FASTTRACK

THE NEWSLETTER OF THE HORIZONS PROGRAM I April 2020

INSIDE THIS ISSUE – WHAT IS SHAPING THE RAIL INDUSTRY TODAY AND INTO THE FUTURE

Energy-efficient Rail

The global demand for transport is growing fast. Rail activities are predicted to double by 2050 as a consequence of population growth and the increased urbanisation of our cities[1]. With this growth comes a greater demand for energy and an increased production of greenhouse gases. Although rail is among one of the most energy efficient modes of transport, the negative effects of growing the current rail transport model still represents a serious concern for achieving sustainable growth.

Energy sources

Today, three-quarters of passenger rail transport activity takes place on electric trains[1]. Making rail, at present, the only mode of transport that is widely electrified. This reliance on electricity can be leveraged to support consolidation of energy conversion to a single location, improving overall system efficiency and allowing for better control of emissions from combustion or the use of renewable energy sources that do not produce emissions[2]. Increased electrification of the rail sector and conversion of vehicles from traditional diesel to bio-diesel or other lower emission alternatives is an effective strategy the rail sector has to reduce its overall energy consumption and emissions.

Vehicle Design

Modification to the railcar design architecture is a great opportunity to improve energy efficiency of the vehicle[3]. Reduction to vehicles aerodynamic resistance, friction losses and weight can greatly reduce the energy consumption and emission of a vehicle. Whilst increasing seating density, train length and altering the configuration of consist can significantly optimise the energy efficiency of the system[2].

Operations

Operational strategies also allow for the optimisation of energy consumption and emissions. Some such strategies include:

- driver advisory systems and optimal costing,
- alternative station stopping patterns
- elimination of unplanned stops and speed restrictions, and
- changing the maximum operating speed [3]

These strategies attempt to offer an alternative to other strategies which often require greater investment to implement new technology or infrastructure.

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[1] https://www.iea.org/reports/the-future-of-rail
[2] https://www.nap.edu/read/22083/chapter/7#79
[3] https://uic.org/IMG/pdf/_27_technologies_and_potential_developments_for_energy_efficiency_and_co2_reductions_in_rail_systems._uic_in_colaboration.pdf

Recuperation of Regenerative Braking Energy

Opportunity

Train networks are large users of energy, be this fuel to power engines, or electrical trains feeding off the power grid. With environmental factors playing an increasing role in technology, there is an opportunity to recuperate some of this energy by the use of Regenerative Braking Energy, thus lowering to overall amount of electrical energy drawn from the grid. This technology has been in place and used on modern trains for a while now. But the challenge now is how best to effectively use this recuperated energy

Regenerative Braking Energy

Regenerative Braking Energy is the process of capturing and reusing the energy generated when a train is breaking or deceleration. This is especially useful on electrical passenger line trains as the short distance between accelerating and decelerating between stations provides ideal opportunities to capture and reuse the energy. This is completed by converting the mechanical breaking energy from the train into electrical energy. This energy is then either stored on board train, fed back into the tracks (in systems with a 3rd power rail) for use by other trains, or by feeding it back into the system.

There are several methods to reuse this generated emery. Examples include timetable optimisation for energy sharing, on-board storage for later use or feeding back to energy into the electrical grid for wider use. Each comes with its own befits and challenges

Timetable optimisation

This is a method of optimising the time table in a passenger network, so that one breaking train can feed a passing by accelerating train. This is completed by the generated energy being fed into the 3rd power rail, which can then be used to help power a passing by train that is accelerating or using power to maintain speed. The challenges here is that thus relies on a reliable train time table, peak vs off peak train volumes, and storage / dissipation of the generated energy when there are no passing trains to use that energy

Storing and reusing

The energy generated can be stored for reuse. This can be achieved via on board storage or dumping of the energy into wayside storage stations. On board storage can be used immediately used by the train when needed. Whereas wayside storage can store energy generated by all passing trains and discharge when / as required. Both have their advantages and disadvantage, but with emerging technology, both are becoming more efficient.

The energy generated can be stored in wayside stations and reused in multiple applications. It can be used to power station facilities such as lights escalators and power outlets. It can also be fed back into the electrical grid for wider use.

