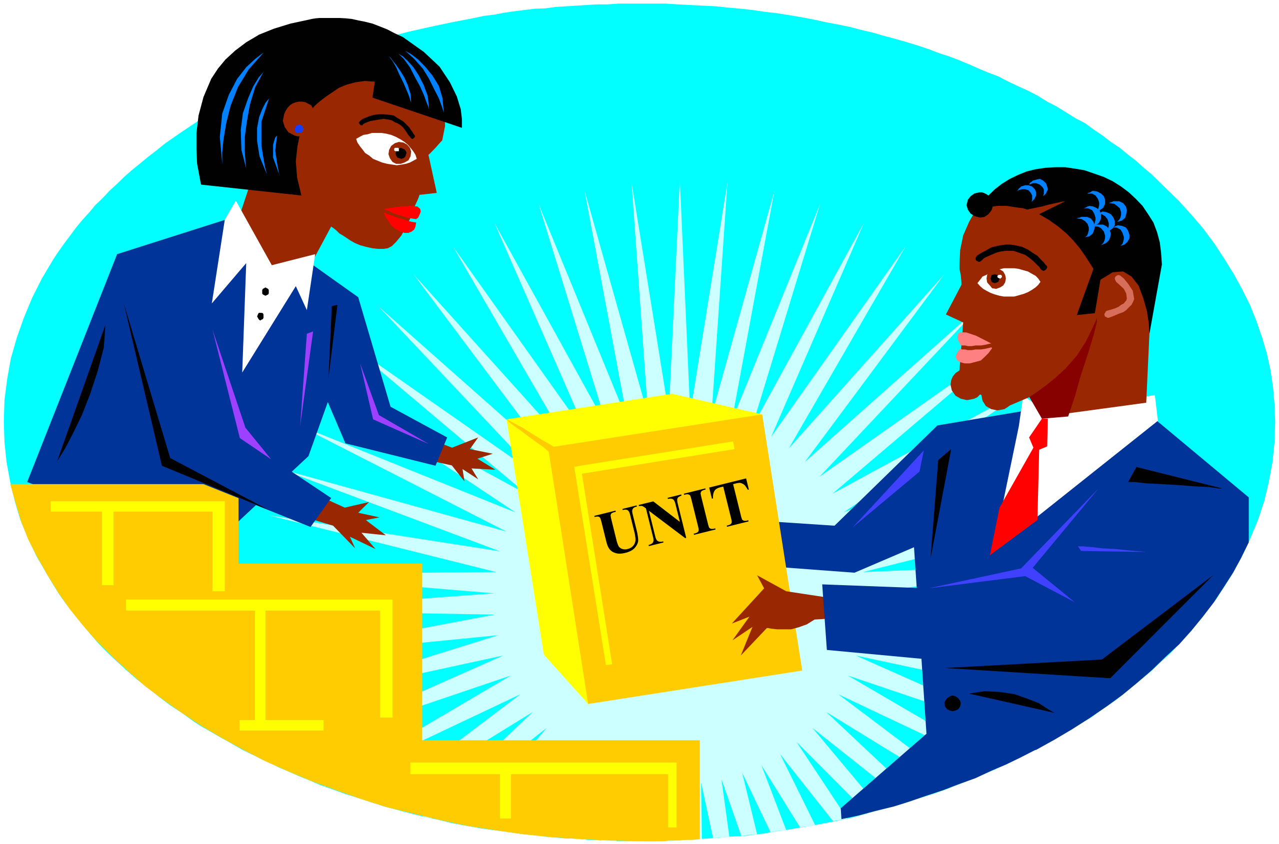
C/SI Brings Related Project Control Elements Together



C/SI Process Flow



Let's Illustrate C/SI



Hurray! The Customer awarded your firm an $8,000 contract to build and deliver a "Unit" on 4/25/01.

C/SI Begins With the Project Manager

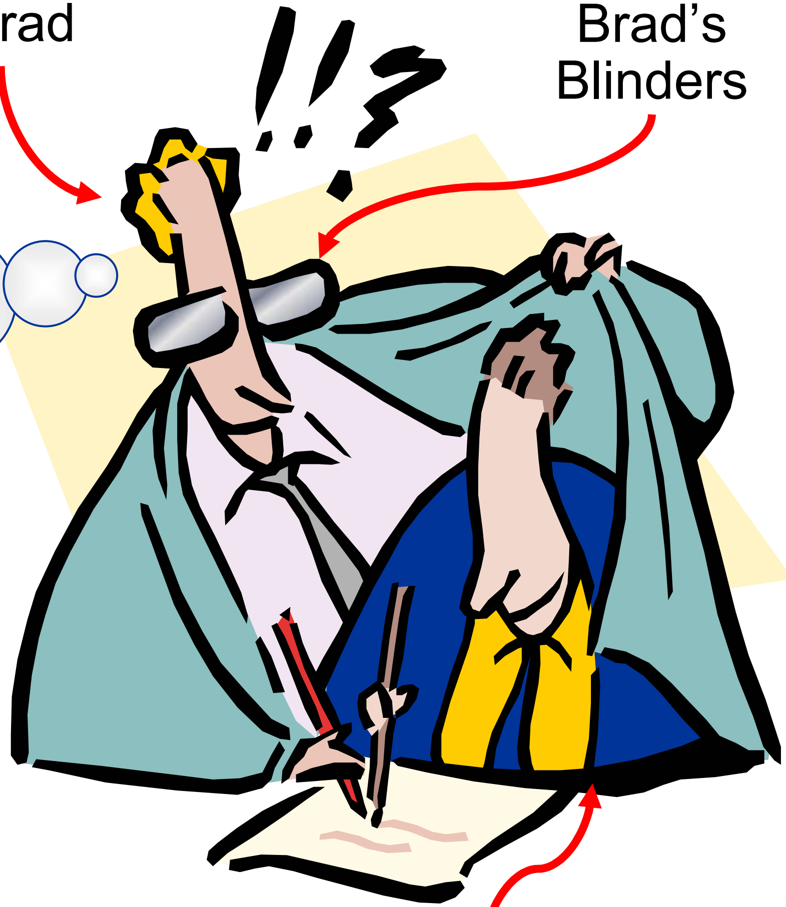
The original proposal team is long gone, so the boss assigns Brad to manage the project and deliver a quality "Unit" on time and within budget.

Not All Project Managers Understand C/SI

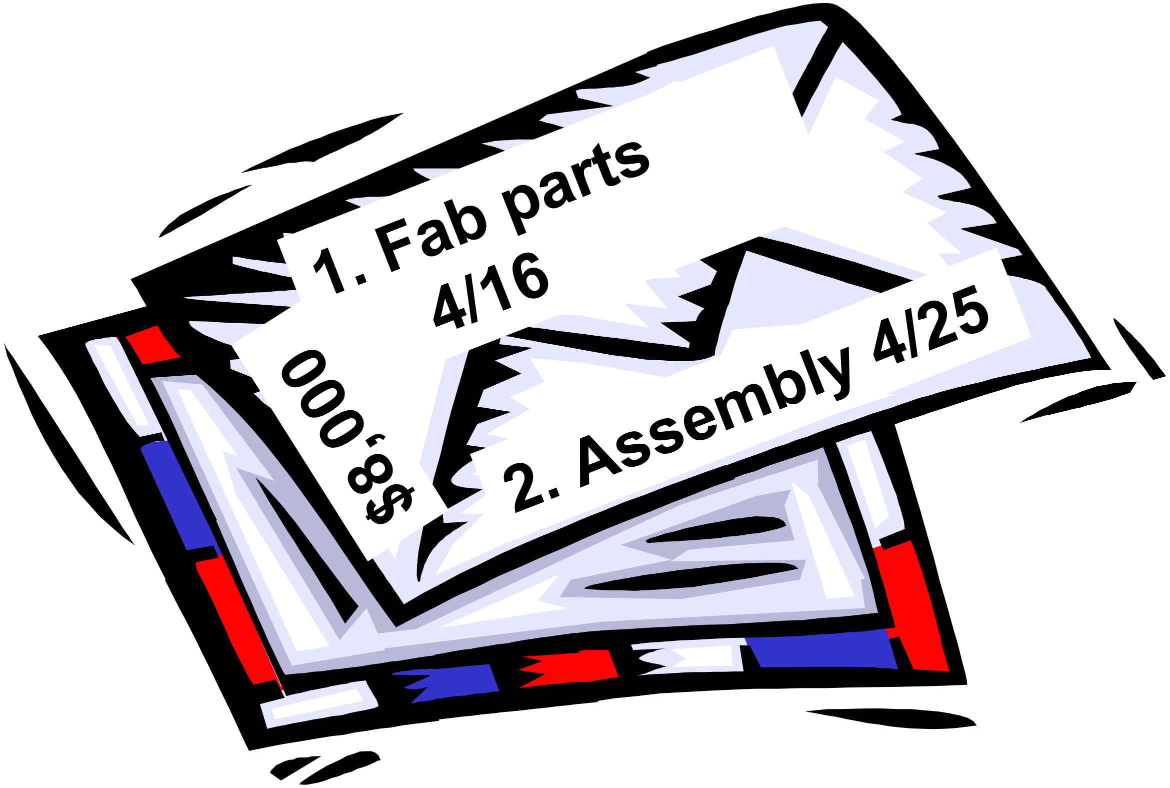
"I don't need all this cost/schedule stuff!

I'll just have Bernie put some dates and dollars on the computer.

I can run this job in my sleep!"



Lack of Planning Leads to Problems



Unfortunately, Brad's "back-of-the-envelope plan" is a bit vague.

C/SI Requires a Team Approach

Al appears to disagree with Brad's budget and schedule.

C/SI is About Communication

Brad is not sure what to do. He's concerned about his project's schedule and cost.

So he decides to get his project team together and develop a plan.

Class Discussion: What Information Should Brad Consider for the Plan?

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________

1. Define the Work Scope

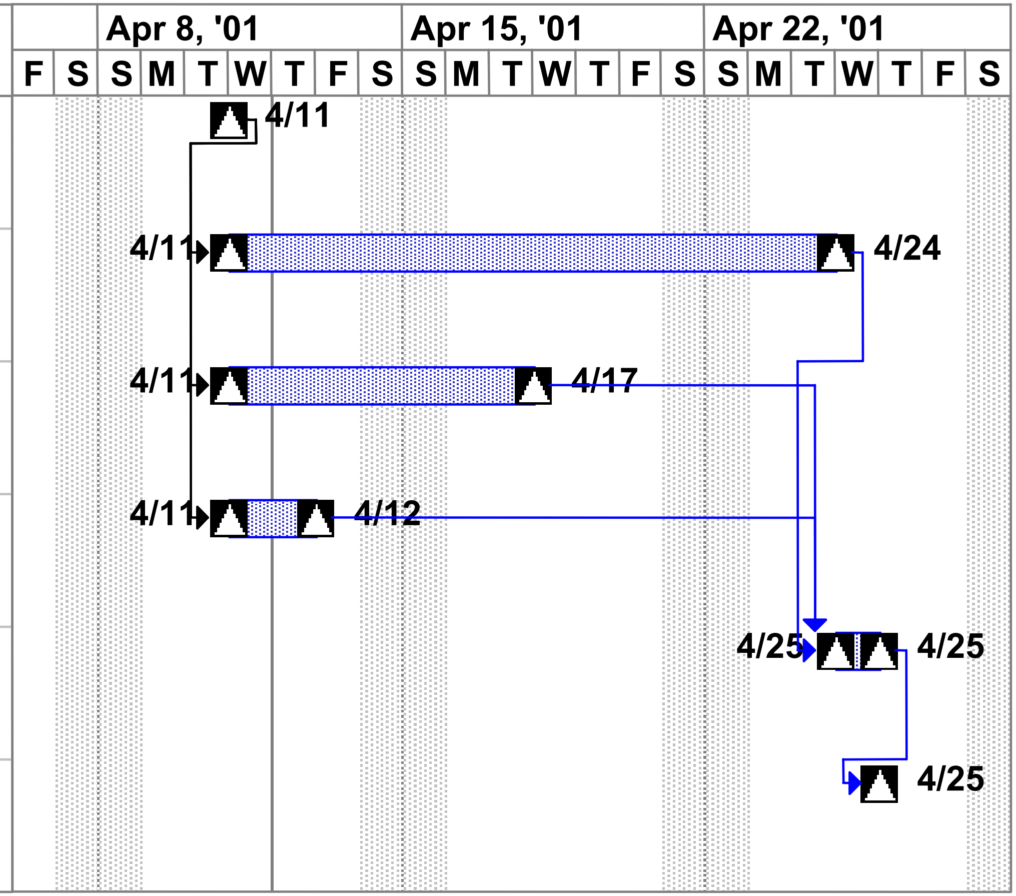
Brad & his project team review the contract SOW, WBS, BOEs, specifications, etc.
Brad also gets "Big" Al involved in the planning.

Once the Work is Defined…

WBS Element	Activity Description	Respons. Person	Est. Duration	Est. Work	Labor Category	Labor Rate	Basis Of Estimate
N/A	Award Contract	Sophia	0 days	0 hours	N/A	N/A	N/A
1.1 Frame	Fabricate Frame	“Big” Al	10 days	80 hours	Mechanical Tech II	$45/hr	Mfg. Standard
1.2 Side Panels	Fabricate Side Panels	“Big” Al	5 days	40 hours	Mechanical Tech II	$45/hr	Mfg. Standard
1.3 Module	Prepare Module	“Big” Al	2 days	16 hours	Mechanical Tech II	$45/hr	Engr. Estimate
1.4 Assembly	Assemble Unit	“Big” Al	1 day	8 hours	Mechanical Tech II	$45/hr	Actuals – similar unit
N/A	Deliver Unit	Brad	0 days	0 hours	N/A	N/A	N/A

2. Develop the Initial Schedule

ID	Task Name	Duration
1	Award Contract	0 days?
2	Fab Housing	10 days?
3	Fab Side Panels	5 days?
4	Prep Module	2 days?
5	Assemble Unit	1 day?
6	Deliver Unit	0 days?



Based on the activities, durations and logic, the team drafts a preliminary schedule.

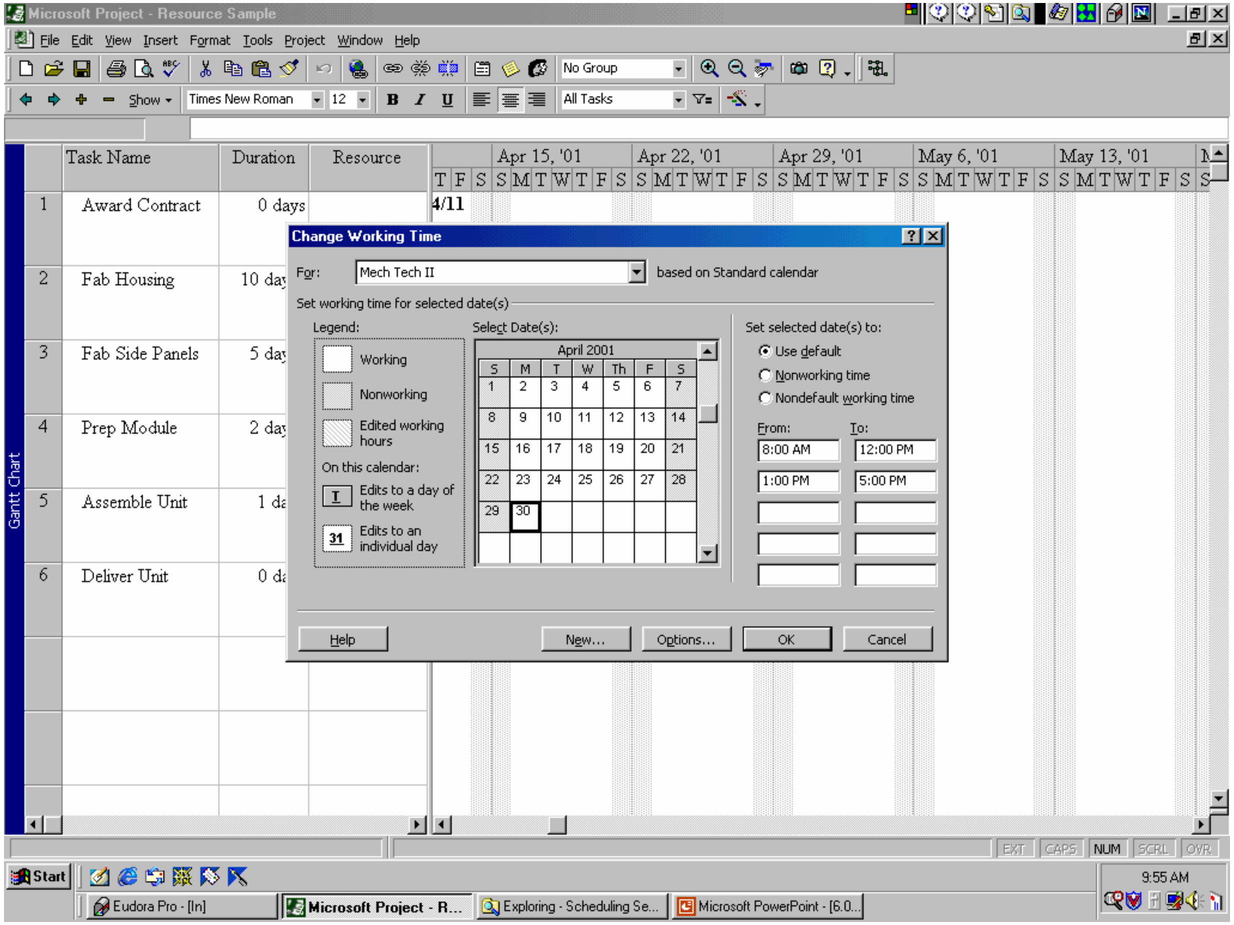
3. Plan the Resources Required

Activity	Hours	Resource
Fab Housing	80	MTII*
Fab Side Panels	40	MTII*
Prep Module	16	MTII*
Assemble Unit	8	MTII*

*Mechanical Technician Grade II

Brad is concerned the initial "Unit" schedule may not be realistic if resource requirements are not taken into account.

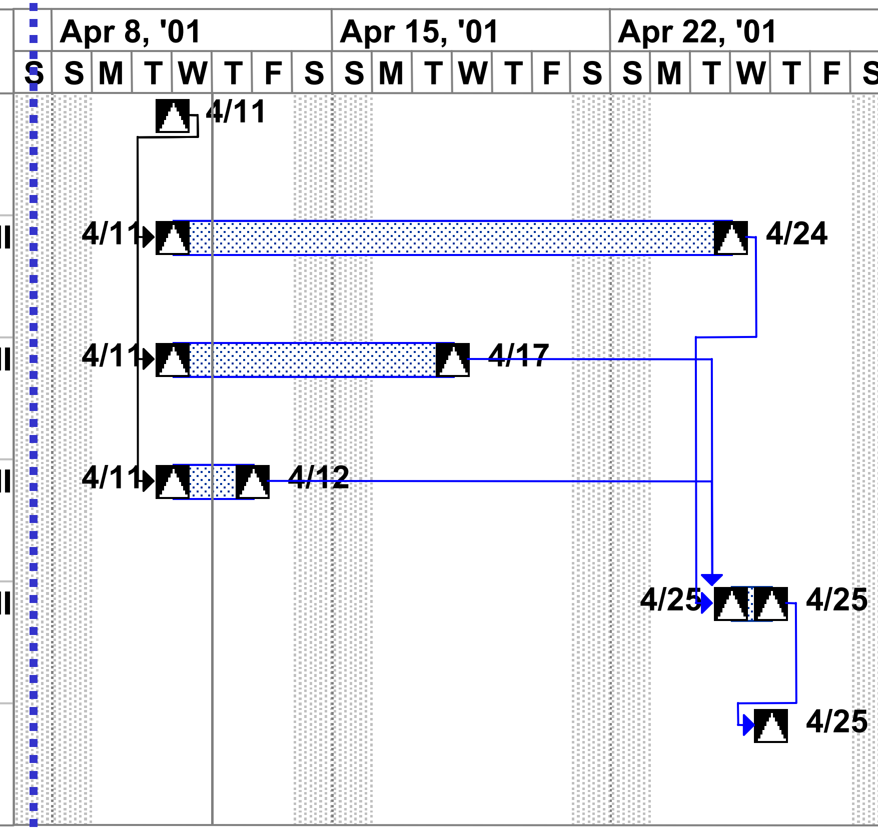
Resource Availability is a Constraint



“Big” Al (shop foreman) has only <u>one</u> “Mechanical Tech II” to assign to Brad’s job.

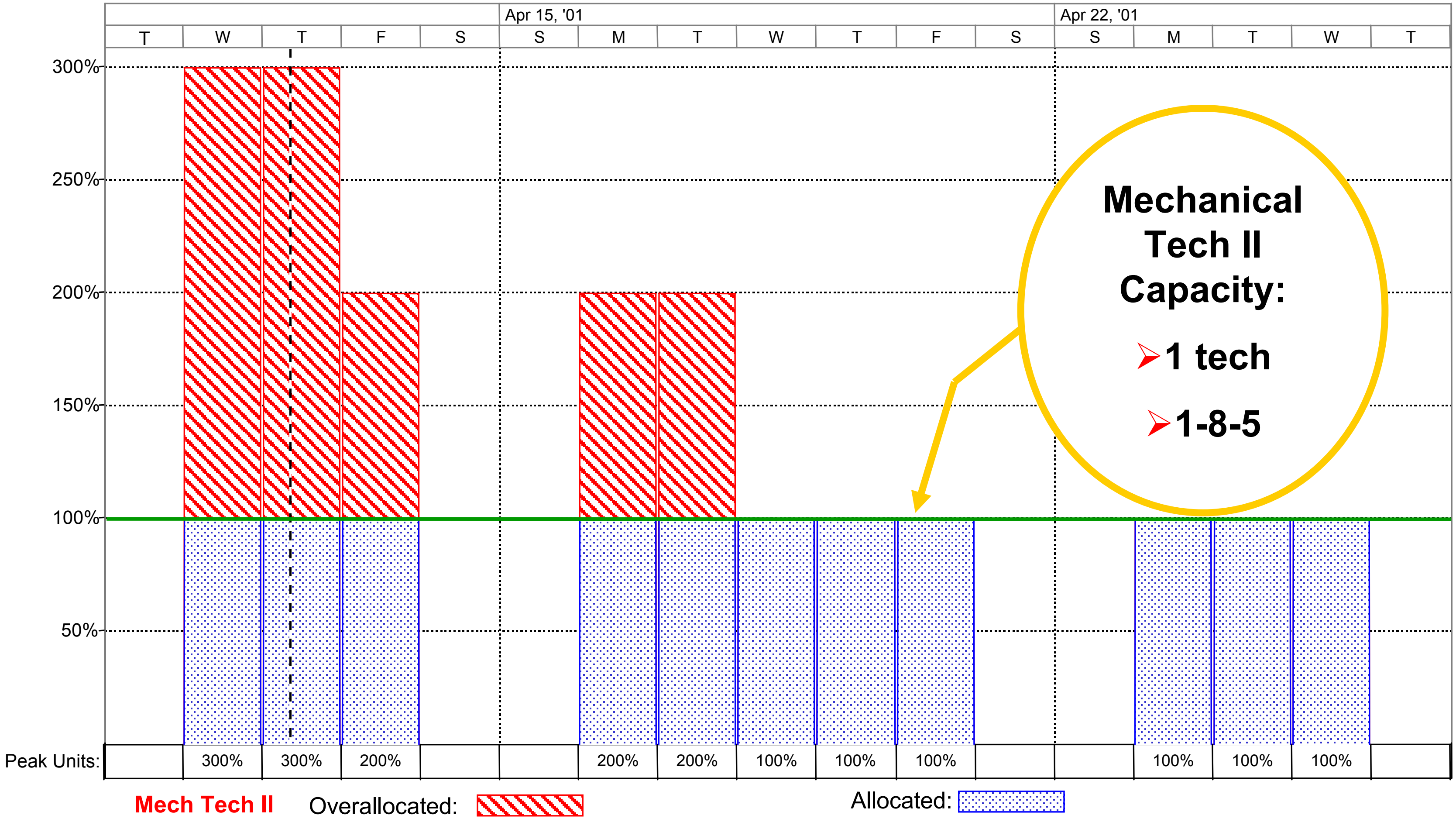
Resources are Allocated or "Loaded"

ID	Task Name	Duration	Work	Resource
1	Award Contract	0 days?	0 hrs	
2	Fab Housing	10 days?	80 hrs	Mech Tech II
3	Fab Side Panels	5 days?	40 hrs	Mech Tech II
4	Prep Module	2 days?	16 hrs	Mech Tech II
5	Assemble Unit	1 day?	8 hrs	Mech Tech II
6	Deliver Unit	0 days?	0 hrs	



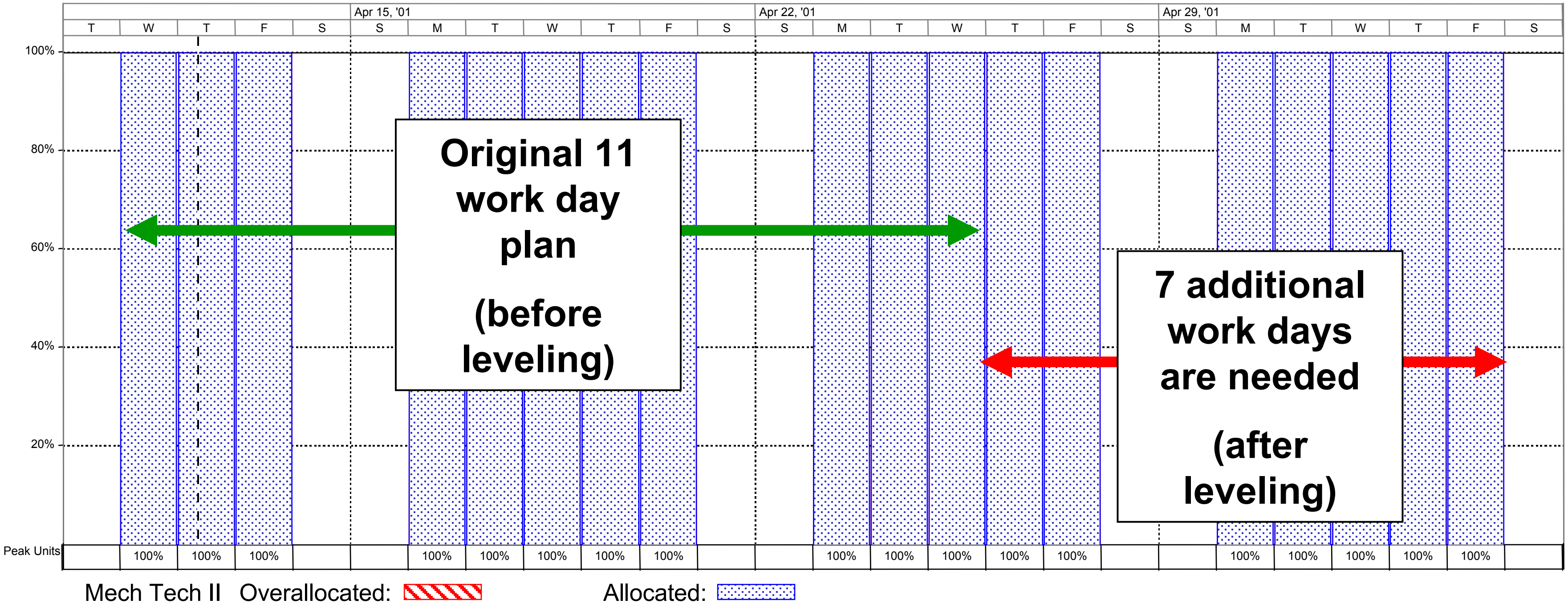
Resources and work estimates are assigned to the activities in the preliminary schedule.

Initial Resource Profile



The shortage or over-commitment of resources is determined by profiling the requested resources and comparing them to their availability or capacity.

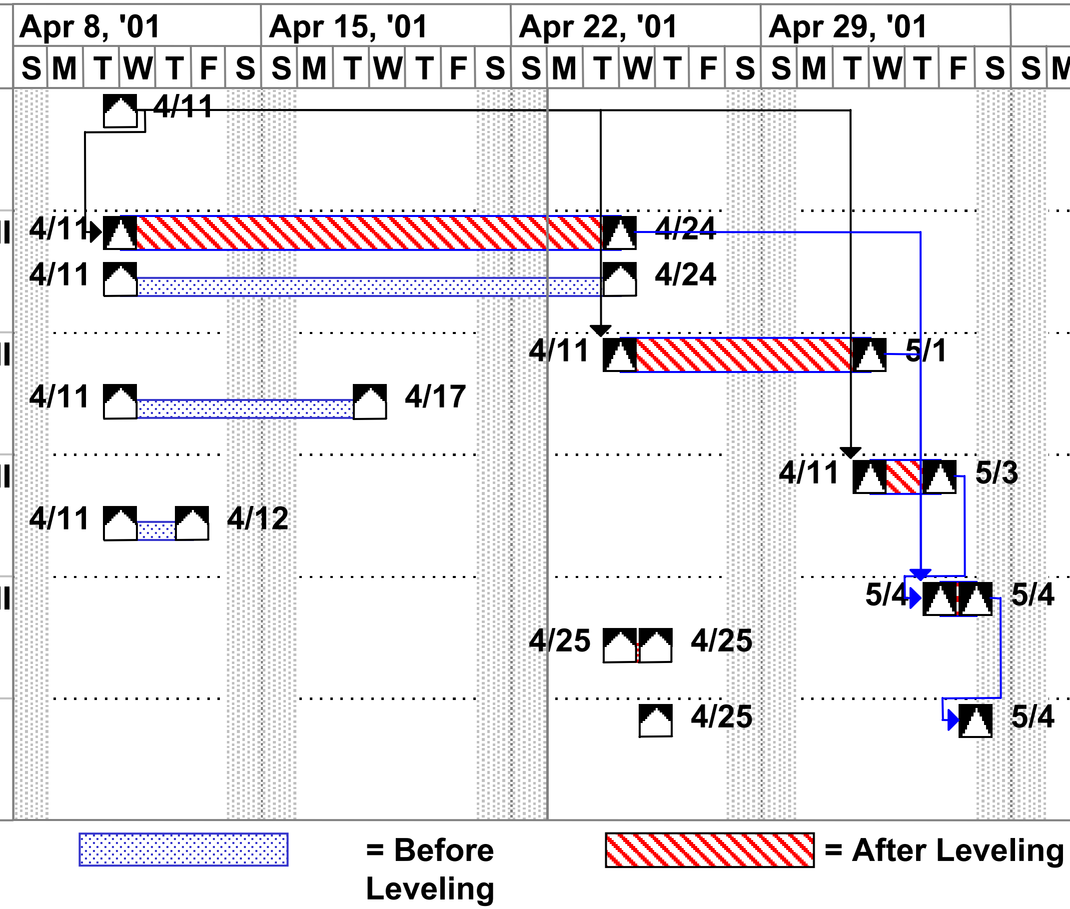
"Leveled" Resource Profile



Brad decides to "level" or smooth his "Mechanical Tech II" resource allocation to fit the available capacity of one MTII.

