Paper ITS EU-TP0036

Using C-ITS on road status information in winter maintenance operations

Lone-Eirin Lervåg[1*], Tomas Levin[2] and Ane Dalsnes Storsæter[3]

1. SINTEF Technology and Society, Norway, lone.lervag@sintef.no

2. Norwegian Public Roads Administration, Norway, tomas.levin@vegvesen.no

3. Norwegian Public Roads Administration, Norway, ane.storsater@vegvesen.no

Abstract

This paper presents a Norwegian pilot on the use of a cooperative ITS (C-ITS) service for road status information data in winter maintenance operations. Approximately 500 ordinary production Volvo vehicles are used as a sensor for data collection and estimation of slippery roads, with the aim of improving winter maintenance in terms of cost efficiency and quality. Cooperation and interaction between the road authorities and the car industry is also expected to be conducive to further development and investment in future C-ITS services. After a short introduction, the paper presents a concept description and the objectives of the application, followed by a presentation of the pilot study and the evaluation framework used for assessing the quality and impacts of the C-ITS service. In conclusion, the expected results and outcome of the project are presented, along with a brief description of the underlying mechanisms causing the expected effects.

Keywords:

Cooperative ITS, winter maintenance, evaluation methodology

Background

Cooperative intelligent transport systems (C-ITS) allow for connected and automated services that stimulate more efficient and cost effective solutions and applications, benefitting both road operators and transport users. The use of road status information (RSI) data in winter maintenance operations is addressed in a cooperation project between the Norwegian Public Roads Administration (NPRA) and Volvo Car Corporation. By using ordinary production vehicles as a sensor for data collection and estimation of road friction (slippery roads), weather and climate status, a comprehensive set of road status information is consecutively made available for the road authorities. The project constitute the Norwegian pilot in the on-going NordicWay project, which aims at deploying and evaluating cooperative services on the NordicWay corridor from Finland to Sweden, Denmark and Norway.

Objectives

The main objectives of making weather and slippery road warnings available by using the vehicle as a sensor are to:

1) Improve winter maintenance in terms of more cost-efficient operations and improved quality and coverage of performance.
2) Enable further development of cooperative RSI services and future driver assistance systems.

Improved winter maintenance will be achieved through the following effects:

a) A more cost-efficient data collection and winter maintenance in terms of decreased costs for operation staff and equipment. When relevant data on weather and slippery roads are collected by ordinary vehicles within the transport system, the extent of dedicated measurement vehicles and equipment can be reduced.
b) Improved quality of winter maintenance in terms of more targeted actions and operations. Inspections of road status can be based on indications from a wide range of sensor vehicles, and thus provide a more targeted and efficient use of the existing maintenance staff, resulting in higher quality and more benefits achieved with the existing amount of resources.
c) Improved planning and organizing of future winter maintenance operations based on increased knowledge on road status and condition.

In addition, it is expected that the pilot will contribute to *further investment from the automotive industry*, in terms of:

d) Future development of cooperative RSI solutions and driver assistance systems. Cooperation and exchange of needs and experiences between the road authorities and car industry will enable further investment and development of C-ITS services based on sensor vehicles and C2C communication. This will enhance the other effects, through continuous quality improvement and increased market implementation.

The concept

Description of the C-ITS service and context

Traffic and road status monitoring is critical for maintaining a safe and efficient transport system. A major challenge to the road authorities is the cost of strict C-ITS implementation, which would require an extensive network of ITS stations along the road network. In the RSI project a hybrid solution is put forward, combining the advantages from extended vehicle and C-ITS standards. The main objective of this choice of solution is to keep the cost down for authorities. Vehicle sensor data are collected by the vehicle and transferred via 3G/4G to the OEM cloud. From the OEM cloud the messages are passed to a message broker where other OEMs, road authorities, and other 3rd parties

can subscribe to the data. This is all nice technical, but the one question remains: Can we use a single vehicle to detect slippery road as seen in the infomercials for C-ITS?

The shift from geographically fixed observation sites to following the individual vehicles as they move is also known as respectively Eulian versus Lagrangian sensing [1][2]. General for Lagrangrian traffic projects is that they focus on traffic flow and state. A third party device located in the vehicle is used to geolocation and vehicle speed recording. The RSI project extends on this to move into the realm of extracting data from production vehicles. The cooperation between road authorities and vehicle manufacturer in collecting complex attributes like friction is novel.

Technical quality assessment

In the RSI project the Norwegian Public Roads Administration (NPRA) has conducted several initial tests and experiments to prove how far a single vehicle can be used to detect slippery roads, and to see if single vehicle data is useful and applicable, including considerations of geographical location of data and coverage of observations.

