APPLICATION OF USE CASES AND THE UML LANGUAGE IN THE DESIGN OF INTELLIGENT TRANSPORTATION SYSTEMS

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Abstract – The purpose of this paper is to analyse the applicability of the description of use cases and the UML language that takes them into account in the process of designing Intelligent Transportation Systems (ITS). These systems are built using standardized solutions and devices, but the system itself and the individual organizational solutions used therein are individually tailored to the needs of the employer - the manager of the road network on which the system is implemented. The first stage of the project may include verbal descriptions of the requirements, proposals for solutions, relations between system elements, contents of databases, etc. However, the next stages of the work should involve the use of tools to formalize the record so that it is understandable to the entire project team, the contractors of the system elements, and then form the basis for the development of design and detailed documentation. The tools that can be used in the design process of an ITS solution are, described in the paper use cases that define the interaction of system users ("actors") with the system, and the UML language used in the design of information systems.
　　The paper describes the legal basis for ITS solutions, ways of defining use cases, the UML, including use case diagrams, behavioural diagrams and structural diagrams. Examples of the application of the UML to describe the design of an ITS system are also presented.

Key words – Intelligent Transportation Systems, ITS, Road Safety, UML, Use Cases

JEL Classification – O3, C61

INTRODUCTION

The trends visible in the global economy are reflected in the trends in the development of the road industry. Modern technologies assume energy efficiency, resource efficiency, decarbonization and the use of intelligent technologies in the process of construction, operation, maintenance of roads and their equipment [12]. The design process, which assumes the use of new methods and tools for road design, also requires improvement and a new approach. IT tools, which include the digital twin, Building Information Modeling (BIM) technologies, Augmented Reality (AR) methods as well as the life cases described in the article and elements of the UML language in application to modeling ITS systems.

IT and tele-information solutions in transportation (taking into account long-distance data transmission) are used in many areas of its operation, including:

- as a component of fleet management systems (monitoring of geographic location and transmission of selected information on vehicle movement and equipment status),
- in logistics, for management in the process of transporting goods and storing them,
- in vehicles – as part of on-board systems, which include:
  ○ safety systems such as Anti-Lock Braking System (ABS) and Electronic Stability Program (ESP),
  ○ e-Call system,
  ○ OBD – on-board diagnostic systems,
  ○ an infotainment system (including navigation and information on environmental conditions and hazards),

◦ active safety and driving automation systems (active cruise control, emergency braking, lane-keeping, or more advanced driving automation systems - currently at a level close to L3, as defined according to the SAE J3016 classification [11]),

− as part of Intelligent Transportation Systems which include the following subsystems:
  ◦ traffic management system, including data collection, processing and analysis, and generating traffic volume forecasts using current and archived data,
  ◦ the system measuring the parameters of atmospheric conditions relevant to road construction,
  ◦ the system providing drivers with information (providing traffic information, instructions, orders and bans),
  ◦ toll collection system for toll road sections and parking,
  ◦ parking information system,
  ◦ the system prioritizing the passage of public transport vehicles,
  ◦ traveller information system,
  ◦ the system for monitoring compliance with traffic regulations (speed control, weighing of vehicles in motion, monitoring of bus lanes, control in paid parking zones, etc.),
  ◦ vehicle-to-vehicle and vehicle-to-infrastructure data exchange system (C-ITS).

As can be seen from the above description, Intelligent Transportation Systems encompass a significant portion of the applications of IT and tele-information solutions in transportation. The rules for the implementation of these systems within the EU are regulated by Directive 40/2010/EC of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and interfaces with other modes of transport [4]. According to Article 5, Member States will take the necessary measures to ensure the application of the specifications to the aforementioned Directive. However, this will not affect the right of each Member State to decide on the implementation of such applications and services in its territory. In other words, the decision to implement ITS solutions will be up to the Member State, but if such solutions are implemented, the Member State should ensure that they comply with the provisions of the Directive. The Directive further specifies activities and priority areas related to the implementation of ITS solutions. The provisions of Directive 40/2010/EC are clarified and supplemented, among others, by:

− **Commission Delegated Regulation (EU) No. 885/2013 of 15 May 2013 supplementing ITS Directive 2010/40/EU of the European Parliament and of the Council with regard to the provision of information services for safe and secure parking places for trucks and commercial vehicles** [9]; The Regulation establishes the specifications necessary to ensure compliance, interoperability and continuity with regard to the implementation and operational use of information services on safe and secure parking for trucks and commercial vehicles at EU level, in accordance with Directive 2010/40/EU; The Regulation applies to the provision of information services located within the Trans-European Road Network (TERN),

