Construction Management Applications: Challenges in Developing Execution Plans

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May 14, 2010 --- ICAPS, Toronto

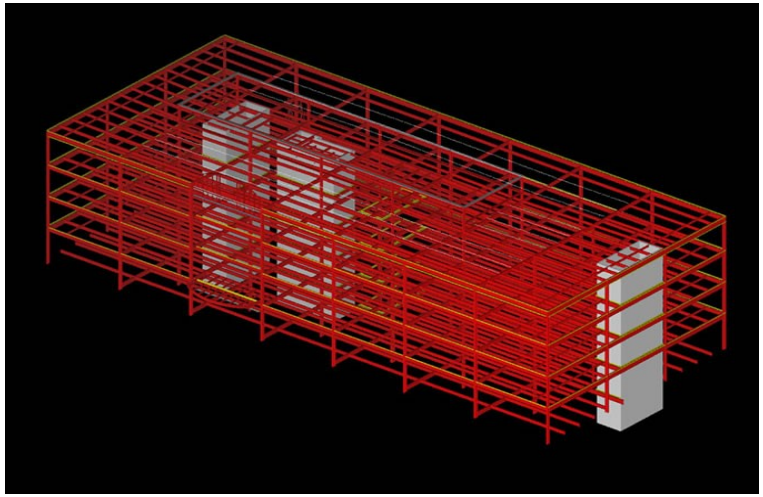
Construction Management Domain

- To build ... under constraints
  - Time
  - Budget
  - Site location
  - Resources: equipment, labor, material
- To avoid or contain ... contingencies
  - Adverse weather
  - Accidents
  - Delivery problems
  - Labor strikes

