INTEGRATED PROJECT MANAGEMENT:

A Case Study in Integrating Cost, Schedule, Technical, & Risk Areas

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Jacobs Sverdrup, Project Management Team

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INTEGRATED PROJECT MANAGEMENT

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OBJECTIVES

- To demonstrate the practical application of good integrated project management principles to a real project
- To endorse those project management principles that support a successfully managed effort
- To share the pain and rewards of discovery with others so that they may avoid the pain and embrace the rewards
CASE STUDY BACKGROUND

- The International Space Station (ISS) fluid filtration system uses disposable cartridges.
- These cartridges were procured from a contractor who developed the fluid filtration system.
- The contractor “lost” the cartridge technology and could no longer provide off-the-shelf replacements.
- The contractor offered to “re-design” and fabricate the replacement cartridges for a cost.
- The ISS Program Office (ISSPO) decided to pursue developing the cartridges “in-house.”
CASE STUDY BACKGROUND

Gas Trap Operation Fundamentals

- Cooling Fluid plus Air Bubbles
- Cooling Fluid Out
- Gas Flow Out

Operational Requirements
- 100% capture of air bubbles in single pass by exterior membrane
- Negligible interference with bulk coolant flow (DP < 5 psid)
- Gas vented to ambient (no vacuum required)
- Single gas vent fiber to control coolant loss
GETTING STARTED

- A need was identified
  - Replacement cartridges for ISS fluid filtration system
- Expectations were conveyed – at a high level
  - Time Frame = X years
  - Budget = $X M
- The project team was formed
  - Work scope was discussed – the conceptual plan was developed
  - Preliminary roles were defined - an informal OBS was developed
- Detailed planning began
  - A WBS template was obtained with a product-orientated structure
  - The template was modified by the project team to suit the project
EXAMPLE OF WBS TEMPLATE
EXAMPLE OF MODIFIED WBS (1 OF 2)
DEVELOPING THE PLAN

- The WBS provided a document outline to begin
- A WBS dictionary from another project was used as a reference to draft a “straw man” document
- The project team developed definitions together
- This was an iterative process that resulted in some minor WBS revisions (important point)
- Activities required to complete WBS elements were discussed in some detail
EXAMPLE OF A WBS DICTIONARY

1.2.1. Test Management – All activities covering the Management of
Project from initiation of the Project to Completion and
termination of the Operations of the
1.2.2. Data Management – All activities covering the Management of
Project Data from initiation of the Project to Completion and
termination of the Operations of the
1.2.3. Verification – All activities related to
or inspection of all hardware for the purpose
with other affected hardware or systems are
fulfill its intended function.
1.3. Safety & Mission Assurance
1.3.1. Safety – All activities related to ensure
hardware, and the environment (earth and
the
1.3.2. Reliability – All activities related to
improving the reliability and maintainability
1.3.3. Quality – All activities involving the
improving the product quality
1.4. Gas Trap Hardware
1.4.1. Hydrophilic Membrane – All activities
of
1.4.2. Hydrophilic Membrane – All activity
analysis, procurement, manufacture, and test
1.4.3. End Caps – All activities concerning
the manufacture of this component.
1.4.4. End Plates – All activities concerning
the manufacture of this component.
1.4.5. O-Rings – All activities concerning the
1.4.6. Stiffeners – All activities concerning the
1.4.7. Glue – All activities concerning the
design of this component.
1.4.8. Hardware Assembly – All activities concerning components identified in this section (1.4). Gene
Trap Insert Housing provided (not within the
same process.

1.5. Ground Systems
1.5.1. Facilities – All activities involving the
use of ground processes, do not remain
including the modification, development, and
maintenance.

