

Dynamic Headway and Its Role in Future Railways

Making the Transition from Scheduled to Demand-Response Services

Dynamic Headway is the world's first solution that offers new rail transport value in the form of flexible rail services based on passenger demand. It analyzes demand conditions with data acquired from sensors installed in stations and trains, and automatically optimizes the number of train services in response to the analyzed demand. It provides value to passengers in the form of congestion alleviation and transport comfort, and to rail service operators in the form of improved service efficiency. Hitachi is currently working on a proof of concept for the solution with Italian railway systems integrator, Ansaldo STS, and Denmark's Copenhagen Metro. As part of these activities, Hitachi has assessed the customer value that Dynamic Headway will bring by using simulations to evaluate its quantitative and qualitative benefits. Hitachi will continue to develop and release solutions driven by digital technologies as it aims to help achieve a more comfortable society to live in through rail transport.

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1. Introduction

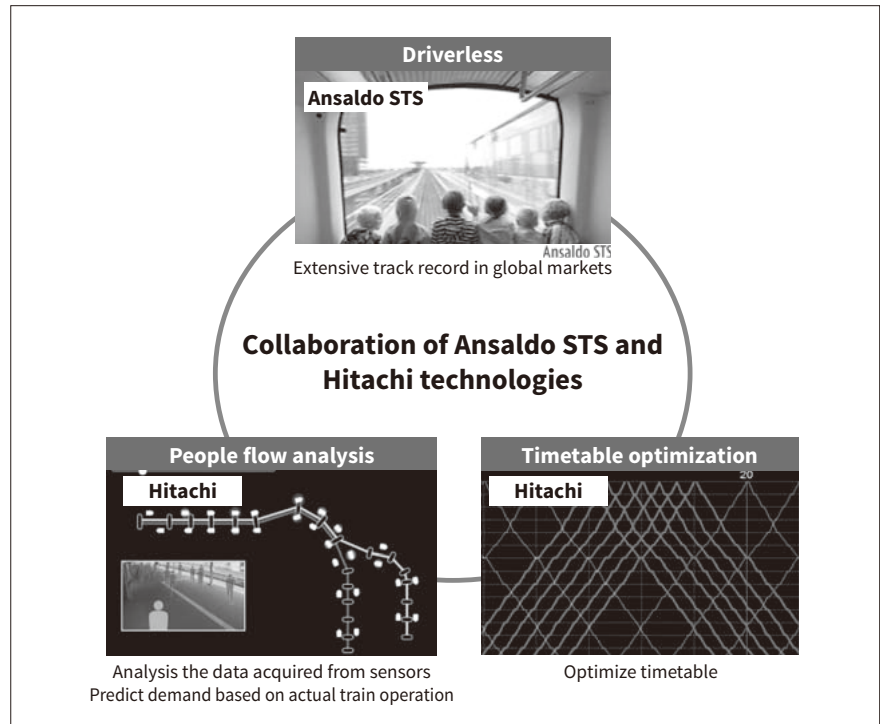
The striking rise of digital technologies in recent years is on the verge of creating major changes in modern living environments. The growth of the Internet of Things (IoT) has dramatically increased the amount of data being generated and used throughout the modern world, and data is fueling the creation of new value in a wide range of industrial sectors.

With the use of the IoT also growing rapidly in the rail transport industry, Hitachi is stepping up

data-driven efforts to provide high value to all rail transport passengers and operators. Effective use of data can provide passengers with greater levels of transport convenience and comfort, and rail service operators with improved transport efficiency per unit time. Creating this new value will also be the first step in creating smart cities and revitalizing entire regions surrounding railways. By developing and releasing digital solutions, Hitachi aims to use rail transport as a starting point for creating universally passenger-friendly and easy-to-use transportation and a more comfortable society to live in.

Figure 1 — Collaboration of Ansaldo STS and Hitachi Technologies

The proprietary technologies of both companies are the core technologies of Dynamic Headway.



