LECTURE

2

TRANSPORT TELEMATIC – definitions, benefits, telecommunication environment

Definition of Transport telematics (Intelligent transport systems)

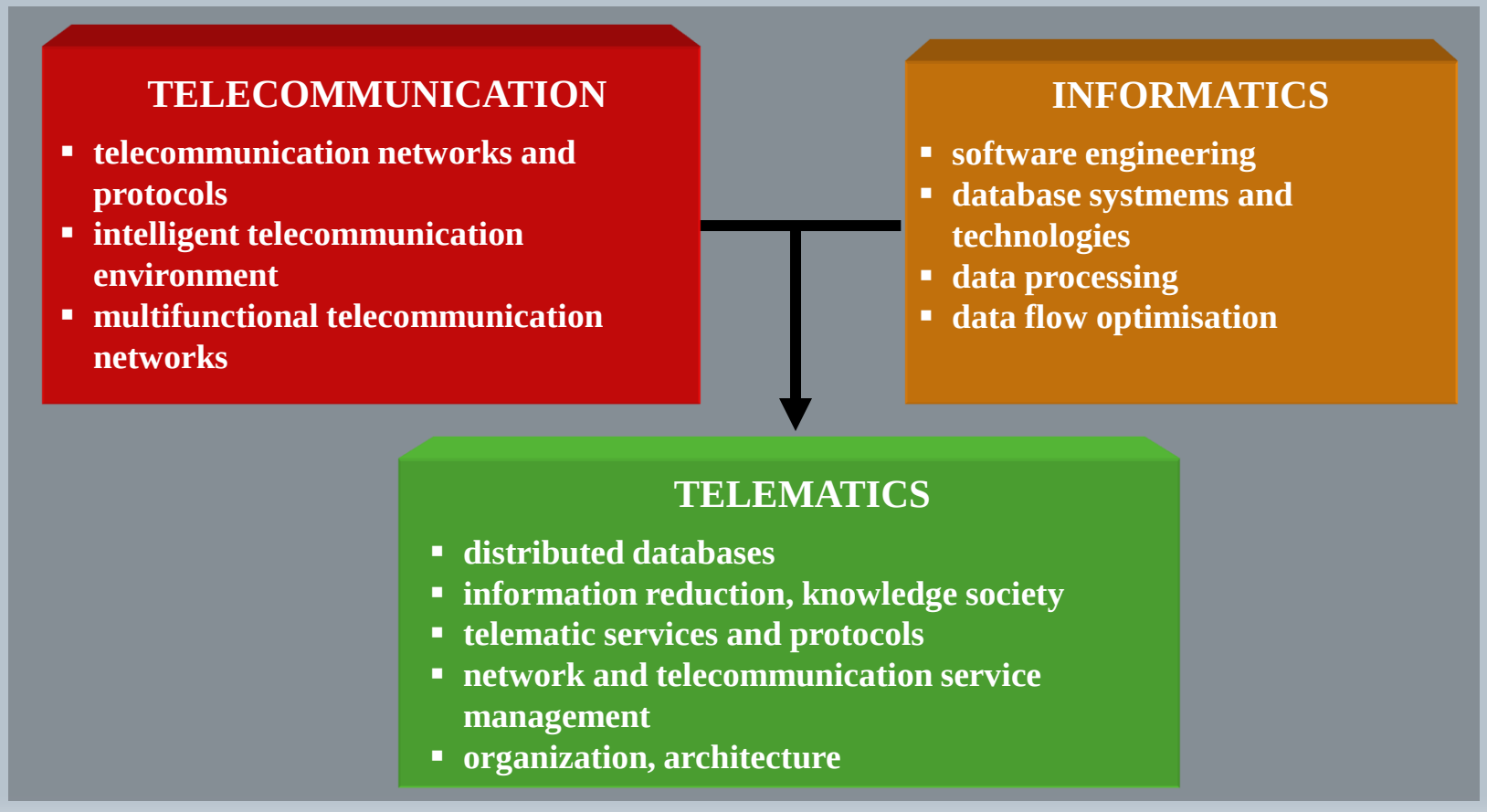
Telematics, intelligent transport systems

- Word TELEMATICS has been first used in 1978 by Simon Nora and Alain Minc in their report titled L'Informatisation de la société (The Computerization of Society)
- Origin in words TELEcommunication and inforMATICS

- Similar meaning as Intelligent transport systems
  - telematics – term used mainly in Europe
  - ITS – term used mainly in USA

Definition of TELEMATICS

- **Telematics** is system engineering branch that aims to create and efficiently use information environment for homeostatic processes (compenzation of disturbing effcets in order to maintain strong processes according to defined criteria – e.g. comfort, economics, etc.) for regions , areas and global network sectors.



Broad definition of telematics

- Telematics is a systematic engineering field, dealing with creation and purpose-made utilization of information environments for homeostatic processes of territorial complexes, up to global field network.

- Homeostatic processes mean compensation of disturbing effects in order to preserve desired states of strong processes according to defined criteria – e.g. comfort, economics, etc.

- Telematics results from **convergence** and subsequent combination of **telecommunication** technologies and **informatics with support** of management **economy** and **mathematical** methods for creation and control of **complex systems**. The effects of telematics is shown in wide spectrum of user area, from multimedia communication of individuals up to intelligent application and control of global network fields such as transport, connections and public administration.

Broad definition of telematics

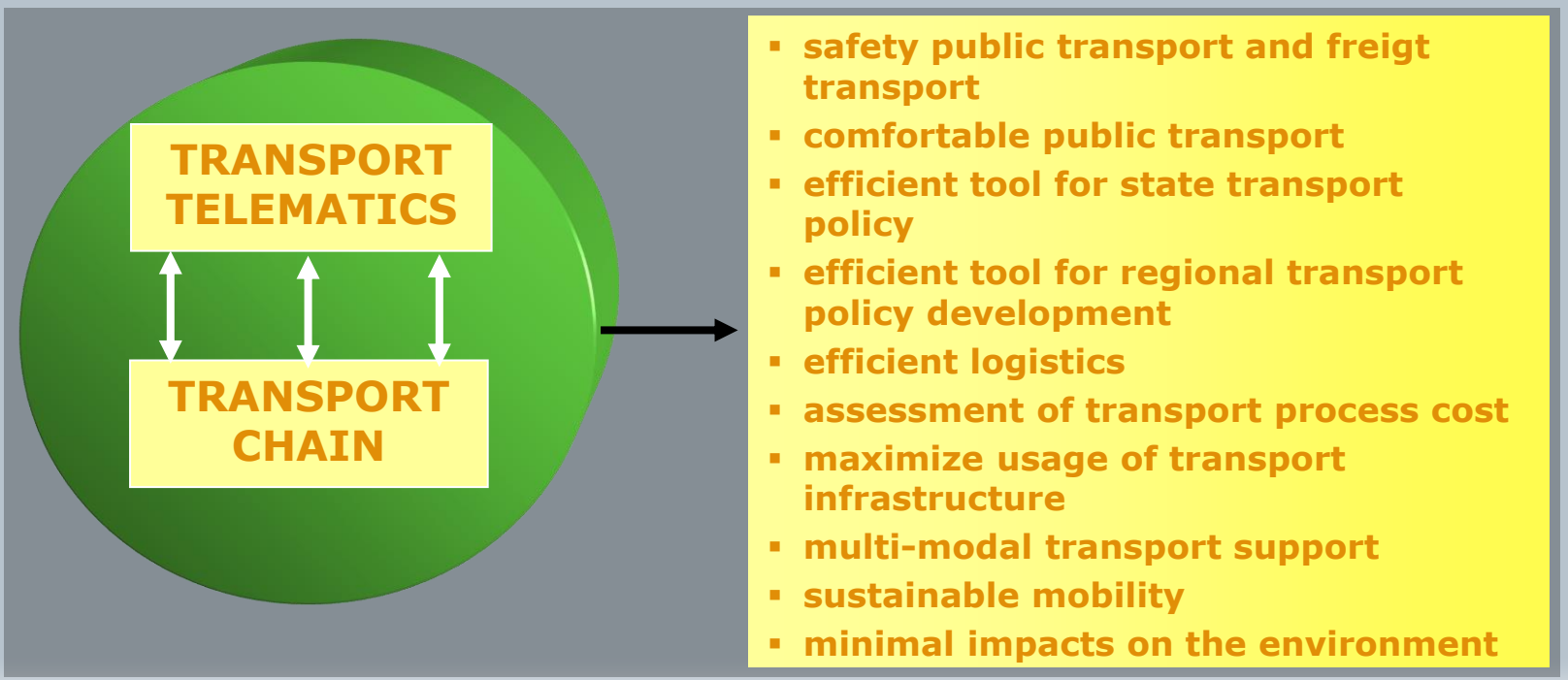
- Advanced telematics is in its applications one of the important conditions for rise of **knowledge society**, creates the intelligent environment for the knowledge society and enables the extraction of complex system knowledge description based on the gained information

- Theoretical fundamentals of telematics are based on findings from **system analysis**, **optimization** of information flows and optimization of telematic systems. It works with **mathematical extraction** of distributed information, **system integration** of information models and telecommunication models, design of telematic systems with respect to the information price, etc.

