Session 3

Intelligent Transport Systems

THE ESTIMATION OF CURRENT POSITION OF INTELLIGENT TRANSPORT SYSTEMS (ITS) AND THEIR IMPLEMENTATION IN LITHUANIAN ROAD SYSTEM

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This paper presents analysis of current position of intelligent transport systems. There are the productivity and operational efficiency, comfort factors of ITS showed in the article. The analysis of the major local transport problems and driving forces, the ways to help ITS to tackle transport problems and plans for the future by ITS are given. The existing situation of measures of ITS deployment and their implementation in Lithuanian road system is showed.

Keywords: ITS architecture, ITS packages, qualitative analysis, ITS strategic planning in Lithuania

1. PRODUCTIVITY AND OPERATIONAL EFFICIENCY

ITS can make transport operations more efficient. Fleet management systems can reduce administrative and operational costs and deliver substantial improvements in productivity, e.g. by enabling reliable journey time calculations and just-in-time delivery; and using positioning and communications technologies to enable the most effective deployment of drivers and vehicles. Electronic pre-clearance (including across borders), compliance checks and weigh-in motion are major time savers. Wider benefits include more reduced congestion and pollution, and less risk of accidents due to monitoring vehicle and driver condition [1, 2]. Relevant ITS services include:

- Fleet management;
- Computer-aided dispatch (CAN);
- Automatic vehicle location (AVL);
- Automatic cargo tracking;
- Electronic pre-clearance;
- Vehicle compliance checking;
- Driver monitoring.

2. COMFORT FACTORS

Users of any transportation systems need to feel comfortable, confident and secure.

Route confirmation, journey time estimates and clear advice on approaching interchanges and connections all play their part. Speed controls, ramp metering, advance incident and congestion warnings, and alternative route guidance can make road journeys easier, and less stressful.

Facilities such as multimedia systems that provide both entertainment and navigation can do this too. Public transport users also expect high standards of comfort, convenience and service. ITS can provide the real-time passenger information, automated scheduling and priority systems needed to improve public transport. Relevant ITS services include the following:

- Real time traffic and public transport information;
- Dynamic route guidance;
- Automatic vehicle location (AVL);
- Smartcard payment systems for toll highway and public transport use [1, 2].

3. INCREASE TRANSPORTATION SYSTEMS EFFICIENCY AND CAPACITY

The analysis of benefits has explicitly considered improvements in the effective capacity and improvements in traffic flow over the existing transportation system infrastructure of the several countries. The ITS macro-packages from the ITS architecture potentially will be providing the highest level of benefits, at least in the short term, include:

- Autonomous Route Guidance;
- Broadcast based ATIS;
- Interactive Traveller Information;
- Dynamic Route Guidance;
- Integrated Transportation Management/Route Guidance;
- Surface Street Control;
- Freeway Control;
- Regional Traffic Control;
- Incident Management System.

Alone, each of these ITS macro-packages hold out the benefits in the form of reduce network travel and delay times, reduction in the number of stops.

These ITS packages provide what seem to be the largest possible gains in transportation systems efficiency in the short run from early deployment.

These gains in systems – wide traffic flow may have considerable implication for induced demand in the travel network. For this reason, it is believed that the ITS architecture must be deployed in a manner that is consistent with local transportation planning and policy objectives. Moreover, it is believed that the architecture can be used to support management of demand, including effects on air quality and the environment [3].

4. IMPROVE SAFETY

The preliminary qualitative and quantitative analysis of safety benefits of the ITS Architecture of the several countries and its corresponding ITS packages suggests that there are significant safety benefits that can be addressed through ITS. Possible ITS macro-packages that could be early and likely big winners from the point of view of safety benefits include as follows:

- Transit security;
- Emergency response;
- Roadside Commercial vehicle Operation (CVO) Safety;
- On-board CVO Safety;
- Mayday Support;
- Vehicles Safety Monitoring;
- Emergency Routing;
- Incident Management System.

In the above description of benefits, there are clear advantages to these ITS macro-packages. Generally, as one might expect, safety are likely to be realized through prevention or early detection of hazardous situations, speedier notification of incidents and emergency situations, and faster response to incidents and other travel-related emergencies. In such cases, significant improvements in vehicle safety seem possible, and are likely to be technically feasible in the short term (5–10 years).

The benefits of more vehicle – based safety systems are still uncertain at the time; however, further investigation of these technologies and their capabilities may give additional insight into the timing and likely benefits of these ITS macro-packages [3].

In any case, it seems that the more advanced vehicle safety ITS packages are not going to be implemented in any significant way before at least in the 5-year time.

The ITS architecture of the several countries incorporates reasonable mitigation approaches to these issues. In response to the first point, our preliminary architecture definition emphasizes vehicle-based functionality, and thus minimizes the need for critical external interfaces.

As for the second point, the critical system design issues are based on potential deployments of the architecture. To this end, it has included important design criteria in development of the architecture's performance requirements.

5. INCREASE ECONOMIC PRODUCTIVITY

One of the stated goals of the ITS program of the countries is to improve economic productivity. Certainly one perspective on improving economic productivity involves providing individual users as well as public and private agencies with a more effective and cost-efficient means of doing business.

The ITS architecture supports a broad range of ITS packages that contain this feature, primarily through automating processes that are now conducted manually, or also by improving the flow of information within the transportation system.

5.1. ITS Packages Increasing Economic Productivity

There are many ITS packages within the ITS architecture to improve personal and corporate productivity. First, in terms of financial transactions, the ITS architecture supports several ITS packages to enhance and automate financial transactions for transportation services.

This may take the form of a debit or smart card to pay for services electronically, or setting up an account with a service provider that is debited (or credited) whenever the system is used. As such, the architecture reduces the cost of manual collection and cash handling. There are substantial financial savings that may be realized here, as evidenced by the development of billing support services, smart cards, and debit cards in other (non-transportation) industries.

Within the ITS architecture the ITS packages that support this function include:

- Dynamic Toll/Parking Fee Management;
- Passenger and Fare Management.

Other ITS packages seek to automate service delivery, or simply reduce the administrative costs of various transportation functions. For emergency management systems, the emergency response and mayday support ITS packages reduces the level of manual handling of emergency calls by providing geographic referencing for incoming calls and forwarding of messages automatically to appropriate personnel.

The CVO safety ITS packages allow the vehicle driver to monitor vehicle and cargo condition, thus allowing prevention of CVO incidents and faster response to vehicle and cargo hazards [1-3].

Perhaps the highest level of benefit for the vehicle, it allows electronic verification of credentials at designated airports of entry, thereby reducing or eliminating the delays that occur when this process is done manually. Delays associated with vehicle weighing may also be reduced by weigh-in-motion capabilities of the weigh-in-motion ITS package.

This ITS package also will be support to electronic filing of credentials with governmental agencies, again saving manual effort and costs associated with performing these tasks manually.

Similar cost and personal productivity improvements may be realized within the transit industry through the APTS ITS macro-packages:

- Transit Vehicle Tracking;
- Fixed-Route Operations;
- Demand-Responsive Operations;
- Passenger and Fare Management;
- Transit Maintenance.

The passenger and fare management and transit vehicle tracking ITS packages provide real-time information to improve transit service. By collecting passenger load and vehicle location information automatically, this reduces the need for manual data collection and increases the accuracy of this data. Moreover, the availability of this data allows for improved service planning, thereby enhancing the job of making transit service more cost-effective and efficient.

Costs associated with service planning and maintenance planning may be reduced by automating the routing and scheduling of services. In addition, electronic vehicle tracking and vehicle condition monitoring (in the transit vehicle maintenance ITS package) allow for reduced manual collection of such information in the field, thereby reducing labour costs.

5.2. ITS Architecture Features Enhancing Economic Productivity

There are several features of the ITS system architecture that enhance the level of economic productivity [3].

First of all, the ITS architecture provides *inter-operability.* Thus, for most of the ITS packages described above, there will be standard interfaces across the countries so that the individuals and firms that use ITS products and services can use them across the country (electronic payment services for commercial vehicles, etc.).

One other aspect of inter-operability that also appears in the ITS architecture is a *commonality of communications systems,* allowing a seamless communications system that may perform any number of tasks. The wide-area communications system may be used for both data and voice messages, and accommodates a broad range of ITS packages. This ensures that many different functions can be accommodated within a single wide-area communications system and interface. Also, the communications systems proposed for, the vehicle-to-roadside communication in the ITS architecture may use a common communications infrastructure for many different functions.

The other advantage of the ITS architecture is that it provides a *modular system with multiple levels of ITS package functionality.* The advantage of this capability for economic productivity is two-fold: firstly, benefits may be realized from a small investment and secondly, the capabilities of a package or set of packages may grow incrementally as an individual or organization is likewise able to grow in their means, but with *compatibility with existing systems.*

This means that the ITS packages are accessible to the broadest possible range of potential users. The market size is thus larger, with a corresponding large set of ITS system beneficiaries [3].

6. THE ANALYSIS OF MAJOR TRANSPORT PROBLEMS AND HOW IS IT HELPING TO TACKLE TRANSPORT PROBLEMS

Table 1. The analysis of different countries of ITS is helping to tackle transport problems

	The Major Transport Problems and driving forces	**How is ITS helping to tackle transport problems?**	**The plans for the Future**
Croatia	• heavy traffic congestion in larger cities • quality of bus and tram services is deteriorating • bad condition of road surfaces; • high accident rates	• traffic information is priority by state broadcast on the traffic situation in the state network • on 9 km of the Split Zagreb highway there is video surveillance and traffic management systems • the sector of the Zagreb–Rijecka highway has weather sensor, surveillance system and VMS for traveller information • some experimental semi-automated tolling systems are in use but at different standards	• more basic electronic data collection infrastructure • real-time information for passengers of public transport both at stops and in-vehicle • information of parking places occupation in real time • radar and speed cameras on busy and sensitive sectors • implementation of network of weather stations along traffic corridors • application of systems for measuring traffic flows especially at tunnels and crossroads

	The Major Transport Problems and driving forces	How is ITS helping to tackle transport problems?	The plans for the Future
Czech Republic	• high increase of traffic volume • poor road quality • very high accident rate and high number of fatalities • transport by rail has declined in favour of roads • the traffic control centres are in a bigger cities (Prague, Brno, Ostrava) • traffic data and information distribution is not yet used for urban transport management	• Prague advanced traffic control and will be used at 25 inter-sectors in Prague 5 • public transport. The bus priority system in Prague is monitored by video at an exposed inter-sector on the outskirt of the city • tunnel integration. Sophisticated traffic control systems are in operation for risk analysis and road tunnel management • ITS on motorways using systems speed detectors, fibre optic signs and flashing lights	• improvement of traffic safety • in Brno a new information system for public transport is underway • each of the 13 newly established regions in the Czech Republic aim to integrate the various modes of transport provided by public and private operators into a singe regional system • information on parking places occupation in real time • dynamic traffic light control and public transport priority
Hungary	• high increase of traffic volume • low quality of road • network and railway infrastructure • rolling stock of public transport is very old • low quality of public transport services • high annual rate of road accidents, although it has been declining over the last years.	• in major cities signal-controlled functions are connected to Control Centres • green wave traffic light systems are commonly used • little done for parking management; Park and Ride facilities are not controlled electronically • Budapest public transport system: Vehicles running on the most frequent lines are monitored by Automatic Vehicle Monitoring System • freight transport management is supported by GPS • traffic control centre gives information for drivers on highway ring road (MARABU) via VMS • Information on public transport timetable is available on Internet	• significant backlog in the information infrastructure • little knowledge about the: advantages of advanced telematics solutions • centralized traffic data collection systems • electronic fee collection • parking management and driver Information via VMS • travel information systems and real-time information at stops and stations • electronic ticket validation and fare collection • better use of GIS technology
Lithuania	• rapid growth of motorized traffic • low quality of rolling stock • parking problems and congestion only in larger cities • heavy through traffic and high emissions in Vilnius	• in Vilnius there are some isolated applications of green waves and some dynamic management of traffic lights • in some large cities (Kaunas, Vilnius, Klaipeda) some basic incident and emergency management can be found • VMS are in use at state roads • advanced modelling and simulation techniques to forecast traffic flows, noise and air pollution are partly used in large cities • automatic traffic data collection system on motorways provides information on road conditions, which is accessible on teletext pages	• implementation of transport control and information centres that collect and process transport related data • public transport vehicle scheduling, control and information systems • parking management systems • real-time information on traffic pollution • passenger and traffic information system

The analysis of different countries showed that there are existing problems in heavy traffic congestion in larger cities, high accident rates, high increase of traffic volume, poor road quality, low quality of public transport service, rapid growth of motorised traffic and showed the plans for the future how ITS is helping to tackle this problems.

7. ITS PLANNING AND FINANCING

In accordance with the experience of foreign countries, the process of creating the Lithuanian strategic planning with regard to all ITS implementation actors [4] is presented in the Table 2.

Table 2. Summing-up of ITS strategic planning in Lithuania

Step	Actions	Existing situation in Lithuania
Step 1	Defining the regional demands for transportation	Tables and forecasts made on the basis of statistical data
Step 2	Inventory of existing ITS	Meteorological/Weather forecast system
Step 3	Review of main stakeholders plans	No existing plans yet
Step 4	Valid agreements between stakeholders	Agreements do not exist yet. Ways should be sought in this direction
Step 5	Analysis of roles and obligations	Agreements should be elaborated with explication of roles and obligations
Step 6	Documentation	Preparing a number of documents defining proposals and reasoning the agreements of all stakeholders

Whereas the ITS environment is complex and multi-lateral, the problem of their creating should be considered on all levels of the State, i.e. by the Seimas of the Republic of Lithuania, by the Government, by the municipalities, by stakeholders, and by all traffic actors. Thus the close cooperation of all these institutions will be ensured.

