Parametrics as a Function of Project Management:
A Tactical Example

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ISPA/SCEA Conference
St. Louis, MO
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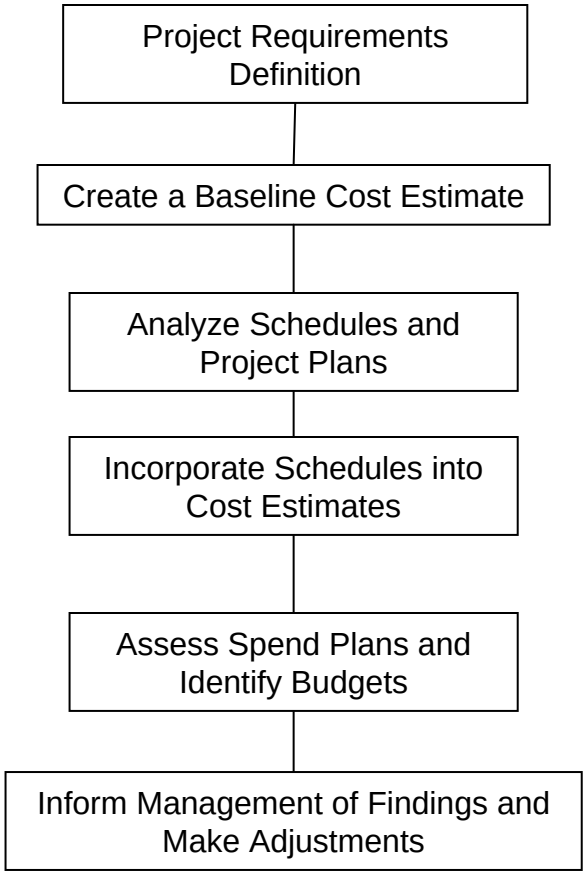
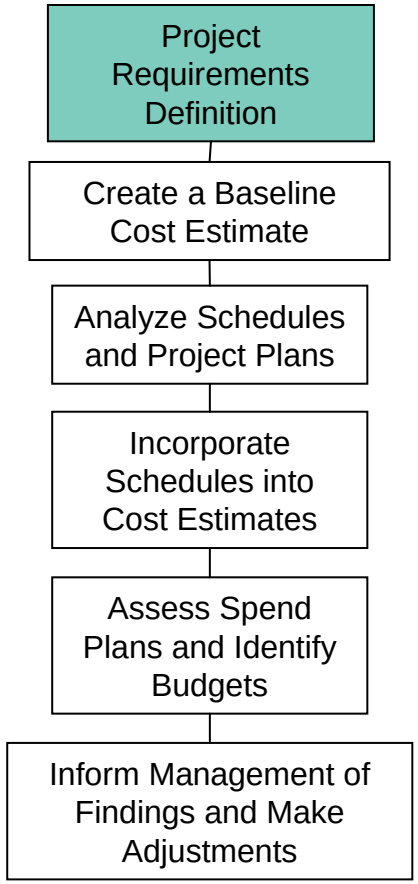
Using parametric tools, we have been able to effectively implement project management/project controls techniques of tying cost and schedule to the technical baselines.



Project requirements have a tendency to evolve as projects progress

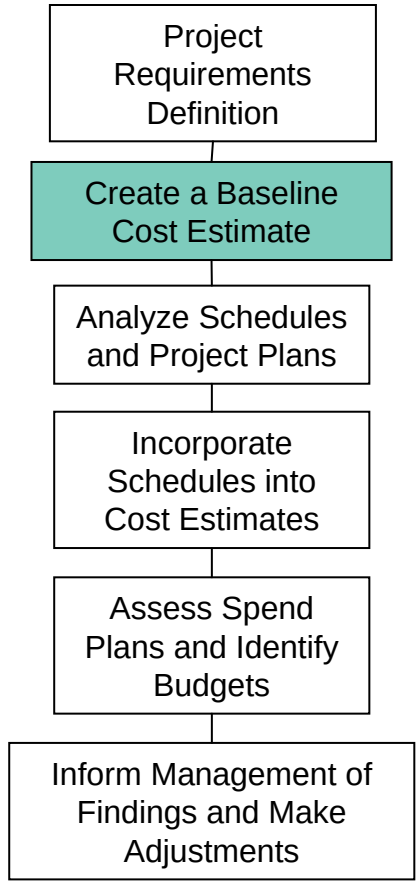
- Identifying as many requirements as possible in the beginning will lend to more accurate estimates

- Maintaining a certain amount of flexibility is important
  - Try to visualize what the engineers see or ask for CAD modals
  - Refer to Program/Agency WBS requirements for any estimating gaps
  - Elements will need to be added
  - Identify risks and alternatives early



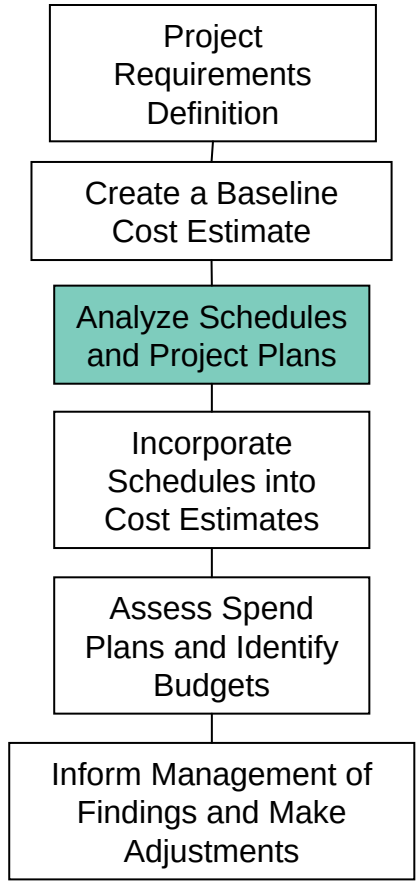
Creating a baseline estimate involves estimating to your “best case scenario”.

- Perform data gathering to create an estimating breakdown structure
- Create the estimates using your preferred tools
  - PRICE Systems ™
  - SEER Suite ™
  - ACE-IT ™
- Use the proposed project schedule
- Identify potential challenges
  - Which WBS elements pose risks to the project?
  - Is there prior expertise or is it limited?
  - Are there contracting concerns?



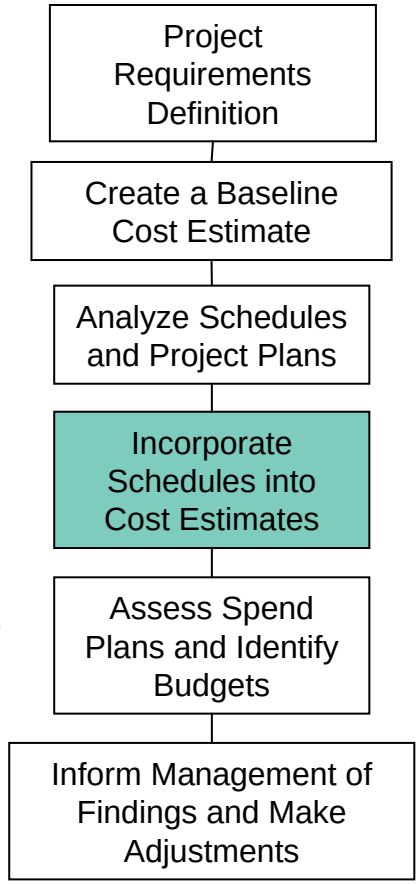
Analyze the schedule to identify the key areas of concern and if the project is progressing as planned.

- Obtain schedule from the project manager
  - Often schedules provided are high level, lack logic or are not complete
  - Critical paths should be well define or schedule health will be poor
- Create a viable schedule using appropriate tools
  - MS Project
  - Primavera ™
  - PertMaster ™
- Analyze the critical path
- Identify potential challenges
  - Is there too much dwell?
  - Should more of the activities be linked?
  - Are there too many constraints to produce an accurate critical path?
  - Is the schedule viable?



