

1. Introduction

The development of the modern society of today is based on the implementation of different information technologies. As a significant factor of modern development, traffic systems also have to adapt to these tendencies. Information science today has been implemented into all the traffic branches.

Traffic information science is oriented towards solving of problems in the sphere of road, rail, air, water, post and telecommunication traffic by applying methods and devices that serve to collect, process and distribute traffic information.

The culmination of traffic information sciences consists of telematics (telecommunication and informatics) supported transport systems - intelligent transport systems (ITS). "Intelligent" behaviour of such systems is reflected in the level of information, ability to communicate, ability to learn, to deduce and to adapt.

Telematics (in loose translation: remote control) is a combination of information and telecommunication technologies.

Telematics includes a wide range of technological connections that simplify the control of the whole transport chain through traffic information exchange.

Telematic systems contribute to the improvement of the traffic flow, road safety, transport efficiency, environmental protection, and business economy. Telematics is also significant regarding its implementation in medicine and industrial manufacture.

The basic reasons for introducing ITS are the following:

- increase in the traffic route capacity (traffic significance),
- reduction of environmental pollution (environmental significance),
- savings in fuel, reduction in transport time (economic significance),
- increase in traffic safety (protection and safety significance).

Introduction, development and implementation of telematics-supported intelligent transport systems

Čedomir Ivaković - Dražen Kovačević - Branko Maković

FAKULTET PROMETNIH ZNANOSTI
SVEUČILIŠTE U ZAGREBU

Significant increase in traffic demand at the end of the 20th century and the increasing anthropogenic environmental pollution have resulted in the need to introduce the telematics-supported intelligent transport systems in all the traffic branches. The work presents the development and the basic characteristics of transport systems managed by information and communication technologies. It also gives an overview and explanation of the operation of some of the numerous telematic systems in traffic, and a detailed presentation of the telematics-controlled public transport of the city of Helsinki. It also presents the possible development and advantages of implementing telematics in the transport along the river Danube through Austria.

KEY WORDS: *traffic, telematics, intelligent transport systems, EUREKA, public urban transport, inland waterways*

2. Consequences of increase in traffic demand at the end of 20 century in the world

In the second half of the 20th century, traffic demand has increased substantially. Transport of unified cargo (palletisation and containerisation) is increasingly used, especially in maritime transport (which transports almost 80% of the overall international trade of goods) and railway traffic. Global increase of container traffic can be best monitored through the increase of container traffic in seaports and on railways (Table 1, and Figures 1, 2 and 3).

Table 1 and Figure 2 show substantial increase in container transport in the ports of the Far East (Shanghai, Jakarta, Port Kelang, Singapore) in the period from 1985 to 2000. This increase is to the greatest extent assigned to cheap labour in the Far Eastern countries,

as well as powerful environmental movements in northern America and western Europe which are fighting against further environmental pollution.

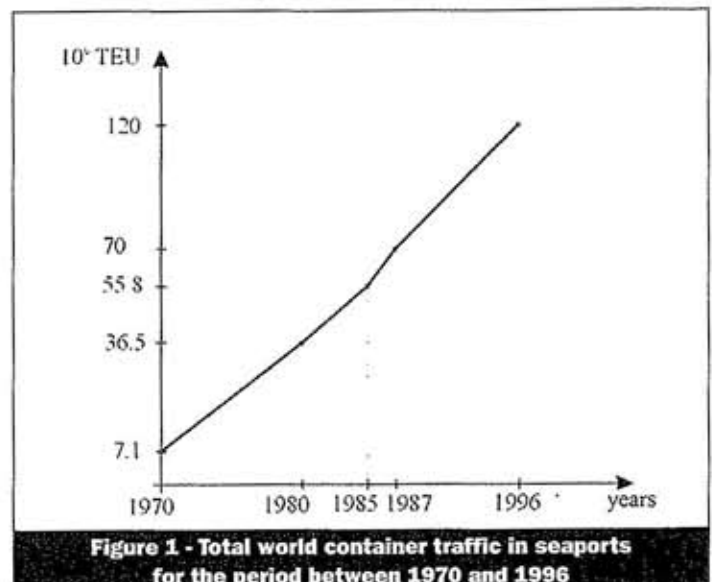


Table 1 - Increase in container traffic for 12 biggest seaports based on the year 1985 (100 %), ports have been listed according to the number of TEU in 2000; data taken from various sources and processed by the authors

Ord. No.	Port	Years			
		1985	1991	1997	2000
1	Hong Kong	100%	269.2 %	628.5 %	790.7 %
2	Singapore	100%	374.0 %	832.1 %	1006.0 %
3	Pusan	100%	233.3 %	453.1 %	652.8 %
4	Kaohsiung	100%	205.9 %	299.5 %	390.7 %
5	Rotterdam	100%	141.8 %	207.0 %	236.3 %
6	Shanghai	100%	285.5 %	1248.9 %	2782.1 %
7	Los Angeles	100%	184.7 %	268.2 %	442.1 %
8	Long Beach	100%	150.9 %	299.1 %	392.7 %
9	Hamburg	100%	188.9 %	288.0 %	366.6 %
10	Antwerp	100%	141.7 %	238.9 %	328.4 %
11	Jakarta	100%	346.1 %	785.4 %	1583.5 %
12	Port Kelang	100%	248.2 %	688.0 %	1309.7 %

