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Generational development in railway informatıon systems

Steven L. Murray*

*GE Transportation Optimization Solutions, Seattle, USA

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ABSTRACT

Advances in Information Technology in the railway sector have enabled automation as well as associated business process changes leading to continual productivity improvements. These can be broken down into several distinct generations beginning in the early 1960s and leading to the current era. The current era contains a multitude of modern IT systems delivering significant value to the railways.

1. Introduction

Railways are often perceived by the general public –at least in North America - as being anachronistic institutions, with the popular image of steam locomotives replacing horse and buggy as being one of the great technological innovations, but one which took place centuries ago.

However, I don't have to tell this audience that this image is unfair, and the reality is quite different. In almost every sector of engineering, and I include business processes in this broad category, railways have continued to lead the curve of adopting new technology.

In the arena of information technology, railways have been leaders in implementing technologies such as RFID, wireless communications, cloud computing, mobile handheld devices, and complex optimization algorithms.

In fact, the railways were some of the very earliest users of computers, implementing systems as early as the 1950s, with features like electronic data interchange (EDI) and bar codes in the late 1960s.

Each of these technological advances has, in turn, enabled an associated advance in business processes as well. This harnessing of transformative information technologies has enabled the railways to continuously improve productivity and maintain commercial competitiveness.

These advances can be broken down into several distinct generations, beginning with the first generation of mainframe computing in the late 1950s and early 1960s leading up to the present era.

For the purposes of my presentation, I'll mainly limit myself to topics where I've more direct experience, which is primarily in the freight side, but many of the same concepts hold equally true for passenger services.

2. Generations

I have divided railway IT into four distinct generations. Each generation has it's own set of transformative technology, associated business processes, and commercial effects.

* Corresponding author. *E-mail address: steven.murray@ge.com* (S. L. Murray).

2.1 First Generation

The business of running a railway has always involved a tremendous amount of information, be it timetables and schedules, waybills or consignment notes, charges and tariffs, and of course the tremendous number of physical assets – locomotives, wagons, signals, and all their specialized parts. Do anything on the railway, with the railway, or for the railway, and it likely involved a form filled with information. Given this metaphorical mountain of data and army of people shoveling paperwork, it is no wonder that railways saw the value in computers.

The first generation is then characterized by the high technology of the era; mainframe computers running in large data centers. Software was usually provided free by the hardware vendors, and programs were punch card routines. Users, who were distributed across the railway at the stations where the work was done manually, accessed the system using specialized terminals over private communications networks.

The business processes were the most data intensive ones involving equipment inventory and revenue processes. Instead of a clerk typing up or hand writing a train list, the list was printed by running a stack of punch cards through the machine. Selecting wagon sequence was done by simply shuffling the deck, and woe unto the poor operator who dropped his stack of cards.

In North America the Tele Rail Automated Information Network (or TRAIN) was one of the first centralized data repositories. Participating railways used Electronic Data Interchange (EDI) to send and receive messages about wagon status and location. These were cutting edge technologies before most people had heard of computers and required significant investment.

This very large investment, however, was returned through massive gains in labor productivity through automation.

2.2 Second Generation

The second generation used the development of midrange computer technology and more widespread communications networks to further deploy the same basic functional processes as the first generation. Smaller railways on smaller data centers, often using shared development or third parties, also started deploying basic inventory and revenue systems.

One significant business process changed involved the centralization of work and data entry. Railways were now able to close agencies and stations and move that data entry to centralized customer service and work order centers.

This again resulted in more labor productivity gains, as well as the beginnings of automation of the customer interface.

2.3 Third Generation

The third generation can be said to begin with the adoption of the Personal Computer or PC as well as the ongoing wiring of the business world over ever cheaper telecommunications technology. This led to both the proliferation of software applications to new parts of the railway, as well as growth of third party software developers.

In North America, the combination of the short line spinoff movement as well as new industry standards for EDI led to tremendous growth for IT. Globally, the restructuring and commercialization of railways nearly everywhere had a similar effect.

This widespread growth of IT brought about the beginning of a very dynamic period of business process changes.

2.4 Fourth/Current Generation

The current, or fourth in my classification, generation is a continuation up the exponential curve of technological change. The railway industry, so long considered change resistant, has become instead one of the most dynamic sectors around.

We'll review some of the current technologies in more detail in the following section, but in general these revolve around the astonishingly rapid spread of the internet and near ubiquity of connectivity.

Railways are now adopting new business processes at a rate unthinkable just a decade ago, and in so doing are positioning themselves as innovation and market leaders.

3. Current Transformative Technologies

So, what are some of these technologies? At GE Transportation I am fortunate to be involved a very broad spectrum of technology, but they broadly fall into three categories: connectivity, mobility, and mathematics.

3.1 Connectivity

The ability to connect to nearly any system from nearly anywhere is a technology capable of driving astonishing change.

Global Positioning Systems (GPS) and Radio Frequency Identification Devices (RFID) connect assets in real time, giving two way communications regarding time and place.

Cloud Computing and Open Systems connect systems to each other.

Geographic Information Systems (GIS) and Data Mining provide visibility connecting data with decisions.

These technologies provide an almost unlimited ability to connect information with assets with systems, which then provide visibility and decision making. More than almost any other factor, the innovations in connectivity have created significant business process changes.

3.2 Mobility

Mobility in the transportation industry seems like a logical fit, and it is. In addition to providing identification to mobile assets, such as through *chips* and *barcodes*, more importantly it delivers information to mobile users through handhelds and smart phones. This places actionable decision support tools right in front of users.

