FINNISH METEOROLOGICAL INSTITUTE

ID: 25

Intelligent Road Weather Forecasting in the CARLINK Platform

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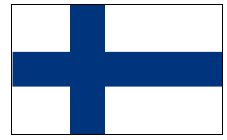
VTT SUNIT · MOBISOFT MOBILE DATA SOFTWARE · infoTripla · moviquity · HENRI TUDOR · SYNERGIUMS · ACL · ETRA I+D · UNIVERSIDAD DE MÁLAGA

Background

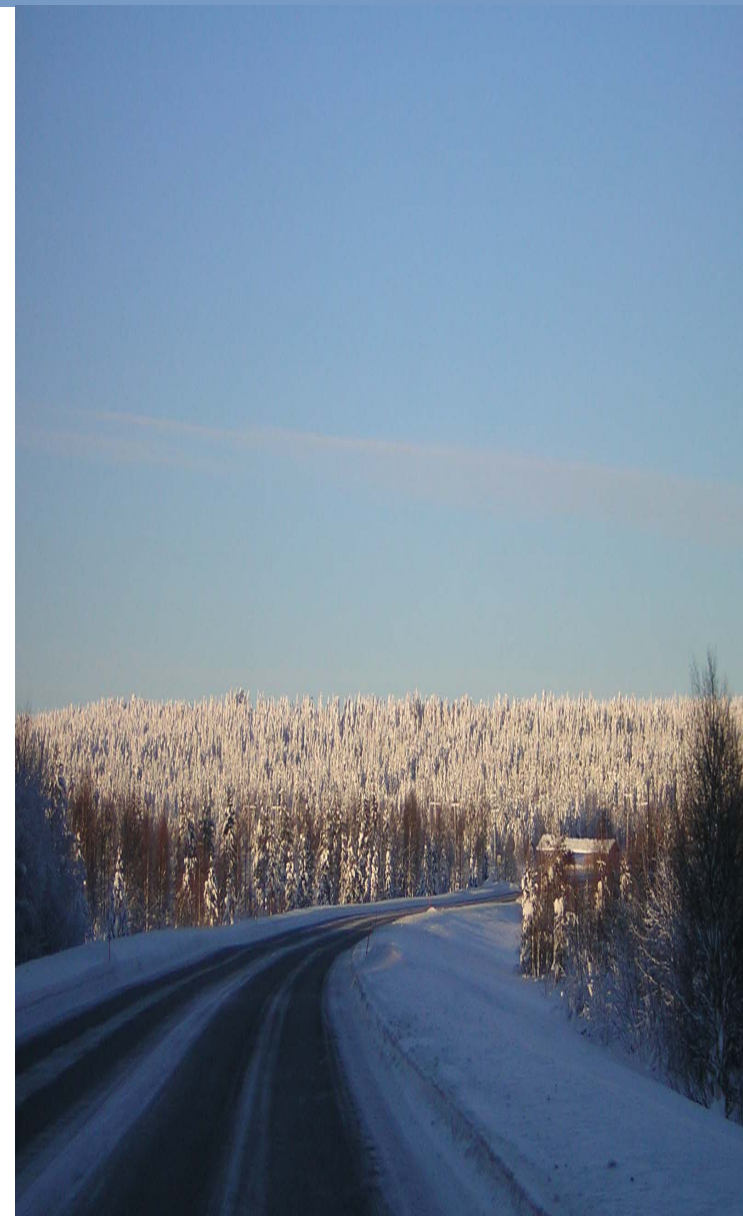
CARLINK:: Wireless Traffic Service Platform for Linking Cars

- Aim ⇔ Develop an intelligent wireless traffic service platform between cars which is supported with wireless **(WLAN / WiMAX)** transceivers along the roads
- Two-year project: Sep 2006 … Dec 2008
- EU_Eureka Program Celtic Cluster - Call 3
- Partners from Finland, Luxembourg, Spain
- Int'l project coordinator: ETRA I+D (Spain)
- Finnish project team coordinator: FMI
  - **Finland: FMI, Mobisoft, Infotripla, Sunit, VTT**
  - **Luxembourg: CRP Henri Tudor, Synergiums, ACL**
  - **Spain: ETRA I+D, Moviquity, University of Malaga**



Approach

- Backbone: Traffic Service Central Unit **(TSCU)** is installed beyond wireless transceivers to maintain the system
- TSCU communicates in real-time with vehicles facilitating various services and applications to be updated
  - **up-to-date local road weather information ⇔ FMI**
- *Intelligent services for public transportation ⇔* ***Luxembourg***
- *Urban traffic management ⇔* ***Spain***



Platform Structure (1)

