InnoSoc
Innovative ICT Solutions
for the Societal Challenges

Information and Communications Technologies (ICT) applications in transport sector

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Agenda

- ICT and ITS
- ICT and car development
- ITS standardization
- Parameters of wireless communications in ITS
- Wireless communications in ITS
  - IEEE 802.11p
  - Public mobile phone networks
  - RFID based systems
  - ……

ICT

- **ICT** stands for
  "Information and Communication Technologies."
- It's an „umbrella" term!
- Refers to
  technologies that provide access to **information**
- The access is realised through **telecommunications**
- ICT includes
  - Internet, **wireless IP** networks
  - Mobile phone systems (2G…**5G**)
  - DAB, DVBT…….etc., etc

ICT

- ICT in different context:
  - ICT in entertainment
  - ICT in education (distance learning)
  - ICT in health care
  - ICT in intelligent building management
  - ……
  - **ICT in traffic management**
- Impact of ICT:
  - Improve business (home banking, hotel booking…….)
  - Economical, environmental
  - Effect society (real time communications, Facebook, etc.)…..

ITS

- ITS stands for
  „Intelligent Transport System”
- ITS = Traffic systems + ICT
- ICT changes the tranport sector, like
  maritime, aviation, railways, **road transport**
- Advantages of application of ICT in road transport:
  - increasing efficiency,
  - reliability and
  - safety and
  - reducing energy consumption

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The problem

What about…..

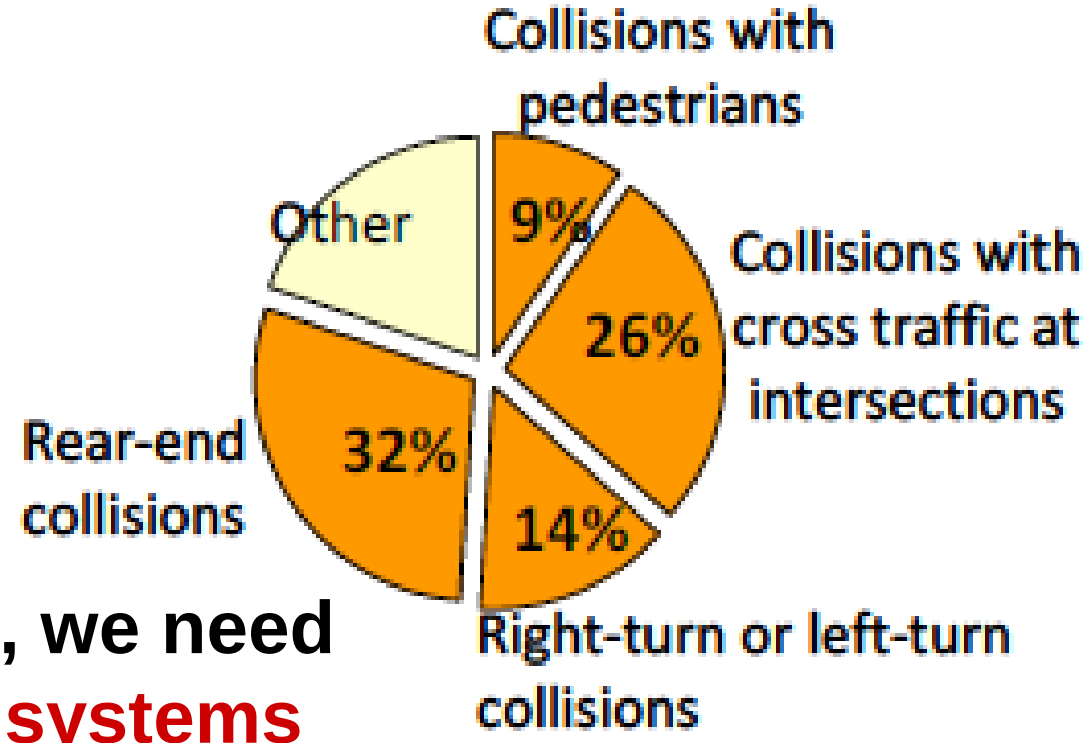
- **Travel safety???**
- Reliability????
- Efficiency???
- Environmental impact???
- …..

Accidents

- Over 40 000 road fatalities per year in Europe
- More than 1.25 million injuries! [ETSI]

- Main reason of accidents: **human failure**
  - Failure to recognize a hazard in time
  - Error in judgment
  - Error in operation

Accidents



To avoid fatalities, we need
driving support systems
a new traffic system supported by
information technology!