3.3 Mathematics

When I refer to mathematics I'm really talking about the basics of computer processing or how quickly a chip can perform mathematic functions. Moore's Law states that computer processing power doubles in power every two years, and since his initial paper in 1965 it has held true, if a bit conservative.

In terms of practical applications for railway IT, this growth in processing horsepower had led to numerous opportunities for optimization. True optimization of the kinds of problems presented by railway operations requires tremendous processing power and complex algorithms which have only been available fairly recently.

4. Current Business Process Changes

The combination of the three technologies has created a critical mass of business process changes across very broad parts of the railway. These changes are creating unprecedented, at least in the past 50 years, value for the railways.

Using the DuPont Model of deconstructed shareholder value, the three areas where value is derived are: increasing revenue, reducing costs or operating expenses (OpEx), and decreased asset expense (CapEx).

These new technologies are achieving such in multiple ways, but I'll outline just a few examples from my direct experience at GE Transportation, but these just illustrative of the multiple ways that multiple railways are able to achieve similar results.

4.1. Increasing revenue

There are two specific ways in which new technology creates increased revenue – improved customer service and increased capacity. We'll start with the more difficult of the two – improved customer service.

4.1.1 Improved customer service

There are multiple methods in which customer service or satisfaction can be measured. Some of the most basic are customer satisfaction surveys. These have the advantage of being quantifiable and measurable.

The relationship of customer satisfaction surveys and technology is long standing. One of the most common irritations of customers is when they receive inaccurate invoices or information. Of course, automation of rating and invoicing frequently corrects these issues. Better systems for entering, storing, and quoting rates has also resulted in reduced railway billing errors. And, astonishingly, some of the most basic customer service questions of: How much does it cost? Where is my shipment? and When will it arrive? are still answered with difficulty and slowly by all too many railways around the world. However, all the generations of railway IT have gone a long way towards answering these to the growing satisfaction of customers. This is the basics of railway service.

Moving beyond that, however, the latest generation is starting to tackle some of the more difficult aspects of railway service, such as reliability and predictability.

Reliability is pretty self-explanatory. The role of current generation IT in reliability is through predictive maintenance and inspection systems. For example, rather than waiting for a locomotive, wagon, or signal asset to fail or break, modern IT systems use *remote monitoring and diagnostics* to alert central systems to impending issues and suggest troubleshooting. Some of the technologies used include GPS, remote sensors and chips, wireless communications, cloud computing, and sophisticated processing. In addition, asset management systems, which employ many of the same technologies, better prescribe *preventative inspection and maintenance* programs. Additional technologies here are advanced databases and mobile or handheld computing.

Predictability is accomplished when a railway has structured operations, but also more reliable service. This allows IT systems to make better assumptions and use very powerful processing to more accurately determine service plans and interruptions over complex networks. Modern *rail movement planners* which incorporate thousands of variables for service execution replace haphazard human “guesswork”. This becomes increasingly important as the industry loses widespread domain knowledge through attrition.
Finally, customers like being able to do business with “modern” partners with whom it is easy to do transactions. Increasingly, people are more and more expecting to do basic business transactions over the internet, or on their smart phone. There are many railway IT systems which allow the same customer experience as shipping a package via DHL, UPS or other courier. It is in fact becoming a basic requirement that railway shippers want to look up a price, order service, track their shipments, and receive an invoice all over the internet.

4.1.2 Increased capacity

IT increases Railway capacity first through better reliability as outlined above. A railway which suffers line or operating failures obviously also suffers from decreased capacity over one which uses planned maintenance.

But IT systems are also able to increase capacity several other ways. Things like Communication Based Train Control (CBTC) and other modern signaling systems allow for increased speed, reduced headways, and overall increased line capacity.

Additional capacity can also be gained through modern Command and Control systems which optimize work flow. Our experience is that overall capacity is increased 15 to 20 percent in real world environment through the use of modern optimization routines. For one example we found approximately a 15 percent increase in overall system capacity with our Rail Edge Movement Planner on the Norfolk Southern Railway in the US, who uses optimization to plan tactical train and yard operations. In another sector, our OASIS intermodal terminal operating system uses optimization for their hostling or crane operations in container terminals. Here, we use a multilevel heuristic optimization engine that allows terminal planners to do real time optimization to optimize for multiple objectives, such as reduced travel time, fuel use, or maximize throughput, or to blend them.

These are just two of many areas in which optimization can be applied. Other areas are in wagon distribution, locomotive and crew management, and maintenance management.

4.2 Reducing Operating Costs (OpEx)

I’ve touched on it above, but many of the systems I’ve mentioned also result in reduced operating costs. Of course, modern systems which compute optimal operations for a locomotive result in direct reductions in fuel use, but the systems which are optimizing operations result in overall more efficient operations, less work, in other words, which also directly results in reduced expenses. Saving work means less fuel and staff costs, and better decisions lead to better outcomes overall.

4.3 Reducing Asset Expense (CapEx)

Finally, railways are well known for being one of the most capital intensive industries around. Reducing the expense of assets is critical for the competitive success of railways, and not just in competition with other modes, but in competition for investment capital as well.

Beyond the direct reduction in need for assets through their more efficient use, modern IT is better able to maintain the assets in use. The need for spare parts, for one example, for locomotives, wagons, and signaling equipment is reduced through use of maintenance management IT systems.

5. Conclusions

IT systems have historically had a significant effect on the bottom line. But, rather than slowing due to already solving easy problems or "picking the low hanging fruit", the technology curve is increasing exponentially, and the business process change curve follows closely behind. More than ever, IT systems are resulting in significant gains, and 15 to 20 percent is very significant, in productivity and cost savings. This is both a golden age for railways, and for railway technology.

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