BOREALIS, E8 FEASIBILITY STUDY

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Borealis workshop

Clarion Hotel the Edge, Tromsø, 23. mai 2017

Foto: Statens vegvesen, Torgeir Vaa

Innhold

- Bakgrunn
- Lovende teknologier
- Noen aktuelle prosjekt
- Forskning og evaluering

Bakgrunn, oppdraget

- Hva skjer på forskningsfronten nasjonalt og internasjonalt med relevans for de ulike innsatsnivåene
- Belyse mulighetene for å etablere samvirkende systemer (C-ITS) med mål om å nå nivå 4 for selvkjørende biler på hele eller deler av E8
- Stikkord kan være krav til infrastrukturen, teknologiutfordringer, mulige bidragsytere og tidsperspektiv.

A Freightliner Inspiration Truck was the first semi –autonomous truck to get a licence to drive on public roads in Nevada, May 2015

Source: Freightliner

Loading video: Otto (Uber) & Budweiser, SAE L4

From sunny Colorado to Snowmatic driving

- Snow in the air
- Snow on the road
- Snow cakes up on the vehicle
- Icy road
- Salt clouds up sensors
- Dew an ice inside vehicle

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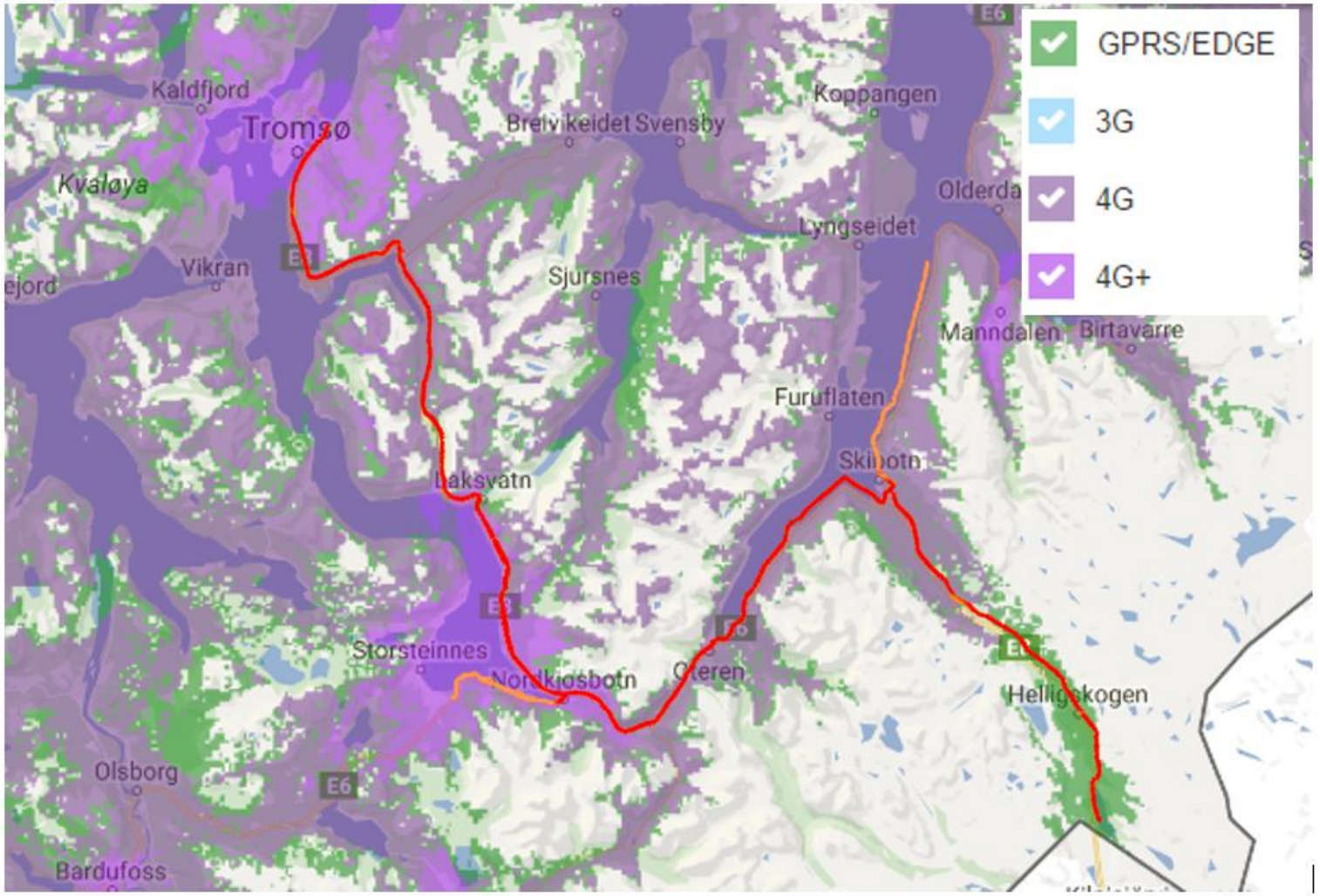
Mobildata, dekning Telia pr 16. januar 2017

(https://telia.no/dekningskart)



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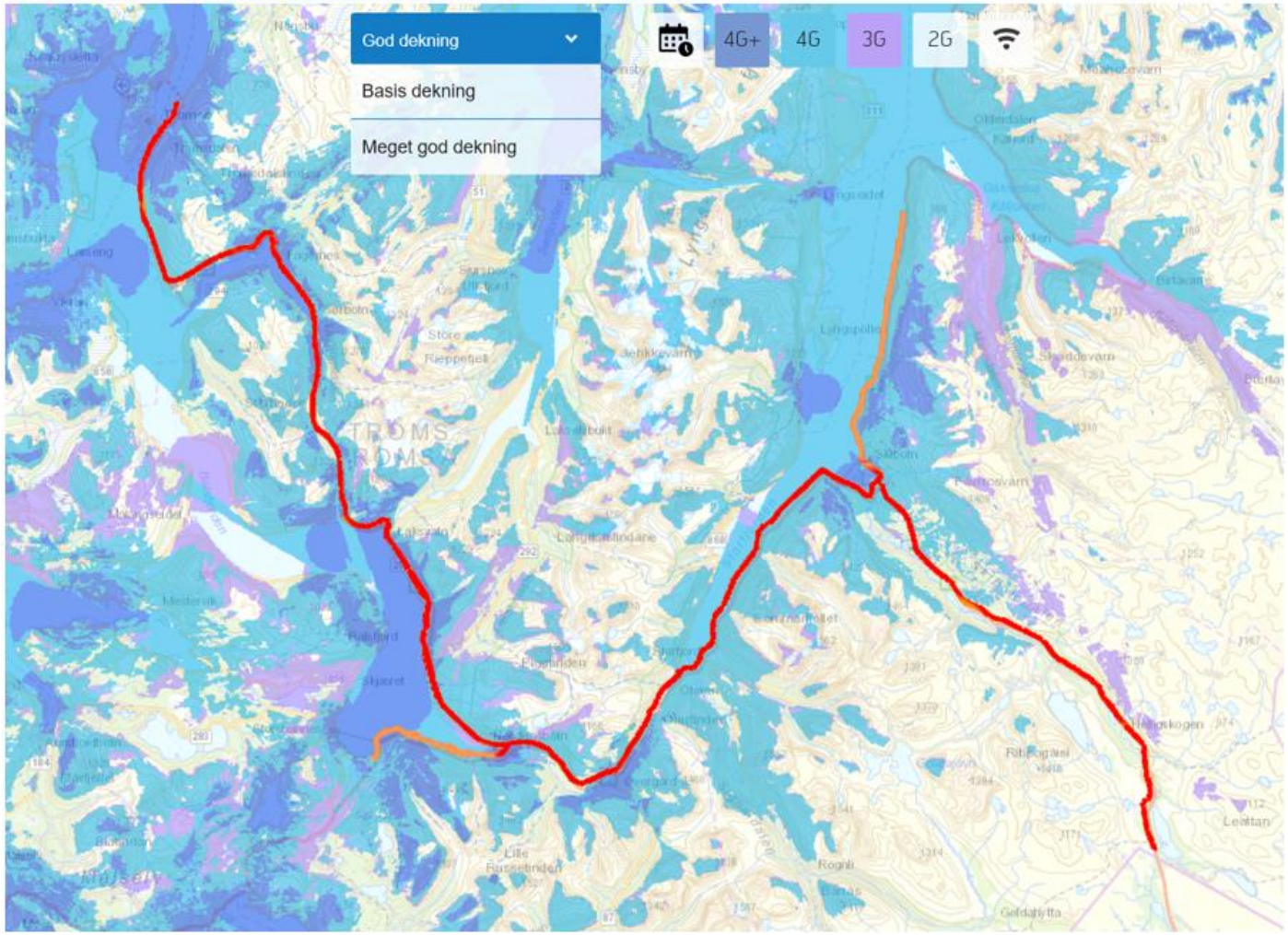
Mobildata, dekning Telenor pr 16. januar 2017