1. Gas Trap Insert – Unless otherwise stated, each WBS element is to include
all elements of cost (i.e., procurements, labor, & indirect costs).
1.1. Management – Includes all aspects of program & project management,
control, and coordination.
1.1.1. ISS Program Office (ISPO) – All activities involving personnel from
the ISS Program Office. Also includes those authorized to act on behalf of the
ISS Program Office that are not assigned to the project by the MSFC project
manager.
1.1.2. Project Management – All activities required to manage the project
according to the applicable NPD, NPG, MML, and MWI including, but not
limited to the Project Manager’s role in development, administration, and
maintenance of the Project Plan, Project Risk Plan, Project WBS, WBS
Dictionary, and other required documentation not specifically covered
elsewhere, and project meetings and reviews (formal and informal).
1.1.3. Project Control – All activities required by applicable NPD, NPG,
MML and MWI including, but not limited to, creating, updating, and
maintaining the project schedule(s), and cost forecasting, monitoring, measurement, analysis, and control measures, including all activities related to
establishing an Earned Value System (EVS).
1.2. Systems Engineering & Integration
1.2.1. Specifications
1.2.1.1. Interface – All activities associated with identifying and
documenting interfaces between the Gas Trap Insert and other
components and systems it will interact with.
1.2.1.2. Requirements – All activities associated with identifying and
documenting system-level requirements for the Gas Trap Insert.
1.2.2. Conceptual Design – All activities related to the identified trade
studies, which are: Hydrophilic Membrane (New Material), Hydrophilic
Membrane (Existing Material & Application), Hydrophilic Membrane
(Single vs. Multiple), End Caps (Existing Material), and End Plates (Single vs.
Multiple Hydrophilic Membrane).
1.2.3. Component & Systems Integration – All activities related to the
determination of chemical and mechanical compatibility between all of the
Gas Trap Insert hardware pieces, as well as the Gas Trap Insert Assembly’s
compatibility with the environment in which it is to be installed.
1.2.4. Configuration & Data Management
1.2.4.1. Configuration Management – All activities covering the control of
Configuration Identification, Control, Accounting and Verification of the
Design Requirements, Design, and Hardware documentation for the
Project.
DIVERGING PATHS (REALLY?)

- Yes AND No - parts of schedule development *can* be done in parallel with parts of estimate development, but other parts of schedule development *must* be done *before* the estimate *can be completed*

- Schedule Development
  - The WBS outline was used to create an initial schedule structure – actually, just a list of activities with no sequence
  - The schedule development effort began by better defining the activities (i.e. adding detail where needed)
  - Once defined, the process of relating the activities to one another sequentially (i.e. establishing network logic) began
  - No date constraints were used except for the Project Start
  - Technical performance measures (TPM’s) were discussed, agreed upon, and documented (*important point*) – there are many varied methods
EXAMPLES OF TPM’S (1 OF 3)

☐ Percent Complete

☐ Subjective – requires someone to estimate physical progress

☐ Least accurate, most used

“I’d say we’re about 25% complete”

☐ An example: an activity called “design” – estimated to be n% complete by the person responsible

<table>
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<tr>
<th>ID</th>
<th>Task Name</th>
<th>% Complete</th>
<th>2002</th>
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<td>Widget</td>
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<td>Design Phase 1</td>
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<tr>
<td>3</td>
<td>Preliminary Design</td>
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<td>Design Review</td>
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<td>6</td>
<td>Design Unit A1</td>
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<tr>
<td>7</td>
<td>Fabricate Unit A1</td>
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</tr>
<tr>
<td>8</td>
<td>Test Unit A1</td>
<td>0%</td>
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</tr>
</tbody>
</table>
EXAMPLES OF TPM’S (1 OF 3)

- Percent Complete
  - Objective – utilizes physical counts to determine progress
  - Most accurate, least used

“We’ve built 50 of the 100 widgets, therefore we’re 50% complete”

- An example: an activity named “design” requires n# drawings to be produced – ½ n drawings are complete, therefore the activity is 50% complete

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>% Complete</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Widget</td>
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<tr>
<td>2</td>
<td>Design Phase 1</td>
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<td>3</td>
<td>Preliminary Design</td>
<td>0%</td>
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<td>4</td>
<td>Design Review</td>
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<td>Design Unit A1</td>
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<tr>
<td>7</td>
<td>Fabricate Unit A1</td>
<td>0%</td>
</tr>
</tbody>
</table>

