Driver Advisory Information for Energy Management and Regulation

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Abstract

A big challenge for GB rail is to develop a modern, sustainable system that is accessible and easy for passengers to use. This has been documented in the UK Department for Transport’s 2007 White Paper, but is also reinforced in the rail industry’s own strategic agenda developed by the cross-industry Technical Strategy Leadership Group (TSLG), to halve cost and carbon while doubling capacity and maximising customer satisfaction. It’s in this context that RSSB conducted a research project on driver advisory information on behalf of the cross-industry Vehicle/Train Control & Communications System Interface Committee (VTC&C SIC), to support industry’s goals to become more sustainable.

The benefits from implementation of a Driver Advisory System (DAS) include reductions in energy consumption by avoiding unnecessary braking and running at reduced speed whilst maintaining on-time arrival. Operational benefits include reduced train delays and better utilisation of track capacity by running through junctions and station approaches at higher speeds whilst reducing maintenance costs as a result of reduced brake wear. There are also potential safety improvements through fewer red signals approached if the DAS is effectively implemented across the network.

The research developed and analysed the generic functionality of a driver advisory system. In addition to engineering considerations and analysis, the work was underpinned by risk assessment and human factors assessment to ensure that information would be provided in a user-friendly way and to ensure safety would not be compromised. This analysis considered the factors that would need to be included to produce a robust and detailed business case that estimates the costs of implementation and the potential for reduced energy consumption and potential traffic performance improvements.

The paper summarises the main research activities including human factors and safety analysis, the definition of data interface requirements, the evaluation of benefits of a proposed system using simulation software, a review of the timetable for operational factors such as allowances and hidden slack, and assessment of alternative system architectures based on driver advice via Global System for Mobile Communications - Railway (GSM-R) text messaging.

The results from the simulations have demonstrated that substantial energy savings are possible from a driver advisory system based on the pre-planned timetable and that a safety benefit is delivered through a reduction in red signal approaches. However, the simulation shows that there is a small increase in lateness of trains arriving at timing points. The research has identified the need for a business case before the introduction of a driver advisory system considering factors such as performance impact, energy saving, greenhouse gas emissions and the cost of implementation.

Keywords: Driver advisory system, energy saving, driver interface, simulation
1 Introduction

The rail industry in Great Britain [2], including the UK Department for Transport (DfT) [1] the importance of improving environmental performances to meet the challenge to develop a modern, sustainable system that is accessible and easy for passengers to use. Reducing energy usage within the railway will not only contribute to the environmental objectives committed by the UK government [3], but will also be beneficial to cost reduction in railway operations especially with rising energy costs. The rail industry can also make contributions to the UK’s environmental objectives by providing sufficient capacity to accommodate those wishing to make greener transport choices on travel and freight movement, as it is well known that railways are a eco-friendly choice for travel, in fact, on average it is 2 - 5 times more energy efficient than road, shipping and aviation [3].

It is recognised by the GB railway industry, through the cross-industry Vehicle/Train Control & Communications System Interface Committee (VTC&C SIC), that there is a need to improve train regulation in order to achieve energy saving, improve performance and reduce cost. A research project Advisory Information for Drivers for Energy Management and Regulation (T724) has been conducted by RSSB on behalf of VTC&C SIC to understand the potential benefit and associated issues of using a Driver Advisory System (DAS).

There are already various existing systems that provide advice to drivers on energy efficient driving [7]. There are also a number of collaborative projects run by different European partners. A list of these can be found in [4]. The objective of T724 research is to develop and assess an integrated engineering and operational approach to improve traffic regulation, utilising advisory information to reduce energy wastage and increase network capacity without reducing the service performance [8], taking into account safety and human factor issues involved.

This paper summarises the main research activities including analysis of timetable allowance and their impact on achieving energy saving, results from human factor and risk assessment analysis, and the identification of requirements for a business case. The paper describes the options and considerations for the system architecture including data interface requirements. The results and conclusions from the simulations are presented. Further details of the research can be found in the relevant RSSB research reports [7] and [8].

