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METEOROLOGISKA INSTITUTET
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# Intelligent Arctic Trucks

Summary report

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# Abstract/Executive Summary

The *Intelligent Arctic Trucks* is a joint label for two (research & development and investment) project funded by the European Regional Development Fund (ERDF). Finnish Meteorological Institute (FMI) is the coordinating organisation in a consortium comprising altogether three partners. The concept of the project is based on utilising a small fleet of heavy trucks transporting ore between a mine and a port as observation platforms. The data collected by the trucks' systems are combined with data from fixed Road Weather Stations (RWSs and this combined data set is used to improve and enhance model analyses and forecasts of both road surface condition. Finally, the drivers of the truck fleet act as testers of a mobile device application (also developed in these projects) used for delivering the road status information and warnings to end users. The benefits and impacts include improved safety and predictability of traffic as well as optimization of road maintenance activities such as plowing and distribution of road salt.

# Introduction and Background

Hazardous weather phenomena (such as strong precipitation in various forms) or dangerous road conditions (such as surface freezing and the resulting reduced friction) are relatively common in Lapland's Arctic climate with long winters. Detection and warning of such phenomena and conditions have significant potential to improve both safety and fluency of road traffic significantly. The impact and value of improved safety are obvious and improved fluency has positive impact on the timeliness and predictability of commercial traffic.

Up to recently, weather and road condition observations have been done primarily at Road Weather Stations (RWSs). The data have typically good quality, but the RWSs are fixed installations and although they can provide observations with relatively short sampling intervals, the number of RWSs is limited and consequently, the spatial coverage is sparse. The fixed nature of the RWSs makes data transfer arrangements to the weather modelling infrastructure somewhat easier, but the sparseness of spatial coverage limits the usefulness of the RWS data for modelling. Obtaining observations with high density is a prerequisite for provision of forecasts and warnings covering the entire road network.

The Intelligent Arctic Trucks is a pilot project testing and assessing the feasibility of a supplemental approach: use of road vehicles as mobile observation platforms covering a selected stretch of road. The underlying assumption is that this approach may eventually be expandable to cover more parts of the national (or wider) road network. The results can be applied to all regions where hazardous weather phenomena and road conditions increase accident risk frequently or as long-duration occurrence (e.g., during long Autumn, Winter and Spring seasons). Lapland is a typical example of such a region.

Use of vehicles supplements the RWS observations. Mobile observations are on the one hand intermittent and – depending on the types of vehicles or vehicle fleets used – less regular in time, but on the other hand provide data from locations not covered by RWSs.

In this project vehicle-based data are collected from two types of sources: from the vehicles' own equipment (such as built-in friction detection systems) and from dedicated, separate instrumentation installed onto the vehicles. Road surface imagery and friction information are the primary parameters recorded. Imaging provides information on wetness and snow & ice coverage of the road surface, supplemental to direct friction data. Data collection and transfer are handled in near-real-time *via* on-board processing and 3G/4G network connections.

## The pilot route and vehicle fleet

The pilot route is the 260 km long stretch of the E75 highway between the Kevitsa mine and the port of Kemi (Figure 1 below). No railway connection exists between these locations, hence ore from the mine is transported by road with heavy trucks to port for onward transport. Consequently, the trucks travel this stretch of road frequently and regularly, hence providing good temporal coverage. Many if not all modern trucks have built-in sensing systems in the Anti-lock Braking and Traction Control Systems (ABS, TCS) as well as in-vehicle data transfer equipment[1], which can be accessed for data collection. The large size of the vehicles means also, that the size and type of additional instrumentation installable on-board is not as restricted as would be the case with smaller vehicles. The trucks assigned for this project by the Transpoint transport company[2] (a consortium member) form a fleet of twelve (12) heavy trucks.

