Driver advice systems for road and rail: innovation and transfer potential

Roberto Palacin | NewRail | Newcastle University | UK.
Very brief

OVERVIEW
Regardless of the transport mode, generally speaking DAS systems contribute to:

– Safety;
– operational management;
– Energy usage optimisation;

...and of course, an important side effect, cost reduction.
• According to the type of support DAS provide:
  – Information
  – Warning
  – Advice
  – Communication with the environment (infrastructure, other vehicles); issue of alert
  – Automation & Intervention (several levels)

• Autonomous or cooperative (several levels)
Overview

RAIL DAS SYSTEMS
Rail DAS systems include...

- ERTMS
- Train Warning and Protection Systems (TWPS)
- Automatic Warning Systems (AWS);
- Automatic Train Protection Systems (ATP)
- Automatic Train Operation Systems (ATO)
- Automatic Train Supervision (ATS)
- Automatic Train Control (ATC)
  - ATC = ATP + ATO + ATS
overview

RAIL DAS SYSTEMS _ EXISING SYSTEMS*

*related to eco driving functionality. source; report T724 RSSB.
<table>
<thead>
<tr>
<th>Name of system and supplier/owner</th>
<th>Status</th>
<th>Location Technology</th>
<th>Commo Technology</th>
<th>Driver Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatiske Funktion Systems/Thales BLS, Switzerland</td>
<td>All ERTMS fitted trains running through Lotteberg base tunnel</td>
<td>ERTMS</td>
<td>ERTMS (ETCS text message packets)</td>
<td>Text message with advisory speed on ETCS DMI</td>
</tr>
<tr>
<td>AVV AZO, Czech Republic</td>
<td>3 vehicles</td>
<td>Balios</td>
<td>None</td>
<td>Automatic driving of train including crossing and braking to timetabled stops</td>
</tr>
<tr>
<td>CATO Computer assisted train operation Transrail, Sweden</td>
<td>Hoping for approval of trial on Swedish inter city line starting October 2005</td>
<td>GPS or ERTMS</td>
<td>GPRS</td>
<td>Enhanced ETCS DMI with speed, gradient profile, adjusted speed profile, early start running</td>
</tr>
<tr>
<td>Dresden S-Bahn TU Dresden, Germany</td>
<td>On trial</td>
<td>GPS</td>
<td>None</td>
<td>Uses a PDA, Countdown to departure at station. Between stations recommendation to cruise at a speed, maintain current speed, or coast.</td>
</tr>
<tr>
<td>EBI Drive 60 Driving Style Manager Bombardier</td>
<td>Tests in Switzerland, Belgium, Spain, Germany</td>
<td>GPS</td>
<td>GSM - SMS or GPRS</td>
<td>Integrated into ETCS DMI. Recommended optimal tractive force and speed, early start running</td>
</tr>
<tr>
<td>Energy Efficient Timetabling, France</td>
<td>Electrified lines in France for last 20 years</td>
<td>None</td>
<td>None</td>
<td>Location of crossing zones and recommended speed zones. in driver's printed timetable</td>
</tr>
</tbody>
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<tr>
<td>EDF and EbuLa DB, Germany</td>
<td>Installed in 9000 vehicles (EbuLa)</td>
<td>None</td>
<td>(dally timetable and speed limit updates)</td>
<td>Scrolling timetable display and recommendation to “boost”</td>
</tr>
<tr>
<td>FARE Fahrreglung (driving regulation) SBB, Switzerland</td>
<td>Part of development of re-scheduling and interactive control to real global and local service intentions</td>
<td>Odometry</td>
<td>GSM public in the prototype</td>
<td>Number of seconds early or late; recommended driving mode (speed up, steady, slow); maximum recoverable delay in each of the next 6 minutes; recommended correction for each of the next 3 minutes</td>
</tr>
<tr>
<td>Fass/ EcoTrainBook Umtwil &amp; Verkehr Erzgebirgskies, Germany</td>
<td>Small number of vehicles on a regional railway</td>
<td>GPS</td>
<td>None</td>
<td>Energy use, gradients and speed limits</td>
