Necessity for Good Scheduling

“Time is money” -- to owners, builders, and users of the constructed facility.
...from the owners perspective:

- lost revenue -- not receiving return on investment
- cash flow crunch
- potential alienation and loss of clients/tenants
- extended interest payments
- tax considerations
- negative marketing impacts
...from the users perspective:

- financial implications similar to owners
- delays in upgrading facilities means operating at below optimum efficiency -- higher cost
- delays in constructing or rehabilitating infrastructure negatively affects businesses and the public at-large
...from the contractor’s perspective:

- liquidated damages (negative)
- incentive or bonus (positive)
- delays result in extended overhead costs and other liabilities
- delays also put a crunch on critical cash flow
...from the contractor’s perspective:

- extending durations beyond the acceptable time frame limits the contractor’s bonding capacity and ability to bid more work
- inefficient time management results in higher labor and equipment costs
- a reputation for late completions is bad for business (especially in negotiated work)
Define “Project”

A project represents a unique set of activities that must take place to produce a unique product. The success of a project is judged by meeting the criteria of cost, time, quality, safety, and resource allocation.
Project Management

The purpose of Project Management is to achieve goals and objectives through the planned expenditure of resources that meet the project’s quality, cost, time, and safety requirements.
Practical Benefits of Good Scheduling

• requires managers to think the project through prior starting the work
• provides a structured approach to planning
• means of communicating the work plan to others
• identify problems before they arise
Practical Benefits of Good Scheduling

- identify long-lead fabricated items
- assess resource requirements
- forecast cash flows
- serves as primary documentation for delay claim analysis and other time impact considerations
The Scheduling Process (4 phases)

- Planning
- Scheduling
- Monitoring
- Controlling
Construction Planning is the necessary forerunner to Scheduling and includes:

- defining work tasks
- determining general sequence
- construction methods
- assigning responsibility
Scheduling Levels - CPM Life Cycle

- Baseline
- Look-ahead
- Updates
- Mock or What-if
- As-built
Short-Interval Schedules

- good scheduling requires more detailed, on-going preparation as activities draw closer to actual execution

- **Weekly Schedules**
- **Milestone or Goal Oriented Schedules**
Short-Interval Schedules

**Weekly Schedules**

- *a weekly schedule more directly communicates the work plan to the field personnel*
- *more accurately reflects immediate work plan because actual conditions are more predictable, i.e.: progress, weather, resources, subcontractor availability, short-term goals, and special considerations*
<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>LOCATION</th>
<th>M</th>
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<td>Abutment Construction</td>
<td>Abutment A NBR and Wingwall B</td>
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<td>Lighting Cable, Standards, &amp; Load Centers</td>
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<td>Type B Hotmix Paving</td>
<td>WB Churchmans Rd. in front of Abutment B</td>
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<td>Guardrail Installation</td>
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<td>PCC Barrier Relocation</td>
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<td>Loop Detector Installation</td>
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<td>Shift Traffic into Stage III/Ph. 2 Config</td>
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<td>Excavation/GABC</td>
<td>EB Churchmans Rd., SR7 to Tech Road</td>
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<td>Sign Structure Foundation Construction</td>
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</table>

Notes/Legend:

1) All work is **weather permitting** and highly dependent upon grade conditions.
# TWO WEEK SCHEDULE

