CATO - Optimization of rail operations

Introduction

Rail transportation companies around the world are facing the challenge of increasing capacity, reducing energy consumption and improving service quality at the same time.

One of the key factors in improving rail transportation is the way trains are actually driven. As the demands on railroads increase, so do the demands on train drivers. To be able to drive more efficiently, they need a clear overview of the current driving situation and recommendations for the optimum driving style.

CATO (Computer-Aided Train Operation) is a pioneering Driver Advisory System (DAS) solution for modern rail transportation. It offers a powerful technology that revolutionizes operational efficiency, environmental friendliness and reliability in rail transport. It is a state of the art digital tool that may be used in any railway application, independent of its complexity.

This description provides an overview of the most important technical details of CATO, the advantages of the technology and its optimization possibilities. It is aimed at decision-makers, engineers and anyone with an interest in efficient rail transportation.

Technical overview

System architecture

CATO has a modular structure and consists of three main components:

CATO On-Board (COB)

This subsystem is located on board the trains and is responsible for calculating the optimum speed profile and displaying precise recommendations to the driver.

CATO Trackside (CTS)

This subsystem is a trackside server, which supplies Journey Data to the COB.

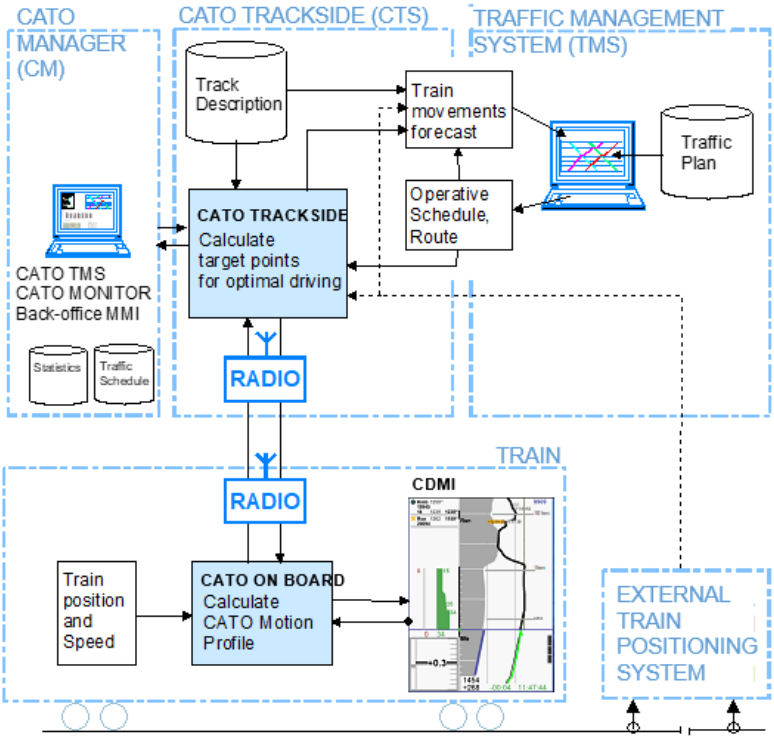
CTS supplies the Journey Data from the traffic management/dispatching system (TMS) of the Infrastructure Managers in different countries/regions and ensures communication with COB. CTS ensures that real-time data, such as timetable changes, is seamlessly integrated.

CATO Manager (CM)

As a back-office suite, the CM is responsible for system monitoring, extensive data analysis and reporting.

The TMS

The TMS is a sub-system related to C-DAS. See more under the headline “Traffic Management / Dispatching” below.



The architecture enables flexible integration in various operating modes:

Standalone DAS (S-DAS):

Independent driver assistance system without real-time communication. Journey Data is based on the planned timetable and is communicated to the On-Board subsystem before departure from the starting terminal.

Connected-DAS (C-DAS):

Systems that are connected to a TMS in real time to receive dynamic updates of timings and/ or the route or train path.