Resource-Constrained Schedule

ID	Task Name	Duration	Work	Resource
1	Award Contract	0 days	0 hrs	
2	Fab Housing	10 days	80 hrs	Mech Tech II
3	Fab Side Panels	5 days	40 hrs	Mech Tech II
4	Prep Module	2 days	16 hrs	Mech Tech II
5	Assemble Unit	1 day	8 hrs	Mech Tech II
6	Deliver Unit	0 days	0 hrs	



"Leveling" the resources results in a more realistic schedule, but the "Unit" can not be delivered on 4/25/01 as currently planned.

Always Consider Resources When Developing Schedules!

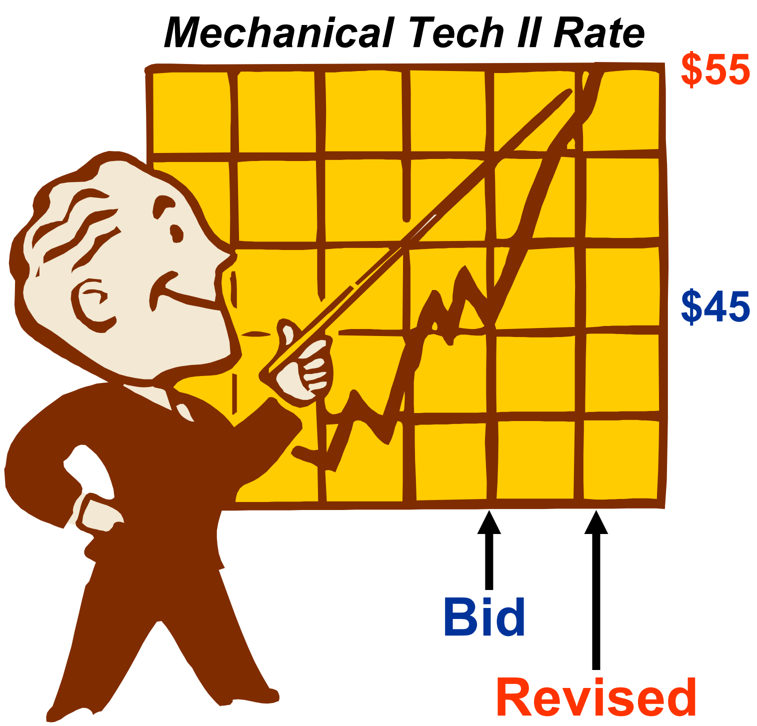
Duration Number of work periods or length of time needed if adequate resources are available	
Work Amount of effort needed to accomplish an activity	**Resources** People, equipment, facilities, etc. needed to perform the work

Realistic schedules must account for resource availability – which help define an accurate cost estimate and budget.

Class Discussion: What Are Some Other Types of Resources?

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________

4. Estimate The Cost



Since Brad's company bid on this job, the labor rate for "Mechanical Tech II" has escalated 22% from $45/hr. to $55/hr.

Revised Cost Estimate

Original Cost Estimate

Activity	Hours		Rate		Cost
Fab Housing	80	x	$45	=	$3,600
Fab Side Panels	40	x	$45	=	$1,800
Prep Module	16	x	$45	=	$720
Assemble Unit	8	x	$45	=	$360
TOTALS	144				$6,480

Revised Cost Estimate

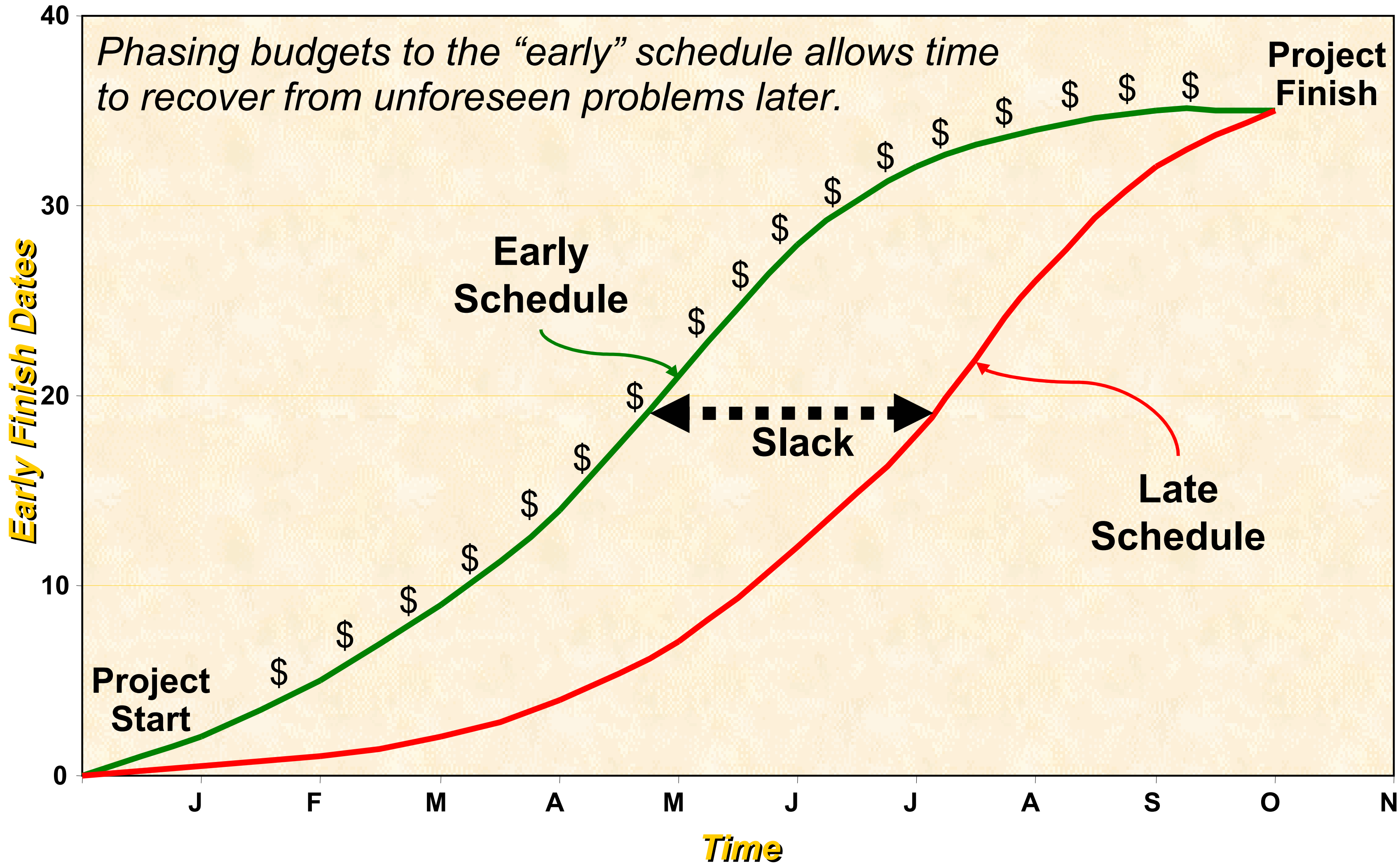
Activity	Hours		Rate		Cost
Fab Housing	80	x	$55	=	$4,400
Fab Side Panels	40	x	$55	=	$2,200
Prep Module	16	x	$55	=	$880
Assemble Unit	8	x	$55	=	$440
TOTALS	144				$7,920

With a better understanding of the scope, schedule, and resources, a new cost estimate is prepared.

5. Establish the Integrated Cost/Schedule Baseline

ID	Task Name	Work	Rate/Hr.	Budget	Resp.	Start	Finish	Details	April				May
									4/1	4/8	4/15	4/22	4/29
1	Award Contract	0 hrs	$0.00	$0.00	Sophia	4/11/01	4/11/01	Work					
								Cost					
2	Fab Housing	80 hrs	$0.00	$4,400.00	"Big" Al	4/11/01	4/24/01	Work		24h	40h	16h	
								Cost		$1,320.00	$2,200.00	$880.00	
	Mech Tech II	80 hrs	$55.00	$4,400.00		4/11/01	4/24/01	Work		24h	40h	16h	
								Cost		$1,320.00	$2,200.00	$880.00	
3	Fab Side Panels	40 hrs	$0.00	$2,200.00	"Big" Al	4/25/01	5/1/01	Work				24h	16h
								Cost				$1,320.00	$880.00
	Mech Tech II	40 hrs	$55.00	$2,200.00		4/25/01	5/1/01	Work				24h	16h
								Cost				$1,320.00	$880.00
4	Prep Module	16 hrs	$0.00	$880.00	"Big" Al	5/2/01	5/3/01	Work					16h
								Cost					$880.00
	Mech Tech II	16 hrs	$55.00	$880.00		5/2/01	5/3/01	Work					16h
								Cost					$880.00
5	Assemble Unit	8 hrs	$0.00	$440.00	"Big" Al	5/4/01	5/4/01	Work					8h
								Cost					$440.00
	Mech Tech II	8 hrs	$55.00	$440.00		5/4/01	5/4/01	Work					8h
								Cost					$440.00
6	Deliver Unit	0 hrs	$0.00	$0.00	Brad	5/4/01	5/4/01	Work					
								Cost					

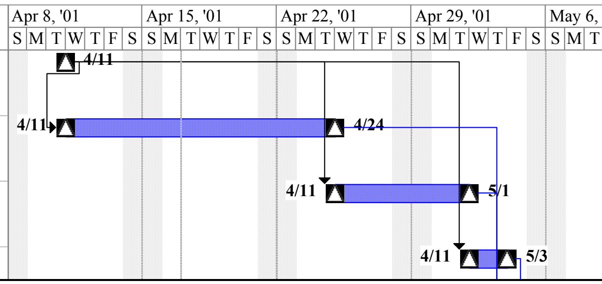
The Cost/Schedule Baseline



6. Measure Performance

Project Schedule

ID	Task Name	Duration
1	Award Contract	0 days
2	Fab Housing	10 days
3	Fab Side Panels	5 days
4	Prep Module	2 days
5	Assemble Unit	
6	Deliver Unit	



Schedules

Resource Task Usage - Labor Hours

Activity	Resources	4/8/01	4/15/01	4/22/01	4/29/01	Total
Fab Housing						
	Mech Tech II	24.00	40.00	16.00		80.00
Fab Side Panels						
	Mech Tech II			24.00	16.00	40.00
Prep Module						
	Mech Tech II				16.00	16.00
Assemble Unit						
	Mech Tech II					
Total		24.00				

Resources

Cost

Budget Phasing

Activity	4/8/01	4/15/01	4/22/01	4/29/01	Total
Fab Housing	$1,320.00	$2,200.00	$880.00		$4,400.00
Fab Side Panels			$1,320.00	$880.00	$2,200.00
Prep Module				$880.00	$880.00
Assemble Unit				$440.00	$440.00
Total	$1,320.00	$2,200.00	$2,200.00	$2,200.00	$7,920.00

Class Discussion

PLEASE DON'T TURN THE PAGE !

What alternatives do Brad and his team have to:

- **Meet the contract delivery date?**
- **Complete the job without overrunning the cost?**

C/SI is Central to Project Control

Subcontract

Overtime

Add Resources

Workarounds

Descope

Renegotiate Delivery

An integrated budget & schedule helps Brad analyze options for meeting objectives

So What Happened to Brad's Project?

Brad's contract administrator, Sophia, negotiated a no-cost change in delivery of the "Unit" from 4/25/01 to 5/5/01 – but the contract value remained $8,000.

The Lesson of Cost/Schedule Integration

Cost

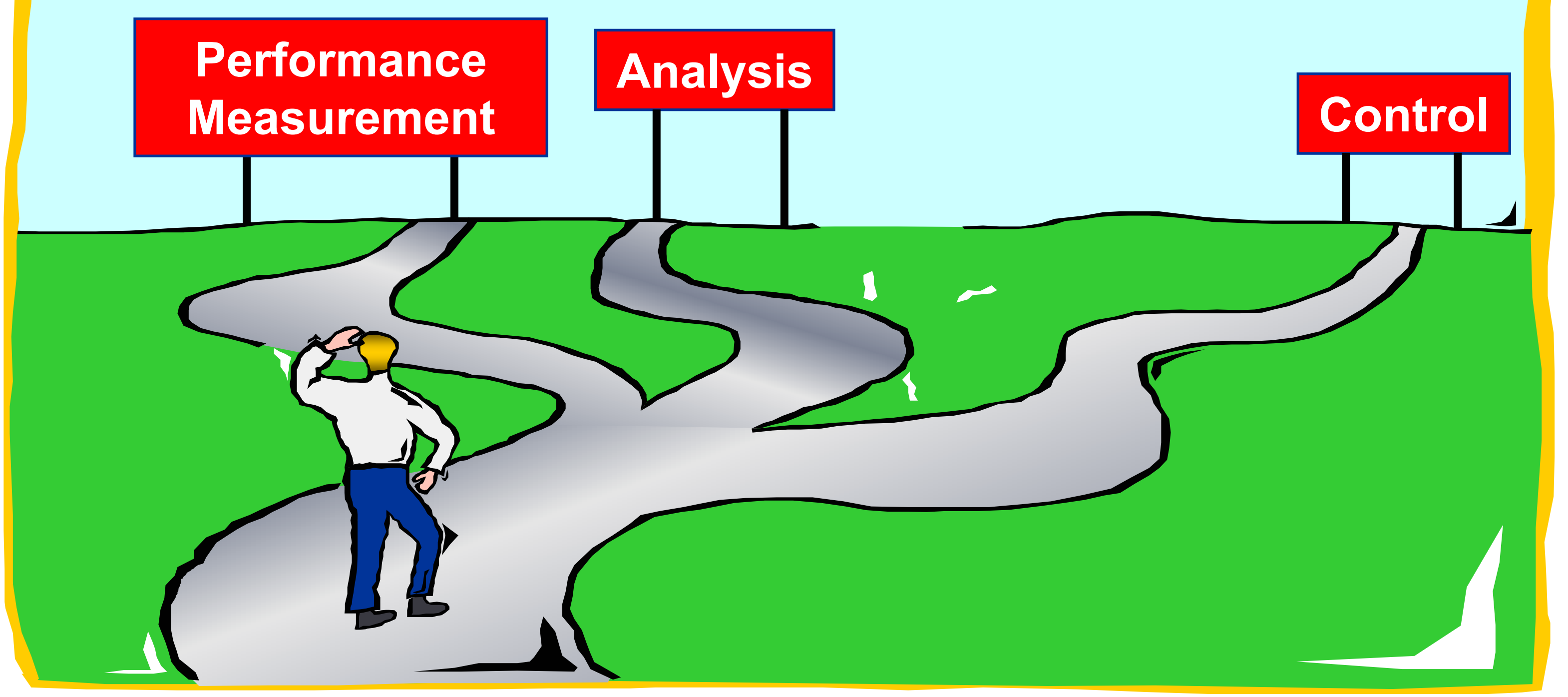
Schedule

Time is money . . .

. . . C/SI enables projects to coordinate planning in order to help meet their objectives on time and within budget.

An Integrated C/S Plan is Just the Start…

Brad must also navigate the routes of C/S Performance Measurement, Analysis & Control



… but that's another story!

8.0
Schedule Status Accounting

Schedule Status Accounting

Schedule Status Accounting is the process of collecting data about:

- a) the condition of activities that were underway or scheduled to start or finish during the reporting period; and
- b) forecasts for activities not yet started.

This data is updated in the project schedule database.

INPUT

- Actual work results and forecasts from:
  - Contractor Schedules
  - Tech Leads
- Project Reviews
- Formal schedule status meetings
- CDRLs

PROCESS

Update Schedule Database

- Actual starts
- Actual finishes
- Expected starts
- Expected Finishes
- Remaining Duration
- % complete

OUTPUT

- Updated Project Schedule Database with:
  - Current status
  - Forecasts-to-complete
  - Slack

Sources of Schedule Status

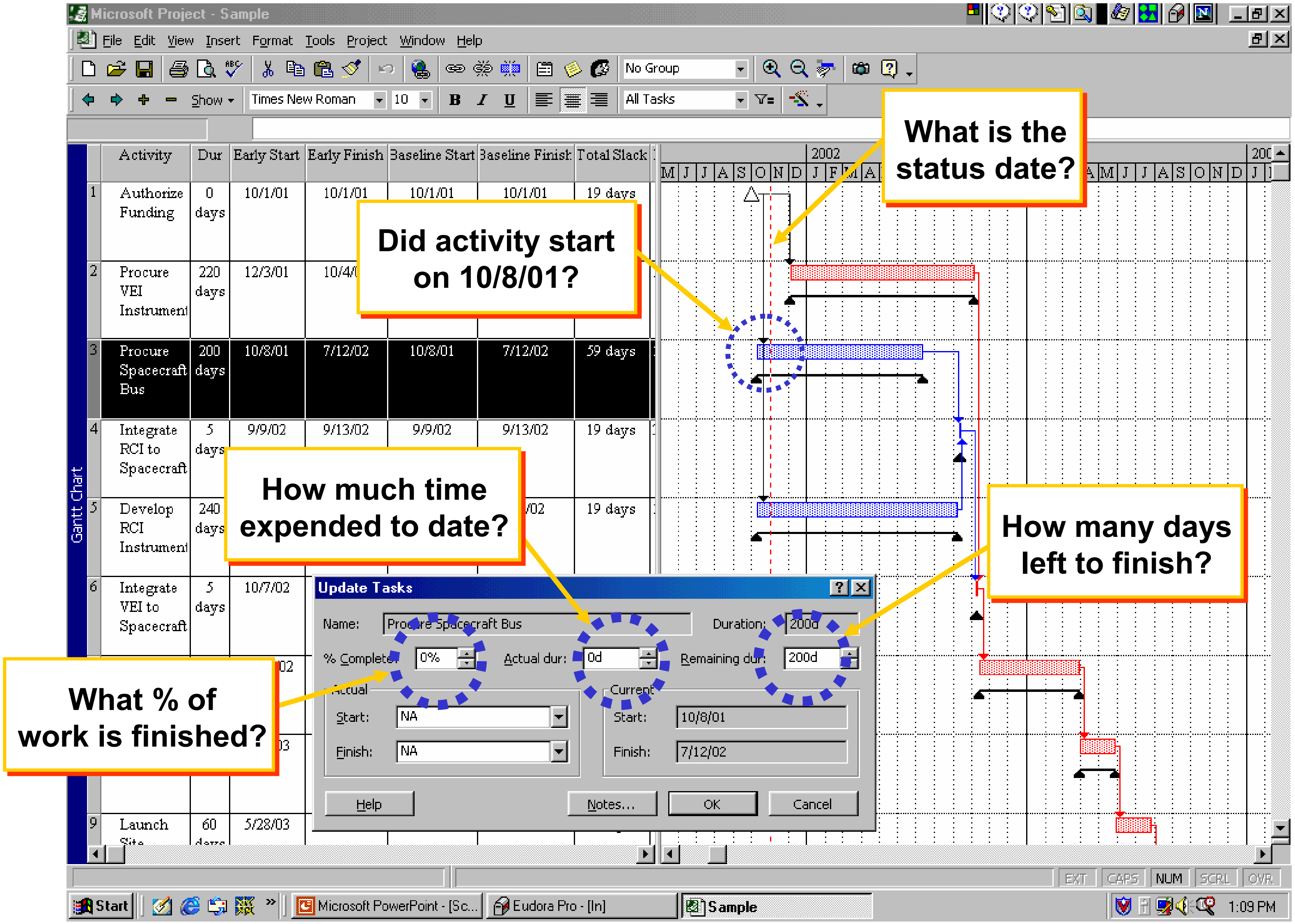
"In-House" Project

- Status meetings with subsystem and instrument managers; logic network "redlines"
- Receipt of updated detailed schedules from subsystem and instrument managers
- Project status reviews
- I&T stand-up meetings
- Informal meetings with functional support (e.g., thermal, test, procurement)

"Out-of-House" Project

- CDRLs
- E-mail/FTP of contractor schedule files
- Contractor teleconferences
- On-site contractor project status reviews
- Formal communications with contractor schedulers
- Informal discussions with contractor technical staff and schedulers

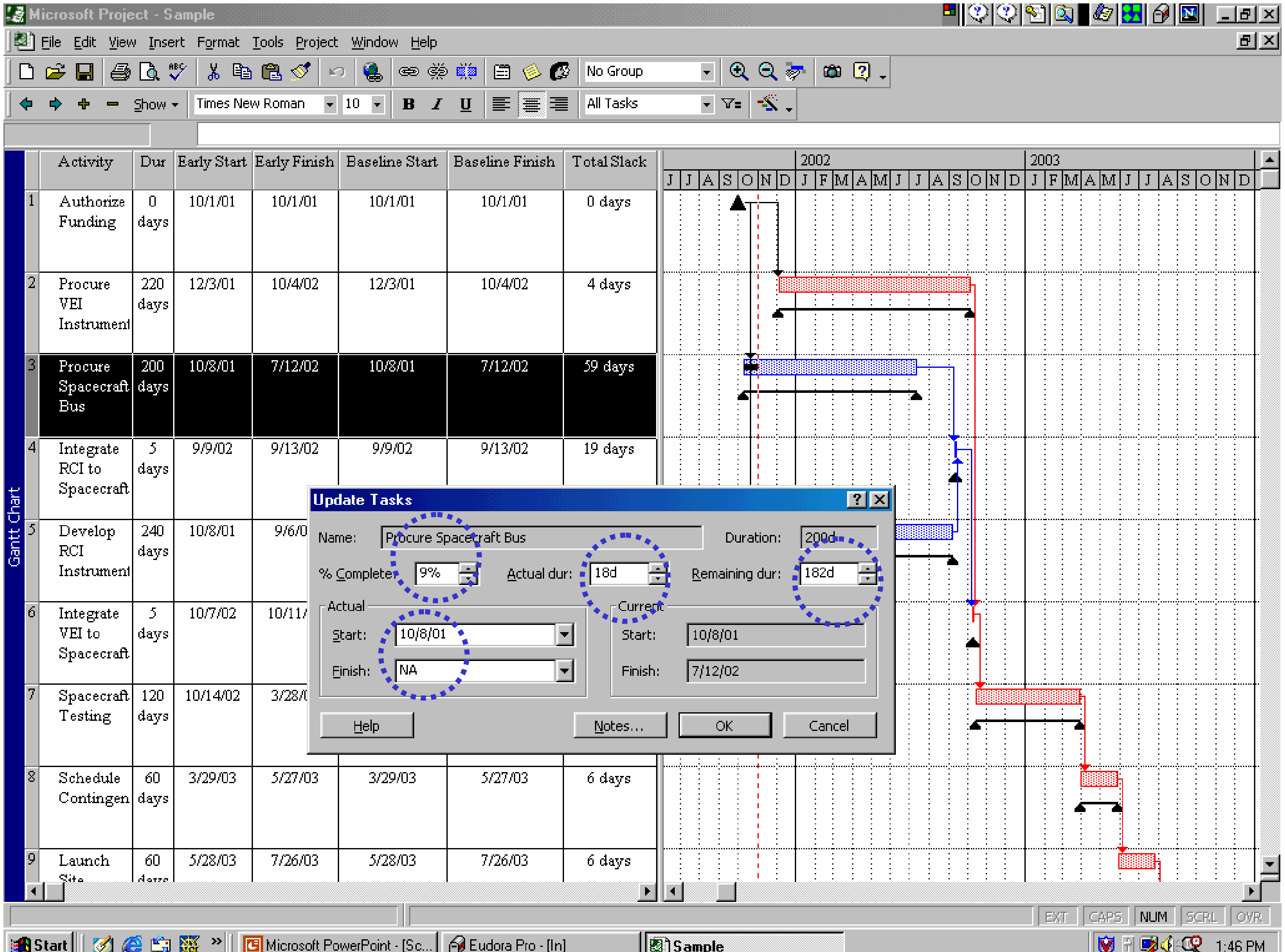
What Schedule Data is Needed?



NBT Status Data as of 10/31/01

- ✓ **Activity #1 *"Authorize Funding"*** for NBT occurred as expected on 10/1/01
- ✓ **Activity #3 *"Procure Spacecraft Bus"*** started as planned on 10/8/01; bus expected to be delivered on time
- ✓ **Activity #5 *"Develop RCI Instrument"*** started as planned on 10/8/01; RCI expected to be completed on time
- ✓ All other activities are anticipated to start/finish as originally planned

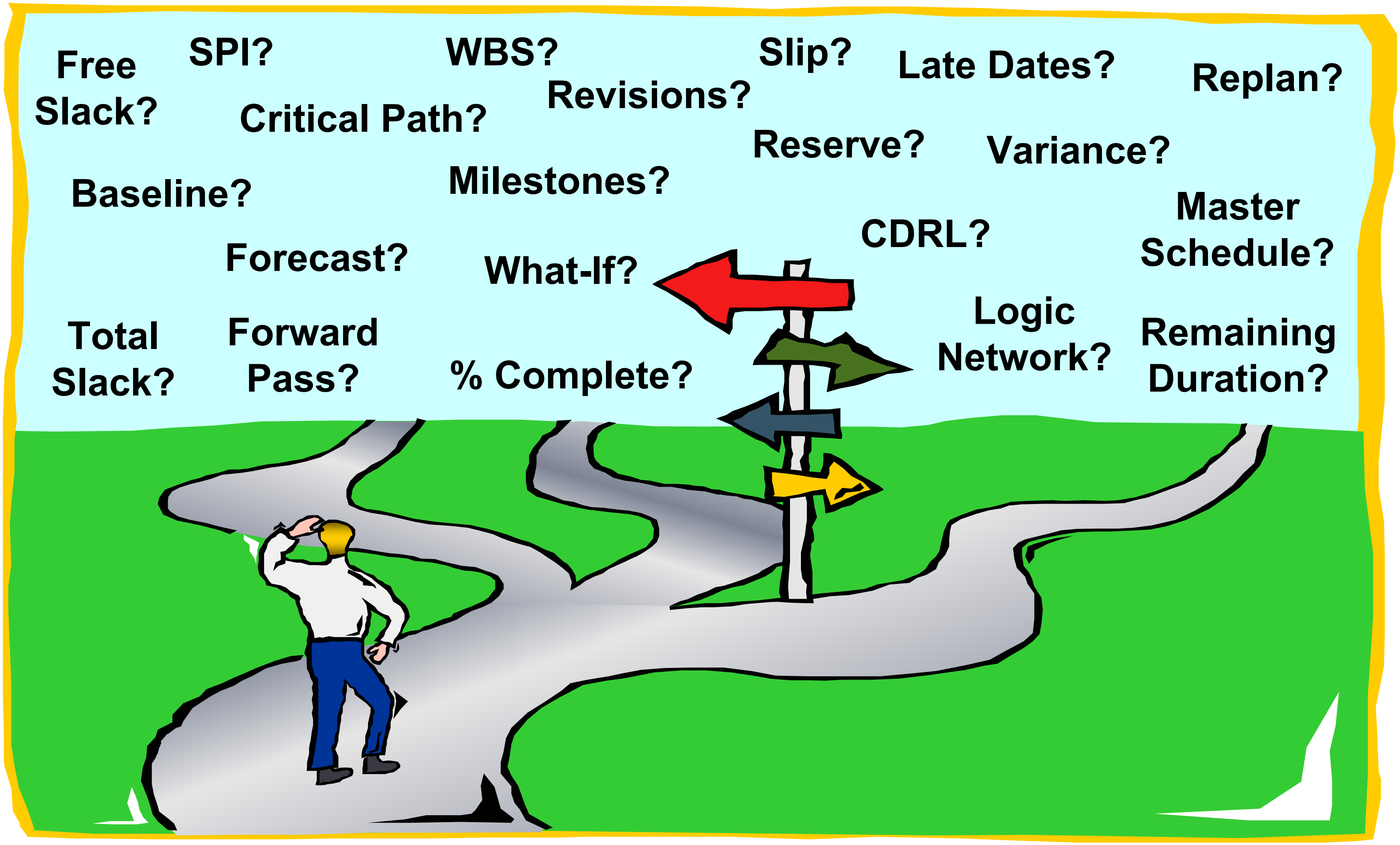
Input Status Into the Schedule Database



9.0
Schedule Analysis

- Overview
- Critical Path
- Accuracy
- Integration
- Realism
- Performance
- Variances
- Forecasting
- What-If
- Risk
- Resources

Schedule Analysis



Schedule Analysis

Schedule Analysis is the process of evaluating schedule results and assessing the magnitude, impact, and significance of actual and forecast variations to the baseline and/or current operating schedules. It begins with the re-calculation of the critical path and the determination of any change in the completion date of the project. Analysis continues by diagnosing the health of the project schedule and its direction.

INPUT

- Baseline Schedule
- Schedule Performance
- Current Schedule
- Changes
- Potential problems

PROCESS

Schedule Analysis Techniques (See Next 2 Pages)

OUTPUT

- Critical Path
- Analysis Reports
- Analysis Metrics
- "What-If" Schedules
- Forecasts

What Schedule Analysis Can Tell Us *(1 of 2)*

Critical Path: what is driving the project's completion?

Accuracy: is the schedule data correct?

Integration: are activity relationships properly defined?

Realism: is the schedule achievable?

Performance: are activities being accomplished in an efficient and timely manner?

Variances: are differences from the baseline significant?

Trends: is the schedule's direction favorable or unfavorable?

- Performance
- Slack
- Reserve/contingency

What Schedule Analysis Can Tell Us *(2 of 2)*

Forecasting: what is the predicted future schedule performance?

What-If: what is the impact on the project's schedule objectives of potential problems and changes?

Risk: is there a significant likelihood of not meeting the project's schedule objectives?

Resources: have sufficient resources been planned to efficiently accomplish the project's schedule activities and achieve it's objectives?

- Identification
- Allocation
- Analysis
- Leveling

Why Perform Schedule Analysis?