8. MEASURES OF ITS DEPLOYMENT

The existing situation is as follows:

1. Real time travel information is not delivered.
2. Transport flows on Lithuanian main roads and urban streets are constantly growing, congestion becoming a threat of traffic safety.
3. Traffic management and travel safety does not meet the growing demands of traffic actors, ITS services are not delivered to travellers.
4. ITS initiatives are faint in Lithuania; also there is insufficient support on the governmental scale.
5. Due to the lack of good quality road transport information infrastructure, and as a maritime country through which two main international transport corridors of European importance are going, Lithuania does not exploit all available transit and tourism potentials.
6. Measures of road information infrastructure improvement in Lithuania are insufficiently applied, and their efficiency in road safety is poor.

Objectives: creating of modern road transport information infrastructure by technical parameters and by service quality corresponding to the standards of EU Member States, and accordingly integrated into the EU transport information infrastructure enabling good road safety on Lithuanian roads.

Tasks:

Improvement of road information infrastructure.

Improvement of traffic conditions on roads and streets.

Enhancement of traffic safety.

Creating of accident management system the Table 3 shows ITS services (according to ISO/TR 14813-1:1999) for the period in Lithuania.

Table 3. ITS services (according by standard ISO/TR 14813-1:1999) in Lithuania

Services Category	Service Number	Service name
Traveller information	1.1 1.2	Traveller information Traffic information
Traffic management and operation	2.1 2.2 2.3 2.4 2.5	Traffic management and control Transport Related Incident management Demand management Transport Infrastructure maintenance management Policing traffic regulation
Emergency accidents management	3.1 3.2 3.3 3.4	Emergency services and personal safety Payment for accidents Emergency vehicle management Hazardous material and Incident notification
Public travel security	4.1 4.2 4.3 4.4	Public Travel security Safety Enhancements for Vulnerable Roads users Safety Enhancements for Disable Road uses Safety Provisions for Pedestrians using Intelligent Junctions and links
Weather and Environmental conditions monitoring	5.1 5.2	Weather monitoring Environmental conditions monitoring
Disaster Response coordination	6.1 6.2 6.3	Disaster Data management Disaster Response management Coordination with Emergency

CONCLUSIONS

1. ITS can make transport operations more efficient.
2. The users of any transportation systems need to feel comfortable, confident and secure.

Route confirmation, journey time estimates and clear advice on approaching interchanges and connections all play their part.

3. The analysis of benefits has explicitly considered improvements in the effective capacity and improvements in traffic flow over the existing transportation system infrastructure of the several countries.
4. The ITS architecture will specify interfaces between ITS subsystems; indeed, this specification of interfaces is one of the main purposes of a physical ITS architecture. The level of detail to which these interfaces are specified is also an important piece of the ITS architecture.
5. Creating of modern road transport information infrastructure by technical parameters and by service quality corresponding to the standards of EU Member States, and accordingly integrated into the EU transport information infrastructure enabling good road safety on Lithuanian roads.

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THEORETICAL BASES OF AUTOMATION OF DESIGNING IN ROAD TRAFFIC

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The questions of projecting of computer-aided design which could allow not only to arrange independently building projects for the road traffic organization (traffic signals, road signs disposal, etc.), but also to formalize the data processing, information counting in the system of automated control system of road traffic are considered in the given paper.

Keywords: computer-aided design of road traffic organization, road traffic control and regulation, automation of designing decisions

The problems of automation of traffic object's designing are broadly known and their decision is vital up to now. At the same time as a rule the attention is paid to automation of designing in road traffic (disposal of traffic signs, road marking and allocation of barriers of different types, calculation of signal control and designing of signal objects, etc.), in connection to absence of typical decisions, especially in rural areas. Of course the sample sign designing for rout orienting is rather formalized and is easy solved (but in typical cases – for instance, CREDO) but the other questions have not been solved yet.

The procedures of scheme projecting of road traffic organization are complicated enough and multi-version. That is why, by taking into account the complexity of designing task formalization, CAD (computer-aided design) must function the expert system which evaluate in *a priori* the variant given of the decision planning and placed variant of the road traffic (together with signal control scheme), which allows making the decision taken by user (designer) in the form of building project.

It is necessary to pay attention to the software product of CAD of road traffic organization, which are widely spread. They are made by world-famous company TRL (Transport Research Laboratory, United Kingdom) [5]:

- *designing of roundabouts* – ARCADY (Assessment of Roundabout Capacity and Delay). The software allows designing the roundabout intersection under the conditions of traffic capacity given, to evaluate the efficiency of road traffic organization on this intersection proposed and given.

At the same time in this software it is possible to change the dimensions of dividing strips, to make the displacement of entrances, to mark road, to allocate traffic signs with specific affixation and also to evaluate the carrying capacity of intersection created by the designer. One of the indisputable advantages is that in the software the designer is a direct user and can by his own to organize pedestrian or bicycle movement – for instance, to organize the movement on the dividing strip, to prohibit the access of pedestrians by means of barriers.

- *designing of non-controlled intersections* – PICADY (Priority Intersection Capacity and Delay). The software allows designing the non-controlled junctions of standard configuration (trilateral and car faxes with dividing strips, traffic islands, etc.) depending on parameters of traffic capacity, to evaluate the carrying capacity of a junction considering different variants of road traffic organization and geometrical parameters designing.

Also by means of the software it is possible to evaluate delays of traffic on the main and minor directions, the moment of carrying capacity exhaustion – when queues will start arise and it will be necessary to make the further perfection.

- *designing of the controlled junctions* – OSCADY (Optimised Signal Capacity and Delay). This software allows by the initial data given (the intention of pedestrian and traffic movement, geometrical parameters of an intersection) calculating the signal cycle parameters and determining the traffic delays (or maximization the traffic capacity of the controlled junction). At the same time the software allows evaluating the efficiency of controlling and road traffic organization on the insulated traffic light. It can be used for the standard intersections (till five entrances) and for pedestrian crossings; it graphs the cartograms of intensity and irregularity (within 24 hours and within a week) of movement, to calculate variants of traffic light controlling for the rush-hours period and rush-off regimes with the defining of length of queue for the any conflict directions of movement on the intersection.

Apparently it is necessary to create the one software complex which would be able to work with all kinds of conflict objects when planning decisions are to be designed. Because it is evidently that controlled junction is non-controlled at the same time when traffic signals do not operate or operates in the regime of amber winking.

More over there are many cases when the roundabout intersections are controlled fully or partly. Plus to all this the specificity of the controlled junction is the trouble of cabining of cable supplied the controller, then from the controller to the traffic light controlled, traffic detectors, indicator panels and other peripheral devices.

That's why as realized the basis could be the software which designs the traffic signal – pedestrians crossing or junction controlled and depending on the necessity some options can be eliminated (for instance, the installing of traffic signals can be eliminated).

Special software described above represents the totality of the programs realizing automated control system of road traffic and providing the formation of interactions for the entire complex of technical devices, the automation of some designing, analytical and researching functions.

At the same time while designing the traffic road organization the following task are being solved: the optimisation of decisions (organization, controlling and designing) from the point of view of quality of building designing decision (profits, minimum of losses quality, etc.), losses for the designing, building and exploitation of the object, defining of initial parameters for designing depending on the assigned by designer task, the working out of total system if interactive control of the process of designing (from the task definition, entering initial data to the result of calculation of objective function and visualization of the results – printing the building project of an intersection) correlation [4]. The InfoBase for the designing is represented as the missives of parameters which describe the controlled object and the modes of system functioning.

The typical structure can be represented as it is shown on the Fig.1. It is significant that preparing of InfoBase is the most laborious process for today.

Apparently CAD – it is not simply build in automated control system of road traffic complex of the correlated programs allowed on the basis of using up-to-day methods of optimisation to design the schemes of road traffic organization and to calculate the modes of traffic flows controlling on the traffic signals that provide the minimum of delays and stops of traffic and other characteristics and delays in road traffic but also reflected the real situation about dislocation of *Technical Devices of Road Traffic Organization and Road Traffic Controlling* (TDRTORTC)

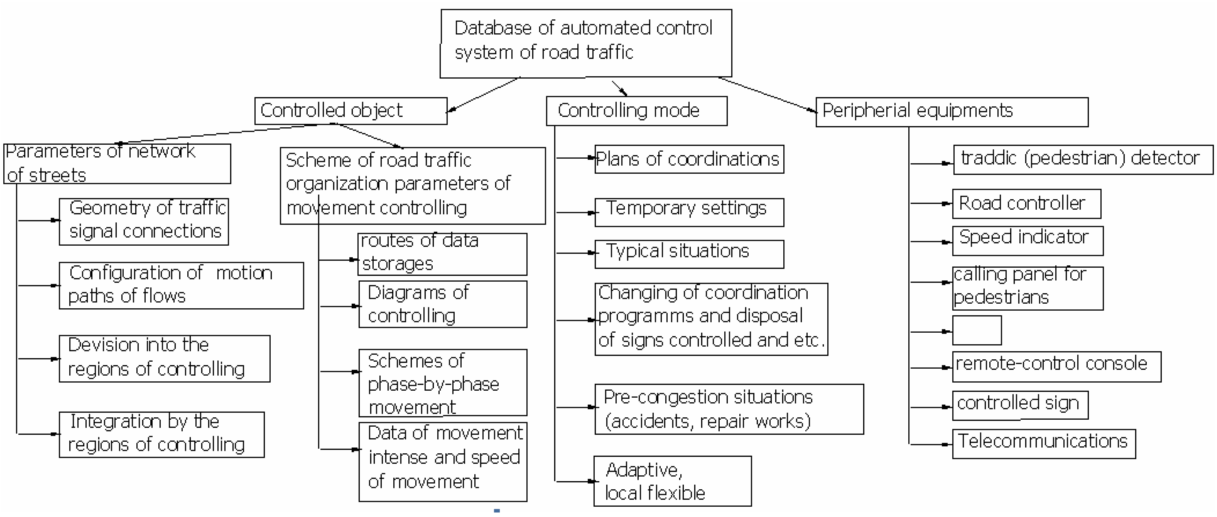

Fig. 1. *Structure of InfoBase of CAD automated control system of road traffic*

That is why there is possible the creation not only CAD but the technology and software for the automation of the Particularized Assembling and Building Enterprise (PABE) namely structural subsections for the counting, arrangement and planning of technical, building and assembly, technological, designing and estimating, aimed at arrangement and maintenance on the appropriate level of TDRTORTC, located on the subordinated network of streets of a city, rural area, district.

The functions of formations of TDRTORTC dislocation (traffic signs, traffic signals, devices for their installation, road controllers, barriers, directing devices, traffic detectors, information indicator panels and panels, controlled signs, artificial irregularities and roughness, road marking, etc.) are designed for the further integration in a one workstation of an engineer PABE. The function of counting the work of subdivisions which fulfil the installing and maintenance of the TDRTORTC are included in the workstation of technically qualified person of PABE and workstation of manager. The functions of planning the work of subdivisions serving TDRTORTC are included in workstation of manager.

The functions of counting materials consumption and other costs are included in the workstation of technically qualified person. All the functions can be united by the concordance.

The technology and software being designed are meant for:

- Creation, designing and further formation of TDRTORTC dislocation by using the electronic map of network of streets of city which is given by costumer;
- Representation, visualization and actualisation of data about dislocation TDRTORTC on the electronic map of network of streets;
- Creation of database and I&R system for TDRTORTC (the place of location, kind and way of fastening, spatial characteristic and time response, the history of service, territory and terms of operating;
- Counting of the service works and service request for the service of TDRTORTC.

The development of t means for interactions between user and the software includes the functions of evaluation and selection and also information preview in graphics mode of objects of electronic card and of whole card, inputting the information about changes (modernization, arrangement, etc.) TDRTORTC on the card, representation the information about TDRTORTC in conversational mode by the appropriate hierarchic request (all the actions are realized as graphic or textual notes, changes in database are provided by explanation and information with common source of information inputting.

The software proposed includes as follows:

1. *Model of executive program (start);*
2. *Module of the automation of designing, counting and dislocation of traffic signs;*
3. *Module of the automation of designing, counting and drawing of road marking;*
4. *Module of the automation of certification of traffic signal objects;*
5. *Module of the designing of traffic signal objects:*
   5.1. System;
   5.2. Local.
6. *Module of the automation of counting the material consumption:*
   6.1. While marking the road;
   6.2. While dislocating traffic signs;
   6.3. While installing (dismantling) of traffic signal object;
   6.4. While installing TDRTORTC (traffic detectors, barriers, controlled signs, variable information);
   6.5. While modernizing (replacement, installation, testing) of controller;

It is significant that counting includes the way of fastening technical controlling devices, the place of dislocation, the method of fastening, costs of current maintenance and so on.

7. *Module of the automation of planning revisions organization, modernization and repairmen (for all the kinds of technical means of system and TDRTORTC);*
8. *Working out the module of combination ОДД for streets (rural roads);*
9. *Working out the module of combination TDRTORTC for the conflict objects;*
10. *Module of the information adding and deleting, interchanging with others databases and graphics editors.*

All the programs (as the software at all) must be provided by the instructions for a user.