Program Manager, Senior Engineer, Documentation [25%]. Jr Engineer, Senior Engineer, Jr Engineer, Documentation [25%], Fab
EXAMPLES OF TPM’S (3 OF 3)

- **Milestone**
  - 0-100% - credit is only earned upon completion (100%)
    - Typically used when tasks span <= 1 acct. period
  - 50-50% - credit is given at the start (50%) and finish (50%)
    - Typical for tasks spanning 2-3 acct. periods
  - Weighted – partial credit is given at key interims
    - Used when tasks span more than 3 acct. periods

- An example: a procurement or fabrication activity with phases or stages

**NOTE ON MILESTONE TPM: REQUIRES THE USE OF A TRACKING PROCESS**
Schedule Development (Continued)

- The tasks of making duration estimates and doing resource identification, assignments and allocations were done hand-in-hand since the skill level (for people) and availability of resources have a direct impact on the activity duration.

- Not one, but three duration estimates were collected for each schedule activity (best case, worst case, most likely – more on this later).

- Every work group (engineers, manufacturing, etc.) participated in developing the schedule – this resulted in a highly integrated plan.

- This process was iterative – adjustments to the sequencing of activities and allocation of resources were made until all stakeholders were satisfied with the results.

- As duration estimates were finalized, the SAME PEOPLE provided inputs for the cost estimates.
DIVERGING PATHS (REALLY?)

Estimate Development

- Initial estimates were compiled by combining work group leads’ estimates (i.e. X heads for Y months) with rates for labor, procurements, and indirect costs – this process was heavily influenced by historical data.

- As schedule development evolved, costs for resources were loaded in the schedule tool and the resulting time-phased cost plan from the schedule tool was compared with initial estimates.

- The cost, schedule, and work groups collaborated to reconcile the gaps between cost and schedule.

- Initial reserves (cost and schedule) were added based on historical data, but later reviewed and revised (see Establishing the Baseline).
# EXAMPLE ESTIMATE WORKSHEET

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<th>Object Level</th>
<th>FY05</th>
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<td>Civil Service</td>
<td>FTE's</td>
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<td>9052</td>
<td>Contractor on-site</td>
<td>WYE's</td>
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<td>Workforce total</td>
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<td>(Salary &amp; Fringe)</td>
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<td>3000</td>
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<td>Contracts, grants, hardware, direct services</td>
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<td></td>
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<td>SUB TOTAL</td>
<td>Direct Cost</td>
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<tr>
<td>8020</td>
<td>Service Pools</td>
<td>(FTE+WYE)*Service Pool rate</td>
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<tr>
<td>8005</td>
<td>Center G&amp;A</td>
<td>(FTE+WYE)*Center G&amp;A rate</td>
<td></td>
<td></td>
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<tr>
<td>8000</td>
<td>Corp G&amp;A</td>
<td>(FTE+WYE)*Corp. G&amp;A rate</td>
<td></td>
<td></td>
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<td>Total Full Cost Budget Plan</td>
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<td>Reserve (15% - held by ISSPO/OB)</td>
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<tr>
<td></td>
<td></td>
<td>Grand Total</td>
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</tr>
</tbody>
</table>
CONVERGING PATHS

- Risky Business
  - The schedule data was used to initially populate a Risk Log template (including best case, worst case, and most likely duration estimates for use later)
  - The project team adopted a list of risk-types that applied to the project (e.g. design engineering difficulty, manufacturing process difficulty, etc.)
  - For each risk-type, the project team defined a scale that consisted of numbers with a description for each number (e.g. a “0” for design engineering difficulty might mean “we do it all the time” while a “25” might mean “never done before”)
  - The same type of scale was developed for the consequence of risk materialization as well
  - The Risk Log items were examined by the project team and risks were rated using the scales developed as described in the preceding steps
  - These risk ratings were converted via formulas into a Performance Difficulty factor, as well as an overall Risk Factor, for each Risk Log item
  - The results were plotted on a standard 5 X 5 Risk Matrix and ranked
EXAMPLE RISK TEMPLATE (1 of 3)