− **Commission Delegated Regulation (EU) No. 886/2013 of 15 May 2013 supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to data and procedures for the provision, where possible, of road safety-related minimum universal traffic information free of charge to users** [10]; The Regulation establishes the specifications necessary to ensure compliance, interoperability and continuity with regard to the implementation and operational use of data and procedures for the provision of free of charge to users, as far as possible, of minimum universal traffic information related to road safety at EU level, in accordance with Directive 2010/40/EU; The Regulation applies to the provision of minimum universal traffic information services related to road safety for the trans-European road network,

− **Commission Delegated Regulation (EU) 2015/962 of 18 December 2014 supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to the provision of EU-wide real-time traffic information services** [6]; This Regulation establishes the specifications necessary to ensure the availability, exchange, reuse and updating of road and traffic data by road authorities, road managers and service providers for the provision of EU-wide real-time traffic information services; It applies to the comprehensive trans-European network of roads and motorways not covered by the network, and to priority zones designated by national authorities to the extent they deem appropriate; the Regulation applies in accordance with Article 5 of Directive 2010/40/EU,

− **Commission Delegated Regulation (EU) 2017/1926 of 31 May 2017 supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to the provision of EU-wide multimodal travel information services** [7]; The Regulation establishes the specifications

necessary to guarantee accurate and internationally available multimodal travel information services to ITS users throughout the EU; This Regulation applies to the entire transport network in the European Union; It is applied in accordance with Article 5 of Directive 2010/40/EU,

− **Commission Delegated Regulation (EU) 2022/670 of 2 February 2022 supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to the provision of EU-wide real-time traffic information services** [8]; The Regulation establishes the specifications necessary to ensure the improvement of the availability, exchange, reuse and updating of data by data holders and data users for the provision of EU-wide real-time traffic information services, as well as to ensure that these services are correct and available to end users across borders; The Regulation applies to the entire road network that is publicly accessible to motorized traffic. As an exception, it does not apply to private roads unless they are part of the TEN-T comprehensive network or are designated as a motorway or trunk road; the Regulation applies in accordance with Article 5 of Directive 2010/40/EU.

As is evident from, among others, the aforementioned Regulations, data and information are increasingly important in transportation, and should be collected and made available in a structured manner that allows for efficient retrieval through the use of, among others, metadata. These data should be stored, collected and made available in a structured manner (using predefined communication protocols), in databases coordinated at the national level and made available free of charge to end users in order to ensure the safe and efficient transport of goods and passengers throughout the European Union. What's more, due to the constant upward trend in the scope and volume of data stored, management concepts specific to Big Data solutions are increasingly being explored as part of the work on EU draft documents. The implementation of the so-called management by data is also planned and underway.

The European FRAME architecture is a tool to support the implementation of ITS solutions. It is a combination of concepts and IT tools that systematize the implementation of systems. It supports the process aimed at determining user requirements by selecting them from a catalogue of defined needs and requirements - "FRAME User Needs". This is followed by the determination of functional architecture (without specifying the technical solutions for the implementation of the various functionalities) and the physical architecture, within which the individual

solutions, technical and ICT devices included in the system are specified. However, the guidelines of the aforementioned Directive, the priority areas and activities defined therein, combined with the European FRAME architecture, will not guarantee the implementation of an ITS solution that meets user requirements, road safety requirements, or the priorities adopted by the road manager and other stakeholders. The ITS solution, which meets these expectations and requirements, with the required priorities, and which in fact is a compromise between all these considerations, is the responsibility of the system designer (this can be a single person, a group of designers, a consulting firm, a design firm, etc.). The designer is the originator of individual solutions, taking into account predefined requirements, constraints and other considerations (priorities, costs, etc.). Thus, it is their knowledge, creativity and experience, that the way of the system's operation and the individual sub-solutions adopted depend on.