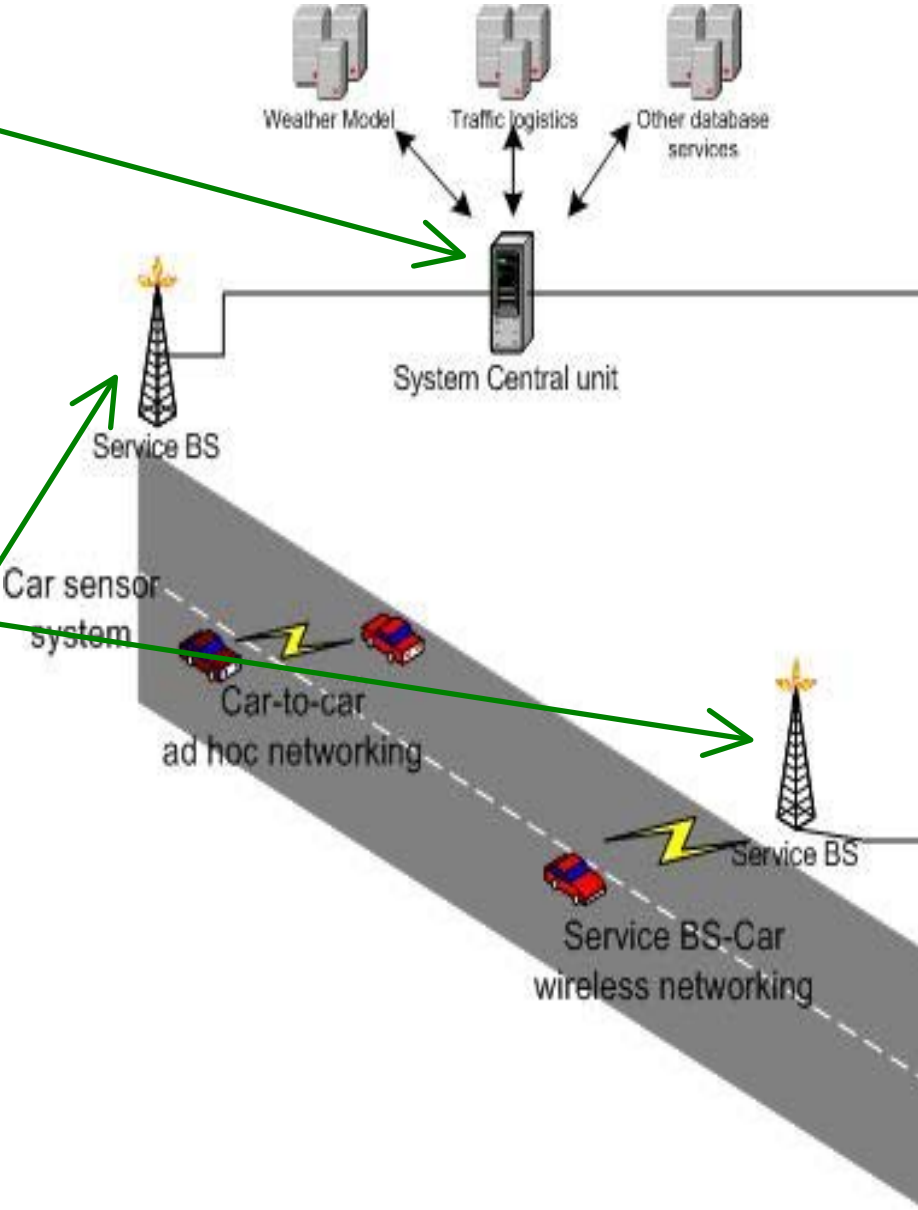
- **Traffic Service Central Unit**

  TSCU: Communication centre collecting vehicle data from Base Stations and GPRS network, delivering data to service cores, and delivering weather and warning data from Base Stations to vehicles

- **Traffic Service Base Stations**

  TSBS: Located along the roads, storing up-to-date data from TSCU and delivering it to bypassing vehicles;

  Vehicle-based observed data are collected simultaneously and delivered to TSCU



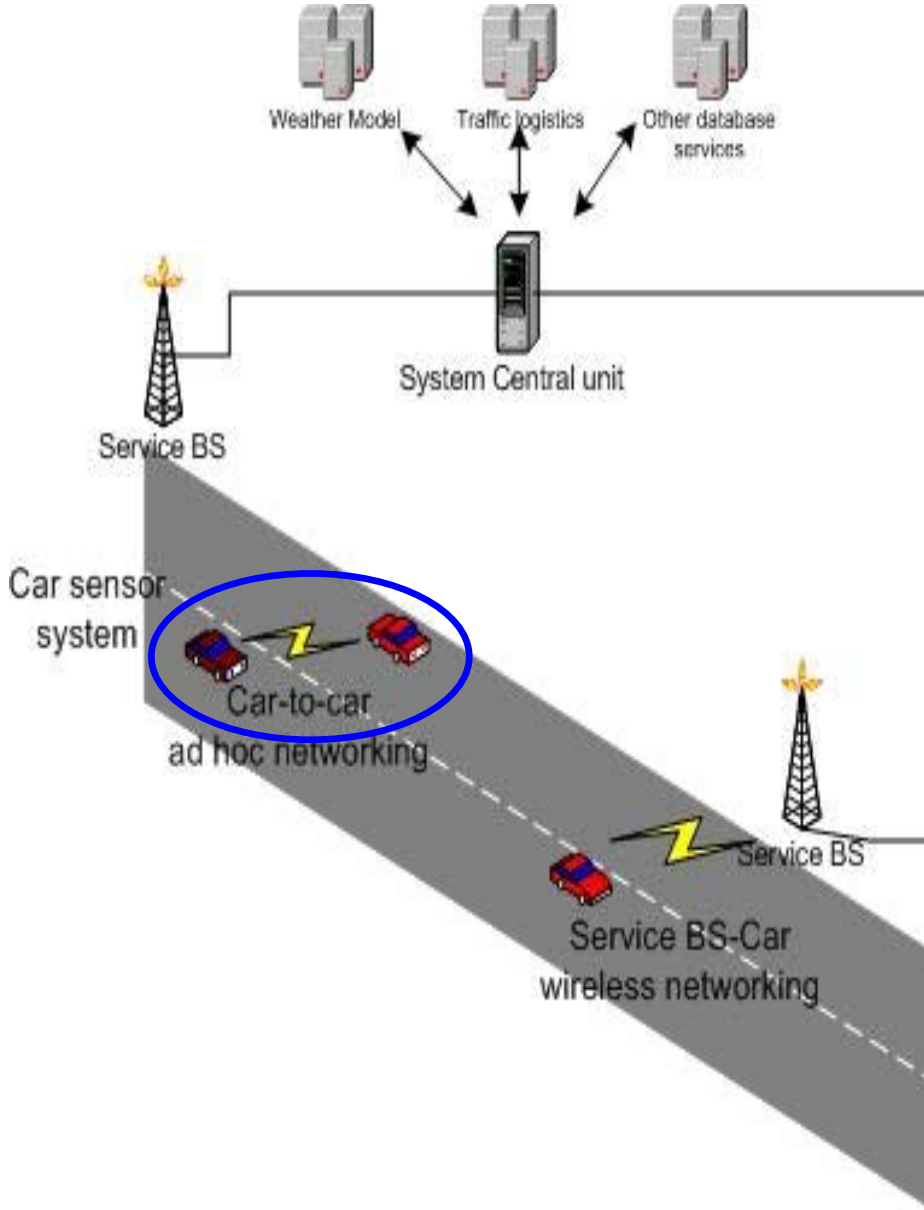
Platform Structure (2)