Table 1

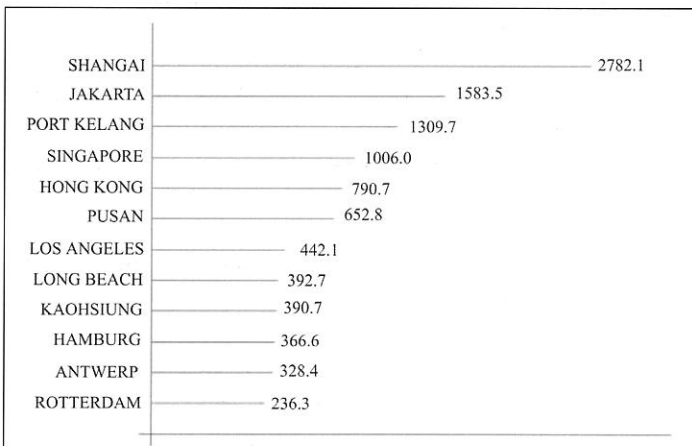


Figure 2 - Relation in percentages of container traffic in 2000 vs. 1985 for 12 world ports with the highest container traffic in 2000

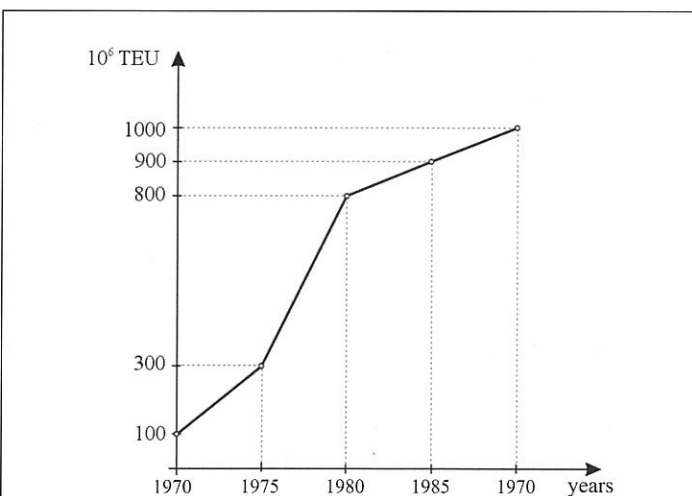


Figure 3 - Container transport organized by the European Railways Agency "Intercontainer" from 1970 to 1990 (Kovačević, D., 1999)

Today, traffic is one of the most important industrial activities. For example, in the European Union, about 7% of the total

national product is accounted for by transport, and over 10 million people in the European Union are employed in direct transport activity or in the manufacture of transportation means and manipulation in transport. Investments into the traffic infrastructure of the EU countries in 1994 amounted to about 67 billion ECU, which is about 1.1% GDP (gross domestic product), increased by 45% compared to the year 1985. (EU Transport in Figures, 1997.).

2.1. The need to introduce advanced transport technologies

Advanced industrialisation, fast economic growth and structural changes in industry in the age of integration, require high efficiency in the traffic systems but also adjustment of these effects to modern changes and the increasing and ever more strict requirements set by the developed world markets. Modern global goods - market exchange, that was greatly increased in the second half of the 20th century, in terms of transport has found solution in modern transport technologies (integral, intermodal and combined transport).

The sixties and the seventies saw the development of palletization in the world. Palletization was then followed by relatively fast development of containerization, and then both piggyback and Ro-Ro technologies.

In order to meet the needs for fast and safe cargo deliveries from one place to another, advanced transport requires efficient interconnections between various traffic modes. Today, there is a series of techniques, technologies and systems that are interconnected and adapted to specific features of transport means of individual traffic branches, with the possibilities of integrating into another traffic branch or another technology.

2.2. External costs in the transport chain

It may be claimed that even in the most developed countries the introduction and implementation of advanced transport technologies is not devoid of problems.

For example, in the EU (European Union), regardless of the fast development and application of advanced transport technologies, the share of road traffic on the transport market has increased (from about 50% in 1970 to about 72% in 1995), whereas railway traffic within the same period declined from about 32% to less than 15% (Sabolović, R., 2000). According to EU estimates, the costs due to traffic congestion in the EU countries already amount to about 120 billion ECU (about 2% GDP), and costs resulting from traffic accidents, pollution, and noise are estimated at additional 2% of GDP (these are, the so-called external costs).

Also, a series of barriers has been noticed that prevent intensive and efficient usage of intermodal transport. Each change of the transport mode within one transport route includes a change of system, and not only technical transshipment, creating additional friction costs that could render intermodal transport uncompetitive compared to single-mode transport.

The most critical points in the existing system of intermodal

transport and the generator of friction costs are the transshipment points between individual transport branches (terminals and cargo-transport hubs). The competitiveness of intermodal transport is also reduced by administrative barriers. Transport documents and regulations in customs formalities mostly differ according to transport branches.

These drawbacks of intermodal transport are successfully reduced by the application of telematics-supported intelligent transport systems.

2.3. The need to introduce intelligent transport systems

Classical answer to continuous growth in traffic demands is the physical expansion of the traffic network, terminals, and the cargo-transport hubs. However, today, due to high costs and attitude towards the environment, such classical solutions are simply not possible any more. It is necessary to consider the solutions in the maximally efficient usage of the existing infrastructure.

Such solutions can be realised by means of advanced technologies of traffic management.

Advanced, intelligent transport systems of today operate in real time, are sensitive to traffic flow changes, combine different functions: traffic information, traffic demand management, regulation of vehicle access to certain parts of the network, light signalling operation control, informing of users at terminal zones.

Intelligent transport systems allow an increase in capacity of the existing traffic routes, reduction of environmental pollution (through reduced emission of exhaust gases, greater traffic safety and reduced need to construct new traffic routes), saving in fuel and shortening of the travelling time.

