10 Reasons Why **Rail industry** Must Embrace **Automation**

Author:

Mr. Elen Katz

Founder & CEO | Rail Vision Ltd.

Research & Drafting: **Dr. Rami Guissin**,

Lead - Operations Research | Rail Vision Ltd.

"At a time when digital solutions are transforming almost every industry, railways simply can't afford to be left behind"

The World Bank [Ref.1]

As automation is being embraced by evolving transportation industries and market segments (e.g. automotive, aviation), the rail industry is likewise considering and moving towards automated and remote-control operation of trains in a broad range of applications.

Fig. 1 illustrates the envisioned functionalities of future rail in the breaking of new grounds towards the development and adoption of automation in its operations.

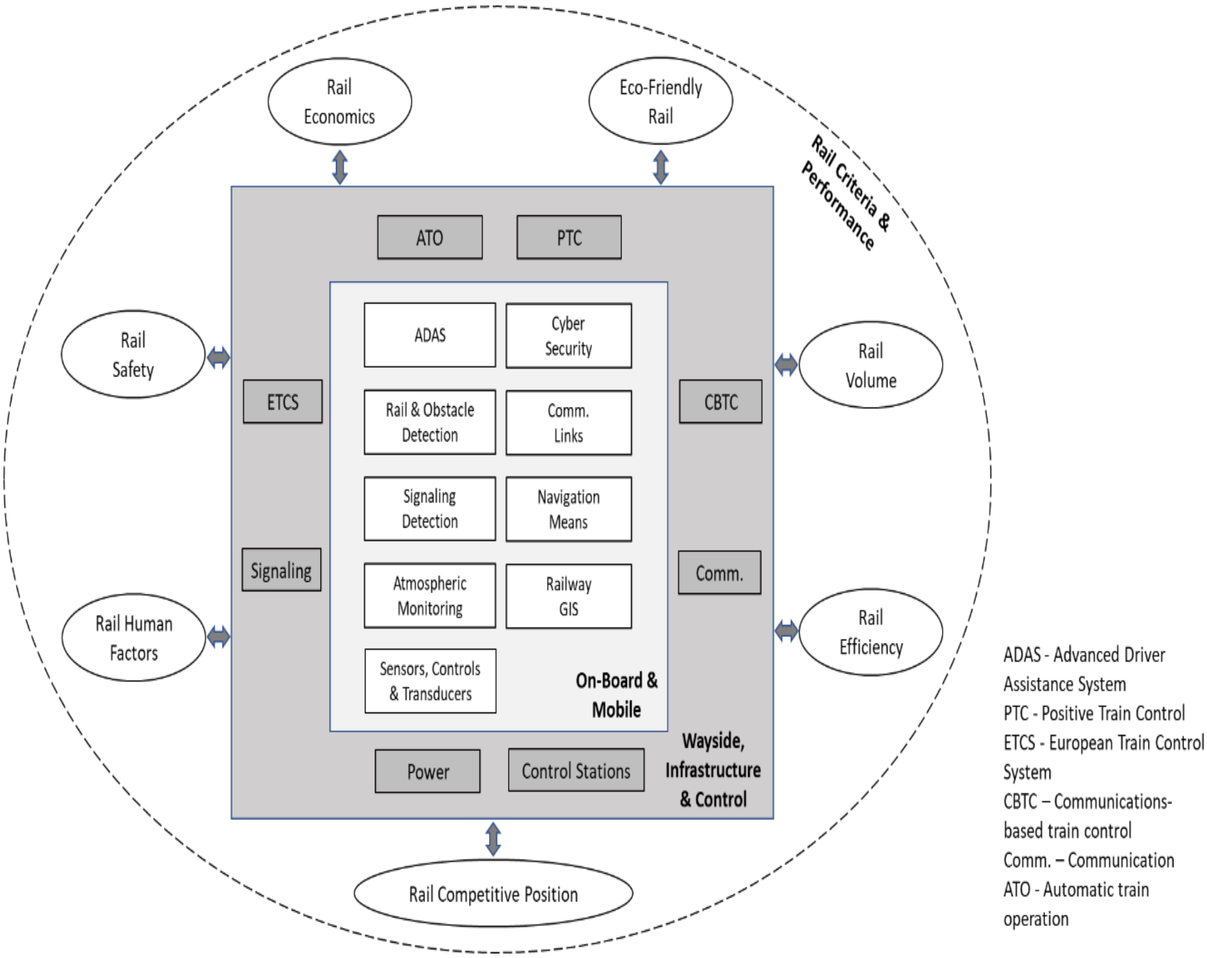

Figure 1 - The envisioned construct of future rail with the development and adoption of automation.

