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 (compensation of disturbing effects in order to maintain strong processes according to defined criteria – e.g. comfort, economics, etc.) for regions, areas and global network sectors.

### TELECOMMUNICATION
- telecommunication networks and protocols
- intelligent telecommunication environment
- multifunctional telecommunication networks

### INFORMATICS
- software engineering
- database systems and technologies
- data processing
- data flow optimisation

### TELEMATICS
- distributed databases
- information reduction, knowledge society
- telematic services and protocols
- network and telecommunication service management
- organization, architecture
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.

- safety public transport and freight transport
- comfortable public transport
- efficient tool for state transport policy
- efficient tool for regional transport policy development
- efficient logistics
- assessment of transport process cost
- maximize usage of transport infrastructure
- multi-modal transport support
- sustainable mobility
- minimal impacts on the environment
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

- Telematic tools:
  - Telematic tools for passengers and cargo
  - Telematic tools for mobile means
  - Telematic tools for transport infrastructure
  - Telematic tools for transport terminals
  - Technical support of transport telematics
- Telematic transport control:
  - Telematic control of passengers and cargo
  - Telematic control of mobil means
  - Telematic control of transport infrastructure flow
  - Telematic control of transport terminals
  - Logistics, transport, shipping
- Telematic economical systems:
  - Economics of passengers and cargo
  - Economics of transport operators
  - Economics of transport infrastructure
  - Economics of transport terminals
  - Economical control of transport process

Enforcement of regional transport policy

Enforcement of state and European transport policy

System users: all transport process users (public authorities, transport companies, etc.)
Road, railway, water, air and multimodal transport.
Transport telematics proces model
Telematic system hierarchy

1st level
- Data - detectors, actors, local logic

2nd level
- Area control of transport processes

3rd level
- Traffic management of large transport areas

4th level
- Transport management on national level
- 4th communication level

5th level
- European management level
- 5th communication level
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

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

ITS influences budgets of
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

- Requirements on safety, reliability and availability of information transmission
  - Without requirements
    - Any environment
  - With requirements
    - Special networks
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

- Eskalátory
- CIS
- AFC
- EPS/EZS
- Video
- Video-interface
- Access Control
- Token Ring
- Ethernet
- ATM/Ethernet ROUTER

- ACM-N
- Emergency and information board
- Phone centre
- Radio
- Parallel I/O

- ISDN
- Systém
- SIS-Workstations
- PBX
- 44,1 kHz 0 dBu
- 4 * pot.-frei

- Wireless network
  - 3,2 Mbps do 3km, 1,6 Mbps do 9km

- Ethernet

- Control centre
- Parking-ticket maschine
- Display
- SIMATIC
- 2 * RS.485
- RS.232
- V.24
- Monitoring FBAS MJPEG
- FBAS MJPEG
- Token Ring
- ATM-interface
Integrated solution for mobile telecommunication network

GPRS, DAB

Communication platform

Portable
Organizer
Headset
Handset
Laptop

Bluetooth Gateway

GSM, GPRS, UMTS

Broadband in-car bus system

DAB, DVB-T

Value Added Services

Emergency Telemed.
Tourist Information
Traffic Information
Middleware
IP-Infrastructure
Radio Access

Base Services

GSM, GPRS, UMTS

QoS API
Location API
Network Management API

CCC

Others

Others

IP

Head Unit

Others
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

<table>
<thead>
<tr>
<th>Wave Length (km)</th>
<th>Frequency (kHz)</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 km</td>
<td>10 kHz</td>
<td>VDV</td>
</tr>
<tr>
<td>10 km</td>
<td>100 kHz</td>
<td>DV</td>
</tr>
<tr>
<td>1 km</td>
<td>1 MHz</td>
<td>SV</td>
</tr>
<tr>
<td>10 m</td>
<td>10 MHz</td>
<td>KV</td>
</tr>
<tr>
<td>10 m</td>
<td>100 MHz</td>
<td>VKV</td>
</tr>
<tr>
<td>1 m</td>
<td>1 GHz</td>
<td>TV</td>
</tr>
<tr>
<td>10 cm</td>
<td>10 GHz</td>
<td>mirovlné mikrovlné</td>
</tr>
<tr>
<td>1 cm</td>
<td>100 GHz</td>
<td>UV</td>
</tr>
<tr>
<td>1 mm</td>
<td>10^{-12} (1 THz)</td>
<td>detekce detection</td>
</tr>
<tr>
<td>100 µm</td>
<td>10^{-13}</td>
<td>infračervené infrared</td>
</tr>
<tr>
<td>10 µm</td>
<td>10^{-14}</td>
<td></td>
</tr>
<tr>
<td>1 µm</td>
<td>10^{-15}</td>
<td>viditelné světlo visible light</td>
</tr>
<tr>
<td>100 nm</td>
<td>10^{-16}</td>
<td>ultrafialové UV</td>
</tr>
<tr>
<td>10 nm</td>
<td>10^{-17}</td>
<td>Roentgen</td>
</tr>
<tr>
<td>1 nm</td>
<td>10^{-18}</td>
<td></td>
</tr>
<tr>
<td>10⁻10</td>
<td>10^{-19}</td>
<td></td>
</tr>
<tr>
<td>10⁻11</td>
<td>10⁻12 (pm)</td>
<td></td>
</tr>
<tr>
<td>10⁻13</td>
<td>10⁻14</td>
<td></td>
</tr>
</tbody>
</table>
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,
- 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

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

- 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

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

- AVI (Automatic Vehicle Identification)

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

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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, theoretical 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 theoretical 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

802.11 – 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, further 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 62591 Ed. 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 802.11 WiFi)

- WiMAX IEEE 802.16m provides up to 40 Mbit/s

- several different frequencies 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-organizing 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
References

- [http://www.com2react-project.org/](http://www.com2react-project.org/)
- [http://www.wimaxforum.org/](http://www.wimaxforum.org/)
- [www.cvisproject.org](http://www.cvisproject.org)