Transrail, together with the Swedish Infrastructure Manager, developed the first C-DAS system in the world with its first full-scale test in 2011. The architecture above illustrates this solution, where the TMS is an important sub-system of the C-DAS.

Signal-Connected DAS (SC-DAS):

An advanced solution, developed by Transrail, that integrates information on train movements of other trains on the line. Conflicts with other trains are avoided.

The flexibility makes CATO scalable and suitable for any type of railway operation, making use of the available TMS information.

Optimization

To achieve optimal results, in specific lowest possible energy consumption and wear, a complex optimization task must be solved including the line profile (speed, vertical and horizontal profile). CATO is based on a complete mathematical-physical model.

CATO uses a combination of a detailed Train Performance Calculation (TPC) and a dynamic traction optimization algorithm.

The algorithm is able to handle multiple targets and constraints, including:

Timed target points

Precise arrival times at stations or passing points within a defined time window.

Energy consumption and wear

Minimization of energy losses and wear and tear through efficient traction management. Efficient and energy-optimized driving means braking as little as possible and making optimum use of the train's kinetic energy in combination with the line profile.

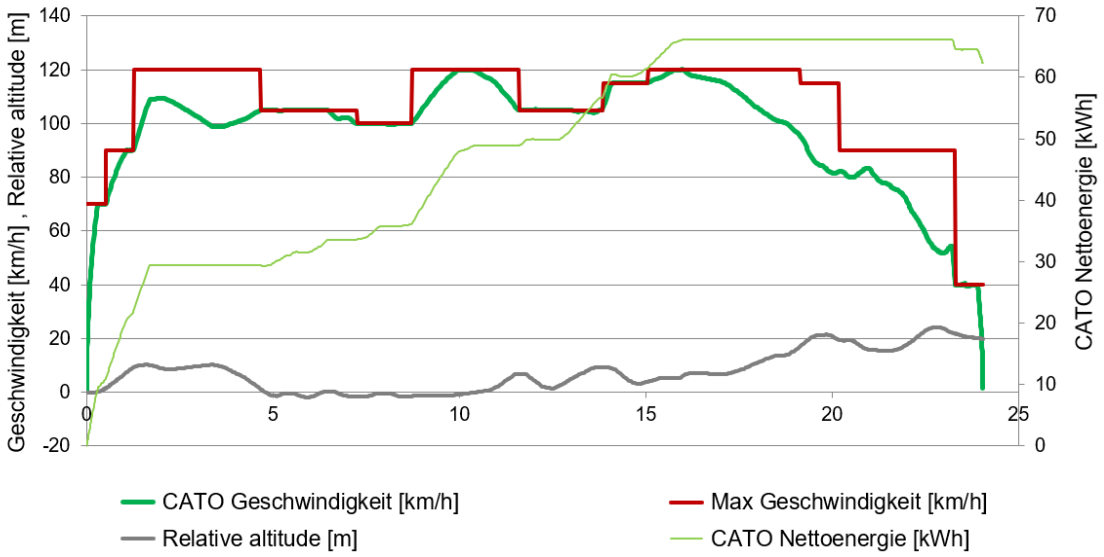
The energy savings through CATO are normally in the order of 15-25 percent and the reduction in brake wear is normally 60-80 percent.

Infrastructure data

Consideration of height profiles, curve radii, speed restrictions and adhesion limits. The elevation profiles of the route are used for energy-optimized driving.