https://www.telenor.no/bedrift/dekning/dekningskart.jsp



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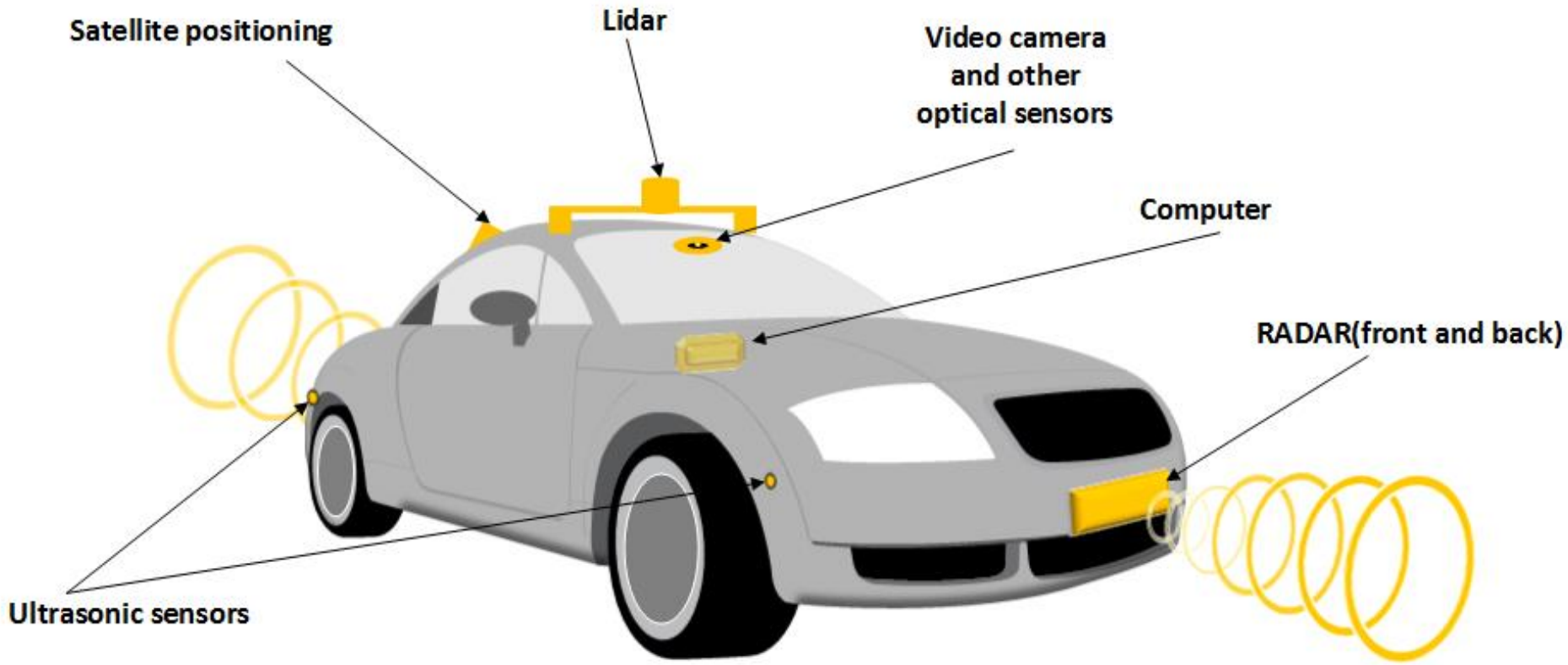
Positioning techniques, GPS/GNSS

- CPOS, no reference station in the Skibotn area, yet
- Update frequence 1 Hz

Promising technologies, categorized on technical aspects

- On-board vehicle systems without interaction with data sources outside the vehicle
- External roadside systems without interaction with data of individual vehicles
- Connected systems that allow for interaction between individual vehicles and other data sources, such as between vehicles or between vehicle and roadside

Key on-board technologies



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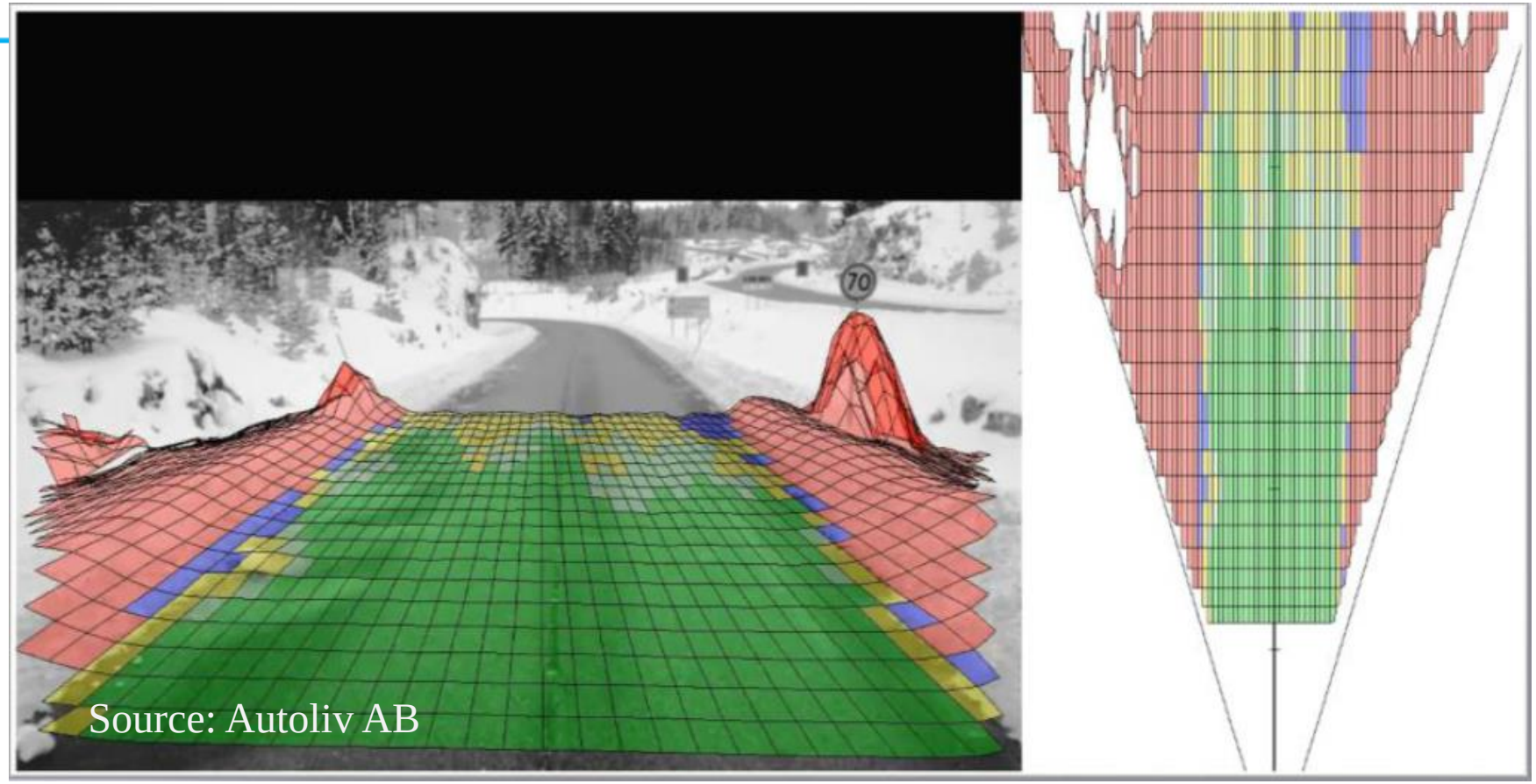
Vehicle radar blocked by slush or snow