Friction and friction estimation is a complex task. Combining data from several vehicles over a period of time and for a specific stretch of roadway holds beneficial potential, especially for road maintenance operations. The testing conducted by the NPRA is set up to answer these questions. The testing is conducted as a cooperation study between the industry partner and the NPRA;

- The NPRA collects reference friction measurements for the OEM to use in their quality assessment

- The OEM collects and provide both processed and raw data from the vehicles for the NPRA to use in the project

The technical assessment provides the OEM with large amounts of high quality friction measurements on public roads under differing conditions. For most of the test driving, the vehicles formed part of a convoy that was lead or followed by NPRA road friction measurement vehicles.

In addition to the quality testing, a fleet of vehicles will simulate the real world scenario, where the NPRA acquires data from a fleet and process this data into information to be used by the road maintenance crews. For this information to be applied in planning and road maintenance operations, certain requirements have to be fulfilled, including knowledge on the data quality and under what conditions one would get good data from the single vehicles in the fleet. Hence the importance of the quality testing is underlined.

Pilot description

The pilot will utilize data from a fleet of approximately 500 Volvo cars. This provides measurement and estimation of RSI data with high frequency and geographical distribution. The geographical focus includes the NordicWay C-ITS corridor, a four lane motorway of approximately 440 Km from Oslo to the Swedish border. This is considered a *best case scenario* road section with a steady cellular network available and thus appropriate conditions for achieving good technical functionality. In addition, Norway has a vast road network where large parts are located in sparsely populated areas with less traffic and limited cellular network available. Of this reason, the pilot will also include a *worst case scenario*, in order to test the functionality of the C-ITS service in a less suitable context.

The C-ITS service on weather and slippery road warning are being tested during winter conditions, to capture the most relevant (and presumably the most difficult) seasonal conditions.

The Evaluation Framework

The quality of technical performance, impacts and benefits and user acceptance of the C-ITS service are addressed in an evaluation assessment following the guidelines of the NordicWay Evaluation Handbook [1].

The NordicWay evaluation approach is oriented towards an evaluation of a) the technical performance of the C-ITS services, b) the impact of the C-ITS services, c) user acceptance of the C-ITS services, d) socio-economic performance of the C-ITS-services, and e) financial performance of the C-ITS services, as illustrated in Figure 1.

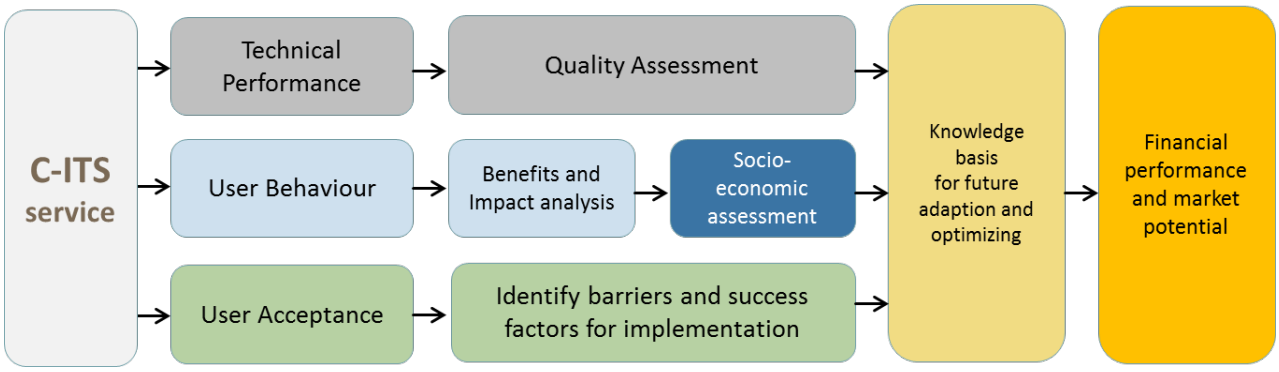

Figure 1 – Structural evaluation approach

The evaluation process will consecutively address problem analysis and needs assessment, establishment of a program theory based on objectives, formulation of evaluation criteria, development of a proper evaluation design, definition of data collection methods, field test execution and data collection, design of data analysis and specification of report content.

The evaluation will generally combine quantitative and qualitative collection methods. On a higher level, the qualitative approach is beneficial in identifying changes and impacts due to the C-ITS service, and to form a view of the occurring mechanisms causing these effects. The quantitative approach brings evidence on the magnitude and confidence values of the effects, proving statistical significance of any observed changes or differences in performance or behaviour.

Expected outcome

Prior to the assessment, it is assumed that the data quality of the road status information achieved is sufficient for decision making support within winter maintenance and traffic management operations, although the accuracy of the vehicle sensors are probably not as good as for the existing climate stations and ROAR (Road Analyzer and Recorder) measurements. Validation and assessment of the technical performance of the C-ITS service will be addressed in the evaluation process, verifying whether the system performs as intended and is capable of providing the necessary information at an acceptable quality and in an efficient manner.

Data collection and application of weather and slippery road warnings by using the vehicle as a sensor are expected to provide impacts in terms of more efficient winter maintenance by;

a) Increased cost-efficiency,
b) Improved quality of winter maintenance,
c) Better knowledge basis for planning and organization of the future winter maintenance, and
d) Investments and future product development of C-ITS solutions.

