



# Design and Implementation of ITS Systems in Urban Agglomerations – Selected System Problems

**G. KAROŃ<sup>a</sup>, J. MIKULSKI<sup>b</sup>, R. JANECKI<sup>c</sup>**

<sup>a</sup> SILESIAN UNIVERSITY OF TECHNOLOGY, Krasińskiego 8, 40-952 Katowice, Poland

<sup>b</sup> KATOWICE SCHOOL OF TECHNOLOGY, Rolna 43, 40-555 Katowice, Poland

<sup>c</sup> UNIVERSITY OF ECONOMICS IN KATOWICE, 1 Maja 50, 40-287 Katowice, Poland

EMAIL: grzegorz.karon@polsl.pl

## ABSTRACT

The article presents selected system problems regarding the design and implementation of ITS systems. Issues concern areas of urban agglomerations and urban ITS systems. Problems were identified during the work on the ITS system's pre-design documentation for one of the cities of the Upper Silesian Agglomeration in Poland.

**KEYWORDS:** urban, ITS systems,

## 1. Introduction

Implementation of ITS systems involves solving many problems already at the **initial investment stages**, i.e. at the **concept stage** and then at the **design stage**. The use of the V model and systems engineering (Fig. 1) enables appropriate design procedures including the process of decomposition and definition, and then system synthesis with integration and recomposition. The paper presents selected important issues regarding the following essential stages of the ITS systems lifecycle, i.e.:

- current status inventory stage,
- design stage,
- implementation stage,
- maintenance stage.

The key issues of ITS design regarding the presented case study of Upper Silesian Agglomeration in Poland are presented in the literature, among others in the following areas:

- use of the transport model on strategic level of management for assessment of ITS configuration [3, 4, 8, 11],

- selected problems of ITS project development in concept exploration and feasibility study [10],
- systems engineering for ITS in urban agglomeration [3],
- functional configuration of ITS for urban agglomerations [3, 5, 6, 7],
- managing traffic congestion with the use of ITS [3, 14].

Issues for the discussed case are presented in terms of systems engineering methods used in the design of ITS systems [1, 2, 12, 13]. The problems identified has been presented synthetically in the following parts of the paper.

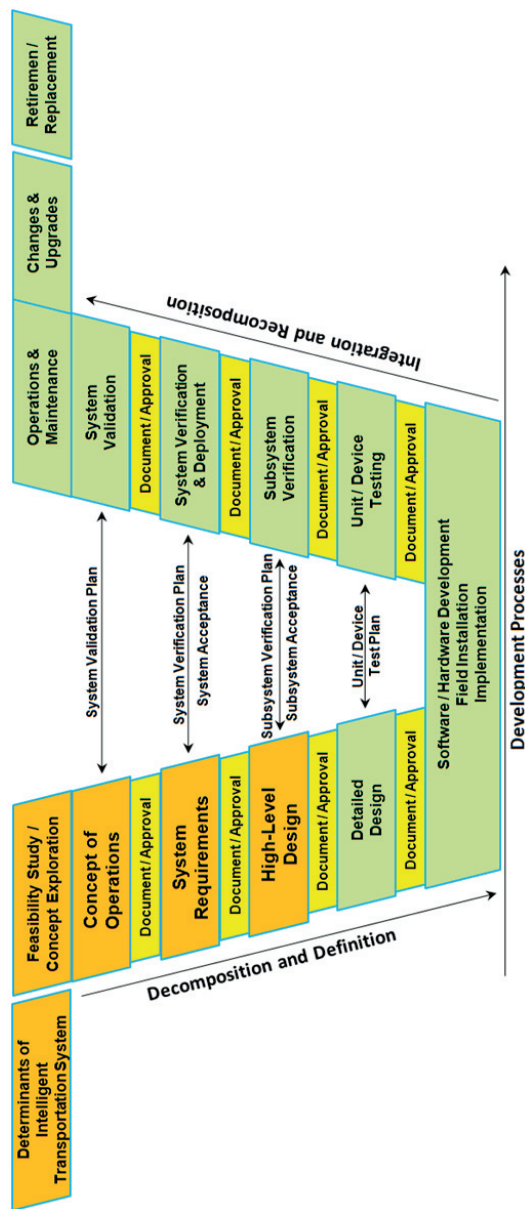


Fig. 1. Model V of Systems Engineering for ITS Design [own study based on 1, 12, 13]

## 2. Selected Problems of Current Status Inventory – Based on Case Study

Problems of current status inventory identified during the ITS contract selection process - when answering the questions posed by the bidders in the unlimited tender, include:

- problems of TMC's location (traffic management centers) – primary and secondary (redundant),
- problems of using existing infrastructure:

- existing traffic lights systems:
  - controller – type, manufacturer, date of installation and last modification,
  - configuration at the intersection: number of inlets, number of lanes, traffic organization on lanes – assigning of streams to the lanes, a sequence of coordinated intersections,
  - traffic controller algorithm: fixed time control, coordinated control, adaptive control, part-time operation, public transport and emergency vehicles priority (preemption), speed signs, railroad preemption,
  - data transmission medium: copper cable, fiber optic cable, wireless,
  - type of traffic monitoring/detection at intersection: number of induction loops, video-monitoring cameras, video-detection cameras, pedestrian entry buttons, radars of speed supervision and passage at red light, sensors of public transport vehicles detection, VMS variable message signs,
  - type of signaling devices and light sources (light bulbs, led) for traffic users: vehicles, pedestrians, public transport vehicles, cyclists, VMS,
- existing parking management systems: type of parking meters, management software, rules of use,
- existing priority systems for public transport vehicles PTS (tram, bus): type of systems, transmitter, receiver, refresh rate-reporting position by the vehicle,
- existing dynamic passenger information systems (DPIS): type of system and data transmission, number and location of DPIS signs,
- existing driver information systems (DIS): type of system and data transmission, number and location of VMS signs,
- problems of using ICT networks: sharing municipal ICT networks or build dedicated ICT networks,
- problems of the bidders presentation of their solution with use of transportation model, including:
  - building the base/reference transport model for the state of existing transport systems and processes,
  - making possible additional traffic measurements to calibrate the ITS solution of the bidder to the base model,
  - problems of evaluation of the proposed ITS solution using various simulation software, presented by each of the bidders,
  - problems of defining and assessing an innovative and equivalent solution in relation to solutions required in the description of the subject of the order,
- problems of project stages regarding the scope of stages and their mutual implementation.

## 3. Selected Problems of Design and Implementation – Based on Case Study

Problems of design and implementations identified during the ITS contract selection process - when answering the questions posed by the bidders in the unlimited tender, include:

- detailed designing of subsystems and the entire ITS system – preparation of a complete project documentation, i.e. all necessary projects and studies (including aspects of traffic engineering, technical, construction and implementation) ensuring the launch of the system together with the approval of all necessary arrangements, decisions and permits provided for this type of construction process, including, but not limited to:
    - development of construction and implementation projects related to the implementation of the ITS system, including maps for project purposes and obtaining necessary approvals, opinions, filings, etc., in accordance with the requirements of construction law and other legal regulations and requirements of administrative permits,
    - development of necessary traffic organization projects, including projects of the target traffic organization, as well as temporary traffic organization projects for the duration of construction works, including the necessary opinions, agreements, decisions and other formal and legal documents,
    - agreeing, on behalf of the investor, all locations and obtaining relevant approvals, including: lease of land, supply of energy,
  - construction – delivery and assembly of ITS components and subsystems, including, among others:
    - preparation of necessary connections and installation of telecommunications and power infrastructure,
    - reconstruction or modernization of traffic lights and other technical devices at intersections including, depending on the scope, replacement or adaptation of the traffic light controller, replacement of masts and signalling devices, modernization of cabling supplying traffic lights,,
    - preparation of as-built documentation in the scope of completed works, including: geodetic as-built documentation with confirmation of bringing it to geodesy resources,
  - calibration and optimization of the ITS system in order to achieve the required functionality and usability:
    - implementation of the ITS system operating in accordance with the latest technical, IT, organizational and legal solutions that allow to achieve real-time control functionality,
    - tuning the system and all its devices, in order to obtain full functionality and utility,
  - workplace trainings of employees and users in a way that ensures the use and ongoing maintenance of ITS subsystems.
- documentation and guidelines of device and software manufacturers,
  - audit of ITS system including procedures for device inspections and software updates for compliance with as-built documentation and guidelines of device and software manufacturers,
  - developing a procedure for creating a database of devices and methods for their configuration and recovery processes in order to maintain the functions and processes of the ITS system,
  - development of procedures of electronic documenting and tracking requests of service problems regarding problems and ways to remove them, including estimation of the time and costs of service problems requests for future service after the warranty period,
  - development of procedure of electronic documenting and tracking incidents that will not be included in the list of service problems, including incident handling and estimation of time and costs of this incidents after the warranty period,
  - development of the procedure of electronic documentation of the knowledge base acquired at the guarantee stage, which will include methods and procedures for solving incidents and service problems,
  - development of procedures of security policy in the area of security and protection of information and data as well as the state of technical and organizational security in terms of maintaining the appropriate level of accessibility, integrity, confidentiality, business continuity, legality in the scope:
    - requirements of the minister competent for interoperability matters and relevant provisions on the protection of personal data and other system documentation, as well as penetration tests of ICT infrastructure for the ITS system,
    - principles of communication security, examination of technical infrastructure and ITS network structure,
    - security rules for data processing and transmission in ITS system devices, in particular in terms of the possibility of interference of unauthorized external and internal users and the performance of tests that should enable detection of vulnerabilities to:
      - unauthorized access to the ITS internal network,
      - use the ITS network to carry out attacks on other networks,
      - bypassing security systems,
      - critical errors and security flaws in ITS equipment and software,
      - propagation of malicious software using the ITS network,
      - threats to the availability, confidentiality and integrity of the data being processed,
      - unauthorized control of the ITS system and destabilization and blocking the ITS system operation,
    - the principles of security of access to ITS system data, in particular in terms of the conditions of access to devices and data, operating conditions, durability and security of data in the field of hardware and software,