Contours of road edges and snowdrifts identified by machine vision



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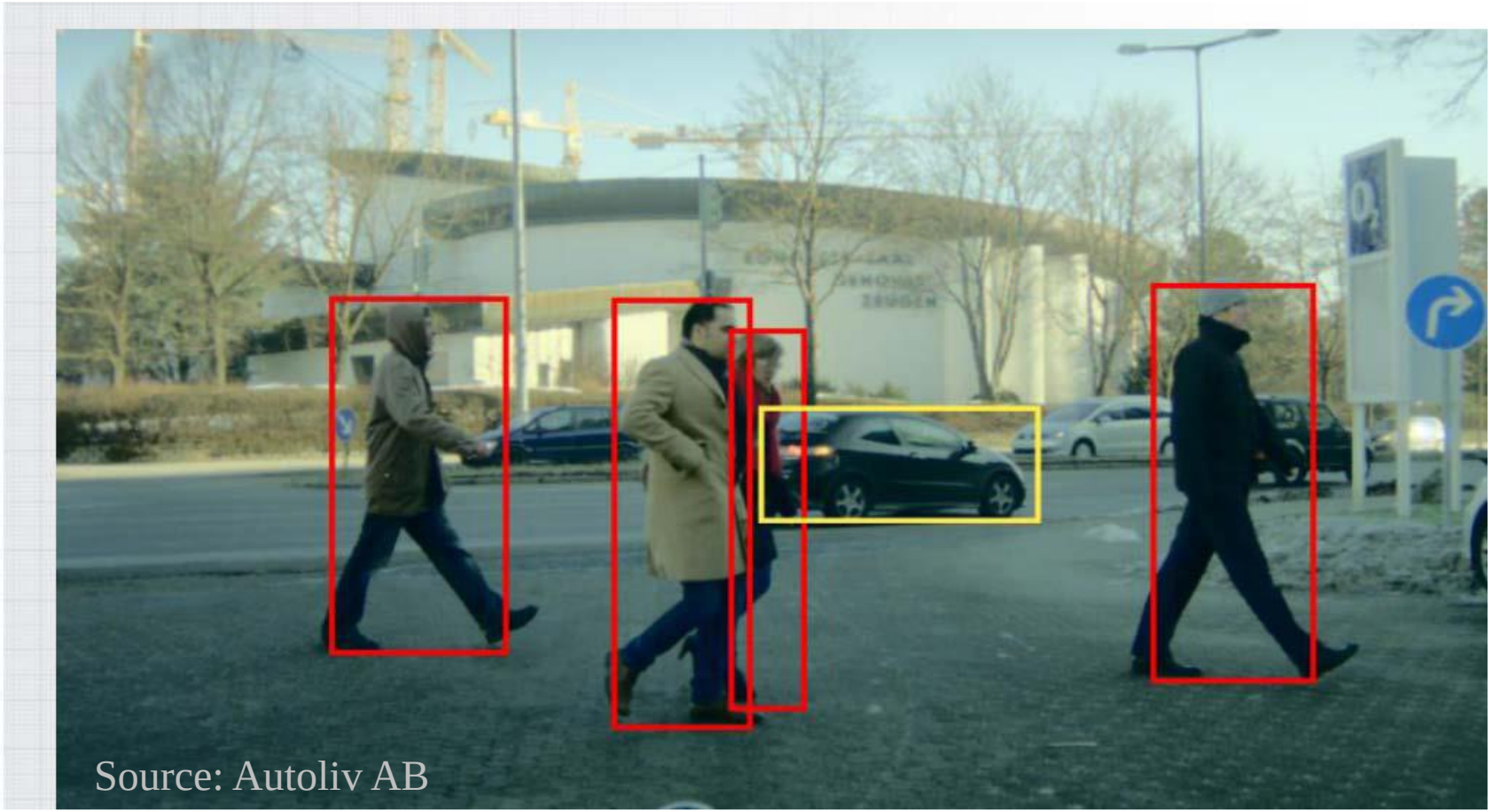
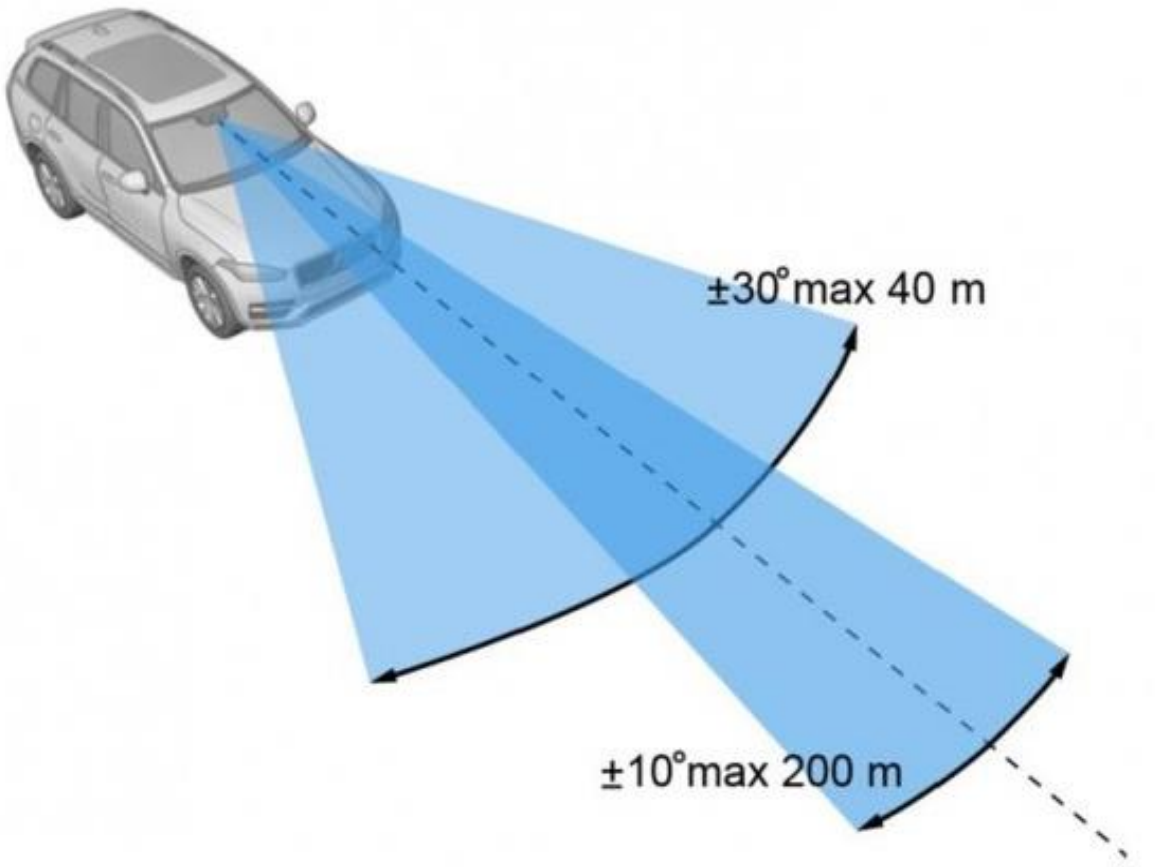
Pedestrian detection based on machine vision





Source: Volvo Car Group and Delphi Automotive

Radar and Camera system (RACam) inside the wind shield

- The RACam module on Volvo XC 90 has two fields of view-short range 40m ahead, 30 degrees either side of centre line and longer range up to 200m, 10 degrees either side of center line.
- The short range radar combined with the camera eliminates the need for a LIDAR sensor.