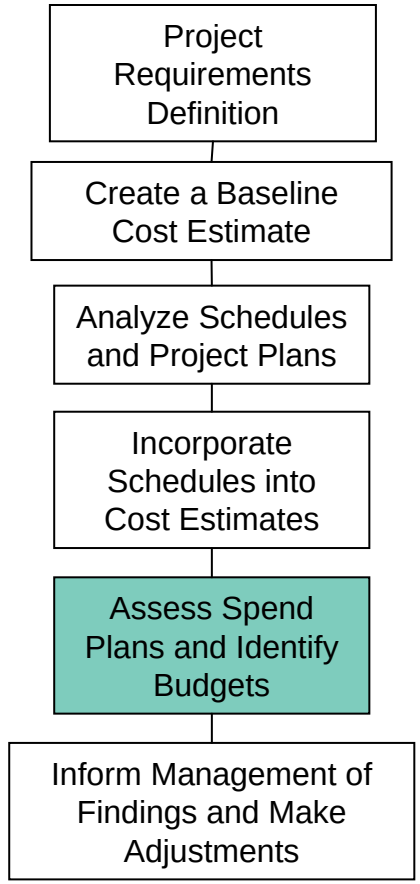
Performing a risk-based schedule assessment and incorporate it into the cost analysis lends itself to more accurate cost estimates.

- Use a schedule risk assessment tool such as PertMaster
  - Identify areas of risk
  - Get a more likely outcome of project plan
- Use data from the schedule assessment
  - Incorporate the assessed dates into the parametric baseline cost estimate
  - Incorporate identified problem areas
  - Determine a more accurate cost analysis



Analyzing staffing trends, existing budgets, and expenditure profiles for appropriate budgetary needs.

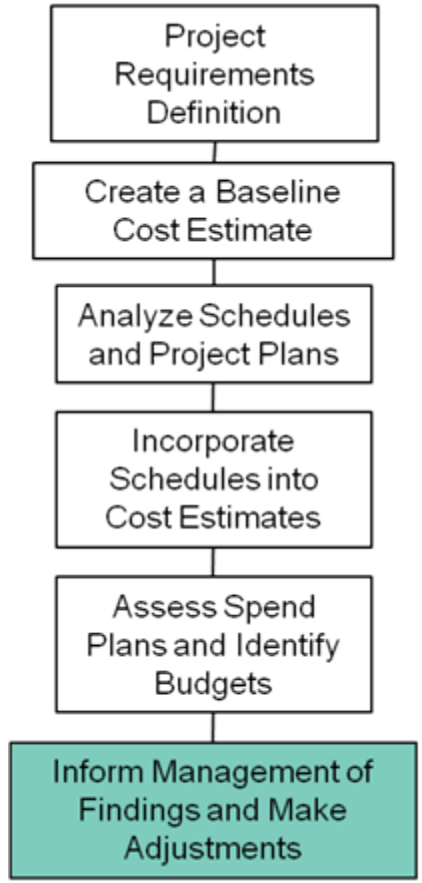
- Projects have limitations
  - Skill mix
  - Hiring trends
  - Contracting concerns
- Availability of funds can play a role
- Determining major milestones for percent of total cost result in likely budget profiles



Informing project and program managers can be the most challenging step of the integrated approach.

- Reactions from the various level of management can be mixed
  - Will the project get funding help?
  - Will the project get cancelled?
  - Will there be a re-baseline?
  - Are the assumptions in the analysis just plain wrong?

- Remain flexible and keep open lines of communication



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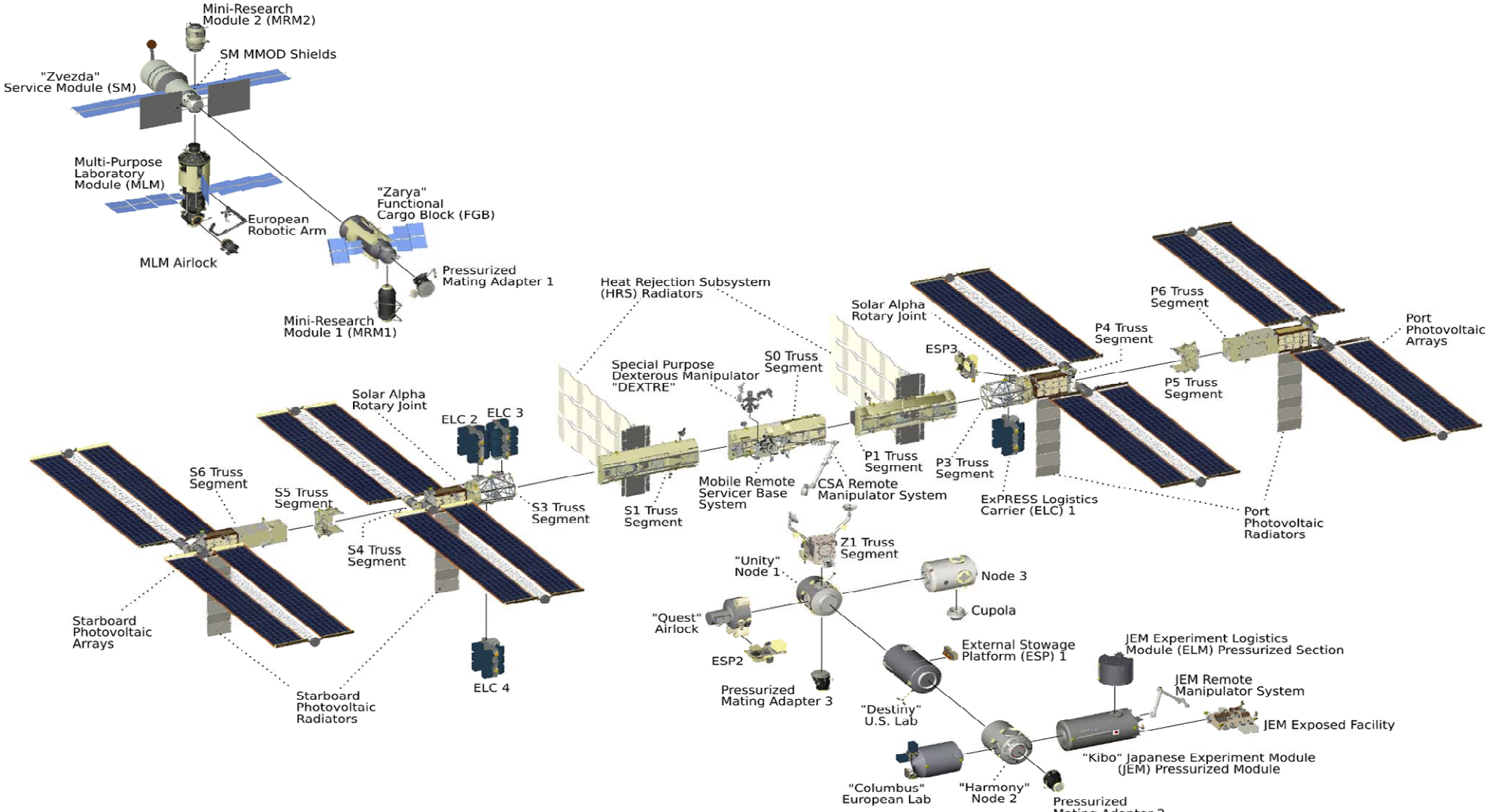
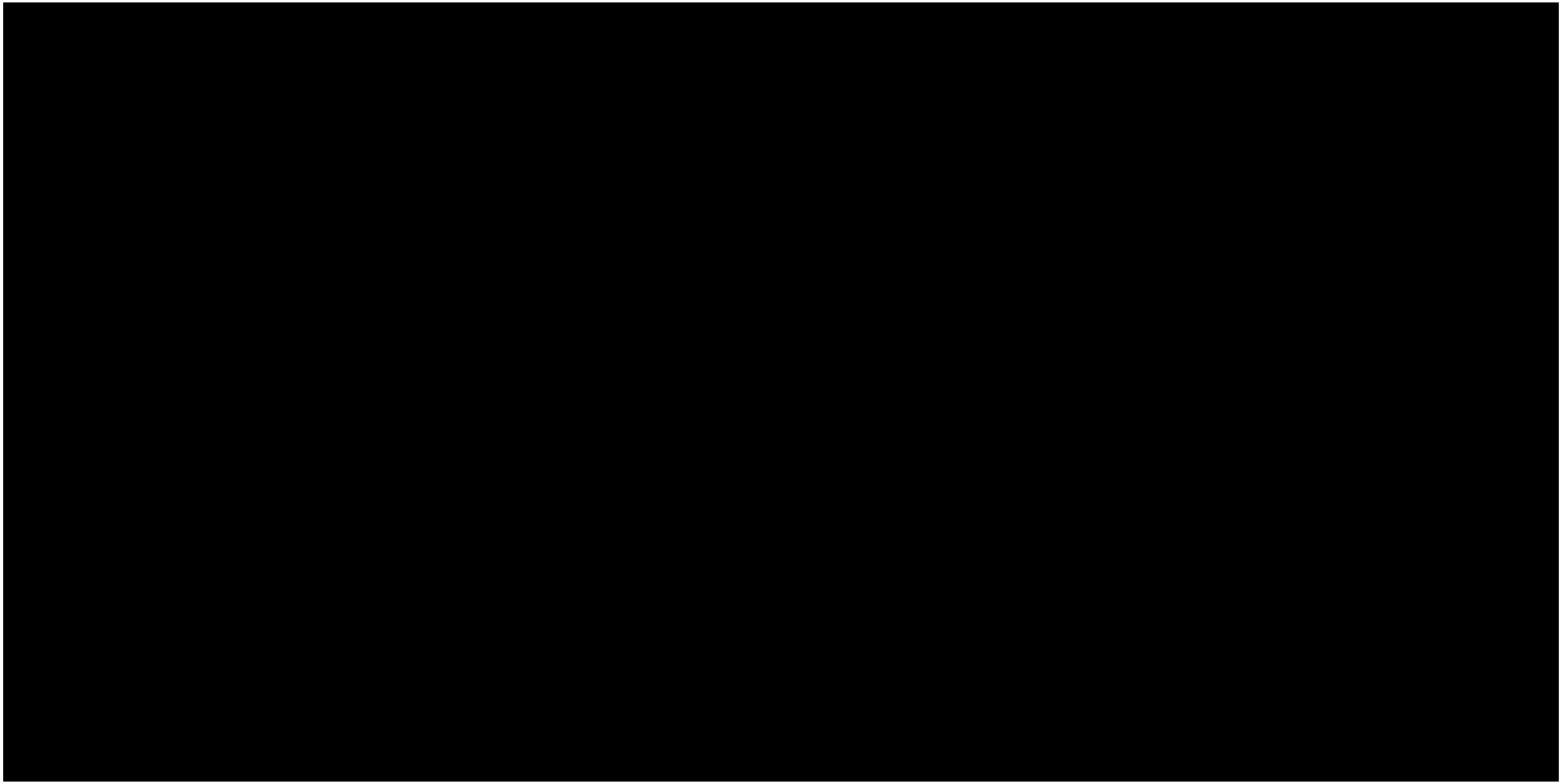
The International Space Station Program (ISS) is a complex project that has numerous countries with varying political climates and four prime contractors coming together for a common mission – to build an international laboratory in low earth orbit.