The truck fleet has operated fairly evenly almost around the clock, as indicated by the data collection statistics (Figure 2 on Page 4Figure 2). Only the time between 23-04 (local time) the trucks have been mainly on hold. Furthermore, the driving has occurred mainly 6 days per week, only Sundays being out of operation. Since the trucks are on the move typically from 04 h to 23 h, maintaining and repairing of the sensor equipment can only be done during the night.

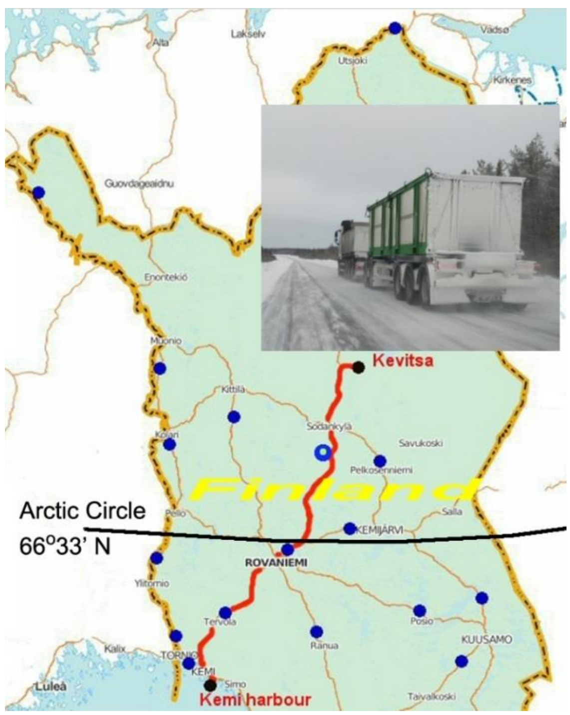


*Figure 1. Intelligent Arctic Trucks route and the existing RWS network. Filled blue dots are RWSs operated by Traficom (the Finnish traffic and communications agency), the interactive research RWS of FMI (located near Sodankylä) is shown with an open blue dot.*

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[1] A single truck can have several internal data buses (typically adhering to the CAN Bus standard), enabling access to and data collection from the built-in sensor and other systems.

[2] https://www.vrtranspoint.fi/en/

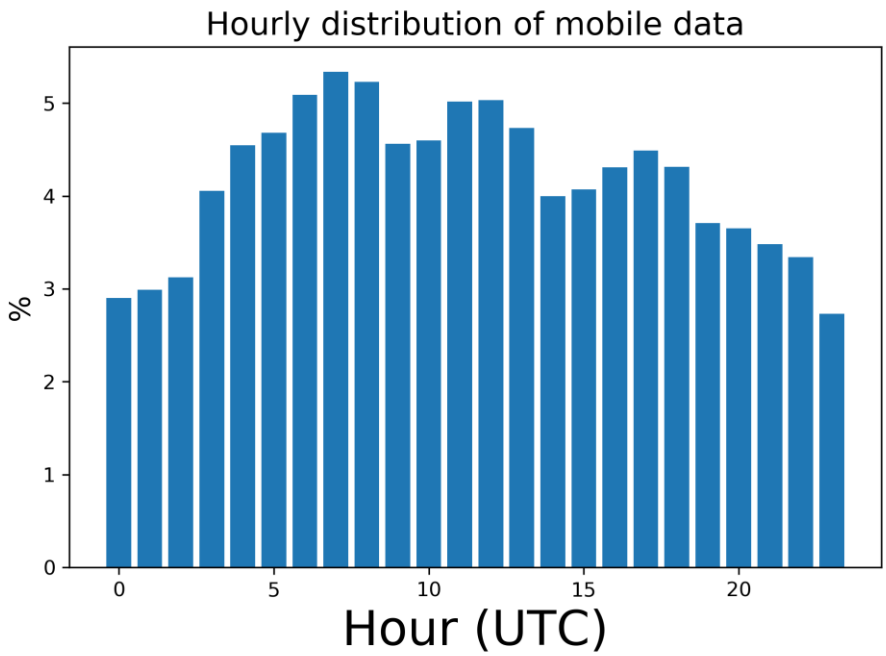


*Figure 2. Hourly distribution of mobile measurements. The bars show the percentage of measurements done during certain hour of the day. The measurements were done mainly during winter periods between February 2017 and April 2019. Note, that the time is given as Universal Time, Coordinated (UTC). The local time on the Kevitsa-Kemi road is 2 h or 3 h ahead of UTC, depending on whether winter or summer time is observed.*