- **Vehicles** receive latest service data ***(e.g. local adverse weather warnings)*** when passing TSBSs;

  Vehicle-based observed data is simultaneously delivered to TSBSs;

  Vehicles can also forward their newest service data to encountering vehicles → Base Station range is enhanced

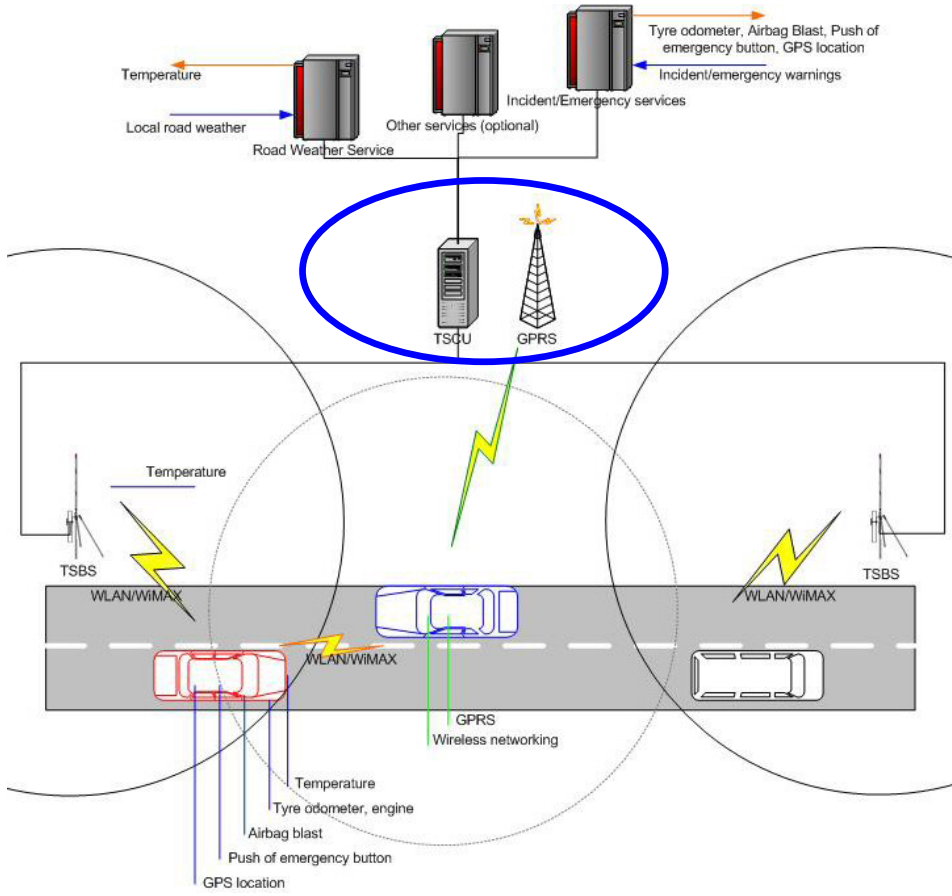
- Potential critical data ***(e.g. accident warning)*** are delivered thru additional **GPRS network** to guarantee instant delivery



Platform Elements (1)

Traffic Service Central Unit (TSCU)

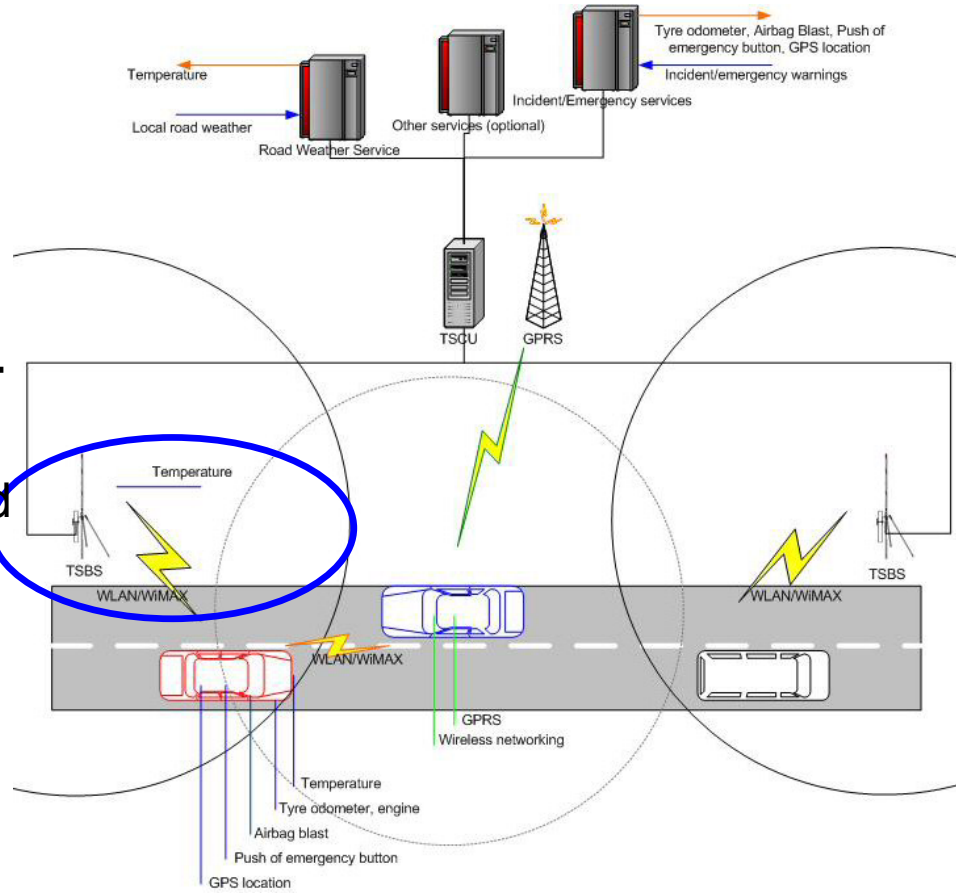
- **System Central Unit**
- **User management**
- **Data storage:**
  i. Vehicle-based observed data
  ii. Service data
- **2-way connection with vehicles**
  i. Indirect connection thru base stations ⇔ Main channel
  ii. GPRS ⇔ Emergency data



