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Connected Driving Advice

A system of systems for the decarbonization of railways

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Introduction

TTG/Trapeze is an established leader in the development of Driving Advice Systems (DAS). Its technology, which leverages groundbreaking research by the University of South Australia, has continued to evolve since first developed some 26 years ago.

Today, an extensive body of knowledge has been derived from worldwide research and development of DAS and its application to a range of trains and operating environments. The primary objective of DAS is to keep trains on time while minimising the energy used in completing each journey.

The integration of Connected Driving Advice Systems (C-DAS) with safety-critical systems such as European Train Control Systems (ETCS) and UK Network Rail's LINX message broker is critical to maximising decarbonisation opportunities available to railways.

DAS DECARBONISING RAIL AND SAVING COSTS

DAS is a mature product widely deployed in revenue service. It has delivered significant and quantifiable benefits for rail operators and in many jurisdictions its use has been mandated by railway operators over a period of many years. SNCF is France's national state-owned railway and includes the signature high speed service, the TGV.

SNCF uses some 7TWh of electricity in France annually – 3% of all electricity consumed in the country. SNCF installed Energymiser on all TGV trains to achieve energy consumption savings of up to 10%, saving millions in electricity bills annually and significantly reducing Co2 emissions.

Increasing environmental awareness and the emergence Net Zero emissions targets have prompted railways to explore decarbonisation options across all aspects of operation. DAS is an obvious supporting technology; it contributes to carbon reduction targets by minimising energy use and also reduces operating costs for any type of energy source - including green energy, which still represents a significant cost. While DAS has been implemented with success over the last 10 years, it has not been without challenges. Early adopters have been faced with:

- **Working with driver champions** and unions to obtain driver acceptance to use and follow energy efficient advice;
- **Working closely with rail operators** to address poor quality data, or a lack of data, including dynamic data such as temporary speed limits;
- **Identification of unrealistic timetables** that result in late running trains with limited opportunity to drive efficiently and arrive on time at every station. Improving the design of timetables remains a major challenge for railways, which must find a 'sweet spot' between shortest travel times and reliable services with maximum energy and emissions savings.

Commitment from railway operators to quantify the benefits of DAS by collecting energy consumption data to compare savings.

DAS is a system that has an on-train sub-system that communicates with drivers, and an on-shore sub-system that manages data and the reporting and communications with all DAS fitted trains.

With the privatisation of many railways, the resulting split between above-rail operations and below-rail infrastructure, including safe working systems and train control, has resulted in increased complexity in implementing whole-of-system technologies such as DAS. This is compounded in franchise operating models where operators may not pay for energy and have lower incentatives for accurate timekeeping. The business case, while valid overall, needs to be shared across all stakeholders and must mesh with other priorities.

DAS AS A SYSTEM OF SYSTEMS

There are two technology thrusts that are relevant to the long-term success of DAS and these are:

Advanced traffic management systems and the centralisation of train operational control decision making (aka TMS); and

In-cab signalling, such as ETCS, CBTC etc, and the introduction of in-cab safe working displays that show safe speed envelopes, which DAS speed profiles will operate within.

Similar to DAS, TMS is a non-vital platform. This has enabled a logical pathway for the integration of TMS and DAS in a connected system, defined as C-DAS. C-DAS is a generic term, so does not define a particular technology. The key for C-DAS is that DAS can provide precise and unique information on train location, speed, planned Estimated Time of Arrival (ETA) and earliest possible ETA to key timing points, which can be fed back to the TMS to enhance the traffic management decision making. Decisions made by TMS can then be sent to DAS, which guides the train using the revised targets.

In contrast, ETCS and Automatic Train Operation (ATO) are not systems that provide traffic management functions; it is a limit of authority system that ensures the safe movement of a train along a route to its next limit of authority. For example, ETCS does not operate in the time domain and DAS does not have its own knowledge of the safety limits. It may be useful for DAS to know about safety limits, but this is not essential for DAS to operate as a driving advice system.

It is clear that all systems used to manage an operational railway should ideally have common sources of truth in terms of the data they use. When they do, there are opportunities to integrate these systems.

The roadmap for integration of DAS and ETCS must evolve further. Having already developed CDAS for an Automatic Train Operation (ATO) system, Trapeze envisages a simple system whereby DAS advice is given when operating within the ETCS safe speed envelope, and suppressed when ETCS is intervening.