LEGEND

MANUFACTURING PROCESS DIFFICULTY (MPD) RATING
- No comparable process, and at least one of the processes C, Y, T, P, or PC are expected to be within the state of the art. 10
- No comparable process, and all of the requirements for C, Y, T, P, or PC are expected to be within the state of the art. 9
- Integrated process is a combination of demonstrated processes and C, Y, T, P, or PC exceed normal or for these processes. 8
- Integrated process is a combination of existing processes and C, Y, T, P, or PC exceed within the norm for these processes. 6
- Modifications of existing processes to meet C, Y, T, P, and requirements. 3
- Existing process meets C, Y, T, P, and requirements. 0

PRODUCTION EQUIPMENT STATUS (EQI) RATING
- Insufficient equipment availability and equipment development. 10
- Insufficient equipment availability, and equipment development 9
- Facility/equipment available and require minimal modifications. 8
- Facility/equipment available, but require minor modifications. 7
- Facility/equipment available, but require major modification. 6
- Facility/equipment available, limited use in designated production. 5
- Facility/equipment being used to manufacture given product. 0

PERSONNEL RESOURCE STATUS (PER) RATING
- Insufficient trained production personnel involved in on going production. 10
- Insufficient high skilled production personnel. 9
- Insufficient moderate low skilled production personnel. 8
- Insufficient trained production personnel. 6
- Insufficient high skilled production personnel involved in on going production. 0

TEST RESOURCE STATUS (TEST) RATING
- No defined test procedures, no equipment and no facilities. 10
- Defined procedures, insufficient equipment/facility. 9
- Defined procedures, available, but less than necessary. 8
- Defined procedures, available, but fewer than necessary. 7
- Defined procedures, available, but fewer than necessary. 6
- Defined procedures, facility available, but fewer than necessary. 5
- Defined procedures, facility available, equipment available, but fewer than necessary. 4

STATE OF TECHNOLOGY (SOI) RATING
- Scientific research ongoing. 10
- Conceptual design completed for performance and qualification. 9
- Conceptual design completed for performance and qualification 8
- Critical function/unit demonstrator demonstrated at prototype. 7
- Critical function/unit demonstrator fabricated and tested for performance and qualification. 6
- Critical function/unit demonstrator fabricated and tested for performance and qualification. 5

DESIGN ENGINEERING DIFFICULTY (CED) RATING
- No alternative and/or requires new or breakthrough advance. 25
- No alternative and/or major engineering development using existing knowledge. 20
- Poor alternatives and/or new component development is required. 15
- Poor alternatives and/or uses standard components beyond accepted spec level. 12
- Design sourcing using standard components within specs. 9
- Off the shelf item with minor modifications. 6
- Off the shelf item which requires qualification. 3
- Off the shelf item which meets all requirements. 0

MATERIAL RESOURCE STATUS (MAT) RATING
- Single off-shore source identified with insufficient material. 20
- Single off-shore source identified with insufficient material. 15
- Multiple off-shore sources identified with insufficient material. 10
- Single U.S. source identified with sufficient material. 5
- Multiple U.S. sources with sufficient material. 0

Consequence of Failure (CDF) Scale

Table 8

Ratings

0.1 NEGLIGIBLE — Failure to achieve mission or target performance. No significant performance impact expected.
0.3 MINOR — Failure to meet requirement results in minor reduction in mission achievement. Small performance reduction.
0.5 MARGINAL — Failure to meet requirement results in degradation of secondary mission. Significant reduction in technical performance.
0.7 CRITICAL — Failure to meet requirement results would degrade performance to a point that primary mission success is in jeopardy.
0.9 CATASTROPHIC — Failure to meet the requirement results in mission failure, vehicle destruction, loss of life.

