Contents

Institutional Adoption of a Learning Management System in Higher Education: A Case Study of the Corvinus University in Budapest

Péter BALKÁNYI,[1] Zsolt ORBÁN[2]

The development of the Moodle e-learning system started in 2002. Since it is an open source platform with a prominently rich functionality, the system has been introduced in more than 100,000 organisations[3] worldwide in the last decade, including numerous Hungarian higher education institutions (Szent István University, Óbuda University, University of Pannonia) and many organisations in the public administration. We have been operating with one of the largest user (12,000 visitors daily) and course (more than 1,000 active courses per semester) numbers in Hungary, a Moodle based system since 2007 at the Corvinus University of Budapest (CUB) with a high level of user satisfaction.

We managed a major, overall system improvement project at CUB in 2016. The development included a version upgrade to the newest Moodle 3, a full redesign, introduction of several new functions regarding the professors' needs and core improvement on the system's stability and security among others with a comprehensive load-impact test.

In this paper, we discuss the success factors and pitfalls of the whole renewal process. We will further focus on analysing the group discussions with the major stakeholders and evaluate the comprehensive load-impact test. At the end of our paper, we will examine the state of the Moodle e-learning system at the National University of Public Service and we will propose elements of an improvement project relying on our recent experience at another university.

Keywords: *e-learning, Moodle, learning management system, Corvinus University of Budapest, National University of Public Service, IT project management*

Introduction

Following the implementation of the central Moodle e-learning system at the Corvinus University of Budapest (CUB) in 2009, no significant organisational or information

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[1]   Assistant Research Fellow, Corvinus University of Budapest, Teacher Training and Digital Learning Center; e-mail: peter.balkanyi@uni-corvinus.hu

[2]   Assistant Research Fellow, Corvinus University of Budapest, Teacher Training and Digital Learning Center; e-mail: zsolt.orban@uni-corvinus.hu

[3]   Source: https://moodle.net/stats/ (Downloaded: 10.09.2018).

technological advances were made for many a year. This lack of improvement was mainly due to the fact that before 2015, the CUB had no dedicated unit to supervise the e-learning services. In 2015, the former Teacher Training Centre and the e-Learning Teaching and Service Centre (that previously had informally operated the university's e-learning system within the framework of the Department of Infocommunications, a member of the Institute of Information Technology at CUB) merged and thus the Teacher Training and Digital Learning Centre (TTDLC) was created. The Centre received a priority status both technologically and methodologically and was tasked with the organisation of digital learning and teaching. Also, it was in these years that the university laid the foundations for the organisational, technological, methodological and financial developments which today provide a secure operational framework for one of the most significant e-learning systems in Hungary. As one of the greatest achievements of the new organisational unit, the new, redesigned and technologically upgraded system was launched in pilot form in the autumn of 2016 and went fully operational in the spring of 2017, proudly servicing almost all the students of the university.

In the present article, we propose to present the findings of the scientific research that complement the numerous organisational, methodological and technological transformation processes and to investigate the entire development process with scientific rigour with the methodology of case study (CS). Through the investigation and the analysis, we aim to formulate general good practices and advice that could be utilised as parts of a guiding vision by other large organisations when developing their own Moodle-based e-learning systems. As Veronika Nagy Takács and Colonel Professor László Kovács put it in their article entitled *Partial Experience of Specific Training for Leaders of Information Security,* [1] students may have a variety of educational background and the trainings also shape the students' attitude, therefore it is recommended to provide them with customised knowledge. These circumstances and goals can be formed and attained through trainings supported by a carefully designed e-learning toolkit.

To these ends, we shall first give a brief overview of the developed e-learning system then provide a comprehensive analysis of the key stakeholders and explore the history and functions of the TTDLC, as it is the unit that made the development possible in the first place. We have pointed out in an earlier study [2] that e-learning system development is not to be regarded as a mere IT development, a process only determined by technological details; the suitable environment and the in-depth knowledge and analysis of the organisational background also play a crucial part in the development process. The scientific acceptance of this approach is illustrated by a 2017 study written by Kovács, Nemeslaki, Orbók and Szabó bearing the title *Structuration Theory and Strategic Alignment in Information Security Management: Introduction of a Comprehensive Research Approach and Program* [3] which highlights that "[a]lignment is about the process to ensure that the organizational strategies adapt harmoniously both horizontally and vertically". During the system development at the CUB, we were fortunate to be able to follow how this theory is put into practice. Working with Moodle means adopt open source IT and educational technology and therefore we had to face some typical IT adaptation challenges, like always advancing technologies, fashion trends etc. It is also clear that the development of Moodle by itself will not be a long-time success without improvements in the fields of "organizational structure, infrastructure, processes and mindsets". [4] Hameed, Counsel and Swift summarised that IT adoption is

based on innovational, organisational, environmental and individual characteristics and user acceptance models. Concerning the organisational characteristics, IT adaptation seeks organisational readiness, top management support, product champions, infrastructure and cultural attributes. The research about environmental characteristics shows that external environments are also crucial factors in adopting a new technology regarding competitive pressure, government support, etc. About the individual characteristic: innovativeness, attitude, IT knowledge are important characteristics of a top manager. [5]

Considering all the above, in this paper, after the introduction of the organisational environment, we analyse the following three dimensions of the system implemented as a result of the development process:

- stability;
- functionality;
- design.

The present article aims to elaborate on the first dimension, as we are convinced that without establishing stability, that is, an adequate IT security framework and a service environment capable of meeting the demand, it is pointless to speak about the functionality or the design of the system.

Following the development process, we sought to investigate the result from a variety of aspects. Considering that the development is a personal and a highly practice-oriented process, we essentially performed research and development adopting a cooperative approach, actively and continuously participating in the analysis of theoretical and practical research issues. [6] This approach prompted us to investigate the organisation through a stakeholder interest analysis, to evaluate the design modification with the help of a survey and to analyse stability via load testing. In the following, we will present these research phases, draw our conclusions and recommend possible directions for development.

About the Research Methodology

This paper is based on our case study (CS) at Corvinus University of Budapest. The CS research is based on observation and analysis of the development of the learning management system (LMS) and we were looking for the answers for the "how?" and "why?" questions. A CS research do not aim to find solutions, it aims to systematically analyse a practical question. [7] [8] [9] CS is a "necessary and sufficient method". [10] We took four viewpoints into consideration:

1. we were looking for *context and the object* of the observation (the learning management system) at the same time;
2. our research was an *empirical* study, since as researchers, we were part of the development;
3. we were also the *interpreters* of the observations;
4. we were *emphatic* about the development regarding our involvement. [11] [12]

The advantage of a CS is the ability to use a wide perspective, to analyse whether in depth and coherence can be found. [13] The CS do not have a well-defined procedure, so it is hard to build the research on it. [12]

A Brief Introduction of the e-Learning System

The central e-learning system of the CUB is based on Moodle, an open-source learning management system (LMS), originally developed for higher educational purposes. Moodle is written in PHP and distributed under the GNU GLP license. The acronym Moodle stands for Modular Object-Oriented Dynamic Learning Environment. At present, Moodle is servicing over 100,000 entities all over the world in more than 228 countries. [14]

The LMS manages the various university courses where learning aids (PPT lectures, guiding manuals in PDF format, etc.) can be uploaded, or complex e-learning content (interactive files, videos, etc.) can be played. The platform supports automated assessment at the end of the courses by selecting random questions for the examinees, measuring the time they have to complete the exercises, and so on. Moodle also automatically corrects tests and, depending on the settings, informs the professor and/or the student of the result. The platform also generates detailed reports covering all student activities (time spent studying, progress, passed/failed exams, etc.) for the professors.

Beyond the above, Moodle also has all the major content management and e-learning functions that are important in the context of higher education. It, for instance, can be integrated with other IT systems. Furthermore, this innovative system has the capacity to stimulate development in a number of fields, such as the area of stationary augmented reality e-learning applications. [15] Moodle also satisfies a wide variety of educational needs with the following features and functionalities: file sharing, playing e-learning content (SCORM), built-in learning content editor, tests, examinations, hand-in assignments, group work, group management, performance assessment, feedback, modular course structure, a wide variety of communication tools (forum, chat, internal message system), blogs, glossaries, wiki module and gamification elements.

The Organisational Background and the Stakeholders

Before 2015, two organisational units attended affairs in connection with digital support provided for teachers and students of the CUB. One of these, the Teacher Training Centre mainly supported new teachers and those participating in professional development programs, while the enthusiastic and dedicated employees of the Centre also sought to shape their colleagues' attitude and provide methodological support in respect of digital education. The other such organisational units started out as a grassroots initiative, such as the e-Learning Teaching and Service Centre (eLTSC), and it, with the support of the IT Service Centre (ISC), created the e-learning system servicing the entire University.

The Teacher Training and Digital Learning Centre (TTDLC) was born out of the marriage of these two organisations and approaches (methodology and technology) in February 2015. The new Centre "on the one hand is the organizational unit responsible

for the training of new teachers and for the coordination of the work of all institutes and departments participating in teacher training ensuring the cooperation thereof. On the other hand, the Centre is expected to operate as a central hub, and to provide e-learning-related methodological and technological services to the University". [20] Besides, the organisation:

- provides support to university students in connection with learning content development and helps them understand how to use the system;
- oversees the IT aspects of the development process;
- acts as Moodle platform supervisor and offers customer services.

We firmly believe that the foundation of the TTDLC was instrumental in improving the system and in promoting e-learning while providing services of higher standards at CUB. Without the proper organisational background, we would have had no authorisation and no human or financial resources whatsoever at our disposal to promote the cause of e-learning at the University. During the present research, it was therefore imperative that we pay special attention not only to the numerical components [2] like the results of the load testing, but also to the organisational and community factors.

By establishing the TTDLC, the leadership of the university intended to methodologically update and streamline the education at the CUB and to provide sufficient technological support to this end. The leadership vision and the dedication came from the Vice-Rector of Educational Affairs, while the Chancellery provided the resources necessary to perform the task at hand extensively in a professional way. The fact that our enterprise enjoyed the support of the leadership of the ISC that has been cooperating with eLTSC for years was a very important factor and the information technology background provided by ISC also proved to be highly useful.

The contribution of major stakeholders, such as professionally concerned Institutes and Faculties, was also a key element in the foundation of TTDLC. It was, beyond doubt, the Corvinus Business School that played a key role in the process. The teachers and students of this faculty were the most enthusiastic users of the earlier Moodle system and this School was the parent organisation of eLTSC both financially and organisationally.

That the present Moodle of the CUB has become a modern, 21st century LMS both in its design and functionality is the result of the cooperation between the above mentioned organisational units. Obviously, we still have a lot to do in order to fine-tune the system loadability or the everyday application of the modern e-learning functionalities, but generally speaking, the system, as it is, provides an adequate and promising basis for future developments.

The decisions of the above parties and other stakeholders played a crucial role in the development process. According to Huber, we have examined the interest and role of the stakeholders introduced above and summarised the result in the diagram below. [16]
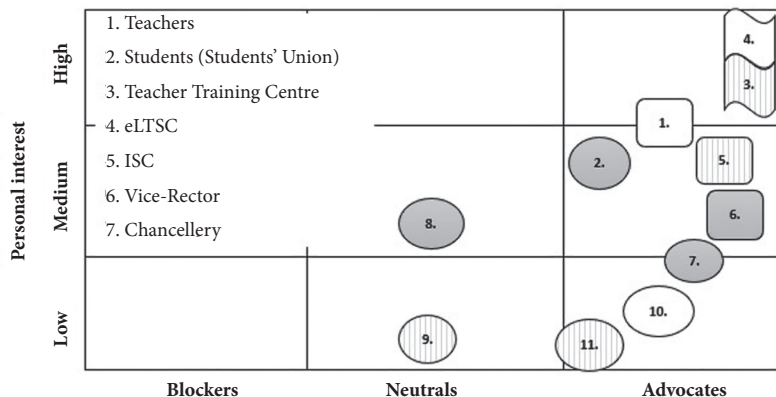
Figure 1. *Analysis of key stakeholders in the foundation of TTDLC based on Huber, 2011.* [16]

The figure classifies stakeholders based on four dimensions:
1. Personal interest, that can be low, medium or high.
2. Based on their level of support, stakeholders can be blockers, neutrals or advocates of the cause.
3. How much the stakeholder is impacted by the change, which can be low, medium or high.
4. The stakeholder's influence over the organisation which can be low, medium or high.

The diagram shows a number of possibilities that may be grounds for positive outcome. It is noteworthy that no stakeholder displayed blocking behaviour in connection with the foundation of the TTDLC; on the contrary, almost all stakeholders were supportive and advocated the establishment of the organisation. We would like to highlight that even though the interest of stakeholders with the highest influence was not outstanding, the value was around medium. It is rather fortunate that the new approach juxtaposing methodological and technological aspects was the brainchild of two organisations that were not antagonists; quite the opposite was true, as the Teacher Training Centre and the eLTSC were eager to work together and viewed the tasks as exciting challenges and promising opportunities. Another important aspect was that the users, teachers and students alike, supported and welcomed the new organisational unit, they forged positive cooperation with the body and recognised that the process of developing, redesigning and updating the system requires an adequate and supportive organisational structure.

Thus, the new unit could start developing Moodle with proper organisational authorisation and sufficient resources. In the following sections, we will introduce an almost one year long information technology and methodological development.

Specifying the Development Directions

The base system of the CUB was launched in 2009 by the eLTSC founded within the department on servers provided by the ISC. The first version was the 1.9 release,

a far more rudimentary system than today's Moodle. After the first major development phase, from 2012, the system relied on the releases above the major version number 2. The development and versioning scheme of Moodle fundamentally changed in 2013, when the developers of the base system switched to the May–November major release pattern, which has been used to date. The next milestone of CUB system development was the switch to version number 3; this process was implemented during the development phase analysed in the present article.

In the period between 2012 and 2016 the Moodle base system improved significantly, and the university system also underwent major changes. While in the fall term of the academic year 2012–2013 CUB Moodle had 3,000–5,000 daily visitors, in the fall term of the year 2015–2016 5,000–7,000 people visited the site on a daily basis.
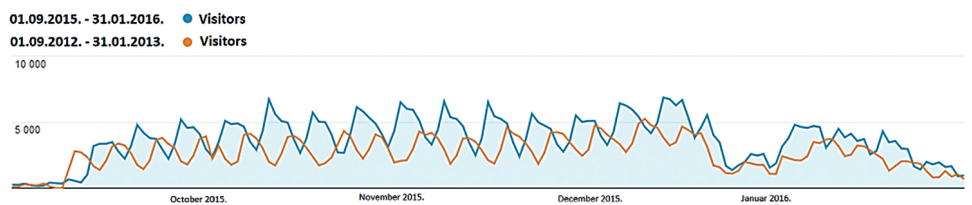
Figure 2. *Number of visitors of the CUB Moodle in the fall terms of academic years 2012–2013 and 2015–2016.* [Prepared by the authors, 2018.]

Apart from the increase in the number of visitors, the number of sessions grew even more significantly (by 48%) and the number of views rose dramatically (by 118%). This meant that an increasing number of students were using the platform more and more actively, performing activities in a continuously growing number of courses. To further illustrate this statement, we compared the number of published courses in the two terms[4] (115% increase) and the number of files uploaded into the system (156% increase).

Table 1. *Comparison table of the fall terms of 2012–2013 and 2015–2016.*
[Prepared by the authors, 2018.]

Aspect	Fall term 2012–2013[5]	Fall term 2015–2016[6]	Growth
Number of visitors	81,465	95,121	+ 16.76%
Number of sessions	627,020	926,312	+ 47.73%
Number of page views	3,587,951	7,835,321	+ 118.38%
Number of revealed courses	768	1,653	+ 115%
Number of uploaded files	24,315	62,325	+ 156%

As the number of university students approached 10,000, in 2016 we took into consideration the previous growth rate when optimising the system for a student population of at least

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[4]   Only relevant for the faculties on the Buda campus.
[5]   01.09.2012 – 31.01.2013.
[6]   01.09.2015 – 31.01.2016.

this value. We also determined increase rates based on previous values. When summarising the results, we will also review whether our forecast on the planned growth rate was accurate.

The increased load illustrated above prompted that the task of the new organisational unit was, first of all, to update the system. Our primary considerations were not functionality or design-related; we understood that first we had to address the issue of stability.

Developing a Complex System Which Is Stable, Has a Wide Variety of Functions and Looks Great on any Device—Results

Figure 3. *Aspects of development.* [Prepared by the authors, 2018.]

We proposed to develop the system along three aspects: stability and long-term maintainability (1), functionality (2) and design (3). The order also signifies the priority we attached to the certain aspects. Regarding *functionality,* our point of departure was the user and operator needs we had been collecting for years. Most of these needs were met "automatically" when the updated system version was launched; major developments, however, were carried out while we updated the examination module. Many developments aimed to provide support for administration, such as the administrator views in connection with leaders' reporting and the beginning of the terms.

From a *design* point of view, it was obvious that members of the new generations Y and Z could only crack a somewhat condescending smile at the former Moodle design, while responsiveness, a basic expectation brought about by the proliferation of mobile phones was also highly accentuated. Once the Moodle version was updated, we called in graphic designers and managed to come up with a generally accepted design, which, on the one hand, met the various expectations of the CUB, while, on the other hand, represented a neat interface allowing great user experience.

In connection with the design, we created a brief, anonymous survey of 5 questions in 2017 after the system went live. Nearly 900 respondents took part in the survey and we found that the new design appealed to the public. As shown in Figure 4, most respondents

gave ratings of at least 4, but more often 5 to the questions, which means that they were *satisfied* or *very satisfied* with the new system, as compared with the old one.
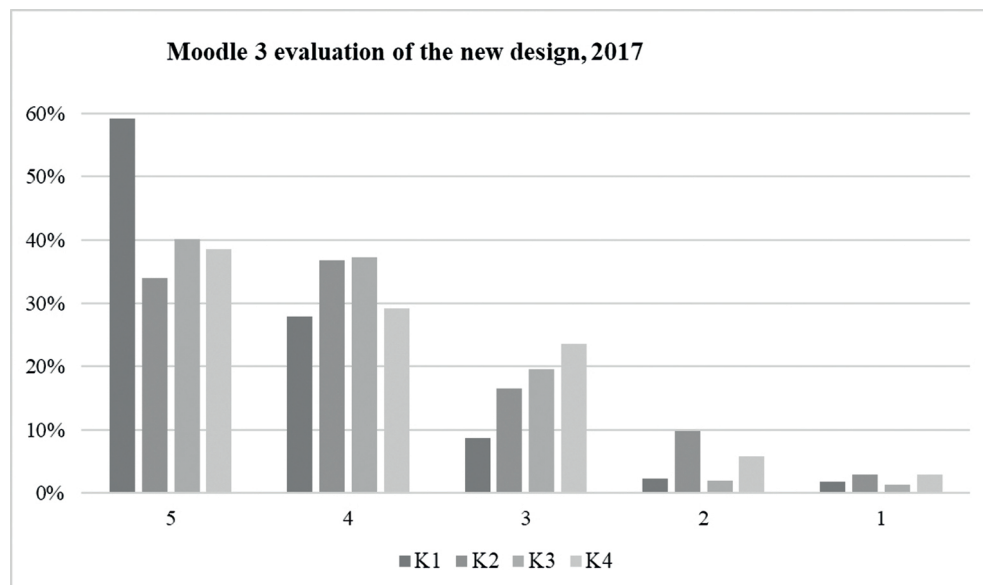
Figure 4. *The findings of the 2017 survey on the new Moodle design.* [Prepared by the authors, 2018.]

K1 asked users to rate the system from an aesthetic point of view, while K2 focused on the neatness and ease of use. From both aspects, positive answers greatly outnumbered the neutral or negative ratings (scores 4 and 5 made up 87% and 71% of the answers, respectively). Many ratings 3 were given for K3 that measured the playfulness of the system and for K4 that asked respondents about how the system looks on their smartphone displays. This score meant that according to many respondents, the new system in these respects were *similar* to the old version of Moodle. However, for both questions we received a very high number of positive scores (77% and 67%, respectively). In light of the above findings, we evaluated the new design as a success, but, in order to get a full picture, we conducted another survey in May 2018. This time, we asked respondents to rate the new system only, so they were not required to compare it with the old version.

475 respondents returned the 2018 survey and they generally gave positive feedback on the system design. The figure below shows that in all respects, the new Moodle received ratings of 3 and 4. This time the respondents had no neutral option, therefore a rating of 1 meant the most negative feedback, 2 meant a slight dissatisfaction, 3 signified a slightly positive feedback, while 4 meant a very positive, highly satisfied attitude.
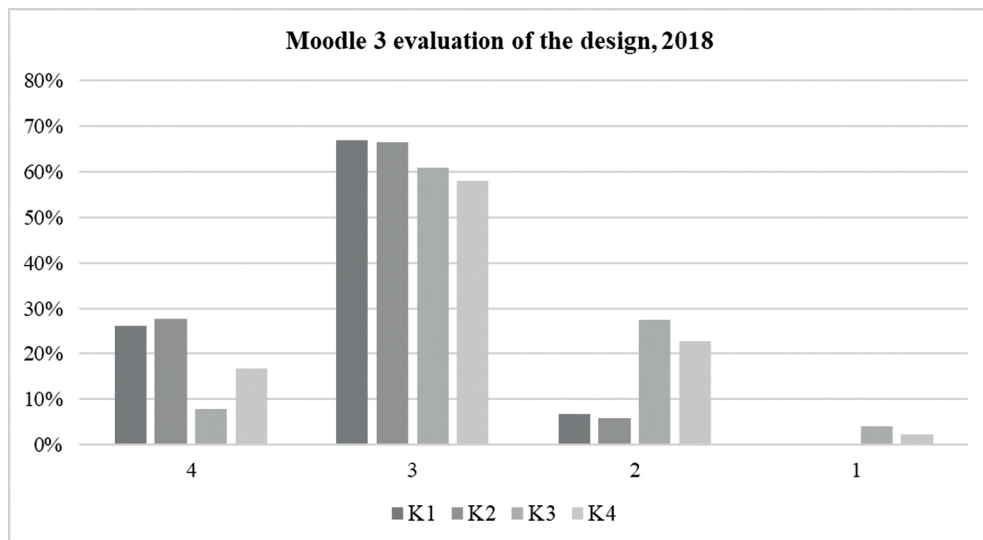
Figure 5. *Findings of the 2018 survey on the new Moodle design.* [Prepared by the authors, 2018.]

Similarly to the previous survey, K1 referred to the aesthetic aspect and K2 measured the ease of use. The number of negative ratings was very low for both questions, but almost one third of the users expressly liked the design. The number of outstandingly positive ratings (4) for K3 (trendiness) and K4 (appearance on mobile devices) dropped to 8% and 17% respectively, and the negative feedback (2) rose dramatically, to 27% and 23%, respectively. All in all, positive ratings (3 and 4) outnumbered the negative answers (69% and 75%, respectively), while the number of ratings signifying utter refusal (1) remained insignificant for these questions, too.

The above results considering user opinion on the system design matched our expectations. The new system represented a serious improvement compared to the old one, but our findings were not without certain caveats: with the advance of technology, Z-generation users expect a university system not only to be robust and stable but also to look trendy and appealing, therefore, the design is not to be neglected in the future, either.

Being pressed for space, we shall focus on the *stability* and *maintainability* of the system in the present article, since we believe that these two factors are the cornerstone of any other development process.

Establishing a stable and maintainable system necessitated developments on two fields:

1. The first problem was posed by the continuously and significantly growing storage needs: due to the increase in user number and activity, the storage capacity of the system servers had to be enhanced continuously. These ever-growing needs brought about financial challenges and the procurement processes often could not be completed in due time.

2. Outstanding load on the database during examinations caused the system to slow down or crash, therefore performance and usability often fell below acceptable levels. We

addressed this issue by implementing a number of administrative and technical tools; however, we have yet to find a comprehensive solution to fully eliminate the problem.

We set out in multiple directions to find solutions for both issues. As for the storage space, we understood that in the absence of a competent organisational background and decision-making process, all content previously stored in the system was available for both the professors and the students of the CUB. While it was a convenient solution for the teachers, it made the system nearly unmaintainable. The establishment of the TTDLC created the organisational framework necessary for making the appropriate methodological and information technology decisions toward the development of the system. For both the bachelor's and the master's training programs, we agreed to store courses, files and all other content through all faculties of the university for a period of four terms. Since educational institutions are legally obliged to store certain information, files and data (e.g. exam results, homework assignments) for a longer period, we needed to develop an archiving solution rather than a delete mechanism. The main task of the archiving module is to free storage space. The developed module, that is currently being tested, automatically archives the content stored in the system five terms prior to the beginning of a new term. The developed public platform of the CUB allows access to all the data and information uploaded in the four preceding terms. The archiving module uses the built-in 'save course' function, which saves all documents, activities, logs and user achievements belonging to a course in a separate file. Archived sources are stored by ISC in an assigned archived zone in a retraceable and catalogued format.

As for the examinations, we faced much more complex developmental and organisational challenges. We broke down the development process into several phases, the first of which was completed during the 2016 developments. As the system had to service several students at the same time, first we had to be aware how many examinations or tests or other testing methods are provided by the teachers and what workload demand the parallel processes place on the system. We had no relevant, exact measurement data, therefore, in the first phase we focused on workload analysis, adopting two approaches. One of these was based on the teachers' compulsory self-report, and developments commenced on an examination scheduler module that complemented Moodle's own test module. All teachers of CUB were requested to give the expected number of examinees in a certain period (the system allows a time window for a specific exam to be open for days or even weeks). The system displays the current, expected (estimated) server load at the time of the examination calculated on the basis of the number of participants set for the other tests or examinations. The load is displayed on a colour scale in intervals, and the system offers other timeframes for the examination in an interval of plus or minus 3 days from the currently set date, in all time slots, showing the calculated load for all the slots. This way, the teacher can easily select an alternative time window for the examination.

The second approach involved the analytic measurement of the system workload via so-called stress-testing, when we programmed and ran automated load tests. During the tests, the program applies virtual users to simulate the behaviour of real users; for example, they navigate the site, fill out tests, download files, etc. Testing was performed with the involvement of internal and external experts and was supported by the application JMeter.

The analyses took place in phases. This article presents the results of the 2017 measurement examining the outcome of the first development phase and lists the achievements of the second phase of the development of the examination module. The results of the extensive testing following the first development phase were presented in the thesis of Imre Szekér. [17]

The objective of the measurement was to determine the maximum number of users the system can provide a stable service for. Stability was investigated from two aspects: one was the crash of the system which can be measured through the appearance of bad packages; the other aspect was the page load time. According to the measurement methodology, testing started with 100 virtual users which was increased by 50 and, toward the end of the testing by 25 at a time. The figure below clearly illustrates the limits of the system loadability.
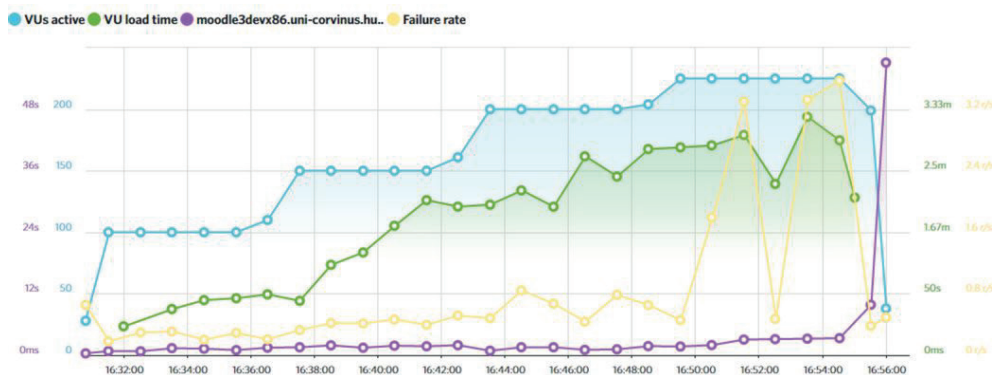
Figure 6. *Stress test results.* [17]

Virtual users (VU) are marked by the uppermost line, the bottom line (with a spike at the end) represents response time and the (lightest) second line from the bottom marks the margin of error. As the graph shows, at 225 virtual users the margin of error changed dramatically which marks the limits of the stable operation of the system. This means that following the first phase of the development, 200 students could safely take exams at the same time. This result was verified later in the examination period after the system went live. [17]

Following the second phase of the development, we once again scrutinised system loadability with 1,000 virtual users in a number of scenarios. During the test phase our primary focus was on response time. We concluded that if 300 to 510 examinees used the system at the same time, it did not corrupt stable operation. We observed a couple of deviations with a response time of over 10 seconds, but the mean value remained around 1.5 seconds. Test results showed that besides 510 examinees, the system can safely service another 200 users who are performing file operations, for example downloading data.

Conclusions for Theory and Practice

Subjective user feedback and objective measurement results evidenced that, through our developments, we have managed to create a system that is stable and maintainable in

the medium term (3–5 years), progressive in its functionality and has a widely accepted design. The above developments and further server configuration allowed doubling the previous number of concurrent examinees (100 students) in the first phase, making it possible for 200 students to take exams simultaneously. Based on the measurements shown above, it is to be expected that the system going live in the summer of 2018 will once again more than double this number. The system then will be able to service 500 concurrent examinees. This number was the final objective we considered during the developments and it clearly proves that the system operates in a stable and maintainable manner.

In a meta-analysis about IT adaptation, researchers find that the most significant factor is organisational readiness. [18] In our study we have analysed a successful development process. Bálint Blaskovics identified the five most often referenced critical success factors (CSF):

1. the support of the leadership;
2. clearly identified objectives;
3. detailed and up-to-date plan (3);
4. good project-related communication;
5. users also participate in the process and they "to a great extent (or, from the project's point of view, to the greatest extent, in extreme cases even in 100%) contribute to the success of the project". [19]

Nearly all factors in the above list are true to our development project, too, and they proved to be really important. The organisational readiness was a key starting point in this case, as well. When creating the organisational background, the development received considerable support from the leadership of the CUB (Vice-Rector and Chancellor) (1). The problems to be tackled were identified and the development proposal was defined by TTDLC in a strategic document and also in the institutional development plan of CUB (2). Accordingly, we had detailed and up-to-date plans that facilitated the development process (3), and the communication of the project elements in agreement with all stakeholders (4). Still, what we find most precious was the involvement of users: as Moodle is a grassroots initiative, it has always been our priority to take into consideration the opinion of the teachers and students, i.e. that end-users of the system (5). As for our recommendations, we consider the CSF list above as our point of departure, as our analysis confirmed that these "most referenced" factors are relevant to the development of an e-learning system for tertiary education, as well.

Our first recommendation for the development of a stable and maintainable system servicing an entire university is that all stakeholders are to define and specify common goals, ensuring the consistency of the development process. Any institution of tertiary education includes several faculties, institutes and service units, making the list of stakeholders very long. We have found that it is recommended for any organisation undertaking a system development to secure the continuous involvement of the following stakeholders, if applicable: chancellery, the leader responsible for educational affairs, IT service provider, library, representatives of the faculties, dedicated "champions" of the already existing LMS (typically certain teachers, administration officials, representatives of institutes) and students' union. The second most important factor is to win the support of the leadership. Their dedication is necessary for any team to carry out the necessary developments. As

far as our experience goes, until a similar project enjoys no high-level support, it is not worth making arrangements towards any system development. We also recommend setting up a dedicated organisation unit responsible for planning the development, for the future operation of the system and for the communication that is of highest importance. We have also observed that the existing educational system is not capable of changing overnight. As far as e-learning is concerned, one may often experience institutional resistance to change and the application of old rather than innovative solutions, therefore, it often requires considerable effort to make stakeholders understand the importance of such developments.

Nevertheless, a couple of limitations needs to be addressed. With the above introduced systematic research aspect, we included a higher education organisation case study into this paper, therefore, a comparative analysis would show more relevant information. Also, the frame of the current article does not allow for an in-depth analysis of the CFSs, such an analysis may be specified as the subject for further research.

