Net-Centric Operations: Defense and Transportation Synergy

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The Department of Defense (DoD) is actively working to transform platform-centric operations into net-centric operations. Net-centric railroading could provide DoD's Strategic Rail Corridor Network (STRACNET) with unified operations in which positioning systems, sensors, computers, advanced mathematical models, and digital communications could be used to collect, process, and disseminate information to improve the safety, security, and operational effectiveness of our nation's railroads in support of national defense. As both departments pursue net-centric operations there will be numerous opportunities to share technology and experience.

Admiral Jay Johnson, Chief of Naval Operations, apparently coined the phrase *net-centric warfare* in 1997[1]. Net-centric warfare has been defined as *an information superiority-enabled concept of operations that generates increased combat power by networking sensors, decision makers, and shooters to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and a degree of self-synchronization* [1].

Rapid and significant advances in information technology hardware and software during the past two decades have made it possible to fundamentally change the way information is gathered, stored, processed, and used. As the DoD Chief Information Officer (CIO), 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 net-centric operations. [2]

The concept of net-centric operations, though, is not limited to warfare and the DoD. The DoD is not the only large government organization that is considering moving to net-centric operations. The Department of Transportation (DoT), for example, is seriously evaluating and encouraging net-centric railroading.

Net-Centric Railroading

Intelligent railroad systems were first described in the Secretary of Transportation's report, *The Changing Face of Transportation*[2], published in 2000, and their description was expanded in the Federal Railroad Administration's (FRA) *Five-Year Strategic Plan for Railroad Research, Development, and Demonstrations*[3], a March 2002 congressional report.

The FRA, railroads, and the railroad supply industry have been working on the development of intelligent railroad systems for command, control, communications, and information (C3I), as well as for braking systems, grade crossings, defect detection, and planning and scheduling systems. These technologies can prevent collisions and overspeed accidents, prevent hijackings and runaways, increase capacity and asset utilization, increase reliability, improve service to customers, improve energy efficiency and emissions, increase economic viability and profits, and enable railroads to measure and control costs and *manage the unexpected* [3].

Intelligent railroad systems could enable railroads to improve their quality of operations on the DoD-designated Strategic Rail Corridor Network[4] (STRACNET), enhancing their responsiveness to military deployments. They would also enable railroads to respond with flexibility and agility to rapid changes in the transportation marketplace. These systems could alleviate the need for a division commander to call railroad executives late at night to find out the location of railroad cars for loading their division's heavy equipment – like Maj. Gen. David Petraeus had to do during the 101st Airborne Division's deployment to participate in Operation Iraqi Freedom [4].

Benefits of Net-Centric Operations

Proponents of net-centric operations – in government, industry, and academia – claim many benefits. Here are some of the most frequently claimed benefits that should apply to the DoD, the DoT, and the railroad industry:

1. Increased operational flexibility.
2. Increased decision-making speed.
3. Cost savings through increased efficiency of asset usage.
4. Improved support to geographically dispersed elements.
5. Increased visibility and a better understanding of operations.
6. Self-synchronization of subordinate organizations. For the DoD, self-synchronization means *the ability of a well-informed force to organize and synchronize complex warfare activities from the bottom up. … Self-synchronization is enabled by a high level of knowledge of one's own forces, enemy forces, and all appropriate elements of the operating environment* [1].
7. General benefits that result due to increased connectivity. *Net-centric computing is 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. The* power *or* payoff *of net-centric computing comes from information-intensive interactions between very large numbers of heterogeneous computational nodes in the network* [1].

Net-Centric Railroad Technologies

Like the DoD's concept of net-centric warfare, the DoT's concept of net-centric railroading is a *system of systems*. Twenty-nine key technologies, programs, and systems, either developed or under development, have been identified which could help create a net-centric railroading system. (For a complete list, please see the sidebar entitled *Railroad Net-Centric Technologies*.)

Here are 10 of the many technologies that are being considered for incorporation into a net-centric railroading system. Some, or all, of these systems may have direct application for the DoD, as well:

- **Positive Train Control (PTC) systems** are integrated C3I systems for controlling train movements with safety, security, precision, and efficiency. PTC systems would improve railroad safety by significantly reducing the probability of collisions between trains, casualties to roadway workers and damage to their equipment, and overspeed accidents. The National Transportation Safety Board (NTSB) has had PTC on its *most wanted* list of transportation safety improvements since 1990[6]. PTC systems are comprised of digital data link communications networks, continuous and accurate positioning systems, on-board computers with digitized maps on locomotives and track maintenance equipment, in-cab displays, throttle-brake interfaces on locomotives, data-link connections at switches (both powered and manual) and wayside detectors, and train control center computers and displays.

