Wabtec CORPORATION

Optimizing the Network: Taking Precision Scheduled Railroading to the Next Level

by Ken Kenjale and Dharma Acharya

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Introduction

Precision-scheduled railroading (PSR) has enabled great financial success at North American railroads. While individual railroads implemented elements of PSR uniquely, they generally all shared a common strategy to optimize key assets and maintain a strict operating plan. The result: improved operating efficiency.

So, what is next? How do railroads build on the success of PSR? The answer lies in the network. There is a compelling opportunity to be realized by rethinking how to operate the network for optimum performance, maximize asset utilization, and drive growth – to take precision scheduled railroading to the next level.

Why Optimize the Network?

- **Increase network fluidity** through improved operating plan and automatic detection and resolution of conflicts across the entire network
- **Improve on-time performance** through increase in network velocity, reduced train miles, fewer unplanned events
- **Reduce costs** through reduction in expired crews, increased asset utilization, and efficient operating plan
- **Expand market share** through improved service and performance

Network Optimization

Freight railroads, by their very nature, are systems of interconnected assets. A typical class 1 railroad operates over 1,000 trains per day using thousands of locomotives, moves millions of carloads per year, and utilizes thousands of employees – all across a track network that spans tens of thousands of miles. Because of the immense scale and the limits of human capacity to comprehend the network implications of decisions made out of millions of possible options, decisions made by individual dispatchers for their territories may result in sub-optimal performance at the network level. In short, what is good for one territory may have cascading negative impacts on other territories.

Designing an optimal network is challenging. From deciding routes, to considering speed restrictions, to selecting assets, to assigning crews, to factoring in maintenance schedules, requires significant planning and modeling. The process is time-consuming and requires the evaluation of an overwhelming amount of data. And all of this is against the backdrop of a constantly changing environment. With a plethora of possible variations, it is difficult for railroads to develop a network model, much less optimize.

Wabtec's Network Optimization & Automation Playbook

To help railroads realize the benefits of network optimization, Wabtec has developed a playbook that enables a phased approach with sequential steps. Each phase chronologically aligns to work railroads are doing today with clear tactical goals. A key advantage is that railroads can jump in at any step and drive immediate incremental improvements, minimizing risk and ensuring return on investment. Ultimately, railroads can use this playbook to map out a strategy to achieve a truly optimized and automated network.

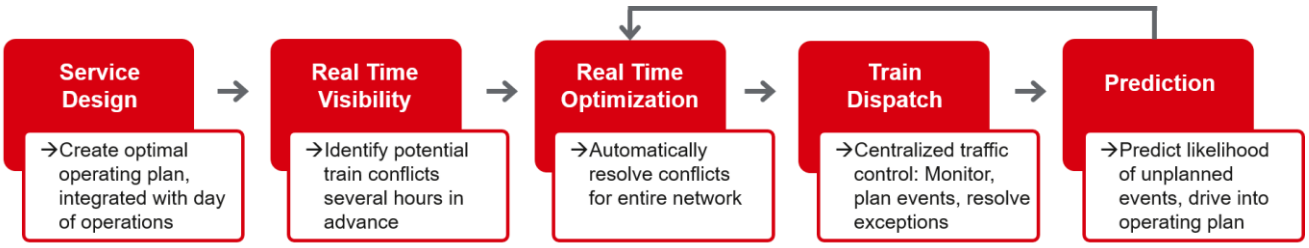

Figure 1: Network Optimization & Automation Playbook

Step 1: Service Design

Service Design – building the operating plan – integrates information from across the entire rail enterprise. The operating plan contains railcar blocking, train schedules, and resource plans, among many details. The operating plan directly translates into operating costs for a railroad.

Current State:
With the vast amount of disparate data that needs to come together, it is no surprise that much of the planning effort is manual. Some of the challenges that railroads face today:

- Resource needs calculated using spreadsheets
- Car blocks determined manually or with ad-hoc tools
- Adding/removing trains manually without knowing network impact
- Maintenance not integrated with operating plans → schedule adherence impacts
- Dynamically changing conditions
- Unexpected train delays and resource waste

Future State / The Opportunity:
For Service Design, network optimization technology can help railroads build an optimal operating plan, a task where utilizing visualization tools and algorithms over manual work will drive significant benefits. Ultimately, this is an opportunity to achieve coordinated decision making leveraging an expansive data set that represents a digital twin of the rail network. Key elements of optimized Service Design:

- Optimized car blocking plan based on terminal/yard capacities, demand forecast, and empty car movement
- Optimized block-to-train assignment
- Analysis of bottlenecks/chokepoints and capacity challenges
- Recommendations for alternate route and departure times
- Incorporation of maintenance needs to determine impacts
- Optimized train schedule generation
- Robust train schedule for all trains on the network, integrated with all assets and resources
- Minimized resource requirements based on optimized train plan