ISS Video Of Assembly



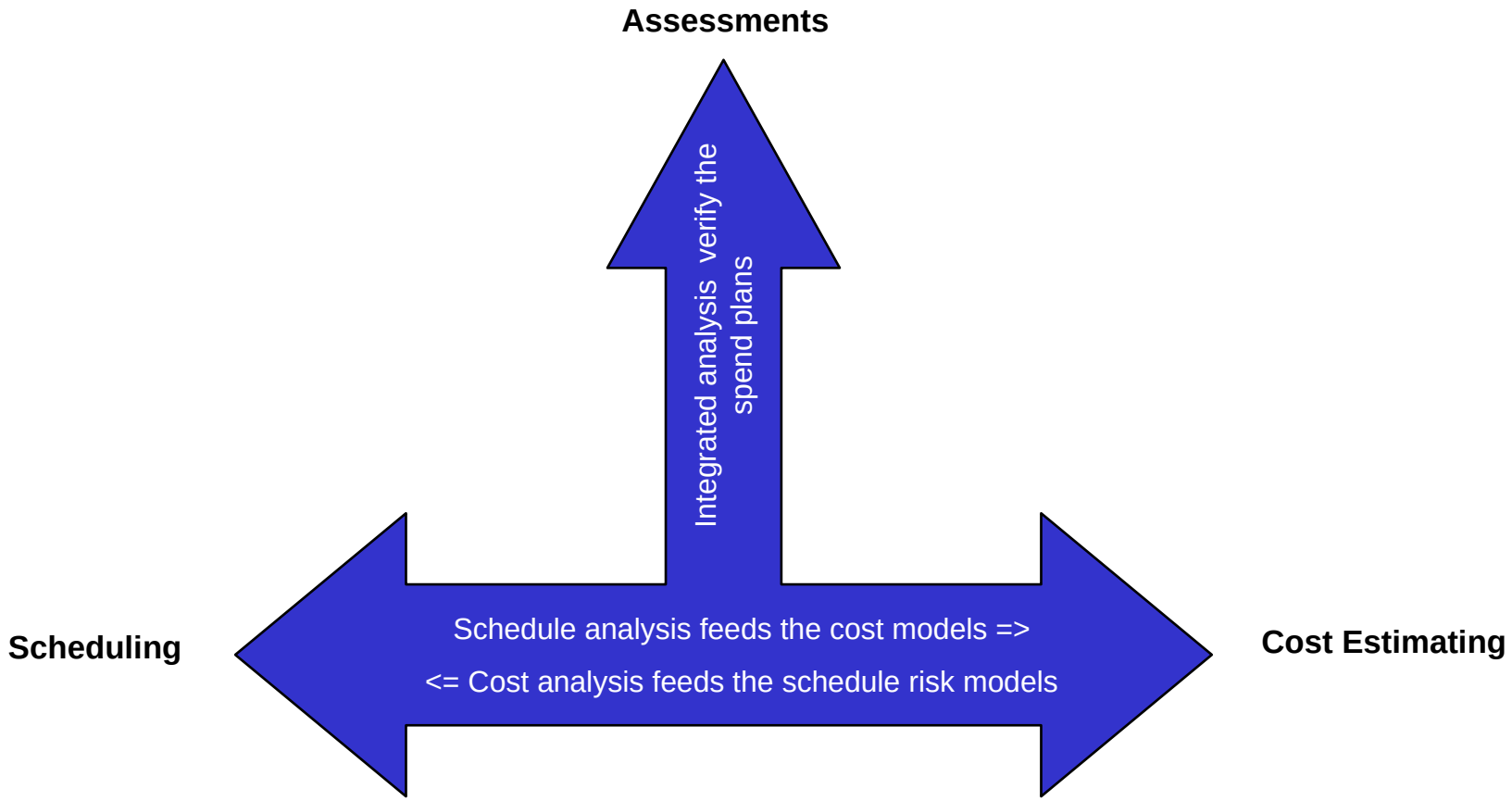
More Interesting International Space Station Program Facts: The ISS is at 51.6 degrees, covering 90% of the world's population, 200 nautical miles (on average) above the Earth 17,500 mph, orbiting the Earth 16 times per day

Date	July 2010
Length	243 ft.
Width	356 ft.
Mass	852,765 lbs.
Habitable Volume	TBD
Pressurized Volume	32,335 cubic ft.
USOS Power Generation	8 solar arrays = 84 kW