In the case of urban areas, the starting point for designing ITS solutions is the sustainable transport development strategy adopted by the city authorities. In the case of non-urban roads, strategies at national and European level are important. These documents provide assumptions for traffic management strategies, which are then implemented as part of the control algorithms used in the sectional and area traffic control systems. Assumptions and requirements are often formulated by the party ordering the system - the city or the manager of the road network on which the system operates. The authors of such studies usually do not have IT competences and are unable to use tools intended for IT specialists. Therefore, the prepared descriptions of the way the system works are usually in the form of lists of requirements for the system. They contain individual organizational and legal requirements as well as specific requirements determined individually for a given project. They also contain the method of implementation of individual functionalities, which may take into account the specificity of a given group of recipients of individual solutions and specific requirements enabling the integration of the ITS solution with other technical and organizational solutions implemented in a given area. All these requirements describing both the system operation area, individual functionalities and the manner of their implementation, as well as the system's behavior in the event of events, are described in a simple descriptive language. However, these are not descriptions prepared by IT specialists using dedicated tools. It seems that such a solution may constitute a good basis for the concluded contract for

the implementation of the system, but already at the stage of work on the system, a better solution would be to use a unified language understood by both the ordering party and the contractor. Such a solution may be "use cases" and the UML language commonly used as an IT tool. It can be used in general systems modeling theory for the static representation of the system (structure) and the dynamic representation (system behavior). The structure of the record is uniform, transparent, easy to modify and understandable for both sides of the system implementation process. The effects of work at the stage of arrangements regarding the detailed implementation of individual functionalities can be easily taken into account and versioned using this tool. Its advantages can speed up the work and make it easier to implement.

1. APPLICATION OF USE CASES

The so-called use cases are a tool that can be used to describe how the ITS system under development works and depict the interaction between an actor (stakeholder) initiating an event in the system's area of operation and the sequence of events triggered by it. They originated in computer science and are a concept often used in the IT field, but much less frequently used in the area related to Intelligent Transportation Systems. They are used to describe how the system behaves triggered by an action/activity taken by an actor [2]. They do not refer to the internal design (functional and technical solutions) of the system, which can respond to an event in different ways (alternative scenarios), performing the required sequence of events leading to the established goal. A "use case" also does not define the reason or behaviour of the actor/stakeholder who knows for what purpose he used the system and what he intended to achieve by doing so. What's more, use cases make possible the so-called encapsulation of concepts that involves grouping and hiding information about the internal structure of a system element and subsequent manipulation of the element created this way as a whole. They make it possible to apply generalizations at the level of the system functionality description and manage the level of detail of the various stages of project work, which is particularly valuable for large projects. Moreover, use cases do not contain information about the internal structure of the system (they do not impose functional solutions), as well as they do not determine how to implement (execute) them. The result of the use case application is the so-called domain model of the system which describes the logic of the system's behaviour under the influence of external stimuli, the so-called domain logic.

2. UML

2.1. CHARACTERISTICS OF THE UML

The UML (Unified Modeling Language), is a unified language used to create models of information systems, but also to model business processes, describe organizational structures, etc. It was developed based on the experience and work of Grady Booch, Ivar Jacobson and James Rumbaugh. The UML uses the concept of object orientation which the concepts of object, class, inheritance, attribute, relationships and methods, among others, are associated with [3]. The language is a combination of defined concepts and graphical diagrams (notations). They make it possible to create models of the analysed problem, to describe the assumptions of the designed information system in a systematic way and the detailed solutions contained therein. Unlike object-oriented programming methods, it does not contain an element of description of how to proceed in each phase of the project, but is only a set of defined concepts and notations. UML makes it easier to write down the concepts of how information systems work in a human-legible way, while leaving aside the use of programming languages and the programme code written using them. This facilitates the creation of clear, easy to analyse and develop concepts and descriptions, during the design and development stages of the application. At the same time, the descriptions are legible due to the notation used which is adapted to human perception. Also, UML is not used exclusively for software development work but it also allows for the creation of system-wide models.

