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# The smarter railroad

An opportunity for the railroad industry

Travel and Transportation

## IBM Institute for Business Value

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# *The smarter railroad*

## An opportunity for the railroad industry

*By Keith Dierkx*

*Global demand for rail services continues to outpace available capacity and infrastructure, while aging systems and traditional business practices limit tangible responses to address the problem. Rail executives are being presented with a mandate by society to build rail systems that are smarter. By embracing new and existing technologies to acquire, associate and analyze information across the rail network and using that information to become more efficient and effective, they can create a more responsive and agile operating environment.*

### Introduction

The global rail industry in 2009 and beyond will struggle to meet the increasing demand for freight and passenger transportation. While it is natural for business to brace itself during difficult economic times, this is actually the antithesis of what rail executives need to be doing today. Now is the time to invest in creating real innovation for an industry that needs to launch itself forward to meet the needs of the twenty-first century.

The rail industry is not immune to recent global challenges, such as the crisis in the financial markets, the slowdown in the manufacturing sector across many industries and shifts in global trade. These issues show that the world has become hyper-connected, economically, socially and technically. We now have a set of complex interrelated global systems, which are making the world smaller.

However, while the world is becoming smaller, it is also becoming *smarter*. Intelligence is being infused into every system and process that creates, sells and moves products and people, and delivers services.

This is possible because our world is becoming more:

***Instrumented***

By 2010, it is estimated that the world will have produced in excess of 30 billion Radio Frequency Identification (RFID) tags, creating the ability to track the location of cargo, the health of an operation and the movement of people through urban centers and travel networks.[1]

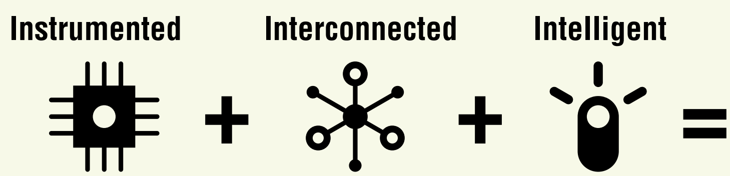
***Interconnected***

Systems and objects now "speak" to each other, and these interactions create the possibility to improve performance while also generating unprecedented amounts of data that can be shared within a company or across ecosystems for collaboration. North American rail operations, for example, have thousands of Automatic Equipment Identification (AEI) readers and tens of thousands of wagons with RFID tags. These trackside AEI sensors provide information on the location of the wagons and then interact with acoustic monitoring, hot box and wheel impact detection devices to provide a more complete and comprehensive view of the conditions of the cars.

***Intelligent***

Instrumented and connected objects and processes are communicating with sophisticated business systems that enable data to be mined, relationships to be analyzed and decision making to be continuous and near realtime. By aggregating wagon information and trends for wheel fatigue, bearing overheating or other mechanical failures, maintenance requirements can be predicted and corrective action can be communicated rapidly based on the urgency and potential harm to the health and safety of passengers and freight.

Building smarter rail networks makes sense not only because of the abundance of available and affordable technology, but also because real change is required in the industry to address society's demands for transportation.




***An opportunity to think and act in new ways***

# The smarter railroad

*An opportunity for the railroad industry*

**For global railroad executives, the top industry challenges are: capacity and congestion, operational efficiency and reliability, structural and competition issues, and safety and security.**

## A mandate for change

Morgan Stanley estimates that there will be US$300 billion worth of global investment to upgrade, expand and initiate railway networks during the next five years.[2] Consistent with this investment, consider the growth that is occurring across the world:

- By 2012, rail industry revenue is forecast to be US$514 billion, with a 3.3 percent compound annual growth rate (CAGR) from 2007 to 2012.[3]
- The global rail supply market grew 9 percent from 2006 to 2007 and is expected to continue growing 2.0-2.5 percent over the next nine years.[4]
- Asia Pacific will grow at 6 percent average CAGR, while China alone will grow 11.8 percent CAGR from 2007 to 2012.[5]
- U.S. freight railroad demand will increase 88 percent by 2035, requiring an estimated US$148 billion of investment for existing lines.[6]
- Europe's passenger railway market will have a value of US$116.5 billion in 2012, an increase of 19.3 percent from 2007 and a CAGR of 3.6 percent.[7]

If the rail industry is to meet this projected growth, it needs to solve substantial, even transformational, business issues and challenges. Based on an independent study commissioned by IBM in 2008, the top four challenges cited by global rail executives were capacity and congestion, operational efficiency and reliability, structural and competition issues, and safety and security.[8]

### *Capacity and congestion*

Increasing demand for rail services is straining existing systems, requiring optimization of the existing passenger and freight rail timetables and schedules to achieve increased throughput on existing rail infrastructure.

