NAVIGARE 2010 - GNSS in ITS: the way of co-operation

NEARCTIS: Excellence in co-operative traffic management, role of technologies

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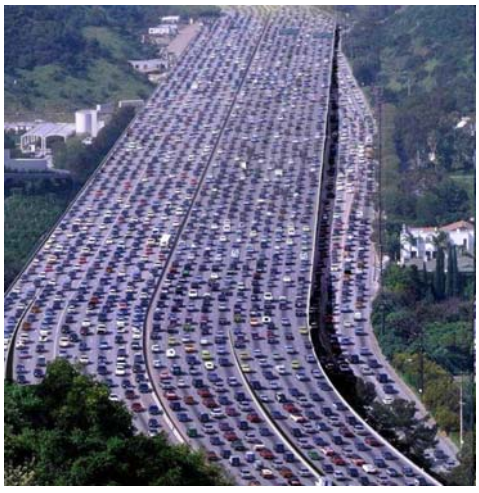
ENAC - Laboratoire de Topométrie
EPFL

Agenda

- The network of excellence NEARCTIS
  - Context & goal of the project
  - Research programme
  - Resources & associate partners
- Traffic management
  - Traffic control cycle
  - Basics micro-macro variables
- Role of technologies
- Requirements in positioning
- Positioning technologies
- Positioning quality
- Research prospects



NEARCTIS

- NEARCTIS: Excellence in co-operative traffic management
  - A 7th framework programme, Network of excellence, Theme 3, ICT
    - Integrating and strengthening the European Research Area
  - Gathering academic research on traffic management (traffic modelling, traffic control, communication and positioning technologies)

NEARCTIS – Core Partners

- INRETS *France, French National Institute for Transport and Safety Research, Scientific Coordinator*
- ERT *France, Europe Research Transport, Management coordinator*
- TUDelft *Netherlands, Technical University of Delft*
- DLR *Germany, Deutsches Zentrum für Luft und Raumfahrt*
- University of Southampton, *United Kingdom*
- UCL *United Kingdom, University College London*
- Imperial College London, *United Kingdom*
- EPFL *Switzerland, Ecole Polytechnique Fédérale de Lausanne, Labs: LAVOC – TRANSP-OR, TOPO*
- Technical University of Crete, *Greece*

NEARCTIS - Goals

- To create a virtual research institute
  - Integrated research programme
  - Common shared resources
  - Policy and structure for results and dissemination
  - Integration of training capabilities
- To ensure a strong link between the core network and associate partners
  - Academic, stakeholders of traffic, industry

NEARCTIS – Research Programme

- Elaborating a common and consistent research programme
  - Various scientific fields
    - Modelling, optimization and control, and evaluation
    - Communication, positioning and tracking
    - Deployment and implementation issues
  - Various systems implementation field
    - Motorway corridors
    - Dense urban network
    - Global Services: information based on co-operative systems

NEARCTIS – Resources

- Common resources
  - Developing a set of shared resources: databases, software, experimental tracks,…
- Education, Training and dissemination
  - Researchers' mobility and training
  - PhD grants
  - Workshops, summers schools
  - Web site: http://www.nearctis.org

- NEARCTIS
  - Summer school
  - EPFL, June 2010
  - 40 participants
  - 6 instructors

Real-Time Road Traffic Monitoring and Control

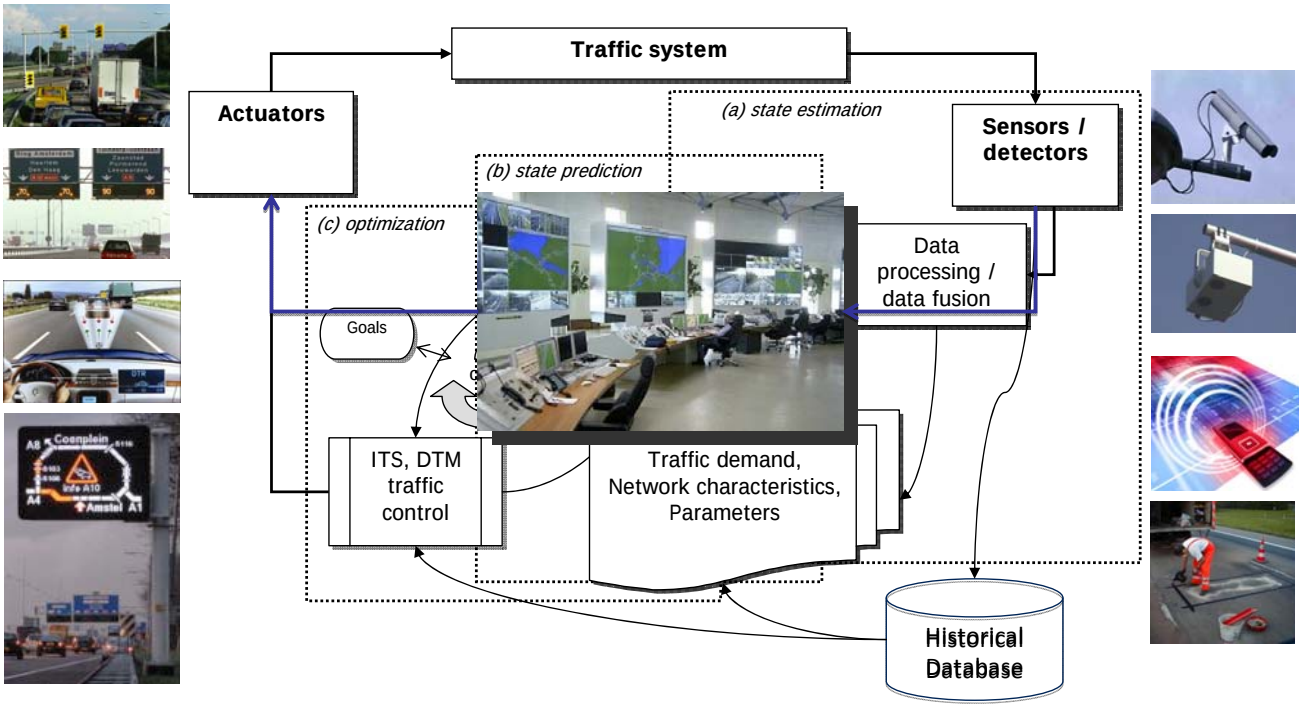
Objectives:
The objectives of this summer school are :
- to provide an opportunity for young researchers and professionals to acquire knowledge on the basics of road network state estimation, modelling and control and
- to allow trainees to get insight on possible implications of these basics in their own research and application field