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The Threat of Forest and Vegetation Fires and the Possibilities of Intervention in Hungary

László BODNÁR,[1] Péter PÁNTYA[2]

Forest fires are natural disasters that endanger human life and material goods, which in many cases may pose a major challenge to the defence sector. Global climate change has been accepted as a fact in the professional literature from all areas of science. The increasing frequency of extreme weather events is a corollary to climate change. Sustained periods of droughts are becoming more common and in some cases, geographically more extended over Europe. In these dry and rainless periods, typically to that area, the vegetation is drier, thus giving rise to the ignition of the vegetation. An important role of this paper is to analyse and study the relevant domestic literature, as well as the personal consultations with the various experts. The results of the paper show that Hungary can be identified as a threat to forest fire and the possibilities of the intervention are set out. In addition, we can find out which are the organisations and technical tools that help us in such an intervention.

Keywords: *forest fire, vegetation fire, forest fire statistics, tactics of the intervention, technical tools*

Introduction

Due to the geographic location and to the climate of the country, Hungary is not among the most vulnerable countries of the risk of forest fires. Even so, the number of forest and vegetation fires are increasing. One of the reasons for this is climate change. Thousands of forest and vegetation fires occur every year. Every year, the number of vegetation fires exceeds the number of 9,000. It has been stated in many Hungarian studies on this issue that huge costs have to be paid during a forest fire, which shows why it is extremely important to examine the subject. [1] [2] [3] [4] Due to the forest and vegetation fires in Hungary, two highly flammable periods can be distinguished. Fires in the first group occur in spring when the snow cover is melted and when the vegetation has not yet grown out, but in the previous year there is a greater amount of dried herbaceous vegetation or foliage in the area that can easily and quickly dry out. These thin parts of the plants can dry up very soon in rainless time. Therefore, they can easily catch fire. The second group includes fires from

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[1]   Ph.D. student, National University of Public Service; email: bodnar.laszlo@uni-nke.hu; ORCID: 0000-0001-9196-8030

[2]   Assistant Professor, National University of Public Service; email: pantya.peter@uni-nke.hu; ORCID: 0000-0003-2732-2766

the droughty summer time. During the summer period, due to the longer dry and warm weather conditions, the duff and the needle leaf layers can completely dry and easily blaze up, also primarily due to human negligence. Their occurrence is typical in June and in August. Based on the data collection of recent years, it can be stated that 70% of forest and vegetation fires occur during the two highly flammable periods. [5]

Characteristics of Forest Fires in Hungary

Weather Conditions and the Forest Cover in Hungary

To determine the threat of a country's forest fire, it is indispensable to examine weather and geographic factors. The Carpathian Basin is located in Central Europe, in the temperate zone. In the north-western part of Hungary, the wet continental climate is typical. In the south-eastern part there is dry continental climate. The country's climate is influenced by the western winds due to the oceanic effect and the Mediterranean effect from the south. The direction of the wind is northwest to the Tisza river, further from it to the east the wind is northeast. The country has a pool-type shape. The middle of the pool is the hottest and the driest. This poses the danger that droughty summers can develop. The weather varies rapidly, largely due to the flow of remote air pressure centres. Based on this, it is possible —because of the weather conditions of the country—that the vegetation can easily ignite. [6]

If we want to investigate Hungary's vulnerability of forest fires, we need to check the forest cover of the country.

Forest cover in Hungary in 2017

County	Forest cover (%)	County	Forest cover (%)
BUDAPEST	10.2	TOLNA COUNTY	17.8
PEST COUNTY	25.8	BORSOD-ABAÚJ-ZEMPLÉN COUNTY	29.2
FEJÉR COUNTY	12.4	HEVES COUNTY	24.3
KOMÁROM-ESZTERGOM COUNTY	27.3	NÓGRÁD COUNTY	39.2
VESZPRÉM COUNTY	30	HAJDÚ-BIHAR COUNTY	11.3
GYŐR-MOSON-SOPRON COUNTY	19	JÁSZ-NAGYKUN-SZOLNOK COUNTY	5.9
VAS COUNTY	28.2	SZABOLCS-SZATMÁR-BEREG COUNTY	21.3
ZALA COUNTY	31.7	BÁCS-KISKUN COUNTY	20.8
BARANYA COUNTY	25.2	BÉKÉS COUNTY	4.6
SOMOGY COUNTY	29.7	CSONGRÁD COUNTY	8.9

Figure 1. *The forest cover in Hungary.* [7]

In Figure 1, we can see the forest cover of the country. Overall, we can say that the forest areas are concentrated in Hungary. Due to geological and climatic conditions, extensive forests were developed in the hilly regions of North Hungary and Southern Transdanubia. According to the counties, the largest forest area is in the northern Borsod-Abaúj-Zemplén county. This is 29% of the country's forests. The forest areas are also significant in Somogy, Bács-Kiskun and Pest county. The degree of forestry varies greatly depending on the territorial characteristics. The least number of forests are in Central Hungary (Budapest, Pest county), but the forest cover is higher than the national average. Northern Hungary

has the largest forested area, as most of its area is covered by hills. The Northern Great Plain region is the least afforested, where agricultural areas are more typical. The forests of the Transdanubia regions are relatively balanced. The proportion of the forest area in Nógrád is highest (nearly 40%), but it is also significant in Veszprém, Zala, Somogy and Borsod-Abaúj-Zemplén. Békés county has the smallest forest cover, it is under 5%. [7]

The Fire Risk of Hungary

Forest fire does not know any boundaries, therefore, forest fires cannot be separated from other vegetation fires burning in non-forest areas, because fires often spread not only in the forest area. In Hungary, due to the characteristic weather conditions and the composition of the vegetation, natural fires are not typical, and their proportion is below 1%. It can be verified by statistical data that the vast majority of outdoor fires are a consequence of human negligence.

Indirectly, the effects of the climate change also appear in the number of outdoor fires and the size of the burned areas, which in the future will be even more challenging for Hungary's disaster management. Due to the increasing number of forest fires, the length of the high flammable periods also increase during the fire season. It is also important to take into account the increasing intensity of the forest fires, so firefighting will be more difficult.

The fire risk of a forest or other non-vegetated area is influenced by a number of parameters, which must be considered together. The risk of forest fire depends on the amount of combustible biomass in the area, on the terrain, on the weather conditions, on the microclimate and on the human activity. The fire risk classification of the forest areas indicates the static vulnerability of the given forest fragment. The forestry authority determines and keeps records of the fire risk classification of forests in a single data store. The forest fire risk classification takes into account the tree parameters used in forestry plant design descriptions. So, it expresses the amount of combustible biomass and its vulnerability, contained in that forest fragment. [8]

In case of all firefighting activity, it is very important to deal with safety intervention. Safety intervention is very important not only at a forest fire, but at radiological emergencies and in all general activities, as well. [9] [10]

Statistics on Forest Fires in Hungary

Besides the forest cover of the country it is very important to deal with the statistics on forest fires. In Figure 2 we can find the risk classification of forest fire in the counties of Hungary. In Hungary, we distinguish largely, middling and moderately vulnerable county categories of the risk of forest fires. As shown in Figure 2, a highly vulnerable county (dark) is Borsod-Abaúj-Zemplén and Bács-Kiskun county.
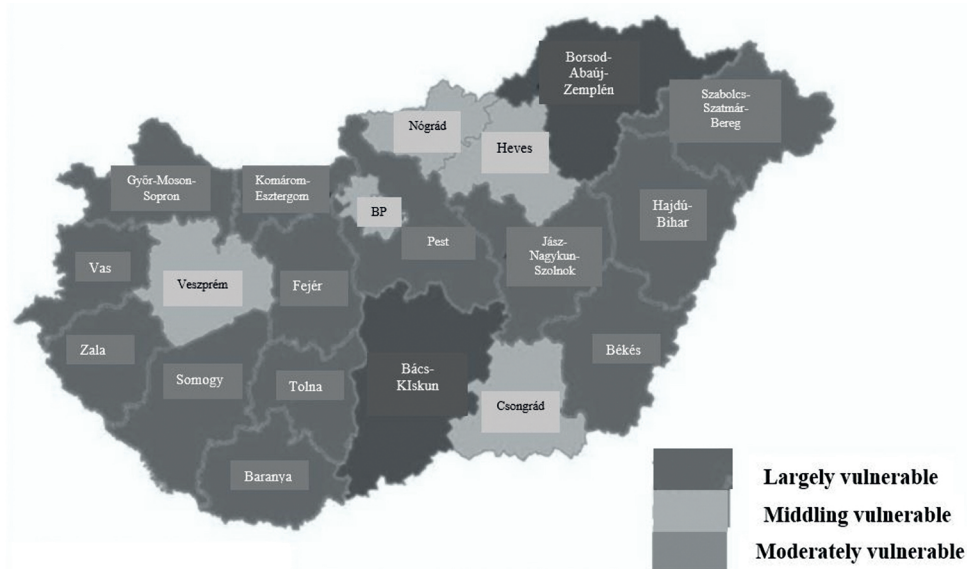
Figure 2. *Vulnerability of the counties in Hungary.* (Based on [11][3] edited by the authors.)

The area of Bács-Kiskun county is composed of large forests and easily sunken juniper stocks. The most vulnerable stocks in the county include bog-spruce. In Borsod-Abaúj-Zemplén county leafy forests are the most vulnerable stock. The county's vulnerability is increased by the fact that there are many abandoned agricultural areas where firefighting is very difficult because of this biomass. In addition to these, there are other reasons such as sociological and economic problems. Similar problems are encountered in Nógrád county and Heves county, where only the smaller forest cover supports the fact that they these counties are not among the most vulnerable areas. Middling vulnerable counties (light color) are Budapest and Pest county, where mainly the agglomeration area of the capital is the most endangered. In the capital, the leafy stocks and the incoming people are the biggest threat. The towns of the Pilis Basin, which are located west of the capital, belong to this category. In these settlements pine trees are subject to the higher risk. Another problem is that these areas are among the favourite recreational areas of the Pilis Basin. Veszprém county is also a middling classified area, where the oaks and shrubs of the Balaton Uplands and the Keszthely Mountains are endangered. In this region we should mention the role of the recreational areas as well, like in Pest county. The danger of Csongrád county is caused by the large number of inhabitants living in the outskirts and by the structures of farmed settlements. Although the county's forest cover is small, the black pines are threatened by forest fire protection risks. [11]

After presenting the vulnerability of Hungary's forest stocks, it is worth noting that besides the fire risks arising from the biomass structure, human influence also has a great impact on the endangerment of forest stocks in individual parts of the country. In the highly

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flammable counties, primarily human negligence or intent (99%) is the cause of the fire. Given that less than 1% of the forest and vegetation fires occur naturally, it can be established that fire risk forecasting can be more effective if this problem is also communicated to the citizens.

Forest and vegetation fires in Hungary			
Year	All vegetation fires	Forest fire	
		Number of Fires	Burned areas (ha)
2007	6,691	603	4,636
2008	6,639	502	2,404
2009	8,658	608	6,463
2010	3,120	109	878
2011	8,436	2,021	8,055
2012	21,581	2,657	14,115
2013	4,602	761	1,955
2014	5,783	1,042	4,454
2015	5,318	1,069	4,730
2016	2,489	452	973

Figure 3. *Statistic presentation of the forest and vegetation fires in Hungary.* [12: 4]

The specific forest fire statistics are shown in Figure 3. The table shows the number of fires of all forest and vegetation in the past 10 years coupled with the size of burned areas. Based on the statistical data it can be stated that the number of fires is different every year. There are also high and low values. The number of fires that occurred in a given year is greatly influenced by the amount of precipitation in the early spring and summer months. Overall, according to the data of the past 10 years, the average size of the areas burned by vegetation fires is approximately 8,000 hectares. The average number of fires is about 1,000 hectares. The total area burned by forest fires is almost 5,000 hectares. According to other articles, at a large forest fire, we need to take into consideration enormous costs. [2] [13]

Overall, it can be stated that in Hungary—although this is not the most significant natural disaster—forest fires should be of utmost importance, as it gives half of the annual fleet of firefighters. We can see how many areas are destroyed by forest fires in a year, so we need to find some sort of solution to prevent this, not especially in the field of intervention but in fire prevention, as well. [14]

Firefighting During Forest and Vegetation Fires

Firefighting during forest and vegetation fires is a complex task. The intervening forces must pay attention to a lot of circumstances. For this reason, in Hungary, a Firefighting Order and a Technical Rescue Order are issued in order to help the intervening forces. [15]

Detection

One of the most important part of the intervention of a forest fire is detection. During detection it is important to deal with the following factors:
- it is important to obtain a map of the affected area, as soon as possible; it is also important to identify the boundaries of the vulnerable area and its vaccination, protection and parry tasks;
- if it cannot be detected due to field conditions or the extent of a fire, it is advisable to arrange for aerial reconnaissance;
- residential areas threatened by the fire must be determined;
- people's way of escape must be determined;
- the direction of the fire must be determined;
- water supply and the approach route must be determined;
- the direction and the speed of the wind must be determined;
- escape and escape routes must be determined.

During a large forest fire, it is important to strive to use aerial detection, because it is more effective than ground detection. [15]

Intervention

Intervention at a forest fire is a difficult activity. Attention should be paid to the following:
- the large-scale forest and vegetation fires require special equipment and tactics;
- if the size, complexity or duration of the fire justifies it, leadership should be organised;
- the members of the leadership should be experts.

In case of a large forest fire, the leader of the firefighters must create and separate firefighting sections. These sections are capable of performing individual and coordinated tasks for each firefighting within the territory. The section commander is at the head of the sections. This commander keeps contact with the other groups and sections.

In the event of an aerial firefighting, rigid wing and rotor units interfere separately from each other. Provision should be made for the supply of air units with vaccines. Aerial reconnaissance, vaccination, rescue with the simultaneous use of multiple aircraft flight control can only be performed by qualified earth stations. In addition, firefighting should be given increased attention in the burning area for high voltage lines.

At the post production activities, it is important to examine the burned area, in order to prevent the further burning of the stumps, trunks and the ground. Smouldering parts are also important—in the absence of water—they should be covered with soil and sand. After the fire, the leader of the firefighters contacts the forest manager for increased surveillance of the affected area. [15]

Intervening Forces

In Hungary, the primary intervening forces are the fire departments. These can be organisations that make various firefighting and rescue tasks. These departments are the following in Hungary:
- *professional fire department:* created for firefighting, technical rescue and fire prevention tasks; they have a separate operating area;
- *disaster management post:* the professional fire department set it up to perform firefighting, technical rescue and fire prevention tasks;
- *municipal fire department:* created for firefighting and technical rescue tasks; they are voluntary fire departments with operational districts;
- *industrial fire department:* created for firefighting and technical rescue tasks; this is a fire service without an independent operating area, created by an economic organisation;
- *voluntary fire department:* an association which can be involved or can participate in fire prevention and rescue task activities;
- *intervener voluntary fire department:* the activity of it is based on an agreement with a professional disaster management agency; they are involved in firefighting and rescue activities. [16]

Disaster Management Operation Services

Disaster Management Operation Services operate on the county level, and are 24/48 hours on a standby service. They can lead complex and higher risk interventions also during forest fires. At an intervention area, they supervise and control the intervention of the intervening staffs. They make effective and safety interventions during a disaster. [17]

Overall, it can be seen that a large number of disaster relief units are intervening during a forest fire in Hungary. However, these units do not properly cover all the territory of the country. The current dislocation of professional fire services does not allow every territory to be available within 25 minutes, therefore creating disaster guards is planned to improve the dislocation. In addition, voluntary fire departments can make firefighting missions as a municipal fire service within their own landing area. The operating site of the professional fire services is the area where a municipal fire service voluntarily assumes the primary intervention activity. They are supervised and controlled by the professional fire services. Firefighting is also assisted by voluntary firefighters who take part in professional activities, who are able to support the professional fire services from the early stages of intervention. Currently there are 315 cooperation agreements with voluntary fire departments in Hungary. Their work can also help to solve the problem of dislocation.

Special Aerial Equipment

Outside Tanks

In the 19th century people tried to perform firefighting tasks from the air, but these ideas were somewhat primitive. These were machines with a single engine, and the firefighters spilled the water from a bin. The idea was good, but was not efficient. The authorities in California saw imagination in it, so they began to innovate the original idea. Before the Second World War, they built a double-decker aeroplane and fixed tanks to it. After the take-off, they dumped the water from these tanks. [18] After many attempts and experiences they improved the outside tank technology. Today we can find different bins and buckets that are especially fabricated for the aim of aerial firefighting. These bins and buckets proved very effective. [19]

According to the German literature there are 4 types of hanged burdens. [20]

Table 1. *Types of the hanged burdens.*
(Based on [20] [21] edited by the authors.)

Load type 1	"Short line" (length of the device < 20 m)
Load type 2	"Long line" (length of the device > 20 m)
Load type 3	"Logging" (Transport of unsorted and disordered logs)
Load type 4	The burden is required to be kept in a certain position on the helicopter.

Bambi Bucket Models

During aerial firefighting, the firefighters used Bambi Buckets most commonly as a hanged burden. [1] These buckets are made in different sizes from the 270 litres to more than 9,000 litres; they not only have different sizes; their types also differ. The most commonly used types are the Bambi Bucket Modell 1012, the Bambi Bucket 2000 and the Bambi Bucket Modell 1518. [19] [21]

Bambi Bucket 1012	
Capacity	460 l
Weight	30 kg

Bambi Bucket 2000	
Capacity	1960 l
Weight	82 kg

Bambi Bucket 1518	
Capacity	680 l
Weight	40 kg

Figure 4. *A collection of Bambi Bucket family.* [21]

The essence of the Bambi Bucket is, that the firemen fix a tank with a rope to the bottom of the helicopter. The helicopter makes the bailing above the water, after that it arrives to the burning zone and dumps the water through an opening of the Bambi Bucket. The advantage of the Bambi Bucket is that the helicopter does not need any necessary changes to use the vehicle for firefighting aims. We just need to connect the burden to the helicopter and the helicopter is ready to do the firefighting. So helicopters made for another aim can be suitable for firefighting, as well. There are two different methods to fill the tanks. On the one hand, the helicopter can be filled from a tank with a pump at a temporary nearby airport. On the other hand, the helicopter can be filled from a nearby lake. In Hungary, Mi–2 and Mi–8 helicopters are used for firefighting aims. These helicopters need minimum 1.5 metres deep water to fill up. Operating a Bambi Bucket bin, we can use the Sackfoam family. It can be controlled from the board, and it can inject a foam compound (0.5–1%) to the bin. To make it more efficient, we can use FireSock mixed bags, which help the solution to mix more efficiency with the air. This equipment helps in the foaming, and exerts a more efficient extinguishing effect. [22]

We can use this method in case of any forest fire; still we have to mention the difficulties, as well. Because of the hanged burden, it is difficult to manoeuvre the helicopter. Furthermore, it is hard to collect enough water to fill the tanks, and the depth of the water is also very important. In Hungary, there are many water sources (ponds, aquifers), because of the pool-type of the country, but in several countries it is a big problem (for example Spain and the South Slavic region).

Conclusion

In this article, we introduced the threat of forest and vegetation fires, the statistics of the forest fires, the intervening forces and some special tools in Hungary. As a result of this article, it is possible to characterise the types of the Hungarian forest and vegetation fires, the fire risk and the most vulnerable forest areas in the country. We also presented how to make an intervention during a wildfire, what are the causes and what kind of special equipment can be used. The most important data and information of this article provides an opportunity for the more effective firefighting and fire prevention of the Hungarian disaster management. The implementation of effective firefighting and fire prevention has a great importance in Hungary, it also has its special methods and practices, such as the forest conversion method, the firebreaks and the water springs established in the forests. They will be presented in another article in the future.

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Analysis of Possibilities in Postgraduate Specialisation Programmes Summarising Government Aimed Info-communication Systems and Services

Fundaments of the Training, Abilities, and Requirements[1]

Tibor FARKAS[2]

An accessible info-communication system is a key element of cooperation between each level of governmental leadership and defence organisation (police, disaster management, army, etc.) during crises, emergency cases and other events of this type. Beyond technology and technical fundaments, the availability of human factor is also a primary criterion in order to execute the activity with success.

To help this, the author analyses the conditions of creating a possible postgraduate specialisation programme, together with the most important elements, knowledge material and criterion requirements of such in the recent publication.

Keywords: *info-communication, ICT, defence sector, defence communication, postgraduate specialisation programme*

Introduction

In his earlier publications [1] [2] [3] [4] the author has analysed all the activities, during which the cooperation of each defence and governmental organisation is a key element in creating and constantly maintaining national security. Beyond disaster situations, the cooperation between governmental and public service organisations is also necessary in everyday life to ensure the broad spectrum of public service and other types of services and support of the citizens, which is a basic principle of the continually sustainable state.

The Hungarian Government, recognising the importance of the own Information and Communication Technology (ICT) sector, and its positive effect on financial and social development, has adjudicated the document *National Info-communication Strategy 2014–2020* with Government Decree 1069/2014 (II.19.) and has set its goal as: "The purpose of this strategy is to give a comprehensive overview of the current situation of the Hungarian information society and the ICT market, to define the ideal target situation and to identify

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[2]   Associate Professor, National University of Public Service; e-mail: farkas.tibor@uni-nke.hu; ORCID: 0000-0002-8868-9628

professional trends and development targets in info-communications for the same period as the 2014–2020 planning cycle." [5: 4]

Of course, this developing tendency has to be true for the activity of all governmental and public service organisations including their info-communication network and service, as well. A National Info-communication Strategy sets the most important goal, in that the possibility of utilising information networks has to be broadened for the population, more people have to use the possibilities within info-communication networks and services, for which the conditions have to be secured by the governmental network. (See Figure 1.)

Main Objectives of the NIS

2014
- 100% basic-level broadband coverage
- Accessibility to all mandatory regulated administration services of the state

2016
- There should not be any (NGA-white) settlement in the country that is not accessible through the optical technology
- Installation of the complete National Telecommunications Backbone Network (NTBN)
- 95% mobile broadband coverage and EU average achieved in the average bandwidth
- 75% of the adult population should be regular internet users
- The ratio of digital illiteracy should fall below 40%
- 50% of the adult population should use e-government services

2020
- At least 30 Mbps internet access in all households
- At least 50% of the households should have 100 Mbps or faster internet access
- The ratio of digital illiteracy should fall below 30%
- At least 85% of the adult population should become regular internet users
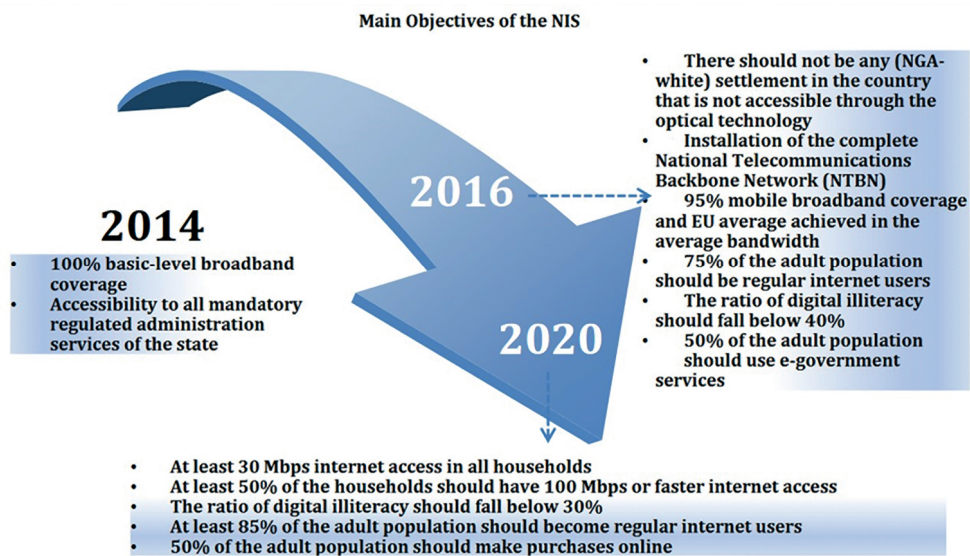- 50% of the adult population should make purchases online

Figure 1. *The main objectives of the National Info-communications Strategy.* [5: 8]

Similarly to the above, info-communication systems of the defence organisations have to secure appropriate level of access to data and information for the whole personnel of the involved organisations, within the whole spectrum of the given operation or task. Thus info-communication systems have to provide such level of support, that is able to secure the constant flow of information, serves the users, and provides the possibility of cooperation between each organisation enabled by its interoperability. Of course these are only the basic features of the networks, which have to be complemented by others, from which one is security. The security of networks and information is one of the most vital criterion requirement nowadays, which has to be realised through local and central protection. The other requirement is that of highly trained operating personnel with broad knowledge on the system, who are able to organise the system and maintain it throughout the timeframe of use. To secure the latter, a basic element is the postgraduate specialisation programme of experts with appropriate professional basic knowledge in the field of maintaining info-communication systems in public service and the defence sector.

A platform for such education and training has to be the National University of Public Service (NUPS), since this institute is concentrating the different education, training and

postgraduate specialisation programmes of professionals for the public, governmental and defence sector.

The present publication is summarising the outcome of the second phase within the *New National Excellence Program of the Ministry of Human Capacities (UNKP)* research activity. This has been defined as follows:

- to analyse the peculiarities and requirements of the national postgraduate specialisation system;
- to define those matching points, that can make the created postgraduate specialisation training fit into the postgraduate specialisation programme system of NUPS;
- to describe the basic elements of the request for starting the postgraduate specialisation training, preparing the process of the request (goal, form, timeframe, certification, evaluation, etc.);
- preparing the process of an educational plan pattern, definition of basic courses and knowledge material.

Postgraduate Specialisation Training within the Hungarian System of Higher Education

The law on Hungarian higher education (Act CCIV of 2011 on the National Higher Education) defines what level an institute of higher education has to reach in their educational activity. The basic activity of education in such institutes involves higher professional education, basic education, master's level education, Ph.D. level education, and postgraduate specialisation, thus the whole spectrum of education levels. Figure 2 shows the system of the Hungarian education.
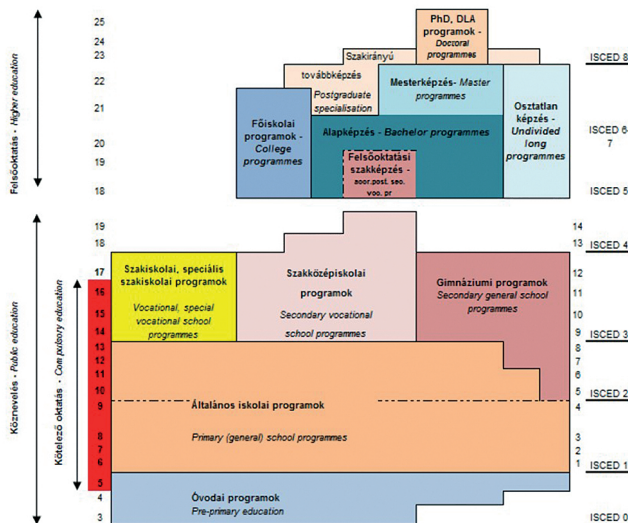

Figure 2. *The Hungarian Education system.* [6]

Following the certification on BSc or MSc level, professional specialised certification can be reached. A basic requirement to apply for the training is the existence of a BSc or MSc level certificate. This basic requirement can be complemented with further requirements defined by the institute, like a given time of professional experience, the existence of other certifications, etc.; these have to be defined by the institute in a way so it will not be dependent on which institutions of higher education the applicant has got the certification. If succeeding with the application, the student takes part in a minimum two, maximum four-semester education, depending on the actual training. The education ends in all cases with a final exam and the certification is prepared, which enables the student to fill in different workplaces and tasks. [7]

According to the regulation of Government Decree 87/2015 (IV. 9.) [8] a professional specialised training can be:

- training giving professional specialisation connected to one or more fields of education;
- training giving professional specialisation connected directly to a specialisation;
- training giving individual professional specialisation defined in the requirements for BSc and MSc education.

Further, point 2.1.3 of Annex 6 within the degree defines the obligatory data of the professional specialisation training announced by the institute, and registered, which are inevitable to define the specialisation precisely.

The creation of a professional specialisation training is a complex and difficult procedure, defined by a great amount of regulation and other documents. The Educational Authority, as the supervising body defines the data necessary and proposal to start the training, also the required documentation, and the most important regulatory framework. These are as follows:

- Act CL of 2016 on General Public Administration Procedures;
- Act CCIV of 2011 on the National Higher Education;
- Government Decree 87/2015 (IV. 9.) on the implementation of certain regulations of Act CCIV of 2011 on HE;
- Government Decree 121/2013 (IV. 26.) on the Educational Authority;
- Ministerial Decree 10/2006 (IX. 25.) on the general requirements for providing post-graduate specialisation courses;
- Government Decree 423/2012 (XII. 29.) on the admission to higher education institutions;
- Government Decree 283/2012 (X. 4.) on the initial teacher education, specialisation and the register of degree courses in teaching;
- Government Decree 248/2012 (VIII. 31.) on measures required for the implementation of Act CCIV of 2011 on Higher Education;
- Government Decree 19/2012 (II. 22.) on the quality assurance and quality development in higher education.

In summary, we can say, that professional specialisation training can be started only by institutes of higher education, following which, additional professional specialisation is accessible beyond BSc and MSc graduation, with the collecting of new knowledge. During the procedure of creation, the educational and final requirements have to be prescribed

as part of the obligatory documentation, which defines the professional fundament of the education. Parts of the requirements for finalising education are: [9]

- *Designation of the professional specialisation training.*
  The designation has to show clearly the professional field and the required level of certification to get in every case. Beyond that, similar names have to be avoided which may refer to other levels of training.
- *The designation of specialisation as given in the final certificate.*
  The designation in the certificate also has to show clearly what type of specialisation the training gives, and it has to differ from other types or levels of professional training.
- *Categorisation of the specialisation training, regarding the field of education and level of certificate.*
  The specialisation training has to be connected to a field of education (e.g. information field of education), and also connected to the minimal starting requirement; further, it also has to be defined to which education category, what category system it belongs (e.g. ISCED 2011).
- *Requirements of admission.*
  A standard requirement is to gain admission with a BSc or MSc graduation, the connecting criteria has to be defined.
- *Timeframe of the training.*
  The timeframe of the training has to be minimum two, maximum four semesters, which has to be defined precisely. A more detailed schedule (like the amount of theory, etc.) is not required, that is included in the education plan.
- *The number of credits to be collected to succeed the training.*
  The credit points to be collected during the training define the weighting of the teaching material.
- *Goal of the training, professional competencies.*
  Description of the goals, abilities and knowledge, on which the training is based, and also of the professional competency, which can be acquired through it in general.
- *Professional attributes and fields of the training.*
  The most important circles of knowledge (not courses), which define the knowledge material essentially.

Based on these, it is easy to see, that the complex system of requirements secures the quality level of the professional specialisation training, according to which the available certification can also meet high expectations.

Fitting Governmental Info-communication Professional Specialisation Training into the Educational System of NUPS

The National University of Public Service (NUPS) came to life in 2012 with the aim of creating the fundaments of standard public service basic education. The university was created with the amalgamation of several already existing institutes, thus securing the basis for high level public service education.

The vision of NUPS is as follows: the National University of Public Service defines itself as the "University of cooperation"—an effective model of cooperation among social needs, national strategic governmental objectives, and higher educational autonomy. The vision of NUPS is to become:

- the best and most attractive university in Hungary;
- a solid research and education basis in the development of Hungarian public service and of public service career model;
- a committed supporter of Hungarian higher education programmes abroad;
- an active member of international research and educational networks, in alliance with leading universities of Europe and the world.

The mission of NUPS, in the intersection of public service profession and academia, is to serve as an effective educational and academic base for state-building and public service development. Through its educational and further training programmes, NUPS supports the development of highly trained and efficient personnel in the field of public administration, law enforcement, defence and other areas of public service. NUPS defines its mission at national, regional, European and global levels. [10]

"Its foundation has created the structural, institutional and human conditions of standard public service basic education. The primary objective of the university is the high-level education of civilian public service, law enforcement, military, and national security personnel, at the same time the support of creating permeability between the standardised public service careers from the educational side." [11: 20]

The University has a significant role in education and training in the fields of public service and defence administration. The above defence activities are part of public service, thus the training of defence organisations (military, police, disaster management, etc.) is also a task of the University. "Defence administration is a task- and organisation system as part of public service, further, as a summary of activities maintained by public service organisations created and appointed to fulfil the defence tasks of the state, it involves the preparation for special legal conditions, and the state activities aiming the planning, organising and execution of defence, civil defence, disaster management, defence economy, and public supply tasks of such periods and situations. […] In order to execute defence administration tasks in a coordinated and efficient manner, the appropriate level and secure communication is inevitable. […] Primary strategic task of the future is the broadening of the started development. […] thus ensuring the standardised and effective flow of information, inevitable to fulfil defence administration tasks on an appropriate level." [11: 14–15]

All these support that NUPS, as a base for the education, preparation and training of public service and state experts, provides an excellent opportunity to realise the "postgraduate specialisation program summarising government aimed info-communication systems and services" researched and analysed by the author. The knowledge material, professional know-how and experience necessary is given at the University, which secures the organising of an excellent postgraduate specialisation programme.

