JOURNAL OF MECHANICAL AND TRANSPORT ENGINEERING
Vol. 69, No. 3 2017
DOI 10.21008/j.2449-920X.2017.69.3.01

Emil AUGUSTYN*
Adam KADZIŃSKI*
(Received: 21 MAR 2017, Received in revised form: 7 OCT 2017, Accepted: 5 OCT 2017)

MODEL OF GENERALIZED TECHNICAL SYSTEM

The main purpose of this paper is to design the Model of Generalized Technical System (MGTS) which derives from spread analysis of presently existing models of technical systems. Undertaken considerations are aimed to indicate a suitable general model based on observed homology between currently existing technical systems in e.g. different transport branches. It is predicted that the following model will be usable in various analyses domains where some technical objects already exist or will exist in the future. Using the systems methodology, systems engineering and technical object oriented attitude, authors design and present the Model of Generalized Technical System. Authors assume that the technical object means a kind of facility (e.g. vehicles, part of infrastructure etc.) in the specific analyses domain. A tree-shaped scheme of the model's decomposition is consistent with some general rules of the organizational taxonomy of any technical objects' operator. Moreover, the scheme presents – in a general way – an operation process of technical objects and arranges the latter ones according to their reliability states. The future application of the model will provides clear and comprehensible configuration and presentation of technical systems which include various kinds of technical objects.

Keywords: technical object (facility), Generalized Technical System, Model of Generalized Technical System, systems methodology

1. INTRODUCTION

The wide dissemination of systems methodology [Cempel 2006, Łunarski 2010] is observed in almost every branch of human activity during recent decades. It proves that systemic attitude is the most common and universal way of researching the surrounding world from the holistic point of view. Nowadays, casual things of human life are being increasingly presented as elements of a system or as systems

* Poznan University of Technology, Faculty of Machines and Transport.

themselves which are built of many elements. The first known systems derive from the nature but progressive human development has been contributing to the creation/configuration of the more complex systems by man – especially man-made systems e.g. technical systems. Man has noticed the structural community and various processes which have been taking place both in the nature and technics. Due to that, it caused wider necessity to use the General Systems Theory and its utilization in systems engineering [Sage 1992, Cempel 2006, Łunarski 2010].

The systemic attitude (systems methodology) is one of opportunities to conduct researches which concern the nature, human being, technics, etc. What is more, it is connected with definitions of the system and other various entities [Chmielecki 1999] to emphasize some objects and phenomena among aggregations of other objects. It is assumed that the appellation of object means a kind of facility (e.g. vehicle, part of infrastructure, etc.) in a specific analyses domain. System is basically defined as the entity which constitutes an aggregation of elements with their strictly determined properties and relationships, generally being as one comprehensive whole [Cempel 2006]. Main feature of systemic entity is synergistic interaction observed between system's elements.

Technical objects [Młyńczak 2012], e.g. cars, trains, or planes, all over the world, are operating in various technical environments whose configuration includes various systems, objects and components. It is required that their mutual interactions must or should be based on common synergy. Literature's analyses [Młyńczak 2012, Kadziński 2013] concerned technical objects (facilities) operation systems and principles of systems' organizing and functioning. On the basis of literature's analyses, it was possible to initiate the authors' idea of extracting and presenting the Generalized Technical System (GTS).

As a result of above mentioned circumstances, the main purpose of this paper is to design the **Model of Generalized Technical System** (**MGTS**). The MGTS will be designed as a comprehensive tool to collect systems, objects and their components, which participate in a specific analyses domain, from a technical point of view. It is assumed that MGTS will be designed via systems engineering and will based on observed homology between presently existing (dedicated) models of technical systems in various transport branches.

2. TECHNICAL SYSTEMS ENGINEERING IN TRANSPORT

The appellation of systems engineering (SE) arose quite recently. At the beginning of seventies of the twentieth century, it has been noticed that the art of systems' constitution significantly differ from conventional objects' constitution process. Due to that, it was obvious that, this kind of art requires dedicated appellation. Systems engineering means the process of designing systems which are being cre-

ated by man, also including processes of their preparation, exploitation, examination, and evaluation [Powierża 1997].

From a cognitive point of view, SE as a branch of science, deals with both designing and modelling processes. In contrast to traditional engineering, SE extracts the object and the subject of consideration and also includes specific attitude. The object could be also defined as a kind of complex system, connected with specific environment – it is not an isolated object (element/facility). However, groups of single objects (elements/facilities) – synergistically related and connected with the determined analyses domain – are usually elements of such the system. The subject of consideration means a formation of various connections in system itself and also between system and surrounding environment [Powierża 1997].