- **A realistic schedule is only a starting point**
- **Project teams needs information to help keep the project on track in order to meet objectives**
- **Schedule analysis provides that information and aids in:**
  - **Determining if objectives can be accomplished on time**
  - **Monitoring the adequacy of schedule slack and reserve**
  - **Assessing the likelihood of potential schedule problems**
  - **Reallocating resources to where they are needed most**
  - **Identifying project schedule priorities**
  - **Highlighting the likelihood of overrunning the project schedule**
  - **Evaluating the effect of new scope changes**
  - **Understanding the cause of schedule problems, their impact and what corrective action is needed to mitigate or avoid them**

Why Perform Schedule Analysis? *(2 of 2)*

- Since management and/or customers will examine the schedule and draw conclusions - the project team needs to be in a position to understand and defend its schedule
  - With "out-of-house" projects, the team needs to understand it's contractors' (and their subcontractors') schedule
  - With "in-house" projects, the team needs to understand its own internal schedule
- Without ongoing schedule analysis, the project team risks:
  - Schedule delays
  - Cost overruns
  - Failure to meet technical requirements
  - Unexpected problems and the fire drills to fix them
  - Replacement of the management team
  - Cancellation

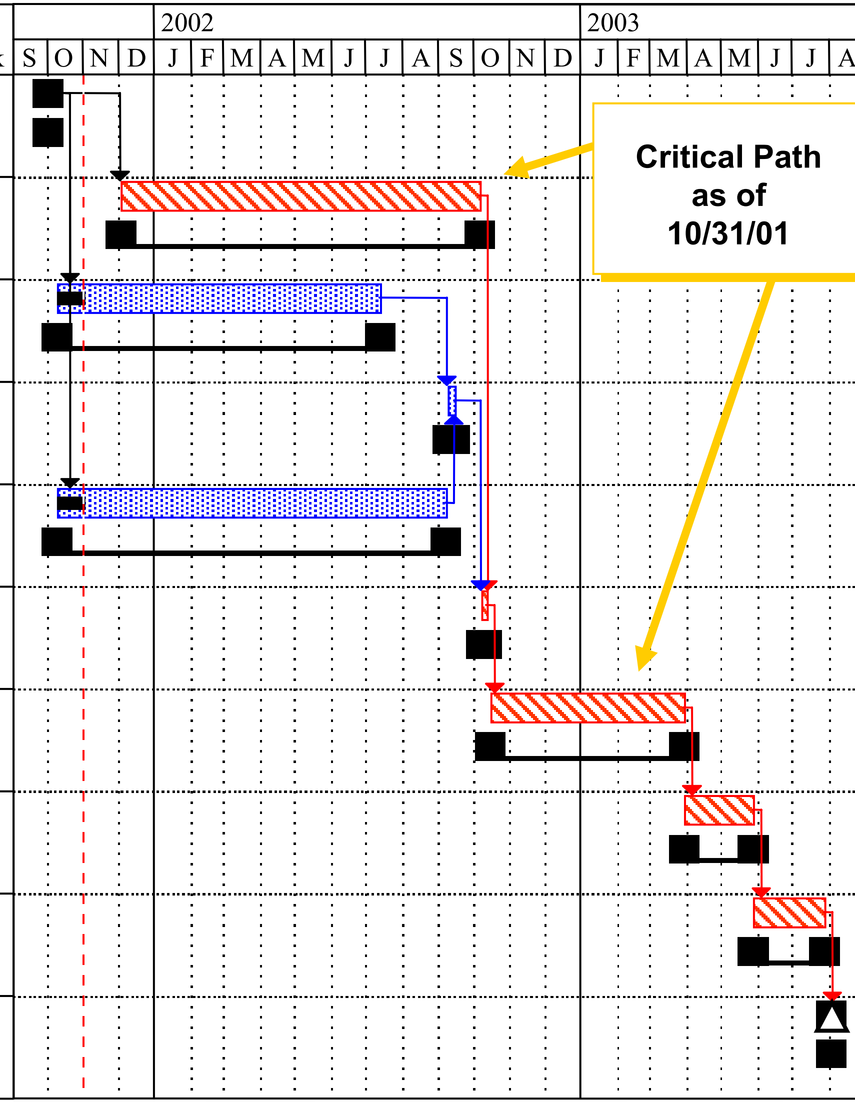
Critical Path

Are there changes to the critical path since the schedule was last updated?

NBT Project Schedule

as of 10/31/01

ID	Activity	Dur	Early Start	Early Finish	Total Slack
1	Authorize Funding	0 days	10/1/01	10/1/01	0 days
2	Procure VEI Instrument	220 days	12/3/01	10/4/02	4 days
3	Procure Spacecraft Bus	200 days	10/8/01	7/12/02	59 days
4	Integrate RCI to Spacecraft	5 days	9/9/02	9/13/02	19 days
5	Develop RCI Instrument	240 days	10/8/01	9/6/02	19 days
6	Integrate VEI to Spacecraft	5 days	10/7/02	10/11/02	4 days
7	Observatory Testing	120 days	10/14/02	3/28/03	4 days
8	Schedule Contingency	60 days	3/29/03	5/27/03	6 days
9	Launch Site Operations	60 days	5/28/03	7/26/03	6 days
10	Launch	0 days	8/1/03	8/1/03	0 days



REV: Baseline 8/15/01

But It's Now One Month Later

It's 11/30/01, one month since we last statused the NBT project schedule…

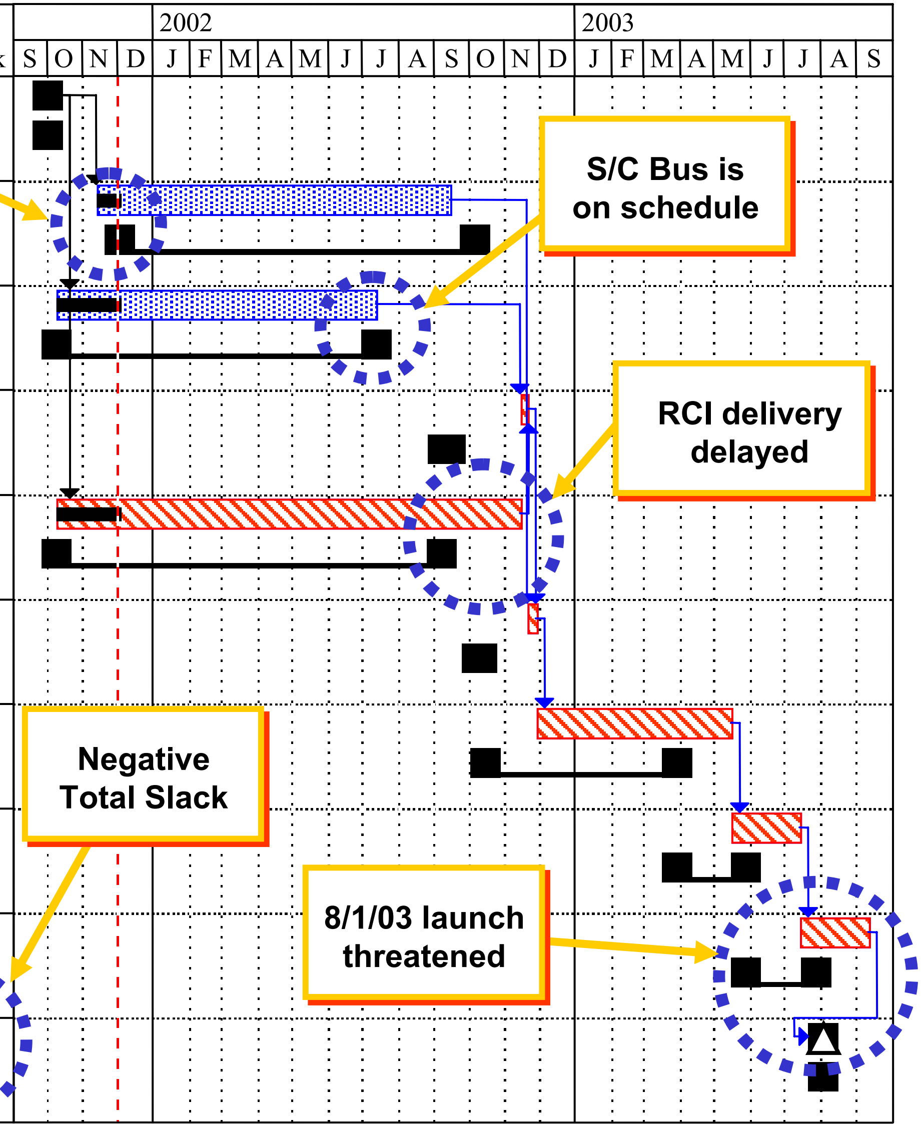
- **The spacecraft bus procurement is on track with no problems; delivery remains 7/12/02**
- **GSFC contract negotiation priorities were re-examined and the VEI contract was actually awarded on 11/12/01 - three weeks ahead of schedule**
- **GSFC management temporarily diverted most of the RCI development team to work on a proposal; RCI delivery is now forecast to slip two months to 11/13/02**

You update the NBT project schedule and . . . . . .

NBT Project Schedule

as of 11/30/01

ID	Activity	Dur	Early Start	Early Finish	Total Slack
1	Authorize Funding	0 days	10/1/01	10/1/01	0 days
2	Procure VEI Instrument	220 days	11/12/01	[illegible]	[illegible]
3	Procure Spacecraft Bus	200 days	10/8/01	7/12/02	59 days
4	Integrate RCI to Spacecraft	5 days	11/14/02	11/20/02	-29 days
5	Develop RCI Instrument	288 days	10/8/01	11/13/02	-29 days
6	Integrate VEI to Spacecraft	5 days	11/21/02	11/27/02	-29 days
7	Observatory Testing	120 days	11/28/02	5/14/03	-29 days
8	Schedule Contingency	60 days	5/15/03	7/13/03	-41 days
9	Launch Site Operations	60 days	7/14/03	9/11/03	-41 days
10	Launch	0 days	8/1/03	8/1/03	-41 days



REV: Baseline 8/15/01

Class Discussion

What alternatives could the NBT consider for:

- Recovering the -41 days of total slack and still launch on August 1, 2003?

Accuracy

Is the schedule data correct?

Schedule Accuracy *(1 of 2)*

Schedule Accuracy: The primary data used to develop the schedule should be correct and based on reality

- Activities capture the entire work scope
- Durations are realistic and feasible, not "success-oriented" or "fat"
- Assumptions are sound and true
- Constraints are legitimate

Analysis Approach:

- Verification of activity traceability to:
  - Statements Of Work
  - Work Breakdown Structures & dictionaries
  - Drawing trees, document trees & specifications
  - Basis of Estimate
  - Test verification matrix

Schedule Accuracy *(2 of 2)*

Analysis Approach – cont'd.:

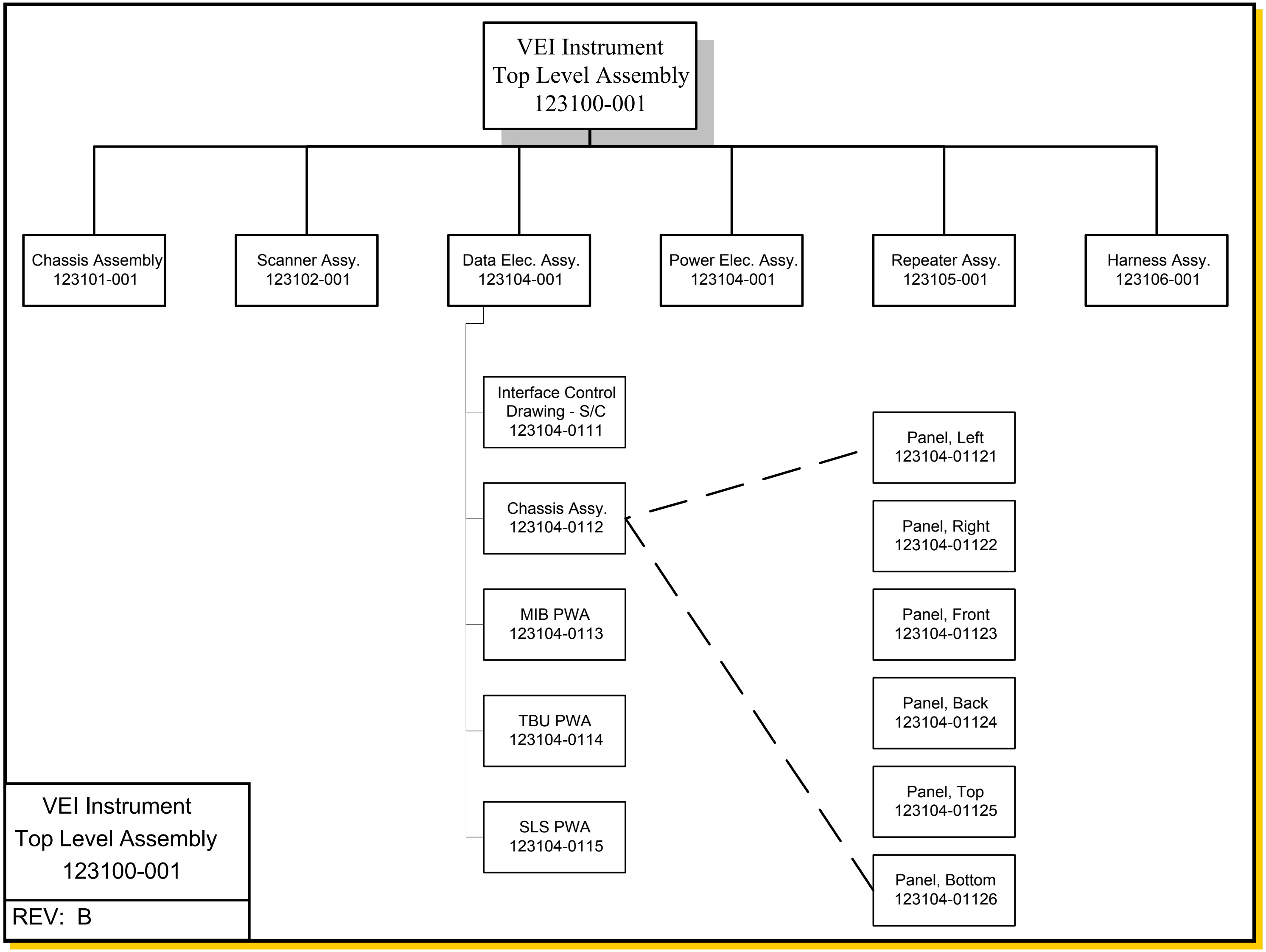
- **Comparison of current schedule durations to:**
  - Baseline durations
  - Prior period's forecast durations
- **Comparison of baseline activity durations to:**
  - "Actuals" from similar projects
  - "Actuals" from previous units, builds, tests, etc.
  - Basis-Of-Estimates
  - Supplier lead time quotes
- **Verification of schedule assumptions with external agreements**
  - Memorandums of Understanding
  - Letters Of Agreement
  - Technology Assistance Agreements
  - Program Commitment Agreements
  - Contracts & contract modifications
  - Government Furnished Equipment Lists

WBS Dictionary Example

WBS Dictionary

Contract Work Breakdown Structure Dictionary		Program Integrated AMSU-A	RFP No.: 5-16372/433 Contract No.: NAS5-32314	Date: July 1997 (March 1997, revised)
Level of CWBS	**CWBS Element**	**CWBS Definition**		
4	3.2.2	ELECTRONICS – CONSOLIDATED FAB The fabrication and assembly of electronic components and assemblies including assembly labor, bargaining unit supervision, inspection labor, manufacturing engineering support, shop order preparation, production control support, design engineering support, test engineering support, and test technician support for the consolidated fabrication, assembly and test of sufficient hardware to deliver the following quantities of EOS and METSAT electronic hardware: 1) 301 Circuit card assemblies of 23 part numbers 2) 12 Detector Pre-Amp assemblies 3) 141 Thermistor component assemblies 4) 48 I/O interface boards 5) 12 Transistor/diode assemblies 6) 18 Card cage assemblies 7) 12 Signal processor assemblies 8) 78 Cable assemblies 9) 2 Power control monitor assemblies 10) 10 Power relay assemblies 11) 420 PRT Terminal boards Included in each item above is all hardware ECN incorporation and all rework and retest. SOW Ref: Para 1.1 – EOS Scope; Para 1.2 – METSAT Scope Para 2.3 – EOS Protoflight Model; Para 2.4 – METSAT Flight Model 7 Para 2.5 – METSAT Flight Model 3; Para 2.6 – METSAT Flight Model 4 Para 2.7 – METSAT Flight Model 5; Para 2.8 – METSAT Flight Model 6		

Example Drawing Tree



Integration

Are activity relationships properly defined?

Schedule Integration

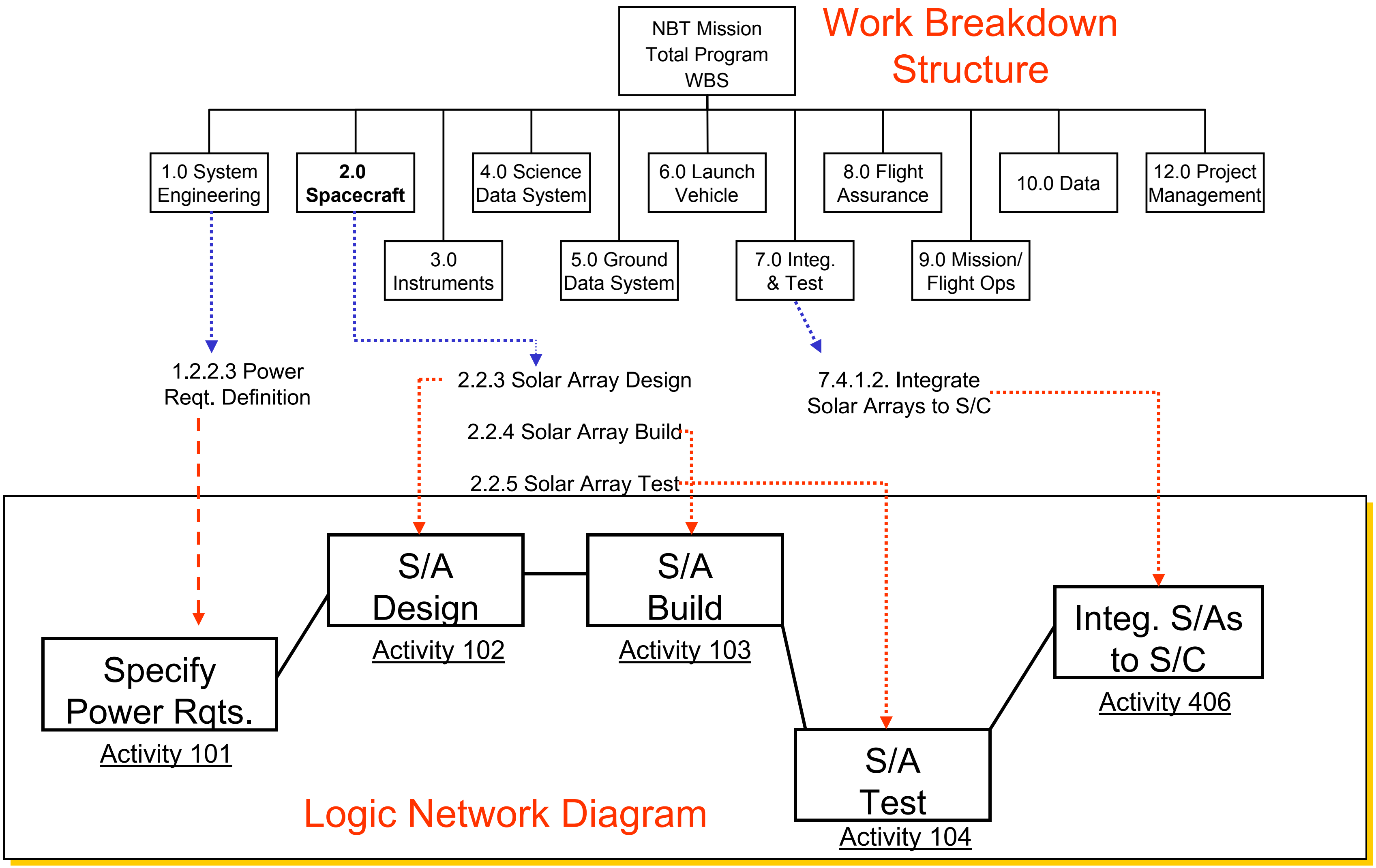
Schedule Integration

- ***Horizontal Integration***: **the logical sequencing of work that ensures task interdependencies; establishes a rational basis for the critical path**
- ***Vertical Integration***: **the top-down alignment of activities, milestones and status from the master schedule to the lowest detailed schedule; helps ensure schedule completeness and accountability; includes subcontractor schedules**

Analysis Approach:

- ***Horizontal Traceability***: **determined through end-to-end activity tracing to verify project logic (e.g. "build" before "test")**
- ***Vertical Traceability***: **determined by comparison of baseline, actual and forecast schedule dates among various levels of schedules**
- **Logic networking and activity flagging/coding features of scheduling software tools help automate schedule integration & traceability**

Logic Networks = Horizontal Schedule Traceability

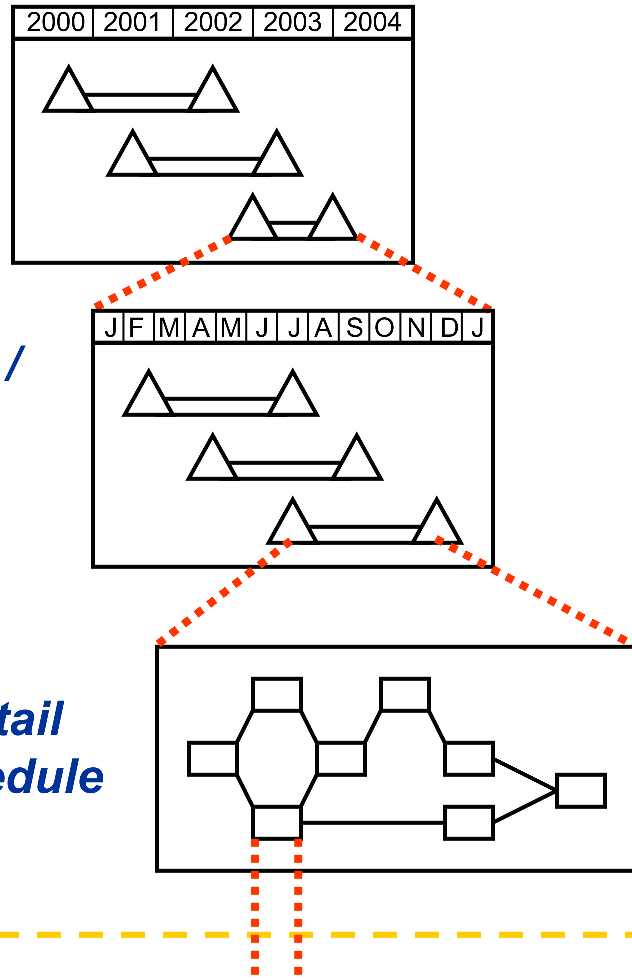


Vertical Schedule Traceability

Master Schedule

Intermediate / Summary Schedule

Detail Schedule



Cost Account / Work Package Schedules

Realism

Is the schedule achievable?

Schedule Realism

Schedule Realism: an achievable schedule is accurate, integrated, "reasonable", and contains sufficient slack and reserve in case of potential problems.

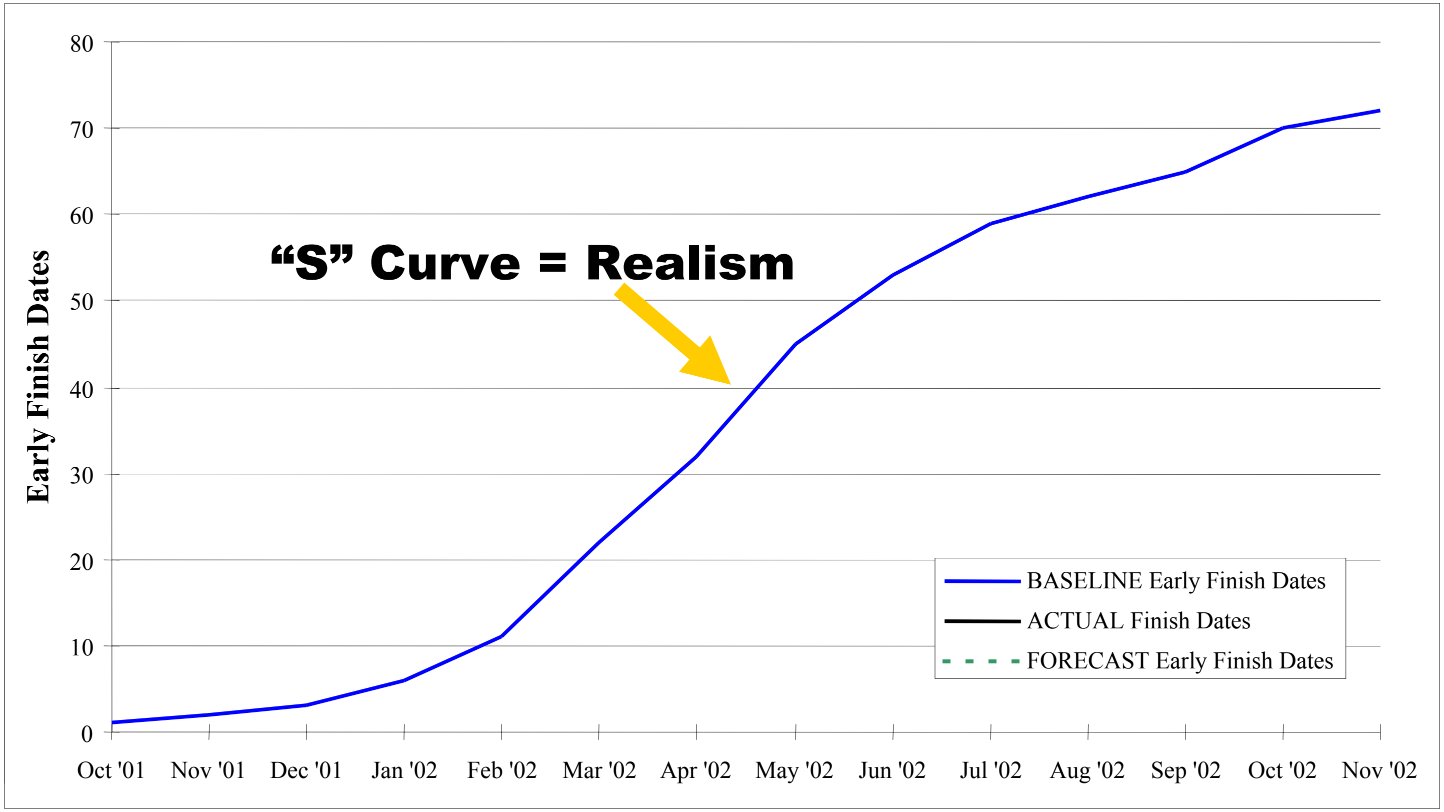
Analysis Approach:

- **Are activities properly identified and do durations have a rational basis ("Accuracy")?**
- **Do activities logically trace, end-to-end ("Integration")?**
- **Have assumptions and constraints been verified ("Accuracy, Integration")?**
- **Have sufficient resources been identified and allocated?**
- **Does the implementation of the schedule seem reasonable: slow start-up, faster acceleration in the middle, and taper off at completion ("S" curve)?**
- **Is there free slack between deliverables and need dates?**
- **Has schedule reserve/contingency been identified?**

"S" Curve Check

NBT Project "Early Finish" Date Baseline Schedule Plan

As of May 30, 2002



	Oct '01	Nov '01	Dec '01	Jan '02	Feb '02	Mar '02	Apr '02	May '02	Jun '02	Jul '02	Aug '02	Sep '02	Oct '02	Nov '02
CUM Baseline	1	2	3	6	11	22	32	45	53	59	62	65	70	72
CUM Actual														
CUM Forecast														

Performance

Are activities being accomplished in an efficient and timely manner?

Schedule Performance

Schedule Performance: measurable schedule progress evidenced by the completion of activities, milestones or other verifiable outcome

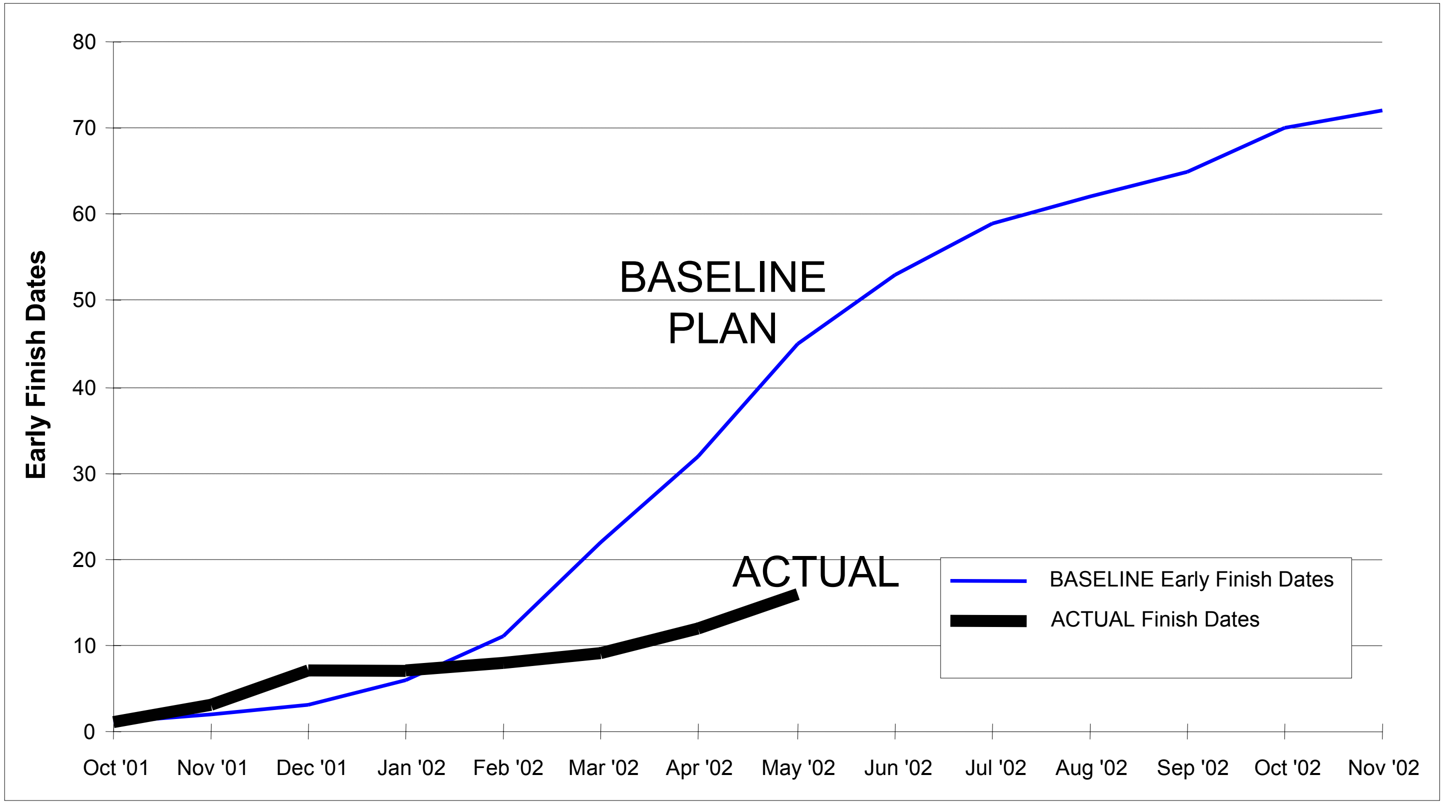
Analysis Approach:

- Comparison of activities' actual start and finish dates to the baseline schedule start and finish dates
- Ratio analysis of the baseline schedule (plan), actual and forecast dates
- Evaluation of the Schedule Performance Index (SPI) on projects using Earned Value Management

Schedule Performance Illustrated

NBT Project "Early Finish" Date Schedule Performance

As of May 30, 2002



	Oct '01	Nov '01	Dec '01	Jan '02	Feb '02	Mar '02	Apr '02	May '02	Jun '02	Jul '02	Aug '02	Sep '02	Oct '02	Nov '02
CUM Baseline	1	2	3	6	11	22	32	45	53	59	62	65	70	72
CUM Actual	1	3	7	7	8	9	12	16						

Software Schedule Performance Ratio Analysis Example

ASTRO Project Software Module Code & Checkout Completion: As of 5/31/02

	2001			2002										
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
CUM Baseline	1	2	3	6	11	22	32	40	50	59	62	65	67	70
CUM Actual	1	3	7	7	8	15	24	30						

TO DATE

30 modules ÷ 8 months = 3.75 (actual rate)

40 modules ÷ 8 months = 5 (baseline rate)

3.75 ÷ 5 = 75% efficiency-to-date

0% - - - - - - - - - - - - 50% - - - - - - - - - - - - 100%

Less Efficient | More Efficient

To date, schedule efficiency is 75% - the ASTRO software development team is accomplishing, on average, 3/4 of what it planned to do.