Rail freight companies are experiencing growth in trade, especially in the areas of energy and commodities. Russian harbors, in particular, are experiencing serious bottlenecks, which are resulting in issues for the railroads. Rail companies are increasing asset utilization and making significant investments in infrastructure to meet the capacity challenge.

### *Operational efficiency and reliability*

Aging IT systems limit the efficiency of resources and reliability in established rail markets and prevent companies from responding quickly to changing needs; new markets have the opportunity to adopt newer, more flexible technology infrastructures, leapfrogging current practices.

Network failures and systems outages can have a large domino effect that impacts customer satisfaction. Many current IT systems are old and complex, making the sharing of data difficult. They are also unable to cope with the scale of growth predicted over the next few years. Upgrades and improvements to ticketing and reservation systems are ongoing in most markets.

### *Structural and competition issues*

Recent liberalization and privatization in some markets is forcing railroads to restructure their operations; structural limitations exacerbate the strain of capacity.

In North America, freight and passenger railroads are entirely separate entities, which causes control issues for the passenger side because of lack of ownership of the tracks. In addition, the passenger services are quasi-governmental organizations that rely heavily on government subsidies.

In Russia, road haulage firms are increasingly competing with railroads for mid-range transport. Similarly, China is seeing a shift from the rail tracks to automobiles as the wealth of urban populations increases. Optimizing business processes and systems and improving customer service will enable stronger competition and pricing.

### *Safety and security*

As the rail networks become an even more attractive alternative to other modes of transportation, stricter requirements are being placed on railroads to help ensure safety.

In North America, political scrutiny and regulatory oversight is increasing, with legislation enacted in October 2008 requiring Positive Train Control (PTC) systems by the end of 2015. Predictive maintenance and data analysis is being used for accident prevention. Ultimately, improving safety standards can drive large cost savings for railroad operators.

With significant opportunity for railroad executives to bring change to the global economy, imagine:

- If passengers could manage their entire door-to-door journey on their mobile devices, receiving continually updated suggestions for more convenient routes based on their own travel history and preferences.
- If rail companies could better identify and optimize the profitability or cost to serve a customer and plan asset utilization and pricing in realtime.
- If rail companies could reduce capital expenditure and improve utilization.
- If unnecessary mainline train stoppages could be reduced because systems are smart enough to identify real mechanical problems and failures.
- If schedules and capacity could be dynamically adjusted to cope with irregular operations, such as holiday festivals and weather outages.
- If rail companies could increase network velocity, capacity and revenue through reduced congestion and increased utilization, without adding locomotives.

All of these scenarios are possible in a smarter rail industry. As intelligence is infused into rail systems and decision making, the industry will benefit from:

**Smarter rail systems are highly instrumented, extremely interconnected and far more intelligent.**

- Increased capacity of freight and passenger rail, with reduced capital expenditures
- Seamless transportation for both passengers and freight
- Quicker, safer rail service
- Increased velocity of the rail network
- Further leveraging of rail's environmental and energy advantages
- Improved passenger service, loyalty and ability to tailor to preferences
- A flexible rail operation that can expand rapidly to meet growth requirements.

## Building a smarter rail system

The smarter railroad requires an intelligence that is networked, communicating and aware across the rail ecosystem. It requires information to be shared across the enterprise and among many different stakeholders, including the rail company, shippers, car owners, travel agents, municipalities, intermodal carriers and customers.

> The rail ecosystem is a highly complex global system comprising the internal rail network and the external rail network. The internal rail network is made up of assets, infrastructure and employees. The external rail network comprises the broader network of travel partners, suppliers, logistics service providers, intermodal carriers, regulatory agencies and customers. Rail companies of the twenty-first century will collaborate and extend their networks across wider ecosystems.

