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WINTER TESTING TRACK ENVIRONMENT FOR THE INTELLIGENT TRAFFIC ROAD WEATHER SERVICES DEVELOPMENT

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Summary

FMI is operating the Arctic vehicular winter testing track with advanced communication capabilities within ITS-G5 and 5G test network, along with accurate road weather data and services supported by road weather stations and on-board weather measurements. The track is located in Sodankylä, Northern Finland, where the long arctic winter period of more than half year allows road weather services development for the severe, Arctic weather conditions.

FMI is continuously studying the possibilities to improve the Arctic Road weather traffic monitoring and related safety services by innovative use of C-ITS and related methodologies. Autonomous driving, energy efficiency, green technology and drones are globally addressed as some of the future trends. 5G and other advanced communication systems are elemental part of the C-ITS, allowing autonomous vehicle services and remote control among other things.

FMI intelligent traffic road weather services research topics are all reflected into the winter testing track as well. The goal is to provide optimal

conditions for the development of advanced vehicular safety services equally for traditional, autonomous, and alternate energy vehicles, with both state-of-the-art and pioneer road weather and roadside infrastructure and communication methods for wide variety of use cases. This paper overviews the new intelligent traffic road weather service systems and technologies relevant in Arctic conditions, and their practical testing and piloting practices in the Sodankylä Arctic winter testing track.

Introduction

The Finnish Meteorological Institute (FMI) has been developing the ITS-enabled road weather services in long-term basis. In the early phase of the research work, pilot ITS-enabled on-board vehicular road weather services were tested and evaluated in the temporary test settings composed on-demand. The idea of permanent testing environment with continuous weather monitoring instrumentation and relevant ITS communication systems started to evolve. During 2017, the first permanent infrastructures were constructed into the vehicle winter testing track of Sodankylä municipality, in the vicinity of Sodankylä airport area. The test track constructed in EU ERDF Sod5G project consisted of LTE-A -based 5G-test network and two road weather stations (RWS) with integrated ITS-G5 communication systems [1].

The communication infrastructure in the test track consisted of several parallel communication entities. ITS-G5 communication was composed by wireless transceivers embedded into the RWS infrastructures and FMI vehicles, allowing the testing of both V2V and V2I communication. The 5G test network consisted of a single base station, operating in license-free 2.3 GHz band. The 5G test network has undergone upgrades and is now following the operative 3.5 GHz system. The test network has also been supplemented with support for the narrowband IoT operation.

Along with the communication, road weather services are another essential element of future driving. Autonomous vehicles are relying on the real-time knowledge of the accurate location of themselves, and co-existing traffic actors and infrastructures and all the knowledge related to their mutual safety margins. In the Sod5G test track the weather monitoring was arranged by deploying two road weather stations along with the test track. The road weather stations instrumentation consists of traditional weather monitoring parameters temperature, wind and wind direction, along with more sophisticated road surface temperature and condition, and road friction.

The test track environment has served well as demonstration platform of FMI's research activities. Among other activities, it has been served as the final demonstration platform of 5G-Safe project autonomous and cooperative vehicles 5G-enabled services [2]. However, the development of the cooperative driving and societal pursue towards the green technologies have caused the necessity for the upgrades. Test track existing infrastructure overview

The Sod5G test site is presented in Fig. 1. The main track is 1.7 km long, supplemented with several "shortcuts" for different types of surface characteristics, with additional testing routes outside the Sod5G road weather and communication testing area, altogether 11 km of test tracks. The track surface under the snow is gravel, except the part of the track

Fig. 1. Sod5G test track. The Road Weather Stations are marked as RWS1 and RWS2, IoT weather sensors as numbers 1-9.

between road weather stations which has asphalt surface and under-surface pipelining across the road.

The current communication infrastructure in the test track consists of several parallel communication entities. ITS-G5 communication based on IEEE 802.11p (IEEE Standard Association 2009 IEEE 802.11p) standard was composed by Cohda Wireless MK5 transceivers embedded into the RWS infrastructures and FMI vehicles, allowing the testing of both V2V and V2I communication. The 5G test network consists of a single LTE anchor station and two 5G stations in the 3.5 GHz band. The LTE and one of the 5G stations is located to the North of the track, just outside the area shown in Fig. 1 (North is approximately to the left-hand side of the figure). The second station 5G station is located at location 4 in the map. 5G cellular networking is expected to provide considerable improvements for the intelligent traffic, among other advances like superior bandwidth and ultra-low end-to-end delays. Reliable and efficient communication is very important aspect in autonomous driving vehicles, to assure safety and comfortability [3].