</tr>
<tr>
<td>FreeFloat DB, Germany</td>
<td>Current research project</td>
<td>Odometry, ERTMS or GPS</td>
<td>GSM-R</td>
<td>Current and maximum permitted deviation from timetable, and recommendations such as “boost” and “maximum speed”</td>
</tr>
<tr>
<td>Freightiser TTG Australia</td>
<td>Tested in 2004 by Pacific National</td>
<td>GPS</td>
<td>GPRS (temporary speed restrictions)</td>
<td>Recommended speed profile for train, colour coded for when to apply power and coast</td>
</tr>
<tr>
<td>GEKKO DSB Denmark</td>
<td>Tralled in Denmark and France</td>
<td>GPS</td>
<td>2G/GPRS/ WiFi</td>
<td>Uses a PDA Speedometer display showing recommended and actual speeds</td>
</tr>
<tr>
<td>LEA Lokpersonal Electronic Assistant SBB, Switzerland</td>
<td>4000 FAD carried by driver in Switzerland</td>
<td>None</td>
<td>None</td>
<td>Uses a PDA. Scrolling timetable display.</td>
</tr>
<tr>
<td>LEADER Know Brese</td>
<td>200 freight locomotives in North and South America</td>
<td>GPS</td>
<td>Radio (spread spectrum)</td>
<td>Route geography, in train crossbar forces, brake status, recommended power and braking.</td>
</tr>
<tr>
<td>Name of system and supplier/user</td>
<td>Status</td>
<td>Location technology</td>
<td>Comm technology</td>
<td>Driver interface</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------------------------------------------------------------</td>
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<td>-----------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Metromiser</td>
<td>All trains of TransAdelaide suburban operation in 1991. No further applications since. No longer marketed</td>
<td>Odometry</td>
<td>WLAN transfer of timetables in depot</td>
<td>Three indications; green - drive as fast as possible; blue - coast; yellow - stop coasting and prepare to brake.</td>
</tr>
<tr>
<td>Route Lnt Prorail, Netherlands</td>
<td>Trial in 2004, available for roll-out in 2008</td>
<td>Signalling train detection</td>
<td>GFRS</td>
<td>Uses a PDA. Displays location and timekeeping of this train and trains in front, as reported by Prorail's train running information system (using signalling information)</td>
</tr>
<tr>
<td>TCAS</td>
<td>Prototype trial in 1980s</td>
<td>Odometry</td>
<td>None</td>
<td>One indication; yellow - coast.</td>
</tr>
<tr>
<td>Tripoptimizer</td>
<td>Offered as an option on new and upgraded GE locomotives</td>
<td>GPS</td>
<td>None</td>
<td>Automatic control of power and braking (but not stopping at stations and signals).</td>
</tr>
<tr>
<td>Vienna line U0, Austria</td>
<td>In use on one light rail line</td>
<td>None</td>
<td>None</td>
<td>Recommended maximum speed to next station displayed on Ineside at departure from each station.</td>
</tr>
</tbody>
</table>
DAS systems-energy efficient driving

- **Type A**
  - Timetable and generic info to driver via paper or screen

- **Type B**
  - Dynamic advice on how to drive the train efficiently to a predetermined timetable

- **Type C**
  - Similar to type B but the system aims to optimise traffic flow by dynamically re-planning the timetable
DAS systems-energy efficient driving

• **Specific driving advice**
  – a current speed target or a speed profile over time, or advice to speed up, slow down, or coast

• **Timekeeping information**
  – telling the driver whether the train is running early or late with regard to the optimum speed profile to realise the timetable

• **Contextual information**
  – e.g. gradient profile, energy usage, or position of other trains
RAIL DAS SYSTEMS _FASSI*

*FASSI Information kindly provided by Mr Oliver Bratton, Operations Director, DB Tyne & Wear.
fASSI Basics