2. Dynamic Headway

Dynamic Headway is a driverless signal/rail service management system that tracks transport capacities in real time in response to variations in demand. While the value of rail transport has traditionally come from providing services precisely at the scheduled times, Dynamic Headway offers new value in the form of more flexible services based on passenger demand. It is an unparalleled world-first solution created through a collaboration of the technologies of Hitachi and Italian railway systems integrator Ansaldo STS (see **Figure 1**). A series of patented proprietary technologies are behind the solution (international publication number WO18/087811).

Hitachi technology is used to detect the congestion rate (the demand conditions) from data acquired in real time from various sensors installed in stations and trains. Existing surveillance cameras can be used as one of the sensor types, enabling a lower initial equipment investment by rail service operators who install Dynamic Headway. The demand detected in real time is used to predict how demand will change in the future, and optimum timetables are generated on the basis of the prediction results. This process uses

Hitachi technology to make immediate condition-based decisions about optimum solutions for varying the number of trains in service or adjusting the headway. Ansaldo STS links the generated timetables to the driverless system to create optimum rail services without human intervention.

The use of Dynamic Headway will improve passenger comfort by alleviating rail transport congestion. It should also provide benefits to rail service operators. Alleviating congestion should improve passenger satisfaction and lead to increased sales, while tracking real-time demand for train services should improve rail service efficiency and lead to energy savings that reduce costs. The efficient energy use enabled by optimized train services will also help reduce the environmental load, which is a significant benefit for the local communities in rail transport zones.

3. Proof of Concept at Copenhagen Metro

3.1

Copenhagen Metro Overview

The Copenhagen Metro is a driverless metro system that links the center of the Danish capital to its airport with round-the-clock driverless operation (see **Table 1**). Its driverless operation system began

Table 1 — Overview of Copenhagen Metro

The Copenhagen Metro has two lines (M1 and M2), and operates 24 hours a day.

Total length	21.3 km
Number of lines	2 (M1, M2)
Number of stations	22
Start of service	2002
Number of trains	34 vehicles, each of which consists of 3 cars
Service hours	24 hours per day
Top speed of trains	80 km/h
Service interval	During the day: 3 to 6 minutes During rush hours: 2 to 4 minutes At night: 15 to 20 minutes

service in October 2002, and has been managed by Ansaldo STS since then. Transport services and maintenance are handled by Metro Service, a joint venture of Ansaldo STS (with a 49% ownership stake) and ATM^{*1} (with 51%).

3.2

Proof of Concept Background

Copenhagen Metro is facing an issue with alleviating congestion on trains caused not only by peak passenger demand in the morning and evening rush hours, but also by demand fluctuations for which the airport

^{*1} Stands for Azienda Trasporti Milanesi. The company responsible for public transport facilities in the city of Milan, Italy and surrounding municipalities.

and multipurpose arena are responsible. Passenger numbers on existing lines are expected to see a major rise after the opening of a new line scheduled for 2019. Train congestion is expected to become a major problem in the future as a result, so the Copenhagen Metro required a solution for improving passenger satisfaction by eliminating congestion.

Dynamic Headway is the optimum solution to this problem. To assist with customer issue-solving and complete solutions through collaborative creation with customers, Ansaldo STS signed a proof of concept agreement with Copenhagen Metro infrastructure owner, Metroselskabet, in June 2017.