Technology Enablers:
Digital solutions can bring a new level of efficiency and accuracy to the development of the operating plan. Technology enablers include:

- → Dispatch topology model
- → Train schedule visualization and optimization model
- → Block and train optimization algorithms
- → Corridor and terminal capacity planning models
- → Meet/pass feasibility analysis
- → Route generation and simulation algorithms

As an example, Wabtec's Schedule Viewer leverages dispatch topology data, production schedules, and meet-pass optimization algorithms to provide users with complete visibility into train schedules across the entire network, analysis of performance impacts, and the ability to resolve conflicts. It utilizes the same optimization algorithms that are used in the Real Time Optimization phase, to build a reliable and feasible schedule in Service Design.

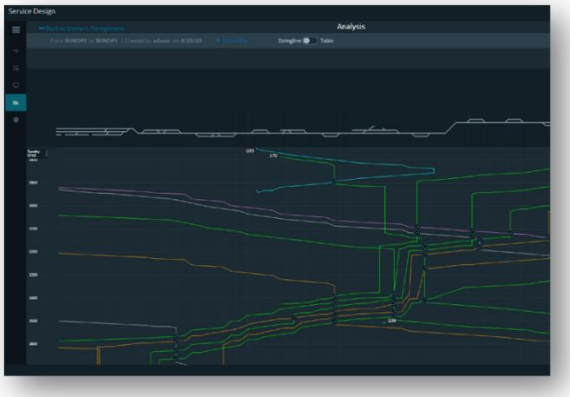

Figure 2: Schedule Viewer

Potential Outcomes:
- ✓ Robust operating plan integrated with day-of-operations
- ✓ Reduced cost driven by efficient and feasible operating plan
- ✓ Reduced variability
- ✓ Increased predictability
- ✓ Increased asset utilization

Step 2: Real Time Visibility

Once the operating plan is created, the next step is to gain visibility into the network – real time. This is typically an 8-12 hour horizon before train dispatch. During this stage, the focus is on detecting train conflicts – in advance – and resolving them manually.

Current State:
Today, in general, individual dispatchers make routing decisions for their territory using manual and cognitive efforts. It's a challenging task, given the following realities for many railroads:
- String line diagrams created manually or not created at all
- Laborious effort to factor in the multitude of data from different systems
- Detailed plans don't exist, other than in the mind of the dispatcher
- Difficult to predict 8-12 hours out
- Reactive communications

Future State / The Opportunity:
Network optimization and automation technologies can enable not only real time access to train status across the network, but also provide a look into the future. Key elements of optimized Real Time Visibility:
- Visualize real time train status across entire network with interactive graph
- Identify potential train conflicts up to 12 hours in advance
- Predict train ETA
- Perform simulation of start-to-end train trips using infrastructure + real-time status
- Improve decision making on train meets and passes
- Frequent ingestion of latest state of the network and generation of a new plan
- Instantly share plan with stakeholders

Technology Enablers:
Digital solutions can bring a new level of situational awareness to the state of the network. Technology enablers include:
- → Dispatch topology model
- → Physical model of train performance: Train Performance Calculator to model train travel time
- → Train schedule visualization

As an example, Wabtec's Movement Planner Network Viewer helps detect conflicts across the entire network and allows for manual resolution. It provides real time train status and uses a Train Performance Calculator to model train travel time. It also generates a look ahead forecast of 8 to 12 hours to better plan for crew call and asset allocation.

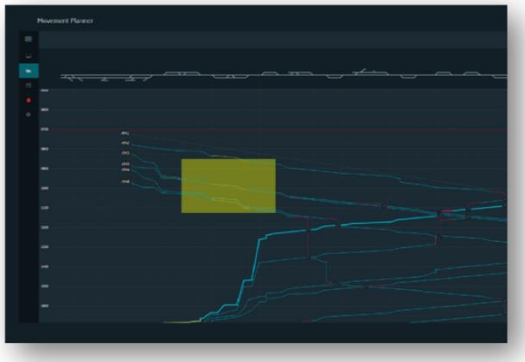

Figure 3: Movement Planner Network Viewer

Potential Outcomes:
- ✓ Improved on-time performance
- ✓ Better resource planning
- ✓ Increased dispatcher/controller productivity
- ✓ Faster decision-making
- ✓ Expanded situational awareness

Step 3: Real Time Optimization

Dispatchers move trains in their territories while responding to constantly changing conditions. Extensive amounts of information are considered, including train priorities, crew availability, and run time. It is a complex and challenging task. Real Time Optimization automates and optimizes this process for the entire network, enabling dispatchers to focus on managing exceptions.

Current State:
Today, in general, dispatchers are using manual and cognitive efforts to perform complex decision-making. There is limited time to find "best fit" solutions for active train moves. And because dispatchers are focused on a specific territory, there is not consideration for the impact of train moves on the entire network.