Variances

Are there actual and forecast differences from the baseline schedule, and what are their significance?

Schedule Variances

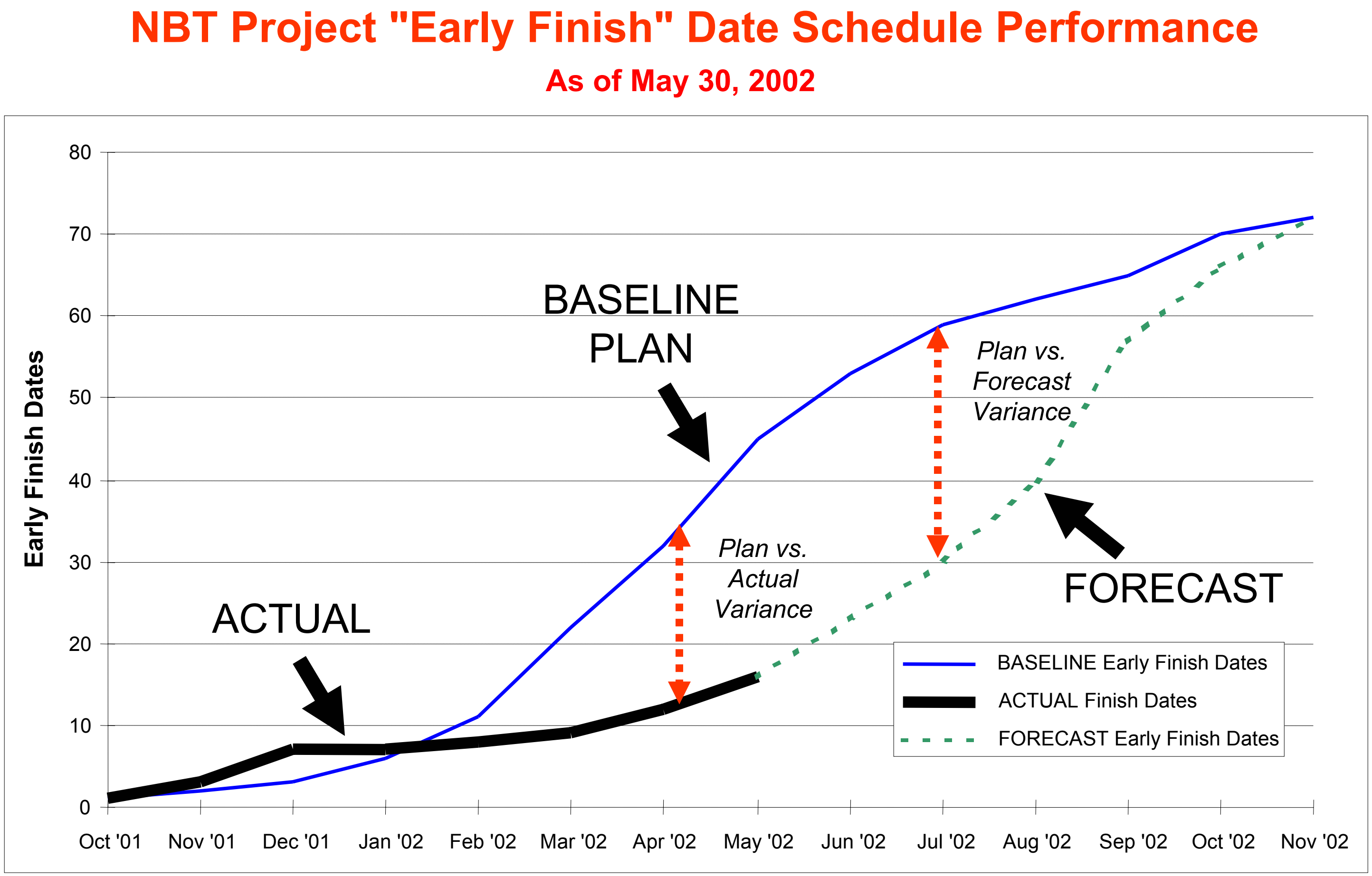
Schedule Variances:

- The difference between the baseline schedule and actual schedule performance (actual results)
- The difference between the baseline schedule and the current or forecast schedule (expected results)

Analysis Approach:

- Comparison of activity baseline start and finish dates to <u>actual</u> start and finish dates
- Comparison of activity baseline start and finish dates to <u>forecast</u> start and finish dates
- Determination of the cause and impact of the variance are needed in order to develop a corrective action or workaround

Schedule Variance Illustrated



	Oct '01	Nov '01	Dec '01	Jan '02	Feb '02	Mar '02	Apr '02	May '02	Jun '02	Jul '02	Aug '02	Sep '02	Oct '02	Nov '02
CUM Baseline	1	2	3	6	11	22	32	45	53	59	62	65	70	72
CUM Actual	1	3	7	7	8	9	12	16						
CUM Forecast									23	30	40	57	66	72

Example
Variance Analysis Report

WBS: 1.1.2 C&DH Subsystem

1.1.2.2 RTT "B" Assembly

MILESTONE: CDH6022 RTT "B" Ready for Observatory Integration & Test

BASELINE: 5/28/01

FORECAST: 6/7/01

CAUSE & CORRECTIVE ACTION:

- Memory anomaly during final test caused a 10 day slip in delivery to I&T, putting the RTT B on the critical path at -5 days total slack.
- A 2nd shift will be added to finish testing.
- I&T Manager can modify I&T work flow to accommodate this delay if necessary.

Trends

Is the schedule's direction favorable or unfavorable?

Schedule Trends

Schedule Trend(s):

- Indicate the schedule's future direction based on historical results
- Provide a means to indicate the extent to which actual and predicted performance are diverging from the baseline schedule

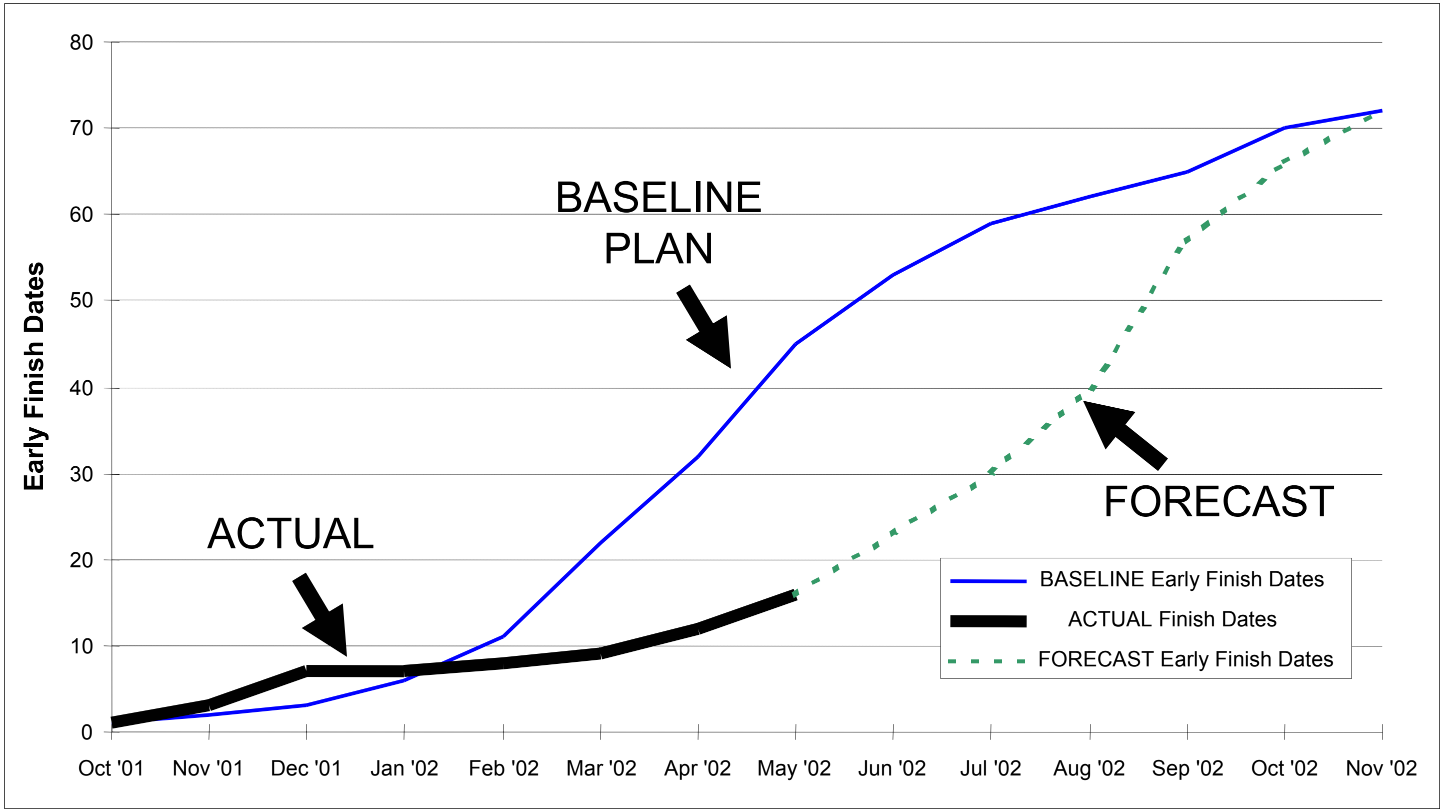
Analysis Approach:

- **Performance trends:** track actual completion of activities and milestones over time to determine if progress is being made
- **Slack trends:** track slack depletion over time to assess if sufficient spare time is available or if resources should be reallocated
- **Reserve trends:** track reserve consumption over time to determine if it is still sufficient
- Thresholds can be established to gauge the significance of the performance, slack and reserve trends (more in "Risk Analysis")

Schedule Performance Trend

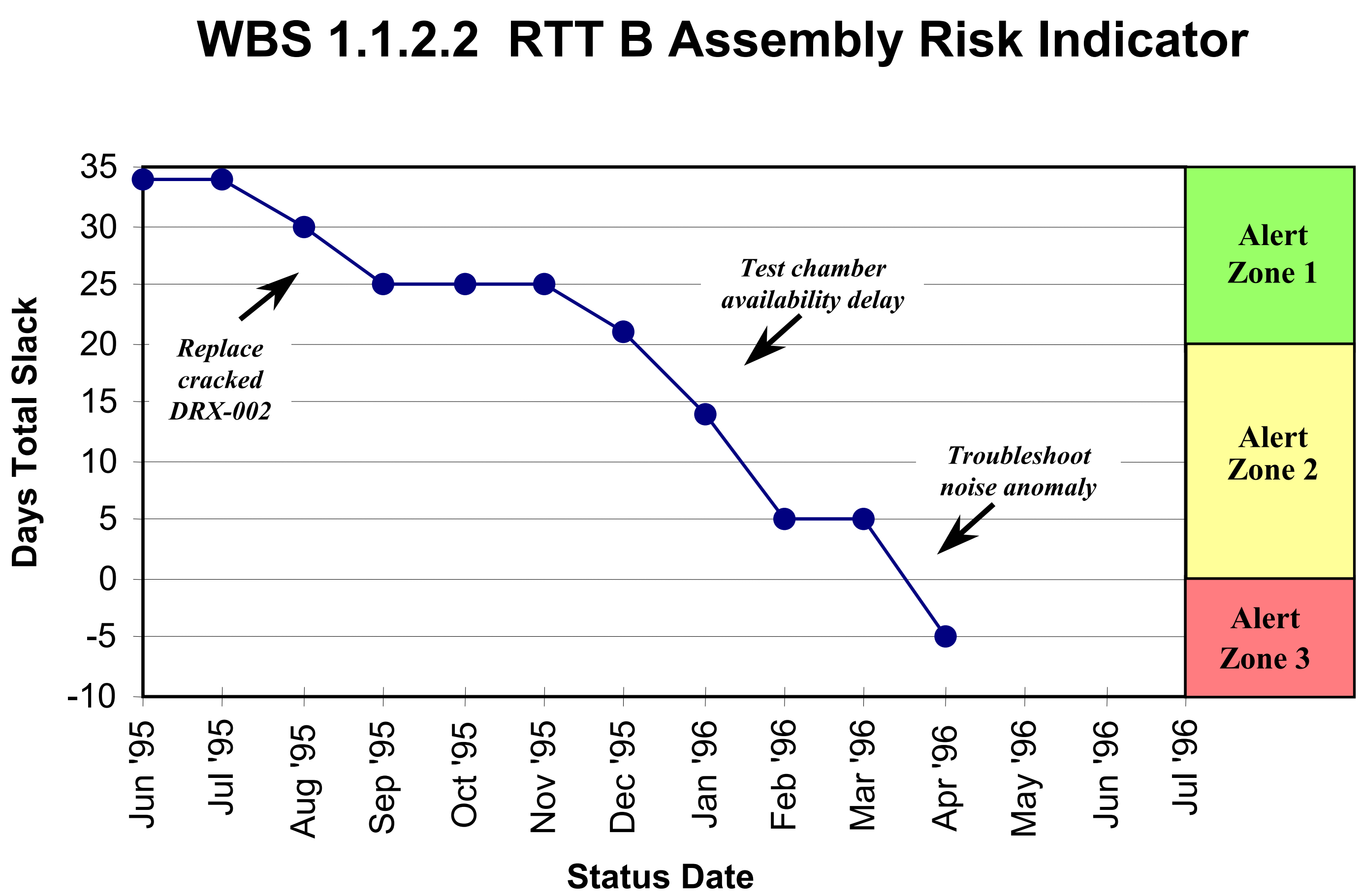
NBT Project "Early Finish" Date Schedule Performance

As of May 30, 2002



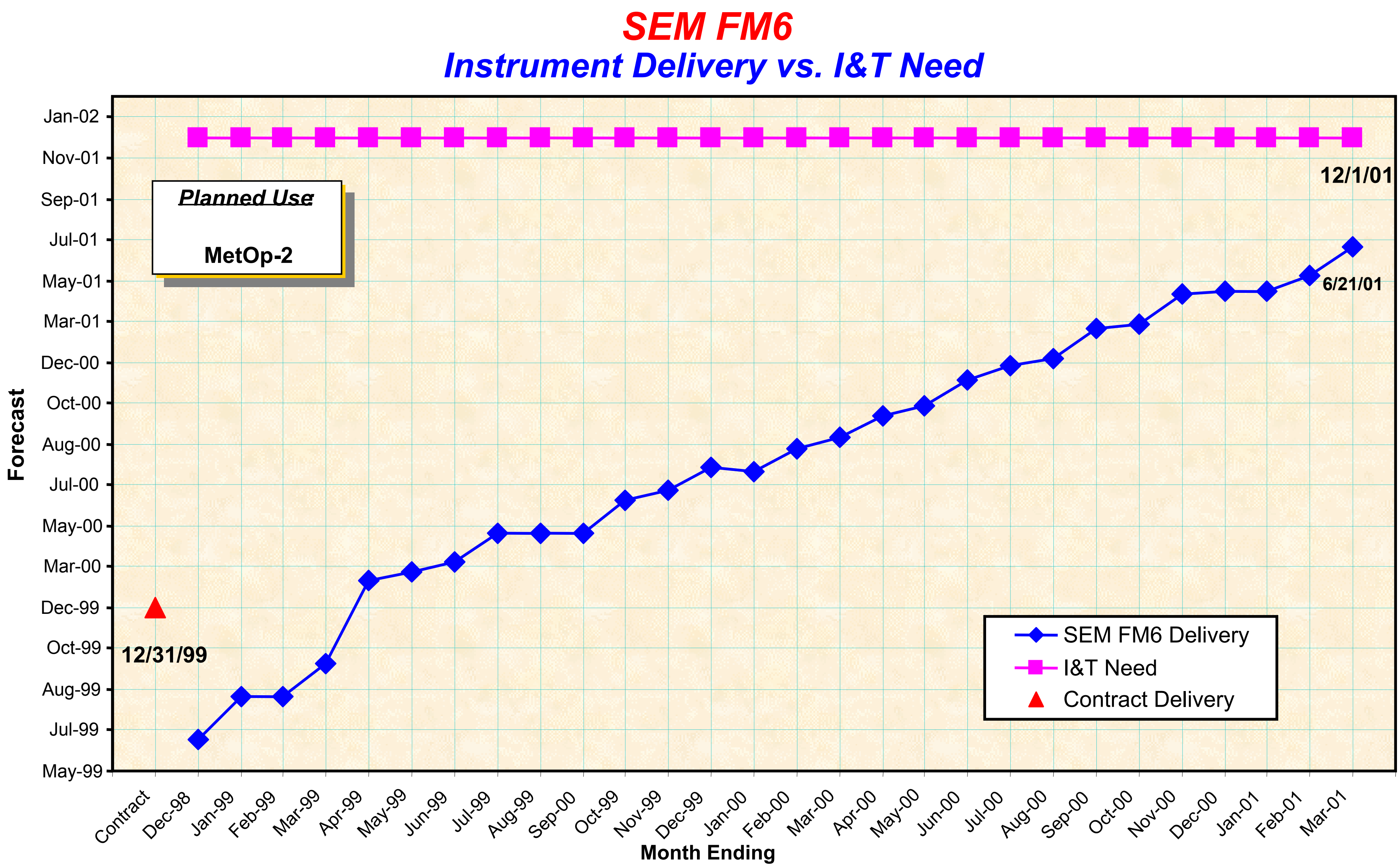
	Oct '01	Nov '01	Dec '01	Jan '02	Feb '02	Mar '02	Apr '02	May '02	Jun '02	Jul '02	Aug '02	Sep '02	Oct '02	Nov '02
CUM Baseline	1	2	3	6	11	22	32	45	53	59	62	65	70	72
CUM Actual	1	3	7	7	8	9	12	16						
CUM Forecast									23	30	40	57	66	72

Slack Trend



WBS 1.1.2.2 RTT B Assembly Risk Indicator
Days Total Slack
35
30
25
20
15
10
5
0
-5
-10
Replace cracked DRX-002
Test chamber availability delay
Troubleshoot noise anomaly
Alert Zone 1
Alert Zone 2
Alert Zone 3
Jun '95
Jul '95
Aug '95
Sep '95
Oct '95
Nov '95
Dec '95
Jan '96
Feb '96
Mar '96
Apr '96
May '96
Jun '96
Jul '96
Status Date

Delivery Trend vs. Need Trend



ASTRO Project Total Slack Summary

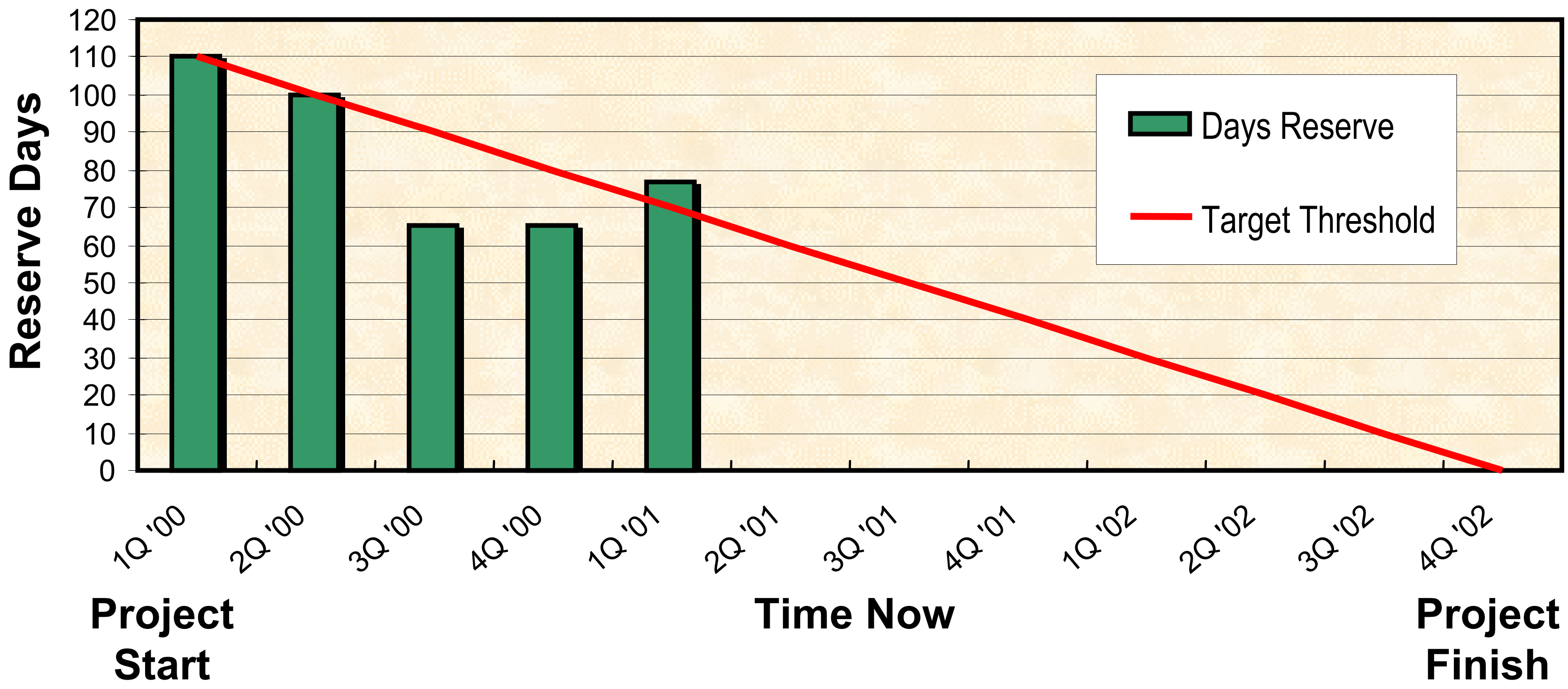
As of April 30, 2001

	Baseline		March 2001		April 2001		
	Delivery	Total Slack	Delivery	Total Slack	Delivery	Total Slack	Driver
Structure	1/5/01	+67	Complete	-	Complete	-	
Propulsion	1/5/01	+70	Complete	-	Complete	-	
Electrical	1/5/01	+88	4/5/01	+55	Complete	-	Main Harness (design change)
Power	2/15/01	+67	4/25/01	+46	5/24/01	+52	Solar Array
C&DH	4/3/01	+45	4/3/01	+45	7/1/01	-15	SDS Box #1 (IC cracks)
ACS	3/30/01	+62	5/1/01	+50	6/1/01	+31	Earth Sensor
Flight Software	6/1/01	+60	6/1/01	+60	6/1/01	+60	FSW Build #1
Deployables	4/22/01	+90	4/22/01	+90	5/3/01	+82	Solar Array Drive Motors
Communications	5/1/01	+56	5/1/01	+56	5/1/01	+56	High Gain Antenna
Thermal	3/15/01	+78	4/16/01	+45	Complete	-	Louvers
EGSE	2/15/01	+48	4/1/01	+22	2/15/01	+45	DTS Rack
MGSE	12/1/00	+65	Complete	-	Complete	-	
Observatory I&T	12/15/03	+45	12/15/03	+45	3/17/04	-15	Late SDS Box #1 Delivery
Instrument A	6/15/02	+60	6/15/02	+60	7/17/02	+30	Cooler
Instrument B	4/3/02	+70	2/15/02	+89	2/15/02	+89	Focal Plane
Instrument C	8/2/02	+60	8/2/02	+60	8/2/02	+60	Vishay Resistors
Ground System	5/1/03	+75	5/1/03	+75	5/1/03	+75	GDS Build #2
Launch Readiness	8/1/04	45	8/1/01	45	9/30/04	-15	Late SDS Box #1 Delivery

Example Schedule Reserve Trend

ASTRO Project Schedule Reserve Consumption Trend

As of: March 31, 2001



Forecasting

What is the predicted future schedule performance?

Schedule Forecasting

Forecast

- An estimate or projection of when:
  - Activities already underway will be completed
  - Activities that have not yet begun will start and finish
- A prediction of future schedule performance

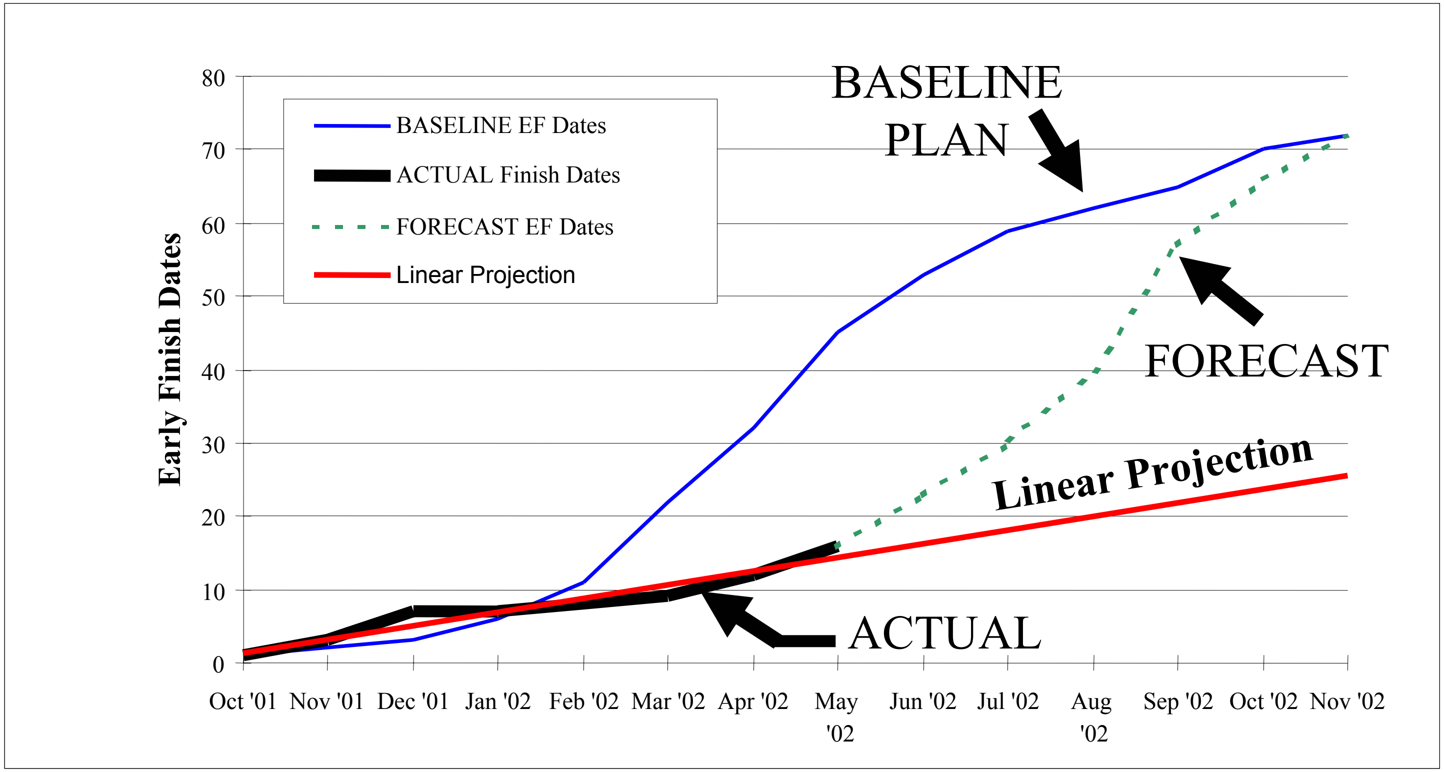
Analysis Approach

- Linear projection of actual performance
- Calculation of when project could finish based on extrapolation of schedule performance efficiency-to-date

Linear Projection of "Actuals"

NBT Project "Early Finish" Date Schedule Performance

As of May 30, 2002



	Oct '01	Nov '01	Dec '01	Jan '02	Feb '02	Mar '02	Apr '02	May '02	Jun '02	Jul '02	Aug '02	Sep '02	Oct '02	Nov '02
CUM Baseline	1	2	3	6	11	22	32	45	53	59	62	65	70	72
CUM Actual	1	3	7	7	8	9	12	16						
CUM Forecast									23	30	40	57	66	72

Projection Based on Efficiency-To-Date

ASTRO Project Software Module Code & Checkout Completion: As of 5/31/02

	2001			2002										
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
CUM Baseline	1	2	3	6	11	22	32	40	50	59	62	65	67	70
CUM Actual	1	3	7	7	8	15	24	30						
CUM Forecast									37	46	52	60	66	70

TO DATE

30 modules ÷ 8 months = 3.75 (actual rate)

40 modules ÷ 8 months = 5 (baseline rate)

3.75 ÷ 5 = 75% efficiency-to-date

TO GO

Actual rate to date = 3.75 modules

40 modules ÷ 6 months = 6.7 (forecast rate)

6.7 ÷ 3.75 = 178% efficiency-to-complete !

0% - - - - - - - - - - - - 50% - - - - - - - - - - - - 100%

Less Efficient — More Efficient

To date, schedule efficiency is 75%. To go, the forecast-to-complete efficiency of 178% is probably unrealistic - unless something has changed (e.g. new technical approach, add more programmers, descope work, etc.)