As the world becomes smarter, customer interactions with rail companies will change. With the recent emergence of Web 2.0 applications and the proliferation of mobile and smart devices, customers are becoming more informed and want more control of their travel, shopping and interaction with railroads. In the future, it will matter less which company gets them from point A to point B; they will care more about how quick, cost effective or easy it was to plan and manage the journey. Similarly, suppliers will want to book their own freight and have it moved directly from manufacturing to stores, regardless of carrier. They will self-select their transit options by cost, efficiency and impact to the environment as required by their customers. Railroads will need to develop new networks across ecosystems and channels as a result of advanced network technologies and increasing customer demands.

The volume and variety of data and the interconnectivity among data sources will increase decision-making velocity. Data will be used in a way that enables the agenda to be shifted from simply managing assets to situational awareness, prediction and planning. This will allow traditional rail business models to be revolutionized, with rail operators and customers becoming more empowered and informed. Investments, therefore, will need to be made in not only collecting the data, but also in its collation and analysis in order to drive practical action.

### *Instrumented*

Systems and solutions are just now beginning to allow the health of the operation to be measured, sensed or seen across supply chains, processes and infrastructures. Trillions of sensors are now deployed in our everyday life. Events, actions and objects are being sensed in ways we never imagined. Today, trackside devices monitor acoustic signatures and heat and wheel impact at most North American and many European railroads. RFID tags, read by fixed infrastructure along the wayside, help identify rail cars, while wireless networks and video systems provide monitoring of assets in rail yards. These discrete solutions are helping rail companies collect information and track the location of assets, which can improve productivity while providing increased safety and security for travelers.

**Instrumentation helps rail companies collect new information to monitor operations more closely and act more proactively.**

New developments in technology are creating new business models. For example, maintenance may be proactively initiated based on prediction of failure rather than regulatory schedule, and passengers can be billed for travel based on actual usage. Rail systems can be more fully optimized with deployed instrumentation technologies, such as the European Rail Traffic Management Signal (ERTMS) system, which is being developed across Europe. What makes ERTMS technology impactful to the industry is that its specifications are publicly available, enabling more consistent standards among rail systems and suppliers, and creating an environment conducive to greater collaboration and a broader ecosystem of service providers.[9]

Intelligent cameras and video systems are now being piloted in rail and intermodal yards in the United States and Canada. Located between the wayside and the station, they enable remote diagnostics and realtime monitoring. Benefits include improvements to the operational efficiency of a railroad's business, as well as the opportunity to improve network velocity, asset utilization, return on assets and operating ratio. Similarly, the use of video surveillance, enabled by transmission from the train to a control center, may also be leveraged to improve passenger and car security.

Although not new, mobile devices are certainly getting smarter, offering Global Positioning Systems (GPS) and other location-based capabilities that can be exploited by passenger rail operators to create new pricing and revenue models based upon actual usage. For example, instead of passengers purchasing cards or tickets for intended future travel from a desk or booth, passengers may instead use stored-value cards or devices and be charged based on usage. This would have the additional benefit of freeing up terminal floor space for use by shops and other revenue-generating opportunities.

The full extent of the smarter railroad enables an operator to know the location, state and condition of every asset within the entire network – a powerful set of data indeed.

Handheld devices used by way crews can improve freight maintenance with near realtime data capture of work progress. This enables the railroad to free up track sooner, increasing network velocity. Workers can also update asset inventory and realtime replenishment information, which facilitates having the right product at the right moment and can reduce inventory carrying costs and safety stock.

### *Interconnected*

When instrumented transportation systems work together, dynamically connecting across the internal rail network or across external rail networks, the flow of data and information can be highly leveraged. The railroads can offer improved and timely decision making for the internal railroad regarding asset deployment, utilization, maintenance and, for the external railroad, regarding schedule changes and services for customers, partners and suppliers.