Database TDRTORTC consist of 6 sections (Fig.2): *1.Traffic signs (catalogues); 2. Devices for the installation traffic signs and light advertisement, controlled signs; 3. Equipments for traffic signals (including road controller, connected informational panel, traffic detectors, etc.); 4. Road marking; 5. Cable network (the way of cabling, sewerage system).*

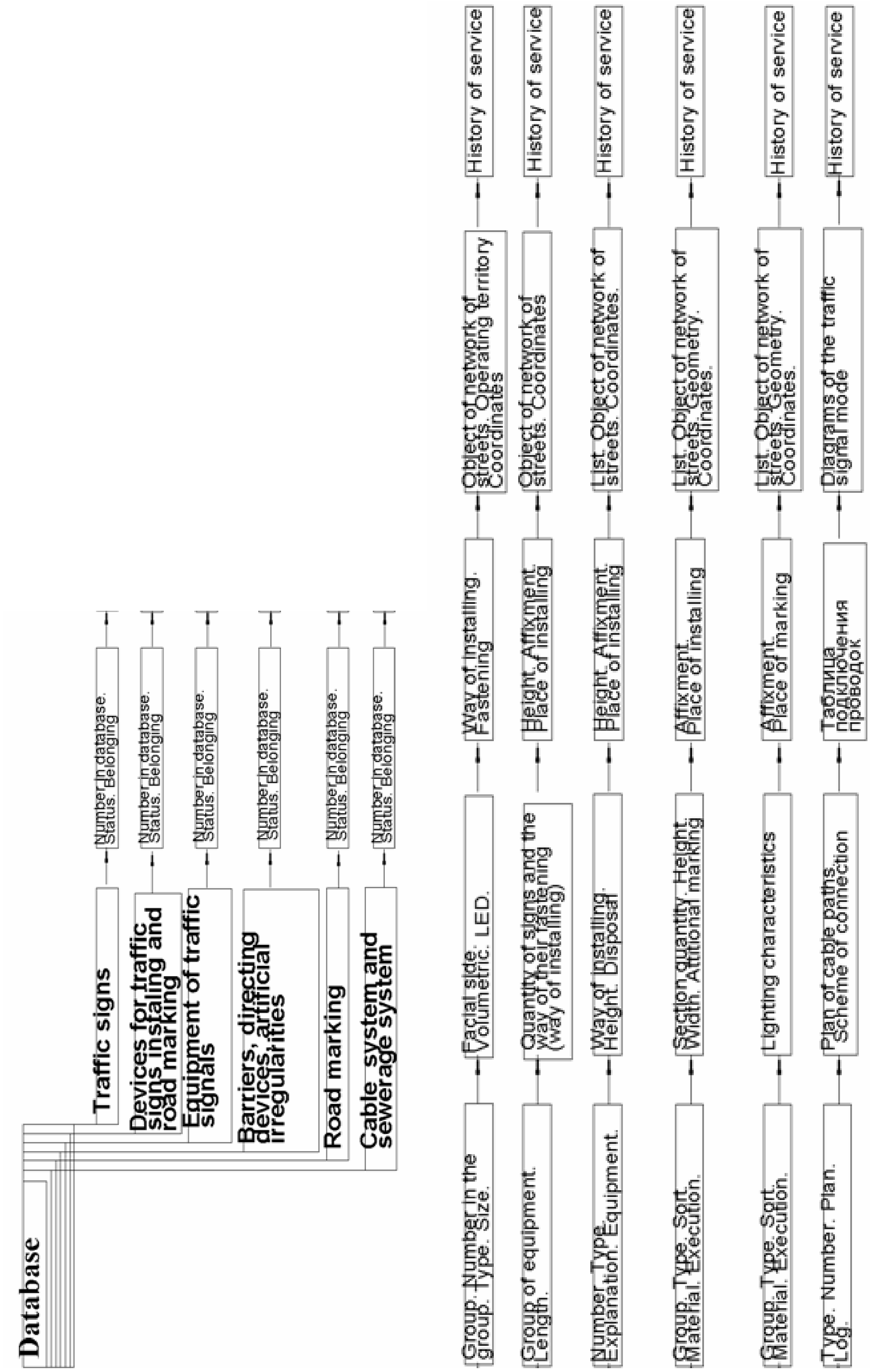

***Fig. 2.** The basic elements of the Database*

The sections differ in structure (quantity and content of database fields). The coordinates for the placing on the basis (electronic map) with the further scale affixation and some active fields are common (for instance, the present condition).

The number of TDRTORTC in the database is provided by an absolute number of all the system.

The information can be entered separately for each section of database and to be activated in succession separately, and if the variable parameters are common the information can be activated in the whole database.

For the work with database (scanning and representing TDRTORTC, selecting, forming the reports, entering to the electronic map) it is proposed to the user to work with any set of TDRTORTC – from the definite TDRTORTC (for example, traffic sign) till all the database(together with other sections).

The subsection “traffic signs” includes the following information which is necessary for the analysis and counting the data: Number of TDRTORTC in database, status (the expediency of the installing is defined; the project is made but not installed, installed, installed instead of traffic sign, installed temporary; installed for the season; there is a task for the dismantle, but the object has not been dismantled; dismantled, traffic sign is installed instead of the object, dismantled; dismantled for a season (the number of a season); belonging to (housing and communal services, communal administration “Minsktrans”, etc.; group of traffic signs under STB 1300-99 (separately for the non-standard traffic signs), the number of TDRTORTC in the group under the STB 1300 (or STB 1140 or other); information of the traffic sign (the speed mode, movement direction on the traffic lanes, existence and sizes of incline, slipperiness, evenness, the radiuses of curbs curving of carriageways, etc.).

It is indicated the marking of information indicator panels existence installed with traffic signs (quantity of indicator panels, names, category of inscriptions), type and size of signs, type of TDRTORTC (flat, volumetric, LED); the kind of facial surface (painted, with retro-reflecting surface of usual or high-quality materials, one-sided or double-sided glass, one-sided or double-sided light-emitting diode matrix); the characteristics of the basis (zinc coating, aluminium, ferrous metal (primed), plastic, plastic or metal frame); operating conditions (for volumetric and LED types) (constant, flashing, 24 hours’, cyclic – for signs of variable information); the way of installation (on the post, signal post, lamp standard, contact system mast, information pillar, presence of additional brackets and devices). By this way it is possible to indicate the kind of the device: lamp standard (or contact system mast), the shape of it (round, square; hexahedron, octahedron, etc.), contact system mast (without lightening) trolley pole, bracing wire or typical bracket (by what project, marking of construction), wall of the building, construction, fence, pavilion of bus-stop or the engineers can indicate the other way of installation and fastening. It is also indicated the diameter of a pillar (in automatic mode while creating a database of existing typical pillars or by a user); the height of installing and disposal (spatial coordinates); affixation of dislocation (city district and sector, street, its type and status, even or odd side of street, to and fro stage) and direct place of installing (main carriageway, entrance to the street or exit, courtyard territory, local streets, crossed street, the closest orienting object (street, house number) with location in transverse profile (right or left side of the street, left or right of dividing strip, under the carriageway (in the centre, on the right, left), on the traffic island, etc.). Belonging to the object of network of streets (number and name of the object), operating territory (under the STB the number of operating territory for every traffic sign with coordinate affixation, describing operating territory); history of service.

For taking into account the specificity of traffic signs installation there is a special block in the software – devices for the installing of traffic signs, which contains the following information: number of TDRTORTC in database, status and belonging, group of equipment (post of traffic sign, bracket, bracing wire, foundation for a post, panel for fastening of traffic sign, panel (model) for drawing traffic sign, two-post frame (“gate”) or three-post, frame with installing on the post and pillar, post of ferrous-concrete, two-post frame on the ferrous-concrete posts, etc., method of fastening (clamp, bracket, threaded connection, etc.); sort of TDRTORTC under the all-USS (all-Union State Standard), SCR (Sanitary Code and Regulations), STB (Standard of the Republic of Belarus), etc., length (m), material, quantity of sign being installed, way of installing, height of installing, affixation and disposal, belonging to the object of network of streets, the history of service.

Separately the special block for the counting of equipment is distinguished. It includes as follows:

1. Number of TDRTORTC in database;
2. Status and belonging;

3. Group of TDRTORTC (traffic signals, controllers, devices for traffic signals installation, commutation devices, display of traffic light, indicator panel of operating by pedestrians, traffic detectors, information indicator panel, communication facilities (cellular, radio), other);
4. Type of TDRTORTC:
   - for traffic signals (traffic, pedestrians, tram, railway);
   - for controllers (Modular system of controlling devices of road traffic microprocessor-based, relay-thyristor, DUMKA, Byelorussia road controller, other);
   - for devices for installing traffic signals (transport or pedestrian post, bracket or bracing wire, contact system mast of tram (trolleybus) or lamp standard, bracket support or external bearing);
   - for commutation devices (signal case, junction box, terminal-block, metal-ware for installing counter or automatic machine of switching off;
   - for displays (rectangular or topped height large or small, low, large or small, colour, dimensions);
   - for calling panel for pedestrians (dimensions, way fastening and arrangement)
   - for traffic detectors (kind of sensitive element, way of arrangement or connecting and installing, quantity on the object or disposal on the entrances);
   - for commutation facilities (kind of commutation, station, etc.);
   - other devices.

For every type of TDRTORTC there is created its own guide of numbers;

5. Sort of TDRTORTC. Every type of TDRTORTC can have its own guide of sorts and numbers of normative documents;
6. Additional data (pavement and its condition; the way of installing (for road controllers – the type of foundation, the way of cabling; height of installing and affixation to the place of installing; belonging to the object of network of streets (number and name of the object); history of service).

Describing of protecting and directing devices besides of standard data (number of TDRTORTC in database; status and belonging, disposal and affixation, belonging to the object of network of streets, history of service), includes also name of the group of TDRTORTC (traffic or pedestrians barrier, directing device, artificial irregularities and roughness); type of TDRTORTC (– for traffic barriers (barrier, parapet, banisters, rope); – for pedestrian barriers (weld-fabricated banisters or cast banisters, net, plate); – for direction devices (ferrous-concrete case, permanent or mobile border), flash-light, build-up construction); – for artificial irregularities and roughness (metal-ware, asphalt concrete, concrete, plastic (cold or hot), rubber); sort (number under the normative document), material, length (width) of section and their quantity, height and coordinate disposal.

Standard information which is asked and requested by user is the following: number of TDRTORTC in database; status and belonging, group of traffic signs under STB (also vertical or horizontal disposal), number of TDRTORTC in the group under STB, type, colour and material of TDRTORTC (marking material, kind and type of lacquer coating, maker, cold or hot plastic, enterprise making the marking), the place of marking (along the surface of border, etc.); parameters of separate elements (name, code, date of drawing, length and width of lanes, curving radius, width of traffic lanes and width of carriageway, dimensions of marking, colour of lanes, retro-reflecting capability) for the road marking (for vertical marking – the values of dimensions and acting restrictions); expenses rate for the road marking (square and consumption of paint or plastic); belonging to the object of network of streets (number and name of the object), history of service.

Special attention is paid to cable network, and ways of cabling. This section includes the following information (Fig.3): plan of cable paths with net of the Organization of regulation and controlling of road traffic and point of connection of a road controller (Fig. 3c); scale with indication of geometrical parameters, evenness, slipperiness, dislocation of road controller and point of connection, etc.); the scheme of electro supply of traffic light post (Fig. 3a); the indicator panel of affixations (distribution) of power modules; the indicator panel of connection external cables; schedules of operating modes of traffic light signal system – Fig. 4 (the scheme of phase-by-phase movements, and the diagram of traffic light cycle with numbers of traffic signals; presence of coordination on traffic light object (centre or without centre) and other); the scheme of external connections of peripheral means (Fig. 3b); cable log; the plan-scheme of cable distribution; grounding of the road controller and the base for installing of the road controller; the road controller (the name, date of manufacturing, quantity of power circuits and a required complete set, modularity, communication lines, connection to controlling centre or territorial controlling computer system, parameters of traffic and pedestrian loading); register of amounts of works and specifications (other acceptance information). All data are rendered with the corresponding affixations, and scale plans.

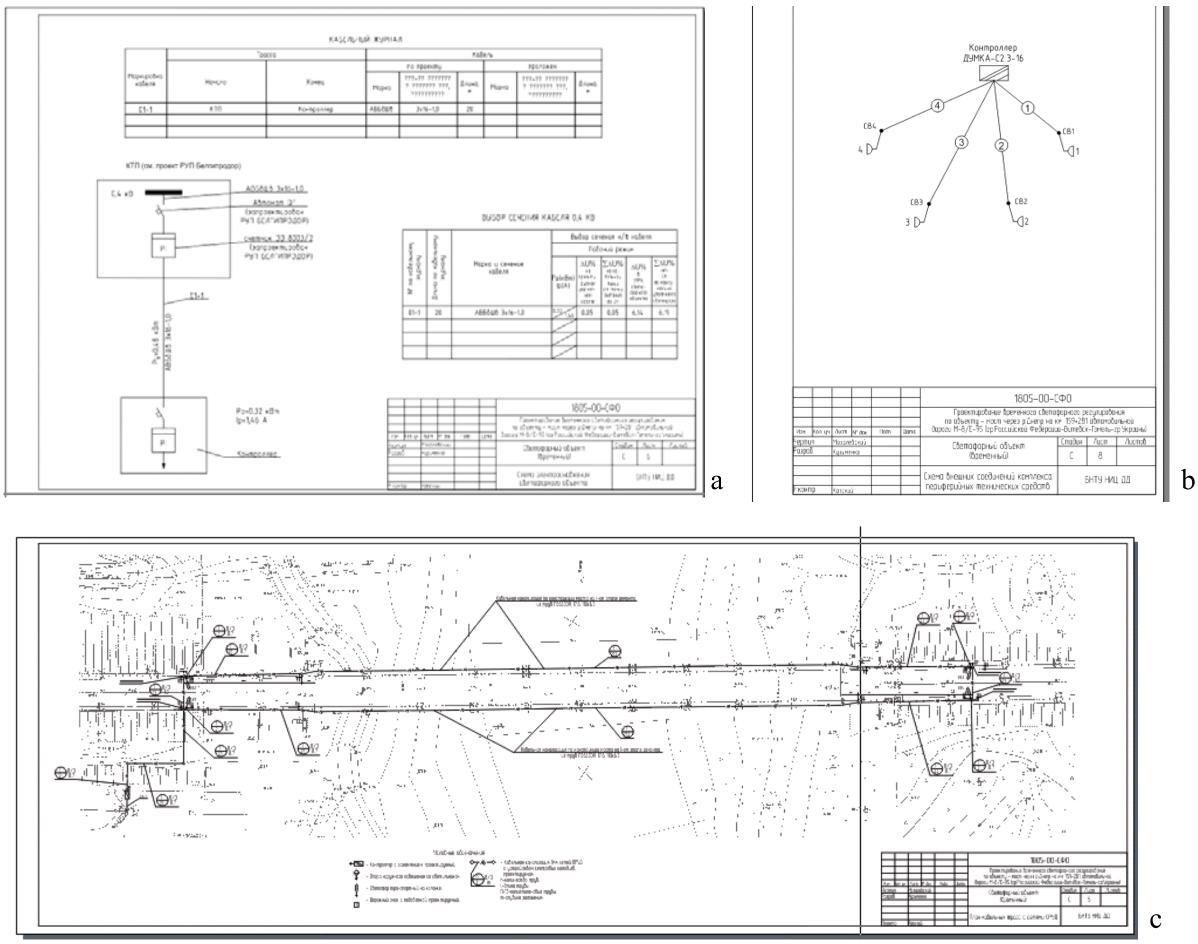

Fig. 3. *Documentation of the building project formed on sections for traffic light object*

