How to Maximize the Benefits From Your Railway’s Large Investment in PTC

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Introduction

In April 2010, the Association of American Railroads (AAR) published a report entitled, “Assessment of the Commercial Benefits of Positive Train Control” by the consulting firm Oliver Wyman, Inc. This report accurately concluded that railways are implementing PTC in a manner that produces minimal business benefits. This is because, with their current implementations, (a) PTC is not being integrated with precision dispatching systems; (b) PTC on-board computers will not know the consist or the size and weight of trains; (c) PTC on-board computers will not know the status of locomotive dynamic brakes; and (d) PTC is being tied to the wayside signal system and fixed blocks.

The entire railway industry – railways, unions, suppliers, and regulators – had long agreed that the safety benefits of PTC were not sufficient by themselves to justify the costs of implementing PTC. Because the Rail Safety Improvement Act of 2008, passed following collisions at Graniteville, SC, and Chatsworth, CA, requires railways to invest substantial capital in the implementation of PTC, it appears imperative that railways organize themselves and implement PTC in a manner that provides business benefits that justify the costs. The railways’ boards of directors, financiers, and investors should all welcome a return on this investment that the railways are being required to make. This paper provides recommendations for steps that railways could take to maximize the return on their large $5 billion investment in PTC.

Other Users of the Same Technology as PTC

Admiral Jay Johnson, Chief of Naval Operations, apparently coined the phrase “network-centric warfare” in 1997. Network-centric warfare uses integrated digital data communications, GPS positioning, sensors, computers, and displays to obtain:

- Increased operational flexibility;
- Increased decision-making speed;
- Cost savings through increased efficiency of asset usage;
- Improved support to geographically dispersed elements;
- Increased visibility; better understanding of operations;
- Self-synchronization of subordinate organizations; and
- General benefits that result due to increased connectivity.

The Chief Information Officer of the US Department of Defense (DOD), John G. Grimes, recently noted, “We must recognize that it is all about information, and we must view information as a strategic asset. Timely, accurate and trusted information lies at the heart of network-centric operations.”

The concept of network-centric operations is not limited to warfare and the DOD. The Federal Aviation Administration (FAA), for example, is implementing network-centric technology in its Next Generation Air Transportation System. FAA is shifting from radar to GPS, from analog voice to digital data communications, and from old to new on-board and control center computers and displays to obtain:
- Increased safety
- Reduced congestion and delays
- Improved efficiency of airline operations
- Reduced fuel consumption and emissions
- Increased capacity of the National Airspace System

Network-Centric Railway Operations

Railways, the railway supply industry, and the FRA have been working for nearly thirty years on the development of network-centric railway operations and intelligent railway systems for command, control, communications, and information (C3I). By implementing digital data communications, GPS positioning, sensors, computers, and displays, railways should be able to achieve the same types of benefits that the military and aviation communities will achieve from their network-centric systems:
- Prevent collisions and overspeed accidents;
- Prevent hijackings and runaways;
- Raise effective capacity;
- Improve asset utilization;
- Improve running time and running time reliability;
- Improve customer service and satisfaction;
- Measure and control costs;
- Reduce energy consumption and emissions;
- Increase economic viability and profits;
- Respond with flexibility and agility to rapid changes in the transportation marketplace;
- “Manage the unexpected.”

Recommendations regarding the implementation of PTC

Following is a “baker’s dozen” of recommendations to railways that I believe may help them generate a return on their investment in PTC:

1. Rather than implementing stand-alone PTC systems, implement PTC systems that are integrated with other information systems, such as Automatic Equipment Identification (AEI) systems, locomotive health monitoring systems, and precision dispatching systems. Incorporating information from AEI, along with information from other databases, will provide train length and weight information to the PTC on-board and control center computers to enable them to calculate more accurate braking distances and to know where the rear ends of trains are located. This is key to preventing fatal rear-end collisions such as those that occurred in the spring of 2011 at McPherson, Iowa, and Mineral Springs, North Carolina.