Date	Time		Lecturer	Lecture Title
9th June	8:15-8:30	Welcome		
	8:30-9:15	Lecture 1	Hans van Lint	Framework
	9:15-9:30	Break		
	9:30-10:15	Lecture 2		Traffic state estimation (using kalman filtering)
	10:15-10:30	Break		
	10:30-11:15	Lecture 3		
	11:15-11:30	Break		
	11:30-12:15	Lecture 4		
	12:15-14:00	Lunch break		
	14:00-14:45	Lecture 5	Mila Mihaylova	Traffic state estimation (particle filter)
	14:45-15:00	Break		
	15:00-15:45	Lecture 6		
	15:45-16:00	Break		
	16:00-16:45	Lecture 7	Nick Hounsell	Urban traffic control and bus priority
	16:45-17:00	Break		
	17:00-17:45	Lecture 8		
10th June	8:30-9:15	Lecture 9	Michael Bell	Traffic and transit assignment
	9:15-9:30	Break		
	9:30-10:15	Lecture 10		
	10:15-10:30	Break		
	10:30-11:15	Lecture 11	Lawarence A. Klein	Data fusion
	11:15-11:30	Break		
	11:30-12:15	Lecture 12		
	12:15-14:30	Lunch break		
	14:30-15:15	Lecture 13	Markos Papageorgiou	Freeway traffic control
	15:15-15:30	Break		
	15:30-16:15	Lecture 14		
	16:15-16:30	Break		
	16:30-17:15	Lecture 15		
	17:15-17:30	Break		
	17:30-18:00	Answer to students questions		
11th June	9:00-16:00	Workshop "Towards new research area in co-operative traffic management"		

NEARCTIS – Associate Partners

- Close integration of partners:
  - International academic community
  - Scientific community
  - Professional community: car manufacturers, traffic systems manufacturers, consultants
  - Traffic management authorities and road operators
- Involvement of partners
  - Easy access to information disseminated by the project
  - Participation in networking activities
  - Specific access to resources shared by the network
  - Attend NEARCTIS workshops
- Interested? Please become AP of NEARCTIS

The traffic control cycle



Source: NEARCTIS-COST TU0702 Summer school "Real time road traffic monitoring and control", June 9-11, EPFL, Lausanne
Acknowledgements: Prof. Hans-Van Lint (TuDelft)

The traffic/transport/transit control cycle







Any traffic, transport, transit system

Actuators

(a) state estimation

Sensors / detectors

(b) state prediction

(c) optimization

Any consistent set of assumptions / models

current state

Data processing / data fusion

Goals

optimize

Control / measures

All (control application) relevant inputs, boundary conditions & parameters

Historical Database

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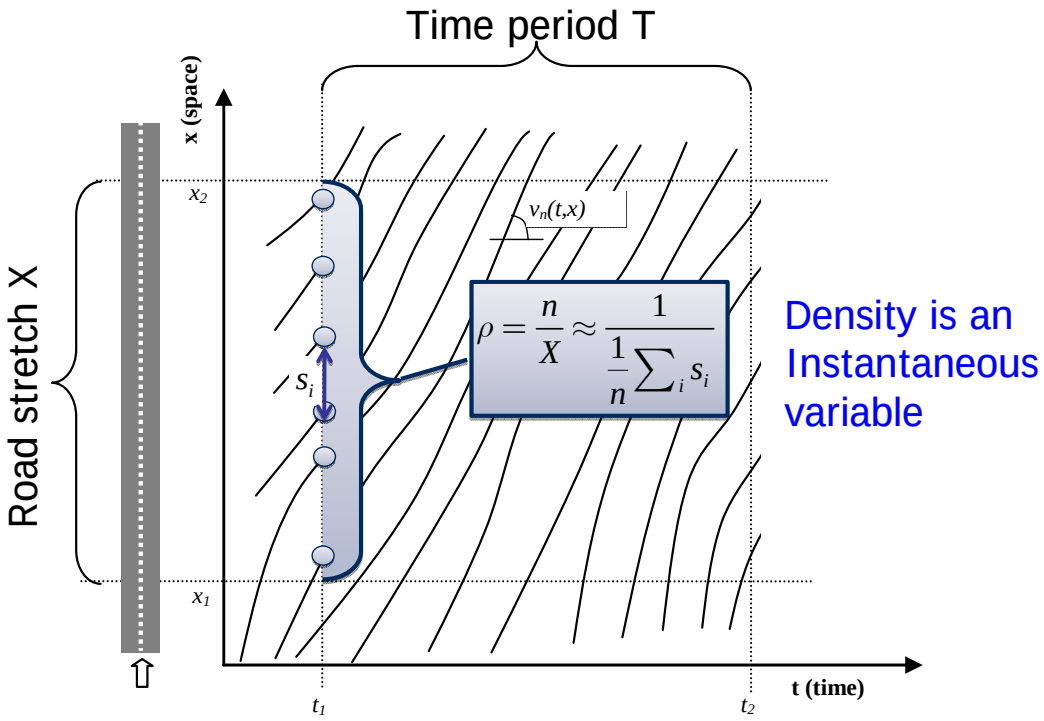
The basics – micro and macro variables



