Using generative scheduling to deliver DOT portfolios

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Context

DOTs have received historic investments in infrastructure at a time of strong headwinds, including labor undersupply, material supply shortages, equipment scarcity, and supply chain disruptions.

As DOTs and sister agencies rethink their capital planning strategies and long-range planning efforts, having a clear assessment of available labor capacity and ability to optimize capital delivery is paramount.

Additionally, transportation agencies have continued to use 20th century tools a time where there are advancements in technology.

Objectives

Walk through an approach to optimize a DOT portfolio of projects for labor capacity

1. Assess labor capacity and changes over time

2. Utilize generative scheduling to create a portfolio-level baseline schedule

3. Develop an action strategy to improve labor capacity
Leveraging generative scheduling to optimize project and portfolio plans

Advanced analytics can be used to rapidly develop resource loaded, logically tied plans/ schedules

**What it is**

Generative scheduling is an approach to modelling a project or portfolio schedule in a **parametric way** to generate an optimal plan through **advanced analytics**

Automatically builds a resource loaded, logically tied plan for a project based on a model and set of constraints

Enables rapid scenario planning to quantitatively test alternative execution ideas

Can be **fully integrated** into current planning processes and tools

**How it works**

Generative Scheduling follows a three-step process:

- **Build a model of the project or portfolio** (e.g., typically by importing the elements of a BIM or GIS model)
- **Build recipes that describe how each part of the work built** (includes steps to complete, sequence of steps, resources, etc.)
- **Run (rapidly) multiple “what-if” scenarios** using an advanced analytics tool (testing millions of potential construction outcomes in minutes) to **generate an optimized execution plan**

**How it helps**

Generative Scheduling helps through two proven use-cases:

- **Define execution strategy before construction across a project or portfolio** (e.g., resources, equipment, work fronts) and adjust it following a significant change
- **Manage construction site as a production system** (based on capacity, productivity rates, inventory)

It enhances traditional scheduling (e.g., with Primavera P6)

Source: McKinsey Capital Excellence Practice
Generative scheduling can be applied at a project or a portfolio level

DOT portfolios
Portfolio-level (multi-project) schedule optimization for DOT portfolios generating L1/L2 (high level schedule) sequence of work and resource allocation
Explore resource availability and allocation across the portfolio

Case example 1: CO2 capture pipeline network construction

Mega-Projects
Mega-project schedule optimization for a wide range of asset types
generating L3/L4 (detailed schedule) sequence of work and resource allocation
Explore cost and schedule implications of resource constraints, productivity variations, shift lengths and access/congestion constraints

Case example 2: $110M light rail construction

Key outputs

Optimized project schedule for different objectives (e.g., time, cost, risk)
Schedule implications of a wide range of scenarios (e.g., material delays, poor productivity etc.)
Library of reusable recipes for how work is executed that can be applied to future work to accelerate schedule development and quality

1. Asset types where GS has been applied: Buildings (semicon fabs, gigafactories), infrastructure (roads, pipelines, bridges), industrial plants, etc.
# Approach to understand and optimize a transportation project portfolio for labor capacity

<table>
<thead>
<tr>
<th>Key activities</th>
<th>Key outcomes</th>
<th>2. Utilize generative scheduling to create a portfolio-level baseline schedule</th>
<th>3. Develop action strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Assess labor capacity</strong></td>
<td><strong>Map of supply and demand gaps by role and district</strong></td>
<td>• Create a baseline and optimize the delivery sequence: Using generative scheduling, establish a baseline/momentum case for a DOTs current project portfolio pipeline, if no mitigation steps are made</td>
<td>• Develop a strategy to improve the capacity in the market and most effectively (and quickly) deliver the portfolio of projects (e.g., add construction laborers using a “quick start training program”)</td>
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<tr>
<td>• Understand the project portfolio: Understand the agency’s requirements to deliver their portfolio of projects</td>
<td>Archetypes and hours needed to deliver projects</td>
<td>• Optimize: Use generative scheduling to optimize the portfolio schedule based on labor capacity in the market</td>
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<tr>
<td>• Assess labor (both internal and external) requirements needed to deliver: Create archetypes to guide specific labor needs by job category to develop the labor needed to deliver each project</td>
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<tr>
<td>• Assess the capacity in the local market: Analyze the available capacity in the market related to labor required</td>
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<tr>
<td><strong>2. Utilize generative scheduling to create a portfolio-level baseline schedule</strong></td>
<td>Baseline look at the planned portfolio given current labor capacity in the market</td>
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<tr>
<td><strong>3. Develop action strategy</strong></td>
<td>High-level strategy to improve capacity in the market</td>
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Deep dive to follow
Generative scheduling enables rapid scenario planning to test project team optimization ideas and risks

Physical and spatial constraints are defined for how the work is performed.

Hundreds of thousands of configurations are generated from an advanced analytics engine.

Configurations are evaluated based on predicted cost and schedule outcomes.

- Decision node
- Configuration outcome

Contractor sequence
Stage completion optimization
Activity completion optimization

Baseline Scenario 1 Scenario 2

Construction cost (Millions of USD)

Calendar days of on-site construction

Original plan
Optimal resources and sequencing
The approach enables decisions on project delivery in the same way that Google Maps finds the best route to a destination

Defining sequence scenarios as an ‘activity journey’ between breaking ground and project completion

<table>
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<tr>
<th>Starting point</th>
<th>Optimal route</th>
<th>Route options</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schedule start date with remaining construction/commissioning activity</td>
<td>Optimized sequence of activities required to move from starting point to destination</td>
<td>Scenarios with alternative constraints to the optimal route</td>
<td>Reactor light off event at the end of the route once all activities have been completed</td>
</tr>
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</table>

Define constraints for route plan and lock in

“What is the optimal route if I were to leave in 30 minutes, drive at 80kph, factor in the poor weather and stop for gas halfway.”

Update plan with progress and explore alternative plans

“I am driving slower than expected. Should I try a different route, conserve fuel and make use of the quieter roads to make a phone call?”

Comparing differences in routes to explore changes in activity sequence and requirements

“If the weather clears and I can drive faster, would I need to stop for gas earlier, and if so, is there a gas station to stop at?”

Route forecasting and forward planning requirements to align on optimal route

“There is a crash up ahead on my chosen route. When do I need it cleared by? I can either slow down and allow for it to be cleared or try an alternative route.”

Source: McKinsey team
Portfolio plan constrained by labor availability and then optimized to maintain original timing

Example scenario

Illustrative

Daily labor resource requirements
Total workers per day (can also be assessed by role & by district)

Key takeaways:
- Reallocating labor to “non-obvious” work fronts that were not believed to be critical can achieve improved schedule outcomes
- External constraints can be easily added to the GS model allowing the model to rapidly rebaseline to an optimal activity sequence and resourcing
- Labor constraints can be explored by role, by district or in total

Source: McKinsey Capital Excellence
Thank you!

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