Since 2001, the ISS PP&C Office has been actively using project controls to help contain costs, provide trade study inputs, and help managers make decisions in terms of costs, schedule and technical attributes

- **Assessments, cost estimation, and scheduling is part of the overall project management function within the Program Planning and Control Office**
  - **This allows team members to be on par with engineers**
  - **Cost estimates can be non-advocate of technical agendas**
  - **Provides a checks and balances process**

All of the Assessments, Cost Estimating and Schedules (ACES) team members have various professional certifications and most are also cross-trained in the other disciplines



The cost estimators are responsible for a variety of cost analysis. With the volume of changes in a dynamic environment such as ISS, parametric tools allow us to create estimates with high fidelity in short time frames

Cost Estimating	Assessments	Schedules
▪ Cost Estimates of Baseline Changes ▪ Cost Estimates of Threats ▪ Quantitative Risk Assessment of Threats/Budget ▪ Documentation of Processes ▪ Utilization of Cost Models ▪ Government Estimates for Procurements ▪ Cost/Benefit Analysis	▪ Early Warning System – Monthly and Quarterly Reports ▪ Earned Value Management Analysis ▪ Program Metrics ▪ Program Performance Measurement System ▪ Assessments of budgets, contracting and processes	▪ Integrated Schedules ▪ Cost/Schedule Risk Analysis ▪ Schedule Assessments

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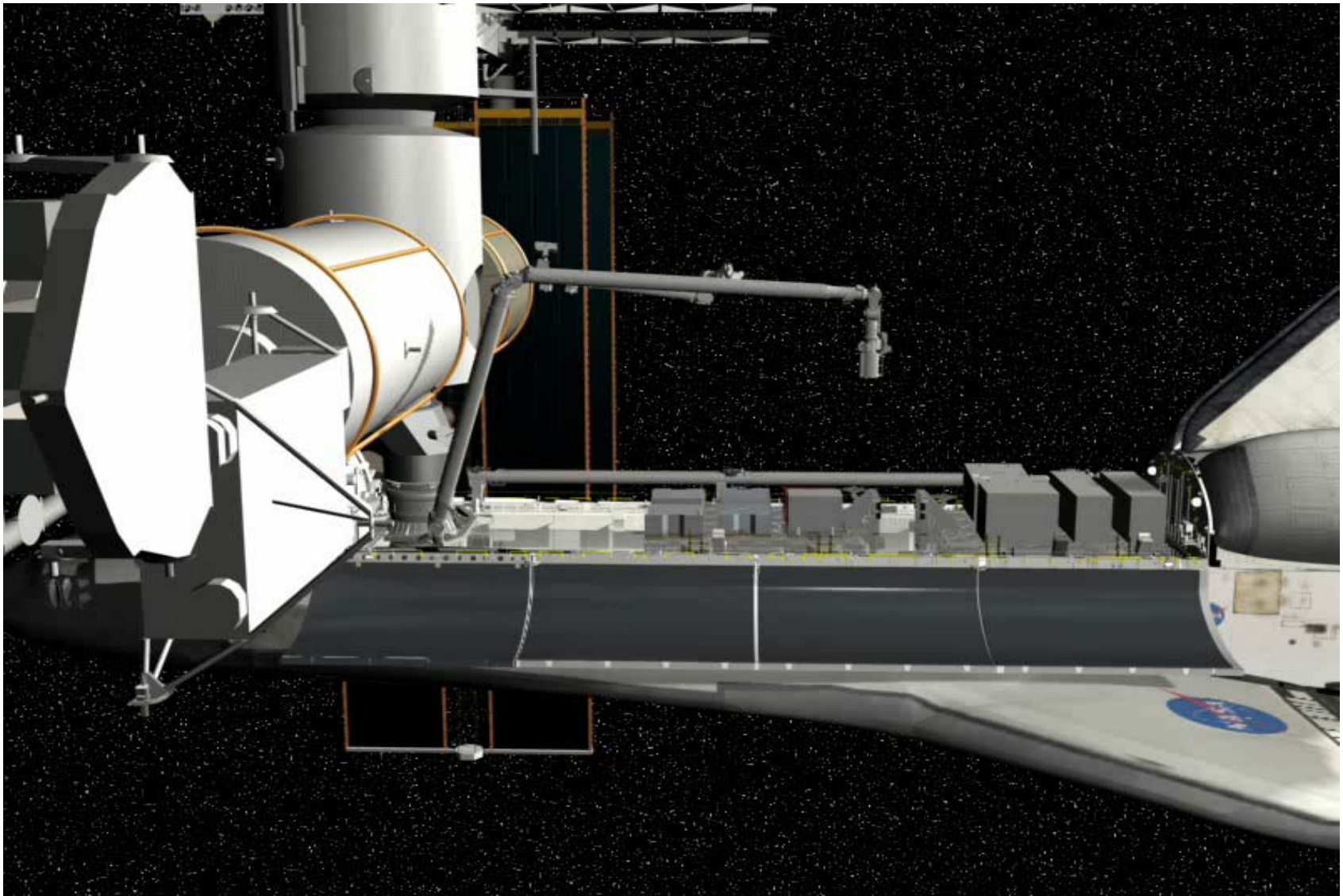
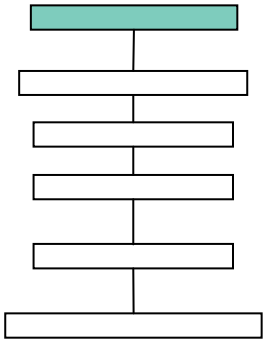
Express Logistics Carrier (ELC) Integrated Cost Assessment Background



ELC Project Assessment Timeline



Carrier Trade Studies 7/05

ELC PDR 06/06

ELC Avionics CDR 01/06

ELC Structural CDR 05/07

ELC Avionics Delta CDR 02/08

Projected Flight of ELC 1 9/2009

Schedule Challenges

Major redesign of avionics

Major reduction of Mass

Iteration 1 – Based on Trade Study – doesn't include phase II of the project

Iteration 2 – 18-20 % cost growth due to schedule challenges, addition of phase II and risks

