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EDITORIAL: CUTTING-EDGE SMART CITIES RESEARCH 5TH SMART SUSTAINABLE AND SAFE CITIES CONFERENCE

Lectori benevolo salutem,

In 2020 we organised the fifth Smart Sustainable and Safe Cities Conference. This event has become a tradition in Óbuda University and a Safety and Security doctoral school in recent years. This conference is an overview of the technology trends driving Smart Cities related to infrastructure such as communication, energy, water, transportation system, etc.

To solve these problems, new and emerging technologies are created. Internet of Things, big data, blockchain, artificial intelligence, data analytics, and machine and cognitive learning are just a few examples. They generate changes in key sectors such as health, energy, transportation, education, public safety, etc.

The present second thematic issue of INDECS examines further the design and research philosophy of complex systems such as smart cities and the developments related to these technologies.

Twenty-one manuscript submissions for two thematic issues of INDECS were received. The scientific articles in this issue were accepted after a multi-circle review by the guest editors and a double-blind review process.

In this thematic issue of INDECS:

Kadena and **Keszthelyi** in their article named *Identified failures in mobile devices approach* present, their main finding is needed on a human-centered design by taking into account people's needs, capabilities, and behaviors.

The next article: *Drone component for radio frequency detection* by **Hell** and **Varga**, development is a radio-frequency detector drone component – a part of the smart city – which can find the mobile device of the person in trouble, and therefore eliminates the prerequisite for adequate visual conditions.

Liebmann and **Schuster** in their article named *Fuzzy system-based event tree analysis support of the health care centers' and hospitals' smart security system* examine the possibility of providing smart health care and its security.

Guarantee safety represents a serious issue in smart cities what is more one of the pillars of a smart city.

The article named *The performance analyses of IEEE 802.15.4g sun low-power wireless networks and their application* by **Dobrilović, Mazalica,** and **Gecin** presents basic features of the emerging IEEE 802.15.4g SUN low-powered wireless network standard, its application scenarios, and performance analyses.

According to research on mobile networks, the Internet of Things (IoT), low power, and long-range wireless technologies play a key role as an enabling technology for the development of the communication backbone for future smart cities, which will be increasingly based on multi-sensor intelligent data analytics. Citizens engage with smart city ecosystems in various ways using smartphones and mobile devices.

Shatnawi and **Rajnai** in their article named *Assessing the sustainability of transportation as critical infrastructure: a prediction model for environmental dimensions using Jordan as a case study* explore benefits through the example of assessing sustainability dimensions for transportation as critical infrastructure in terms of social, economic, environmental, technological, and energy aspects, with emphasis on environmental aspects.

Assessment of societal vulnerability in case of power failure in rail network the article by **Szatmári** and **Lusková** articles aims the societal vulnerability due to a power failure in the rail network, and a specific event will be described in the form of a case study.

Varga and **Illési** in their article named *WI-FI 6 application in IoT environment* pointed out that future IoT consumption will increase the number of misconfigured or poorly configured devices, which will increase the potential to use these against critical infrastructure.

Szalanczi-Orban and Váczi in their article named *Use of drones in logistics: options in inventory control systems* demonstrate the spread, the usability, the challenges, and the opportunities of this technology in the transport and logistics sector.

There are many problems in cities from societal vulnerability, threats, and crimes to the epidemic, but in smart cities, we can find good solutions to these problems in the areas of cutting-edge smart city research.

The present thematic issue aims to offer researchers an opportunity to extend their existing scientific relationships all over the world in the field of interdisciplinary research in complex systems, such as the field of smart, sustainable, and safe cities programmed by NextTechnologies Ltd. Complex Systems Research Institute.

These studies connect to leading-edge smart cities research, and they can be successfully implemented in various areas of developing sustainable and safe communities all over the world. This work is connected to the MEC_N-141290 project and the result of the International collaboration in promoting science. This is a good example of supporting community science.

Cordially,

Budapest, 27th April 2022

Guest editors:
Gyula Mester
Daniel Tokody

Interdisciplinary Description of Complex Systems 20(3), 222-229, 2022

IDENTIFYING FAILURES IN MOBILE DEVICES

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ABSTRACT

Mobile devices are well-known communication tools. People, especially young people, cannot go even one step without them. Technological advancements provide better features, but at the same time, such systems still face security risks. Protective layers do exist, but some systems are automated and engineered, while others rely on humans. This work begins with examining some critical points related to the weakest link in the security chain: the human factor. Errors are given in the view of the Swiss Cheese Model by emphasizing the role of latent conditions in "holes".

We found that the Swiss Cheese Model has some limitations. In order to enhance it, we have used the Failure Mode and Effect Analysis risk matrix methodology. Thus, we represent its application on mobile devices to demonstrate that it can give us more accurate results by identifying the most critical points where manufacturers should focus on. This work is based on qualitative data, and it provides the basis for quantitative research. In the end, we suggest that in order to obtain more accurate findings, the Failure Mode and Effect Analysis can be further extended.

KEY WORDS

mobile device, SCM, FMEA, human errors, failures

CLASSIFICATION

JEL: C25, L15, L63, L96

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INTRODUCTION

Over the years, the industry of information technology has made increasing progress, and we can find it present whereever we are. People's life is related to mobile devices as the use of them for personal, and business, purposes has become very popular. On the other hand, these devices and systems are posed to some risks. One of the main issues is the impact of human errors in such systems. Human and organizational errors stand for unanticipated or undesirable effects resulted by the poor performance of an individual or a group. The human factor is the weakest link in the interfacing process and keeping secure information with machines that they interact with [1]. The errors to hardware or software can be unintentional because of the lack of training or intentional violation of guidelines [2]. Information security loss also happens because of the corporations; the reactive management approaches that they use in security incidents [3] as well as a result of the human factor. The progress related to such issues is still slow and fails to keep pace with the evolution of threats [4].

Senders and Moray defined human error as a behavior that can be observed [5]. Its origin processes on different levels where performance standards are needed for its evaluation, and it is initiated by an event where there was a possibility to act in another way, but correctly. Hollnagel states that a human error can only be observed by observing human behaviors first. In his surveys' review, it is showed that the estimated contribution of "human errors" to incidents ranges from about 20 % to around 80 % [6]. Accordingly, human errors are comprised of three parts. The first one is the evaluation of the human behavior against a criterion or standard performance. The second one is related to an event that results in a measurable performance the expected level of which is not met by the acting agent. The third part is a degree of volition where the actor can act in a way that will not be accounted for mistakes.

We examine how human errors and latent conditions are represented in mobile devices systems under the Swiss Cheese Model (SCM). Then we propose the application of the Failure Mode and Effect Analysis (FMEA) risk matrix methodology as an extension of the SCM. After applying this methodology in mobile devices, we present and discuss the results. Our conclusions are drawn in the final section.

HUMAN ERRORS IN VIEW OF THE SCM

The Swiss Cheese Model of accident causation, developed by Reason, is a popular tool used to analyze root cause and investigate incidents [7]. It was shown that accidents are a result of the relationship between active failures – "unsafe acts" by operators and latent conditions of the system. Active failures stand for unsafe acts made by operators [7]. Latent conditions are known as "pathogen agents" that involve factors that contribute to an accident such as organizational culture, decisions made by the management, design of procedures, or training deficiency. Accordingly, when active failures or underlying conditions successfully penetrate the defenses, accident(s) can occur [8, 9]. Moreover, the SCM can be seen as a means of communication and used for primary analysis and measurements [10]. The crucial point is related to knowing "holes" or system failures and what they are. After this, investigators should detect and eliminate them to avoid the occurrence of an accident [11].

Human actions are classified as skill-based, rule-based, and knowledge-based [8]. There are also intentional actions that cause non-compliance routinely; when a rule is barely implemented, and its removal has become a norm. Before the entire culture is at high risk, there is a need to fix the wrong practice. Violations can also be exceptional when a calculated risk is taken because of specific conditions to carry out another task. According to Balaouras and Cser, employees have expectations for their mobile experience. They are not willing to wait for security leaders to provide them with the proper devices and apps they need to do their jobs

effectively. The results show that employees do not fully understand the risks in mobile devices [12]. Maxion and Reeder found that undependable user interfaces are more prone to the flaws in the design, and they can be a significant factor in the human error that causes security breaches [13]. Malware is becoming more and more undetectable. Mobile devices are exploited by four vectors running in the background all the time, such as alarm clocks, emoji keyboard, music applications, and flashlight applications [14]. Additionally, when the lack of security in mobile devices is combined with the privileges granted in the privacy agreements, it poses a considerable risk to them.

Mobiles are always in the peoples' pockets, and they bring those to the workplace, too. BYOD is one of the challenges that mobile security is dealing with. In many organizations, people want to bring their own devices and use them on company networks. According to the Check Point, the companies allowing the use of mobile for work purposes were attacked 54 times more frequently on average [15]. Kaspersky found that more than half of industrial organizations permitting outsiders to access critical systems remotely and 63 % of those that allow access to outsiders are more likely to experience a cybersecurity breach than those that do not allow access [16]. People tend to be lazy while installing and accessing applications. Developers have realized that collecting keystrokes is useful for marketing purposes, and accessing the contact lists for it, is more profitable. Consequently, spying on customers and collecting data without peoples' permission help developers to make more money. Furthermore, employees do not access only their information on mobile devices; they also access sensitive organizational content (financial data, strategy materials of the corporate, etc.) [12].

Another critical issue is related to the coming and going of employees. They can bring risks they already have in their mobile devices even though the network might be locked down. Vanson Bourne states that from all the threats that organizations face these days, phishing attacks remain the most significant challenge, with 56 % of respondents identifying these attacks as a main concern [17]. There do exist some ways to address these challenges. A possible countermeasure might be the education and training of employees. Human errors may cause accidents, but accidents may not be caused purely by human errors. The confluence of a whole chain of mistakes can cause accidents. To reduce casualties, safety analysts must firstly identify the type of human and company errors that cause fatalities and then study and determine how accidents happen.

Following the SCM, the barriers presented as layers consist of technology, processes, and people in the end. So, we cannot imagine that the most significant holes are in the last layer. Neither that a single error can cause an accident. The presence of latent conditions that are present before a specific accident occurs is also significant [10]. Thus, not only the human factor in the end, but also the alignment of several holes through all layers can cause failures. The main point is to detect the "holes" and correct them before an accident occurs. These can be achieved by identifying what the "holes" are, how big they are, and what their correlation is [18]. Before developing new devices, engineers can consider human behavior as accepted in the way it is. A solution might be the approach of human-centered design, which puts on first-line human needs, capabilities, and behavior and then start designing to accommodate them [19]. For this, an understanding of psychology and technology is needed.

FAILURE MODE AND EFFECT ANALYSIS IN MOBILE DEVICES

FMEA was developed in 1949 and is used to identify and analyze all failure modes of various parts of the system [8]. FMEA is a step by step tactic, and its objectives are to identify all possible failures throughout the processes, study the consequences of these failures, find the links between causes and effects, search and solve and make decisions based on the requirements of the appropriate action [20]. According to Johnson and Khan, the aim of

applying FMEA is to continuously develop products and procedures consistent with consumers' satisfaction [21].

The indicator used for determining the right corrective action on failure modes is called the Risk Priority Number (RPN). After calculating RPNs values, it is easy to identify the areas of the most significant problem. Then the focus shifts to the solution of failure modes [22]. The advantage of FMEA is that it can be used in all phases of the system lifecycle from requirement specification to design, implementation, operation, and maintenance [23]. The significant benefit from FMEA can be achieved at the early design phases because the weakest point in the structure of the system can be revealed and addressed before doing expensive design changes in later stages. The process of FMEA starts with the identification of the scope of the system and its functions [23]. Brainstorming can be a useful method to find possible failure modes. Later, the effects and the causes of potential failures are determined. Risk analyses are done after detecting these possible causes and effects. The final phase consists of documenting the process and taking actions to reduce the risks.

RELATED WORK

Few researchers have addressed the failures issues in mobile devices. Marques analyzed FMEA in mobile phones, specifically the hardware [24]. His results showed that when designing a mobile device, manufacturers should give top priority to the device's shell. Two other researchers were focused on finding the weakest point of a mobile device at the design stage [25]. They concluded that to receive what is expected from the device, it is crucial to know its performance reliability.

Cinque et al. analyzed software failure data regarding freeze, self-shutdown, unstable behavior, output failure, and input failure on Symbian OS [26]. The results showed that most problems are caused by memory access violation errors and heap management. Furthermore, Cinque studied enabling online dependability assessment of the Android smartphone [26]. The author discussed the logging platform for the collection of failure data. Usually two types of failure occur in mobile devices; one can be the result of an accident and the other of the malfunction of hardware or software. Vijayalakshmi studied FMEA in Android OS [27]. According to his conclusions, top priority should be given to hardware. Only a few years ago, a malware was part of the ROM on factory-default in brand new smartphones [28]. From the software side, the problem of self-shut down was most dangerous issue as it could contribute to data loss or the failure of the OS.

APPLYING FAILURE MODE AND EFFECT ANALYSIS IN MOBILE DEVICES

In this study, we determined nine of the most frequent mobile device failures by using the brainstorming technique [29]. Six of the most frequent failure modes related to hardware and three of the most frequent software failure modes were highlighted. The FMEA method was conducted based on the following steps.

Step1: Identification of potential failures and effects. The most problematic components that we found in a mobile device are classified as *Hardware Failure Modes:* Touchscreen; Battery; Device Shell; Front camera; Rear camera; Microphones, and *Software Failure Modes:* Freeze; Self-shutdown; Output failure. Step 2: Determining severity. Severity (S) is a rating of the seriousness of the effect of a failure mode to the system, assembly, product, customer, or government regulation [23]. It is related to the Failure effect. Severity rates on a scale of 1 to 10, where 1 is the lowest and 10 is the highest. Step 3: Estimating Occurrence. Occurrence (O) is a rating responding to cumulative numbers of failures that could occur over the design life of a system or component [23]. It is related to the Failure Cause, and CNF stands for

Cumulative Number of Failures. Step 4: Failure Detection. Detectability (D) that is a rating of the ability of the proposed design control to detect a potential failure mode or occurrence [23]. It is related to Failure Control. The higher the value of D, the more likely the failure will not be detected. Step 5: Calculating Risk Priority Number (RPN). RPN is calculated based on the three above explained criteria - formula (1): a) The severity of the effect on the user and the mobile system itself, b) How frequently the problem is likely to occur, and c) How easily the problem can be detected.

$$RPN = S \times O \times D. \tag{1}$$

Considering these steps, first we filled the FMEA form. The potential causes of failure occurrence for each failure mode and effects have been determined by taking into account the influence they have on the components and on the whole system of the mobile devices. To eliminate or reduce the potential causes of failures, recommended actions were given for each of the defined failure modes.

RESULTS AND DISCUSSION

Following FMEA steps, we calculated the values of Severity, Occurrence, and Detectability and then calculated the RPNs according to the respective formula (1). Our findings are represented in the table below:

Table 1. Collection of evaluated S, O, D and RPNs values.

COMPONENT	S	O	D	RPN
Touchscreen	9	6	3	162
Battery	9	7	4	252
Shell	4	8	4	128
Front-facing camera	4	2	8	64
Rare-facing camera	3	2	7	42
Microphones	5	6	3	90
Freeze	8	6	5	240
Self-shutdown	8	5	4	160
Output failure	7	4	5	140

According to the details and results from the FMEA method, we analyzed the RPNs values and reached our conclusions. The results highlight that the critical failures of the battery (RPN = 252) followed by mobile device freeze (RPN = 240) show that these should be given high priority. Their severity values are also high, and we can state that they pose a high risk. Severity criteria should be prioritized as they are related to failure effects in the whole system. Thus, touchscreen and self-shutdown components have to be considered. Possible recommendations derived from the FMEA form for each failure are as follows:

In the Hardware part – Touch-screen: more supervision; selection of more resistant material; improve sensitiveness; improve the quality design of (sys) apps - here responsive design should be taken into consideration. Battery: continuous work on making chips and OSs more efficient to save power; manufacturers should think seriously about the replacement of existing batteries. Device Shell: more supervision; selection of appropriate and more resistant material. Front camera: more supervision; improving the default camera app. Micro-phones: more supervision; improving the quality.

In the software part – Freeze: selection of proper and reliable software; more supervision. Self-shut-down: batteries should be checked; more supervision. Output failure: more cautiousness from the manufacturer side; more supervision.

We suggest that when conducting FMEA, it is essential to understand and decide which failure modes are more significant than others by extending this method with an additional weighting factor [30]. Moreover, by considering the potential causes, many of them are closely related to users' practices and behaviors in mobile devices. The digital habits of users and their unconsciousness about potential online threats pose a high risk in mobile device systems [31]. As human error is inevitable, two options can be seen: one is related to the acceptance of the current level of harm, and the other is to start viewing the current failures as a result of the present conditions of the system. Putting continuous effort into training, education, and programs about user awareness is a good measure, still, it does not promise the wanted results. Therefore, we suggest that on the extension of FMEA, increased attention must be paid on human errors. Putting more effort and focus on the design of elements in mobile device systems would be a good attempt to reduce or eliminate potential failure effects.

CONCLUSIONS

This article has highlighted the importance of the human factor in mobile devices. Following the SCM, any of the elements of such systems can contribute to the likelihood of an error occurrence. The design has a crucial role in reducing the risks. The evidence from this work suggests that as the SCM is a theoretical framework and not a prescriptive investigation technique, it has few details on its application in a real word. So, the SCM has its limitations as it does not provide a detailed accident model or a comprehensive theory of how functions and entities in a complex socio-technical system interact and depend on each other.

We suggested the application of FMEA Risk Matrix Methodology in mobile devices. Here, nine failure modes were considered. The RPNs results revealed that a failure on battery, followed by the freeze of mobile devices are the ones with the highest priority. On the other hand, touchscreen and self-shutdown failures also have high severity, and even though their RPNs are not the highest, they should be considered with top priority as well. Besides, we propose an extension of the FMEA method that uses additional weighting factors. More focus is needed on a human-centered design by taking into account people's needs, capabilities, and behaviors.

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DRONE COMPONENT FOR RADIO FREQUENCY DETECTION

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ABSTRACT

Recovering people who have lost their way during a hike or disappeared during a disaster is a significant task for disaster management agencies. Nowadays, there are numerous technological devices at our disposal in such cases. Night-vision devices, thermal imagers, and drones are among such technologies. Time is a critical factor in a disaster situation, so by deploying drones, a greater area can be inspected in a given time. These types of general-purpose aircraft are primarily equipped with visual reconnaissance components, such as high-resolution or infrared cameras. The disadvantage of these devices is that they only work effectively in open terrains with adequate visibility conditions. If the missing person is in a dense forest or in a covered space, the chances of recovery decrease significantly.

Our development is a radio-frequency detector drone component, which can find the mobile device of the person in trouble, and therefore eliminates the prerequisite for adequate visual conditions. This enables greater efficiency in the case of recovery efforts.

KEY WORDS

drone, communication, disaster, radio, detection, component

CLASSIFICATION

JEL: L63, L92

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INTRODUCTION

Disaster management agencies use drones for carrying out special tasks on a daily basis. Their usefulness is undeniable. These aircraft have been one of the most important tools for assisting disaster management in recent years [1]. By using drones, not only can we shorten the time it takes to complete tasks, but we can also look at events from a perspective that we cannot obtain from ground level at all. With the help of well-known drone components – such as a camera or a thermal camera – we can transfer images/videos to the drone pilot. This information helps and speeds up decision-making on relief tasks. There may be cases in which the examined area is covered. This means the camera is no longer able to detect objects and people trapped under the covered area. During disasters and accidents, the primary goal is to save human life. Therefore, time is the primary factor. Our goal was to develop a drone component that, in addition to visual information, also supports rescue efforts with radiofrequency data.

DISASTER MANAGEMENT AND THE POSSIBILITIES OF USING A RADIO FREQUENCY DRONE COMPONENT

Drones currently used in disaster management perform the following tasks:

- search and rescue tasks,
- firefighting tasks,
- law enforcement, prevention, and policing,
- prevention of natural and industrial disasters.

During **search and rescue missions**, disaster management agencies have to save lives in different terrain conditions. Drones with visual observation components can identify the human shape from a distance of up to tens of meters. With the help of a thermal camera, it can detect an organism with a different temperature than its surroundings even if it's under a thinner cover. It transmits these videos in real-time to the search and rescue management team [2].

In all cases, the primary goal of **firefighting tasks** is to save and secure human life. The task of drones may be to locate a person/people trapped in a building or even in an enclosed area. But localizing the focal point of larger natural fires can also be done faster with these aircraft. Drones flying high see the target area from a different perspective, which is a huge help to firefighters. This added information allows them to do a faster and more accurate job, while their security is less at risk. In these cases, a regular camera image combined with a thermal image plays a prominent role [3].

In **law enforcement, prevention, and policing**, the tasks are multi-layered. The drones are suitable for mapping crime scenes, so the action of the law enforcement agencies can be planned more precisely. This can improve the outcome of an action and minimise the endangerment of civilian life. In addition to the traditional imaging component, infrared cameras also play an important role in crime prevention and policing. Nowadays, law enforcement agencies primarily use drones to control border violations and curfews.

To **prevent natural and industrial disasters**, and to assist when they occur, drones are capable of performing tasks across multiple platforms. They can transmit a large amount of information to defence agencies and engineering teams that is invisible from the ground or difficult to access. This includes traditional imaging, but shots combined with a thermal imager provide even more information. For example, they can be used in case of a dam rupture to localise water breakthrough sites. In the event of an industrial disaster, a component capable of detecting hazardous gases integrated on the drone can predict hazardous locations for task performers.

INTEGRATION OF A RADIO FREQUENCY DRONE COMPONENT FOR DISASTER MANAGEMENT TASKS

Our current research focuses on how the information provided by existing imaging components can be combined with a drone-mounted radiofrequency reconnaissance component. We have found that the radio frequency scanner component we have developed can provide additional information to the ground team of disaster management organizations, primarily during search and rescue tasks and natural disasters [4].

The prepared drone component and the supporting software were named the SOS-SSID system.

STRUCTURE OF THE SOS-SSID SYSTEM

The new system has three components. During development, the drone-mounted radio frequency detection component was designed for an environment that includes the following elements:

- terrestrial transmitter station (mobile device + sos application),
- drone-mounted radiofrequency detection component + drone (hardware and software environment),
- ground server system (drone navigation + sos application locator software environment).