The impact of digitization on the railway sector cannot be overstated. In fact, digital technology is disrupting essentially all components of railway operations [Ref.1]:

- Rolling stock. Due to advances in automation, self-diagnosing and real-time geolocation tracking, trains are becoming increasingly smarter and safer.
- Control and signaling systems: Digital systems will enhance the reliability and performance of rail operations.
- Railway infrastructure. Internet of Things (IoT) sensors and devices are enabling a variety of obstacle and damage detection, preventive maintenance, logistics providers and transport modes.
- Revolutionary communications and cloud infrastructure will offer attractive solutions for handling large volumes of data.
- Computerized self-learning algorithms will make for more efficient dispatching, routing, and maintenance scheduling.
- Smart monitoring and surveillance systems will increase safety by improved and reliable detection and mitigation of hazards, intrusions, railway crossings and driver behavior in challenging and accumulated stressing situations.

1. Economic Viability of Rail

- ✓ **Reducing "down-time" of rail operations** caused by unnecessary stoppages due to accidents, infrastructure failures and wear, human errors, environmental and illumination factors, and adverse weather conditions.
- ✓ **Reducing infrastructure maintenance costs** by mounting unique sensors on locomotives and vehicles that support multiple sensory functions and data processing, including obstacle detection, navigation and infrastructure monitoring. The combined use of (i) infrastructure monitoring based on imagery and analysis compiled from daily and regular freight and passenger train runs, together with (ii) existing maintenance operations that provide high quality data albeit at sparsely scheduled runs (every few months), is envisioned to provide an optimized and cost-effective solution to future railway infrastructure monitoring needs.
- ✓ **Governments consider trains and railways as critical infrastructure,** and the transport of cargo and humans as strategic to society. The continued support and commitment to such critical systems, relies on technological advancement that will justify such support of the railway industry segment.

2. Eco-Friendly Rail

- ✓ **Improving the use and consumption of energy** is key to any and all future envisioned rail applications, irrespective of the propulsion means (diesel or electric). One determinant of optimized railway energy consumption (and minimal brakes use) is associated with intermittent acceleration and deceleration of trains throughout their routes. Train driving skills include the ability to maintain and adapt train speed to the driver's situation awareness of safety criteria, responsivity to track signals and signs, and route timelines.
- ✓ **A significant saving of energy consumption**, as well as reduced brake and infrastructure wear, can be achieved by real-time computer-controlled train speed, acceleration and braking decelerations, based on communication and access to multiple data sources including train type and load (passenger/cargo, type of cargo e.g. refrigerant, hazardous material), track geometries and conditions, train dynamics, automated image-based signs and signals interpretation, and automated driver scene visibility estimation.

3. Enhanced Rail Safety

- ✓ **The introduction of Advanced Driver Assistance Systems (ADAS)** in rail applications aims to increase the availability and accuracy of safety and driving-related information for the driver's decision-making processes. For example, in Light Rail Vehicle (LRV) applications, it is known that more than 90 percent of accidents are caused by human factors, while 80 percent of these are caused by distractions in the three seconds before the accident occurred. An ADAS that warns drivers some 4-5 seconds earlier, will prevent many of such accidents.
- ✓ **By incorporating real time communication** between compatible (i) stationary wayside sensors along the tracks and (ii) rolling stock-mounted sensors, important information such as train speed and position, weather and environmental conditions, track condition, knowns hazards and level crossing information may be exchanged and utilized in such ADAS applications.

  Automated cargo handling, unlike passenger traffic, can be transported and delivered without human intervention. All operations and works at and around shunting yards may be performed either autonomously or via remote control, hence reducing the exposure of rail employees to danger in such operations.