The transport systems engineering is an example of particular SE. The appeallation of transport systems engineering means the art of transport systems constitution. Transport systems are complex structures with specific technical (connected with the branch of transport and its functions), organizational, financial, and control objects (systems) [Strategia…, 2013]. The main technical objects of transport systems are primarily vehicles and infrastructure of specific transport's branch. Vehicles and infrastructure as the technical objects are being organized, managed and operated properly by the specific operator (manager). Adequate decomposition of organizational and operational exploitation elements allows to extract technical system as the fragment of specific branch of transport. Only the fragment of specific branch of transport is being considered because in the newly designed MGTS some elements are going to be omitted. Undeniably, in a commonly known transport systems, elements of an operators' logistics and administration are also essential but from typical technical point of view they are not significant. Technical objects are going to be most significant in the newly designed model (MGTS).

Notwithstanding the type of transport system which is going to be created, there is no possibility to design the same structure for all transport branches. Every kind of operator, vehicle or infrastructure's elements are characterized by different specifics, requirements and organizational structure. This state of affairs caused that it is needed to find the most convenient solution. Due to that, it is required to collect all common features of various transport branches and design a kind of model of generalized system. The model will be a simplified way to represent even all or vast majority of transport systems. Having considered technical systems, it is required to design the MGTS which will represent not only technical transport systems but also every analyses domain in which technical objects exist too.

So far, the analyzed literature has presented e.g. railway transport system and urban transport system as the systems based on specific technical objects [Kadziński 2013]. The above mentioned transport systems have some common features which will be presented via MGTS. The MGTS will replace originally existed transport systems. As a result, it will constitute a kind of adopted form of technical systems' representation. The MGTS will be used as a tool of presenting,

simulating and explaining the original system adequately in a specific analyses domain. Additionally, the newly designed MGTS will give an opportunity of its implementation in different fields of technics. Being considered fields of technics are obviously connected with an analyses domain in which technical objects also exist and are adequately operated and organized. On the basis of the MGTS, it will be possible to constitute new systems what means creative act of creation a new entity (object/facility as a system) according to the set idea and inspired by arisen needs in a specific analyses domain. The systems' constitution, as it was mentioned, could also refer to a kind of transformation the fragment of a specific analyses domain into a new shape which is defined by the needs and requirements [Powierża 1997].

3. DESIGNING THE MODEL OF GENERALIZED TECHNICAL SYSTEM

The science and technology development have been generating outright ideal situation which causes that the human possibility of designing and creating new systems seems to be unlimited. Thanks to the observed homology, in already existed and known systems and also with the usage of a specific analyses domain's knowledge, it is possible to design a new man-made system. The system's designing process is being carried out via systems engineering which synthesis all available knowledge (of a specific analyses domain) and gives the required product as a result – system (Fig. 1) [Sage 1992, Cempel 2006, Łunarski 2010]. In that case, the Generalized Technical System (GTS) is treated as a required product (system).

Based on all-embracing expertise and experience, it is certain that each newly designed system usually delivers a kind of double feedback eventually. Basically, it could be usually noticed as the next new system's definition and extension of the systemic knowledge but on the other hand it has also an influence on a specific analyses domain's development. It is commonly known process, that at each stage of systems' evolution new expertise could be acquired as a result of following system's operation. If that kind of process does not proceed, man probably does not create so many various systems yet. Specific attitude, which is being presented, is required to make a kind of knowledge and principles transformation between different sciences [Sage 1992, Cempel 2006, Łunarski 2010]. Consequently, it extends the knowledge base, commonly known as the General Systems Theory, which could be used by anyone who creates a new system. Additionally, based on predecessors' experience and known structural intersystem homology, it will be possible to avoid a lot of mistakes during the designing process which are going to be carried out by the future scientific successors.