"What-If" Analysis

What is the impact of potential problems, changes, or alternative strategies on the project's schedule objectives?

“What-If” Schedule Analysis

“What-If” Schedule

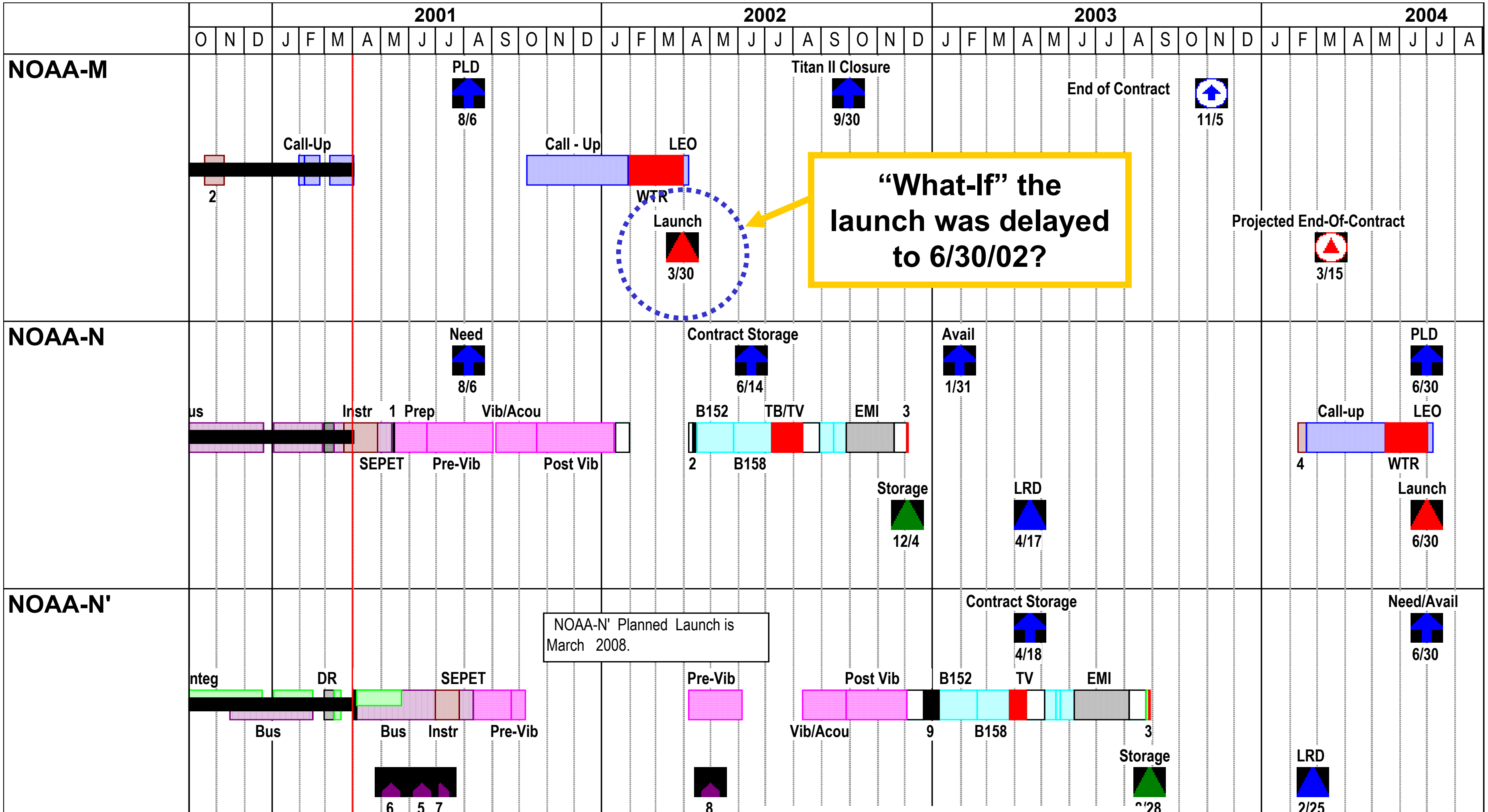
- Projects the effect on the baseline or current operating schedule of a potential problem, new constraint, or changed assumption
- Provides the project team with insight into the impact of potential changes on the project’s schedule objectives

Analysis Approach

- Develop a “What-If” Schedule by modifying the baseline and/or current operating schedule to reflect a desired schedule change
- Examples:
  - Change a key assumption
  - Late parts or GFE delivery
  - Funding shortfalls
  - Descope of work

NOAA M-N' Integration & Test Summary Schedule As of 3/31/01

***Based on Preliminary LMMS Rev S Schedule**



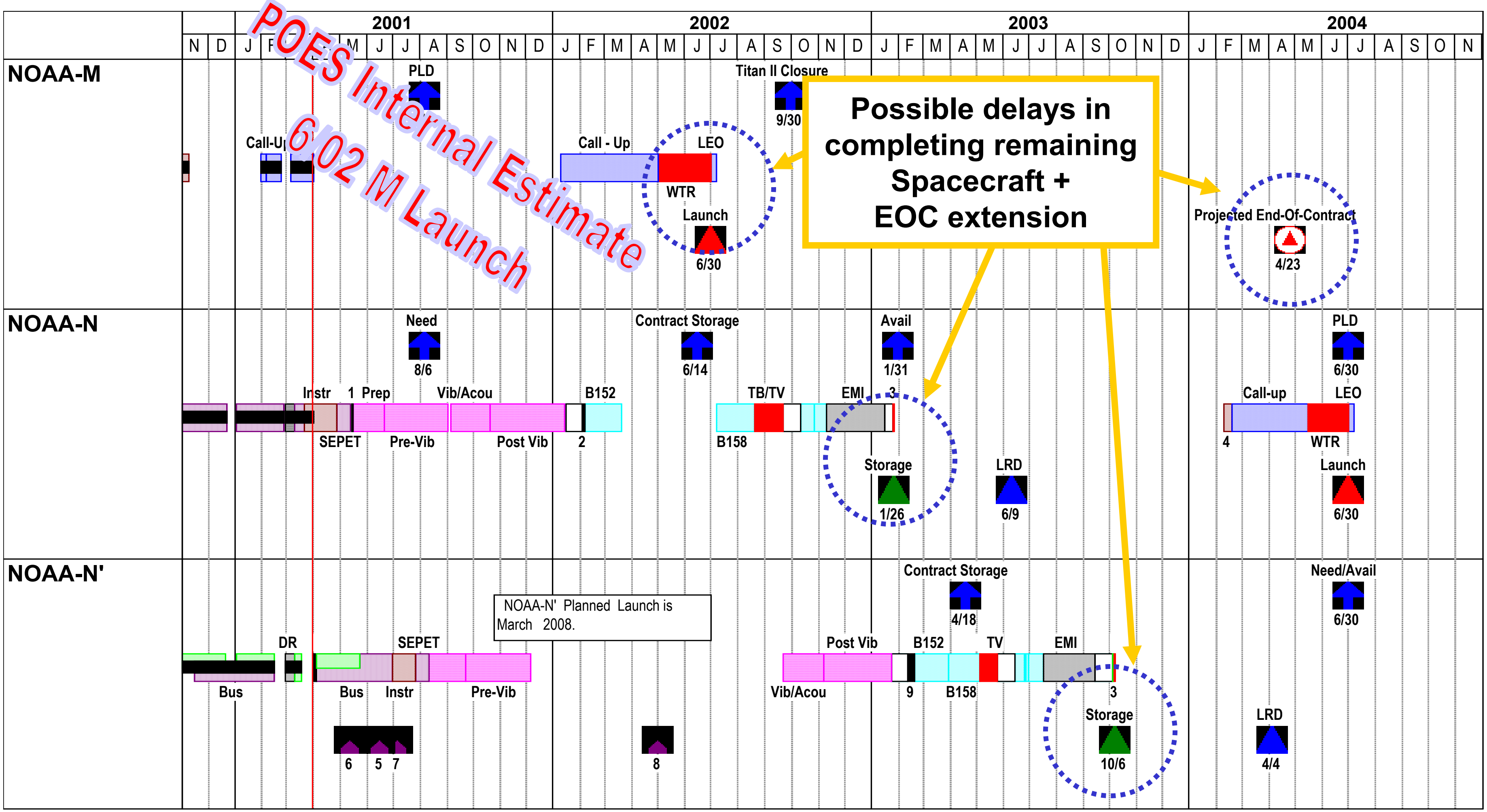
Foot Notes:

1. A303 Removal; Installation of Mass Models*
2. A303 Re-Integration & IPF/DET*
3. SEM & SBUV* Removal
4. SEM & SBUV* Re-Integration
5. SARR Delivery 6/15/01
6. A303 Installation on N' 5/13/01
7. SBUV Delivery 7/6/01
8. SARP/ADCS Delivery 4/30/02
9. SARP & ADCS Integration*

* = Not yet in LMMS Master Schedule

NOAA M-N' Integration & Test Summary Schedule: 6/30/02 M Launch

*Based on Preliminary LMMS Rev S Schedule



Foot Notes:
1. SEM, SBUV, AVHRR & H303 Removal
2. SEM, SBUV, AVHRR & H303 Re-Integration
3. A303 Removal; Installation of Mass Model*
4. A303 Re-Integration & IPF/DET*
5. SEM & SBUV* Removal
6. SEM & SBUV* Re-Integration
7. SARP & ADCS Software Upgrades*
8. SARP/ADCS Delivery 4/30/02
9. SARP & ADCS Integration*

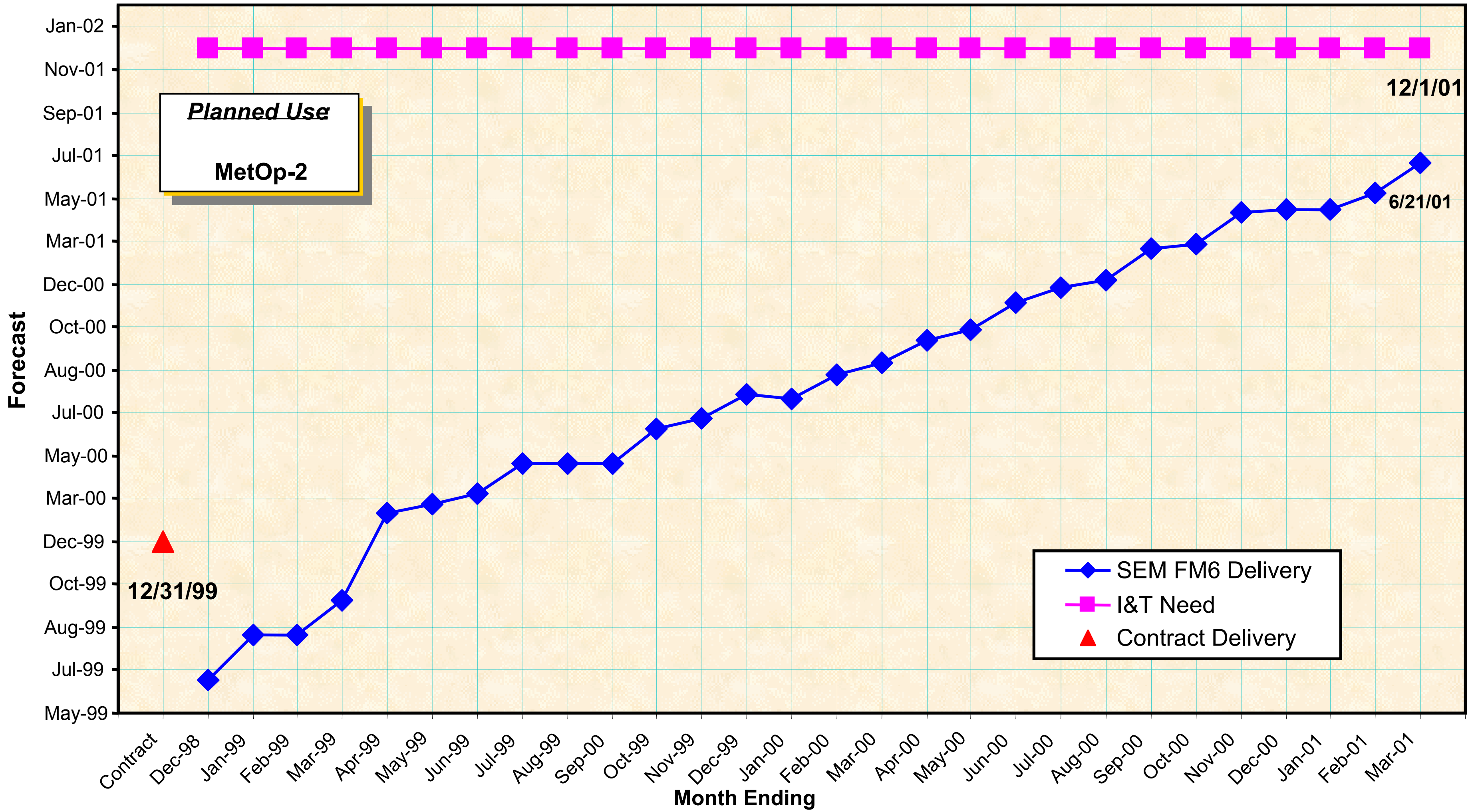
* = Not yet in LMMS Master Schedule

NOAA-M Launch From VAFB, CA – 6/24/02

Remember the SEM Delivery Trend?

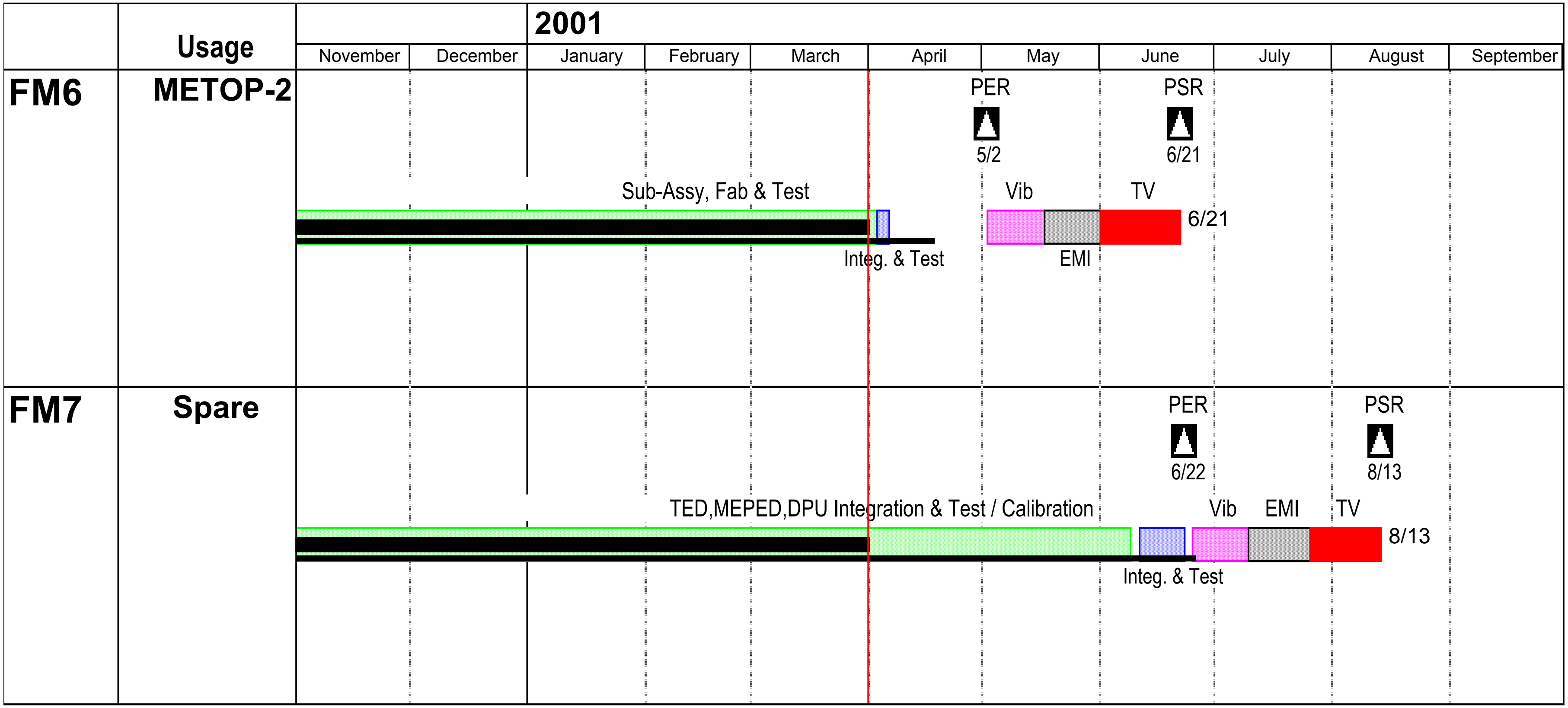
SEM FM6

Instrument Delivery vs. I&T Need



SEM Summary Schedule

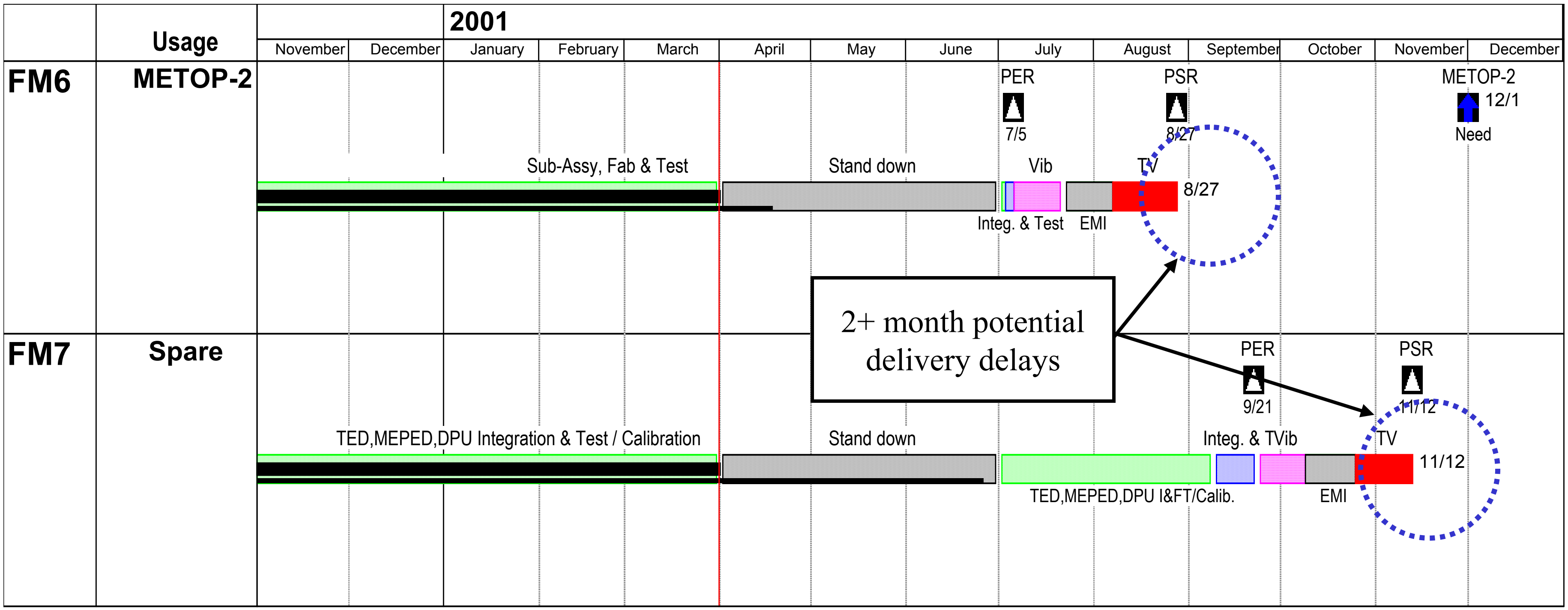
Status as of 3/31/01



What if SEM's assembly & test resources were diverted to another job until July 1st?

SEM Stand down "What-if" Schedule

Status as of 3/31/01



Major delivery delays in remaining SEM instruments are likely if resources are diverted.

Risk Analysis

Is there a significant likelihood of not meeting the project's schedule objectives?

Schedule Risk Analysis *(1 of 5)*

Risk: a threat or uncertainty that could adversely impact the project's schedule objectives

Risk Analysis provides a framework for:

- Reducing, mitigating, avoiding or accepting schedule risks
- Verifying the project's overall schedule duration as calculated by the critical path
- Highlighting the areas of greatest schedule risk
- Early warning of potential schedule problems
- Identifying necessary schedule reserve or contingency
- Quantifying the probability of risks occurring and the extent of the possible schedule delays
- Gauging the significance of threats to the project's overall schedule objectives if they were to become problems

Schedule Risk Analysis *(2 of 5)*

Sources of Schedule Risk:

- Logic networks
  - Except for "what-if" exercises, networks tell the project team nothing about the *likelihood* of schedule delays and their possible effect on the project's overall duration
- Lack of a realistic project schedule that identifies the total work scope
- Inadequate or incorrect resource planning
- Uncertainty inherent in the work scope due to factors such as:
  - Advanced technology
  - New designs
  - New manufacturing or test processes
- Insufficient schedule reserve or contingency
- Inexperienced or inadequate project management
- Improper or poor change control

Schedule Risk Analysis *(3 of 5)*

Sources of Schedule Risk – cont'd.:

- External factors
  - Labor relations
  - Government regulations
  - Geography
  - Weather, etc.
- Complex organizational interfaces:
  - Foreign partners
  - Other NASA centers or government agencies
  - Contractors and their subcontractors
- Poor or inaccurate activity duration estimates:
  - Padded by the estimator to keep a hidden contingency
  - Reduced by the estimator to be optimistic
  - Arbitrarily cut by management

Schedule Risk Analysis *(4 of 5)*

Sources of Schedule Risk – cont'd.:

- Single point activity duration estimates in logic networks
- Planning to the "late schedule" or promoting a "just-in-time" approach that leaves no time to recover from problems
- Failure of the project team to focus on the critical path
- Failure of the project team to focus on secondary critical paths
- Multiple convergence paths
- "Fast Tracking" (starting some activities before predecessors are finished)
- Schedule abuse: arbitrarily reducing future schedule durations to absorb delays making the schedule "look good"
- Overuse of directed constraints that override true network logic
- Tendency for projects to look backward and prepare for what just went wrong, rather than look forward to prepare for what might go wrong

Analysis Approach:

- **Multi-disciplined subgroup of the project team lists and ranks qualitative or "gut feel" risks based on past experience early in the project life cycle**
- **Formal Risk Management Systems: establish and track schedule parameters using alert zones or thresholds that when triggered lead to corrective action planning**
- **Simulation Analysis: mathematical modeling which translates the uncertainties associated with activity durations into their potential impact on the project's schedule objectives ("Monte Carlo" technique)**

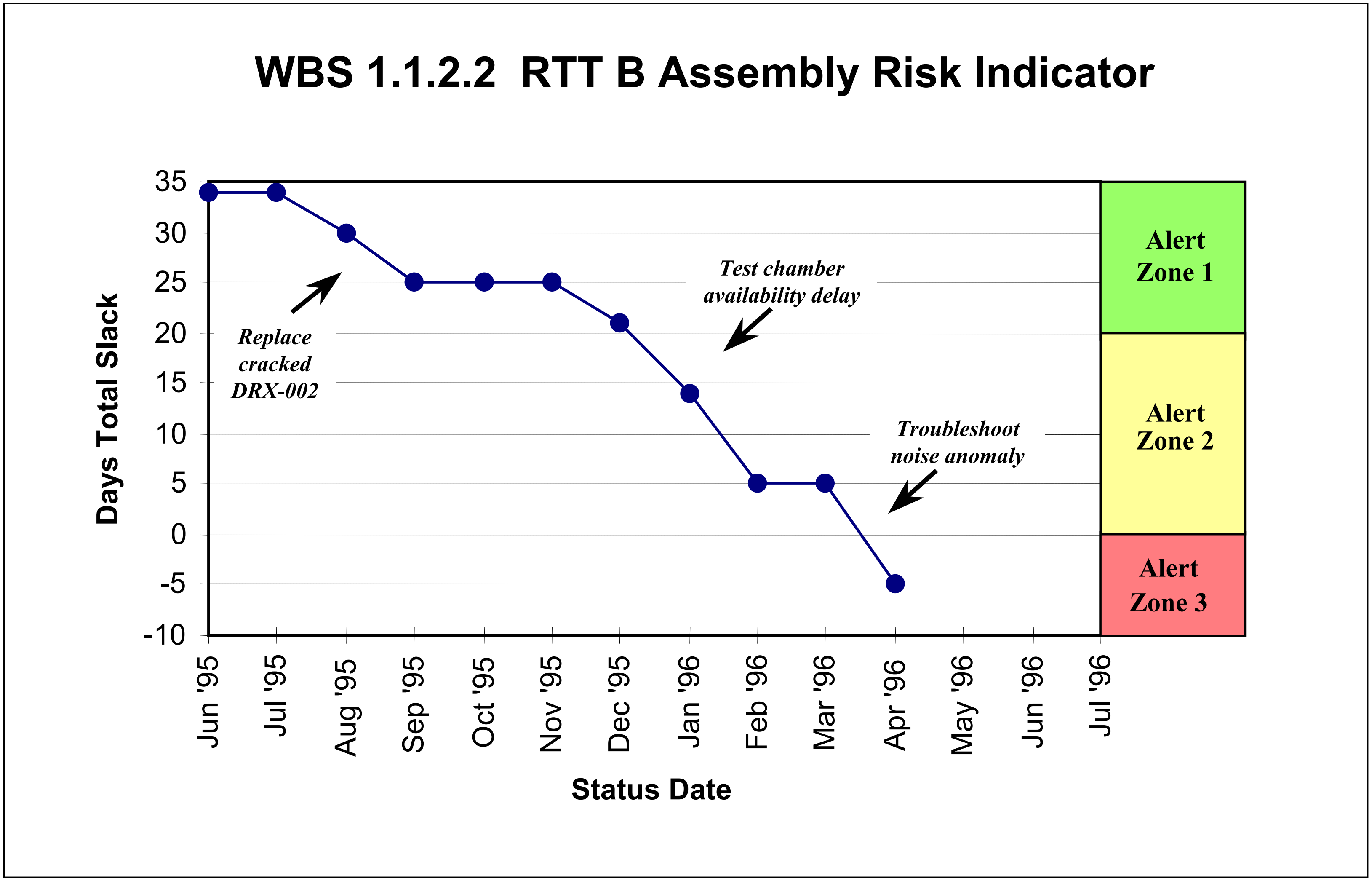
Example Project Risk Listing

1. $10-$15 million dollar funding reduction in FY 02
2. Major test failure of subsystem during thermal vacuum testing
3. Radiative cooler failure resulting in late Government Furnished Equipment (GFE) instrument delivery to prime contractor
4. Supplier plant closure resulting in late parts delivery
5. Technology Assistance Agreement (TAA) will not be approved by U.S. State Department in time for foreign partners to support testing
6. Rebuild of replacement filters will not meet specification

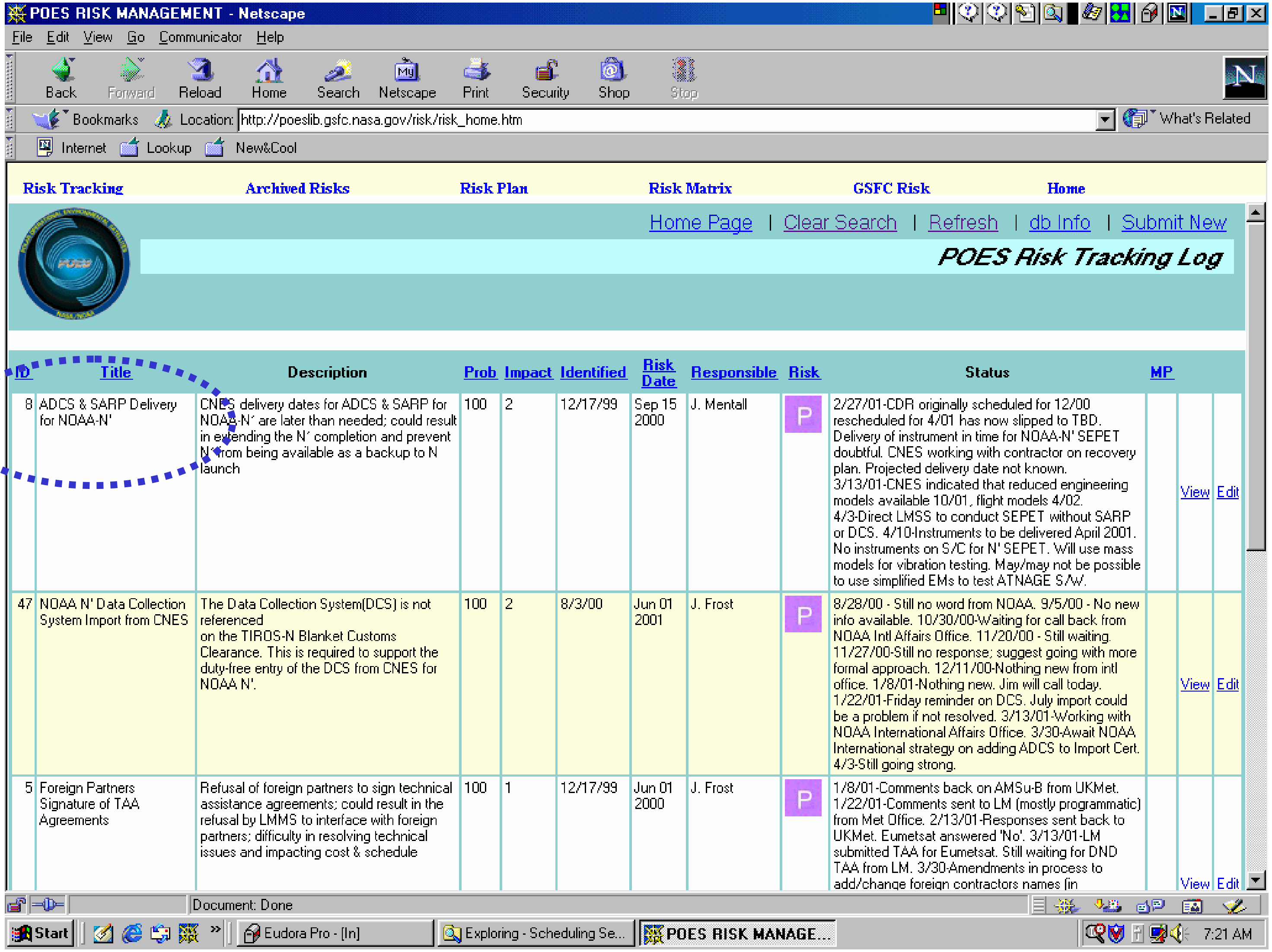
What Other Schedule Risks Could Threaten Your Project's Objectives?