With greater interconnectivity, business model transformation is possible and is already occurring in a number of ways:

- *Block train scheduling* for passenger and freight rail creates greater utilization of assets and capacity on shared lines by shortening the block distance between trains. Open sharing and connectivity of operational data and systems is essential to increase train velocity and reduce waiting times during intermodal connections.
- *High-speed passenger rail connectivity* is being developed across Europe through Railteam, a network of high-speed rail operators that bring together schedules, ticketing and services to offer customers a broader network, similar to alliance networks across the airline industry.[10] This kind of interconnection can also be deployed in the developing world in China, Russia, India and South America.
- *Seamless passenger travel* is possible by decoupling sales systems' business logic from distribution channels so passenger travel can be booked end to end, including regional rail, airline, hotel and bus.
- *Seamless freight delivery* is possible when freight operators allow inventory and schedules to be accessed by customers and interconnecting transit carriers.
- *iTransit and Google Transit* are examples of "mash-ups," interconnected Web sites that pull information from various sources and allow a person to navigate public transportation systems, with several options offered, such as pedestrian routes, subways and trains. The next wave of innovation will be for customers to purchase tickets via their mobile devices and use the boarding barcode they receive to pass through security checkpoints and ticket gates. This type of customer accessibility can be applied in the freight market too. It is possible customers could use data or voice input (such as Google's new voice search for the Apple iPhone) to log a shipment's start and end point and then book based on such factors as time, cost and even carbon impact, which are calculated for multiple transit options.

**Through greater interconnectivity, railroads can exchange information more broadly and make better, faster decisions.**

The benefit for customers in all of this is that their needs are accommodated intelligently, while distribution, scheduling and pricing management systems are brought together seamlessly in the background. The benefit for rail operators is the ability to fully utilize their networks and assets.

These examples of interconnectivity rely on an open software architecture, which provides the flexibility to support new, best-of-breed applications as well as legacy systems and enables future growth in the business. This supports business applications at the enterprise level including master data and asset management, resource planning, application integration and business process modeling.

### *Intelligent*

Business becomes smarter when relevant information is available to sense, analyze and act upon. More information on its own doesn't add insight; it needs to be transformed to allow for better planning, decision making, alerts and proactive execution. Every insight of the smarter railroad should result in actions that create new value for the internal and external railroad networks.

As rail distribution and transport management systems become more flexible, informative and easily accessed, customers and companies will choose rail because it is simply good business and adheres to suppliers' increasing requirements for transport that is cost effective, reliable, timely and socially responsible. Customers will choose passenger rail because it is convenient to book with other travel and is accessible via multiple self-service channels.

Mobile condition-based monitoring systems will provide railroads with more intelligence through continuous realtime capture and analysis of critical data, such as the health of a car (air pressure and brake monitoring, wheel bearing temperature, engine performance) as well as operational data (manifest verification, "dark car" identification, time-stamping of car spotting, freight condition, intrusion detection and hazardous materials). Mote-based sensors mounted on the cars trigger messages based on decision modeling and analytics that interpret the information. Autonomic routines built into this system will distribute information, dispatch service, order parts, schedule maintenance and perform remote diagnostics.

These new intelligent technologies can significantly reduce the need for fixed infrastructure along the wayside and provide a smarter, more flexible and predominantly mobile infrastructure. Fixed infrastructure is expensive to install and maintain, and difficult to update. A mobile, train-based system can mitigate significant capital expenditures over time, providing greater flexibility to take advantage of both evolutionary and revolutionary technology improvements. Train-based systems could sense changes in infrastructure, such as metal fatigue in overpasses and concrete fissures in ties, and notify work crews, procurement offices and public entities. These systems are programmable and have the ability to change their reporting based on their physical locations as they cross borders, city boundaries or other municipalities.

Both passenger and freight enterprises can operate with flexibility and responsiveness when information from operating systems across the business is leveraged for decision making, thus operating more intelligently. For example, when inventory – whether it be freight forward loads or passenger forward bookings – is integrated with scheduling, cars can be added and removed from lines based on need. Crew scheduling can be optimized and adjusted when crew management systems are similarly integrated. This type of business intelligence is supported by analytics.

> A key benefit of condition-based monitoring is a transformational shift from tracking cars with transponders to proactive monitoring of events, conditions and health of cars. As mentioned earlier, predictive maintenance can be implemented with greater assurances – a result of more, better and timely information that has been collected and analyzed.

**Information integration, sophisticated analytics and data modeling can infuse strategic and operational decision making with an entirely new level of intelligence.**

Analytics are fundamental for bringing together and making sense of valuable sources of data about the operation and its customers. Customers' use of online travel booking tools and transit sites create very rich data about their purchasing habits and how they travel. The benefit for rail operators is the ability to directly capture customer information that may be used to better understand travel patterns, intermodal utilization and route preferences. The analysis of such rich data enables a company to gain insights into maximizing revenue with intelligent pricing and yield models and to make better decisions about asset utilization, retailing and sales.