Optimization cost function

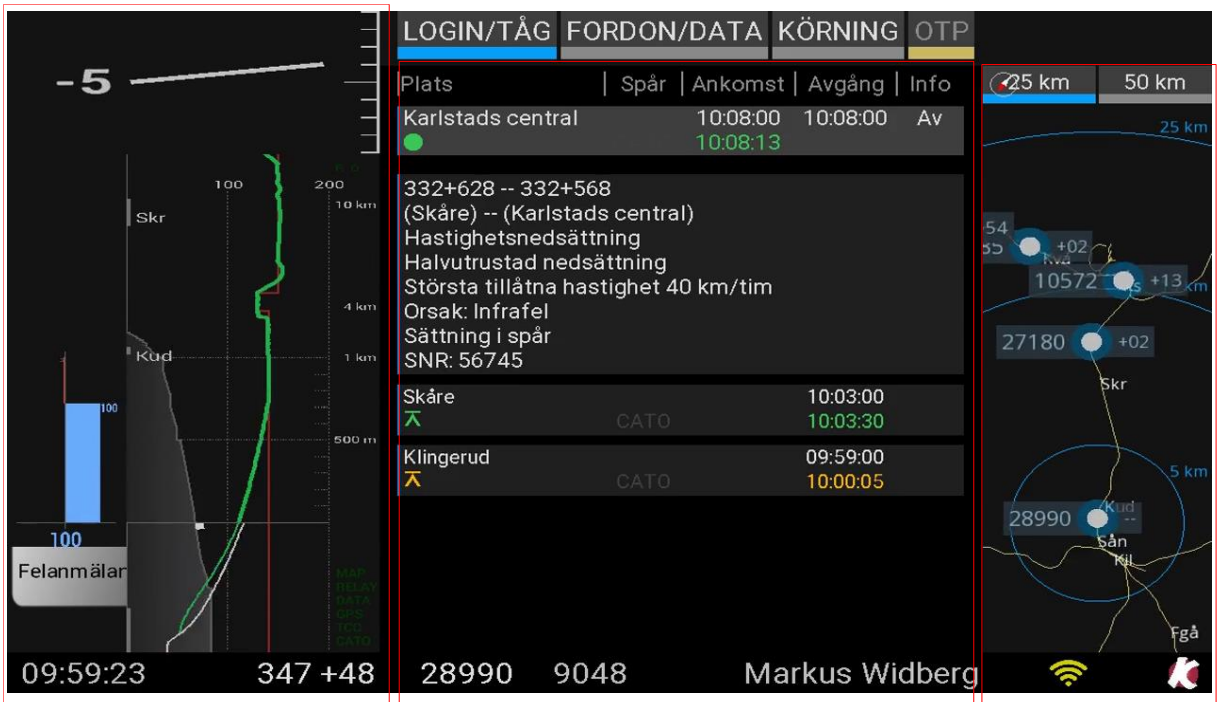
A dynamic cost function makes it possible to flexibly weight various optimization targets, such as energy savings, wear minimization and other aspects of importance to the customer. The economic and operational targets defined by the customer may be integrated into the cost function.



CATO Driver-Machine Interface (CDMI)

CATO On-board is the heart of the system. This software calculates the driving instructions on the basis of the current driving situation and the Journey Data received from the trackside server. The CDMI displays the driving advice and is a central component of the CATO technology.

The information displayed on the CDMI provides the driver with a complete overview of the driving situation and enables him to use the driving recommendations to optimize the journey. The driver is able to easily plan and carry out even demanding journeys with complex driving situations and infrastructure profiles.



Driving Advice | Time table / Timings and Safety Information | Other trains

The CDMI offers:

Clear display of the current and upcoming driving situation

By previewing upcoming sections of the route, drivers can foresee the driving situation and understand the advised driving style to save energy and improve punctuality.

Predictive planning by the CATO Motion Profile

Ergonomic and intuitive user interface showing the driver recommendations for speed, motoring, coasting, braking etc.

Customization

The user interface can be customized to meet specific customer requirements.

Intelligent cruise control (ICC)

CATO offers integrated intelligent speed control, making it possible to let the system operate the train optimally. The CATO optimal driving profile is automatically maintained, comparable to a GoA2 system.

Feedback and Performance Monitoring

The reports and statistics from each journey generated by CATO provide valuable insights into:

Energy consumption and wear

Punctuality

Identification of punctuality problems and improvement potential for timetables.

A solution for delay attribution reporting from the drivers is provided as an option.

Driver performance

Analysis of individual driving behavior and its effects on efficiency and punctuality.

Operational problems

System status and possible failures

Advantages of the CATO technology

Operational optimization

Greater punctuality

Thanks to precise travel profiles, time-based destinations can be reached with a deviation of just a few seconds.