Platform Elements (2)

Traffic Service Base Stations (TSBS)

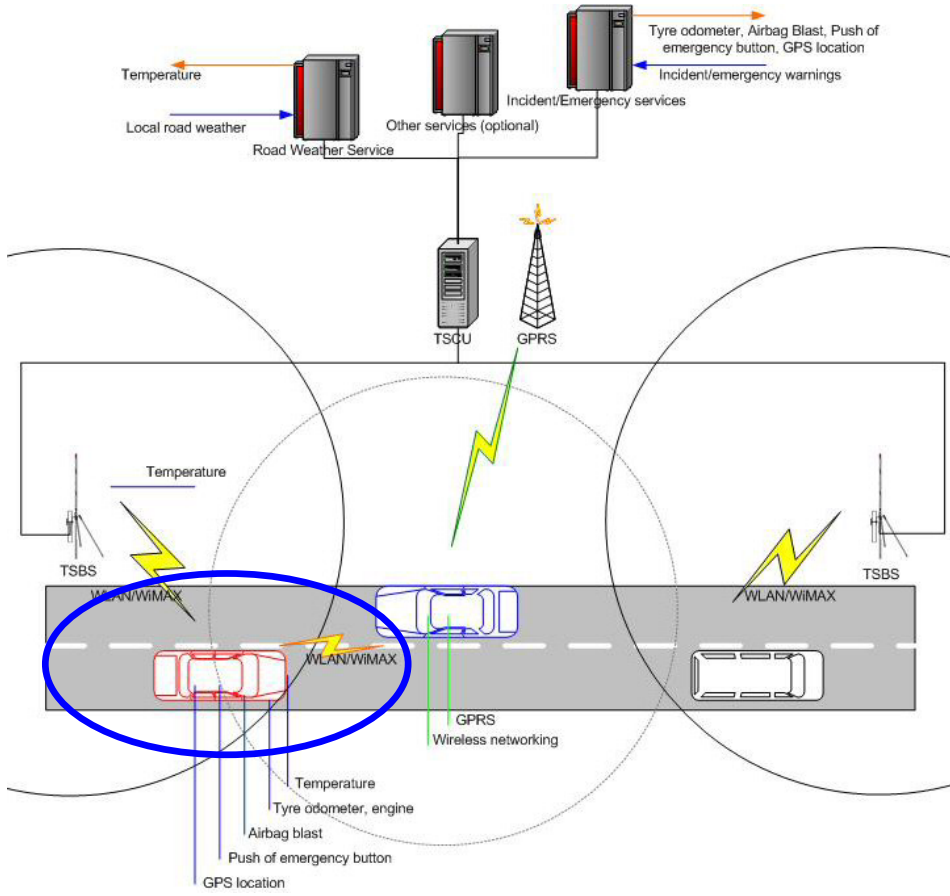
- **Base station network along roads**
- **Delivers TSCU data to vehicles + collects vehicle-observed data**
  - Up-to-date TSCU data is stored into TSBS ⇔ Delivery during vehicle bypassing
  - TSBS instrumentation provide more accurate weather observations than vehicles ⇔ Applicable for vehicle data calibration and monitoring
- **Wireless communication by 2 means**
  i. Mobile WiMAX
  ii. WLAN_IEE 802.11g



Platform Elements (3)

Mobile End Users (MEU)

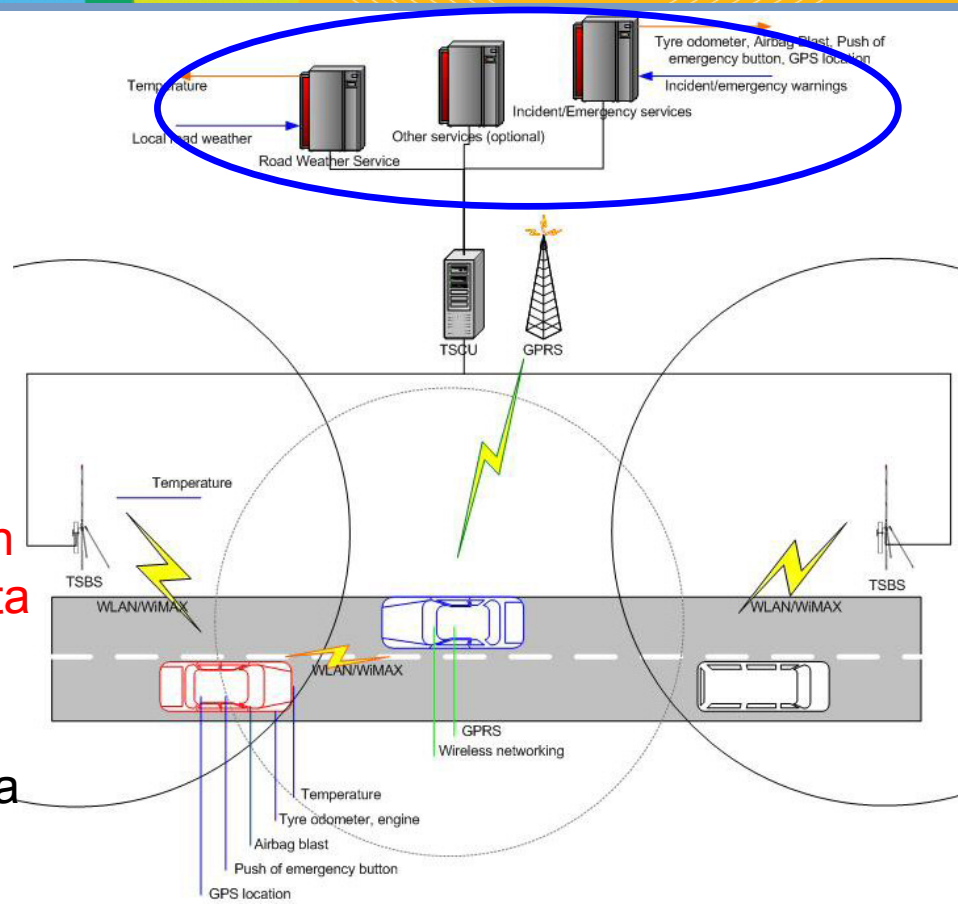
- **Vehicle communication system**
- **2-way communication with TSCU**
  - i. Indirectly thru base stations ⇔ Main channel (hi-capacity)
  - ii. GPRS: Emergency data (lo-capacity)
- **Vehicle-to-vehicle communication**
  - WLAN or WiMAX
  - Emergency data
  - Most recent platform data
  - *True networking with multihop connection to base stations (future)*