These results are achieved by a number of causal mechanisms, triggered off by the application of RSI data, including;

- An extended area of data collection, as using the car as a sensor enables monitoring of a larger area than what is possible to cover by the current measurement equipment and climate stations.
- A shift in focus from the road characteristics and state to how the road is perceived by the vehicles (data entry triggered by ABS and/or ESP), which allows for a more targeted prioritization of winter maintenance to the road sections with real need of actions and operations.
- Control and verification of winter maintenance operations, as the effect of maintenance actions can be proved. Today this is a costly type of data to provide by using dedicated measuring vehicles (ROAR).
- Comprehensive location based statistics through continuous monitoring, which will increase the knowledge on road conditions and state over time.
- Networking and cooperation between road authorities and the automotive industry, which

will enable further investments and future product development of RSI solutions.

- Sufficient user acceptance in terms of positive attitude, perceived benefits and trust among the road authorities, winter maintenance operators and the car industry.

In a longer term, it is expected that increased efficiency in winter maintenance operations will lead to increased traffic safety and a more efficient road network performance. An overview of the program theory (logical framework) of the C-ITS service is presented in Figure 2.

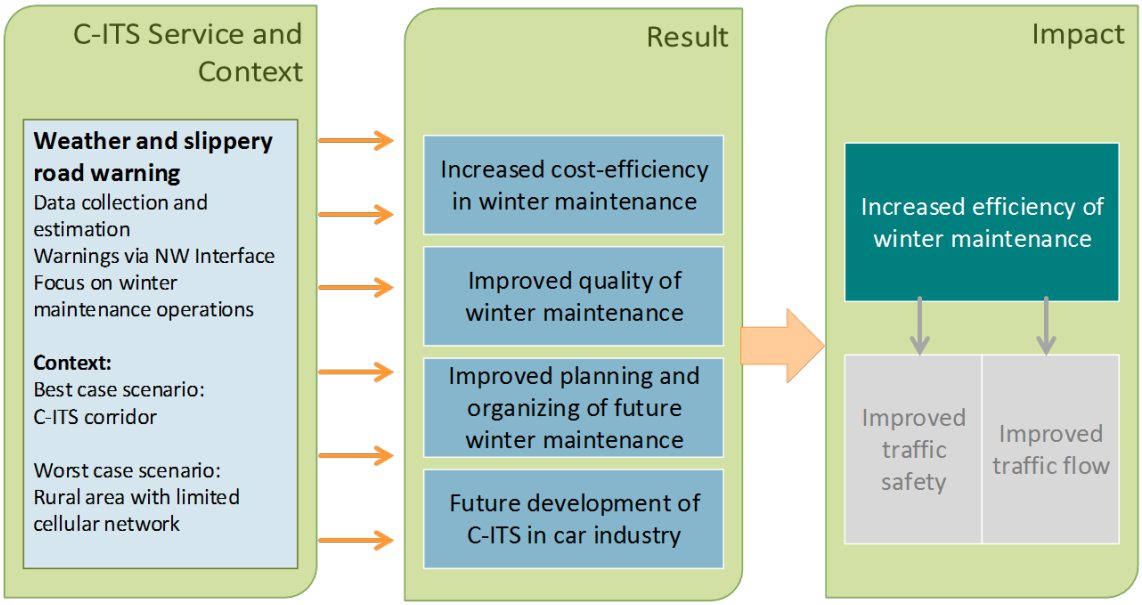

Figure 2 – Program theory for the C-ITS service on weather and slippery road warning

Wider Impacts

The objective of the NordicWay pilot presented in this paper is to test and evaluate a C-ITS solution for weather and slippery road warning with the intention of increasing the efficiency of winter maintenance operations. By making data on slippery roads available, additional benefits may be achieved, e.g. by allowing the traffic operator to perform more targeted traffic management and information services towards the affected drivers [4]. This premises the establishment of a system for handling and supporting decisions based on the data flow that is made available. Continued investment and future development of RSI solutions in the automotive industry, will enable systems for C2C communication and warning of safety critical incidents directly to the end users.

References

1. Work, D.B., Tossavainen, O.P., Jacobson, Q. and A.M. Bayen (2009). *Lagrangian sensing: traffic estimation with mobile devices.* American Control Conference, St. Louis, MO, 2009 pp 1536-1543.

2. Herrera, J.C. and A.M. Bayen (2010). *Incorporation of Lagrangian measurements in freeway traffic estimation.* Transportation Research Part B: Methodological, Vol 44, Issue 4 pp 460-481.

3. Lervåg, L.E. (2016). *Evaluation Handbook. NordicWay.* NordicWay project report, March 2016.

4. Foss, T. and Roche-Cerasi (2016). A feasibility study for Weather-controlled Variable Speed Limits (VSL) in Norway. (In progress) SINTEF Technology and Society, , Trondheim, Norway