3. Development and characteristics of telematics-supported transport systems

Telematics-supported intelligent transport systems use modern computer, information and communication advances in order to increase mobility, safety and improve environmental protection. The main objective of applying intelligent transport systems is to establish full understanding (communication) between the system user and those who manage the transport system.

By applying telematics, traffic system is managed in real time, and the traffic participants can provide direct feedback and immediate responses to possible changes in traffic regulation.

The development of the traffic management system features three phases:

1. Classical traffic management method using vertical, horizontal and light signalling.
2. One-way systems for communication with drivers, based on information transfer by means of radio (RDS), usage of digitised maps in finding the optimal way to the destination and variable signalling on the roads. The best known systems are CARMINAT and SOCRATES.
3. Two-way systems for communication with drivers –

systems AUTOGUIDE, ALI-SCOUT-Siemens and ULISSEE. The driver sends real-time travel data on his/her route to the control centre. The obtained data change the existing database and in turn determine current optimal routes sent as information to other drivers.

Generally, the ITS development can be monitored through nine basic development areas:

1. navigation systems,
2. control and cash-free charging systems,
3. safety systems,
4. traffic control and management systems,
5. maintenance,
6. public transport,
7. commercial transport,
8. pedestrian traffic,
9. itineraries (detours) for emergency situations.

The most significant advantages of implementing ITS include:

1. availability – Mobile communications shift meeting of transport needs from mobility to availability. New modes of transport and communications allow:

- increase in the availability by using different transport modes or improving the existing ones,
- decrease in traffic demand by development of communications, thus reducing the number of journeys, but not reducing business activities.

2. benefits for the traffic system user include:

- improved safety of all traffic participants,
- better information provided to traffic participants,
- better co-ordination of different public transport modes,
- easier integration of traffic systems of the countries in a region and beyond.

3. planning and using land allows:

- rational usage of land,
- giving priority to environmentally-friendly transport branches,
- increase in public transport attractiveness.

4. better environmental protection is reflected in the following:

- reduction of harmful emissions,
- noise reduction,
- less waste (by recycling),
- increase in the fuel quality,
- development of environmentally-friendlier alternative fuels.

5. economic advantages:

- expressing total costs for various transport modes as basis for decision-making,
- establishing of economic price of using planned and existing systems,

- expressing level of usefulness of modernising the existing system through increase in industrial activity.

With the aim of establishing international co-operation regarding development of advanced transport technologies, 1985 saw the start of the EUREKA program in 19 European countries. The most significant projects within this program include:

- PROMETHEUS – Program for a European Traffic with Highest Efficiency and Unprecedented Safety. This scientific project was started by the European Union automotive industry in 1986, with the aim of developing and implementing sophisticated information and communication systems in road traffic and development of intelligent vehicle. The project was completed in 1994 and 14 car manufacturers participated in its development.
- DRIVE – Dedicated Road Infrastructure for Vehicle Safety in Europe. This scientific program of the European Union for development of advanced information and communication systems in road traffic has three basic objectives: increase of safety, increase of traffic system efficiency and improved environmental protection. These objectives are achieved by controlling traffic and guiding vehicles along the network, using digital maps and databases on road networks.
- CARIN – Car Information and Navigation System. The system is used to guide vehicles along the network based on digitised data about the network obtained on a CD-ROM. The vehicle must be fitted with a computer, CD-ROM reader and the equipment which determines the location of the vehicle in space. The driver marks his/her current position and the destination, and the computer determines the optimal route and suggests to the driver how to get there along the network. Numerous intelligent transport systems have been developed today in the world. Apart from those mentioned already previously, some of the major ones include also:
 - ABS – Anti Brake-Locking System. ABS is a system which prevents wheel skidding during excessive braking. At any intensity of braking, it insures rolling of the wheels and thus reduces the braking distance and the braking time compared to skidding (increases vehicle deceleration). It also enables better vehicle steerability during the whole braking phase.
 - ACC – Adaptive Cruise Control. ACC is a system of services for traffic flow homogenising, ensuring greater efficiency and road traffic safety, as well as better environmental protection. ACC control of the relative vehicle speed in bumper-to-bumper driving insures an adequately safe spacing for various absolute vehicle speeds.
 - GPS – Global Positioning System In the Earth orbit, 24 global positioning system satellites are circling at an altitude of about 20,000 km, in six orbital levels. By transferring radio signals they provide positioning with an accuracy of about 100 meters.
- PDC – Park Distance Control. Sensors measure the spacing between moving vehicles and the barrier, and a sound signal warns of inadequate spacing.
- ATIS – Advanced Traveller Information Systems. These are systems which enable improved traffic information of passengers and drivers about e.g. road conditions or timetables.
- ETC – Electronic Toll Collection. ETC systems do away with the stopping of vehicles due to manual toll collection. Queuing and harmful emissions at tollbooths are thus reduced. For instance, by the application of ETC at tollbooths in Norway, the CO, CH and NO_x concentrations have been reduced by 72%, 83% and 45% respectively.
- ATMS – Advanced Traffic Management Systems. By supervising and controlling traffic flows, these systems make decisions depending on the traffic condition with the aim of achieving maximally continuous traffic flow. With the application of ATMS system in the road traffic of the city of Los Angeles, fuel consumption has been reduced by 13% and exhaust emissions by 14%.
- ALC – Adaptive Light Control. The system which controls the angle and/or focus of the headlights according to the drivers' needs depending on different traffic situations and road conditions.
- MOTIV – Mobility and Transport in Intermodal Transport Systems. This is a research program which inherited the programs PROMETHEUS and DRIVE. The basic aim is to provide an overall solution to traffic problems by intelligent linking of the transport systems and optimal usage of the existing capacities, mainly in densely populated areas. The next goal is to increase traffic safety by means of in-vehicle systems assisting the driver.
- PTA – Personal Travel Assistant. A small portable computer that can be fitted onboard vehicle. It can serve as navigation and route planning system, and it can be used for booking air-tickets, hotels, etc.
- GSM – European mobile network for two-way communication. It connects mobile and fixed stations, and transfer speeds are between 2.4 kb/s and 9.6 kb/s. The call is realised via commutation network, and cars fitted with GSM are each called separately.
- Route Guidance or Navigation Systems