FOR THE WEEK BEGINNING MONDAY, 10/11/99 TO MONDAY, 10/25/99

<table>
<thead>
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<th>LOCATION</th>
<th>M</th>
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<tr>
<td>Form Removal and Misc. Cleanup/Finishing</td>
<td>NB SR7 Bridge over Churchmans Rd./Wall B</td>
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<td>Bridge Deck Construction</td>
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<td>Type B Hotmix Paving</td>
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<td>Type B Hotmix Paving</td>
<td>SB SR7 Frontage Rd. thru SR4</td>
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<td>Signal Head Inst./Adjust. &amp; Loop Detector Inst.</td>
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<td>Realigning Traffic to Final Configuration</td>
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<td>Safety Barrier</td>
<td>MSE Wall A</td>
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<td>Light Poles and Wiring</td>
<td>NB SR7, South End Thru Churchmans Rd.</td>
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<tr>
<td>Pole Base, Conduit, Wire, and Light Pole Inst.</td>
<td>SB SR7, SR4 to North End and other locations</td>
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<td>X</td>
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<td>X</td>
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<td>Guardrail and Impact Attenuator Installation</td>
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<td>Sign Foundations</td>
<td>GM-9</td>
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<td>Sign Installation</td>
<td>All avail. signage required for NB SR7 Opening</td>
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<tr>
<td>Opening New Roadway to Traffic</td>
<td>NB SR7 and Ramps B/B-1/C/C-1</td>
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<tr>
<td>PCC Barrier Relocation</td>
<td>Ramps A/D and NB/SB SSR7</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>Remove Hotmix Crossovers</td>
<td>SR7 Med. &amp; SB Roadways @ North &amp; South Ends</td>
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<td>Complete Embankment</td>
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<td>PCC Removal</td>
<td>SB SR7, South End Tie-in</td>
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<tr>
<td>Complete MSE Wall</td>
<td>MSE Wall A</td>
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</tbody>
</table>

**Notes/Legend:**

1) All work is weather permitting.
2) All hotmix paving operations are contingent upon plant and crew availability.
3) New Road Opening includes relocating PCC Barrier and pavement striping.
4) Placing Traffic into Final Configuration includes temporary striping placed according to final striping pattern shown on the plans.

Night Work [X]  Night Paving 8PM to 6AM [X]  Deck Pour [X]  Road Opening [ ]
### THREE-WEEK SCHEDULE

**FOR THE PERIOD BEGINNING 4/16/01 TO 5/7/01**

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<tr>
<td>Relocating Temp. Barrier</td>
<td>SB I-295/Toll Plaza/Ramps A-D</td>
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<tr>
<td>Relocating Temp. Barrier</td>
<td>SB I-295, Stage V(B)</td>
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<tr>
<td>Jersey Barrier</td>
<td>SB I-295 @ Pier 4</td>
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<tr>
<td>Guiderail Removal</td>
<td>SB I-295, Shldr. &amp; Ramp D</td>
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<tr>
<td>Construct New Service Road (4)</td>
<td>Ramp LN-8</td>
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<tr>
<td>Replace Toll Lanes</td>
<td>Toll Lanes 4 &amp; 5</td>
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<td>X</td>
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<tr>
<td>Replace Toll Lanes</td>
<td>Toll Lanes 6 &amp; 7</td>
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<tr>
<td>Widening/Reconstruction</td>
<td>SB I-295 Shldr.</td>
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<tr>
<td>Hotmix Overlay</td>
<td>SB I-295 Lanes 7, 8, &amp; Shldr.</td>
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<tr>
<td>Final Striping, Polyurea</td>
<td>NB I-295 &amp; Ramps E - H</td>
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<tr>
<td>Reconstructing Ramps (3)</td>
<td>Ramp D</td>
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<tr>
<td>Reconstructing Ramps (3)</td>
<td>Ramp B</td>
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<tr>
<td>Reconstructing Ramps (3)</td>
<td>Ramp A</td>
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<tr>
<td>Relocating Temp. Barrier</td>
<td>SB I-295, Stage VI(B)</td>
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<td>PCC Pavement Removal</td>
<td>DE9 Median, Roadway</td>
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<td>X</td>
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<tr>
<td>Excavation/GABC</td>
<td>DE9 Median, Roadway</td>
<td>X</td>
<td>X</td>
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<td>Hotmix Paving, Base</td>
<td>DE9 Median, Roadway</td>
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<td>Backwall Reconstruction</td>
<td>NB &amp; SB DE9 over I-295, Med.</td>
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<tr>
<td>Demo/Patch Ex. 8’ Median</td>
<td>NB &amp; SB DE9 over I-295</td>
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</tr>
</tbody>
</table>

**Notes/Legend:**

1) All work is weather and/or temperature permitting.

2) Hotmix Paving is dependent upon crew and plant availability.