In my perspective, the requirements defined in the Public Administration and Public Service Development Strategy can be achieved. The strategy prescribes that the Hungarian public service shall be organised and consistent, with a clear organisational structure,

and has to work with a personnel maintaining patriotic professional call, expertise and motivation.

The cooperation strategy of NUPS strengthens further all the efforts, which secure the high-level public service education by the process of national and international knowledge and research results. Basic success is guaranteed by the cooperation model of the University, being present in the institutional development plan as follows: [12: 4]

- national strategy, governmental goals;
- students;
- international bilateral mobility and research partnership;
- international scientific organisations;
- fellow universities;
- public service, law enforcement and military institutes.

All these support the basic strategy, according to which the task of NUPS is to build a state meeting the challenges of the 21st century, good and efficient government, and a dedicated public service with the means of science and education. Thus the task of the University is to provide complex and up-to-date knowledge, complemented with the results based on international cooperation.

In summary, the education maintained by NUPS results in experts professional both in public service and in defence administration, educated at all levels of higher education, with a special scope on the achieving further certifications, constant learning and training. The training meets the requirements of ANHE, gives an education pertaining to that regulation, securing the consistency of public service education, and fitting in the system of postgraduate specialisation programme. One of the most important parts of the regulatory framework is *Government Decree No. 273/2012 (IX.28.) on the Further Training of Public Servants,* which describes the possibility and directions of professional specialisation training for public service officers, and the necessary background to it. The results of the research at the University get built-in into all levels of education, thus into professional specialisation training as well, making them more efficient this way. Recently there are more than ten specialisation trainings in the education system of NUPS,[3] which realise the postgraduate specialisation programme of professionals with a scope on public service requirements.

Governmental info-communication specialisation training is thus easy to be fitted within the education system at NUPS, it can become a solid and leading training of the University. Based on the above, in my opinion, the knowledge material has to follow the strategic guidelines shown below:

- knowledge in focus;
- constructive methods in the teaching;
- operation oriented;
- unified;
- standardised;
- sustainable;
- secure.

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[3] See: https://vtkk.uni-nke.hu/szakiranyu-tovabbkepzesek/szakiranyu-tovabbkepzesi-szakok

With the basic principles constantly in focus, the education has to be maintained by constantly keeping the knowledge material up-to-date, responding to changes, and keeping the basic scope. Through this, a high level education can be created, which can serve the constantly changing goals efficiently, and can meet the changing requirements effectively.

General Description of Info-communication Professional Specialisation Training, most Important Data of Starting the Training

One basic element of governmental info-communication networks, regarding their utilisation is the level of sophistication of the used technology and devices, and also the preparedness of the operating personnel. In certain cases, (classified situations, disasters) a greater level of cooperation between the info-communication networks of each organisations takes place in order to fulfil their task with success. In such cases, successful ICT support greatly affects the ability of cooperation between the different systems, with the operating personnel being a key element to it. According to this, governmental cooperation is not to be desired without the support of connected information systems and info-communication devices. A basic requirement is the reliability of the info-communication system, which secures constant support and disposability, also securing operation.

To meet these challenges and expectations, a specialisation training is offering a solution with a possible title like *Professional Specialisation Training of Governmental Info-communication Experts.* The field of education is IT.

The aim of the training is to give high level, up-to-date theoretical and practical knowledge to all governmental info-communication professionals, who maintain a high level of professional knowledge already earned earlier.

A further aim of the training is to get the partakers to know the build-up and operation of governmental info-communication technologies, systems and networks, and the possibilities of realising cooperation between them, also the importance and possibilities of info-communication competency development.

Following the training, *possessing of their knowledge will make them able* to fulfil the organising and planning tasks evolving within the given info-communication field, to respond to problems, and to meet the new challenges and expectations of the age. Beyond that, they build up a knowledge, which makes them able to make well prepared decisions on the fields of planning, organising and operation through the development of their ICT competency.

Thus the expert graduating at the specialisation training will be able to:
- understand the necessity, place and role of governmental info-communication system within the national control system;
- realise and understand the importance of the governmental info-communication system and its operation, also to utilise it at a high level;
- operate info-communication systems;
- understand the info-communication support of the government sector, the peculiarities of each network and the possibilities of cooperation;

- further raise the info-communication support of the sector with high level professional expertise;
- take part or getting involved into development activities (ordering-development-test run-education-handing over-monitoring).

The target group of the training are professionals, who are working with planning and operating governmental (public administration, military, disaster management, law enforcement, police, national security etc.) info-communication systems. The knowledge material has to combine constructive organising and planning methods and approaches and the systems and sub-systems of the governmental info-communication sector, thus securing the possibility of access to the broad spectrum knowledge material. In any case, the training can be realised efficiently by involving experts maintaining special preparedness, years long experience in the given field and development of it as well.

The training can be organised in minimum three semesters with 300 hours which, beyond the general theory, also secures the presentation of knowledge regarding each professional field, in theoretical as well as practical regards.

The training can be successful if prescribing (non-professional) higher education level BSc or MSc certificate as an *incoming requirement.*

Regarding the method of the training, postal tuition supports the gaining of knowledge with theoretical and practical classes, also to the utilisation of knowledge in real life.

The knowledge material has to comprise sub-fields and knowledge circles easy to tell apart, from general defence and administration knowledge to the operation of special aim systems:

- *Activity, call and tasks of governmental, public service, defence administration organisations*
  The Hungarian governmental system and its sub-fields are in primary focus of the education, since the knowledge of these is inevitable to provide info-communication support to the command and control activities. The operator has to maintain appropriate knowledge in order to see through the most efficient systems and networks necessary to the work and control of the given organisation, also to see the possibilities of further development.
  Comprehensive knowledge of the roles and responsibilities of the defence sector (law enforcement agencies, disaster management, armed forces, etc.) and the public sector.
- *Knowledge on utilised info-communication technology*
  The second sub-field is that of the professional basic knowledge, introducing the summary of the most important technology, methods and knowledge in our days. The importance of this field is defined by the fact that most likely the partakers will be at different levels of professional knowledge, thus the creation of a uniform picture is of primary importance, presenting technologies and applications starting from basic principles. The knowledge material of the sub-field has to comprise quality management systems (systems, applications, methods and proposals), info-communication technologies, information infrastructure, basic cyberspace technologies, cyber-defence and information security knowledge and operating systems. Since the transmission technologies operate differently in governmental networks, spectrum management has

to be a primary part of the material. *(Comprehensive knowledge on info-communication network management.)*

- *Governmental info-communication systems*
  The third and most important part of the education material is the presentation of actual professional knowledge. Based on the basic, technology and network management fields, governmental info-communication systems, networks, their structure, and the newest technology solutions, network-, service-, and application development ideas have to be introduced. Beyond the exact knowledge, it is also important to show the developments, preferred network technologies to be expected, together with the social, administration, defence and EU developments and innovation goals. The aim is that the knowledge material supports the infrastructural conditions of the uniform central administration and defence services in the field of info-communication infrastructure and operation, and that it finds the realisations of high level security for governmental info-communication services.

In case of governmental level networks, the legislative background has to be presented, together with the network structure, aims and tasks, and the sub-fields of maintaining, as well. Network monitoring, network security and the question of interoperability also give a great part of the material to be educated. Following the common, uniform part, each subsystem, like police, military, disaster management, law enforcement and the networks attaching to public administration have to be presented, with their structure, operation, maintaining and capabilities, with a focus on the special systems within the networks. During the building of the material, the logic of presenting the networks of each organisation has to be similar supporting easier understanding. A possible approach to this can be to follow the "transport network", "traffic management network" and "user networks—special applications" division of presentation securing a uniform system-centric process.

In summary the training gives a complex knowledge on government level info-communication systems, on their operation, processing the knowledge material with a view on connecting laws and regulations, complemented by professional experience and the newest results in research. The importance of the training is increased further by the fact that the additional value in case of info-communication systems is much higher than at other fields.

Summary

A basic element of cooperation between governmental level organisations (public administration, defence) is the utilisation of integrated, communication capable info-communication systems, their constant and secure operation in order to support the leadership requirements and executants' expectations efficiently. Beyond technology conditions, the maintaining personnel are also a key feature.

Thus, specialisation training, vocational education and competency development of public service professionals is a primary task to secure, prescribed by different related regulations, as well. The inevitability of constant specialisation training is beyond doubt, so

securing these postgraduate specialisation programmes is to be regarded as a high priority mission.

The professional specialisation training is based on certification already achieved and prescribed, not giving a new graduation, and ending with the earning of a certificate verifying the professional specialisation. It supports the further education of those attending based on their own professional knowledge and experience.

The presented specialisation training is developed based on the research results generated by professional experiences gained in the past years, securing the fundaments of documents to be prepared obligatory for an actual realisation. The structure, aim and basic competencies of the training secure the in-depth process of education material, with the utilisation of publications presenting results of earlier research.

NUPS, giving home to the training is clearly able to secure the human, material and other necessary conditions that enable the realisation. According to all these, the postgraduate specialisation programme fits well into the vision and mission of the University as described earlier, and its strategy as it follows:

"The intention to build good governance and committed officials, thus enabling the state to respond to 21st century challenges with the means of science and education is at the heart of NUPS's strategy.

In order to fulfil its mission, NUPS strives to:
- provide public service oriented training for the youth, in combination with modern and comprehensive knowledge based on solid moral and values;
- participate in the further training of civil servants and public administration executives;
- be successful in public service development 2020;
- provide outstanding education and continuing education;
- conduct successful research;
- provide international quality with state-of-the-art infrastructure and services;
- maintain sound institutional functioning embedded in a culture of quality and excellence." [10]

Summing it up, the broadening of services provided by info-communication systems is inevitable responding to the changing expectations, the increasing number of users (institutes, organisations) and the brightened utilisation (the coordinated work of more organisations in disaster situations and crises is necessary), which can be realised through the modernisation of operation supporting info-communication applications and systems. This can only and exceptionally be maintained by the operating personnel with constant training and professional preparation.

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Examining Some Key Issues of the Maintenance Organisation from the Point of View of the Operator and the Manufacturer

József GYARMATI[1]

An important fundamental question of maintenance organisation after the selection of maintenance systems is the determination of maintenance cycle times. With the help of the cycle time, it is possible to determine how often the most exposed parts and lubricants have to be replaced. The replacement of components or lubricants can be expensive, but performing these activities at the appropriate time will increase the reliability of the machines. With more frequent maintenance, the number of unexpected failures can be reduced, along with the resulting costs, while maintenance costs will also increase. The paper analyses how to determine the maintenance cycle time to the minimum of both of these cost components. The rest of the analysis deals with the analysis of the strategy of the manufacturer if it is in the interest of performing maintenance and repairs done. A further objective of the study is to determine the impact of the cost increase of unexpected failure resulting from maintenance failure on the minimum of the total cost.

Introduction

Machinery and equipment during their lifetime are undergoing physical, chemical and biological changes. As a result of these changes, the parameters of each component may also change. The result of the change can be, for example, the wear of a metal part due to friction, or the softening of a spring and thus the reduction of the spring force.

Problems also occur with parts subject to high friction, such as increasing gap of bearings due to wear of the rolling surfaces or a change in the viscosity of the lubricants, or an increase in the concentration of particles insoluble in the lubricant.

As a result of these processes, the machines can fail during their service life. The failure can be caused directly or indirectly by a change in the condition of a component. A direct consequence can be the break of a clutch spring, which may cause a critical interruption in the power transmission by the failure of the clutch. Indirect failure occurs when the flow

1   Ph.D., Associate Professor, National University of Public Service, Faculty of Military Science and Officer Training, Department of Military Technology; e-mail: gyarmati.jozsef@uni-nke.hu; ORCID: 0000-0001-7594-2383

properties of an oil change, that results in insufficient lubrication, which for example can result in a bearing failure.

The decisive parameters of each component in terms of failure may change due to the following reasons: [1] [2]

- wear;
- fatigue;
- aging;
- corrosion.

The listed processes occur in time, but the failure can be from different causes:

- suddenly;
- gradually.

Breakdown can occur suddenly by a fracture if there is an overload in some parts, but the same fracture can occur due to material fatigue, which is a process that is gradually happening at the same time where the result is the sudden failure itself.

Unexpected, unforeseeable failure can occur:

- some unknown material defect;
- overload;
- due to irregular machine operation.

The processes that occur in time can be predicted either by knowing the relations between the cause and effect or by using statistical methods. Whenever the operator has this information at his disposal, systematic measures can be introduced to prevent progressive failures and to eliminate sudden failures, such as:

- countermeasure type activities;
- preventive type activities.

The aim of countermeasure type activities are the various levels of repairs that are used to restore a machine that has already failed. Different levels of repairs can be listed for countermeasure technologies. Until the 1950s, practically no maintenance system can be mentioned, where the operation practically continued until the failure. The system is known as run to failure in the source. [7]

The aim of preventive type activities are to prolong the expected lifetime of the machines, or to restore the machine. These include cleaning, maintenance and technical condition survey. After the 1950s, maintenance systems developed drastically and these systems define preventive technologies according to different principles.

This allows the operator to select the most appropriate system for the applied strategy. Major maintenance organisation models are: [8] [9]

- Preventive Maintenance (PM);
- Risk Based Maintenance (RBM);
- Reliability Centred Maintenance (RCM);
- Total Productive Maintenance (TPM).

Based on the previously described processes, it can be stated that the failure can be considered an event that will most certainly occur due to wear processes. Changing the frequency of maintenance changes not only the reliability but also the operating costs, which include the costs of preventive and the countermeasure type technologies. [3]

This paper examines how maintenance cycles determine the overall costs, affects the operator and how this has an impact on the manufacturer. In other words, what is the relation between the quality and the costs, and how the operator and the manufacturer are interested in the development of these costs.

Description of Failure Statistics

According to [4], those failures that are gradually generated by a mechanical process can be described by using a normal distribution with a density function:

$$f(t) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(t-\mu)^2}{2\sigma^2}} \tag{1}$$

where: μ is the expected value of the distribution and σ is the standard deviation.
The probability theory interpretation of the density function is:

$$P(a < \tau \leq b) = \int_a^b f(t)dt \tag{2}$$

meaning that the probability of τ is between the values of a and b equals the definite integral of the density function between the values of a and b.
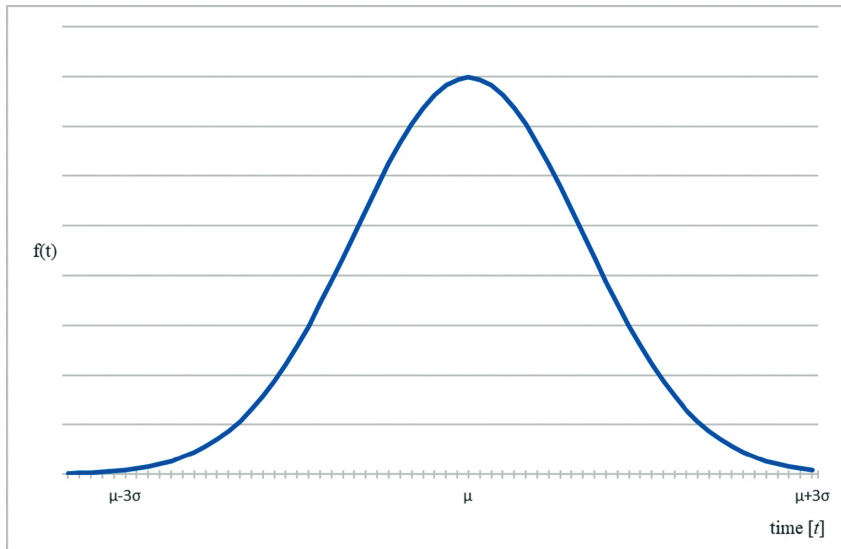

Figure 1. *The density function of normal distribution.*
[Edited by the author.]

In the formulation of reliability theory, the probability that the failure occurs in the time interval of {a, b} is the same as the definite integral of the density function between a and b (Figure 1). The primitive function of the density function is the cumulative distribution function:

$$F(t) = P(\tau < t) \tag{3}$$

meaning that, the probability of failure up to time t corresponds to the value of the cumulative distribution function at t. If the maintenance cycle is scheduled for time t_0 then the probability of the failure up to t_0 using (3) is:

$$F(t_0) = P(\tau < t_0) \tag{4}$$

According to [4], the cumulative distribution function of normal distribution is strictly monotonous, so the probability of failure increases with the increase of t_0. Thus, by extending the time of maintenance, the probability of failure increases, but with reducing the cycle time the number of maintenance increases. These are two opposing processes where the time of the minimal cost of maintenance can be selected according to the joint inquiry of the two costs. Naturally, the operator may choose a different strategy without considering the total costs and can establish the time of maintenance compared to the level of reliability expected by Equation (1) and Figure 1.

$$F(t_0) = p_{\max} \tag{5}$$

by solving the equation where $p_{\max}$ is the upper limit (supreme) of the probability of failure and the value determined by the operator. In military terms, $(1 - p_{\max})$ is the bottom-up (infimum) value of the probability of availability, or the military usability.

Possible Strategies of the Operator and the Manufacturer

The time of maintenance can be selected by the operator according to two different strategies as described in the previous section:
- minimising the total cost of maintenance and repair;
- according to expected reliability (the military usability).

If the operator requires the minimum cost, the two costs must be calculated as a function of the maintenance cycle time.

According to [4], the process of deterioration of a defective part can be considered to have a normal distribution. The time during which the failure will definitely occur will be infinite because:

$$F(\infty) = P(\tau < \infty) = 1 \qquad (6)$$

where: $F(\infty)$ is the value of the distribution function at infinity

τ: is the probability variable describing the failure and τ N(μ, σ) that is τ has a normal distribution with μ expected value and σ dispersion.

It is known from the formula of normal distribution, where:

$$\int_{\mu-3\sigma}^{\mu+3\sigma} f(t)dt = 0.998 \qquad (7)$$

The expected cost of repairs resulting from unexpected failures can be determined as follows:

$$M(K_j(t)) = F(t) \ K_j \qquad (8)$$

where: K_j: is the cost of repair due to unexpected failure

$M(K_j(t))$: is the expected cost of repair due to unexpected failure without maintenance at time t.

The total cost of maintenance:

$$M\left(K_c(t)\right) = \frac{t_c}{t}K_c \qquad (9)$$

where: $M(K_c(t))$ is the total cost of maintenance in the interval of $\{0, t_c\}$ if the maintenance cycle time is t;

K_c: is the maintenance cost;

t_c: is the time during which without any maintenance the failure can be guaranteed and $t_c=\mu+3\sigma$ according to Equation (7).

The total cost is:

$$K_s(t) = M\left(Kj(t)\right) + M\left(K_c(t)\right) = F(t)K_j + \frac{t_c}{t}K_c \qquad (10)$$

The aim of the operator is to minimise Equation (10), for this, the following equation has to be solved:

$$\dot{K}_s(t) = 0 \qquad (11)$$

The first derivative of Equation (10) is:

$$\dot{K}_s(t) = f(t)K_j - \frac{t_c}{t^2}K_c \qquad (12)$$

where:

$$f(t) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(t-\mu)^2}{2\sigma^2}}$$
(13)

Equation (11) cannot be solved analytically because $K_s(t)$ cannot be derived, that is why only a numerical solution can be expected. The minimum of the sum of the two costs is defined graphically in Figure 2.
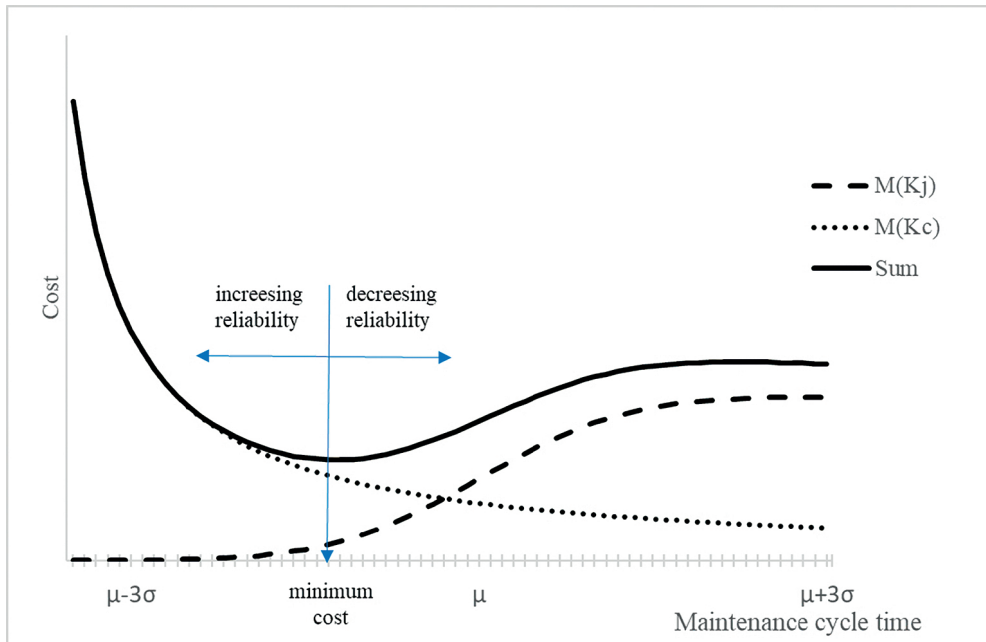

Figure 2. *Changes in maintenance and repair costs depending on the maintenance cycle time.* [Edited by the author.]

Figure 2 shows the evolution of maintenance and repair costs as a function of cycle time. The cost of maintenance increases with the reduction of the cycle time, because more maintenance is required in the given period. Part or lubricant replacement should be done more frequently, which will result in the loss of increasing uptime reserve in favour of reliability. Accordingly, the cost of maintenance increases with the reduction of the cycle time and decreases with its growth, so in this case it is a strictly monotonous decreasing function.

The cost of repairs due to unexpected failures increases with the increase maintenance cycle time, as the probability of failure increases with the operation time, as shown in Figure 1 and Equation (3).

The sum of the two functions is shown by a continuous line in Figure 2. The curve has a clearly visible minimum, indicated by an arrow.

The operator who wishes to minimise the costs, should solve Equation (11) using the graphical method shown in Figure 3. Accordingly, the maintenance cycle time will be determined in such a way that the operator can minimise the costs of repair and maintenance resulting from unexpected failure.

The strategy of the manufacturer may differ from the operator if the manufacturer is interested in repairs or in maintenance, too. But it is not the aim to minimise these costs, but to maximise the income within a certain limit, which means that it may be necessary to deviate from the minimum maintenance cycle time in a positive or negative way to increase the costs, in order to increasing the income. This can be solved in two ways, as shown in Figure 2, by increasing the maintenance cycle time (which reduces reliability) or reducing the maintenance cycle time, which improves the reliability.

It is in the interest of the manufacturer that the customer, who is also the operator, is satisfied with the product, so it is not advisable to resort to any operation that would seriously compromise reliability. However, by reducing the maintenance cycle time, the income and reliability can be increased at the same time.

Overall, it can be stated that, the manufacturer compared to the operator may prescribe less maintenance cycle times as shown in Figure 2, which means higher overall reliability for the operator.

The Effect of Maintenance and Repair Costs on the Cost Minimum

The cost of repairs resulting from unexpected failures consists of three main components:
- replacing the defective component;
- replacing or repairing the main parts that became defective in the consequence of the defective parts;
- other indirect costs of the asset.

The cost components listed above are best analysed by an example. For example, due to a change in the viscosity of the applied lubricant in a given gearbox, the bearings may be damaged (bearing seize up), but in extreme cases, it can cause a complete failure of the whole gearbox by a break of a tooth.

From the three cost components, the first one can be estimated with the best accuracy. The prices of the components or lubricants and the work-hours needed to replace it and their costs are considered to be known in advance. The situation is more difficult with the other two components. Various fault tree analyses are performed on faults caused by a given component failure. [5] [6] In our case, the question is generally formulated, so these procedures are not applicable here.

Defining the third cost component is a problem in military practice. The absence of a training equipment affects the quality and duration of the training, which clearly has adverse effects, but can only be estimated, with a high standard of deviation, and this can degrade the accuracy of the calculations, so these costs are not taken into consideration in further calculations.

For a general approach, and not for a particular failure, the following ratio should be assumed

$$\frac{K_{\mathrm{j}}}{K_{\mathrm{c}}} \tag{14}$$

and the change in the cost minimum given in Figure 2 should be examined through this.

The ratio of formula (14) can be varied so that the value of K_{c} can be considered constant and the K_{j}, is the variable, so a function from equation (10) can be defined as a two-variable function:

$$K_{\mathrm{\ddot{o}}}(K_{\mathrm{j}}, t) = F(t)K_{\mathrm{j}} + \frac{t_{\mathrm{c}}}{t}K_{\mathrm{c}} \tag{15}$$

and the solution is:

$$\frac{\partial\big(K_{\mathrm{\ddot{o}}}(K_{\mathrm{j}},t)\big)}{\partial K_{j}} = \frac{\partial\big(K_{\mathrm{\ddot{o}}}(K_{\mathrm{j}},t)\big)}{\partial t} = 0 \tag{16}$$

The analytical solution is still not possible, the system of Equations (16) can only be solved numerically or graphically, so the solution will be determined graphically.
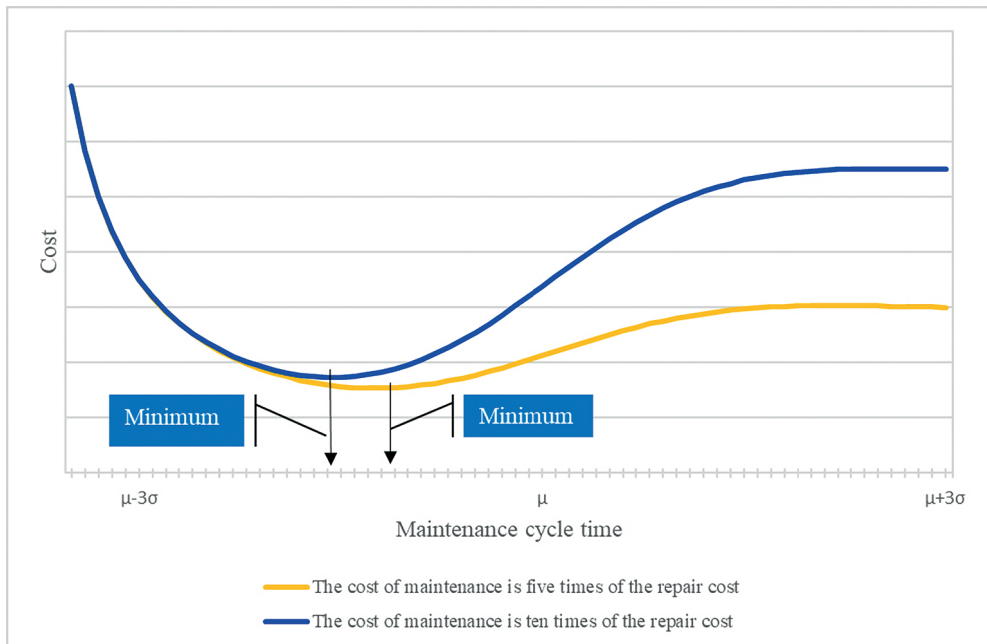

Figure 3. *The variation in the ratio of repair and maintenance costs to the minimum of the total costs.* [Edited by the author.]

Figure 3 shows two possible situations in which the effect of the change in the quotient of formula (14) on the maximum cost can be seen. In the figure, the dotted line represents the case where the cost of maintenance is five times of the repair cost, and the dashed line is the case where the repair cost is ten times.

Figure 3 shows clearly that with the increase of repair costs, the maintenance cycle time is reduced. The greater the damage caused by the failure of a component, the sooner the maintenance have to be performed, that is the replacement of the defective part.

Summary

As a result of the procedures presented in the paper, it can be stated that there is an optimum time for the operator to carry out the maintenance that has a minimum of the total cost of maintenance and repairs. The operator can also choose a different strategy besides the minimum cost, where the operator determines the maintenance according to the expected reliability.

The manufacturer, if performing maintenance and repairs, is not interested in reaching the minimum cost of the whole operation, but is interested in increasing its own profit, which in turn leads to a reduction in maintenance cycle times. In this case, reliability will increase, but the cost of the remaining operating reserve will be higher, which will result in additional costs for the operator.

If the cost of repairs increases, this will result in a reduction in the maintenance cycle time.

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The Possibilities of Supporting the Public Functions with Fleet and Force Tracking Systems[1]

Krisztián KÁROLY,[2] András NÉMETH[3]

The variable tracking systems for troops monitoring on field were popular for espionage in the 1980s and 1990s. Then they became essential materials for the action movies of the 21st century. Due to the rapid development of information technologies, the different navigation methods, systems and tools, this is now a 24/7 service and can be purchased by anyone to have detections and observations of the actions of vehicles, groups of people, individuals or even animals.

From the number of variable options available for navigation, the applicable procedures are based on radio frequencies, even within that, those solutions that work in the frame of the service of global navigation satellite systems. This is due to their universalities. Gratitude to the up-to-date wireless data transfer solutions that can assure the near-real time geographical location detection of the respective moving object and individuals. Nowadays, these alternate services are widely used in many areas of public life i.e. fleet tracking or personal and property security.

The proper way of integration into the state administrational technical support subsystem of these developed technologies and the implementation of the available services can significantly increase the effectiveness of the public duties' performance, both in the area of public services and governmental organisations. These could contribute to the creation of the picture of "Good State" and to raise the standardised level of services provided to the citizens.

Keywords: *Fleet and Force Tracking Systems (FTS), Global Navigation Satellite System (GNSS), radio communication and data transmission systems, public services*

Introduction

Today's society and human relations are defined by services of information technology (IT) and the mission tailored application of them. The users can distribute a significant amount of data in a faster and easier way while the costs of them are continuously

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[2] Ph.D. candidate, National University of Public Service, Faculty of Military Sciences and Officer Training, Doctoral School of Military Engineering; e-mail: krisztian.karoly@mil.hu; ORCID: 0000-0002-5835-7980

[3] Ph.D., Associate Professor, National University of Public Service, Faculty of Military Sciences and Officer Training; e-mail: nemeth.andras@uni-nke.hu; ORCID: 0000-0003-2397-189X

decreasing. This sector became one of the most important driving powers of globalisation and the development of world economy, as well. The quick improvement of the technical background of communication and content services generated rapid increase for the created and transmitted data within a specified unit of time. Due to the appearance of new market segments, it has dramatically changed the sales, the advertisement and the whole service industry altogether. One can easily say the importance of information was valorised in the last decade. For the proper economic decisions, more and more data needs to be processed and its efficiency is driven by its complexity and the speed of applied algorithms. These elements had an impact on other sectors as well, continuously shaping our day-to-day life. Therefore, we can call—among other things—today's society information society.

The basis of information society is the information itself that could be extracted from different sources and strictly defined and structured data mass (databases), with the help of applications using algorithms.

The achievements of information society have heavily impacted different areas of public administration, the quality of public services or the efficiency of the services of (even local) governmental organisations. Let us think about the improvement of public administration, [1] [2] the growing services of the general e-governmental client gate ("Ügyfélkapu" in Hungarian) or the registry and decision support information systems of some governmental bodies.

Nowadays in governmental offices, governmental bodies or public services, the administration is running through networks with IT[4] support, the same way how it works through other government monitored institutions like healthcare or public education. This integration level of IT services automatically pulled up the transformation of public institutions. Through the IT solutions, the speed of certain tasks has been increasing while the pertaining human resources has been decreasing in a compulsory way. In parallel with these, administration has become almost fully transparent.