Density is an Instantaneous variable

Source: NEARCTIS-COST TU0702 Summer school "Real time road traffic monitoring and control", June 9-11, EPFL, Lausanne
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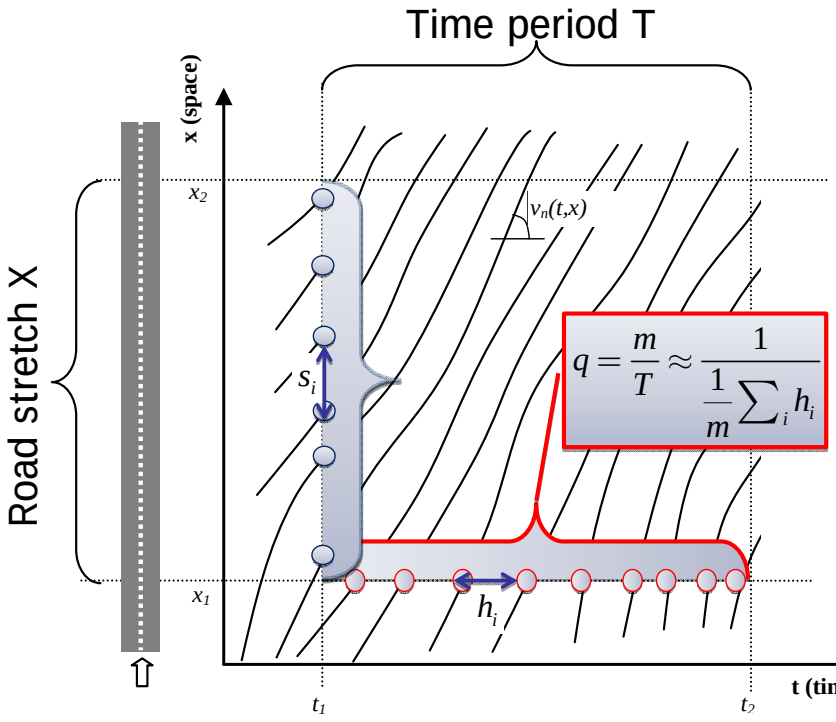
The basics – micro and macro variables



Density (veh/m, instantaneous variable)

$$\rho = \frac{n}{X} \approx \frac{1}{\frac{1}{n}\sum_i s_i}$$

Flow is a local variable

Source: NEARCTIS-COST TU0702 Summer school "Real time road traffic monitoring and control", June 9-11, EPFL, Lausanne
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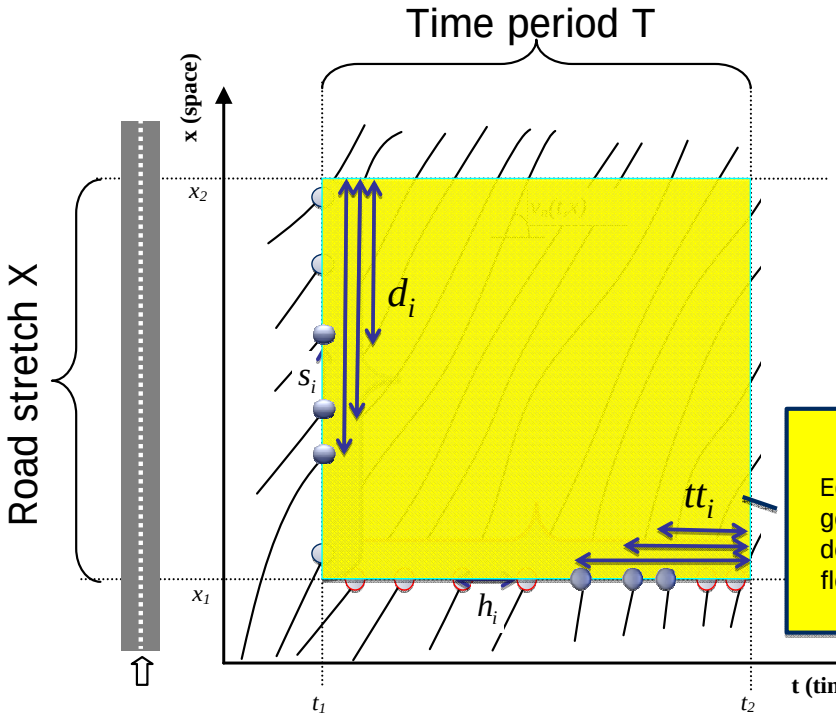
The basics – micro and macro variables



