Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 00 (2016) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

12th International Conference "Organization and Traffic Safety Management in Large Cities", SPbOTSIC-2016, 28-30 September 2016, St. Petersburg, Russia

The Project of Intellectual Multimodal Transport System

Anatolii Asaul [1a] *, Igor Malygin [2b], Vladimir Komashinskiy [2c]

[1] Saint Petersburg State University of Architecture and Civil Engineering, 4 2nd Krasnoarmeyskaya str., Saint Petersburg, 190005, Russia
[2] Solomenko Institute of Transport Problems of the Russian Academy of Sciences, 13 12-th Line VO, Saint Petersburg, 199178, Russia

Abstract

The article present ways to design and develop intelligent multi-modal transport system capable of improving the safety of citizens, society and the state, protect their interests from the various types of threats. Its architecture is described herein which ensures implementation of main functional elements, strategic model of the telecommunication subsystem of the motor transport mode (as a component of the intellectual transport system). Architecture of the road subsystem to manage the intellectual multimodal transport system is described in detail. Its design and implementation are able to improve functional efficiency, general service quality, level of ensured safety and environmental functioning of both the Russian and international transport systems.

Peer-review under responsibility of the organizing committee of the 12th International Conference "Organization and Traffic Safety Management in large cities".

Keywords: Safety, vehicles, transport infrastructure, information telecommunication system, Intellectual multimodal transport system.

1. Introduction

Transport safety of the Russian Federation means "the state of transport infrastructure and vehicles protection against acts of unlawful interference" (Federal Law "On Transport Safety" FZ-16 of 09.02.2007). The system of transport safety ensuring is regarded as a totality of functional subsystems [Asaul (2013), Asaul (2012)]: prevention of any and all dangers, counteraction and suppression of crime, including terrorism; prevention of natural and technogenic emergencies; prevention or minimizing material and moral damage caused by crimes and accidents;

* Corresponding author. Tel.: +0-000-000-0000 ; fax: +0-000-000-0000 .
E-mail address: asaul@yandex.ru [a]*, malygin_com@mail.ru [b], kama54@rambler.ru [c]

2214-241X © 2016 The Authors. Published by Elsevier B.V.
Peer-review under responsibility of the organizing committee of the 12th International Conference "Organization and Traffic Safety Management in large cities".

ensuring environmental safety of transport and transport system environmental sustainability; implementation of national security objectives *in the transport sector as a whole.*

The most important transport infrastructure functional element of Russia is also its information-telecommunication system ensuring navigation, information, telecommunication support, traffic management and vehicles safety.Rapid design processes distribution, built-up and development of automated, intellectualized and autonomous vehicles and various modality infrastructures (motor transport, railway, sea, air transport) and their integrated (multi-modal) use, explains the need for convergence of heterogeneous infrastructures, expediency of their development on the basis of intellectual information telecommunication system platforms [Asaul (2011)].

The project proposed by the authors is the Intellectual Multimodal Transport System (IMTS) which is a new type of information-telecommunication system, allowing for effective monitoring and management (technological and administrative) of intra-modal and multimodal transport flows. IMTS includes modal access networks and integrated trunk info-communication network, converted (by using interfaces, drivers and software (SW)) with various transport infrastructure elements. The following have to be taken into account while developing IMTS:

- stations mobility (components of the vehicles) which allows for rapid alteration of the network topology (stereology in air transport mode);
- the necessity to support a wide spectrum of telecommunication technologies and various types of application processes (multiserviceability), including global applicability of network elements prioritizing user service and execution of application process (taking into account rules and safety requirements and services rating in each transport mode);
- dynamic and flexible accountability of user demands (transfer rate and probabilistic time response characteristics preset by the applications); reliability, availability, confidentiality and security of info-communication processes and hardware and subnet hosts modular design.