The structure of our system is shown in Figure 1 [5, 6].

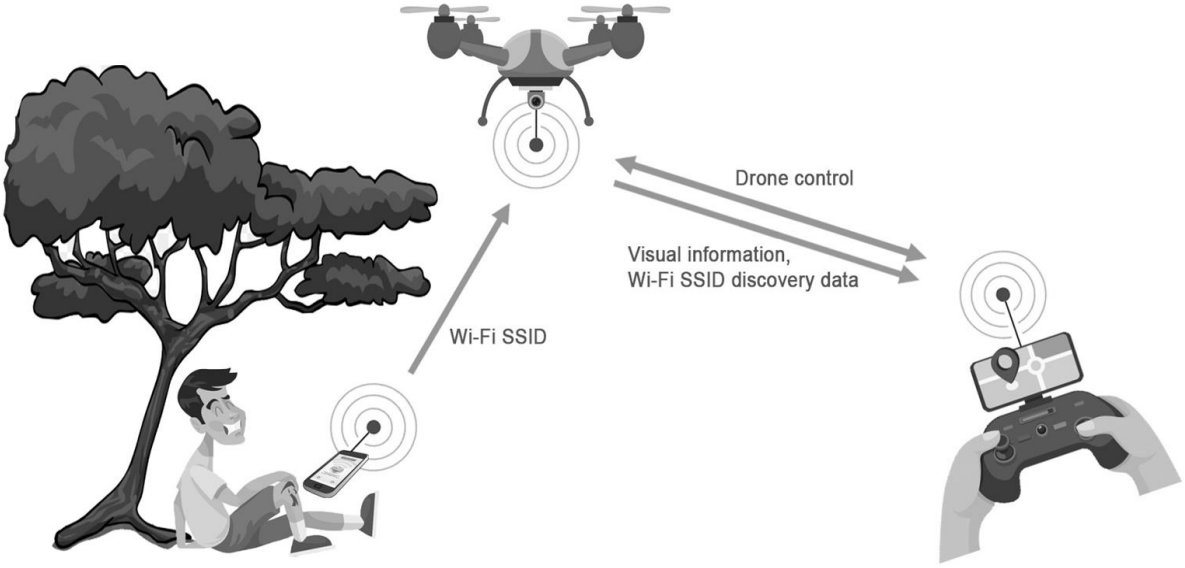

Figure 1. The SOS discovery system.

TERRESTRIAL TRANSMITTER STATION

The ground transmitter station will be established by a software environment (SOS-SSID application) created for mobile devices. With this software, the person in trouble will be able to turn their device into a wireless network transmitter station, or – in other words – a hotspot. The mobile phone converted using the software can transmit information for assistance by radiofrequency for up to ten hours when charged. The windows of the program perform the following functions, which are shown in Figure 2 [7].

A) Main Screen – A large SOS button to initiate an emergency call. The function can only be activated by four seconds of continuous pressing, to eliminate accidental activation. Different kinds of instant information can be selected on the main screen using quick switches. Profile setting and basic setting options are also available as submenus.

B) Emergency Call Active Status Screen – This page shows the emergency call application in active status. The following information is displayed here: The maximum expected operating time and battery charge, as well as the STOP button that interrupts the active service. In the active state, it is no longer possible to enter or modify basic data. This was necessary because the application had to generate a new SSID for each modification or new information.

C) Basic Application Settings Screen – This interface allows the user to customize the application's language, the unit of mass, the active status switch of the positioning system, the interval for regenerating the SSID due to changing coordinates, and settings for stopping other applications.

D) Personal Profile Creation Screen – Provides basic information about the user. There are fill and select fields on the interface.

Figure 2. SOS-SSID screenshots – "A" Basic screen, "B" Active SOS hotspot, "C" App settings, "D" Profile settings, basic data.

The code sequence generated by the application contains the SOS prefix, geographical coordinates and the name of the person [8]. The Wi-Fi SSID can be up to 32 characters long. The SOS-SSID application thus combines the SOS prefix and the characters to follow this pattern: SOS_47.504102,19.134257_NAGY_KAT [9].

At the same time, the application on the phone creates a static HTML page with the personal and important dates, which are as follows:

- positioning coordinates: lat. 47.504102, lon. 19.134257 – the number of coordinate characters has been chosen to show the location within 5 meters after decoding,
- name: na. nagy katalin – all characters are used when encoding the name,
- date of birth: bd. 1983 – only the year numbers of the birth information is used for coding,
- number of people: pe. 01 – with this option, the software allows the user to record the number of people in trouble. the default coding value is 1,
- injury: in. 1 – this option allows a person in distress to notify the rescue team if they have an injury. this option is disabled by default,
- medication requirements: me. 0 – this option allows a person in distress to indicate to the rescue team if they need medication. this option is disabled by default,
- user gender: ge. w – man or woman can be selected within the application,
- blood type: bl. 0+ – this option is used to enter the blood type,

- person's weight: wekg. 63 – the person's weight is recorded and coded in kilograms by the application,
- chronic illness: ci. 00 – with this option, the person in distress can signal to the rescue team if they have a chronic illness. this can be selected from a database. this option is disabled by default,
- notable medications: id. 00 – this option allows the person in distress to indicate to the rescue team what notable medications they are taking regularly. these can be selected from a database. this option is disabled by default,
- drug sensitivity: ds. 00 – with this option, a person in distress can signal to the rescue team if they have a known drug sensitivity. these can be selected from a database. this option is disabled by default,
- spoken languages: la. hu-en – this option allows the person in trouble to indicate to the rescue team in which languages they can communicate. these can be selected from a database. the abbreviation of the hungarian language (hu) is coded by default,
- other information: oi. 00 – the person can record other important information up to 40 characters long. this option is disabled by default.

The generated static HTML page data sample follow this pattern:

LAT: 47.504102_LON: 19.134257_NA:NAGY.KATALIN_BD:1983_PE:01_
IN:1_ME:0_GE:W_BL:0+_WEKG:63_CI:00_ID:00_DS:00_LA:HU-EN_OI:00

DRONE-MOUNTED RADIOFREQUENCY DETECTION COMPONENT

The primary task of the drone-mounted scanning component is to locate the person in trouble through their mobile device. The mobile device acting as a radio frequency transmitting station and the SOS-SSID application running on it transmit the information which is then received by a drone-mounted radiofrequency detection component and transmitted to the terrestrial drone operator (search team). The drone-mounted reconnaissance component consists of a hardware and software environment. The hardware component includes a converted mobile phone for detecting Wi-Fi signals, an external antenna, and a radio frequency transmitter for transmitting the acquired data. The radio channels of the drone control and the drone component of the SOS-SSID system have been chosen so that they do not interfere with the search frequencies, which, in our case are 2,4 and 5 GHz.

Testing and trial measurements of the system were performed at two sites. Figure 3 shows an image taken by a drone camera in a densely populated area and a field and a mobile device requesting assistance. In both cases, the mobile phone we were looking for was placed on the ground in an opened, non-covered area and we were running the SOS-SSID application on the device.

Figure 3. Measurement sites and the SOS mobile phone.

GROUND SUPPORT SYSTEM

The developed drone component primarily aids the effort of the ground support system by providing decision-makers with reconnaissance data in addition to visual information. Such reconnaissance information includes the number and location of the emergency call devices and other information that can be extracted from the SSIDs. Figure 4 shows an image of a locator application running on an operator team test phone [10, 11].

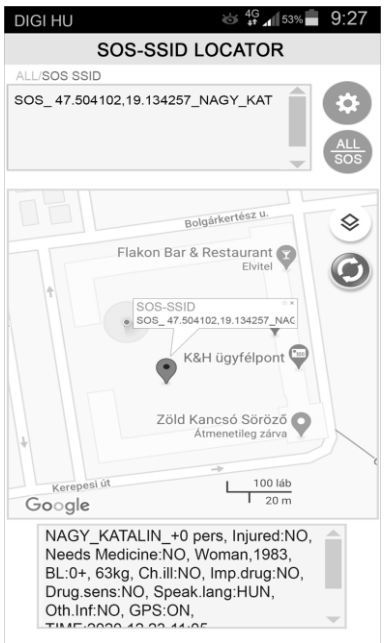

Figure 4. Locator APP for mobile phone.

MEASUREMENTS WITH THE RADIO FREQUENCY DRONE COMPONENT

To obtain accurate results, we have done measurements on the efficiency of our development with different software and hardware pairings under different terrain conditions. Our tools used in the tests are:

- ground mobile Wi-Fi hotspot – SOS-SSID transmitter (Vernee mobile),
- drone and drone control (F550 drone),
- Wi-Fi scanner application + drone-mounted data transmitter (Samsung A70),
- evaluation applications (Wi-Fi heatmap scanner application, SOS-SSID decoder application on Samsung S10 and Huawei P20 mobile).

We started our measurements with the SSID search. The radio system on the drone was set to scanner mode and the drone was given a pre-programmed flight path. After filtering the results obtained during the flight, we identified the exact location of the ground transmitter for SOS_XXXXXXXX. In the second step, we were able to localize the device using a Wi-Fi heat mapping application. This is a confirmatory test to verify that the device which provided the location data had sent it accurately. In the absence of accurate positioning data, the result of the second measurement leads to a target.

FIRST SITE DENSELY POPULATED AREA

Even before we started the measurements, we were aware that we would find several interfering Wi-Fi devices at this measurement site, which was confirmed by the scanning. At the time of the first measurement, 162 active Wi-Fi devices were listed, of which the SSID starting with SOS was easily identifiable. Figure 5 shows the result of a part of the measurement [12, 13].

SSID	FirstSeen	RSSI	CurrentLatitude	CurrentLongitude	AltitudeMeters
UPC8495F4C	2020.12.23 9:26	-70	47.5041759666538	19.134428616101957	172.57224515857615
SOS_47.504102,19.134257_NAGY_KAT	2020.12.23 9:26	-63	47.504148968334675	19.134366740376823	174.35563866489167
UPC8384108	2020.12.23 9:26	-77	47.50425026451712	19.134416163528172	165.32530212402344
Flakon_Privat	2020.12.23 9:26	-86	47.50425026451712	19.134416163528172	165.32530212402344
Mobile	2020.12.23 9:26	-82	47.50425026451712	19.134416163528172	165.32530212402344
UPCBDC7D7C	2020.12.23 9:26	-70	47.50425026451712	19.134416163528172	165.32530212402344
UPC Wi-Free	2020.12.23 9:26	-78	47.50425026451712	19.134416163528172	165.32530212402344
UPC3472114	2020.12.23 9:26	-75	47.50425026451712	19.134416163528172	165.32530212402344
UPC5417917	2020.12.23 9:26	-84	47.50425026451712	19.134416163528172	165.32530212402344
UPC0426658	2020.12.23 9:26	-80	47.50425026451712	19.134416163528172	165.32530212402344
RedWolf	2020.12.23 9:26	-77	47.50425026451712	19.134416163528172	165.32530212402344
chello	2020.12.23 9:26	-89	47.5041759666538	19.134428616101957	172.57224515857615
UPC Wi-Free	2020.12.23 9:26	-87	47.5041759666538	19.134428616101957	172.57224515857615
UPC Wi-Free	2020.12.23 9:26	-85	47.5041759666538	19.134428616101957	172.57224515857615
UPC Wi-Free	2020.12.23 9:26	-82	47.5041759666538	19.134428616101957	172.57224515857615
UPC Wi-Free	2020.12.23 9:26	-73	47.5041759666538	19.134428616101957	172.57224515857615
UPC5417917	2020.12.23 9:26	-72	47.5041759666538	19.134428616101957	172.57224515857615
UPC Wi-Free	2020.12.23 9:26	-79	47.5041759666538	19.134428616101957	172.57224515857615

Figure 5. SSIDs gathered in a densely populated area.

The coordinates recorded by the scanning application do not determine the exact location of the devices, but the drone's location at detection. Therefore, a second, more accurate measurement based on Wi-Fi heat mapping is needed. It can determine the position of a specific SSID with an accuracy of a few meters [14].

The drone scanned around the coordinate of the SOS-SSID location identified in the first measurement. With this flight pattern and using the Wi-Fi Heat Mapping application, we got Figure 6 [15].

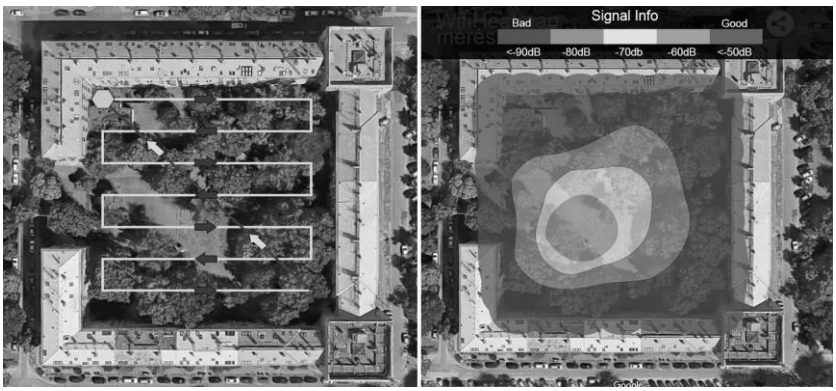

Figure 6. To the left, the flight path of the drone. The right side shows the measured location of the mobile phone that broadcasts the selected SOS SSID.

Second site – Field

The method used for the first measurement was repeated at a second location, a field. From our experience, we knew that radio pollution would be lower at this location. Our assumption was confirmed, we were able to record a total of 4 SSIDs in the field, which also included our own SOS-SSIDs. Figure 7 shows our measurement result. Wi-Fi heat mapping was also performed at this location. Its result is shown in Figure 8.

SSID	FirstSeen	RSSI	CurrentLatitude	CurrentLongitude	AltitudeMeters
STRONG_Extender1610_7Y8R	2020.12.23 10:08	-82	47.5325433965851	19.15625230782399	175.88851928710938
f_anddi_vendeg	2020.12.23 10:08	-91	47.5325433965851	19.15625230782399	175.88851928710938
SOS_47.534936,19.153535_NAGY_KAT	2020.12.23 10:08	-44	47.5325433965851	19.15625230782399	175.88851928710938
Stormy	2020.12.23 10:09	-93	47.532561181240844	19.156246793202683	175.8848419189453

Figure 7. SSIDs gathered in a thinly populated area.

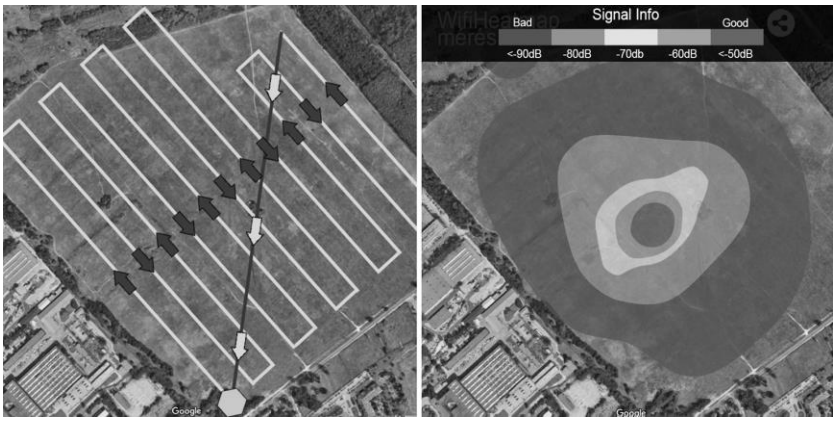

Figure 8. To the left, the flight path of the drone. The right side shows the measured location of the mobile phone that broadcasts the selected SOS SSID.

CONCLUSION

During the developments, we were able to create and successfully test an SOS-SSID radiofrequency system that may be suitable to be integrated into disaster management agencies' systems. During our measurements, it was confirmed that the system we created works efficiently. All its components work in harmony with each other. With this system, the search time can be reduced and human life can be saved. The prepared article and the information contained in it demonstrated the operation of a prototype. Its integration into disaster management systems requires further development.

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FUZZY SYSTEM-BASED EVENT TREE ANALYSIS SUPPORT OF THE SMART SECURITY SYSTEM OF HEALTH CARE CENTERS AND HOSPITALS

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ABSTRACT

One of the keystones of the smart city is the medical area. Health care centres and hospital building structures will change in smart cities, because of the increasing trend of in-day surgery procedures, smart bracelets, and additional wearable sensors, which give a better and more accurate possibility to make a diagnosis from a distance. It means that the functionality of medical centres and hospitals will constantly change, the number of bedridden places will decrease, research and development and IT areas will grow, and fast-medical areas will multiply. The result of the above-mentioned processes is that many more patients will be visiting the buildings near the high-security R&D and IT areas. This may result in an increased incidence of robberies, vandalism, and even terrorism, because of radioactive and psychoactive materials. The new concept of medical and health care centres of smart cities is a source of great difficulty for security systems. For patients, it is a good experience to enter a spacious friendly area without any restrictions, which can significantly reduce the stress factor and can give a healthier atmosphere, while the opposite of this means that nobody is allowed to enter the medical treatment and research area without authorization. Managing (financing, operating, developing, maintaining) smart complex security systems in the above mentioned medical and health care centres is difficult because of the human factor and a large number of connections and internal processes. However, the fuzzy system-based event tree analysis can be a useful mathematical solution to receive inbound values of the systems' elements and the online prediction of the processes' states. The continuous analysis of these factors and information provides facility management with a guideline about the current state of complex security systems. The optimal usage of procedures can maximize the fully functional operational efficiency and reduce hazards. This article gives a useful guideline for operating complex security systems of smart cities in medical health care centres and hospitals. It detects the main connections between their successes and hazards to find the key elements and the inbound and outbound parameters of the smart cities' complex security system. The generated mathematical values provide additional information that could be used as an operational indicator of the whole smart city security system.

KEY WORDS

smart security, smart health care center and smart hospitals, complex security system, event tree analysis, probabilistic approach

CLASSIFICATION

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INTRODUCTION

Nowadays "smart city" is one of the most common expressions, which can be found everywhere, but the real extent of which is poorly defined or not defined at all. Everybody has their own notion of it, and there can be found the broad-, the data-driven-, and the citizen-focused definitions depending on which sector is in the focus. Some rarely defined notions include livability and sustainability [1].

One of the keystones of the smart city is the medical area. Healthcare plays a crucial part in the way people feel about city life, and its significance is constantly growing. Health care centers and hospital building structures will change in smart cities, because of the increasing trend of in-day surgery procedures, smart bracelets and additional wearable sensors, which give a better and more accurate possibility to set up a diagnosis from a distance. It means that the functionality of medical centers and hospitals will constantly change, the number of bedridden places will decrease, research and development and IT areas will rise, and fast-medical areas will multiple.

The result of the above-mentioned processes is that much more patients will be visiting the buildings near to the high security R&D and IT areas. That means a rise in incidences of robbery, vandalism, and even terrorism, because of radioactive and psychoactive materials. The new concept of medical and health care centers of smart cities causes great difficulty for the security systems. For patients it is a good experience to enter a spacious friendly area without any restrictions, which can significantly reduce the stress factor and can give a healthier atmosphere, while the opposite of this means that nobody is allowed to enter the medical treatment and research area without authorization. The facility management has to know the state of the building's security risk in every moment to reduce it and to be able to give prompt answers to any needs for changes, as well as to follow the changes of medical areas.

Our thesis states that with a fuzzy-based expert analysis we will be able to generate a special event tree analysis which shows the efficiency of the complex security system.

ENVIRONMENTAL RISK OF THE HEALTH CARE AND MEDICAL AREAS

New smart cities need the above-mentioned medical services with optimized function. On a minimized territory it is an essential condition, which concentrates the quantity of patients and all other employees, like healing, research, education, IT, R&D etc. The new sections of the medical area, for example diagnosis from distance, big data-based medicine research, blockchain technology, virtual rehabilitation [2] comprise diverse outdoor and indoor facilities with 7/24 work. Diagnosis from distance will bring an explosion of treatments in the near future, as new wearable devices will be able to send personal data directly to health center servers, where an AI application will predefine the diagnosis and will send it to the doctor, who send it to the patient, and from distance can be stimulate the patient for the healing. Every step of this diagnosis from distance procedure is full of security risk. The big data-based AI drug and medicine research applications give the opportunity to provide oncology a good method for precision medicine research [3].

There is a crucial need to guard patients, visitors, employees, goods, infrastructure, and assets against possible threats. It can be seen that all medical centers' entrance is open, but the research and IT facilities in particular have become at least as vulnerable as airports. They must therefore, meet very demanding criteria with regard to security, safety, communications, and building automation – also to uphold their reputation as providers of safe, well-organized services that patients and visitors can rely on.

It is clear that the operation of new medical centers generates security challenges of the complex system, because it has to prevent and respond to in- and outside vandalism, robberies, sabotage and terrorism.

When the security challenges are successfully met, it gives employees and patients confidence in the safety of healthcare centers.

Over the patients' best practice of the health care and medical centers, we have to find out what kind of new features will be implemented in the treatment, then we will be able to get information about the change of the environment.

OPERATIONAL MODEL OF THE ANALYSIS OF THE COMPLEX SECURITY SYSTEM OF MEDICAL AREAS

In this article we define that the complex security system contains several spherical security layers, from prevention, through the mechanical-, electrical-, human layers to insurance.

For the better understanding of the complete security system, it is indispensable to clarify the main connections in the system. The health care center's security analysis without any predefined model has shown a difficult diagram with uncountable variables, events, connections and values. To prevent the malfunctions and to get the highest efficiency of the complex security system it is needed to generate a special pointer that can show the momentary state of the protection. It can be useful for facility management to get on-line information about the level of the whole system.

For a pointer generation the first step is to determine the inputs, the variables, the outputs and the functions of the complex security system in health care centers or hospitals with their inner connections. The following subsystems can be found in the complex security system of our medical center.

The peripheral elements of the system include the preventive security actions, which has - from the building's structure to the well represented hospital regulations – a wide spectrum. It is followed by the mechanical protection sphere where other protection areas get "time" to generate true alarms and to stop hazards. The next element is the access control area which connects the mechanical devices with the electrical signal control devices. Then comes the human force that can respond to the signal. Technical signals can be controlled from a Center and commands will be sent from here. The guards and the patrols can solve unexpected security or hazard situations.

With the above-mentioned elements, the operation diagram of the global security system of health care centers is shown in Figure 1. The model is designed for the inner connections of the global security system. The arrows represent the connections and directions, and the bulk of the area represents the importance of the subsystem.