Finally, the energy efficient IoT sensor network consists of 9 Ursalink temperature and humidity sensors, operating in Digita LoRaWAN network. Sensors are periodically delivering the measurement data to the IoT network, further collected to FMI observation systems. In terms of road weather instrumentation, the Sod5G track has currently two fixed RWS, presented in the Fig. 1. RWS contain ITS-G5 communication transceivers, so they can be used as interactive roadside infrastructure in cooperative driving. IoT sensor

network temperature and humidity measurements are supplementing the RWS data, and as a result we have weather data throughout the (main) test track. The weather observation network can be supplemented with under-surface sensors in the instrument pipelines buried to the ground.

Test track services

The current infrastructure allows the testing of various services related to intelligent traffic, road weather and their advanced combining. Starting from the cooperative driving, European Commission has defined a set of so-called “day one” services of hazardous location notifications, to be standing for first set of cooperative driving services. These services are indications of 1) Slow or stationary vehicles. 2) Road works warning, 3) Weather conditions, 4) Emergency brake light, 5) Emergency vehicle approaching and 6) Other hazards [4]. These services, also known as C-ITS services, are tailored for short range ITS-G5 communication. In Sod5G test track, the ITS-G5 communication is composed with Cohda Wireless transceivers located on the RWS infrastructure and specific research vehicles. The day-one services have been successfully tested in the track.

The first set of 5G-enabled pilot road weather services contained three (plus one) different road weather services especially tailored to benefit autonomous vehicles, as presented in the Fig. 2. The autonomous vehicle can select the preferred route based on 1) weather forecast data of each route, 2) existing road weather-related alerts on the route and 3) existing safety-related alerts on the route. All these pilot services were generated by exploiting the 5G test network in real-time collection of observation data and warnings, ultimately delivered to the vehicles in near-real-time by the 5G test network. Furthermore, the V2V communication in the 5G test network and the ITS-G5 was tested with special 4) See-through -application, tailored to deliver vehicle camera data information from the front of a vehicle queue during the poor visibility conditions, allowing preparedness for unexpected anomalies in the traffic. See-through application is very sensitive to the transmission delay and possesses also juridical questions, therefore it is not

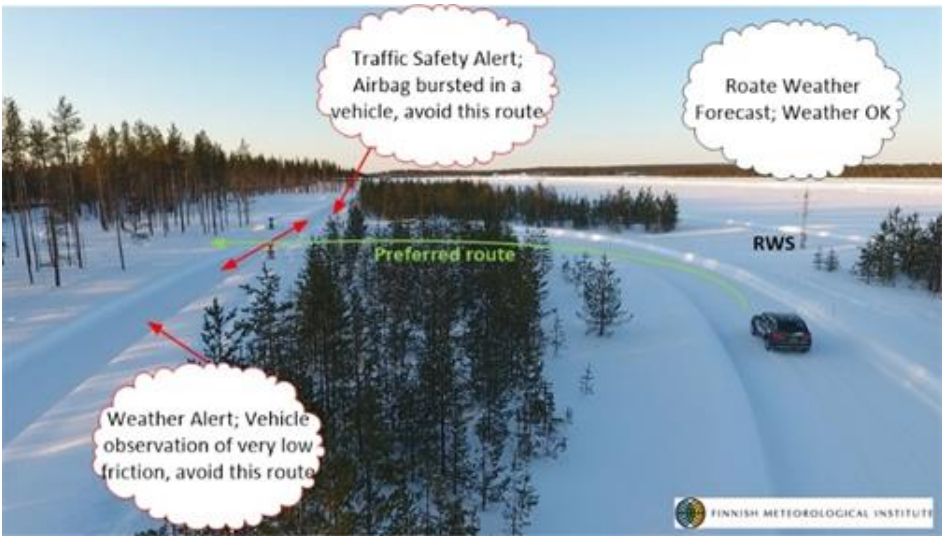

Fig.2 Pilot services exploiting 5G communication capabilities.

ready for the operational traffic environment yet. Nevertheless, the set of pilot services tailored for 5G and autonomous driving are available on the test track. Exploiting both ITS-G5 and cellular networking (4G/5G) features offers the best communication approach at hand, as long as ITS-G5, cellular or C-V2X is not clearly the superior approach [2].

Accurate road weather services for the test track are generated by combining 1) general meteorological road weather information for the area produced by FMI, 2) road weather station (RWS) measurements in the area, and 3) supplemental mobile data provided by the vehicles on the test track. Both 5G cellular networking test system and ITS-G5 vehicular networking are employed in this scenario and the experiments have been conducted with both systems. Road weather services exploiting road traffic data allow more accurate instantaneous service generation directly to different traffic and transport actors, in the very spot of observed hazardous weather condition. The target is to generate very localized warnings, furthermore leading drivers to pay more attention to “more concrete” warnings. Another aspect in the road weather service development is the tailored road weather services. The different actors demand different type of information and therefore we are fine-tuning the different contents for e.g., professional drivers, road maintenance operators, autonomous vehicles and traditional drivers [5,6,7].

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