The other main achievement of the 4th industrial revolution (information revolution) [3] is the accurate location at local, regional or even global level where network based services and beacon enabled tools, vehicles and people owning "smart" devices (e.g. mobiles, tablets, etc.), their location information can be fetched through remote monitoring services and the marking can be displayed in digital maps on a computer or mobile phone all over the world. This is not only providing features but initiates serious information security questions.

In our research, we will deal with the definition of the fleet and force monitoring terminology and the challenges that could impact the creation and adaptation of systems for supporting the public services.

Definition of Fleet and Force Tracking Systems (FTS)

Systems for the purposes of public services built by advanced technical and IT solutions are called fleet tracking systems, which are enabling the tracking of the devices and personnel of a given society organisation or business enterprise. A more complex term is

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4   Information Technology.

fleet management system, which still builds to advanced technical and IT solutions, but enables the tracking and management (planning, controlling, maintenance) of the whole fleet of a society organisation or business enterprise to optimise the resources. [4: 1] As per Karmazin, this can be interpreted in several ways; the wider interpretation is the handling of different tasks raised around vehicles (e.g. management, procurement, administration, vehicle tracking, maintenance, sales culling, etc.). Per a more specific interpretation, it is the management of different administrative tasks around the fleet. From a financial point of view, we speak about the cost around activities from a service provider, such as complex fleet renting and its associated tasks as service, licensing and fuel accounting. An advanced fleet management system has several functionalities like navigation, tracking (by geographic location and by activities carried out by the driver), protection against damage (vehicle theft or fuel theft), duplex communications channel between dispatcher and driver. It can also calculate routes, complete pre-calculations (estimated fuel using and time of arrival), be it used for control of fleet and drivers and their driving habits, record the actual driving/resting times in real time and create reports with alerts if needed. [4: 1–2] Due to the changing nature of the business sector and so of the technical improvements, it is almost impossible to find only fleet tracking systems. The simple tracking has been replaced by complex, fleet management systems with integrated services. After analysing multiple participants of the market, companies providing fleet management systems often use the term fleet tracking for their profile.

Primarily used in military terms, the (blue or own-neutral) force tracking systems are generally location positioning and reporting systems and their main function is sharing the actual geolocation information of units (sub-units, vehicles or even dismounted soldiers) with a periodic frequency refreshing and visualising those in digitalised maps so commanders and their staff can utilise this information making their situational awareness. The connected processes are executing automatically using advanced IT routines without the need of manual intervention from the users. [5: 5] [6]

It is valid to ask whether the only difference between fleet tracking and force tracking is the area of usage (civil or military terminology). By considering the definitions and understanding the complex task structure behind them, one can determine that the aim and the used technical solutions are very much similar within the two systems. Still, looking at their content and intension, there are basic differences between them. Even if both are used to increase the efficiency of "resource management", in the civil segment the focus is on the financial interest while in the military segment, the focus is on force protection and minimalising the human and material loss. Basically, fleet tracking systems are used to serve logistic purposes while force tracking systems are taking post-logistic tasks, as well (e.g. organising the re-supply). Other significant difference is the time factor. As for fleet management, the tasks can be pre-processed by the nature of the procedures on a daily, weekly or even monthly basis, while for force tracking systems, we can expect more emergency related tasks in combat situation. Last but not least, the stability and security of the systems are different within the two terms. The weight of the consequences defines the difference as a malfunction which for a fleet tracking system would end in financial or material loss, but in the military world, malfunction can take human lives (not only manpower but civilian lives present on the operational area as well).

As per the above and per our understanding, fleet tracking is a public/sales driven logistic term and force tracking is for the command and control (C2) of armed forces and law enforcement organisations (military, police, disaster management). These latter organisations have strict hierarchical echelons and their characteristic of command is directing by orders (from the chain of command). Information gathered by force tracking systems are pushed forward to the battle management system (BMS), tactical mission management or search and rescue management systems as per the profile of the given organisation.[5] Commanders with appropriate level of authority can make decisions based on this information and these orders can be passed to their subordinates or superiors (even neutrals) through that respective system. These could apply in the following situations:

- within disaster recovery, carrying out marching, rescue, discharge, protective and damage control tasks;
- within law enforcement, carrying out crime prevention and location securing tasks;
- within military, carrying out offensive, defensive and delaying defence tactics.

It is still worth mentioning even if it is not connected directly to the terminology but there are significant differences in the method of data flow and technical solutions used by fleet tracking and FTS. While fleet tracking systems use cellular networks or other PMR[6] platforms, FTS use various spectrum of data transfer (i.e. HF[7] and VHF[8] networks, satellite channels) for passing geolocation information.

We would like to highlight, that the primary scope of our research is fleet and force tracking, which include specifying the geolocation position and displaying it on interactive maps, as well as the possibility of transfer and integration of data and its limitations. As we said earlier, these systems are integrated into the management or C2 system. The inspection of these complex systems is not in our current scope, only considering the necessary level of examination.

On the below table, you can see how fleet tracking and FTS are divided.

Table 1. *Segmentation of fleet tracking and BFTS.*
[Edited by the authors.]

Fleet Tracking and FTS			
For public purposes	*For defensive purposes*		
Tracking level	Fleet tracking	Force tracking		
Management/C2 level	Fleet management	Search and Rescue Management System (disaster recovery)	Tactical Mission Management System (law enforcement)	Battle Management System (military)

After defining the terminologies, let us examine the nature of fleet and FTS and also their connection to public services from the relevant processes of information society point of view.

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5   The two functions are often placed into an integrated system on a modular base, where a communication platform is also connected.
6   Personal Mobile Radio.
7   High Frequency: 3–30 MHz via International Telecommunication Union (ITU) normative.
8   Very High Frequency: 30–300 MHz via International Telecommunication Union (ITU) normative.

Information Society and Public Administration in the View of Fleet and Force Tracking Systems

The information-industrial society is a new type of society and production model that is based on the continuous and intense usage of scientific results. This new model based on its content is called knowledge society and intense knowledge economy. [7]

The traditional industrial society is being replaced by this computer network and IT based production aeons, which intensively implements the scientific results and represents an extraordinarily high standard of production technologies. In this society, the determinative value and driving force is information and its compacted version, competence and science. [8: 78–79] From a HR[9] point of view, the training of the new human workforce can take up to 20–30 years, because it requires more complex and higher competence *(Lifelong Learning).* It generates major structure changes in the society, it changes the life of people by even postponing the time when children move out from their parents and start their own family life.

Looking at the content of this information society, this is an enlightened and ultra-developed society, which follows democratic rules. It can be characterised as a global economic society, which is built on the principle of private ownership and free market competition. Therefore, it is often called democratic global capitalism. The European Union has also been building the information society in the 21st century. [8: 79] The newest scientific researches establish the possibility for creating a cutting-edge—computer network—based social management system. During the implementation of the rolling development plans, the European Union relies on a statistical observation system in which the development of each member state is being observed on a yearly basis and according to the statistical parameters of their results, they receive further goals to reach. The EU's[10] integration economic system is the number one of the world due to the fact that the key sector of its economic force is the targeted supporting system. [8: 80]

The different aspects of information society have a wide range of literature, which will not be covered now in details due to space limitations. From this range, there is an outstanding early forerunner, Alvin Toffler, American sociologist, the creator of the social wave theory. In his theories, he marked the agricultural revolution to be the first world wave. It started about 10–12 thousand years ago and lasted until 1650. The agricultural yield stood at its Centrum while the field was the basis for power, so the social structure was typically feudalism. (This differs a bit from the feudalism described in the Hungarian education system, where they usually focus on a triangle of agriculture-terra-power.) The second wave started with the first industrial revolution between 1650 and 1950. This was the industrial society, which was the industrial production period founded on the traditional mass production. Its social model is industrial capitalism. The third wave is the information society, which currently has its preliminary phase as we estimate since 1950 until 2025 and it will last approximately for 100–200 years. In this new model of society, the hard, dangerous, monotone work will be performed by robots, while the human workforce will mainly cover the intellectual and creative works. [8: 80–81] [9]

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9   Human Resources.
10   European Union.

This is a global private equity and parliamentary democracy based on an economic system using advanced capitalist principles and is built on science, competence and networked information systems. This is not a form of government but a well-developed form of society and living. Its characteristics are as follows: it is fully digitalised, broadband (high transmission speed), multimedia, and electronic institutions are in place such as electronic (marked with "e", i.e. e-public administration) state organisation, state government, state and local administration, court, public infrastructure, law enforcement organisations and tax authority. Its further attribution is the networking remote society, the members of which manage their private, public and corporate matters remotely due to the developed telecommunications and information networks. One of its main principles is the principle of authority, which requires proper authorisation for each mission in order to allow later prosecutions. Another principle is subsidiarity, which requires every decision to be delegated to the lowest possible level so that decisions can be made where they are most applicable. The different advanced fleet and force tracking solutions contribute to the fulfilment of these principles.

On the other hand, due to it is being ultra-developed, the information society is extremely vulnerable. It is exaggeratedly dependent on the developed, however, highly vulnerable information infrastructures, telecommunication or information systems and on their services. These systems can be in danger of a variety of functionality issues and of outages caused by deliberate damages or destruction. Due to their (strategic) central roles, they can be in target of business opponents at micro level and of hostile states, terrorists at macro level. Since the beginning of the year 2000, it has come into the public view that during these attacks all the following sections can be paralysed of a well networked country: its leadership, financial life, trade market and bank system, public transport and other logistical subsystems, power providing and public services' systems (gas, petrol, oil, electricity, water, sewer, tele-heating), raw material and food supply. Consequently, even health care can be faltered, public security can collapse and the previously organised functioning system falls apart. [8: 85–87] A good example for this is the malfunction of the basic public utilities on the east coast of the United States in August 2003. The nearly 3 days long power outages caused riots in some places. [10] [11] [12]

After the introduction of the different aspects and main characteristics of the information society, it is expedient to write about the categorisation of the different public service operators according to their fleet and tracking applications. To do this, of course, first it is required to define who these operators are. In Hungary we distinguish public servants in a specific and in a wider aspect, as well. In the wider sense, we consider the public service area composed of public servants, judges, prosecutors, military and public security professional members or career soldiers, members of secret and intelligence services, the full personnel of the public administration. In a more specific sense, only the personnel of the public administration belongs to the public service area, such as the public servants working in the public offices, the paramilitary and local government delegates and workers, the employees of the bodies carrying out public service activities (i.e. health care professionals, teachers) and the employees of state enterprises. [13: 3–5] [14: 1–2] It is necessary to mention that the usage of the above specific and wider sense is not unified neither in the European Union nor in the NATO literature. In the Anglo–Saxon literature, the word "public service" is used in the wider interpretation (i.e. doctors, teachers, policemen, public servants, etc.),

while the expression "civil service" is used for the public servants according to the specific interpretation (i.e. clerks). [13: 4]

In our research, we are mainly dealing with the fleet and tracking solutions of the members of the public administration according to the wider interpretation. Based on a self-created model, we can categorise the public administration members from the fleet and force tracking systems' point of view as per the following.

Public service belongs to the first group, such as the public servants and governmental officials employed by government organisations, offices (i.e. government offices, schools, hospitals, state enterprises, foundations, courts, prosecutions, etc.). Their common features are that during their fleet tracking tasks, it is sufficient to implement such commercial oriented services, that forward the data of tracking systems equipped with GPS[11] or other satellite navigation systems via mobile broadband data connection. It is worth mentioning that in some cases (i.e. based on information security or availability point of view) the communication platform can be a closed-circuit network, TETRA.[12]

We list into the second group the systems of public security, the ambulance deployment and rescue management. Based on the provided services, they can be considered a transition between the fleet and tracking systems. Their common feature is that the circumstances of their usage is often not optimal because the moving and deployment units of the public security organisations can normally be required to act in damaged or destroyed infrastructures (i.e. earthquake, floods, storm) and also in some cases the operation management's work can be hardened with blocked communication channels by different groups with conflicting interests (criminal groups). Their further characteristic is that they can even implement the services of military systems in order to perform a successful task accomplishment. The primary communications platforms of these operation management systems are usually the TETRA systems.

We list the military bodies in the third group, the force tracking systems of these are usually used integrated into a Battle Management System.

As a fourth group, totally separately from the other groups, we list the secret services and intelligence agencies. The principal reason for this is the information sensitivity in relation to their actions.

Fleet Tracking, FTS and other Applicable Supporting Systems in Public Services

Nowadays, it is very common to use fleet tracking or FTS solutions in public services. Good examples are the PAJZS[13] and DÖMI[14] systems used within disaster management or National Ambulance Service' Rescue Control system, which partially is based on the EDR's[15] (the Hungarian TETRA system), the fourth "governmental cellular network

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[11]   Global Positioning System.
[12]   Terrestrial Trunked Radio.
[13]   Operations management decision support system.
[14]   On-duty decision support GIS.
[15]   Common Digital Radio Communication System.

supplier", TETRA AVL[16] solution. With the help of these systems, associates on duty could monitor the organisation's vehicles and coordinate tasks in almost real time.

The best example for personal tracking would be within criminal sentencing where the movement of people within house arrest are tracked and monitored using ankle bracelets in order to control the compliance of restrictions. The device, with proper network signal, can track the movement of people under house arrest. Another perfect example within fixed track transport is the information service of MÁV (Hungarian State Railways) called "Vonat Infó" where passengers can follow railroad traffic in real time. [15] Similar services are available within air transport. Flight radar 24 is an international service, which is often used domestically as well, provides a platform for tracking the movement of aircraft in international airspace, we also can search for their type (fixed or rotary wing), ID or other information. [16]

Tracking applications are also used in different areas of defence. Different FTS play a critical role in the missionary of Hungarian Defence Forces, like IFTS[17] or FBCB2 BFT[18] based on satellite communications used on the battlefields of Afghanistan, or KFTS[19] used by allied police officers and military personnel based on TETRAPOL[20] network in the battlefields of Kosovo. All the above examples are basically an IT based solution, therefore their development (and obsolescence) is showing an accelerating trend.

In our present-day life, many critical infrastructure and IT infrastructure systems have integrated different FTS services and their stability became the depository of safety. Luckily, the days of our lives pass peacefully but it is actually a fragile state, which is affected by multiple sources of danger. Let us just think about the migration crises afflicting our homes and the whole European Union or the large-scale, global climate change. These natural effects directly or indirectly could cause disturbance or damage in critical infrastructure. In order to minimise the consequences, specialists usually use military or other special technologies and systems.

During our research, we paid special attention to the implementation or military FTS solutions into public functions. As the information society we live in is threatened, the key for safety is the major reduction of known threats where adapting military technologies into different tasks is giving proper solution. Of course, it is possible to use developments from public functions into the expansion of different military systems and services. [17]

From previous results and professional experience, we have identified several research fields and challenges. In domestic location positioning, NAVSTAR,[21] a USA based GPS still has a dominant role. Thanks to its coverage and reliability in the market of positioning systems, we find many GPS navigation or GPS escorting devices. However, recent studies highlighted the vulnerability of the above. [18] [19]

While in the middle of the 20th century radio navigation was the privilege of air and navy forces (also flight and shipping), [19: 8–11] the second part of the century became the era of satellites for the global extension of navigation, and the first system was the satellite

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16   Terrestrial Trunked Radio Automatic Vehicle Location.
17   International Security and Assistance Forces (ISAF) Force Tracking System.
18   Force XXI Battle Command Brigade and Bellow Blue Force Tracking.
19   Kosovo Force Tracking System.
20   Different from the time scaled TETRA standard, French frequency scaled terrestrial trunked radio system.
21   Navigation System with Timing and Ranging.

GPS of the United States. In 2001 it became available for public applications to receive punctual signals, giving a massive push for research and development and innovation, as well as the extension of the area of fields where we could use them. Without the trail-blazing services of GPS, we cannot imagine today's automatic positioning, fleet and BFT solutions.

At the same time, this service has its threats just to think about the extreme environment of satellites in space. On the 13th of March 1989, due to a space storm, hundreds of satellites "vanished" and became out of service. [20] To use a not-so-extreme example as well, simple solar flares could also cause problems even in electrical networks like on the 23rd of July 2016. [21]

Of course, not only the satellites are in danger of the disturbance coming from outer space, there are solutions blocking the services on Earth, as well. It is a widely known fact that GPS bugger equipment is available to buy even from the internet, which can make the puncture location identification in their radius impossible. In terms of the on purpose disturbances, the literature distinguishes jamming, spoofing, meaconing and the electromagnetic compatibility (EMC)[22] issues caused not on purpose by different interference sources. [18] [19] A partial solution can be for some issues the usage of GNSS[23] receivers, which are able to receive the signal of several global satellite navigation systems at the same time, so these calculate the location from the data received from more satellites. Other than the GPS, global coverage is also provided by the Russian GLONASS,[24] the European Galileo or the Chinese Beidou (Compass) which provides partial coverage for now.

The aim of our research is to examine the possibilities of carrying out public functions from fleet and force tracking aspects with the usage of GNSS based satellite navigation systems, with special attention to the available geographical information systems (GIS).[25] Professor Haig defines GIS as follows: "The GIS is a way of proceeding and also a device that is for location and state recorder of objects, for geographic phenomena on the surface of the Earth and near to it, to track the changes in space and time focusing on the effects of all above. Furthermore, it is to receive, store, manage, analyse and visualize the attributes and supplementary data of different content and in different formats." [22: 75]

During the management processes to make the optimal decision one of the essential conditions is to set the proper situational awareness (SA[26]). This can be deeply supported by GIS based interactive maps that show in real time the people and devices belonging to our responsibility. This is the reason for our analysis of the possible ways of utilisation of the special software that could raise the level of carrying out public functions.

According to our understanding, in relation to this, it is necessary to examine the possible ways to transfer the information provided by the fleet and tracking terminals. Considering the requirements and possibilities today, there are several solutions and channels for this purpose. The radios and radio communication systems working in HF are able to cover big distances at a relatively low cost. On the other hand, the creation and quality of the connection is greatly affected by meteorological factors and the momentary state

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22   Electromagnetic Compatibility.
23   Global Navigation Satellite System.
24   Globalnaya Navigazionnaya Sputnikovaya Sistema (Global Navigation Satellite System).
25   Geographical Information Systems.
26   Situational Awareness.

of the ionosphere while the available bandwidth is also strongly limited. Although these negative effects can be well counteracted by using modern digital modes [23] that are based on up-to-date adaptive and cognitive radio solutions. [24]

In addition to the HF devices, it is worth paying attention to the UHF[27] radios, radio communication systems as well, which, however, ensure less range but provide faster data transfer speed. The establishment and maintenance of this type of connection can be determined in a lot deeper detail.

Obviously, we also plan to examine the data transfer possibilities via the up-to-date mobile communication systems. Within this area, it is worth mentioning again the TETRA/TETRAPOL technologies used in different closed mobile communication systems. The TETRA standard was established between 1989–1993 by the European Telecommunication Standards Institute (ETSI), as such the digital Personal Mobile Radio (dPMR[28]) system, that is able to replace the bigger private networked analogue radio systems i.e. analogue VHF/UHF solutions spread within the standby and public security bodies of the European countries. It is important to highlight that the TETRA standard does not set fix system parameters, it contains the services that must be provided by the system and the description of outer interfaces. So the TETRA systems of different countries and manufacturers may contain different solutions but we can state that their main technical parameters are nearly the same. [25] [26] In Hungary, since 1 February 2007, the Hungarian TETRA system has been working in its full set and came into the professional society as the Unified Digital Radio Communication System (EDR). The EDR covers more than 90% of the country with 266 stationers and 5 mobile base stations. It serves 42,000 users with a 99.9% availability indicator. [27: 3] Due to a framework (TETRA AVL) integrated into the EDR, it is possible to track the terminals in near real time. The Hungarian development of this service includes a great variety of possibilities in itself.

Moreover, there will be a great chance to improve the possibilities of TETRA systems. Expected from 2020, the TETRA LTE[29] framework will be introduced, which will be able to provide wider bandwidth for the applications. It would be an excellent chance to build a modern closed-circuit wireless telecommunication network, which can support the mission critical communication, voice and data transfer, the applications (like on the smart phones), and the Big Bang[30] in IoT.[31] Via this development, it will be able to effectively support the blue force tracking capability such as near-real time automatic tracking of the geolocation and the share of the data from the sensor networks (technical, medical). [28] [29]

In terms of the data transfer path, even the satellite communications services deserve special attention, which can ensure the required channels for fleet tracking even in the barely populated, remote from continental infrastructure or destroyed infrastructure (i.e. hit by disaster) areas. This solution requires a higher cost but the available bandwidth can be much bigger than in case of using the long distance HF systems. The connection setting and maintenance can be well determined.

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27 Ultra-High Frequency: 0.3–3 GHz via International Telecommunication Union (ITU) normative.
28 Digital Personal Mobile Radio.
29 Long Term Evolution – 4th Generation mobile communication solution.
30 The revolution of IoT or Internet of Everything (IoE).
31 Internet of Things.

With the fast speed development of information technologies and miniaturisation, it became possible to satisfy such a demand that as a complementary service of the fleet tracking systems, we are able to track the firefighters participating in rescue, soldiers on the battlefield, policemen in deployment or even gain additional information about them in order to make optimal decisions. The aim of our research through examining the available technologies are the capabilities of systems and devices. Those are to define the services and possibilities through which the effectiveness of carrying out public services, the quality of work can be developed or the decision-making processes can be optimised. In relation to this, it is important to forward, process, evaluate and distribute the data gained from the terminals in a timely manner. In other words, the data fusion is an important question in order to own the information in the appropriate way and format by the experts and decision makers. To support this, the interoperability and need to share/need to know requires further research, which are generated by serious cybersecurity [30] [31] questions.

Another approach is to take opportunities in the field of sensor networks' applications. If we connect the FTS with sensor networks the data from these networks will be able to increase our situational awareness. From the point of view of force tracking systems, the best sensor networks capabilities are: medical monitoring and diagnostic networks (WBAN[32]–WPAN[33] level), technical monitoring networks. There are many and more features that we can monitor, such as the temperature, pulse, blood pressure of the warriors, or the level of fuel/ammo/batteries of devices. We would like to research the application of IEEE 802.15.4 ZigBee and LoRa[34] in the sensor networks, which can support the force tracking systems.

Conclusion

Through the exponential development of information technologies, it is possible to track people and technical devices nearly in real time. Using this skill in carrying out public services creates serious opportunities. On the other hand, it is also a well-known fact that several issues and impacts made on purpose or not, can endanger the secure functioning of these systems.

In our article, we defined the background of fleet and force tracking terminology and demonstrated the impacts of information society. We grouped the different organisations providing public services from the fleet and force tracking point of view. Also we determined the challenges of fleet and force tracking solutions as a basis for our future research.

In our paper, we analysed the development opportunities of tracking technologies. There is a serious potential in changing the GPS receivers to GNSS receivers. Moreover, we recommend increasing the deployment of the TETRA networks in the force tracking systems in the governmental sector.

Referring to the exponential trend of the IoT evolution, there will be a serious demand for data of sensor networks. Nowadays, the users of these fleet and force tracking systems

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32   Wireless Body Area Network.
33   Wireless Personal Area Network.
34   Long Range.

want to know the geolocation position of the people and vehicles. We think it will be a basic feature to support the tracking systems with sensor data in the not-too-distant future.

We think our publication indicated more research topics, for example, as we determined previously, the separation of the technical features of the four governmental groups.

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Dubai's Answer to the Challenges of the 21st Century: Organised Crime and Prostitution, in Particular of the Police Forces

István KOVÁCS,[1] Adrián CSAJKA-VÁNDOR[2]

By now Dubai has not only grown into a futuristic, modern tourist paradise but has also become a major economic power, centralising a certain part of the global capital. This has also been realised by organised crime which tries to make use of accumulated dollar billions by the help of different kinds of crimes often even without using violent means. The present paper analyses, on the one hand, the supply system of Dubai, that is its economy, army, police and social system, on the other hand, the system of international organised crime and trafficking. The method used is critical source analysis, basic historical research, as well as case and judgement/verdict analysis. This is not a classic analysis but a criminal analysis of specific cases. Our strategic aim is to create a database which can show the new profile of the organised crime in the 21st century.

Keywords: *oil market, global economy, organised crime, military strategy, Middle East, Gulf States, the "to Dubai" phenomenon*

Introduction

Flourishing metropolises are being built in this fast, globalised world. This is just what has happened in Dubai, the country that has become an economic power and so it has attracted the attention of organised crime. Oil-crime, money laundering, weapons- drugs- and sex trafficking, to mention just a few common crimes regarding Dubai. [1] The paper describes the military, economic and police system of Dubai, but mostly focuses on the activity of organised crime that is related to the above-mentioned systems. Thus, the so-called "to Dubai" phenomenon—threatening constitutional and human rights—well known in the field of international prostitution has gained ground in Hungary in the past five years.

The first part of the article is based on basic historical research, where the authors collected abstracts and general information. Primer and seconder sources were used to gain reliable data about the state system of Dubai—national and international articles, studies, monographs, police- and defence reports—from archives, museums and online resources.

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1   Ph.D., Police Major, Assistant Lecturer, National University of Public Service, Department of Law Enforcement Management; e-mail: kovacs.istvan@uni-nke.hu; ORCID: 0000-0002-7210-1981

2   MA, Police Staff Sergeant, law student, Pázmány Péter Catholic University, Faculty of Law and Political Sciences; e-mail: adriancsv@gmail.com; ORCID: 0000-0001-7968-0042

The second part analyses court judgements in cases of "Dubai-ing",[3] prostitution and organised crimes to gain new scientific results. Analysis and synthesis are the two pillars of the article; breaking the whole to its components, the paper analyses and evaluates these components, understanding the connections between them, reunite these components to open up a new dimension generating new results.

The strategic aim of the paper is to collect data to show a realistic picture of organised crime in the 21st century in a country which due to its leading economic position has become the citadel of the utilisation of the possibilities for criminals.

In this article, we will discuss the work of the international prostitution network from Eastern Europe to the Emirates and the actions or lack thereof of local and international police forces, in addition to introducing the state of armed forces of the Emirates.

Bird's-Eye-View of the History of UAE

The United Arab Emirates (UAE) was formed on the 2nd of December 1971, with the federation of six Emirates (Abu Dhabi, Ajman, Dubai, Fujairah, Sharjah, Umm al-Quwain). The seventh Emirate (Ras al Khaimah) entered the Union on February 1972, thereby acquiring the UAE's now known federal form and its present borders. [16] The Emirates is an absolute electoral monarchy, in which the Federal Supreme Council, that is the (practically sovereign) rulers of the seven emirates chooses the king from among its members. (The Federal Supreme Council consists of Rulers of the seven emirates constituting the federation or their deputies in their emirates in case of the Ruler's absence or unavailability. Each emirate has one single vote in the council resolutions and deliberations.)

The Emirates is a federal system, each Emirate has autonomous administration, legislation, and internal affairs, however, foreign affairs and defence are dealt with commonly at the federal level, under the direct authority of the ruler. The Emirates is the 7th largest oil producer in the world and 3rd in the Gulf States; as for oil exporting, it is the 3rd largest oil-exporter in the Gulf after Saudi Arabia and Iraq and globally it is the 5th largest oil exporter. However, it is increasingly seeking to strengthen its economy through innovation in the money and banking sector, in tourism and services, and to decouple it from the oil market by investing in oil revenues, to remain among the strongest economies in the world in the era of alternative energies. According to the Global Financial Centres Index, in the United Arab Emirates (and the Middle East) the largest financial centre is Dubai, it is the world's 12th largest financial investment centre, overtakes Abu Dhabi.

The leadership of the Emirates recognises that the financial sector is closely linked to tourism and service, which has been developed to a professional level, so that every investor, businessman or tourist visiting the Emirates from the middle class to the top ten thousand could find the adequate services and entertainment opportunities, the well-established infrastructure helps providing excellent services like the Emirates, the largest airlines in the Middle East, and the world's 12th largest airline in terms of fleet size.

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3   It is a new Hungarian term, which is used in connection with international prostitution from Hungary to Dubai.

The Emirates—including the emirate of Dubai—of Islamic traditions and largely Sharia-based legislation, has been forced to bargain for business, a good example is the sale of alcoholic drinks which is contrary to the Islamic law. Sharia forbids alcohol consumption, however, non-Islamic foreigners are exempt from this part of the law, thus alcohol can be sold with significant tax charges, while in principle Islamic law is respected. They also have a very flexible approach to dress standards. In addition to the above-mentioned legitimate loopholes, they are tacitly tolerating and, in a sense, building a market for illegal activities such as drug trafficking or world-famous luxury prostitution in Dubai.

The Economy of the Emirates and Dubai

The huge wealth of the Emirates is due to the profits from oil production. Besides, as it was said, being the 7th largest oil-producing country in the world, its area is small (83,600 km^2), has a population of 1.2 million, so unlike Saudi Arabia or Iran, the amount of oil revenue is distributed among a small proportion of the population. The Emirates differs from the aforementioned oil powers in other respects, as well. While Saudi Arabia basically used to build its economy on the oil industry, the Emirates has long term plans, so it invests its oil proceeds in different businesses because, on the one hand, it wants its economy to be multicomponent, on the other hand, it wants to be prepared to the time when the world is moving from fossil fuels to alternative energy sources; for years now the world talks about the Vision 2030, the aim of which is to reduce the country's dependence on oil. So, although about one-third of the GDP comes from oil production, the Emirates has a good chance to maintain their economic stability and quality of life in the future.

Comparing the seven emirates, their economy—as well as their territory or population—is uneven. More than 90% of the oil production is in Abu Dhabi, while Dubai produces less than 5%. However, oil production accounts for less than 1% of Dubai's economy, but Dubai still accounts for 30% of the UAE's economic output. Most of Dubai's economy comes from the financial sector, real estate and tourism. The Emirates has a much more open, investor-friendly market than the other Gulf states with economically more conservative views. The Government of Dubai has not maximised foreign ownership in domestically-owned companies since the 1980s, creating free zones in which foreign investments have been virtually unrestricted. [2] Dubai broke with conservative views in other respects, as well. To transform the financial and banking sector, it wanted to make the city of Dubai more attractive to investors. Marketing was needed to make Dubai more attractive to investors. This is the shiny side of Dubai. Examples of such projects include the construction of the Burj Khalifa or the 7-star Burj al Arab Hotel. Thanks to these innovations, besides the dynamic growth of the banking and financial sector, tourism and services sectors have also developed strong and have now become one of the main pillars of Dubai's economy. For the glamour and luxury of Dubai, the infiltration of Western values is inevitable. Thus, they had to integrate such things into the conservative Arab society and world-order—for example—as the beauty industry, alcohol consumption of foreigner visitors, or, in a sense, legal sexuality, as foreigner women are allowed to wear bikinis on the beach that do not exactly comply with women wearing Islamic clothing. Allowing these types of changes have been partly solved by

liberalising the Islamic legal system, partly by turning a blind eye—to some degree—to some illegal activities such as drugs or prostitution, and partly by informal control over the police.

Armed Forces, Geopolitical and Strategic Position of the UAE

Due to the geopolitical position of the UAE, like all Gulf countries, it is forced to invest large sums in military development. The Persian Gulf has been an area of particular economic and strategic importance since the discovery of oil reserves, and the Middle East has always been a proxy buffer zone for the world-power countries. Each of the Gulf states has a strong economy and has enough resources to finance their forces, so the UAE must face major military and economic challenges. The Gulf War (take the example of Iraq and Kuwait) showed that the potential of a country with a sizeable territory, large population and significant military force could pose a threat to the Gulf's oil-monarchies. In case of the UAE, neighbouring Saudi Arabia is most likely to pose a quasi-threat, and it is no coincidence that the UAE is looking for a partnership with Saudi Arabia and/or with its ally, the USA. The UAE was a member of the Saudi led coalition until 2019, which militarily supports the Yemeni Hadi Government against Iran-backed Houthi rebels. Another critical military point for the UAE is the Strait of Hormuz. It is a gateway to the Gulf with a strong international status, however, according to Ferenc Erdősi, in the light of the events of the last half-century, the Strait of Hormuz has proved to be the hottest spot of global oil logistics in terms of global oil logistics. [3] 21% of the global oil export is transacted through the Strait between Iran and Oman, which, according to 2018 data, is 17.4 million barrels a day. The monitoring of the Strait is a priority issue for Iran, as well as for the Gulf Cooperation Council (GCC) countries. Both Iran and Saudi Arabia have naval forces that can block the entrance of the Gulf from world trade. The tensions between the Emirates and Iran are further exacerbated by the unresolved issue of three islands between the two countries: Abu Musa, Tunb and Lesser Tunb. The Tunb Islands were occupied by Iran just two days before the Emirates was proclaimed in 1971. As for Abu Musa, Sharjah and Iran signed an agreement according to which the control of the island together with its resources is shared between Iran and the subsequent UAE, however, Iran in 1992 occupied Abu Musa, too.