If you want to travel…

You need a

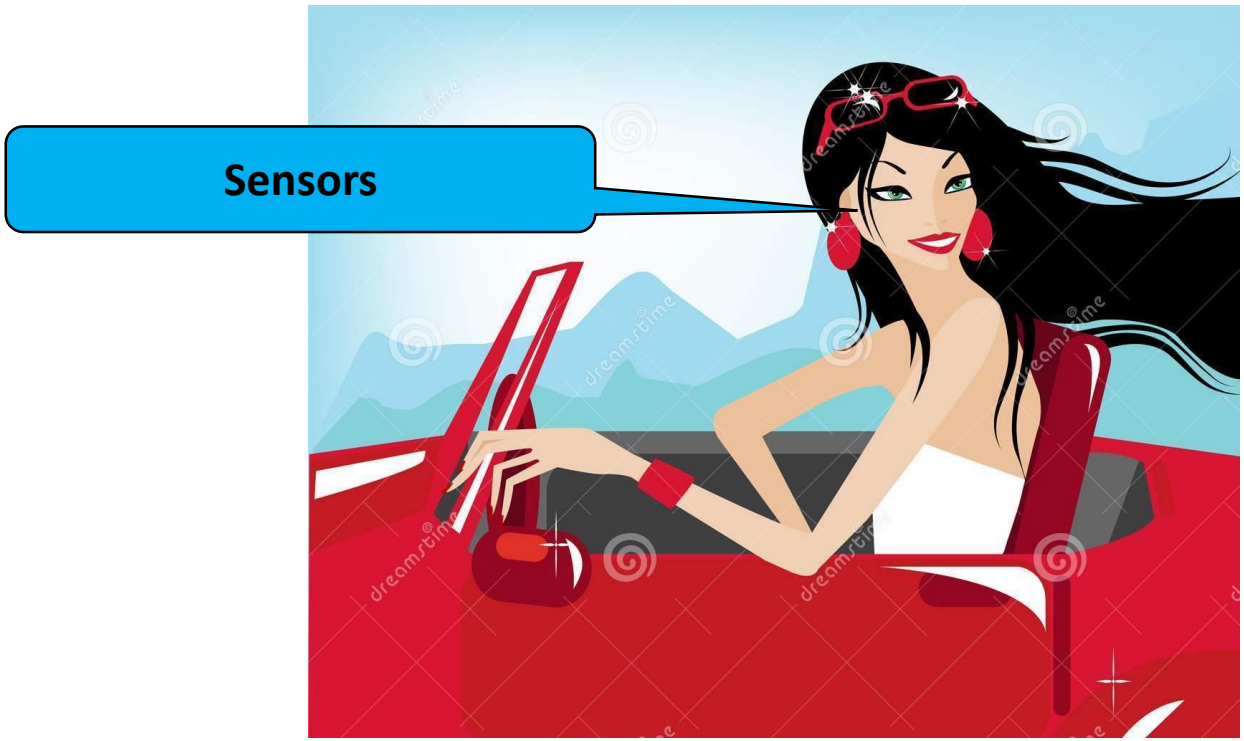
- **Car**
- Traffic infrastructure
  - Road network
  - Petrol stations
  - ICT support
    (motorway traffic control, smart traffic lamps, GPS ……)

If you want to travel…

You need a

- **Car**
- Traffic infrastructure
  - Road network
  - Petrol stations
  - ICT support
  - ……
- ***Driver***

The driver



The driver

The driver

The driver


Computer
Sensors
Communication device
Mechanical interfaces

The dream

Driverless car
(autonomous car, self-driving car, robotic car),

- Substitute the driver by computer, sensors, etc.
- Reconstruct the infrastructure
- **Car -to-Car and Car-to-Infrastructure Communications**

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An experiment

- Google driverless (self-driving) car

Steps of the car development

- The aim of **car developments**: to produce a
  - driver support system (basic and advanced),
  - later an intelligent car (driverless car)

  which can cooperate with **Intelligent Transport System** (ITS)

Steps of the car development (2014)

Estimations (in 2014):

- ~2016 Partially automated
  - Anti collision radar, parking system (legal problem!)
  - Toll collection, E-call, stolen car info….
  - No communications among vehicles!
- ~2020 Highly automated
  - Advanced Driver Assistance (Texas Instr.)
    - Camera–based and radar–based assistance
  - Communication among vehicles
- >2025 Fully automated

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Steps of the car development (2014)

Steps of the car development

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Autonomous car forecasts (2015)

- Toyota: 2020 (Wired.com, 2015-10-08)
- Ford: 2020 (Forbes.com, 2015-02-09)
- Audi A8: 2017 (motoring.com.au/)
- Nissan: 2020 (Nissan Motors, Forbes.com,)

- **Uber fleet to be driverless by 2030 (Mobility Lab, 2015-08-18)**

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Intelligent Transport System

Development of ITS

Intelligent Transport System (ITS)

- Set of communication related applications
  - mainly wireless system based applications
- The aim of ITS: to increase
  - Travel safety
  - Reliability
  - Efficiency
  - Quality

Intelligent Transport System

- Based on **cooperation** of vehicles (M2M)
- No centralized control!
- Participants
  - have own identity code
  - form ad-hoc telecommunication networks
  - Change information about their
    - position, direction, emergency, warnings…..
- Problem: **security**, human rights….

Intelligent Transport System

- Technically
  - based on SRD devices
    - SRD: Short Range Devices
    - Communication range: nx10m….nx100m
  - excluding public mobile network based services
    - For example: **e-Call**
- SRD:
    - high amount of radio equipment operate
    - on limited area
    - on limited frequency band >>> **interference!**

ITS standardization

- ***International Telecommunication Union***, ITU
  - http://www.itu.int/en/Pages/default.aspx
- **European Telecommunications Standards Institute (ETSI)**
  - http://www.etsi.org/standards

Downloading standards—free of charge!!!!!

ITS

- We are focusing on **road traffic**!
- ITS applications:
  - Road safety applications
  - Non safety applications
  - On demand services applications
- ITS standardizes
  - Communications demands,
  - Applications
  - **Not technology!!!!**

Communications in ITS

- **Vehicle-to-vehicle (V2V; C2C)**
- Vehicle-to-Infrastructure (V2I;C2I)
- Infrastructure -to-Vehicle (I2V;I2C)
- Infrastructure-to-Infrastructure (I2I;I2I)