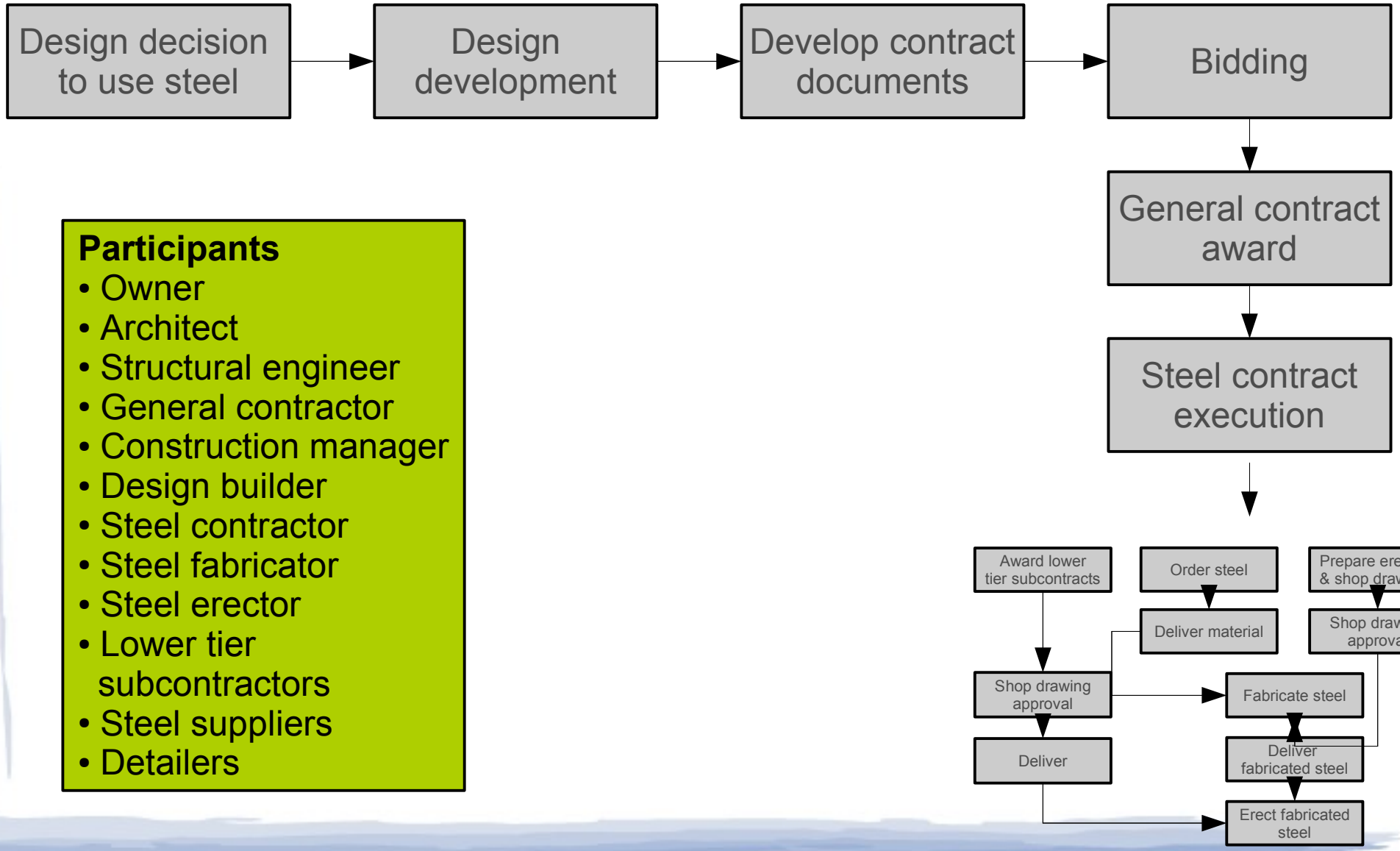
Our objective

Provide automated project management support for

- Project execution
- What-if analysis
- Contingency planning



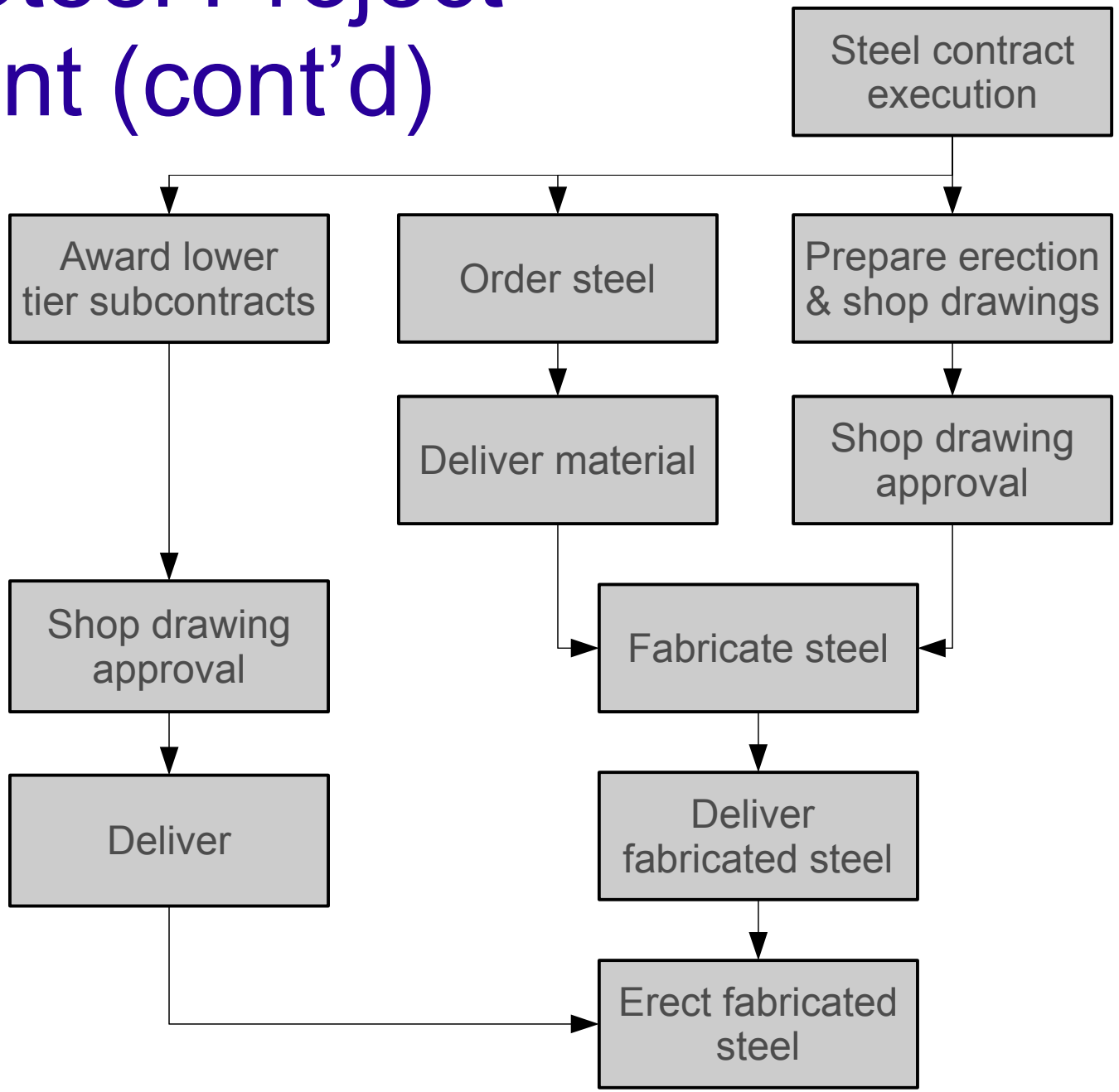
Stages of Steel Project Management



Participants

- Owner
- Architect
- Structural engineer
- General contractor
- Construction manager
- Design builder
- Steel contractor
- Steel fabricator
- Steel erector
- Lower tier subcontractors
- Steel suppliers
- Detailers

Stages of Steel Project Management (cont'd)