2 Research Activities

2.1 Timetable planning and implication

The process of developing the timetable requires close co-operation between infrastructure manager and train operators. The timetable needs to take into account train service specification and is constrained by the train speed, the infrastructure’s layout and signalling block lengths. The Operational Planning function within Network Rail (NR) produces robust plans of train movement, whether permanent, weekly or ‘one-off’ services. The plan is communicated through a Working Timetable (WTT), which is a detailed record of train movements to the nearest 30 seconds.

In addition to developing a WTT to reflect a long-term service plan, NR accommodates short-term requirements for paths through mechanisms known as Short Term Planning (STP) and Very Short Term Planning (VSTP). STP and VSTP are primarily to accommodate freight and engineering trains.

The elements of train timings included within the WTT are:

- Point-to-Point timings, which represents the time a train takes between timing points.
- Engineering Allowance. This allowance is incorporated to consider reduced speeds over sections of route as a result of engineering works.
- Performance Allowance. This is a margin added to allow for late running on a day-to-day basis to achieve arrival times.
• Pathing Allowance. Additional time added to resolve conflicts at junctions or remove any headway violations.

The implication of the way in which allowances are included in the timetable is that on many occasions a train arrives unnecessarily early at a junction or station, and experiences conflict with a previous train. A driver advisory system can be used to manage the speed profile of each train to extend the running time to incorporate the unused allowances, so that the train arrives at the station or junction at exactly the right time. This will allow energy savings in the following circumstances:

• When the train delay due to the actual temporary speed restrictions on the route is less than the engineering allowance.

• When a train is running on time and the performance and pathing allowance are not required to achieve on-time arrival.

• When a train is capable of shorter point to point timings than those used in the timetable planning.

A number of scenarios were selected for simulations to exploit the energy saving potentials available from the explicit allowances within the timetable (i.e. engineering, performance or pathing allowance) and hidden slack time within the timetable (i.e., the difference between the actual time required for a particular train and the planned time used for the timetable), to arrive exactly on time at station stops rather than early. The results are detailed in section 4.

2.2 Human factors analysis

The human factors work for the project has adopted a human-centred design approach to address the general human factors requirements [7]. The human-centred design approach encourages designers to consider the requirements, capabilities and preferences of the operators.

The DAS represents a human-machine interface (HMI) which supports the exchange of information between the railway system and the human operator (the driver). The human operator needs to process the information received, and produce instructions or control actions. The following summarises the human factors work related to the operator’s activities in relation to the HMI; details can be found in the stage 1 report [6]:

• Receiving information from the equipment - this requires an understanding of human perceptual abilities; it is also important to understand the train-cab environment. These factors are addressed in the description of the train cab environment, the requirements for a train driver’s perceptual capabilities and the evaluation of different presentation options for the DAS.

• Understanding the information received - the driver must interpret the information presented on the DAS in the context of the driving operation. The quality, clarity and dynamics (changes over time) of the information are important factors, as is the other information the driver must process in executing the driving operation. These matters are addressed through analysing the main information used by the driver to control train speed, identifying ways of driving behaviour which can be supported by DAS to improve energy efficiency and the evaluation of different information options.

• Planning the most effective response - the operator uses the information to prompt a new behaviour or adjust existing behaviour. The driver has a responsibility to drive safely, meeting the service targets, in an energy efficient manner. These matters are addressed in the description of the driver’s responsibilities and broad activities, the strategy the driver uses to depart the train from stops and adjust speed through the journey and the driver’s influence on energy efficiency.