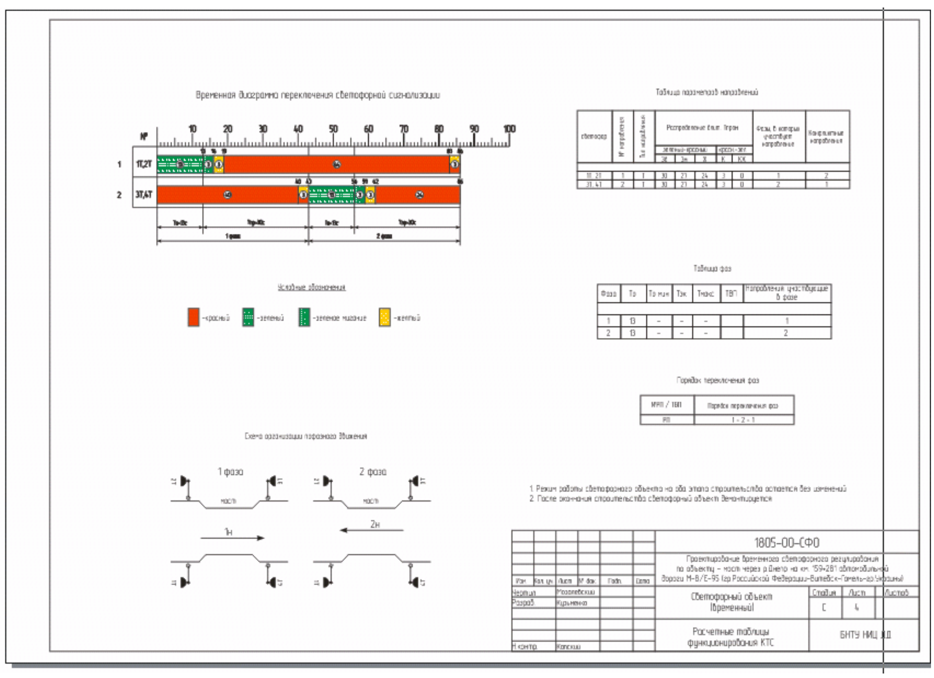

Fig. 4. *Documentation of the building project formed on sections for traffic light object*

In section ”the History of Service” is registered the full information on the works which are carried out with the given TDRTORTC (a kind of works (from the directory of works); number (or other document) and date of drawing up of the task for performance of works; a post and first name, middle initial, last name of the person who have made the task; date (number, month, year) and time of performance of works (hours, minutes), together with the executor of works (a site, a part, a brigade, a surname of the person); first name, middle initial, last name the person who have brought in the information in a database; number of the act of performance). Also the directory of works which is broken into five basic parts conducted:

1. *Traffic signs* (installation of traffic signs on a post, on a bracket; on a support; on the post (temporarily); on a bracket (temporarily); on a support (temporarily); on a barrier; on a building; routine maintenance or emergency repair or replacement of a sign; installation of a sign, instead of demounted; dismantle of a sign for installation instead of other sign; dismantle or rearrangement of a sign; replacement of lamps in a volumetric sign or a light-emitting diode matrix (a bridge, replacement of glass); cleaning, washing, painting of a sign from a underside; pasting of fine retro-reflecting details and restoration of a sign without dismantle).
2. *The devices for installation of signs* (installation instead of other devices with the indication of the device dismantled; painting of the post, a bracket and collars; alignment of the post; dismantle for installation instead of other devices or full dismantle, installation on the base and other).
3. *The equipment of traffic light signals* (a maintenance of object with the controller; maintenance service of flashing devices and traffic signal’s heads; painting of traffic signal post, a cable protection and spiral wrap hoses, traffic light cases; replacement a calling panel for pedestrians, pedestrian information panel, controlled road sign, detectors; repair of a post, etc.; installation or the arrangement; installation instead of other equipment with the indication of the equipment dismantled); dismantle for installation instead of other equipment; dismantle).
4. *Barriers and directing devices, artificial* roughness (servicing of pedestrian barriers, painting and repair of barriers (with application of welding or without), replacement (dismantle, installation) a ferrous-concrete or plastic curb-stone, its installation, or installation instead of other equipment or dismantle for installation instead of other barrier; the device of roughness, its repair, marking, dismantle).
5. A road marking (servicing, drawing, removal of plastic, drawing stop, and so forth).

The separate database of requests and tasks for repair, installation, dismantle and installation, and also reflecting and counting of their performance are developed. The list of the works included in the task, is chosen of the directory of works. After performance of works the information on kinds of works on separate positions (executed or not executed) is registered in a base with display of a concrete affixation of works to TDRTORTC and on the fact of performance the mark is put. The following structure of a databases of tasks is used: number, type (scheduled, emergency); date and time of carrying out; a required kind of works; a place of performance of works, and also a scheme of their performance (if necessary and temporary scheme of road traffic organization for the period of work); first name, middle initial, last name the person who are giving the task, both the executor (executors); date and time of a mark about execution; first name, middle initial, last name of the person who have brought the information in a base.

The database of requests and tasks on possible technological operations (see above) and reports with the instruction of a list of the carried out works, for the required period, and an opportunity of graphic visualization (diagrams of the executed works for the chosen period, schedules of change of quantity established by TDRTORTC for every year, every month, distributions of quantity of TDRTORTC on sections and groups, on conflict and linear regions of the network of streets) is separately formed.

By the separate module the program realizes the following target documents which also can be printed or placed on the external carrier:

The FORM 1 – inventory of controlling means of movement on traffic signals;

The FORM 2 – inventory of controlling means of movement on signs;

The FORM 3.1 – installation of controlling means of movement for the specified period (traffic signals);

The FORM 3.2 – installation of controlling means of traffic for the specified period (traffic signs);

The FORM 3.3 – installation of controlling means of traffic for the specified period (marking of a road);

The FORM 4 – the act on write-off signs by types for the specified period (also on traffic signals and others TDRTORTC with precise defecting and a complete set);

The FORM 5 – the list of failures and the centres for the certain period with the indication of a place and the reasons of occurrence (according to a card);

It is planned, that the user of system will have an opportunity to draw (to edit or bring in corrective amendments) in a map of a region of a network of streets with TDRTORTC put which list is defined by a field of the filters (requirements) declared to execution. The map is displayed by separate elements (objects) with a necessary level of detailed elaboration (the name of street, contours of houses, support of illumination, contours of traffic signals and traffic signs, etc.), rendered on it as an additional level-by-level sub-base, it is prepared and filled in by the Executor within the framework of the given contract or under the separate contract (cost of the given works is stipulated with the Customer separately and does not enter into the given amount of works).

The Executor can draw an electronic map (by coordinates): with all traffic signals and the equipment for their installation (Fig. 5); road signs, road marking, volumetric sign, road controller, traffic (pedestrian) detector, illuminated signs; with all demounted traffic signs, traffic signals and foot protections, artificial roughness; with cable networks and the sewerage system; passports of traffic signs (a cycle of controlling, an operating mode of traffic signals) and other in standard, perceived by system, packages (Autodesk (Autocad), CorelDraw, etc.). Representation of TDRTORTC on a map can be in several variants (a contour; a contour with number of TDRTORTC under the normative documents and in a database, a contour with number of traffic sign under SNB and the indication of type and the text).

It is significant, that at introduction of system, either by experts of PABE or a designer, it is possible to transfer to an empty database available in PABE the data on disposition of TDRTORTC and cabling of networks, and also further to develop and make changes on a disposition according to requirements of TDRTORTC maintaining the organization (to serve and further to fill a database, to modernize it).

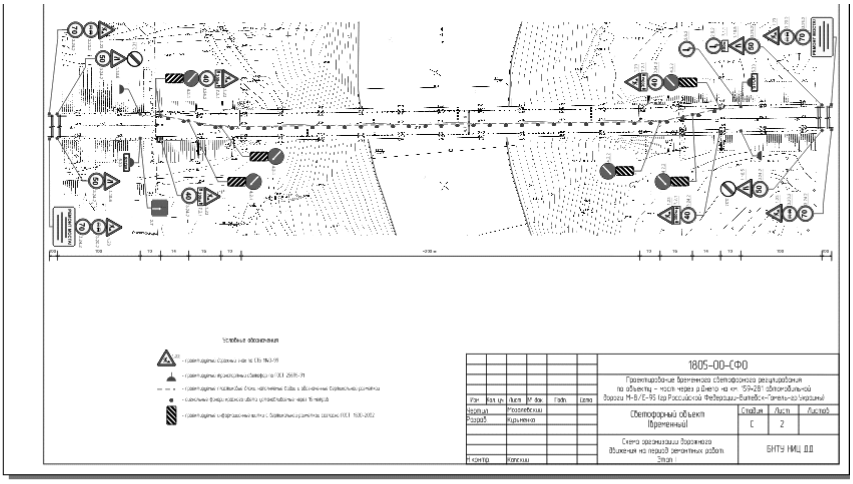

Fig. 5. *Scheme of the organization of traffic (accommodation TDRTORTC)*

Moreover, now there is a work on combination of the given design system with the research system developed also in BNTU which allows optimising the traffic light cycles, calculating and planning coordination, automatically forming sample forms for input in the road controller.

However, for today, it is necessary to introduce techniques for definition of efficiency, definition of losses in traffic in order the calculations resulted in the program are legitimate.

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INVESTIGATION OF TEMPORAL DATA MODELS IN INFORMATION SYSTEMS ON THE RAILWAY

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Temporal technologies are highly demanded in the databases which serve operation of transport. But transport systems possess a number of features, such as great volumes of data, increased requirements to integrity and availability of data. Special conditions of management of versions of objects, use of a calendar and periodicity are peculiar to temporal objects of these systems. The following work investigates the features of construction of temporal systems and pays special attention to these special cases. The special kind of temporal relations with overlapped time lifespan is estimated. The CIA model of information security is recommended to use for the estimation of temporal models. The given examples have been executed with the reference to problems of information-analytical systems of the railway.

Keywords: temporal databases, lifespan, periodicity, integrity, availability

1. INTRODUCTION

Temporal technologies are highly demanded in the databases serving operation of transport. Analysing, planning and forecasting the activities of the enterprise, as well as maintenance of its daily operation functions – all these tasks have the temporal basis. The perfect temporal data structure and the reasonable way of access to it lead to the effective overall performance and quality of functioning of the information-analytical systems (IS) responsible for the functioning of these tasks.

The given research is devoted to the problems of description and management of temporal objects. Temporal character of objects in transport systems is so diverse and full of nuances that use of the well-known methods for their description in a database and approaches to management of them is not always optimal, or even comprehensible.

Some problems on transport are allocated with special requirements to a lifespan [1,2] of temporal objects. For them it is very important to have a faltering lifespan and to inure repeatedly (several times during an action to enter and leave a “shadow zone”). An example of a problem with such requirements is the system of account of schedule of passenger trains [3]. Temporal object in it is the schedule. The same version can be actual during a certain period of time and repeatedly leave for a “shadow zone”. As, for example, the basic train diagram for some days can be changed for other schedule adapted for carrying out repair work on railways, and after they have finished to come into force again. Many sources [2,3] show the cases when one version of object exists only during the continuous period of time and does not appear again. The other example of necessity of interruption of a lifespan are the problems that arise if the management of temporal object is connected with the calendar and periodicity (holidays, days of week, parity of day, labour shifts and so forth).

The use of the well-known kinds of temporal relations does not allow to describe temporal objects sufficiently enough because sometimes they have the above-mentioned features, which lead to inefficient use of disk space and the high risk of infringement of integrity of temporal data in case of their changes. In conditions of constant increase in volumes of data and increased requirements to integrity and availability of the data natural to transport systems the above-mentioned drawbacks become critical.

For the decision of the given problems the author offers to use new types of temporal relations and temporal models of the databases, directed on support the specificities of management of versions of objects, a calendar and periodicity.

This work investigates a special temporal model of the data which does not possess any lacks specified above – the model of the relation with overlapped lifespan. It includes the basic properties of common types of temporal relations, namely an opportunity of existence of several versions of the object which consistently become important. The investigated type of the relation in addition allows the versions of the object to become actual more than once, for a while of being "out of function" or "inactive" to be substituted with other versions. Such functionality enables the lifespan to overlap.

The model of a temporal database using specific time attributes and solving the problem of support of the calendar and periodicity is offered. The special attention is paid to the problem of sequence of filters in case of inquiry to data. Shows the incorrect understanding of sequence of application of filters negatively influences reliability and availability of data. Habitual representation of structure of temporal data in the form of ER-model does not allow showing such specificity designating the order of application of filters.