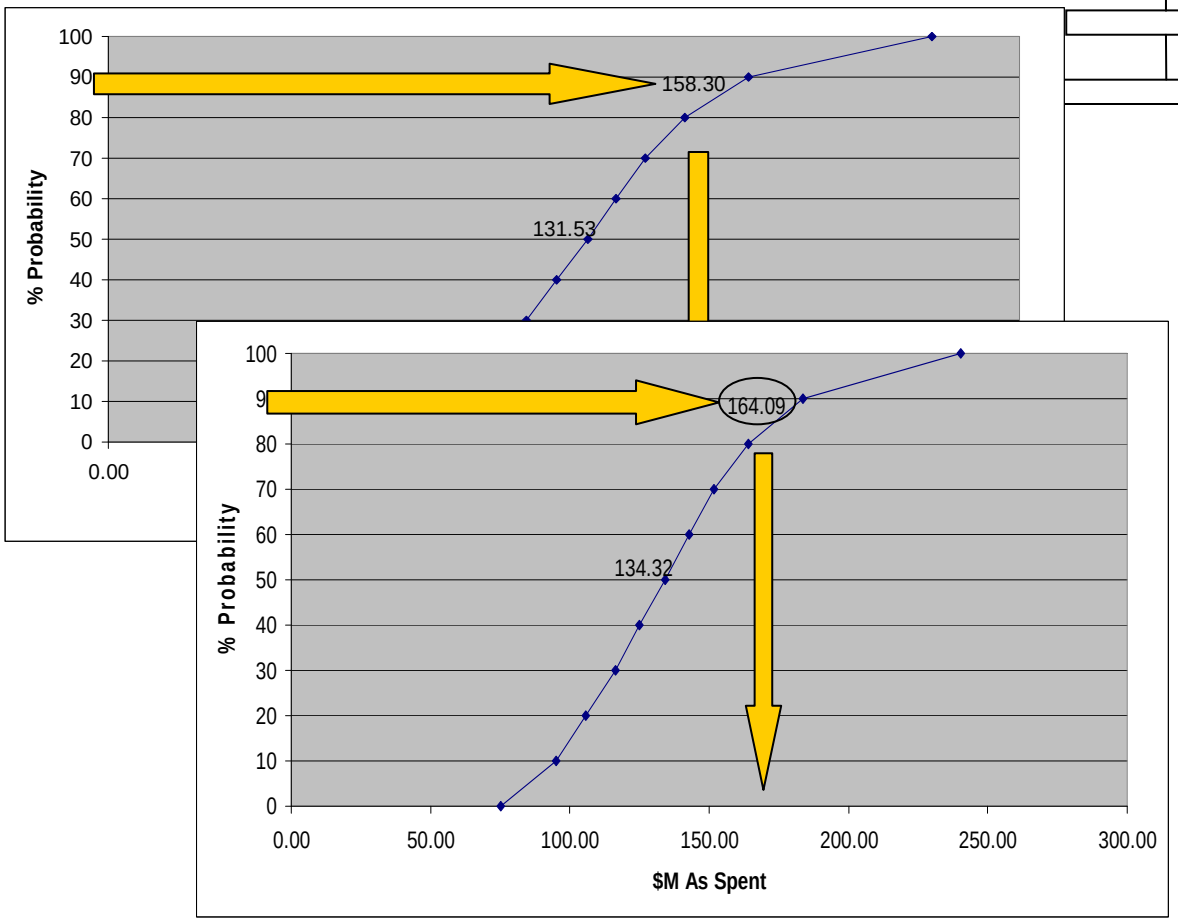
Iteration 3 – close to iteration 2 incorporates major redesign

Iteration 4 – Similar to iteration 3 incorporates major mass reductions

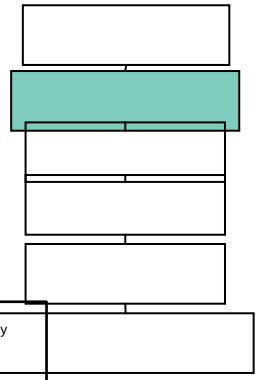
Current Project Manager's EAC - Falls in the range on iteration 4

We created a baseline estimate for the best case scenario using the typical cost estimating process. This was very different from the initial $85M budget estimate.

- Data gathered
- Documented the ground rules and assumptions
- Defined the approach and methodology
- Used PRICE H for modeling
- Added a small amount of uncertainty to various parameters
- Developed the S-Curve within the tools
- Created a cross-check using SEER for Hardware



At the trade study phase, the estimate was modeled at the system level with 1-10 work elements. By PDR, the estimate was re-modeled to a subsystem level growing from about 10 to 72 work elements .



1 ExPRESS Logistics Carrier
1.1 Avionics
1.1.1 Orbiter Power Distribution Box
1.1.1.1 Chassis
1.1.1.2 28V Heater CCA
1.1.2 Avionics "Coffin"
1.1.2.1 Avionics Enclosure
1.1.2.2 SpaceCube
1.1.2.2.1 28V Power Module & 1553 Remote Terminal (RT) CCA
1.1.2.2.2 Multi-Input/Output 1553 BC CCA
1.1.2.2.3 Qualification of non class K components
1.1.2.2.4 Processor CCA
1.1.2.2.5 Qualification of 2 Xilinx Vertix 4 FPGA
1.1.2.3 Experiment Control Module (ECM)
1.1.2.3.1 Chassis
1.1.2.3.2 Science Analog Board
1.1.2.3.3 DC/DC Switched Power CCA
1.1.2.3.4 Qualification of 600v MOSFET

1 Express Logistics Carrier
1.1 Avionics
1.1.1 Orbital Power Distribution Box (OPDB)
1.1.1.1 28V Heater CCA
1.1.1.2 Chassis
1.1.2 ExPCA - "
1.1.2.1 Chassis
1.1.2.1.1 Radiato
1.1.2.1.2 Closeou
1.1.2.1.3 Drive As
1.1.2.1.4 Drive As
1.1.2.1.5 K-Core
1.1.2.1.6 End Ca
1.1.2.1.7 Rear Co
1.1.2.1.8 Micro-S
1.1.2.1.9 Therma
1.1.2.1.10 Pressur
1.1.2.1.11 Tether
1.1.2.1.12 Dummy
1.1.2.1.13 Harness
1.1.2.1.14 MLI Bla
1.1.2.1.15 Stiffene
1.1.2.1.16 Hardwa

1.2.1.5 Cross Bay Members
1.2.1.5.1 Trunnions Cross Bay Member
1.2.1.5.2 PCAS Cross Bay Member
1.2.1.5.3 Cross Bay (Row 2)
1.2.1.5.4 Cross Bay - Far Side
1.2.1.5.5 Cross Bay (Rows 5 -
1.2.1.5.6 Cross Bay (Rows 3,
1.2.1.5.7 Cross Bay (Row 12)
1.2.1.6 Diagonal Member Sm
1.2.1.7 Diagonal Member Lar
1.2.1.8 Diagonal Side
1.2.1.9 Trunnion Structure
1.2.1.9.1 Trunnion Pins
1.2.1.9.2 Primary Enclosure
1.2.1.9.3 Secondary Enclosure
1.2.1.10 Scuff Plates
1.2.1.11 Keel Interface
1.2.1.11.1 Keel Interface Plate

1.2.4.5.2 Cross Member Clevis (+x)
1.2.4.6 Aft and Forward Beam Flexure Assy
1.2.4.6.1 Cross Member Housing
1.2.4.6.2 Cross Member Mechanism
1.2.4.6.3 EVA Interface Assy
1.2.4.7 UMA Bracketry
1.2.4.8 EBCS Bracketry
1.2.4.9 Capture Bar
1.2.4.10 Capture Bar Removal Mechanism
1.2.4.11 Hardware
1.2.4.12 FSE Brackets
1.2.5 Harnessing

- At the Structural Critical Design Review (11/07), the estimate iterated to a component level of detail (180+ components) and incorporated some critical design changes such as weight reduction - a major driver of parametric estimating.
- Estimates with CDR fidelity detail are within 5% of actual costs on three estimates in which this process was applied.
- What-if analysis was performed as technical challenges were faced.
- *Being integrated with the engineering community early was crucial to the process.*

1.2.1.9 Clips
1.2.1.10 Mini Cr
1.2.1.11 Small T
1.2.1.12 Large T
1.2.1.13 Trunnio
1.2.1.14 Splice
1.2.1.15 Scuff P
1.2.1.16 Interfac

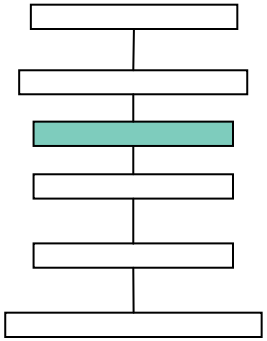
1.2.3.7 Load Release Mechanism
1.2.3.8 Capture Bar
1.2.3.9 Capture Bar Removal Mechanism
1.2.3.10 UMA Bracketry
1.2.3.11 EBCS Bracketry
1.2.4 Power Interface
1.2.5 FSE to mount EVA/EVR aids
1.2.6 Passive FRAM Adapter Plates (PFAP)
1.2.6.1 PFRAM Harness including Connector Box
1.2.6.2 PFRAM components
1.2.6.3 Passive FRAM Adapter Plate (PFAP)

1.2.1.3 Seconda
1.2.1.3.1 Small H
1.2.1.3.2 Large H
1.2.1.3.3 Wide H
1.2.1.3.4 Diagona
1.2.1.4 Backbon
1.2.1.4.1 Horizon
1.2.1.4.2 Diagona