- Methodology of telematic system creation defines mutual **interfaces**, modular **system conception**, programmable **data protocols**, **methodology of evaluation** reliability, **security** and information availability for particular system architecture, **interoperability** of particular telematic subsystems, optimization of demands on telematic technical means, etc

Transport telematics definition

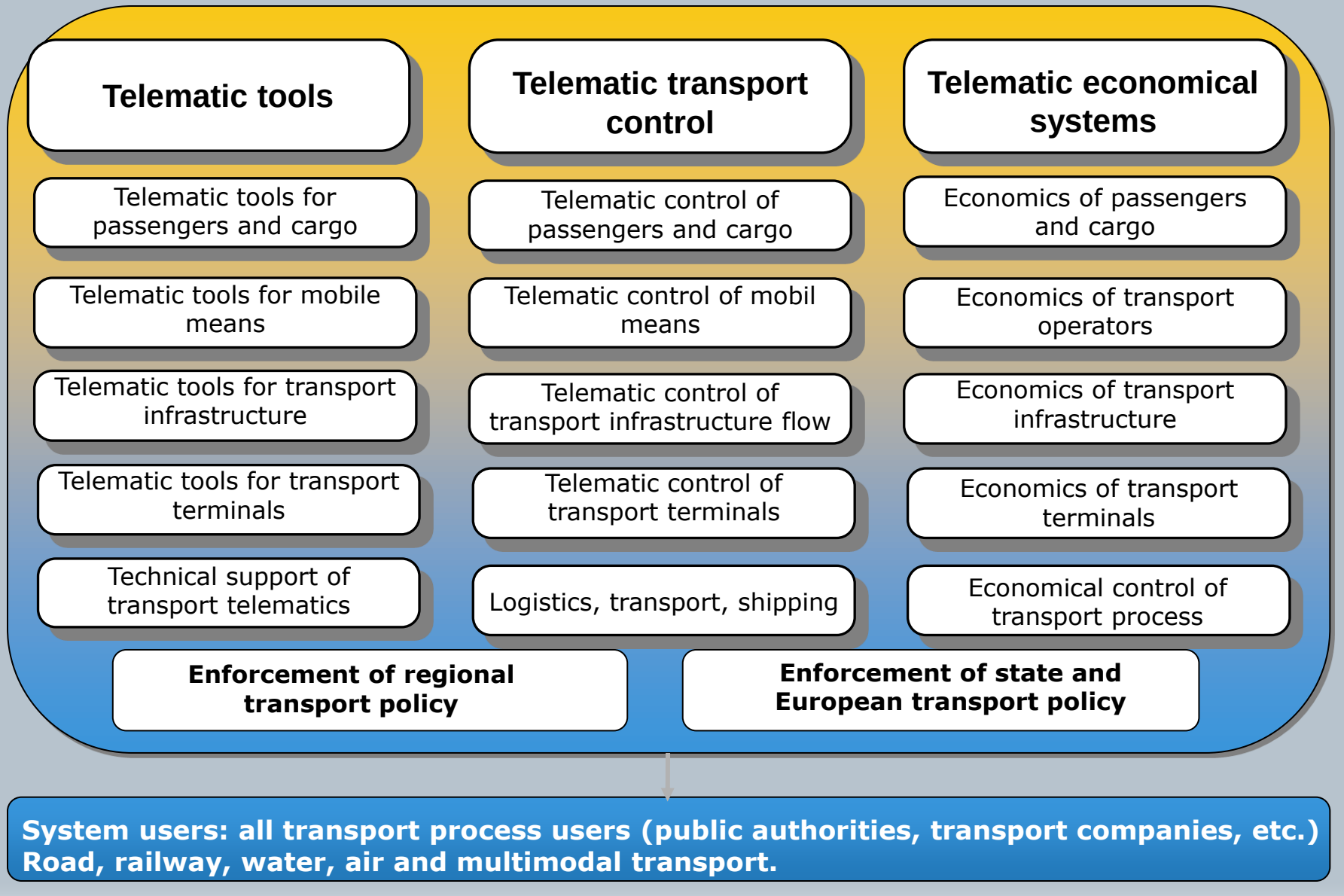
- **Transport Telematics (ITS, Intelligent Transport Systems and Services)** integrates information and telecommunication technologies with transport engineering under the support of other related industry, in order to provide for the existing traffic infrastructure an advanced system of control of traffic and transport processes – enhancing the transport performance, traffic efficiency, road safety and comfort of transportation etc.
- The main objectives of transport telematics is to offer intelligent services at several levels: for travelers and drivers (users), infrastructure administrators, transport operators (carriers), security and rescue system, financial and control institutions.



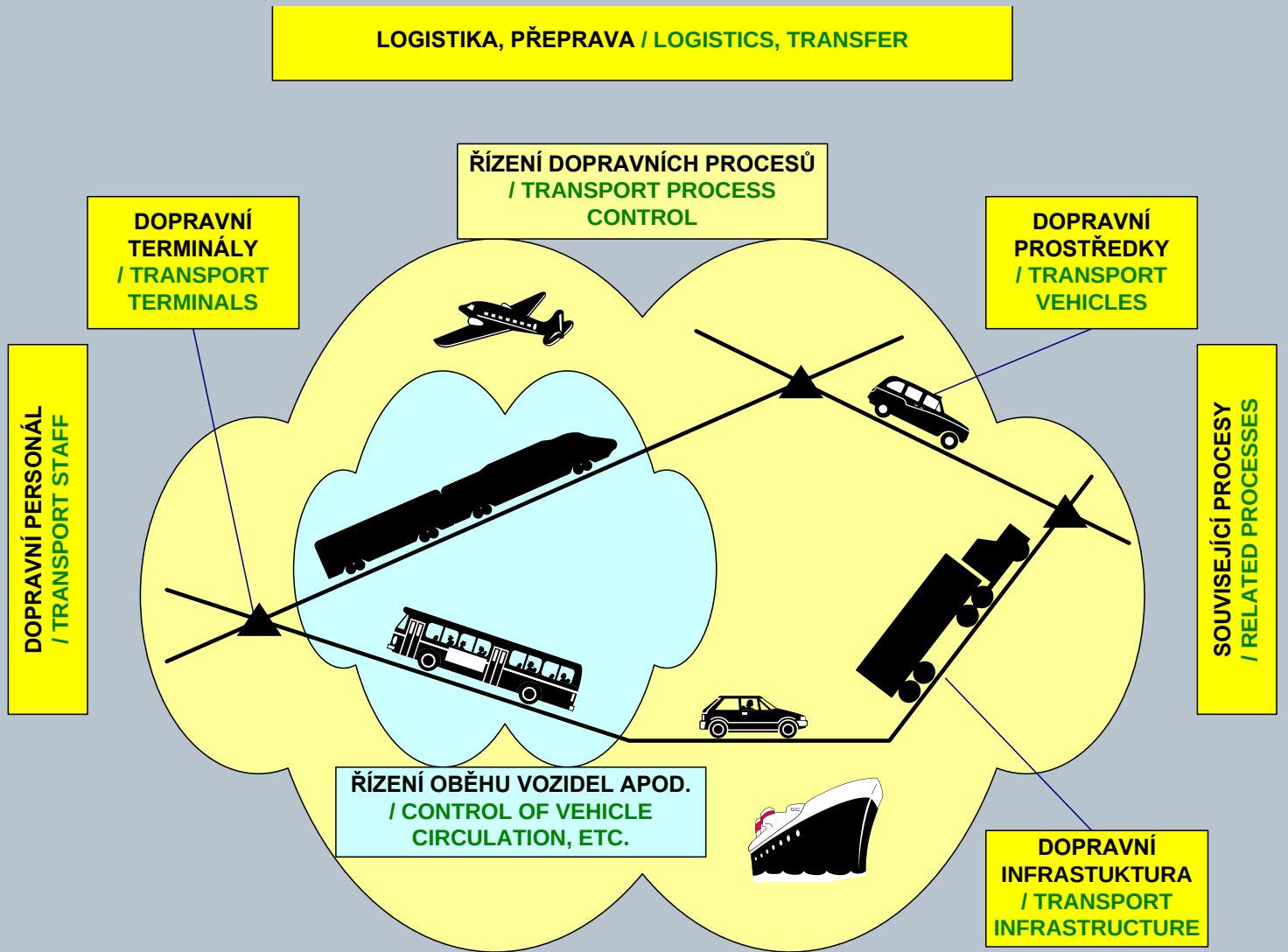
Definition of ITS (according ITS-EduNet association)