4. **Increased Rail Volume**

- ✓ **The essence of autonomous and automated rail operations** (e.g. CBTC, ATO, ETCS) is the increase of rail throughput in terms of transport efficiency, productivity and volume. More passengers and cargo, in shorter periods of time, with reduced wear and tear, and without compromising the highest safety levels.
- ✓ **As passenger and cargo volume increases**, increased demand for railway tracks and professional rail personnel workers to support the expanding industry. Associated upgrades in rolling stock platforms will increase the production of a wide range of on-board and wayside equipment in the rail industry.

5. **Human Factors in Rail Operations**

- ✓ **Manpower in the rail industry is a significant and costly element**, both in terms of drivers and infrastructure maintenance. Railways typically comprise long linear strips that span thousands of kilometers. The continuous and timely operation of such systems requires a great deal of effort, as drivers are required to cover extensive distances, often in challenging conditions (e.g. visibility, weather), hence pushing their physiological (e.g. exhaustion, vision), and mental abilities (e.g. alertness, concentration, stress) to their limits. Another aspect of train driver's mental fear and trauma is associated with suicides along railway tracks, which in turn may result in treatments, leave of absence and resignations.
- ✓ **The human aspects and the accumulated stress of train drivers** calls for the adoption of ADAS solutions, that will accelerate the adoption of automation in the industry. The train driver's role is highlighted by three functions: (i) Observation and situation awareness of the tracks and their immediate surrounds, (ii) Acceleration and deceleration, and (iii) braking when needed. These three important roles may be assisted (and eventually replaced) by technological and computerized systems (e.g. ADAS) that will incorporate the multitude of available and computed information regarding the train and locomotive, tracks, signaling, environmental conditions etc. This will also reduce train drivers' variability in the behavior, interpretation and response to acute and diverse circumstances, as they will increasingly be assisted by, and relying on highly integrated and real-time computerized data. Such ADAS solutions will also be designed to minimize driver distractions as they can automatically monitor the drivers' level of alertness, concentration and response to the system's generated data, and attract their attention.

- ✓ **The recruitment and training of new train drivers** is an enduring and costly process. In recent years, in light of drivers' responsibilities and accumulated stress, we are witnessing a decline in the number of train drivers in Europe and such recruitment is becoming very challenging. Dealings with manpower and labor unions of railroad professionals requires tremendous HR systems and suffers from occasional union strikes that significantly effect operations. The need to transport drivers to and from train parking areas and lines is both costly and logistically complex. With the use of autonomous systems, a significant reduction in the number of employees and organizational is achievable.

6. Development of Related Industries

The introduction of autonomous and remote-controlled operations in the rail industry must combine additional key building-block functionalities and technologies from other industries:

- ✓ **Cyber Security:** Rail systems with autonomous and remote-control capabilities bear cyber-attack strategic vulnerability that must be addressed and resolved, as they will otherwise impose hurdles in such systems' acceptance in the industry.
- ✓ **Obstacle detection / Situation Awareness:** During the interim phase of the autonomous systems implementation, ADAS solutions will include rail detection, object and obstacle detection, signaling (signals and signs) detection and environmental and visibility determination, whereby these functionalities will exceed the abilities of direct view of the drivers. These systems will provide extended detection ranges, in extreme weather and environmental conditions, and will respond rapidly thereby facilitating driver appropriate reactions. In future autonomous trains in which train drivers will be removed from the cabin, high performance obstacle detection and automated situation awareness will become requisite to any such applications.
- ✓ **Track Wayside Sensors:** The ability to combine and fuse onboard sensors with stationary wayside sensors is envisioned in future autonomous operations in improving and maintaining safety.
- ✓ **Communication:** As passenger and cargo railway traffic increase over time, higher volumes of data transmission will be needed. Information traffic will become more intense and precise, and will require reliable information communication systems. Moreover, a larger number of passengers relying on onboard communications networks, will expect to connect with the outside world, meaning that broadband communications will be called for. The

automation and improvement of the rail industry is directly related to improving the communications infrastructure.