With this structure all probability of the possible participants can be predeclared. The most important task is to declare the probability of the subsystem's success and fault states. We decided that we would use our earlier research experiences about railway systems, so that we could declare the new probability values of all subsystems and we could implement it to the health care center [4].

Nowadays it is also necessary to prevent unauthorized entrance into the treatment or research area, but in the near future it will be the highest security risk in hospitals. For security reasons special mechanical elements like lattices, security foils on windows and doors or locks are

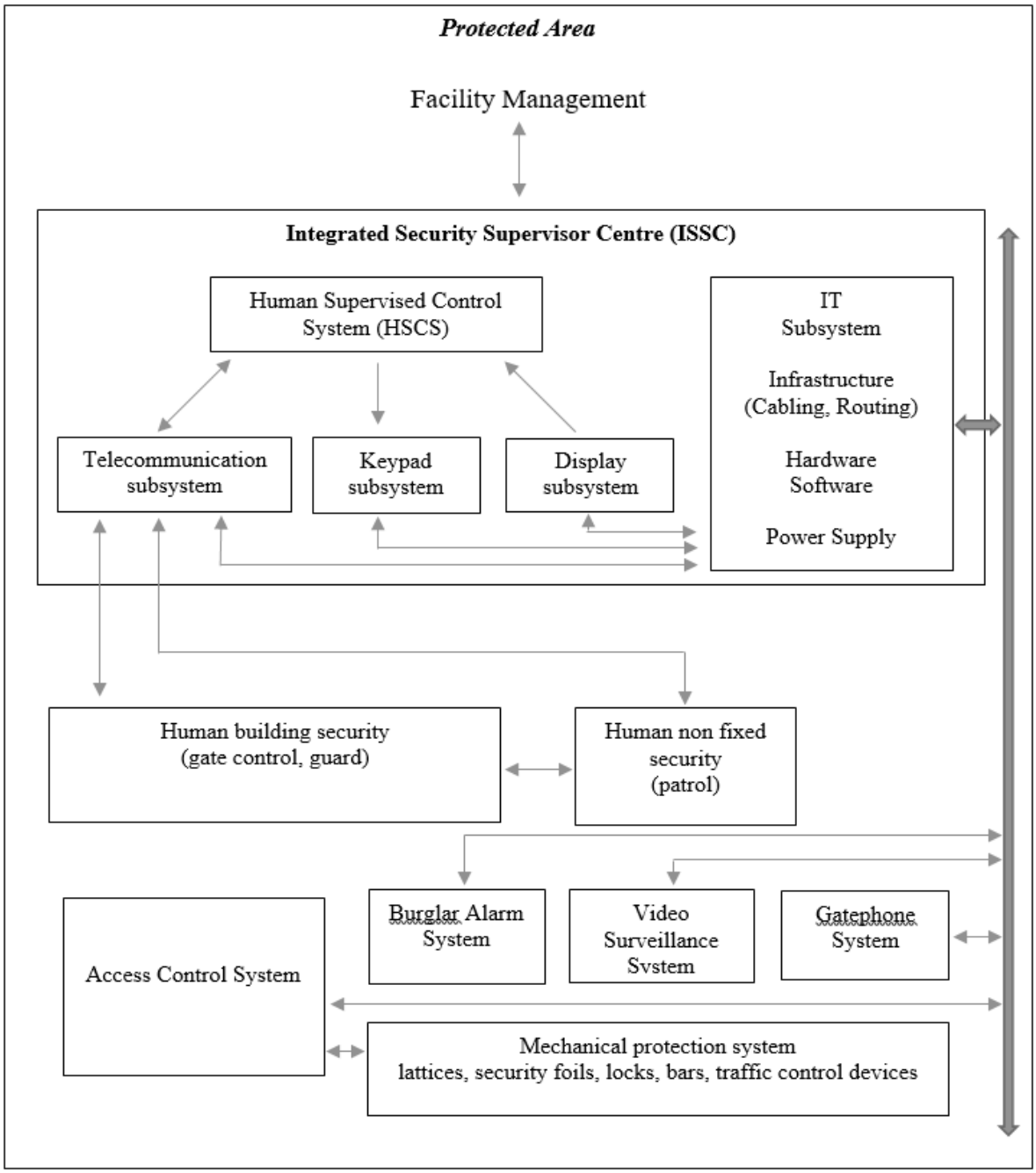

Figure 1. The model of the complex security system in a health care center.

installed inside buildings. Bars and traffic control devices at the entrances control vehicle traffic. At other places fence systems are installed. These mechanical devices form the grounds of a complex protection, as these elements give the other subsystems time to sense, transmit and process the signal and start the procedures of protection.

The access control system is the bridge between the mechanical and the electrical protection subsystems. We could declare that it is neither a mechanical, nor an electrical part, it is an independent element of the complex system in our cases. The main function of this subsystem is to prevent the unauthorized entrance into the restricted area, but it also generates alarm signals to the ISSC. It is not only for controlling traffic, but it also stores all information with timestamps in a non-volatile memory at the controlled area and sends them into the supervisor system.

The electrical protection subsystem contains the video surveillance, the burglar alarm and the gate-phone system. These systems are working together and some inputs and outputs of the access control is integrated here through the ISSC, too. It means a burglar alarm signal can create a video event, so the connected camera will display on the alarm monitor and can also generate an access control event, where all connected electric locks are disabled, only the security guards are allowed to pass through these gates.

The "human" security of the complex system is the most important element, because without any physical force the security system would not be effective. It has two independent parts, the first one is for the security of the building, where guards stand on a pre-defined place (e.g. on the passenger and the industrial entrances of railway stations) of the area, check the traffic and operate the mechanical, electrical, and access control systems. The other part of the human security is the patrol. They are well trained guards divided into small teams. They patrol the area, to prevent the hazards of unattended baggage or unauthorized entrance. Their official uniform and demonstrative physical presence gives a feeling of security in the area, which can reduce the possibility of hazards. In an unexpected event the Integrated Security Supervisor Center (ISSC) can send these teams immediately and directly to the place at risk to prevent or to solve the problems. For the efficient managing of this system, we need a hierarchical structure with well-defined information and command routes.

The ISSC ensures the efficient operation of the protection system, which collects all information related to the protection of the inner and outer area and converts them into the same protocol. With the converted and pre-analyzed signals, it can coordinate with the subsystems.

It can be seen that the subsystems can work together without the ISSC, but in this case because of the low-level integration their efficiency is poor. To prevent any security hazard or bomb attack, an efficient multilevel (low and high) integrated protection system is needed with well-educated and well-trained operators, patrols and security guards. Without the suited trainings it can occur that the efficiency of the complex system is lower than the separated and low-level integrated systems in a disaster, as because of the latent feeling of security, the response can be slow or wrong.

EVENT TREE ANALYSIS

The most important question was what type of probability analysis gives the best performance to the complex security system model of health care centers. We have chosen the Event Tree Analysis (ETA) method.

The ETA was developed for nuclear power plants in the 1970s. It needed to reduce the Fail Tree Analysis trees, because they were too big to get all useful information and the solving methods time was very long. The elements of event trees were physical entities that exist in the nuclear power plant and the processes involved in the tree follow engineering and physical principles.

The ETA is a forward (bottom-up) symbolic logic modeling technique generated in both the success and failure domain. This method gives us the possibility to explore the complex system's responses to an initiating event and enables assessment of the probability of the solved or unsolved subsystems' procedures [5].

Our complex security system in the health care center territory worked for 2 years. The events were recorded by the ISSC's servers and the relevant events were directly sent to an independent database storage server. For the best result, the data was checked manually by us and the undefined statuses were regenerated to get a homogenous database.

After the verification, the events were sent through a type-selection function and was ordered by event type. We could declare the event types, e.g., stolen objects, brawl, or attack against

an employee, missed patients, vandalism, burglar alarms, etc. We thought that the greater quantity of an event type predetermines the probability of the system.

TESTING THE ETA OF THE COMPLEX FOR EFFICIENCY METHOD

At the testing phase we selected the complex security system of a real medical center. We connected to the databases and we scanned all entries. We found that in the database there were more than 2 000 independent events. We made all the auxiliary tables and diagrams to test the method, get enough information to automatize the procedure and make a converter function to the database.

To set up the tree diagrams from the converted database events, the following mathematical functions was used where *P(S)* means the probability of the success events, *P(F)*-the probability of the fail events, *I*-the initiating event, *AND*-the Boolean expression of the logical gate:

$$P(S) + P(F) = 1, \tag{1}$$

$$P(S) = 1 - P(F), \tag{2}$$

$$P(I.F_i.S_i) = P(I.AND.F_i.AND.S_i) = P(I)P(F_i)P(S_i), \tag{3}$$

$$P(I.F_i.S_i) = P(I)P(F_i)P(1 - F_i). \tag{4}$$

In our case the above functions gave the best result for generating an indicator. We used the following method for designing the event tree:

1. the initiating event was identified in each event type,
2. the system elements and components connected with the initiating event were determined,
3. the event sequences were derived though the different system components assuming the success / failure state,
4. to reduce the complexity of the trees the illogical branches were pruned,
5. the probabilities or the possibilities were assigned for the success and failure states,
6. the probability or possibility of each sequence were calculated,
7. the generated trees were analyzed to check the meaning of the numbers.

The following event occurred: from the directors' room of the health care center two mobile phones had been stolen. The event was reported by the secretary to the guard of the health center, who reported it to the ISSC, where the personnel started the protocol to get the information about the security event. Finally, the police were able to identify the culprit. We tested it in more cases, and we found six independent events. The event tree analysis was made of all cases. We found that the success trees average sum value was 0,4107, from 0,3714 to 0,4401. The fault trees average value was 0,59 from 0,5599 to 0,6286.

With our special declaration method, the numbers in the example in Figure 2 mean that the probability of preventing a theft event is 0,3918375.

We tested this method on different security parameters on different events. The difference was significant, we found that on those sites where no camera controls were used the success tree maximal sum value was 0,18 and the fault tree minimal sum value was 0,82.

It can be said that the success and the fail values can be used as an efficiency indicator in this case.

The following event occurred: On the 4th Floor, there was a massive brawl and a hit against a treatment employee. The event was reported by the guard of the hospital to the security center ISSC, where the personnel started the protocol to get the information about the security event. Finally, the patrol of the hospital was able to identify the participants and took them out. The ETA diagram shows that the complex system functionality was near zero, but information about this event is absolutely positive, because the culprits were arrested by the police. We found four independent events in the database with the same event type.

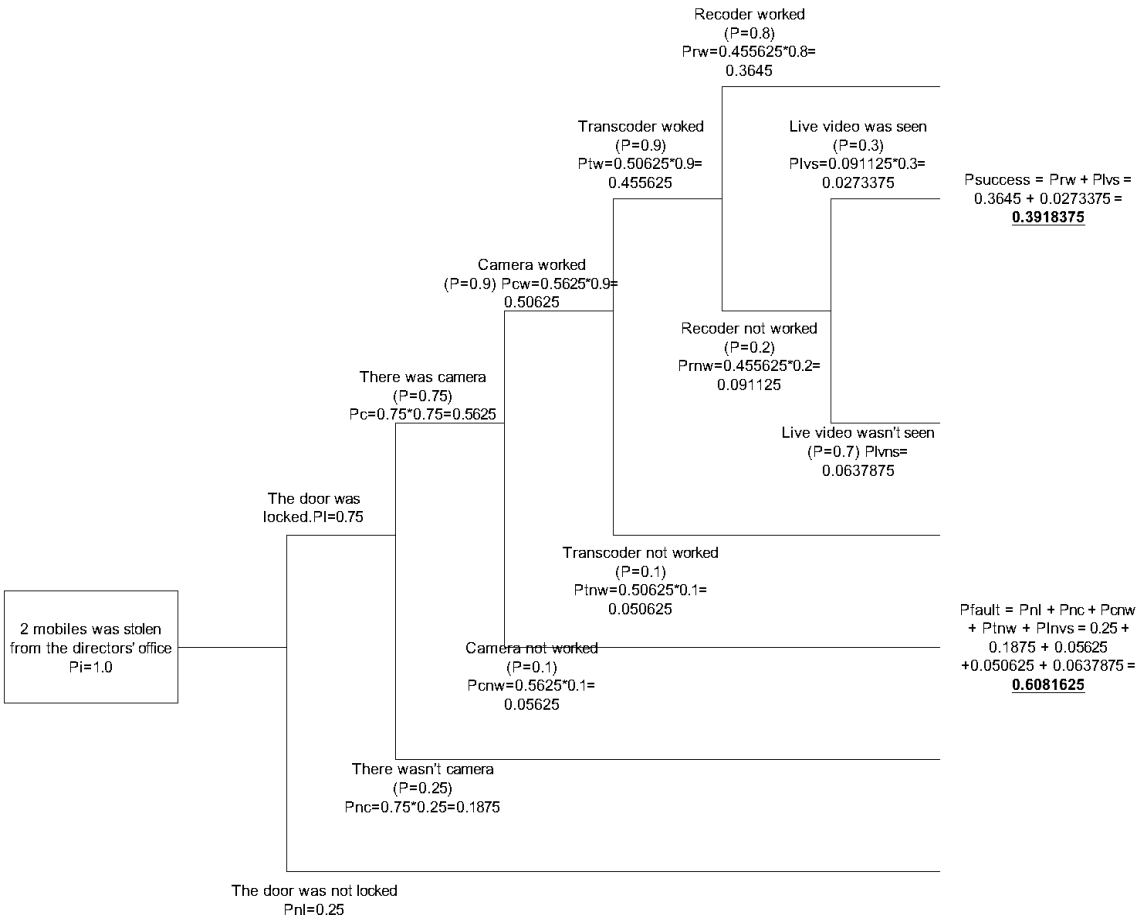

Figure 2. The ETA diagram of the example of a theft event.

The event tree analysis was made for all cases. We found that the success trees average sum value was 0,0904, from 0,0772 to 0,104. The fault trees average value was 0,9096 from 0,896 to 0,9228.

With our special declaration method, the numbers in the example in Figure 3 mean that the probability of preventing an array event is 0,08505.

We tested this method on different security parameters on different events. The difference was significant, we found that on those sites where no camera controls were used the success tree maximal sum value was 0,18 and the fault tree minimal sum value was 0,82.

It can be said that the success and the fail values can be used as an efficiency indicator in this case.

The following event occurred: The wall of the hospital was broken because of vandalism, or for robbery. The event was reported by the guard of the hospital to the security center ISSC, where the personnel started the protocol to get the information about the security event. Finally, the police were able to identify the culprit.

The ETA diagram shows that the complex system functionality was near 0,17, but the information about this event is absolutely positive, because the culprits were arrested. We found three independent events in the database with the same event type.

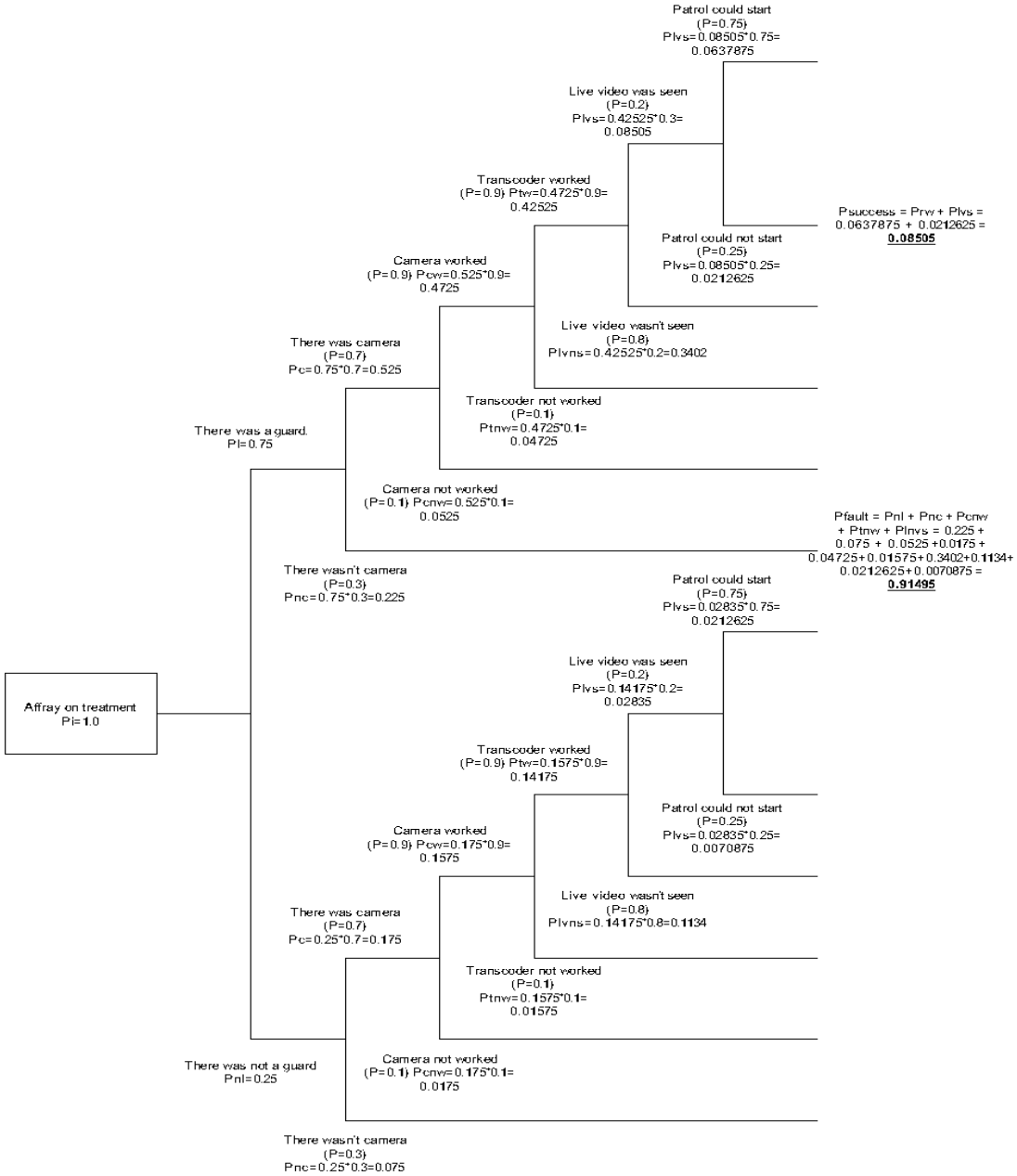

Figure 3. The ETA diagram of the example of an affray event.

The event tree analysis was made for all cases. We found that the success trees average sum value was 0,1764, from 0,1694 to 0,1811. The fault trees average value was 0,8236 from 0,8189 to 0,8306.

With our special declaration method, the numbers in the example on Figure 4 mean that the probability of preventing a vandalism event is 0,17415.

We tested this method on different security parameters on different events. The difference was not significant, we found that on those sites where no camera controls were used the success tree maximal sum value was 0,08 and the fault tree minimal sum value was 0,92.

It can be said that the success and the fail values can be used as an efficiency indicator in this case.

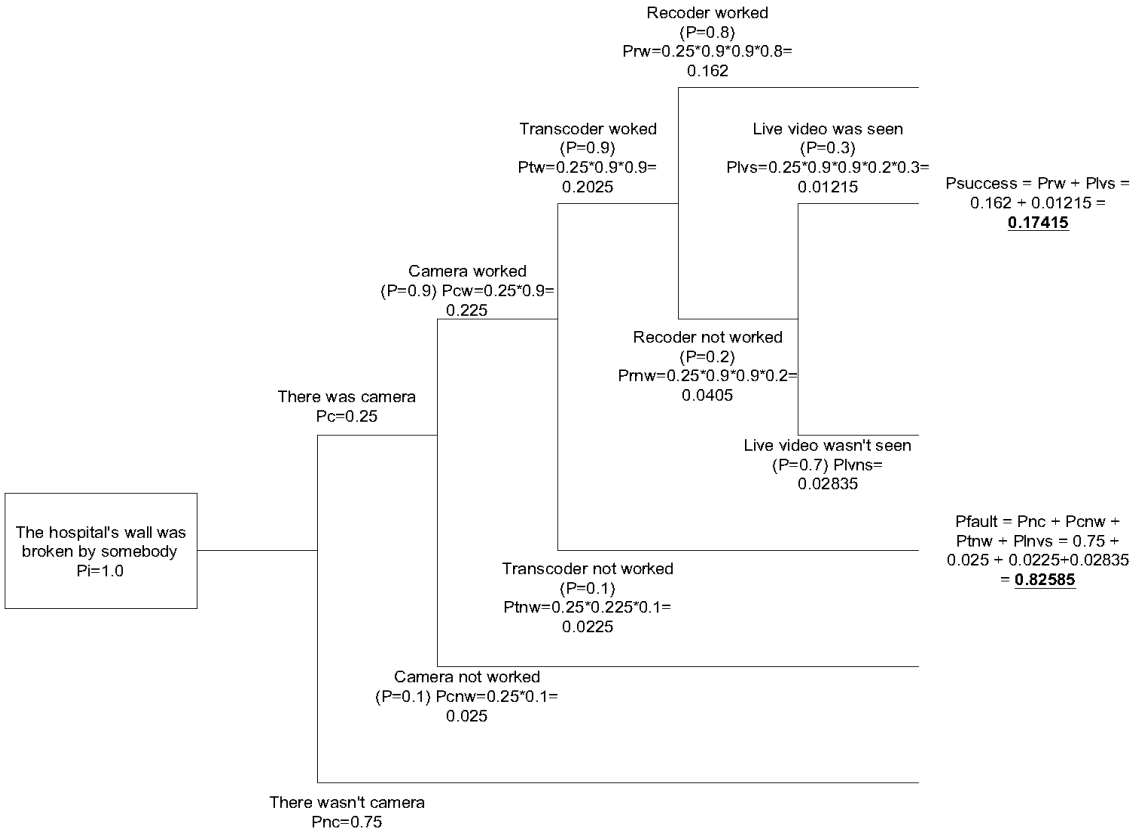

Figure 4. The ETA diagram of the example of a vandalism event.

The following event occurred: The patient was on a treatment in the hospital – where the interval was indifferent – and during the treatment the patient went missing. The event was reported by the health staff of the hospital to the buildings guard, who informed the security center ISSC, where the personnel started the protocol to get the information about the security event. Finally, the police, or a citizen were able to find the missing patient.