- "ITS integrate telecommunications, electronics and information technologies - in short, ‘telematics’ - with transport engineering in order to plan, design, operate, maintain and manage transport systems.
- This integration aims to improve safety, security, quality and efficiency of the transport systems for passengers and freight, optimizing the use of natural resources and respecting the environment.
- To achieve such aims, ITS require procedures, systems and devices to allow the collection, communication, analysis and distribution of information and data among moving subjects, the transport infrastructure and information technology applications."

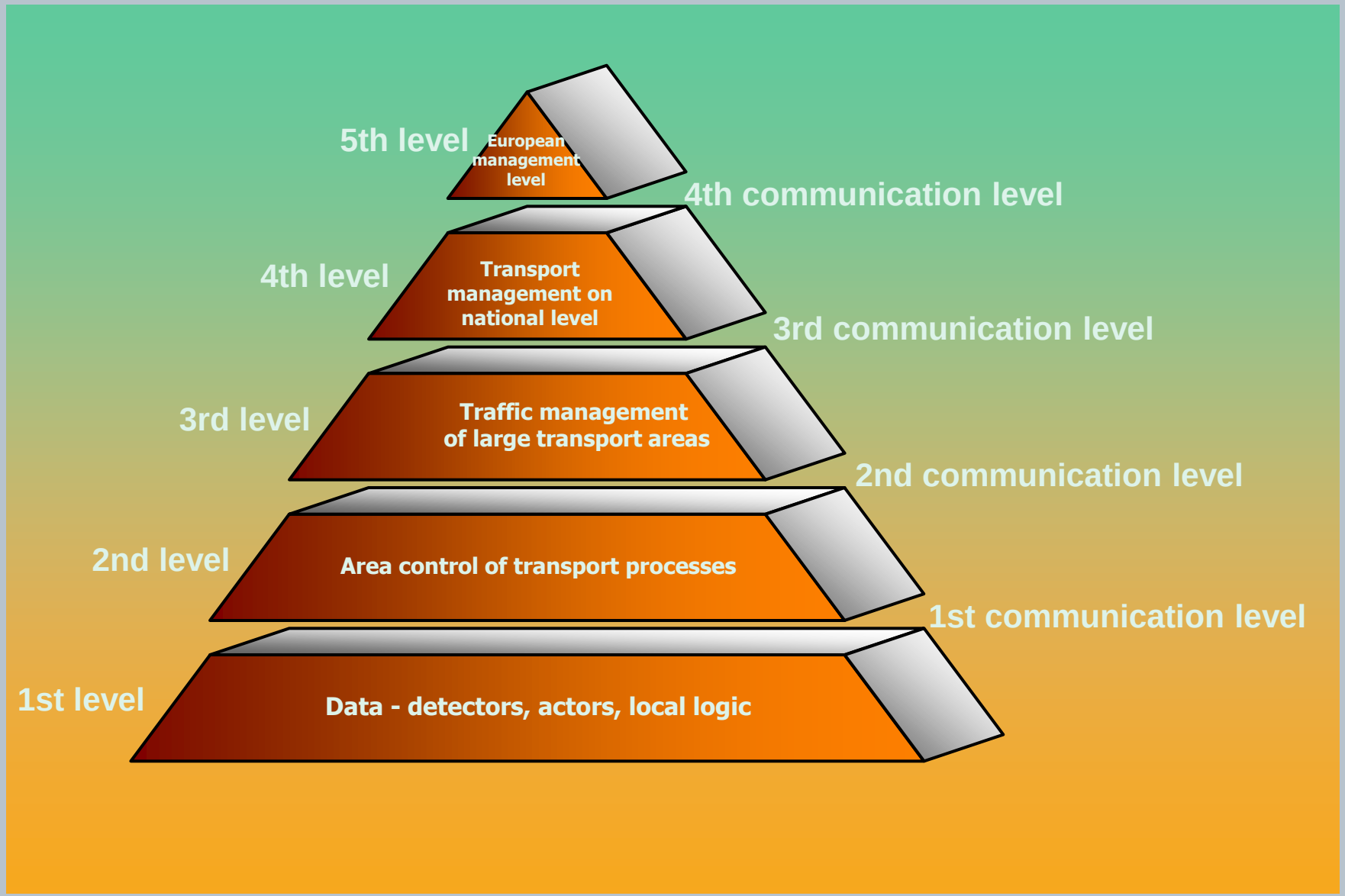
Transport telematics



Transport telematics proces model



Telematic system hierarchy



Transport telematics definition - conclusion

- Aims to
  - increasing road safety
  - enhancing the transport performance and traffic efficiency
  - increasing comfort of transportation
  - etc.
- Uses
  - information and telecommunication technologies
  - transport engineering
  - existing traffic infrastructure

Transport telematics benefits

Financial benefits

State budget
-ecology
-development of infrastructure
-health and social insurance
-transport fund