• Effecting the response through the controls - the operator implements the plan through the equipment controls. The driver’s operation of the speed controls is assumed to be unaffected by the DAS, however, the effectiveness of the DAS will be judged by any improvement in energy efficiency arising from its influence on speed control decision-making. This is addressed by evaluating the benefits achievable under different types of advisory information.
The options analysis considers three components relating to the human factors of the information presented to the driver by the DAS: (1) what advisory information to present, (2) the information format, and (3) where to present the information in the cab environment. Existing driver advisory systems exhibit a very wide variety in the content and format of information displayed to the driver. The options selected should consider the fact that too much information presented to the driver will have adverse effects on the safe operation of the train.

The recommended approach to design the driver interface is as follows:

- **Advisory information** - the driver advisory system should operate on the basis of a fixed speed profile with compensatory feedback. When the train passes a timing point, the system will calculate an energy efficient speed-time-distance profile to achieve precise on-time arrival at the next timing point. The system will then monitor deviations from the profile and advise the driver. The speed profile will only be updated if a new target arrival time is requested from the control centre. The driver interface should provide feedback to the driver on deviation from the target speed-time-distance progress expressed in seconds ahead or behind the target. This supports the driver’s existing responsibility for monitoring train progress against the timetable, and is less susceptible to confusion with safety critical speed or signalling information than an advisory speed display. It is also less susceptible to latency in the system.

- **Information format** - the driver interface should display timetable information to the driver in the form of scheduled departure and arrival times at particular waypoints through the journey to encourage punctual departure and arrival in service.

- **Information presentation** - the driver interface should provide information through a combination of visual and auditory displays with detailed information presented in the visual display, constantly available for reference, and the significant changes in the status of the advisory information indicated to the driver through the auditory display, reducing the need to constantly monitor the visual interface and minimising the visual workload.

It was recommended that further human factors studies and trials are required to arrive at a detailed specification for the system.

### 2.3 Safety analysis

A hazard and operability study (HAZOP) was carried out to identify the hazards that might be introduced by a DAS. This can be used in the identification of safety requirements to guide the system definition and interface specifications.

A generic system diagram was produced which defines the system in two parts:

- An on-board Driver Advice System, which monitors progress of the train against the planned timetable and provides advice to the driver.

- A Conflict Resolution System in the control centre which informs the on-board system when the planned arrival time at a station or junction has to be adjusted to avoid conflict with another train.

The HAZOP was attended by the project team, representatives of train operating companies (TOCs) and rolling stock leasing companies (ROSCOs), and a human factors expert. Each of the interfaces and entities in the diagram were considered in turn.

It is suggested from the preliminary risk assessment that the main safety hazard associated with the use of the DAS is mishandling of the train, due to confusion in the driver’s mind caused by the speed-modifying messages received from the system. This mishandling could manifest itself through signals passed at danger (SPADs) or overspeed incidents resulting in collision or derailment. However, risk of derailment due to overspeed was considered to be negligible.

There is also the possibility of other driver safety duties being affected for example checking the Closed-circuit television (CCTV) monitor before starting away, but these are seen as secondary.
In terms of safety improvements, DAS could potentially be capable of reducing the risk of SPADs, due to the net reduction in the number of signals approached at red.

These risks were investigated using the RSSB Risk Profile Bulletin (Version 5.5) to identify existing risk which might be influenced by DAS, specifically the SPAD risk which can be decreased by reducing the number of red signal approaches.

It is concluded that the main safety impacts of introducing a driver advisory system are:

- A potential reduction in risk arising from signals passed at danger, through a reduced number of red signal approaches because the system will advise drivers to regulate train speed to arrive at conflict points when a clear path is available
- A possible increase in risk arising from the driver being distracted from other safety critical activities whilst driving the train.

The benefit from reduced red signal approaches applies both in normal running to the timetable (avoiding early arrival before a path is available through a junction or station), and in perturbed conditions (regulating train speed to avoid unplanned conflicts). A functionally effective advisory system will maximise the safety benefit through reducing the number of red signal approaches, and a well-designed driver interface will minimise the safety disbenefit from distraction. The target for system design should be to achieve a neutral or positive safety benefit, and it is reasonable to assume that this will be possible.