- Message type:
  - Dedicated
  - Broadcasted

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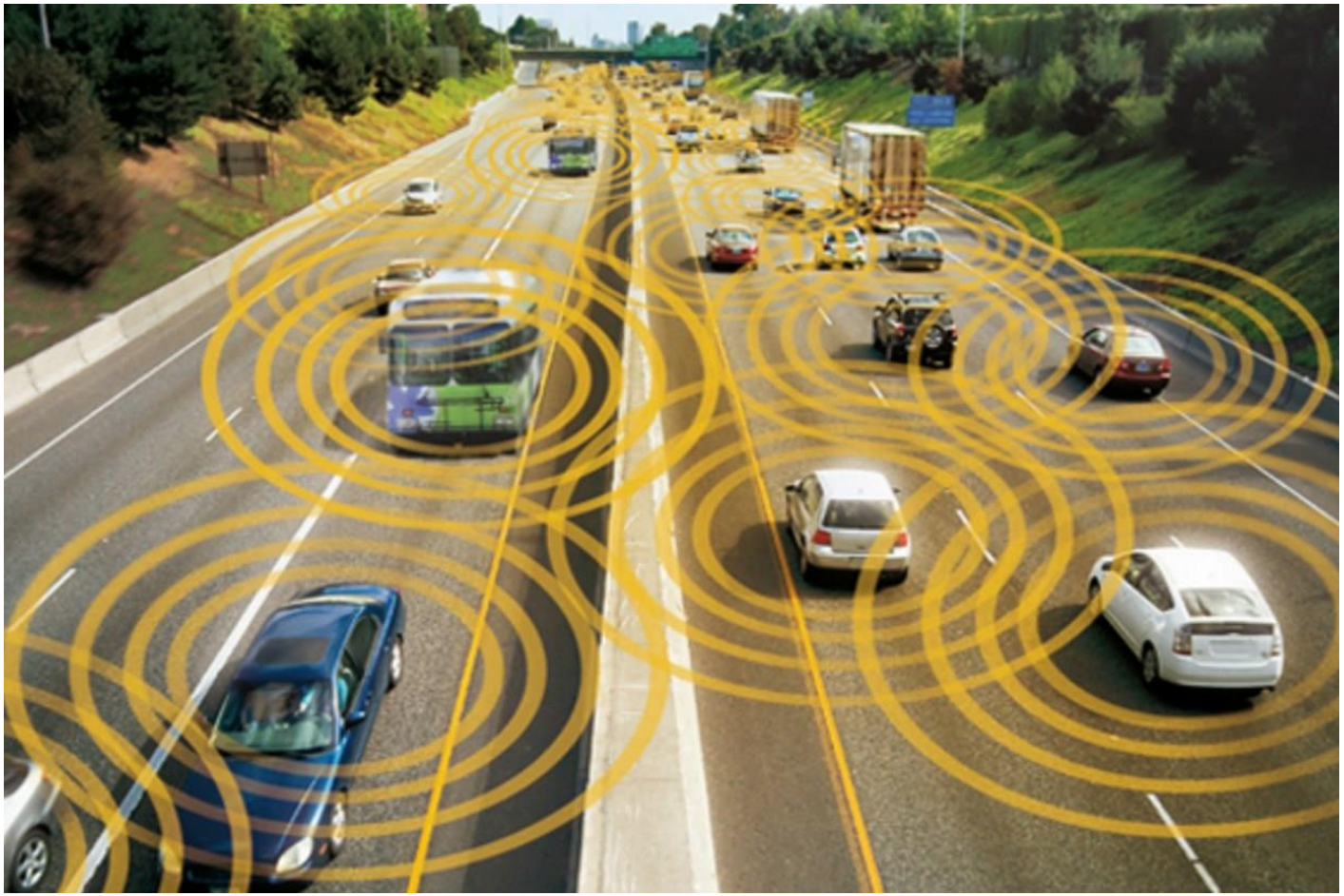
Car-to Car communications



ETSI TR 102 638 technical report

TR 102 638

Intelligent Transport Systems (ITS);

Vehicular Communications;

Basic Set of Applications; Definitions

- **ITS application**: system that ***defines and implements an ITS service*** to users of the system
- **ITS use cases: *procedure*** of executing an application in a particular situation with a specific purpose

Applications

Classes of applications (ETSI TR 102 638):

- Cooperative road safety
  - The aim is to improve the road safety
  - (with secondary benefits)
- Cooperative traffic efficiency
  - The aim is to improve the traffic fluidity
- Cooperative local and global internet services
  - Advertisements, on-demand information

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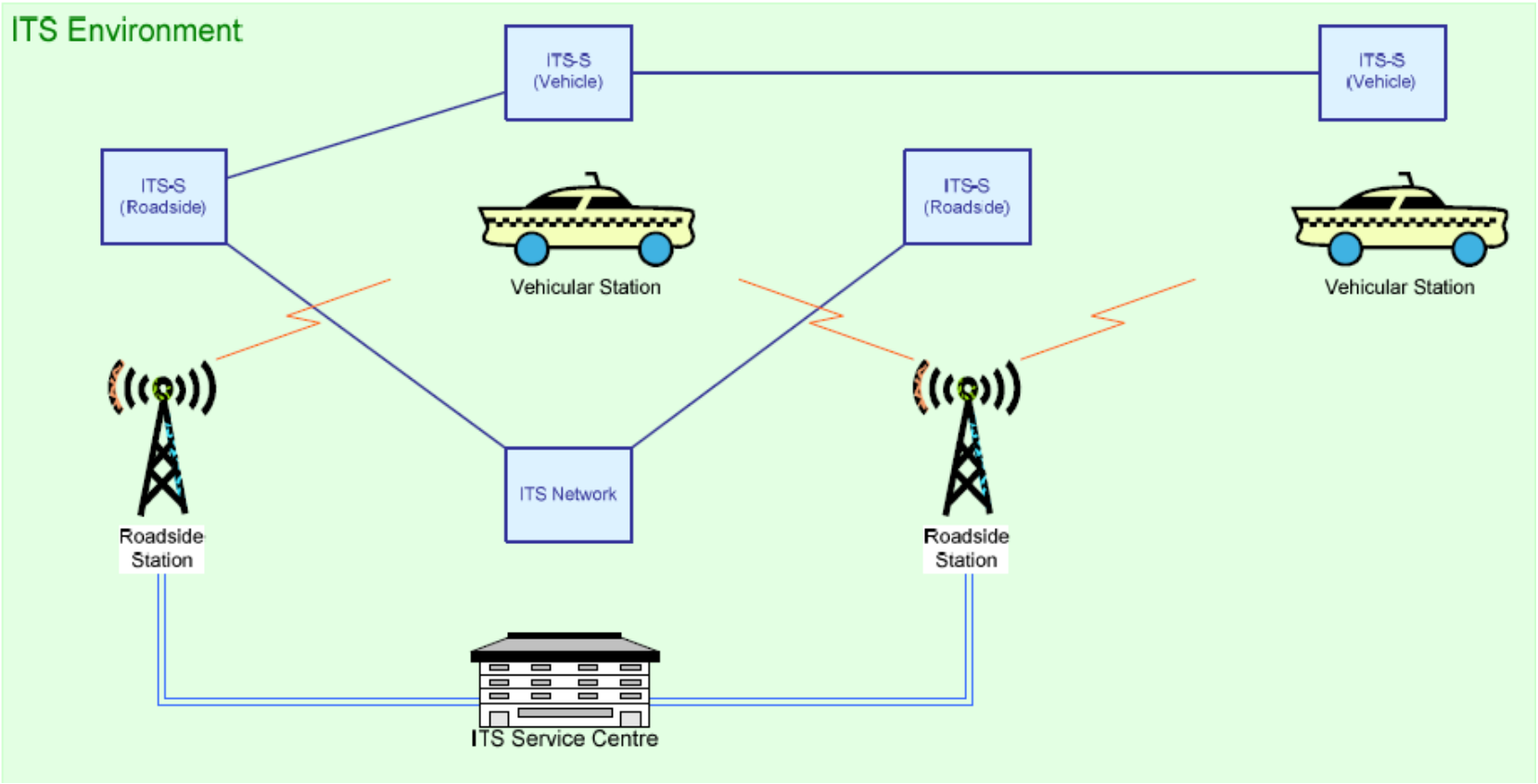
Simplified ITS environment