The Gulf War had a huge impact on the security policy of the Emirates. As a member of the GCC, along with other Gulf states, it supported Baghdad in the Iraq–Iran War in the 1980s. Saddam's "betrayal" in 1991 when he invaded Kuwait, however, made it clear to the Emirates that it could not rely solely on "external bulwarks", it needs an independent, capable army that guarantees border-protection and the sovereignty of the country. [4] Nonetheless, the Emirates is seeking to secure itself through mutually beneficial arrangements, such as the official military cooperation with the United States in 1994, which allowed the US to use the Al Dhafra Air Base and the strategically vital port of Jebel Ali, a bay deep enough to accommodate aircraft carriers. [17]

The UAE Military Force

Next to Saudi Arabia, the Emirates has the strongest army among the Gulf monarchies. Though in terms of its citizens, it is a small country and the permanent number of its

military force is not more than 59,000, the small number is compensated by technological superiority. In 2015, the UAE was the world's 3rd largest military importer. Around 70% of its combat equipment comes from the United States. [4] Most of the remaining 30% is purchased from Russia, Britain and France. In 2016, 22.8 billion USD was spent solely on military development. The two main challenges facing the UAE army are maintaining their technical superiority and increasing their combat capacity. For the latter, the government has developed two solutions. On the one hand, compulsory military service was introduced in 2014 (on completing high school, men between 18–30 are obliged to serve 9 months; those who do not serve in the armed service must perform other forces for 2 years; for women a 9-month military service is optional.) On the other hand, foreign citizens from poorer Sunni countries, from the Far East and Africa can serve in certain army units though they can only perform basic services. Practically, all officers are of UAE nationality. Just for comparison, Hungary with its population of almost 10 million within the framework of "Zrínyi 2026" plans to raise the number of soldiers from 30,000 to 37,650, but because of the abolition of compulsory military service, only the police have mobilisable resources.

Law Enforcement in the UAE—the Dubai Police

Law enforcement is the responsibility of each independent emirate of the United Arab Emirates. The police force of each emirate is responsible for issues within their borders, but they share information. Dubai, as an independent state of the Federation, has an independent, sovereign police force. The Dubai Police is the most advanced police in the region as far as technical equipment is concerned. It was the first police force in the Arab world that used DNA fingerprinting in criminal investigations, the first whose database used electronic fingerprints, and GPS tracking systems to locate stolen vehicles. The police forces aim to provide the highest standards of public security, law enforcement and detection through professional equipment, tools and professional training. However, the Dubai Police tends to apply double standards. In case of immigrant workers, people of lower social status, the police strongly acts when it is about drug use, drug trafficking, which improves the statistics of detected crimes. On the other hand, the police are much lenient or tolerant when dealing with wealthy Emirati citizens and foreign investors, businessmen and tourists. The issue of dealing with sexual crimes deserves special attention. Like in other Arab states, national law on domestic violence does not meet European standards, but the Dubai Police is the first in the Arab world to have a "Human Rights Department", an administrative body dedicated to protecting women's rights. It is of particular interest that prostitution, as a definition of an independent crime concept, is not recognised by the Arab legal systems, like Dubai. In the United Arab Emirates, there is a lack of legal texts that define prostitution in plain language, thus leaving definitions to be given by courts and testimonies to legally characterise the crime. [5] In the figure below, statistics are shown which were downloaded from the Dubai Police website. The chart shows that although there are statistics related to prostitution crimes, they appear only as related crimes such as human trafficking or rape. At the same time, the number of drug-related offences is high.
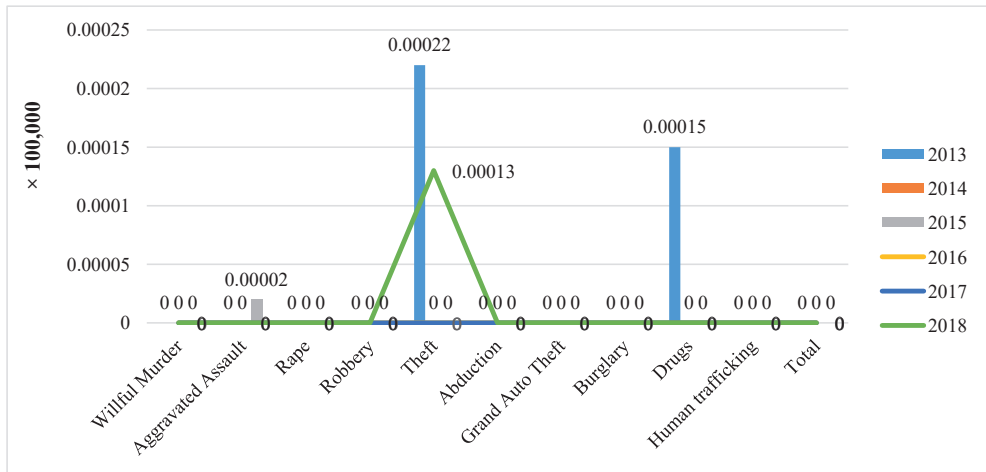
Figure 1. *Major Crime Statistics—Per a hundred thousand people.*
(Edited by the author based [18] on the UAE's Police Statistics 2018.)

The Relation Between Dubai and Organised Crime

The previous part of the paper described that after the Millennium, Dubai has not only grown into a futuristic, modern tourist paradise but has become a major economic power that centralises some of the global capital. This has also been noticed by organised crime groups, which try to get hold of billions of dollars by various crimes, often without turning to violent means. These non-violent yet illegal sources are then used to finance new crimes in the grey and black market of Europe, threatening global security and jeopardising global peace.

We are talking about crimes like drug trafficking, prostitution, corruption, money laundering, etc. [6] The present study does not deal with corruption, money laundering or drug trafficking, but recent researches have shown that they are interrelated and complementary. [7] [8] We must not forget that there is a relevant link between corruption and organised crime. Organised crime often uses corruption tools to operate. This case study research also shows that the accused have committed acts of corruption to keep the organisation running for years. On the other hand, it is very difficult to determine where the boundary of integrity between individuals and bodies lies, which is considered a classic form of corruption. Where does legal become illegal and illegal legal.

With this in mind, an effort is made to introduce the concept known as "Dubai-ing", to describe accompanying phenomena, and to explore what means are used by the mediators between prostitution and organised crime to gain illegal profit.

Dubai-ing", a New Concept of Prostitution in Hungary

In the Hungarian slang, the term "Dubai-ing" has started to gain ground when as a by-product of global thinking, travelling without borders began and an increasing number of Hungarians

went to Dubai, partly for holidays, partly as e.g. singers and dancers to take the opportunity of a booming tourist industry. This was also followed by an unknown number of "others" working on the dark side of tourism, criminals, prostitutes, etc. Of course, the international scene of prostitution was always accessible to participants, only it was not named after the country (Switzerland, Italy), but was called "dancing". (See the book on prostitution by Kovács, [9] who takes the reader to the international scenes of prostitution.) Or the case of Krisztián Zsolt V. who was prosecuted for the crime of multiple counts of procuring. (The Central District Court of Pest's case number III/ 17.B.32343/2013.)

Nowadays, the name of this city has been interwoven in Hungary with the practice of luxury prostitution. This is not due to the Arab Spring or the *One Thousand and One Nights* collection of tales, but rather to the inexhaustible potential for enjoyment and earning money in the fabulous Middle East. Unfortunately, however, the media misleads ordinary people with news that is far away from reality, instead of focusing on the phenomenon, they concentrate on celebrities and public figures. See for example the criminal case against Lajos R. (The Central District Court of Pest's case number III/10.B. 32089/2014), who, after a lengthy police investigation, was accused before the Pest Central District Court for the crime of multiple counts of procuring. In this case, several models, Hungarian Celebrities and media personalities were affected. This, in turn, was only a side-step to the real process known as the "Dubai lawsuit", which laid the groundwork for a conceptual definition in 2009. According to the indictment and the investigation, Zoltán K. and his two accomplices proceeded girls as prostitutes to African, Asian, Far Eastern countries to provide sexual services to clients. (The Budapest-Capital Regional Court's case number III/ 3.B.32435/2013). During the prosecution, several celebrities, models, beauty queens, media personalities, members of reality shows, even presenters and anchors who gained a deeper understanding of this kind of world were interrogated. That was the point when information from the media, the facts of the prosecution and the stereotypes of the public blended international prostitution with hostessing, escorting, modelling, thus creating the notion of "Dubai-ing". (Of course, we cannot claim that there is no connection between these concepts and prostitution, but they do not form a coherent unit. A very good example is the matrix of similarity and difference between pornography and prostitution.) [10] Most of the procedures are still ongoing, and according to the current Hungarian criminal law, perpetrators can only be found guilty by the final judgment which is not available at the time of the study and therefore cannot be analysed. However, there are final court judgments and rulings that completely model this segment of the world and by using scientific methods of analysis and synthesis, we can reach a conclusion, thus guaranteeing new scientific results. Scientific research always seeks to understand reality and truth; therefore, the purpose of this study is not to argue in favour of acquiring and/or convicting those who are prosecuted.

Therefore, a prosecution/case was chosen which relies on a final court ruling, and is focused on international prostitution, solicitation, procuring and corruption. It was also important that there were no "celebrities" involved, but the elements of the cases were well known to the members of organised crime. Therefore, the Budapest-Capital Regional Court 7.B.7/2007/263 and the Budapest-Capital Regional Court of Appeal 3.Bf.12/2011/29 cases were chosen.

Organising of Prostitution, Mediating of the Illegal Income

It is important to bear in mind that prostitution is a complex, latent phenomenon. It is composed of different layers, different locations, methods, social mapping, individual cases and unique stories. [11] When we look at the phenomenon of "Dubai-ing", we cannot ignore the fact that the romantic stereotypes of prostitution (for more details see Kovács' latest work) are outdated. [12] In this case, there are no pimps who use psychological and physical violence to exploit and intimidate the prostitutes who become victims. As Kovács writes, as early as 2016, different levels of prostitution can be associated with different behaviours. [13] While on the one hand, in case of street prostitutes pimps clearly use intimidation and violence, threats and coercion, on the other hand, the transforming institution of "rooming (or getting a room)" and the international arena operates on a different level, pimps are the mediators, the business is profit-oriented, the payment is proportional. No violence is used, mediators and girls alike have realised that symbiosis can only work if the reward is proportionate and not based on one-sided exploitation. Collaboration is established between the mediator and the prostitute, and the remuneration is distributed proportionally, more to the prostitute's account than to the mediator's pocket. (Generally speaking, we cannot say that there is a 30–70, or 40–60, or 50–50 ratio of revenue, but we can generally determine ⅓–⅔ ratios.) This mutual, work-based collaboration brings in millions of dollars to the organised crime groups and girls, who, on a voluntary basis, benefit in the same way, their earning depends on their choice and willingness.

In the following, this modernised system and its operating mechanism will be shown. (To limit the scope of the study, the evidence process is not fully described, and the focus is on the mechanism of action, structure, and familiarity with organised crime and runner behaviour.)

In this case, the Budapest Investigative Prosecutor's Office submitted to the Budapest-Capital Regional Court on 3 January 2007 the 9/2005 filed indictment no. 16 in which it charged 16 defendants with solicitation, procuring and corruption and bribery. According to the indictment, the lead defendant accused before the charges transferred dancers abroad,[4] organised their employment abroad for a long time. His reason was that on the one hand, there is a great demand to prostitution and on the other hand, there are many women who, for various reasons, are willing to provide sexual services for a fair financial reward. (Nowadays these are called "push and pull" factors in prostitution.) After the accused realised that this activity is worth billions of profit, he started to transfer dancers abroad and organised their employment abroad. To establish a smoothly going, well organised, profitable, long-term and safe venture, the accused founded a criminal organisation, including, but not limited to, his family, relatives, close friends, and their acquaintances. (This phenomenon assumes a high degree of organisation, leadership and management functions, division of labour, responsibility, decision-making mechanism and tailor-made work tasks, which are visible not only in the domestic but also in the international arena.) Here it is important to note how notable is the positive impact of trust when an organisation is being built up. Social environment—family, close relatives, friends—also served as an important scene for the formation of a criminal organisation, it is almost like an educational institution. This is

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[4]   Dancers who are connected to prostitution and peep shows.

a typical representation of the Italian mafia, or of Italian criminal organisations that later emigrated from Italy, most notably from Sicily, to the United States, where bloodline was a prerequisite for positions in the hierarchy. (This criminal organisation was in operation for at least 5 years until the accused was captured.)

Initially, the criminal organisation was run by the first-degree accused, who was at the top of the hierarchy, but to run a diverse criminal group, that works across borders and has centres in different cities of different countries, is in regular commercial connection and cooperation with other foreign criminal organisations meant that the accused needed help and partners to accomplish organisational and other executive sub-tasks. (There are countless examples of literature on the rivalry between criminal organisations—see turf wars and violent advocacy—but no cooperation between organisations.) The above is of enormous importance because it contradicts power struggles; for example, they demonstrate the dynamic volatility of organised crime, which is necessarily adapted to its environment, opening a new chapter in the history of organised crime research that has not yet been known to us. It can be assumed in modern law enforcement that globalisation made international organised criminal circles cooperate and work side by side instead of acting against each other. Thus, their future can be secured by working together, in cooperation, complementing each other in a large organisation made up of smaller cells. Change management as a new organisational tool has its effect on organised crime, as well.

The other defendants actively took part in sharing the tasks, they were directly under the lead defendant in the hierarchy. They were men of trust. Their task was to recruit prostitutes who volunteered for sexual work, to keep records of women and income, and to operate flats abroad as brothels. There, in the flats, they had to provide the necessary and appropriate conditions and equipment for prostitution, had to produce a portfolio of photographs of women applying for prostitution and to advertise them on the Internet, and to organise the details of travelling abroad and returning home, arranging specific dates for women traveling abroad, reconciliation, dealing with housing problems and, in some cases, collecting money from prostitutes or other agents. Organisational work included giving detailed information (where to go, how much to ask for, etc.) to the girls, but it was also common to do a "job aptitude test" for the girls, based on testing the girls. (Kovács in his dissertation [13] also proved this, several interviewees saying that they were always "tasted" by the pimps.) The same is reported in studies done abroad. Here it is worth mentioning that the second accused originally was a driver (just like the seventh, eighth, tenth, and fourteenth accused) whose task was to drive the girls from home abroad and then back. In 2004, the first accused had the information that the police opened a criminal investigation against his criminal organisation and at the same time against a foreign partner criminal organisation, therefore he resigned and he pulled the strings from behind the scene. (This is another example of cooperation between international criminal organisations and of gaining illegal information. The notion of corruption and the integrated concept of personnel and organisation just fits this section.) At that point, the second-degree defendant stepped up who, from a footsoldier became a leader. Of course, this was only informal power, since the decision-making was in the hands of the first-degree defendant, the evidence of which is the fact that the second-degree defendant had to report everything to the first-degree defendant. It is rather a way of manual drive, but this study does not deal with the management system of organised crime.

The third- and fourth-degree defendant performed administrative duties, posting photos of the girls at various sex-sites, and it was their responsibility to make portfolios of the girls, although many of the girls already had some kind of a portfolio. For example, the fifth-degree defendant had a model agency through which he could post advertisements on the Internet and recruit girls for prostitution. He received 5–10% of the income of the prostitutes he recruited as a commission from the criminal organisation. A team of photographers was employed to carry out background activities. (This also proves that there is a very precise division of labour, everyone has his task and follows the given instructions. If it is needed, external experts are employed.) The fourth-degree accused did the interpreting job, because he spoke foreign languages, which was part of the recruitment, his task was also to do accounting. This section also links money laundering and prostitution. (See Kovács' study for details. [14])

The girls worked in rented apartments abroad, usually one or two prostitutes per apartment, depending on the size and location of the apartments. As a rule, income was distributed: 50% went to the prostitute, the other 50% was the commission to the organisers. Sometimes this portion was 40:60. The commission was compulsory, however, the recruited girls were informed, as if in a verbal contract and they voluntarily accepted the terms. Collecting the commission had several ways, depending on the relationship of the trust between the recruiter and the prostitute. This clearly shows that recruitment and the behaviour of the recruiter are based on the division of work and on a "fair wage" system. Fairer, at least, than that of the pimp who exploits the prostitutes and takes all her earnings. The fare paid by the customer was collected by service members who also dealt with the telephone calls, and at the end of the day, 50% of the income was redistributed to the girls. Control is an integral part of the criminal organisation's work-sharing principle; however, profit-orientation and profit-sharing can only be ensured through follow-up. This is not different from the control methods used in the private sector or the administration, for example, where the employee's daily activities are monitored by cameras and the income is collected at the end of the day. However, in some cases, prostitutes—primarily and almost exclusively those who have developed a close relationship of trust with the organisers in the long run—collected the income, and they put aside the adequate amount that should be given to the organisers. (This can be traced back to the intimate relationship between the prostitute and the organiser, which was in the focus of another study. This is how the Stockholm Syndrome works.) [15] The system worked well, at the end of the workday either the "receptionist" or the girls themselves informed one of the four organisers (first- to fourth-degree accused) usually by SMS. The girls usually worked in ten-day turns and depending on the number of clients, a prostitute gave the organisers the equal of HUF 500,000 to 1,000,000 in Euro after a ten-day turn. (Just a short calculation: it means 53 crimes, a minimum of 53 girls/flat, 5 turns, that equals at least 26 million HUF/turn for five years, 365 days. And this is only what we know about.)

It is difficult to obtain real numbers about prostitution without the help of records, and this lack of data further enhances latency. However, what is registered and/or proven also generated an incredible amount of illegal profit. We should not forget the fact that the girls had a clean, net profit because the organisers took care of the living expenses of the apartments, settled rents, utility bills, paying the cost of advertising prostitutes on the Internet, securing the apartments, line large quantities of condoms. This is deducted

from the brokerage fee, so the net profit on the brokerage side is reduced. (Supported by a ⅓–⅔ ratio called generic at the beginning of the study.)

In the flats used as brothels, there are the so-called telephone operators, to coordinate the meetings between the prostitute and the client who they also checked before letting him in, also in that way they control prostitutes and register their income. Their activity concerned making the business. This, however, may contradict the notion of the voluntary agreement and free choice of work unless there was a previous agreement between the prostitute and the client. The girls theoretically have the right to free choice, since the first step of recruitment is when the working conditions and tasks are outlined. As it was mentioned earlier, the operators managed the revenue, redistributed the money, and reported the daily income to the leader of the organisation in an SMS. The sixth-, ninth-, eleventh-, twelfth- and thirteenth-degree defendants also served in the telephone support staff. The organisation also had security personnel (the seventh-, eighth- and tenth-degree defendants). Their task was primarily to monitor and manage the revenue. To provide physical security was only a secondary activity. The security staff were on standby and intervened promptly if the first-degree defendant ordered them. This could happen if there was a problem with accounting for example. Typically, it was meant not against the prostitutes but the clients.

Concerning court judgments, given that legal proof and judicial decision are not dealt with in this paper, it is only stated that certain parts of the first instance judgment were upheld and some parts of the second instance reversed. Read more in the judgments.

Summary

The analysis of the second part of the paper made it clear that "Dubai-ing" is a billion-dollar business involving organised crime both in national and international settings. The transformative nature of organised crime is embodied in the fact that the groups work together, and self-interest has been replaced by the pursuit of maximum profit and co-operation. A system based on a strict hierarchy, levels of the executive and decision-making alternate with each other and each level has its responsibilities. The violent tools of prostitution are replaced by a system of division of labour and assuming proportional pay. There is no coercion or threat, instead, there is prior agreement, "contracting" and disclosure. Hungary is in the 21st century concerning prostitution. By the 21st century, it has become a transit country, providing various Asian, African, European markets with prostitutes, where the consumers pay millions of dollars thus enriching the illegal profit-making of organised crime, and supporting the illegitimate goals that organised crime has set itself.

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Digital Service Maturity: Development of an e-Cohesion-Specific Model[1]

Tamás LAPOSA[2]

This paper presents a new approach to measure the impacts of e-government concepts on the reduction of administrative burdens, in the domain of European fund management.

The present European legislation specifies that Member States shall provide online portal services for beneficiaries to reduce the administrative burdens of cohesion policy. This concept is marked with the term "e-Cohesion" in the scientific discourse. Based on former studies, the concept has several attributes that leverage its impact on burden reduction. Nevertheless, the level of their influence has not been underpinned by evidence-based research yet.

The present paper has three main aims. First, to present the methodology and findings of an international research on the capabilities and impacts of e-Cohesion portals. Second, to evaluate the relevance of the above attributes based on these findings. Third, to make suggestions for the development of an e-Cohesion specific maturity model to measure the effectiveness of electronic portals.

Introduction

Pursuant to Regulation 1303/2013 of the European Parliament and of the Council, Member States receive development funds from the Union through multi-annual programmes to support the implementation of the EU2020 strategy for smart, sustainable and inclusive growth, as well as the realisation of specific development objectives including social, territorial and economic cohesion. According to the regulation, the management and the delivery of funds shall be based on the principle of administrative burden reduction.

With regard to these provisions, the European Commission launched the e-Cohesion initiative to introduce the mandatory use of electronic portals and e-government solutions in the domain of fund management. [1]

In addition to the European legal provisions, national regulations can further extend the level of efficiency gains. As a result, e-Cohesion can be realised on differentiated stages of maturity as also proven by the study of the Commission and Deloitte. [2] This progress can be best addressed with the methodology of maturity models.

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[2]   Ph.D. student, National University of Public Service, Doctoral School of Public Administration Sciences; e-mail: tamas.laposa@gmail.com; ORCID: 0000-0002-4809-5796

The European Commission and Deloitte made a specific e-Cohesion maturity model but it dominantly focuses on the functionality of e-Cohesion portals. Based on the analysis of e-Cohesion requirements and previous studies, four micro-level attributes *(portal functionality, only once encoding, interoperability, one stop shop)* and two macro-level attributes[3] *(procedural complexity, extent of funds)* were identified which may be relevant from the perspective of efficiency. Reviewing the pertinent maturity models, there is no specific model that can address the complexity of these attributes. Nonetheless, their relevance has not been confirmed by empirical research yet.

This paper presents and evaluates the results of an online survey conducted among e-Cohesion specialists and applicants[4] of different Member States. The finding of the evaluation supports the selection of the relevant attributes for the creation of an e-Cohesion-specific maturity model.

Conceptual Background

The Reduction of Administrative Burdens

European legislation consists of a wide-ranging structure of different legal acts on all policy areas to guarantee the realisation of the underlying policy objectives. These rules are in direct effect in all Member States to ensure the seamless implementation of the strategic policy objectives. No doubt, the application of common rules has a strategic importance but the compliance with them has a series of costs on the other side. Citizens and legal entities are subject to different legal provisions which impose a wide range of financial, procedural or administrative obligations on them. All of these obligations incur different types of direct or indirect costs.

Consequently, a good regulation shall be effective and efficient. It needs to ensure the realisation of policy objectives at the optimal level of costs. Unnecessary legal provisions and regulatory costs represent a socio-economic loss. From a different perspective, the reduction of unnecessary obligations generates extra savings which can boost investment and innovation and contribute to economic growth. [3]

One of the above regulatory costs is labelled as administrative cost which is defined by the Standard Cost Model manual as "the costs incurred by enterprises, the voluntary sector, public authorities and citizens in meeting legal obligations to provide information on their action or production, either to public authorities or to private parties". [4: 5]

Administrative costs can be spilt into two categories: cost of information obligations[5] that would appear even in the absence of regulation *(business-as-usual costs)* and cost of information obligations which are directly connected to legal provisions *(administrative burdens).*

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[3] Micro-level attributes are linked to the technological context of e-Cohesion concepts while macro-level attributes describe the organisational and economical context.

[4] Applicant means a public or private body or a natural person, responsible for initiating a funding project in the framework of a call for proposal.

[5] Information obligations (IO) are the obligations arising from regulation to provide information and data to the public sector or third parties. [4]

From a regulatory perspective, some administrative burdens are inevitable to safeguard the fulfilment of policy objectives and certain burdens could be eliminated without jeopardising the above strategic objectives. As a consequence, the reduction of administrative burdens is targeted at the latter category, the so-called *unnecessary burdens*.

As the first step of burden reduction, administrative costs and burdens need to be identified and quantified. The Standard Cost Model (SCM) provides a well-known methodology for the measurement of the administrative costs of regulations. The SCM is independent of the objectives of policy areas. It is applicable in different domains. The methodology provides coherent and comparable estimates and it is focussed on the administrative activities[6] and information obligations (provision of information, submission of data and documents) set by legislation.

The model enables decision-makers to break down regulatory requirements into elementary components to make the costs of activities measurable. In the SCM methodology, these components are labelled as *cost parameters (Time, Price, Quantity, Frequency and Population)* of administrative activities. Price measures the wage and overhead costs of administrative activities. Time represents the amount of time required for the completion of activities. Quantity indicates the size of the population of citizens and organisations affected and the annual frequency of the activity. These elements make up the SCM formula to calculate the costs of different administrative activities and administrative burdens of beneficiaries.[7] The formula is shown in Figure 1. [4]

$$\text{Cost of an administrative activity} = \text{Time} \times \text{Quantity} \times \text{Price}$$
$$\text{Quantity} = (\text{Population} \times \text{Frequency})$$

Figure 1. *The SCM formula.* [4]

The Creation of the e-Cohesion Concept

In 2007, the Action Programme for Reducing Administrative Burdens was introduced by the European Commission for the simplification of administrative requirements and the elimination of unnecessary administrative burdens of businesses. The above programme identified 13 priority key policy areas for the reduction of administrative burdens. Cohesion policy, as one of the selected priority areas, was estimated to bring about a 24% reduction of administrative costs. [3]

According to experts, the key factor of the above burden reduction is the provision of interactive portal services and the elimination of parallel paper-based business procedures. These online portal services can facilitate the interoperability of information systems

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[6]   To provide the information for each data requirement, a number of specific administrative activities must be undertaken. The SCM estimates the costs of completing each activity. [4]

[7]   Beneficiary means a public or private body or a natural person, responsible for initiating and implementing a funding project selected for the reception of grants.

and the re-use of already available data. The realisation of these measures can result in a significant efficiency gain by the reduction of burdens.

Following the above recommendations, the Commission launched an initiative to reduce the administrative burdens of cohesion policy and rural development policy by the utilisation of online portal service and e-government solutions. The initiative was labelled as "e-Cohesion" and its concept addressed a wide range of legal, procedural, organisational and Member State-specific factors. [5]

To ensure the expected level of efficiency, the Commission included the requirements of the e-Cohesion concept in the legal provisions of funding of the 2014–2020 period. Regulation (EU) No 1303/2013 of the European Parliament and of the Council nominates the three fundamental components of e-Cohesion: *the provision of electronic data exchange services, interoperability of systems and the implementation of the only once encoding principle.* These components have a direct impact on burden reduction.

The digital transformation of organisational procedures requires special guarantees to ensure the quality and efficiency of procedures, as well as the authenticity of digital transactions. These requirements are fulfilled by the establishment of *collateral components such as e-document management, e-signature, and e-audit and interoperability.* Their main requirements are regulated by the Commission Implementing Regulations (EU) No 821/2014 and No 1011/2014. [6] The structure of e-Cohesion components is depicted by
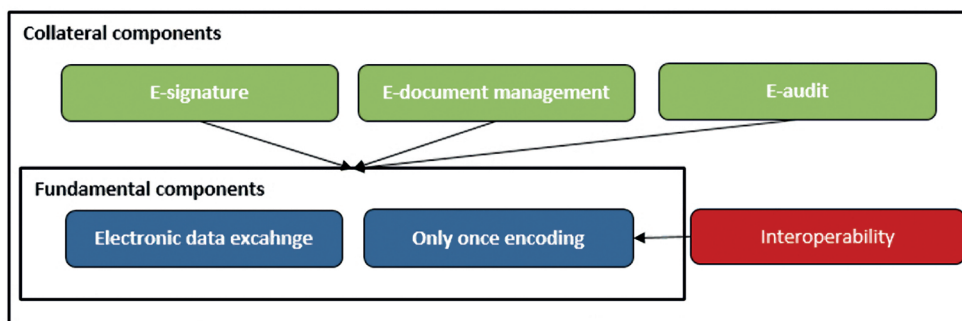

Figure 2. *The e-Cohesion framework.*
[Edited by the author.]

The Malmö Declaration and further Commission action plans on e-Government nominates the enhancement of the efficiency of government services, by the reduction of administrative burdens and the usage of information technology solutions, as a high level objective. [7] The prioritisation of the above approach also confirms the relevance of e-Cohesion.

The Components of e-Cohesion

Electronic data exchange: Member States shall ensure that all exchanges of information between beneficiaries with a grant agreement and relevant authorities can be carried out by means of electronic data exchange systems.

Taking into consideration the specificities of national regulations, the European legislation leaves it to the Member States to make the use of e-Cohesion compulsory or optional to clients. It is also up to the Member States whether they provide electronic services for only beneficiaries or they make these services available to applicants applying for a grant, as well.

The expanding use of financial instruments—particularly when those are combined with grants—also brings a new area with some specific features where the interpretation of e-Cohesion is to be addressed. [8]

Taking into account the paperless nature of funding procedures, the regulations introduce special functional, operational and security requirements to guarantee the quality of services and the efficiency of procedures. [9]

The "only once encoding" principle and interoperability: In terms of the *only once encoding* principle, relevant authorities need to share all data and documents already submitted by the beneficiaries regarding the same funding project. This principle approaches the reduction of burdens from a procedural perspective. The application of this requirement excludes the possibility of multiple data requests and parallel information obligations. Its realisation is strongly connected to another e-Cohesion component—interoperability.

Interoperability can be defined as "the ability of disparate and diverse organisations to interact towards mutually beneficial and agreed common goals, involving the sharing of information and knowledge between the organisations, through the business processes they support, by means of the exchange of data between their respective ICT systems". [9] [10] As a prerequisite of the only once encoding principle, the regulation sets the cooperation of authorities at the development programme level as a minimum requirement.

In the approach of e-Cohesion, interoperability has a special status. It is the collateral component of only once encoding but it also appears as a fundamental component. Fund management systems can interface with other national registries to retrieve and valid data on applicants and beneficiaries in order to reduce the number of data requested from them. This kind of interoperability is not mandatory by the concept of e-Cohesion but these solutions can reduce burdens directly and appear as a fundamental component.

E-signature: Considering the full-electronic nature of data exchanges, funding procedures require adequate authentication methods to ensure the veracity of digital transactions. The European legislation specifies that transactions carried out in the electronic data exchange system shall bear one of the three types of electronic signature defined by Regulation (EU) No 910/2014 of the European Parliament and of the Council. The applied method of authentication and the required level of security can be set by the national legislation in line with national requirements of verification and audit. [9] [11]

E-document management: The application of the e-Cohesion concept completely transforms funding procedures and the methods of document management. To cope with the challenges of this transformation, digital exchange systems need to meet specific functional, security and procedural requirements. From a functional perspective, information systems need to be equipped with a document management module to facilitate the day-to-day management of digital document flows. As regards security, systems need to comply with internationally accepted standards to ensure the veracity and integrity of documents. Procedurally, national authorities need to define the scope of accepted data carriers and the compliance criteria of digital documents. [12]

Electronic audit: In certain cases, national audit and verification requirements and the paperless business procedures might be in conflict, so the concept of e-Cohesion needs to bring them in balance by providing guarantees for the compliance of documents and data while still enabling digital submission. For this reason, European regulations specify that the content of electronic exchange systems need to be regarded as reliable sources for audits and financial verification. This provision is ensured by the fact that electronic data exchange systems need to meet national legal requirements, compliance rules and security standards. [9]

Main Attributes and the Maturity of e-Cohesion Concepts

European legislations specify the main requirements of e-Cohesion to ensure a reasonable level of burden reduction. However, the compliance with these common requirements does not mean that the concept is utilised to its full potential. Regulations open the ground for Member States to further specify these requirements to adapt them to local economic, technological and societal conditions and to realise additional efficiency gains. This implies that national e-Cohesion concepts can be realised at different efficiency levels according to the approach and decisions of Member States.