### 2.4 Business case requirements

A preliminary business case has been developed in the first stage of the research. It has examined the cost and benefits for installation of a driver advisory system to the whole Great Britain main line railway train fleet. Only energy saving benefit has been considered in this business case as the benefits on performance, carbon emissions, or safety are expected to be much lower than energy savings.

Two implementation solutions were looked at to estimate the cost:

- Fitment locally within cabs
- A system solution at Control Centres

The analysis of cost for full installation in cab for the cab based systems has considered three installation options; these are low, medium, and high one-off costs. The cost includes software development, installation, design and approval amortised over the fleet.

Table 1 shows the Benefit to Cost Ratio (BCR) considering a range of train installation costs and service life over which the equipment will be operated. The result has been based on the following assumptions and estimates:

- There are approximately 11,000 passenger vehicles across the GB rail network, on average 1 driver’s cab per 2 passenger vehicles, so the estimated total driver’s cabs for passenger trains across the network is around 5,500.
- Full installation in cab of £30k at the high end, and 5k at the low end (ie, using portable device, combined with low end software costs), also a medium figure of installation cost of £15k per cab has been considered.
- An estimate of £1m a year to Network Rail has been assumed for the cost of the control centre element of driver advice, implemented nationally including a payback of the initial software development.
- Benefits have been estimated to be £19.6m for a cab based system, and an additional £2.8m for the control centre system. These figures are based purely on traction energy savings and using the simulation results from stage 1 of the research of 4.9% for the cab based system and 0.7% additional with a system at the control centre. The baseline energy cost figure has
been assumed to be £400m [6] based on 2007/8 power consumption and 2008/9 energy prices.

<table>
<thead>
<tr>
<th>Fitment option \ over</th>
<th>10 years</th>
<th>20 years</th>
<th>30 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cab based:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>2.3</td>
<td>2.7</td>
<td>2.8</td>
</tr>
<tr>
<td>Medium</td>
<td>1.3</td>
<td>1.8</td>
<td>2.0</td>
</tr>
<tr>
<td>High</td>
<td>0.8</td>
<td>1.2</td>
<td>1.4</td>
</tr>
<tr>
<td>Control centre</td>
<td>2.8</td>
<td>2.8</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Table 1 BCR for fitment options over different periods (taken from Table 8.1 in [6])

It should be noted that the BCR values are calculated based on the DfT's standard 3.5 % real discount rate. It can be seen from the table that there is a positive business case in all cases except for the highest installation cost option on the shortest life rolling stock.

The requirements for a full business case have been captured in stage 2 of the project [7]. Factors to be considered in the Business case are:

- Benefits: (1) Energy, (2) Greenhouse gas emissions, (3) Local air quality, (4) Train punctuality and reliability, (5) Accidents
- Costs: (1) Capital cost of cab equipment, annual running costs of cab equipment; (2) Capital and running cost associated with control centre (3) Up front and annual costs for driver training and familiarisation.

It is recommended that the energy benefit in the full business case is calculated taking account of factors of future years’ real prices, the changes in the proportion of diesel and electric trains and also the effect of regenerative braking. The energy use will be assumed to be proportional to the number of seat-kms run. Consideration should also be given to the costs for driver familiarisation and training in the full business case.

Carbon dioxide is the predominant greenhouse gas as far as rail emissions are concerned. It is suggested that the social cost of carbon dioxide emissions are to be estimated. Local air quality is a significant factor which needs to be considered where diesel trains are involved. A detailed prediction of the impact of DAS on local air quality would be complex if different operating modes of diesel engines are considered. It is thus proposed that a simpler approach be adopted assuming a reduction in particulates proportional to energy savings.

It is not clear whether the train punctuality will be slightly affected by using advisory speeds to reduce energy consumption as it can take up part of the performance allowance. In either case the business case will incorporate changes to punctuality, whether positive or negative.

The estimates of potential reduction in SPADs are suggested to be included in the full business case, based on the values of prevent fatalities.