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Ice and dew problem

- Ice and dew inside or outside the windshield may give malfunction in camera sensors placed behind the windshield

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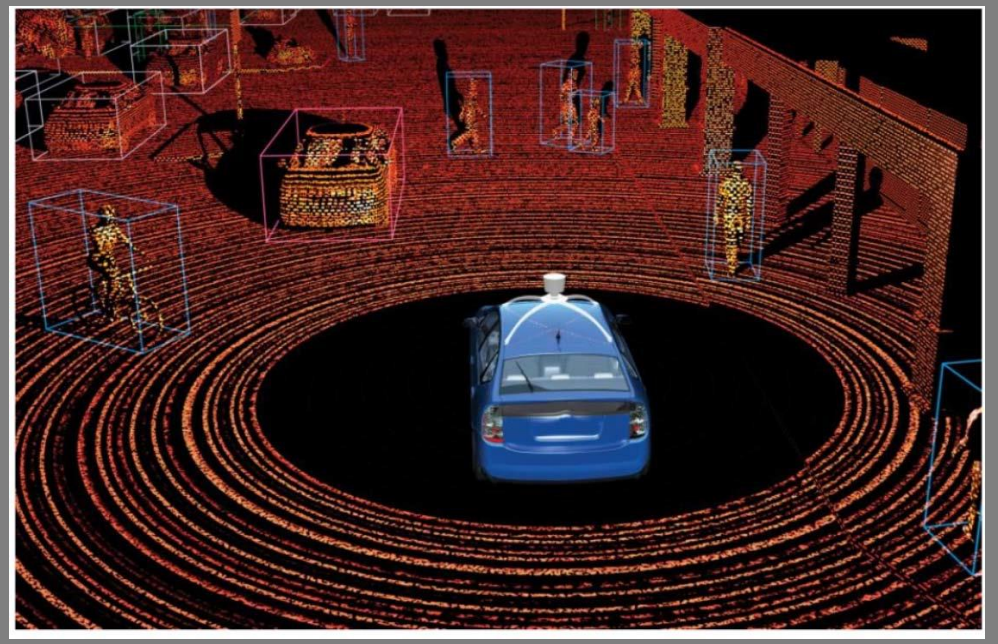
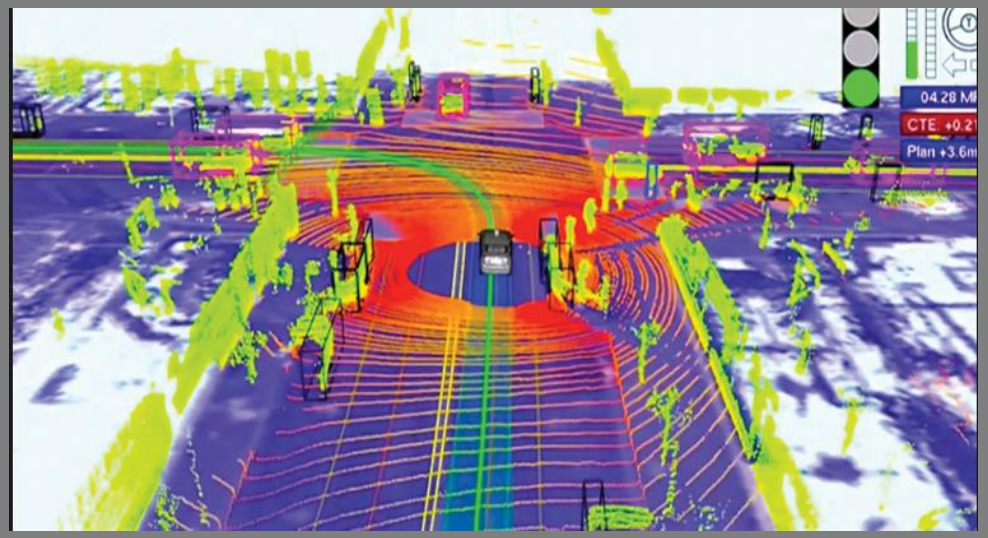
Sensor fusion

- Rooftop mounted Point cloud LIDAR scan 360 degrees of vehicle surrounding's.

Source: Google Autonomous car project.





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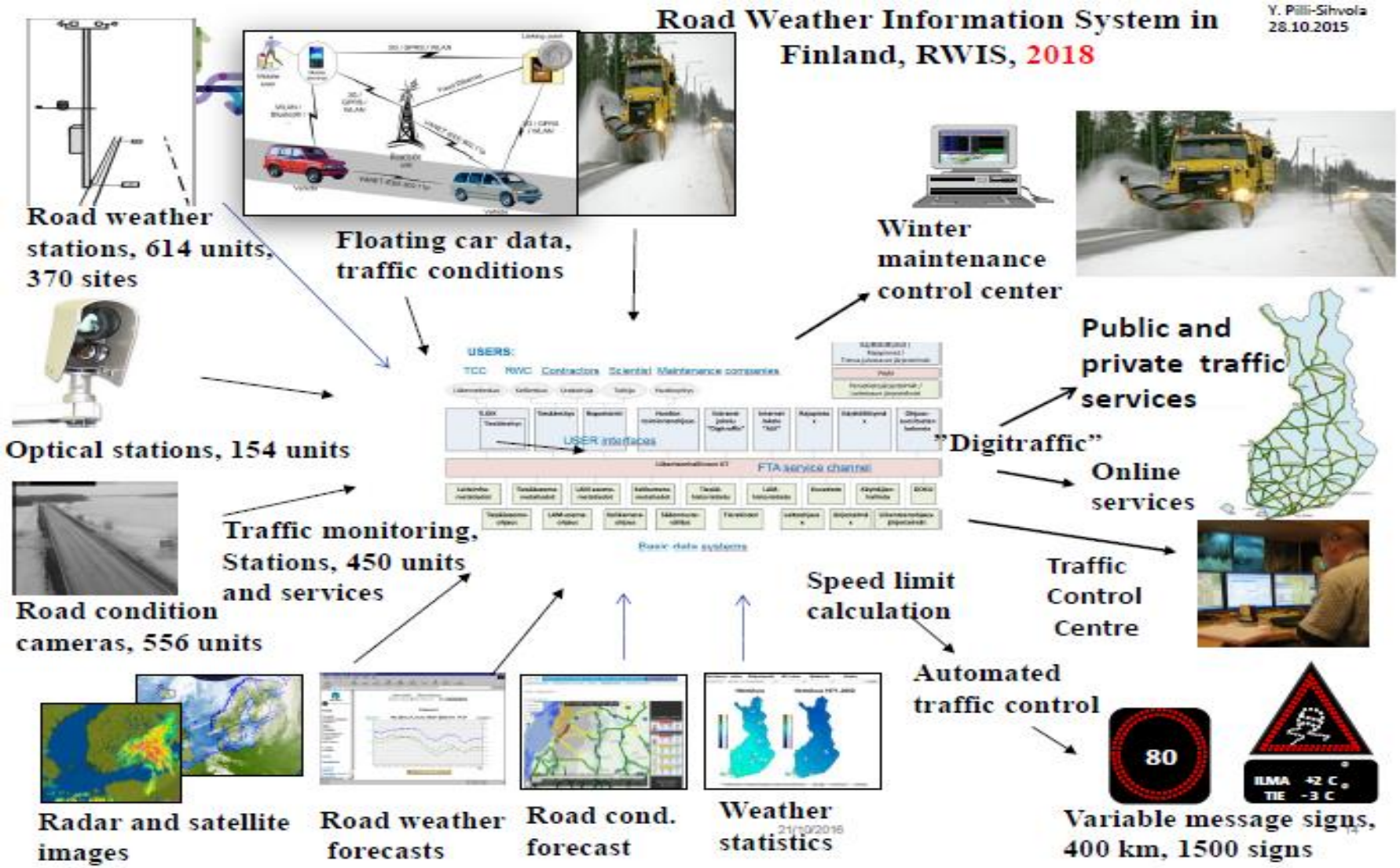
Positioning techniques

Detectable objects	Sensor	Advantages	Disadvantages
Painted lane markings	Camera, lidar	Cheap and simple	Degradation of lane markings. Camera performs poor in snow, rain, fog, backlight
Snow Poles	Camera	Cheap, work in snow	Easily displaced; not applicable on multi-lane roads; camera problems
Traffic signs	Camera, lidar (and potentially radar)	Exist in many places, provide rich information to the driver	Too few; require text recognition; camera problems
Cat's eyes pavement markers	Camera	Cheap, visible in darkness	Not visible during daytime; camera problems
Guardrails	Camera and radar	Provide passive safety	Not applicable on multi-lane roads
Delineator posts	Camera and radar	Cheap, steady	Not applicable on multi-lane roads
Landmarks (buildings, trees etc)	Lidar, stereo camera, camera + structure from motion	Big amounts of data available from a laser scan	Change often (can be outdated); require complex algorithms
Positioning + 3D map	RTK GPS + HD Map	Provide lateral and longitudinal position	Often changing (can be outdated); Dependency on GPS/GLONASS which can be scrambled
Magnets	Hall-effect sensor	Work in snow; do not distract the driver	Require new equipment and cannot be used by non-equipped vehicles; sensitive to electromagnetic noise
RFID	RF readers	Rich information	Requires new equipment and cannot be used by non-equipped vehicles; Uncertain lifespan and weather protection
Radio Communication	WiFi, Bluethooth etc	Cheap	Short-range, requires many active beacons/anchors
Dead-reckoning	Gyro, Accelerometer, Odometer, known starting position	Self-contained	High error accumulation rate
Radar reflectors (this study)	Radar	Many vehicles already have radars	Accuracy; New algorithms