3) Ramp Reconstruction includes patching PCC pavement, excavation, GABC, u’drain, and hotmix paving.

   MOT for Ramp Reconstruction includes full closure and detour of traffic during construction.

4) New Service Road Ramp LN-8 construction includes slope stabilization using Gabions and Reno Mattresses.

<table>
<thead>
<tr>
<th>Night work requiring lane closures</th>
<th>Hotmix Paving</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

**GREGGO & FERRARA, INC.**

**DMB Contract No. 578**

West Approach Repaving and Modifications

Landers Lane to DMB

Project Manager

Greggo & Ferrara, Inc.
Short-Interval Schedules

**Milestone or Goal-Oriented Schedules**
- show a path or chain of events leading to attaining a goal or reaching a milestone
- excellent planning and communication tool
- can encompass more or less detail than full project CPM schedule
- can depart from the project schedule if accurate
Workplan for Opening New SB SR7

**Week of 11/1/99**
- Ramp A & Ramp D Construction
- Underdrain Ramp D & SB SR7
- Lighting SB SR7 & Ramps A & D
- Int. Curb & Gutter, Ramps A & D
- Sign Foundation OH-1
- Drainage Structures
- SB SR7 Bridge Approach Slab
- SB SR7 Bridge Parapets
- SR7 Median Barrier Footing
- Moment Slab on MSE Wall A
- Guardrail Maintenance Pav’t.
- Crossable Median, SR7

**Week of 11/8/99**
- SB SR7 Bridge Parapets
- Moment Slab on MSE Wall A
- Safety Barrier in SR 7 Median
- Safety Barrier on MSE Wall A
- Safety Barrier, face of MSE Wall A
- Complete GABC SB SR7
- BCBC SB SR7
- Lighting SB SR7 & Ramps A & D
- Sign Foundation OH-4

**Week of 11/15/99**
- SB SR7 Bridge Parapets
- Safety Barrier on Approach Slabs
- Barrier Transition @ OH-4
- BCBC & Type B Hotmix SB SR7 (South of Churchmans Rd.)
- Safety Barrier @ Pole 32 on Wall A
- Hotmix Curb SB SR7
- Abutment Backwalls @ Median

**Week of 11/22/99**
- BCBC & Type B Hotmix SB SR7 (North of Churchmans Rd.)
- Complete Lighting SB SR7
- Guardrail SB SR7 & Ramp A
- Backfill SR7Median @ Approaches
- Sidewalk in SR7 Median
- Portable PCC Barrier Relocation
- Temp. Striping & Symbols SB SR7 (South of Churchmans Rd.)
- Grooving SB SR7 Bridge Deck

**Week of 11/29/99**
- Signal Relocation SB SR7
- Loop Detectors
- Epoxy Line Painting SB SR7

**12/1/99**
- SB SR7 into Ultimate Alignment
- Reflectors on Safety Barrier SB SR7

**CHURCHMANS ROAD & SR7 INTERCHANGE**
**REHAB OF BRIDGES 716, 716A, & 717 I-95 OVER SR7**
**CONTRACT 91-101-04/96-074-02**