On this site there were several independent missing patient events (five events), so we made all the ETA diagrams of them to get more information about the system. After the analysis we found that the same type of complex security systems the success and the fail results gave significantly the same numbers. The success tree average sum value was 0,0534, from 0,036 to 0,072. The fault tree average value was 0,9466 from 0,928 to 0,964.

We tested this method on different security parameters on different events. The difference was significant, we found that on those sites where no access control (physical authentication checking point) was used the success tree maximal sum value was 0,03 and the fault tree minimal sum value was 0,97. It can be said that the success and the fail values can be used as an efficiency indicator in this case.

The results of the test showed us that the event trees can be used for indicators, but in the complex system the different types of events derive different value spread. It means that the probability numbers cannot be used directly, but there is a possibility to get the efficiency of the system. First, event tree diagrams must be generated for all event types, and the probability and the possibility averages and the spreads can be declared. When a new event occurs and after the analysis the indicator number is over or below the spread, it means that the efficiency of the system is out of the optimal state, so an element change or another subsystem installation is needed.

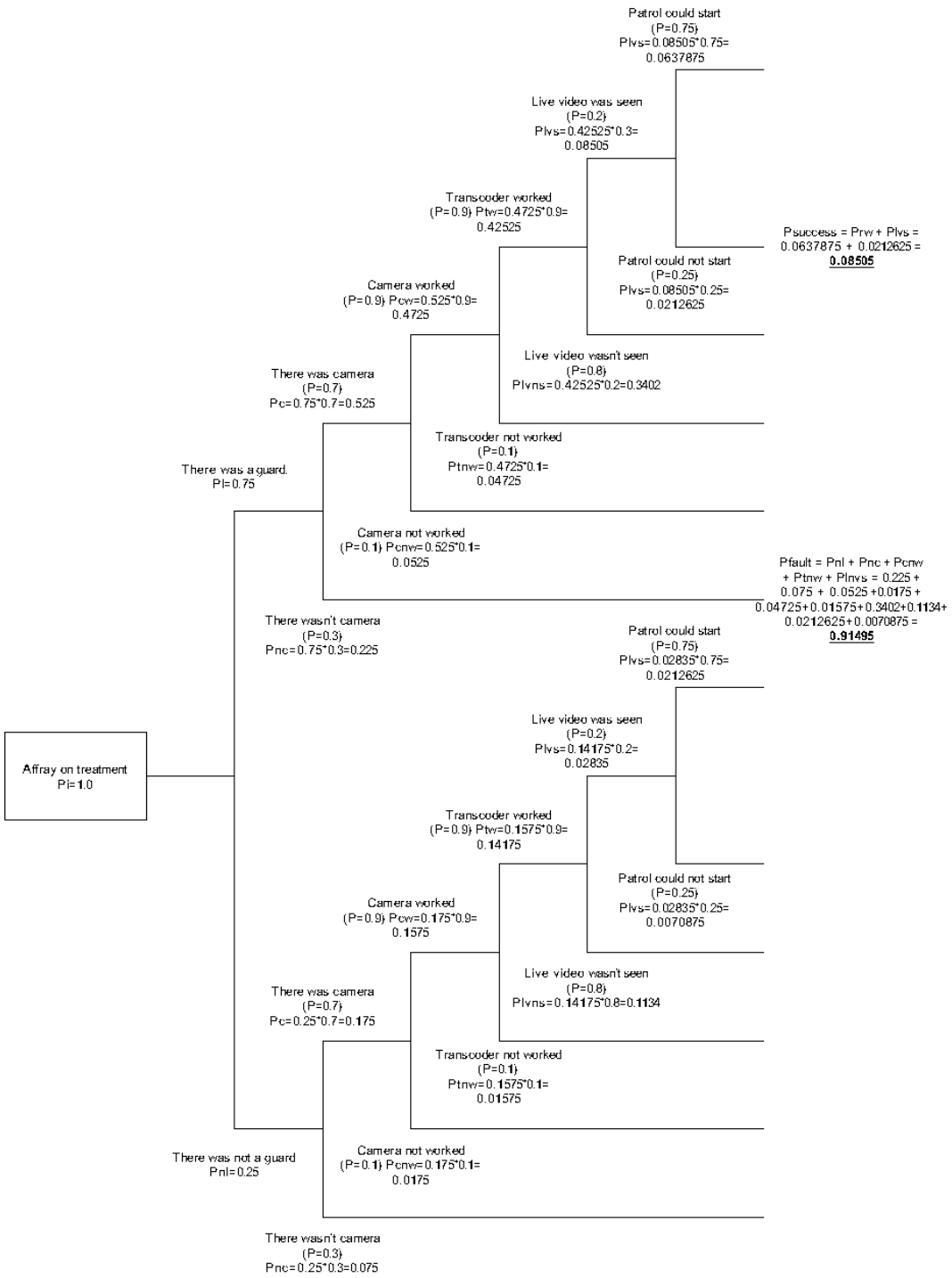

Figure 5. The ETA diagram of the example of a missing patient event.

Table 1. Event – Succes – Fault.

Event	Success	Fault	At the end
Patient missing	0,072	0,928	Found at home
Mobile Stolen	0,3918375	0,6081625	No Result
Wall broken	0,17415	0,82585	Found by police
Affray	0,08505	0,91495	Found by police

The Success Indicator Values mean that the preventive strength of the complex security system against the Initiating Event can be declared in every case and that shows the efficiency of the whole system.

CONCLUSION

In this article we analyzed the changes of health centers and hospitals in smart cities. The future possibilities were collected and we tried to find a useful operating method for the facility management to keep the efficiency of the complex security system in an optimum position during these fast-changing times. First the main connections with their hazards were declared to find the key elements and the in- and outbound parameters of the security system, and generate an operating subsystem-based model of it. The pre-generated knowledge base and the Event Tree Analysis with well-defined event type templates can generate the efficiency values of the security system. With these numbers the facility management gets on-line information about the state of the system with the needs of improvement, and also the cost, which means that the management receives all important information for the proper budget planning for years and the ability to reduce the security risk of health care centers in smart cities. With a simple self-learning function, it will be possible to create an application that can provide exact suggestions on what the most vulnerable part of the protection is and what needs to be changed in the near future. This method can be adopted to another territory if the knowledge base is redefined, and the database structure is the same as in this case.

The aforementioned theoretical, logical and mathematical methods can give an exact on-line information about the efficiency of the complex system.

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THE PERFORMANCE ANALYSES OF IEEE 802.15.4G SUN LOW-POWER WIRELESS NETWORKS AND THEIR APPLICATION

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ABSTRACT

In the era of expansion of smart sensing interconnected devices and their growing application in complex systems, the application of wireless communication technology becomes evident. Many wireless technologies are developed to facilitate the growth of systems such as the Internet of Things and Smart Cities. The application of a particular wireless technology in a particular system depends on many factors, such as purpose, requirements, complexity, range, and node deployment. IEEE 802.15.4 is a technical standard that defines the operation of low-rate wireless personal area networks. It is used as the basis for a group of network standards and protocols designed for wireless sensor networks. In this article, the basic features of the emerging IEEE 802.15.4g SUN low-powered wireless network standard, its application scenarios, and performance analyses are presented.

KEYWORDS

smart utility networks, wireless network performance evaluation, indoor propagation, wireless sensor networks, wireless communications

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INTRODUCTION

The appliance of a variety of emerging wireless communication technologies grows together with the increase in the numbers of smart sensing interconnected devices and their application in complex systems. All these factors influenced the development of a variety of metering systems applicable in industry and new field services designed to improve the efficiency and productivity of utility sites, especially in the smart-grid infrastructure. These new services, among others, are the Smart Metering Utility Networks (SUN). SUNs enable multiple applications to operate over shared network resources, providing monitoring and control of utility systems. The scenarios of usage of SUNs include very large-scale, low-power wireless applications designed to use the maximum power available under applicable regulations. The technology should provide long-range, point-to-point connections and coverage of geographically widespread areas containing a large number of outdoor devices. Wireless SUN (Wi-SUN) networks are designed to enable wireless connectivity between smart-grid devices. Wi-SUN Alliance [1] is a consortium of global corporations and world leaders in Smart Utility, Smart City, and IoT Markets formed to improve utility networks using narrowband wireless technology.

With the existence of a great number of applicable wireless technologies used to facilitate the growth of these systems, experiments on the usability of emerging technologies in industrial environments continue to have an important role. The IEEE 802.15.4 is a technical standard that defines the operation of Low-Rate Wireless Personal Area Networks (LR-WPANs). This standard is used as the basis for a group of network standards and protocols designed for wireless sensor networks. This standard has a high potential for implementation in smart metering and similar systems. In this article, the basic features of the emerging IEEE 802.15.4g SUN low-powered wireless network, its application scenarios, and performance analyses in the industrial environment are presented.

IEEE 802.15.4g AND SUN NETWORKS

IEEE 802.15.4g [2] and IEEE 802.15.4e [3] are amendments of IEEE 802.15.4-2011 [4]. These amendments give additional enhancement in industrial application features and radio communications mechanism suited for a SUN. The inclusion of various functionalities such as robust multihop, power saving, interference detection/avoidance, and optimized physical layer design are also enabled with these standards [5]. These additions to the physical layer and MAC layer requirements made both standards more effective for applications in SUN. IEEE 802.15.4g targets usage scenarios in Neighbourhood Area Networks (NAN) too, for the environments where utility meters are deployed outdoor and form mesh/ad hoc networks [6]. Compared with the baseline standard, such usage scenarios present more technical challenges due to a harsher environment [7].

The IEEE 802.15.4-2015 [4] standard revision dates from 2015. It includes three new physical layers targeted to SUN applications. The three layers are MR-FSK, MR-OQPSK, and MR-OFDM. MR stands for multi-rate multi-regional. The MR-FSK and MR-OQPSK modulations focus on maintaining backward compatibility with previous standards and commercially available transceivers, whereas the MR-OFDM focuses on adding robustness and improving spectrum efficiency at the physical layer [7]. The IEEE 802.15.4g as revision defines the PHY specifications for outdoor networking environments, e.g. Wi-SUN. The frequency bands for this technology are 868 MHz (Europe), 915 MHz (USA), and 2,4 GHz ISM (global). Combining different parameter values (speed, bandwidth, etc.), this standard offers numerous options for PHY, and achievable speeds ranging from 6.25 kbps to 800 kbps and frames up to 2 047 bytes [2, 8].

Besides the data rates up to 800 kbps, the IEEE 802.15.4g SUN specification supports a long communication range of several hundred meters and a reliable mesh-routing protocol, which is expected to be a promising solution for mesh sensor networks. It has been processed to offer a global

standard that facilitates large-scale process control applications, such as smart-grid networks. This standard also provides application mainly to outdoor communications, and mechanisms to coexist with other systems in the same bands, such as the IEEE 802.11, IEEE 802.15, and 802.16. [9]

The Wi-SUN systems for the wide-area of the IoT are composed of two types of wireless stations, i.e. the devices and the coordinators. In the uplink (UL), the devices with sensors or meters transmit acquired data to the coordinators. In the downlink (DL), the coordinators send control signals to the devices. Although Wi-SUN systems support multi-hop transmission, from the viewpoint of running cost, the area in which the coordinators can communicate with the devices directly should be as wide as possible. [10]

APPLICATIONS OF IEEE 802.15.4g Wi-SUN

The usage of the IEEE 802.15.4.g standard for smart metering and SUN as a part of a smart grid is presented in the article [6]. In other research [8], the example of an application of IEEE 802.15.4g standard in healthcare systems, developed for health monitoring and data aggregation is given. The article [11] shows the application of the IEEE 802.15.4.g standard in environmental indoor monitoring systems for sensing temperature, humidity, CO2, and energy control. The article [12] presents the usage of IEEE 802.15.4g for OpenMote open-hardware prototyping ecosystems, which is used for the implementation of the Industrial Internet of Things (IIoT). In the research [13] the evaluation of IEEE 802.15.4g is given for environmental monitoring and it is proved that this standard can be used for outdoor operations with the ability to reduce the number of repeater nodes. In the same research, the usage of the IEEE 802.15.4g standard for monitoring, intrusion and fire detection, elevator monitoring, HVAC, and lighting management in Smart Building application is presented. The article [5] shows the usage of IEEE 802.15.4g in applications in outdoor environments for facilitating communication in SUN, machine-to-machine (M2M) networks, and sensor networks.

In [10] a wide area Wi-SUN system is proposed based on IEEE 802.15.4g composed of a high-performance base station (BS) and terminal devices with sensors and meters. In the proposed system, the high-performance BS is developed as the coordinator, which is rich in power supply and calculation resources. In the DL, transmission power is enlarged, and in the UL, high gain directional antennas are used, e.g. the transmission power of the BS is around 10 dB more compared to other devices. In the same research, a method for measuring the performance of proposed systems during the field experiments in the urban area is presented.

PERFORMANCE ANALYSES OF IEEE 802.15.4g

Considering the potential of the IEEE 802.15.4g, the evaluation and analysis of the performance of standards are presented in this article. For the evaluation, the data set presented in [7] is used. The data set is available at [14]. During the evaluation, the three PHY layers are compared: SUN-FSK, SUN-OQPSK, and SUN-OFDM. The data set is collected during the experiment described in the same source [7] in the industrial indoor environment. Eleven nodes are evaluated. The distances of the nodes from the receiver range from 34 to 273,5 meters. The data set is evaluated in two ways. First, the measured Received Signal Strength Indicator (RSSI) data from each node are compared with the ITU Indoor Propagation model [15]. The estimated signal strength at the receiver side is calculated using the following formula:

$$P_{rx} = P_{tx}+G_{tx}+G_{rx} - L_{pl}. \quad (1)$$

The parameters of the formula (1) are as follows: P_{rx} is received power presented in dBm, P_{tx} is transmitter output power also in dBm, G_{tx} is transmitter antenna gain in dBi, L_{tx} is total

transmitter losses in cable, connectors, etc. in dB, and L_{pl} is propagation loss or path loss also in dB, calculated with the formula (2).

The ITU indoor propagation model uses the following formula [15] for calculating indoor propagation path loss L_{pl} in decibels [dB]:

$$L_{pl} = 20 \cdot \log_{10}(f) + N \cdot \log_{10}(d) + L_f(n) - 28, \quad (2)$$

with the following parameters: N is the distance power loss coefficient, f is the frequency in MHz, d is the distance in meters, $L_f(n)$ is the floor penetration loss factor in decibels, n is the number of floors between the transmitter and the receiver. The $L_f(n)$ is omitted from the calculation because all nodes in the experiments were deployed at the same level. In [15] the recommended values for N are 22, 28, and 30. For the best fitting of the model, the range of values from 22 to 38 are used for N to achieve the highest accuracy in estimating signal strength. The best-fitting is determined with the use of the Root Mean Square Error (RMSE) value.

RESULTS

The results of the analyses are displayed in Fig. 1. The SUN-FSK is shown in Fig. 1 a) with the best fitting for the value of N = 34, and the SUN-OFDM is shown in Fig. 1 b) with the best fitting for the value of N = 31.

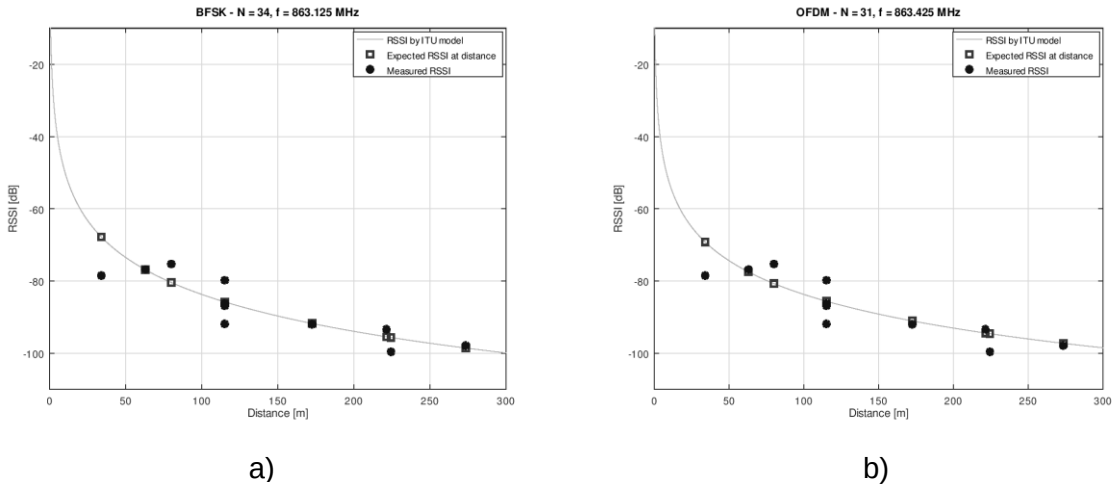


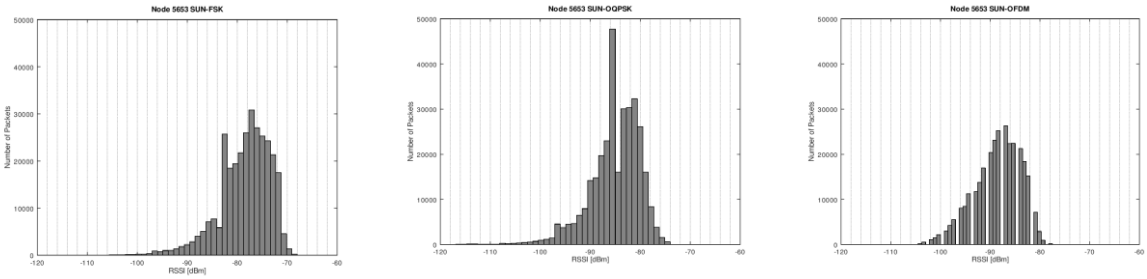
Figure 1. The accuracy of the ITU model with a) SUN-FSK and b) SUN-OFDM modulation.

The fitting of the ITU indoor model with the different values for N and with resulting RSME in decibels is shown in Table 1. The SUN-FSK and SUN-OQPSK have similar results with the lowest RMSE with N = 34 when RMSE is around 4,6 dB. SUN-OFDM has the best fitting with N = 31 when the RMSE is 4,46 dB.

Table 1. The architecture of the learning system.

No.	Modulation	TX frequency	N value	RMSE
1	FSK	863.125	22	26,0868
2	FSK	863.125	28	13,9049
3	FSK	863.125	30	10,0506
4	FSK	863.125	34	4,6304
5	OQPSK	868.3	22	26,0357
6	OQPSK	868.3	28	13,8555
7	OQPSK	868.3	30	10,0037
8	OQPSK	868.3	34	4,6219
9	OFDM	863.425	22	20,199
10	OFDM	863.425	28	8,3934
11	OFDM	863.425	30	5,2909
12	OFDM	863.425	31	4,4611

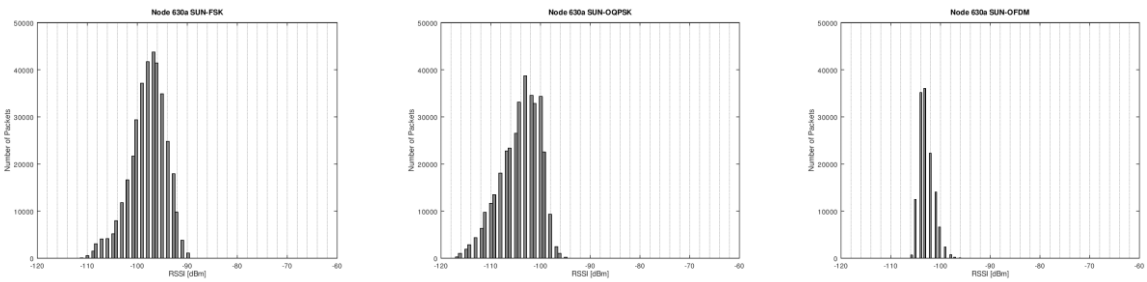
The second approach in comparison of three different PHY layers is the analysis of the variations of signal strength of nodes 5 653 and 630a. Two nodes are selected as the closest (5 653) and furthest (630a) nodes from the receiver. The distribution of RSSI per packet of those two nodes is shown in Fig. 2 for node 5 663 and in Fig. 3 for node 630a, for FSK, OQPSK and OFDM respectively.



a) b) c)

Figure 2. The RSSI of packets of node 5 653 a) SUN-FSK b) SUN-OQPSK c) SUN-OFDM.

In Fig. 2 and Fig. 3 it can be seen that the packet RSSI distribution differs for all three modulations. The standard deviation of RSSI for node 5 653 is 5,0187 dB for SUN-FSK, 5,0663 dB for SUN-OQPSK, and 4,7193 dB for SUN-OFDM. Node 5653 is deployed at a distance of 34 m from the receiver. The difference between the maximal and minimal RSSI values is 43 dB for SUN-FSK, 44 dB for SUN-OQPSK, and 30 dB for SUN-OFDM.



a) b) c)

Figure 3. The RSSI of packets of node 630a a) SUN-FSK b) SUN-OQPSK c) SUN-OFDM.

The distance between the node 630a and the receiver is 273,5m. The standard deviation of RSSI is 3,5661 dB for SUN-FSK, 3,9341 dB for SUN-OQPSK, and 1,5061 dB for SUN-OFDM. The difference between the maximal and minimal RSSI values is 23 dB for SUN-FSK, 25 dB for SUN-OQPSK, and 15 dB for SUN-OFDM.

CONCLUSION

This article deals with the performance analyses of the IEEE 802.15.4g Wi-SUN and its behavior in industrial applications. The third-party dataset is used for the analyses. The analyzed data contain the RSSI of received packets and the distance between transmitter and receiver. For the analyses, the comparison of collected data with the ITU indoor propagation model is made. The ITU model shows great accuracy in the estimation of the received signal strength (RSSI) for given locations and experimental environments. The distribution of received packet strengths, as well as the values of standard deviation, indicate that the IEEE 802.15.4g Wi-SUN technology is highly applicable for industrial scenarios. This research and its results will be used as a motivation for authors to make further analyses and experimentation with the IEEE 802.15.4g technology.