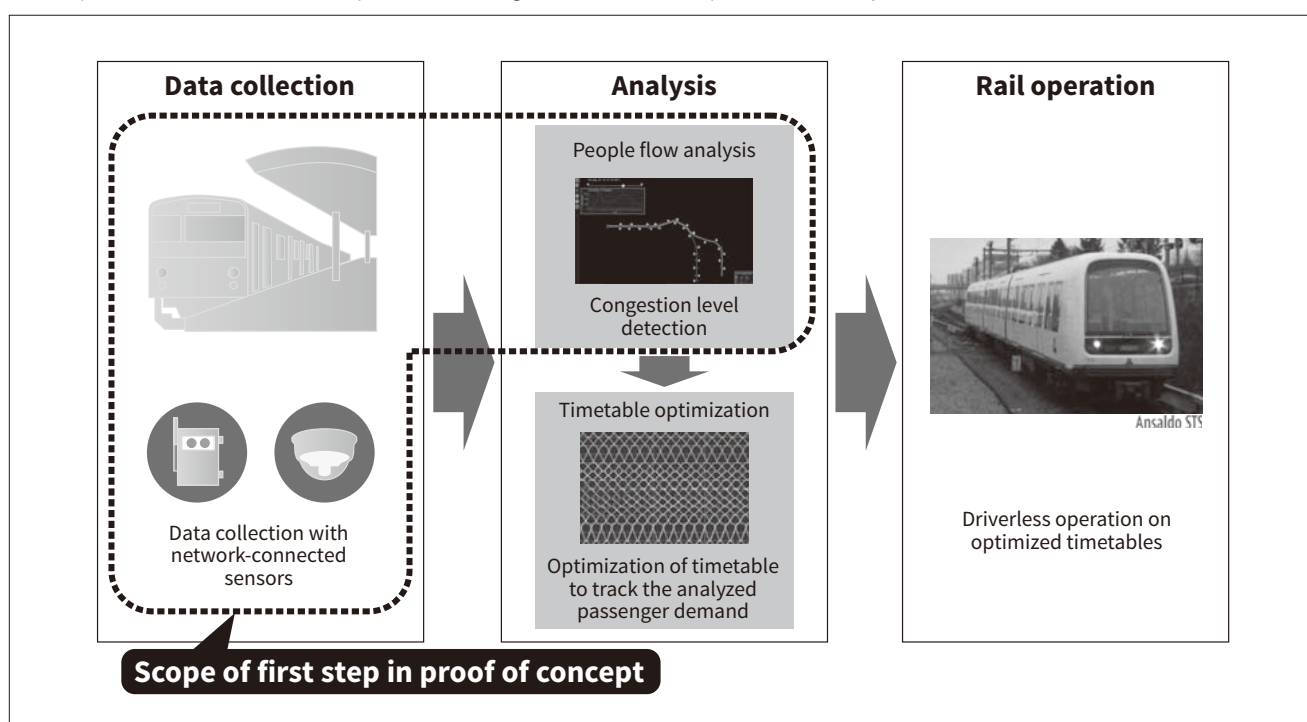
3.3

Proof of Concept Protocol and Findings

The first step in the proof of concept covered processes from collecting data to analyzing people flow (see **Figure 2**). This step consisted of using the existing infrared sensors and closed-circuit television (CCTV) cameras installed in Copenhagen Metro stations to acquire data, analyze current congestion rates, and predict future demand based on current congestion rates. The results indicated that it was possible to analyze congestion rates and predict demand with high

Figure 2—Scope of First Step in Proof of Concept for Dynamic Headway

Data acquired from sensors was used to predict future congestion levels, and the prediction accuracy was assessed.



accuracy. The system was also able to maintain high prediction accuracy during the high-demand morning and evening rush hours, and at times when demand varied greatly as rush hours began.

For the second step, more practical experimentation is under consideration to integrate timetable optimization and the driverless operation system.

3.4

Simulation of Achieved Benefits

Along with the proof of concept done to assess analysis accuracy, simulations were also conducted to quantitatively assess the benefits that Dynamic Headway will provide. The estimate created by the simulations used 2025 demand created with Hitachi prediction data as the input, and under the assumption that imbalances between supply and demand will become increasingly severe with the 2019 opening of a new line. This prediction foresees congestion intensifying in 2025 in an area where the two existing lines converge, generating situations in which passengers will be unable to board during rush hours and will have to wait on the platform for the next train (see **Figure 3**). But the estimate has predicted that the use of Dynamic Headway will make it possible to reduce the number of these passengers in this area by about 80%.