2.2. USE CASE DIAGRAMS

In the early stages of a project implementation, the way a system responds to an actor's commands can be described simply in words, while in the longer term it can be formalized using the UML that allows a clear record of the "use case" in graphic form, the so-called "use case diagrams". They provide a universal record that, in addition to fulfilling its primary function of recording how the system behaves in the case under analysis, allows easy presentation of how the system works, during project work, to groups of stakeholders and experts. We can describe individual use cases using the following characteristics [5]:
- **identifier/tag** - a string of characters identifying the requirement being described,
- **name** - the name of the use case, e.g. start of toll parking, granting of passage priority,
- **actor** - a role (a system user belonging to a group with defined permissions), an external system or a device using a use case,

- **initial conditions** - required conditions, the fulfilment of which enables the implementation of the use case, such as the passage of a vehicle at a red light, the appearance of a queue of waiting vehicles, etc.
- **initiating event** - an event initiated by an actor, which is the reason for starting the procedure described within the defined use case; The event can be initiated from outside the system, by its user, or as a result of a trigger by another system or event (e.g., generation of a periodic report, after the end of a calendar month),
- **description of the interaction process** - the stages of data exchange between the actor and the system occurring during the implementation of the use case, e.g., selection of the type of printout by the actor, display of the correct form, selection of the printout option by the actor, confirmation of the printout, etc.
- **main procedure** - a list of standard actions performed within the use case,
- **result** - a description of the effects of the implementation of the use case,
- **alternative procedures** – which represent a different course of handling an event in the system (use case) than the standard one, the execution of which, however, results in the achievement of the originally intended purpose,
- **exceptional events** - situations in which the execution of the use case is not possible, for which, at the same time, the way of handling the event is specified in the form of, for example, a message about the need and manner of completion of the data form by the user, an error message, the implementation of an emergency procedure, etc.
- **final conditions** - the consequences of the correct implementation of the procedure provided for under the use case, such as the correct implementation of calculations and their storage in the database,
- **links** - a directory of identifiers of related use cases.

2.3. BEHAVIOURAL DIAGRAMS AND STRUCTURED DIAGRAMS

As already mentioned, use cases define how the system will behave as a result of the actions/activities taken by the actor (system user/stakeholder), but the actor's interaction with the system should also be defined and described at the system design stage. To this end, it is also recommended to encapsulate the work and manage the level of detail in the descriptions at each stage of the project. Defining how an actor interacts with the system is a separate issue and a separate stage of design work.

UML owes the legibility of the records to the ability to present content graphically, thanks to the use of diagrams. Due to the complexity of real systems and the processes within them, it becomes insufficient to present the system from one point of view only – such as the structure, or the flow of data. Therefore, the UML proposes a number of perspectives represented by diagrams for, customized representation of the structure and properties of a system. Among the 14 types of UML diagrams, behavioural and structural diagrams are distinguished. Behavioural diagrams show how system components interact with each other to provide the required functionality. Structural diagrams show how the system is organized and the relationships between its elements. The group of <u>behavioural</u> diagrams includes:

- **class diagram** – the most popular of the UML diagrams used to present the classes in the system and their interrelationships; Each class is presented in the form of a rectangle divided into three parts containing the class name, attributes and behaviour; Classes are elements of the future system (to be designed) and are interrelated, but the diagram of classes and of their interrelationships does not yet reflect the structure of the system, which the object diagram is used to present,
- **component diagram** – is used to illustrate the system by component, thus enabling a schematic, easy-to-analyse representation of its structure,
- **package diagram** – is used to group the elements of the system, in order to ensure the clarity of the diagram; These diagrams are internally consistent (concern the same or similar elements of the designed solution), but are loosely related to the other elements of the system (of a different nature),
- **object diagram** – is used to represent the structure of the designed system or a part of it, using the elements of the previously developed class diagram; Within the object diagram, the symbols of objects and their interrelationships are presented,
- **complex structure diagram** – is rarely used in practical solutions, since its role is to present the internal structure of classes and interactions between class components,
- **Deployment Diagram** – contains processing nodes and the components and objects within them, as well as the processes running therein,
- **profile diagram** – allows defining new elements of the system model, described using the UML, better suited to modeling within specific application areas.

The group of structural diagrams includes:
- **sequence diagram** – is used to graphically record the sequence of messages and the sequence of interactions between the objects of the system, in the case of the analysed scenario; The processes

implemented are shown chronologically on the vertical axis, and the interactions between them are shown using connection lines, ended with arrows,

– **temporal diagram** – resembles a sequence diagram in that it also presents the interaction between objects, but its main purpose is to show how objects act over a limited time period,

– **action (activity) diagram** – represents the activities that take place in the system and represent the flow of process control and data between system elements,

– **interaction overview diagram** – is used to graphically present various diagrams of system component interactions, in the order in which they occur,

– **use case diagram** – is used to model the actors (people or organizations) in the system, the method of their operation, and the interactions between

the actions,

– **state diagram** – represents the state of the objects that make up the system, changing their properties under the influence of factors from outside the object; The state diagram presents information about the transition from one state to another,

– **communication diagram** – is used to show the method of communication and information flow between objects.