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Basic Set of Applications 1

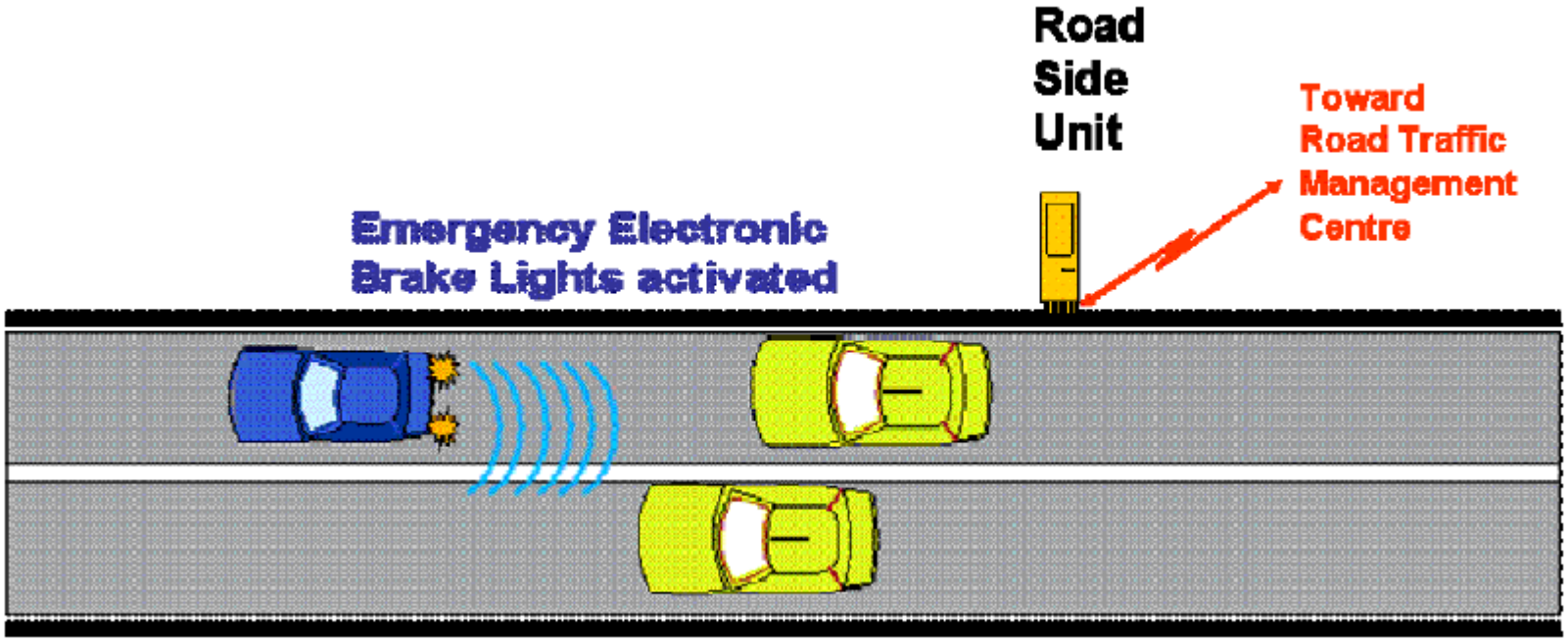
Applications Class	Application	Use case
Active road safety	Driving assistance - Co-operative awareness	Emergency vehicle warning
		Slow vehicle indication
		Intersection collision warning
		Motorcycle approaching indication
	Driving assistance - Road Hazard Warning	Emergency electronic brake lights
		Wrong way driving warning
		Stationary vehicle - accident
		Stationary vehicle - vehicle problem
		Traffic condition warning
		Signal violation warning
		Roadwork warning
		Collision risk warning
		Decentralized floating car data - Hazardous location
		Decentralized floating car data - Precipitations
		Decentralized floating car data - Road adhesion
		Decentralized floating car data - Visibility
		Decentralized floating car data - Wind

Basic Set of Applications 2

Applications Class	Application	Use case
Cooperative traffic efficiency	Speed management	Regulatory / contextual speed limits notification
		Traffic light optimal speed advisory
	Co-operative navigation	Traffic information and recommended itinerary
		Enhanced route guidance and navigation
		Limited access warning and detour notification
		In-vehicle signage
Co-operative local services	Location based services	Point of Interest notification
		Automatic access control and parking management
		ITS local electronic commerce
		Media downloading
Global internet services	Communities services	Insurance and financial services
		Fleet management
		Loading zone management
	ITS station life cycle management	Vehicle software / data provisioning and update
		Vehicle and RSU data calibration.