Platform Elements (4)

Services

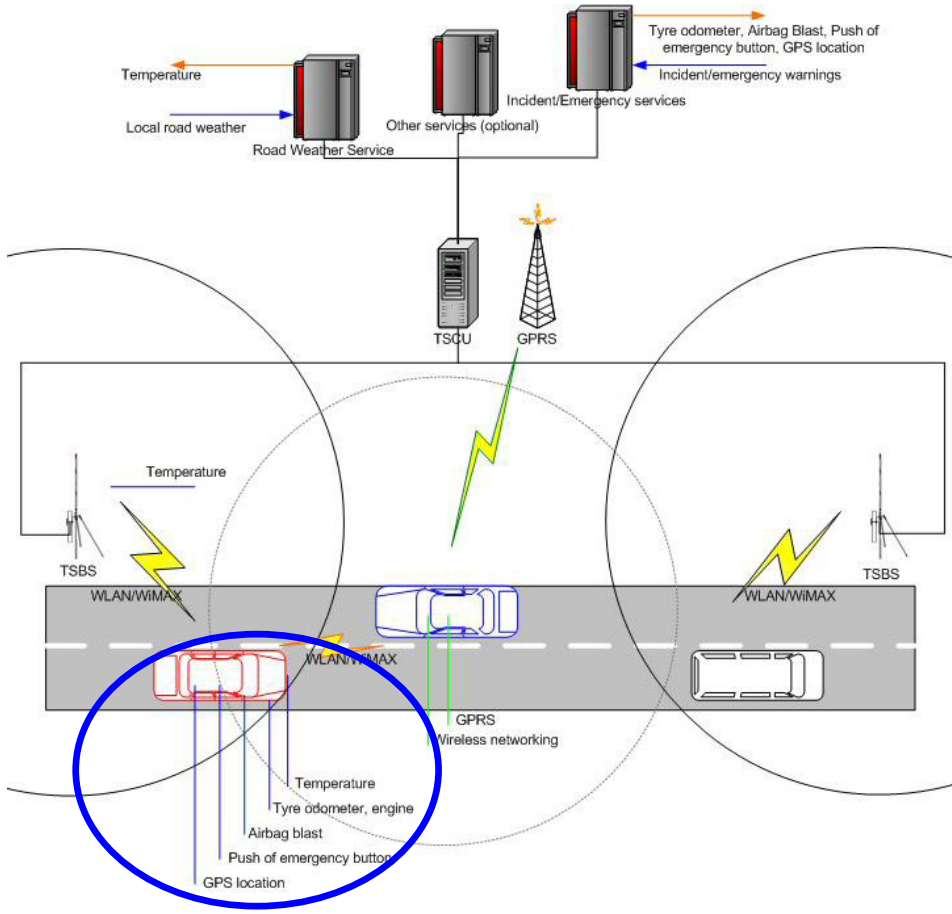
- Located in a fixed network beyond TSCU
- Direct connection to TSCU
- Allowing for various services...
- Road Weather Service
  - Based on FMI RWM
  - Present 10 km model resolution enhanced with local vehicle data
  - Delivered to TSBSs
- **Emergency services**
  - Accidents and other critical data collected/delivered as local warnings
- **Traffic logistics**
  - Exploiting inofrmation of traffic load
- **Mobile user**
  - Guidance and information services for moving users



Platform Elements (5)

Vehicle systems

- Communication system in vehicle computer unit - data from:
  - Car Internal CAN-Bus
    - ✓ Tire rotation speed
    - ✓ Airbag burst
  - CAN-Bus or own measurements
    - ✓ Outside temperature
    - ✓ Road surface temperature
    - ✓ GPS location
  - User interface
    - ✓ Emergency button



- Observation data at pre-defined intervals, with GPS location; Delivered thru TSBS to TSCU
- Emergency data instantly over GPRS to TSCU, and thru WLAN / WiMAX to encountering vehicles

Goals

- Define interfaces between various elements of the platform
- Define individual elements and ensure their interfacing compatibilities (done by participating Partners, locally)
- Piloting operability and efficiency
  - Simulations and testing of the demonstration systems