Table 9

Probability Distribution Curve

1. Uniform
2. Triangular
3. Normal
# EXAMPLE RISK TEMPLATE (2 of 3)

<table>
<thead>
<tr>
<th>ASOS</th>
<th>Title</th>
<th>Risk ID</th>
<th>Risk Description</th>
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<th>DFD</th>
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<th>PER</th>
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<th>CT</th>
<th>Pt</th>
<th>FM</th>
<th>FD</th>
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**ASOS**

**Title**

**Risk ID**

**Risk Description**

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</tbody>
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**Glossary**

ASOS: Acronyms, Schedules, Operations, Systems, and Services

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**Scheduling & Controls**

**Site & Environmental**
## EXAMPLE RISK TEMPLATE (3 of 3)

<table>
<thead>
<tr>
<th>WBS</th>
<th>Title</th>
<th>Cf</th>
<th>Pd</th>
<th>RF</th>
</tr>
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<tbody>
<tr>
<td>1.2.2.2</td>
<td>Trade Study - Membrane Coating</td>
<td>1.5</td>
<td>3.1</td>
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<tr>
<td>1.4.1.1</td>
<td>Hydrophilic Membrane Design &amp; Analysis</td>
<td>3.5</td>
<td>1.0</td>
<td>0.13</td>
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<td>0.1</td>
<td>0.01</td>
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*GTI Risk Matrix*
ESTABLISHING THE BASELINE

- The risk data, along with data collected during interviews, was used to characterize schedule tasks.
- This characterization and the 3 duration estimates collected earlier were used to perform a schedule risk assessment.
- Since the schedule was resource loaded and resources were costed, a cost risk assessment was performed simultaneously.
- The results of both assessments were used to determine the needed cost and schedule reserves.
- These reserve numbers were compared to the initial reserve estimates and an informed decision was made – THE BASELINE WAS ESTABLISHED.
RESERVE JUSTIFICATION

Cost Reserve Justification

Assumptions
- Desired reserve is 10-20% (based on historical data).
- Cost and risk estimates are accurate and complete as of the time of this analysis.
- All planned work has an estimated cost and is identified in the schedule.
- Total project costs are estimated to be $X.XXXK.

Basis
- Cost is directly proportional to the cost of resources and the duration of the task.
- Certain indirect, travel, material, facility test support, and level-of-effort costs are fixed.
- There are widely varying levels of risk associated with different tasks.

Analysis
- The project was evaluated as a whole and each section was analyzed independently.
- A combined approach is recommended to ascertain the most accurate results.
- At a project level, an 80% level of confidence can be obtained for $X.XXXK.
- This represents a reserve of $XXXK for estimate uncertainty.

<table>
<thead>
<tr>
<th>Cost Probability Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prob</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>0.05</td>
</tr>
<tr>
<td>0.10</td>
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<tr>
<td>0.15</td>
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<tr>
<td>0.20</td>
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<td>0.25</td>
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<tr>
<td>0.35</td>
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<tr>
<td>0.40</td>
</tr>
<tr>
<td>0.45</td>
</tr>
<tr>
<td>0.50</td>
</tr>
</tbody>
</table>

- Using mean data, the table below represents recommended additions to the reserve.

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
<th>Estimated Cost (SK)</th>
<th>Mean Cost (SK)</th>
<th>Recommended Reserve Add (SK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4</td>
<td>Hardware</td>
<td>$X.XXXK</td>
<td>$X.XXXK</td>
<td>$X.XXXK</td>
</tr>
<tr>
<td>1.5</td>
<td>Testing &amp; Evaluation</td>
<td>$X.XXXK</td>
<td>$X.XXXK</td>
<td>$X.XXXK</td>
</tr>
</tbody>
</table>

- The basis for fixed costs is not valid, therefore it is recommended that an additional 5% be allotted to cover these costs (based on the schedule reserve analysis).

Reserve Built Up

<table>
<thead>
<tr>
<th>Estimate Uncertainty</th>
<th>High Risk Items</th>
<th>Fixed Costs variation</th>
<th>Project Estimate</th>
<th>Total Project Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>$XXX</td>
<td>$XX</td>
<td>$XX</td>
<td>$X.XXXK</td>
<td>$X.XXXK</td>
</tr>
</tbody>
</table>

Schedule Reserve Justification

Assumptions
- Desired reserve is approximately 20% (based on historical data).
- Schedule and risk data is accurate and complete as of the time of this analysis.
- All planned work is identified in the schedule.