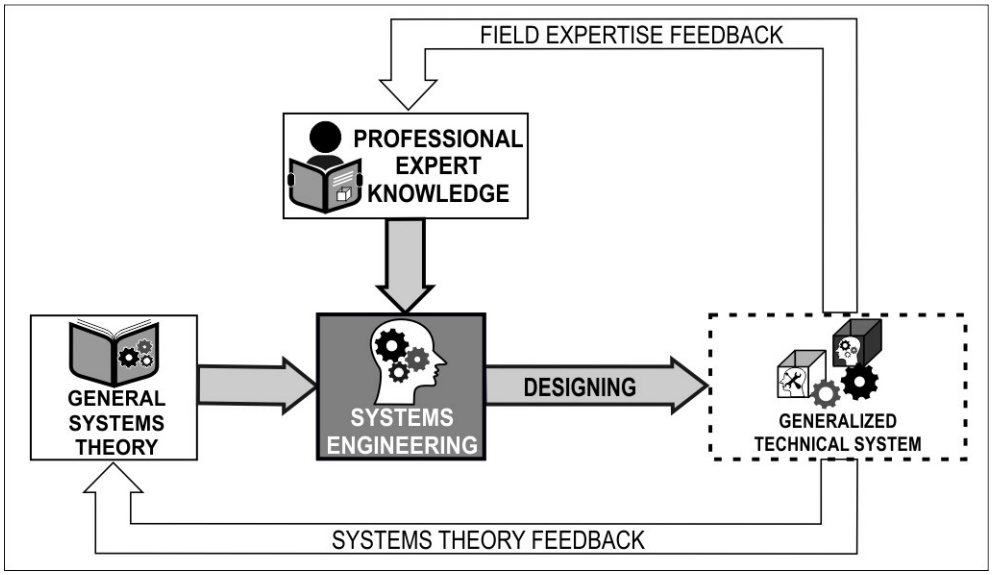


Fig. 1. Scheme of simplified designing process of GTS

The technical system (generally) is a kind of real and man-made entity, which constitutes a specific aggregation of components, technical objects, and even systems of technical objects – every element of this kind of aggregation is synergistically linked and depends on the remaining ones [Łunarski 2010, Młyńczak 2012, Kadziński 2013]. Each system – in particular a technical system – is characterized by the certain structure that is decomposable. Assuming the systemic attitude to construction of some selected objects, allows to decompose it up to a certain level or to qualify it as one of the elements (systems) at a higher level of decomposition. A number of decomposition levels usually depends on the assumptions and complexity of being conducted research.

On the basis of related literature [Młyńczak 2012, Kadziński 2013] including comprehensive analysis of already existing or newly created technical systems (e.g. transport systems), it has become possible to give raise to an idea of creating the MGTS which aims at representing the major model of GTS. It is worthwhile to remind that GTS constitutes a kind of pattern for already existing or prospect technical systems in which technical objects exist. The structure of MGTS is based on some technical objects which are linked with a specific analyses domain. The model is presented by tree-shaped scheme which decomposes GTS into five levels (Fig. 2). Following this method of decomposition gives a lot of capabilities which are required in technical systems' environment, by the way. Assuming this way of decomposition, GTS offers e.g. a possibility to keep a taxonomy of particular objects/systems which are presented at each level of decomposition. It also exhibits some rules for organization and functioning of systems in other systems, technical

objects in systems, or components in systems [Młyńczak 2012, Kadziński 2013]. GTS has been decomposed into levels numbered from 1 to 5, via boxes' symbols (the meaning of the boxes is explained in Fig. 2).