When operational data is brought together from across the enterprise, such as scheduling, crew optimization, maintenance, sales, revenue management and inventory, the railroad can use analytics to make informed and near realtime decisions about the operation. For example:

- How will a schedule change impact revenue, crew and capacity?
- How can empty wagons be better utilized and turned into revenue opportunities or redeployed?
- How will we forecast and respond to shifts in supply chain requirements?
- How can we better serve the secondary cities that airlines no longer serve (a more common occurrence in the United States), or open up new territories such as in China or Russia?

### *Creating a smarter railroad*

A smarter railroad will not be built overnight. But it does require bold steps, investments and the will to create real transformation. Rail executives should consider these questions in planning the path to a smarter railroad:

- Can the health of the operation be measured, sensed and incorporated into near realtime decision making?
- Are your business functions flexible enough to meet changing customer demands?
- Can you predict your maintenance needs based on actual conditions?
- Do you know the value, location, availability and condition of all your spare parts across the network?
- Are your systems fully integrated with those of external suppliers, customers and partners to leverage your combined assets, capacity and services?
- Have you conducted an analysis of your core competencies versus business functions that could be done elsewhere?
- Are you using your best talent to become instrumented, interconnected and intelligent?

**Leaders will use this time of economic challenge to invest in making their businesses smarter so that they emerge from this period stronger and more competitively positioned.**

## Conclusion

Rail executives must meet society's demand for rail systems that are integrated into our global economy, competitive with other transportation systems and flexible to meet global trade and passenger demands. The current economic slowdown provides a window of opportunity for making these investments; railroads should use this time to begin the transformation rather than being forced to do so in crisis mode.

For first movers, becoming a smarter railroad can help create important competitive advantages – an expanded rail ecosystem, asset optimization, new revenue model opportunities and new ways to serve customers. These advantages resonate with the global social movements that have emerged: railroads are "green," railroads are efficient, and railroads are economical.

For operators in expansion mode, smarter railroads can help reduce new line and rolling stock costs and significantly increase customer service in a capacity-constrained environment.

As the rail industry becomes more instrumented, interconnected and intelligent, business model innovation becomes more attainable. For rail executives to capitalize on such change, they need to accelerate investment in new intelligence. Building a smarter rail industry will not be a one-size-fits-all approach for everyone. The path to transformation for each railroad will depend on the maturity of the existing rail system, current capabilities and market demands.

## Appendix 1 – Smarter railroads around the world

### *China*

The forecasted growth in passenger and freight rail in China is driving the need for increased capacity for both existing rights of way and new lines. In the Chinese government's last five-year plan (2006-2010), US$182 billion was allocated for the development of railways between the years of 2010 and 2020.[11] In November 2008, the government announced an economic stimulus package centered on rail construction that will speed up this investment and bring its schedule ahead to potentially 2012-2015.[12]

China is planning to build 17,000 kilometers of new rail lines by the end of 2010. Of that, 7,500 kilometers will be built for passenger transport, and 5,500 kilometers will be built or upgraded to high-speed rail lines.[13] Large investments in predictive maintenance systems and traffic control are currently underway and will be critical to managing growth.

The advantage of China's sizable new infrastructure growth may not be dissimilar to when developing nations leaped from no telephony infrastructure to cellular/mobile technology, bypassing land-line telephone networks historically built on copper wire. China's rail system has a similar opportunity to leapfrog current rail infrastructure systems with new smarter capabilities.

Examples of potential performance improvement:

- *Safety and preventative maintenance* – Smarter capabilities can help to prevent accidents, collisions and derailments. Sensor-based early detection of potential equipment failures, which enables condition-based monitoring and a better predictive maintenance scheme, and various monitoring capabilities for rail infrastructure, such as track and bridge inspections, can reduce disruptions to passenger and freight service.
- *Reduce congestion* – Capturing realtime data in intelligent, world-aware systems, the smarter railroad will be a safer, higher performance railroad. Continual performance optimization can help reduce rail freight and container congestion.
- *Customer service* – Using intelligent aggregation of data, a smarter railroad can gain new insights to enable process transformations that result in improved efficiencies, increased effectiveness and new business capabilities. With event information such as train delays, perishable expiration dates, unauthorized asset moves, critical late parts, and service levels or quality of service not met, the railroad can evaluate, correlate and respond dynamically.