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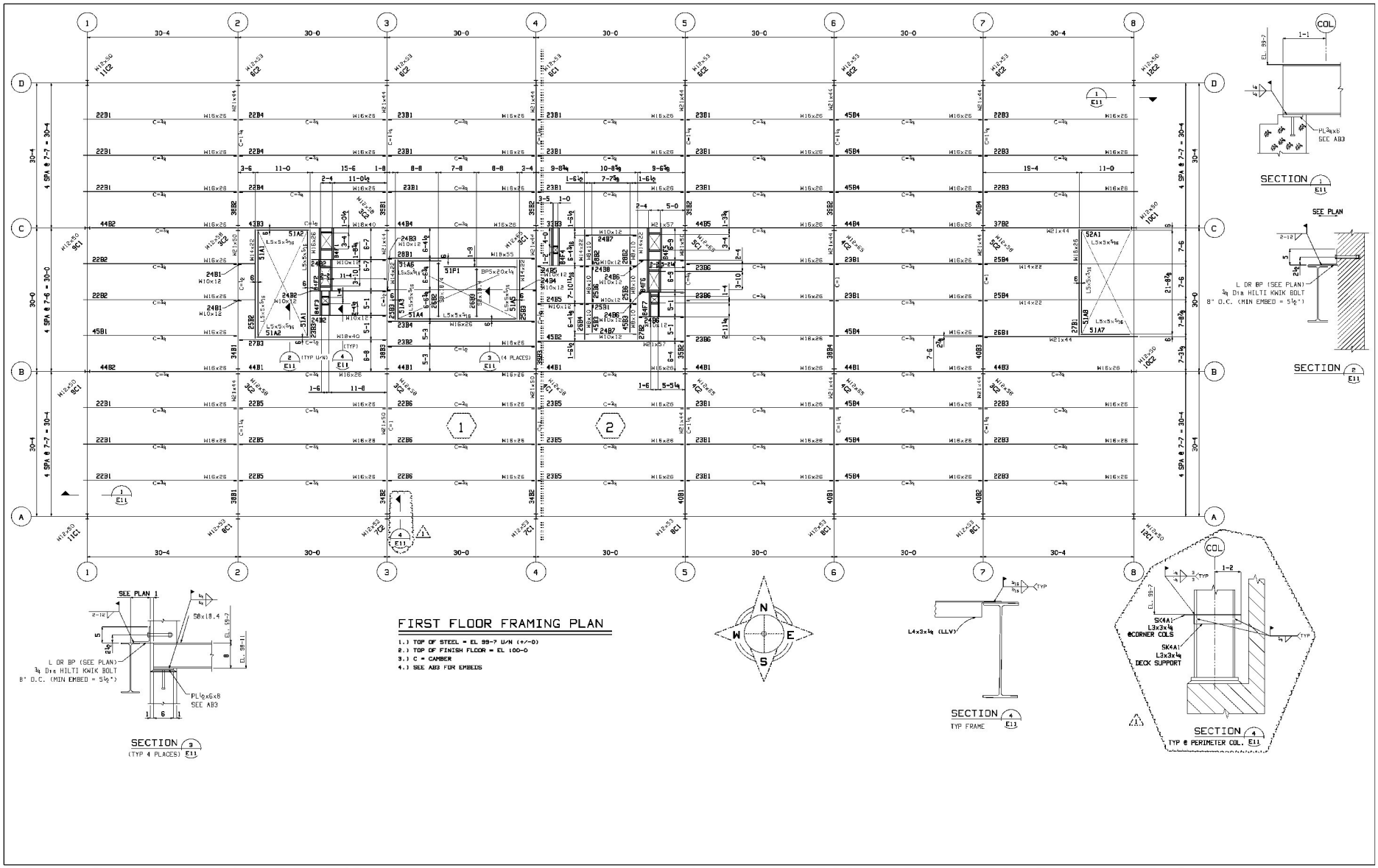
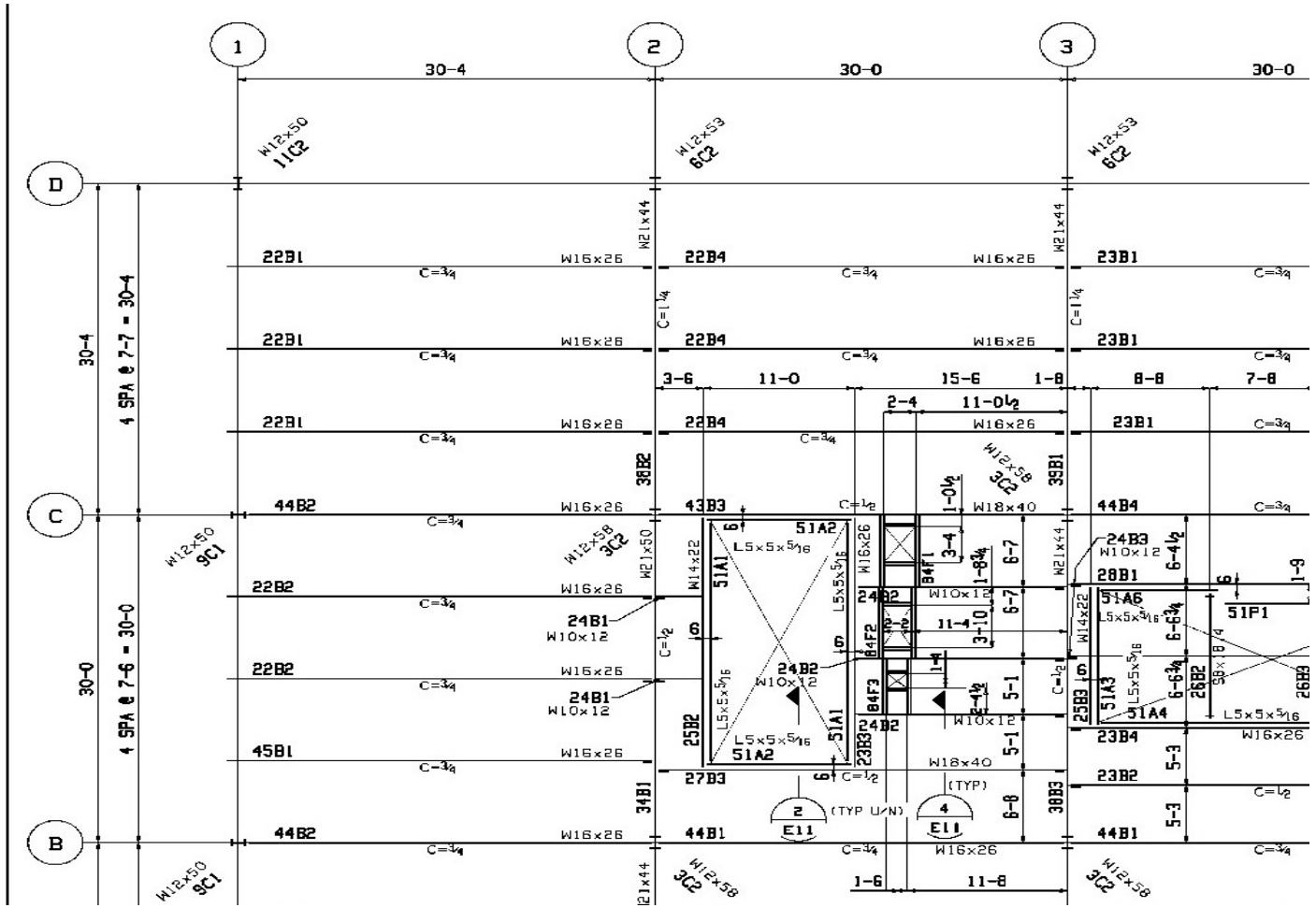
Structural Framing Plan

