ASTOC
Digitalization, AI and Predictive Maintenance

UIC Digital Days
Paris, December 6th, 2018

CEO, Björn Westerberg
42 members
Quality - Capacity – Competitiveness

Associerade medlemmar

- Ansaldo STS Sweden AB
- ALSTOM
- BOMBARDIER
- Grenland Rail
- Jernhusen
- ProTrain

Föreningens medlemmar

- Arlanda Express
- Arriva
- BLÅ TÅGET
- Botnia Tåg AB
- DSB
- Keolis
- Inlandsbanan
- Nordiska Tåg AB
- Railcare
- Schenker
- Södertäljebanan
- Stockholms Spårvägar
- Tågfrakt
- TMRail AB
- Tågåkeriet i Bergslagen AB
- Trafikförvaltningen
- Trafikverket
- Tågkompaniet
- Trafikomläggning
- CargoNet
- LKAB
- Eurocontrol
- Cargo
- CFT
- Transdev
- MTR
- Nobina
-_deep
- trainpool
- Real Rail AB
- Nóva
- Cargo
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Agenda

01 Digitalization and AI
02 Predictive Maintenance - Past – Present – Future
03 Predictive Maintenance – Operator Examples
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01 Digitalization and AI

02 Predictive Maintenance - Past – Present – Future

03 Predictive Maintenance – Operator Examples
Digitalization is underway; maturity varies by industry, but most potential is yet untapped

<table>
<thead>
<tr>
<th>Industry</th>
<th>Digital maturity</th>
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<tbody>
<tr>
<td>Airlines</td>
<td></td>
</tr>
<tr>
<td>Hotels</td>
<td></td>
</tr>
<tr>
<td>Car rental</td>
<td></td>
</tr>
<tr>
<td>Mail, courier, express, parcel delivery providers</td>
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<tr>
<td>Contract logistics providers</td>
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<tr>
<td>Rail</td>
<td></td>
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<tr>
<td>Freight forwarders and carriers</td>
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</tbody>
</table>

- Efforts to date have mostly digitized the business “as-is”
- Organizations either haven’t recognized the real digitalization opportunities yet, or aren’t capable of implementing them
The rail industry may soon face the tipping point of the digital lifecycle.
6 disruptions could fundamentally change the travel and transportation industry

- **Online platforms**
  - "Traditional TTL companies as capacity providers only?"

- **Expansion of large technology companies**
  - "Fear of the hungry tech giants?"

- **Advanced robotics**
  - "Fundamental changes to cost structures?"

- **Asset sharing**
  - "The door opener for innovative startups in the industry?"

- **Autonomous vehicles**
  - "Cost structures, opportunities, competitors – will everything change?"

- **Additive manufacturing**
  - "The 'big hit' to the logistics industry?"

SOURCE: McKinsey & Company
Reconfigure or be reconfigured – Rail as prime mover..?
Internet of Things
Enabling technologies

- Monetization of Service
- Applications & Analytics
- Cloud & Connectivity
- Devices & Sensors

Manufacturing, Energy, Transport, Public Safety, Health—care, Media, Telecom Operators, Other industries...
A BROAD SPECTRUM OF REQUIREMENTS

Massive IoT-communication

- SMART BUILDING
- LOGISTICS, TRACKING AND FLEET MANAGEMENT
- SMART METER
- SMART AGRICULTURE
- CAPILLARY NETWORKS

Low cost, low energy
Small data volumes
Massive numbers

Critical IoT-communication

- REMOTE HEALTH CARE
- TRAFFIC SAFETY & CONTROL
- INDUSTRIAL APPLICATION & CONTROL
- REMOTE MANUFACTURING, TRAINING, SURGERY

Ultra reliable
Very low latency
Very high availability

Accelerating IoT
MOBILITY-AS-A-SERVICE
ONE-STOP-SHOP FOR TRAVEL SERVICE COMBINATIONS

TRAVEL NEEDS
- COMMUTE TO WORK
- COMMUTE TO SCHOOL
- BUSINESS TRIPS
- VISIT FRIENDS AND RELATIVES
- TRAVEL TO EVENTS
- TRAVEL TO SPORTING ACTIVITIES

Simplicity
Your Mobility-as-a-Service broker
New and more loyal customers

TRAVEL SERVICES
- RENT
- POOL
- SHARE
- TAXI
- PUBLIC TRANSPORT
- RENT

ADDITIONAL SERVICES
- TRAVEL GUARANTEE
- BONUS PROGRAMS

Simplicity
Data-integration platforms consolidate transport data across providers and modes, supplying mobility services providers with coherent data sets.