The Con Ops Specification and relevant railway standards must be developed to support the wider integration of DAS given the technology largely exists and is being implemented as C-DAS.

INCREASING AUTOMATION & THE ROLE OF DAS

DAS is the technology that connects systems and contributes its unique data to traffic management systems by ensuing trains adhere precisely to their planned paths, thereby reducing or minimising interaction with restrictive signalling. The algorithms that DAS uses to calculate advice to drivers is extremely accurate, but still assumes that a driver is in control and will operate the train in a safe way.

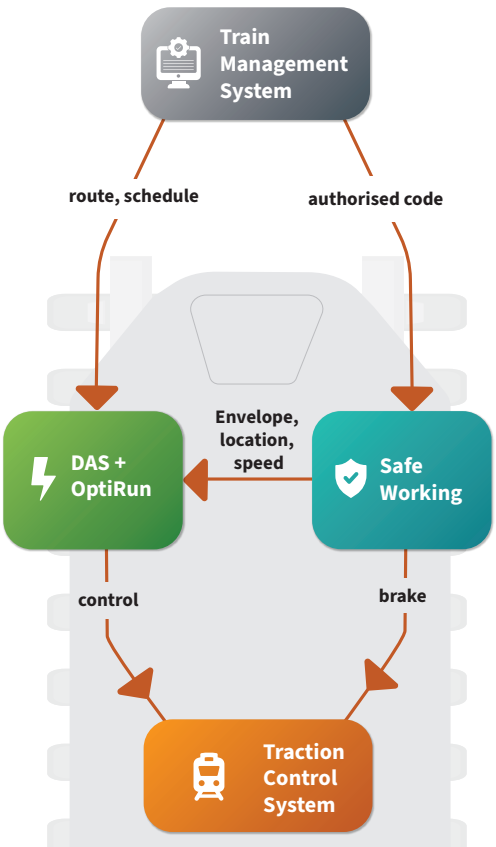
As systems become increasingly automated, including systems that automate driving such as Cruise Control and ATO, the driving advice that DAS calculates must also reflect safe train handling rules.

Trapeze is incorporating advanced algorithms into DAS to manage the precise transitions between driving modes that support Cruise Control and ATO and will also augment the driver display to help drivers optimise driving, including the use of braking.

In particular, optimal driving of long and heavy trains will prioritise the use of regenerative or rheostatic braking ahead of air braking. This is already a feature of DAS's intrinsic energy efficiency. It will also assist the progress towards green energy driving, in which there will also be a requirement to return braking energy to the grid and/or energy storage systems.

PLACING DAS INTO ITS FUTURE CONTEXT

Here is a high-level, conceptual diagram of how DAS fits into future rail systems.



The **Traffic Management System (TMS)** is responsible for managing all the trains on a network. Each train (orange box) has a Safe working unit, a Driving Advice System (DAS) and a Traction Control System.

The **Safe working unit** is responsible for ensuring that the train does not exceed speed limits within, and travel beyond, the authorised portion of its route. The authorised route data includes gradients, curves and speed limits along the authorised portion of the route.

The Safe working system uses this data, plus train performance data, to calculate the {location, speed} envelope that the train must stay within. It also monitors the location and speed of the train and will generally send a brake command to the traction control system if the {location, speed} envelope is about to be breached. This brake command will override any other control.

The **Driving Advice System (DAS)** is responsible for producing driving advice that keeps the train within the safe working envelope and on time according to the planned schedule, using minimum energy. It uses route data that extends beyond the authorised route to plan beyond the limit of authority. It must use the same location and speed data as the in-cab Safe working system. However, for systems without an in-cab Safe working system, location and speed data must come from a location system, such as GPS which is available as part of standard DAS functionality

The **OptiRun component of DAS** is used to send control signals to the Traction Control System when operating in Cruise Control mode. If OptiRun is not fitted, or the driver has not selected Cruise Control, the driver controls the train based on displayed driving advice.

In the matter of timetable design, the process should be about providing conflict-free paths for as many trains as possible along a line, subject to trains being bounded by their practical minimum, and their commercial maximum, travel times. Inferior trains should be refuged to enable superior trains to pass, where that is feasible and optimal. With the ETCS, CBTC, etc. displays, these should show the {location, speed} braking envelopes, which actual trains are not permitted to break out of.