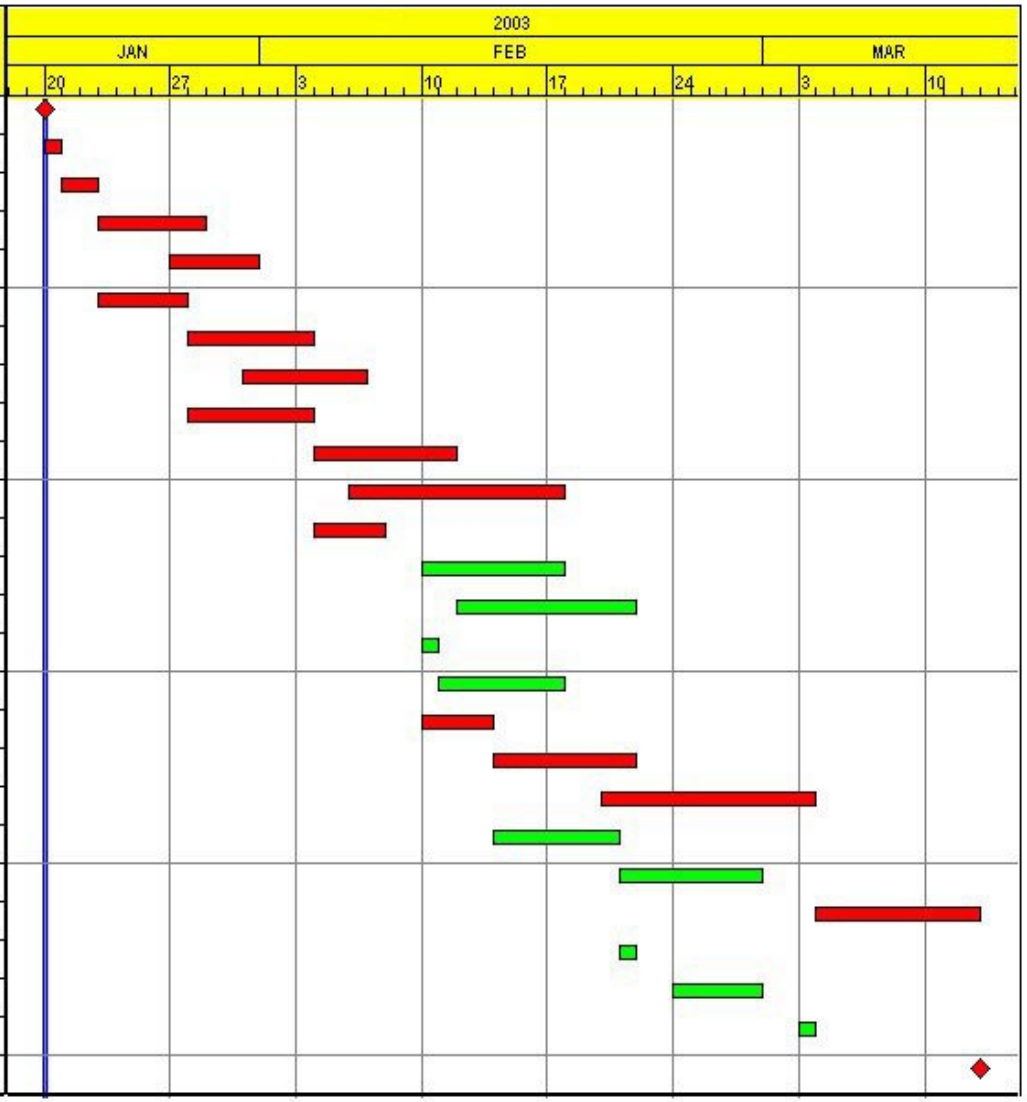


Corner of the floor



The schedule

Activity ID	Activity Description	Orig Dur
1200	Structural Steel Erection Start	0
1205	Crane Set Up	1
1210	Hoisting Sequence 1	2
1215	Bolt up and Detail Work Sequence 1	4
1220	Deck and Studs Sequence 1	5
1225	Hoisting Sequence 2	3
1230	Bolt up and Detail Work Sequence 2	5
1235	Deck and Studs Sequence 2	5
1240	Hoisting Sequence 3	5
1245	Bolt up and Detail Work Sequence 3	6
1250	Deck and Studs Sequence 3	8
1255	Hoisting Sequence 4	4
1260	Bolt up and Detail Work Sequence 4	6
1265	Deck and Studs Sequence 4	8
1270	Plumbing Up Sequences 1-4	1
1275	Final Bolt Up Sequences 1-4	5
1280	Hoisting Sequence 5	4
1285	Bolt up and Detail Work Sequence 5	6
1290	Decking and Studs Sequence 5	8
1295	Hoisting Sequence 6	5
1300	Bolt up and Detail Work Sequence 6	6
1305	Decking and Studs Sequence 6	7
1310	Plumbing Up Sequences 5-6	1
1315	Final Bolt Up Sequences 5-6	5
1320	Crane Demobilization	1
1325	Structural Steel Erection Finish	0

