Scheduling Challenges in the Industrial Construction Sector

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Scheduling Practices and Project Success
Schedule Specifications and Schedule Planning
  - Rolling Wave
  - Traditional – Integrated or Stand Alone
Managing Multiple Schedules and Schedule Distribution
Schedule Checking
Update Cycle and Capturing Impacts
Cool Reports ~
Scheduling Practices and Project Success

Dr. Andrew F. Griffith, PE

Independent Project Analysis, Inc. based study

- 494 completed major industrial capital projects (72% from North America, 58% petro-chemical)
- Projects authorized from 1993 to 2003 (Median Q3 2000)
- Average cost of $24M, median $4.3M, range $100k to $934M
- 59 different owner organizations~
Scheduling Practices and Project Success

Methodology:
- IPA project data collected at project authorization and project completion

Measures of project success:
- Cost
  - Cost Index - Cost performance relative to the industry benchmark for comparable projects
  - Cost growth relative to the estimated cost at the time of project execution
- Time
  - Schedule Index - Execution schedule relative to the industry benchmark for comparable projects
  - Schedule slip relative to the planned project finish date set at the time of authorization~
Scheduling Practices and Project Success

- **Project Definition Rating – 494 Projects:**
  - No schedule – 3% (15 projects)
  - Milestone schedule – 55% (272 projects)
  - CPM Network schedule – 29% (143 projects)
  - CPM Network with resource loading – 13% (64 projects)
<table>
<thead>
<tr>
<th>Outcome Metric</th>
<th>Resource Loaded CPM</th>
<th>CPM</th>
<th>Milestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute Cost Index</td>
<td>0.95</td>
<td>0.98</td>
<td>1.03</td>
</tr>
<tr>
<td>Absolute Schedule Performance</td>
<td>0.91</td>
<td>0.97</td>
<td>1.04</td>
</tr>
<tr>
<td>Percent Cost Growth</td>
<td>-1%</td>
<td>2%</td>
<td>5%</td>
</tr>
<tr>
<td>Absolute Schedule Performance</td>
<td>0.91</td>
<td>0.97</td>
<td>1.04</td>
</tr>
<tr>
<td>Percent Schedule Slip</td>
<td>2%</td>
<td>19%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Cost & Schedule Comparable to Similar Projects

Cost & Schedule Baseline Comparison
<table>
<thead>
<tr>
<th>Outcome Metric</th>
<th>Projects that did Core Team reviews</th>
<th>Projects that did not do Core Team reviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Cost Growth</td>
<td>0%</td>
<td>11%</td>
</tr>
</tbody>
</table>
Scheduling Practices and Project Success

- Summary of Dr. Griffith’s findings:
  - Fully Integrated schedule
  - Use Critical Path Method (CPM)
  - Resource load the schedule
  - Early detailed review of the schedule by the core project team

- This is the starting point!
  - Add Risk Analysis, Buffers, Analysis, What If’s~
Scheduling Practices and Project Success

- Projects with the highest level of schedule definition at authorization had on average:
  - 8% lower cost
  - 13% faster schedules

- They were more predictable:
  - 6% less cost growth
  - 23% less schedule slip~
Owners vs. Prime Contractors

 Owners: You get what you ask for
  - Review current schedule specification requirements P3 vs. P6
  - Ability to withhold progress payment

 Primes: Most Prime Contractors do some form of scheduling and believe they are doing enough
  - Cost more to develop and maintain (full vs. part-time scheduler)
  - Misconceptions - Loose control of the schedule
  - Size of the project – 40 M+ ~
Common Specifications

- **Project Schedule Structure**
  - Contractual Milestones
  - Clear Complete Scope of Work
  - WBS
    - Easily understood
    - Supports the major phases of the project
    - Supports the major components of the project
- **Coding**
  - Phase
  - Area & Sub-Area (physical or administrative area)
  - Equipment #
  - Responsibility
  - Discipline
- **Activity ID structure**
- **Calendars**
Common Specifications

- Standards/Definitions/Conventions
  - Activities
    - Criteria (scope, duration)
    - Descriptions: Location, Verb, Noun
    - Understandable when taken out of context
    - Links and Open Ends - CPM
  - Resources
    - Major disciplines (electricians, welders, ironworkers…)
    - Major Equipment
    - Major Quantities~
Common Specifications

- **Standards/ Definitions /Conventions**
  - Numbering scheme and format for:
    - Filters
    - Layouts
    - Reports
  - Conventions for Adding Activities
  - Master Project / Subproject Process
  - Updating Cycle / Process
  - Updating Requirements
  - Reports - Provides appropriate information for each entity – Owner, Engineer/Architect, Contractor, Subcontractor

- **Email / CC Owner all subcontractor schedule correspondence**
- **Owner attend subcontractor meetings ~**
Schedule Planning