Future State / The Opportunity:
Railroads can realize the benefits of true network optimization through the application of digital technologies. Key elements of Real Time Optimization:

- Automatic conflict detection and resolution for entire network
- Decisions optimized and consistent across the enterprise
- Frequent ingestion of latest state of the network and generation of new plan
- Decisions communicated to dispatch systems for automatic route setting
- Instantly share latest plan

Technology Enablers:
Digital solutions make optimization a reality. Technology enablers include:

- → Meet pass optimization algorithms
- → Route generation and simulation algorithms
- → Physical model of train performance: Train Performance Calculator to model train travel time
- → Dispatch situational awareness algorithm

As an example, Wabtec's Movement Planner Network Optimizer provides automated meet/pass conflict resolution tailored to configurable business objectives. It determines the best route based on track blocks, speed restrictions, and route constraints. And every two minutes it ingests the latest state of the network and generates a new optimized plan.

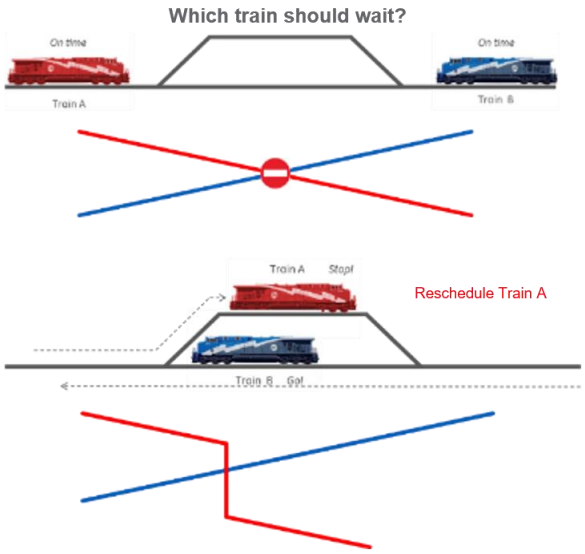

Figure 4: Solving the problem of optimal meets and passes for every train in the network – automatically

Potential Outcomes:

- ✓ Increase in network velocity
- ✓ Reduction in expired crews
- ✓ Significant improvement in on-time performance
- ✓ Improved asset utilization
- ✓ Increased network capacity & fluidity

Step 4: Train Dispatch

The next step is to direct the movement of trains safely and efficiently across the rail network in both signaled and dark territory and monitor all trains on the network.

Current State:
Today, in general, before a dispatcher can move a train, they must do at least three things: First, look at multiple user interfaces, each representing a different system, to understand the current state of their territory. Second, use manual efforts to put the mental plan in their head into the dispatch system. And third, continue to monitor dynamically changing traffic conditions. This challenging process results in fatigue and stress for the dispatcher, process variation between dispatchers, and sub-optimal network performance.

Future State / The Opportunity:
Network optimization and automation technologies can transform the dispatcher's work to monitoring the network, planning network events, and resolving exceptions.
Key elements of optimized Train Dispatch:

- Auto routing to enable the visual plan to be requested through the dispatching system without manual action from the dispatcher
- Automatic translation of the train movement plan into route requests
- Dispatchers handling only exceptions and performing more value-added tasks to improve train operations
- Integrated traffic control and dark territory control from a single unified interface
- Moving blocks for improved throughput
- Train trip visibility to the dispatcher, enhancing situational awareness
- Advanced analytics to facilitate preventative maintenance
- Network or individual territory based KPI monitoring at a glance
- Proactive monitoring of subsystems
- Forecast impact of actions
- Automatic information propagation to other users, maintenance of way, supervisors, executives, etc.

Technology Enablers:
Digital solutions make Train Dispatch optimization a reality. Technology enablers include:

- → Integrated service-oriented architecture
- → Unified, network-centric visualization and control
- → Dispatch topology model
- → Dispatch train visualization graph
- → Real time analytics and algorithms

As an example, Wabtec's Precision Dispatch System integrates multiple dispatching functions for centralized traffic control and dark territory control into one system inclusive of train control, train information, train tracking, track warrants, wayside information and auto-routing. The solution is fully integrated with Movement Planner for automated execution of dispatching operations and enabling a more efficient and effective rail operation.