## On-board equipment

The instrumentation consists of surface friction and temperature instruments (Teconer RCM411, RTS411), special vehicle telematics devices (Sunit FD2 vehicle PCs and E3 Grip telematics device) for retrieving data from the vehicle's CAN bus along with several cameras collecting both video and still image data from the vehicle front. The size of the equipment and its installation on the truck are illustrated in **Error! Reference source not found.** below.

The data are transmitted from the trucks using cellular 3G/4G communication to a cloud storage, from which it is retrieved to the road weather forecasting system. The completed service data (including road weather forecast) is regularly delivered back to the trucks.

*Figure 3. Left image: a heavy Transpoint ore transport combination truck. Right image: the externally visible road surface observation equipment installed onto the truck. The location of the equipment on the truck is indicated by a red arrow on the left image.*

## The Project: Structure, Funding, Consortium and Timeline

*Intelligent Arctic Trucks* comprises two projects, both funded by European Union's European Regional Development Fund (ERDF). Research is conducted in the Research and Development project, while the investments related to the project (friction instrumentation, telematics instrumentation and end user devices) as well as activities related thereto are conducted in the investment project. The combined ERDF support for the two projects amounts to approximately 165000 EUR.

The consortium for the projects includes three partners. The table below lists the partners, the combined external funding they have received for both the development and investment projects:

| Organisation | URL | External Funding (EUR) | Main responsibilities |
|---|---|---|---|
| Finnish Meteorological Institute | https://en.ilmatieteenlaitos.fi/ | 155328 | Project coordination, measurements, services, maintenance. |
| Lapland University of Applied Sciences | https://www.lapinamk.fi/en | 9548 | Reference data coming from separate fleet, online data services within Wirma project. |
| Transpoint | https://www.vrtranspoint.fi/en/ | No ERDF funding (in-kind contribution) | Truck fleet operation, independently of the project |

# Results: Products and services

As mentioned, the data collected on-board the trucks is transmitted to the road weather forecasting system of the FMI. These data are combined with weather and surface condition data from other sources (such as RWSs and other forecast products) to produce dedicated road and traffic forecast products (such as road surface state information) as well as warnings of hazardous conditions. Such warnings can include location, timing and probability information.

Road surface temperature observations made with Teconer RTS411 were compared with road weather station (RWS) measurements to assess the data quality. It was found out that the mean difference between mobile observations and RWS observations was dependent on the measurement device and was evolving over time. The location of the device in the truck can affect the measurements, since thermal radiation from the truck can be reflected from the road surface to the instrument. This bias can be particularly significant, if the device is installed near the engine or other sources of heat. However, the measurements can be corrected with a statistical correction. **Error! Reference source not found.** shows example measurements done with one device with and without correction. The correction was calculated as mean difference between measurements of the device and RWS measurements done in Sep-Nov 2017. The comparisons were done at times when the truck passed an RWS along the route.