Based on the research carried out by the European Commission and Deloitte, e-Cohesion can have a very impressive impact on the reduction of administrative burdens if it is implemented to its full extent. The study estimated that the concept can bring about an annual 8% burden reduction if the highest level of portal sophistication would be implemented in all EU Member States. Taking into consideration these significant estimates and the potential socio-economic savings of burden reduction, e-Cohesion is worth studying more thoroughly.

To assist Member States in the full exploitation of the e-Cohesion concept, the Commission and Deloitte created a methodological tool, a maturity model, to measure the level of functional sophistication of national e-Cohesion portals and their potential impact on the reduction of administrative burdens. [2]

The first tool of maturity measurement (Capability Maturity Model) was introduced by the Carnegie Mellon University. [13] The review of the relevant literature shows that more than a hundred of models on different domains have been created since. [14]

Caralli et al. defines a maturity model as a set of characteristics, attributes, indicators or patterns representing progress in a particular domain or discipline. These models help organisations to evaluate and benchmark their practices, processes and methods against a clear set of standards or best practices of the given domain or discipline. Organisations can apply maturity models to define their current level of maturity and then determine the expected path of improvement. [15]

According to Bruin et al., maturity models are evaluative tools to assess and increase the maturity *(competency, capability, level of sophistication)* of a specific domain on the basis of an agreed set of criteria. [13]

A maturity model represents a desired evolution path for organisations or processes as discrete stages (a sequence of maturity levels). [14] The most frequently-used way of evaluation is a five-point Likert scale where Level 5 represents the highest level. Levels

represent the transitional states in the model, they describe evolutionary steps or express a measurable attribute. Attributes are the core model components that appear on each level. They are based on best practices or standards expressed as characteristics, indicators or processes. [15]

In the model, organisations or processes advance between an initial stage and a final stage that represents total maturity. During this advancement, the capabilities of the organisations or their process performance progresses evolutionarily. The maturity model is a tool to determine the position of the organisation or the process on the evolution path by providing criteria and characteristics to be fulfilled to reach a particular maturity level. [14]

The e-Cohesion model of Deloitte is a useful tool to help positioning e-Cohesion portals and setting development targets but it applies a dominantly functionality-oriented approach. As supposed by previous papers, e-Cohesion is a more complex framework, so it is advisable to develop a maturity model that encompasses different *micro-level functionality, only once encoding and interoperability, one stop shop and macro-level (procedural complexity, extent of funds) attributes.* In this context, micro-level attributes contribute to the reduction of administrative burdens from a technological perspective while macro-level attributes define the organisational and economical context of e-Cohesion.

The impacts of these micro and macro attributes seem to be convincing although their relevance has not been underpinned by evidence-based research. For this reason, a previous paper described a research design for the impact-assessment of these presupposed attributes. [16] Based on this design, an online survey was conducted among experts of different Member States lately. The following sections summarise the findings of this survey.

Methods

The fundamental objective of the survey was two-fold: to discover the context of different national e-Cohesion concepts and to clarify the relevance of the presupposed e-Cohesion attributes.

Contextual questions try to map the scope of different e-Cohesion concepts *(number of portals, number of back-office IT systems, types of funds managed, total funding budget managed by portals, type and number of development programmes managed).*

The formulation of *clarifying questions* was driven by the supposition that attributes are cost drivers influencing the level of administrative costs in different ways. Following this logic, the nature of their influence can be described by different elements of the SCM formula. These questions link attributes with different SCM cost parameters *(Time and Frequency)* and measure the impact of the single attributes. The research focuses on only two cost parameters since they are the ones that can be influenced by the usage of digital services. The other two parameters *(Population and Price)* depend on external economic factors independently from the quality and efficiency of portal services.

The survey *contains two groups of clarifying questions, perception-based ones and evidence-based ones.* Perception-based questions focus on micro-level attributes and single portal functions while evidence-based questions focus on the procedural macro-attribute and the general performance of e-Cohesion portals. The impacts of the extent of funds attribute will be examined by secondary research in a different article.

The perception-based question group measures the experience and expectations of respondents regarding different portal features on a 1–7 scale. It is important to note that all scaled questions use homogenous scales in the survey in order to make responses easily comparable. The structure and layout of perception-based questions is illustrated by Figure 3.

2 Assess your experience regarding the importance of use of the following functions.			
2.1	Data retrieval from other databases	not available ○ ○ ○ ○ ○ ○ ○ very frequently used	○ have no experience
2.2	Automatic embedded controls	not available ○ ○ ○ ○ ○ ○ ○ very frequently used	○ have no experience
2.3	Built-in guides	not available ○ ○ ○ ○ ○ ○ ○ very frequently used	○ have no experience
2.4	Automatic calculations	not available ○ ○ ○ ○ ○ ○ ○ very frequently used	○ have no experience
2.5	Warning messages	not available ○ ○ ○ ○ ○ ○ ○ very frequently used	○ have no experience
2.6	Interactive and pre-filled forms	not available ○ ○ ○ ○ ○ ○ ○ very frequently used	○ have no experience
2.7	Online status tracking	not available ○ ○ ○ ○ ○ ○ ○ very frequently used	○ have no experience
2.8	Availability of different funds / calls via one portal	not available ○ ○ ○ ○ ○ ○ ○ very frequently used	○ have no experience
2.9	Direct access to main portal functions from main page	not available ○ ○ ○ ○ ○ ○ ○ very frequently used	○ have no experience
2.10	Online chat with customer service	not available ○ ○ ○ ○ ○ ○ ○ very frequently used	○ have no experience
2.11	Data retrieval from previously submitted applications	not available ○ ○ ○ ○ ○ ○ ○ very frequently used	○ have no experience

Figure 3. *Perception-based questions.*
[Edited by the author.]

This question group examines eleven portal features classified according to micro-attributes. The features of portal functionality have been chosen following the requirements of Article 9 of the 1011/2014/EU regulation. [9] Previous studies analysed the hypothetical linkages between micro-attributes and cost parameters. The above features were selected according to these hypothesised linkages which are summarised by Table 1.

Table 1. *Hypothetical relations of micro-attributes and cost parameters.*
[Edited by the author.]

e-Cohesion attribute	Portal feature	Relationship
Portal functionality	Automatic embedded controls. Built-in guides. Automatic calculations. Warning messages. Interactive and pre-filled forms. Online status tracking. Direct access to main portal functions from main page. Online chat with customer service.	Usability of portal functions facilitates data processing (Time) and automatisation and embedded controls reduce repetitive information obligations and the chance of corrections (Frequency).
Only once encoding	Data retrieval from previously submitted applications.	The re-use of already submitted data and documents decreases parallel data submission and accelerates the completion of administrative activities (Time). The utilization of validated data reduces the chance of corrections (Frequency).

e-Cohesion attribute	Portal feature	Relationship
Interoperability	Data retrieval from other databases.	The retrieval of valid data from other databases substitutes data submission (Time) and prevents corrective exchanges (Frequency).
One stop shop	Availability of different funds/calls via one portal.	The usage of different accounts and portals for the management of different programmes makes the completion of administrative activities more complicated (Time). The usage of different portals cannot ensure the same level of error reduction (Frequency).

Perception-based questions of the survey have three main sections which assess the same eleven portal functions from different points of view *(Usage, Time, Frequency).* The "Usage" section surveys the availability and popularity of different portal features in order to have a general view on their applicability. The "Time" section intends to explore the respondents' opinion on the impact of the single features on the duration of administrative activities. Finally, the "Frequency" section examines the impact of the features on the quality of data entry.

It is important to note that respondents were not familiar with the main focal points *(attributes, cost parameters)* of the research. These broader concepts might influence their judgements so they were asked to share their perceptions on more tangible concepts *(portal features).*

Evidence-based questions are aimed at the procedural attribute. In this section respondents gave answers according to a nominal scale. These questions intend to evaluate the procedural background of e-Cohesion concepts from the perspective of "Time" *(number of data items and documents required)* and "Frequency" *(frequency of submissions during a project life cycle).*

Two further evidence-based questions assess the general performance of portals *(lead times and correction rates[8] of different administrative activities)* which may be influenced by both functional features and procedural factors. These estimates can support a further in depth research on the possible relations between the above two attributes.

During the selection of the target group, two main requirements were set. First, to reach respondents directly involved in e-Cohesion in order to receive real and valid answers. Second, to select respondents representing a wide variety of development programmes and e-Cohesion portals.

At first, the questionnaire was sent to certain experts known to have participated in the preparatory e-Cohesion discussions of the European Commission. Besides, the survey was also sent to representatives of the Managing Authorities and Joint Secretariats of various mainstream, interregional and transnational funding programmes. Thirdly, the respondents contacted were asked to forward the survey to other users, applicants or beneficiaries they can reach. According to preliminary expectations, the research was targeted to gather

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[8] Frequency of repeated administrative activities because of the incompleteness or incorrectness of already submitted information.

at least 50–100 responses from different countries of the European Union so as to reach a statistically significant population.

It has been rather challenging to reach such a wide audience. The survey has been sent to almost four-hundred respondents all-over the Union and the online research took almost one month. At its closure, the survey received altogether 73 responses and its results are evaluated under the *Results and Discussion* section of the paper.

Results and Discussion

Concerning the population of the respondents, 68.5% of them represent a funding institution *(Managing Authority, Intermediary Body, Joint Secretariat)* and 31.5% of them were applicants and beneficiaries. The answers were received from 21 Member States which almost covers the geographical area of the European Union. The division of countries (according to main geographical regions) is shown in Table 2.

Table 2. *Countries of origin of the respondents.*
[Edited by the author.]

Geographical location	Responding countries	Responses (number)	Responses (%)
Central-Eastern Europe	Austria, Croatia, Czech Republic, Hungary, Poland, Slovakia, Slovenia	32	43.8
Norther Europe and Baltic states	Denmark, Estonia, Finland, Latvia, Lithuania, Sweden	19	26.0
Southern Europe	Greece, Italy, Portugal, Spain	7	9.6
Western Europe	Belgium, Germany, Netherlands, United Kingdom	15	20.5

The study population covers a wide range of programme types. About two-third (64%) of the institutional respondents represent mainstream (entirely Member State-specific) programmes and 36% of them is dealing with interregional or transnational (more countries involved) programmes. The representation of European development funds covered by the survey is shown in Figure 4.

What kind of funds do you mange in you eCohesion portal? (multiple choice possible)

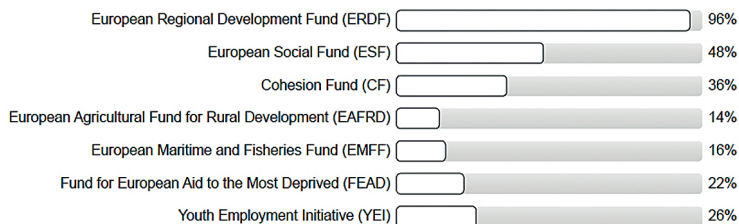|	
European Regional Development Fund (ERDF)	96%
European Social Fund (ESF)	48%
Cohesion Fund (CF)	36%
European Agricultural Fund for Rural Development (EAFRD)	14%
European Maritime and Fisheries Fund (EMFF)	16%
Fund for European Aid to the Most Deprived (FEAD)	22%
Youth Employment Initiative (YEI)	26%

Figure 4. *Representation of development funds.*
[Edited by the author.]

It is reasonable to suppose that the e-Cohesion concept has an impact on the number of systems and portals. The concept in itself does not restrict the development of programme-specific systems or portals. Meanwhile, the range of system requirements anchored in the current legislation increase development and operational costs, so the concept tends to shift Member States toward the concentration of IT resources.

As regards the information systems covered by the research, more than half (56.3%) of the respondents said that a single e-Cohesion portal is used for the management of programmes. Another 39.6% indicated the use of maximum five funding portals and only 4.2% reported the usage of 6–20 portals. These figures seem to confirm the above supposition but it is advisable to carry out a further in-depth analysis on the main drivers that influence the concentration of the number of portals.

The provision of electronic services is mandatory for all countries but their use can be optional or compulsory depending on the national legislation. Compulsory e-Cohesion can rationalise procedures and bring about a significant burden reduction. On the other hand, the optionality of paper-based and digital procedures may better address the preferences and needs of some target groups. At this point, Member States need to consider a wide range of factors such as penetration of digital technologies and e-Government solutions, the nature of procedures of the previous periods, digital literacy of applicant and equality of opportunities. 72% of those surveyed reported that e-Cohesion is compulsory in his/her country of origin. The division of optionality between mainstream and international programmes is 50–50%.

Member States need to make another crucial procedural decision to define their national e-Cohesion concepts. By the European legislation, digital services shall be provided for beneficiaries (applicants selected for funding and having a grant agreement) but may be extended to the application phase, as well. The complete digitisation of funding procedures can elevate the level of burden reduction and rationalise the management of projects. Meanwhile, the digital management of all applications may increase IT operational costs and capacity needs significantly. The survey shows that 90% of the responses reflect completely digital fund management.

The complete digitisation does not guarantee absolute burden reduction; it shall be introduced in an optimal way and tailored to programme-specific and country-specific factors. Nonetheless the above results reflect that countries and institutions approach e-Cohesion as a remarkable opportunity to completely digitise funding procedures and the reduction of burdens.

It is conceivably hypothesised that the procedural context has a dominant impact on administrative burdens by two main drivers: *the number of data requirements*[9] *(structured data and documents) and the number of legally prescribed information obligations.* The number of data and documents requested can determine the duration (Time) of administrative activities fundamentally. The scope of information obligations can also leverage the frequency of activities. These information obligations cover mandatory (periodically repeated) information exchanges and optional (corrections) exchanges *to*

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[9]   Each information obligation consists of one or more data requirements. A data requirement is each element of information that must be provided in complying with an IO. In the context of e-Cohesion, data requirements can refer to the electronic exchange of documents and data, including audio-visual media supports, scanned documents and electronic files. [9] [4]

complement or correct previous information exchanges. Table 3–5 summarise the results of the survey regarding the above procedural factors.

Table 3. *Division of responses—data requirements (structured data) of different procedures.* [Edited by the author.]

Number of data items	Application	Payments	Progress report
0–10	19.6%	19.6%	28.9%
11–25	10.9%	39.1%	35.6%
26–50	23.9%	17.4%	28.9%
51–75	6.5%	8.7%	2.2%
76–100	13%	8.7%	2.2%
101–150	17.4%	4.3%	2.2%
more than 150	8.7%	2.2%	0%

Table 4. *Division of responses—data requirements (documents and files) of different procedures.* [Edited by the author.]

Number of data documents	Application	Payments	Progress report
0	2.1%	6.4%	16.7%
1	6.3%	6.4%	2.1%
2–3	12.5%	10.6%	31.3%
4–5	14.6%	17%	20.8%
6–10	29.2%	17%	10.4%
11–20	27.1%	14.9%	4.2%
more than 20	8.3%	27.7%	14.6%

Table 5. *Frequency of information obligations of different procedures.* [Edited by the author.]

Frequency of IOs	Short-term projects (0-1 years)	Medium-term projects (1-3 years)	Long-term projects (more than 3 years)
0-5 times	73.9%	24.4%	10.6%
6-10 times	17.4%	40%	25.5%
11-15 times	8.7%	24.4%	27.7%
16-20 times	0%	6.7%	10.6%
21-25 times	0%	2.2%	8.5%
26-30 times	0%	0%	4.3%
more than 30 times	0%	2.2%	12.8%

The results testify that the range of procedural requirements is rather differentiated. It is hypothesised that the number of data requirements and information obligations can directly influence administrative burdens. However, electronic portals can leverage and equilibrate these burdens by the reduction of corrective information exchanges by controlled data processing. Furthermore, portals can shorten the lead times of administrative activities by user-friendly interfaces, automatisation and the re-use of already available data. On

the other hand, portals have no direct influence on the number of mandatory information obligations as they need to be completed according to legal requirements.

In order to verify the above assumptions, it is advisable to compare the level of data requirements with the *efficiency indices (lead times and correction rates)* of administrative activities of the analysed portals. The results are shown in Table 6–7 indicating different levels of lead times and correction rates, as well as the most frequent data requirements together with the proportion of their occurrence.

The comparison made refers to information exchanges related to application forms. This choice is based on the fact that the submission of application is the first information obligation in the project life cycle, so the vast majority of data and documents may be requested at this point.

Table 6. *Comparison of lead times of application submission and data requirements.*
[Edited by the author.]

Lead time	Number of data-items	Number of documents
0–30 minutes	26–50 (25%); 76–100 (25%); 101–150 (25%)	2–3 (25%); 4–5 (37,5%);
0–60 minutes	0–10 (36%); 26-50 (18,8%); 76–100 (18,8%)	6–10 (45%)
60–120 minutes	101–150 (40%)	11–20 (50%)
2–3 hours	0–10 (42%); 26–50 (28,5%)	6–10 (42,8%)
3–5 hours	26–50 (50%)	6–10 (50%)
5–7 hours	no responses	no responses
more than 7 hours	more than 150 (28,5%)	11–20 (62,5%)

Table 7. *Comparison of correction rates of portals and data requirements.*
[Edited by the author.]

Correction rate	Number of data-items	Number of documents
No correction	no responses	no responses
Level 2	26–50 (33.3%)	4–5 (25%); 6–10 (25%); 11–20 (25%)
Level 3	0–10 (33.3%); 26–50 (33.3%)	6–10 (50%)
Level 4	0–10 (21,4%); 26–50 (21,4%); 101–150 (21.4%)	6–10 (21.4%); 11–20 (21.4%); more than 20 (21.4%)
Level 5	26–50 (33.3%)	6–10 (33.3%); 11–20 (33.3%)
Level 6	76–100 (50%)	6-10 (60%)
Level 7	51–75 (100%)	more than 20 (100%)

Table 6–7 reveals no significant correlation between data requirements and lead times or correction rates, so the influence of the procedural context seems to be questionable. Based on these results the procedural attribute should not be incorporated in the maturity model but it is advisable to make a further in-depth analysis on their influence.

The above results may suggest that portal features influence the reduction of administrative burdens. Nevertheless, the relevance of the single portal features has not been confirmed. Table 8 shows the median values of the perception-based research on the relevance of portal features and e-Cohesion attributes. The results are shown in different columns according to the usage of features and their impact on the duration and frequency of administrative activities.

Table 8. *Results of the perception-based research on Time and Frequency.*
[Edited by the author.]

Portal feature	Importance (median)	Time (median)	Frequency (median)
Data retrieval from other databases	5	5	6
Automatic embedded controls	6	6	6
Built-in guides	5	4	5
Automatic calculations	7	6	7
Warning messages	6	6	6
Interactive and pre-filled forms	6	6	6
Online status tracking	6	5	4
Availability of different funds / calls via one portal	6	5	4
Direct access to main portal functions from main page	6	5	4
Online chat with customer service	1	4	4
Data retrieval from previously submitted applications	5	5	5

Respondents were asked to score the relevance of portal functions on a 1–7 scale in the perception-based research. In order to evaluate the relevance of portal features, this paper sets the following requirements. First, relevant features shall be dominantly relevant among the vast majority of the respondents. Second, at least half of the respondents need to score relevant features in the upper tercile (scores above 4.66 i.e. at least 5) of the scale. Third, features need to be relevant at least from the perspective of Time or Frequency.

The first evaluation was based on the median values of the responses since it provides a reasonable approach to assess the results according to the above three criteria. This evaluation shows that all micro-level attributes may have relevance and three attributes *(functionality, interoperability, only once encoding)* met in the above requirements regarding both "Time" and "Frequency". The ones stop shop attribute met the requirements only in the "Time" column. Only the online chat feature had very low scores but it can be regarded as a special case since the majority of the study population reported to have no such function. Irrespective of this feature, the functionality attribute had very strong scores. Following this approach, almost all micro-level attributes worth further consideration to support the development of an e-Cohesion maturity model.

Conclusion

The e-Cohesion concept makes the utilisation of e-government services mandatory for Member States in the European fund management. Earlier studies of the European Commission have revealed that the provision of online portal services for beneficiaries can bring about a significant reduction of administrative burdens and improve the efficiency of fund management.

In addition to European legal provisions, national regulations can further extend the level of efficiency gains. As a result, e-Cohesion can be realised on differentiated stages of maturity as also proven by the study of the Commission and Deloitte. [2] This progress can be best addressed with the methodology of maturity models.

The European Commission and Deloitte made a specific e-Cohesion maturity model but it dominantly focuses on the functionality attribute of e-Cohesion portals. Based on the analysis of e-Cohesion requirements and previous studies *four micro-level attributes (portal functionality, only once encoding, interoperability, one stop shop)* and *two macro-level attributes (procedural complexity, extent of funds)* were identified which may be relevant from the perspective of efficiency. Reviewing the pertinent maturity models, there is no specific model that can address the complexity of these attributes.

However, the relevance of the above attributes has not been confirmed by evidence-based research yet. This paper analyses the relevance of the identified micro-level attributes and the impact of procedural complexity. The analysis is based on an online survey conducted among e-Cohesion specialists and users of electronic portals in EU countries. The survey received 73 responses from 21 Member States and covers different types of development programmes.

The survey intended to assess the general context of information systems and digital portals in EU fund management. Besides, participants were asked to give perception-based answers regarding portal features from the perspective of the main cost drivers of administrative burdens. Finally, respondents provided evidence-based data on the procedural context of e-Cohesion concepts and the usage of electronic portals.

The evaluation of the research indicates that all micro-level attributes are relevant from the point of view of burden reduction. Meanwhile, procedural context seems to be not as determinative as the impact of portal features. Nevertheless, it is advisable to conduct a further in-depth analysis on its impact. As stated above, the influence of the extent of funds managed by portals will be analysed in a different paper.

These results open the ground for a further and more extended research on the impacts and relevance of e-Cohesion attributes. Finally, the findings of the proposed research can be used to construct a more comprehensive e-Cohesion-specific maturity model.

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Leadership Tasks Associated with the Use of Coercive Means by Professional Disaster Management Bodies

Gotthilf SCHWEICKHARDT[1]

Professional disaster management bodies were granted statutory authorisation on the 1ˢᵗ of January 2017 to take limited coercive measures. Professional disaster management bodies are entities performing primarily state administration tasks, and secondly law enforcement tasks. Fire brigades and from the mid-1990s, professional disaster management bodies have been and are involved in the road inspection of dangerous goods in addition to other entities authorised to inspect under the Act on traffic. The use of coercive means requires special training, to which the obligation of leaders (commanders) correlates: to investigate the use of coercive means.

Keywords: *disaster management, coercive device, control, dangerous goods*

The Professional Disaster Management Body as a Law Enforcement Body

Before discussing the topic in the title, it is necessary to clarify a few notions. The President of the "Szemere Bertalan" Hungarian Scientific Society of the History of Law Enforcement defined law enforcement as:

"The action of the State to prevent or stop acts dangerous to public order, which undoubtedly belongs to public law, within it, it forms a branch of policing, and as such, can be regarded as part of public administration and public administration law." [1]

Certain features of law enforcement

Its basic function: to manage internal hazards threatening safety and security. Leadership and execution are hierarchically regulated, the rule of the chain of command prevails.

The notion of policing is linked to law enforcement, it is compared to it; in this case, I skip this step and try to narrow my message exclusively to law enforcement. The system

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[1] Lieutenant Colonel, Ph.D., Master of Laws, Associate Professor, National University of Public Service, Institute of Disaster Management, Department of Disaster Management Operations; e-mail: schweickhardt.gotthilf@uni-nke.hu; ORCID: 0000-0001-5609-338X

of tasks of professional disaster management bodies incorporates the systems of tasks of the individual bodies that constitute them. Fire protection, civil protection and, last but not least, industrial safety activities differ from each other. If water management systems are also added to these activities, it is quite clear that the state administration tasks are predominant. The protection of the life and property of the citizens of Hungary, as well as the prevention of damage to the environment can be considered largely the main tasks of professional disaster management bodies. These tasks require Hungarian citizens and foreigners to enforce and comply with national, international or other regulations, determining their actions and relevant to them, that is, to be lawful. The law-abiding behaviour, the control of compliance with the prescribed authoritative decisions is an important task, and it is clearly highlighted at present by the inspection of the transportation of dangerous goods and industrial safety. After inspection, sanctioning is done in many cases. Following the failure to comply with the prescribed conduct, the person inspected tries to escape sanctioning or wants to avoid the inspection itself. Given that the transportation of dangerous goods is fundamentally governed by international conventions, therefore, during inspections, the international element is present. Persons performing fire protection tasks have never possessed any weapons, since their main task has been and still is to prevent the breakout of fire in general. However, the civil protection system of tasks, by its very nature, is related to military activities, and as such, it is natural that the right of carrying arms is present. In relation to the system of tasks of civil protection organisations, members of civil protection organisations may carry light individual weapons for self-defence or policing in case of war or military actions, governed by the Geneva Conventions. "If the civil protection (defence) personnel of the civilian population, for reasons of maintaining order or for self-defence, are equipped with light individual weapons, it is not considered an act of harm to the enemy. However, in areas where ground forces are or may be engaged, the conflicting Parties are bound to restrict these weapons to small arms, for example, pistols or revolvers, and with appropriate measures, to promote the distinction between civil protection (defence) personnel and combat personnel. Civil protection (defence) personnel, however, starting from being recognized in such capacity of theirs, are also to be provided with mercy and protection even if, in such an area, they are equipped with other light individual weapons." [2] Organisations constituting the individual elements of the professional disaster management organisation were earlier regarded as law enforcement bodies. With regard to the fire service, more specifically, the state fire service was defined as a policing body based on Law Decree 10 of 1973 on the protection against fire and on the fire service. [3] In 1991, Section 10 of Act XX of 1991 on the responsibilities and competences of local governments and their bodies, of commissioners of the Republic, and of certain centrally subordinated bodies, omitted the part established on uniform principles. Another change occurred when Act XLIX of 1995 deleted the definition "policing body" in its entirety. By doing so, it removed the policing tasks from the responsibilities of the fire brigades. Only firefighting and rescue tasks remained at the fire brigades. Act XXXI of 1996 on the protection against fire, rescue and the fire service, on 3 May 1996, addressed the professional fire service as a law enforcement body: "Paragraph (1) of Section 30 of the above Act says the professional state fire service and the professional municipal fire service (hereinafter referred to as the professional fire service) are law enforcement bodies established on uniform principles."

Point g) of Section 2 of Act XXXVII of 1996 on civil protection, on 15 May 1996, defined law enforcement bodies: "Law enforcement bodies are the Police, the non-military (civilian) national security services, the penitentiary organization, the customs and finance guard, the professional civil protection body, and the professional state and municipal fire service."

Professional disaster management bodies were established on 1 January 2000. Based on the Act establishing them, professional disaster management bodies: "The National Directorate General for Disaster Management, involved in the implementation of disaster management, integrated from the national bodies of civil protection and the state fire service, their regional bodies, integrated from county headquarters, are law enforcement bodies also performing state administration tasks." [4]

The professional disaster management body, in this context, only consisted of civil protection organisations and of the state fire service, the professional municipal fire brigades were not included in this organisation. With regard to professional disaster management bodies, only the civil protection organisation and the state fire service were named as law enforcement bodies. The professional municipal fire service continued to be regarded as a law enforcement body. Law did not permit the use of coercive means for these law enforcement bodies. Act LVII of 2006 on central state administration bodies, and on the legal status of the members of the Government and state secretaries only confirmed that the entire professional disaster management organisation does not qualify for a law enforcement body. An interesting definition is expressed by point h) of paragraph (2) of Section 2 of the before-mentioned Act that defined the national headquarters of law enforcement bodies as a central state administration body. The State Fire Service and the Parliament Fire Brigade had a national body (headquarters), the professional municipal bodies (fire brigades) did not. The notion of civil protection logically ruled out the existence of a national headquarters, since it was defined as part of the defence system. [5] Home defence responsibilities are not law enforcement tasks. Act XLIII of 2010 on central state administration bodies, and on the legal status of the members of the Government and state secretaries, in this respect, maintained this status. A progress was only made on 1 January 2012, when Act CXXVIII of 2011 on disaster management and the amendment of certain relevant acts (hereinafter referred to as Act CXXVIII of 2011) entered into force. Act CXXVIII of 2011 defined the notion of a professional disaster management body as follows: "A professional disaster management body is a law enforcement body also fulfilling state administration tasks, whose members are professional personnel, civil servants, public employees, employees and officer cadets." [6]

The provisions of Act XLIII of 2010 were adjusted to this status [paragraphs (2) and (5) of Section 2]. Accordingly, a law enforcement body is a central public administration body, and exclusively a professional disaster management body is a law enforcement body.

Use of Coercive Means at Professional Disaster Management Bodies

Paragraphs A–D of Section 24 of Act CXXVII of 2011 entered into force on 1 January 2017. These paragraphs regulate the normal and coercive measures that may be taken or used by the personnel of the professional disaster management body performing authoritative

inspection tasks in the field of the transportation of hazardous materials. As I have already explained before, the professional disaster management body is a law enforcement body also performing state administration. Based on this, a professional disaster management body's basic function is to enforce the stipulations described in the legislation and regulations, authorised by the State, and to inspect and supervise them. During inspection, a situation may develop that may evoke an attack against the person performing the inspection, by the inspected, or the desire to avoid the inspection. Legislation determining the tasks for law enforcement bodies provides them with the possibility to take coercive measures. "To remove hindrances when taking measures, and to ensure the efficiency of the measures taken, stipulated by law, coercive means may be used. A person under procedure may be ordered to do or not to do, or to tolerate something." [7: 8]

Before I engage more thoroughly with the analysis, it should be stated that the use of coercive means is only an option and not an obligation.

The basis for the inspection of the transportation of hazardous materials are the below-mentioned international agreements transpositioned into the Hungarian legal system:

1. European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR);
2. European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN);
3. Convention Concerning International Carriage by Rail (COTIF);
4. International Air Transport Association, Dangerous Goods Regulations (IATA DGR).

The review of the conventions specified in points 1 to 3 is mandatory every 2 years, and therefore, they are amended on these occasions.

The transposition of international conventions into the Hungarian legal system is currently governed by the following legislation:

- Act CIII of 2017 amending certain acts related to the transportation of dangerous goods;
- Government Decree 178/2017 (VII. 5.) on the promulgation of Annexes A and B to the European Agreement concerning the International Carriage of Dangerous Goods by Road, and on certain aspects of its application in Hungary;
- Government Decree 177/2017 (VII. 5.) on the promulgation of the (AND) Regulation annexed to the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways, and on certain aspects of its application in Hungary;
- Government Decree 179/2017 (VII. 5.) on the promulgation of the Appendix of its Annex C of the Minutes adopted in Vilnius on 03 June 1999 on the amendment of the Convention concerning International Carriage by Rail (COTIF), and on certain aspects of its application in Hungary;
- Government Decree 313/2014 (XII. 12.) on the disaster management authoritative inspection concerning the air carriage of dangerous goods and on the regulation of imposing fine;
- Government Decree 312/2011 (XII. 23.) on the regulation of the uniform procedure on the inspection of the carriage of dangerous goods by rail and inland waterways during the measures by the professional disaster management body and on imposing

fine, furthermore, on the amounts of fines imposable for certain irregularities, and on the general regulation of the authoritative tasks concerning fining;

- Government Decree 1/2002 (I. 11.) on the uniform procedure concerning the inspection of the transportation of dangerous goods by road.