Source: Viktoria Institute, Voronov 2016

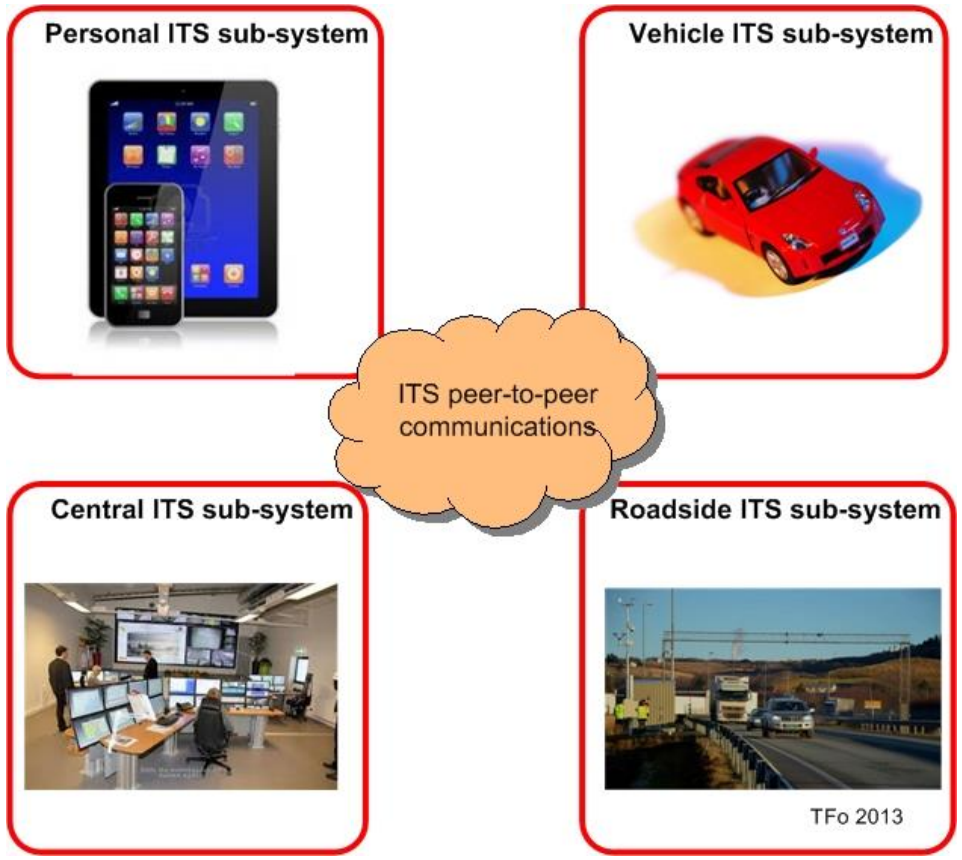
External technologies

Status and plans for the road weather information system (RWIS) in Finland

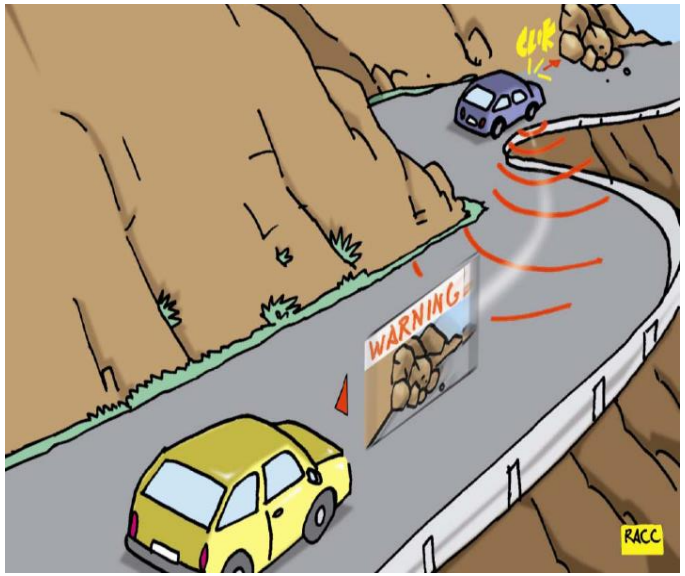


Connected systems

Cooperative Intelligent Transport System (C-ITS)



The ITS station architecture is based on the reference model developed by the European Telecommunication Standards Institute defined in ETSI EN 302 665.



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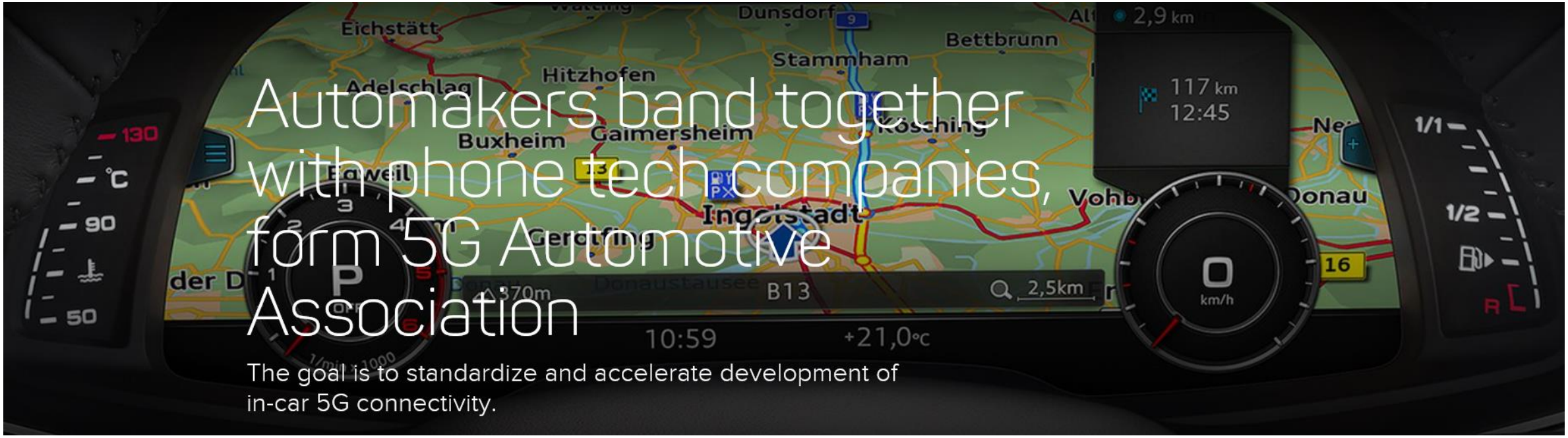
ITS Station challenge 1; 802.11p and ETSI vs ISO stack implementation

There are several standards internationally based on this standard such as:

- ETSI ITS stack (EU), ITS-G5
- ISO ITS stack (EU)
- IEEE WAVE (Wireless access in vehicular environments) (USA)

5G Automotive Association (OEMer og Telekom)