Research of efficiency of use of the offered type of relations with overlapped lifespan is carried out work from positions of maintenance of integrity and availability of data. For the analysis of parameters of quality temporal models of data it is offered to use model of information safety CIA.

2. FORMS OF TEMPORAL RELATIONS

The important question at construction of temporal DB is the choice of the form of the timporal relation. The form of the temporal relation defines its temporal functionality, influences productivity at work with it, on complexity of access to data and on volume of borrowed disk space. Mainly timporal relations share on a degree of inclusion of the basic temporal attributes: valid time (VT, Valid Time) and time of transaction (TT, Transaction Time). Let's consider these types of time in more detail.

VT – it is a valid time of the fact when this fact takes place in the simulated reality (TDB Glossary, Christian S. Jensen). In other words, VT is the period of existence of the object, characterized by time of the beginning and the termination. Values VT, as a rule, are supported at a level of the user.TT – the period of action of record in a database. It is usually characterized by time of addition of record in a database and time of its logic removal. Values of transaction time it is considered automatically.

Depending on the degree of inclusion presented above temporal attributes 4 forms of relations are allocated [10]: Snapshot, Historical, Rollback, Bi-temporal (see Fig.1). The Snapshot form does not support any of time dimensions. The Historical form supports only attribute of Valid-time. The Rollback form is the only attribute Transaction-time. Bi-temporal form supports 2 time dimensions: Valid-time and Transaction-time. Let's note, that in the standard classification we add a special type of the relation – the Overlapped lifespan relation.

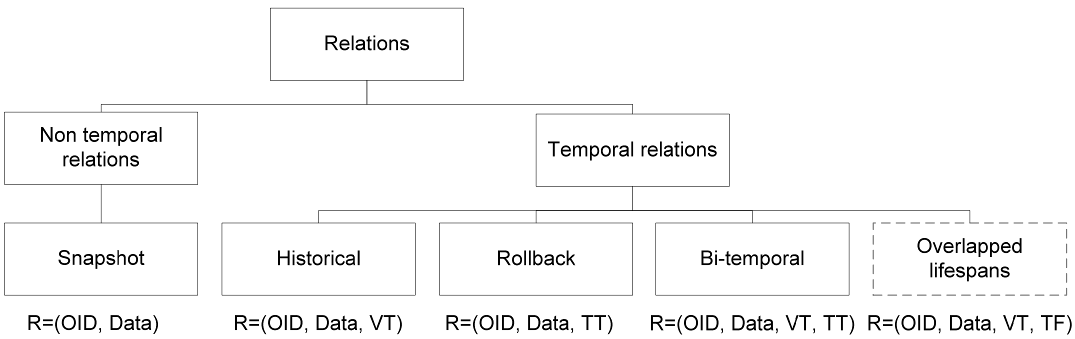

Fig. 1. *The forms of the relations in temporal databases*

Some forms are derivatives of others. For example, by a temporal slice form Snapshot can be received from any temporal relation, form Historical and Rollback from the relation of type Bi-temporal.

All three above-mentioned classic forms of temporal relations to some extent are demanded in transport information systems. Besides the degree of inclusion of temporal attributes the temporal relations also are characterized by the restrictions make to lifespan. An example of such restriction is the condition of existence in the relation only one record describing behaviour of object on all extent of its lifespan, i.e. lifespan of object cannot be crossed or overlapped:

$R = (OID, Data, VT)$, where $((\forall OID)(i, j \in \{1..v\} \wedge i \neq j))(VT_i \cap \mathrm{VT}_j = \varnothing)$,

where i,j – versions of objects.

The relations designed thus, are the most widespread and more all described in the literature [2,3,10,11]. Further we shall name them classical relations. On the basis of these relations it is possible to decide to realize the majority of temporal problems on transport. As an example it is possible to result such problems, as system of railway classifiers and codifiers, tariff handbooks.

But there is a number of problems on transport which demand use of special type of temporal relations – relations with overlapped lifespan. In the modern literature the relation of such type is practically not considered. Whereas, they are absolutely natural data presentation, for example, for such problems, as the railway schedule of passenger trains [1]. The scheme of the temporal relation with overlapped lifespan can be presented as follows:

$R = (OID, Data, VT, TF)$,

where $((\exists OID)(i, j \in \{1..v\} \wedge i \neq j))(VT_i \cap \mathrm{VT_j} \neq \varnothing)$,

TF – time of fixing a transaction. The modified version of TT time. Time of fixing a transaction is formed during the moment of hit or change of record in a database. On the basis of values of this attribute the actual version of object OID is calculated.

As demonstration of efficiency of relations with overlapped lifespan we shall consider a following example.

Example 1. A problem of drawing up of the machinists' schedule.

The essence of a problem consists in fastening a train by a certain machinist. Such fastening has long character. But as a result of holidays, illnesses and other overlays scheduled and emergency substitutions by another machinist are possible. Apparently from the diagram presented on Fig.2, behind some train for the period (01.02.2006-11.07.2006) has been fixed machinist Pavel. Then in the schedule in connection with leaving Pavel the corrections have been brought in scheduled holiday during (03.03.2006-30.03.2006). For this period to operate train it is appointed Tom. In connection with overlays for one day (06.03.2006) Tom has been changed by Albert.

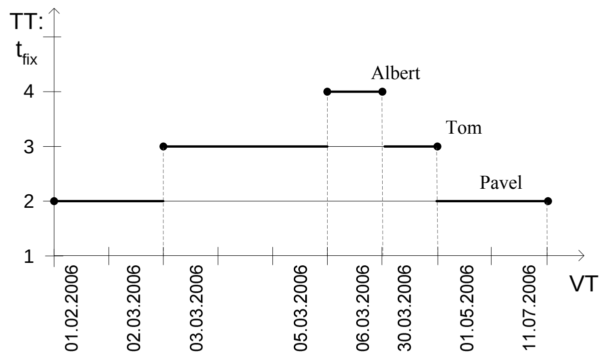

***Fig. 2.** Example of overlapped of object lifespan in schedule of train machinists*

In the classical relation with not overlapped lifespan data can be presented in the form of Table 1. In the relation with overlapped lifespan, the same data can be presented in the different way than it is shown in Table 2. The attributes $\mathrm{VT_{start}}$ and $\mathrm{VT_{end}}$ represent valid time (VT): the beginning and end of fastening machinist in the schedule on a route of a train, TF attribute – time of transaction.

Table 1. Table «train machinist» with non overlapped of object lifespan

OID Train	Machinist	$\mathrm{VT_{start}}$	$\mathrm{VT_{end}}$
123P	Pavel	01.02.2006	02.03.2006
123P	Tom	03.03.2006	05.03.2006
123P	Albert	06.03.2006	06.03.2006
123P	Tom	07.03.2006	30.03.2006
123P	Pavel	01.05.2006	11.07.2006

Table 2. Table «train machinist» with overlapped of object lifespan

OID Train	Machinist	$\mathrm{VT_{start}}$	$\mathrm{VT_{end}}$	TF
123P	Pavel	01.02.2006	11.07.2006	1
123P	Tom	03.03.2006	30.03.2006	2
123P	Albert	06.03.2006	06.03.2006	3

The content of Table 1 and Table 2 show that the relation with overlapped lifespan is more advantageous from the point of view of economy of place, and also without introduction of additional attributes expresses semantics of a problem more clearly. The prize in transfer of semantics is reached by that in Table 2 the tuple represents also the fact of replacement instead of simply sequence of fastening machinists behind trains as Table 1 allows submitting data.

3. CRITERIA OF THE ESTIMATION OF TEMPORAL SYSTEMS

For estimation DBMS, models and type of the temporal relation we have offered for considering from the point of view of model of information safety CIA which is based on three basic parameters of databases – confidentiality, integrity, availability (ISO 17799). As shown in Fig.3, these three parameters harmoniously supplement each other, following them allows achieving the basic purpose of information security.

The purpose of maintenance of information security is granting to the authorized users of access to the necessary information and maintenance of confidence that this information is correct and that the system is accessible.

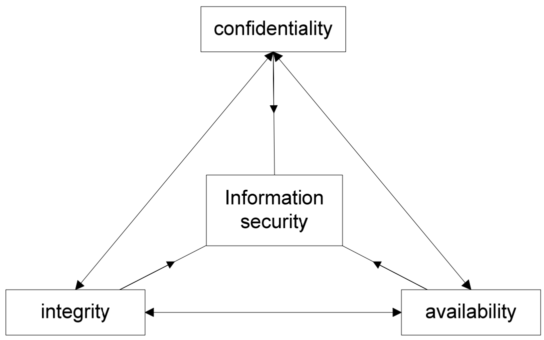

Fig. 3. *CIA model components*

Performance of one of main principles of temporal technology – maintenance of correct access to the previous versions of object and the guaranteed existence only the one version at any moment is represented as rather actual problem in modern transport systems. We shall stop on it in the more detailed way. The condition of performance of this principle demands not only correct data, but also correct and robust methods of access to them and processing. These problems belong to area of maintenance of integrity and availability.

The following aspect concerns confidentiality of temporal data. As a rule, transport agencies work in conditions of the strongest competition. It forces on the one hand as it is possible to protect more reliably the data from competitors, on the other hand bind to make their more accessible to the clients. Temporal data underlie practically all vital business-processes on transport. Thereof, the enterprises are very sensitive to distortion or damage of these data. A major factor, which can cause such negative correction of data, is the human factor: mistakes of the operator, program or hardware maintenance. Factors of non-authorized access to data are essential, but in this work they are not considered.

Concepts of confidentiality, integrity and availability are stated in the popular literature [2,6,7], however at work with temporal systems the author has collided with necessity to expand the given definitions in the context of temporal systems. In the context of information safety of temporal data we shall consider concepts of confidentiality, integrity and availability in the form formulated below.

Confidentiality – security of temporal data in time from non-authorized access on operations of introduction and change, and also transfers of powers without any permission to certain people [9].

On Fig.4 the change in time of the values of an attribute of confidentiality of a temporal tuple concerning users TDB is illustrated. The same tuple is at various times accessible to different users, which are shown in Figure by two time cuts during the moment t1 and t2. During the moment t1 the tuple is accessible to users User 1, User 3, and during the moment t2 – to users User 1, User 2, User 4. The tuple in this case can display a lifespan of object or its property.

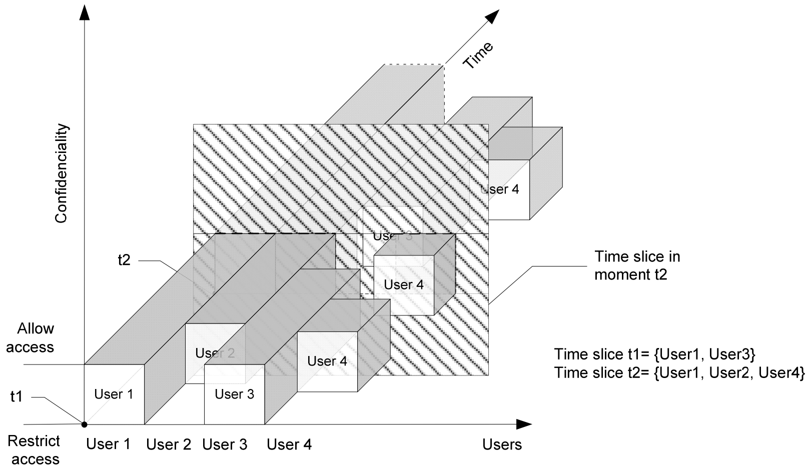

Fig. 4. *Change of an attribute of confidentiality of a tuple in time concerning users of a DB*

Integrity – security of the historical information from non-authorized change, maintenance of its consistency and completeness. The complete part includes set of rules which provide maintenance of base of temporal data in a consistent condition, and also protect it from losses during conducting.

Availability – an opportunity to use the information in TDB when it is required. To paraphrase it, this condition of data, when it are in the form necessary for the user; in a place necessary for the user and when they are necessary for him or her. Means of availability provide a unimpeded access to the temporal information for carrying out of the authorized operations on acquaintance, change and destruction.

All these three parameters are reduced to management of access. Standard access control means in relational DBMS are based on discretionary model, i.e. management of access privileges of users probably at the level of the named objects. For example, it is possible to limit access of users to various operations or access to the relation or even to its columns as both of them have names. The problem is represented with differentiation of access on tuples, which as those have no names. The tuple is characterized by a lifespan of object or its property, hence, it itself is that size of the information to which it is required to limit or resolve access in TDB. Concerning real time the settings of confidentiality and availability of a tuple of the temporal relation are dynamic whereas the settings of restriction of access in relational DBMS are static values [9].

For the decision of the above described problem of the control of access to a tuple of the relation the method of restriction of access to tuples of the relational table, described in one of works of the author [8] is used.

4. RELATIONS WITH OVERLAPPED LIFESPAN

Relations with overlapped lifespan are considered by the author in her work [1,9]. We shall consider advantages and lacks of use of the given kind of relations concerning classical temporal relations in which lifespan are not overlapped. Comparison is spent from the point of view of criteria of CIA model: confidentiality, integrity and reliability.

Confidentiality

By way of confidentiality of a special prize and distinctions is not observed. In the relation there can be overlapped lifespan that represents the varied information for the various users during the moment of time. Depending on the user this or that information can be given. However, the analysis of these opportunities is represented as a theme for a separate research and does not enter this work.

Integrity at correction of data

The principle of management of versions of objects in relations with overlapped lifespan differs from management in classical tables. Distinctive feature in them is that occurrence of a new version of object is not preceded with processing of values of time attributes next (previous and/or following) versions of object. An addition of the new version of object does not lead to any additional actions except the creation of the version. Whereas in classical time the relation creation of a new version of object is connected with processing time of end of a lifespan of the previous version and/or time of the beginning of a lifespan of the following version.

We shall compare the mechanism of performance of operations of changes of data of the object for these two types of relations. Two situations are possible in case of change:

1) when data change *inside* the lifespan;
2) when data change *on crossing* of the lifespan.