Density (veh/m, instantaneous variable)

$$\rho = \frac{n}{X} \approx \frac{1}{\frac{1}{n}\sum_i s_i}$$

Flow (veh/s, local variable)

$$q = \frac{m}{T} \approx \frac{1}{\frac{1}{m}\sum_i h_i}$$

Edie's generalized definitions for flow and density

$$\begin{cases} \rho = \dfrac{\sum tt_i}{TX} \\ q = \dfrac{\sum d_i}{TX} \end{cases}$$

spatiotemporal variables

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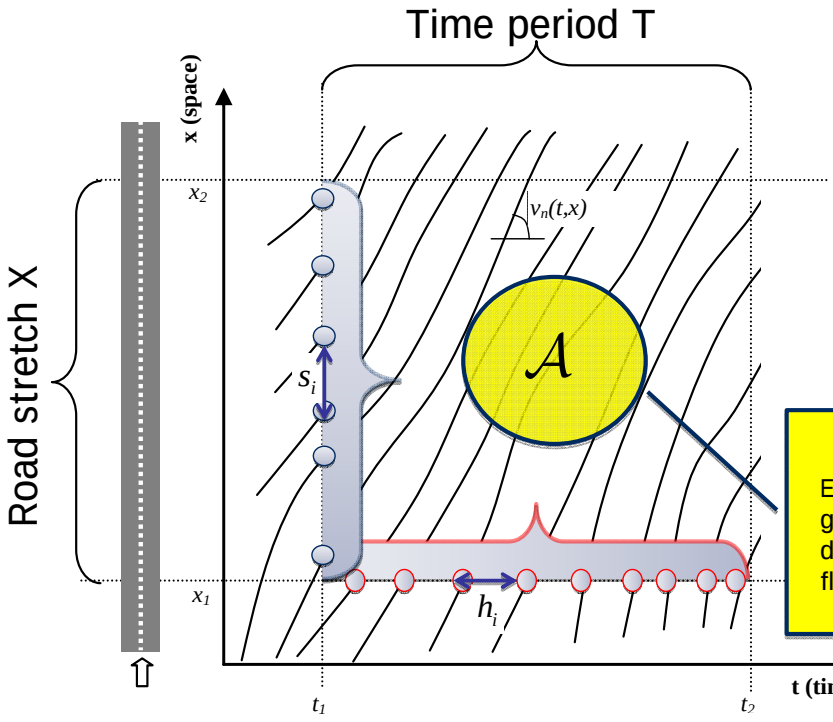
The basics – micro and macro variables



Density (veh/m, instantaneous variable)

$$k = \frac{n}{X} \approx \frac{1}{\frac{1}{n}\sum_i d_i}$$

Flow (veh/s, local variable)

$$q = \frac{m}{T} \approx \frac{1}{\frac{1}{m}\sum_i h_i}$$

Edie's generalized definitions for flow and density

$$\begin{cases} \rho = \dfrac{\sum tt_i}{\mathcal{A}} \\ q = \dfrac{\sum d_i}{\mathcal{A}} \end{cases}$$

spatiotemporal variables

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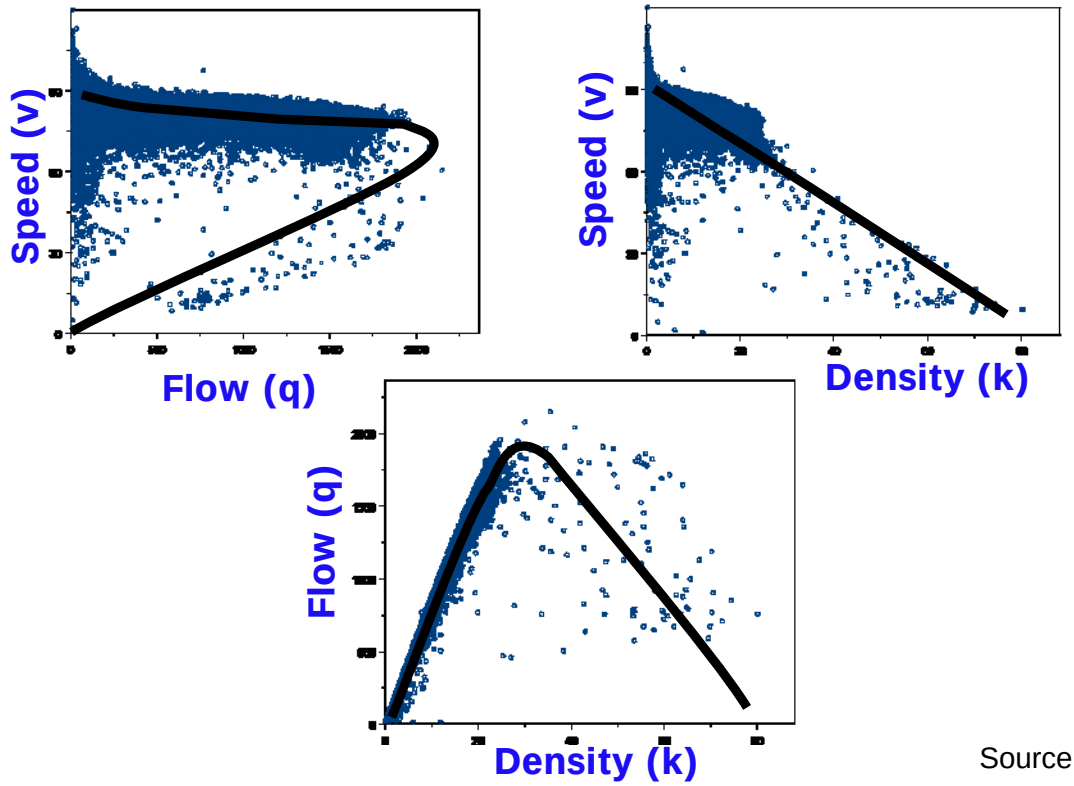
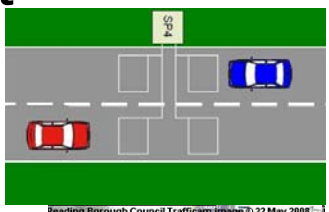
Real Traffic Data