3.5

Solution Evaluation from an Operational Perspective

In response to the proof of concept and simulation findings, Metro Service has qualitatively evaluated

the value provided by the solution from an operational perspective in terms of both rail services and maintenance. Some of Metro Service's feedback to Hitachi was as follows:

In terms of rail services, the use of Dynamic Headway will provide value to both passengers and operators by providing additional trains in areas of high passenger numbers, and maximizing transport efficiency. Operators making manual changes to timetables during times of congestion need to rely on their individual skills and experience, resulting in variable accuracy. But using the solution will enable optimum rail services from optimum handling without relying on personal skills. Operators creating or changing timetables will also be able to reference accurate demand data accumulated from the use of Dynamic Headway, enabling them to create timetables that are more accurately based on the demand. The volume of data accumulated will increase as the solution continues to be used, continually increasing the accuracy of demand prediction and timetable optimization.

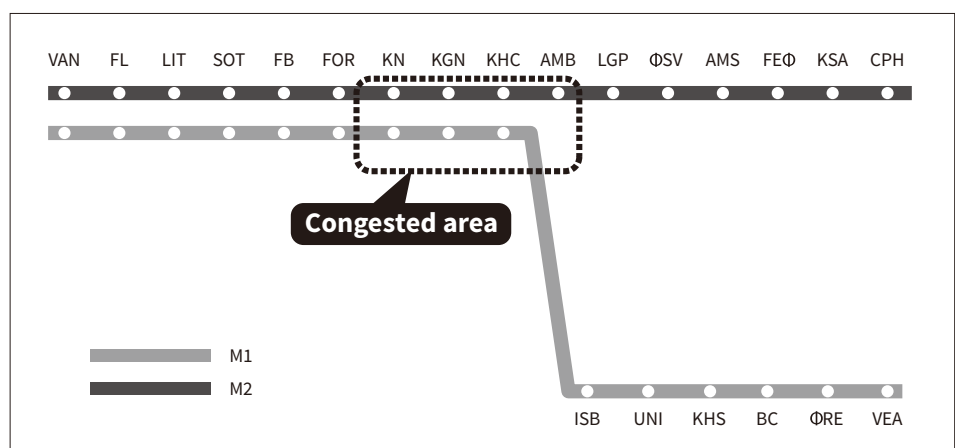
In terms of maintenance, coordinating the solution with train maintenance planning in the future will enable maintenance plan optimization and maximum use of existing trains.

4. Working Toward Greater Value Creation

The people flow analysis data used by Dynamic Headway can fuel the creation of various types of new value in areas besides demand-based rail service

Figure 3—Congested Area Prediction for 2025

The area where the two lines (M1 and M2) converge is predicted to be heavily congested.



optimization. Using this data in more advanced ways could provide an entry point for rail digitalization.

For example, using acquired people flow analysis data to give passengers information about real-time congestion conditions on station displays or mobile apps could let passengers avoid congestion at their own discretion. This innovation should improve convenience while simultaneously reducing congestion. Promoting passenger behaviors by publicly releasing information will give rail service operators some control over congestion conditions, letting them take proactive steps toward solving problems. Another way to provide individuals with higher levels of convenience could be to accumulate rail transport people flow analysis data, and to provide and share it with other public transport facilities, as well as with commercial facilities and local authorities around stations.

Using Dynamic Headway as a starting point, Hitachi plans to step up its work on releasing solutions driven by people flow analysis data so that it can provide digitalization-based value in a wider range of areas.

5. Conclusions

Dynamic Headway is a solution that will innovate rail transport value, offering new rail transport value in the form of on-demand rail services. It will provide passengers with transport comfort and convenience, and rail service operators with improved service efficiency and energy savings. It can also serve as an entry point for creating a rail transport future made possible by the use of digital technologies. Creating an environmentally friendly rail transport future that increases city convenience and comfort will help enable sustainable cities and communities, which is one of the United Nation's Sustainable Development Goals (SDGs^{*2}). Seeking to achieve a more comfortable society to live in through rail transport, Hitachi will continue to develop and release Dynamic Headway and other digital solutions through collaborative creation activities with customers.

^{*2} The Sustainable Development Goals are a collection of international goals set by the UN at a summit in September 2015 for implementation from 2016 to 2030.

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