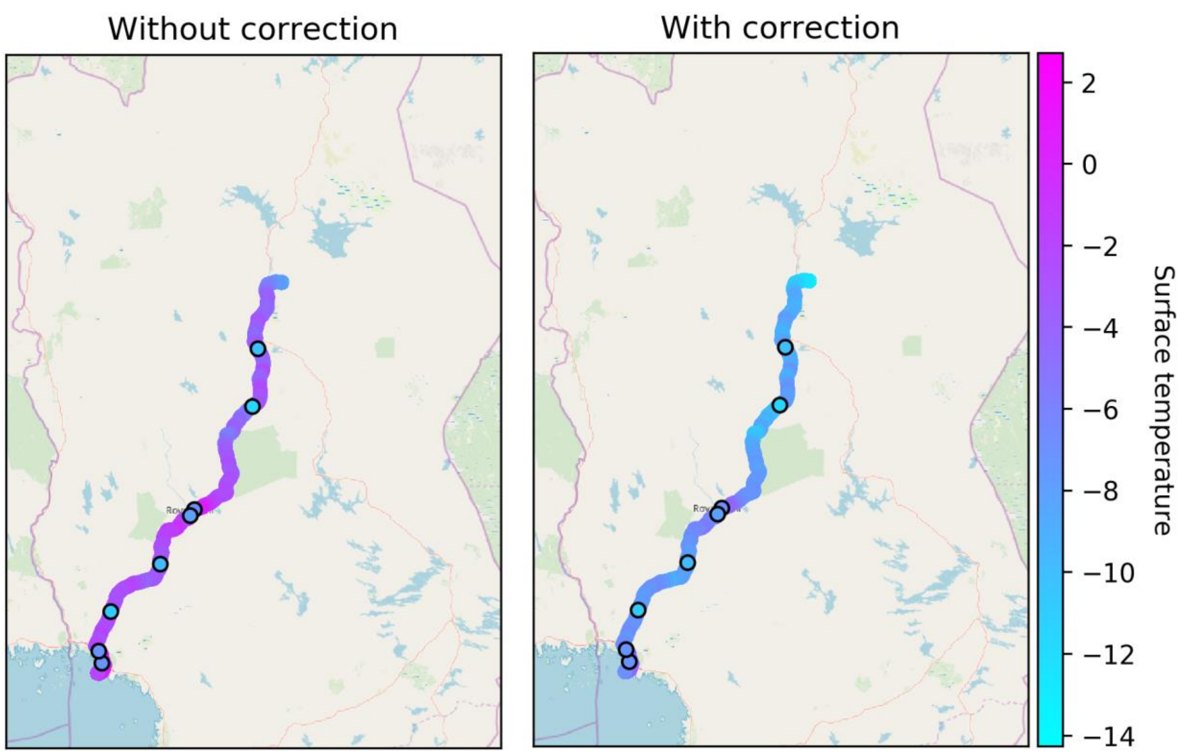


*Figure 4. Mobile road surface temperature observations (continuous line) and road weather station observations (circles with black borders) along the Kevitsa-Kemi truck route. Mobile observations were carried out on 4 Dec 2017 between 06:00 and 13:00 local time. Observations from road weather stations are from times when the truck passed the station. Left panel shows observations without correction and the right panel with statistical correction applied.*

During the project there were several devices providing measurements. When the forecast production for the project started in Spring 2017, measurements were available from Teconers installed to two trucks. One of these provided measurements until the end of April 2018 and the other until June 2018. Starting from December 2017, measurements were available also from a third Teconer. It provided measurements until February 2019. Statistical corrections were not applied to the observations when they were initially assimilated to the forecasts, but corrections were applied later. However, in Autumn 2018 it was observed that the warm bias in the third device's measurements was so large that the data from this device were no longer assimilated to the forecast.

A part of the Intelligent Arctic Trucks project is development of an application for the tablet computers for delivery of the road surface condition and warning products to the end users. A screen capture from the application user interface is presented below in the Figure 5. The development of the delivery application has been supported by a group of test users providing reliability, functionality and usability feedback. The quantity of the feedback received has, however, been limited. As the result drawing any general conclusions from the responses would be premature, as a larger sample would be needed. Very briefly summarized, the application was found beneficial especially if it would be offered in national scale, but it should be integrated to vehicle systems, in order to avoid too many screens in vehicle (although some users preferred smart phone application). The service/application should be free-of-charge, to ensure necessary penetration leading to real improvements in the traffic safety.