## North America

For the U.S. freight rail industry to meet demand and growth forecasts, significant investments will need to be made to existing and new infrastructure and rolling stock. The U.S. Department of Transportation forecasts that freight railroad demand will increase 88 percent by 2035.[14]

The American Association of Railroads estimates that US$148 billion of investment is required to meet 2035 volumes based on existing lines. This estimate pertains only to the expansion of lines and facilities and does not account for maintenance of lines or stock. Capital, maintenance and infrastructure expenditure made up nearly 40 cents on every revenue dollar U.S. railroads spent to keep up with capacity from 1980-2007.[15]

To meet this capacity shortage, U.S. rail companies are going to be reliant on productivity improvements and technological advances not accounted for in investment estimates, as well as further developing successful public-private partnerships. A recent example of this is the planned California High-Speed Rail Network connecting San Francisco to San Diego. Funding will largely come from a combination of state and federal funds as well as other public-private partnerships.[16]

The U.S. Rail Safety Improvement Act of 2008 (RSIA) mandates that Positive Train Control must be installed on all rail main lines used to carry passengers or certain highly hazardous materials by December 31, 2015. This and other elements of the RSIA present significant challenges for the U.S. rail industry.

### *Russia*

Liberalization and privatization is driving large-scale structural reform within Russian Railways, the wholly government-owned rail system. Rapid growth in both freight and passenger rail, along with plans to separate the freight and passenger businesses, require both modernization of infrastructure, railcars and locomotives as well as expansion of rail lines to support multimodal transport logistics and passenger services. Russian Railways plans to invest US$50 million by 2010 and US$390 billion by 2030.[17] A sizable focus on interconnectivity will be required to manage the many private rail operators and integration into the passenger and freight networks of Western Europe.

Moving manufactured consumer goods via intermodal containers from European and Baltic ports requires tighter integration with the transportation and logistics networks. Further, Russian Railway's potential injection of capital into providers such as Deutsche Bahn will require smarter rail capabilities from Russia.[18] Interchanging rail cars between Russian Rail and the European rail networks will require assurances related to the health and safety of the wagons, integration with condition-based monitoring systems and tight delivery schedules in performance based logistics contracts that require smooth rail yard performance and interchange. New and evolving regulations on the movement of hazardous materials will require implementation of railcar instrumentation and providing reliable information and connection to rail, government and municipal agencies.

Looking east, Russia has the opportunity to link Asian manufacturing capabilities with European consumer markets. Trans-Siberian movement of intermodal and commodity freight (timber and coal) into Europe will offer an alternative to maritime movements. In early 2008, Russia was part of a first-of-a-kind pilot for a direct rail line from Beijing to Hamburg, crossing through Mongolia, Russia, Belarus and Poland. The freight moved in 15 days, a vast improvement from 45 days by sea.[19]

### *Europe*

The European railroads are continuing to evolve and become smarter, raising the bar for all participants in their ecosystem. The European railroads are leading the world in how they interoperate and connect with each other and their customers. Due to its geographic nature, reliance on cross-border trade and passenger travel and recent liberalization, Europe's mature rail industry has invested more in the interconnectivity of rail networks than other global regions. Examples of this include the ERTMS project, which is establishing a standard for signaling systems across Europe (*see page 6*), and Railteam, which is building a network of already established high-speed rail operators *(see page 7*).

High rail utilization across most of Europe is increasing the need for dynamic freight scheduling and block train scheduling for freight and passenger lines as well as creating growth in high-speed rail.

DB Schenker Rail is an example of how interconnectivity may work successfully across borders and varied systems. Operating across five countries – Germany, Netherlands, Italy, Switzerland and Denmark – 60 percent of its freight volume crosses international borders. The company offers block train, single freight and combined transport services from a single source, with a focus on road-to-rail transport.[20]

## About the author

Keith Dierkx is Director of the IBM Global Rail Innovation Center. He has worked with railroads for over 22 years, primarily in logistics and information technology. He has been CIO of a global transportation company, and Vice President of a successful Silicon Valley technology startup. Keith is currently on the Business Advisory Board at the San Francisco State School of Business and is a past Technology Board member at the Auto-ID Center at the Massachusetts Institute of Technology. Keith may be reached at *kwdierkx@us.ibm.com*.

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