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________

Slack Trend With Thresholds



Example Risk Report



ID	Title	Description	Prob	Impact	Identified	Risk Date	Responsible	Risk	Status	MP		
8	ADCS & SARP Delivery for NOAA-N'	CNES delivery dates for ADCS & SARP for NOAA-N′ are later than needed; could result in extending the N′ completion and prevent N′ from being available as a backup to N launch	100	2	12/17/99	Sep 15 2000	J. Mentall	P	2/27/01-CDR originally scheduled for 12/00 rescheduled for 4/01 has now slipped to TBD. Delivery of instrument in time for NOAA-N' SEPET doubtful. CNES working with contractor on recovery plan. Projected delivery date not known. 3/13/01-CNES indicated that reduced engineering models available 10/01, flight models 4/02. 4/3-Direct LMSS to conduct SEPET without SARP or DCS. 4/10-Instruments to be delivered April 2001. No instruments on S/C for N' SEPET. Will use mass models for vibration testing. May/may not be possible to use simplified EMs to test ATNAGE S/W.		View	Edit
47	NOAA N' Data Collection System Import from CNES	The Data Collection System(DCS) is not referenced on the TIROS-N Blanket Customs Clearance. This is required to support the duty-free entry of the DCS from CNES for NOAA N'.	100	2	8/3/00	Jun 01 2001	J. Frost	P	8/28/00 - Still no word from NOAA. 9/5/00 - No new info available. 10/30/00-Waiting for call back from NOAA Intl Affairs Office. 11/20/00 - Still waiting. 11/27/00-Still no response; suggest going with more formal approach. 12/11/00-Nothing new from intl office. 1/8/01-Nothing new. Jim will call today. 1/22/01-Friday reminder on DCS. July import could be a problem if not resolved. 3/13/01-Working with NOAA International Affairs Office. 3/30-Await NOAA International strategy on adding ADCS to Import Cert. 4/3-Still going strong.		View	Edit
5	Foreign Partners Signature of TAA Agreements	Refusal of foreign partners to sign technical assistance agreements; could result in the refusal by LMMS to interface with foreign partners; difficulty in resolving technical issues and impacting cost & schedule	100	1	12/17/99	Jun 01 2000	J. Frost	P	1/8/01-Comments back on AMSu-B from UKMet. 1/22/01-Comments sent to LM (mostly programmatic) from Met Office. 2/13/01-Responses sent back to UKMet. Eumetsat answered 'No'. 3/13/01-LM submitted TAA for Eumetsat. Still waiting for DND TAA from LM. 3/30-Amendments in process to add/change foreign contractors names (in		View	Edit

Quantifying Schedule Risk

- Logic networks are based on the accuracy of "single point" or "most likely" activity duration estimates
  - These durations tend to overrun more than underrun
- Uncertain activity durations = uncertain critical path
  - It is a good idea to watch the "secondary" or "near" critical paths
- The critical path derived from a logic network cannot tell us:
  - If the total overall project duration is reasonable
  - If the project will overrun it's planned duration
  - How likely the project will overrun it's planned duration
  - How much the project will overrun it's planned duration
- A quantified risk assessment can help answer these questions

Quantifying Schedule Risk *(Cont'd.)*

- **Quantified Schedule Risk Assessment can:**
  - Identify a range of possible durations for each activity from low (optimistic) to high (pessimistic)
  - Establish a distribution for all possible durations within the range and their probability of occurrence
  - Calculate the "average" activity duration (low + most likely + high) ÷ 3

- **Suppose a project has three serial activities:**
  - Design 30 days
  - Fabrication & assembly 40 days
  - Integration & test 20 days
  - Total project duration 90 days

Quantifying Schedule Risk *(Cont'd.)*

- Range of duration estimates:

	Activity Duration Estimates - Work Days			
Activity	Logic Network Duration	Low Estimate	High Estimate	Expected
Design	30.00	10.00	60.00	33.33
Fab & Assy	40.00	20.00	75.00	45.00
I&T	20.00	15.00	40.00	25.00
Total	90.00	45.00	175.00	103.33

- The difference between the "single point"/most likely duration from the logic network and the average/expected duration computed from the distribution is expressed as a potential overrun:

  103.33 – 90 = 13.33 work days of potential overrun

Quantifying Schedule Risk *(Cont'd.)*

- "Monte Carlo" risk analysis software can augment project scheduling software tools by randomly selecting durations from user-defined distributions for each uncertain activity
- Numerous iterations of the overall project duration is automatically simulated based on the uncertainty associated with the activities in the logic network
- High risk activities appear on the critical path in the largest percentage of iterations during the Monte Carlo simulation

Resource Analysis

Have sufficient resources been planned to efficiently accomplish the project's schedule activities and achieve it's objectives?

Resource Loaded/ Constrained Schedules

Duration Number of work periods or length of time needed if adequate resources are available	
Work Amount of effort needed to accomplish an activity	**Resources** People, equipment, facilities, etc. needed to perform the work

Realistic schedules must account for resource availability – which help define an accurate cost estimate and budget.

Resource Analysis *(1 of 5)*

Resources: the project schedule may not be achievable or efficient unless all necessary resources are considered

- Obvious resource constraints are highlighted in the network's logic
- Resources that are scarce, in surplus, inefficiently utilized or out of phase with requirements should be examined
- Some activities can happen early or later since they are not critical to the completion of the total project - the project team can assess their priority and redirect resources as needed

Analysis Approach:

- Resource identification, allocation, analysis and leveling

Resource Analysis *(2 of 5)*

Resource Identification: **the selection and definition of resource categories that are needed to accomplish the project's activities:**

- **Funding**
- **Equipment**
- **Facilities**
- **Data**
- **Staffing/labor**
- **Materials**

Resource Analysis *(3 of 5)*

Resource Allocation: once identified, the resources required to accomplish the project's activities are assigned and then "loaded" with the amounts of resources estimated to accomplish them:

Activity 302 "Design Main Chassis"

Senior mechanical engineer	230 hours
Draftsman II	95 hours
CAD System	90 hours
Thermal engineer I	15 hours
Reproduction services	16 hours
Travel to backplane supplier	$765

Resource Analysis *(4 of 5)*

Resource Analysis: once "loaded" into the project schedule database, analysis is conducted to resolve inconsistencies between resource supply and demand in a specific period of time

- The shortage or over-commitment of specific, limited resources can be determined by profiling the requested resources and comparing them to their availability or capacity
- Once a resource problem is identified, alternatives include:
  - Add more of the resource (e.g. 2nd shift)
  - Find a substitute for the resource (e.g. subcontract)
  - Delay some activities (examine free slack)
  - Perform some activities earlier than planned (examine logic)
  - Combination of the above

Resource Analysis *(5 of 5)*

Resource Leveling: a methodology for "smoothing" resources so that planned utilization matches availability in the most efficient manner while still meeting the project schedule's objectives if possible

- Schedule slack is a key consideration in leveling
- Leveling most useful for critical, near-term activities
- See example in section 7.0 "Cost/Schedule Integration"

10.0 Schedule Performance Reporting

Schedule Performance Reporting

Schedule Performance Reporting is the dissemination of meaningful information about the schedule's overall status, progress-to-date, and forecast-to-complete. Performance reporting aids in determining whether the project's objectives are being met.

INPUT

- Current project schedule
- Prior period(s) project schedule
- Schedule baseline

PROCESS

- Status reporting
- Progress reporting
- Forecasting

OUTPUT

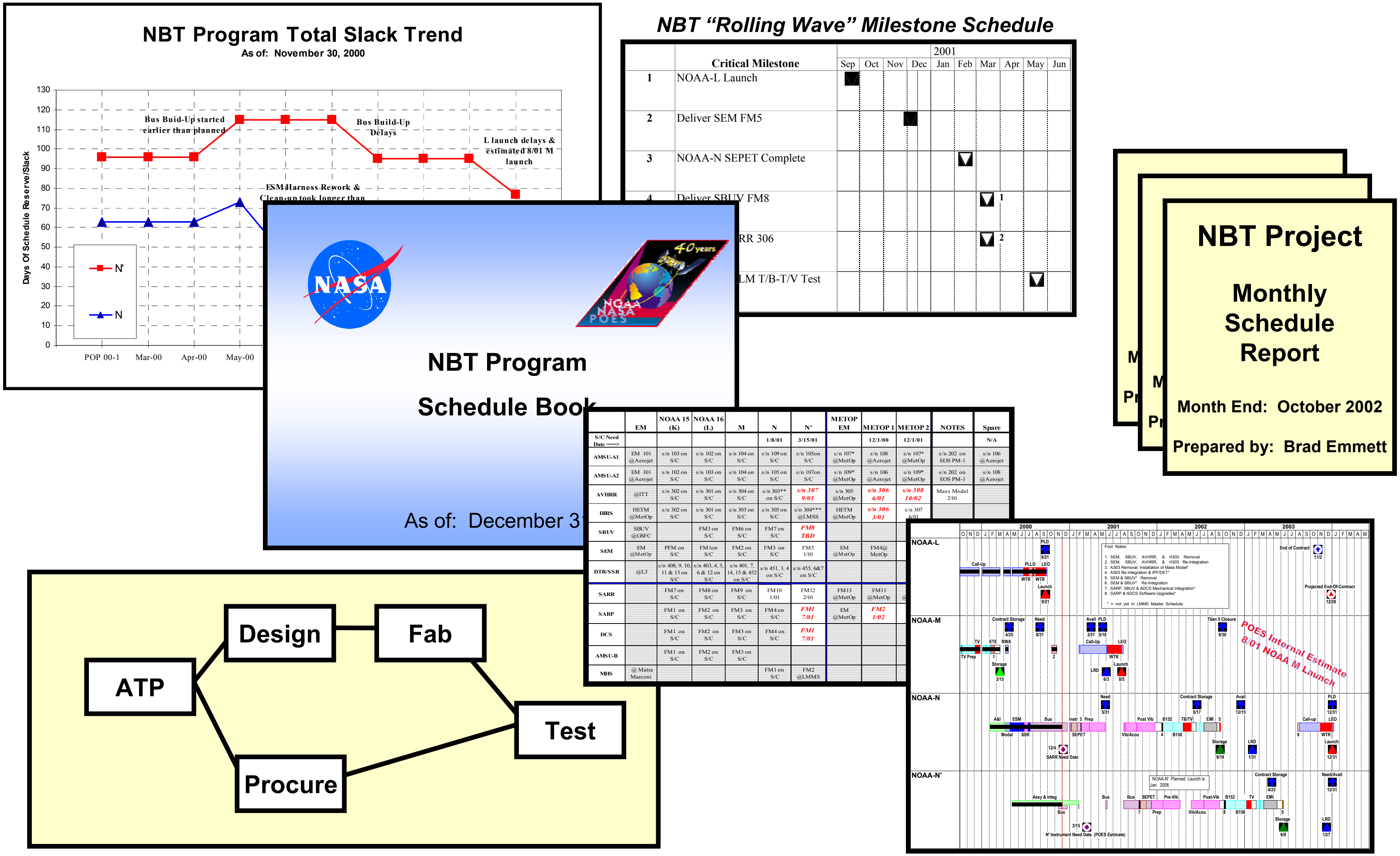
- Schedule Updates
- Metrics
- Variances
- Narrative Reports
- Custom reports and graphics

Schedule Performance Reporting

Schedule Performance Reporting

- **Status Reporting** → Where the schedule now stands — *Actual data*
- **Progress Reporting** → What has been accomplished — *Plan vs. actual*
- **Forecasting** → Prediction of future status and progress — *Projections*

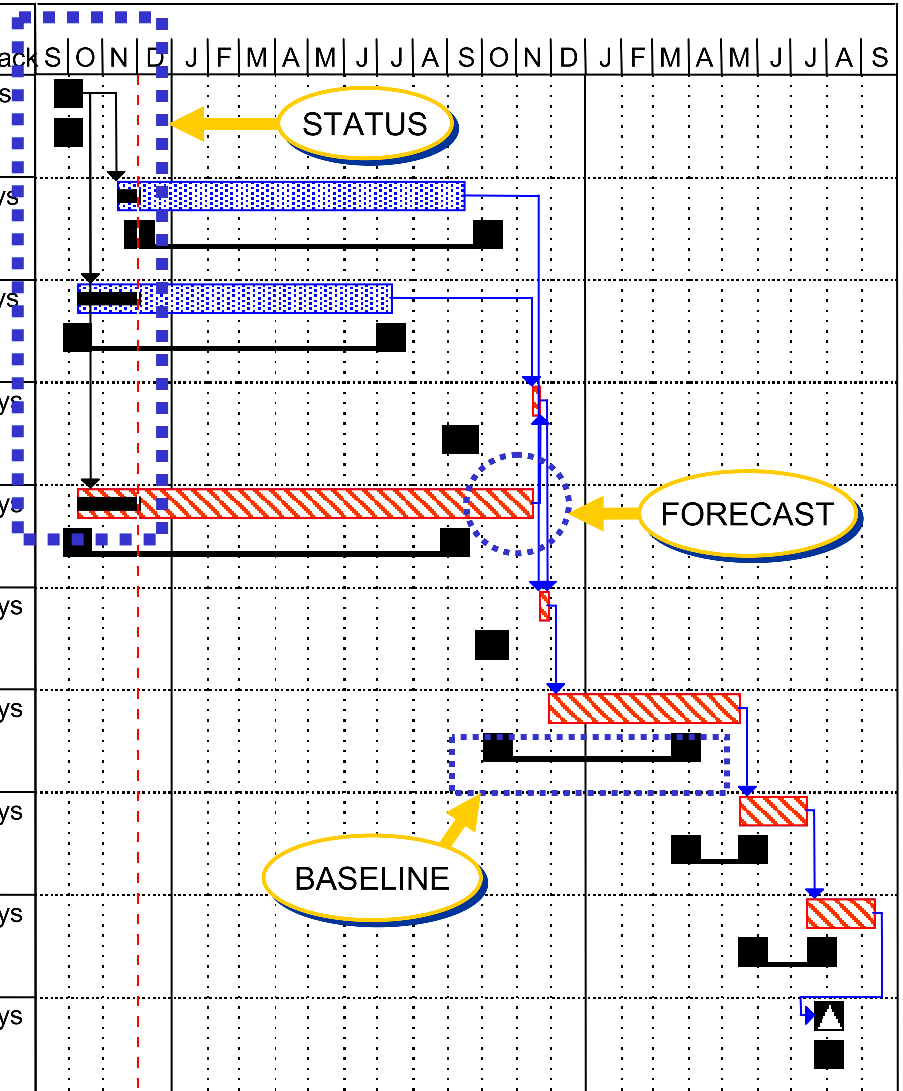
Examples of Schedule Reporting Products



NBT Project Schedule

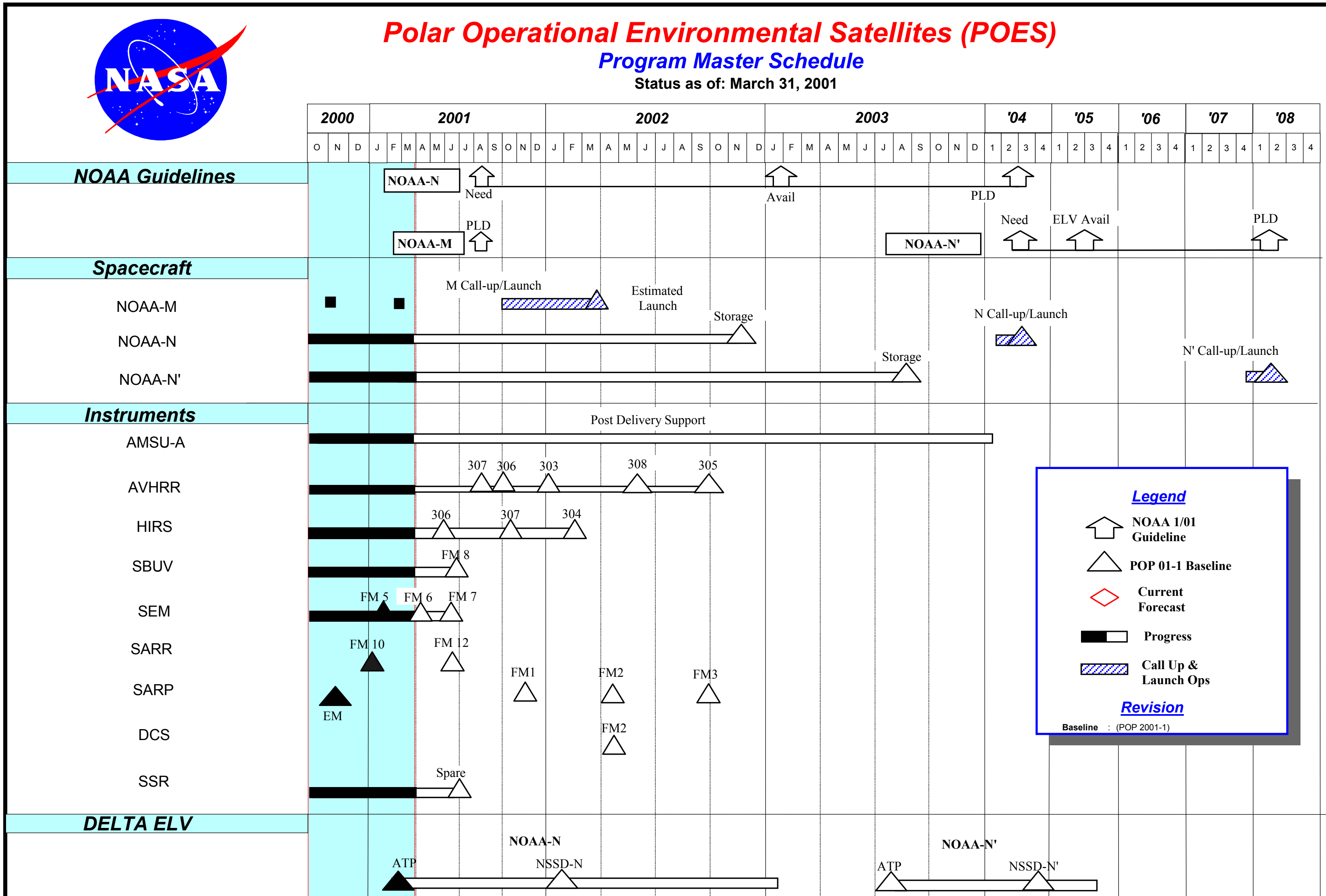
As of 11/30/01

ID	Activity	Dur	Early Start	Early Finish	Total Slack
1	Authorize Funding	0 days	10/1/01	10/1/01	0 days
2	Procure VEI Instrument	220 days	11/12/01	9/13/02	19 days
3	Procure Spacecraft Bus	200 days	10/8/01	7/12/02	59 days
4	Integrate RCI to Spacecraft	5 days	11/14/02	11/20/02	-29 days
5	Develop RCI Instrument	288 days	10/8/01	11/13/02	-29 days
6	Integrate VEI to Spacecraft	5 days	11/21/02	11/27/02	-29 days
7	Observatory Testing	120 days	11/28/02	5/14/03	-29 days
8	Schedule Contingency	60 days	5/15/03	7/13/03	-41 days
9	Launch Site Operations	60 days	7/14/03	9/11/03	-41 days
10	Launch	0 days	8/1/03	8/1/03	-41 days



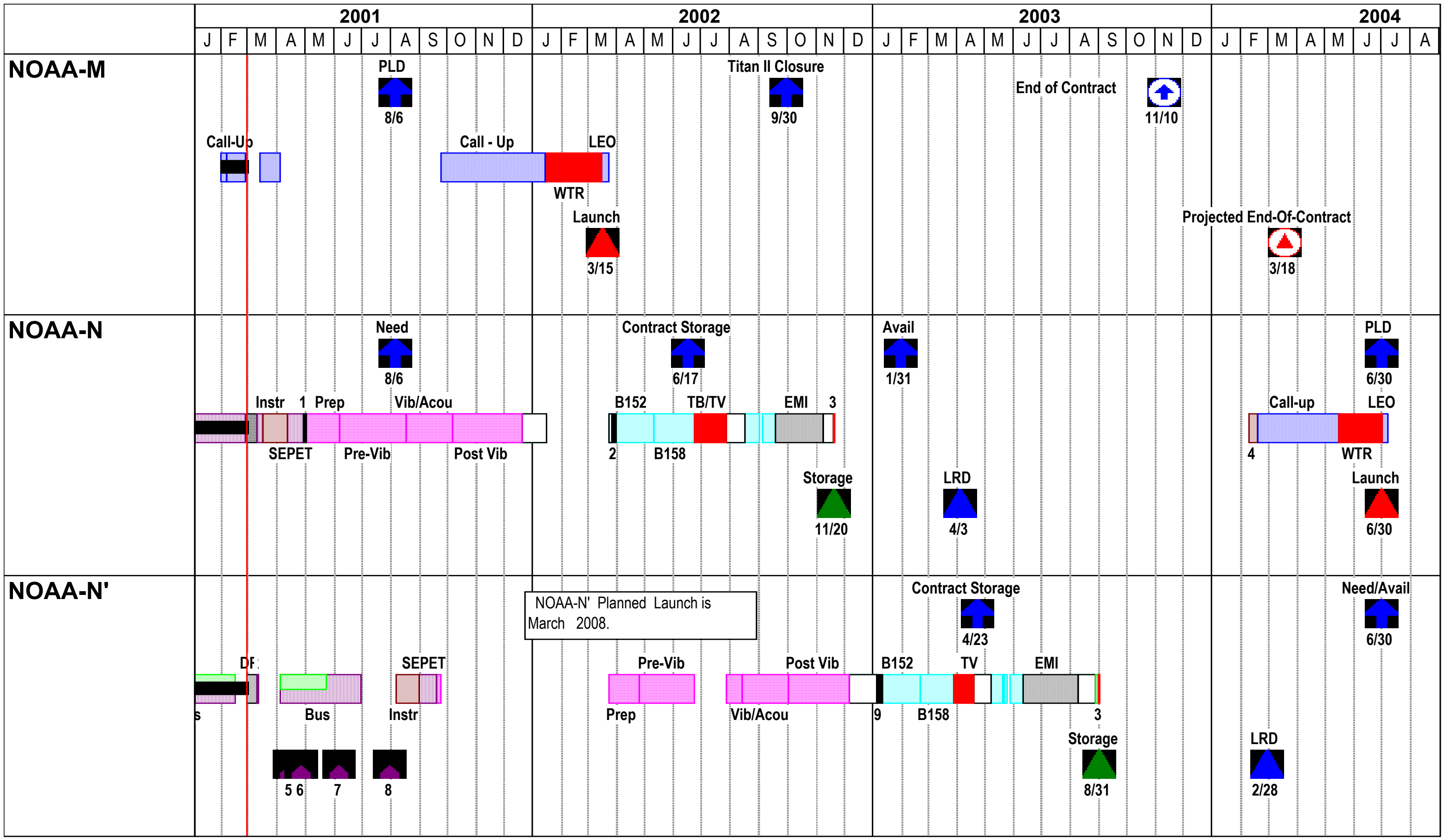
REV: Baseline 8/15/01

Example Master Schedule



Example Intermediate Schedule

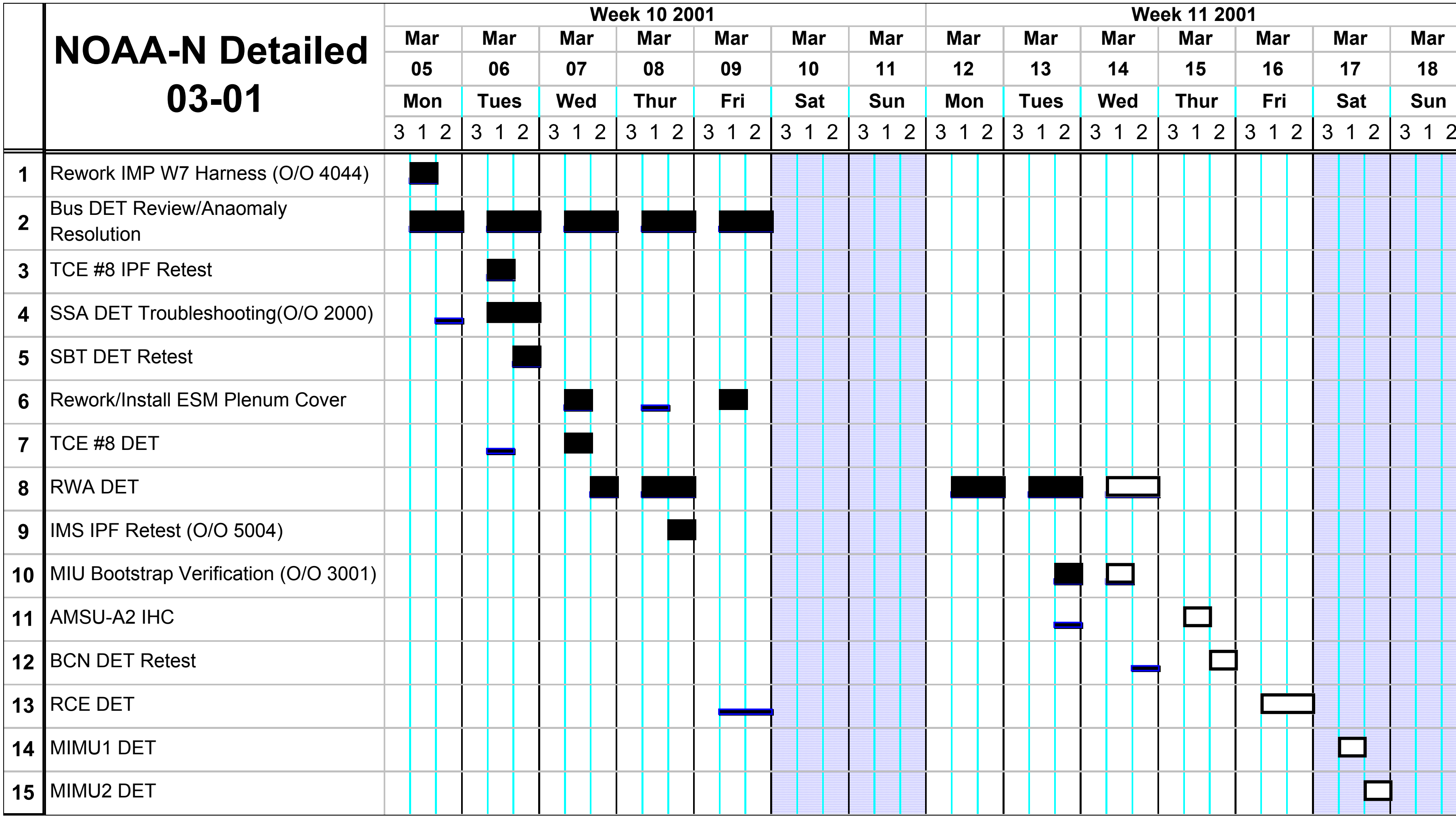
NOAA M-N' Integration & Test Summary Schedule: As of 2/28/01



Foot Notes:
1. A303 Removal; Installation of Mass Model*
2. A303 Re-Integration & IPF/DET*
3. SEM & SBUV* Removal
4. SEM & SBUV* Re-Integration
5. SARR Delivery 4/15/01
6. A303 Installation on N' 4/27/01
7. SBUV Delivery 6/7/01
8. SARP/ADCS Delivery 7/31/01
9. SARP & ADCS Software Upgrades*