• Simplest form
  – Electronic train running board
    • Able to give driver accurate timetables
    • Calculates lowest possible running time between stations based on lateness
  – Two units with energy meters
    • Used to calibrate driving styles
    • Used to provide advice on where excess energy being consumed
  – Re-iterative process
    • Information on where energy being wasted fed back into timetable
    • New section times for drivers
fASSI driver screen

Source: DBTW
FASSI-differences from the mainline

- Is the Metro* special?
  - 4.7 million station stops a year
  - Drivers stop, on average, every three minutes
    - How do you publish this amount of information?
  - Timetables not accurate
  - Energy consumption is higher than it needs to be
- But:
  - How accurate is any timetable?
  - How do you give advice to a driver in the cab?
- FASSI has potential uses beyond those we can think of

*figures on this slide are related to Newcastle Metro
fASSI-what is the output

• Timetable of the future?
  – Accuracy to the second
  – Better control of intervals between trains
  – Better energy consumption
  – Easier to amend workings
  – Feedback to driver on energy consumption
fASSI-what is the potential?

• What ideas are there?
  – Punctuality reports in real time
  – Web applications for passengers
  – Transport interchange information
  – Leaf fall reporting
  – Publication of WON/PON information
  – Electronic booking on
Research domain example

RAIL DAS SYSTEMS
Research domain example

• Sustainable and intelligent management of energy for smarter railway systems in Europe: an integrated optimisation approach
  – …or as it is better known, MERLIN.
• A key component of the research will be the interface with advanced DAS systems to allow significant improvements such as:
  – Energy usage optimisation
  – Mixed traffic operation
Overview

OTHER MODES DAS SYSTEMS
other modes DAS systems

• Road
  – Satellite navigation
  – Headway advisory systems
  – Indicators for
    • fuel efficiency
    • Electronic maintenance
    • Gear shift
  – Variable message signs
other modes DAS systems

• aviation
  – Medium term conflict detection
  – Flight management systems
  – Electronic flight bag (EFB)
Overview

TRANSPORT TELEMATICS (ROAD)

source: Dr. Evangelos Bekiaris, Director Hellenic Institute for Transport and visiting professor at Newcastle University
• **ITS: Intelligent Transport Systems and Services**
  – All those systems and services which contribute to safer, more secure, cost-efficient and “smart” mobility of persons and goods.

• **ADAS: Advanced Driver Assistance Systems**
  – Support systems/services provided to the driver while driving to enhance driver safety.

• **IVICS: In-vehicle Information Communication Systems**
  – Include specialised traffic information systems, cell phones, text messaging, email, vehicle diagnostics, and, in some situations, warning systems and emergency help systems, provided to drivers in order to support the driving task.
• **ITS for Private Vehicles (1/2)**
  – Traffic, Weather and Parking Information Systems
  – Location-Based Devices
  – Emergency-Related Services
  – Advanced Driver Assistance Systems
  – Lateral control
  – Lane keeping and warning
  – Blind spot monitoring
  – Longitudinal control
  – Advanced Cruise Control (ACC)
ITS for Private Vehicles (2/2)

- Collision Warning and Avoidance (CAS)
- Intelligent Speed Adaptation (ISA)
- Stop&Go
- Pedestrian detection
- Reversing/parking aids
- Vision enhancement
- Driver/vehicle status monitoring
- Integrated systems
- Cooperative systems
• **ITS for Public Transport**
  – Traveler Information Services
  – Automatic Vehicle Location (AVL)
  – e-Ticketing
  – Systems for Vulnerable Road Users

• **ITS for Commercial Vehicles**
  – Fleet Management
  – Freight Management
  – Hazardous Good Monitoring
  – Speed Control
  – Weigh-in-Motion (WIM)
  – Railway Systems
• **ITS for Infrastructure**
  – Traffic Information Systems (TIS)
  – Traffic Management Systems (TMS)
  – Incident Management Systems
  – Tunnel Management
  – Electronic Tolling and Road Use Charging
  – Enforcement Systems
MICHON (1985) model