In conclusion, the cost in the preliminary business case has been estimated taking into account the capital for fitment of advisory speed system and its running cost for two cases of on-board and control centre based solutions. Further work will be required for the full business case.

### 3 System Architecture

This project has classified the existing DAS systems into three main categories; type A are simple systems that provide the driver with timetable information and other generic advice on paper or on a screen (this may include coasting boards); type B provide the driver of one train with advice on how to drive the train in an energy-efficient manner; type C aims to optimise the traffic flow of the railways as a whole by dynamic re-planning of the timetable to avoid conflicts [7].
The European research project Railenergy [6] has also proposed three levels of EETROP (Energy Efficient Train Operation) implementations. As the EETROP concept is likely to become a European standard, it is suggested it is best to focus on the system architecture and interface options that are compatible with EETROP.

Stage 1 of the project has suggested a system architecture which consists of control centres and on-board components. This is compatible with level 2 of the EETROP structure. The following subsections describe the recommended architecture and the set of the input data required. The alternative control centre solution via GSM-R text messaging developed at stage 2 of the project is also summarised.

### 3.1 Outline architecture and data interface requirements

The outlined architecture and interfaces for the system recommended by the project can be seen in Figure 1, which consists of a control centre sub-system and onboard sub-system. This is a simplified version, a more detailed diagram can be found in section 9.1 of the stage 1 report [7].

![Figure 1 outline architecture](image)

In this scheme the intelligence is distributed between the control centre and the train. The on-train system calculates an energy efficient speed profile to achieve the pre-planned or dynamically updated train timings, and generates detailed driver advice to follow the profile and achieve the timings. The control centre is responsible for conflict detection and calculation of new target train timings. This architecture allows some of the benefits to be obtained from the on-board system independently of the control centre, by optimising running to a pre-defined timetable, without a real time data link between the train and control centre. It should be noted that most of the existing commercial driver advisory systems have been developed on this basis.
The data requirements based on this architecture are summarised below; the data requirements should be applicable to most driver advisory information systems.

<table>
<thead>
<tr>
<th>Category</th>
<th>Data required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static (data is fixed unless there is a permanent change to the railway network or train characteristics that is relevant to the system)</td>
<td>Route data: route map, gradients, curvature, geographical location references</td>
</tr>
<tr>
<td></td>
<td>Train data: train performance</td>
</tr>
<tr>
<td>Quasi-static (data is fixed during an individual journey, but may change in the preceding weeks, days or hours)</td>
<td>Route data: temporary speed limits</td>
</tr>
<tr>
<td></td>
<td>Train data: pre-planned timetable; train head code, train length</td>
</tr>
<tr>
<td>Dynamic (data is updated in close to real time whilst the train is running)</td>
<td>Dynamic train performance update; timetable update; Actual train running data</td>
</tr>
</tbody>
</table>

Table 2 Data categorisation for driver advisory systems

3.2 Driver advice via GSM-R text messaging
The preferred system architecture has been described in the above section, with intelligence both on-train and in the control centre. However this approach implies that the benefits of driver advisory information will only be realised for trains that have been fitted with such a system. An alternative system has been identified during the research that places all the intelligence of the system in the control centre, and uses GSM-R text messages displayed on the cab radio Driver Machine Interface (DMI) as a means to display advice to the driver. The abbreviation DATM (Driver Advisory Information via GSM-R Txt Messaging) is used for this concept.