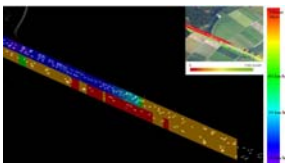
Source: LAVOC

Traffic Management

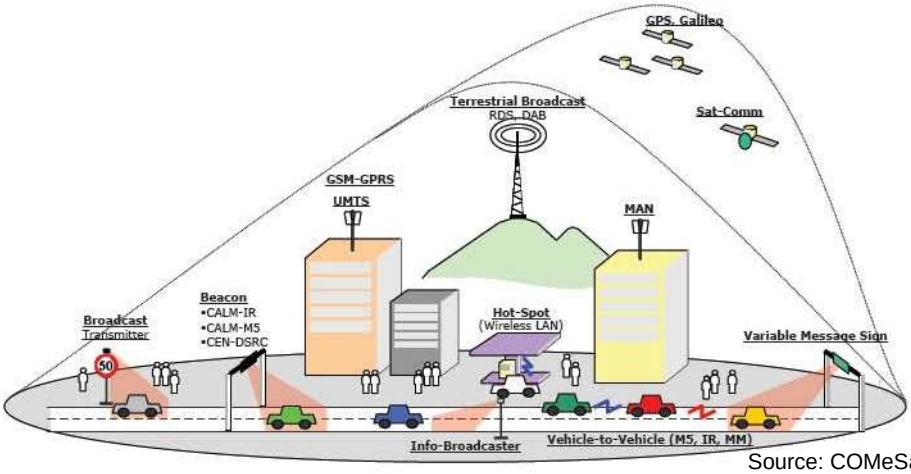
- Techniques used for measuring the traffic variables
  - Fixed
    - Loop detectors, IR
    - Optical sensors, camera
  - Mobile
    - Floating car data
    - Floating phone data
    - Remote sensing, aerial



Floating Car Data (FCD)



Role of Technologies



Source: COMeSafety, 2008

- The improvement of transport efficiency will be based on new traffic and travel information services
- Co-operative systems will play a key role in this context
- V2V – Vehicle to vehicle; V2I: Vehicle to Infrastructure

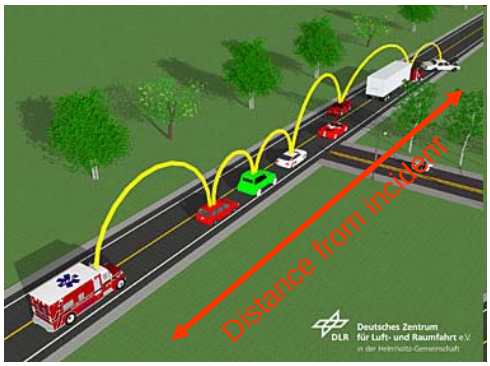
COMeSafety: action funded by the EU Commission for the establishment of a communication architecture task force

Role of Technologies

- Communication and positioning systems are basic components of co-operative systems
- The ongoing development of GNSS and the new short range communication systems lead to new possibilities for traffic management
- Innovative traffic management systems require development of specific positioning and communication systems

What are the requirements in positioning?

Why do we need positioning systems?



Requirements in Positioning

- Grouping of ITS services according issues of safety or liability
  - Safety-of-life: applications considered as safety critical, or having any safety implication
  - Liability-critical: applications presenting any commercial or legal relationship between the service provider and the users
  - Non safety-of-life; non liability-critical: application not presenting any commercial, legal or safety implication

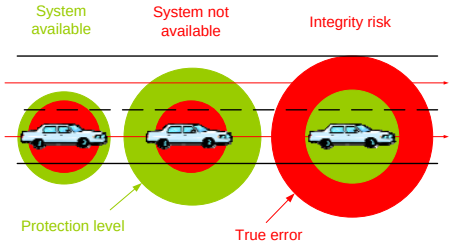
Requirements in Positioning

- Specific requirements
  - Accuracy: measure of the difference between the estimated position of a vehicle and its true position
    - Which road, which lane, where in the lane?
  - Integrity: measure of the trust that can be placed in the correctness of the information supplied by the positioning system
  - Continuity: capability of the system to perform without unscheduled interruptions during the intended operation
  - Availability: percentage of the time that the positioning service is usable and is delivering the required accuracy, continuity and integrity