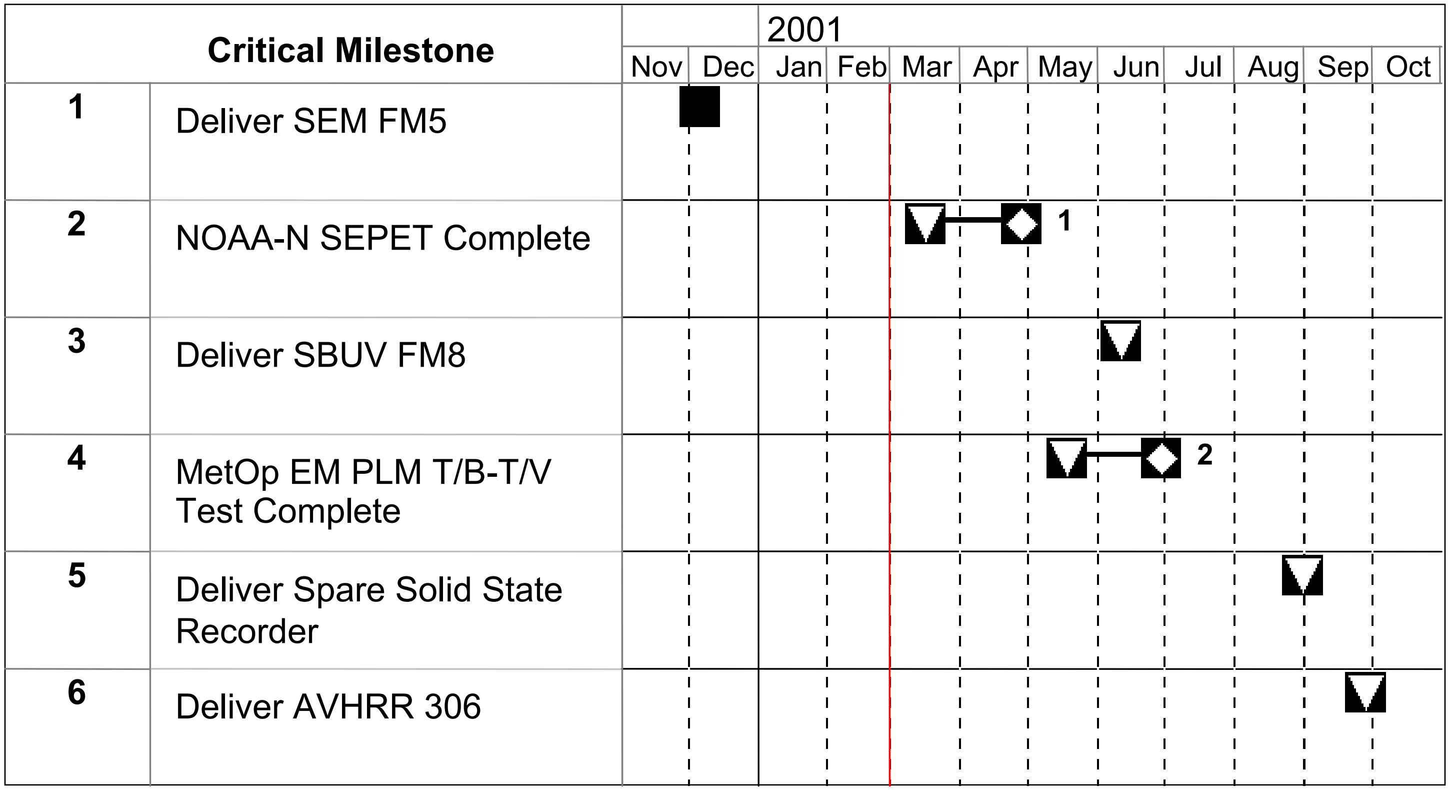
* = Not yet in LMMS Master Schedule

Example Detailed Schedule



Example Milestone Chart

POES CRITICAL MILESTONE CHART – March 2001

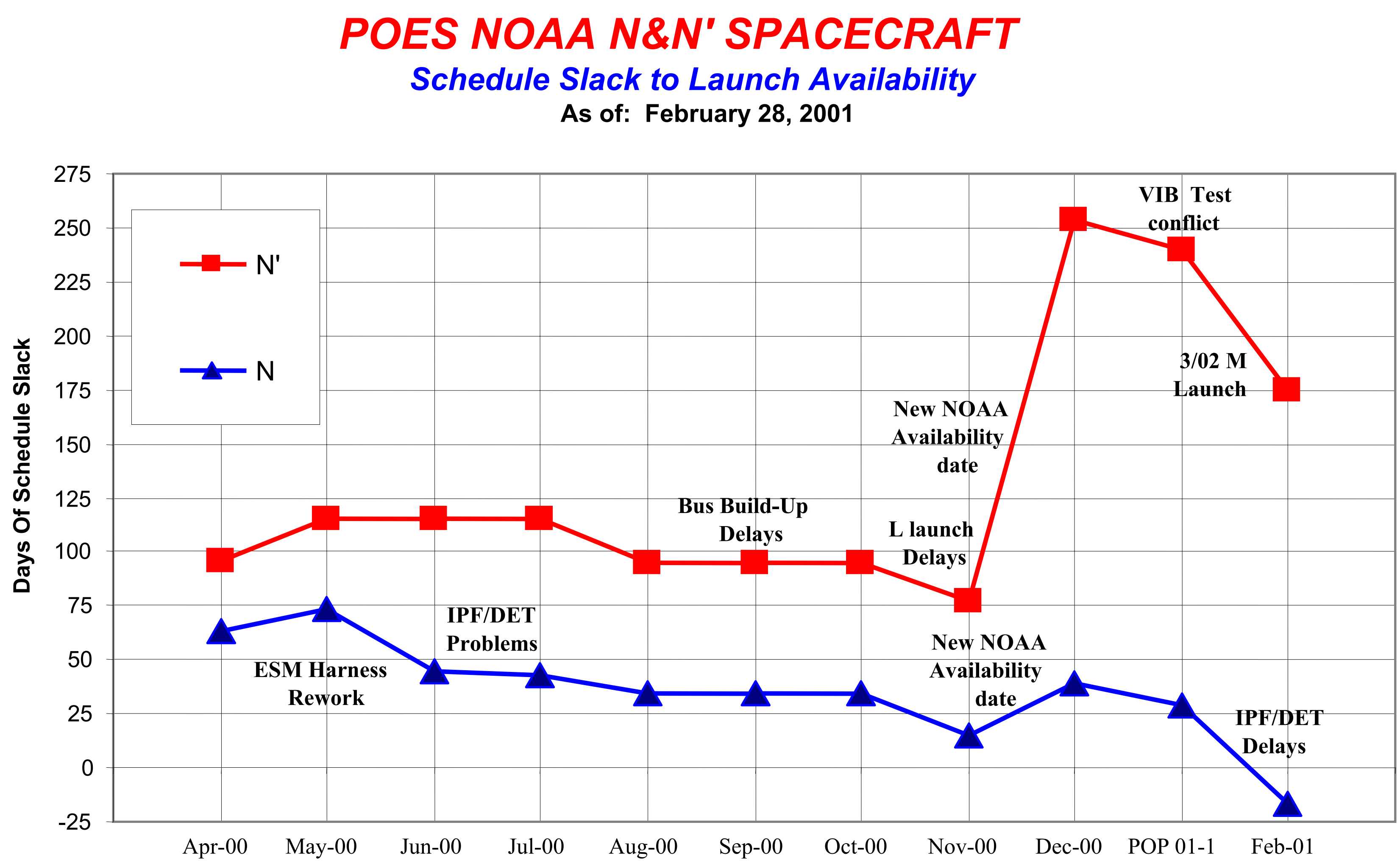


1. DET troubleshooting and retesting.
2. Late GOME delivery and holiday shut down.

Example Slack Report

XYZ Project Total Slack Summary - As of April 30, 2001							
	Baseline		March 2001		April 2001		
	Delivery	Total Slack	Delivery	Total Slack	Delivery	Total Slack	Driver
Structure	1/5/2001	+67	Complete	-	Complete	-	
Propulsion	1/5/2001	+70	Complete	-	Complete	-	
Electrical	1/5/2001	+88	4/5/2001	+55	Complete	-	Main Harness (design change)
Power	2/15/2001	+67	4/25/2001	+46	5/24/2001	+52	Solar Array
C&DH	4/3/2001	+45	4/3/2001	+45	7/1/2001	-15	SDS Box #1 (IC cracks)
ACS	3/30/2001	+62	5/1/2001	+50	6/1/2001	+31	Earth Sensor
Flight Software	6/1/2001	+60	6/1/2001	+60	6/1/2001	+60	FSW Build #1
Deployables	4/22/2001	+90	4/22/2001	+90	5/3/2001	+90	Solar Array Drive Motors
Communications	5/1/2001	+56	5/1/2001	+56	5/1/2001	+56	High Gain Antenna
Thermal	3/15/2001	+78	4/16/2001	+45	Complete	-	Louvers
EGSE	2/15/2001	+48	4/1/2001	+22	2/15/2001	+45	DTS Rack
MGSE	12/1/2000	+65	Complete	-	Complete	-	
Observatory I&T	12/15/2003	+45	12/15/2003	+45	3/17/2004	-15	Late SDS Box #1 Delivery
Instrument A	6/15/2002	+60	6/15/2002	+60	7/17/2002	+30	Cooler
Instrument B	4/3/2002	+70	2/15/2002	+89	2/15/2002	+89	Focal Plane
Instrument C	8/2/2002	+60	8/2/2002	+60	8/2/2002	+60	Vishay Resistors
Ground System	5/1/2003	+75	5/1/2003	+75	5/1/2003	+75	GDS Build #2
Launch Readiness	8/1/2004	45	8/1/2001	45	9/30/2004	-15	Late SDS Box #1 Delivery

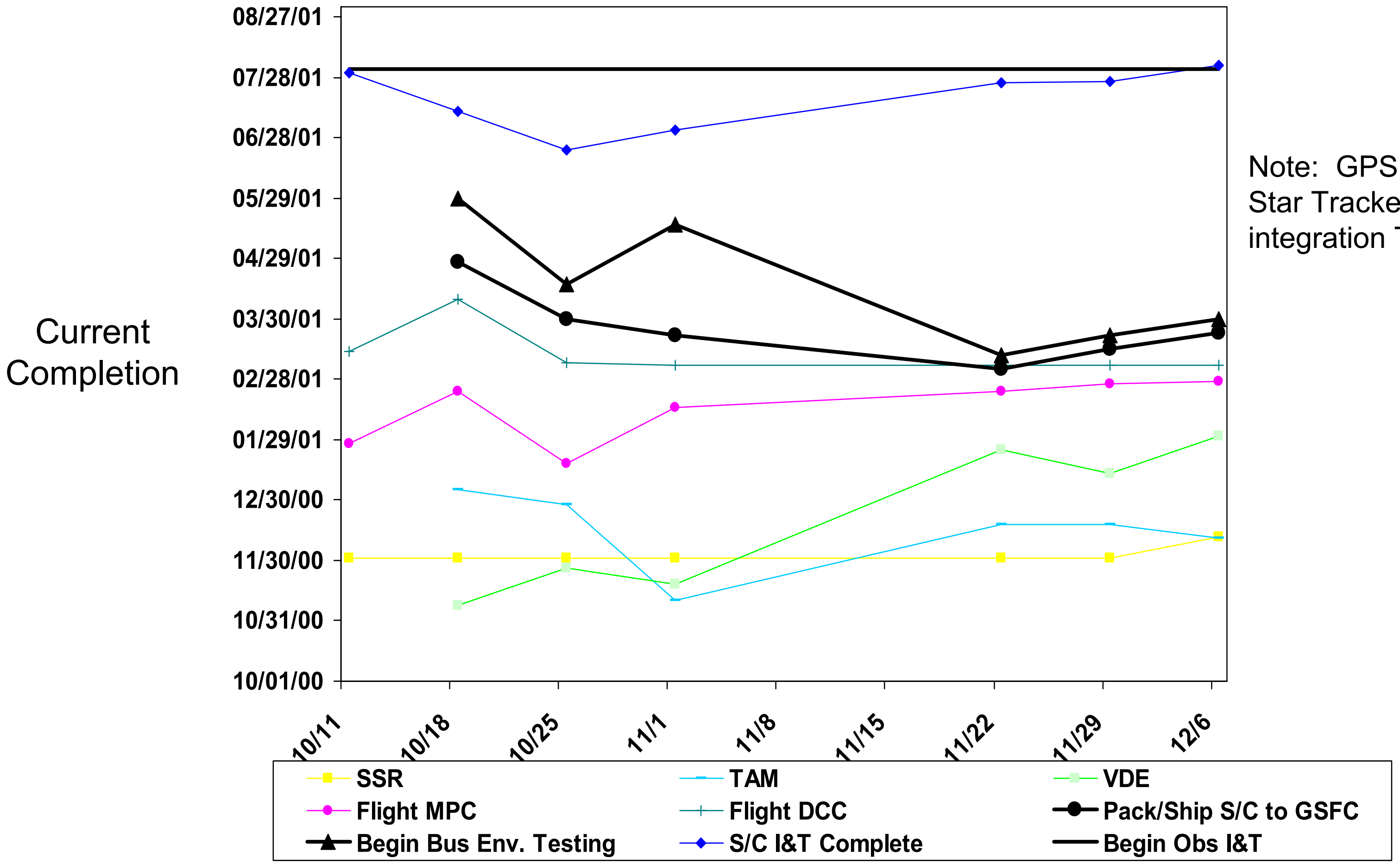
Example Slack Trend



Delivery vs. Need Trend

Critical S/C Milestones vs. Observatory I&T Need

Week Ending 12/6/00



Note: GPS and Star Tracker integration TBD.

Example Control Milestones Report

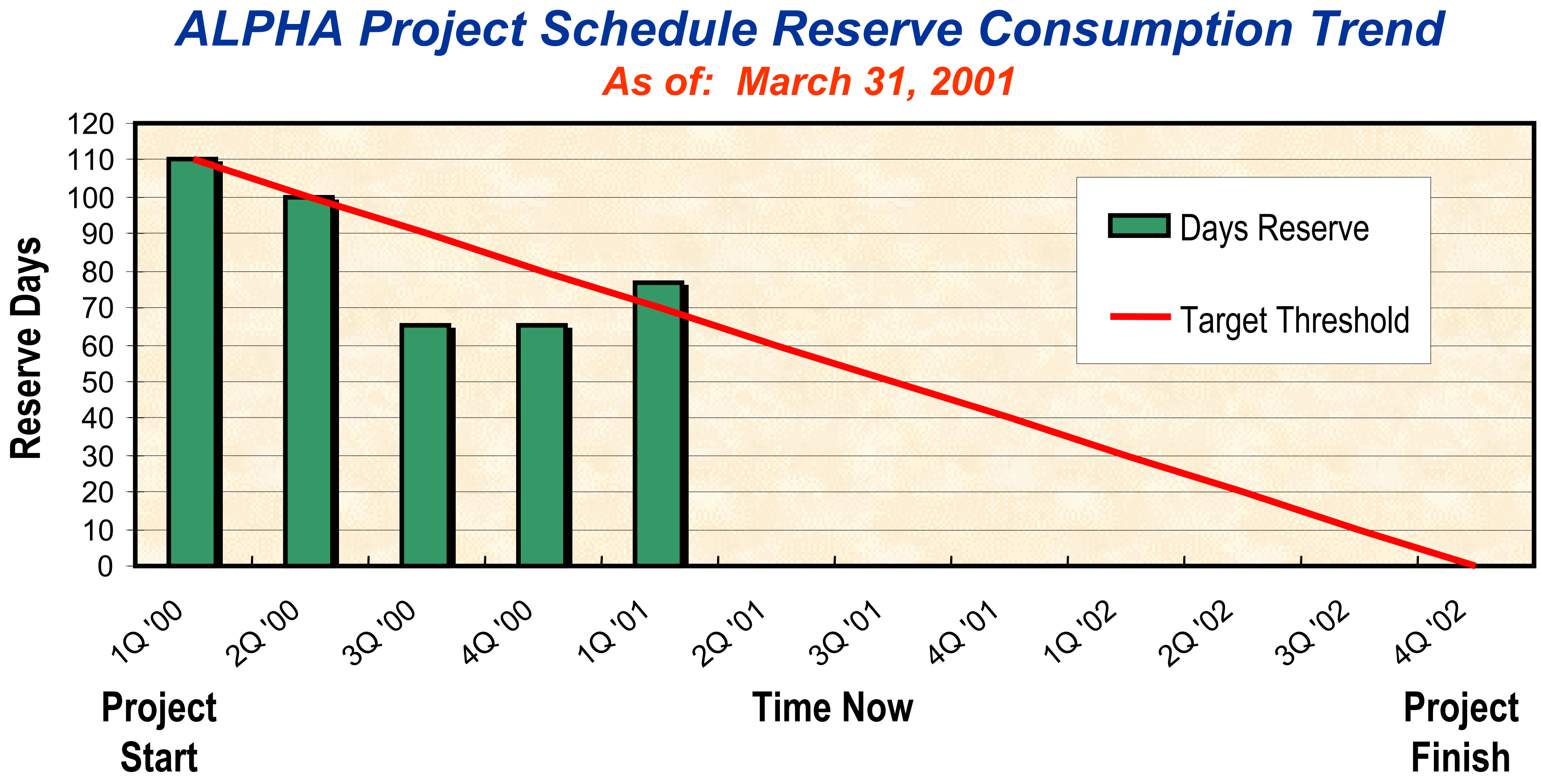
Page 1 of 8

METEOROID IDENTIFICATION & SPACE TRACKING (MIST) PROJECT
PROJECT CONTROL MILESTONE & TOTAL FLOAT REPORT

DATA DATE: 30APR96

ACTIVITY IDENTIFIER	ACTIVITY DESCRIPTION	BASELINE DELIVERY	BASELINE TOTAL FLOAT	MARCH DELIVERY	MARCH TOTAL FLOAT	APRIL DELIVERY	APRIL TOTAL FLOAT	TF CHANGE MAR / APR
MIST MILESTONES								
MIST255	Pre-Environmental Test Review (PER)	17MAY96	19	17MAY96	23	17MAY96	23	0
OBS242	Pre-Shipment Review (PSR)	17MAR97	15	26MAR97	9	02APR97	3	-6
OBS240	Observatory Ready for Shipment	27MAR97	11	05APR97	3	12APR97	-5	-8
OBS0248	Observatory Arrival at Launch Site	22APR97	11	01MAY97	1	08MAY97	-5	-6
OBS500	MIST Launch Readiness	01APR98	0	01APR98	0	06APR98	-5	-5
MIST250	MIST Mission Operations Review (MOR)	28MAR96	87	28MAR96	87	29MAR96(A)	0	0
POWER SUBSYSTEM								
POSA670	+Z Solar Array Panels Delivery	06MAR96	84	19APR96	52	10MAY96	44	-8
POSA695	+Z Solar Array Panels Ready for SADDS I&T	20MAR96	84	03MAY96	52	24MAY96	44	-8
POSA671	-Z Solar Array Panels Delivery	03MAY96	49	31MAY96	26	31MAY96	33	7
POSA696	-Z Solar Array Panels Ready for SADDS I&T	17MAY96	49	14JUN96	26	14JUN96	33	7
POBAT960	Super NiCd Battery Delivery	15APR96	152	30APR96	142	30APR96(A)	0	0
POBAT980	Super NiCd Battery Delivery (spare set)	13MAY96	152	29MAY96	142	29MAY96	144	2
C&DH SUBSYSTEM								
CDH6012	RTT A Ready for OBS I&T	22MAR96	49	12APR96	5	23APR96(A)	0	0
CDH6022	RTT B Ready for OBS I&T	28MAY96	5	28MAY96	5	07JUN96	-5	-10
ATTITUDE CONTROL SUBSYSTEM								
ACS402A	ACS B5.2 Ready for Formal S/W IV&V	15MAR96	35	14MAR96	0	14MAR96(A)	0	0
DEPLOYABLES SUBSYSTEM								
DES08021	+Z SADDS Flight Wing Ready for OBS I&T	04SEP96	12	12SEP96	2	03SEP96	14	12
DES08022	-Z SADDS Flight Wing Ready for OBS I&T	06SEP96	14	12SEP96	6	02OCT96	-3	-9
DES2016	SADA Ready for OBS I&T	15MAR96	10	18MAR96	0	18MAR96(A)	0	0

Example Schedule Reserve Trend



Example Baseline Schedule Revision Matrix

LMSS Master Schedule Revisions

TASK	July 1999 BASELINE	REV A A-DCS/ SARP-3	REV A' -6 days for A-DCS/ SARP3	REV B 5/9/00 L LAUNCH	REV B' -6 days for A-DCS/ SARP 3	REV C 8-9-00 L LAUNCH	REV D Early M Instrument Re-Integration	REV E 8-18-00 L LAUNCH	REV F 8-29-00 L LAUNCH	REV G 8/29/00 L Launch	REV H 8/29/00 L Launch	REV I 9/14/00 L Launch	REV J 9/20/00 L Launch	REV K 9/21/00 L Launch	REV L 8/6/01 M Launch
L to Storage	2/26/99	2/26/99	2/26/99	2/26/99	2/26/99	2/26/99	3/8/99 (A)								
L Launch	4/1/00	4/1/00	4/1/00	5/9/00	5/9/00	8/9/00	8/9/00	8/18/00	8/29/00	8/29/00	8/29/00	9/14/00	9/20/00	9/21/00	
M to Storage	4/25/00	4/25/00	4/25/00	2/18/00	2/18/00	2/18/00	4/25/00 (A)								
M Launch	5/15/01	5/15/01	5/15/01	5/15/01	5/15/01	5/15/01	5/15/01	5/15/01	5/15/01	5/15/01	5/15/01	5/15/01	5/15/01	5/15/01	8/6/01
N to Storage	4/22/02	4/22/02	4/22/02	3/29/02	3/29/02	6/17/02	6/17/02	6/17/02	6/17/02	6/17/02	6/17/02	6/26/02	7/2/02	7/3/02	7/2/02
N Launch	1/21/03	2/25/03	2/18/03	3/21/03	3/14/03	5/30/03	5/30/03	5/30/03	5/30/03	6/6/03	6/15/03	6/27/03	7/2/03	7/3/03	7/13/03
N' to Storage	12/3/02	1/11/03	1/4/03	2/4/03	1/28/03	4/15/03	4/15/03	4/15/03	4/15/03	4/23/03	5/2/03	5/14/03	5/19/03	5/20/03	5/30/03
N' Launch	6/10/03	7/17/03	7/10/03	8/10/03	8/3/03	10/19/03	10/19/03	10/19/03	10/19/03	10/30/03	11/8/03	11/22/03	11/24/03	11/26/03	12/6/03
End of Contact	6/17/03	7/23/03	7/16/03	8/16/03	8/9/03	10/25/03	10/25/03	10/25/03	10/25/03	11/10/03	11/15/03	11/29/03	12/1/03	12/3/03	12/13/03

= Latest Contract Modification (shaded column: REV G)

Example Project Schedule Book

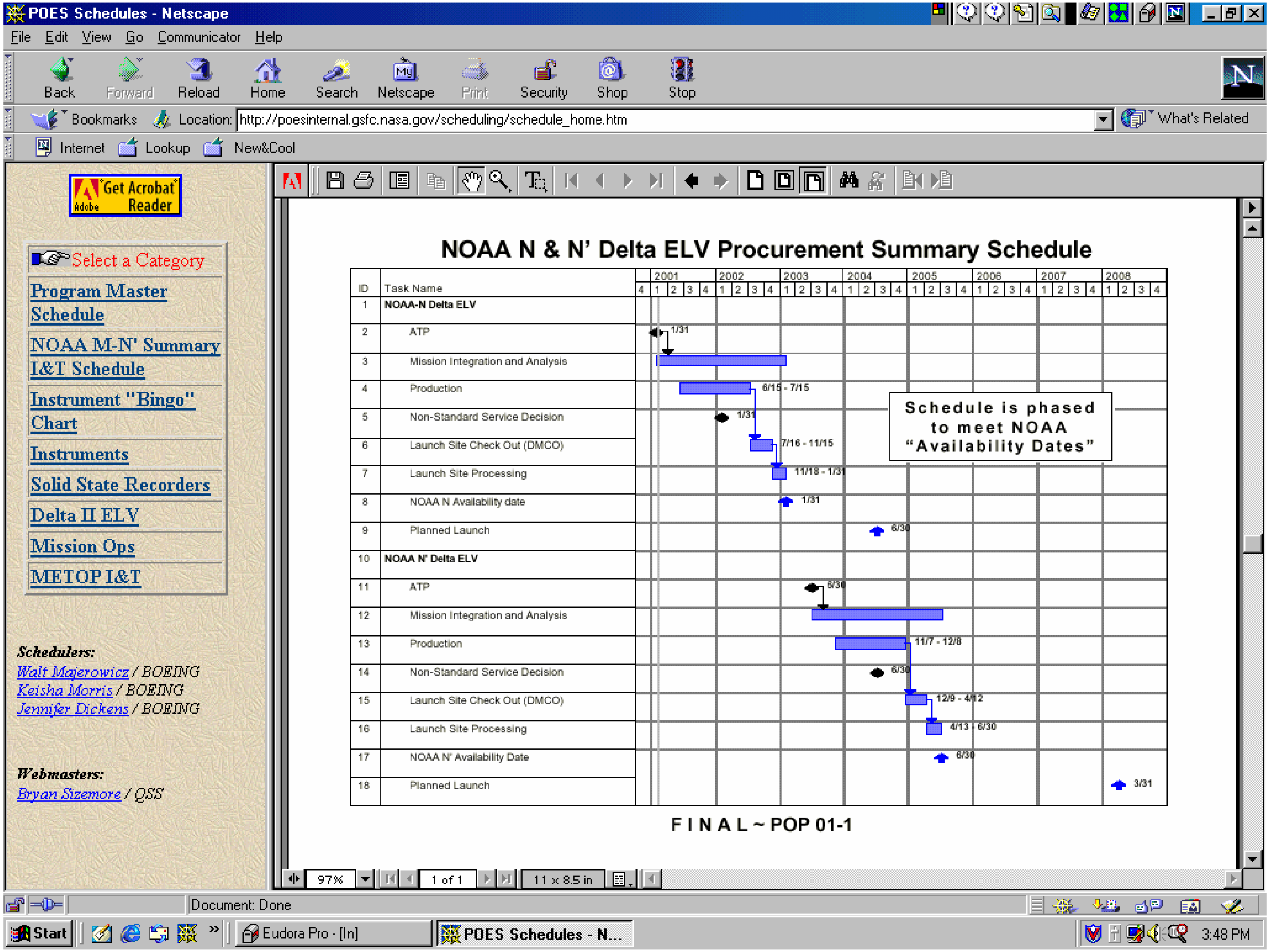
POES Program Schedules

As of: Feb

INTERNAL POES PRO

Contents

Example Project Schedule Web Site



Other Types of Schedule Reports

- Critical Activities
- Milestones
- Working Days
- Unstarted Activities
- Activities Starting Soon
- Activities In Progress
- Completed Activities
- Slipping Activities
- Should Have Started Activities
- Past Due Activities/Milestones
- Activity Resource Usage
- Overallocated Resources
- Resource Usage

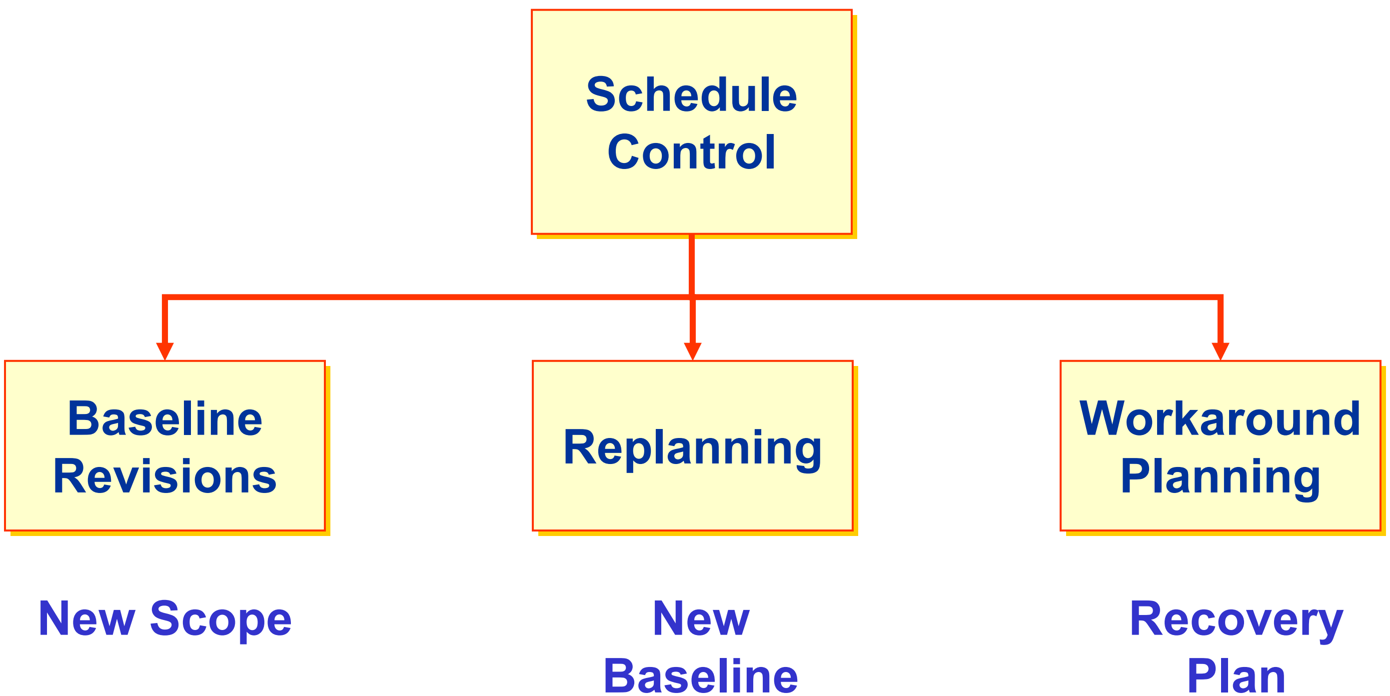
11.0
Schedule Control

– Baseline Schedule Revision
– Replanning
– Workaround Planning

Schedule Control

Schedule Control is the process of changing the project schedule in a timely, disciplined manner in response to:

a) new work scope
b) the need for a new baseline schedule
c) recovery from actual or potential schedule problems



Baseline Schedule Revisions

The baseline schedule revision process consists of modifying the baseline schedule through the incorporation of new authorized work scope.

INPUT

- Baseline schedule
- Contract deliverables
- New Scope
- Change requests
- Authorization

PROCESS

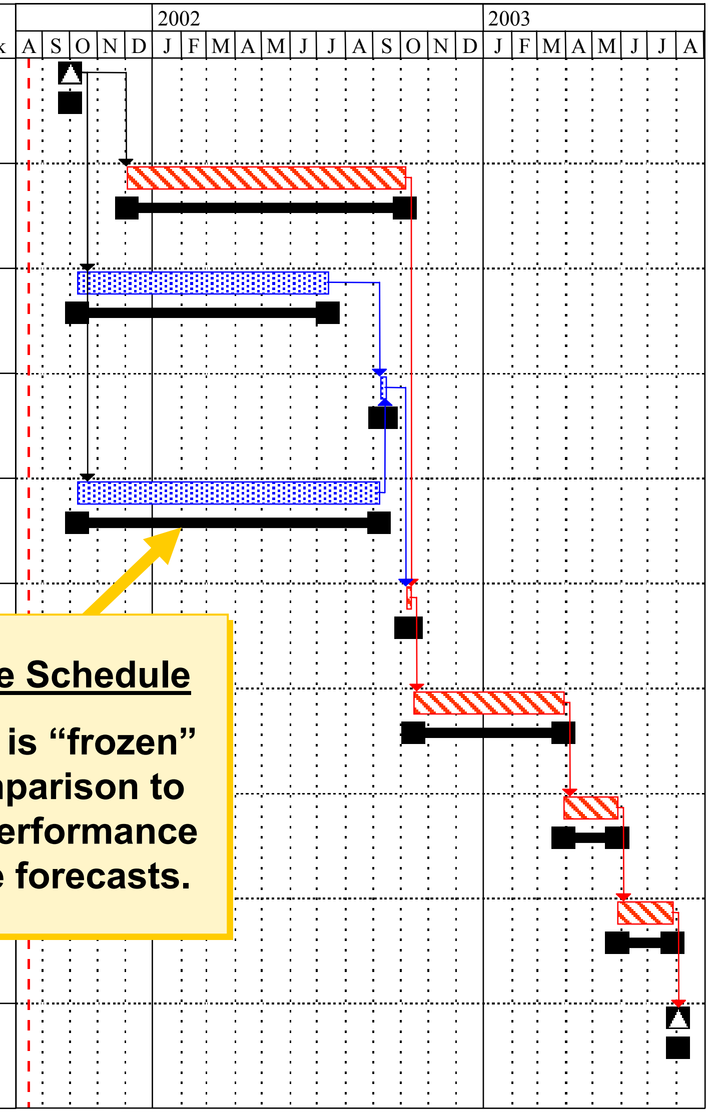
- Incorporate the change into the baseline schedule
- Analyze it's effect on project objectives
- Issue schedule revision

OUTPUT

- Baseline schedule revisions: REV A, REV B, etc.
- Contract delivery date mods

Remember the Baseline Schedule?