3. EXAMPLES OF USE CASES IN ITS DESIGN

ITS systems are designed to meet the needs of stakeholders (system users). Drawings were used as illustrations for the descriptions of use cases in ITS systems, examples of drawings from the paper [1]. Figure 1 shows a **use case diagram of** an ITS stakeholder labelled "Traveller".
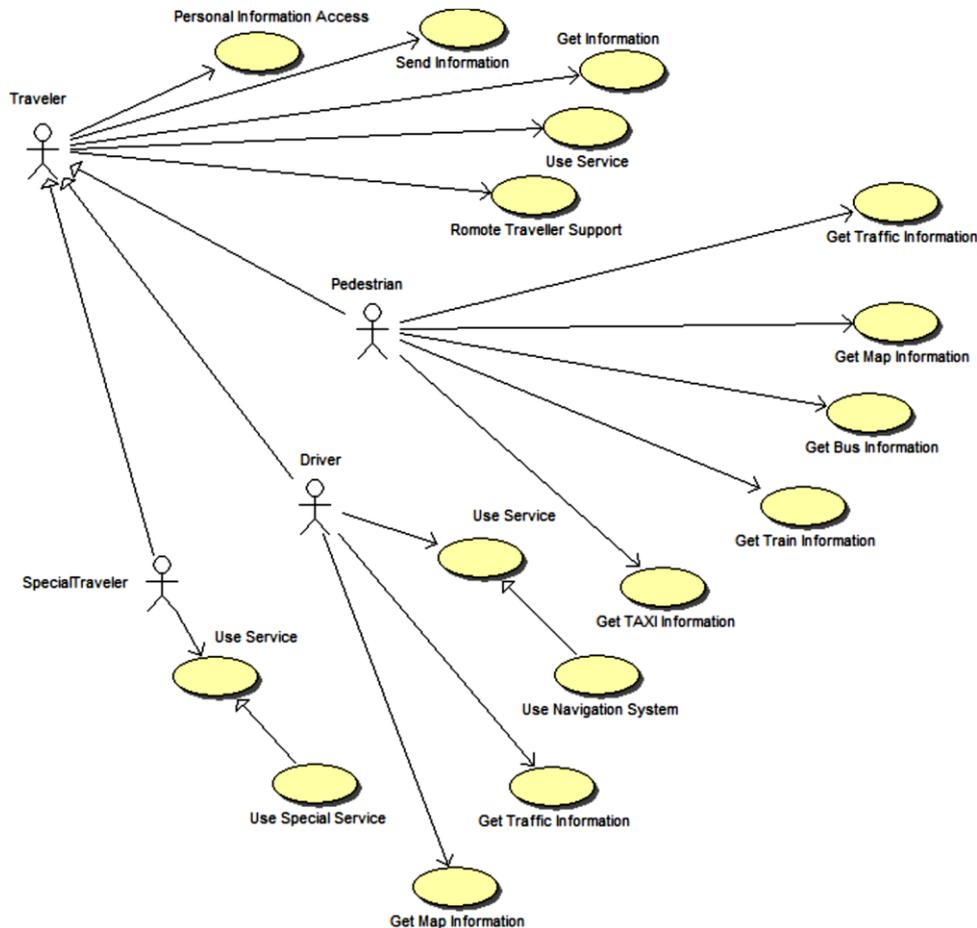

Fig. 1. ITS system stakeholder's use case diagram [1]

The diagram shows, within a simplified graphic diagram, a traveller who undertakes activities or performs specific roles, which include the following elements [1]:

- Personal Information Access,
- Send Information (sending data and information),
- Get Information (obtaining data and information),
- Use Service (using an external service),
- Remote Traveller Support (using a remote user support),
- Pedestrian (pedestrian's role):
  - Get Traffic Information (receiving information relevant to pedestrian traffic, such as information about closed parts of streets with pedestrian crossings),
  - Get Map Information (obtaining geographic location information and data for map presentation),
  - Get Bus Information (obtaining information for bus travel purposes, such as timetables and dynamic information on the location of transportation modes),
  - Get Train Information (obtaining information for train travel purposes, e.g. timetables and dynamic information on the location of means of transportation),
  - Get Taxi Information (obtaining information for taxi travel purposes, e.g., confirmation of means of transport reservation, scheduled arrival time, expected cost of service),
- Driver (driver's role):
  - Use Service (use of the service):
    - Use Navigation System (use of the vehicle's navigation system to help select the optimal route, taking into account current road conditions and obstructions, and ensure that the vehicle is guided to the programmed destination),
- Get Traffic Information (obtaining traffic information, including road works and other obstructions),
- Get Map Information (obtaining geographic location information, background maps and information about objects located on the map),
- Special Traveller (the role of the "special" traveller):
  - Service Use (use of the service):
    - Special Service Use (use of a special service reserved for a dedicated group of recipients, for example).

Figure 2 shows an example class diagram containing the **Traveller main class** and the following subclasses: Pedestrian, Driver, Special Traveller.
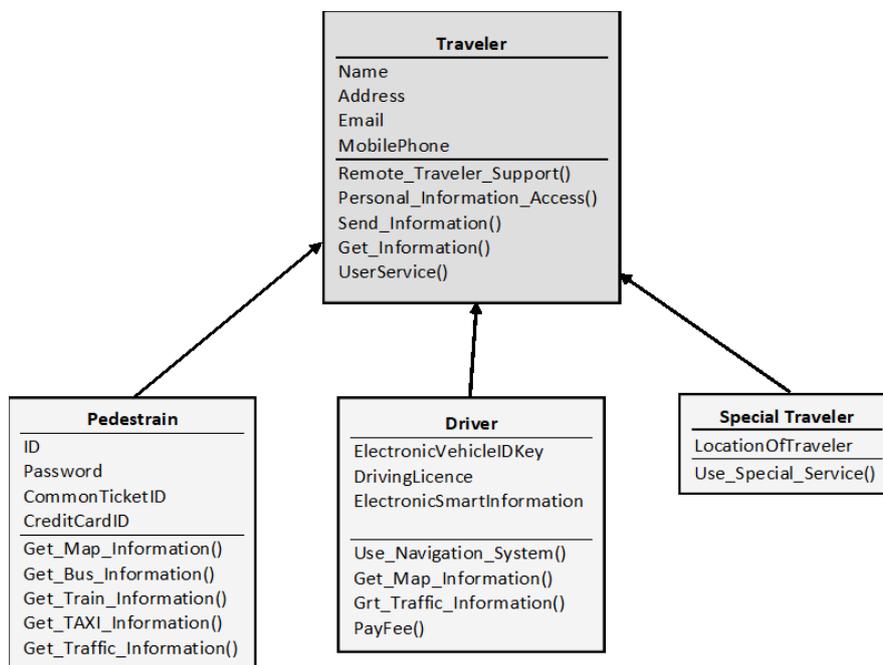

Fig. 2. An example class diagram containing the Traveller main class and the following subclasses: Pedestrian, Driver, Special Traveller [1]

The Traveller class contains a set of data in the form of class "properties", which include name, address, email address, mobile phone number and class-specific methods, which are essentially the programme fragments that are triggered when predefined circumstances occur (e.g. obtaining geographic location data). **The Pedestrian subclass** contains a unique pedestrian identification number ("ID"), a password used to log into the system, a ticket identification number common to different means of transport ("CommonTicketID"), and a credit card number ("CreditCardID"). **The Driver subclass** contains a collection of data about: electronic vehicle identification key ("ElectronicVehicleIDKey"), driver's license number ("DrivingLicence"), electronic additional

information related to the driver ("ElectronicSmart-Information"). **The Special Traveller subclass** contains information about the geographic location of the traveller ("LocationOfTraveler").

Figure 3 shows a diagram of the main class of the system, labelled "Center" in the diagram.

The "Center" class includes 4 elements, i.e.:
- – "TrafficCenter",
- – "SafetyCenter",
- – "TravelInformationCenter",
- – "CommercialCenter".