Requirements in Positioning

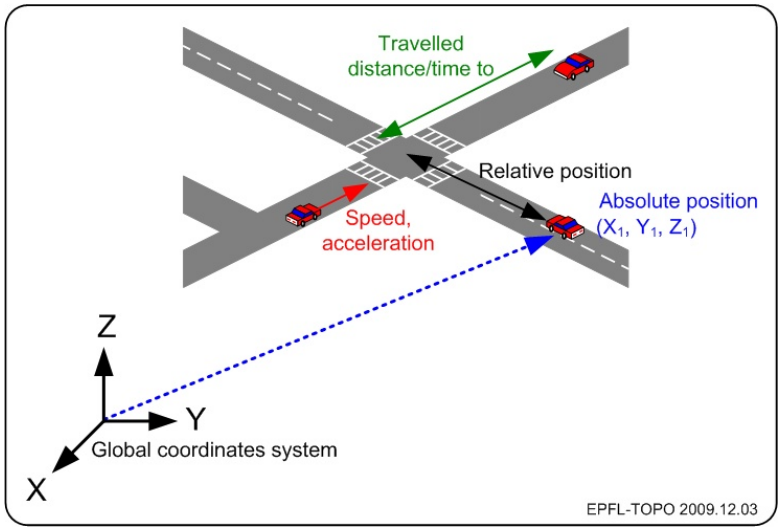
- Available: True error < Protection level < Alert Limit
- Not available: True error < Protection level **>** Alert Limit
- Integrity Risk: True error **>** Protection Level

AL:Alert Limit



Positioning Technologies

- Fundamental parameters used in positioning
- From fixed locatioon to dynamic measurements
  « Linking the measuring device (e.g. GPS) to the vehicle »
  - Set of « particles » distributed in the road network
  - Capability to provide instantaneous parameters



Positioning Technologies

Parameter

- Absolute position
  - Tech.: GNSS, combination with other sensors
  - Perf.: availability (e.g. tunnels, urban canyon)
  - Role: tracking, locate the vehicle on the map
- Relative position
  - Tech.: beacons, radio-based systems
  - Perf.: limited to specific location (e.g. gantry)
  - Role: relevant in V2V & V2I architecture

Positioning Technologies

Parameter

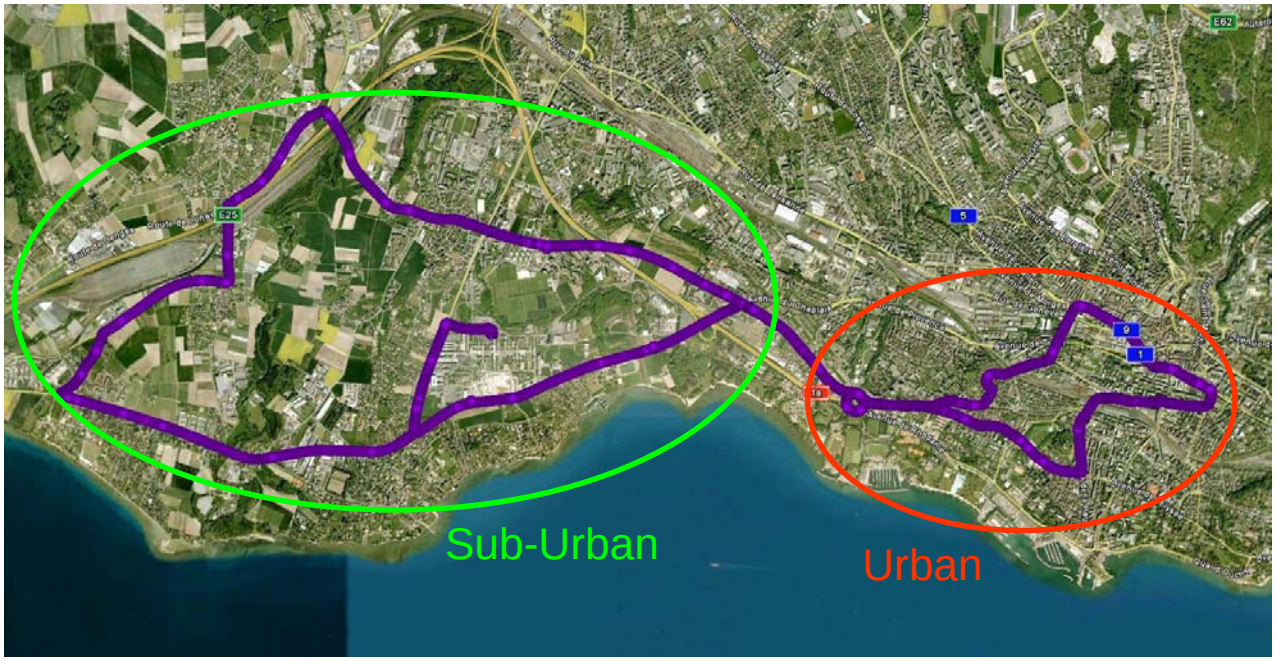
- Time
  - Tech.: GNSS provide an accurate time scale
  - Perf.: availability (e.g. tunnels)
  - Role: key parameter for real time applications
- Speed
  - Tech.: speed sensors or GNSS based sensors
  - Perf.: continuity
  - Role: traffic state estimation, safety, enforcement

Positioning Technologies

Parameter

- Acceleration
  - Tech.: onboard inertial sensors
  - Perf.: continuity
  - Role: ADAS application, crash recorder
- Travelled distance
  - Tech.: wheel sensors, GNSS based systems
  - Perf.: availability
  - Role: management systems (e.g. fleet)