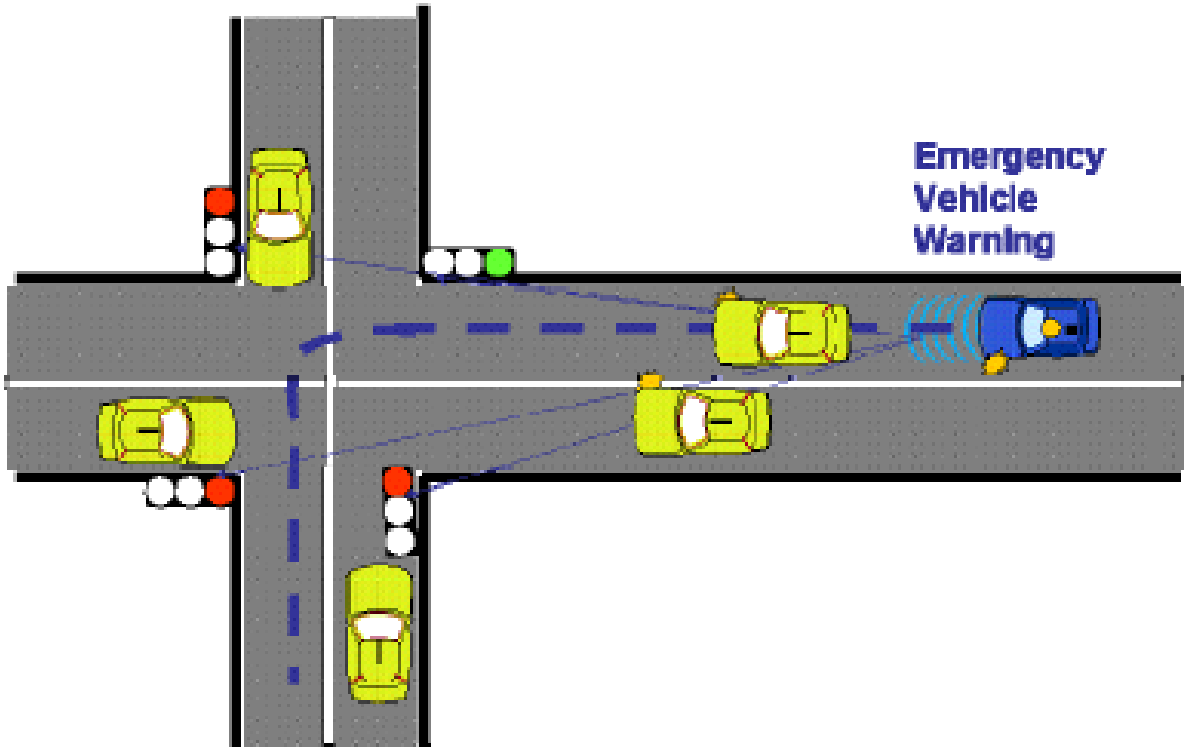
ITS use case (example1)

- **Application class:** Active road safety
- **Application name:** Road hazard warning.
- **Use case:** Emergency electronic brake lights



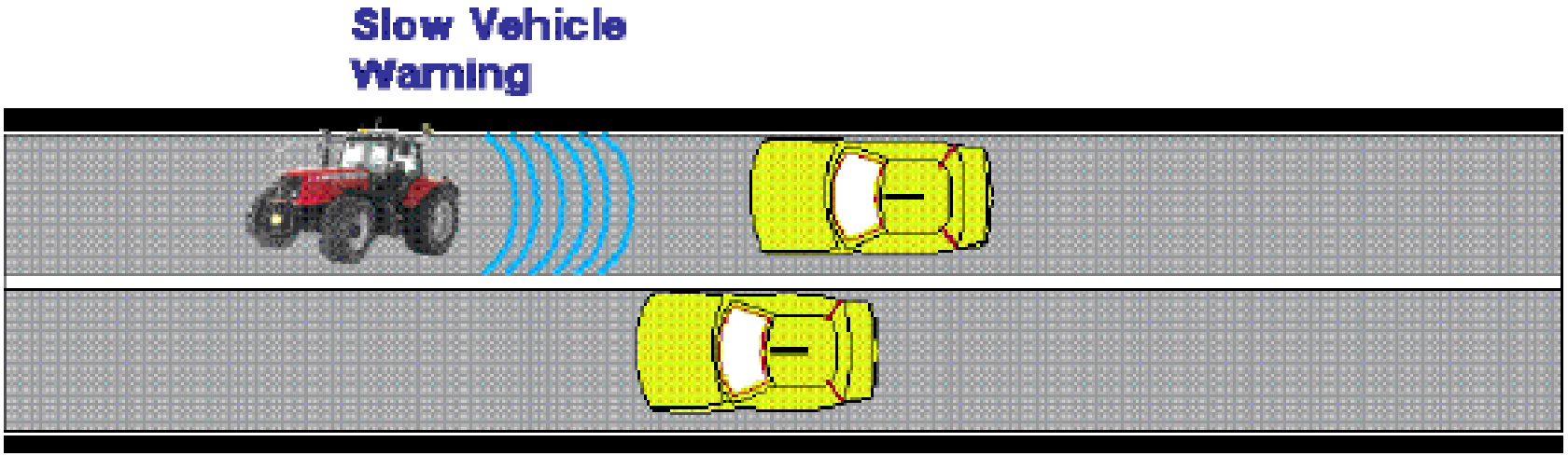
ITS use case (example2)

- **Application class:** Active road safety
- **Application name:** Co-operative awareness.
- **Use case:** Emergency vehicle warning