There are four levels of route guidance system today:

1. Information systems that inform the driver about traffic conditions, but do not offer guidance along alternative routes. RDS/TMC – one-way communication of traffic messages. This is a digital traffic radio system which broadcasts coded traffic reports parallel with usual radio channels. Drawbacks: limited amount of data, receiving unimportant messages as well, the driver cannot obtain a specific information.

2. Assistance in navigation that shows the vehicle positioning in relation to the map on the display. Available in Japan in numerous systems sold with the vehicles or included in accessories.

3. Autonomous route guidance systems giving voice instructions and present information based on the static map in the vehicle. Such vehicle locating systems use algorithms for finding the optimal route.

4. Dynamic route guidance with information changing depending on the current traffic conditions. With algorithms for finding the optimal routes, these systems use also communication networks to send and receive messages.

4. Basic applications of telematics in traffic

Telematics-supported intelligent transport systems are used in the following advanced traffic systems:

1. Multimodal transport systems in passenger transport. The journey starts usually at home by car, changing to train, bus, ship or plane, and eventually the passenger reaches the final destination by car. The systems inform the passenger and suggest optimal travelling route in accordance with the timetables of respective traffic modes

2. Intelligent traffic control systems – systems that control traffic networks:

- traffic lights,
- urban public transport systems,
- guidance systems for ambulance vehicles, police, fire-fighters,
- parking system of informing and guidance,
- (in West European countries the introduction of control and surveillance systems of dangerous supporter groups before and after major sport events is being considered).

3. Navigation systems – enable drivers to obtain information in the vehicle about:

- weather conditions,
- current traffic situation on a certain section of the traffic network,
- alternative routes in case of traffic congestion or accident,
- optimal route to a certain destination depending on the current traffic network and current traffic situation.

4. Intelligent transport systems in advanced transport technologies – particularly significant in intermodal and

combined transport. They allow minimal stay of transport means for transshipment and monitoring of cargo along the whole transport route.

5. Safety systems. These are systems that use meteorological stations to warn of severe weather conditions. Certain solutions are installed in the latest generations of passenger cars, and they warn the driver of the following:

- ice,
- wet road,
- gusts of lateral wind, insufficient spacing between the vehicles and they decelerate the vehicle.

6. Systems of variable traffic signs and message signs, as well as radio-messages. Variable message signs are big panels with messages written on them intended for the traffic system users. Such information systems allow traffic users to avoid critical spots before reaching the point at which it would be impossible to do that. Car-radio receivers are fitted with RDS (Radio Data System) which in case of important news interrupts broadcasting and provides the driver with the information.

5. Telematics in urban transport

Characteristic traffic problems in the cities are most often reflected in the impossibility to substantially increase the useful traffic areas, so that urban transport has to be considered from other aspects. In cities, there is the need to use the telematics-supported intelligent transport systems that have found their place in three major traffic control systems:

- traffic lights control system,
- surveillance system and management of urban public transport,
- parking systems of informing and guidance.

The main objective that is to be achieved by these systems is to find the optimal relation between traffic supply and demand, taking into consideration the time as one of the most significant factors in the traffic process.

Traffic supply is related to the existing traffic routes and technological resources, whereas traffic demand is determined in the following ways:

- using detectors,
- using pedestrian buttons,
- by announcing approach of public urban transport vehicle (inductive loop, system of detectors and transmitters onboard vehicles, GPS, etc.),
- using internal television (video-surveillance and Video Image Processing).

The Video Image Processing technology has multiple applications:

- counting traffic regarding number and structure,

- measuring traffic flow characteristics (speed and average follow-up intervals),
- standstill detection,
- urban public vehicles detection (according to the line number, i.e. required direction of movement),
- traffic accident detection,
- neglect of traffic regulations detection.

The traffic light control system is the most developed since it has passed a series of technological periods: from relay technology in the signalling devices to today's high level of information, communication and computer technologies.

The traffic light control systems can be divided into two basic groups:

1. off-line techniques: based on site measurements using computers the traffic light operation elements are calculated. This technique is used for constant control over time. Off-line techniques are divided into two groups:

- optimising functioning of an intersection (techniques: Webster model, Akcelik model, mathematical programming, SIGOP, etc.),
- optimising operation of a group of intersections or a traffic network (green aspect maximising technique, or the width of the green wave: MAXBAND, MULTIBAND, PASSER etc.; traffic indicators minimising techniques: MITROP, TRANSYT, NETSIM etc.).

2. on-line techniques to optimise the functioning of traffic lights in real time based on the collected data from the detector, and realised in three ways:

- control depending on traffic conditions,
- control depending on the part of day (morning or afternoon peak hours),
- manual control.

On-line techniques can be divided depending on the method of operation:

- optimising the functioning of a single intersection (techniques: MOVA, OPAC, LHOVRA etc.),
- optimising the functioning of a group of intersections or a traffic network (techniques: UTCS, CIC, SCOOT, SCATS etc.).