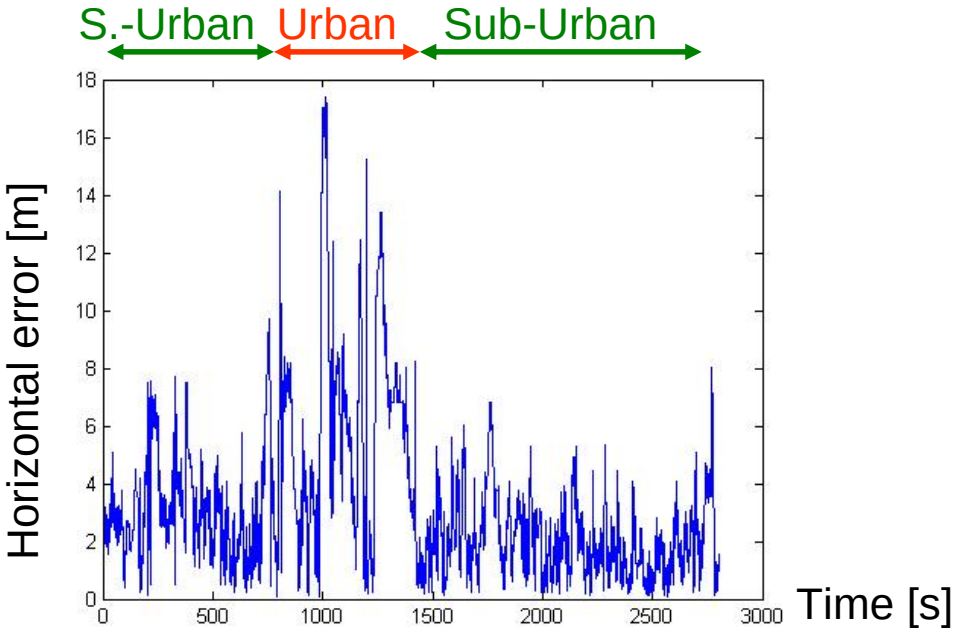
Positioning Quality - Example



- Field test: 18 km, travelled time: 40 min
- Comparison: GPS “low cost” – High end GPS/INS

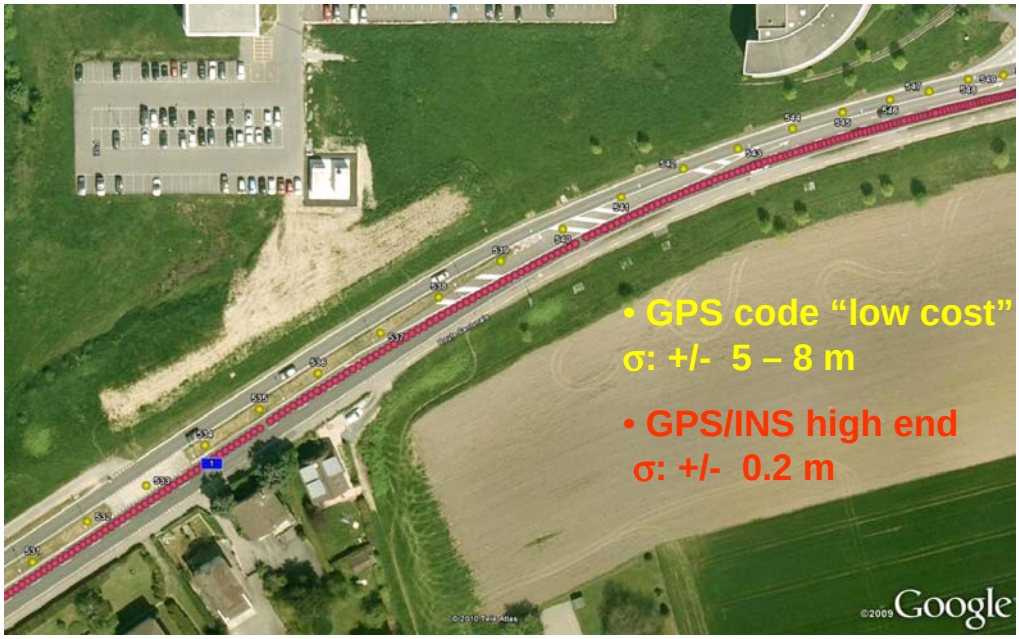
Ref.: Project ENAC, Master students: Paola Cavadia, Amir Sohrab Sahaleh

Positioning Quality - Example



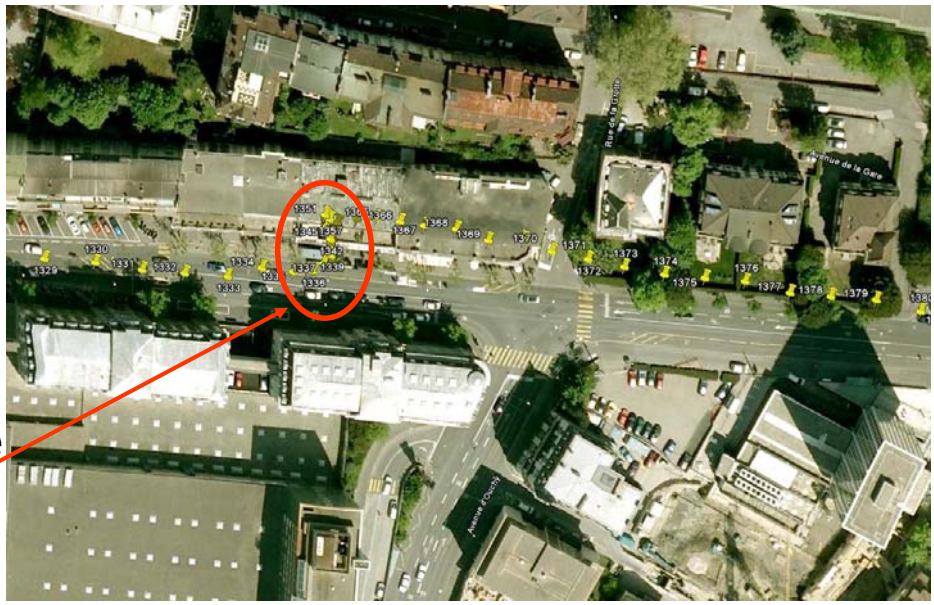
- Horizontal error: GPS “low cost” vs reference trajectory