Which method to use

The selection of which method to use will depend on a number of factors. The type and age of the trains running on the network, the timetable including peak vs off peak, space available for wayside storage, regulations regarding reuse of energy

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Recuperation of Regenerative Braking Energy in Electric Rail Transit Systems
A strategy for utilization of regenerative energy in urban railway system by application of smart train scheduling and wayside energy storage system

Thermal Monitoring of the OHLW

There are wide range of monitoring devices or systems available around the world to predict the dynamic thermal rating of the Overhead Line Wire (OHLW) with the power system operating normally or during a system contingency. The contact wire is required for the overhead traction supply to 1500V DC metropolitan railway system. The conductor is generally be used with pantograph type carbon (metalized) current collectors. A real time monitoring device is required to determine the maximum allowable temperature limit between the OHLW (including the rigid bar) and the pantograph strip. The technical specification of the contact wire used in metropolitan melbourne infrastructure is Hard-Drawn Copper 161 mm^2 with a temperature limit of 75° before the recrystalization of the material starts. Although this is not considering the different operating conditions of the vehicle.

The real time monitoring also depends on the accurate prediction of the wind speed, altitude and direction. Even low speed wind is able to decrease temperatures materially. According to the study, when the direction of wind is parallel to the wire, a 4 km/hr wind permits temperature to rise 205° C compared with 180° C for wind at right angles to the wire. High speed and high altitude wind can be predicted upto a certain degree of reliablity, but the low speed and low altitude wind within the transmission line can not be predicted more than 1 to 4 hrs in advance through any existing system. The effect of having fluctuating wind speed and direction in Melbourne makes it more complicated to determine the real thermal behaviour of the overhead transmission line.

With the real time monitoring device and data from the actual ride simulation, the maximum allowable temperature in terms of time can be explored to cater for all operating conditions including full performance and degraded conditions for both moving and standstill operations of the train. These data can help providing a baseline of the standard value for new rolling stock design and testing or upgrading the existing fleets without causing any damage to the infrastructure.

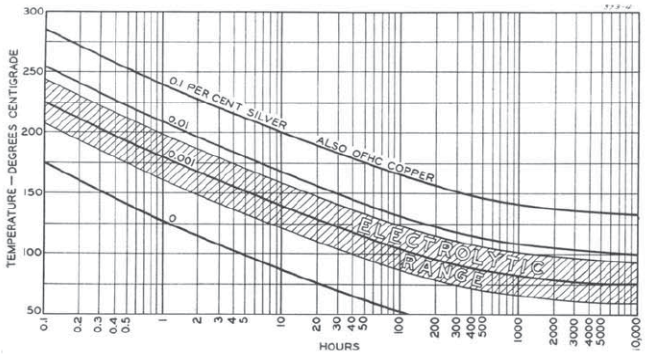


Figure 1: Increase of Temperature with Time

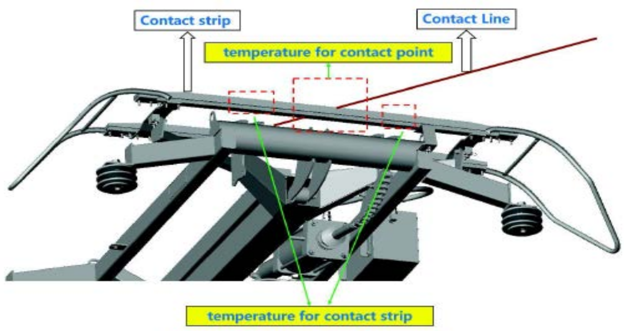


Figure 2: Temperature Area Concern

Value Capture

What is value capture?

The Grattan Institute has defined value capture as 'a tax on the increase in land values that results when a new or upgraded piece of infrastructure improves an area's accessibility'.[1] Value capture can be used by governments to fund some of the costs associated with infrastructure.

For example, a new train line will improve the accessibility to and from the area for its residents when travelling for work, education or leisure. All else constant, this should increase the desirability of the area and lead to higher house and land prices in the areas near the new train line. Value capture would seek to obtain a proportion of this uplift in value through some form of tax, while allowing the area's residents to also retain some of the benefit of the uplift in land values.

What are some of the benefits of using value capture?

Transport infrastructure is generally funded from some combination of user charging and general taxation (which is then provided to a project through government funding). However, governments are responsible for the provision of many services—including health, defence, infrastructure, social services and education—and budgets are constrained. Generating additional revenue through value capture from beneficiaries of a project may mean that additional infrastructure gets built, or built earlier, than would be the case if value capture was not used.

Value capture is also in some ways a 'fairer' way of helping to fund a project, as the beneficiaries of the project are helping to provide the project's funding (which is not the case when a project is funded from general taxation).

Are there any examples of value capture being used to fund rail infrastructure?

The following table, from a report by the Bureau of Infrastructure, Transport and Regional Economics (BITRE)[2], summarises land value uplifts from various transport projects around the world.