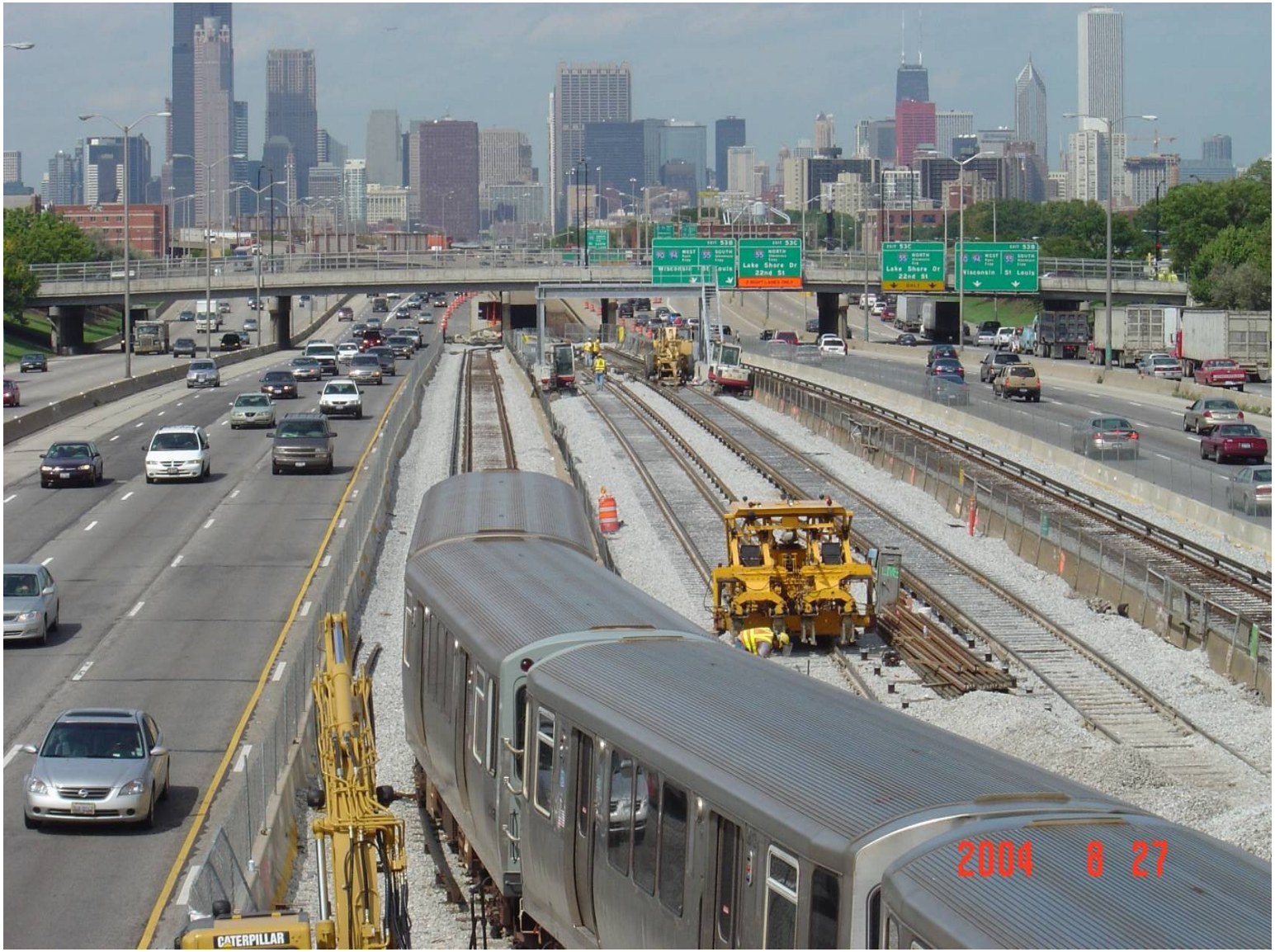


Contingencies – Planning error

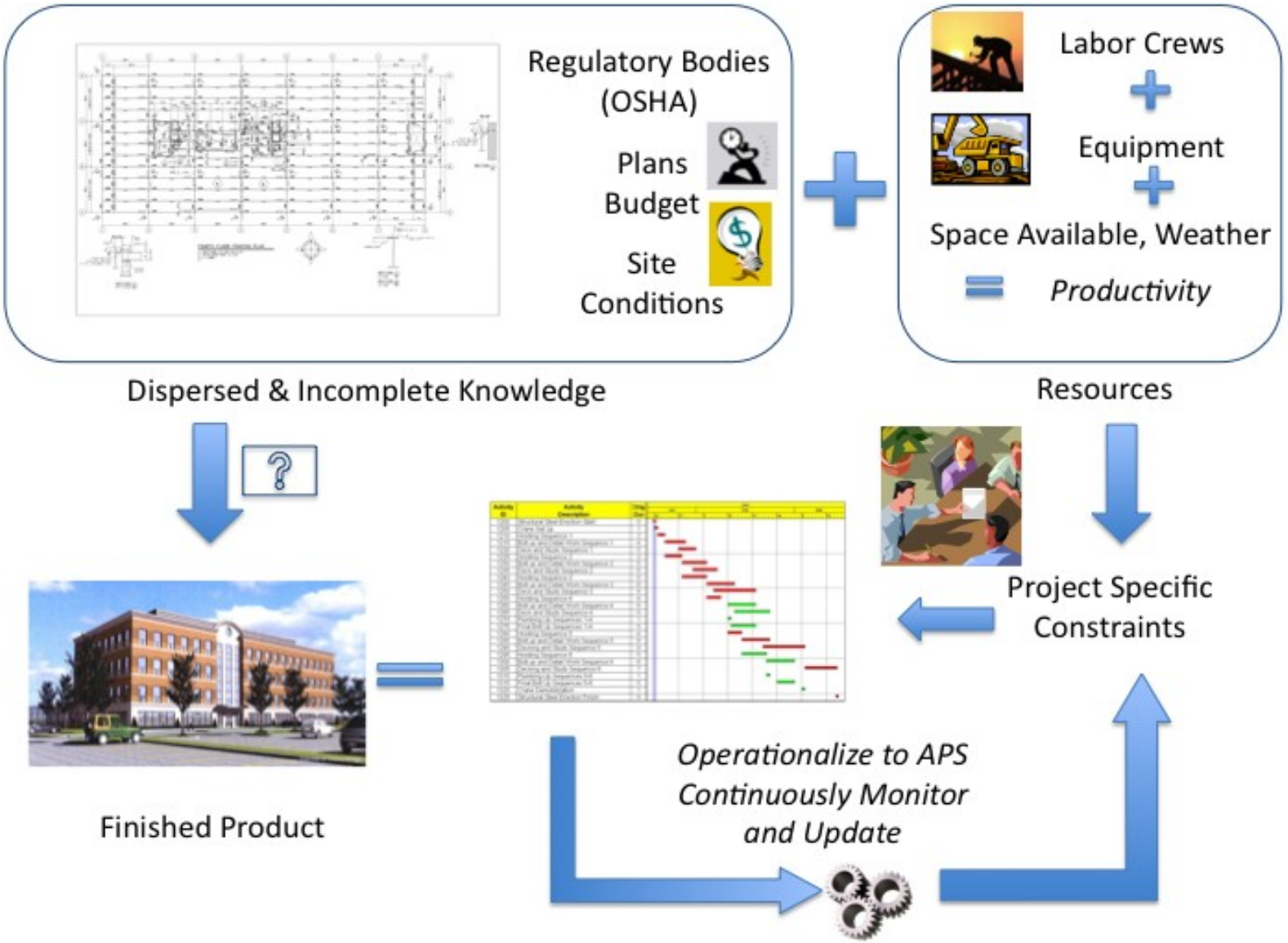
Contingencies – Productivity changes

Contingencies – Material not delivered

Contingencies – Space is a concern



The big picture



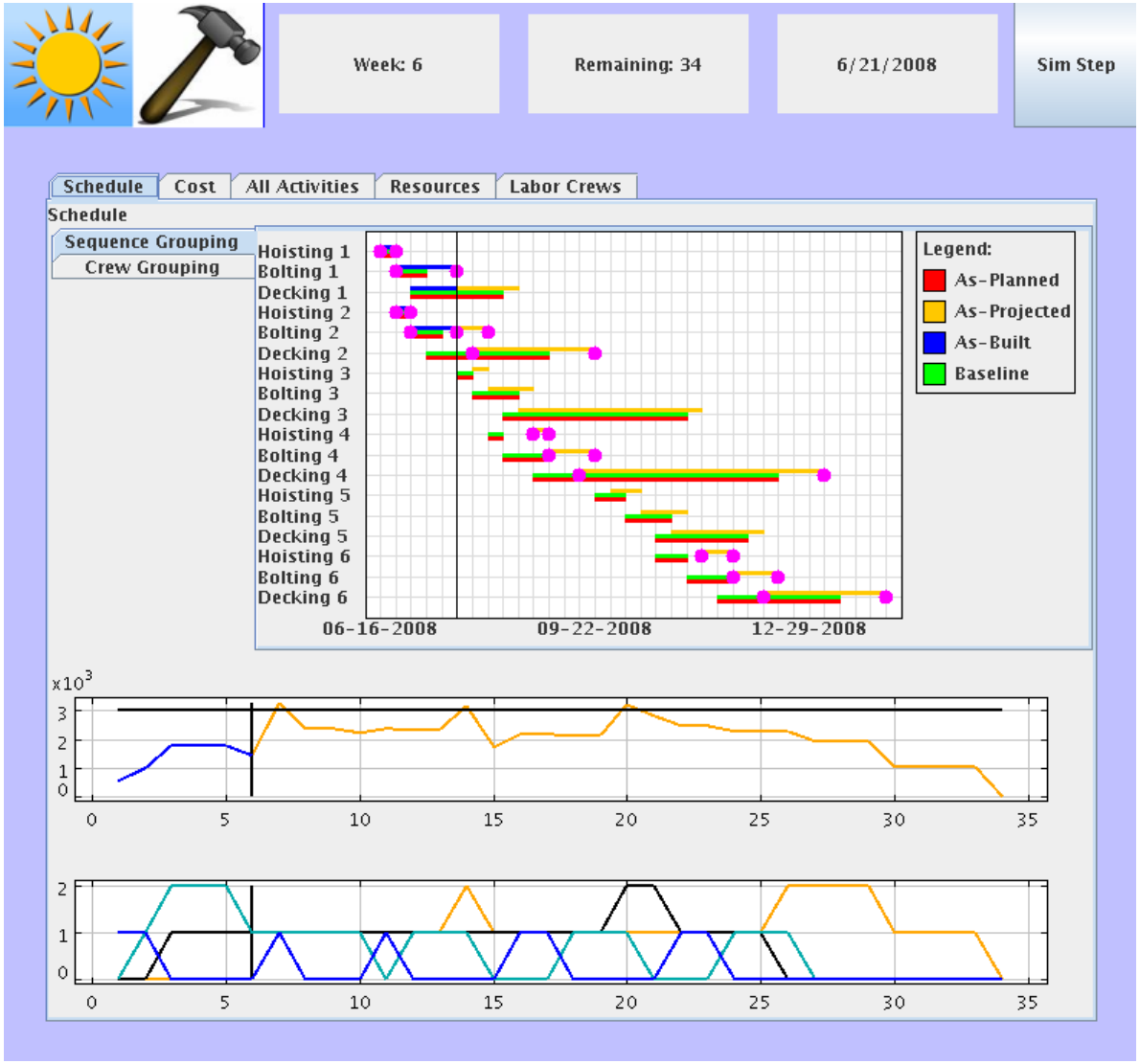
Current Abilities & Future Needs