Results of comparison of the performance mechanism of object data change operations in relations of classic temporal relation form (Historical, Rollback) and Overlapped lifespan are resulted in Table 3.

Table 3. Results of comparison of the performance mechanism of object data change operations

Relation type / Operation	Classical relation with not overlapped lifespan	Overlapped lifespan
1. data change *inside* the lifespan	changes 1 tuple and generates 2 new	generates only 1 new tuple
2. data change *on crossing* of the lifespan	changes 2 tuples, deletes or marks as invalid x tuples (x – quantity of crossings–1) and generates 1 new	generates only 1 new tuple

By c_{keep} denote keeping tuples quantity. Then the aforesaid can be written down in the following way:

$$c_{keep} = \begin{cases} \mathrm{C}^1_{keep}, & ((\forall OID)(i, j \in \{1..v\} \wedge i \neq j))(VT_i \cap \mathrm{VT_j} = \varnothing) \\ \mathrm{C}^2_{keep}, & \text{otherwise} \end{cases},$$

where

$\mathrm{C}^1_{keep} \in \{k, 2k-1\}$, $\mathrm{C}^2_{keep} = k$,

v – quantity of versions of object OID, k – keeping tuples count in relation.

By c_{udp} denote the quantity of necessary updating of tuples in case of one change of data. Then

$$c_{upd} = \begin{cases} \mathrm{C}^1_{upd}, & ((\forall OID)(i, j \in \{1..v\} \wedge i \neq j))(VT_i \cap \mathrm{VT_j} = \varnothing) \\ \mathrm{C}^2_{udp}, & \text{otherwise} \end{cases},$$

where

$\mathrm{C}^1_{upd} \in \{1, 2\}$, $\mathrm{C}^2_{upd} = 0$.

Advantages: more safe and economic model.

Lacks: it is not revealed.

Availability at selecting

By c_{pr} denote the quantity of procedural tuples. Then

$$c_{pr} = \begin{cases} \mathrm{C}^1_{pr}, & ((\forall OID)(i, j \in \{1..v\} \wedge i \neq j))(VT_i \cap \mathrm{VT_j} = \varnothing) \\ \mathrm{C}^2_{pr}, & \text{otherwise} \end{cases},$$

where

$\mathrm{C}^1_{pr} \in \{0, 2\}$, $\mathrm{C}^2_{pr} = \{0, v^t\}$,

v^t – quantity of versions of the object which is being a necessary time slice.

The lacks:

More complex access to data since besides check of occurrence in a range of action of the version of object, it is necessary to choose the freshest version of object.

In case of use of additional conditions of sample, it is necessary to define very precisely the order of filters; otherwise the results can be doubtful.

5. THE TEMPORAL MODELS USING THE CALENDAR AND PERIODICITY

The use of specific time attributes (like days of week, parity of days, labour shifts and so forth) is also an inevitable part of transport systems daily functions. In general, it means that continuity of a time lifespan can be broken by necessity of application of cyclic time imposing. In terms of technology of temporal databases such cyclic intermittence of a lifespan refers to as periodicity.

Formal record about temporal object in which periodicity is inherent looks as follows:

$$R = (OID, Data, [VT, TT, TF], p),$$

where p – vector defining periodicity of lifespan.

The examples of p: "on Tuesdays and Fridays", "on even days", "on days off", "each first Monday of month".

Presence of periodicity in problems, where relations with overlapped time ranges are used is especially interesting. Here the special attention is given to sequence of filters at inquiry to data. Misunderstanding of sequence of application of filters negatively influences trustworthiness and availability of data. Habitual presentation of temporal data structure in the form of ER-model does not allow showing such specificity designating the order of application of filters.

A vivid example of the organization of temporal data in the form of the relation with overlapped lifespan and with presence of periodicity is the temporal database of a problem of the schedule of passenger trains (see an example 2).

Example 2. A task of the schedule of passenger trains

In a task under the schedule we understand the schedule of train Train_ID characterized by the identifier of schedule Sch_ID and a set of stops times at stations, described in affiliated Table Schedule. The train plies only on the certain days of week. ER-model of the given problem is presented in Figure 5. ER model designed according to model of data with the abstract identifier of object [1].

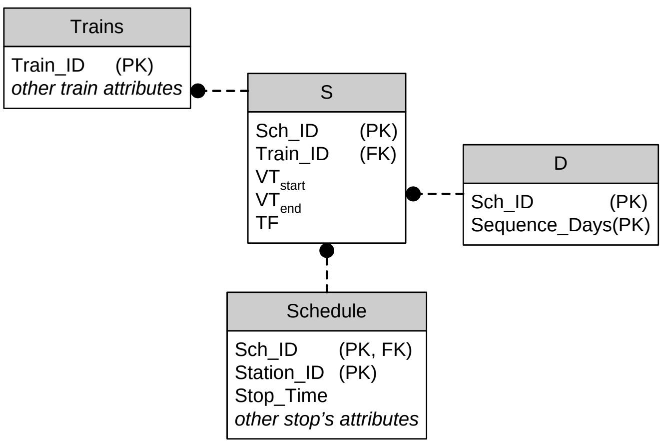

Fig. 5. *Elements of ER-model of train schedule task*

Relation Trains – non-temporal relation, that contains absolute train identifier Train_ID. Table S – Bi-temporal relation describes versions of train schedule, Sch_ID is a version of schedule. Days of trains movement under schedule Sch_ID are described in Table D. The detailed description of the schedule in due course at stations is described by stops in Table Schedule.

The diagram of overlapped lifespan of the schedule and a time slice is presented in Fig.6. Data of the relations necessary for the explanatory of an example are presented in Tables 4, 5.

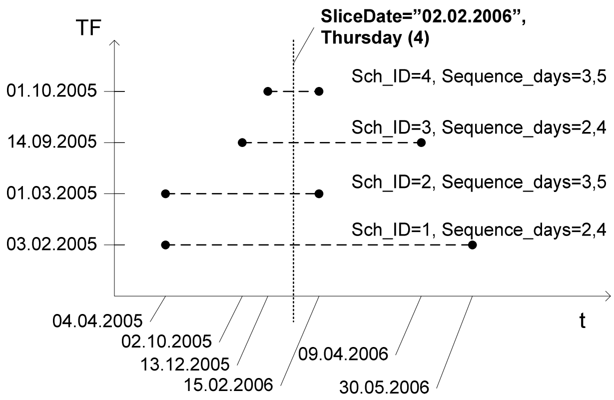

Fig. 6. *The diagram of overlapping of lifespan in a schedule and a slice at the moment of time SliceDate*

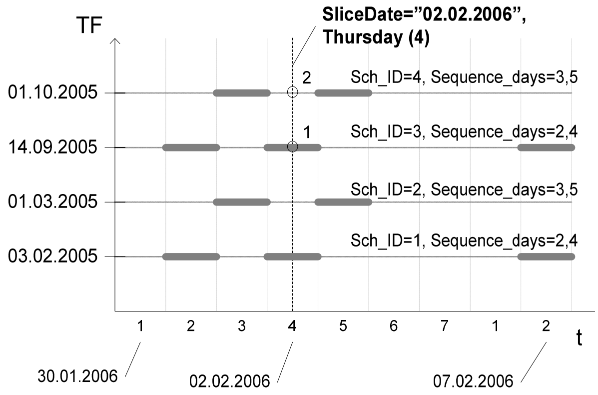

Fig. 7. *Periodicity of days of trains plying under schedules of various versions in a circle of time of cut SliceDate*

Table 4. Relation S data

Sch_ID	Train_ID	VT_{start}	VT_{end}	TF
1	14B	04.04.2005	30.05.2006	03.02.2005
2	14B	04.04.2005	15.02.2006	01.03.2005
3	14B	02.10.2005	09.04.2006	14.09.2005
4	14B	13.12.2005	14.02.2005	01.10.2005

Table 5. Relation D data

Sch_ID	Sequence_Days
1	2
1	4
2	3
2	5
3	2
3	4
4	3
4	5

In the description of a database by means of accessible designations of ER-model there is an ambiguity in treatment of real model trains movement. Possible interpretation of model and scripts of finding the valid schedule corresponding to them are resulted below.

Interpretation 1. The train plies some times in a week under different schedules.

During one period of time the train can have **several** schedules for every weekday the another one.

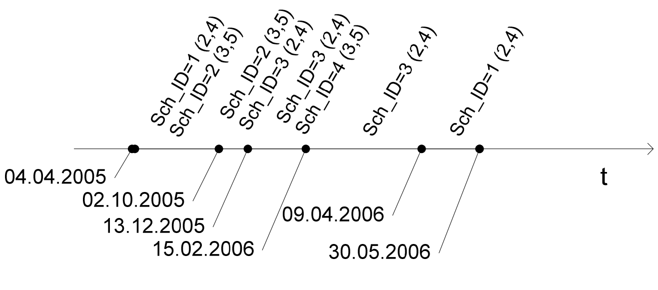

Fig. 8. *Imposing of various versions of schedules on valid time axis according to interpretation 1*

As it is visible from Table D a train 14B goes on Tuesdays, Wednesdays, Thursdays and Fridays, but on Wednesdays and Fridays according to one schedule and on Tuesdays and Thursdays to another.

The script of search of the valid schedule in this case is the following: we define the actual schedule for a period of slice, thus considering the days of train movement.

Function of search can be written down in an algebraic way:

$$Sch\_ID = \pi_{Sch\_ID}(\sigma_{t(SliceDate), fd(SliceDate)=Sequence\_days}(S \times D)),$$

where $t(SliceDate)$ – temporal function for sample actual for date of a slice of a tuple $SliceDate$, $fd(SliceDate)$ – function of transformation of date of a time slice in a format of attribute $Sequence\_day$.

In this case, at the moment of a slice 02.02.2006 (Thursday) schedule Sch_ID=4, and on 03.02.2006 (Friday) – the schedule Sch_ID=3 will be found.

Interpretation 2. The train plies some times in a week under the same schedule.

During one period of time the train can have only **one** schedule. The train plies on those days weeks which are appointed for this schedule.

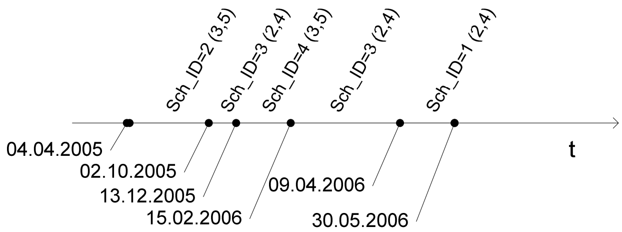

***Fig. 9**. Imposing of various versions of schedules on valid time axis according to interpretation 2*

The train 14B goes only twice a week: during from 04.04.2005 till 02.10.2005 on Wednesdays and Fridays according to schedule Sch_ID=2, during from 03.10.2005 till 13.12.2005 on Tuesdays and Thursdays according to schedule Sch_ID=3, during from 14.12.2005 till 15.02.2006, on Wednesdays and Fridays according to schedule Sch_ID=4, from 16.02.2006 till 09.04.2006 on Tuesdays and Thursdays again according to the schedule 3, etc. (see Fig.9).

The script of search of the valid schedule in this case is the following: check of conformity of time of supervision to days of trains movement is primary definitions of the actual schedule.

Function of search can be written down in an algebraic kind:

$$Sch\_ID = \pi_{Sch\_ID}(\sigma_{fd(SliceDate)=Sequence\_days}(D \times \sigma_{t(SliceDate)}(S)).$$

In this case, valid at the moment of a slice 02.02.2006 (Thursday) schedule Sch_ID=4 will be found, and on 03.02.2006 (Friday) will be certain that the train does not go.

Apparently, from the above described example, standard designations of ER-model do not allow to interpret a real model of a subject domain unequivocally. From the chosen treatment the result of a choice of this or that version of temporal object can cardinally vary. Such situation negatively influences integrity and availability of data.

The given problem takes place not only in relations with overlapped of lifespan, but also in other forms of time tables.

CONCLUSIONS

Specificity of temporal systems on transport is caused by a number of factors, among which are: special requirements to temporal models of data, namely ability of a lifespan to interrupt and inure several times; use of periodicity and the calendar; requirements to type used DBMS, great volume of data, increased requirements to integrity and availability of data.

Common temporal models do not meet these requirements in full and their use in a number of problems is not optimal. In this work the special form of temporal tables, not possessing the lacks listed above – model of the relation with overlapped lifespan is investigated. The model of temporal database using specific time attributes and solving a problem of support of the calendar and periodicity is offered.

In this work it is proved that temporal systems can be estimated from positions of the basic criteria of model of information safety CIA: confidentiality, integrity, and availability. The analysis of relations with overlapped lifespan lead from these positions has shown that they are the safest in the way of infringement of rules of integrity in case of data change, and also the most economic in the way of quantity of trains in the table, necessary for the description of a situation of a subject domain. But the lacks expressed in more complex access to data and necessity of the control of the order of used filters is revealed.

In work questions of periodicity are investigated. Classic form of ER-model does not allow interpreting unequivocally temporal character of objects in real model of a subject domain. The given problem is shown in the example of a problem from railway sphere. It is shown, how the interpretation of ER-model the result of search of the actual version of temporal object can cardinally vary. Such situation negatively influences integrity and availability of the whole system. The decision of this question can demand additional research.