Table 1: Average value uplift per transit mode

Mode	Average value uplift (%)	Range (%)	Number of observations
Heavy rail	6.9	-42 to +40	18
Light rail	9.5	-19 to +30	32
Bus rapid transit	9.7	-5 to +32	14

Some examples of value capture being used in the rail sector include[3]:

- London CrossRail: Around 28% of the forecast £14.8 billion (A$29.2 billion) construction cost is being funded by a Business Rate Supplement.
- Hong Kong Mass Transit Railway: The Hong Kong government owns land around stations and leases it to the train network operator, MTR Corporation, at low cost. MTR Corporation generates income from the land near and above the stations by partnering with property developers to construct and operate shopping centres, apartment buildings or office buildings near stations.
- Melbourne's City Loop: A levy on properties in Melbourne's central business district was intended to operate for 53 years and collect 25% of the project's forecast $80 million cost. However, the project experienced significant cost increases (to $650 million), and political opposition meant that the levy was removed earlier than scheduled, meaning that in total only around 3% of the project's costs were funded by value capture.

[1] Grattan Institute, *What price value capture?*, March 2017, p. 3.
[2] BITRE, *Transport infrastructure and land value uplift*, May 2015.
[3] These examples are based on information in: Grattan Institute, *What price value capture?*, March 2017.

Will Tech Start-ups Shape the Future of Rail?

The global rail industry is worth over US$660 billion and has a history that dates back centuries. Through its lifespan it has evolved from animal hauled railways to steam powered trains to hydrogen powered trains with many iterations along the way. Each iteration has improved our networks and our ability to move people and freight around the world. However, historically these new inventions have taken years or even decades to perfect and implement which in the current world isn't fast enough to keep up.

An option for the rail industry is to explore whether there is a digital solution, these can often be rolled out in months rather than the years it can take to roll out a physical solution. As a traditionally slower moving industry it may also be worth considering whether there is the opportunity to subcontract out the challenge of finding a solution to a company more familiar with the fast-paced digital space. This is where the small fast-moving tech start-ups enter the picture. They would be briefed with a specific problem and working in a series of quick innovation cycles would design a solution to capture a specific market area before anyone else. Their size allows them much more agility and speed than their larger counterparts as they are often not as restricted by as many processes and regulations. Their size also means that there is minimal room for error and for them to remain successful they need to continually innovate and improve to ensure that they have the best possible solution.

A barrier tech start-up companies can face when trying to break into the rail industry is that the current problems facing the rail industry can be complex and it can be difficult to identify the specific problem they are trying to solve. To combat this the rail industry across the world has begun proactively involving the tech start up community in designing solutions for the current industry problems. For example, in Austria the Austrian Federal Railways (OBB) has used the Open Innovation Platform to engage with tech start-ups and has an Open Innovation Lab providing space for the innovate ideas to be discussed and developed[1]. In America, Norfolk Southern (NS) has partnered with Plug and Play, a start-up accelerator, to gain access to tech start-up companies which has resulted in a breakthrough in track inspection technology[2].

To deliver a good solution the problem needs to be well understood and the correct tools need to be used. Collaboration between the existing rail companies who understand the problems and tech start-ups who know how to use the tools seems like the ideal pairing and has yielded good results so far, could be this be what shapes the rail industry of the future.

Some cool tech innovations to look out for in 2020 can be found here:
https://rail.nridigital.com/future_rail_jan20/tech_start-ups_disrupting_the_rail_industry_in_2020
And here:
https://www.startus-insights.com/innovators-guide/disrupting-rail-industry-breakdown-startup-driven-innovation/

[1]https://openinnovation.oebb.at/servlet/hype/IMT?userAction=BrowseCurrentUser&rkId=69678f875c93246332dda4dc5adc8fbc&templateName=MenuItem

[2] http://www.nscorp.com/content/nscorp/en/news/with-homegrown-ingenuity--norfolk-southern-achieves-a-first-with.html

Using AI to improve active listening

RIo Tinto is investigating the use of Artificial Intelligence (AI) to improve its safeworking communications.