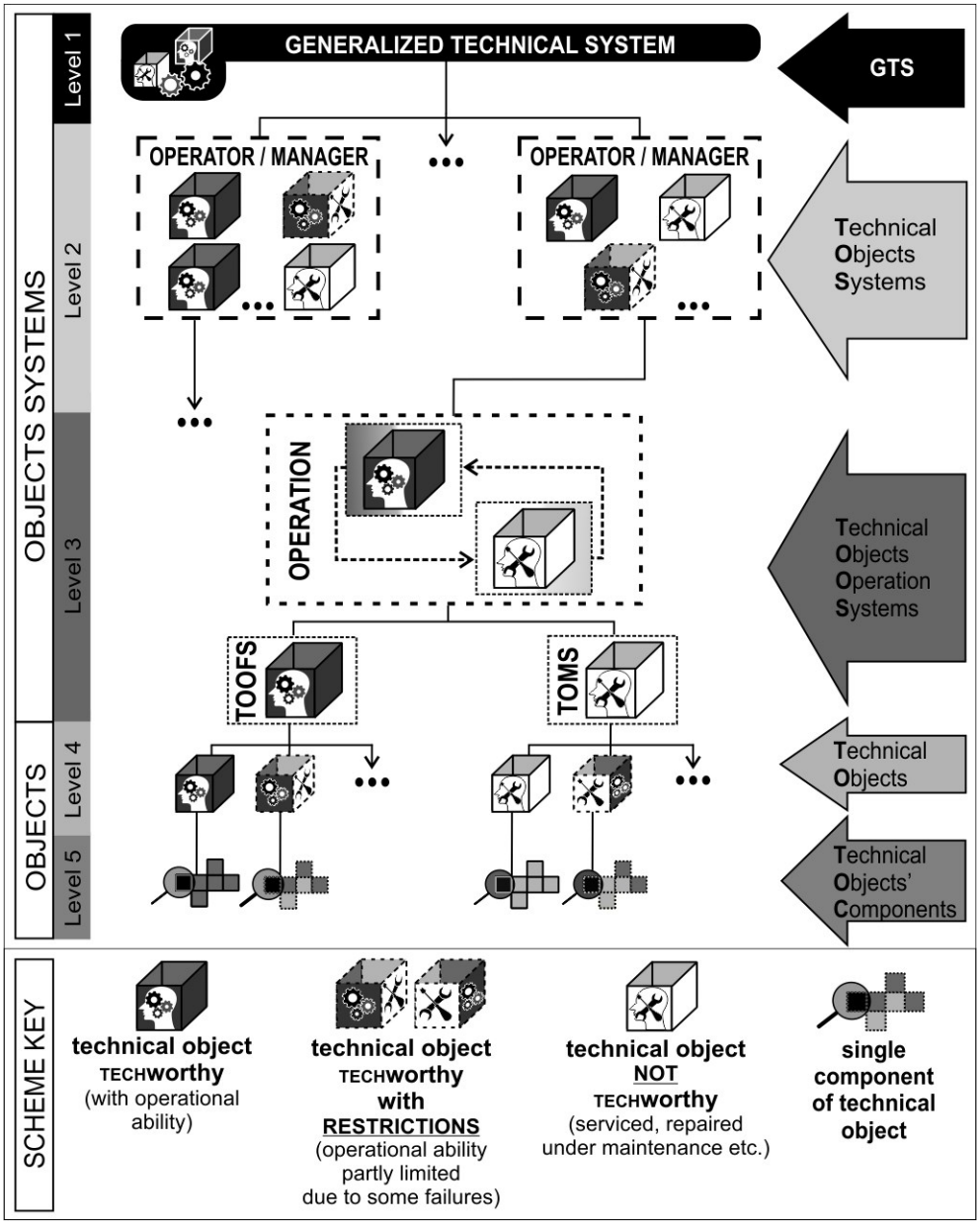


Fig. 2. Schematic diagram of the Model of Generalized Technical System

Level 1 – it is a kind of **system's heading** which is treated as the name of the system. According to the authors, it is a place where the considered analyses domain should be presented as a core of new system – designed via MGTS.

Level 2 – presents the **Technical Objects Systems** (Technical Facilities System), i.e. systems of technical objects' organization or division, conducted by a specific operator/manager and devoted to a specific analyses domain.

Level 3 – presents the **Technical Objects Operation Systems** (Technical Facilities Operation System). It is assumed that in each newly designed technical system, both the Technical Objects Operational Functioning Systems (TOOFS) and the Technical Objects Maintenance Systems (TOMS) will be integrated as the Technical Objects (Facilities) Operation Systems at this level. The main purpose of the following level is to present all rules and mechanisms of technical objects' operation which generally consists of their active operational functioning and maintenance in the appropriate systems (TOOFS & TOMS). The technical objects' operation also includes a kind of objects' migration between active operational functioning and maintenance systems. The presence of a technical object in one of the operation systems (TOOFS or TOMS), in a specific time, mainly depends on its reliability state [Migdalski (red.) 1982, Młyńczak 2012].

Level 4 – is obtained as a result of a division of the exploitation system into TOOFS and TOMS. Due to that, it is possible to present at this level the single and specific **Technical Object** (Technical Facility) including its reliability state – via appropriate box. The Model of Generalized Technical System generally determines the following reliability states of technical objects: **full techworthy**, **techworthy with restrictions** (partial techworthy), and **not techworthy**. In each newly designed technical system – based on the MGTS – it is possible to use varied terminology which concerns the reliability states. The terminology mainly depends on phraseology which is linked to a specific analyses domain. The name of reliability state could be easily adjusted to a specific technical domain by using adequate prefix, e.g. air-, road- or rail-, to the term "worthy".

Level 5 – presents components of technical objects (facilities) in the considered analyses domain. A technical object usually consists of hundreds of elements – including their working surfaces – subassemblies, assemblies, modules, and even systems. Despite the fact that level 5 is named as the **Technical Objects' Components**, it is worthwhile to mention that modern technical objects are usually systems of synergistically linked multilevel systems [Łunarski 2010] with their deliberately designed functions.

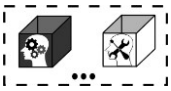
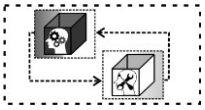
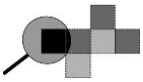
Each box on the scheme of the MGTS could be replaced by any technical object (bus, tram, plane, truck, etc.). Following this kind of design, it will be possible to create a structure of a new technical system. Undeniably, an expert knowledge of a specific analyses domain will be required. The required knowledge includes structures, organization, functions and operation of a technical object within the considered analyses domain.