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DRIVING SIMULATOR ANALYSIS ACCORDING TO DIRECTIVE 2003/59

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The paper refers to some problems of a top-of-the-range driving simulators that have been implemented in 27 EU members by Directive 2003/59/EC. The emphasis is put on the truck simulators from France, Finland, Germany and USA. The Mark III Motion-Based Driver Training Simulator combines a fully operational truck cab with the latest digital simulation technology to create life-like training scenarios that improve driving behaviour and skill. Renault has built the simulator which can offer several truck configurations (tractor, rigid, articulated) with different engine and equipment types. Additionally the TRUST 3000 simulator for Truck Driving Training and BUS 3000 simulator for Bus Driving Training are described. A top-of-the-range simulator may play the main role in many training areas, it is clear that the particular requirements of the driving industry must be considered in order to develop optimal cost-effective systems. Preliminary analysis shows that simulation can have a beneficial contribution in the areas of fuel efficient driving, emergency situations, poor weather driving skills, and learning handling characteristics of different types of load. The authors have determined requirements of top-of-the-range driving simulators.

Keywords: a top-of-the-range simulator

1. INTRODUCTION

Directive 2003/59/EC of the European Parliament and of the Council (Initial qualification and periodic training for drivers of road vehicles for the carriage of goods or passengers) recommends the use a top-of-the-range simulator in 27 EU members during initial qualification and periodic training for coaches and buses – mandatory September 2008, for trucks – mandatory September 2009 [1]. According to Directive, training for the full initial qualification must take at least 280 hours (approximately 8 weeks). At least 20 of the 280 hours must be devoted to driving a vehicle. Each driver may drive for a maximum of 8 hours of the 20 hours of individual driving to obtain adequate training in rational driving based on safety regulations, in particular with regard to vehicle handling in different road conditions and the way they change with different atmospheric conditions and the time of day or night. When driving individually, an instructor, employed by an approved training centre, must accompany the trainee driver. Each driver may drive for a maximum of four hours of the 10 hours of individual driving on a top-of-the-range simulator. The same conditions as above apply to the accelerated initial qualification. The training for the accelerated initial qualification must be at least 140 hours (approximately 4 weeks), of which at least 10 hours must be practical driving. Member States may allow a maximum of 4 out of the 10 hours which can be undertaken on a top-of-the-range simulator. Compulsory periodic training must be organized by an approved training centre. Their duration must be of 35 hours every 5 years, given in periods of at least 7 hours. Such periodic training may be provided, in part, on top-of-the-range simulator. The maximum administrative validity may be of 5 years for trucks and buses drivers of age below 65 years and of 1 year for drivers over 65 years of age.

According to the Directive, basic vocational training is divided into three areas:

- Advanced training in rational driving based on safety rules,
- Compliance with regulations,
- Health, safety, service and logistics.

In addition there are other areas of direct relevance to possible simulator training.

These relate to as follows:

- Road traffic regulations,
- Ergonomic principles,
- Behaviour in an emergency situation.

The provisions contained in the Directive must be translated into national law in the EU member states by September 2006. Effectives from that date, further training measures to reduce the frequency of accidents and energy consumption for trucks will become mandatory.

The Directive does not define precisely the term a top-of-the-range simulator, but many member states interpret it as a cab type fully moving simulator.

2. DRIVING SIMULATOR CHARACTERISTICS

2.1. Driving Simulator General Characteristics

Simulation provides a representation of reality; and is used when the real thing is dangerous, expensive or not feasible for training. Simulation is often used for a part of training, as a practice phase, to allow the learners to try new skills until they have mastered it or at least have reached a point where it is safe to try for real. There are several levels of driving simulators, such as:

– Level 1, desk-top driving simulator, that can be used for driver assessment, as a driving practice tool, a training aid for classroom instruction, and for remedial action or driving behavioural modification. It provides drivers with a method of practicing and improving their driving skills in a safe, "virtual" environment;
– Level 2, non-motion partial-cab driving simulator. The system is designed for the novice driver who needs more time behind the wheel in a realistic driving situation within a safe environment. It provides an intensive AAR (After-Action-Review) report using 3 LCD monitors;
– Level 3, limited-motion partial cab driving simulator, allows teaching and assessing driver skills for non-synchronous transmissions. Although the system is not motion-based, it does have force feedback steering and a rumble seat that vibrates according to surface conditions and sound wave inputs;
– Level 4, full motion full size driving simulator. An adaptable and flexible driver training tool provides realistic vehicle dynamics including interaction between road surface, tires, and automobile suspension. Diverse scenarios educate and evaluate trainees under many different road, weather, dangerous driving situations, and various traffic conditions;
– Level 5, authentic driving cab mounted on a motion base that provides six degrees of freedom (DOF) to give the driver a complete training experience, and offers experience that is as close to reality as possible.

A truck simulator provides an opportunity to reproduce the characteristics of real vehicles in a virtual environment. It replicates the external factors and conditions with which a vehicle makes drivers to feel as if they are sitting in the cab of their own vehicle. Scenarios and events are replicated with sufficient reality to ensure that drivers become fully immersed in the experience rather than simply viewing it as an educational program.

The system is controlled via a computer network and realistically replicates a virtual world with all known road topographies and traffic situations. The core of the system is a graphical user interface allowing driver training instructors to quickly and easily create complex driver training exercises with critical traffic situations. This also includes dangerous situations, such as blowing tires, nodding off, improper traffic behaviour of pedestrians and cyclists, crosswind or a variety of different weather and road conditions. Also available for training are variable own vehicles, such as different types of trailers and semi-trailers, touring coaches or public transport buses, load conditions, etc. Additionally, complex loading and docking manoeuvres can be trained without any risk of damage on a specially developed virtual manoeuvring course. Furthermore, the simulator offers a sophisticated module designed to evaluate driver proficiency as well as a "blue light" module to train drivers of fire fighting and task forces. Driving over snow-covered mountain passes or preparation for left-hand traffic in England at a training site in Berlin are but a few examples of this type of modern training.

The simulator provides a constructive experience for the novice driver and enables more complex exercises to be undertaken by the more mature driver. For novice drivers, truck simulators provide an opportunity to begin their career by applying best practice. For mature drivers, simulation provides the ability to enhance good driving or to detect poor practice and to suggest the necessary steps for remedial action. For companies, it provides an opportunity to educate staff in the driving skills that achieve reduced maintenance costs, improved productivity and, most importantly, to ensure the safety of their actions in all possible situations.

An example of truck simulator architecture consists of a cabin including motion platform, projection system, sound and image generators, and simulation host and control station [3, 4]. A complete software environment called SCANeR II allows defining the scenario and simulation data, to reproduce the driving context, including traffic and road signs, as well as the behaviour of the driven car.

Motion perception is stimulated both by the visual and motion rendering systems. Tilting the driver cockpit should not induce a modification of visual references, such as the perceived horizon, so as not to produce visual-vestibular conflicts. When the display system is not on-board, for instance, a visual compensation should be done with a sufficient synchronization in order for the driver not to perceive discrepancies between visual and vestibular stimuli. It guarantees the stability of the perceived horizon during motion with nonzero acceleration.

For motion perception, crucial information is given by the steering wheel force feedback, perceived by human muscular and particular receptors. This kinaesthetic feedback, perhaps is the most important, when driving a simulator is difficult to render properly mainly because of the transport delay of the whole simulation system.

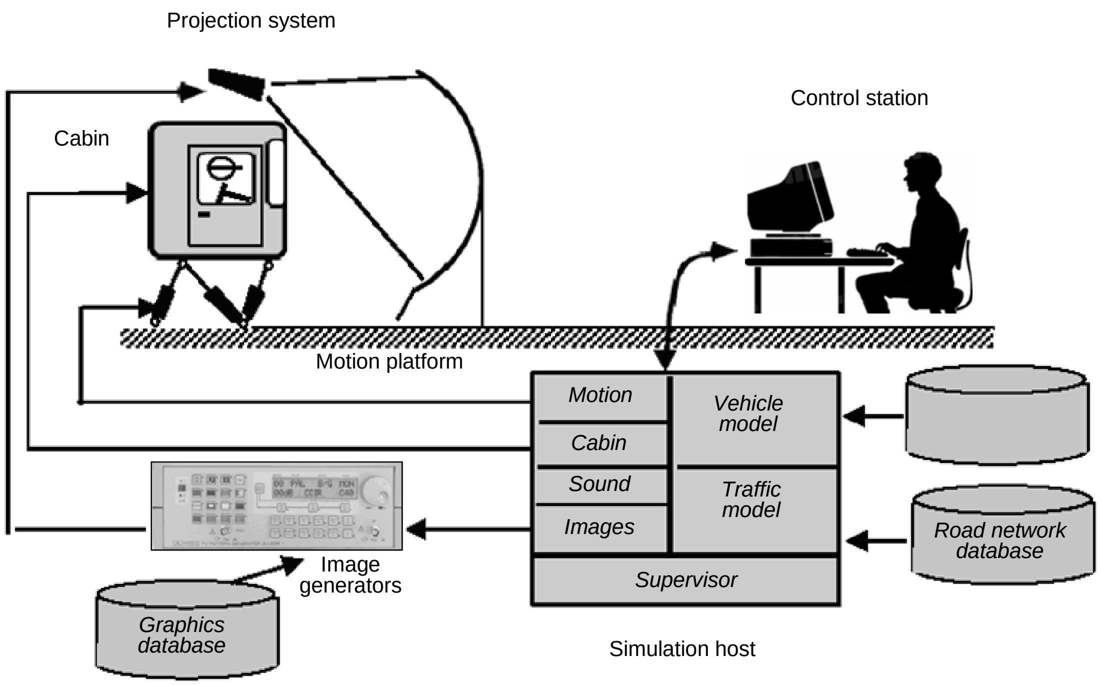

***Figure 1**. An example of truck simulator architecture*

Building realistic and effective driving simulators requires huge amount of engineering knowledge and a deep expertise of the underlying perceptual processes of the driving behaviour. Driving is first of all, a sensory-motor and cognitive activity in which patterns of sensory information are analysed and exploited to control the state of the vehicle. It is somehow obvious that one of the main concerns of designers and users of driving simulators is to know to what extent the control strategies and the decision-making rules used by the drivers in real-world situations are transposed with fidelity in simulation conditions.

2.2. Top-of-the-range Driving Simulator Requirements

A top-of-the-range simulator serves to provide training in rational driving based on safety regulations, in particular with regard to vehicle handling in different road conditions and the way they change with different atmospheric conditions and the time of day or night. The new methods, using the latest technology, have been put in place to prepare for the forthcoming European directive on the qualification and continuous training of drivers.

The simulator method has been chosen as it offers a number of advantages over traditional training in the vehicle. Its features include traffic situations with gradually increasing difficulty levels, programmable weather conditions, the simulation of extreme situations, etc., all in a safe and cost-effective environment. Simulator should faithfully reproduce the visual, audio and dynamic environment (effects of braking, acceleration, etc.), while allowing interaction with passengers, thanks to the inclusion of ten seats in the cab. It also offers educational advantages, as it allows objective evaluation of the driver's performance.

While it is not intended to replace on-road training, the simulator is a high-quality complementary tool, enhancing the training experience.

The validation of driving simulator from a perceptual point of view is an extremely important step in order to qualify driving simulators as a productive tool (i.e. reducing time and costs in prototyping new solutions) and as a realistic and controlled environments to study driver's behaviour. Visual information is the most important sensory signal determining driving behaviour [8, 9]. If the characteristics of the visual information are changed in simulation according to a predetermined amount so as to impact the perception of the driver, one can expect a corresponding change in his driving behaviour. Principles of geometry, but also more sophisticated theoretical tools, like the optic flow equations [6], can be used to predict the behaviour of the driver [2]. Many perceptual experiments in psychophysical literature have shown that dynamic visual information, such as the optic flow, play an important role in the control of motor variables [10]. The following elements are named: the theory of depth perception, ruling out the importance of different visual cues to depth perception [7] and the theoretical framework of the optic flow, which establishes a formal relationship between the amount of induced visual motion pattern and the movement of the observer in a three-dimensional environment [5].

Truck and bus simulator should include such elements and technical details as follows:

1. Original truck or bus driver cabin:
   - vehicle controls and operation elements,
   - force feedback steering wheel.
2. Multi-channel projection of computer generated scenes:
   - 5 channels for drivers out-of window-view covering 210° horizontal x 40° vertical,
   - 3 channels for representation of mirror view,
   - Resolution per channel of 3 angle minutes and 60 Hz refresh rate.
3. PC based Image Generator:
   - typical road network,
   - Various weather conditions (four weather seasons, other conditions, like: rain, fog, snow),
   - Time of the day/night,
   - Special effects (vehicle lights, tree shadows, thunders).
4. Autonomous traffic with different categories of road users:
   - Up to 40 vehicles visible at the same time,
   - Moving pedestrians, bicyclists, trucks, cars, buses, etc.,
   - Adjustable traffic density and road user's behaviour.
5. Electrical motion system with 6 degrees of freedom (6DOF) and 3D virtual objects:
   - Motion system design allows exchanging of driver's cabin,
   - Acceleration up to 1 g.
6. Sound system for simulation of vehicle and environmental sounds.
7. Accurate model for vehicle dynamic and loading.
8. Instructor Station:
   - Exercise Creation & Control,
   - Debriefing Facility,
   - Administrative functions / report evaluation.

2.3. Renault Truck Simulator

Renault has developed a new dynamic simulator as the need to enhance the driving realism and the emergence of new simulation necessitude. Its application field covers the development of vehicle dynamic control systems (stability control, adaptive cruise control), lighting simulation, dynamic comfort, ergonomics and accidentology.

The driving station is a Premium cab which controls have been replicated. Driver actions on the controls are transmitted to a computer executing the vehicle dynamics model (Tridym). It is a variable parameter model which can offer several truck configurations (tractor, rigid, articulated) with different engine and equipment types.

The dynamic data computed by the model is transmitted to the dynamic platform for kinaesthetic effects, to the image generator for visual effects and to the sound generation system. Two other computers are dedicated, one for simulation scenario management and the other for sound generation.