### Public transport data-integration platform

**Quality-assured** (complete, consistent, current) plan, real-time, and infrastructure data

- Trip data and vehicle characteristics
- Infrastructure data
- High-speed rail
- Regional train
- Rapid transit
- Bus

**Data can be accessed by all mobility services providers and displayed across all channels**

- **Cost savings**
  - Information channels (from stations to apps) benefit from centralized provision

- **Consistent data**
  - Access to one central database prevents inconsistencies across channels

- **Competition focuses on user experience, not on data access**
  - Data from all public transport operators in the country, across modes
Definitions AI

Artificial intelligence: A definition
AI is typically defined as the ability of a machine to perform cognitive functions we associate with human minds, such as perceiving, reasoning, learning, and problem solving. Examples of technologies that enable AI to solve business problems are robotics and autonomous vehicles, computer vision, language, virtual agents, and machine learning.

Machine learning: A definition
Most recent advances in AI have been achieved by applying machine learning to very large data sets. Machine-learning algorithms detect patterns and learn how to make predictions and recommendations by processing data and experiences, rather than by receiving explicit programming instruction. The algorithms also adapt in response to new data and experiences to improve efficacy over time.
Definitions – Machine Learning

Machine learning provides predictions and prescriptions
Types of analytics (in order of increasing complexity)

Descriptive
- Describe what happened
- Employed heavily across all industries

Predictive
- Anticipate what will happen (inherently probabilistic)
- Employed in data-driven organizations as a key source of insight

Prescriptive
- Provide recommendations on what to do to achieve goals
- Employed heavily by leading data and Internet companies

Focus of machine learning
### Problem types and sample techniques

<table>
<thead>
<tr>
<th>Problem types</th>
<th>Sample techniques</th>
<th>% total AI value potential that could be unlocked by problem types as essential vs. relevant to use cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification</td>
<td>CNNs, logistic regression</td>
<td><img src="chart.png" alt="Chart" /></td>
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<tr>
<td>Continuous estimation</td>
<td>Feed forward neural networks, linear regression</td>
<td><img src="chart.png" alt="Chart" /></td>
</tr>
<tr>
<td>Clustering</td>
<td>K-means, affinity propagation</td>
<td><img src="chart.png" alt="Chart" /></td>
</tr>
<tr>
<td>All other optimization</td>
<td>Genetic algorithms</td>
<td><img src="chart.png" alt="Chart" /></td>
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<tr>
<td>Anomaly detection</td>
<td>One-class support vector machines, k-nearest neighbors, neural networks</td>
<td><img src="chart.png" alt="Chart" /></td>
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<tr>
<td>Ranking</td>
<td>Ranking support vector machines, neural networks</td>
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<tr>
<td>Recommender systems</td>
<td>Collaborative filtering</td>
<td><img src="chart.png" alt="Chart" /></td>
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<tr>
<td>Data generation</td>
<td>Generative adversarial networks (GANs), hidden Markov models</td>
<td><img src="chart.png" alt="Chart" /></td>
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**NOTE:** Sample techniques include traditional analytical techniques, machine learning, and the deep learning techniques we describe in this paper as AI. Numbers may not sum due to rounding.

**SOURCE:** McKinsey Global Institute analysis
Use of AI and Big Data

**What will happen?:** … uses data to forecast based on complex algorithms or rules; this can be e.g., the forecasting of traffic jams, preventive maintenance.