## 4. Selected Problems of Maintenance – Based on Case Study

Problems of maintenance identified during the ITS contract selection process - when answering the questions posed by the bidders in the unlimited tender, include:

- ensuring consistency of documentation for the ITS system, including, inter alia:
  - development and updating of device inspection and software update procedures for compliance with as-built

- ensuring continuity of correct ITS system operation through periodic maintenance activities for devices and software including:
  - updating the as-built documentation with the use of administrative and operational procedures of the ITS system - each time after the introduction of changes,
  - monitoring of the ITS systems and detection of anomalies in the ITS system functioning, in the scope of access to ITS subsystems, use of RAM, use of SWAP space, CPU load, disk space usage, operation of key processes (especially taking into account the preparing and securing backup copies and verifying their correctness and taking corrective actions in case of errors), verification of system logs for occurrence of critical events, monitoring of application logs in terms of occurrence of critical errors,
  - monitoring and reconfiguration of ICT network infrastructure in accordance with the scope of rules of access to network devices, state of network interfaces, use of network interfaces, memory usage, CPU load, device temperature, automatic backup of archival device configuration files,
  - changes implementation in the configuration of ITS equipment installation,
  - updating the ITS system in accordance with the manufacturer's recommendations and user requests, including ensuring the validity of all ITS subsystems, monitoring of updates and patches for individual subsystems, reporting on updates and fixes made available by software and hardware manufacturers, broken down into categories and installation dates,
  - anti-virus protection of the ITS system, including in terms of updating the antivirus software and its databases, a non-intrusive ITS scanning plan (a scan that can not interfere with the ITS equipment and can not cause ITS system instability), storing files quarantined for a specified period,
  - performing a system restore procedures from backups, if the scope of the failure requires it and the regression tests specified in the recovery plan,
  - review of technical condition of devices and infrastructure of ITS subsystems, including periodical cleaning, maintenance and calibration of sensors and measuring devices, detection devices, actuators (controllers, signalling devices, cameras, VMS signs), air conditioning devices, network devices, computers, monitors, etc., in justified cases, replacement of used batteries and batteries in devices, carry out complaint procedures with device manufacturers - in justified cases, replacement of elements that have been subject to natural wear bearing in mind the nature of work (e.g. filters, light bulbs, etc.) - in justified cases,
  - periodic legalization of measuring devices in accordance with the manufacturer's instructions,
  - technical consultations in the field of among others development of new communication technologies, adaptation to legal regulations, integration with other systems.

## 5. Conclusion

The presented problem issues were identified at the beginning of the ITS system design for the urban agglomeration, during the tender for the design and construction of the ITS system in the design and build formula. In the V model it is the initial stage of "Feasibility Study/Concept Exploration" (see Fig.1). The basic documentation at this stage are:

- the ITS concept,
- specification of essential terms of order for the ITS,
- pre-design functional and utility program of the ITS,
- the feasibility study of ITS.

The issues presented in the article are important because it indicates the large amount of practical knowledge that potential ITS contractors have. This is due to the relatively large number of ITS already implemented in the country, the development of ITS design methods as well as new technological solutions used in subsystems and ITS systems. At the same time, the large number of problems identified when responding to tenderers' questions after the tender is announced and the pre-project documentation made public discloses the need to develop a good practice manual, which would include key issues to be resolved at the pre-design documentation stage.

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