4. CONCLUSION

Due to the application of systems methodology and observed homology between the existing technical systems, it was possible to achieve the main effect – MGTS. The MGTS can be perceived as a tool which organizationally and functionally bonds technical elements and structures of a selected analyses domain. Five-level decomposition (Table 1) is adequate for technical systems' domains. The designed MGTS broadens the possibility of applying the systems methodology in many various domains in which technical objects already exist or will exist in the future. A potential use of the presented MGTS seems to be almost unlimited among technical systems. In the surrounding reality, which is marked with a dynamic development of technology, there appear new machines, vehicles or elements of infrastructure designed to provide even more advanced functionality. Their common feature is the fact that they are usually organized in structures under control of a specific operator or manager. What is more, the term of operation, with its derivatives, is also strictly linked to every technical object in all technical domains.

Table 1

Generalized Technical Systems decomposition

Level	GTS decomposition	
1	General Technical System	
2	Technical Objects Systems	
3	Technical Objects Operation Systems	
4	Technical Objects	
5	Technical Objects' Components	

Authors hope that the MGTS will arise wide interest in various systemic and technical scientific communities. Probably, designing processes of new technical systems (whose operating capabilities will be based on specific and dominant technical objects), followed by the MGTS, could be called as **technical objects systems engineering**.

ACKNOWLEDGEMENTS

The research work financed with the means of statutory activities of Faculty of Machines and Transport Poznan University of Technology No 5/52/DSPB/0259.

REFERENCES

Cempel Cz., 2008, Teoria i inżynieria systemów – zasady i zastosowania myślenia systemowego: dla studentów wydziałów politechnicznych, Wydawnictwo Naukowe Instytutu Technologii Eksploatacji, Radom.

Chmielecki A., 1999, Rzeczy i wartości, Wydawnictwo Naukowe PWN, Warszawa.

Kadziński A., 2013, Studium wybranych aspektów niezawodności systemów oraz obiektów pojazdów szynowych, Wydawnictwo Politechniki Poznańskiej, Poznań.

Łunarski J., 2010, Inżynieria systemów i analiza systemowa, Oficyna Wydawnicza Politechniki Rzeszowskiej, Rzeszów.

Migdalski J. (red.), 1982, Poradnik niezawodności, Wydawnictwo Przemysłu Maszynowego, Warszawa.

Młyńczak M., 2012, Metodyka badań eksploatacyjnych obiektów mechanicznych, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław.

Powierża L., 1997, Zarys inżynierii systemów bioagrotechnicznych. Część I. Podstawy, Wydawnictwo i Zakład Poligrafii ITE, Radom–Płock.

Sage A.P., 1992, Systems Engineering, John Wiley & Sons, New York.

Strategia Rozwoju Transportu do 2020 roku (z perspektywą do 2030 roku), 2013, Załącznik 1 – Słownik Pojęć Transportowych SRT, Warszawa.

MODEL UOGÓLNIONEGO SYSTEMU TECHNICZNEGO

Streszczenie

Głównym celem tej pracy jest zaprojektowanie modelu uogólnionego systemu technicznego (MUST), utworzonego na podstawie analiz istniejących modeli systemów technicznych. Prowadzone rozważania mają na celu wskazanie modelu opartego na zaobser-

wowanych homologiach między systemami istniejącymi np. w transporcie. Oczekiwanym efektem takich działań jest możliwość późniejszego wykorzystania uzyskanego modelu w innych analizowanych obszarach, w których również występują obiekty techniczne. Przez pojęcie „obiekty techniczne" autorzy rozumieją wszelkiego rodzaju pojazdy, urządzenia, a także elementy infrastruktury, które z technicznego punktu widzenia są związane z wybranym analizowanym obszarem. Z zastosowaniem metodologii systemowej, inżynierii systemów oraz podejścia obiektowego autorzy stworzyli zaprezentowany model uogólnionego systemu technicznego. Drzewiasty schemat dekompozycji modelu jest zgodny z ogólnymi zasadami taksonomii organizacji dowolnego operatora obiektów technicznych, stanowi ogólną prezentację procesu eksploatacji obiektów technicznych oraz służy uporządkowaniu obiektów technicznych według kryterium stanu niezawodnościowego. Przyszłe zastosowania modelu umożliwią klarowną i zrozumiałą konfigurację i prezentację systemów technicznych, w których różnego rodzaju obiekty techniczne działają jako dominujące.

Słowa kluczowe: obiekt techniczny, uogólniony system techniczny, model uogólnionego systemu technicznego, metodologia systemowa