_GREGGO & FERRARA, INC._
# Critical Sign Structure & Panel Installation Schedule

<table>
<thead>
<tr>
<th>Structure No.</th>
<th>Panel(s) Designation</th>
<th>Early Start</th>
<th>Late Finish</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-2</td>
<td>C-2</td>
<td>8/30/99</td>
<td>10/10/99</td>
<td></td>
</tr>
<tr>
<td>C-5</td>
<td>C-5</td>
<td>8/30/99</td>
<td>10/10/99</td>
<td></td>
</tr>
<tr>
<td>GM-3</td>
<td>GM-3</td>
<td>8/30/99</td>
<td>10/10/99</td>
<td></td>
</tr>
<tr>
<td>GM-5</td>
<td>GM-5</td>
<td>8/30/99</td>
<td>10/10/99</td>
<td>Posts have been installed</td>
</tr>
<tr>
<td>GM-6</td>
<td>GM-6</td>
<td>8/30/99</td>
<td>10/10/99</td>
<td>Posts have been installed</td>
</tr>
<tr>
<td>GM-7</td>
<td>GM-7</td>
<td>8/30/99</td>
<td>10/10/99</td>
<td>Posts have been installed</td>
</tr>
<tr>
<td>GM-13</td>
<td>GM-13</td>
<td>8/30/99</td>
<td>10/10/99</td>
<td></td>
</tr>
<tr>
<td>GM-14</td>
<td>GM-14</td>
<td>8/30/99</td>
<td>10/10/99</td>
<td></td>
</tr>
<tr>
<td>GM-17</td>
<td>GM-17</td>
<td>8/30/99</td>
<td>10/10/99</td>
<td></td>
</tr>
<tr>
<td>GM-18</td>
<td>GM-18</td>
<td>8/30/99</td>
<td>10/10/99</td>
<td></td>
</tr>
<tr>
<td>OH-6</td>
<td>OH-6a / OH-6b / OH-6c</td>
<td>10/1/99</td>
<td>10/10/99</td>
<td></td>
</tr>
<tr>
<td>OH-7</td>
<td>OH-7a / OH-7b</td>
<td>10/1/99</td>
<td>10/10/99</td>
<td></td>
</tr>
<tr>
<td>C-8</td>
<td>C-8</td>
<td>8/30/99</td>
<td>10/10/99</td>
<td></td>
</tr>
<tr>
<td>GM-11</td>
<td>GM-11a / GM-11b</td>
<td>8/30/99</td>
<td>10/10/99</td>
<td></td>
</tr>
<tr>
<td>BM-1</td>
<td>BM-1a / BM-1b</td>
<td>10/1/99</td>
<td>10/10/99</td>
<td>Mount on NB SR7 Bridge</td>
</tr>
</tbody>
</table>

Notes:
1) This list represents signage that must be in place to open NB SR7 and Ramps B & C to traffic and includes ground mount, overhead, and cantilever sign supports.
2) The scheduled opening is October 11, 1999.
3) All permanent regulatory and warning signs proposed for NB SR7, Churchmans Rd., and Ramps B & C must also be in place prior to the opening.
## GUARDRAIL INSTALLATION SCHEDULE