5.1. Implementation of telematics in the urban public transport of the city of Helsinki

The implementation system of telematics in the public transport of the city of Helsinki started operating in 1999. This telematic system called HeLMi provides several telematic functions of the urban public transport, such as: real-time information for passengers, priority of buses and trams at traffic lights and scheduling control. Similar systems are used in several European cities, but this is one of the most complex ones since it has been based almost on completely wireless communication by radio modems.

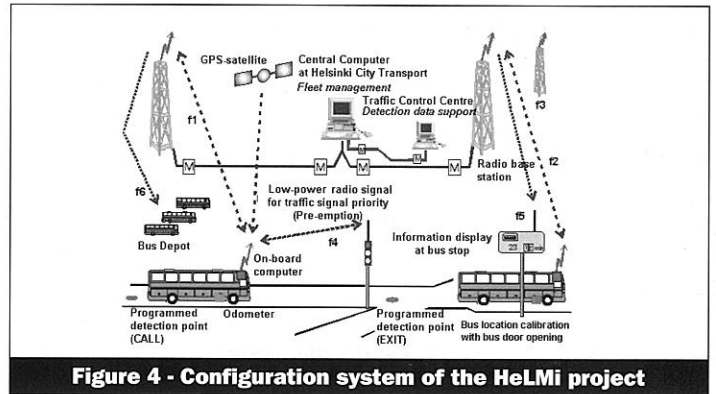


Figure 4 - Configuration system of the HeLMi project

Telematics in public urban transport has been accepted as a new means of making buses more attractive, even in smaller towns like Västerås and Jönköping in Sweden. In Nordic countries the biggest telematics system implemented in urban public transport is in Gothenburg and it comprises all bus and tram lines in the city.

The basis for telematic system is the position of buses which is determined in three steps:

- GPS – satellite navigation draws the bus approximately in the area around the actual bus station,
- opening of the doors at the station locates the bus exactly on the right spot along the route,
- position of the bus along the line is based on the kilometre counter in relation to the previous bus station.

The central device calls each bus once every ten seconds. Thus, the central computer constantly has the exact position of every bus along the route.

Scheduling timetable is based on the comparison of the actual location of the bus and the location calculated according to the schedule. The difference expressed in seconds is constantly displayed on the driver's display (Figures 2 and 3). The same information is sent also to the dispatcher every ten seconds. The dispatcher can monitor the movement of all the buses along their lines and give instructions to the bus drivers in case of traffic congestion.



Figure 5 - Travel computer C90 and keyboard are on the left and the display on the right, precisely in front of the bus driver

Vehicle location control is based on constantly new data on the position of every vehicle. Figure 7 shows the control display. On the display each row represents a station and the name of the station is in the middle column. The numbers

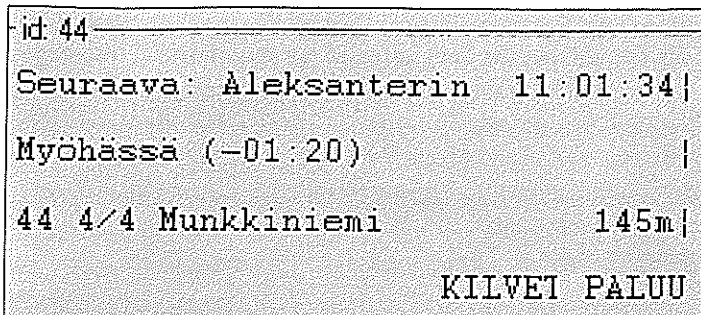


Figure 6 - Driver's display in tram No. 44: distance to the next station "Aleksanterinkatu" is 145 metres, message -01:20 means that the tram is one minute and twenty seconds late according to the timetable

in the left and in the right columns represent trams that are moving along the line.

For example, tram No. 49 is at the station called "Ooppera" or has just passed it. The black figure 0 on the right side of the left column means that the tram No. 49 is running according to the schedule.

Tram No. 41 is at the station called "Senaatintori" or has just passed it. The red figure +1 on the right side of the left column means that tram No. 41 is running one minute faster than according to the schedule.

Tram No. 145 is at the station called "Ylioppilastalo" or has just passed it. The blue number -1 on the right side of the right column informs that the tram No. 145 is one minute late according to the schedule.

4	B	12 Vehicle(s)	X
		Seunaahdentie@	
		Tilimäki@tecelbc	
		Laaialahdenaukio	
48	0	Munkkin puistot@	
		Pöykkösenkaari@	
		Mellahdentie@me	47 0
149	0	Sairaalan puisto@	
		Töölön tulli@tööl	
		Kansaneläkelait@	146 0
		Töölön helik@tööl	
49	0	Ooppera@oppera	
		Hesperien puisto@	
		Kansallismuseo@	45 0
		Postitalo@posthu	
		Ylioppilastalo@st	145 -1
		Aleksanterinkatu@	
41	+1	Senaatintori@sen	
42	+1	Pitärihuone@idd	
		Katzenok.puisto@	
		Kauppienkatu@k	44 0
		Yrjökatu@yrdet	
		Puolijärvenkatu@	144 -1
		Menssiläntori@e	43 0
		Malmisinkatu@m	
		Mersiläntori@m	

Figure 7 - Control display

Real-time information for passengers allows passengers waiting at bus stations to see real-time information on displays about the arrival time of the next bus in minutes. Besides, the operator can send immediate information message to the display about possible problems in bus transport.

The forecast of expected actual time of bus arrival to the station can be found also on the Internet. The user selects a desired bus station from the list and after a few seconds information is displayed about the time (in minutes) needed for the next bus and for the first subsequent one to arrive at the station.