There is much to discuss between the industry providers of ETCS and DAS, such as establishing the 'common truth' for safe working and driving advice systems.

It is not clear what minimum level of alignment and speed limit data is required to calculate both safe working braking envelopes and long-line driving advice. One part of this problem is the granularity of the alignment and speed limit data. Another issue is the quantum of the alignment and speed limit data. Without a push from industry, discussions will not progress and further decarbonisation of railway will be at risk.

THE DIGITAL DILEMMA

As computing technology has advanced over the last 30 years, so have the opportunities for developing new digital systems for controlling railway operations. Conventional railway operations have relied upon:

- **A fixed block wayside signalling system** to control the safe movement of trains over plain track;
- **Local signal boxes or control centre panels** to control the movement of trains at stations and junctions; and
- **A supervisory system** laid over distributed control centres.

These systems have served the industry well and have evolved over time into modern electronic systems. However, there are limitations to such systems:

- They are expensive to maintain;
- There is limited scope for increasing the capacity of such systems; and
- Replacing old life-expired systems is disruptive and difficult.

Digital systems can now use the reliability of telecoms and electronic detection to move away from wayside systems to on-train systems.

This means it is possible for drivers in the cab to access information regarding the state of the safe working system, as well as the most optimal way to drive the train to keep to the timetable and minimise energy use. It becomes immediately clear that, where there are multiple systems being presented to a driver, there is also potential for conflicting information, as well as human factor conflicts in simply accommodating multiple systems within the confines of a driving cab.

To date, vital systems, such as ETCS etc, and non-vital systems such as DAS, have been developed as standalone systems using their own sources of data. We have ETCS as a safety system with an enforceable limit of authority but no time domain, and DAS with a time domain and trip optimisation but no enforceable limit of authority. Each system uses its own data set and data feed which, although they may be the same, do not represent a single source of truth.

Integration of safety and train regulation systems will be required to achieve higher levels of automation and digital connectivity of a system of systems.

That integration path must be established to ensure that technology decisions being made today do not create barriers to future integration and harmonisation of systems. Systems that optimise operating efficiency integrated with those that manage safety will drive the continual improvements required to achieve decarbonisation targets.

ETCS, in spite of claims made about its benefits, remains a safety system for maintaining safe separation between trains. Unlike DAS, it is not a trip optimisation system. We can see this demonstrated by the fact that Trapeze, in partnership with Bombardier, delivered a DAS/ATO system for Spanish high-speed trains, which combines the benefits of ATO and DAS in a single integrated system. This was made possible through the implementation of one integrated driver display with DAS advice being sent directly to the ATO controller.

As operators begin to roll out ETCS and ATO, it is important that integration of C-DAS is considered, as it will not otherwise be possible to achieve the sustainable efficiency gains. Safety system providers must work together with DAS solution providers to ensure that systems such as ETCS, CBTC, etc. integrate sustainable energy reducing driving advice. Authorities should be asking for proof of this within their tenders.

DECARBONISING RAIL

Significant focus is being given to decarbonising railways and the solutions that will help to meet climate targets. Although electrification and hydrogen fuel will have an impact by changing the source of traction to green energy, there is another very real and practical opportunity to drive sustainability. This is to be more efficient by adopting technologies that optimise energy use and improve schedule compliance, which we can do now. This will drive the decarobonisation of railways and reduce future energy system use. The technologies being deployed today must include sustainable driving advice, be viewed as systems of systems and be future proofed by ensuring they are able to integrate and use common data sources.

These proven driving advice systems, like Trapeze Energymiser®, show major environmental benefits can be achieved, with the added advantage of cost savings and service improvements.

As of 2021, TTG Energymiser ® has been installed on over

16,000 train and driver applications

80,000 kilmeters of track

in ten countries and four continents. The Energymiser solution is enabled to provide for higher levels of technology integration as a system of systems, making future sacalability more possible, while enabling rail efficiency and improving the contribution that these future systems will make to the wider decarbonisation effort. of transport.

Trapeze™
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Trapeze Group works with public transport agencies and their communities to develop and deliver smarter, more effective public transport solutions. For more than 25 years we have been Here for the Journey, evolving with our customers around the world to help them move people from point A to Z and everywhere in between.

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