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Platooning

kapsch
challenging limits

> Distance > Speed > Direction Lead vehicle

Time critical applications

Cellular:
- Infotainment
- Road Maps
- Payment Services

Direct ad-hoc link

ITS-G5 ITS-G5

Radar
Laser
Infrared

> Distance
> Speed

Actual projects

Snow clearance of a Colorado highway in a Conga Line

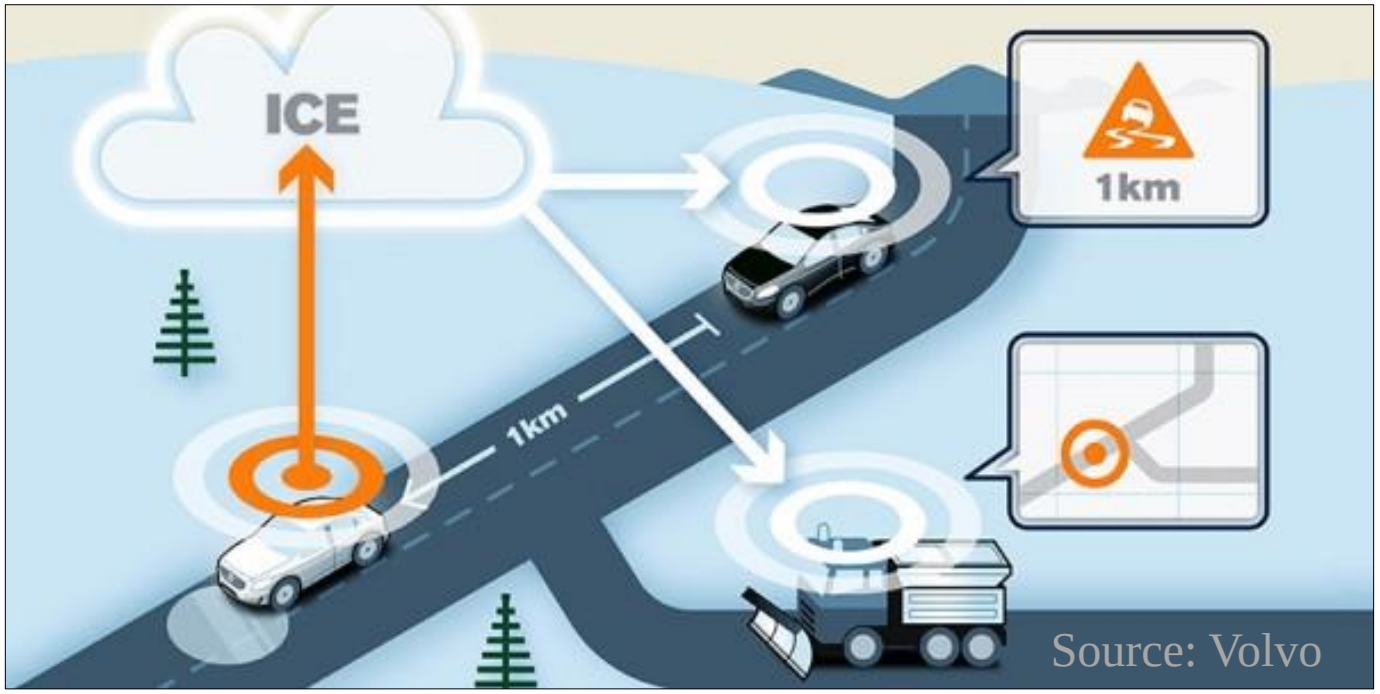
Source: Wired (2014)

The YETI project: Snow clearance truck tailored for automated winter maintenance of airports, adapted to for self-driving in a Conga Line

Photo Øveraasen AS

NordicWay, (EU, DG MOVE), FI, SE, DK & NO cooperation. Road Status Information (RSI)

- Best case scenario:
  - C-ITS corridor, the E6 from Oslo to the Swedish border.
  - Four lane motorway road section with a steady cellular network available
- Worst case scenario:
  - Sparsely populated areas with less traffic
  - limited cellular network available



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Prosjekt, SVV: Vind og friksjonsvarsling på E6 Dovrefjell og Case-Based Reasoning (CBR)

- *Mål: estimere hvor nær man er til en situasjon hvor man bør stenge veien eller starte kolonnekjøring (støtte til entreprenør – for bedre sikkerhet).*
- Tidligere beregninger, kalkulator
  - stopplengde - ved lav friksjon og liten sikt
  - grep - ved lav friksjon og høy vind (basert på utforming og areal på busser).
  - beregner også maksimal anbefalt fart
- Benytte "Case Based Reasoning"
  - Sammenligner observert situasjon med tidligere observasjoner
  - Gir likhetsmål (og kan vis hvilke tiltak som ble gjort)
  - Gir en mulighet for læring gjennom å legge inn nye observasjoner/tiltak.

CBR Dovrefjell, GUI

Nå

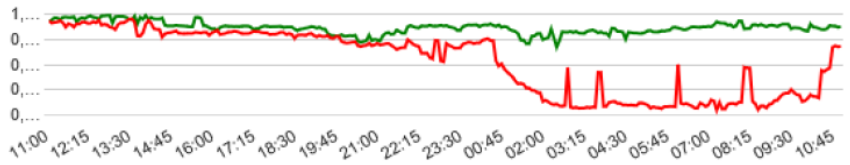
	Fokstugu	Avsjøen	Hjerkinn
Vindstyrke:	5 m/s	5 m/s	6 m/s
Vindretning:	195	251	247
Friksjon:	0.12	0.26	-
Nedbør:	1 mm	0 mm	0 mm
Snødybdeøkning:	-	-	-

Nærmeste åpne

93%

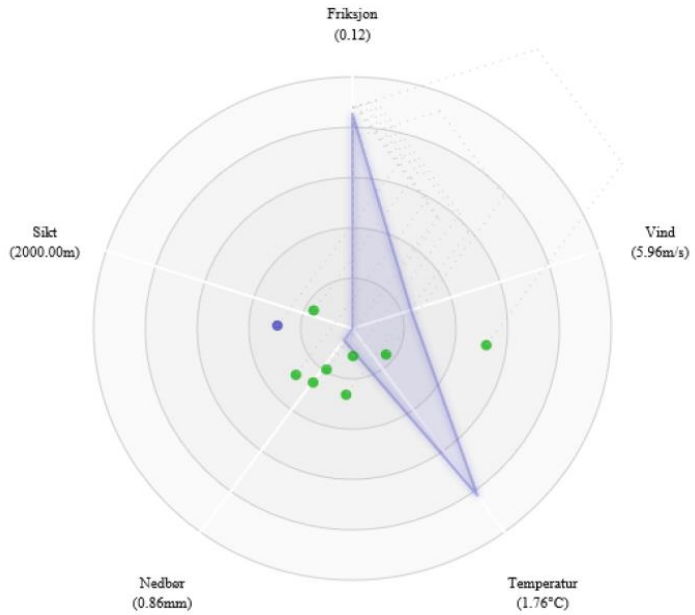
Nærmeste stenging

83%



Denne grafen viser utviklingen av nærmeste åpne (grønn) og stengte (rød) situasjon over tid. Dersom den åpne er på veg nedover, og den stengte på veg oppover, kan dette tyde på at det går mot en farlig værsituasjon.

Sist sendte SMS *: [Ingen SMS sendt]
Send SMS



Det blå områdeplottet viser værsituasjonen akkurat nå. Desto mer dette området strekker seg ut fra sentrum, desto verre er situasjonen.
Friksjon har verdier fra 0.82 (origo) til 0.
Nedbør har verdier fra 0 (origo) til 15.
Temperatur har verdier fra 10 (origo) til 0 (merk: vi plotter absoluttverdien).
Vindstyrke har verdier fra 0 (origo) til 25.
Sikt har verdier fra 500 (origo) til 0.

Punktene på plottet representerer de 10 nærmeste åpne (grønn) og stengte (rød) tilfellene, og nå-situasjonen (blå). Akkurat hvor punktene befinner seg på plottet er ikke betydningsfullt, kun hvordan de er gruppert.

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Project NPRA: Road Weather Analysis Based on Web Camera Images

Go to offline test system

Road Surface Condition Monitoring System

Choose Camera: 112296 Oppdal Submit

Use road mask? Yes No

Road Surface Classification Results

Camera ID: 112296
Camera site: Name: Oppdal, Road: E6, County: 16
Approximate image taken time: 27-12-2016 13:28
Road condition: FullSnowy
Warning: PackedSnow FreezingRain
Probability: 0.00% (Dry), 0.00% (PartialSnowy), ***100.00% (FullSnowy)***, 0.00% (Wet)
Weather: ***Relative humidity (%)***:90.4;***Precipitation intensity (mm) per hour***:0.6;***Road surface temperature***:-2.0;Wind speed:11.16;Wind direction:281;***Air temperature***:-2.7;***Dew point temperature***:-4.1;