Priority request is based on the message sent directly via radio modem of the bus approaching the signalled intersection. The first message is sent 150 – 250 metres before the intersection (Figure 8). Depending on the status of the signalling cycle at the moment of receiving the message, the traffic light controller either activates green light for the bus or lengthens the green phase. The second message is sent immediately after the bus passes the stop-line as a sign that the bus has passed the traffic light and that the green light for the bus can be turned off. Such priority is not given to buses running ahead of their timetable.

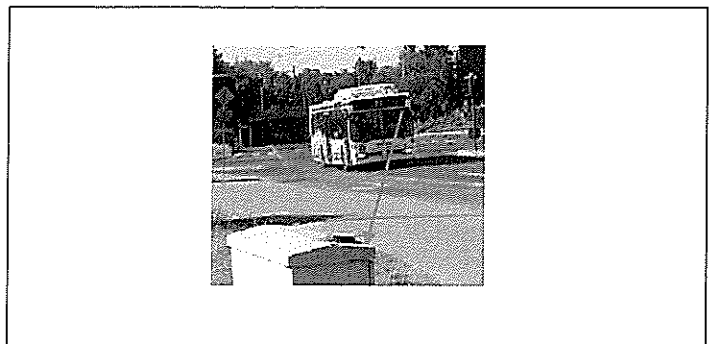


Figure 8 - Priority request sent from the bus directly to the antenna located on the top of the traffic light controller

Communication in the system is based on the radio network owned by the city. Three basic stations are located on high chimneys in various parts of the city (Figure 9). A total of six frequencies are used in the radio network: three for making calls to buses, one for traffic light priority, one for new data at bus and tram station displays and one for maintenance at depots during nights. It is possible to make calls to three hundred vehicles simultaneously.

All the buses and trams are fitted with computers and radio modems. The displays at bus and tram stations, as well as the traffic light control equipment are fitted with radio modems. No additional cabling was necessary at intersections, because an imperceptible flat antenna was installed on the top of the traffic light controller case, and all communication within the system relies on the radio network. Such a system is less expensive compared to cabling systems, since no additional utility works are necessary. Only data transfer between base stations and central work stations is realised via cable network.

Total costs of the system amount to about 0.9 MECU, including radio network, installed computers for 20 buses and 24 trams, displays for 15 stations and all installations. This amount does not include costs of the Helsinki urban transport personnel, nor of the Department for Traffic Planning.

Implementation of telematics in traffic of the city of Helsinki has shown that the priority of public transport vehicles at traffic lights efficiently reduces unnecessary stopping at intersections. Since the main aims of this system (speed increase and punctuality of the public transport vehicles) have been realised, Helsinki plans to expand its implementation to other tram and bus lines as well.

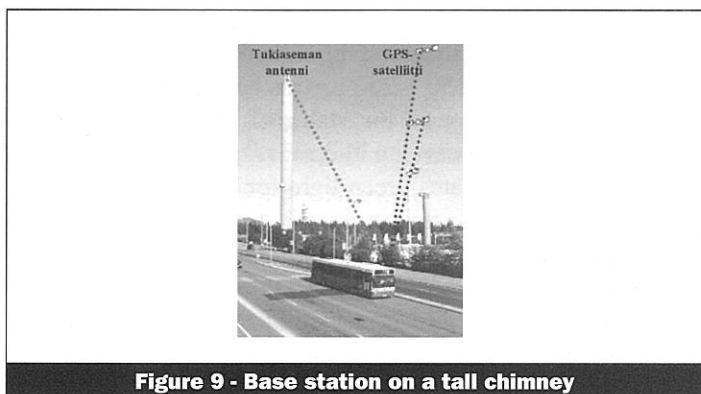


Figure 9 - Base station on a tall chimney

6. Telematics in traffic on inland waterways

Traffic on inland waterways has not been used fully yet, as reliable, cost-effective and environmentally friendly traffic branch for medium and long distances. This is precisely the reason, with a tendency to maximise operation efficiency, for substantial investments in inland waterway development in countries with developed inland waterway network.

In recent years the growth of cargo volumes transported via western parts of the Danube corridor VII has been obvious (particularly following the year 1992 and the opening of the Rhine-Main-Danube canal, which transported in the year 2000 over 8.5 million tonnes of cargo), and after removing the destroyed bridges on the Danube in Yugoslavia, a substantial increase in river transport is expected, also in its eastern part. The expansion of the European Union allows greater freedom in trading, and lower transport tariffs in south-eastern Europe will create the basis for further increase of river transport. Accordingly, the traffic infrastructure in the Danube countries has to be adjusted to this corridor.

The Danube countries have recognised the importance of the Danube corridor VII by signing the Memorandum of Networked Transport Development in the region (6 September 2001 in Rotterdam).

On 2 October 2001 the European Commission adopted the instructions for the trans-European network. This stressed the importance of traffic on inland waterways, intermodal transport and interconnections.

In the recent and the next ten years the European Union has been and will be stressing great significance of maximal usage of transport, including optimal environmental protection. Therefore, inland waterway transport occupies a significant position, but only as reliable, efficient and adequately equipped traffic branch.

In the Danube countries inland waterway navigation will successfully integrate into intermodal transport chain if key problems in inland waterway traffic are solved:

- excessive delay of vessels due to customs formalities,
- unreliable information about vessel position and possibly transported dangerous cargo,
- insufficient information about the vessel arrival to a river port and excessive waiting for cargo handling.