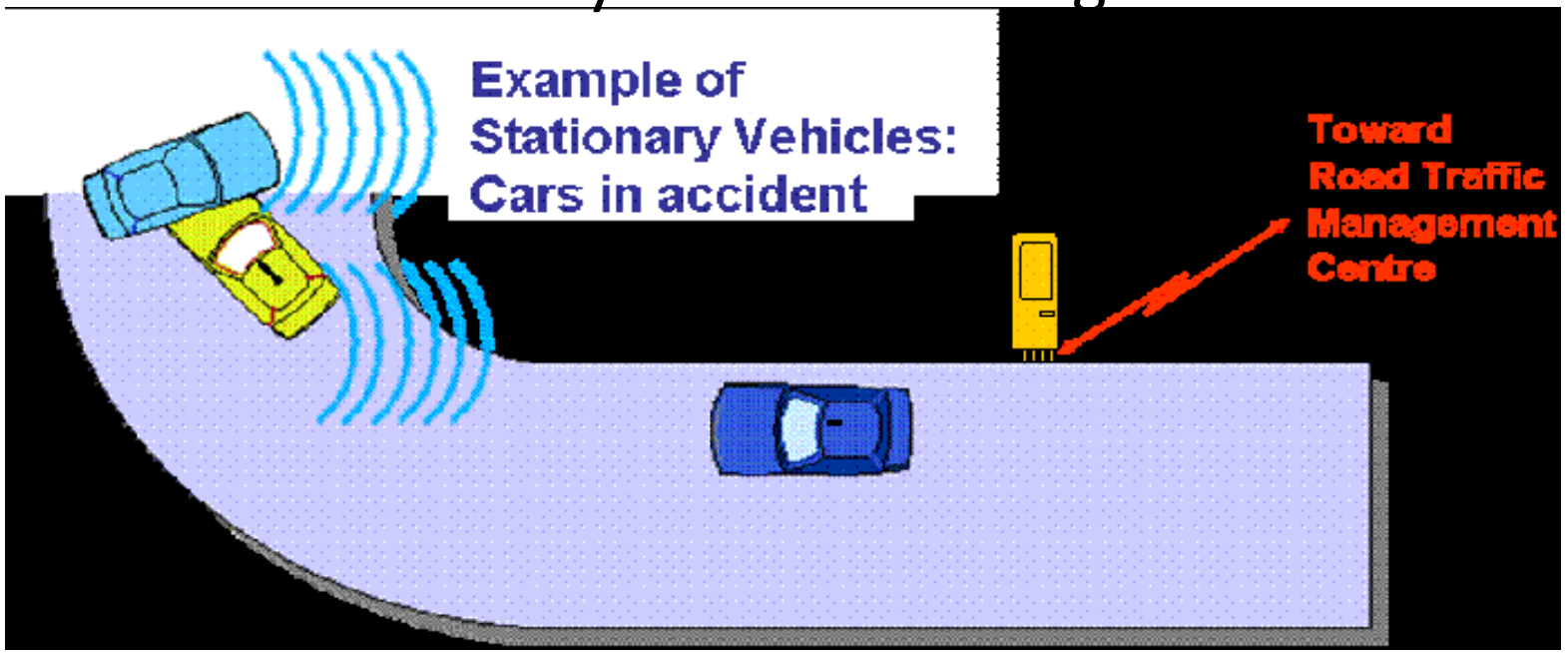
ITS use case (example3)

- **Application class:** Active road safety
- **Application name:** Co-operative awareness.
- **Use case:** Slow vehicle warning



ITS use case (example 4)

- **Application class:** Active road safety
- **Application name:** Road hazard warning**.**
- **Use case :** Stationary vehicle warning



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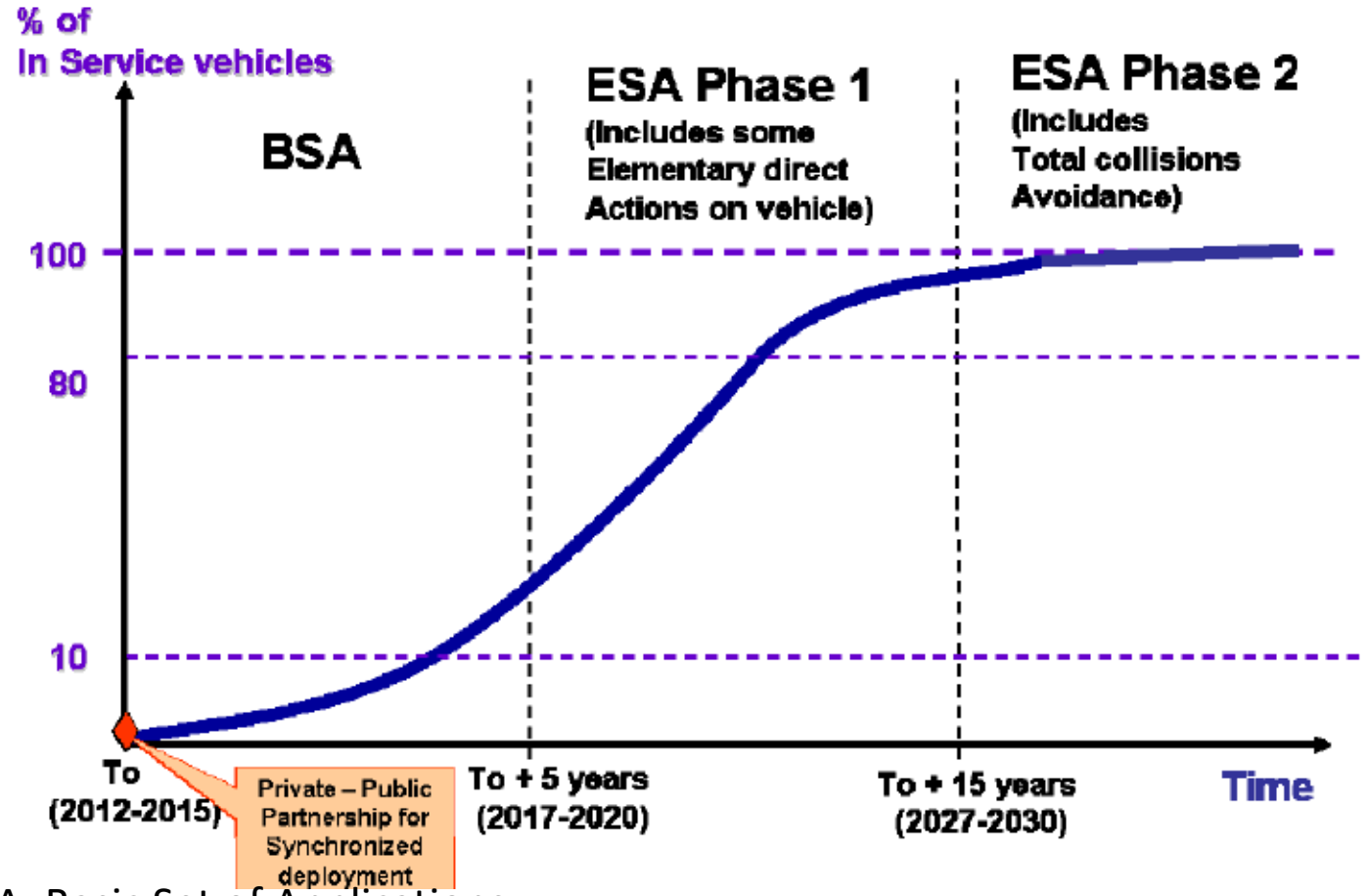
Parameters of wireless system