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>Sht. No.</th>
<th>ES/LF</th>
<th>Approximate Quantities/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Churchmans Rd. Median 11+438 to 11+500</td>
<td>66</td>
<td>8/23/99-10/1/99</td>
<td>81m GR, 4m median barrier beam, 2 - CAT 350</td>
</tr>
<tr>
<td>2</td>
<td>Churchmans Rd. Median 12+197 to 12+263</td>
<td>69A</td>
<td>8/23/99-10/1/99</td>
<td>86m GR, 4m median barrier beam, 2 - CAT 350</td>
</tr>
<tr>
<td>3</td>
<td>Churchmans Rd. Median 12+409 to 12+461</td>
<td>69A &amp; 70A</td>
<td>8/23/99-10/1/99</td>
<td>84m GR, 4m median barrier beam, 2 - CAT 350</td>
</tr>
<tr>
<td>4</td>
<td>Frontage Rd. 22+134 to 22+178, Lt. SR7</td>
<td>62 &amp; 63</td>
<td>8/23/99-10/1/99</td>
<td>2 - ET 2000, 15m GR</td>
</tr>
<tr>
<td>5</td>
<td>Frontage Rd. 22+404 to 22+447, Lt SR7</td>
<td>63</td>
<td>8/23/99-10/1/99</td>
<td>2 - ET 2000, 15m GR</td>
</tr>
<tr>
<td>6</td>
<td>NB SR7 22+385 to 22+440, Rt.</td>
<td>63</td>
<td>9/20/99-10/1/99</td>
<td>1 - ET 2000, 36m GR</td>
</tr>
<tr>
<td>7</td>
<td>NB SR7 21+413 to 21+436, Rt.</td>
<td>60A</td>
<td>9/20/99-10/1/99</td>
<td>1 - ET 2000, GR to barrier connection (approach)</td>
</tr>
<tr>
<td>8</td>
<td>AAA 33+033 to Service Rd. A 9+670, Rt.</td>
<td>62</td>
<td>9/20/99-10/1/99</td>
<td>2 - ET 2000, 34m GR incl. Thrie Beam attached to HW</td>
</tr>
<tr>
<td>9</td>
<td>NB SR7 21+810 to 21+920, Rt.</td>
<td>61 &amp; 62</td>
<td>9/20/99-10/1/99</td>
<td>1 - ET 2000, 91m GR</td>
</tr>
<tr>
<td>10</td>
<td>Ramp C 0+270 to 0+310, Lt.</td>
<td>62</td>
<td>9/20/99-10/1/99</td>
<td>1 - ET 2000, 21m GR</td>
</tr>
<tr>
<td>11</td>
<td>NB SR7 21+694 to Ramp B 0+300, Rt.</td>
<td>60A, 61, 68, 71</td>
<td>9/20/99-10/1/99</td>
<td>1 - GR to barrier connection (exit), 212m GR</td>
</tr>
<tr>
<td>12</td>
<td>Ramp B 0+110 to 0+190, Lt.</td>
<td>61 &amp; 71</td>
<td>9/20/99-10/1/99</td>
<td>1 - ET 2000, 68m GR</td>
</tr>
<tr>
<td>13</td>
<td>Churchmans Rd. Median Br. Pier to 11+889</td>
<td>60A</td>
<td>9/20/99-10/1/99</td>
<td>1 - CAT 350, 9m GR, 2m med. barrier beam (exit)</td>
</tr>
<tr>
<td>14</td>
<td>SB SR7 22+730 to 22+800, Lt.</td>
<td>65</td>
<td>10/4/99-11/12/99</td>
<td>1 - ET 2000, 51m GR</td>
</tr>
<tr>
<td>15</td>
<td>SB SR7 21+690 to 21+835, Lt.</td>
<td>60A &amp; 61</td>
<td>10/4/99-11/12/99</td>
<td>1 - ET 2000, GR to bridge conn. (approach) 124m GR</td>
</tr>
<tr>
<td>16</td>
<td>Ramp A 1+200 to 1+231, Lt.</td>
<td>61</td>
<td>10/4/99-11/12/99</td>
<td>31m GR, 1 - Buried End Section</td>
</tr>
<tr>
<td>17</td>
<td>SR7 Median 21+200 to 21+280</td>
<td>59</td>
<td>4/1/00-5/1/00</td>
<td>1 - GR to barrier connection (exit), 76m GR</td>
</tr>
</tbody>
</table>

### Notes:

1) The table shown above is the tentative schedule for Guardrail Installation required for this project. The schedule is based on the current workplan and is subject to change. This schedule will be updated from time to time to show current status.

2) Quantities listed are approximate and must be checked against the plans and/or verified in the field.

3) The Number in Column 1 represents the priority order of guardrail installation.

4) Dates in the ES/LF column are the early starts and late finishes at each location, and indicates the approximate window to complete the installation.
Construction Planning & Scheduling

**Monitoring (or Statusing)**

- tracking actual starts and finishes (AS/AF)
- modifying the remaining duration to reflect the current status of an activity
- must keep schedule current to realize its full value
- serves as documentation for determining damages or eligibility for time extensions
Updating

- statusing
- reasonable modifications to logic
- change orders
- insert or modify coding for better organization in working with and presenting the schedule

• more significant changes are usually referred to as Schedule Revisions
Revising or Modifying

- necessary reaction to change
- modify logic to reflect work plan
- internal or external pressure to accelerate or regain lost time
Influences changing the original schedule

- weather
- acts of God
- better or worse productivity than anticipated
- delivery problems
- greater insight to the actual scope of work
- subcontractor performance/availability
- change in scope of work
- differing site conditions
Planning

Planning is...