The driver task has a hierarchical structure
Drivability model contributors
Navigation systems

- route guidance to a specific destination
  - In-vehicle navigation systems
  - Dynamic navigation systems (e.g. touch screen)
Enhanced navigation systems

- information and warning provision, localisation (GPS) and autonomous execution of driving tasks
  - Route Guidance
  - Over speeding
  - Dangerous spots
  - Critical distance to the leading vehicle
  - Collision risk
User needs (1/2)

• Users need accurate info for obstacles ahead and would like to receive recommendations for deceleration and braking.
  – However, autonomous braking or acceleration is not desirable!

• According to IN-ARTE project trials results:
  – When overspeeding (by 10%), 26 warnings per 30 minutes were provided (irritating for the users).
  
    Recommendation: Warning if overspeeding by 20% for more than 2 sec.
User needs (2/2)

- IN-ARTE trials (cont.)
  - If no imminent risk (i.e. overspeeding), visual warnings are preferable for users
  - For imminent risks (i.e. obstacle detection), acoustical and haptic warnings (also automatic braking) are preferable
Driver (status) monitoring systems

- **Aim:** Detection of driver hypo-vigilance and in-time warning.

- **Technology:** Driver monitoring with multiple sensors and processing via data fusion.

- **Main parameters:**
  - Lateral vehicle position
  - Steering wheel angle
  - Eyelid movements
  - Force on steering wheel
  - Braking and acceleration behaviour
Driver (status) monitoring systems

Toyota driver pulse recording system (EMG, EEG and physiological parameters)
Driver (status) monitoring systems

Nissan driver eyelid movements detection system

Nissan driver eyelid movements detection system
Driver (status) monitoring systems

SIEMENS VDO (currently CONTINENTAL) Eyelid Sensor (ELS) system. Real-time image processing from infrared camera (50 Hz); (Eye) blink duration is estimated.
Driver (status) monitoring systems

Steering Attention Monitor (SAM) system. Steering wheel corrective actions recording (via magnetic sensor) and audio warning provision.
Driver (status) monitoring systems

The SENSATION Integrated Project aimed at promoting the health, safety and quality of life of people and protect the environment by reducing relevant accidents and thus the impact on environment through the application of 22 novel micro and nano sensors and related technologies, of low-cost and high-efficiency, for physiological state monitoring. The focus of the work was the brain activity, including the sleep and wakefulness states and their boundaries, stress, inattention and hypovigilance states, for hypovigilance detection, prediction and management as well as diagnosis, treatment and remote monitoring of sleep disorders.
Driver (status) monitoring systems

- Driver warning
  - In 4 phases:
    - Green phase: Normal driver state.
    - Yellow phase: Slight driver problem; simple warning.
    - Orange phase: Uncertain driver state, warning and waiting for feedback (i.e. pushing special confirmation key)
    - Red phase: Abnormal driver state or lack of sufficient time for warning, automatic activation of control system
Driver (status) monitoring systems

• Driver warning

  – Optimal HMI

  • Haptic warning by seat belt vibration as early warning, not intrusive;
  • Warning sound at 85 Db for critical warning, adjusted in terms of duration and number of repetitions, according to the driver specific problem;
  • Haptic/ audio warning with rumble strips sound emulator or even driver seat movement-only in case of vehicle lane drifting;
  • Visual warning in side mirror, of different colour (yellow, orange, red) according to the case (as back-up, secondary system), only in case of vehicle lane drifting;
  • Message in in-vehicle display, respective to the voice message (as back-up, secondary system).
Driver (status) monitoring systems

• User needs and acceptance
  – The system should not be perceived by the driver, while just monitoring him/her.
  – Automatic execution of driving tasks has to be activated only in cases of driver inefficiency, in extremely risky situations.
  – Avoidance of “abrupt” ways of warning (vibration of driver seat or steering wheel), since driver may be terrified and act inappropriately. The audio channel, the visual channel (secondarily), smooth seat belt vibrations and “rumble strips” simulation are preferable.
  – Driver is always responsible in case of accident (supported or not by a system), thus no 100% reliable system to avoid overreliance
Driver support (longitudinal)