The use of coercive means is one of the limitations of fundamental human rights. Hence, its use, under strict legal conditions, is subject to the simultaneous presence of the criteria under which human freedom may be restricted. Freedom, free movement, among other things, are fundamental human rights. The restriction of such fundamental rights is only permitted by statutory provision for bodies and organisations authorised to do so, and only until reaching the desired goal. A professional disaster management body, to verify the existence of law-abiding behaviour, or to enforce it, authorised by law, carries out inspections in several areas of expertise, including the transportation of dangerous goods. An important element of the inspection is that it should be carried out as defined in the legislation. If a violation occurs, it should be sanctioned. In order to be able to carry out the inspection, sometimes, it may become necessary to restrict the inspected person or the shipment. This, inter alia, may mean the temporary restriction of the free movement of a person or the temporary storage of the shipment at a specified location. Occasionally, the person inspected may want to withdraw themselves from the inspection and attempt violence against an official person inspecting. In these cases, the use of force may be necessary, which is permitted for the persons of the professional disaster management bodies authorised to do so by law to take certain coercive measures. For the personnel of professional disaster management bodies inspecting the transportation of dangerous goods, Act CXXVIII of 2011 on disaster management and the amendment of certain relevant acts ensures the use of coercive measures in case of offenses and crimes related to the tasks of professional disaster management bodies. At present, our code of offenses and other legislations do not include penal law stipulations related to the transportation of dangerous goods (e.g. ADR) and that belong solely to the responsibility of professional disaster management bodies.

With regard to using coercive means, from the aspect of professional disaster management bodies, the following principles should be considered:

- *lawfulness:* a member of a professional disaster management body performs their duties in their competence, keeping legal regulations;
- *professionalism:* the use of coercive means with adequate knowledge of theoretical and practical skills, according to legal regulations and manuals, using the most suitable means and tactics, without causing injury;
- *proportionality:* causing the least detriment when taking measures;
- *necessity:* the use of coercive means in cases, when an inspection (measure) started cannot be conducted or concluded. After achieving the required goal or breaking the resistance or preventing escape, the use of coercive means should be immediately ceased.

"It is a general requirement that coercive means may only be used by persons with adequate theoretical and practical training, who have authorization for inspecting dangerous goods transported on road." [8]

With all this in mind, it would seem appropriate to screen persons performing such a task on special psychology tests and have them go through training of knowledge of human nature. With these latter screenings and training courses, it would be possible to avoid the use of coercive means and establish a measure-taking culture.

Along with all this, of course, maintaining the level of professional knowledge must also be ensured. For the personnel participating in ADR inspections, regular attendance at first aid courses is required.

The inspector authorised to take coercive measures must meet three simultaneous criteria:

- having participated in course(s) providing entitlement to inspect the transportation of dangerous goods, participation in periodic refresher courses;
- successful completion of a course entitling to use coercive means;
- participating in half-yearly refresher courses.

Coercive means and measures

Coercive means or measures that may be used or taken by professional disaster management bodies may only be means or measures used or taken by the Police. During inspection activities concerning the transportation of dangerous goods, the wearing of coercive means by the inspector is ordered by the director of the regional body. Coercive means are received by the inspector before starting the inspection from the person appointed, and are returned after the end of the inspection. In cases when the wearing of coercive means during an inspection is not expedient for any reason, they must be locked in the service vehicle in a place that is not visible from the outside. The law only provides limited possibilities for professional disaster management bodies. *For example, there is no possibility to screen either clothing or packages.* If a person under inspection is not willing to present their ID card may be detained until the arrival of the Police. Act CXXVIII of 2011, besides physical coercion, also provides the possibility to use chemical means and/or handcuffs. The provision of the affected personnel with coercive means may exclusively take place using the coercive means in service at the Police and acquisitioned by professional disaster management bodies. For self-defence the personnel are entitled to carry chemical means and a police baton. This possibility raises several questions: may a person inspecting use a police baton during their official activities, was the use of chemical means for self-defence or to facilitate the measures taken, etc., but I am not discussing them in my present study. *After the use of coercive means, there is an obligation to grant first aid and/or medical assistance.*

Leadership Tasks

Before discussing specific leadership tasks, it is necessary briefly to explain some of the requirements leadership that are related to our topic.

Planning means that a commander, a leader comprehends the expedient use of resources to accomplish their task, linking them to the task. The feature of purposefulness is to make and keep high quality plans. To this end, it is necessary to adequately analyse and assess

road inspections and plan the personnel participating in them. In addition, flexibility should also be present at planning of inspections.

Continuity means that leadership must be, in all circumstances, uninterrupted. This is a very important aspect of inspections, as road transport, apart from statutory exceptions, is ongoing every day of the year and every part of the day. Therefore, the presence of the personnel possessing proper expertise and experience should be ensured, as well as the presence of the leader controlling them efficiently.

Consistency provides for the predictability. This primarily means leadership activity. Among other things, it includes requirements authorised the personnel assigned for inspections, determined by laws and regulations, as well as objective assessment of their activities.

With regard to coercive measures, many first think of the commander's investigation. However, it is only an option for a leader. Leadership tasks are differentiated by command levels. They are as follows:

- Director General of the National Directorate General for Disaster Management (NDGDM);
- Head of the regional body;
- Head of the local body (branch office);
- Heads of certain organisations.

Director General of the NDGDM

As the chief executive of the professional disaster management body, he defines the requirements of the acquisition of coercive means. His most important task is to issue an internal regulator, in which, under the law, he imposes the personal and material conditions concerning coercive means, the internal rules of investigation after the use of the coercive means and the creation of legal unity. The organisation of training courses and regular refresher courses for the affected personnel is part of their responsibilities. Of course, in close relation, they regularly order to assess and analyse the legitimacy and the professionalism of taking coercive measures. If necessary, they would take measures to restore lawfulness.

The control of the inspection activity of the transportation of dangerous goods, within the organisation, is in the responsibility of the deputy director general for authoritative affairs. Taking this into account, the national level tasks of the assessment process following the use of coercive measures are performed by them. The Director General reviews appeals against the use of coercive measures.

Head of the Regional Body (County Director)

The county director performs several tasks related to coercive measures. First, wearing coercive means falls within his competence. This task is related to the planned and extraordinary inspection tasks of county directorates and branch offices. This activity is considered an administrative, automatic activity. Behind ordering the wearing of

coercive means, in case of professional disaster management bodies, several inspection and verification tasks appear, contrary to the Police. Ordering the wearing of coercive means for inspection is possible in several ways. In case of the county personnel, since the person ordering the wearing of coercive means for the inspectors is located in the same building, therefore, in this case, the person ordering it may verify the inspector's suitability almost every time. The range of suitability extends to the status of being non-influenced by drugs or alcohol. The eligibility to issue coercive means to an inspector is verifiable from documents and records. In case of a branch office, the director can only check this task periodically on the site and at the time of issuing. The instruction to wear coercive means is issued in advance, according to the inspection plan, and in case of a person replacing an inspector who is not inspecting for any reason, an individual decision shall be made. The director also has the task of designating a person performing the issue and reception of coercive means, and, of course, the appointment of their deputy, furthermore, taking into account the particularities of the area of the directorate and the regulation of other possible tasks related to coercive measures. The director shall regulate the rules of reporting following the use of coercive means and the activities of the central duty office in relation. The installation of duty offices of regional police and disaster management bodies in one building accelerates and facilitates the eventual measures to be taken by the Police. Cases when an inspector performs inspections outside their jurisdiction, in the area of other directorates, may not be omitted from the reporting system. Based on relevant legislation and public administration regulative means, the director shall ensure the control of status of coercive means and only means meeting the requirements shall be issued. The director's additional responsibilities are to organise refresher courses for the inspectors every six months, involving the regional Police Headquarters or the National Tax and Customs Office. The director is also responsible for the appointment of mentors and to ensure refresher courses for them as well. If the inspector is on the county staff, they may inspect the carriage of dangerous goods by air, as well; in such cases, they, as the head of the body taking measures, investigate the rules of using coercive means. (The investigation is detailed in the section discussing the head of the branch office.)

Head of the Local Body (Head of the Branch Office)

The inspection of the transportation of dangerous goods, with the exception by air, is in the competence of disaster management branch offices. Therefore, in general, the head of a branch office is responsible for taking measures in relation to the inspectors belonging to the personnel of the branch office. The head of the branch office, with the help of the industrial safety inspector and the head of the authoritative section, ensures the daily training of the inspectors on their staff, including raising the awareness of new legislation. The verification of the preparedness of the inspectors can be successfully performed by the head of the branch office with the help of the above-mentioned two officers. Before the inspection, in the framework of a briefing, the inspectors' knowledge shall be verified. At this briefing, besides professional issues, other topics concerning the inspection, including the eligibility of taking coercive measures should also be addressed. Inspection

may never be a routine task. If it happens in a different area of competence, the competent regional leader or commander conducts the briefing.

Investigation Following the Use of Coercive Means

After the use of coercive means, an investigation shall be conducted by the head of the body taking the measures. The investigation starts with the verbal report of the person using the coercive means. Afterwards, the inspector shall submit a written report within two days following the use of coercive means.

Report Obligations of the Person Taking Measures

A verbal report should only contain the most important information related to taking coercive measures. If the inspector was attacked, investigation of violence against an official shall be ordered. The oral report shall be made to the head of the body taking measures.

Main content elements of the verbal report:
- when, where, for what reason, against whom was it used and what coercive measures were taken;
- did personal injury happen, if yes, what treatment was the injured granted;
- other aspects regarded as important by the person reporting.

After an oral report, one shall prepare a written report at their service location. In this report, facts and information related to the use of coercive means must be described in detail. The written report shall be made by all who were present at the inspection for the sake of a posterior thorough commander's investigation. At a joint and combined inspection, the personnel are seconded from several organisations. In such cases, reports made at different service locations shall be sent by email to the person investigating, then in original, signed by the person reporting. This report on the use of coercive means shall detail the answers to the below main questions: *where, when, against whom, for how long time, what kind of coercive measures were taken and for what reason.*

Content elements of the written report:
- name(s) of the person(s) against whom measures were taken or coercive means used;
- concerning the use of coercive means or measures taken:
  - location
  - time
  - duration
  - the method of defiance against their use
  - type
  - short description of use
- the occurrence and description of the injury during the use of coercive means, in case of eventual medical treatment, the name of the ambulance officer or physician. If the injured was transported, the name of the health care institution;
- if notice was given to stop the unlawful behaviour, if not, what was its reason;

- if preliminary notice was provided on the use of coercive means, if not, what was its reason;
- if property was damaged, its amount;
- what happened to the injured, any measure taken to treat them, if not, what was its reason;
- description of the means used for attack, if coercive means were used because of an attack;
- natural identification data and address of witnesses;
- a reference to all legislation sources allowing the use of coercive means.

Commander's Investigation

In the summary report, ascertainment on legitimacy and professionalism shall be made, referring to the relevant legislation sources. The legitimacy of the use of coercive means shall be adjudged based on Act CXXVIII of 2011 and according to Act CXX of 2012 on the activities of persons performing certain policing tasks, and on the amendment of certain acts ensuring actions against truancy. Under paragraph (1) of Section 24/A of Act CXXVIII of 2011: "A professional personnel of a professional disaster management body performing the authoritative inspection of the transportation of dangerous goods (hereinafter referred to as a member of the personnel) is authorized

  a) to give verbal notice to the person caught in the act of offense or crime to cease the act, and to prevent them from continuing the act,
  b) to detain a person caught in the act of crime until the arrival of the Police, but maximum up to two hours of duration."

Based on legal connotations, a general authorisation seems to appear in relation to professional disaster management bodies. Therefore, it is also necessary to investigate the extent an inspector knows and is able to apply different penal laws. The limitation of the scope of responsibilities of professional disaster management bodies was omitted from the regulation.

An investigation should always be performed uniquely, adjusted to a particular situation. After using handcuffs, real-life as well as special and unique circumstances should also be assessed. Based on the written reports of the persons taking measures and those present, the person investigating, submits to their commander, within three days, through their professional superior their summary report containing their classification recommendation.

During the investigation, the commander, inter alia:
- investigates the report of the inspector and the data available; if needed, the commander interviews the inspectors who were present during the action and witnessed the use of coercive means;
- investigates all duty documents and registries computerised databases and applications that (may) contain information on the incident, and the relevant data shall be included in the report;
- publicly accessible imagery or voice recording(s) eventually made on the measures taken by the inspector; if possible, they should be collected, and the facts assessed based on the latter, recorded in the minutes.

During the commander's investigation, inter alia, it is necessary to investigate the conditions for the use of coercive means. It not only means that the conditions for the use of coercive means shall be investigated, but also the existence of the conditions and the duration of detention. If the duration of detention was over two hours, the inspector has committed a criminal offense, and a criminal report shall be submitted. An inspector may commit certain other official criminal offenses during the use of coercive means, e.g. unlawful detention.

The same way, during an injury caused by the use of coercive means, if it had caused serious bodily injury, criminal procedure shall be launched.

The main content elements of the summary report:
- time and venue of the incident;
- name, rank and site of assignment of the person taking the measures;
- description of the incident:
  - if the conduct of the person against whom measures were taken justified the use of coercive means
  - if the use of coercive means was preceded by a verbal notice on the cessation of an unlawful act and a warning envisaging the use of a coercive means
  - if the legal requirements of the use of coercive means prevailed: i.e. if it was necessary, if it was lawfully used, if its use was proportionate, if proper means in service were used for a justifiable duration
  - if the use of coercive means had caused injury, who suffered what kind of injury
  - if measured were taken for first aid or medical care by a physician, in case of hospitalisation, data concerning transportation and the hospital
  - if the superior interviewed the affected persons or witnesses
  - if the eventual contradictions were clarified
  - if the superior has made a detailed report on the investigation
  - if the initiation of additional procedures has become necessary, the necessary measures were taken or not.

Within 5 days following the commander's investigation, the report shall be submitted to the Deputy Director General for Authoritative Affairs.

The result of the commander's investigation may be that the use of coercive means was:
- Case 1: lawful and proper (professional);
- Case 2: lawful but improper (unprofessional);
- Case 3: unlawful and improper (unprofessional).

In Case 1, the use of coercive means fully met the legal requirements, and was performed according to technical regulations.

In Case 2, the measures were taken unprofessionally; at least, a disciplinary procedure shall be conducted. If the use of coercive means has caused a permanent injury or an injury lasting over 8 (eight) days, a criminal procedure shall be carried out already based on the suspicion of crime.

In Case 3, a criminal procedure shall be carried out already based on the suspicion of crime.

Complaint Investigation Following the Use of Coercive Means

The investigation of complaints following the use of coercive means may be requested by the person whose basic rights were infringed or whose legitimate interests were affected. Complaint may be submitted to the head of the professional disaster management body taking coercive measures. The complaint shall be investigated asper the rules of public administration authoritative procedures, and a decision shall be made within 21 days following the receipt of the submission. Request shall be submitted within 8 (eight) days; in case the person affected becomes aware of the detriment of their rights post factum, within 3 months following the use of coercive means may a request be submitted.

Summary

The public road inspection of dangerous goods, in addition to special knowledge, sets further requirements for the inspecting personnel. In this respect, a new criterion has appeared concerning the use of coercive means also for persons commanding and controlling such personnel. By this, the law enforcement tasks of professional disaster management organisations have increased. Leaders and commanders should establish legal knowledge and leadership skills concerning the use of coercive means.

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[4] *Act LXXIV of 1999 on the Direction of Protection against Disasters, on Its Organization and on the Protection against Major Accidents Involving Hazardous Materials.*

[5] *Act XXXVII of 1996 on the Civil Protection.*

[6] *Act CXXVIII of 2011 on Disaster Management and the Amendment of Certain Relevant Acts.*

[7] NECEFOR B.: *Kényszerítő eszközök alkalmazása a rendvédelemben. [Application of non-lethal weapons in law enforcement.]* Degree thesis. Miskolc: Miskolci Egyetem, 2015.

[8] *Decree of the Minister of the Interior 49/2011 (XII. 20.) on the Service Regulations of the Personnel of Professional Disaster Management Bodies and of Civil Protection Organizations.*

How the Planned V0 Railway Line Would Increase the Resilience of the Railway Network of Hungary Against Attacks

Bence G. TÓTH,[1] István HORVÁTH[2]

The spatial distribution of the railway crossings on the river Danube in Hungary is very uneven. There is only one electrified and double-tracked bridge in the country, the Southern Railway Bridge in Budapest. The Újpest bridge in Budapest only provides a connection through line 4 which is not electrified and the Baja bridge is not electrified, too, and both of them are single-tracked. The long-planned V0 railway line that is to be cross the Danube approximately halfway between Budapest and Baja would not only help to redistribute the total network flow which currently passes through almost exclusively the Southern bridge but would also provide redundancy for the existing bridges in the case of their disruption. Four of the five proposed V0 path alternatives are analysed based on these two network properties.

Keywords: *railway, network, disruption, redundancy*

Introduction

The vulnerability of transportation networks due to highly threatened network elements is a central topic of critical infrastructure analysis. [1] [2] [3] The transportation network of Hungary is heavily centred on Budapest, the country's capital. The main airport of the country with 90% of the traffic is located here, the highways meet in the suburbs and lead to the downtown and the railway lines end at the three main terminals in the city of Budapest. This means that the usage of these networks is not only highly dependent on the urban transport of Budapest but also vulnerable because on the disruption of the common network elements, several transportation lines or even modes are simultaneously disabled.

As the risk of terrorist attacks on the urban railway networks increases, [4] the protection and also the substitution of the highly threatened network elements have to be planned. The dependence of railway lines on each other is the most pronounced at the Southern Railway Bridge in Budapest, which is used by all international freight traffic through

1 Ph.D., Assistant Professor, National University of Public Service; e-mail: toth.bence@uni-nke.hu; ORCID: 0000-0003-3958-187X

2 Ph.D., DSc., Full Professor, National University of Public Service; e-mail: horvath.istvan@uni-nke.hu; ORCID: 0000-0002-1343-1761

Hungary to cross the Danube. This meant 36,445,000 tons of goods equal to 8,589 million ton-kilometres for 2018. [5]

The Southern bridge is the only double-tracked railway crossing on the Danube in Hungary, which is electrified. Since 2018, the Budapest–Esztergom railway line, including the single-tracked Újpest Railway Bridge, is also electrified, but the Esztergom–Almásfüzítő line, which would make it as an alternative of the Southern bridge, is still not.

Furthermore, the transportation tasks of the Hungarian Army also depend highly on the proper condition of the railway network of Hungary, including the sufficient connections between the locations of the troops and also the border of the country. [6] Having only one double-tracked crossing over the Danube, which is the only one which can be used by exclusively electric engines, makes the whole network vulnerable in defence aspects. [7]

The Defence Requirements of the Railway Network of Hungary

The condition of the Southern Railway Bridge gets poorer every year, therefore, the Government of Hungary decided in 2018 [8] [9] to build a third track which can be used as a replacement while the existing tracks are reconstructed. This third track would also allow increased traffic which would make the whole network depend more on this single network element. [10] [11]

To meet the defence requirements of the nation, the construction of another railway bridge (of another railway line) is necessary. This line could be the long-planned double-tracked electrified V0 railway line. The V0 name is the parallel of the M0 motorway ring around Budapest which connects all the other numbered motorways approaching the city as the V0 line is planned to be a circular line around Budapest exclusively for freight transport that connects the railway lines outside the city. This provides the opportunity for trains with a destination other than Budapest to bypass the few and busy lines (and most of all the critical Southern bridge) inside the capital. [12]

This proposed line was designed by the consortium led by the Association of Hungarian Logistics Service Centres (Magyar Logisztikai Szolgáltató Központok Szövetsége, MLSZKSZ) in 2012 for six alternative routes. However, it was not included in the Integrated Transportation Operative Programme (Integrált Közlekedésfejlesztési Operatív Program, IKOP) [13] and is still not a Government priority for transportation development plans. [14] This is mainly because the Budapest Intermodal Logistics Centre (Budapesti Intermodális Logisztikai Központ, BILK), the main container transfer station was built inside Budapest and therefore entering the city is necessary for all freight trains to exchange their load. Furthermore, a network of intermodal container terminals was also decided to be built. [15]

However, the V0 plan is reintroduced from time to time by railway development specialists to the Government, last time in 2017 by the Hungrail, Hungarian Railway Association [16] as this would promote the establishment of new logistics centres via the advantages of the simultaneous presence of motorways and railways. Furthermore, the important role the V0 railway line could play in the defence capabilities of the country is also an important aspect when considering the necessity of its construction.

Therefore, the aim of the present study is to analyse the proposed paths of the V0 railway line in two manners: which alternative would redistribute the paths of the trains

more evenly in the network and which alternative would provide the most redundancy for the existing Danube bridges, i.e. which one is the most sufficient for the defence preparation of the country.

The V0 Alternatives

Six alternative routes for the planned V0 was proposed by the MLSZKSZ (see Figure 1). [17] Route #6 was, however, only the maintenance of the existing lines while Route #5 is not only very similar to route #4 but also too close to Budapest though one of the goals of the project is to relieve the suburbs of Budapest from the heavy rail freight traffic. Therefore, only the analysis of routes #1–#4 was carried out.
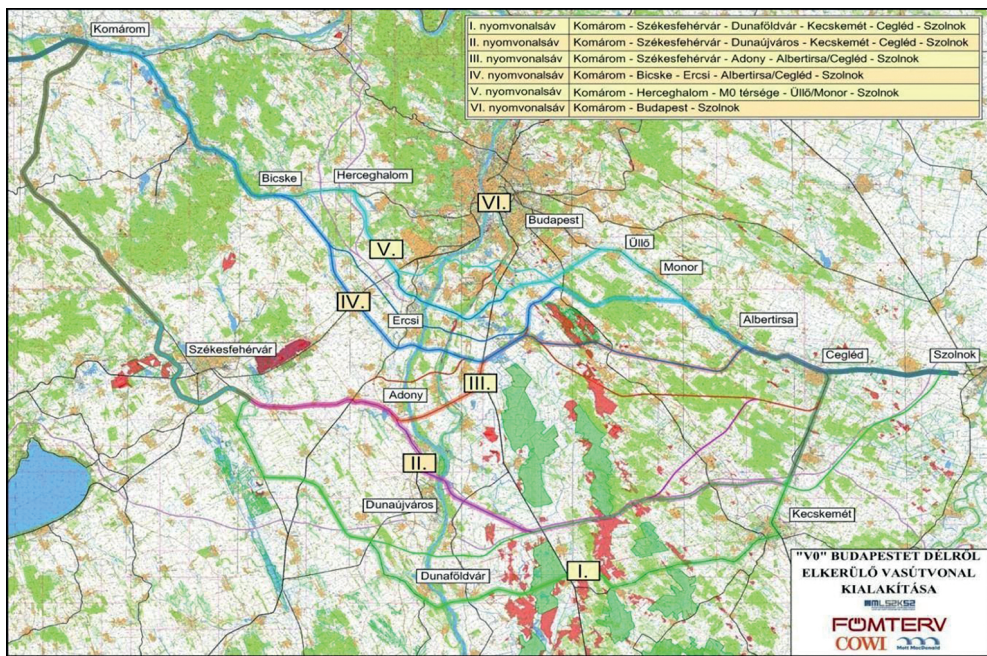

Figure 1. *The six alternative routes for the V0 railway line proposed by the MLSZKSZ.* [17]

The Graph Model of the Railway Network of Hungary

The railway network of Hungary is a 7,441 km long standard gauge system. This means 8.00 km/100 km^2 density, [18] which is one of the densest in the world. [19] A weighted graph is used to model the network. [20] The nodes of the graph are the stations and the termini, i.e. where reversing of the trains is possible. Thus, stops with no switches were not included in the model. The edges of the graph are the line sections between the stations.

Two weights can be assigned to each edge, either the length of the travel time of the corresponding line section. The travel time of a line section is calculated as the ratio of

the length and line speed. When the line speed is different for different axle loads or trains with locomotive and EMUs, the speed for the highest axle load was taken and a train with a locomotive was assumed, i.e. the smallest line speed value was used. The length and speed data are available online at the page of the Hungarian Rail Capacity Allocation Office (Vasúti Pályakapacitás-elosztó Kft.). [21] The data for the sidings of the Hungarian Army is from a Government Decree. [22] Other parameters of the infrastructure, such as the number of tracks, electrification, maximum allowed axle loads, temporary and permanent speed restrictions are not included in the model.

The stations with exactly two neighbouring stations, the so-called joint nodes, are also transformed out: each joint node and its two connecting edges were substituted by a single edge with a weight of the sum of the two edges replaced. [23] [24] The only exceptions were the stations at which there are no sidings of the Hungarian Army but the nearest towns are the dislocations of a troop.

In total, the railway network was reduced to 292 stations (including termini) and 364 line sections. Within Budapest, four extra nodes were added to the graph to ease further addition of edges related to planned development studies. These four nodes were not regarded as stations, i.e. they were neither origins nor destinations of any path. [25]

The model was developed to find the shortest paths either in distance or time between two arbitrary stations for freight trains with locomotives. This led to the need for adding extra time at the station(s) where locomotive reversal is necessary, for which 15 minutes was assigned. No extra trip length or travel time was assigned to passing a station and no extra distance was assigned to reversing. For this purpose, the graph describing the network had to be modified for the algorithm calculating the shortest path to add the extra time of reversing when needed.

To achieve this, each station was represented by four nodes instead of one: an arrival and a departure node at each side of the stations and four directed edges between them, with the two edges connecting the arrival and the departure node on the same side of the station weighted with 15 minutes. The realisation can be seen in Figure 2.
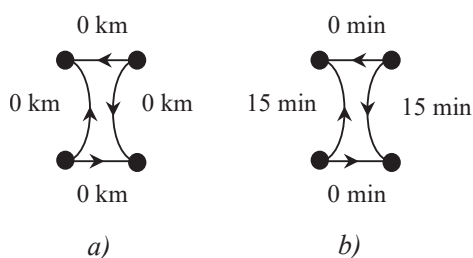

Figure 2. *The weighting of the edges between the four nodes representing a station in the case of calculations of a) trip lengths and b) travel times.* [Made by the authors.]

However, this is not enough, as a path arriving at a station at its arrival node can continue to the next station without passing through the 15-minute edge. To prevent this, the edges between the stations have to be doubled (with the same weight for both) and directed, each pointing from a departure node to an arrival node (see Figure 3/a). This arrangement ensures the addition of the extra time of the reversing.

Furthermore, there are seventeen stations in the network which can be bypassed using a wye (or, in some cases, multiple wyes), which were also represented in the graph with four nodes, similarly to the stations. Since reversing on wyes without entering the corresponding station is not possible, the edges connecting the arrival and departure nodes on the same sides of these quasi-stations were not included (see Figure 3/b).

Therefore, the 289 + 4 stations (plus the wyes) and the 361 line sections were represented by a total of 1,136 nodes and 1,810 edges in the graph.
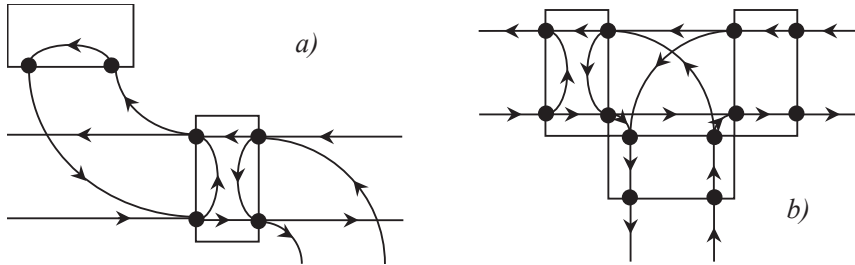

Figure 3. *The representation of termini (a) and wyes (b) in the graph.*
[Made by authors.]

Methods and Measures

Calculating the Shortest Path

For the calculations and the visualisation, the *igraph* package developed by Gábor Csárdi and Tamás Nepusz [26] in the *R* programming Language and Environment [27] was used. The *igraph* package handles graphs as a set of edges, a so-called edge list: an edge is defined by the two nodes it connects (and optionally, a weight).

The shortest path between two stations in kilometres or minutes was calculated using the *distances()* function of the *igraph* package. For weighted directed graphs with no negative weights (as in our case), the function uses Dijkstra's algorithm [28] as a default.

Calculating the shortest path between all ⟨*a,b*⟩ pairs of stations with both the time and length weights, 41,616 trip length values and the same number of travel time values are obtained. The *shortest_paths()* function of the *igraph* package makes it easy to determine whether a path passes through a specific line section or station as the function gives four values as a result, two of which are lists, *$epath* and *$vpath*, which list the *ids* of the edges and nodes on the shortest path, respectively. The *id* of an edge is its position in the edge list, while the *id* of a node is the number the node is referred to in the edge list. From these lists, the one with the line section *ids* is needed for the calculations presented.

Flow in the Network without the V0

Calculating the exact shortest paths between all ⟨a,b⟩ pairs of stations both for distance and time weights, an artificial flow on the network is obtained (Figure 4).

By summing the trip length and travel time values for all shortest paths, the so-called total network trip length (c_ℓ) and total network travel time (c_t) are obtained. For the railway network of Hungary, in its undisrupted state, these values are c_ℓ = 10,047,606 km and c_t = 6,834,569 min = 12.99 year.
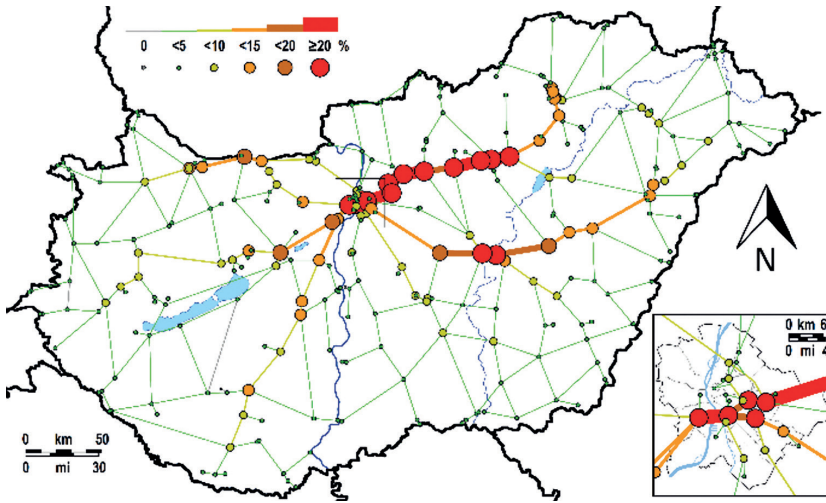
(a)
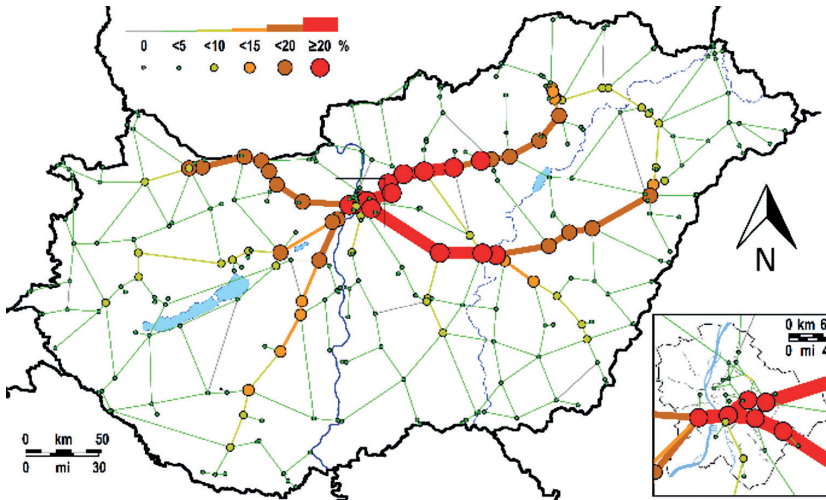
(b)

Figure 4. *The traffic flow values used in the analysis for paths with shortest trip lengths (a) and shortest travel times (b).* [29]

Quantifying the Effect of Disruptions

The term "disruption" will be used in the meaning that the given line section is not available for traffic at all, i.e. no shortest path can pass through it. This was realised by deleting the two corresponding edges of the appropriately weighted graph.

The Network Robustness Index

A commonly used measure to describe the overall resilience of a network against disruptions is the so-called Network Robustness Index (NRI) introduced by Scott et al. [30] The NRI can be calculated for all edges of the graph based on which the importance of the individual line sections can be determined.

To calculate the NRI for line section u, the shortest paths between all pairs of stations in the undisrupted graph has to be determined. Then, the total network trip length or the total network travel time is calculated. As the calculation of the NRI does not depend on the weighting, instead of c_ℓ and c_t, simply c is used to denote this measure.