In the way of IMTS development it is important to remember that transport is a critically needed technology in Russia, therefore the transport infrastructure is among the most critical infrastructure projects in the Russian Federation and the countries of the Eurasian Economic Union [Asaul (2013)].In addition it is important to also consider the following:dynamic pattern of potential transportation threats, tending to increase as a result of increasing transportation volume of hazardous cargoes (nuclear weapons, petroleum, chemical hazardous substances, radioactive materials, nuclear waste to a site of disposal); high degree of wear and accidents risk of transport complex objects; traffic intensity increase in line with economic development of the country, development of new territories, operations adjusting of the international transport corridors; growth of road traffic accidents, which is one of the most crucial social – and – economic problems (according to expert estimates the damages resulting thereof reaches 4-5% of the gross national product worldwide and the number of killed and wounded reach up to 1.5 million persons annually); facts to improve the methods and ways of unlawful activity of criminal groups (especially terrorist organizations) relating to the transport sector, strengthening of the dangerous tendency to unite and coordinate their activities, including the same at the international level.

Stratified IMTS project architecture description in the Russian Federation reflects its basic functional elements [Komashinskiy (2014), Zulkarnain and Leviakangas (2012), (Figure 1 gives detailed presentation of architectural subsystems and functions thereof). The first lowest level reflects functionality of the telecommunication protocol stack OSI: modal access networks (wire and wireless) and integrated trunk network. The second layer (data stratum) reflects functionality of the shared data space, composed of modal context data and the data required to support multimodal transport control and management. The third level is the information level (information stratum) represents functionality of converting big data into context information reflecting the current state of modal and trans-modal transport facilities and infrastructures. The fourth level supports derivation functions of contextual knowledge from time sequence of contextual information at the query of the application processes (ensures request-based provision of knowledge). The sixth layer includes application processes (modal and transformer-modal), that can use data, information and knowledge through direct and cross-layer interfaces.

The control plane (refer to Figure 1) ensured agreed management of all functional architecture layers and inter-strata interaction. The safety plane ensures protection of the processes running in each stratum against accidental or intended impacts.

The general (stereologic (3-D) model of IMTS motor transport mode of the telecommunication section (motor transport ITS (IT-support) includes the following subsystems: GPS / GLONASS, providing navigation services (for all types of transport); satellite communication; radio and TV broadcasting; cellular (2[nd] -4[th] generations); road communication (traffic control communications, etc.) and ensures transparent interaction of the management, personal (subscription), motor vehicle and road subsystems

