Operations Simulation for Railroad Capital Project Development

Peter Schwartz & Richard Cogswell
Federal Railroad Administration
What is Railroad Operations Simulation?

• Tool for analyzing railroad operating performance
  • Predefined set of trains
  • Predefined infrastructure configuration
  • Does NOT provide the solutions to problems

• Consists of three basic elements
  1. 1st Input – Train Traffic
  2. 2nd Input – Infrastructure
  3. Simulation Methodology - the model software
Why do Operations Simulation?

- Planning on changes to train traffic?
  - What infrastructure is needed to meet performance goals?
- Planning on changes to infrastructure?
  - What will it do to train performance?
- Relationship between operational requirements and physical resources
- For railroad capital projects
  - Simulation links operational objectives to scope and design (and environmental impacts)
What Kind of Projects Should Involve Operations Simulation?

• Changes to line-haul railroad operations
• Rail lines with emphasis on unscheduled or highly-variable operations
• Simulation less useful for:
  • Highly scheduled operations
  • Complex operations within terminals or at major junctions
  • Other operations analysis tools are available
When during a project’s development is operating simulation done?

- Beginning during the Planning Phase
  - Key input for Service Development Planning and Service NEPA
- Continues through finalized Preliminary Engineering
- Iterative process with other elements of Service Planning
  - Effects of operationally relevant design refinements
  - Requirements for refinements in service plan
  - Changes in forecasts and assumptions for background traffic
- For passenger projects, ultimately used to support Service Outcomes Agreement
Who participates in operations simulation, and in what roles?

<table>
<thead>
<tr>
<th>Party</th>
<th>Preferred Roles</th>
<th>Secondary Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Sponsor</td>
<td>Guides overall work; Coordinates with other service planning elements; Coordinates between all parties; Helps establish inputs and assumptions</td>
<td></td>
</tr>
<tr>
<td>FRA</td>
<td>Monitors development of model methodology, assumptions, inputs; Assesses conclusions; Reviews reports; Requests necessary changes</td>
<td></td>
</tr>
<tr>
<td>Planning/Design Consultant</td>
<td>Works for Project Sponsor; Proposes methodology; Performs simulations work; Authors reports</td>
<td></td>
</tr>
<tr>
<td>Host Railroads</td>
<td>Contributes input data; Helps verify and calibrate base case; Suggests possible infrastructure changes</td>
<td>Performs role of planning consultant</td>
</tr>
<tr>
<td>Amtrak</td>
<td>Contributes input data</td>
<td></td>
</tr>
</tbody>
</table>
The Simulation Process

The Simulation Tool

• Two basic elements

  1. Train Performance Calculator (TPC) – Pure (Ideal) Running Time for a train
     • No meets or overtakes
     • No restrictive signals
     • Try to operate at exactly the speed limit

  2. Dispatching Simulator
     • Optimization algorithm for mimicking decision-making of actual dispatcher
     • Coordinate meets and overtakes to minimize delay
     • All delay not created equal – varies based on priority assigned by train type
### The Simulation Process

#### Assembling Input Data

<table>
<thead>
<tr>
<th><strong>Train Traffic</strong></th>
<th><strong>Infrastructure</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>“Schedules”</td>
<td>Track Configuration</td>
</tr>
<tr>
<td>Consists</td>
<td>Signal Design</td>
</tr>
<tr>
<td>Train Types (with priorities)</td>
<td>Grades</td>
</tr>
<tr>
<td></td>
<td>Speed Limits</td>
</tr>
</tbody>
</table>

- Begin by developing for the existing conditions, then use as basis for alternative scenarios
The Simulation Process

Scenario Development and Scenario Control

- **Base Case**
  - Existing conditions
  - Used for calibration (or setting performance targets)

- **Do-Minimum (No Build)**
  - Committed changes to infrastructure and train traffic
  - Forecasted changes to freight traffic and necessary improvements

- **Do-Something (Build)**
  - Project’s intended operating changes
  - Use to identify infrastructure improvements to achieve desired performance

- Need to control for changes individually
The Simulation Process

Variability and Resiliency Testing

- Real-world operations not consistent or always predictable
  - Model thinks they are, unless you tell it otherwise
  - Need to demonstrate infrastructure can accommodate variability while maintaining performance

- "Normal" Variability
  - Unscheduled/loosely-scheduled freight trains, varied consists
  - Varied passenger timetables

- Irregular variability
  - En-route failures, maintenance-of-way events

- Tools for reflecting variability and testing resiliency
  - Multi-day simulation
  - Randomized train traffic input
The Simulation Process

Measuring Performance and Interpreting Results

• Major performance metrics
  • Minutes of Delay (per 10k train-miles)
  • Velocity
  • On-time performance

• Stringline diagrams

• TPC Plots (logarithmic speed scale)

• Pitfalls in interpreting results
  • Statistical significance of differences in results
  • Delay metrics accounting for changes in Pure Running Time
Figure B.4: Washington - Richmond TPC Run, 110 mph, 2 P-42 and 6 cars, 9 in. E_u

[Graph showing speed variation over distance from Washington Union Station]
The Simulation Process

Stringline Diagrams