The "TrafficCenter" class implements the area traffic management function using the "TrafficControlAnd-ManagementCenter" and "TrafficInformationCenter" classes.
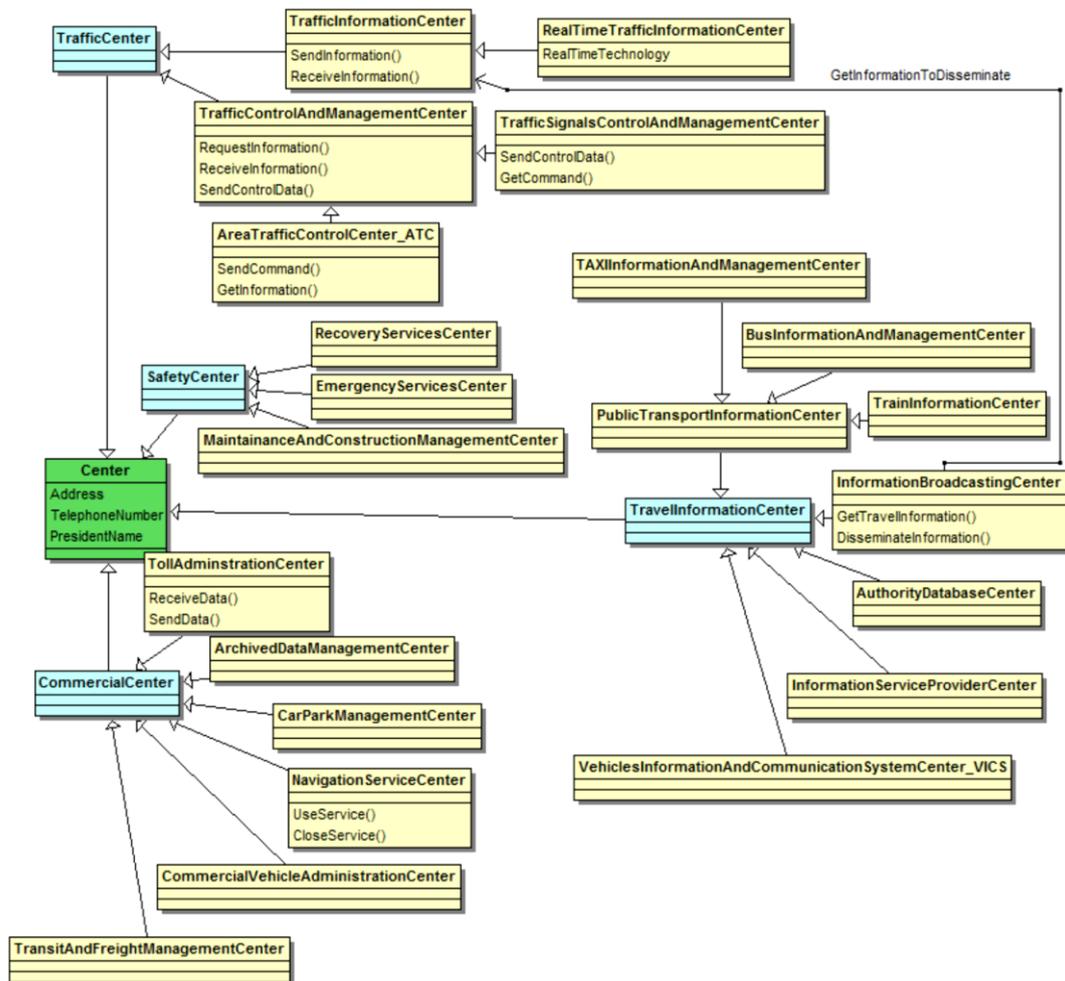

Fig. 3. System main class diagram [1]

The first of the aforementioned classes is used to manage traffic signals at intersections located in the area covered by the system. For this purpose, cooperation with other devices for measurement data acquisition and traffic control is also implemented. The "Traffic-InformationCenter" class is used to collect data on the traffic situation (which is done in real time), as well as to receive data from the class that provides data in the form of broadcasting services ("Broadcasting").

The "SafetyCenter" class is used to provide traffic safety services during normal system operation, as well as during the implementation of maintenance services of road infrastructure and ITS infrastructure. This class also includes procedures related to the conducting rescue operations, as well as services aimed at restoring normal condition after a traffic incident.

The "TravelInformationCenter" class is associated with multiple subclasses and is used to provide comprehensive traveller information, such as information for public transport users, information and communication for participating vehicles, information from third-party service providers (outside the ITS system), and data from the official database and information from public broadcasting systems. There is a strong emphasis on data and management in public transport. For this reason, the "PublicTransport-InformationSystem" class is associated with as many as three subclasses to include: a class for handling services provided by taxi companies (data acquisition and management), a class for handling services provided by bus transportation and a class for handling rail transportation.