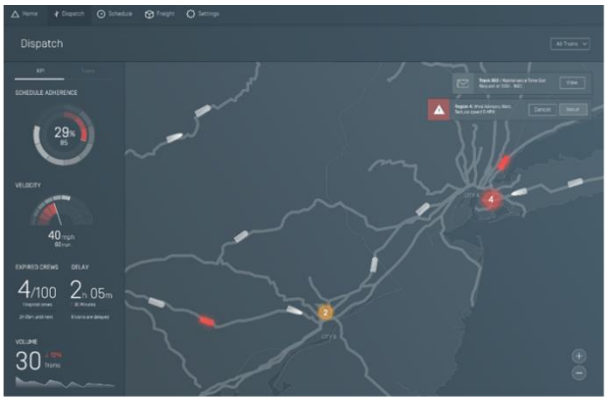

Figure 5: Precision Dispatch System

Potential Outcomes:

- ✓ Reduced operating costs
- ✓ Increased dispatcher productivity
- ✓ Complete situational awareness
- ✓ Reduced/eliminated human error
- ✓ Increased service excellence

Step 5: Prediction

The final step is to use data to predict the likelihood of unplanned events and create a new plan based on this information. In short, it's moving from reactive actions (e.g. break/fix, congestion) to proactive actions (predict/plan/schedule).

Current State:
The increasing abundance of data being collected by railroads is often overwhelming, and as a result underutilized. Organizations often find it challenging to translate the large volume of data from disparate sources into useful insights. Consequently, there is considerable effort expended reacting to unplanned events.

Future State / The Opportunity:
Key elements of optimized Prediction:

- Using data and analytics to see the likelihood of unplanned events downstream. For example, terminal congestion, line of road congestion, locomotive failures, crew delays, weather impacts, etc.
- Driving predictive insights into the plan
- What-if analysis to re-plan and maintain network fluidity

Technology Enablers:
Technology enablers include:

- → Predictive analytics algorithms
- → Machine learning algorithms
- → Meet pass optimization algorithms
- → Network digital twin

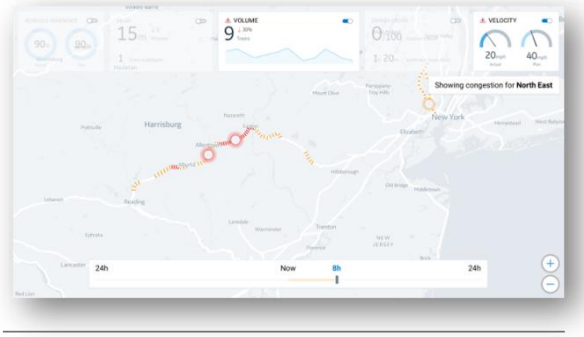

Figure 6: Prediction

Potential Outcomes:

- ✓ Increased planning accuracy
- ✓ Reduction in delays and resource waste
- ✓ Improved confidence in the plan
- ✓ Improvement in service level
- ✓ Opportunities for more automation

Conclusion

By optimizing the performance of the rail network, railroads can reduce cost, improve on-time performance, and increase predictability. Railroads leveraging this strategy recognize that transforming the performance of the rail network is not an event, but a journey that can be executed in logical steps – from planning in Service Design to execution in Train Dispatch. Ultimately, it represents an opportunity for growth and competitive advantage: Railroads that optimize their networks can deliver greater levels of service, grow their customer base, and take precision scheduled railroading to the next level.

About the Authors

Ken Kenjale leads the Network Optimization and Dispatch product lines at Wabtec. He has an extensive background in product strategy and has brought large and data intensive products to market spanning power utilities, LiDAR, aerospace and communications. He studied at Caltech doing research into the optimization of swarms of drones/UAVs and went to business school at the Univ of California followed by roles of increasing responsibility in Product, Private Equity, Engineering and Business Development.

Dharma Acharya is the Sr. Director – Operations Research and Advanced Analytics at Wabtec, leading the analytics team supporting algorithm development and improvements for Wabtec's network solutions. Dharma has over 30 years of experience developing and implementing advanced solutions for railways. Prior to joining Wabtec, Dharma was an Assistant Vice President – Operations Research at CSX Transportation for 10 years during his 20+ years tenure. Dharma holds a Ph. D. in Transportation Systems from MIT.

About Wabtec

Wabtec Corporation is a leading global provider of equipment, systems, digital solutions and value-added services for freight and transit rail. Drawing on nearly four centuries of collective experience across Wabtec, GE Transportation and Faiveley Transport, the company has unmatched digital expertise, technological innovation, and world-class manufacturing and services, enabling the digital-rail-and-transit ecosystems. Wabtec is focused on performance that drives progress, creating transportation solutions that move and improve the world. The freight portfolio features a comprehensive line of locomotives, software applications and a broad selection of mission-critical controls systems, including Positive Train Control (PTC). The transit portfolio provides highly-engineered systems and services to virtually every major rail transit system around the world, supplying an integrated series of components for buses and all train-related market segments that deliver safety, efficiency and passenger comfort. Along with its industry-leading portfolio of products and solutions for the rail and transit industries, Wabtec is a leader in mining, marine and industrial solutions. Wabtec has approximately 27,000 employees in facilities throughout the world. Visit the company's new website at www.WabtecCorp.com.