- ✓ **Envisioned automated passenger services will incorporate technologies** such as broadband, mobile internet, big data analytics and cloud computing. The digital concept for passenger rail will include for example connected commuters, Intelligent stations and smart ticketing supporting intermodal travel.
- ✓ **Rail-related Data:** The extensive rail onboard and wayside sensors will create enormous amounts of diverse data, including for example visual, acoustic, electric, weather, visibility, signaling, maintenance, passenger and cargo information etc. The immense data volume will need to be gathered, recorded, analyzed, stored and distributed, as cloud storage will become a key element of the future of rail.

7. The Future Rail Competitive Position

- ✓ **The current and future rail transport competitive position** as compared to road and maritime transport depends largely on its transition and procurement of ADAS solutions, thereafter evolving towards remote-controlled and autonomous platforms and operations.

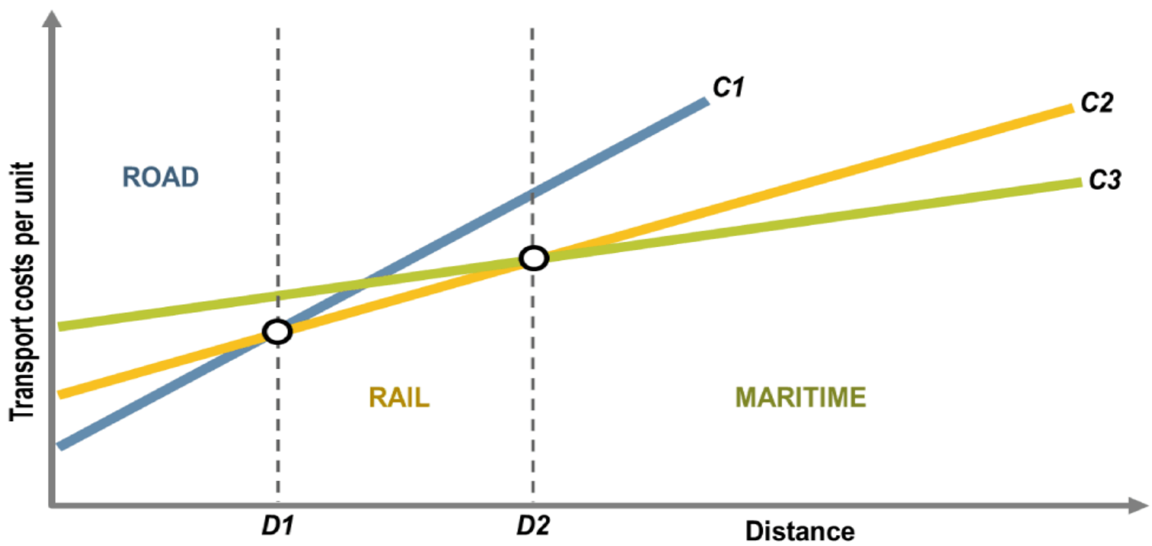

Figure 2 - Generalized comparative cost functions of road (C1), rail (C2) and maritime (C3) transport as a function of distance.

- ✓ **Freight transport modes (e.g. road, rail, maritime, aviation) have different cost functions** according to the serviced distance and varying geographies. Fig. 2 illustrates generalized comparative cost functions of road (C1), rail (C2) and maritime (C3) transport as a function of distance [Ref.2]. Although these functions vary over geographies and market densities, they do reflect the lower cost of road transport for short distances, and its cost increase compared to rail and maritime costs. At a break-even distance D1, it becomes more profitable to use rail transport than road transport while from a break-even distance D2, maritime transport becomes more advantageous. Point D1 is generally located between 500 and 750 km from the point of departure, while D2 is approximately 1,500 km. Evidence from passenger transport also underlines a similar distance-based behavior. Rail transport has several key advantages over road (trucking), particularly in terms of energy efficiency (4 times), capacity (6 times) and costs (2 times).
- ✓ **Future expansion of the rail freight market** builds on increased efficiency and volume of rail via automation of shunting yards and ADAS-equipped freight trains. The advance of freight rail operations will reduce the D1 break-even distance and will increase the respective D2 distance.
- ✓ **In the passenger transportation market, High Speed Rail (HSR) and air transportation are close competitors** over many regional transport systems, whereby time and distance factors are considered. Airports are usually located far from city centers, while conventional and HSR stations are much closer. For short distances of less than 150 km, conventional rail services are usually more competitive (air transport is almost never flown over these distances) than HSR. This is mainly due to higher frequencies of services for conventional rail. As illustrated in Fig. 3 [Ref.3], the main service window for HSR is between 150 and 775 km, a segment over which it generally has a time advantage over air transportation. On trains passengers can carry increased weight, chat on mobile phones at any time, move freely along the carriages, and generally feel more secure being on land. For distances over 800 km, air transportation is usually more advantageous.