Then, the edges representing line section u are deleted from the graph. Again, the shortest paths between all pairs of stations are determined and their lengths or durations are summed. This value is denoted by c^u. The NRI is calculated as the difference between these two values and is denoted by q^u:

$$q^u = c^u - c. \tag{1}$$

The difference is made in this order for q^u to be non-negative since for most kinds of weights (as in the case of length and duration) the deletion of a line section makes c^u larger than c (or at least does not make it smaller). This can be done for all line sections or multiple line sections. If line sections u and v are simultaneously deleted, the NRI is calculated as

$$q^{uv} = c^{uv} - c \tag{2}$$

where c^{uv} is the total network trip length or the total network travel time without the two pairs of edges corresponding to line sections u and v. The value of q^u_{ab} (the difference in the shortest path between stations a and b in the disrupted and the undisrupted network) shows if the shortest path in the undisrupted network passes through line section u. If $q^u_{ab} = 0$, then line section u is not part of the shortest path between stations a and b neither in the undisrupted nor in the disrupted network. If $q^u_{ab} = 0$, then by deleting line section u, the length or duration of the shortest path between station a and b increases compared to the shortest path in the undisrupted network. This means that line section u was part of the shortest path in the undisrupted network but there is still a non-infinite route between stations a and b in the disrupted network.

The Redundancy Index

The Network Robustness Index measures the increase in the total network trip length or the total network travel time in the case of the deletion of a line section. But on the disruption of line section v, the exact route of the shortest path between stations a and b changes compared to the shortest path in the undisrupted network.

Let us assume that the shortest path between stations a and b in the undisrupted network did not pass through line section u but in the disrupted network it does. How much would be the additional increment in the shortest path if u would be deleted, too? In other words, how larger would q_{ab}^u be than q_{ab}^u, i.e. we want to know how much total increase is caused by deleting not only line section v but also line section u for those paths that did not pass through line section u in the undisrupted network but did pass through in the network without line section v. This increase is the redundancy provided by line section u to line section v. Paths that do not pass through line section u in graph G^0 or in graph G^v or do pass through it in both graphs are not relevant, since they are not sensitive for the disruption of line section u.

Therefore, only those shortest paths are taken into account for which $q_{ab}^u = 0$. The r^{uv} redundancy index is defined by the sum of the increase in the shortest paths in the network without both line sections u and v compared to the sum of the increase in the shortest paths in the network without line section v:

$$r^{uv} = q^{uv} - q^v = (c^{uv} - c) - (c^v - c) = c^{uv} - c^v \tag{3}$$

By calculating r^{uv} for all v line sections that are not identical with u and summing them up, one gets the total redundancy that line section u provides to line section v:

$$r^u = \sum_v r^{uv} = \sum_v (q^{uv} - q^v) = \sum_v (c^{uv} - c^v) \tag{4}$$

This definition was introduced by Jenelius. [31]

Application on 1-Edge-Connected Graphs

It can be seen from the definition, that if such line section(s) are deleted from the graph that makes at least one station unreachable from the others, the value of both q^u and r^u becomes infinite. The railway network of Hungary has this property, which means that the graph describing it is a so-called 1-edge-connected graph. In several cases, by deleting only one line section from the undisrupted graph the graph will remain connected.

However, if two line sections are deleted, the number of reasonable results will rapidly decrease. If all these line sections were excluded from the calculations, only a few would remain and if only those line sections were excluded which give infinity as a result in that

particular calculation, then different line sections would be taken into account for each v line section, which would make the obtained r^u values incomparable to each other.

Therefore, it is practical to use the reciprocals of the travel time and trip length values of the shortest paths. By changing the order in which the difference is calculated in the summation of (2), the redundancy index remains positive since longer distances mean shorter values in the reciprocal space.

By summing the values of the redundancy indices calculated in the reciprocal space for all v line sections, one gets the total redundancy of a line section u:

$$\sum_v r_\ell^{uv'} = \sum_v \left(c_\ell^{v'} - c_\ell^{uv'}\right) = \sum_v \left(\sum_{\langle a,b \rangle} \frac{1}{\ell_{ab}^v} - \sum_{\langle a,b \rangle} \frac{1}{\ell_{ab}^{uv}}\right) \tag{5}$$

$$\sum_v r_t^{uv'} = \sum_v \left(c_t^{v'} - c_t^{uv'}\right) = \sum_v \left(\sum_{\langle a,b \rangle} \frac{1}{t_{ab}^v} - \sum_{\langle a,b \rangle} \frac{1}{t_{ab}^{uv}}\right) \tag{6}$$

However, it is more informative to normalise these values with values of the total trip length or the total travel time of the undisrupted network (which value is denoted by c_ℓ' and c_t', respectively):

$$r_\ell^{u'} = \frac{\sum_v r_\ell^{uv'}}{c_\ell'} = \frac{\sum_v \left(c_\ell^{v'} - c_\ell^{uv'}\right)}{c_\ell'} = \frac{\sum_v \left(\sum_{\langle a,b \rangle} \frac{1}{\ell_{ab}^v} - \sum_{\langle a,b \rangle} \frac{1}{\ell_{ab}^{uv}}\right)}{\sum_{\langle a,b \rangle} \frac{1}{\ell_{ab}^0}} \tag{7}$$

$$r_t^{u'} = \frac{\sum_v r_t^{uv'}}{c_t'} = \frac{\sum_v \left(c_t^{v'} - c_t^{uv'}\right)}{c_t'} = \frac{\sum_v \left(\sum_{\langle a,b \rangle} \frac{1}{t_{ab}^v} - \sum_{\langle a,b \rangle} \frac{1}{t_{ab}^{uv}}\right)}{\sum_{\langle a,b \rangle} \frac{1}{t_{ab}^0}} \tag{8}$$

The $r^{u'}$ redundancy index is the total relative decrease in the reciprocal trip length or travel time for those shortest paths that do not pass through the line section u in the undisrupted network but pass through it in the case of the disruption of line section v with line section u fixed for the calculation.

However, because of the definition, the redundancy values of the line sections calculated in a specific graph cannot be used to compare with values obtained for line sections in other

graphs. They have meaning only in that specific graph that they were calculated for and also only relative to the redundancy values of other line sections.

Results and Discussion

Redistribution of the Network Flow

Paths with Minimal Trip Length

By calculating the shortest path for all ⟨a,b⟩ pairs of stations with minimal trip lengths in the networks with the four V0 alternatives, the ratio of paths passing through the line sections will differ from the values in the network without V0 (presented in subchapter *Flow in the network without the V0*) as some of the shortest paths will use the new railway routes.

The total network trip length is 10,047,606 km in the network without the V0 line, which value decreases if the V0 line (in either route) is introduced (see Table 1).

Table 1.
The percentile decrease in the total network trip length and the percentile decrease in the number of paths between all pairs of stations with shortest trip lengths passing through the line section with the highest traffic. [Made by the authors.]

	V0 route alternative			
	#1	**#2**	**#3**	**#4**
The decrease in total network trip length (%)	0.85	1.27	1.29	1.39
The decrease in the percentile ratio of the number of paths passing through the line section with the heaviest traffic	6.66	8.08	14.71	13.94

The alternative causing the most decrease and thus the best is alternative #4, which makes the total network trip length 139,573 km shorter. However, the alternative making the line section in the network without the V0 handling the heaviest traffic, the Ferencváros–Kelenföld line section containing the Southern Railway Bridge, to handle the less traffic possible is alternative #3. Alternative #4 is almost as good, both causing about a 14% decrease in the ratio of paths passing through the Southern Railway Bridge.

The change in the percentile ratio of paths passing through each line section can be seen in Figure 5 for the four alternative V0 routes.
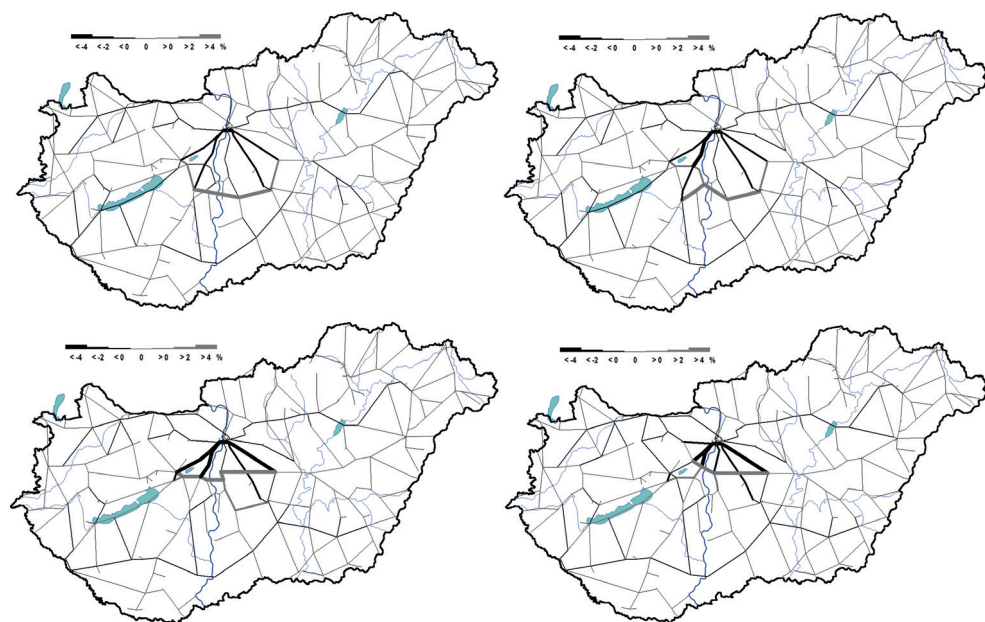
Figure 5. *The change in the percentile ratio of paths between all pairs of stations passing through each line section by introducing the four V0 alternatives (#1 top left, #2 top right, #3 bottom left, #4 bottom right) for minimal trip lengths.* [Made by the authors.]

In case of alternative #1, the ratio of the paths passing through the individual network elements decreases only for the Southern Railway Bridge with more than 4%: from 36.98% to 30.32%. The traffic of the radial main lines leading to Budapest (like lines 30a, 40a, 142, 100a) is affected less.

For alternative #2, the case is similar, only the traffic of line 40a between its crossing with V0 and Budapest decreases significantly.

Alternatives #3 and #4 are the best in reducing the traffic of the aforementioned main lines: these alternatives reroute so many paths that the traffic of existing lines decreases with more than 5%. If one of them has to be chosen, alternative #4 is the best choice because it not only reroutes the traffic effectively but also it is the shortest of the four.

Paths with Minimal Travel Time

The total network travel time is 6,834,569 minutes in the network without the V0 line, which value decreases if the V0 line (in either route) is introduced (see Table 2).

Table 2. *The percentile decrease in the total network travel time and the percentile decrease in the number of paths between all pairs of stations with the shortest travel times passing through the line section with the highest traffic.* [Made by the authors.]

	V0 route alternatives			
	#1	#2	#3	#4
The decrease in total network travel time (%)	1.23	1.03	0.82	1.56
The decrease in the percentile ratio of the number of paths passing through the busiest line section	2.49	2.41	2.73	14.29

The alternative causing the most decrease in the total network travel time and thus the best, similar to the case of trip lengths, is alternative #4: the total travel time decrease is 106,392.6 minutes. But in this case, the decrease this alternative causes in the traffic of the busiest line section is by far the highest among all four, more than 14%, which is six-time larger than for the other alternatives. This makes a clear indication that this is the best alternative not only for trip lengths but also for travel times.

The change in the percentile ratio of paths passing through each line section can be seen in Figure 6 for the four alternative V0 routes.
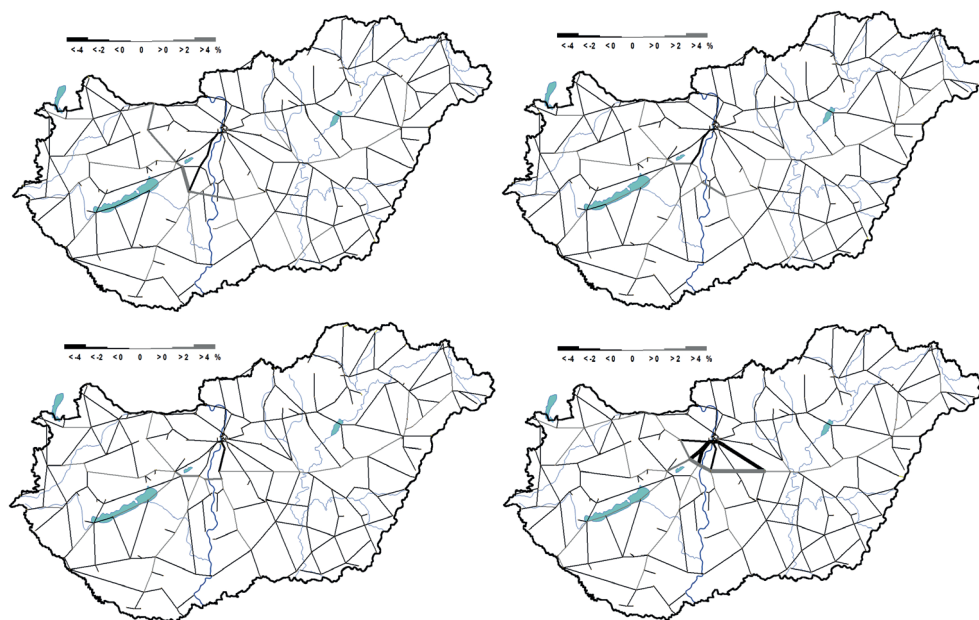

Figure 6. *The change in the percentile ratio of paths between all pairs of stations passing through each line section by introducing the four V0 alternatives (#1 top left, #2 top right, #3 bottom left, #4 bottom right) for minimal travel times.* [Made by the authors.]

As it can be seen, alternatives #1–#3 make only a small ratio of paths to reroute. The most affected line is 40a but the others are only affected by less than 2%. Alternative #4, however, makes the traffic of lines 1, 30a, 40a and 100a decrease dramatically and thus clearly

reducing the traffic currently passing through Budapest. It reroutes the paths approaching Budapest, leading them around it on a faster way to their destination.

This means that alternative #4 is the best choice in simultaneously reducing the total network trip length, the total network travel time and rerouting as many paths as possible to bypass Budapest. A further advantage of this path is that it is sufficiently far from the capital of the country and the Southern Railway Bridge. [32]

The Redundancy of V0

The redundancy value of the three-line sections with the existing Danube bridges and the (length and time-weighted) average redundancy of the V0 line alternatives were calculated for the network without the V0 line and for the four networks with the four V0 alternatives for both minimal trip length and minimal travel time paths. [33] The results can be seen in Figure 7.
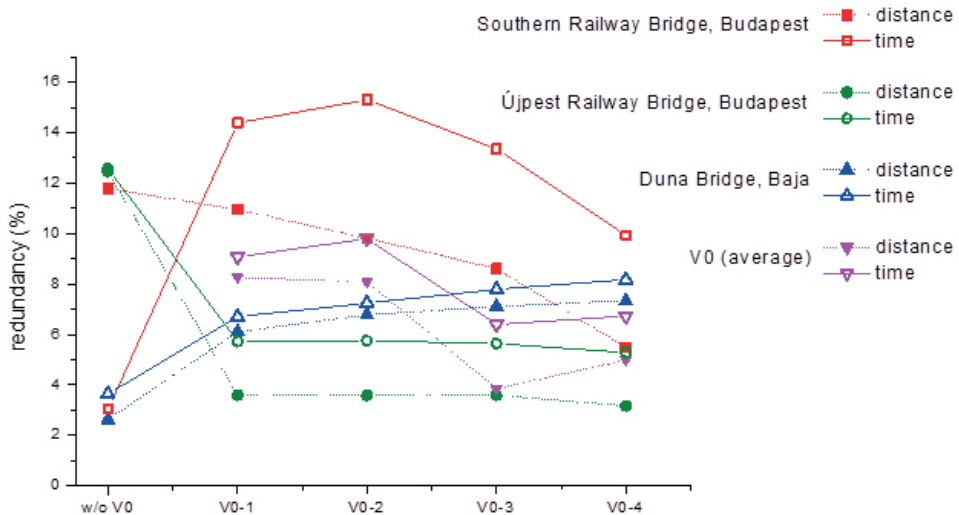

Figure 7. *The r^u' percentile redundancy values calculated using Eqs. (7) and (8), u being the line sections containing the Southern Railway Bridge (square), the Újpest Railway Bridge (circle), the Duna Bridge at Baja (upward triangle) and the Duna bridge of the V0 line (downward triangle). Each value is calculated for the network without the V0 line (w/o V0) and the four V0 alternatives (V0-1, V0-2, V0-3 and V0-4) for paths with the shortest trip length (closed symbol) and shortest travel time (open symbol), except for the V0 bridge for which the redundancy value cannot be calculated for the network without the V0 line.* [Made by the authors.]

Without V0

As it was shown by previous works, [24] [34] the Baja bridge has very little effect on the network as it is only used as a rerouting alternative for a few paths crossing the Southern bridge in the undisrupted network (see Table 3). No path passing through the Újpest bridge in the undisrupted network is rerouted through Baja. This is the case for paths with both minimal length and minimal time: the increase is so much that if this bridge is also disrupted, the further rerouting through the Újpest bridge makes a much smaller further increase in the length of the shortest paths and thus its redundancy is low.

The majority of paths passing through the Southern bridge in the undisrupted network are rerouted through the Újpest bridge on its disruption. The high redundancy value of the Újpest bridge is because the increase caused by this rerouting is relatively small related to the further increase caused by the rerouting through Baja, both for trip lengths and travel times.

The redundancy of the Southern Railway Bridge is very different for minimal trip lengths and travel times. For travel times, the increase caused by the rerouting through it from either of the other two bridges is so large, that the further increase caused by the rerouting when the Southern bridge is also disrupted, is relatively small. The case is very different for trip lengths. If a rerouted path has to pass through the Southern bridge instead of the Újpest bridge, it becomes only a few kilometres longer. Compared to this increase, rerouting through Baja on the disruption of the Southern bridge makes the paths much longer which increases its redundancy.

The rerouted paths passing through the Southern bridge in the undisrupted network are plotted in Figure 8.

Table 3. *The change of the number of paths passing through each Duna bridge on the disruption of one of the Duna bridges and the percentile change it means for that specific bridge compared to the number of paths passing thríough it in the undisrupted network.* [Made by the authors.]

Minimal distance		Change in the number of routes passing through the bridge		
		Southern	Újpest	Baja
Disruption of bridge	Southern	−15,603 (−100.0%)	+11,063 (+314.3%)	+3,907 (+330.17%)
	Újpest	+3,124 (+20.0%)	−3,520 (−100.0%)	0 (0.0%)
	Baja	+1,015 (+6.5%)	0 (0.0%)	−1,203 (−100.0%)

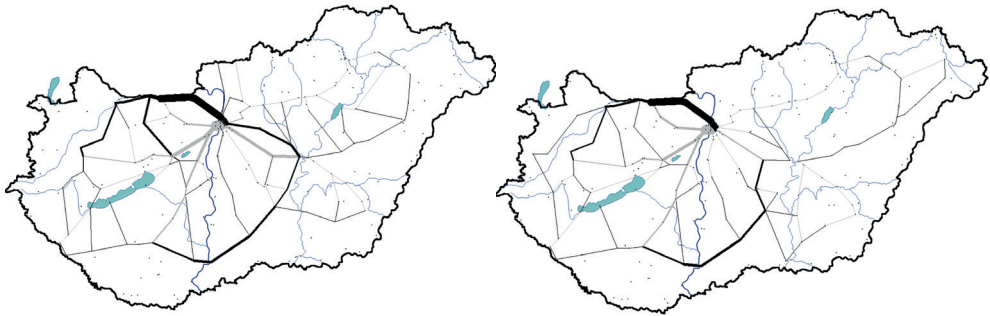| Minimal time		Change in the number of routes passing through the bridge		
		Southern	Újpest	Baja
Disruption of bridge	Southern	−18,995 (−100.0%)	+13,105 (+1,378.0%)	+5,080 (+806.3%)
	Újpest	+457 (+2.4%)	−951 (−100.0%)	0 (0.0%)
	Baja	+290 (+1.5%)	0 (0.0%)	−630 (−100.0%)

Figure 8. *The redistribution of paths with shortest trip length (left) and shortest travel time (right) on the disruption of the Southern Railway Bridge in the network without the V0 line. The thickness of the lines is proportional to the change in the number of paths passing through each line section: red standing for decrease and green standing for the increase* [Made by the authors.]

With V0

By introducing the V0 line, the redundancy values of the existing bridges converge. This is due to the role V0 ought to play in the railway network of Hungary: providing an alternative for the Southern Railway Bridge. As it is clear from the structure of the network, the disruption of the V0 bridge mostly makes the individual paths to reroute to their distribution as it was in the network without the V0 line (see Figure 9). Similarly, on the disruption of the Southern bridge, the vast majority of the lines is rerouted through the V0 bridge (and also the Újpest bridge). As it is clear from Figure 7, alternative #4 makes the network to be the most balanced in the view of redundancy as the difference between the values of the Southern bridge and the V0 bridge is the smallest for this alternative.

According to the traffic flow values (Table 4), the ratios of the rerouted paths between the three older bridges remain approximately the same, but the newly introduced V0 bridge becomes the main rerouting alternative for all other bridges, even some paths passing through the Újpest bridge in the undisrupted network. Paths passing through the Újpest bridge and the Baja bridge in the undisrupted network are never rerouted on the other one, as was the case in the network without the V0 line.

The change in the flow values in Table 4 clearly shows that V0 becomes the most important rerouting alternative. This is because the disruption of the V0 bridge results in significantly longer paths which, combined with the high number of paths passing through it leads to a high redundancy value. As the spatial distribution of the Danube bridges become more even on the introduction of the V0 line, one alternative route is always significantly better than the others for a chosen path. This also means that there is always a better rerouting path in the network with the V0 line than in the present network without V0 and thus the substitution of the Danube bridges can be handled much more sufficiently making the railway network of the country less vulnerable. [35]
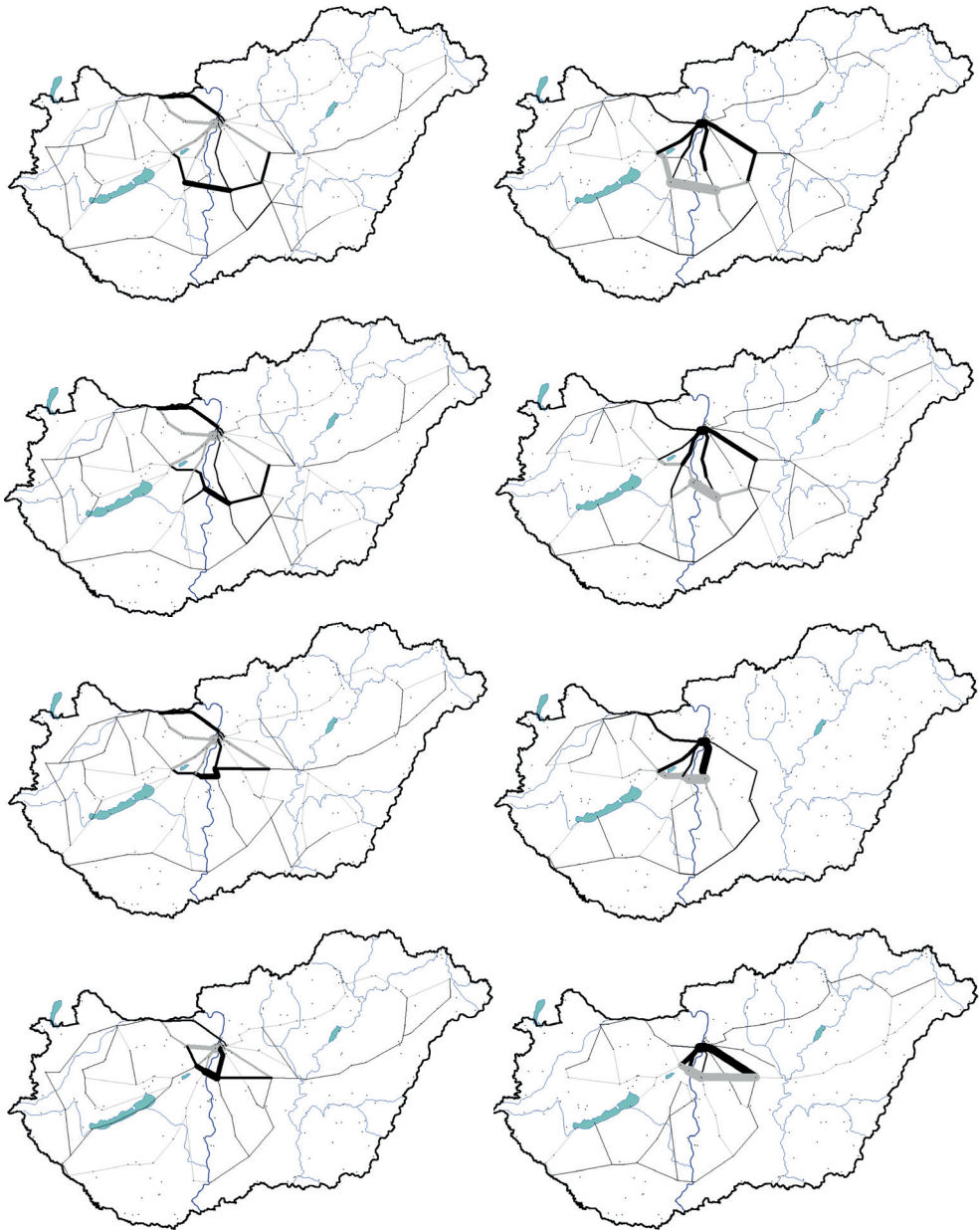
Figure 9. *The redistribution of paths with shortest travel time on the disruption of the Southern Railway Bridge (left) and the Duna bridge on the V0 line (right) in the network with the V0 line (from top to bottom V0 alternative #1, #2, #3 and #4). The thickness of the lines is proportional to the change in the number of paths passing through each line section: red standing for decrease and green standing for the increase.*
[Made by the authors.]

Table 4. *The change of the number of paths passing through each Duna bridge on the disruption of one of the Duna bridges and the percentile change it means for that specific bridge compared to the number of paths passing through it in the undisrupted network.* [Made by the authors.]

Alternative #1 min. distance		Change in the number of routes passing through the bridge			
		Southern	Újpest	Baja	V0
Disruption of bridge	Southern	−12,794 (−100.0%)	+6527 (+185.4%)	−32 (−3.8%)	+5731 (+181.1%)
	Újpest	+3,124 (+24.4%)	−3520 (−100.0%)	0 (0.0%)	0 (0.0%)
	Baja	−27 (−0.2%)	0 (0.0%)	−847 (−100.0%)	+686 (+21.7%)
	V0	+2809 (+22.0%)	0 (0.0%)	+356 (+42.0%)	−3165 (−100.0%)

Alternative #1 min. time		Change in the number of routes passing through the bridge			
		Southern	Újpest	Baja	V0
Disruption of bridge	Southern	−17,835 (−100.0%)	6939 (+729.7%)	+240 (+50.0%)	+9838 (+751.0%)
	Újpest	+429 (+2.4%)	−951 (−100.0%)	0 (0.0%)	+28 (+2.1%)
	Baja	−75 (−0.4%)	0 (0.0%)	−480 (−100.0%)	+215 (+16.4%)
	V0	+1160 (+6.5%)	0 (0.0%)	+150 (+31.3%)	−1310 (−100.0%)

Alternative #2 min. distance		Change in the number of routes passing through the bridge			
		Southern	Újpest	Baja	V0
Disruption of bridge	Southern	−12,195 (−100.0%)	+5,441 (+154.6%)	−50 (−10.9%)	+6,276 (+151.2%)
	Újpest	3,124 (+25.6%)	−3,520 (−100.0%)	0 (0.0%)	0 (0.0%)
	Baja	−72 (−0.6%)	0 (0.0%)	−460 (−100.0%)	+344 (+8.3%)
	V0	+3,408 (+27.9%)	0 (0.0%)	+743 (+161.5%)	−4,151 (−100.0%)

Alternative #2 min. time		Change in the number of routes passing through the bridge			
		Southern	Újpest	Baja	V0
Disruption of bridge	Southern	−17,892 (−100.0%)	+7,288 (+766.4%)	+244 (+50.8%)	+9,710 (+774.9%)
	Újpest	+441 (+2.5%)	−951 (−100.0%)	0 (0.0%)	+16 (+1.3%)
	Baja	−79 (−0.4%)	0 (0.0%)	−480 (−100.0%)	+219 (+17.5%)
	V0	+1,109 (+6.2%)	0 (0.0%)	+144 (+30.0%)	−1,253 (−100.0%)

Alternative #3 min. distance		Change in the number of routes passing through the bridge			
		Southern	Újpest	Baja	V0
Disruption of bridge	Southern	−9,398 (−100.0%)	+3,702 (+105.5%)	−18 (−1.8%)	+5,516 (+85.8%)
	Újpest	+3,134 (+33.3%)	−3,508 (−100.0%)	0 (0.0%)	−22 (−0.3%)
	Baja	−31 (−0.3%)	0 (0.0%)	−1,005 (−100.0%)	+832 (+12.9%)
	V0	+6,205 (+66.0%)	+12 (+0.3%)	+198 (+19.7%)	−6,431 (−100.0%)

Alternative #3 min. time		Change in the number of routes passing through the bridge			
		Southern	Újpest	Baja	V0
Disruption of bridge	Southern	−18,128 (−100.0%)	+6,696 (+704.1%)	+2 (+0.4%)	+10,918 (+1134.9%)
	Újpest	+457 (+2.5%)	−951 (−100.0%)	0 (0.0%)	0 (0.0%)
	Baja	−24 (−0.1%)	0 (0.0%)	−535 (−100.0%)	+219 (+22.8%)
	V0	+868 (+17.6%)	0 (0.0%)	+94 (+17.6%)	−962 (−100.0%)

Alternative #4 min. distance		Change in the number of routes passing through the bridge			
		Southern	Újpest	Baja	V0
Disruption of bridge	Southern	−9,723 (−100.0%)	+3,089 (+89.1%)	−18 (−1.7%)	+6,464 (+105.7%)
	Újpest	+3,022 (+31.1%)	−3,466 (−100.0%)	0 (0.0%)	+48 (+0.8%)
	Baja	−84 (−0.9%)	0 (0.0%)	−1,039 (−100.0%)	+919 (+15.0%)
	V0	+5,880 (+60.5%)	+54 (+1.6%)	+164 (+15.8%)	−6,114 (−100.0%)

Alternative #4 min. time		Change in the number of routes passing through the bridge			
		Southern	Újpest	Baja	V0
Disruption of bridge	Southern	−12,858 (−100.0%)	+2,442 (+256.8%)	−155 (−28.9%)	+10,125 (+162.3%)
	Újpest	+409 (+3.2%)	−951 (−100.0%)	0 (0.0%)	+48 (+0.8%)
	Baja	−164 (−1.3%)	0 (0.0%)	−537 (−100.0%)	+353 (+5.7%)
	V0	+6,137 (+47.7%)	0 (0.0%)	+93 (+17.3%)	−6,238 (−100.0%)

Conclusions

We modelled the effect of the long-planned V0 railway line on the railway network of Hungary using a weighted directed graph. Four of the proposed alternative routes were analysed. It is clear from our results that alternative #4, the one not too close to and not too far from Budapest leads to the best results. As it is not too far from the Southern Railway Bridge, it can provide a reasonable alternative route to it, and as it is not too close to it, the rerouting is not limited exclusively to the paths passing through the Southern bridge.

Regarding travel times, alternatives #3 and #4 provide the best redistribution of paths for paths with the shortest possible length, but for paths with minimal travel times, alternative #4 is the only case in which the Southern bridge is effectively disencumbered.

The V0 line provides high redundancy for the network as many routes are rerouted through it on the disruption of the other Danube bridges and its disruption leads to a significant further increase in the length of these paths. V0 also increases the redundancy of the other three bridges: as numerous paths pass through it in the undisrupted network (particularly in the case of alternative #4), on the rerouting of these paths, they have to pass through one of the other bridges, and their simultaneous disruption increases the trip length or the travel time further with a significant amount.

This means that the V0 line is not only necessary for the railway network of Hungary to make the existing bridges (especially the Southern Railway Bridge in Budapest) handle moderate traffic but also for the redundancy it provides in the case of the disruption of any other Danube bridge.

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