Basis
- Task duration is 2 years and 7 months.
- Project start is assumed to be 1/1/04 for the purpose of this exercise.
- Scheduled project completion date with 120 days of reserve is 1/207.
- The last unit is scheduled to ship on 7/18/05. This is the completion date with reserve.

Analysis
- To an 80% level of confidence, the project will be complete by 10/24/06.
- The difference between 7/18/06 and 10/24/06 is 72 working days of reserve, or about 6.3%.
- Recommend adding an additional 9.3% for unknown or unrealized risks.
- A total schedule reserve of between 120 to 150 days, or about 18-20% should be adequate.

<table>
<thead>
<tr>
<th>Completion Probability Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prob</td>
</tr>
<tr>
<td>0.05</td>
</tr>
<tr>
<td>0.10</td>
</tr>
<tr>
<td>0.15</td>
</tr>
<tr>
<td>0.20</td>
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<td>0.25</td>
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<td>0.40</td>
</tr>
<tr>
<td>0.45</td>
</tr>
<tr>
<td>0.50</td>
</tr>
</tbody>
</table>

11th run - revised CS FTE and other costs
The result – a time-phased and costed plan with built-in performance measurement capability

- **Time = Schedule** – Our schedule tool provided a complete list of all activities required to complete our scope of work, arranged in a logical, sequential fashion, along with the capability to assess the impact on our completion date due to changes (scope, sequence, risk materialization)

- **Dollars = Estimates** – By assigning costed resources to schedule activities, we had a cost plan that not only indicated total costs, but when those costs would be incurred, along with the impact of changes (scope, sequence, risk materialization)

- **Performance = Work Accomplished** – The baseline contained the record of our commitment to perform work for a specified cost during a specified time period, which could then be used to compare with actual costs and actual time as the project moved forward (this also provided us with a tool to enable forecasts of time and cost for future work planned)
Key Questions Answered

“How long will it take?”

Answer - X years

Along with key project milestone times...
IT ALL COMES TOGETHER

Key Questions Answered

“How much will it cost?”

Answer - $X M

1. Risk Assessment

2. Build Up (Estimate + Risk)
IT ALL COMES TOGETHER

Key Questions Answered

“What’s the critical path?”

Answer – See graphic

...and goes thru Project Completion

Starts at Time Now…
Key Questions Answered

“What resources are required and when?”

Answer – See graphic

By resource…
# IT ALL COMES TOGETHER

## Key Questions Answered

- **“What if ...?”**

- Answer – Using a copy of the schedule, change sequencing or durations or risk factors and analyze the outcome...

## Cost Profile

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Total Slack</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Gas Trap Insert</td>
<td>0 days</td>
</tr>
<tr>
<td>2 Management</td>
<td>0 days</td>
</tr>
<tr>
<td>3 ISSPO Support - LOE</td>
<td>355 days</td>
</tr>
<tr>
<td>4 Project Management</td>
<td>0 days</td>
</tr>
<tr>
<td>5 Project Management - LOE</td>
<td>0 days</td>
</tr>
<tr>
<td>6 Authorization To Proceed</td>
<td>0 days</td>
</tr>
<tr>
<td>7 Project Plan Development</td>
<td>155 days</td>
</tr>
<tr>
<td>8 Quality Plan Development</td>
<td>155 days</td>
</tr>
<tr>
<td>9 Quality Plan Approved</td>
<td>155 days</td>
</tr>
<tr>
<td>10 PDR Complete</td>
<td>95 days</td>
</tr>
<tr>
<td>11 CDR Complete</td>
<td>118 days</td>
</tr>
<tr>
<td>12 Hardware Design Complete</td>
<td>548 days</td>
</tr>
<tr>
<td>13 All Drawings Reviewed &amp; Released</td>
<td>528 days</td>
</tr>
<tr>
<td>14 Procurement Complete</td>
<td>1450 days</td>
</tr>
<tr>
<td>15 Hardware Test Complete</td>
<td>0 days</td>
</tr>
<tr>
<td>16 Systems Engineering</td>
<td>57 days</td>
</tr>
<tr>
<td>17 Specification Development</td>
<td>0 days</td>
</tr>
<tr>
<td>18 Hardware Design Test</td>
<td>0 days</td>
</tr>
<tr>
<td>19 Project Controls - LOE</td>
<td>0 days</td>
</tr>
<tr>
<td>20 Systems Engineering</td>
<td>57 days</td>
</tr>
<tr>
<td>21 Hardware Test</td>
<td>0 days</td>
</tr>
<tr>
<td>22 Manufacturing</td>
<td>57 days</td>
</tr>
<tr>
<td>23 All Membrane Test</td>
<td>0 days</td>
</tr>
<tr>
<td>24 Qualification Review</td>
<td>0 days</td>
</tr>
<tr>
<td>25 Final Pre-ship Review</td>
<td>0 days</td>
</tr>
<tr>
<td>26 All Units Shipped</td>
<td>0 days</td>
</tr>
<tr>
<td>27 Schedule Margin</td>
<td>0 days</td>
</tr>
<tr>
<td>28 Project Controls - LOE</td>
<td>0 days</td>
</tr>
<tr>
<td>29 Systems Engineering</td>
<td>0 days</td>
</tr>
<tr>
<td>30 Specification Development</td>
<td>57 days</td>
</tr>
</tbody>
</table>