- Cruise Control system
- Adaptive Cruise Control (ACC) system
- Collision Avoidance System (CAS)
- Stop&Go system
- Intelligent Speed Adaptation (ISA) system
- Vision enhancement systems
- VRU (Vulnerable Road Users) detection (and protection) systems
Driver support (longitudinal)

Applications with cameras
Driver support (longitudinal)

CAS applications with cameras

CAS applications with radar
Driver support (longitudinal)

Intelligent speed adaptation
Driver support (longitudinal)

Intelligent speed adaptation
Driver support (longitudinal)

• Vision enhancement systems
  – Acceptance issues
    • **Warning signal**: To capture the driver attention before display some information
    • **Alert information**: Aware the driver of a dangerous situation
    • **Evasive manoeuvre suggestion**: Avoid cognitive planning effort to the driver in order to reduce driver response time
Driver support (longitudinal)

• Vision enhancement systems (HMI)

Information on an automotive display and with use of audio and/or haptic warning

Head-Down Virtual Image Display (HD-VID)

Head-Up Display (HUD)
Driver support (longitudinal)

- Pedestrian detection systems (VRU)
Driver support (longitudinal)

- HMI of the Watch over System
ADAS for power-two-wheelers (PTW)

• ..aka MOTORBIKES!
• The SAFERIDER case: ADAS functions
  – Speed Alerts: to warn the rider when the speed exceed the legal speed limit
  – Curve Speed Warning: to warn the rider when approaching speed is too high in relation to the curve ahead.
  – Frontal Collision Warning: to warn the rider when obstacle is detected in the PTW near field area
  – Intersection Support: integration of the three previous functionality
...ALMOST FINISHED...
Towards cooperative & integrated systems (1/3)

- Possible communication ways between the vehicle and the infrastructure:
  - Car to Car communication-C2C
  - Vehicle to Infrastructure-I2C / Infrastructure to Vehicle-I2V
  - Infrastructure to Infrastructure-I2I
Towards cooperative & integrated systems (2/3)

e-safety forum vision
Towards cooperative & integrated systems (3/3)

• An optimum driver support system is the one that, via multiple sensorial systems, warns the driver for any potential risk in both lateral and longitudinal axis and, if needed, automatically proceeds with corrective actions
  – and as with the rest of the info in this section...[Bekiaris A, 2010]
...SO...

• THE VISION
  – Integrated, cooperative, seamless and personalised systems for optimal impact on the Road Sector

• Need for:
  – Systematic assessment of ADAS, to identify potential dysfunctions and corrective strategies.
  – Assessment of alternative design strategies for the recognition of short and long term impacts in road safety, driving behaviour, driver workload, environment and traffic efficiency in order to identify the most optimum one.
  – Long and large scale trials in real traffic conditions with equipped and non-equipped vehicles.
..THE END IS REALLY NIGH...
To conclude...

- Rail increasingly uses DAS/DAS COTS systems as the interface between sophisticated safety traffic management systems;
- Road safety and traffic management is increasingly using telematics as the major tool with a variety of interfaces with the driver;
- There is clear scope for mutual transfer of knowledge and between both modes
  - Road is moving towards systems that interact with the infrastructure. The very core of railway operations!
  - Rail is in need to increase the information that is conveyed to the drivers very much as road is doing;
- Challenges/key technologies in the research domain...
  - Real-time information to train drivers
  - Eye-tracking technologies for rail application
• http://www.bbc.co.uk/news/uk-17812140
• http://tyneandwear.sky.com/news/article/18600
More information...

www.newrail.org
Contact details.

Roberto Palacin | roberto.palacin@ncl.ac.uk |
Manager Rail Systems Group |
NewRail | Newcastle University |
School of Mechanical and Systems Engineering | Stephenson Building | NE1 7RU | UK.