Cockpit is an instrumented, lightened Premium cab. Controls force feedback includes active and passive devices. Active devices on the steering wheel and gearbox lever (including synchronic efforts), but passive devices – accelerator, clutch, brake and parking brake pedals. Mobile platform is an electromechanical Moog platform with 6 degrees of freedom (DOS). Image generator – Silicon Graphics Onyx Infinite Reality for the frontal view 2 PC/Windows NT with Quantum 3D Voodoo 2 graphics boards for the rear views. Field of view – horizontal: 200° – Vertical: 50° Left, right and wide-angle rear-view mirrors. Software – SCANeR II simulation software.

2.4. Finnish Truck and Bus Simulator

The SimTruck truck and bus simulators have been accepted as top-of-the-range simulators referenced in the EU directive 2003/59/EC by Finnish authorities, The Ministry of Transport and Communication Finish Vehicle Administration AKF.

The SimTruck driving simulator can be used to train 20 of the required 80 hours for the CE-license in Finland.

SimTruck driving simulator is based on a Scania R-series Topline cab modified so that driving is possible with both manual and automatic gears. In simulation the simulator represents and behaves like all typical truck models from a delivery van to a 25-meter heavy truck. Several different loads and cargo types can be simulated.

The simulator control devices include all necessary devices to run a truck: steering, adjustable steering wheel including the steering axle, manual and automatic gearbox, and control switches for automatic gears, throttle pedal, clutch pedal (mechanical), brake pedal (pneumatic). Brakes electronically controlled, ABS included (can be switched off). Retarded controls, parking brake controls, horn, headlight controls (lights implemented virtually), blinkers, instrument panel and indicator lights, door functions (front door), kneeling of chassis, adjustable mirrors. The mirrors react to the normal mirror adjustment controls, which are available to the driver. Fan controls for driver area, cabin fan controls, cabin light controls: roof lights, reading lights, lights, night lights, driver area light controls, ignition lock, cruise control controls, windscreen wiper/washer controls, radio/CD-player, stop sign reset switch, emergency stop for fuel, main power switch, drive level switch, kneeling switch, emergency lights switch, mirror adjustment switch, front fog lights switch, rear fog lights switch.

Instrument panel includes: Speedometer/Tachograph, tachometer, fuel gauge, oil pressure gauge, engine temperature gauge, brake pressure 1 gauge, brake pressure 2 gauge

The feeling of movement in the simulator is created with a moving landscape and a motion platform. The motion platform consists of pneumatic system and a supporting frame for the movement platform.

For visualizing the landscape four projectors are used. Angle of view: over 180 degrees. Visualization set of city includes: a bus station with platforms, several crossings with traffic lights, crossings with and without separate lanes for different directions, streets with multiple lanes, narrow streets, traffic circles, different kind of stops, overpasses and underpasses, tunnels, speed bumps.

A highway visualization set includes: ramps both in and out of the highway, acceleration lanes (short and long), parts with 2 and 3 lanes, a stop ramp. Rural landscape including: wide roads, narrow roads, partially asphalt, partially gravel, speed bumps. Garage environment, parking manoeuvres, all manoeuvres requested by the driving license, parking, bus stop, need stop.

All parts have up and down hills and viewing obstacles as the real landscape. The total area of the virtual landscape is about 200 square kilometres and the total length of the streets and roads is approximately 1000 kilometres. The routes can be selected freely. Localizing of the landscape and inclusion of other cities can be done.

Minimum of 25 vehicles, pedestrians, bicyclists, slow vehicles, a roadwork with traffic signs, unexpected situations: pedestrian steps on the lane, an animal runs out onto the road, a vehicle disobeys red light, a traffic jam, and the bus develops a technical fault (flat tire, engine stop while driving).

Different weather and road conditions and times of day: daylight: clear, rain, snow, fog, wind. Dark: step less adjustment of darkness, clear, rain, snow, fog, winds. All weather and road conditions can be combined with all traffic conditions.

The simulator makes it possible to practice e.g. different weather and traffic conditions, reversing and approaching a stop, customer service situations, ticket sales, driving with automatic or manual gearbox, driving with different RPMs, use of retarded and other control devices, economical driving so that changes in the environment can be eliminated, only the driver's actions affect fuel consumption, driving in a city, in the countryside, on a motorway, in traffic circles.

SimBus driving simulator, as defined, is a device that as closely as possible emulates a bus in traffic. The moving base makes it possible for the simulator to move in different directions, real sounds, real control devices and the cabin of a real bus make the device so realistic that the driver feels like driving a real bus.

SimBus driving simulator can take up to 11 passengers, which allows also practicing customer service situation along with driving.

The SimBus driving simulator is based on a complete bus body (Volvo, Van Hool, etc.) modified so that driving is possible with both manual and automatic gears. Chassis length is about 5 meters, width about 2.5 meters and height about 3.1 meters. Weight including the movement platform is about 4 000 kg. In simulation the simulator represents and behaves as a two-axle, 10-meter to 15-meter bus (also articulated bus, 18 meters).

The space needed for the simulator: approximately 100 square meters. Height: minimum of 5 meters. As a custom option the SimBus driving simulator can be built on different cabin types and models as specified by the customer. Also the traffic environment can be modified according to customer's wishes.

2.5. The FTM Truck Simulator (Germany)

The Institute in Munchen has built up a dynamic FTM driving simulator for the research of vehicle components, vehicle intersystem and vehicle handling. The choice of a convenient motion platform and the positioning of the projectors permit the usage of different car and truck cabins. The interchange ability of the cabins will be realized by a flexible mechanical interface. By the implementation it is important to set great store by basing the computer on PC, what concerns the extension with additionally personal computers as well as the disclosure of the interface and codes, therewith it is possible to update and upgrade the system. The adaptation of different software models for the actual application in cooperation with Vehicle and Simulator producer offers a very big field of activity for interdisciplinary working. The projection dome will be designed and manufactured at the institute according to the requirements. The FTM driving simulator was constructed at the interface of the field vehicle and simulator development. Beside the visualization this is the most important factor for the driver. One part of the accelerations at driving operation can be represented by the pitch of the cabin. It has been shown, that this part is infinitely small, when the speed of pitch sub-threshold for angular acceleration (0,1-0,2 rad/s2). If the sensory threshold will be exceeded, the test person will perceive the pitch motion.

To offer the driver real operating, an original vehicle will be replicated. Because the driving simulator will be used with different car and truck cabins, a mechanical interface of the motion platform should be designed.

For the FTM driving simulator it is important to install a software concept that allows unfolded and standardized interfaces enhancements and accommodations. It concerns especially the model of driving dynamics, which can be modified and can be exchanged for different vehicles and above all the replica of a truck.

As for the visualization, the driving situations are immediately determined. Besides the quality of texture and the definition of attributes of the passable surfaces, the system determines which visual, vestibular and tactile information can be created for the driver. Therefore it must be possible to generate task-specified user-defined landscapes and streets and to integrate this in the visualization.

The further development of the necessary intelligent autonomic road user in interaction with a dynamical changeable visualization is visible on a basic point in the driving simulator development. Furthermore software modules are to be integrated in the simulator environments which simulate the functionality of driving assistant systems and utilize the analogical information of the driving environment, traffic and the street course of the visualization.

Because of the big qualitative and quantitative deviation of the diagrammed accelerations in the driving simulator compared to a real driving, there is a high failure rate of test persons. Simulator and motion sickness make it impossible to carry out long tests in the simulator with the concerned persons. The decrease of this rate by the use of an improved calculating algorithm of the acceleration execution is a further approach of further development of the planned driving simulator. Beneath an improvement of the software the disassembly with a transversal skid system shall contribute to an improvement of the acceleration presentation. This topic offers students of the faculty of mechanical engineering the possibility, to handle challenging and interdisciplinary tasks at the field of informatics together with the driving simulator manufacturers.

Sound libraries and sound generation are included in delivery, but FTM wants to specify and build up the end equipment. The high quality presentation of sounds is to get improved by a clever choice and installation. A system of high capacity subwoofer for deep frequencies in combination with a tuned booster will allow the optimisation of the sound presentation for the driving simulator with relative small expenditure.

The following components are designed and realized in active work:
– Electro motor for the simulation of the steering moment with electronics and control,
– Simulation of the brake-pedal and accelerator pedal,
– Camera, screen and intercom.

The projection dome has to be designed and produced individually for the FTM driving simulator concept.

Because of the increase of traffic and the rise of comfort and drive functions at the vehicle the driver has to work in his car with more information input. To manage the more complex driver controls in the traffic, he will be observed and provided with sophisticated sensors and control technical driving assistant systems. This innovation for the increase of the active driving safety is combined in the term driving assistant system.

At the development stages of the systems it is especially important, to create flexible and reproducible situations, which in reality are difficult to realize. The driving simulator will be an important development tool for the tests of these systems, because he can simulate real situations.

2.6. The Mark III Motion-Based Driver Training Simulator (USA)

The Mark III Motion-Based Driver Training Simulator combines a fully operational truck cab with the latest digital simulation technology to create life-like training scenarios that improve driving behaviour and skill. It uses high resolution projection imaging on three screens to create a 180° field of vision that is expandable to 360°. Two LCD side mirrors simulate the rear view from the truck cab. Users can select from a variety of visual environments, training scenarios and special effects including extreme weather conditions. Audio and vibration systems add accurate driving noise and feel. Users can choose from more than 140 transmissions, 240 engines and 33 axle ratios. Closed-circuit television allows observers to watch the driver from the operator console. Driver’s training program includes a unique combination of state-of-the-art simulation, Computer-Based Training and classroom instruction. Drivers receive cost-effective, realistic training in a risk-free environment.

Table 1. Specifications of the Mark III

Height	180 inches	4.57 meters
Width	240 inches	6.40 meters
Depth	288 inches	7.32 meters
Weight	4200 pounds	1906Kg
Power Requirements	90-amp	220 VAC
Minimum Room Size	30 feet by 30 feet by 16 feet high	
Cooling BTU per hour	20,000	

The Mark III features:

- Five-channel immerse driving environment.
- 1024x768 resolutions.
- Three screen 180° display expandable to 360°.
- Two simulated rear-view mirrors.
- Adjustable properties such as vehicle and load weight.
- Visual databases available: urban, highway, rural, suburban, freeway and off-road.
- Multiple interactive driving scenarios.
- Special effects: day/night/dusk and adverse weather (e.g., fog, rain, snow).
- Artificial intelligence scenario vehicles.
- 1024x768 High-resolution projectors provide six-screen imaging.
- Audio and vibration system for accurate driving noises.
- Fully operation dash, instrument panel and controls.
- Windows based operating systems.
- Closed-circuit TV for observation of driver.

2.7. Truck and Bus Simulators of Thales

Thales is a leading international electronics and systems group, serving defence, aerospace, security and services markets worldwide and global leader in simulation, modelling, and training, for civil and military markets.

Specifications include:

- a cabin replicating that of a real truck,
- a realistic motion of a truck on the road,
- a screen on which a virtual environment is projected and which reproduces the most critical situations in all areas of training,
- an instructor station allowing the teacher to monitor up to 5 pupils at the same time,
- an automatic evaluation tool which will allow a detailed analysis of each student to be made during a training session and used for subsequent debriefing,
- a visual data base reproducing a skid pad area,
- a tool to create a library of training courses fully adapted to aptitude evaluation, initial qualification and periodic training.

TRUST 3000 is a tool for training Heavy Goods Vehicles (HGV) drivers. It recreates most of the situations encountered on the road, from the simplest to the most complicated. Until 2006, 42 units have been sold to training organizations spread amongst ten European countries (Belgium, Denmark, Finland, France, Germany, Holland, United Kingdom, Norway, Portugal and Spain). The simulator has contributed to the training of around 140,000 transport professional drivers (goods, passenger and armed forces vehicles).

It should be noted that TRUST 3000 replicates a Premium truck of Renault Vehicle Industry and comprises a software model developed in collaboration with Renault themselves.

In the same way, BUS 3000 will conform to the technical requirements of the European committee responsible for following-up on Directive 2003/59/CE transposition, to ensure it is recognized as a "Top-of-the-range Simulator". Lastly, BUS 3000 will be manufactured to the same quality standards as Thales high-end simulators, which will ensure a high availability ratio. Long term support higher than 10 years will be provided at the customer request.

BUS3000 will have all the characteristics of the Truck Simulator (TRUST3000) manufactured by Thales, of which 36 items have been delivered or are on order, and have been used to train more than 85,000 drivers in 6 EU Member States to date (Belgium, Denmark, Spain, France, UK and the Netherlands).

CONCLUSION

A wide variety of driving simulators is available nowadays. The technical characteristics of the simulators cover a wide range of specifications. The present state of the technology seems to make it possible to implement different driver training applications with a growing level of complexity and fidelity to real driving conditions. The validation of simulators is also an area where there is still a need for further advance. A methodological approach to driver simulator validation for driver's training is required as a key step towards extended use of simulators as standard tools in the driver's training process in Europe.

Research of driving simulators should focus on needs of different groups of drivers, but it should also consider the role of the trainer and his task in the process of simulator training.

The further research should also take more into account, like the psychological factors that influence the safe behaviour on roads but also on motion sickness is needed.

Nevertheless, there is a lack of common technical specifications both at national level and at European level that define the minimum conditions that a simulator should have to be suitable for use in the different levels of driver's training applications.

At the present no more than 10% of commercial drivers have received training beyond what is required for obtaining their driving licenses. The implementation of Directive 2003/59/EC of the European Parliament and of the Council of 15 July 2003 on the initial qualification and periodic training of drivers of certain road vehicles for the carriage of goods or passengers will contribute to changing this situation, as drivers will have the obligation to undergo periodic training every five years.

The final objective has to be a continuous training program that is keeping drivers up dated about the main issues of the daily duties of a bus driver, and also covering prevention procedures for cases when the vehicle is stopped.

Research carried out by accidents analyses confirm that formal training for professional drivers, in particular training in defensive driving, combined with other incentive systems, can reduce the accident rate by around 20%.

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