Information on the status of dynamic brakes on locomotives will also enable the PTC computers to calculate more accurate braking distances. By incorporating the real-time train location and speed information from PTC into precision dispatching systems will provide improved meet-pass planning and will eliminate the need for
separate radios and GPS receivers (which at least one railway is installing) to feed information to the precision dispatching system. The digital data link communications systems being implemented for PTC have the capacity for moving this additional information.

2. Have a thorough discussion within your company regarding information flows. Provide each employee in every department with all the information – and only the information – he/she needs to do his/her job. Make sure that the information is intelligible. Decide which information should be “pushed” to users and which information should be “pulled” by users.

3. An overarching issue that affects the design and deployment of network-centric railway operations and intelligent railway systems is the security of information. It must be incorporated in PTC before deployment. Data regarding trains, cars, crews, and shipments must be kept secure, and unwarranted extraction of information from the digital data link communications network must be prevented. Authentication of data insures that content is genuine, unaltered, and complete. Encryption is the security mechanism that converts plaintext into cyphertext that is unintelligible to those who do not have access to the appropriate key. Archiving of data from intelligent railway systems must also be done in a secure manner through the control of access privileges to prevent loss of data.

4. The importance of redundant and backup capabilities cannot be overstated. A pessimistic look at history will show that failures often occur at the worst possible moment. The architecture of existing signaling and train control systems is such that it permits one person, either a locomotive engineer or a dispatcher, to make a mistake (because of fatigue, illness, drugs, inattention, distraction, carelessness, visual or aural impairment, or some other reason) that can cause two trains to collide. The safety of PTC systems derives from an integrated, fault-tolerant architecture that provides checks and balances, which limit the impact and propagation of human error. Supervisory control and data acquisition (SCADA) systems need to be installed to monitor all the wayside and on-board systems and system components and report their status via the digital data link communications network to appropriate control centers and other organizations on the railway. A railway may want to use leased telecommunications circuits, but it also needs to remember that if does not own one of the communication paths for a system, it does not have control over the reliability or availability of that system.

5. Do not underestimate the tension that exists between investment in legacy systems and the cost of replacement systems. Some railways want the logic of new PTC systems to be the same as the logic of their existing operating rule books and signaling systems, which is based on knowledge of which track blocks are occupied and has different procedures and priorities for trains and maintenance vehicles. This implementation scheme results in congested communications channels and reduced capacity and efficiency, as the Oliver Wyman report notes. PTC systems, based on the new and different paradigm of continuous real-time knowledge of the precise
location and speed of all trains and maintenance vehicles, can provide closer headways and greater capacity while simultaneously increasing safety. Furthermore, railways must resist the temptation to preserve their investment in wayside signal systems; they need to view such investments as “sunk costs” and write them off.

6. Technological changes will affect the companies within the railway industry in unforeseen ways. Additional staff with proper skills (e.g., expertise in systems design and integration, program management, avionics, data communications) will need to be hired and trained. A temporary reallocation of capital is needed to implement PTC, which, if implemented properly, can in the future generate capital for investment in infrastructure and rolling stock. Budgeting processes must be modernized; “soft dollar” benefits (e.g., traffic increases from shorter transit time and improved reliability) must be included in analyses, not just “hard” dollar benefits (i.e., reduction in labor and fuel costs). Finally, do not work to optimize individual subsystems (e.g., the communications system or the on-board systems), optimize the total PTC system.

7. Understand that your organizational culture will be affected by all these changes. “One of the major lessons learned is that without changes in the way an organization does business, it is not possible to fully leverage the power of information.” Because information flows will be different; some in the organization will feel threatened. For a successful PTC implementation, telecommunications and train control staffs will need an extremely close working relationship.

8. Make sure the implementation team represents all affected departments. Team members must coordinate project activities with their home departments, with their counterparts at their system integrator, suppliers, and contractors, and with each other. Do not try to minimize the size of the team. And remember, a steering committee that meets periodically, while desirable, is not an implementation team.