Cities, municipalities, regions
-ecology
-infrastructure development

Transport organizations
-fuel
-spare parts
-operating costs

ITS influences budgets of

Insurance companies
-settlement of claim after accidents
- health, material

Manufacturing corporations
lowering costs for transport of goods up to 70%

Citizens
-lowering of accidents impacts, stresses
-lowering costs

Definition of transport cost

$$C = N_i + N_o + O + N_e$$

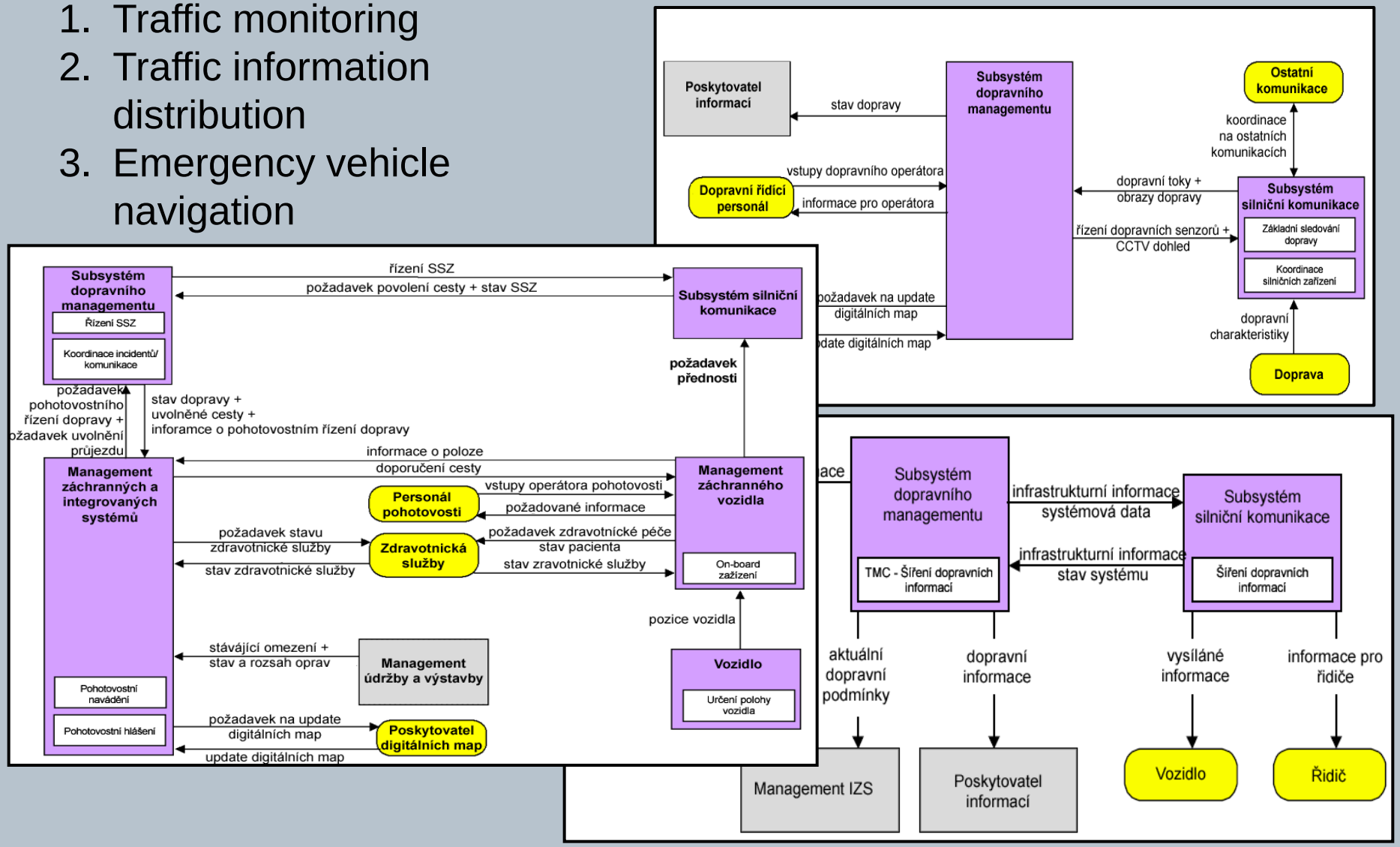
- C .. Total transport process cost (related to unit of length)
- N_i .. Transport infrastructure maintenance costs (road maintenance, track maintenance, etc.)
- N_o .. Transport infrastructure service cost (dispatchers, control operators, police, emergency services, etc.)
- O .. Depreciations of tangible property, transport infrastructure and maintenance devices defined for unit of length
- N_e .. Fuel costs

Methodological evaluation of ITS projects

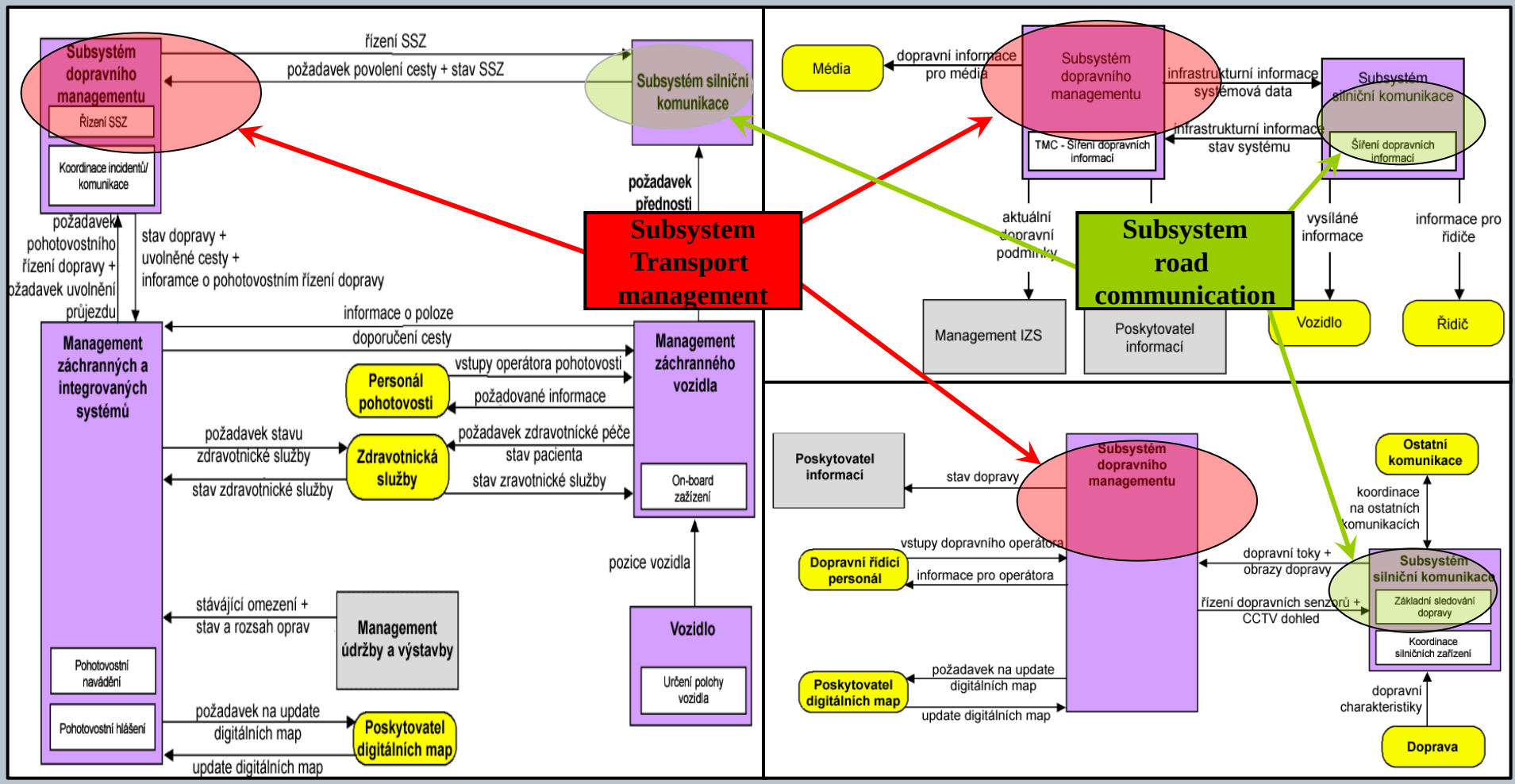
- **ITS system design**
  - Definition of alternatives of the ITS solution that influence the problem
  - Definition of technical solution according to the ITS architecture and system parameters for every alternative
  - Representation of ITS alternative solutions using service packages
- **Evaluation of the benefits/ costs**
  - Assigning cost indicators to the service packages
  - Solution using synergie via the for or expert rules
  - Financial calculation
  - Cost/benefit summary