- **Crew alertness monitoring systems** promote on-duty alertness and vigilance of train crews through the use of non-invasive technology applications. Real-time monitoring and feedback of *individual alertness levels* would allow crew members to modify their behavior and reduce their risk of unsafe performance.
- **Crew registration and time-keeping systems** would use identification techniques such as the Department of Homeland Security's proposed Transportation Worker Identification Credential (TWIC), other electronic card keys, passwords, or biometrics such as fingerprints and/or retinal scans to ensure that only authorized crew members are permitted to control locomotives and track maintenance vehicles.
- **Locomotive health-monitoring systems** consist of sensors mounted on engines, traction motors, electrical systems, air systems, exhaust systems, and fuel tanks on locomotives. Most new locomotives are equipped with most of these sensors. In the future, the data would be transmitted over the digital data link communications network to train control centers, maintenance facilities, and motive power distribution centers to permit real-time monitoring of locomotive performance and efficiency, improved diagnosis of problems, and more effective assignment of locomotives to trains.
- **Wayside track sensors** are installed to identify a number of defects that occur on and alongside the track as well as identify conditions and obstructions along the track. Among the conditions and defects that could be detected are switch position, broken rail, misaligned track, high water, rock and snow slides, excessive rail stress, misaligned bridges and trestles, blocked culverts, and earthquakes.
- **Energy management systems (EMS)** are installed on locomotives to optimize fuel consumption and emissions. An EMS would receive information on track profile and conditions, speed limits, train length and weight, locomotive engine fuel performance characteristics, locomotive health monitoring systems, etc. Conceptual work has been done on EMS, but a prototype system has not yet been implemented.
- **Car on-board commodity sensors** are being installed on freight cars to monitor the status of the commodities being carried – measuring, for example, temperatures, pressures, vibrations, load position, radiation, gases, and biohazards.
- **Intelligent weather systems** consist of networks of local weather sensors and instrumentation – both wayside and on-board locomotives – combined with national, regional, and local forecast data to alert train control centers, train crews, and maintenance crews of actual or potentially hazardous weather conditions.
- **Security systems** consisting of closed-circuit television cameras and infrared presence detectors are being deployed at bridges and tunnels, and even on some locomotives, to provide detection of intruders and obstructions. Appropriate information would be transmitted via data link to train control centers and train and maintenance crews in addition to security forces.
- **Emergency notification systems** installed at train control centers provide for the automated notification of all involved organizations following railroad accidents, incidents, or threats.

The implementation of net-centric railroading with intelligent railroad systems is not without impediments – the competition for capital within railroad companies, for example. Railroad companies need to understand, though, that a well-executed investment in intelligent railroad systems should reduce the capital needed for locomotives, cars, and tracks.

Net-centric railroading should enable railroads to manage unexpected situations by providing real-time information about current operations and the current environment. The DoD, as well as commercial railroad customers, could benefit significantly from improvements in visibility, running time, and service reliability resulting from the implementation of net-centric railroading.

Increasing Capacity

Today there is a capacity problem in railroading. During the past 25 years (following the deregulation of the railroad industry), American railroads have physically downsized – tracks, locomotives, train cars, and employees – while, at the same time, overall rail traffic has increased. With a growing economy and growing imports, railroads face congestion on many of their lines. The last time the nation faced a similar crisis was during World War II.

Net-centric railroading will provide an effective increase in capacity. It enables railroads to handle different types of traffic (such as coal, grain, container, and even passenger) that have different service requirements, enabling them to co-exist on the same facility. Different types of trains can each be managed according to their individual requirements.

Railroad Net-Centric Technologies

The accompanying article highlights several of the key technologies, programs and systems that can be incorporated in net-centric railroading. The following is the complete list:

- Digital data link communications networks.
- Nationwide Differential Global Positioning System.
- Positive train control systems.
- Electronically controlled pneumatic brakes.
- Knowledge display interfaces.
- Crew registration and time-keeping systems.
- Crew alertness monitoring systems.
- Track forces terminals.
- Automatic equipment identification.
- Wayside equipment sensors.
- Wayside track sensors.
- Locomotive health monitoring systems.
- Energy management systems.
- Vehicle-borne track monitoring sensors.
- Car on-board component sensors.
- Car on-board commodity sensors.
- Intelligent grade crossings.
- Intelligent weather systems.
- Tactical traffic planners.
- Strategic traffic planners.
- Yard management systems.
- Work order reporting systems.
- Locomotive scheduling systems.
- Car reservation and scheduling systems.
- Train crew scheduling systems.
- Yield management systems.
- Security systems.
- Emergency notification systems.
- Traveler's advisory systems.