9. Recognize that network-centric operations are not a panacea. Increased asset and data visibility may encourage micromanagement. Recent experience with the US military forces in Afghanistan and Iraq has shown that “another consequence of our expanded global connectivity was that ‘reach-back,’ a desirable capability when used with discrimination, metamorphosed into ‘reach-forward’ as rear headquarters sought information…and then used that information to try to influence events from the rear.” Furthermore, use information to improve performance of the railway, not to monitor the performance of individuals.

10. Choose top leaders well. Larry Kaufman has written a history of BNSF Railway and its predecessor companies entitled, “Leaders Count.” The title says it all. Top leaders must understand the technology of PTC, establish the proper environment for its deployment, and provide proper incentives to the people who are installing it.
and who will be operating it. The top leaders must elevate the project implementation team in the hierarchy and talk with the team regularly.

11. The implementation strategy must be clear and unambiguous. Top leadership and project implementation team must jointly set strategy. Is the organization going to implement a “safety-only” system, or a system that encompasses safety, efficiency, and service? Is it too late to change strategy?

12. Communicating is important! The implementation strategy must be communicated throughout the railroad to all departments. Suppliers and customers need to be informed. Communicate early and often with the unions; they are the folks who will install, operate, and maintain the systems. They are key to a successful implementation.

13. Maintain realistic expectations and be patient. Network-centric systems are governed by Metcalfe’s Law, which asserts that the power of a network is proportional to the square of the number of nodes in the network. However, “Metcalfe’s Law is really about potential gains; there is no guarantee that simply hooking things up will make the results better.”10 Thinking, planning, and organizing are essential.

Conclusions

A new era is upon us. As the DOD CIO, John G. Grimes, recently summarized, “Net-enabled operations, while clearly complex, can actually be described quite simply. It is all about ensuring timely and accurate information gets where it’s needed, when it’s needed and to those who need it most.”11

Network-centric operations are the way of the future in many different organizations (e.g., military, aviation, intelligent highway systems, vessel tracking systems, parcel delivery services, emergency responders). Learn from the successes and failures of these other users of the technology.

PTC could be the key to making railways safer, reducing delays and costs, raising effective capacity, increasing reliability, improving customer satisfaction, improving energy utilization, reducing emissions, increasing security, and making railways more economically viable. Railways have the opportunity, should they elect to take it, to maximize the benefits from the investments they are required to make in PTC.
References and Notes

1 Address at the U.S. Naval Institute Annapolis Seminar and 123d Annual Meeting, Annapolis, MD, 23 April 1997.
6 Weick, Karl E. and Kathleen M. Sutcliffe, Managing the Unexpected, San Francisco: Jossey-Bass, 2001
7 Conversation with Ed Kemp, AVP – Telecommunications, Union Pacific Railroad.
8 Alberts, Garstka, and Stein, p. 85.
10 Alberts, Garstka, and Stein, p. 100.

About the author:
Steven Ditmeyer received a BS degree in Industrial Management from MIT and an MA degree in Economics and The Certificate in Transportation from Yale University. He served his Army active duty tour with the Office of the Special Assistant for Strategic Mobility in the Organization of the Joint Chiefs of Staff, and in the Army Reserve he served with the Headquarters, 3rd Transportation Brigade (Railway). His civilian career has been in a number of transportation-related positions in both the public and private sectors. He was a transportation economist at the World Bank; General Manager of The Alaska Railroad; Chief Engineer - Research, Communications, and Control Systems at Burlington Northern Railroad; and Vice President - Marketing and Business Development at the Locomotive Division of Morrison Knudsen Corporation. He served as Associate Administrator for Policy and Associate Administrator for Research and Development at the Federal Railroad Administration, and as the US Department of Transportation Faculty Chair and Associate Professor of Economics at the Industrial College of the Armed Forces, National Defense University. He is now an adjunct professor with the Railway Management Program at Michigan State University. He is a member of Tau Beta Pi engineering honorary society, a fellow of the Permanent Way Institution, a life member of AREMA, and was a member of the AAR Communication and Signal Section’s Committee of Direction from 1986 to 1993 and its Executive Chairman in 1992 and 1993.
How to Maximize the Benefits from Your Railway’s Large Investment in PTC