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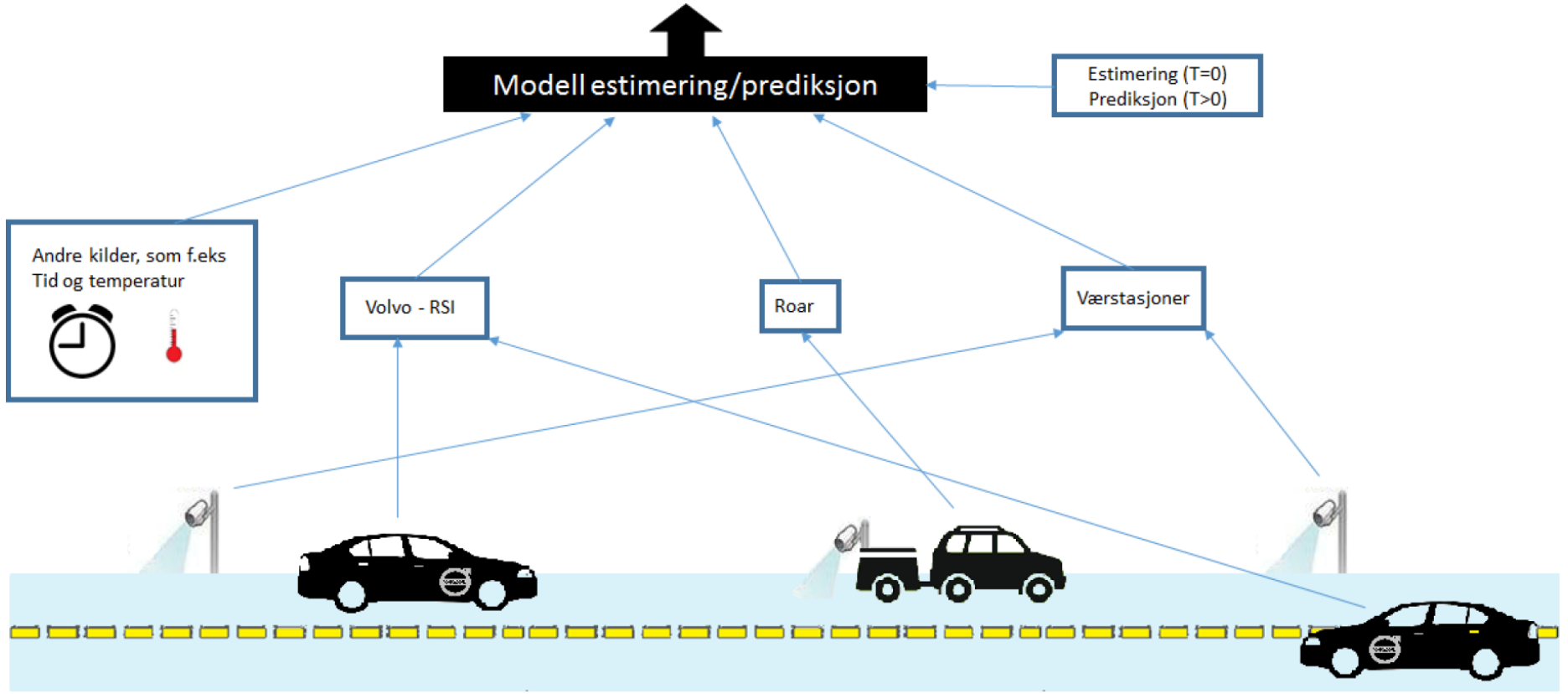
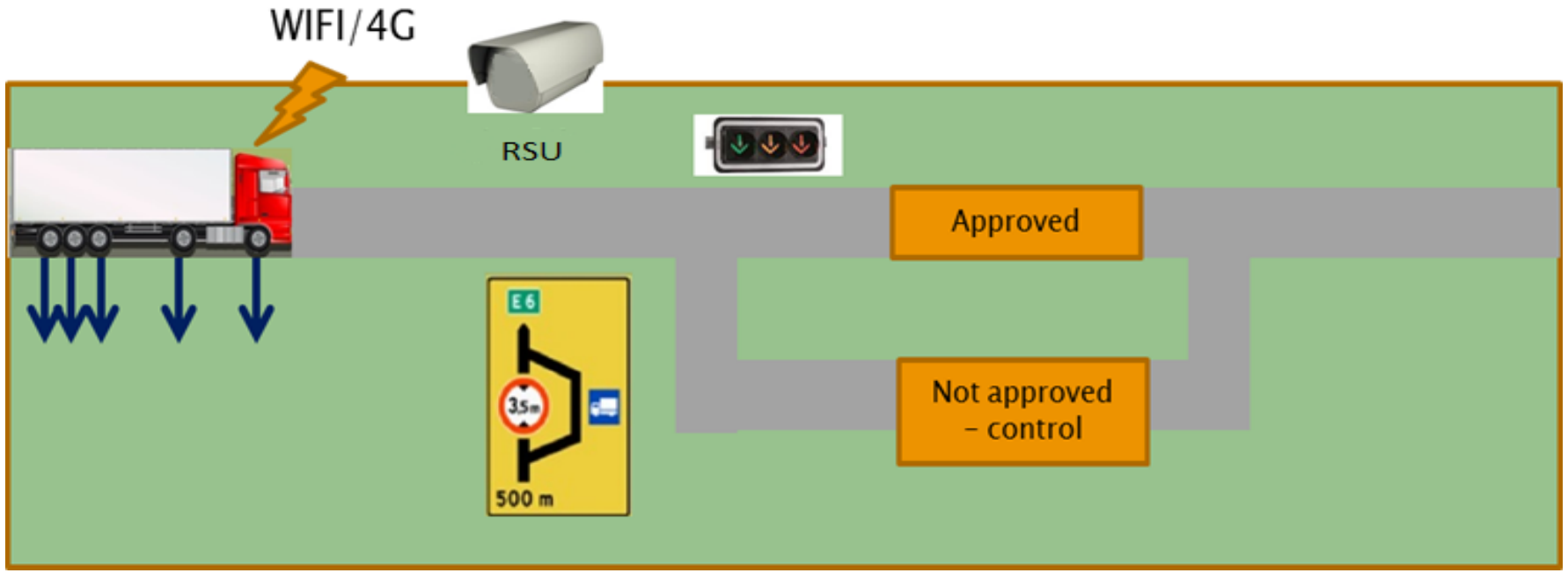
Andre datakilder som støtte til estimering/prediksjon av friksjon



MOBiNET (EU) and the NonStop II service

A heavy goods vehicle automatically declare its weight data through wireless communication (802.11p) for clearance at a weight control station.



MOBiNET
Internet of mobility

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Research needs

The need for new equipment

- Road side equipment
- Mobile measurements
- Data communication
- Electric energy
- Data storage and processing

Demonstrating SAE level 4 vehicles

- Demonstrating SAE level 4 self-driving vehicles puts demands to the road infrastructure.
- Not only technologies supporting the driving process, but also safety precautions regarding other traffic, ATVs, people and wild animals.
- It is important to establish both physical and other barriers as before starting the demonstration.

Legislation

- Norway: new upcoming law on testing of self-driving vehicles on public roads
- Finland: Finnish authorities have stated that the Finnish legislation already allows extensive experiments with self-driving vehicles.
  - Vehicles are not required by law to have a human driver
  - There are for example no requirement that a physical driver must be located inside the vehicle

Safety

- Technical, human and operational barriers to mitigate system risks
  - Create barriers that can prevent things from going wrong.
  - Developing methods and approaches to improve safety, security, and resilience in highly automated systems
  - Contribute to the development of international standards
- General vulnerabilities and threats
  - vulnerabilities of physical road infrastructure, ICT equipment, communication systems, navigation systems…
- Physical precautions
  - Median barriers and Road-side fencing

The SAE J3016, taxonomy for Driving Automation Systems

More on this in the next presentation…

Safety and level 4 precautions

- DDT (SAE J3016) precautions, human driver supervision
  - A level 4 self-driving vehicle may also have a physical driver
- DDT and control of vehicles position
  - Different technologies within the DDT are used to control the vehicle position.
  - This may be a combination of GNSS, video camera, radar and Lidar