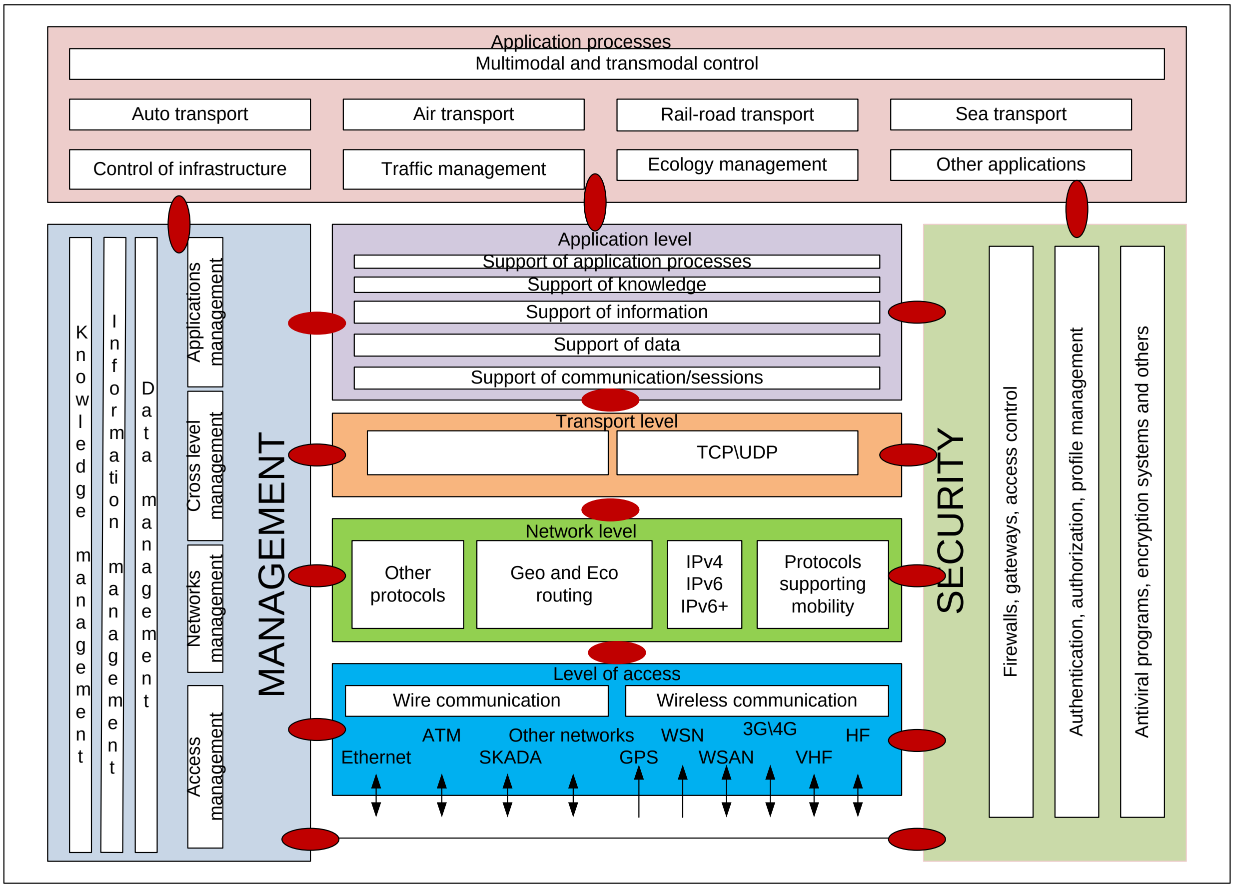

Fig. 1 Detailed presentation of IMTS architectural subsystems.

Personal (subscription) motor transport ITS subsystem is versatile (supports technological and network-wide transport-user applications). It is developed on the platform of heterogeneous personal devices (the so-called "gadgets").

Personal subscriber subsystem of pedestrian support ensures its interaction with the motor road infrastructure (information reception on running times and optimal multi-modal routes through wireless base station) and with moving vehicles (is able to ensure a vehicle emergency braking emergency situations through interaction via "man – machine " M2P network). Driver's personal subscriber subsystem of a vehicle ensures its interaction with various vehicle systems via built-in wireless data communications networks.

The control system architecture of motor transport ITS is presented in Figure 2 and ensures the following: control, interaction and management of personal, vehicular and traffic subsystems via wire and wireless access subsystems; interaction via trunk network and access networks with ITS of other transport modes; data, information and knowledge submission on their subsystems to IMTS central control station and carries out tasks to support multi-modal transportation services (including vehicle control and management); interaction with other vehicles in the interests of conflict-free and safe traffic; interaction with s subscriber and traffic ITS subsystems; provides (on request) data, information and knowledge on a vehicle; provides notification of emergency and medical services in case of road emergencies [Zografos and Androutsopoulos (2008), Pajor (2009), Rehrl et al. (2007), Zhang et al. (2011)].