Example – 3 packages of ITS services

1. Traffic monitoring
2. Traffic information distribution
3. Emergency vehicle navigation

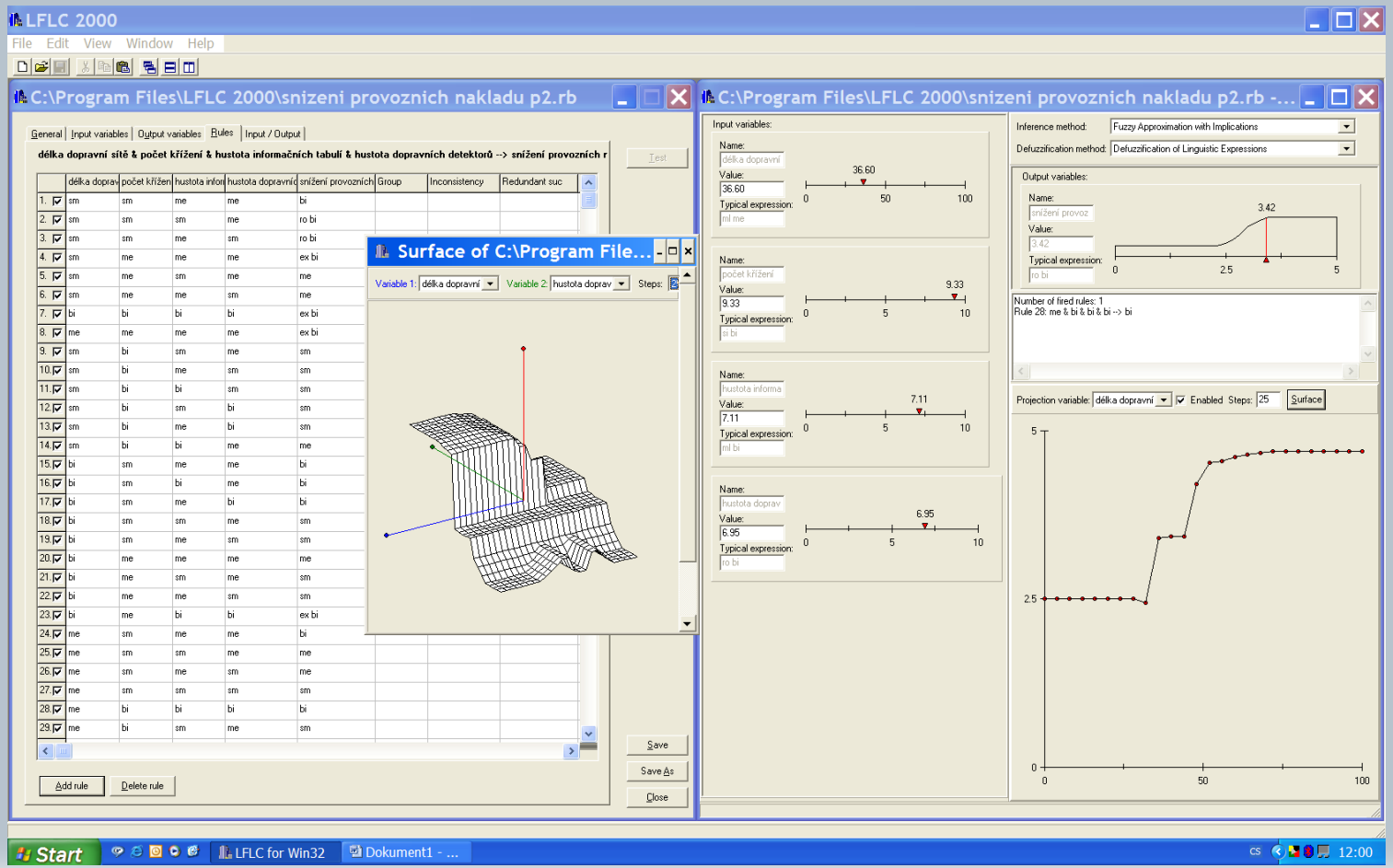


Example – using synergie of the ITS services packages



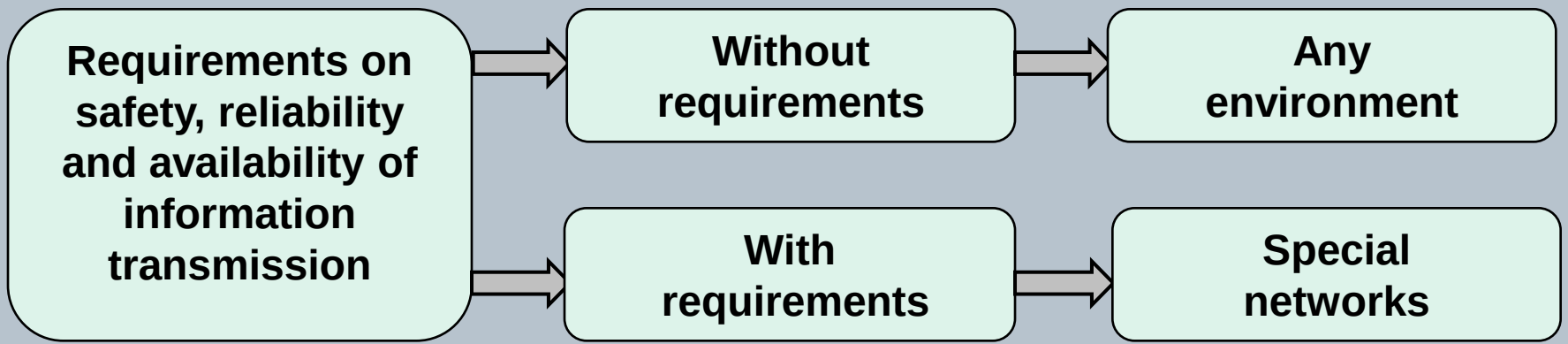
Fuzzy-lingvistic aproximation

- Processing of different information (expert knowledge, equations, statistical knowledge)
- Solving of synergies of cost/benefit indicators