One of the key elements to improve transport on the Danube corridor VII and for integration of traffic on inland waterways into intermodal transport chains is the purchase and usage of telematic equipment. These River Information Services (RIS) will increase the traffic safety and improve environmental protection, intermodal transport operations, using electronic information systems, for all the participants in the intermodal transport chain.

The advantages of RIS at the government level:

- increase of traffic safety on inland waterways,
- efficient traffic control on inland waterways,
- efficient control of dangerous cargo on inland waterways,
- efficient information exchange about the status of possible accidents (collision, environmental pollution, rescue),
- more efficient customs control,
- electronic monitoring of the conditions at terminals, depots,
- more efficient data and information exchange in international traffic on inland waterways,
- increased safety through free access to the information services (information to captains about water depth, waves, meteorological data – wind, ice),
- development of digital river maps according to European standards,
- accurate overview of waterways, navigation marks and river banks,
- general definition of administrative permit for cargo and passenger transportation,
- establishing of an efficient traffic management system based on the European standard (AIS, ECDIS) in all European countries that have significant inland waterway networks.

The advantages of RIS at commercial level:

- more efficient integration of traffic on inland waterways into intermodal transport through electronic integration of all the factors in the logistic chain,
- improvement of traffic efficiency at border crossings,
- better planning of cargo handling operations due to the existence of exact and reliable estimates about vessel arrival to the river port,
- optimal usage of inland vessels and reducing the time waiting for cargo handling services,
- reduction of administrative activities,
- more efficient planning and control of transport operations, and continuous and full compliance with the transport status by information exchange between the participants in the logistic chain.

The advantages of RIS at social and economic level:

- increase in transport volume on inland waterways by taking over cargo from road and railway traffic, and consequently improved environmental protection,
- facilitating creation of a new logistic chain by introduction of high-quality transport service into the river traffic.

6.1. Introduction of river information services in Austria

RIS Introduction Strategy in Austria

Recognising the importance of River Information Services the Austrian Ministry of Transport, Innovations and Technology will integrate this service at the Austrian part of the Danube.

RIS will be implemented on the Danube by the following approach:

1. The initial centre and establishing of the basic RIS will take place in summer 2002 for 30 km of the Danube section between the Freudenuau and Greifenstein locks (Figure 10). This will determine exactly the technical approach and commercial value of services.
2. The expanded RIS at the Austrian route of the Danube will be fully set in 2003. All factors and interests of the inland waterway navigation (commercial and government) are going to be gradually connected.

Operation of the basic RIS

The basic objectives of the basic RIS include the following:

- valid traffic information (current vessel location, vessel identification, dimensions, vessel draught, information about transport of dangerous cargo),
- presentation of navigation on the electronic map,
- presentation of traffic information to the inland waterway transport control,
- support to the personnel of the Austrian locks for better planning of lock operations,
- reliable support to customs and state border officials with the aim of increasing the efficiency of customs and border vessel control procedures,
- control and monitoring of transport of dangerous cargo.

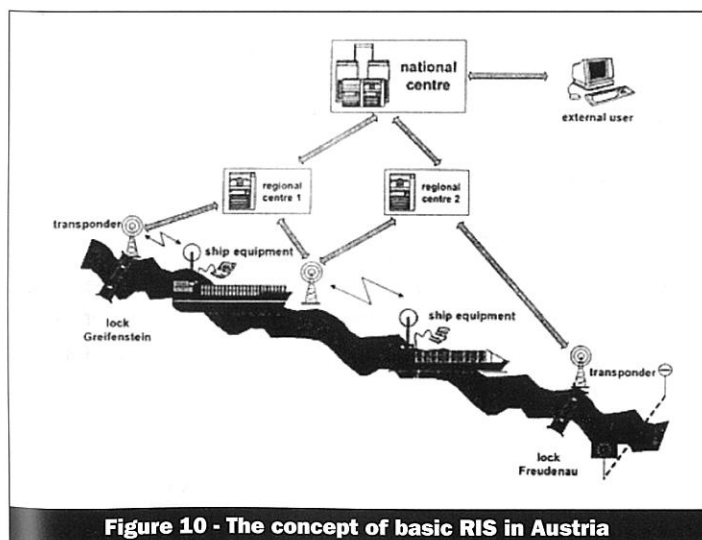


Figure 10 - The concept of basic RIS in Austria

Telematic system of basic RIS is composed of the following elements:

- electronic nautical map (ECDIS – presentation and

information system of the inland navigation),

- positioning system,
- radio communication based on transponders (transceiver with automatic signal transmission) based on AIS – Automatic Identification System,
- data processing.

The electronic presentation on the map and the information system (ECDIS) are available to the computer onboard vessel, and communication and control centres on land. Positioning is performed by satellite systems to determine the position (e.g. NAVSTAR-DGPS) with the accuracy of several metres. Communication infrastructure onboard vessel will be based on the ship transponder, through techniques based on AIS standard.

Data processing by means of computers provides efficient, updated, reliable and comprehensive information regarding overall inland navigation.

The following system components will be implemented into the development of River Information Services:

- ship segment,
- land segment,
- control segment.

The ship segment consists of the ship transponder system (radio modem for data exchange), positioning system and computer for communication data processing. Computer with electronic river map can display the proper vessel position, but also the positions of other vessels.

The land infrastructure (land segment) will be set along the waterway and will consist of the land transponder system and information exchange network with the control segment.

The control segment consists of regional and national centres and processes all traffic information. In Austria the regional centres will be located at the locks as assistance in their operation. Here, current traffic information can be presented on the electronic river maps, but all the vessels fitted with transponders can be monitored by the authorised bodies.