**Why did it happened (hypothesis type):** … thoroughly analyses data to support important (strategic) decisions or to understand root causes for unusual observations; typically a one-off effort.

**Why did it happened (machine type):** … looks for patterns in the data to explain a – so far – not understood observation.

**What is happening now?:** … looks for trigger information in the data that indicates need for action; examples can be triggers for preemptive maintenance.

**What happened?** … slices and dices data to create transparency on activities, financial or quality outcomes.

SOURCE: McKinsey & Company Big Data Analytics Team
Exhibit 12

Marketing and sales and supply-chain management and manufacturing are among the functions where AI can create the most incremental value.

Highest potential impact business problems per functional area
Impact size comparison by chart area
$ trillion

NOTE: Numbers may not sum due to rounding.

SOURCE: McKinsey Global Institute analysis
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Corrective maintenance

- Fix trains when broken
- Workshop dependent for information regarding maintenance
- Manual follow up
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- Workshop dependent for information regarding maintenance
- Manual follow up

Preventive maintenance
- Relative static maintenance plans
- Manual planning
- Bulk delivery creating maintenance spikes affecting the availability
Predictive maintenance

› Predict the maintenance needed based on historical data such as MTBF, performance and current vehicle status

› Perform “What if” analysis to eliminate future risk factors and ensure highest availability

› Ensure no maintenance spikes in the budget the coming 5 years
Corrective maintenance
- Automated follow up of corrective actions
- Statistical basis for improvement of preventive maintenance
- Automated systematic failures
- Overview of MTBF for components

Preventive maintenance
- Automated follow up of preventive maintenance
- Identify improvement potential by knowing how the maintenance is performed relative plan
- Ensure highest availability by knowing which task that are critical

Predictive maintenance
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By analysing the performance and measurement data, building a decision tree gave the possibility to do predictive maintenance on critical components. The model provided a better understanding of reliability, asset value and economic outcome of different scenarios.
Data Harvest
Collect data from different sources, API, IoT, .xlsx

Master Data Management
Secure and certified processes enhanced data quality.
Data sources are connected to enable effective and standardized analyses.

Domain expertise
Industry experience and genuine system knowledge combined with advanced data analytics resulted in industry leading know-how.

Data science and BI
KPI’s, algorithms, statistical models, machine learning, reports and system data for business recommendations and decision making.

Making the difference
Through change management processes and implementation, identified opportunities that provided local lasting value.
Agile and continuous improvements of business processes.
Operator case II: SJ

- Punctuality
- Availability
- Efficiency
Virtual

Physical

Assets

?
Solution: Wheelbearings

- Continuous measurement of temperature and vibrations
- External analysis
  - Bearing condition reported to SJ
- Added values
  - Wheel damage
  - Rail health
- 3 months warning
Making the data useful

- Component condition data
- Traffic plan
- Passenger occupancy
- Workshop plan

= Predictive maintenance
Structure

Systems perspective

Purpose
- Availability
- Reliability
- Safety
- Efficiency
...

Goals
- Decrease cost
- Increase capacity
- Customer satisfaction
...

Method
- Sensors
- Detectors
- Analysts
- AI Algorithms

Processes
- Education
- Operations
- ...

Perspective
Future outlook
Lessons learned

Digitalization and the extended condition based monitoring approach with remote diagnostics offered the following key benefits:

• Predictive Maintenance/Condition Based Maintenance
• Fewer disruptions in traffic and better decision support when problems occurs
• Better analytical capabilities to find improvements
• Lower costs
Implications of AI
Member feedback

• The real question: How to improve decision making?
• No definition of AI, need for a standard?
• No clear business case yet, moving target. Automatization most common area
• AI – useful for pattern recognition, classification and prediction
• AI – machine learning and probabilities
• AI does not yet solve new problems, do we fit AI to the right problem?
• Moving AI to complex and unsolved existing problems
• New trains equipped with many sensors and data - potential
Think Big,
Start Small,
Act now!

Björn Westerberg, CEO, ASTOC
Mobil: +4673 - 802 67 11
E-post: bjorn.westerberg@tagoperatorerna.se