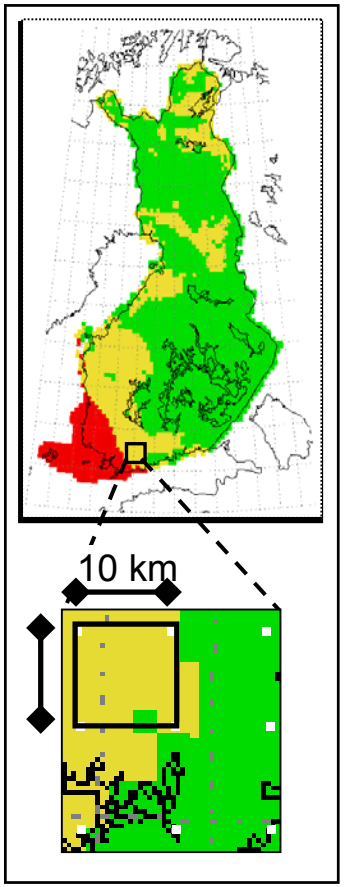
FMI

- **Compare and analyze WiMAX- and WLAN-based platform structures**
- **Test and further develop FMI's local Road Weather Service components by comparison to additional RW observations and/or forecasting systems**

"Demonstration systems will be constructed to test various usage scenarios and services…"

Road Weather Model

Model resolution



Model structure

1-dimensional energy balance model for vertical heat transfer

Upper boundary forcing

Atmosphere
- wind speed (V_z)
- air temperature and humidity (T_a, Rh)
- global (short wave) radiation ($R_{S\downarrow}$)
- incoming long wave radiation ($R_{L\downarrow}$)
- precipitation (P)

Traffic
- mechanical wear, heating

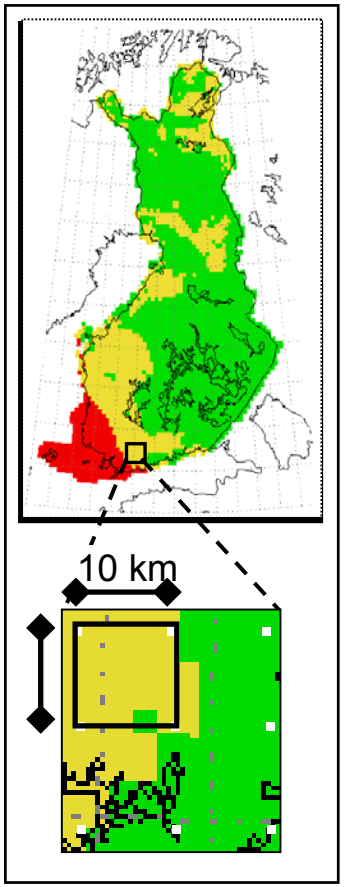
Turbulence
- natural
- traffic induced

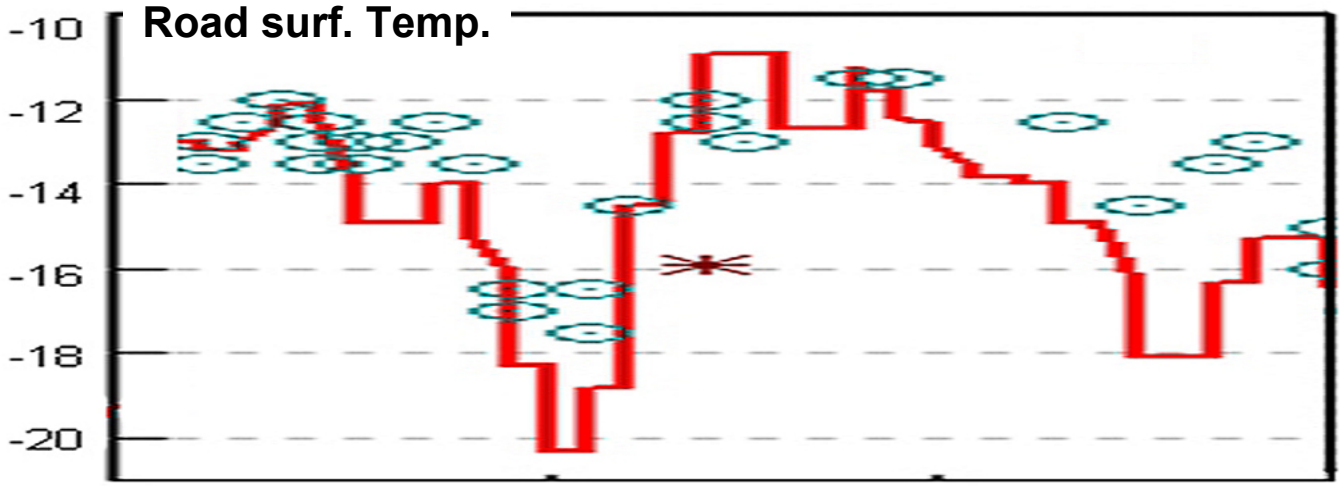
Surface heat exchange
- sensible heat flux (H)
- latent heat flux (LE)
- long wave radiation (R_L)
- stability