How are we going to manage the project and schedule

Type of Schedules

- Rolling Wave
- Traditional - Consistent Level of Detail
  - Integrated
  - Individual – Stand Alone~
Rolling Wave

- Schedule Development Rolling Wave
  - Initially High level of Detail then add additional activities prior to start
  - Original duration does not increase
  - Original Activity becomes a Level of Effort and tracks duration to baseline plan.
  - Project Duration or Engineering Considerations~
Integrated Schedules

- Master Project/Subproject structure
  - Time and cost savings
    - Dates are synchronized between schedules
    - Information updated one time only
    - Concurrent updating of schedules
  - Ability to link between projects
    - Schedules stay synchronized even when checked out
    - Links between projects are maintained at the master schedule level
    - Activity coding dictionaries, layouts, and filters are synchronized
  - Ability to "check out and check in" a project to individual companies for their updating.
    - Ability to do schedule comparisons both at the master project and sub project levels~
Integrated Schedules

- **Master Project/Subproject structure**
  - Subprojects are usable during the month without affecting the master schedule.
    - 3 week look ahead
    - "what if" analysis
  - Subprojects can be transmitted as legal documents
- **Security**
  - Each entity has access to only their subproject.
  - Subprojects do not have access to activities in the master other than viewing linked activities.
  - Data dictionary structure is controlled at the master level.
Management of Multiple Schedules

- Multiple Schedules with multiple levels of details
- Multiple schedulers with different skill levels.
- Mega Projects – Multiple departments with multiple schedules
  - Planning, Field, Quantity Tracking, Pay Apps, Design/Engineers, Monthly Reporting Narratives
Management of Multiple Schedules

- **Owner**
  - Summary Bars and Milestones

- **Prime Contractor**
  - Full Scope of Work
    - 5 to 20 day activities
    - One activity per responsibility party/Subcontractor
    - One activity per area / sub-area or equipment # ~
Management of Multiple Schedules

- Sub-contractor
  - Subcontractor’s Scope of Work
  - Relative Milestones or concurrent impacting activities
  - Crew tracking and man hours
  - Mini windows of access before next trade

- Change Order Preparation

- Associate Activities by ACT ID~
Schedules Distribution

- Electronic data distribution
  - Give out an electronic vs. paper schedule vs. no distribution
  - Monthly vs. weekly master schedule distribution
    - Monthly – dates change over time.
- Export considerations
  - P6 versions
  - MS Project
  - Excel
  - Adobe Reader ~
Common Scheduling Problems

- Mechanically Correct
  - Level of Detail
  - Open Ends
  - Critical Path
  - Proper Links / Tie Offs
  - Coding vs. WBS
  - Minimum coding – Phase, Area, Equipment #, Sub-area, Responsibility ~
Common Scheduling Problems

- Mechanically Correct
  - P6 Settings
  - Resource loaded – Quantities, Man-hours, Costs
  - Calendar Start / Finish Hours
  - Data Date start Hour
  - AS / AF Hour
  - Constraints Start / Finish Hour
  - Duration not in whole days ~
Not Allowed Schedule Changes

- Schedule changes –
- Activity ID
- Activity Description
- Responsibility reassignment
- Deleting and adding activities~
Schedule Integrity - Mechanically Correct

- QA steps
  - Configure software options
  - Close open ends
  - Remove Mandatory and Start/Finish On constraints
  - Justify every constraint used
  - Verify contractual Milestones / Dates are entered
  - Balance resource loading to the estimate
  - Review Float
    - Low Float
    - High Float
  - “Test” the schedule~
Schedule Software Checkers

- Primavera
  - P6 built-in checker (F9 Report)
  - Claim digger – Schedule Comparison
  - Primavera Risk Analysis
- SA Pro / Enterprise
- Acumen Fuse~
### Schedule Software Checkers

<table>
<thead>
<tr>
<th>Feature</th>
<th>SA Pro / Enterprises</th>
<th>Primavera P6</th>
<th>Primavera Claim Digger</th>
<th>Deltek Acument Fuse</th>
<th>Primavera Risk Analysis</th>
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</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$1,900.00</td>
<td>$2,750 + $605 yrly maint.</td>
<td>Free with P6</td>
<td>$5,000 + $1100 yr maint + $470 tax</td>
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<td>Schedule Comparisons</td>
<td>x</td>
<td>x</td>
<td></td>
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<td></td>
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<tr>
<td>Taskview</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Software if Analyses</td>
<td>P6, MSP</td>
<td>P6</td>
<td>P6, MSP, Excel</td>
<td>P6, MSP</td>
<td></td>
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<tr>
<td>Constraints</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td>Open-ended tasks (Does not include ignored links)</td>
<td>x</td>
<td>x</td>
<td></td>
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<tr>
<td>Out of sequence updates (&quot;broken logic&quot;)</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
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<tr>
<td>Lags longer than 100 units</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td>Negative lags (&quot;leads&quot;)</td>
<td>x</td>
<td>x</td>
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<td>Positive lags on Finish-to-Start links</td>
<td>x</td>
<td>x</td>
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<td>Start-to-Finish links</td>
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<td>Lags between tasks with different calendars</td>
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<tr>
<td>Links to / from summary tasks</td>
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<td>Duration uncertainty distribution shape 2</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Update Cycle