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Railways are indeed implementing PTC in a way that produces minimal business benefits:

- PTC is not being integrated with precision dispatching systems;
- PTC on-board computers will not know the consist or the size and weight of trains;
- PTC on-board computers will not know the status of locomotive dynamic brakes; and
- PTC is being tied to the wayside signal system and fixed blocks.
Are others getting benefits from the application of the same technology?
Network Centric Warfare

DoD is using integrated digital data communications, GPS positioning, sensors, computers, and displays to obtain:
- Increased operational flexibility
- Increased decision-making speed
- Cost savings due to improved asset utilization
- Improved support to dispersed elements
- Increased visibility and better understanding of operations
- Self-synchronization of subordinate organizations
- Benefits resulting from increased connectivity

Department of Defense Command and Control Research Program
www.dodccrp.org
Asst. Secy. of Defense for Networks and Information Integration
"We must view information as a strategic asset. Timely, accurate, and trusted information lies at the heart of network-centric operations."

– John G. Grimes, DoD CIO
Next Generation Air Transportation System

FAA is shifting from radar to GPS, from analog voice to digital data communications, and from old to new on-board and control center computers and displays to:

- Increase safety
- Reduce congestion and delays
- Improve the efficiency of airline operations
- Reduce fuel consumption and emissions
- Increase the capacity of the National Airspace System
Ditmeyer’s Vision of “Network Centric Railway Operations”

Use *integrated* digital data communications, GPS positioning, sensors, computers, and displays on railways to:

- Improve both safety and security
- Raise effective capacity
- Improve asset utilization
- Improve running time and running time reliability
- Improve customer satisfaction
- Measure and control costs
- Reduce energy consumption and emissions
- Increase economic viability and profits
- Manage the unexpected
What Railway Managers Need to Know:

- Where mobile assets* were (for billing, payments, and analysis)
  * Mobile assets = trains and train crews, locomotives, cars, EOTDs, and maintenance equipment and crews
- Real-time status of mobile assets (i.e., Are they serviceworthy?)
- Real-time status of fixed assets** (i.e., Is the infrastructure trainworthy?)
  ** Fixed assets = track, switches, bridges, tunnels, yards, terminals
- Where mobile assets are and what they are doing, in real time
- Where mobile assets will be at time $t_1$ in the future
- Where mobile assets need to be at time $t_2$ in the future
- How best to get the mobile assets from where they are and will be to where they need to be
- That the correct instructions are being conveyed to the right crews and vehicles, and that the instructions are being complied with
Recommendation #1

- Implement **integrated** systems, rather than free-standing systems
  - Integrate PTC with precision dispatching, AEI, work order reporting systems, locomotive health monitoring systems, and others
  - Digital data communications channels have substantial capacity – much greater than analog voice channels – and permit discretely addressed messages to single or multiple recipients
Recommendation #2

Study information flows

- Provide each employee with **all** the information he/she needs to do his/her job
- Provide each employee with **only** the information he/she needs to do his/her job
- Make sure the information is intelligible
- Decide which information to “push to” users and which to have “pulled by” users
- Consult the users
Recommendation #3

Security and information assurance must be constant considerations

- Data regarding trains, freight cars, crews, and shipments must be kept confidential
- Authentication of data will insure that the content is genuine, unaltered, and complete
- Unwarranted extraction of information from communications network must be prevented
- Encrypt data to keep it out of wrong hands
Backup and redundancy are important
- Fault-tolerant system architecture
- Dual-redundant components
- Integrated architecture provides checks and balances to limit the impact and propagation of human errors
- SCADA systems will monitor integrity of wayside and on-board components
Recommendation #5