» Decision making
» Information gathering
» Identifying/defining activities
» Creativity
» Flexibility
» Interrelationships
Preconstruction Planning Activities

• Recognize preconstruction planning must occur quickly …usually 25 days to 3 months

• Develop project organization
  – Define general responsibilities
  – Determine chain of communication
Team Approach

• Synergy
  ….the whole is greater than the sum of its parts

• Modern management theory emphasizes team-oriented approach to business

• Successful projects require a mind-set of teamwork geared for problem solving
Team Approach

“No man is an island”
John Donne, 1624

“…..he’s a peninsula!”
Jefferson Airplane, 1967
Planning Team

• Define objectives and Scope of Work
• Review plans, specs, and estimate
• Visit jobsite
• Identify potential problems/conflicts and critical issues
Planning Team

- Determine general sequence (logic)
- Draft rough diagram
- Determine techniques & equipment

**BRAINSTORMING**

- Identify long lead-time items
Planning Team

• Initial meeting
  – Estimator, general superintendent, project manager, scheduler, superintendent

• In-depth planning meeting(s)
  – Probably exclude estimator, possibly include key foremen
Planning & Scheduling

Planning

develop schedule

Team Review

Outside Review
Planning & Scheduling

• Outside review
  – Subcontractors
  – Suppliers
  – Owner
  – Utility Companies

• Upon completion of reviews:

Finalization
Scheduling

Bar chart (Gantt chart)

- Graphical representation employed since early 1900’s
- Horizontal axis = timescale
- Vertical scale lists activities
Scheduling

*Bar chart (Gantt chart)*

- **Advantages**
  - Easy to read
  - Good communication tool
  - Easy to update

- **Disadvantages**
  - Does not show interrelationships
  - Cannot evaluate impact of delays = does not provide adequate documentation for claims
Scheduling

*Network Diagrams*

- Displays project graphically
- Presents activities as they relate to each other
  - Logic ties
  - Predecessors and successors
- Computer software enables greater use of network diagrams
Scheduling

**CPM Scheduling**

- Activity-on-Arrow Diagrams a.k.a. Arrow Diagramming Method (ADM)
  - Original CPM developed by duPont in late 1950’s
  - Shows relationship and activity on arrows connected by nodes
  - Refer to pages 447, 448, and 449
Activity-on-Arrow
CPM Scheduling

• Activity-on-Node Diagrams
  – Arrows show relationship only
  – Originally developed as PERT by the U.S. Navy also during late 1950’s
  – Precedence Diagramming Method (PDM)
    • Incorporates additional precedence relationships
    • Time-lag factors
Activity-on-Node
Definitions

• *Activity*
  – Detailed work unit
  – Several individual activities construct a project
  – Task activities
    1. Consumes time (duration)
    2. Consumes resources
    3. Have a definable start and finish
    4. Are assignable
    5. Measurable or quantifiable
Definitions

- Other types of activities include
  - Start & finish milestones
  - Start & finish flags
  - Independent
  - Meeting
  - Hammock
Definitions

• **Early Start (ES)**
  – Earliest time an activity can start according to its assigned relationships
  – Determined by forward pass

• **Early Finish (EF)**
  – Earliest time an activity can finish
  – \( EF = ES + \) activity duration
Definitions

• **Forward Pass**
  – Completed left to right
  – Calculates ES, EF, and project duration
  – Where 2 or more chains converge on a single activity, the larger value controls

• **Backward Pass**
  – Completed right to left or end back to the beginning
  – Calculates LF, LS
  – Where 2 or more chains converge on a single activity, the smallest value governs
Definitions

Float

- “slack time”
- Difference between earlies and lates
- Allows activity to begin later than ES and not prolong the project
- Two types of float: total and free float
  - Total float – leeway in start and completing an activity without delaying the project
  - Free float – “activity float”, time the start of an activity can be delayed without delaying the start of a successor activity
Definitions

• **Float**
  
  \[ TF = LF - (ES + \text{activity duration}) \]
  
  \[ TF = LS - ES \quad \text{or} \quad LF - EF \]
  
  \[ FF = \text{ES of successor} - \text{LF of predecessor} \]

• **Critical Path**
  
  – Continuous chain of activities with longest durations
  
  – Determines project duration
Definitions

- **Network**
  - Interconnection of chains
  - paths along network

- **Relationships**
  - Predecessor
  - Successor
  - Concurrent
  - Driving relationship – determines successors
PRIMAVERA
How the World Says
Project Management