- Technical parameters of wireless communications are determined mainly by ***use case*** requirements
  - Amount of data to transmit
  - Latency (delay)
  - Frequency of periodicity
  - Broadcasted or dedicated message
  - Location (positioning) accuracy
  - …….

Optimistic deployment roadmap



- BSA: Basic Set of Applications
- ESA: Enhenced set of Applications

Technical characteristics of ITS

- ITS in Europe is based on ***IEEE 802.11p***
- Standardization: ETSI ES 202 663
- This standard defines ITS-G5 parameters
- Frequency bands for applications:
  - ITS-G5A: 5.875 to 5.905 GHz safety related
  - ITS-G5B: 5.855 to 5.875 GHz non-safety related
  - ITS-G5C: 5.470 to 5.725 GHz

There are available other systems also!

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Characteristics of transmission scheme

Channels		Centre frequency	Name	Tx power limit (EIRP)	Default data rate
	ITS-G5A	5 900 MHz	G5CC – control channel	33 dBm	6 Mbit/s
		5 890 MHz	G5SC2 – service channel 2	23 dBm	12 Mbit/s
		5 880 MHz	G5SC1 – service channel 1	33 dBm	6 Mbit/s
	ITS-G5B	5 870 MHz	G5SC3 – service channel 3	23 dBm	6 Mbit/s
		5 860 MHz	G5SC4 – service channel 4	0 dBm	6 Mbit/s
Channel bandwidth	10 MHz				
Modulation scheme	OFDM with channel access CSMA/CA (see IEEE 802.11p)				
Available data rates	3/4.5/6/9/12/18/24/27 Mbit/s				

*CSMA/CA = Carrier Sense Multiple Access/Collision Avoidance

Mobile network based ITS services

- **E-call** system (emergency call system)
- Uses existing mobile networks (112 or 911)
- Manual or automatic operation
- Location system is needed!

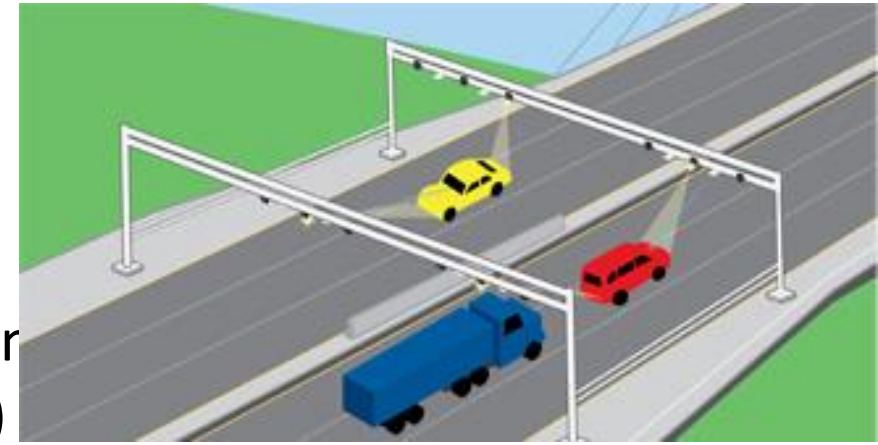
- Stolen car report (GPS+GSM)

- **The future: 5G** *(Ericsson!)*

RFID based ITS services

- RFID stands for ***Radio-Frequency IDentification***
- General RFID applications***:***
  - pay pass bank card, passport, ID, access management
  - transportation payment (on the bus),
  - tracking goods (in chocolate factory)

- **RFID applications in ITS:**
  - Toll collection system
  - Engine immobilizer
- Parts of RFID system:
  - RFID reader (RSU, road site ur
  - RFID tag (OBU, onboard unit)