These net-centric systems will enable control centers to know the location of all trains and the status of their performance, whether they are on schedule, behind schedule, or ahead of schedule. The tactical and strategic planning systems will enable railroads with flow control – similar to what the Federal Aviation Administration is able to currently do with aircraft – to anticipate the location of trains (two hours from now, four hours from now, etc.) and to initiate actions to reduce or remove congestion problems before they actually occur.

Sharing Insights

As the DoD continues to shift to net-centric operations, there is no reason that insights and lessons learned from work done thus far should not be shared with other federal agencies. The authors propose several concepts that may be beneficial to the railroad industry as they begin a net-centric transformation:

1. **Have a thorough discussion with the railroad industry regarding which information should be pushed to users and which information should be pulled by users.** The answers to those two questions are not necessarily disjointed data sets.
2. **Information security and information assurance must be part of every net-centric discussion.**
3. **Do not underestimate** the tension that exists between continuing investment in legacy systems and the upfront costs of replacement net-centric systems that offer a higher rate of return.
4. **Technological changes will affect the companies within the railroading industry in unforeseen ways.**

> …we must change how we train, how we organize, and how we allocate our resources … Because a net-centric force operates under a different, more modern rule set than a platform-centric force, we must make fundamental choices in at least three areas: intellectual capital, financial capital, and process. [1]

5. **The importance of redundant and back-up capabilities cannot be overstated.** A pessimistic look at history shows that failures often occur at the worst possible moment. The November issue of *Technology Review* provided an in-depth review of one such challenge during Operation Iraqi Freedom. On April 2, 2003, Army LTC Ernest *Rock* Marcone (a battalion commander with the 69th Armor of the Third Infantry Division) led an armored battalion of almost 1,000 U.S. soldiers to seize Objective Peach – a key bridge across the Euphrates River and the last major obstacle before American forces would reach Baghdad. That night, Marcone's battalion was surprised by the largest counterattack of the war. All his net-centric sensing and communications technologies failed to warn him of the attack's scale. He did not realize that between 5,000 and 10,000 Iraqi troops with about 100 tanks and other vehicles were about to attack his position:

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> Next to the fall of Baghdad, says Marcone, that bridge was the most important piece of terrain in the theater, and no one can tell me what's defending it. Not how many troops, what units, what tanks, anything. There is zero information getting to me. [5]

6. **Understand that your organizational culture will be affected by 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 [1].
7. **Maintain realistic expectations.** Metcalfe's Law is really about potential gains; there is no guarantee that simply hooking things up will make the results better [1].
8. **Recognize that net-centric operations are not a panacea.** Increased asset and data visibility may encourage micromanagement. Recent experience 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. [5]

It is ironic that net-centric operations enables both *reach back* (providing increased information for local leaders to make decisions) and *reach forward* (providing rear headquarters with additional information and an increased temptation to micromanage). There must be a balance reached between centralized planning and local execution.

9. **Be patient.** The DoD has been actively working on net-centric warfare for several years, but as John G. Grimes, DoD-CIO, recently noted:

> Unlike designing a tank or launching a satellite, our transformation to net-centric operations is traversing new ground. We stand at the brink of an era when networked capabilities will increase efficiency, enhance mission success, save lives and potentially reduce force structure… [2]

Conclusion

The DoD is in the process of transforming to net-centric operations. Net-centric railroading could be the key to making railroads safer, reducing delays and costs, raising effective capacity, increasing reliability, improving customer satisfaction, improving energy utilization, reducing emissions, increasing security, and making railroads more economically viable. At the same time, these efforts should provide numerous opportunities for sharing hardware, software, and experiences.

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. [2]

This is equally true for the DoD, the DoT, the railroad industry, other modes of transportation, and other government agencies. Reasonable sharing of plans, research, experience, and lessons learned regarding net-centric operations should be in everyone's best interest.◆

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Notes

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