1.2.3.1.1 Cargo Bay Trunnion
1.2.3.1.2 Sill Trunnions
1.2.3.2 Fittings
1.2.3.3 Base
1.2.3.4 Tubing
1.2.3.4.1 Top
1.2.3.4.2 Side
1.2.3.5 Y Constraint
1.2.3.6 Miscellaneous Hardwa
1.2.3.7 End Caps
1.2.4 Passive Common Attac
1.2.4.1 Frame
1.2.4.2 Aft Guide Pin
1.2.4.3 Forward Guide Pin
1.2.4.4 Scuff Plate
1.2.4.5 Clevis
1.2.4.5.1 Cross Member Clevi

1.2.5.6.3 Fastener
1.2.5.7 CIP - ExPCA
1.2.5.7.1 Connectors
1.2.5.7.2 Cable
1.2.5.7.3 Fasteners
1.2.6 Power Interface
1.2.7 FSE to mount EVA/EVR aids
1.2.8 Passive FRAM Adapter Plates (PFAP)
1.2.8.1 Standard PFAP
1.2.8.1.1 Standard PFAP Plate
1.2.8.1.2 Shear Slide
1.2.8.1.3 Tension Slide
1.2.8.1.4 Slide Nut
1.2.8.1.5 Shear Bushing
1.2.8.1.6 Insert Bushing
1.2.8.1.7 Slide Shim
1.2.8.1.8 Shear Bushing Shim
1.2.8.1.9 Shear Block
1.2.8.1.10 Washer, Block Retainer
1.2.8.1.11 Pin Retainer
1.2.8.2 Lightweight PFAP
1.2.8.2.1 Lightweight PFAP Plate
1.2.8.2.2 Shear Slide
1.2.8.2.3 Tension Slide

Analyze the schedule to identify the key areas of concern and if the project is progressing as planned.



Express Logistics Carrier (ELC)
Qual and Flight Build

Critical

Name	Description	Total Float	Early Start	Early Finish
00412	Mechanical System Plan	-120	01/Nov/05	
00804	Qual			
TOTALS				

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Express Logistics Carrier (ELC)
Qual and Flight Build

Name	Description	Rem Duration	Early Start	Mean Start	Early Finish	Mean Finish
00412	Mechanical System Plan	687	01/Nov/05	15/May/06	02/Feb/09	05/Apr/09
00804	Qual	428	03/Jan/06	15/May/06	24/Jan/08	20/Feb/08
00805	Qual Deck	126	02/Oct/06	02/Oct/06	02/Apr/07	21/Apr/07
00806	Hardware Fabrication	105	02/Oct/06	02/Oct/06	02/Mar/07	13/Mar/07
00811	Horizontal Beams (Shuttle X-Axis)	105	02/Oct/06	02/Oct/06	02/Mar/07	13/Mar/07
00882	Flight Unit #1	301	04/Jan/07	06/Jan/07	14/Mar/08	21/Apr/08
00883	Flight Unit #1 Deck	186	04/Jan/07	06/Jan/07	27/Sep/07	24/Oct/07
00884	Hardware Fabrication	175	04/Jan/07	06/Jan/07	12/Sep/07	03/Oct/07
00889	Horizontal Beams (Shuttle X-Axis)	105	16/Apr/07	25/Apr/07	12/Sep/07	03/Oct/07
00892	Deck Assy	110	23/Apr/07	07/May/07	26/Sep/07	22/Oct/07
00895	Horizontal Beams & Clips	15	15/Aug/07	05/Sep/07	05/Sep/07	28/Sep/07
00896	Short Vertical Beams & Clips	25	22/Aug/07	14/Sep/07	26/Sep/07	22/Oct/07
00897	Deck ready for next Assembly	1	27/Sep/07	24/Oct/07	27/Sep/07	24/Oct/07
01017	Trunnion Housings	25	21/Feb/08	27/Mar/08	26/Mar/08	03/May/08
01018	Horizontal Beams & Clips	15	27/Mar/08	04/May/08	16/Apr/08	26/May/08
01019	Short Vertical Beams & Clips	25	17/Apr/08	28/May/08	21/May/08	04/Jul/08
01020	Deck ready for next Assembly	1	08/May/08	21/Jun/08	08/May/08	21/Jun/08

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MSP Risk Inputs
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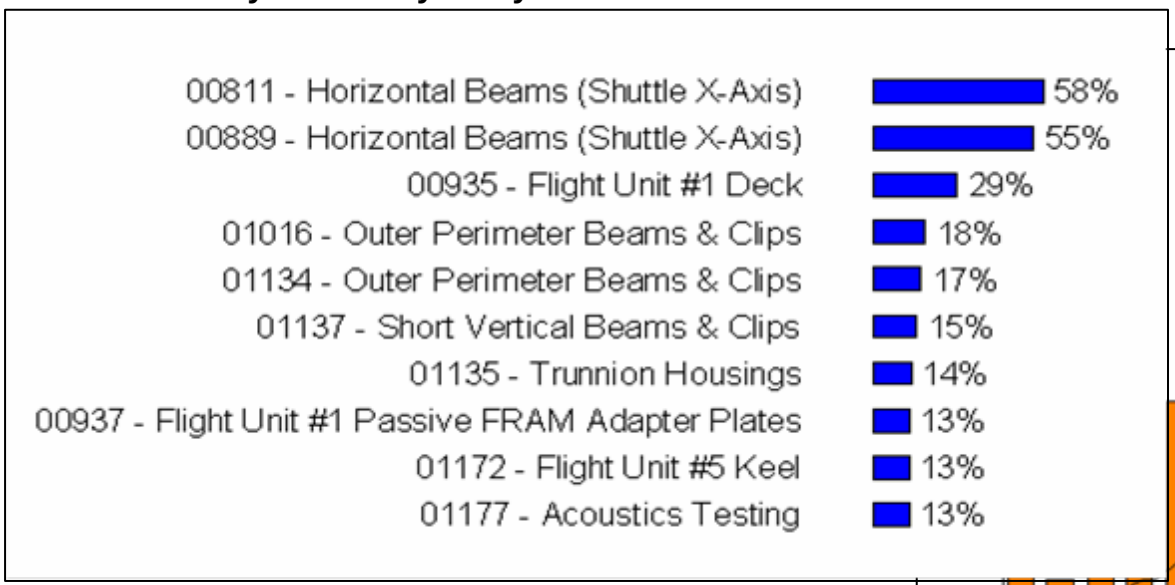
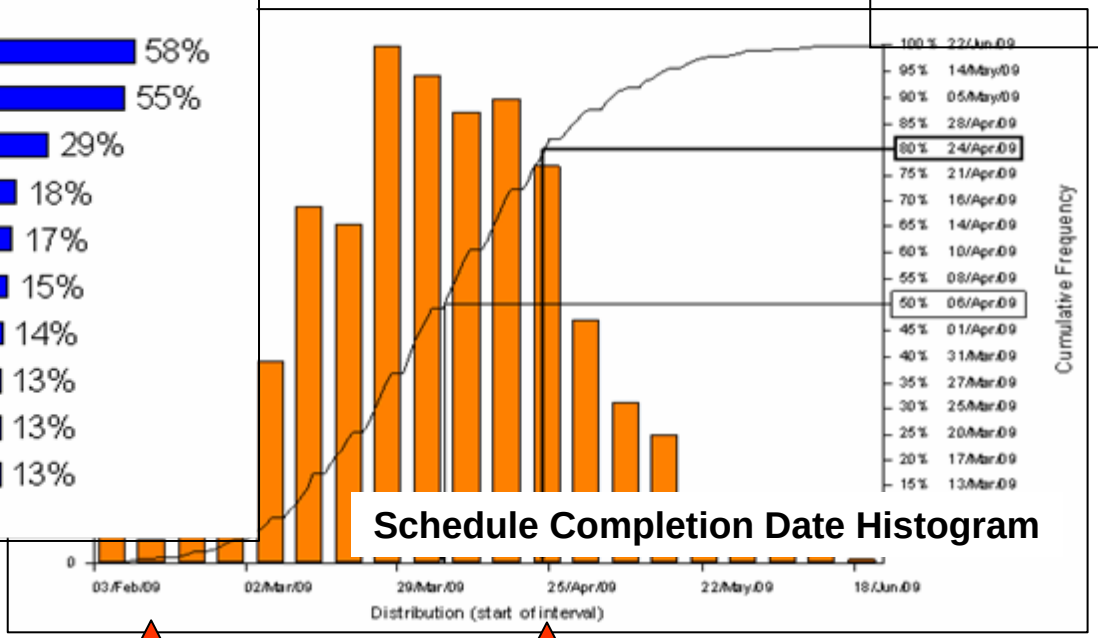
- Ask yourself…
  - Is there too much dwell?
  - Should more of the activities be linked?
  - Are there too many constraints to produce an accurate critical path?
  - Is the schedule viable?