Positioning Quality - Example



- Position accuracy: influenced by the environment, variable in time and space

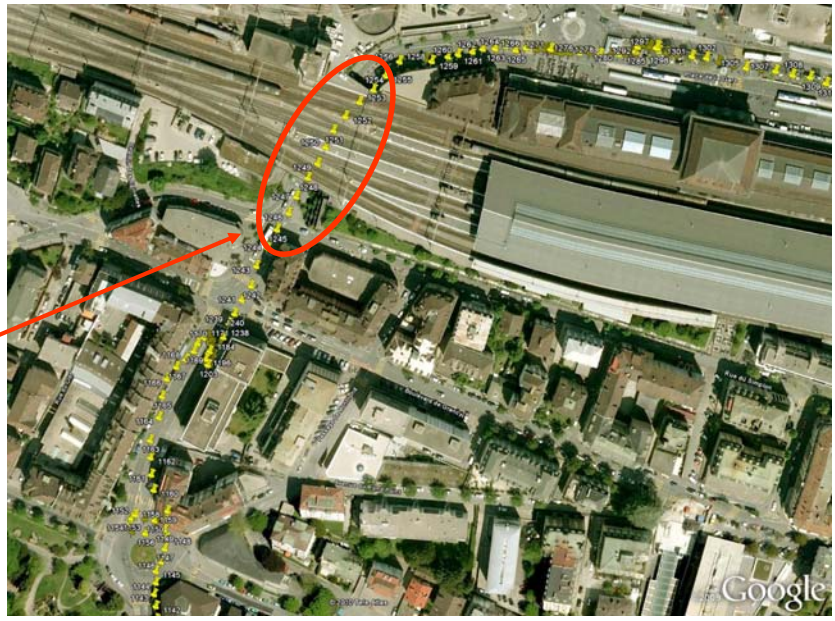
Positioning Quality - Example



Stop of the vehicle

- Position accuracy: bias, systematic error

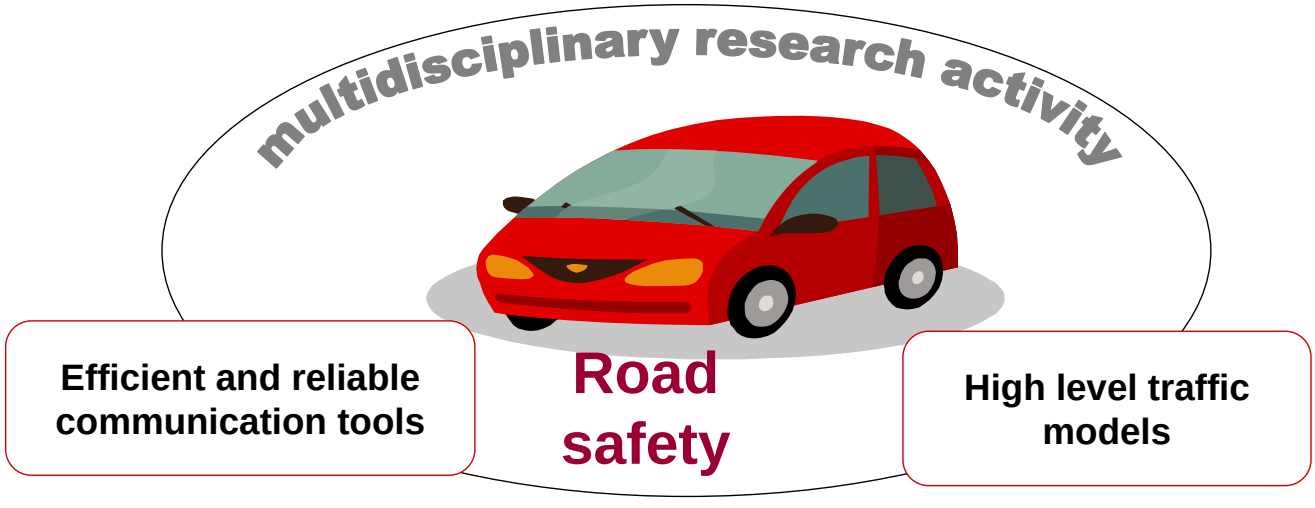
Positioning Quality - Example



- Continuity of the positioning signal

Research prospects

NEARCTIS has identified some interesting researched areas on the integration of emerging technologies in traffic management



Nearctis

Research prospects

- Reliable positioning and tracking in dense traffic areas
- Secure vehicles positioning for traffic management
- Enhanced and multi-scale positioning, combination between global (GNSS) and local positioning (sensors)
- Accurate distance identification between vehicles for traffic safety
- Self-calibration and synchronisation of image-based positioning and tracking systems

NAVIGARE 2010

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30 Juin 2010
EPFL - Lausanne

Organisé par
Institut Suisse de Navigation
(ION-CH)

www.ion-ch.ch

Partenariat

Thank you for your attention

Road authorities

Car manufacturers

co-operation?

Research centers

Road operators

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