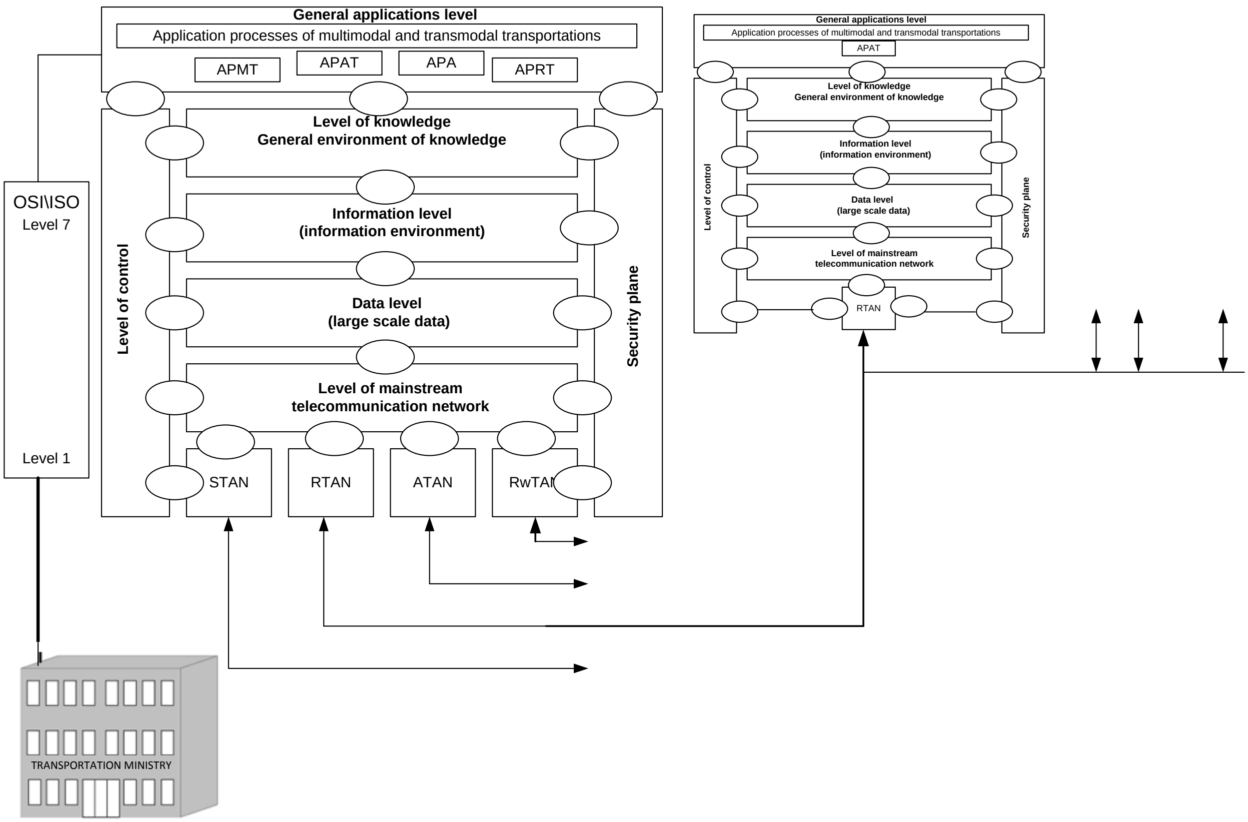

Fig. 2. Architecture of motor transport ITS control subsystem.

The control system architecture of motor transport ITS [Malygin et al. (2015)] is presented in Figure 3 and ensures the following: state control and road infrastructure management (traffic lights, content of electronic informative signs and displays, surveillance cameras and recording of offenses, etc.) and provides telematics services to the motor transport subsystem, and information services to drivers of vehicles; it also provides data, information and knowledge of its elements (devices) and other subsystems involved in tasks of multimodal transport services provision.