Performing the health check identifies potential challenges such as critical activities, watch items, and verify with the project managers. These activities may not yet be on their radar screen.

Task Criticality/Sensitivity Analysis





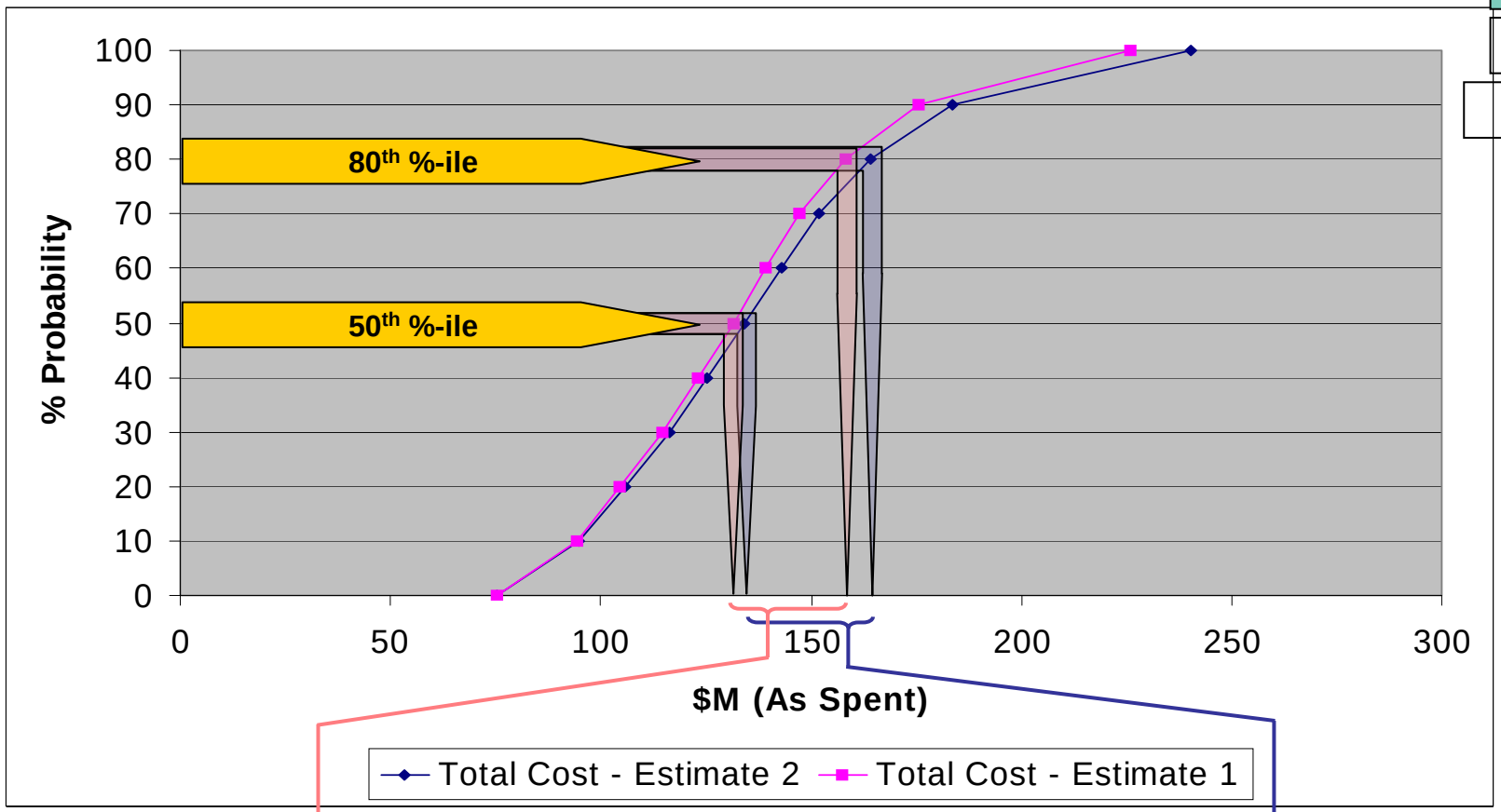
Schedule Completion Date Histogram

Advertised delivery
(0% success probability)

80th %-ile delivery
(80% success probability)

Projected delay: 81 days
(from 2/2/09 to 4/24/09)

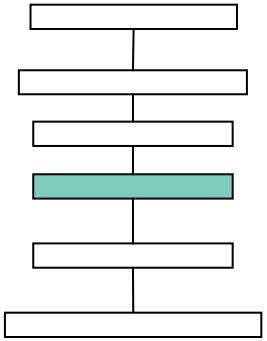
After performing a risk-based schedule assessment, incorporate it into the cost analysis to quantify the schedule slip and supply a more accurate cost estimate.