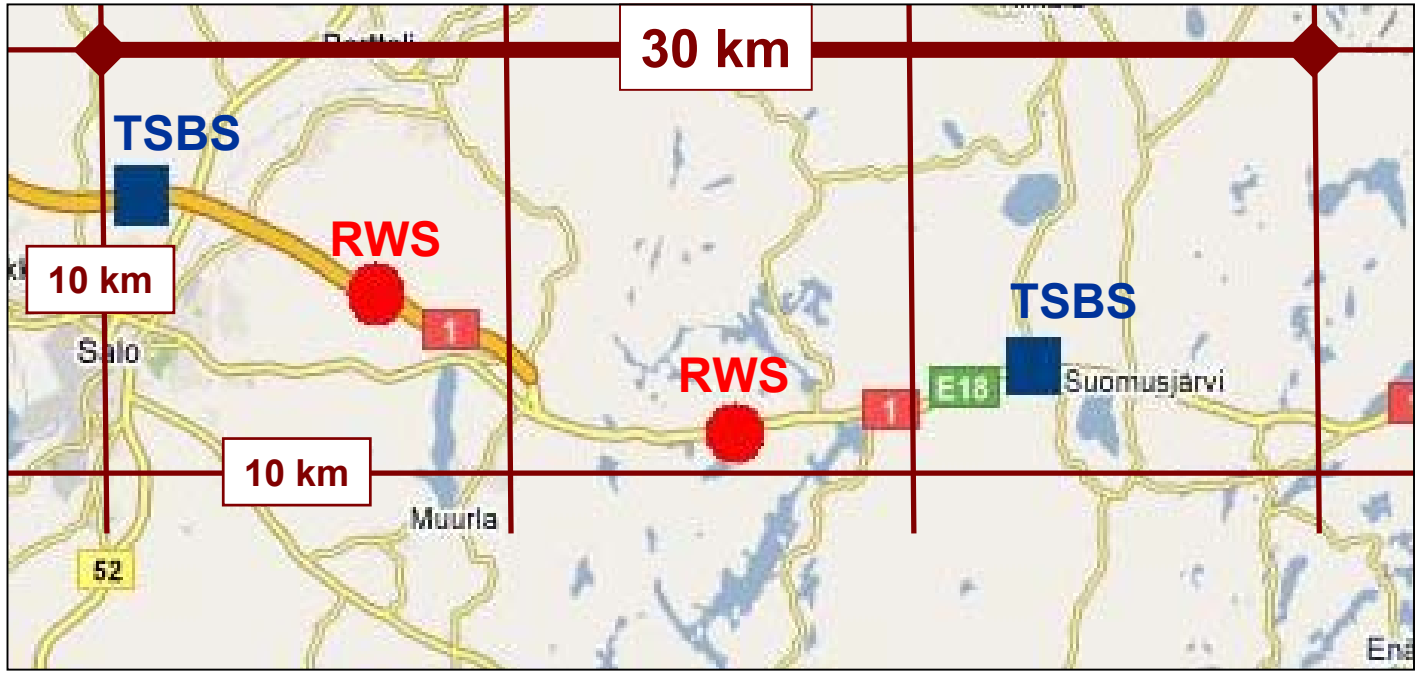
Ground heat transfer
- heat conductivity (λ)
- specific heat (c)
- density (ρ)
- porosity (ϕ)

Road Weather example adopted from "ColdSpots" project

RWM resolution







Test Simulations (1)

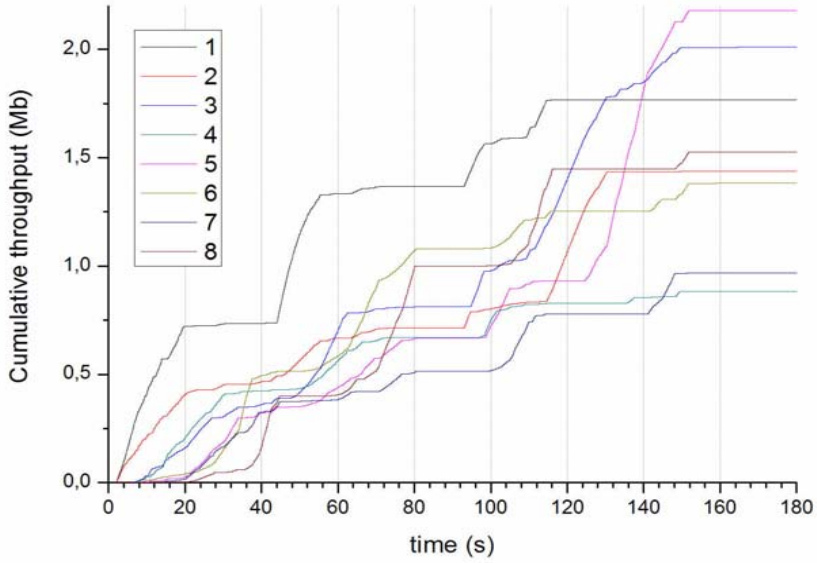
- Conducted with a NS-2 simulator, with a **802.11 protocol**
- Simulation of 2 scenarios:
  i. Scenario: 8 vehicles driving to same direction at equal 100 m distance
  ii. Scenario: 8 + 8 vehicles driving to opposite directions
  (those driving to same direction at equal 100 m distance)
  - Both scenarios: 4 base stations beside the road, 1000 m apart
- **Connection break times and thruputs studied**, with increasing traffic amounts
  ⇔ **Optimization of base station distances**

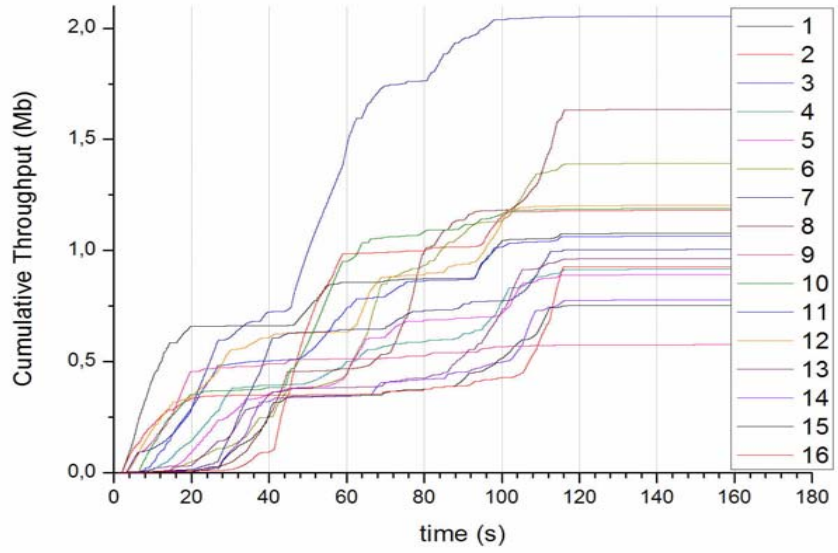
Test Simulations (2)

- **Scenario (i) vs. Scenario (ii):**
  - Longer breaks in communication
  - Higher thruput

	Connection time (%)	Cumulative thruput per vehicle	Average thruput per vehicle
Scenario 1	64	1,5 Mb	15,8 kbps
Scenario 2	81	1,1 Mb	11,7 kbps