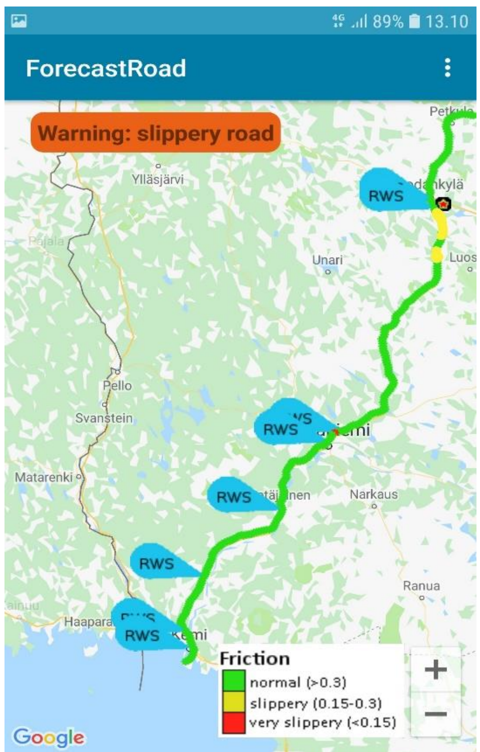


*Figure 5. User interface of local road weather application.*

# Analysis, Conclusions and Future Potential

As referred to earlier, the approach to road surface observations demonstrated in this project may be expandable to achieve better and more comprehensive coverage of the road network. Observations of road surface friction may be available from the ABSs and TCSs as well as and road surface imagery from cameras of a wide range of vehicles (cars, vans, buses, trucks), especially since vehicles are increasingly connected to mobile networks. The vehicle-internal data buses need, however, to be coupled with the external communications equipment. Technically, data collection, transmission, storage and input to, e.g., road condition & weather prediction and warning systems is feasible. Friction data is, however, potentially sporadic as observations may be available only when ABSs and TCSs activate during driving. Such activation may be dependent not only on the road conditions, but also the driving speed, style and profile of the driver.

Sensor systems such as the Teconers used in this project are more versatile in terms of observed parameters. Such systems also provide more consistent and regular observations and hence add value over collection of data only from built-in vehicle systems. However, these “Teconer-type” systems have a higher threshold of adoption into vehicles; the equipment is additional to what is already available built-in to a vehicle and hence requires separate installation(s). The size of such equipment is also fairly large. The latter characteristic constrains both the types of vehicles useable as platforms as well as the suitable installation locations in or on a vehicle. Cars might not be ideal platforms due to vehicle size and the large numbers of vehicle owners. Vans, buses and trucks would appear more suitable in terms of vehicle size and also, since these types of vehicles often are parts of larger vehicle fleets with relatively small numbers of owners.

Data transmission issues are most likely solvable already with existing mobile (3G & 4G) networks. In the foreseeable future the 5G networks are expected to improve the situation further.

Finally, issues such as privacy and the attractiveness to vehicle (and data) owners of making the data available need to be resolved. Basically, the benefits to the vehicle owners need to outweigh possible risks (such as privacy erosion) and costs (such as vehicle unavailability due to equipment installation, maintenance or upgrade).

We foresee that the presented methodology implemented on a single road stretch in the Northern Finland could be expandable to the national level (to the main road network). There are lot of open questions in such a scenario:

1) selecting and recruiting vehicles to collect intensive friction data,
2) ensuring equal coverage of friction data throughout the main road network,
3) maintaining the quality of measurements with appropriate maintenance procedures.

The most important burden is the cost of the system. Even with very low rate of measuring vehicles (0.5 vehicles for each 200 km), the main road network of 8603 km requires 50 friction instruments with considerable maintenance activities. The one-time investment cost is not so high (estimated to be around 400000-600000 EUR, including the installation costs), but the recurring maintenance costs are very hard to estimate, most likely being on the same scale annually. However, this kind of service would clearly improve the accuracy of road weather services and warnings, potentially avoiding a significant number of traffic accidents, casualties and fatalities. Once deployed, this kind of service platform could also boost entirely new kind of weather and safety services, leading to new innovations and safer roads.