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Interdisciplinary Description of Complex Systems 20(3), 257-266, 2022

ASSESSING THE SUSTAINABILITY OF TRANSPORTATION AS CRITICAL INFRASTRUCTURE: A PREDICTION MODEL FOR ENVIRONMENTAL DIMENSIONS USING JORDAN AS A CASE STUDY

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ABSTRACT

Sustainable development, for various sectors, aims to achieve a balance between several objectives, maintaining the environmental, economic, and social dimensions to allow development to continue invariably over time. The planning processes for sustainability to improve civilization and urban development must include urban infrastructure and transportation since they are the major sectors that provide a continual flow of goods, materials, products, services, and information to improve living conditions and protect a country's defence, economic viability, prosperity, awareness, safety, and security. The right transportation mode will allow the provision of good levels of service, thus increasing the satisfaction of current and future potential users. The development of sustainable transportation infrastructure is key in modern societies. If the sustainable transportation system is well planned and managed in developing countries, it will improve and facilitate living conditions in a way that is compatible with the next generation's needs and will facilitate progress, prosperity, environmental, social, and economic welfare; if it is not well planned, it will hinder such progress. This article aims to assess sustainability dimensions for transportation as a critical infrastructure in terms of social, economic, environmental, technological, and energy aspects, with emphasis on environmental aspects. Measures of performance indicators for each dimensional goal are developed based on the data and statistical findings. The study uses models, an analytical descriptive style, and a methodology based on previous studies, as well as secondary data sources. Recommendations for enhancing transportation sustainability and potential reforms are proposed that can be applied to Jordan and generalized for other developing countries with similar circumstances.

KEY WORDS

critical infrastructure development, transportation sustainability, economic, energy, environment

CLASSIFICATION

JEL: R40, R42, R48

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INTRODUCTION

Sustainability implies the provision of more efficient services that maintain public health and welfare, are cost-effective, and reduce negative environmental impacts, both now and in the future. A definition of sustainable development provided by an ASCE/UNESCO working group on developing sustainability asserts that sustainable development is truly about achieving a balance between several objectives (environmental, economic, and social) over dynamic time and spatial horizons. Accordingly, research in the area of sustainable urban infrastructure reflects the need to design and manage engineering systems in light both of environmental and socioeconomic considerations. A principal challenge for the engineer is the development of practical tools for measuring and enhancing the sustainability of urban infrastructure over its life cycle [1, 2].In order to assess environmental sustainability performance, two major aspects (technology and energy) must be taken into consideration, in addition to the known three dimensions of transportation sustainability, since they affect the economy not only through operational processes but also through the manufacturing of vehicles and the construction of the infrastructure [3]. The development of environmentally sustainable transportation is vital since the modes of transportation that depend on fossil fuels are causing all kinds of pollution, emissions, waste, etc. Adopting the suitable planning and modelling strategies for the development of transportation system infrastructure is the main goal for any study, since this will improve the current and long-term situation. However, as the population has increased over time, cities have grown, and globalization and free trade have increased the regional and international movement of people and goods, leading to the dramatic expansion of our transportation infrastructure and systems. The cars, trucks, buses, subways, trains, airplanes, ships, and ferries that we use to move ourselves and our goods today have significant implications in terms of energy and material resource use, environmental pollution, noise, and land use at local, regional, and global levels. Transport is a vital sector for the Jordanian economy and an important component of the daily life of Jordanians. In the past decade, the country has heavily invested in expanding the road network, which constitutes the backbone of the national transport system, improving urban transport, and enhancing the logistics industry and international connections. In parallel, the transport sector has seen a gradual process of liberalisation, opening the market to private operators and private investors. To face these new tasks, the institutional set up has been, and is still being, gradually transformed [4]. Transport demand, both for passengers and freight, is growing rapidly, due to the growing population and the economic development within the country and in the region. This growth is concentrated on parts of the transport networks near the main urban areas and along the key corridors. As a consequence, parts of these networks are under pressure, and performance is below that required. This situation is predicted to worsen to the end of the next decade, with the system becoming unable to perform as needed to support the Jordanian economy and the daily life of citizens. Like any other developing country, the infrastructure and transportation sector in Jordan suffers from short-sighted planning and lacks a comprehensive and integrated vision, which has left Jordan with serious problems related to high levels of congestion, especially at rush hours, poor safety procedures, high incremental traffic accident figures, and low-quality requirements for transporting goods and passengers. The remainder of this article is structured as follows: the next section provides a literature review related to sustainability and transportation. The subsequent section provides an analysis of Jordan's infrastructure and transportation. This is followed by an explanation of the methodology adopted in this research. The subsequent section presents and analyses the results. Conclusions, including predictions and recommendations are provided in the final section.

LITERATURE REVIEW

Defining sustainability and the sustainable development of transport systems in the current research climate is not easy since it incorporates global aspects related to meeting present needs without reducing the ability of future generations to also meet their needs; for example, "There are no common opinions also about city public transport safety systems and controlling the public transport system in a whole, it is necessary to remember also about sociological factors. Europe needs professionals and also young professionals especially in the field of sustainability, sustainability in transport including energy efficiency, ecology and other aspects". Achieving energy efficiency and reducing global pollution is possible if, and only if, sustainability is implemented in each field. A re-examination of the definition of sustainability will be key for new scientific ideas and ways of thinking about public transport systems and their sustainable development. Public transport systems can be sustainable based on the type of impact they have on the environment and society. They can also be a means of helping to achieve sustainability in other aspects of human life [5]. There is much discussion about sustainability and about transportation indicators. Jeon, Amekudzi and Guensler [6] developed 11 indicators to determine environmental, social, and economic impacts, as well as the sustainability performance of the transportation system for different scenarios in Metropolitan Atlanta. The 11 quantified indicators were aggregated into four dimensions of sustainability indices (environmental, social, and economic impacts, and transportation performance). Scenarios were evaluated based on a composite sustainability index encompassing the indices for the four sustainability categories. Maoh and Kanaroglou [7] developed a tool as an add-on module in an integrated transportation and land-use model for assessing urban sustainability. The indicators were based on large-scale simulation models such as SPARTACUS, PROPOLIS, and PROSPECTS to reflect aspects of the environment, society, and economy, grouped into three sustainability categories. The weights for the individual criteria were developed through a Delphi process using four experts in the field of transportation planning. The weights of the indicators were based on the relative costs to society for those indicators. The tool thus provides information on identifying appropriate performance measures for sustainable transportation (see Figure 1).

Sustainability dimension	Goals	performance measures
Social	Max Mobility	Travel Rate
	Max Safety	Accidents per VMT
Economic	Max Affordability	Point-to-Point Cost
Environmental	Min Air pollution	VOC, Car on CO and NOx Emissions
	Min Energy Use	Fuel Consumption

Figure 1. Maoh and Kanaroglou's sustainability categories for assessing urban sustainability [7].

According to Haghshenas and Vaziri [8], although there has been numerous studies about indicators and their application, few studies uses sustainability indicators to compare systems. Previous studies that have applied this concept include Jeon [9], Kennedy [10], Haghshenas and Vaziri [8], Miller [11], and Jeon, Amekudzi and Guensler [12], considered sustainability in terms of dimensions that can be quantified.

JORDAN'S INFRASTRUCTURE

Jordan is unlike other neighbouring Arab countries; it is a non-oil-producing country with limited natural resources and minerals. The country faces persistent unemployment, in addition to a growing budget deficit and inflation. Jordan is known as a politically stable country;

however, the area surrounding Jordan currently is not. Like many other developing countries, it has experienced rapid population growth. Furthermore, the nation is experiencing increased pressure on natural resources, widening income disparities, and growing poverty. Countrywide, access to fresh water represents the most pressing challenge, both in terms of quantity and quality [13]. Since Jordan enjoys conditions of security and political stability, Jordan has been subject to many waves of forced migration since 1948, which were mostly for political reasons due to wars and revolutions in several neighbouring countries. Jordan experienced four major immigration waves, which caused unexpected increases in the population; the population has increased 10 times in the last 65 years. [14]. Infrastructure has been affected by these unexpected increases in population, the major effects were on water, transportation, energy, education, and health. The civil war in Syria, which began in 2011, is still having serious impacts on the region, while the situation in Iraq, dating back to 1990, can still be valued as unstable [4].

ENERGY

Jordan imports 96 % of its energy from other countries, which constitutes a high percentage (8 %-20 %) of the country's GDP. This has led to scaling up the development of alternative energy sources and enhancing energy efficiency in buildings and industrial processes; this is critical since demand for energy is increasing year on year (driven largely by the population increase discussed above) (see Figure 2).

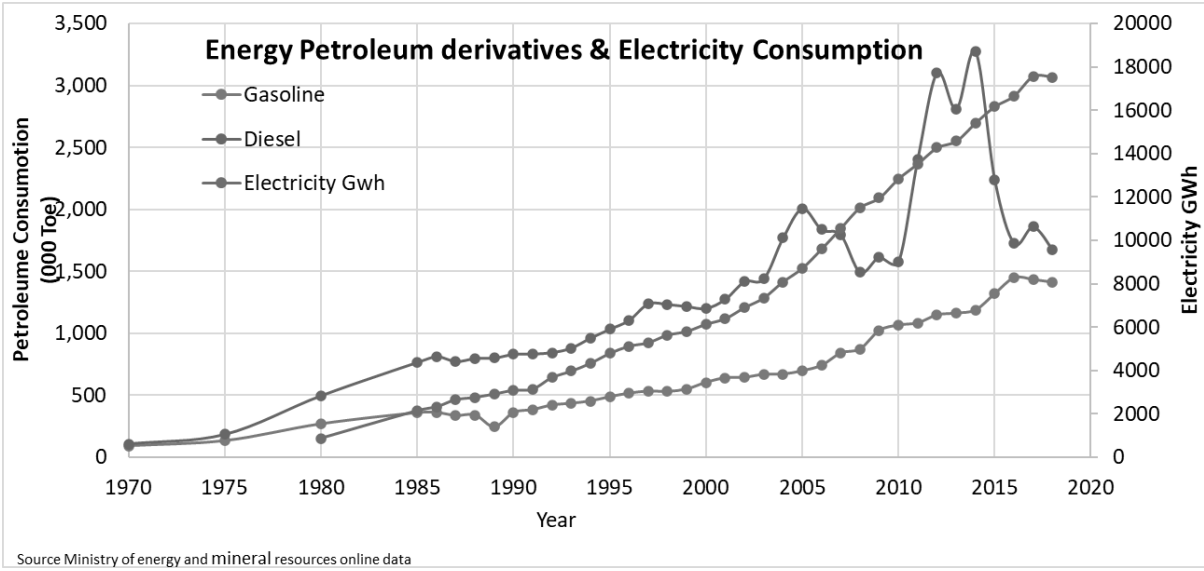

Figure 2. Jordan's energy consumption, petroleum derivatives and electricity consumption [16].

Jordan enjoys an atmosphere that meets many of the criteria for successful renewable energy investment. One of the most crucial perquisites for renewable energy success in Jordan is that it enjoys 300-320 days of full sunshine a year. It also has an above-world-average wind speed of 7 meters per second (as high as 7,5 meters to 11,5 meters per second in hilly areas) and has among the highest per capita ratios of engineers in the world.

TRAFFIC, MOBILITY, AND SAFETY

Jordan has one of the highest per capita and per vehicle ratios for traffic accidents involving fatalities in the world coinciding with low pedestrian safety procedures. Based on Jordan's Long Term National Transport Strategy, transport safety is a critical issue in Jordan. Although the Jordan National Transport Strategy encompasses all transport modes, the most significant improvements in Jordan's transport-related safety challenges need to be achieved mainly in the road sector. The proposed relevant measures cover three fields of action: road users' behaviour;

vehicles characteristics; and infrastructure characteristics. Although a national strategy for transport safety is still missing, there is a separate National Transport Safety Programme, which complements the strategy document and aims to fill this gap, suggesting several integrated measures to mitigate the major risk factors affecting road safety [4].

ENVIRONMENT

Car ownership rates have increased in Jordan, leading to more passenger trips by motorized vehicles and thus more pollutants and greenhouse gases are emitted and more noise is generated. Similarly, in freight transport, alternatives to transporting goods by road vehicles (heavy or light duty vehicle [HGV/LGV]) barely exist. Therefore, the Jordan freight industry depends heavily on road transport (trucks). Both passenger transport by car and freight transport by truck have serious environmental impacts, including the emission of pollutants and greenhouse gases and increased noise levels. Air quality is already deteriorating in Jordan, particularly in urban areas, and is predicted to continue to do so. Other environmental impacts of cars and trucks in Jordan have costs for other users, economic processes, natural and man-made, or social environments. The costs resulting from these impacts on other individuals or other processes are usually called externalities or external costs [15]. As well as aiming to improve the competitiveness of alternative private road transport, both for passengers and freight, Jordan's Long Term National Transport Strategy and Action Plan [4] is also aiming to reduce the impact of the transport sector in relation to the environment (pollutant emissions, greenhouse gasses, and fuel consumption). Transport model simulations show that the vehicle kilometres in private transport are predicted to increase by 56 % (road freight transport by 44 %) in the long term (by 2030), fuel consumption is predicted to grow by approximately 30 %, CO_2 emissions will increase by 26 %, and NO_x emissions are predicted to decrease by 14 %. Figure 3 shows the growth rate for several years [4].

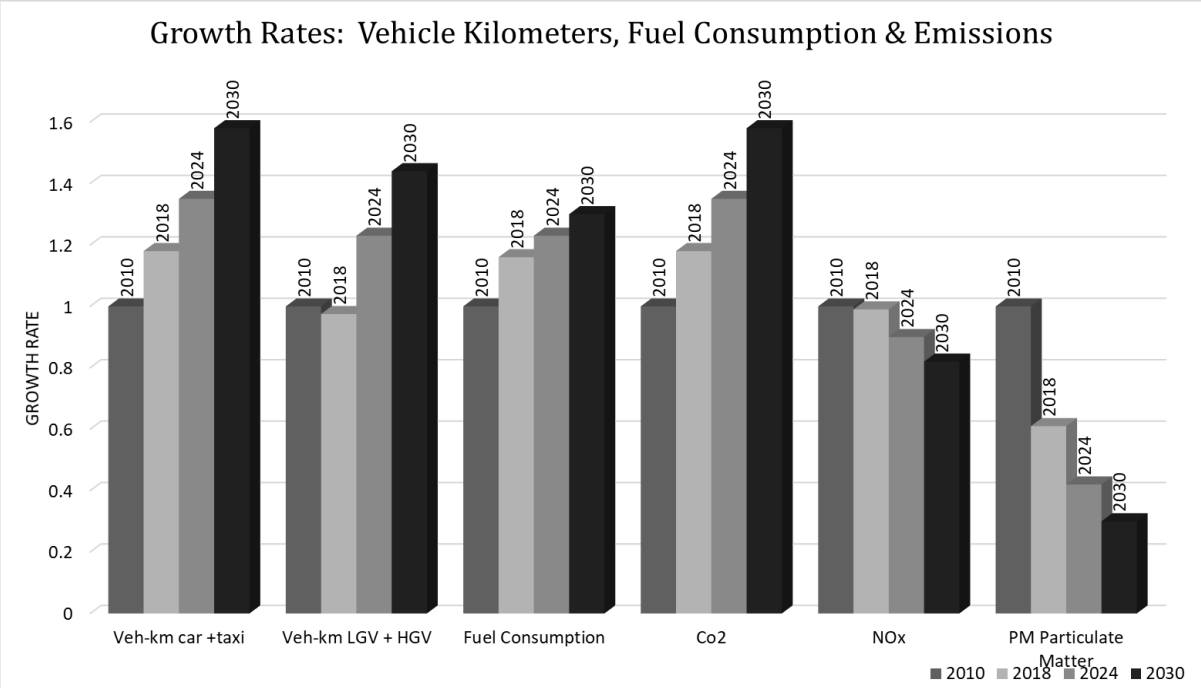

Figure 3. Growth rates in Jordan vehicle kilometres, fuel consumption and emissions [4].

Transportation is one of the major contributors to climate change, which is caused by the so-called greenhouse gases (GHGs) that trap heat reflected from the surface of the planet in the lower atmosphere causing the greenhouse effect. The primary GHG is carbon dioxide, which is responsible for about two-thirds of human-induced climate change.

METHODOLOGY

The quantitative methodology adopted in this article uses data retrieved from various prior studies (individual authors, institutions, organizations, and companies, both public and private) as well as from secondary sources, such as periodicals, brochures, articles, and relevant regional, local, and international studies. Regression analysis is used as a form of predictive modelling to forecast the future demands related to transport. As is well known in the field of transportation, data analysis is probably the most important and widely used research tool available for demand analysis.

ANALYSIS

Jordan imports almost 96 % of its primary energy and this equals to 7-10 % of the country's GDP. The primary energy consumption for the transportation sector was 50 % of the total throughout the years 2013 to 2018, so it is vital to carefully analyse this sector. Jordan's transport system is primarily based on individual transport, with almost no public transport system, and the high growth rate in the number of vehicles, combined with the high growth rate of the population is creating pressure on the country's infrastructure and seriously affecting the country's economy. In this analysis, the transportation system will be evaluated with respect to sustainability, based primarily on the number of registered vehicles, energy consumption and its effect on the environment. Statistics shows that the consumption of primary energy has followed the same trend over the last 27 years, with energy consumption growing from 3 million equivalent tons to 10 million equivalent tons over this period. The country's population followed a similar upward trend, as has the number of registered vehicles, the vast majority of which are privately registered. It is difficult to predict the future growth in the number of vehicles since it is linked to the growth in population, which is governed by geopolitical issues in the region, even though in making future predictions the curve behaves perfectly, with the straight-line regression with a high R^2 value of 99,85 % (see Figure 4).

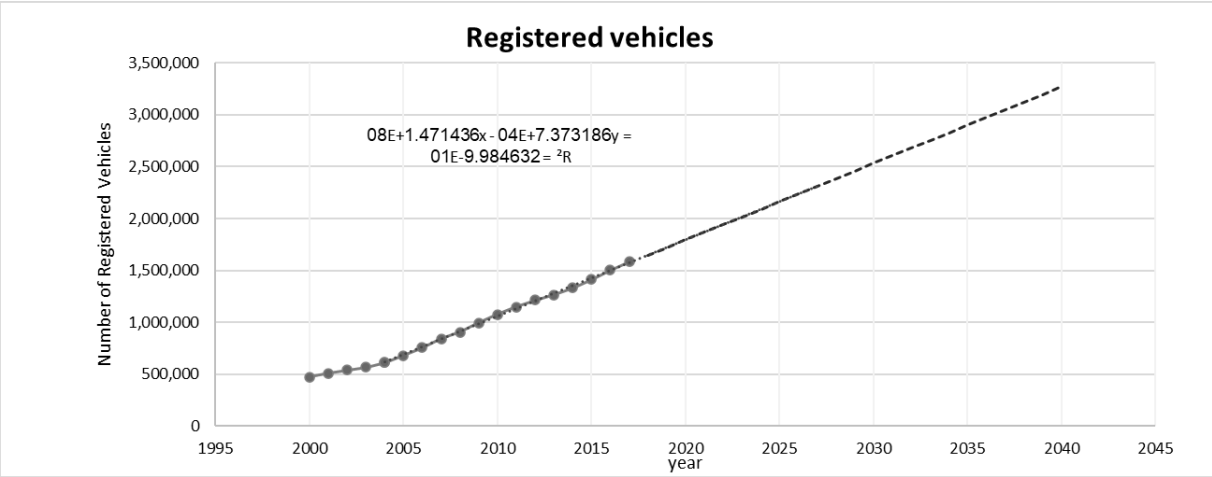

Figure 4. Vehicles registered in Jordan, current trends, and predictions [4].

The trend for buying hybrid and electric cars in Jordan is not high enough; although, unfortunately, there is no adequate information available on the number of vehicles based on fuel type. Yet, it is common to see hybrid and electrical cars on the streets because of the continuous rising in fuel prices has encouraged people to buy hybrid cars, also supported by adequate maintenance and spare parts availability. The future is possibly more encouraging for electric vehicles than for hybrid vehicles, as shown by recent trends. Figure 5 shows recent trends for vehicles (and their types) imported into Jordan.

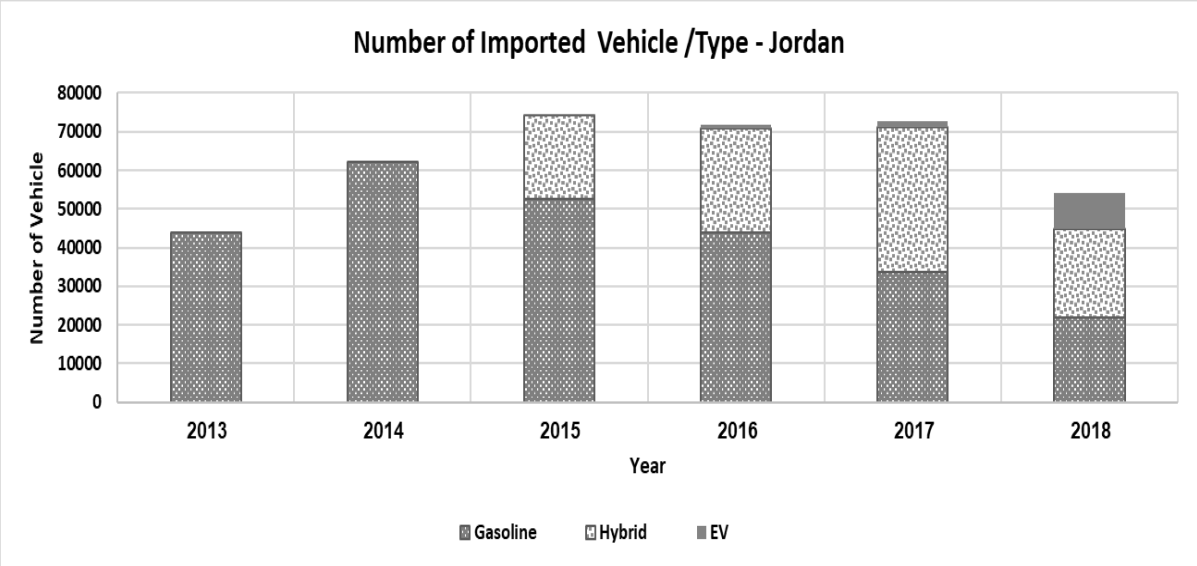

Figure 5. Number of imported vehicles by type in Jordan [4].

FUTURE PREDICTIONS

To predict the future growth of the transportation sector, this article has used the available historical data that has an influence in this sector, starting with historical population growth, which is hard to predict, as it is controlled by external issues. The population has increased by 50 % in the last seven years. Prediction is to focus on electricity and gasoline consumption since almost all of the vehicles in Jordan run by gasoline, unlike diesel, which is used by other sectors such as heating, pumping, and electricity generation in areas with no natural gas supply. Gasoline consumption demonstrates the best fit, historically and for future predictions, showing a linear regression relationship with an R^2 value of 98,9 %. Assuming that the use of the internal combustion engine in vehicles is to be replaced by hybrid and electric vehicles, we should take into consideration the electricity consumption (see Figure 6) and make predictions for the future demands with and without electric cars to see if extra generation capacity is required.