- Current Abilities
  - Gantt charts, critical path method (CPM)
  - Linear scheduling (Ioannou et al.)
  - Simulation of operations (AbouRizk et al.)
  - Virtual/Augmented reality (Martinez, Kamat et al.)
- Resource/resource to human/resource interactions:
  - Decision-making at a system-level
  - Constraint driven approaches
  - Contingency planning

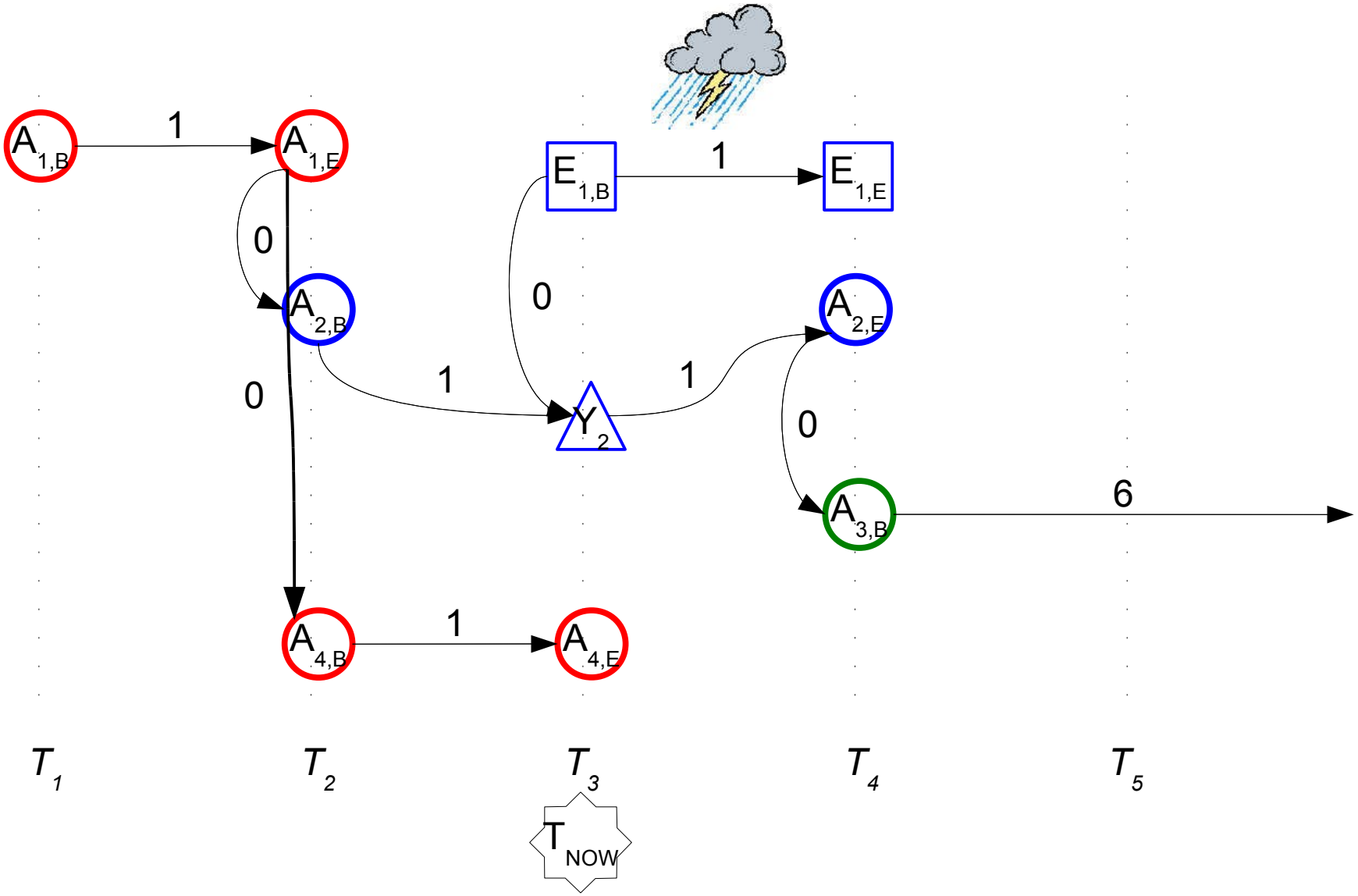
Our system

- ICDMA (Interactive Construction Decision Making Aid)
- Can perform what-if analysis on As Planned Schedules (APSs) if provided with
  - Tasks and dependencies
  - Relevant constraints
  - External events
  - Relevant effects of events such as productivity