## 2. What impact does that have on this milestone & ...

## 1. If I change a task’s duration, or sequence, or risk factor...

## 3. How does this change affect my project completion date, resource & cost phasing?
IT ALL COMES TOGETHER

- Changes in work scope create a “data cascade”
  - The WBS is updated
  - The WBS Dictionary is updated
  - The Schedule is updated
  - Estimates are updated
  - The Risk Log is updated
  - A new cost/schedule risk assessment is performed
  - Reserves (cost &/or schedule) adjusted accordingly

- A change in any of the following creates a similar ripple effect
  - Schedule – actual versus planned durations, revised plans
  - Cost – rate differences, resource expenditures
  - Technical – design issues, technology development issues
  - Risk – retirement of risks, new risks, evolving risks
IT ALL COMES TOGETHER

- One key to successfully managing the project – A DISCIPLINED SYSTEM OF PROCESSES
  - Management Philosophy – “plan the work, work the plan” approach
  - Configuration Control (WBS, WBS Dictionary, etc.)
  - Data Management (cost, schedule, etc.)

- Another key - COMMUNICATION !!! Is there an ECHOO in here?
  - An “ECHOO” implies repetition – necessary part of effectiveness
  - Early – gives stakeholders the most precious commodity (TIME)
  - Clearly – ensures understanding and commonality of purpose
  - Honestly – fosters teamwork and trust
  - Often – makes certain that all information is current
  - Openly – eliminates fear and builds the information power base

- Historical Note – this “package” was “bought” by our customers with only minor comments
LESSONS LEARNED (1 of 3)

- “Lock in” the WBS before proceeding with schedule, cost, or risk efforts – this will save much grief and wasted effort later on
- Establish rigorous configuration & data management processes as early as possible – define the “data cascade”
- Don’t trust your memory – write EVERYTHING down (agreements, definitions, information, etc.)
- It is extremely difficult (if not impossible) to separate estimating durations and making people-resource allocations – each has a bearing on the other
- Have the people doing the work involved in planning the work – they know more about it than anyone else
- Decide which TPM’s you will use, on which tasks, and document them during the planning process
- Cost and schedule should tell the same story from different perspectives with the same ending
LESSONS LEARNED (2 of 3)

- Cost and schedule inputs are related – some are serial (such as resource use), some are parallel (resource & indirect rates)
- It always takes more than you think (money, time, & resources) – unproductive costs are a reality, be prepared
- Indirect costs are real and may double (or more) the total cost of your project – be prepared for this reality
- Schedule, cost, and technical risks are related – but are not necessarily always directly proportional
- Historical data is very valuable – USE IT! – chances are, someone else paid very dearly for it
- When using historical data, ensure you understand its context, especially in relation to your own
LESSONS LEARNED (3 of 3)

There is no such thing as a project too large or too small to benefit from good integrated project management practices – the best practices are those that are consistent in ideology but scalable in use (i.e. they can shrink or grow to fit the circumstances)