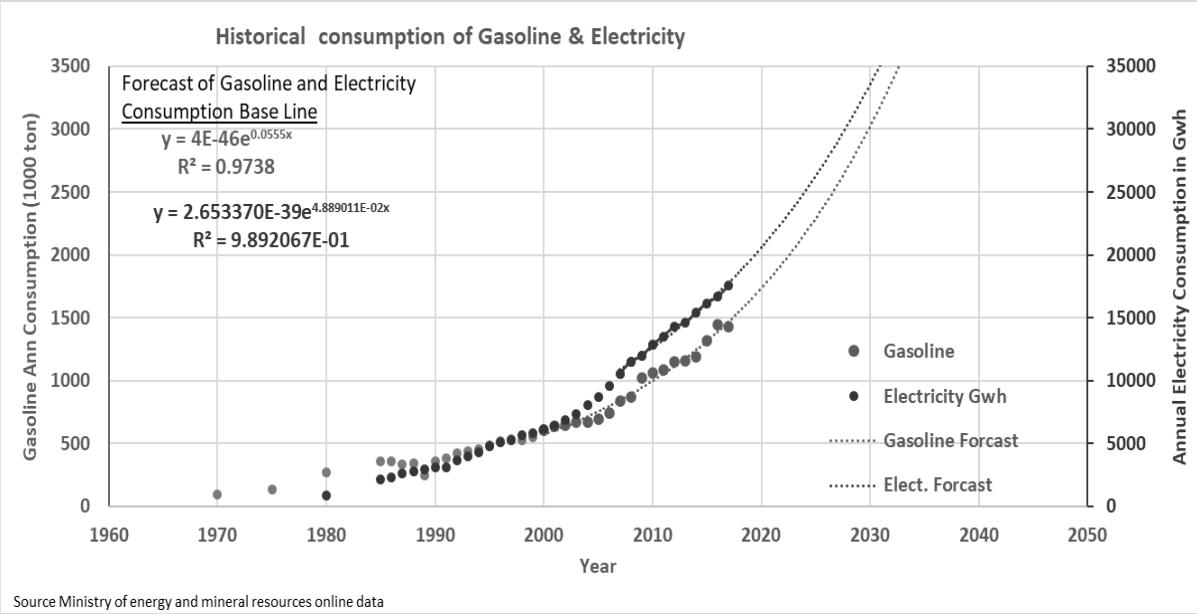

Figure 6. Historical consumption of gasoline and electricity [4].

To predict the number of electrical vehicles and the rate of replacement, this article assumes three different scenarios, compared to what happens if we do nothing:

- **scenario (1) best case:** 90 % of vehicles will be electric in 2040.
- **scenario (2) most likely case:** 65 % of vehicles will be electric in 2040.
- **scenario (3) worst case:** 40 % of vehicles will be electric in 2040.

To predict the number of vehicles and engine types, a forecast model (Figure 7) was made at the above three different scenarios for the replacement rate of internal combustion engines by electric engines by 2040 with a constant rate of growth linked to the forecasted number of vehicles.

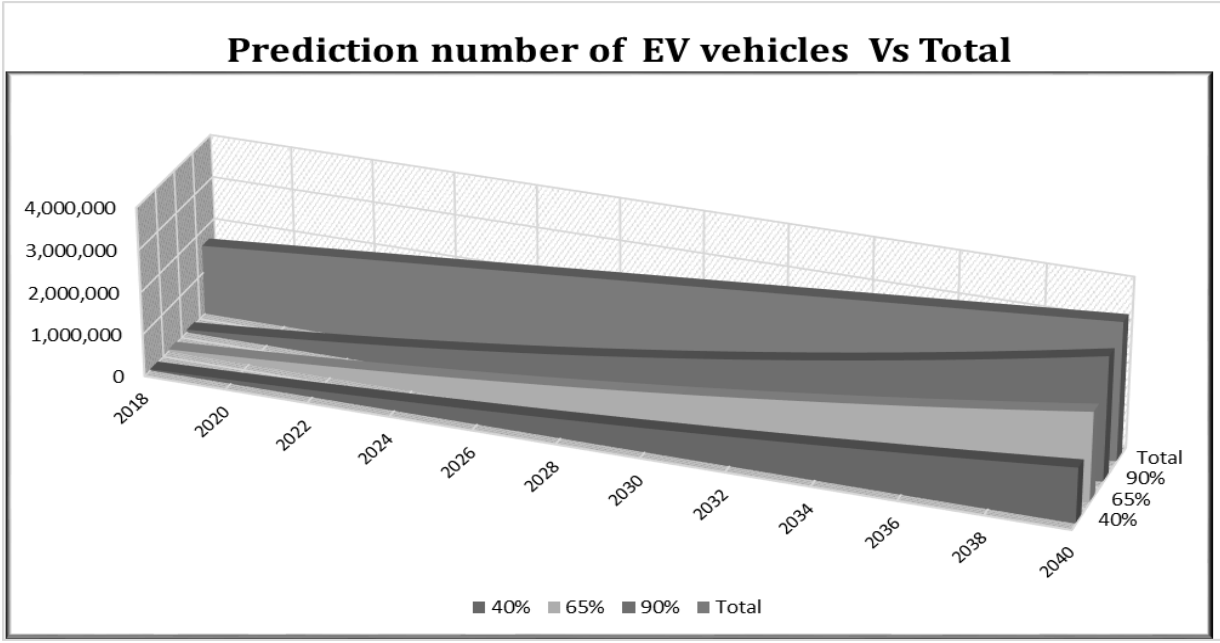

Figure 7. Predicted number of electric vehicles VS total.

Based on the number of vehicles, the modelling was performed for gasoline consumption as internal combustion engines are being replaced, and the quantity of gasoline was estimated for each scenario (Figure 7).

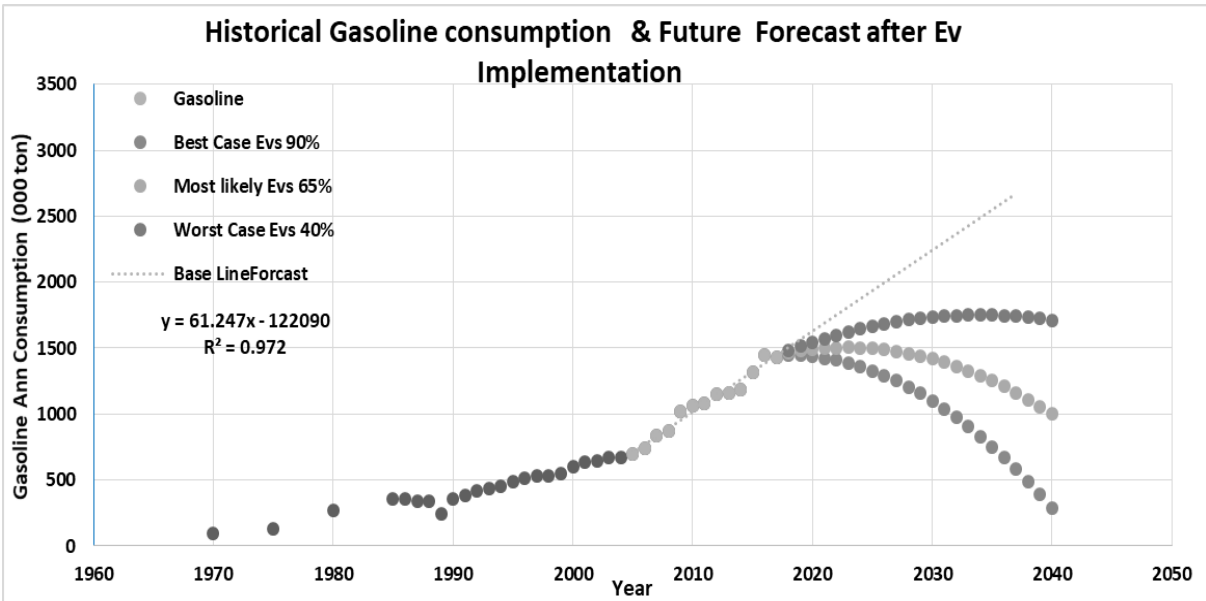

Figure 8. Gasoline consumption, historical and predicted after EV implementation.

Similarly, based on the number of electric vehicles compared to the total number of vehicles as for the electricity capacity, the future electricity demand was estimated from the base line, and the power requirements were estimated for each scenario based on the assumptions of average annual distance of each electric vehicle of 15 000 km, and an average electricity consumption per vehicle of 0,2 kWh/km. As shown in Figure 9, the effect of the extra load consumed by electric cars in the three scenarios is negligible.

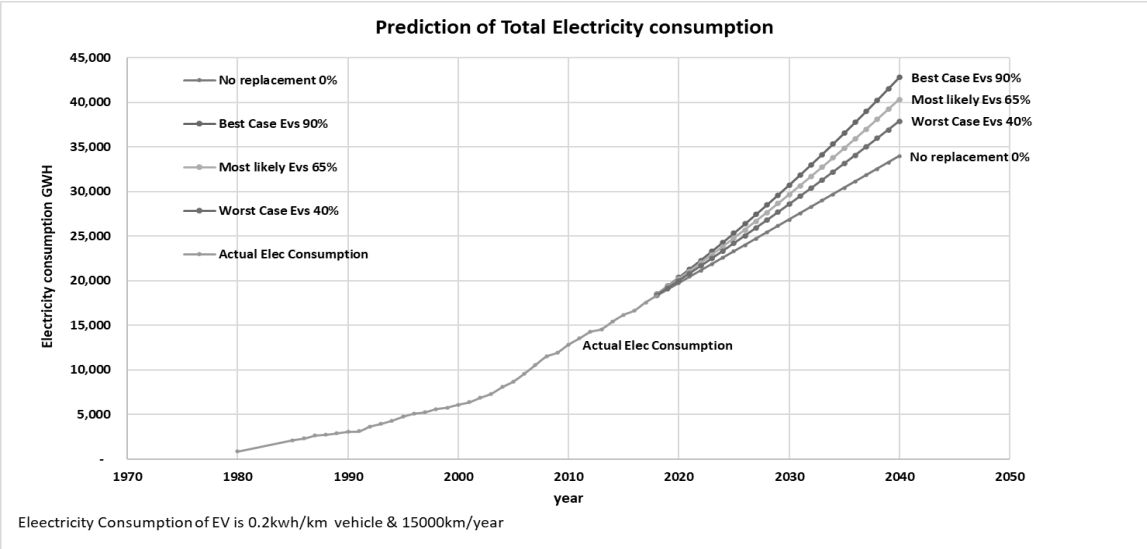

Figure 9. Electricity consumption (historical and predicted).

All the results of the scenarios are presented in Table 2, it shows a significant Annual savings in gasoline consumption compared to the base line

			Year 2040			
	Unit	Base Line	No	Best Case	Most likely	Worst Case
		Year 2017	replacement	90%	65%	40%
Population	Millon	10.05	15 - 20			
# of Gasoline Vehicles	Millon	1.58	3.27	0.33	1.14	1.96
# of Vehicles EV	Millon	-	-	2.942	2.13	1.31
Gasoline *	000 teo	1,431	2,854	285	999	1,712
Gasoline Saving	000 teo		-	2,569	1,855	1,142
Electricity **	Gwh	17,574	33,963	42,790	40,338	37,886
Electricity Increase	Gwh		-	8,827	6,375	3,923

*Gasoline consumption in 2040 is predicted to be 2,854 thousand Teo if no replacement is assumed
** Ev electricity consumption assumed as 0.2kwh/km vehicle & 15000km/year

Figure 10. Electricity consumption (historical and predicted).

CONCLUSION AND RECOMMENDATION

Based on the results of prediction models, huge savings can be seen in terms of gasoline consumption. In year 2040 the savings in gasoline in best case scenario will be 2 569 000 teo, whereas the savings in worst case scenario will be 1142 000 teo. The transition to electric vehicles will cause an increase in electricity consumption of 8 827, 6 375 and 3 923 GWh in the assumed three scenarios respectively. The increase in electricity consumption and the decrease in gasoline consumption will encourage the use of renewable energy and reduce the import of fossil fuels. This will also have a significant impact on the environment due to reduced emissions. To encourage the shift to electric vehicles, it is recommended that the government adopt new policies and measures by accelerating the replacement and imposing taxes on cars with internal combustion engines. Moreover, the infrastructure for electric vehicles should be improved accordingly, which would have a significant impact both on the economy and on the environment.

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ASSESSMENT OF SOCIETAL VULNERABILITY IN CASE OF POWER FAILURE IN RAIL NETWORK

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ABSTRACT

Vulnerability means the degree to which a reference object can withstand external or internal threats. The reference object can have a human, material character. The article will address the societal vulnerability due to a power failure in the rail network, and a specific event will be described in the form of a case study. Each part of the railway network, whether it be a depot, a station, a terminal, or others, is largely dependent on the supply of the electricity network to its functional elements in the system. To assess vulnerability, it should be quantified using available methods. Adequate measures must be taken to reduce vulnerability and a comprehensive protection system must be developed. These measures may be of organizational, methodological, or operational origin, but may also be a part of the system, such as subject protection, spatial protection, shell protection, or perimeter protection.

KEY WORDS

social vulnerability, power failure, railway station

CLASSIFICATION

JEL: L92, O18, R42

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INTRODUCTION

The railway station or the overall system of the railway network is dependent on the supply of electricity for the efficient functioning of most of the services and activities provided. Human resources can provide staff in the train set, for manual ticket sales, control of the operating rules of the object, but are unable to transport people and material by rail, process data on reservation tickets in the train set, monitor and detect unwanted persons who do not have verified access into specific rooms. In today's era of automation and technological advances, the company is much more vulnerable to the necessary condition of the necessary supply of electricity than in the past, when it was mainly the human factor that had to be considered.

The term vulnerability can be defined and examined from the point of several scientific fields. It is important to know the subject of the vulnerability study. Experts and authors have different definitions of vulnerability in their publications. Here are some examples:

- vulnerability can be understood as one of the characteristics of the environment, which is not unitedly defined, but it is assessed on the basis of various facts [1],
- the vulnerability of the advanced world is increased in particular by the growing complexity and interconnectedness of modern societies, the economic and technological systems of modern societies represent systems of nodes such as the city center and the connection between them, which can be a railway line or power lines, the interdependence of individual nodes and connections is so considerable that the failure of one can cause the collapse of the entire system [2],
- vulnerability generally means the property of any material object, technical device or social entity to lose the ability to perform its natural or established function as a result of external or internal threats of varying nature and intensity [3],
- the vulnerability of the object and the effect of the threat directly or indirectly condition the possibility of a greater risk [4],
- vulnerability is considered as a result of the interactions between physical (territorial) characteristics and the susceptibility and capacities of the socioeconomic system to adapt and cope with a specific hazard, expressed as a nondimensional index [5],
- vulnerability means a deficiency, weakness or condition of the analyzed asset, or entity, object, system, organization, region, or part thereof, that the threat may use to exert its adverse effects [6],
- vulnerability is the ability of a system and its components to accept hazard in the form of loss and damage [7],
- vulnerabilities are also represented by those parts of the object, or those elements of the protection system that do not provide the required degree of protection, they are a weak or easily overcome element, or create favorable conditions for attacking the object, increase the probability of an attack and its success [8].

In general, however, vulnerability is not a negative factor. Its negative impact will only be manifested if the threat uses the vulnerability of the reference object to achieve its goal. This means that the subject of research (material, people, resources, services, etc.) must be exposed to an existing or potential threat, which by its negative effect creates a causal chain of cause creating a possible consequence. The consequence of a negative event is already the overcoming of vulnerability.

SOCIAL VULNERABILITY

The concept of vulnerability is originated from social sciences, and in the beginning it was almost exclusively used in the social sphere. In the article, the subject of research will be social vulnerability in the event of a power failure in the reference building of a railway station.

In security terminology, vulnerability is assessed semi-quantitatively, qualitatively and quantitatively. These methods consist of a verbal description, a numerical description, or a combination [8].

Social vulnerability is a complex issue that needs to be assessed from a variety of perspectives. A correct and objective assessment of social vulnerability requires answers to three questions [9]:

1. Who is vulnerable? The question aims to identify social actors.
2. What makes them vulnerable? The answer is to identify the phenomena and events that can cause existential problems for social actors or social systems.
3. Why are they vulnerable? In this case, we identify the root causes that predispose to exposure to negative phenomena and events [9].

Social vulnerability is a phenomenon difficult to measure, so groups of social indicators will be used to assess the level of social vulnerability. Usually, the variability of the fact being examined cannot be described with one indicator, and therefore whole groups of indicators are used, and the interpretation of the obtained data is then based on the combination of data found by the indicators. Social indicators are easily identifiable indicators that make it possible to examine or measure phenomena and processes in the social environment. They represent a complex usually created using quantitative methods, which provide data on the characteristics of social life. They have a dynamic character, change over time, they are the result of interactions between social actors and reveal some basic features of social reality. In general, the most commonly used indicators are derived from official statistics and are therefore used to assess the level of development of a company [9].

CASE STUDY

The authors will examine the possible situation of a power failure at a railway station in the Slovak Republic. As the number of passengers by ZSSK railway transport in the Slovak Republic has tended to increase in the last 4 years (Table 1), it is necessary for passenger transport, as one of the railway transport services, to be as reliable as possible without the loss of trust of customers.

Table 1. Railway passenger transport statistics in the Slovak Republic by ZSSK for the period 2016-2019 [11].

Year	Number of passengers in millions
2016	65,61
2017	72,47
2018	73,81
2019	77,36

Disturbances in the electric power supply can originate from natural disasters, adverse weather, technical failures, human errors, labor conflicts, sabotage, terrorism, and acts of war. A disturbance has its starting point in an initiating event, i.e. a threat or hazard that is materialized [10].

In terms of time, we assume that a significant part of the electricity infrastructure has been damaged by extreme natural events. Resumption of electricity supply will be possible after a few days to weeks, unless a replacement solution is implemented, either in the form of construction of a replacement line at the site of the damage, or by the transport and installation of backup transformers in the affected substations. For the purpose of social vulnerability

assessment, the following scenarios and events have been determined, which may affect the reference object according to Table 2, where the risk carrier will be a natural disaster in the contribution and the scenario will always result in long-term power failure at the railway station.

Table 2. The natural factor causing the event with potential scenario.

Event	Scenario
Earthquake	Electrical equipment will lose its stability and power lines will be damaged.
Flood	The area in which the railway station is located is flooded.
	There will be flooding and short circuits in the server room of the railway station.
Landslide	The slope loses its long-term stability and falls apart, which damages the energy supply.
Wind spout	The wind will cause considerable damage to the power lines.

In Table 3, the social actors have been identified, as well as the kind of social phenomenon that makes them vulnerable, and why they are vulnerable in the potential event of a long-term power outage that affects them at a railway station.

Table 3. Who is vulnerable, what makes them vulnerable and why they are vulnerable.

Who is vulnerable?	What makes them vulnerable?	Why are they vulnerable?
Passengers reliant on rail transport	Impossibility to travel to work	Limited on the possibility of traveling by other means of transport
Unemployed	Penury	Education and qualifications
Children	Stress	Limited transportation options on the places
Seniors	Impossibility travel to the doctor	Social status
Persons with disabilities	Criminality	Disability

Passengers reliant on rail transport (do not own a car, do not have a driver's license, etc.) in the event of a power failure, for example do not have the possibility to use another type of transport to the place of work or to a greater distance, so their options are limited. During a long outage and the impossibility to travel to work, they could lose their jobs.

Unemployed people often cannot afford road transport due to their financial prospect of approaching penury. They often rely on rail transport. In addition, they may be vulnerable to their lack of education and qualifications, making it very difficult for them to find a job that would lead them to a better economic and social situation. They often have only limited opportunities in employment, such as a part time job, seasonal employment agreement or occasional temporary job offers without long-term stable employment. Due to a long-term power outage at the railway station, they could lose the possibility of their work potential where it could be used.

Children may have the usual way of going to school or certain places by rail. In the event of a long-term power outage and a necessary change in the usual way, they can be affected by a sudden, unusual situation which can make them anxious. As children cannot drive a car, they have limited means of transport without the help of another person holding a driving license and a car or an alternative to public transport.

Seniors have a higher incidence of health problems and diseases than the younger generations. Many seniors have no one to transport them during the day to a larger city for a medical examination, and therefore, often use rail transport. A power failure at a railway station and the cessation of the operation of a long-term interval may lead to the cancellation of their original intention to receive medical assistance on a given date. This could cause potential future health problems or failure to obtain the necessary medication for their health problems. Their social status as people who are often reliant on the help of doctors makes them socially vulnerable actors.

Persons with disabilities due to a power outage at a railway station will potentially be forced to use another form of passenger transport. These people usually cannot afford to spend money on a taxi service and must therefore use other passenger transport options. Boarding places, for example public transport, are not necessarily in close proximity to a railway station, therefore these people are sometimes forced to cross sites which could be considered as crime magnets [12]. Potential attackers can see them as an easy target, as they have a predisposition to be unable to defend themselves as a disabled person against a robbery or violent attack.

For the purpose of assessing social vulnerability in the event of a power failure at the reference object of the railway station, the following three indicators have been determined, which contain their specific characteristics.

To assess social vulnerability, the Social Vulnerability Index (SVI) will be used, which will be calculated from the indicators and their specific characteristics of selected social actors. As mentioned in the second chapter, vulnerability can be assessed by various methods, and here the quantitative point method has been chosen. Point 1 means the minimum social vulnerability and, conversely, the highest point in the range of scoring is the maximum vulnerability. The individual indicators with their characteristics can be found in Tables 4-6. In Table 4, the age criterion intentionally varies by gender.

Table 4. Socio-structural evaluation.

Indicators	**Point evaluation**					
	Male			**Female**		
	1	2	3	1	2	3
Age	≤ 29	30-59	60+	≤ 19	20-49	50+
Health Condition	Healthy	Health problems	Half invalid / Invalid	Healthy	Light health problem	Half invalid / Invalid
Qualification / Education	Without qualifications / -	High School (HS)	University (U)	Without qualifications / -	High School (HS)	University (U)
Type of family	Complete / Incomplete	2 members and more	Solo	Complete / Incomplete	2 members and more	Solo

Table 5. Socio-economic evaluation.