Telecommunication environment for transport telematics

Requirements on telecommunication environment for transport telematics

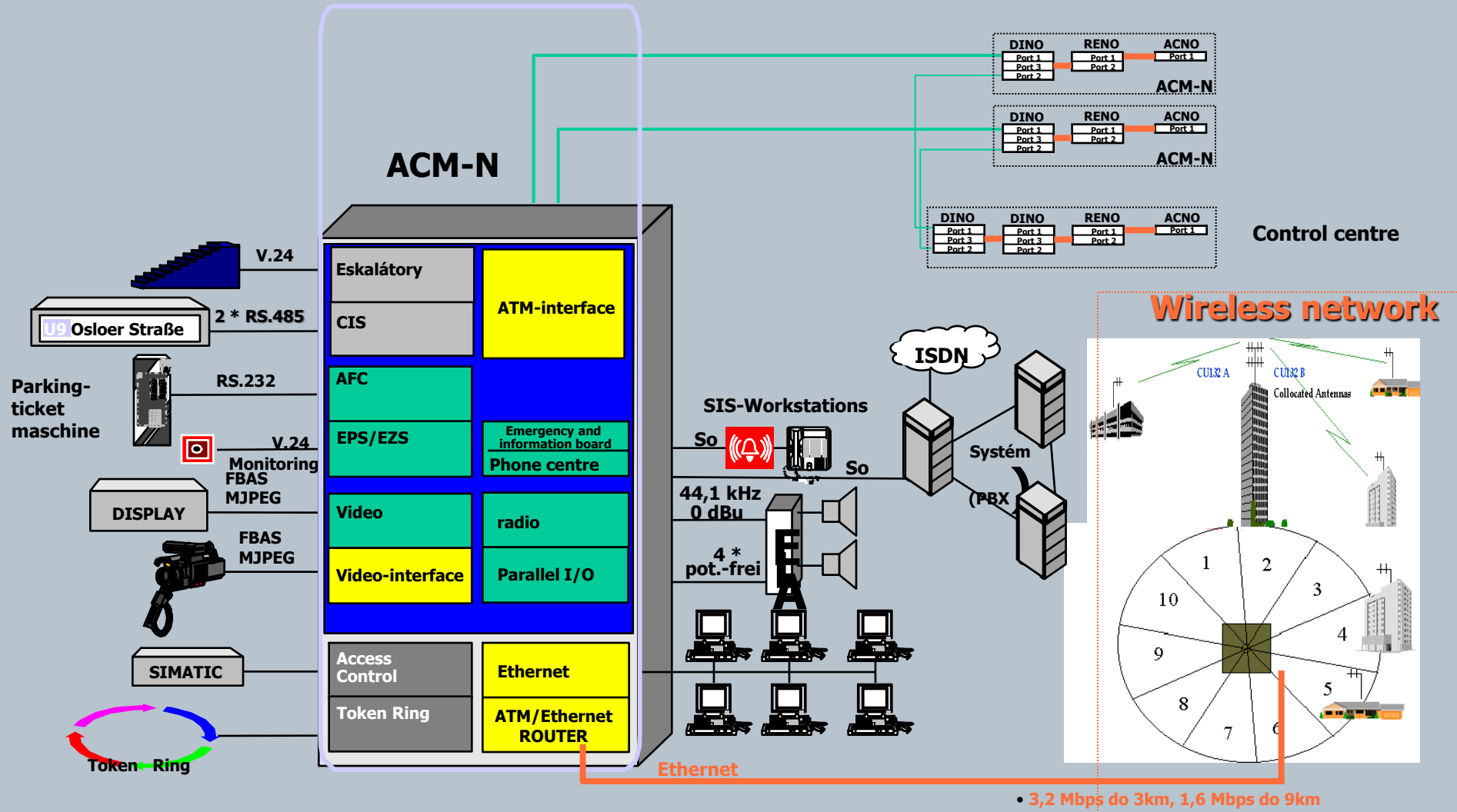


Stationary telecommunication networks

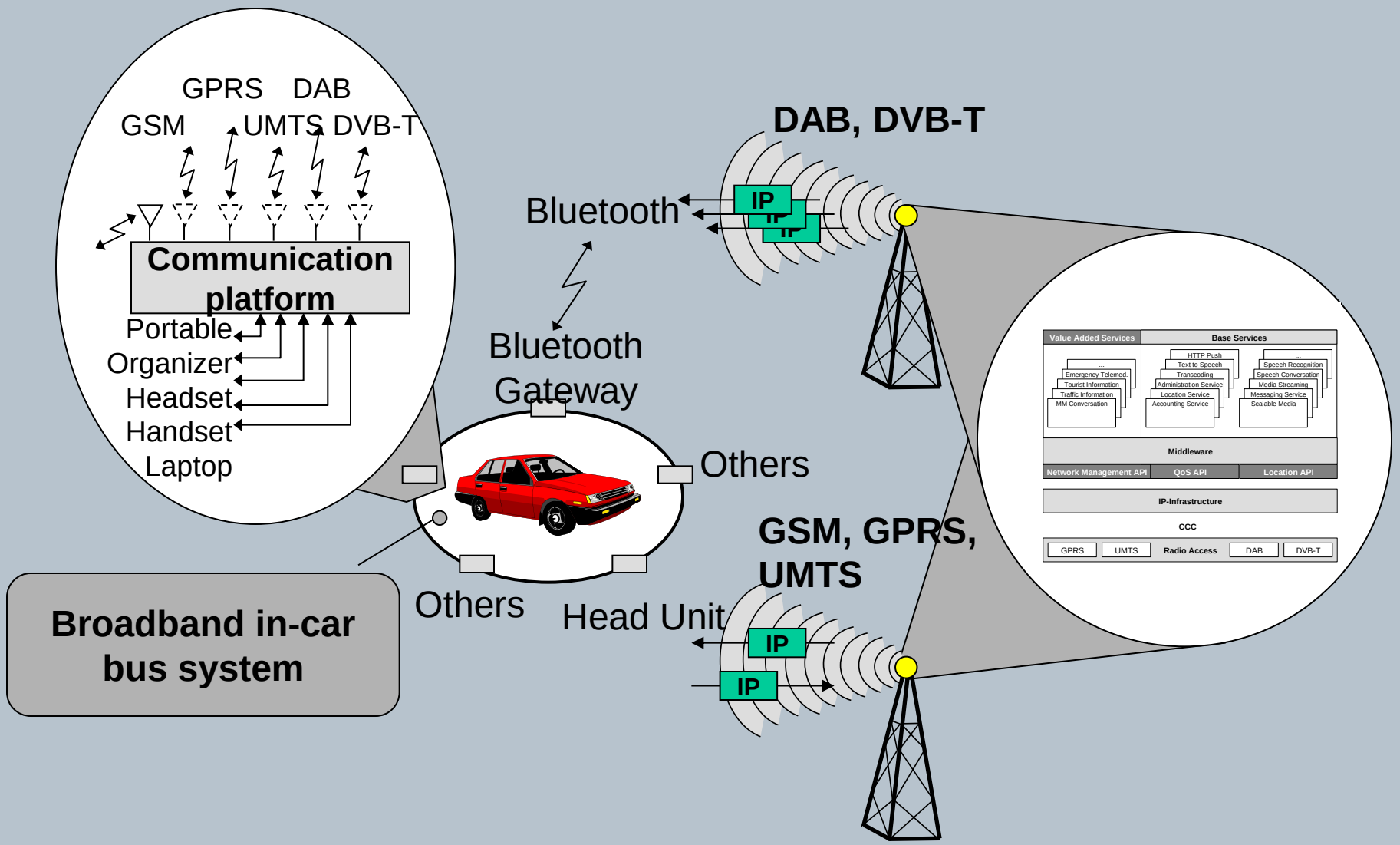
- Without special safety, availability and reliability requirements
  - Internet, Intranet, public data services, etc.

- With special safety, availability and reliability requirements
  - private telecommunication networks, ATM networks with special management or safety protocol

Example of access node technical solution of special transport telecommunication network



Integrated solution for mobile telecommunication network



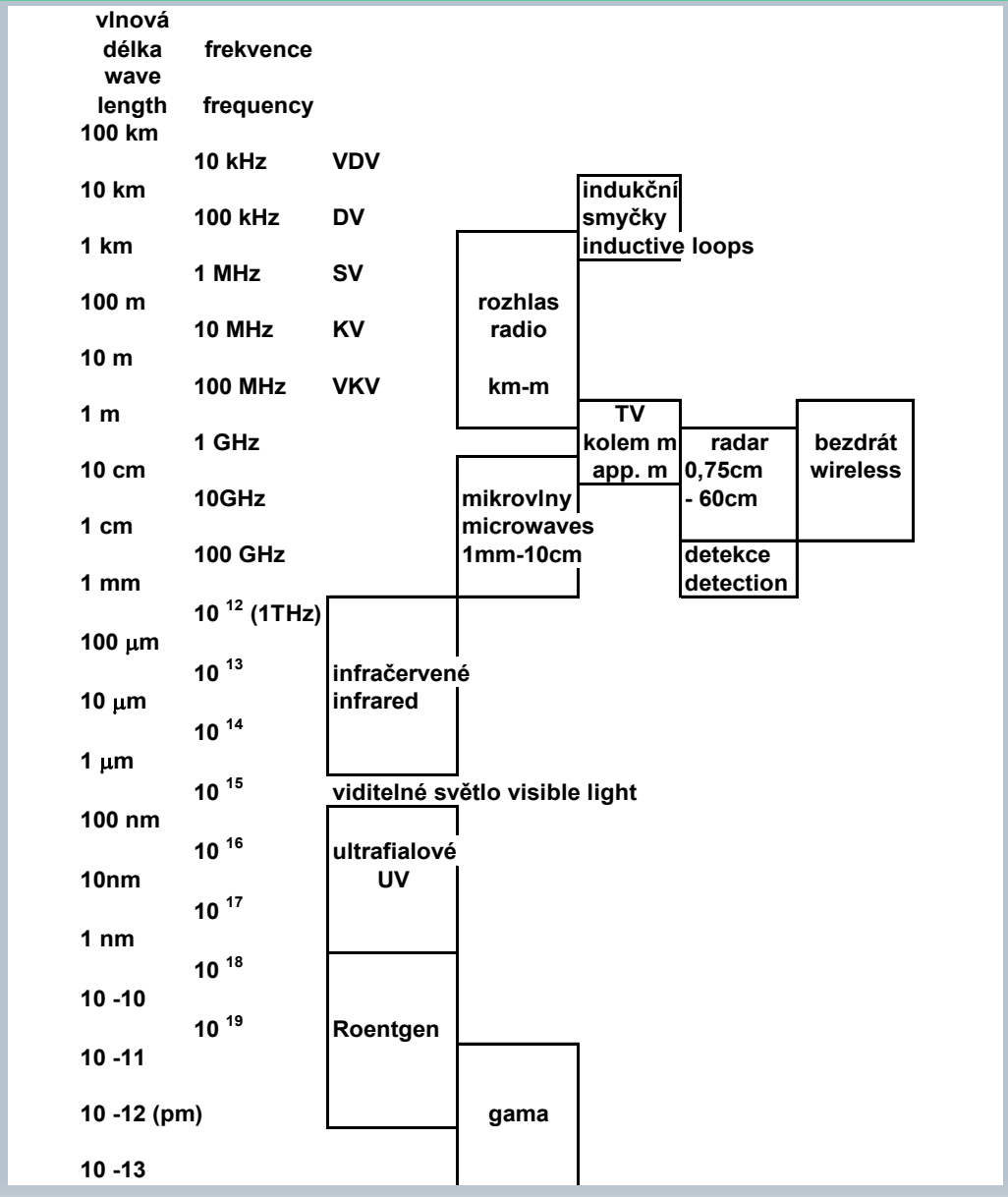
Types of telecommunication networks used in ITS

- Stationary wired networks

- Wireless networks

As in many applications in transport telematics mobile elements are important part, wireless networks are needed in many cases

Frequency overview



Mobile telecommunication networks

- Without special safety, availability and reliability requirements
  - GSM,SMS, WAP, public radio transmissions, etc.
- With special safety, availability and reliability requirements
  - DSRC, TETRA, private radio transmission with safety protocols, etc.