Don’t underestimate the inertia of legacy systems (i.e., signal systems)

- PTC offers a new paradigm – it enforces train separation, not signal indications
- Digital data link and GPS provide real-time information
- Operating rules must be changed; don’t saddle PTC with old rules that were based on delayed information flows
- Legacy systems must be written off as “sunk costs”
Recommendation #6

Technological change will affect companies in unforeseen ways; choices have to be made in intellectual capital, financial capital, and process

- Additional staff with proper skills (e.g., expertise in systems design and integration, program management, avionics, data communications) will need to be hired and trained
- A reallocation of capital is needed to implement PTC and net-centric systems
- PTC and net-centric systems, if implemented properly, can generate capital for investment in infrastructure and rolling stock
- Budgeting processes must be modernized; “soft dollar” benefits must be included in analyses, not just “hard”
- Don’t optimize subsystems - optimize the total system
Recommendation #7

Be aware that net-centric operations will affect an organization’s culture

- Only with changes in the way an organization does business can it fully leverage the power of information
- Information flows will be different; some in the organization will feel threatened
- Telecommunications and train control staffs need extremely close working relationship
Recommendation #8

Make sure the implementation team represents *all* affected departments.

- Team members must coordinate project activities
  - with their home departments;
  - with their counterparts at their system integrator, suppliers, and contractors; and
  - with each other
- Do not try to minimize the size of the team
- A steering committee is not an implementation team
Recognize that net-centric operations are not a panacea; they may encourage micromanagement

- Use information to improve performance of the railway, not to monitor the performance of individuals.
- Net-centric systems enable both “reach back” and “reach forward” for information. There must be a balance between centralized planning and local execution.
Recommendation #10

Choose top leaders well

“Leaders Count”

The top leaders must understand the technology, establish the proper environment for its deployment, and provide proper incentives

The top leaders must elevate the project implementation team in the hierarchy and talk with the team regularly
Recommendation #11

The implementation strategy must be clear and unambiguous

- Top leadership and project implementation team must jointly set strategy
- Is the organization going to implement a “safety-only” system, or a system that encompasses safety, efficiency, and service?
- Is it too late to change strategy?
Communicating is important!

- The implementation strategy must be communicated throughout the railroad to all departments.
- Suppliers and customers need to be informed.
- Communicate early and often with the unions; they are the folks who will install, operate, and maintain the systems. They are key to a successful implementation.
Recommendation #13

Maintain realistic expectations, and be patient

- Net-centric systems are governed by Metcalfe’s Law, which asserts that the power of a network is proportional to the square of the number of nodes in the network.
- Metcalfe’s Law is really about potential gains; there is no guarantee that simply hooking things up will make the results better.
- Thinking, planning, and organizing are essential.
“Net-enabled operations, while clearly complex, can actually be described quite simply. It is all about ensuring timely and accurate information gets where it’s needed, when it’s needed, and to those who need it most.”

– John G. Grimes, DoD CIO
Summary

- A new era is upon us
- Railways have the opportunity to maximize the benefits from the investments they are required to make in PTC
- Network-centric operations are the way of the future in many different organizations (e.g., military, aviation, parcel delivery services, emergency responders)
- Learn from successes and failures of other users
- Improved railway safety, security, efficiency, and profitability are all achievable with proper implementation of PTC and net-centric operations
Questions?

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How PTC Permits More Efficient Train Meets

Accurate projections of train location reveal opportunities to reduce meet/pass delays.
How PTC Permits More Efficient Train Passes

The ability to operate with short headways can reduce meet/pass delays.
Locomotive Cab Displays
Locomotive Cab Displays

4011 LOW OIL PRESSURE
HOT WHEEL RIGHT SIDE AXLE 63

ONE ISSUED TRACK WARRANT IS 121.
87 LOADS 24 EMPTIES 9200 TONS 8150 FEET

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Locomotive Cab Displays
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