![Diagram](image-url)  
Figure 2 Driver Advisory Information via GSM-R Text Messaging
The DATM uses planned scheduled data to generate driver advice for the initial stage. In the longer term, the scheduled data could be derived from a conflict detection and resolution tool, so that the advice to drivers can be updated to resolve conflicts during service disruption. The energy efficient speed profile is calculated for each train/journey segment for which advisory information has been requested taking account of factors such as departure time, train characteristics, speed restriction and the need to arrive on time at the end of the segment. The energy efficient profile for each train shall be used to calculate whether the train should be in acceleration, cruising, or deceleration phase at the berth location, so that the relevant advice can be provided to the driver through a GSM-R text message at these locations. The form of advice provided to the driver is constrained by the text display of the GSM-R DMI and the intermittent train location available to the system from the train descriptor. A sequence is proposed for suitable messages to be provided at each stage of a journey profile through a route segment between timing points in the stage 2 report [8]. It is recommended that a further human factor study is required. A trial is also recommended to ensure that suitable messages are provided at each stage of the journey profile.

The text message containing driver advice can be addressed to the correct train by means of GSM-R functional addressing. This is a facility provided by the GSM-R train radio system for voice calls, data calls or Short Message Service (SMS) text message to be routed to the radio in the leading cab of a specified train service using the train’s head-code rather than the telephone number of the cab radio. Functional addressing of SMS text messages within the GSM-R network is managed by an SMS Gateway system, which is currently configured so that text messages to cab radios will only be accepted from a signaler’s fixed terminal. However there is no technical obstacle to prevent the SMS Gateway also accepting SMS text messages from the driver advisory system. Transmission of text messages from the driver advisory system to the SMS Gateway would be via Internet Protocol packets over the Network Rail Information Management wide area network, or via a dedicated link through the Fixed Telecommunications Network.

The DATM is potentially a very cost effective solution as it avoids any train installation costs. However, there are still questions remaining over the type and frequency of update of advice that can be provided within the constraints of the GSM-R DMI and use of signalling information as a location data source. Further investigation is required of this alternative system architecture.

4 Performance Simulation

Simulation of an area of the national network has been undertaken to investigate the potential influence of DAS systems on energy savings, performance and safety. VISION® simulation tool has been used to model a number of scenarios that include:

- Normal driving (non-DAS)
- Individual train DAS: where advice to the driver is dynamically determined by the punctuality, location and timetable of the train
- Control centre DAS: where advice to the driver is dynamically determined by the punctuality, location and timetable of the train, together with route-setting limitations awaiting the clearance of other trains given priority at common junctions.

The Kent area morning peak was selected for simulation as it is considered to be a reasonably representative starting point suitable to scale-up to a national level. The December 2007 timetable for a weekday morning peak (0700 to 1000) was used in the simulation, comprising 403 train portions\(^1\) divided as follows:

- 326 passenger services
- 66 ECS (Empty Coaching Stock)

\(^1\) Within the simulation a train portion neither reverses nor gains or loses vehicles as a result of splitting or joining. The number of train portions therefore typically exceeds the number of trains as defined by the working timetable.
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- 3 Class 4 freight
- 8 Classes 6 and 7 freight, and light locomotives

For perturbed operation, trains entering the modelled area at its boundary points were allocated with random lateness according to the punctuality distribution observed for the Kent-bound trains at these locations during the weekday morning peak over the 12-month period to March 2009.

The key findings from the simulations for energy savings can be seen in the table below.

<table>
<thead>
<tr>
<th>Energy Savings from DAS</th>
<th>Typically Perturbed Timetable (95% confidence interval)</th>
<th>Unperturbed Timetable</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Energy Recovered</td>
<td>90% of Braking Energy Recovered</td>
<td>No Energy Recovered</td>
</tr>
<tr>
<td>Individual Train DAS</td>
<td>14.36% ± 0.53%</td>
<td>26.68%</td>
</tr>
<tr>
<td>Control Centre DAS</td>
<td>14.47% ± 0.53%</td>
<td>26.43%</td>
</tr>
</tbody>
</table>

Table 3 Simulation results – energy savings from DAS (copied from Table 2.2 in [8])

It can be seen from the table, assuming no energy recoverable, that DASs save over 14% of energy in typical Kent morning peak timetable operation, and over 26% of energy in ideal unperturbed operation of the same timetable. If 90% of the energy lost through braking is recoverable, then the energy savings are still over 8% and 15% for typically perturbed and unperturbed timetable operation respectively.