ID	Activity	Dur	Early Start	Early Finish	Baseline Start	Baseline Finish	Total Slack
1	Authorize Funding	0 days	10/1/01	10/1/01	10/1/01	10/1/01	19 days
2	Procure VEI Instrument	220 days	12/3/01	10/4/02	12/3/01	10/4/02	4 days
3	Procure Spacecraft Bus	200 days	10/8/01	7/12/02	10/8/01	7/12/02	59 days
4	Integrate RCI to Spacecraft	5 days	9/9/02	9/13/02	9/9/02	9/13/02	19 days
5	Develop RCI Instrument	240 days	10/8/01	9/6/02	10/8/01	9/6/02	19 days
6	Integrate VEI to Spacecraft	5 days	10/7/02	10/11/02	10/7/02	10/11/02	4 days
7	Spacecraft Testing	120 days	10/14/02	3/28/03	10/14/02	3/28	
8	Schedule Contingency	60 days	3/29/03	5/27/03	3/29/03	5/27	
9	Launch Site Operations	60 days	5/28/03	7/26/03	5/28/03	7/26	
10	Launch	0 days	8/1/03	8/1/03	8/1/03	8/1/03	0 days



Baseline Schedule

A target is “frozen” for comparison to actual performance & future forecasts.

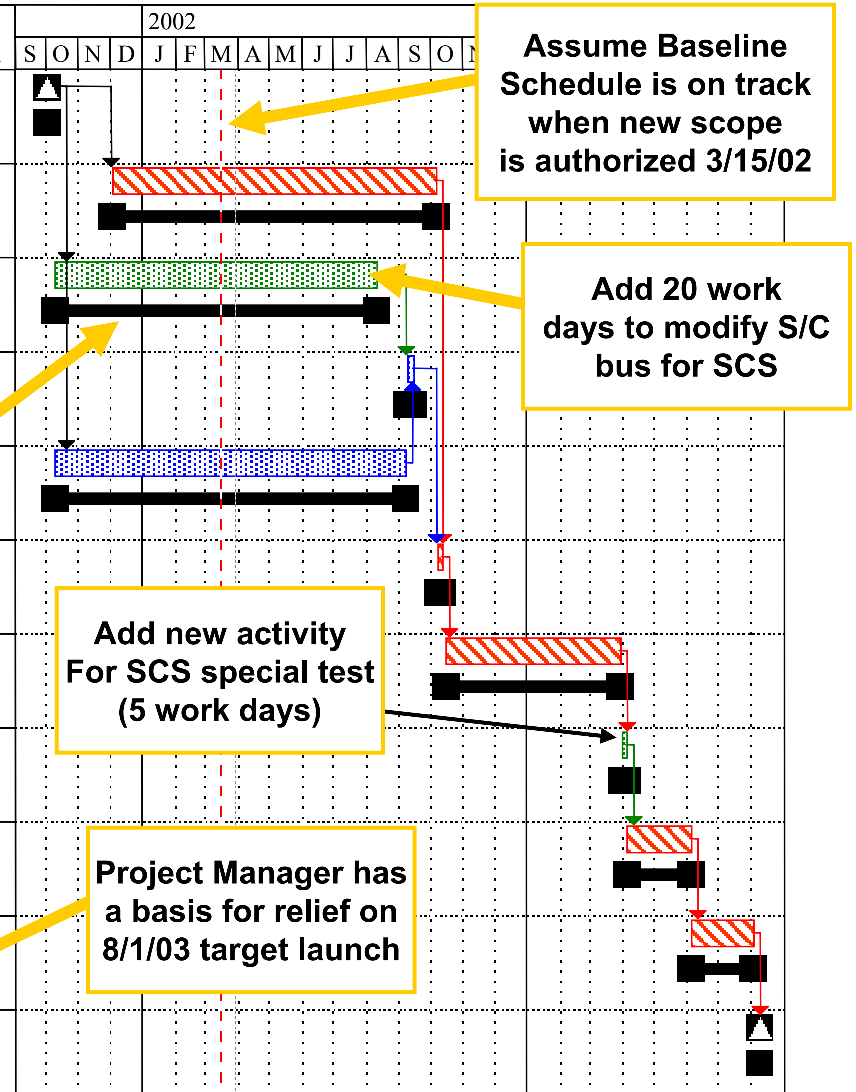
REV: Baseline 8/15/01

Adding New Scope to the NBT Baseline Schedule

- On 3/15/02, NASA HQ authorized additional scope and funding to the NBT Project to add a Special Contamination Sensor (SCS) to the spacecraft bus to gather data for future missions.
- The NBT Project team has analyzed the change and determined:
  - Ultra Corporation will need 20 more work days to modify the spacecraft bus for the SCS;
  - A “Special SCS Compatibility Test” lasting 5 work days will be needed after observatory testing is completed.
- The SCS change is incorporated into the NBT Baseline Schedule and . . .

NBT Project Baseline Schedule – Revision A

ID	Activity	Dur	Baseline Start	Baseline Finish	Total Slack
1	Authorize Funding	0 days	10/1/01	10/1/01	19 days
2	Procure VEI Instrument	220 days	12/3/01	10/4/02	4 days
3	Procure Spacecraft Bus	220 days	10/8/01	8/9/02	39 days
4	Integrate RCI to Spacecraft	5 days	9/9/02		
5	Develop RCI Instrument	240 days	10/8/01		
6	Integrate VEI to Spacecraft	5 days	10/7/02	10/11/02	4 days
7	Spacecraft Testing	120 days	10/14/02	3/28/03	4 days
8	SCS Special Test	5 days	3/31/03	4/4/03	4 days
9	Schedule Contingency	60 days	4/5/03	6/3/03	6 days
10	Launch Site Operations	60 days	6/4/03	8/2/03	6 days
11	Launch	0 days	8/8/03	8/8/03	0 days



NBT Baseline Revision Comparison

	Baseline	REV A (add SCS)
VEI Delivery	10-4-02	10-4-02
S/C Bus Delivery	7-12-02	**8-9-02**
RCI Delivery	9-6-02	9-6-02
Observatory Delivery	3-28-03	**4-4-03**
Planned Launch	8-1-03	**8-8-03**

Schedule Revision Guidelines

- Lock the baseline schedule away… but keep the key handy!
- Authorization is needed before incorporating new scope into baseline schedule
- Assume existing baseline schedule is in "on track" at the time new scope change is authorized
- Incorporate the change into the existing "unstatused" baseline schedule
- Do not use schedule reserve or slack to absorb impact of new scope changes
- Review schedule revision with project team, change board, and customer
- Release formal baseline schedule revision to project team

Schedule Replanning

Replanning is the process of changing the original baseline schedule and establishing a new baseline (rebaseline). A new baseline is necessary because the original baseline schedule is no longer achievable, and tracking performance and variances is not meaningful and even misleading.

INPUT

- Baseline schedule
- Contract deliverables
- New scope
- Change requests
- Poor schedule performance
- Project problems
- New approaches

PROCESS

- Internal schedule replanning
- External schedule replanning
- Reprogramming

OUTPUT

- New baseline schedule
- Contract delivery date mods
- Schedule replan
- Over Target Schedule

Internal & External Replanning

Internal Schedule Replanning - A restructuring of the original baseline schedule to compensate for cost, schedule or technical problems

- Original baseline schedule no longer achievable
- Project scope, requirements, and delivery objectives remain same
- Results in a new baseline schedule that still meets the project's objectives
- Initiated internally by the project team

External Schedule Replanning – "Customer-directed" change to the original baseline schedule

- Project scope, requirements or delivery objectives are changed by the project sponsor, customer, or funding authority
- Results in a new baseline schedule and project objective
- Initiated externally by the project sponsor, customer, or funding authority (e.g. "change order)

Schedule Reprogramming

Schedule Reprogramming - A comprehensive replanning of the "to go" part of the project schedule

- Original baseline schedule no longer achievable
- Project scope, requirements, and delivery objectives remain same
- Results in an "Over Target Schedule" that will not meet the project's objectives
- Typically associated with cost overruns
- Usually requires customer or project sponsor approval

Note on Internal & External Replanning and Reprogramming:

These terms have specific meanings within Earned Value Management (EVM). The underlying concepts have been modified to better illustrate their applicability to project schedules.

Workaround Planning

Workaround planning is the process of formulating alternative schedule approaches in order to overcome actual or potential schedule problems. The objective is to either avoid the potential problem or recover from its actual occurrence while still meeting the project's schedule objectives (baseline or current operating schedule).

INPUT

- Baseline schedule
- Current schedule
- Poor schedule performance
- Project problems
- New approaches

PROCESS

- Brainstorming
- "What-If" schedule analysis
- Risk analysis
- Cost/schedule/technical trade-offs

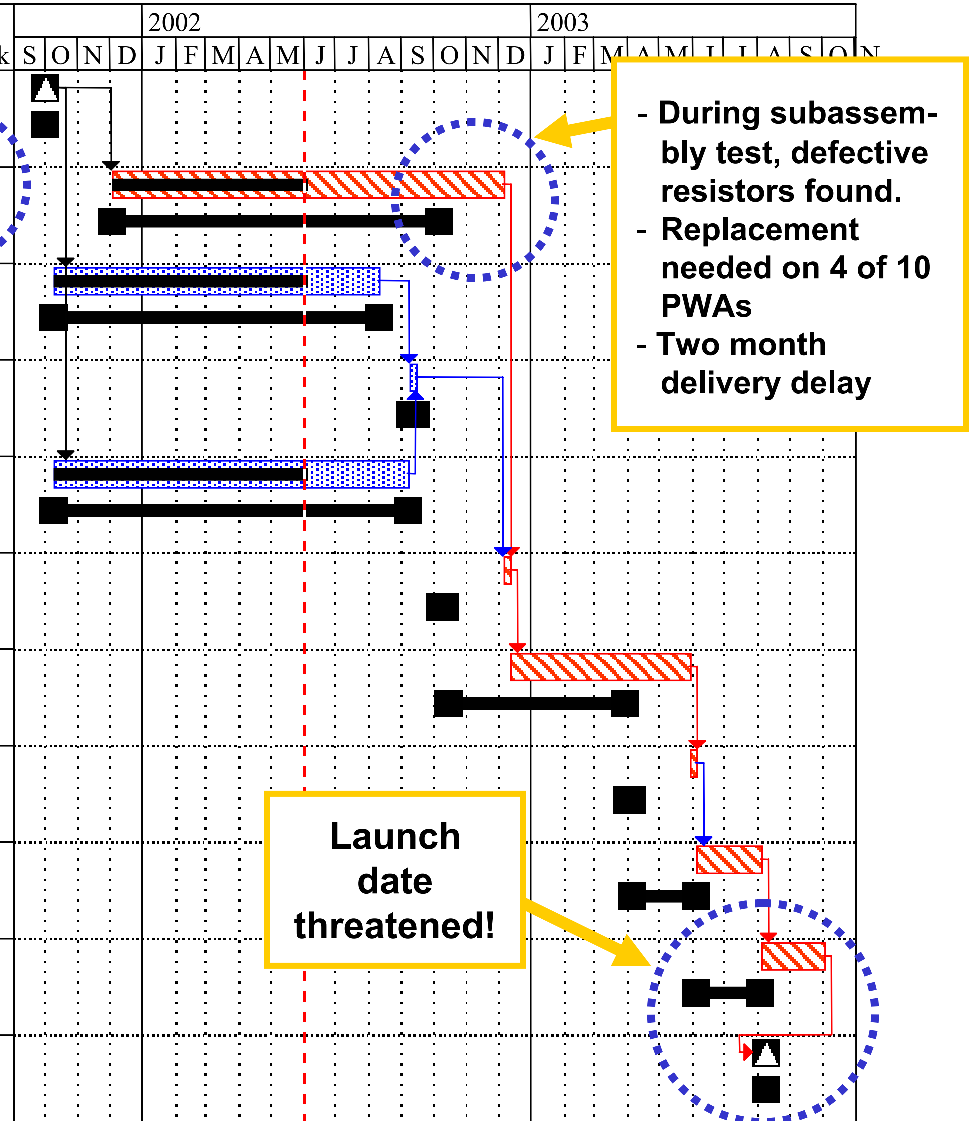
OUTPUT

- Workaround or recovery schedules
- *Corrective Action*

Workaround Planning Illustrated

ID	Activity	Dur	Early Start	Early Finish	Total Slack
1	Authorize Funding	0 days	10/1/01	10/1/01	175 days
2	Procure VEI Instrument	263 days	[illegible]	/02	-39 days
3	Procure Spacecraft Bus	220 days	10/8/01	8/9/02	39 days
4	Integrate RCI to Spacecraft	5 days	9/9/02	9/13/02	19 days
5	Develop RCI Instrument	240 days	10/8/01	9/6/02	19 days
6	Integrate VEI to Spacecraft	5 days	12/5/02	12/11/02	-39 days
7	Spacecraft Testing	120 days	12/12/02	5/28/03	-39 days
8	SCS Special Test	5 days	5/29/03	6/4/03	-39 days
9	Schedule Contingency	60 days	6/5/03	8/3/03	-55 days
10	Launch Site Operations	60 days	8/4/03	10/2/03	-55 days
11	Launch	0 days	8/8/03	8/8/03	-55 days

Negative total slack



Class Discussion

PLEASE DON'T TURN THE PAGE !

How can the NBT Project team "workaround" the potential VEI delivery delay?

Some Workaround Options

Acme Instrument (VEI supplier)

- Use internal schedule reserve
- Add additional resources (e.g., 2nd I&T shift to make up delay)
- Use spares, “borrow” good PWAs from other units or use engineering PWAs to continue testing
- Restructure/streamline I&T workflow
- Expedite replacement resistor deliveries from vendor

NBT project team

- Descope VEI contract
- Utilize mass models and VEI Engineering Test Unit (ETU) for early observatory integration
- Use project-level schedule reserve
- Add additional resources to observatory I&T phase to absorb delay

12.0

CASE STUDY:

“The MIST Project”

Case Study: The MIST Project
(1 of 5)

Background

The Meteoroid Identification & Space Tracking (MIST) mission is an "out-of-house" project managed by GSFC. It is currently well into the implementation phase and consists of a single observatory, one primary mission scientific instrument and two secondary scientific instruments. While of minimal importance to MIST's primary mission of identifying and tracking potential meteoroid threats to Earth, the two secondary instruments are nonetheless highly visible in political and scientific circles. Moreover, their inclusion on the MIST spacecraft was a key factor in obtaining Congressional support and early funding for the mission. The ground system is being developed "in-house" at GSFC. MIST will be launched on a Delta launch vehicle from KSC in February 2003. Failure to launch MIST by February 15, 2003 would virtually eliminate the opportunity to collect trajectory data from the Opekean comet's debris field for the next 44 years. Additionally, any serious threat to launching MIST as planned could result in cancellation of the mission.

AstroCorp is the prime contractor responsible for developing the MIST spacecraft. It will also handle launch site operations. STI Systems is developing the SRV/2 instrument which is the primary scientific instrument critical to mission success. The SRV/2 will be Government Furnished Equipment (GFE) to AstroCorp. The OMEGA-1 instrument is a secondary scientific instrument being provided by the Republic of Chile's National Space Institute (RCNSI) at no cost to the U.S. government. Additionally, the MIST project has funded the U.S. Naval Academy (USNA) to develop the TRIAD instrument, the other secondary scientific instrument. The OMEGA-1 and the TRIAD are also GFE to AstroCorp.

Case Study – *(2 of 5)*

Statement of the Problem

Several months ago STI notified GSFC that due to extensive rework needed on the SRV/2 harness, and the subsequent retesting of the instrument that will be required, delivery will be delayed five months later than the contract delivery date of 8/1/01. It is now 8/31/01 and STI has submitted it's repair schedule (see Figure 1). This delivery also happens to be about three months later than when AstroCorp was planning to integrate the SRV/2 onto the MIST spacecraft, as indicated on their current integration & test (I&T) schedule (see Figure 2).

A secondary issue has also emerged: analysis indicates that the OMEGA-1 instrument may exhibit an electromagnetic interference (EMI) problem that could affect the TRIAD instrument. The USNA's position is that the OMEGA-1 problem should either be corrected or not flown on MIST. While not critical to the primary mission, TRIAD's inclusion on MIST was important in obtaining early funding from Congress. Moreover, removing the OMEGA-1 from MIST would be a severe blow to Chile's fledgling space program and could threaten NASA's future use of Chile's new launch complex near Punta Arenas. Both instruments are complete and ready for delivery to AstroCorp.

Therefore, based on AstroCorp's current observatory I&T schedule and the late SRV/2 delivery from STI, it appears that MIST's planned launch of February 15, 2003 is threatened unless a workaround is found. Additionally, it is important that the OMEGA-1 and TRIAD instrument EMI issue be resolved soon. While further engineering analysis indicates that some additional shielding of the OMEGA-1 harness will solve the EMI problem, the only options for verifying this fix are through a special test between the two instruments, or waiting for observatory EMI testing.

SRV/2 Harness Repair Schedule – STI Systems

As of: August 31, 2001

ID	Task Name	Dur	Start	Finish
1	Remove Harness	3 days	8/15/01	8/17/01
2	Repair Harness	30 days	8/20/01	10/1/01
3	Hi-pot	5 days	10/2/01	10/9/01
4	Buzzout	5 days	10/10/01	10/16/01
5	Bakeout	10 days	10/17/01	10/30/01
6	Install Harness	3 days	10/31/01	11/2/01
7	Functional Test	5 days	11/5/01	11/9/01
8	EMI/ EMC	10 days	11/13/01	11/27/01
9	Vibration	7 days	11/28/01	12/6/01
10	Acoustic	5 days	12/7/01	12/13/01
11	Thermal Balance/ Vacuum	20 edays	12/13/01	1/2/02
12	Mass Properties	2 days	1/3/02	1/4/02
13	Pack & Ship Instrument	4 days	1/7/02	1/10/02
14	Instrument Delivery	0 days	1/10/02	1/10/02
15	Contract Delivery	0 days	8/1/01	8/1/01

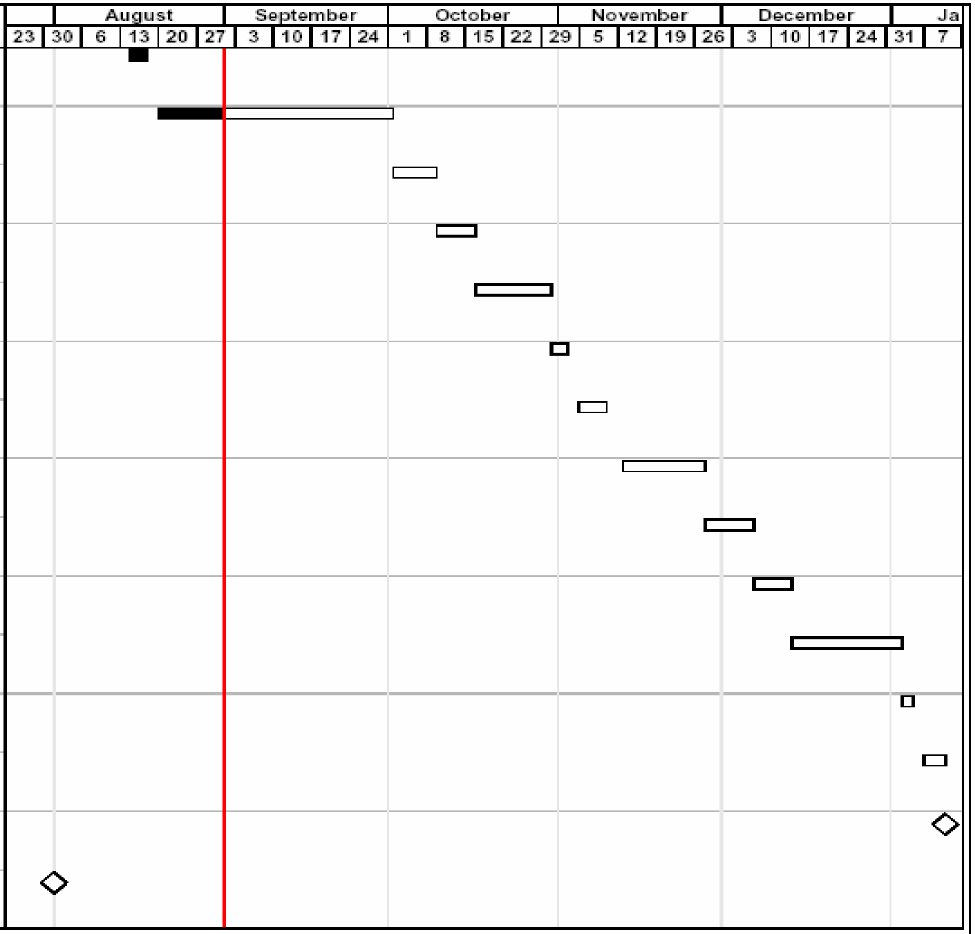


Figure 1

1 of 1

MIST Observatory I&T Schedule

As of: August 31, 2001

ID	Activity Name	Dur	Start	Finish
1	Deliver Spacecraft Structure to I&T	0 d	4/15/01	4/15/01
2	Propulsion Subsystem I&T	47 d	4/15/01	5/31/01
3	Electrical Subsystem I&T	16 d	6/1/01	6/16/01
4	C&DH Subsystem I&T	14 d	6/17/01	6/30/01
5	Power Subsystem I&T	20 d	8/1/01	8/20/01
6	RF Comm Subsystem I&T	20 d	7/1/01	7/20/01
7	Attitude Control Subsystem I&T	19 d	8/21/01	9/8/01
8	Deployables Subsystem I&T	20 d	9/9/01	9/28/01
9	Spacecraft CPT	9 d	9/29/01	10/7/01
10	SRV/2 I&T	15 d	10/8/01	10/22/01
11	TRIAD I&T	10 d	10/23/01	11/1/01
12	OMEGA-1 I&T	10 d	11/2/01	11/11/01
13	Observatory CPT	12 d	11/12/01	11/23/01
14	Deployments/Vibration/Acou	40 d	11/24/01	1/2/02
15	Observatory CPT #2 + ETE	13 d	1/3/02	1/15/02
16	Thermal Balance/Vacuum	65 d	1/16/02	3/21/02
17	EMI	25 d	3/22/02	4/15/02
18	Schedule Reserve	77 d	4/16/02	7/1/02
19	Contract Delivery	0 d	7/1/02	7/1/02
20	Launch Preps	90 d	9/19/02	12/17/02
21	Deliver to MIST Launch Site	0 d	12/17/02	12/17/02
22	Launch Site Operations	60 d	12/18/02	2/15/03
23	Launch	0 d	2/15/03	2/15/03

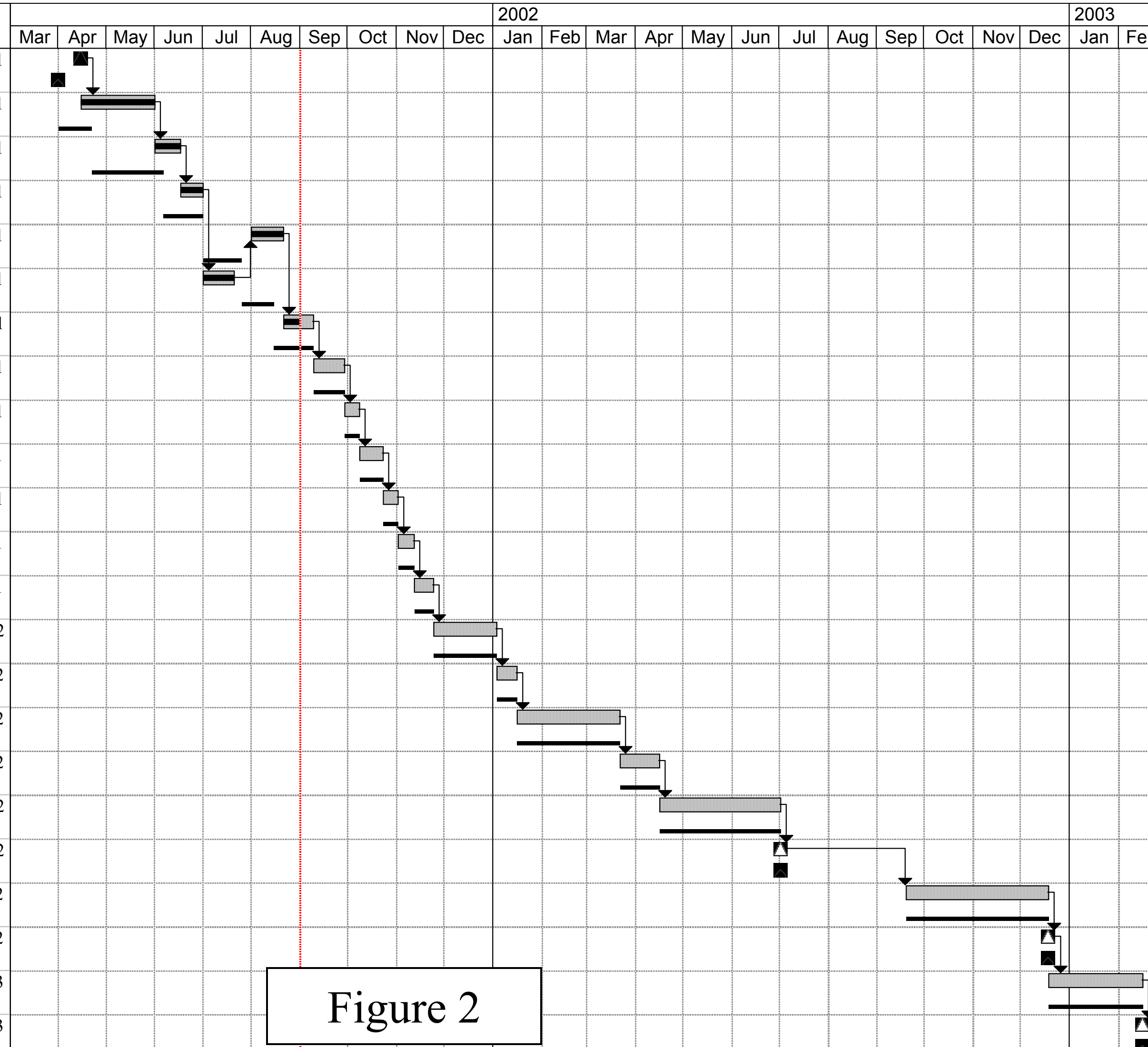


Figure 2

Case Study *(3 of 5)*

The Workaround Plan

The MIST Project Manager has gathered his team together to look at the "big picture" and determine a course of action to mitigate the impact of the late SRV/2 instrument delivery on AstroCorp's I&T schedule and ensure a MIST launch by February 15, 2003. He has also requested that AstroCorp provide an assessment of the impact of the late GFE delivery on their schedule and what could be done to mitigate it. Likewise, he has discussed the SRV/2 main harness problem with STI's senior management and has asked for a recovery plan to deliver the SRV/2 to support observatory I&T now projected to start on 10/8/01. Finally, the MIST project manager has formed a "Tiger Team" led by his Instrument Systems Manager and Observatory Manager to resolve the EMI issue between the OMEGA-1 and TRIAD instruments with minimal schedule impact.

Case Study Review Teams

Four teams will formulate workaround alternatives in response to the information the MIST Project Manager has requested: Team "A" represents the GSFC MIST Project, Team "B" represents AstroCorp, Team "C" represents STI and Team "D" is the EMI "Tiger Team." After identifying a team spokesperson, develop your best workaround recommendation for solving your team's schedule problem. Be sure to document the advantages and disadvantages of your team's approach. Keep in mind some of the topics we discussed during the scheduling seminar, but use your best judgment as well.

We'll take 40 minutes for each team to discuss the case and prepare their workaround approach. Next each team will present it's recommendation to the seminar group.

Case Study *(4 of 5)*

ADDITIONAL INFORMATION

Engineering Models of the SRV/2, OMEGA-1 and TRIAD instruments are available at their respective instrument suppliers

Mass models of the instruments can be built in six weeks

A "special test" between the OMEGA-1 and TRIAD performed at the observatory level would add 30 days to the current I&T flow

Any change in the order of the current sequence of the environmental test activities would add 45 days to the schedule due to test preparation/teardown modifications

STI System's repair schedule is based on a single shift, 5-day work week (thermal balance/vacuum test is planned as a 7-day per week, 3 shift operation)

AstroCorp's I&T schedule is based on a 2 shift, 6-day work week (thermal balance/test is planned as a 7-day per week, 3 shift operation)

AstroCorp maintains a fully operational Spacecraft Development & Verification Facility (SDVF) which essentially duplicates the form, fit and function of the actual spacecraft bus, and is used as a testbed

Case Study *(5 of 5)*

A final note . . . be creative, make assumptions and try to think "out-of-the-box" in formulating your workaround recommendations.

The MIST Project is counting on you!

13.0
Summary

This Seminar Has:

- Provided an overview of proven scheduling concepts and practices that have been successfully applied on projects.
- Described the steps needed to develop, status, and control meaningful project schedules.
- Promoted an awareness of the benefits of proper project planning & scheduling.

Self Evaluation

- **This self evaluation consists of several "true-or-false" and "multiple choice" questions intended to gauge your understanding of the project scheduling process seminar material.**
- **Please take a few minutes to complete the exam and return it to your instructor.**
- **We will review the answers as a group when you are finished.**

14.0
Acronym List

Acronyms *(1 of 3)*

ASAP – As Soon As Possible (planning and scheduling term)
ALAP – As Late As Possible (planning and scheduling term)
ATP – Authorization to Proceed
BOE – Basis of Estimate
CAD – Computer Aided Design
CDR – Critical Design Review
CDRL – Contract Data Requirements List
CSI – Cost/ Schedule Integration
EDU – Engineering Development Unit
EOC – End of Contract
ETE – End to End
ETU – Engineering Test Unit
EV – Earned Value
EVM – Earned Value Management
FNET – Finish No Earlier Than (planning and scheduling term)
FNLT – Finish No Later Than (planning and scheduling term)
FTP – File Transfer Protocol
GFE – Government Furnished Equipment

Acronyms *(2 of 3)*

GSFC	–	Goddard Space Flight Center
HQ	–	Headquarters
I&T	–	Integration & Test
IC	–	Integrated Circuit
KSC	–	Kennedy Space Center
LOA	–	Letter of Agreement
MFO	–	Must Finish On (planning and scheduling term)
MOU	–	Memo of Understanding
MSO	–	Must Start On (planning and scheduling term)
MTII	–	example term, Mechanical Technician II
NASA	–	National Aeronautics and Space Administration
NPG	–	NASA Program Guideline
Ops	–	Operations
PCA	–	Program Commitment Agreements
PCRS	–	Project Cross-Referencing System
PDM	–	Precedence Diagramming Method
PDR	–	Preliminary Design Review
PSDB	–	Project Schedule Database

Acronyms *(3 of 3)*

PWA	–	Printed Wiring Assembly
QA	–	Quality Assurance
RAO	–	Resource Analysis Office
S/C	–	Spacecraft
SNET	–	Start No Earlier Than (planning and scheduling term)
SNLT	–	Start No Later Than (planning and scheduling term)
SOW	–	Statement of Work
SPECM	–	Spacecraft Equipment Cost Model
SPI	–	Schedule Performance Index
SRR	–	Systems Requirements Review
TAA	–	Technology Assistance Agreement
WBS	–	Work Breakdown Structure