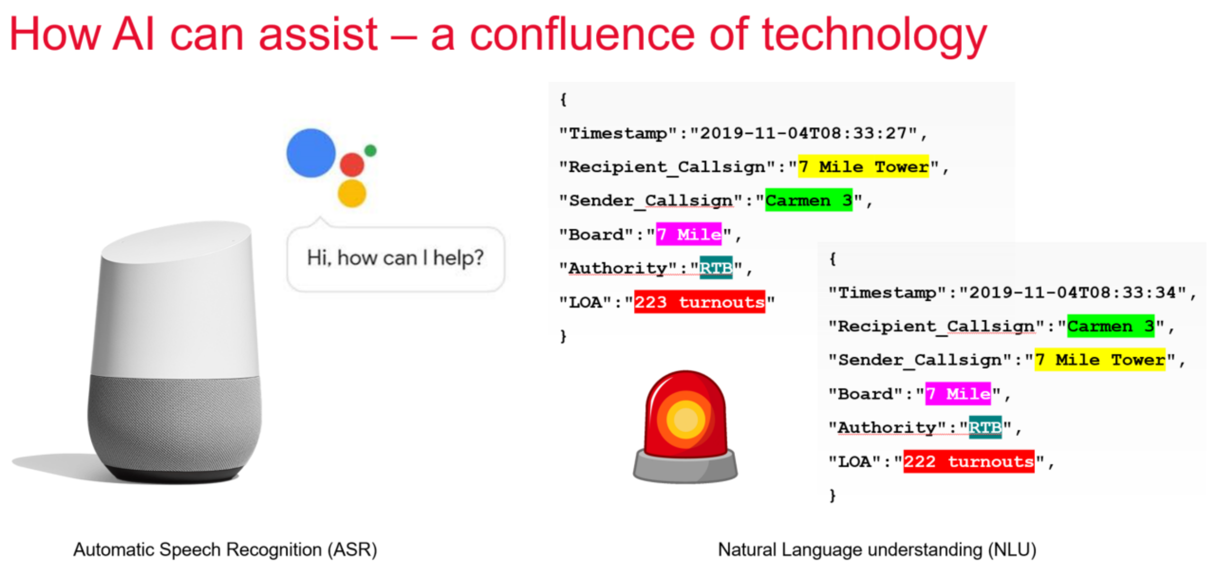
A Train Controller is responsible for managing the safeworking of their control area. This includes authorising the movement of rail vehicles, making sure there is safe route integrity for vehicle movements, issuing authorities for track occupations, and implementing electronic protections. All verbal communications between Train Controllers at the control centre and in-field rail crews are conducted via UHF voice radio system. Like most railways, voice radio is the primary way of communicating safeworking information across the network.

To ensure the safe operations of the railway, administrative controls have been implemented that necessarily mandates the methodology and substance of these communications. These safeworking messages include a requirement for the recipient to repeat the message back to the person sending them – an act of positive acknowledgement by both parties. However administrative controls alone have proven to be insufficient to ensure incident free operations.

Studies in the aviation industry have found that almost 80% of all pilot radio communications contain one or more errors. For air traffic controllers, the same statistics show that 30% of all incidents are caused by communication errors and 23% of flight level intrusions are caused by communications errors – this increases to 40% in the case of runway incursions[1]. While equivalent rail industry statistics are difficult to find, there is no evidence that our systems and process would lead to substantially different results.

Automatic speech recognition (ASR) enables computers to detect and transcribe communications – first pioneered by Bell Labratories in the 1950's[2]. Thanks to deep learning and big data, major breakthroughs in the technology have been realised in the last decade. While the characteristics of operational radio broadcasts, with distortion, digital sampled rates, and ambient noise, are particularly challenging for ASR algorithms, there are now numerous commercial speech recognition solutions. Systems like Microsoft's Azure Speech Services, Google's Cloud Speech-to-Text, or Amazon's Transcribe are capable of affordably processing voice streams in real-time with incredible accuracy. Class-leaders have demonstrated real-world Word Error Rates (WER) of less than 5%[3].

The solution being investigated is a cloud based AI communications platform that enhances the communication of front line rail teams by augmenting this technology into the existing radio infrastructure. This system would act to supervise communications ensuring that the positive communication messages are compliant. Such a tool would not only ensure correct radio procedure is being followed (e.g. the use of correct signal identifiers), it would integrate an alarm if a work instruction is not repeated correctly. This would engineer out the likelihood of a positive communication failure. The ability to transcribe natural language also opens the possibility of rich real-time human factors analysis by quantifying the metadata of workload, distraction, confusion, or hesitation to raise alerts to help manage controller and network safety.



[1] Mihai Geacăr, Claudiu. (2010) ICAS. *Reducing Pilot / ATC Communication Errors Using Voice Recognition*
[2] Kincaid, J. (2018) Medium. *A Brief History of ASR: Automatic Speech Recognition*
[3] Zeyer, A., Irie, K., Schlüter, R., & Ney, H. (2018) Google. *Improved training of end-to-end attention models for speech recognition*

Thanks for reading

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