The energy savings from a Control Centre DAS are barely distinguishable from those of Individual Train DAS, for both perturbed and unperturbed operations. This may be due to the simplified algorithm used in the simulation, further investigations are required.

Alongside the significant energy savings, however, it is found that there is some deterioration in performance as measured by train lateness on exit from the model area. In Public Performance Measure terms the difference in performance is less apparent with the number of trains less than 5 minutes late reducing from 92.0% with Normal Driving to 91.9% with DAS. The increase in lateness in the unperturbed timetable is overwhelmingly due to the simplified calculation of target speeds which take only a limited account of line speed restriction and professional driving. In the perturbed situation the lateness is due to the limitation in the calculation of target speeds (to timing point location and to signals protecting reserved junctions), and other situations such as when one train runs behind another, with the first train slowed down by DAS when the second train is already late. It is suggested that a better algorithm could improve the performance.

For the safety performance, the simulation results has shown that DAS reduces red signal sightings by around 11% in typical Kent morning peak timetable operation, and by over 22% in ideal unperturbed operation of the same timetable.

The simulation results have demonstrated that in both normal and perturbed running conditions:

- Substantial energy savings are possible from a DAS based on the pre-planned timetable, by avoiding early arrival at timing points
- A very small additional energy saving is possible if the DAS is linked to a control centre conflict resolution system
• Both types of DAS (with and without the control centre system) result in a small increase in lateness of train arriving at timing points

• Both types of DAS deliver a safety benefit through a reduction in red signal approaches.

5 Conclusions and Recommendations
The main conclusions and recommendations from the project are:

• Timetable allowance with potential for energy saving exist for all types passenger and freight services.

• An outline approach to the design of driver interface has been recommended and based on adoption of a human-centred design concept. Further human factors analysis is required which may include trials using cab simulations to provide more detailed specification for the human machine interface.

• Safety analysis including a HAZOP involving cross-industry stakeholders, and the preliminary risk assessment has concluded that positive safety benefit is achievable.

• A preliminary business case has been developed which concluded a positive business case in all cases except for the highest installation cost option on the shortest life rolling stock. A full business case has been recommended, with the relevant requirements captured.

• The system architecture with intelligence distributed between train and control centre is recommended. The project also presented an alternative system architecture based on driver advice GSM-R text messaging.

• The data requirements based on the recommended architecture have been summarised, which should also apply to most DASs.

• It has been demonstrated by performance simulations that there are potentially significant energy savings achievable by the implementation of DASs. According to the simulation, there is a very small additional energy saving if the DAS is linked to a control centre conflict resolution system although this needs to be investigated further. The simulation shows a small increase in lateness of trains arriving at timing points, which may be caused by the simplified algorithm used in calculating target speeds. A potential safety benefit is achievable through a reduction in red signal approaches.

• Further simulations are required to incorporate a wider mix of traffic to include intercity and more freight services. This is to strengthen and diversity the pool of simulation results. There is a possibility to improve understanding the effects of DAS algorithms, particularly in the setting of target speeds in response to junction conflicts.

With the encouraging findings of the research, V/TC&C SIC has worked with the Technical Strategy Leadership Group (TSLG) to develop the next steps from a more strategic perspective. The related, and more generic, “next generation traffic management programme” set up by TSLG’s predecessor TSAG (the Technical Strategy Advisory Group) [2] has identified the short term work relating to DAS includes defining the data interfaces, understanding the human factors, developing ‘real-time’ timetables and modelling the commercial implications for all stakeholders. One train operator is currently investigating the practical application of DAS.

6 Acknowledgement
The authors would like to thank DeltaRail Group limited who supplied services to RSSB for the project, and the cross industry stakeholder group with representatives from DfT, Network Rail, Association of Train Operating Companies and rolling stock leasing companies.
Challenge A: A more and more energy efficient railway

References