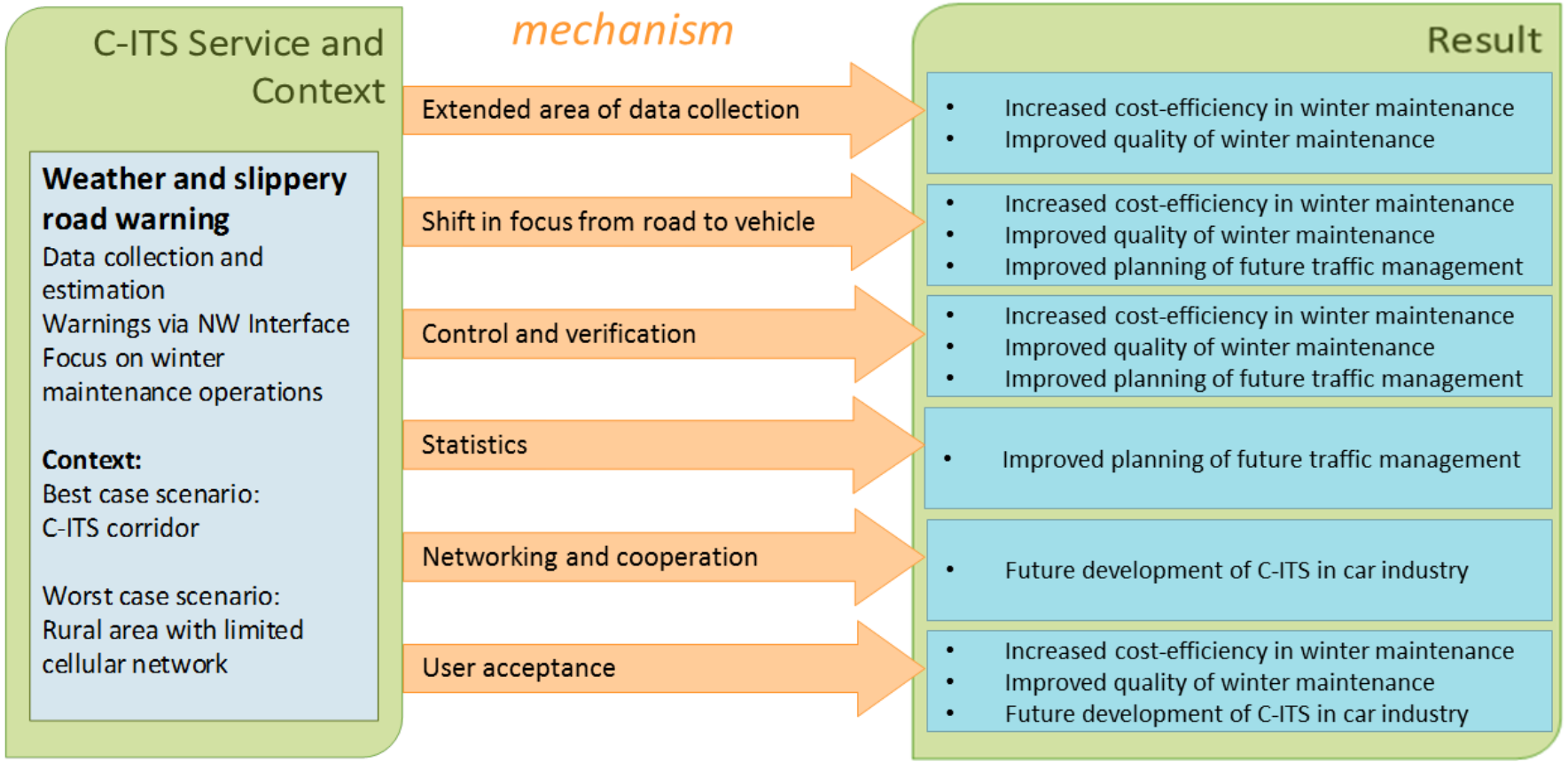
Forskningsprosjektet SAREPTA

Sikre overgangen til et grønt, smart, trygt og sikkert automatisert transportsystem

- Finansiert av Norges Forskningsråds program Transport 2025
- Forskerprosjekt ledet av SINTEF med NTNU som partner
- Varighet 2017-2020
- Hovedfokus på veg- og sjøtransport, men henter inn kunnskap fra jernbane og luft der det finnes og er relevant

Evaluation methodology

Relationship between C-ITS service (Weather and slippery road warning) and expected effects



SINTEF/Lervåg 2016

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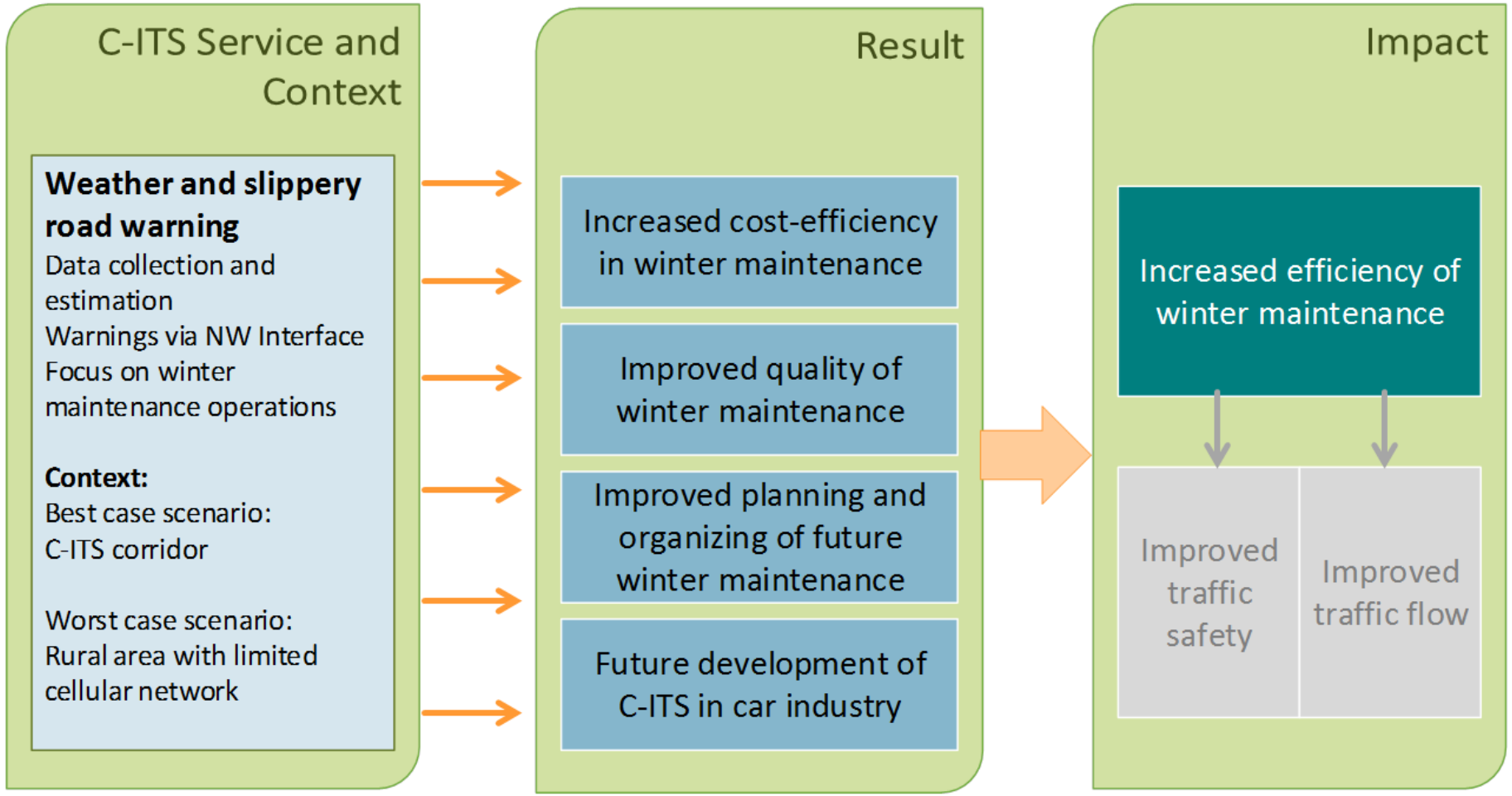
Expected impact for C-ITS services
Weather and slippery road warning



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Self-driving vehicles causing increased asphalt wear?

- self-driving vehicles may increase asphalt wear with resulting increase in maintenance cost.
- It is interesting to perform exact measurement of highly automated vehicles lateral position

The need for research sum-up

- Positioning technologies
- Communication technologies
- Artificial intelligence and machine learning
- The data processing and handling of large amounts of data
- Economics and business models: How to develop, evaluate and establish viable ITS technologies and services
- Evaluation models and analysis: Address the need for new evaluation models suited for highly automated transport systems
- Impact Assessments and changes in road user behavior
- User Acceptance, system understanding and trust

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Teknologi for et bedre samfunn