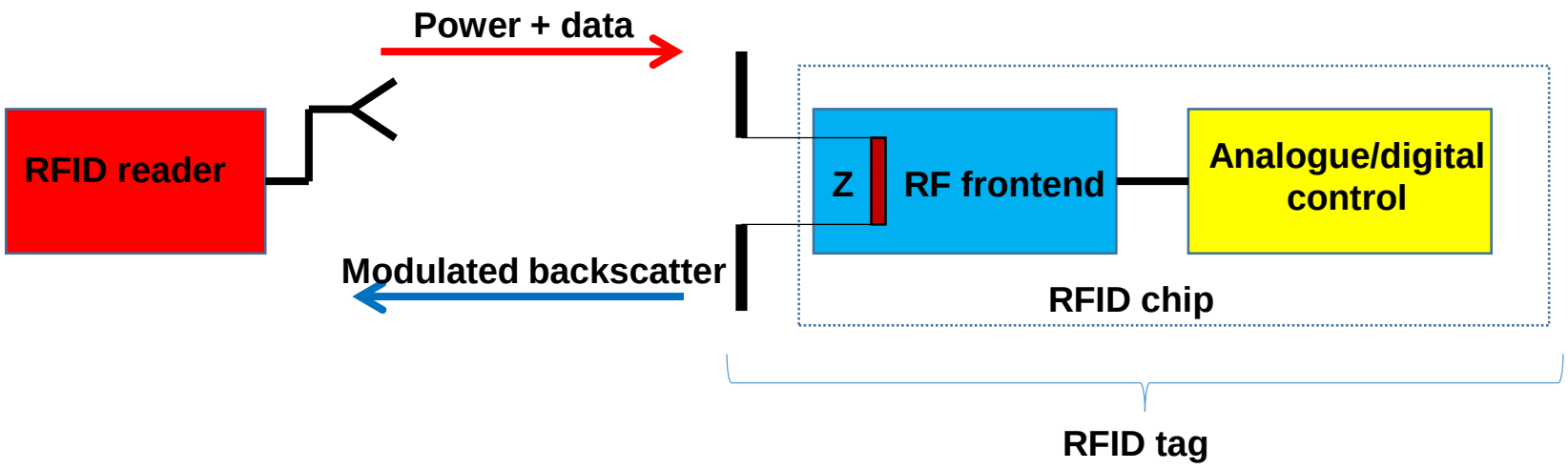
Frequency bands for RFID applications

- 125 kHz animal ID
- 13.65 MHz logistics, antitheft systems, NFC, Near Field Communications

- **860 MHz** logistics, electronic toll collection
- 920 MHz logistics electronic toll collection
- 2.4 GHz logistics, electronic toll collection
- **5.8 GHz** logistics, electronic toll collection

RFID system

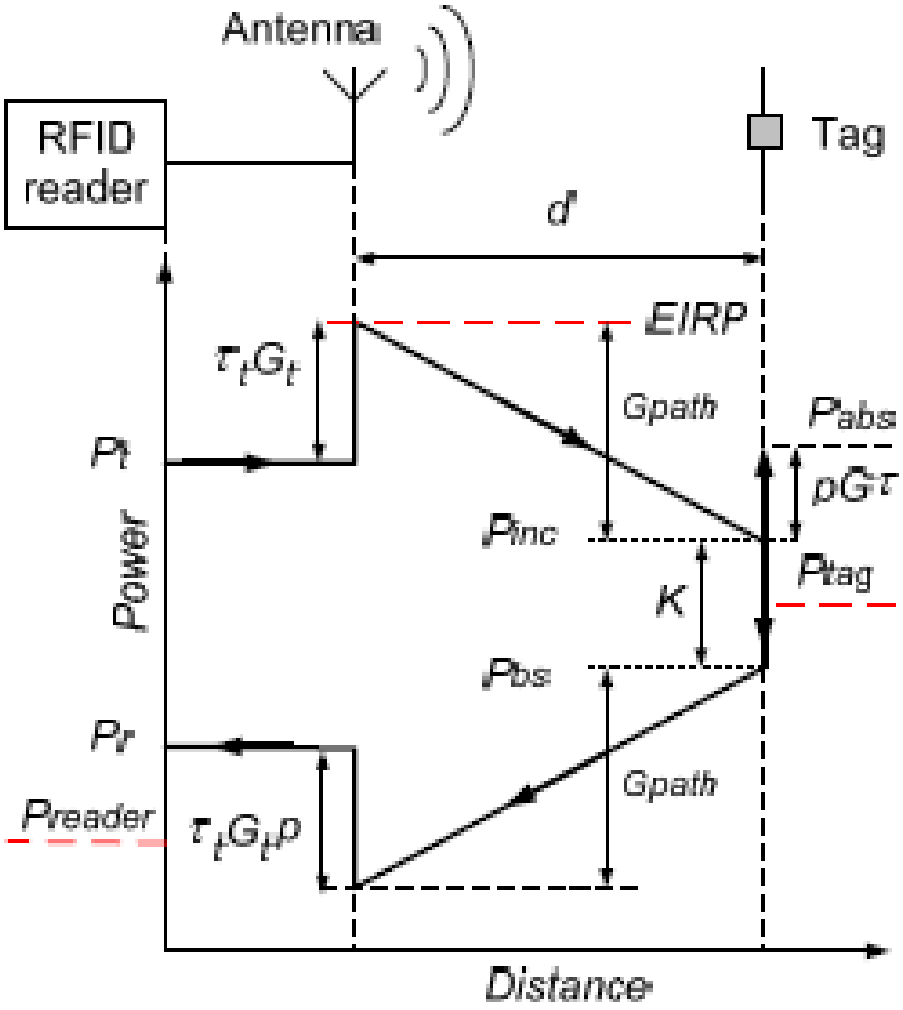
- RFID reader
- RFID transponders (RFID tags)
  - Very cheap!



RFID tag

- Passive (Low sensitivity, but no battery!!)
- Active (High sensitivity, battery is needed!)
- Battery Assisted Passive (BAP)
    - Battery supply for the microcontroller

RFID link budget



RFID parameters

- Standard: ETSI EN 302 208-1
- Interference with GSM-R downlink
- Reader:
  - 865 MHz to 868 MHz ERP: max. 2W (continuous)
  - 915 MHz to 921 MHz ERP: max. 4W (not cont.)
  - (ERP depends on antenna beam width!)
    - ERP = Equivalent Radiated Power >>> ERP = P_{TX}*G_A
- Tag sensitivity:
  - Passive: about -9 dBm
  - Battery assisted passive: -28 dBm [EM MICROELECTRONIC]

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Thanks for the attention!

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