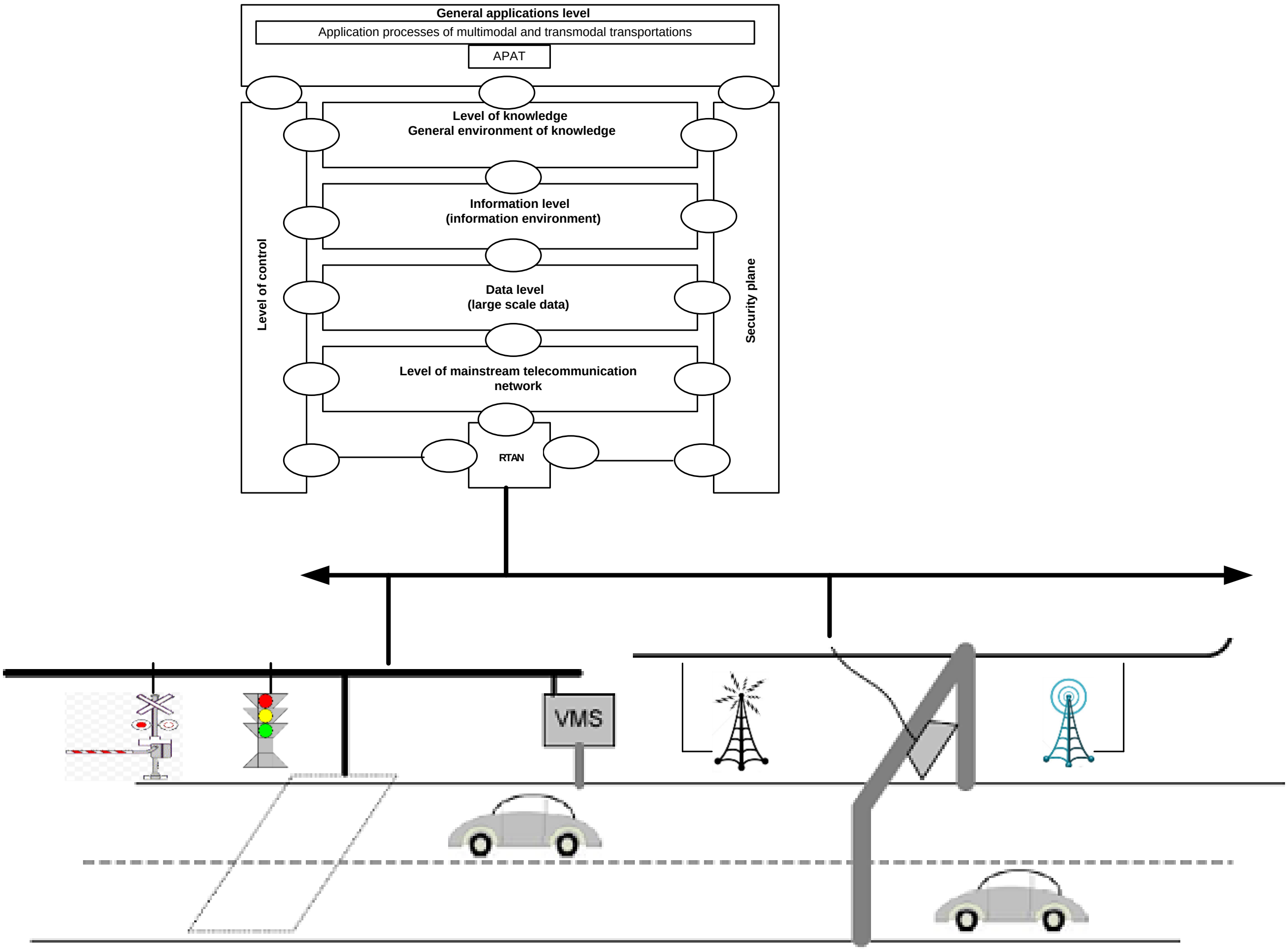

Fig. 3. Motor Transport ITS architecture of road subsystem, where VMS (Video Management System) is the video surveillance control system.