- Execution – Following the Plan
- Forecasting vs. Historical
- Completion of activities – Rolling wave ~
Weekly Information Flow

- **Owner**
- **Engineering**
- **Procurement**
- **Change Orders**
- **Delays, Impacts**
- **RFI’s**
- **Work Packages**
- **Prime Contractor**
- **Subcontractors**

- Move data date to the following Monday Collect actual information M-F
- Update the schedule
- Publish first pass on Friday
- Add last minute changes

- Review and Publish weekly reports to all participants on Monday morning
- Milestones: Completion Date – Critical Path Analysis
- Impact/RFI/ Analysis – Effects and Mitigation
- Plan upcoming Work:
- Look a-heads by Discipline/Subs
Schedule Impact Form

Date:________
Company:________________________________________
Project:________________________________________

Impact Number:________ → Schedule Activity ID:________
Impact Start Date:________ → Impact End Date:________
Impact Description:________________________________

Impact Type: (check one)
- Excusable, Non-compensable
- Force Majeure (severe weather)
- Unexpected Subsurface conditions
- Excusable, Compensable
- Design Error
- RFI’s
- Non-excusable, Non-compensable
- Subcontractor Performance
- Contractor Performance

Impact Cause: (check all that apply) Section Break (Continuous)
- Act of God
- Unknown Conditions
- Design Omission
- Design Error
- RFI Process
- RFI Answer
- Estimate Omission
- Scope Change
- Late Submittal Approval
- Late Submittal
- Late Material or Order
- Late Material Delivery
- Late Material or Subcontractor
- Mobilization or Interference
- Field Install
- Schedule Logic Error

Impact Responsibility: (check all that apply)
- Owner
- Contractor
- Subcontractor (name:__________________________)
- Other (name:__________________________)

Consequence of Impact: (attach additional pages, copies of RFI’s or pictures, etc…):
______________________________________________________________________________
______________________________________________________________________________

Schedule Activity(s) Directly Impacted: (list Activity IDs):
______________________________________________________________________________
______________________________________________________________________________
Delays & Impacts

Types of Impacts:

- **EC - Excusable, Compensable**
  - Generally receive Time and $.
  - Examples - Design Error, RFI’s, Owner requested change.

- **ENC - Excusable, Non–compensable**
  - Generally receive Time.
  - Examples - Force Majeure (severe weather), Unexpected Subsurface conditions.

- **NENC - Non–excusable, Non–compensable**
  - No Compensation.
  - Examples - Subcontractor Performance, Contractor Performance.
Delays & Impacts

■ Additional Coding - used to show changes from the baseline schedule during the project
  ■ IMPT – Impact Type
    ■ EC - Excusable, Compensable
    ■ ENC - Excusable, Non-compensable
    ■ NENC - Non-excusable, Non-compensable
  ■ IMPN – Impact Number
    ■ 001 – Increase Scope of Work
    ■ 002 – Activity Duration Extended by Contractor ~
Delays & Impacts

- Delays / Impacts evaluated against the current plan (contemporaneous schedule) and/or baseline
- Document, Illustrate, Analyze the impact/delay to the schedule immediately
- Get acknowledgement of the delay from all parties immediately
- Set a recovery plan. Recover immediately.
  - Additional work hours/days
  - Additional resources
  - Additional time (date extension)
Uncontrollable Delays

- Delays are addressed in the schedule after the impact has been identified
  - Impact can affect work in progress or work in the future
  - Add the impact to the schedule
  - Add the “consequence” activity or extend the duration of the in progress activity
  - Add logic
  - Illustrate the impact ~
P6 Variance Reports
Performance Monitoring

S Curves
Finish Date Analysis

Entire Plan: Finish Date

Analysis
Simulation: Latin Hypercube
Iterations: 1000

Convergence
Plan Finish Date:
Converged in 200 iterations
(variation < 1% over 100 iterations)
Total Plan Cost:
Converged in 200 iterations
(variation < 1% over 100 iterations)

Statistics
Minimum: 19/Dec/04
Maximum: 12/Jan/05
Mean: 01/Jan/05
Max Hits: 306
Std Deviation: 3.730

Selected Confidence
85%:
Deterministic Finish: 28/Dec/04
Probability: 16%
The End

Scheduling Techniques to Optimize Execution
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