The national centre has been set in the Austrian supreme shipping body. There, all activities in inland navigation can be monitored and controlled. Outside users (government and commercial) can have access to current traffic information if adequately authorised.

Functionality of improved River Information Services (RIS)

Whereas basic RIS are focused on creation, presentation and processing of direct information about river traffic regarding implementation by authorised bodies, the improved River Information Services process direct information on river traffic and combine them with other information necessary for river navigation.

The following groups will have advantages of improved services:

- authorised bodies for border control,
- authorised bodies for customs control,

- authorised bodies for environmental protection,
- lock operators,
- inland ports,
- shipping operators,
- forwarders and logistics,
- shippers.

The following information services are expected to be developed and used:

- greater control and monitoring of the ship by authorised bodies,
- electronic pre-informing of the authorised bodies about the border crossing of passengers and personnel,
- electronic pre-informing of the authorised customs officials about the cargo,
- electronic registration of dangerous cargo,
- traffic management by means of a lock operation planning system,
- providing accurate and reliable vessel positioning in the port of loading,
- international data exchange on river transport.

RIS at the European level

All the countries on the Danube and Rhine have acknowledged and published the significance of River Information Services at the European Conference on Traffic on Inland Waterways in Rotterdam, in September 2001:

“...invite all the involved governments to found the European River Information Services (RIS) by 2005 based on the standard that will be formed within the European Community, UN/ECE and River committees since River Information Services contribute to safer and more efficient transport on inland waterways...”

As result of this conference it was concluded that two comprehensive measures have to be undertaken at the European level:

- First step – Preparation to establish RIS at the European level!
- Second step – To set and start operation of RIS in each country!

7. Conclusion

The growth of traffic demand in the world at the end of the 20th century has caused great congestion in road traffic and respectively increased environmental pollution, especially in urban areas. Instead of expanding road traffic network, attempts have been made to maximise the efficiency of using the existing traffic routes. In this process the telematics-supported intelligent transport systems play a significant role.

One-way information, and especially two-way information exchange (traffic participant – control centre) have achieved significant improvements in traffic flows and accordingly greater safety and improved environmental protection.

Today, numerous telematic systems have been developed in the world, which have been implemented in all traffic branches and are especially efficient in information technology

connecting all factors in intermodal transport chain.

Application of telematics in public urban transport substantially increases the traffic according to the timetable and passenger informing, and reduces exhaust gas pollution.

By introducing intelligent transport systems in inland waterway traffic, this inexpensive, safe and environmentally friendly traffic branch is becoming increasingly significant. The biggest disadvantage of this traffic branch, lower vessel speed compared to road and railway vehicles, is reduced by the development and application of advanced navigation and information systems (ITS), which enable navigation by night and in adverse weather conditions (e.g. fog). Sustainable and environmentally acceptable traffic on inland waterways provides a solution for congested road infrastructure and offers transportation alternative for the countries of central and south-eastern Europe.

Beside many advantages of telematics-supported intelligent transport systems the most important are the following: increase of safety and traffic route capacities, lower environmental pollution, fuel savings, shortening of transport times and cargo handling activities, as well as better information level of all traffic participants.

NOTES

KOVAČEVIĆ, D.: (1999.) Luka Rijeka kao osnovni čimbenik željezničkog prijevoza Jadran – Srednja Europa, Master's Thesis, Sveučilište u Rijeci, Rijeka.

EU Transport in Figures, European Commission, DG VII, Bruxelles, 1997.

SABOLOVIĆ, R.: (2000.) Intermodalni prijevoz tereta, *Suvremeni promet*, Vol. 20, No. 1 – 2, Zagreb.

REFERENCES

GOLD, H., KOVAČEVIĆ, D., KAVRAN, Z.: (2001.) *Informatika u prometnom inženjerstvu 1*, Fakultet prometnih znanosti, Zagreb.

LANOVIĆ, Z., ŽAGAR, S., KLJUČARIĆ, M.: (1999.) *Suvremene koncepcije i tehnologije vođenja prometa u gradovima*, *Suvremeni promet*, Vol.19, No. 1 – 2, Zagreb.

BOMBOL, K. M.: (2001.) *Moderne tehnologije – inteligentni sustavi komuniciranja u prometu*, *Suvremeni promet*, Vol. 21, No. 3 – 4, Zagreb.

www.warwick.ac.uk

CHEN, K.: (1999.) *Intelligent Transport Systems: Today and Tomorrow*, *Promet – Traffic – Traffico*, Vol. 11, Supplement No. 4, Portorož, Trieste, Zagreb.

www.siemens.com

ŠTRUMBERGER, N., KLJAK, T.: (2002.) *Utjecaj tehnologije inteligentnih transportnih sustava na zaštitu okoliša u prometu*, Zbornik radova desetog međunarodnog znanstvenostručnog savjetovanja “Promet i okoliš”, Hrvatsko znanstveno društvo za promet, Opatija.

Proceedings of 5th World Congress on Intelligent Transport Systems, Seoul, 1998. (CD-ROM).

www.hel.fi

FINN, B. ET AL.: (1996.) *The Use of Transport Telematics in Inter-Urban and Rural Bus Services*. In: *International Conference on Public Transport Electronic System*, 1996, no. 25, 5-10: IEE.

GOEDE, E. & NIJKAMP, P.: (2001.) *Travel information on urban public transport: a comparative analysis of Berlin and Amsterdam*, *Trasporti Europei*. Rivista quadrimestrale di Diritto, Economia e Ingegneria dei Trasporti. Anno VII – Numero 18, Trieste.