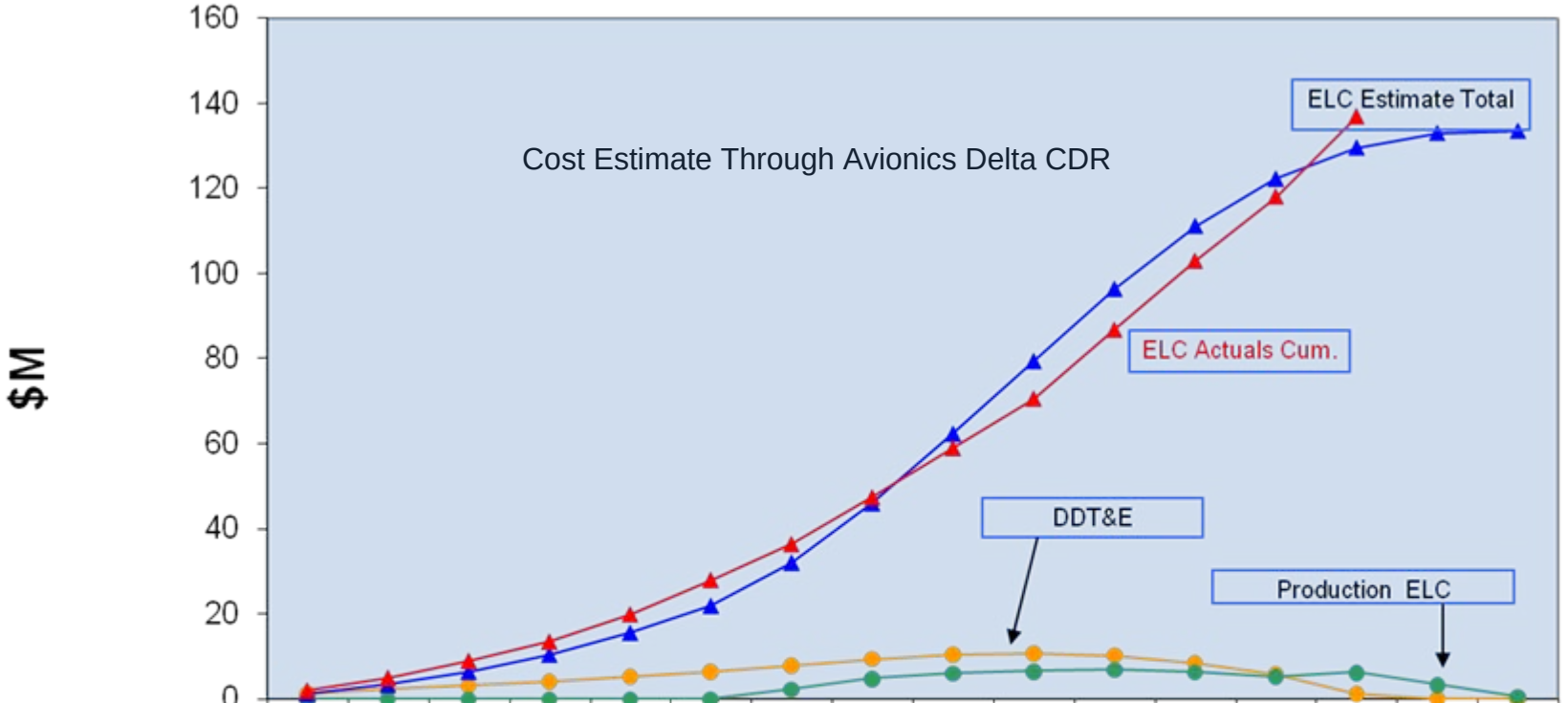


PRICE base estimate, original schedule: $132-158M

Slipped-schedule, risk-augmented estimate: $134-164M

Using this method for the cost assessments has yielded very interesting results and many lessons learned through the iterative process.

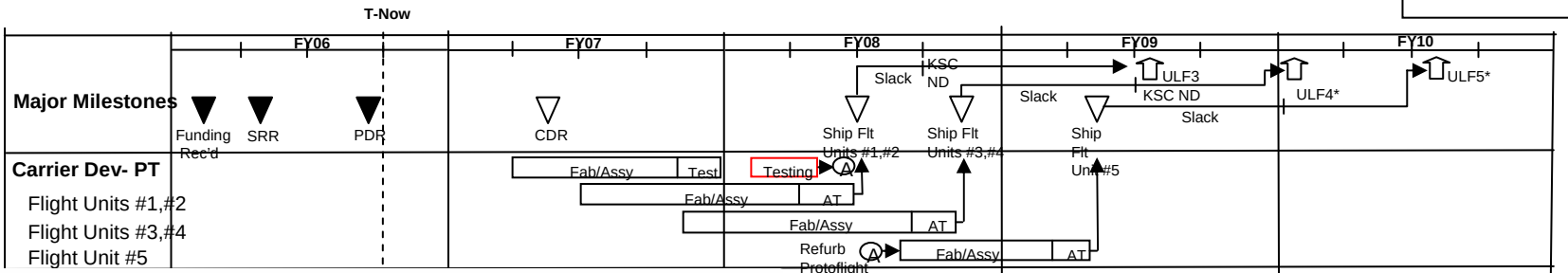


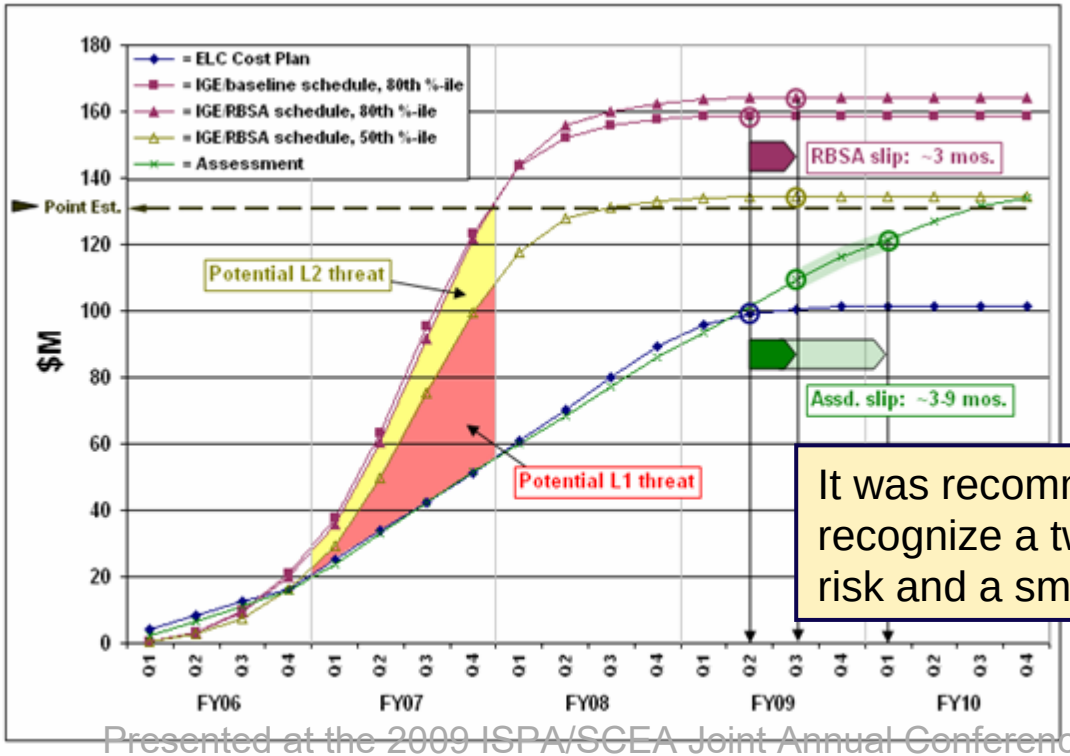


	Q1 2006	Q2 2006	Q3 2006	Q4 2006	Q1 2007	Q2 2007	Q3 2007	Q4 2007	Q1 2008	Q2 2008	Q3 2008	Q4 2008	Q1 2009	Q2 2009	Q3 2009	Q4 2009
ELC DDT&E	1.1	2.2	3.1	4.0	5.1	6.4	7.8	9.3	10.3	10.6	10.1	8.4	5.9	1.1	0.1	0.0
ELC Production	0.0	0.0	0.0	0.0	0.0	0.0	2.3	4.8	6.1	6.5	6.8	6.4	5.3	6.2	3.3	0.5
Total Cum. Cost	1	3	6	10	16	22	32	46	62	79	96	111	122	130	133	134
Actuals Cum.	2.00	5.00	9.00	13.50	19.90	28.00	36.40	47.40	58.95	70.60	86.80	103.00	118.13	137		

Quarterly Spread – 70th % Probability

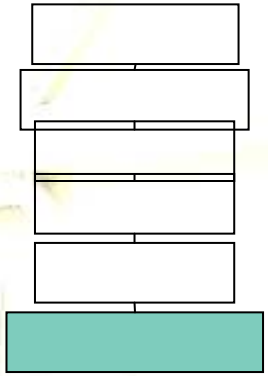
As a cross check the process, assess budget trends and expenditure profiles for appropriate budgetary needs at the various milestones and implement appropriate risk management.





It was recommended to the program to recognize a two phased risk: a large imminent risk and a smaller risk with a 50/50 probability.

Informing project and program managers can be the most challenging step of the integrated approach.



- Draw conclusions
- Make doable recommendations
  - Create watch/risk items
  - Create key performance indicators

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In summary…

…Complex programs face intense challenges

…There is an importance in practicing stringent project controls within PM

…Parametric Tools are an important part of cost analysis

- Enable cost and schedule estimates for informed decision making
- Provide auditable, defensible and well documented assessments
- Help to ensure best practices for users

Questions?

Acknowledgements

Richard Fox – Program Planning and Control Manager

Greg Tobeck – Assessments, Cost Estimates, and Schedules Office Manager

Oscar Gutierrez – Cost Estimating Lead

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