IMTS transportation gateways ensure the safety control and performance of transit functions between related transport modes on the basis of the following: unloading control and management (between modes); checking cargo integrity and storage (if required); cargoes reformatting and repackaging; labeling, recording, transshipment and delivery to their points of destination (in the next mode), etc.; cargo loading control and management.

2. Conclusion

IMTS project is a new type of information – and – telecommunication system which still is implemented neither in the Russian Federation nor in foreign countries. Scientific explanations submitted herein will help, in the course of the further implementation, to ensure efficient control and management of intra-modal and multimodal transport flows, to improve transport safety, save lives and health of the people which will ultimately result in significant economic synergistic effect of Russian and international transport systems.

Investigations completed by the authors permit creating in the nearest future a full-scale IMTS in the Russian Federation. In the first stage, taking into account the available domestic scientific results, achievements of the information and telecommunication technologies and technical capabilities and in case of the required financial resources provision a pilot IMTS project may be implemented in any entity of the Russian Federation, which will increase efficiency, quality of services and safety of the transportation system; it will also reduce cargo delivery time and will improve efficiency of the required transport system capacity of the Russian Federation; improve safety of people and cargo carriage will ensure a higher environmental safety of the functioning.

The task to built-up and develop IMTS in the Russian Federation (within the framework of the modern "Industry-4.0") assumes creation of the "fifth mode" within the framework of the Ministry of Transport, which will meet and ensure development of information, telecommunication and intellectual transport technologies.

References

Asaul, N.A. (2011). *National ITS Establishment as Issue of State Concern of the Russian Federation*. Transport, 4(35): 6–7.

Asaul, N.A. (2011). *Participation of Russia in the UN program on Road Safety Improvement*. Transport of the Russian Federation, 2(33): 37–39.

Asaul, N.A. (2012). Transport and Society. Transport Strategy – XXI Century, (16): 8.

Asaul, N.A. (2013). *Coordinated Transport Policy of the Customs Union and the Common Economic Space Member States.* In proceedings of the XV International Scientific Conference, vol.1, pp.311–320.

Asaul, N.A. (2013). *Strategic Objectives of the Russian Transport System Development*. In proceedings of the XV International Scientific Conference, vol.1, pp. 87–98.

Asaul, A.N., Malygin, I.G., Komashinskiy, V.I. (2016). *The fourth industrial revolution (INDUSTRIE 4.0) in transport and related industries*.

Komashinskiy, V.I. (2014). *Fundamentals of wireless data transmission*. *Architecture and Models.* Palmarium Academic Publishing, 285 p.

Malygin, I.G. Komashinskiy, V.I. Afonin, P.N. (2015). *Systematic approach to construction of cognitive transport systems and networks*. Bulletin of St. Petersburg State University Fire Service of EMERCOM of Russia, (4): 68–73.

Malygin, I.G. Komashinskiy, V.I., Kattsyn, D.V. (2015). *Some problems of cognitive transport systems and networks construction*. In proceedings of International Scientific Conference "Transport of Russia: Problems and Perspectives", (1): 3–8.

Pajor, T. (2009). *Multi-modal route planning*. Karlsruhe Institute of Technology.

Rehrl, K., Bruntsch, S., Mentz, H.J. (2007). *Assisting multimodal travelers: design and prototypical implementation of a personal travel companion*. IEEE Transactions on Intelligent Transportation Systems, 8(1): 31-41.

Zhang, L., Li, J.Q., Zhou, K. (2011). *Design and implementation of a traveler information tool with integrated real-time transit information and multi-modal trip planning*. Washington: Transportation Research Board Annual Meeting.

Zografos, K.G., and Androutsopoulos, K.N. (2008). *Algorithms for itinerary planning in multimodal transportation networks*. IEEE Transactions on Intelligent Transportation. Systems, 9(1): 175–184.

Zulkarnain, Leviäkangas, P. (2012). *The Size, Structure and Characteristics of Finland's ITS Industry*. Technology & Investment, Scientific Research Publishing, 3(3): 158–167.