- **Average thruput was insufficient**
  - Increase base station density
  - Optimization of simulation parameters
- **Base station distance < 1 km for breakless communication**





Test measurements (1)

- Communication between base station and vehicles tested with vehicle passing by station at different speeds
- Preliminary testing within demonstration system ⇔ Driving speeds 60, 70, 80 and 90 km/h

  (with 95 km/h communication could not be conducted)
- End of January 2008

Equipment:

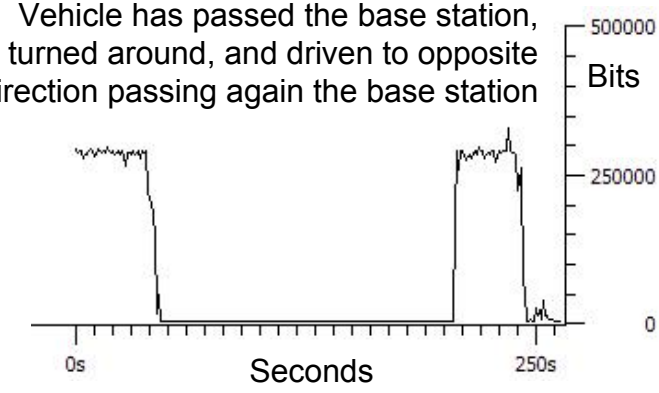
- ✓ *Colubris MAP-330 Multiservice Access Points*
- ✓ Sunit D7 Vehicle PC System
- ✓ Toyota Hilux 2007

Test measurements (2)

- **Preliminary results only indicative:**
  Thruput expected to decrease with increasing speed
  - Illogical results due to small sample (?)
  - Variations dependable on vehicle's approaching direction, temperature, etc.
- **Main result, however:**
  Thruput appears adequate for platform services, at least
  - Up to 90 km/h
  - For base station-to-vehicle communication

Example of test measurement:

Vehicle has passed the base station, turned around, and driven to opposite direction passing again the base station

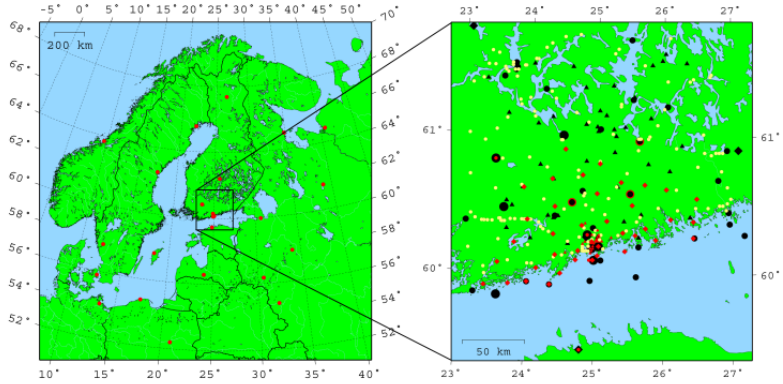


Speed	Connection uptime during one pass	Average thruput during one pass	Avg. cumulative thruput during one pass
60 km/h	50 s	0,27 Mbps	13,3 Mb
70 km/h	38 s	0,27 Mbps	10,1 Mb
80 km/h	40 s	0,27 Mbps	10,8 Mb
90 km/h	42 s	0,26 Mbps	10,8 Mb

Demonstration (1)

- **Scheduled for autumn/winter 2008**
- Along Helsinki-Turku highway
- Dense weather observation network: http://testbed.fmi.fi
- **Infrastructure**:
  - TSCU: Server in a fixed network, not physically in the area;

    with GPRS capabilities
  - TSBS: IEEE 802.11g access points on laptop PCs; Additional connection to weather stations
  - Mobile End User: Sunit vehicle PC, IEEE 802.11g tranceiver, GPS locator, GPRS unit, and interfaces to CAN-Bus and external measurements
  - Services: Road Weather and Warning service

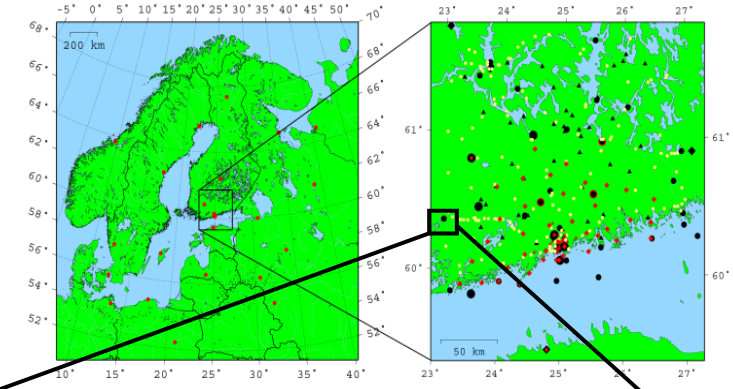


No.	Sites in Helsinki Testbed domain	
46	FMI weather stations	●
34	FMI precipitation stations	▲
13	Off-line temperature loggers in greater Helsinki area	▲
8	Weather transmitters in greater Helsinki area	▲
191	Road weather stations	●
292	**Surface weather stations, total**	
42	Pairs of weather transmitters in masts	◆
5	Optical backscatter profilers (new ceilometers)	●
6	FMI ceilometers	●
4	C-band Doppler radars	◆
1	Dual polarization Doppler radar	◆
4	RAOB sounding stations	●
1	UHF wind profiler	▲
-	Total lightning network	-

Demonstration (2)

Parameters to test & demonstrate:

- ✓ **Base station distance optimization**
- ✓ **Vehicle vs. observed data evaluation**
- ✓ **User-interface evaluation**
- ✓ **Connection time (%)**
- ✓ **Thruput**
- ✓ **Service update time**
  - Road weather
  - Accident warning



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Web links:

- ✓ **http://carlink.lcc.uma.es**
- ✓ **www.celtic-initiative.org/Projects/CARLINK**

Thank You for Your Attention !

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