- ✓ **Future expansion of the rail passenger market** builds as well on automation that first comprises ADAS-equipped solutions to regional trains, followed by ADAS upgrades to HSR systems, all aiming to increased efficiency and volume, and eventually leading to autonomous operation. Increased speed of HSR systems is also envisioned subject to upgraded HSR infrastructure.

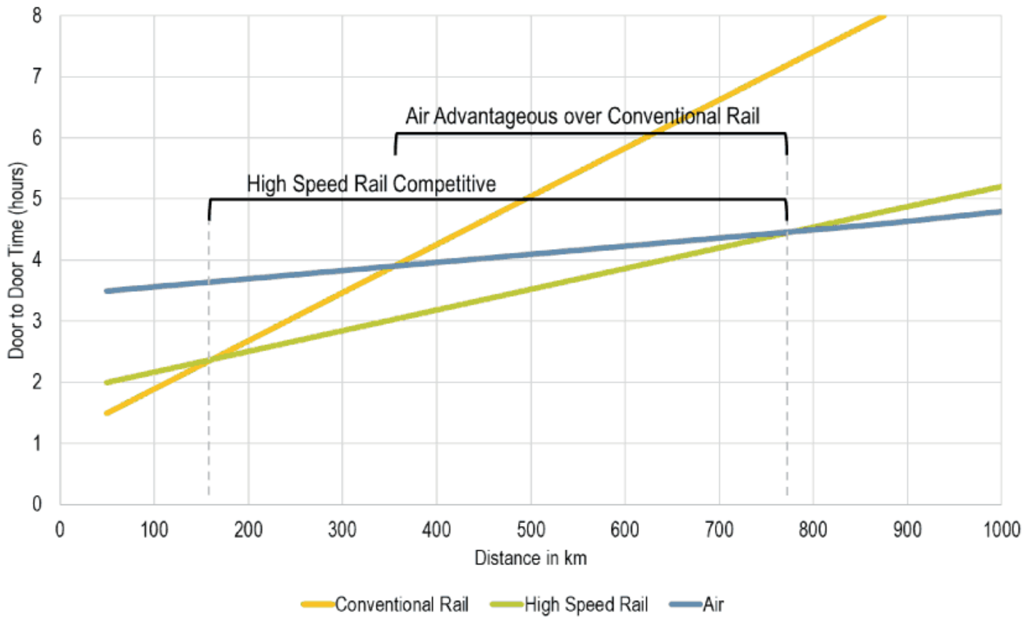

Figure 3 - Breakeven distances between conventional passenger rail, HSR and air transportation.

8. Comparative Risk in Transport Automation

- ✓ **Autonomous road vehicles:** In the event of a malfunction of a private vehicle on a public roadway, safety hazards and damages may occur everywhere as the vehicle is free to move anywhere.
- ✓ **Aircraft autopilot:** Automation in aviation has been there for about 60 years, and has brought reduced aircrew and ground personnel, and increased efficiency and safety. In the early days of commercial aviation, an aircrew consisted some five airmen in the cockpit, who were engaged in flying, navigation, system monitoring, weather and communications. Currently with the entry of technology into the aviation platforms, the cockpit and ground stations, there is only a pilot and a co-pilot whereby all other operations are performed by technology. Over the years, technologies have proven their reliability and safety, efficiency and cost-effectiveness.

- ✓ **Autonomous trains:** Because modern trains communicate with the infrastructure and are aware of its condition, and because trains travel only along tracks and in a controlled environment, in the event of future autonomous train failures, damages incurred will be generally limited to track locations and will not pose a danger to the external environment. Therefore, managing risk along the tracks and in their vicinity are more manageable.