Indicators	Point evaluation					
	1	**2**	**3**	**4**	**5**	**6**
Employment	Public administration	Private sector	Part-time job	Agreement on performance of work	Temporary job	Without work
Source of income	State	Businessman	Self employed	Reward for a specific work	Occasional income	State benefit / Pension / -
Income size (SR conditions)	≥ 1500 €	1499 - 1000 €	999 - 750 €	749 - 500 €	Living wage	Under level of living wage
Housing conditions	Own house	Own flat	Long term lease	Short term lease	Family	Hostel

Table 6. Socio-urban evaluation.

Indicators	Point evaluation			
	1	2	3	4
Size of residence	Regional capital	District town	Village	Sparsely populated areas
Distance of residence	≥ 120 km	≥ 100 km	≥ 80 km	≥ 60 km

For a comprehensive assessment of social vulnerability, we will use the Social Vulnerability Index (SVI), which was calculated according to the relationship [13]:

$$\text{SVI} = \sum_{i=1}^{n} p_i/n, \tag{1}$$

where p_i is the point evaluation of the characteristics of the indicator, n is the number of indicators.

The calculated values of the social vulnerability index can be included in Table 7, with the final assessment of social vulnerability for a given social actor and the characteristics of individual indicators. For social actors, Table 3 was used again, where an expert estimation determined 20

Table 7. Scope of social vulnerability index.

SVI	Assessment of social vulnerability
0-1,19	Low vulnerability
1,2-2,19	Medium vulnerability
2,2-3,19	High vulnerability
3,2-4,4	Very high vulnerability

possible alternatives or groups of communities using rail transport with their social indicators and characteristics. The minimum score is therefore 10 points for the indicators set, while the maximum score is 44 points.

As a critical threshold for social vulnerability, an unacceptable threshold of 2,2 has been set, which, according to the scope that has been chosen, represents a large and very high vulnerability. Overcoming the critical vulnerability threshold means that the negative consequence of a potential natural threat caused by a long-term power outage can have a serious impact, whether financially, socially or indirectly on the health of the social actors. The resulting values of the Social Vulnerability Index (SVI) from Table 8 can be compared with the acceptable threshold values of the range of the Social Vulnerability Index in Table 7.

In Table 8, following abbreviations have been used for indicators:

- socio-structural: S = Sex Male/Female, A = Age, HC = Health condition, Q = Education / qualification, ToF = Type of family,
- socio-economic: E = Employment, SoI = Source of income, IS = Income size, HS = Housing conditions,
- socio-urban: SoR = Size of residence; DoR = Distance of residence.

Table 8. Final assessment of social vulnerability (continued on p.274).

Social actors	Unemployed				Passengers reliant on rail transport			
S	F	M	M	F	F	M	M	M
A	22	59	19	48	37	27	54	54
HC	Healthy	Health problem	Healthy	Healthy	Health problem	Healthy	Healthy	Healthy
Q	HS	-	HS	-	U	HS	HS	HS
ToF	Complete	Solo	Complete	2 member	Solo	Solo	2 member	2 member
E	Agreement on	Temporary job	Private sector	Public administ	Agreement on	Without work	Public administ	Public administ
SoI	Businessman	Occasional	Reward for a	State	Reward for a	State benefit	State	State
IS	749 - 500 €	999 - 750 €	≥ 1500 €	1499 - 1000 €	999 - 750 €	Living wage	≥ 1500 €	≥ 1500 €
HS	Short term	Long term	Long term	Own house	Long term	Hostel	Own flat	Own flat
SoR	Regional capital	District town	Regional capital	Regional capital	District town	Regional capital	District town	District town
DoR	≥ 60 km	≥ 60 km	≥ 60 km	≥ 80 km	≥ 60 km	≥ 60 km	≥ 120 km	≥ 120 km
∑	25	31	21	17	28	35	15	15
SVI	**2,5**	**3,1**	2,1	1,7	**2,8**	**3,5**	1,5	1,5

Persons with disabilities				Seniors				Children				
F	F	M	M	F	F	M	M	F	F	M	M	F
33	52	45	37	67	65	74	69	14	13	16	12	47
Half invalid	Health problem	Invalid	Health problem	Health problem	Half invalid	Invalid	Health problem	Health problem	Healthy	Healthy	Healthy	Healthy
-	HS	HS	U	-	HS	U	HS	-	-	SŠ	-	U
Incomplete	2 member	Incomplete	Solo	Solo	Complete	Solo	Solo	Complete	Incomplete	Complete	Incomplete	Solo
Without work	Part-time job	Private sector	Private sector	Without work	Brigády	Without work	Public administ	Without work	Without work	Temporary job	Without work	Agreement on
State benefit	Businessman	Self employe	Businessman	Pension	Occasional	Pension	State	-	-	Occasional	-	Occasional
Living wage	1499 - 1000 €	≥ 1500 €	≥ 1500 €	749 - 500 €	749 - 500 €	749 - 500 €	Nad 1500 €	Under level of	Under level of	999 - 750 €	Under level of	749-500 € brutto
Long term lease	Own flat	Family	Own house	Own flat	Own house	Own flat	Own house	Family	Family	Family	Family	Long term
Regional capital	Regional capital	Village	District town	Regional capital	Sparsely populate	District town	Village	Sparsely populate	Village	District town	Regional capital	Regional capital
≥ 60 km	≥ 120 km	Do 80 km	≥ 100 km	≥ 80 km	≥ 100 km	≥ 80 km	Do 120 km	≥ 80 km	≥ 100 km	≥ 80 km	≥ 80 km	≥ 60 km
34	20	26	18	31	31	33	19	37	33	29	32	28
3,4	2	**2,6**	1,8	**3,1**	**3,1**	**3,3**	1,9	**3,7**	**3,3**	**2,9**	**3,2**	**2,8**

EXAMPLE OF SVI COMPUTATION

A healthy passenger 54-year-old man reliant on rail transport with a high school education has a family of two members. He works in the public administration and receives a payment from the state over € 1500. He is also the owner of a flat. He lives in a district town located within 120 km from the place of power failure at the railway station.

Socio-structural evaluation according to Table 4: 2, 1, 2, 2.
Socio-economic evaluation according to Table 5: 1, 1, 1, 2.
Socio-urban evaluation according to Table 6: 2, 1.
Rated indicators added will give the value p_i: 2 + 1 + 2 + 2 + 1 +1 +1 +2 +2 +1=15.

The number of our social indicators is marked as n equal to 10. In the last step, these values can be used in the following formula to find out the final value of the social vulnerability for the social actor:

$$\text{SVI} = \sum_{i=1}^{n} p_i/n, \frac{15}{10} = 1{,}5. \quad (2)$$

The remaining values of the social vulnerability for all social actors were calculated in the same way.

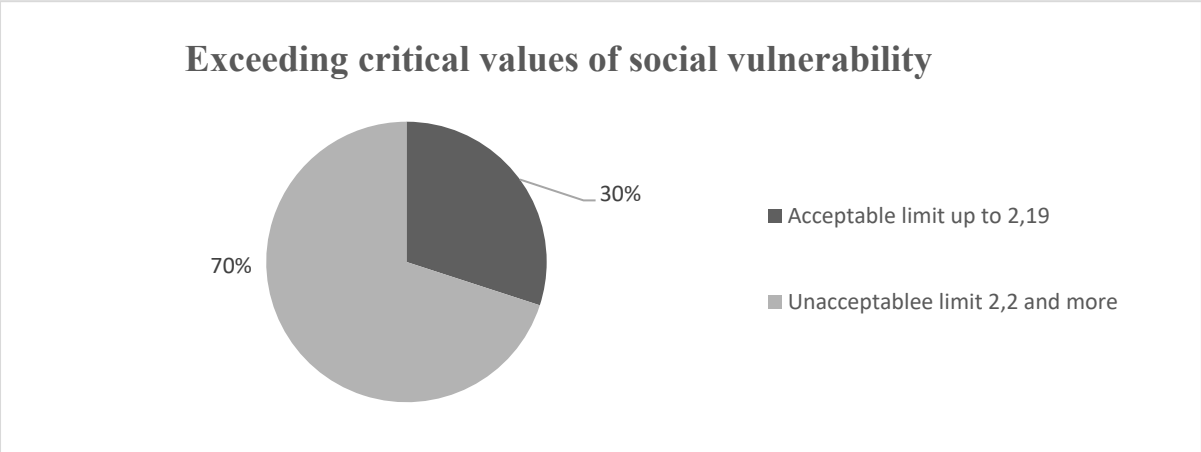

Figure 1. Resulted ratio exceeding critical values of the social vulnerability of our social actors.

CONCLUSION

The results show that out of the 20 different types of social actors selected, the number exceeding the critical threshold of social vulnerability (Figure 1) represents 70 %, that is 14 of the total number, while at the same time 30 %, that is 6 social actors do not pass that threshold. Therefore, it has been found that the impact of a power failure due to a natural factor can endanger a significant part of the examined population. According to the results, the most socially vulnerable groups are children, the elderly and the unemployed, as together up to 10 potentially vulnerable social actors from these groups would have difficulties in continuing their activities, usual transport practices, finances, health, etc. From this result it is possible to conclude that in the event of a power failure, there may be a significant halt or even a decrease in the number of passengers using rail transport.The state, regional self-governing bodies or private investors could support other forms of public transport in the given locality, and this way, in the competition for customers using passenger transport services, they could threaten the vision and goal of the largest passenger railway carrier, ZSSK in Slovakia to transport up to 1 billion people a year by 2030. In addition to the various negative social impacts of this potential natural threat that prevents the supply of electricity and functionality in a certain section of the rail transport, escalating CO2 emissions can also be assumed, due to the increase in passenger car traffic, which would also damage the environment.

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WI-FI 6 APPLICATION IN IOT ENVIRONMENT

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ABSTRACT

When thinking of wireless communication solutions for IoT devices, the 5G networking technology is the first thing that comes to mind. Besides this, one cannot overlook the fact that a new wireless communication solution is also available, built on the 802.11ax standard. Until now, wireless networking solutions allowed to manage the simultaneous connections of 250 devices via a single router. Meanwhile, the new technology is designed to support 1024 concurrent connections with one router. This enables the management of a large number of Internet of Things devices in smart homes.

KEY WORDS

Wi-Fi, IoT, security

CLASSIFICATION

JEL: L63, L92

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INTRODUCTION

Today, the concept of the Internet of Things or IoT for short, is becoming increasingly widespread. This is not a coincidence, as numerous companies are now producing such devices wordwide.

In a few words, IoT devices, besides two-way communication, can execute specific tasks. They store information in cloud-based systems, and these are available for the users at any time. Based on statistical data, IoT devices are used most in the following areas: manufacturing / industrial, transportation / mobility, energy, retail, cities, healthcare, supply chain, agriculture, buildings.

In 2020 the number of IoT devices reached 50 billion [1]. This means almost 6 IoT devices per person worldwide. Besides the small gadgets surrounding us, there are groups of interrelated devices that should be treated as complex systems. These are smart houses, smart factories, smart grids – intelligent electricity distribution systems, and other extensive networking infrastructures [2].

The primary function of IoT devices is to provide solutions that save time, energy, and money, simplify life and make it more comfortable. The trend of their usage shows that the developers and manufacturers of these devices have successfully achieved this goal.

One of the reasons for this explosive development of IoT is the rapid evolution of the two-way communication solutions needed. These devices can use the following wireless communication protocols: Bluetooth, NB-IoT, Wi-Fi, ZigBee, NFC, LoRa. These technologies are summarised in the following table.

Table 1. IoT Communication Protocol Comparison [3].

Protocol	Frequency	Range	Data Rate	Power Draw	Topology
Bluetooth	2.4 GHz	~ 92 m	125 kbps to 2 Mbps	Low	Point to point, Mesh
NB-IoT	Below 1 GHz	~ 32 km	100 kbps	Low	Star
Wi-Fi	2.4 GHZ / 5 GHz	~ 45 m - 5 km	9.6 Gbps	High	Star, Point to point
ZigBee	2.4 GHz	~ 270 m	250 kbps	Low	Mesh
NFC	13.56 MHz	~ 4 cm	106 kbps to 424 kbps	Low	Point to point
LoRa	150 MHz - 1 GHz	up to 16 km	50 kbps	Low	Star

The table above shows that the various communication solutions can bridge different distances, using different transmission speeds and frequency brands. Accordingly, it follows that these communication technologies supported the proliferation of IoT devices. In the following sections, the relationship between IoT devices and Wi-Fi will be discussed.

RELATIONSHIP BETWEEN WI-FI AND IOT DEVICES

Wi-Fi 4, 5 AND 6

With the introduction of the 802.11ax Wi-Fi standard, these technologies were renamed, including 3 Wi-Fi standards. In 2009 the 802.11n standard was published, supporting the 2.4 GHz and the 5 GHz solutions, with up to 600Mbps theoretical data transfer. This standard was renamed Wi-Fi 4.

In 2013 the 802.11ac standard was published, which further improved both range and data transfer speed. This standard works in the 5 GHz frequency band, up to 3,5 GHz data transfer. This standard is called Wi-Fi 5.

However, standardisation did not stop because wireless devices are responsible for a significant amount of internet traffic. The table above also shows that bandwidth-hungry IoT solutions are among those [4].

Therefore, in 2019 IEEE introduced the 801.11ax standard, a new and innovative version of wireless communication. This standard is called Wi-Fi 6. The following table shows the summary of the three technologies.

Table 2. Comparison of Wi-Fi generations [3].

Feature	IEEE 802.11n	IEEE 802.11ac	IEEE 802.11ax
New name	Wi-Fi 4	Wi-Fi 5	Wi-Fi 6
Channel bandwidth	20, 40	20, 40, 80, 80+80, 160	20, 40, 80, 80+80, 160
Frequency bands	2,4 GHZ / 5 GHz	5 GHz	2,4 GHZ / 5 GHz
Maximum data rate	600 Mbps	3.5 Gbps	9.6 Gbps
Modulation	64QAM	256QAM	1024QAM
Antennas	4x4	8x8	8x8

Wi-Fi SURVEY

The penetration of wireless and IoT technologies is unstoppable. These areas, however, are developing hand in hand. Therefore, we would like to assess some of the impacts and relations of IoT systems from a series of wireless network surveys [5].

Since 2012, we have surveyed the wireless systems on a 29 km route in Budapest. This route was selected to represent all vital urban settings, such as high-rise apartment buildings, suburbs, industrial units, and offices [6]. The following figure shows the survey route:

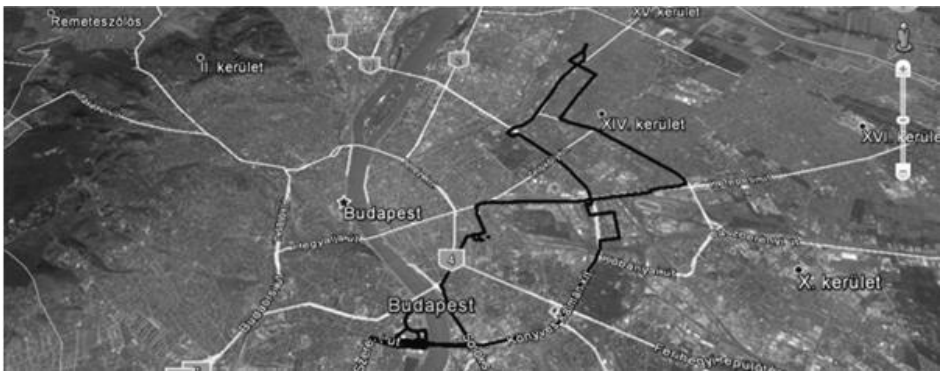

Figure 1. Budapest survey route.

During measurement, up-to-date hardware and software tools were used every time. The hardware environment was a USB connected Wi-Fi device and a GPS receiver unit [7]. The software environment kept changing, depending on the actual operating system and hardware support.

The collected data was compared to the Wireless Geographic Logging Engine (WIGLE) figures to get the overall picture and verify the measured numbers' rationality. WIGLE is an open international database, which shares data about Wi-Fi devices.

The following figure shows the measured and WIGLE data between 2012 and 2020.

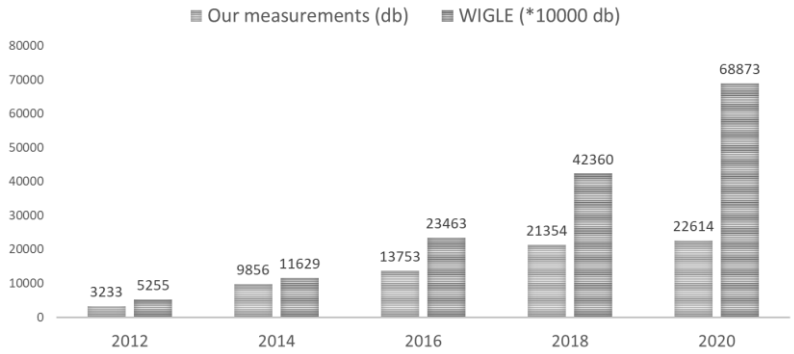

Figure 2. Measured and WIGLE data.

During the survey, not only the number of devices were recorded, but the following transmitted data was also collected [8]: SSID (Service Set Identifier), MAC Address, RSSI (Received signal strength indication), Channel, Channel Width, 802.11 standard,Security and authentication mechanisms, GPS coordinates.

Based on these pieces of information, some trends and wireless network and IoT relations can be concluded. One of the possible benchmarks is the operational frequency based on the measured data. This is important because 2,4 GHz and 5GHz devices can operate with different transfer rates. 2,4 GHz has higher coverage but supports lower, several hundreds of Mbps transfer speed; meanwhile, 5 GHz supports several Gbps transfer speed at a lesser range. The following figure shows the volume trend of 2,4 GHz and 5GHz devices.

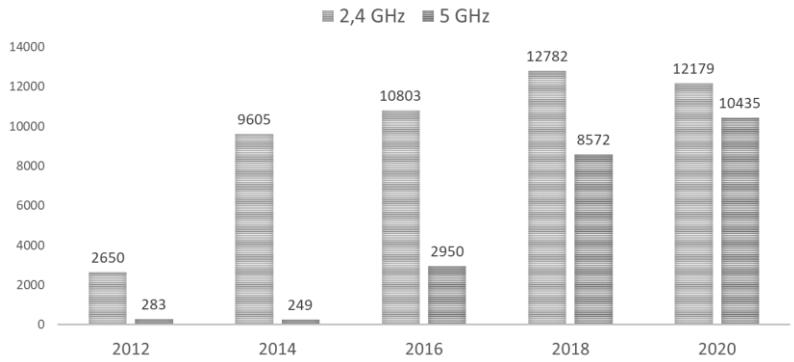

Figure 3. Number of 2,4 GHz and 5 GHz devices.

The survey results indicate that the number of 5 GHz devices increased fivefold in the last four years. This tendency is demonstrated in the following figure, showing the changes in the number of Wi-Fi 4, Wi-Fi 5, and Wi-Fi 6 devices.

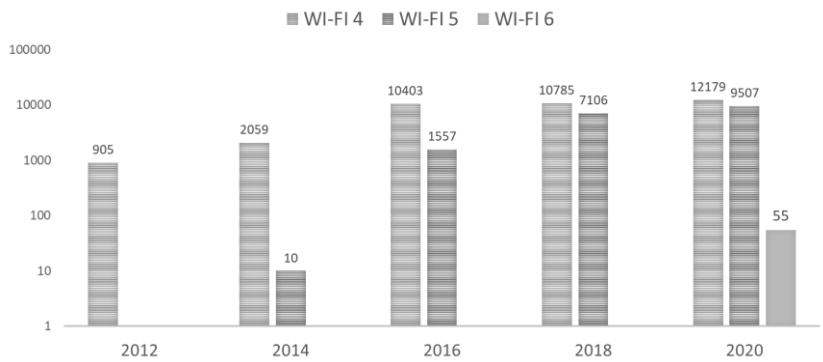

Figure 4. Wi-Fi 4, Wi-Fi 5 and Wi-Fi 6 trends.

The y-axis, on the logarithmic scale, shows the number of devices to highlight the low number of devices when a new technology is introduced to the market. By grouping the data from this perspective, the 2013 introduction and rising of Wi-Fi 5 devices are similar to the Wi-Fi 4 launching tendency, which started in 2012. In our view, Wi-Fi 6 has followed this tendency since its appearance in 2019. After one year of introducing Wi-Fi 5, only 10 of such devices were identified on the survey route. In 2020, one year after introducing Wi-Fi 6, 55 of such technology devices were found. Projecting this trend to IoT devices, it can be concluded that at the increase of the Wi-Fi 6 devices, the number of IoT devices per person can reach 9-10 in the following years.

The survey data also supports defining the number of secure and insecure networks for the overall test population. The following figure shows this trend:

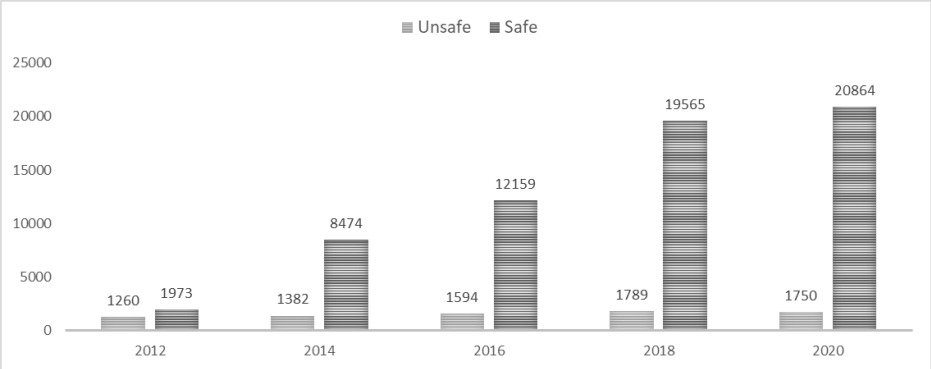

Figure 5. Secure and insecure devices.

Results show that the number of secured-closed-networks has been continually rising since 2012. However, there is another point to remember: in 2020, the number of not secured networks was still 1750. The following figure shows in percentages the changes in the number of secure and insecure networks.