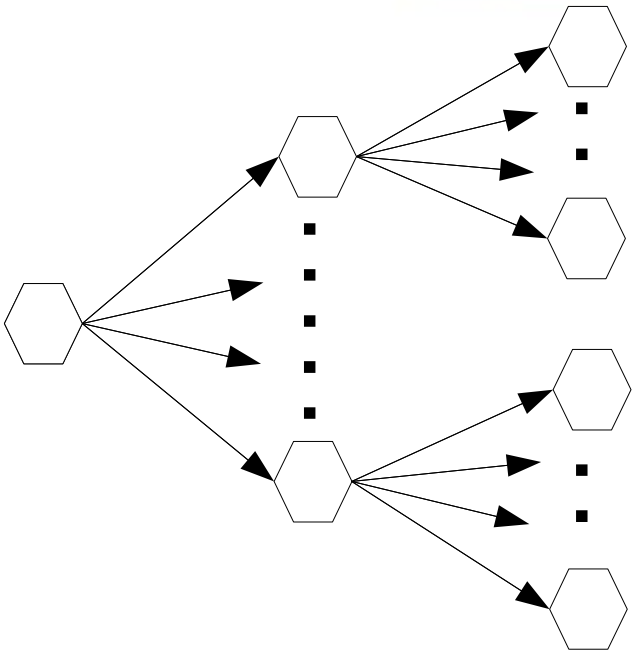
ICDMA interface

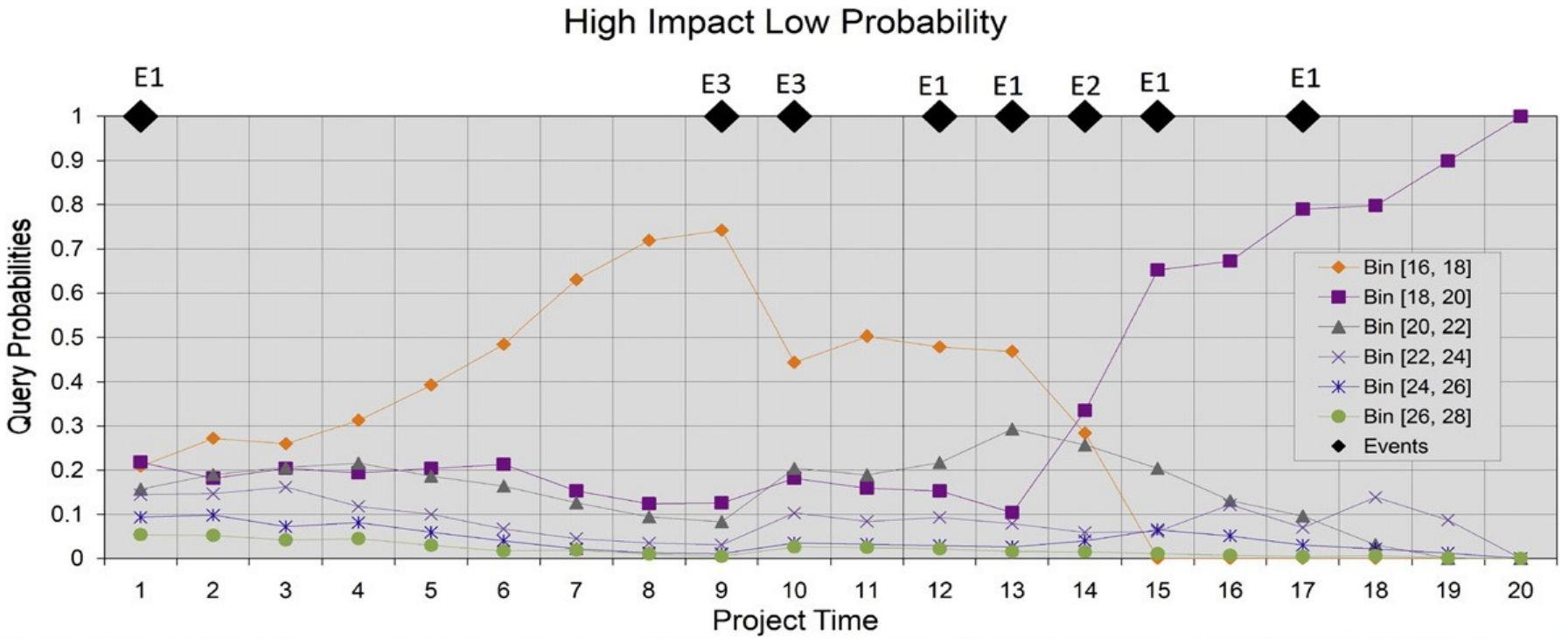


Temporal Network with Activities and Events (TONAE)



Monte Carlo Simulations





Extend ICMDA with contingency planning

- When the execution deviates from the as-planned schedule (APS), automatically suggest alternatives
- Assumptions of automated planners
  - The domain information is represented in PDDL format
  - There is a single plan
  - All planning activities are done “offline”

Challenge 1: knowledge representation

- Knowledge:
  - Dispersed, multi-format
  - Incomplete operationalization
- Need to represent:
  - The project plans and schedules
  - Constraints
  - Stochastic events

Challenge 2: execution time deviations

- Need to consider:
  - Effects on the cost and the duration
  - Constraints that are violated
  - Soft constraints
- Show:
  - Various levels of detail (HTN-style, macro-style)
  - Different views to stakeholders

Challenge 3: contingency responses

- Possible responses:
  - Do nothing (use contingency funds)
  - Reschedule, reallocate
  - Replan
- Available technologies
  - Plan generation
  - Planning under uncertainty
  - Planning with constraints

Conclusion

- Construction management: knowledge-rich domain
- Challenge 1: knowledge representation to aid contingency responses
- Challenge 2: Understanding the contingencies
- Challenge 3: Responding to contingencies

Thank You!

Acknowledgments
NSF #SES0624118

Additional References

- Ansari, Alex. “Target Costing: When the Client Looks Under the Hood,” Constructor, p. 64, March/April 2010.
- Mrozowski, Tim, Matt Syal, and Syed Aqeel Kakakhel. “Construction Management of Steel Construction: Project Management Module,’’ Technical Report, American Institute of Steel Construction (AISC), 1999.