9. Automation – A Unique Opportunity for Rail

- ✓ **Digital development provides a unique opportunity for railways** not just to stay relevant, but also to increase their share in the overall transport and logistics market, and to become an integral part of the transition toward greener, more sustainable freight transport as well as passenger transportation.
- ✓ **The potential benefits of digitization and automation include:**
  - Performance: Automated and predictive systems will result in fewer delays and breakdowns, automated dispatching, routing and scheduling, increased capacity with trains running closer together and lower costs.
  - Competitiveness: Digital solutions will substantially improve journey times, reliability, traceability, and coordination with other modes of transportation.
  - Increased efficiency: Reduced transaction costs, especially with the integration of blockchain into rail operations.
  - Improvements in safety and security: Advanced detection and tracking of potential obstacles and impending collisions, and automated infrastructure monitoring will address and mitigate the variety of rail operations risk.

10. A Proposed Initiative for Promoting Automation in Rail:

- ✓ **With the potential advantages of future rail automation** and the broad diversity of multi-disciplinary technologies, solutions and connectivity required for such strategic industry transition, a collaborative industry forum/framework initiative is called for. The envisioned time frame of the initiative is a three-year term, and is primarily intended to serve and boost the rail industry's initial transition period towards automation, and to deepen the collaboration across industries thereby enhancing the adoption of rail automation.
- ✓ **The proposed *AutomateRail* initiative** will function as a non-profit organization (NPO) acting on behalf of, and financed by, a selective industry consortium, and will provide an open and transparent stage for developers and manufacturers (e.g. startups, corporates,

academia, rail operators and agencies) to demonstrate their respective technologies and solutions which are considered viable for current and future rail automation. Demonstrations will focus primarily on viable solutions based on (at least) prototypes and technology demonstrators.

- ✓ ***AutomateRail* management, officers and consultants** will designate, prioritize and coordinate such demonstrations to the rail industry, and will publish its activities, field demo's and results in a digitally distributed newsletter. The *AutomateRail* operations, including management and staff salaries, consulting fees and administrative costs, will be financed by the consortium membership fees. Out of pocket demonstration expenses of promising yet early stage startups or academia will be favorably considered.

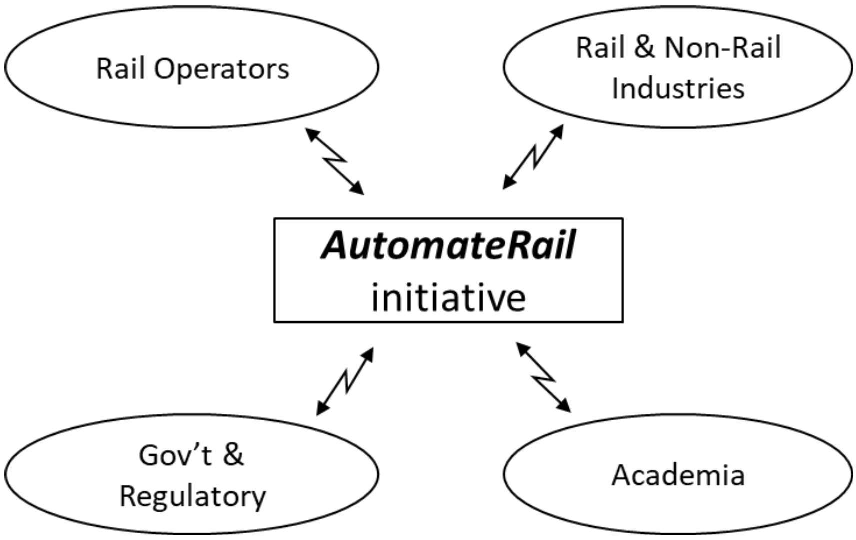

*Figure 4 – The envisioned **AutomateRail** initiative framework.*

A personal note by the author:

Rail Vision as a startup with its founders being newcomers to the rail industry, we bring a new and bottom-up perspective to the field. While being primarily focused technologically on obstacle detection and safety, we are now realizing the breadth of the industry's needs in automation, and the multiple disciplines and connectedness which will be needed in due course to support the collaborative transition to automation and to the industry's ATO vision that we all share.

If any of the above resonates with you, please contact us.

References:

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[3] Adapted from the Commission for Integrated Transport, London (2004) High-speed rails: International comparisons, Steer Davies Gleave.