Overview of frequency bands – multiple usage

- 470-862 MHz: TV broadcasting
- 880-915 MHz / 925-960 MHz, 1710-1785 MHz / 1805-1880 MHz: GSM mobile services,
- 1900-1980 MHz / 2010-2025 MHz / 2110-2170 MHz; 3. generation of mobile services (IMT-2000/UMTS).
- 2,4 - 2,4835 GHz, WiFi
- 2500-2690 MHz (pásmo 2.6 GHz); assigned for 3. generation of mobile services, broadband for other technologies (e.g. WiMAX).
- 3.4-3.8 GHz: high-speed connection, in future mobile services. Satellite communications in Africa,
- 5,4 GHz WiFi 5
- 3-66 GHz WiMax
- Infrared optical communication (180-240 THz)

Frequency bands in transport and traffic telematics – example from the Czech Republic (from the Czech Telecommunication Office‘s general licence)

- In road transport and for Intelligent transport systems

Ozn.	Kmitočtové pásmo	Vyzářený výkon	Kanálová rozteč
a	5795 – 5805 MHz	2 W nebo 8 W e.i.r.p. [16])	5 MHz nebo 10 MHz [17])
b	5805 – 5815 MHz	2 W nebo 8 W e.i.r.p. [16])	5 MHz nebo 10 MHz [17])
c	63 – 64 GHz	dosud nestanoven	není stanovena, může být použito celé pásmo
d	76 – 77 GHz	23,5 dBm e.i.r.p. (střední výkon pulzního radaru); 55 dBm e.i.r.p. (špičkový výkon)	není stanovena, může být použito celé pásmo
e	21,65 – 26,65 GHz	podle odstavce 4	podle odstavce 4
f	5,875 – 5,905 GHz	2 W e.i.r.p.; spektrální hustota výkonu je omezena na 23 dBm/MHz	podle odstavce 5
g	77 – 81 GHz	55 dBm e.i.r.p. (špičkový výkon); spektrální hustota výkonu –3 dBm/MHz, mimo vozidlo –9 dBm/MHz	není stanovena, může být použito celé pásmo

- a) for car-to-infrastructure transmissions, especially EFC
- d) and g) dedicated for vehicle and infrastructure radars
- e) UWB

Source: všeobecné oprávnění ČTÚ č. VQ-R/10/06.2009-9

Frequency bands in transport and traffic telematics – example from the Czech Republic (from the Czech Telecommunication Office‘s general licence)

- Rail applications

Ozn.	Aplikace	Kmitočty	Vyzářený výkon	Další podmínky
a	AVI	2447,0 MHz; 2448,5 MHz; 2450,0 MHz; 2451,5 MHz; 2453,0 MHz	500 mW e.i.r.p.	vysílání pouze v přítomnosti vlaku
b	EUROBALISE	27,095 MHz	podle odstavce 3	
c	EUROLOOP	4515 kHz	podle odstavce 4	vysílání pouze po příjmu signálu systému EUROBALISE z vlaku

- AVI (Automatic Vehicle Identification)

Zdroj: všeobecné oprávnění ČTÚ č. VQ-R/10/06.2009-9

Frequency bands in transport and traffic telematics – example from the Czech Republic (from the Czech Telecommunication Office‘s general licence)

- Further dedicated ranges with usage in transport telematics e.g.:
  - Statitions with inductive loops
  - RFID
  - Wireless applications for sound transmissions (e.g. communication means in vehicles)
  - Acoustic information devices for sightless people

Important wireless networks

- **IEEE 802.11** - Wireless Local Area Network, WLAN
- **IEEE 802.15** - Wireless Personal Area Network, WPAN
- **IEEE 802.16** - Wireless Metropolitan Area Networks
- **IEEE 802.20** –Mobile Broadband Wireless Access, MBWA

802.11 - WiFi

- 802.11a (1999) – WLAN in frequency band 5Ghz, range 50-70 m, teoretical transfer rate 54 Mbit/s
- 802.11b (1999) - Wi-Fi (Wireless Fidelity) working in 2,4 GHz band, range up to 100-300 m and maximal teoretical transfer rate 11 Mbit/s
- 802.11g (2003) - faster Wi-Fi in 2,4 GHz band, compatible with 802.11b, transfer rate 54 Mbit/s in the physical layer
- 802.11n Enhancements for Higher Throughput, transfer rate minimally 100 Mbit/s
- 802.11p Wireless Access for the Vehicular Environment (WAVE) – mobility support for use in ITS – approved 2010

802.11 – WiFi – future development

- Wireless GigaBit Alliance in cooperation with the Wifi Alliance agreed on the creation of **WiGig** standard
  - Standard **802.11.ad**
  - Transfer rate up to Gbit/s
  - Frequency range 60 GHz
  - Shorter range – cca 10 m
  - Backward compatible with WiFi

Protocols with similar parameters, already standardized

- WirelessHD (60GHz, 25Gbit/s, up to 10m)
- Wireless Home digital Interface (WHDI) (5GHz, 3Gbit/s, up to 30m)

DSRC (Dedicated Short Range Communication)

- Standardized by ETSI (European Telecommunications Standards Institute)
- one-way or two-way short- to medium-range wireless communication channels specifically designed for automotive use and a corresponding set of protocols and standards
- allocated 30 MHz of spectrum in the 5.9GHz band for ITS
- standard developed in cooperation with IEEE 802.11a
- data rate communications up to 54Mbit/s
- for long distances (up to 1000 meters) with low weather dependence.

IEEE 802.15 - Wireless Personal Area Network, WPAN

- standard 802.15.1 compatible with the Bluetooth specification
- frequency band 2,402-2,480 GHz
- maximal transfer rate 1Mbit/s
- in telematics part of car systems, for communication among devices, etc.

IEEE 802.15 - Wireless Personal Area Network, WPAN

- **802.15.3 (e.g. Ultra Wide Band - UWB)**
- IEEE standard for a high-data-rate WPAN
- designed to provide sufficient quality of service for the real-time distribution of content such as video and music
- The original standard uses a traditional carrier-based 2.4-GHz radio as the physical transmission layer.
- Transfer rate up to Gb/s, short distances (cca 10m)
- possible interferences
- 802.15.3a – follow-on standard, alternative physical layer – UWB
- Frequency range 3,1-10,6 Ghz, futher ranges are being defined (in higher frequencies)

IEEE 802.15 - Wireless Personal Area Network, WPAN

802.15.4 - ZigBee

- for wireless home area networks, consumer electronics, …
- Standard maintained and published by ZigBee Alliance - a group of companies
- operates in the industrial, scientific and medical (ISM) radio bands;
  - 868.0-868.6 MHz: Europe, allows one communication channel (2003, 2006)
  - 902-928 MHz: North America, up to ten channels (2003), extended to thirty (2006)
  - 2400-2483.5 MHz: worldwide use, up to sixteen channels (2003, 2006)
- low consumption of particular nodes of the network
- range between 10 and 75 meters
- a large number of elements in the network – 64-bit address offers up to 264 addressable devices in 216 networks at maximum - wireless mesh networking standard
- favourable relation price/performance – should be simpler and less expensive than other wireless technologies
- usage for hierarchic network communication
  - e.g. in configuration of the communication between the control unit and particular sensors

IEEE 802.15 - Wireless Personal Area Network, WPAN

- WirelessHART
  - open-standard for wireless communication using 802.15.4
  - developed by HART Communication Foundation
  - utilizes a time synchronized, self-organizing, and self-healing mesh architecture
  - operation in the 2.4 GHz ISM Band
  - International Electrotechnical Commission (IEC) has approved the WirelessHART® specification as a full international standard (IEC 62591Ed. 1.0) in April 2010
- MiWi specification
  - proprietary wireless protocols designed by Microchip Technology using 802.15.4
- Etc.