Increased capacity

The optimized driving strategies allow more efficient use of track capacity, which means that more trains can be operated safely and reliably.

Energy efficiency

Theory and experience support that with CATO, long distances can normally be covered by coasting.

The combination of maximum coasting and minimum usage of braking minimizes energy losses.

Environmental friendliness including reduction of emissions.

Suitability

Train operations

CATO is very efficient in any type of railway operation: from heavy freight traffic to metros.

Traction systems

The type and complexity of the traction system are irrelevant.

This is solved by mathematical modeling of the train including weight, length, maximum speed, traction and braking characteristics, adhesion limits, energy efficiency etc

Safety

CATO is not safety-critical in itself.

On-Board installation

CATO can, from a technical point of view, be installed On-Board according to various solutions. It can be stand-alone independent of the other vehicle systems or be more or less integrated with existing vehicle systems.

Future-proof

The basic structure and mathematics of CATO guarantee the future proof of the system and enable effortless expansion for new, even highly complex scenarios.

Feasibility studies and Benefit Analysis

By virtue of the mathematical model, the CATO system is well suited for technical studies and calculations predicting the results to be expected by an implementation.

A DAS is a tool for drivers, aiming to improve the way trains are driven. This means that the end result, the savings obtained by the system, will depend on the way the trains are driven before installing the DAS and the new situation after its installation. Transrail has developed a Benefit Analysis (BA) method to identify the savings of CATO. The BA makes use of the mathematical model to calculate
1) the traction energies from train motion logs of driving before a CATO installation
2) traction energies if the train driving would have used the CATO advice.
The BA is a quick and low-cost method to calculate savings compared to field tests. Furthermore, the effects of various situations can easily be evaluated. Experiences from the BA model are very good.

Traffic Management / Dispatching

As mentioned above, a C-DAS solution, includes an external sub-system for traffic management / dispatching. Thus, C-DAS depends on the TMS of the (Infrastructure Manager, IM) in the countries/regions covered by the train Journey.

C-DAS is a relatively new technology to the IMs in Europe and many legacy TMS systems are not yet fit for C-DAS operation.

However, all IMs work towards C-DAS to improve the traffic capacity of the infrastructure. A common guideline/"standard" IRS 90940 has been developed in a UIC-project named "Sfera". The concept includes provision of Journey Profiles (information on the route of the train and its real-time traffic plan) and the associated Segment Profiles (the infrastructure data). Even if it will take some years before this is commonly implemented, the IMs already give access to the JP/SP background data. This is what Transrail is currently using in Germany and we will be able to use in France, Italy, Austria, Switzerland etc. Based on available IM data, Transrail has long experience of generating JP/SP for CATO operation in the Nordic Countries and England.

C-DAS capability of the RFC (Rail Freight Corridor) Network is likely to become on the agenda of RailNetEurope.

Conclusion

CATO technology is a pioneering solution for modern rail transportation. It combines energy efficiency, operational optimization and environmental friendliness in a flexible, scalable system. With its modular architecture and powerful optimization algorithms, it can be adapted to the specific requirements of different types of rail operations: from high-speed trains to heavy freight transport.

By combining technical excellence and data-based decision making, CATO provides an unparalleled foundation for a sustainable and efficient future of rail transportation.

With CATO, we provide drivers with a powerful tool to increase rail efficiency.

Transrail Sweden AB

Trainsrail is a limited company founded in 1995. It was one of the first private railway consultancy services in Sweden.

First pre-studies on DAS were done at the turn of the millennium, followed by development of our ambitious C-DAS solution CATO. First field tests were done in 2007. Full-scale C-DAS tests, STEG-CATO, with heavy iron-ore freight trains were done in 2011. Commercial installation on the Iron-Ore line in northern Sweden in 2012. Since then, Transrail has gained valuable experience of various DAS-solutions in many countries worldwide.

In 2016 the company took the strategic decision to focus on DAS.

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