The "CommercialCenter" class connects to a number of classes for the implementation of toll collection (e.g., for vehicle parking), management of archival data collected by the system, parking space management, vehicle navigation services, commercial vehicle fleet management, and transit and freight delivery management.

CONCLUSIONS

Intelligent Transportation Systems are a combination of ICT and organizational solutions, applied to the road industry, to improve road safety and efficiency. From a technical point of view, these are information systems, the recipients of which are traffic participants – pedestrians, cyclists, passengers of cars, buses, trolleybuses, drivers of personal transport vehicles, and passengers of rail vehicles, which include trams and railway vehicles (urban, metropolitan and long-distance rail). In the case of IT solutions, in particular, the tools described in this paper that facilitate the preparation of a detailed description of the ITS

solution of the tool being developed are applicable. A structured approach that is easy to understand for the team designing and implementing the ITS solution, based on clear flowcharts and graphical charts, facilitates its implementation. This is particularly important due to the involvement of IT specialists, programmers and database administrators who are very familiar with this type of solution. The UML, used within the framework of such an approach, allows unification (standardization) of descriptions by combining defined blocks in the form of graphic diagrams (notations). This makes it possible to create a model that describes the analysed problem, by systematizing the description of the designed information system and the detailed solutions contained therein. In contrast, unlike object-oriented programming methods, this description does not include the characteristics of how to proceed in each phase of the project. The UML, therefore, facilitates the preparation of a description of the operation concept of ITS systems in a human-legible way, without referring to concepts relating to programming languages and programme code. This facilitates the creation of clear, easy to analyse and develop concepts and descriptions, during the design and development stages of the application. Such an approach is appropriate, both at the stage of designing the ITS system when discussing the details of individual solutions directly with the ordering party – the future user of the system – and at the stage of design work related to the implementation of the system. Facilitated by the UML, use case diagrams, behavioural diagrams and structural diagrams describe the system in a clear graphic way. Thus, they are a tool that facilitates work at every stage of the system implementation.

ABBREVIATIONS

1. **C-ITS** - Cooperative Intelligent Transport System.
2. **FRAME** - European Intelligent Transport Systems Framework Architecture.
3. **IT** - information technology (IT discipline and industry in the labour market dealing with the application of computing technologies).
4. **ITS** - Intelligent Transportation Systems.
5. **EU** - European Union.
6. **UML** - Unified Modeling Language.
7. **EC** - European Community.

ZASTOSOWANIE PRZYPADKÓW UŻYCIA I JĘZYKA UML W PROJEKTOWANIU INTELIGENTNYCH SYSTEMÓW TRANSPORTOWYCH

Celem artykułu jest analiza możliwości zastosowania opisu „przypadków użycia" i uwzględniającego je języka UML w procesie projektowania Inteligentnych Systemów Transportowych (ITS).

Systemy te budowane są z użyciem znormalizowanych i ustandaryzowanych rozwiązań i urządzeń, jednak sam system i poszczególne rozwiązania organizacyjne w nim zastosowane są indywidualnie dostosowywane do potrzeb zamawiającego – zarządcy sieci dróg na których został zaimplementowany system. Pierwszy etap projektu może zawierać słowne opisy wymagań, propozycje rozwiązań, relacji między elementami systemu, zawartości baz danych itp. Jednak kolejne etapy prac powinny polegać na użyciu narzędzi umożliwiających sformalizowanie zapisu, tak aby był on zrozumiały dla całego zespołu projektowego, wykonawców elementów systemu, a następnie stanowił podstawę do opracowania dokumentacji projektowej i wykonawczej. Narzędziami, które mogą być zastosowane w procesie projektowania rozwiązania ITS są, opisane w artykule, „przypadki użycia" definiujące interakcję użytkowników systemu („aktorów") z systemem oraz stosowany w projektowaniu systemów informatycznych język UML.

W artykule opisano podstawy prawne funkcjonowania rozwiązań ITS, sposób definiowania „przypadków użycia", język UML, w tym diagramy przypadków użycia, diagramy behawioralne i diagramy strukturalne. Przedstawiono również przykłady zastosowania języka UML do opisu projektu systemu ITS.

Słowa kluczowe: Inteligentne Systemy Transportowe, ITS, Bezpieczeństwo Ruchu Drogowego, UML, przypadki użycia

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