802.16 Wireless MAN

- 802.16 WiMax (Worldwide Interoperability for Microwave Access)
- for outside networks (different from primary use of 802.11WiFi)
- WiMAX IEEE 802.16m provides up to 40 Mbit/s
- several different frequences in 2-66GHz band
- range 40-70km
- IEEE 802.16e-2005 improves WiMax by adding support for mobility – „Mobile WiMAX“
- Usually used to cover city areas

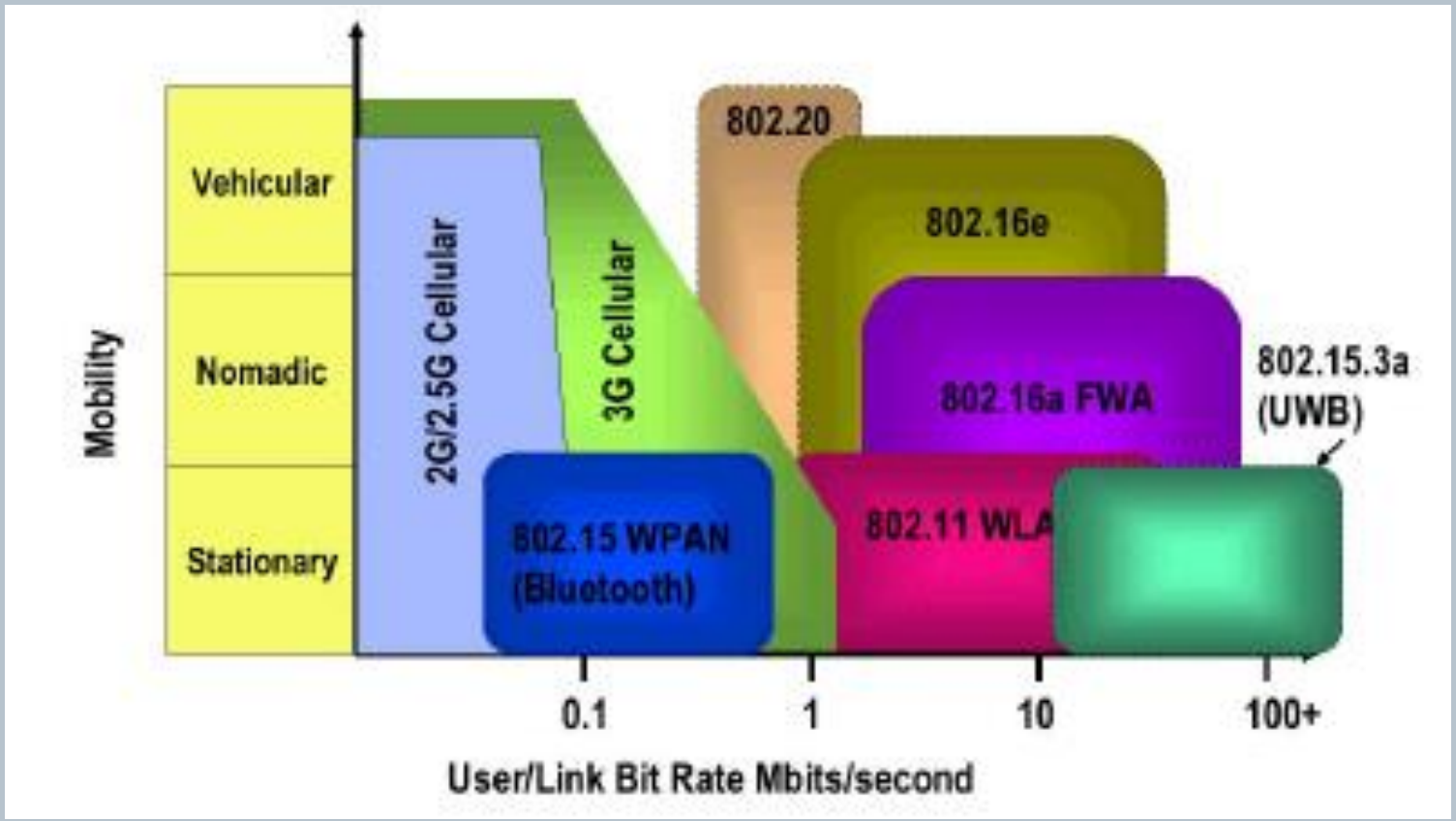
802.16 Wireless MAN

- 802.16m – WiMax 2 (WirelessMAN-Advanced)
- Approved 2011
- the first true 4G technology to be approved by the IEEE
- Speed up to 300Mbps
- Supports multiple inputs and outputs, self-organazing networks, cooperative communication

802.20 MBWA (Mobile Broadband Wireless Access)

- Mobile Broadband Wireless Access
- aimed at wireless mobile broadband for operations from 120 to 350 km/h
- Range up to 10 km
- operate in bands below 3.5 GHz (licensed)
- peak data rate of over 1 Mbit/s
- standard approved by IEEE 12 June 2008

Wireless mobility for ITS



- source: WiMAX Forum

Cellular networks (GSM) upgrades

Technologies for upgrading to the 4G

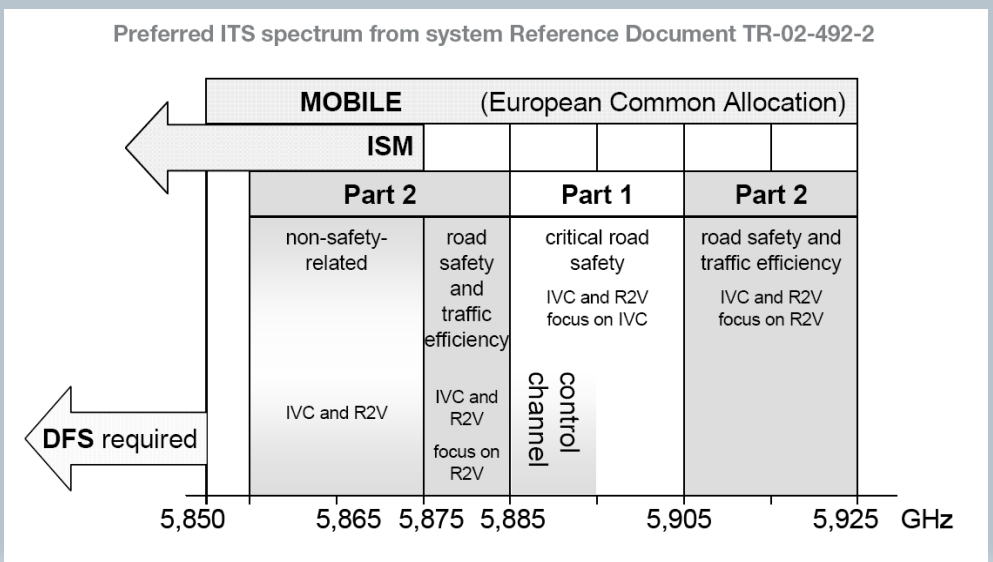
- HSPA+
  - Speed up to 18 Mb/s
- LTE (Long Term Evolution)
  - Multiple In Multiple Out (MIMO)
  - Orthogonal Frequency Division Multiple Access (OFDMA) in the downlink and Single Carrier FDMA in the uplink
  - Using TCP/IP

CALM standards

- Solution without necessity to choose on technology
- CALM – Communication Access for Land Mobiles
- Set of standards enabling (by using layered solution) continuous communications on the principle of making best use of the resources available
- CALM Media are defined as:
  - 5GHz wireless LAN systems, based on IEEE 802.11 normal WiFi as well as the new CALM M5/802.11p mode
  - Cellular systems, GSM/HSDSC/GPRS and 3G UMTS
  - 60GHz systems
  - Infrared communication
  - A Convergence Layer, supporting DSRC, broadcast, positioning

EU plan for ITS telecommunication

- COMMISSION DECISION of 5 August 2008
  - on the harmonised use of radio spectrum in the 5 875-5 905 MHz frequency band for safety-related applications of Intelligent Transport Systems (ITS)
- ECC recommendation on the 5 855-5 875 MHz usage in non-safety related ITS applications



Thank you for your attention

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