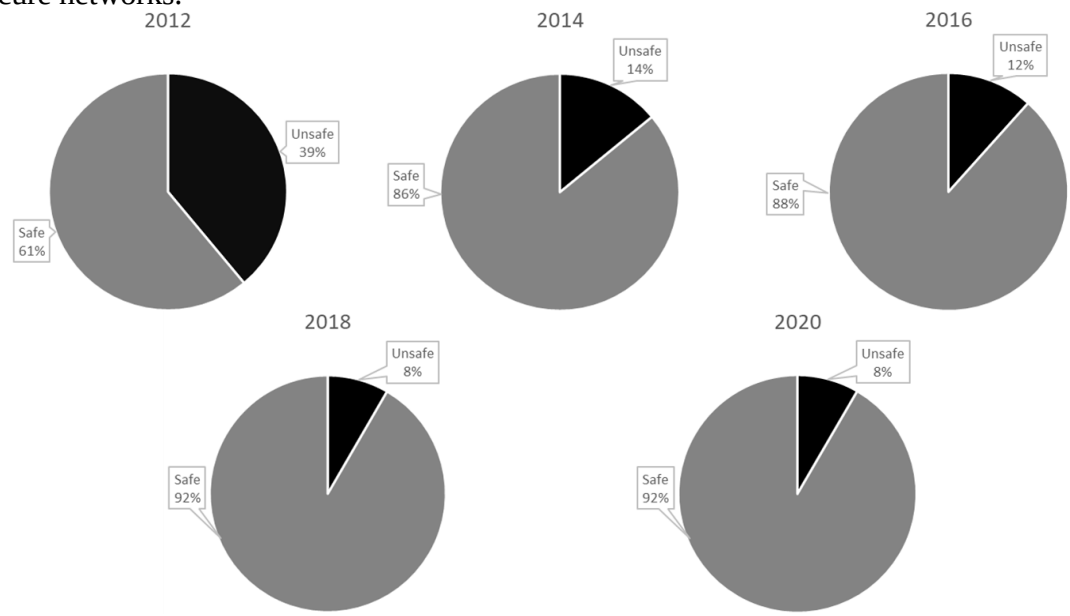

Figure 6. Secure and insecure device percentage.

The above pie charts clearly describe the trend of secure/insecure network proportions from 2012. This figure also shows that in 2020 insecure network had a rate of 8 % in the overall test population. We believe that inadequate configuration and negligence is behind this poor security [9].

Projecting this tendency to the IoT devices, the security of 8 % (4 billion) of the total number of 50 billion devices is managed poorly and can serve as a potential attack point.

OPTIONS TO INCREASE PROTECTION

The spread of insecure Wi-Fi networks and IoT devices increases the potential for attackers to find endpoints, which can be used to launch an attack against critical infrastructures. Based on the technology trends, we can estimate a significant increase in weaponised gadgets in the cyberspace. Mitigation strategies should focus on the end-users, internet service providers (ISPs) and enterprises that employ Wi-Fi networks and IoT devices.

As for end-user protection, there are two main options to nudge people towards a more security-conscious attitude. Firstly, negligence needs to be addressed. Users need to be more aware of the consequences of poorly secured networks and IoT devices by increasing the liability of misconfigured or unprotected devices. However, enforcing legal liability is difficult, especially when most of the users are not technically trained.

There is another option to increase security awareness for IT products by implementing a cybersecurity labelling scheme (CLS). The Cybersecurity Agency of Singapore launched a labelling scheme for smart devices, which identifies four tiers of security assessment [10]:

- tier 1: Security Baseline Requirements,
- tier 2: Lifecycle Requirements,
- tier 3: Software Binary Analysis,
- tier 4: Penetration Testing.

The tier sequence corresponds to the increasing level of assurance and improved cyber resilience. This model informs the public about the security resistance of devices and increases manufacturers' competition to develop more secure appliances.

CONCLUSIONS

The evolution of smart devices increased network utilisation in both households and enterprises. We have been collecting data about Wi-Fi systems in Budapest since 2012, by scanning devices connected to them, in order to be able to assess the used technologies. In this article, we presented some utilisation trends. Based on the strongly coupled development of Wi-Fi networks and IoT devices, we showed how Wi-Fi 4, Wi-Fi 5 and Wi-Fi 6 transition happens, and what are the tendencies in change of the secure/insecure proportions of these devices. We pointed out that future IoT consumption will increase the number of misconfigured or poorly configured devices, which will increase the potential to use these against critical infrastructure. We also pointed out that some action was needed to raise the security awareness of end-users and manufacturers to reduce operational negligence.

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ENVIRONMENTAL AWARENESS SURVEY IN THE HUNGARIAN ONLINE FOOD TRADE

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ABSTRACT

By the time of publishing this article, the economic situation created by the pandemic had caused us to face some serious issues. The food sector underwent significant changes in the first year of COVID-19 with online shopping and e-commerce becoming one of the most important channels for market operators. The rapid and significant increase has made everyone face challenges, particularly from the perspective of environmental protection. There are more vehicles on the road and more packaging is being used. When the pandemic started, customers did not consider how this business affected the environment, but conscious customers now give priority to environmental impacts. This study is aimed at exploring how customers' expectations mirror their environmental consciousness. The article is based on the evaluation of a questionnaire, in which the authors investigated whether customers, driven by environmental awareness, were willing to pay more for transport and packaging in a situation when COVID-19 intensified food e-commerce activities. Based on the respondents' level of education and income, the article shows their reaction to the topic. The result indicates that the behaviour of the younger generation differs from that of the older generation, and it is suggested that service providers react to this by focusing on green solutions, such as ecologically friendly packaging, electric vans, or other alternative delivery solutions. Additionally, it is also expected that the increase of order numbers won't have a negative impact on social sustainability, such as traffic jams, air pollution, and noise. Based on the findings, the service provider is seen as responsible with only a limited willingness by customers to bear the financial consequences. It can be concluded that the economical challenge of the increase in e-commerce caused by the pandemic remains with retailers in Hungary.

KEYWORDS

online food trade, survey, environmental awareness, home delivery

CLASSIFICATION

JEL: Q56

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INTRODUCTION

The commercial sector is undergoing continuous transformation. A growing number of players are entering the market, consumer habits arechanging, and online commerce is gaining ground. All factors of this business were forever changed in the spring of 2020, due to the COVID-19 epidemic. Distrust, restrictions on access, and the impact on society placed an increased burden on operators who introduced rapid developments in online commerce markets to remain competitive. However, this posed a number of challenges for all stakeholders. According to the GKI Digital [1] report, in 2020, the combined turnover of the fifteen largest e-merchants exceeded HUF 380 billion (more than 1 billion EUR), which makes up 41 % of the market, while the total number of orders was close to 11,5 million. In this highly volatile and unpredictable market and social environment, online retail achieved a record high 45 % increase in turnover.

The pollution caused by deliveries cannot be avoided in e-commerce. The transport of goods to warehouses and customers places a significant burden on the environment, and sooner or later, this will become unsustainable. As a result, companies are under increasing pressure from society and Non-Governmental Organisations to adopt more sustainable and environmentally friendly logistics systems.

A study by the Clean Air Action Group (in Hungarian: Levegő Munkacsoport) also criticizes the environmental impact of freight transport. A number of studies show [2-4] that road transportation is the greatest pollutant and responsible for 40 % of nitrogen oxides emitted by transport vehicles. Along with PM10 and nitrogen oxides and tyre and road wear, the main factors are PM2.5 particles discharged into the atmosphere from exhausts. The costs they incur are related to the circulatory and respiratory diseases they cause. Greenhouse gas emissions account for 4 % of the EU's annual emissions, 25 % of which come from lorries. The costs should also account for the growing risk of a range of accidents, noise pollution and congestion [5].

The growth of e-commerce has also affected the field of traditional commerce which has shown accelerated development during the pandemic. As the number of online customers increased and more webstores were opened, smaller orders for individual customers started to replace the old way of preparing bulk orders. This naturally affects the entire supply chain process and requires more flexibility, particularly in terms of delivery [6].

The environmental impact of online commerce is a timely subject, while the effects of the growing fleet and the problem of non-recyclable packaging have to be considered.

In November 2020, Sabrina Madi interviewed experts from sixteen international e-commerce companies on how they envision the e-commerce logistics innovations for 2040. The answers are not surprising: the experts agreed that electric and hydrogen-powered cars replace the current diesel and gasoline vehicles. Electric and conventional bicycles can solve the problems of urban logistics. As plastic bags and sacks will no longer be used, recyclable boxes can provide a solution for the issue of packaging. Further possibilities include taking advantage of shared fleets and Big Data [7].

Two hypotheses on environmental issues were formulated:

- **H_1**: according to the first hypothesis, environmentally friendly packaging is important for customers who shop online; therefore, they tend to accept higher costs,
- **H_2**: an environmentally friendly fleet is important for online customers; therefore, they tend to pay higher shipping fees.

LITERATURE REVIEW

The present article addresses the topic of environmentally friendly packaging, which has been the subject of a great deal of research supported by a rich body of scientific results [8, 9-15].

Reviewing the relevant demographic characteristics (age, income and education), a literature review [16] of research results in 2006 appeared to be somewhat contradictory. Several researchers consider the effect of these factors to be significant, while others disagree [8, 17-19]. The former concept is seemingly logical, but results may be influenced by other factors. These factors can include market variables, in which price is of the utmost importance, and in line with expectations, studies have shown that price has a negative impact. [18, 20] Recent Hungarian research also pointed out that social groups show differences in terms of environmental awareness [21]. A pre-pandemic survey [22] with 7000 respondents from several countries (France, Germany, Italy, Poland, Spain, Turkey, UK) indicated, that 77 % of all respondents are willing to pay extra for packaging with a reduced impact on the environment. As a critic, the survey respondents could choose between answers "nothing" and also "0-5 %". The latter is classified as willingness to pay extra, however 0 % is also included In our opinion the outcome is rather 53 % are not willing to pay extra or just a very small amount and 47 % showed tangible interest to spend money for green packaging. Another European survey in 2020 indicated a similar result [23]. The study involved multiple countries (Germany, Italy, Norway, Sweden, UK, Austria, Denmark, Finland, France) and 5 900 respondents with 44 % agreeing or strongly agreeing to pay more.

Scopus database has been reviewed looking for scientific articles issued in the years of the pandemic (years 2019-2022). The search words "environment" and "packaging" resulted to 193 documents, further to application of multiple filters, such as document type to article, review and book chapter and exclusion of irrelevant subject areas. Based on a final evaluation by reading the abstracts, 10 relevant documents remained in scope. Two documents were listed as literature reviews, which was found to be very useful in order to understand the current state of the research. Wandosell et al. [24] concluded that there is a growing awareness around sustainable development though green packaging alternatives revealing the growing interest of scholars and researchers. The literature review of Brennan et al. [25] highlighted that there is little research on the role of consumer perceptions and more research is needed to explore the same regarding the understanding and acceptance of packaging technologies. As a conclusion of the reviews it can be stated that a research of customer payment readiness for environment friendly packaging is actual. On the other hand, three scientific articles have been identified in the SCOPUS database, dealing with the same topic in two countries, China and Italy. The Italian researchers were looking for consumer perceptions of specific packaging types, such as biodegradable materials [26] or BIO-bottles [27]. The result indicates different consumer attitudes dependent on the food product and packaging, respectively low willingness to pay for milk offered in biodegradable packaging and higher willingness to buy water in BIO bottles. Recycled materials are not preferred in this respect. In multiple countries, China, Malaysia and Italy, researchers highlight that the increase of consumer knowledge about the environment friendly packaging solutions is inevitable. Moorthy et al. concluded, that the knowledge towards green packaging has a direct relationship with intention to purchase green packaging products [28]. Although the findings are similar in China where researchers found in a survey study with 781 respondents [29] that there is a strong willingness to pay for it. Another questionnaire survey of 10 067 participants from 13 countries (Argentina, Brazil, Croatia, Greece, Hungary, Latvia, Lithuania, Poland, Portugal, Serbia, Slovenia, Romania and United States) indicated that consumers prefer foods that have been produced and packed in sustainable way [30]. Guo et al. studied the Chinese catering platforms as the largest three market players possess 20 million daily orders and consume 60 million plastic packaging products. The result found it evident that the main reasons which contribute to the plastic packaging pollution are related to recycling costs, technology and efficiency [31] Similarly to Guo et al. other researchers addressed the problem and proposed different solutions by streamlining logistics processes [32] and presenting an econometric efficiency model [33].

Reviewing the literature, it seems worthwhile to capture a snapshot of the relationship between individual demographic factors and price and environmental awareness in the field of online commerce, which has flourished during the epidemic.

MARKET ANALYSIS

The reorganization of consumer behavior that happened due to COVID-19 naturally led to changes on the supply side. Several food chains started to trade online, many webshops were launched and countless operators, such as eMAG, expanded their portfolios with food products.

Tesco is currently the market leader in Hungary. In 2013, the online shopping business was launched with three stores in Budapest. The UK operating model was implemented, but local legislation was also taken into account. Currently, they offer two types of online services: online shopping (referred to as Tesco Home as of March 2021) and webshop (Tesco Box). Half of the Hungarian population has access to the Tesco Home service, which is available in twenty stores.

It is important to clarify the fundamental differences between the two services. Tesco Box is available throughout the entire country. In addition, these services have a slightly different product range. Tesco Home has a selection of nearly fifteen thousand products, including frozen and fresh (chilled) lines. Customers can finalize the order by 11pm the day prior to delivery and book a two-hour time slot in which a Tesco employee or contracted partner delivers the order to the customer's address. Customers can also pick up orders at a chosen store. Another essential difference is the conclusion of the contract. In the case of the Tesco Home service, the order is compiled at one of twenty different stores, so it is not guaranteed that all ordered products are available. In addition, prices are "guide" prices, so the final contract is only concluded upon receipt of the products.

The Tesco Box webshop offers a limited selection of approximately three thousand ambient and non-food products to the entire population of the country. The products are collected at a specific store (Pesterzsébet) and delivered to the customer by a contracted partner within 3 days. In this case, the contract is concluded when the order is completed on the website.

Aldi started cooperating with Roksh in November 2020. They offer 3 000 food products online and provide distribution in Budapest and at Lake Balaton. Their selection includes (typically self-branded) high-quality fresh and grocery products. Aldi has not developed an online platform, therefore customers place their orders on the Roksh website. Respectively, the latter company fulfils the logistics related tasks.

Auchan had planned to expand its online presence even prior to the pandemic and made significant capital investments. Due to COVID-19, this activity has accelerated, the fleet has been improved, services were expanded and thanks to their webshop, has achieved nationwide coverage. Auchan offers a wide range of mainly fresh food and grocery products. Its delivery services are only available in Budapest and the surrounding areas Customer feedback indicates product availability issues, which has a direct negative impact on the level of customer satisfaction.

CBA is one of the first operators to enter the online market, but the pandemic did not trigger any additional activity. The delivery range is concentrated around Budapest. The strength of its selection lies in its fresh produce lines. It is rumored that the Hungarian government intends to boost CBA's market position, however, its activities show no signs of innovation.

COOP, as a Hungarian operator, has also launched its webshop. They provide basic grocery products on a nationwide level (similar to Tesco Box). The selection includes popular products that require no refrigeration. COOP is typically accessible in rural areas and small settlements, therefore its online activity is expected to be successful in these locations.

GRoby also has a long-standing presence on the market. Owner Róbert Gárdonyi, started home delivery in 1999 and launched his online store in 2000. They are currently working with an assortment of around 9000 items, including many high-quality fresh produce lines. No further innovation or activities have been noticeable in recent years.

Kifli is currently the most innovative market player. The company had already been present in the Czech Republic before entering the Hungarian market, and it now operates in Austria and Germany as well. Its selection is continuously growing. It offers high-quality products sourced directly from producers, as well as special brands such as Marks and Spencer and Alnatura. The company places great emphasis on environmental protection as its entire fleet is CNG-powered, the packaging is recyclable and a packaging-free option is also available. Kifli operates a Bistro service that allows customers to order from established restaurants. The company operates a fulfilment center, thanks to which Kifli maintains a high level of product availability. Kifli's primary targets are premium customers. The innovations serve to successfully boost customer satisfaction.

Foodpanda targets customers with smaller needs looking for a fast delivery service. The narrow product range includes basic lines and they can fulfil orders within half an hour in Budapest. They also cooperate with Tesco.

The Penny Market is also a market player in Hungary and collaborates with Foodpanda. The catchment is mainly around Budapest but as they entered the online market in Czechia, the same approach is expected in Hungary in the near future.

Spar is also present on the online market. As noticeable at Spar stores, the company's strength lies in its selection of fresh produce lines. Spar operates in Budapest and the surrounding areas. There was no intensive expansion during the pandemic (only a handful of pickup points were opened).

The above-mentioned GKI report [1] supports this analysis. In respect of the TOP5 online FMCG retailers, in 2020, the field of FMCG (fast-moving consumer goods) recorded a turnover of HUF 76,6 billion and achieved the greatest growth in the online retail business.

RESEARCH METHODOLOGY

According to an analysis from 2018, 4,2 million Hungarian customers order online, however, only 7 % can be considered regular customers, while the proportion of customers who regularly order food online is 6 % [34].

This means that approx. 300 000 people placed orders online prior to the pandemic. A significant portion of these customers opt for multinational companies (Tesco, Auchan, Kifli and Spar) for online services. Considering the population of Hungary, we may calculate with 500 000 people in the current situation.

According to Rubin and Babbie [35], the advantage of a questionnaire is the ability to define the characteristics of large quantities, providing the possibility of a detailed, standardized analysis. The disadvantage of a questionnaire is the limitations caused by research participants' admissions and their validity [36]. The method of using a survey have been mostly adopted by previous researches related to the current topic referred herein [22, 23, 26, 27, 29, 39]. The usage of the same method increases the comparability of the results. Although questions and focus areas may differ, this aspect was also considered at the definition of the research method.

Potential customers received a Google questionnaire with 16 questions, which was available on various social network sites between 7 Feb and 21 Feb 2021. Apart from basic questions, there were open-ended questions, focusing on age and income and the Likert-scale method was also used in several cases. We evaluated the results in an Excel spreadsheet and a descriptive evaluation was also prepared. Statistical methods of averaging, standard deviation and cross-

tabulation were used to calculate the results. We also conducted descriptive research, the results of which are not considered to be representative.

We received 646 responses to the questionnaire in the given period, which can be considered a high statistical sample size. 43 respondents indicated that they did not order food online, so we excluded these responses from the analysis.

RESULTS

Reviewing shopping habits, we can see that 19 % of the respondents spend less than 25 GBP, 55 % spend between 25 and 50 GBP, 22 % spend 120 GBP and only 4 % spend more than 120 GBP per purchase.

When it comes to product groups, 299 respondents indicated items other than food products as their primary purchases which represents almost half of the total sample. Only 41 respondents indicated that they mainly buy fresh products when they shop online.

We received the following responses in answer to the question as to whether environmental protection is important in online food trade, which were processed by educational attainment (Table 1):

Table 1. Importance of environmental protection based on educational attainment (source: Self-edited primary research. N:603).

Education	Average	Deviation
Elementary school	5,6	1,16
Grammar school	5,3	1,13
Vocational school	5,3	1,14
Higher education	5,22	1,14

Based on the results, all respondents agreed that environmental protection is also important in this business line, regardless of level of education. Their response was not as obvious when it comes to the pollution of delivery vans. The evaluation given by all respondents is an average value of 4 – which means they are polluting – but the standard deviation value is slightly higher (1, 4), which shows that the resolution is not so clear in this regard.

We also examined customers' willingness to take financial responsibility to reduce the environmental impact of online food delivery. Figure 1. groups the responses by educational attainment.

Education	Number of responses	I willing to pay higher fee with more then 20%	Definitely yes, the everyone is responsible for environment protection	Definitely not, it is retailer responsibility	I willing to pay higher fee with maximum 10%	I willing to pay higher fee with maximum 20%	I willing to pay higher fee with maximum 5%	I don't care about the environment protection
Higher education	316	1%	19%	30%	15%	2%	33%	0%
Secondary school	190	0%	18%	29%	19%	3%	29%	1%
Vocational school	92	1%	26%	42%	7%	0%	21%	3%
Elementary school	5	0%	40%	60%	0%	0%	0%	0%
Average	603	0%	26%	40%	10%	1%	21%	1%

Figure 1. Importance of environmental protection based on educational attainment.

Figure 2 shows how this tendency changes when examined on family income.

Family income	Number of responses	I am ready to pay higher fee with more then 20%	Definitely yes, the everyone is responsible for environment protection	Definitely not, it is retailer's responsibility	I am ready to pay higher fee with maximum 10%	I willing to pay higher fee with maximum 20%	I willing to pay higher fee with maximum 5%	I don't care about the environment protection
Less than 700 GBP	118	0%	27%	35%	15%	2%	21%	0%
Between 701 and 950 GBP	122	1%	15%	37%	16%	2%	30%	0%
Between 951 and 1150 GBP	106	0%	22%	27%	11%	1%	38%	1%
Between 1151 and 1400 GBP	75	1%	15%	35%	15%	1%	33%	0%
Between 1401 and 1650 GBP	68	0%	12%	35%	15%	1%	37%	0%
Above 1651 GBP	114	1%	40%	32%	25%	4%	44%	5%
Average	603	1%	22%	33%	16%	2%	34%	1%

Figure 2. Importance of environmental protection based on family income.

Some conclusions can be clearly be drawn from the two figures. In terms of education, even if everyone agrees on the importance of protecting the environment when delivering food ordered online, the costs involved should be borne by the trader (40 %). 25 % of the respondents would be willing to pay no more than an additional 5 % to make the delivery of their ordered products more environmentally friendly. The income-based survey shows slightly different results. The proportion of those willing to pay no more than an additional 5 % is similar to the number of those who put the responsibility on the retailer (31 % and 32 %, respectively). This is possibly due to the fact that people with higher incomes have higher willingness to pay more. However, customers cannot be segmented by income, therefore we can say that customers — even if they consider the environment to be important — do not want to pay more for the service.

The answers below were given in relation to packaging. The importance of receiving an order in eco-friendly packaging obtained a mean score of 4,8 on the Likert-scale of six alternatives, which is a high result. The 1,2 standard deviation is higher than the previous results, which indicates that the opinions on this topic are more divergent. 409 respondents gave preference to recycled paper boxes. Figure 3 which shows their willingness to pay extra fees for environmentally friendly packaging. Many respondents think that retailers are responsible for providing environmentally friendly packaging but the number of respondents who are willing to pay 5 % more is nearly equal to them.

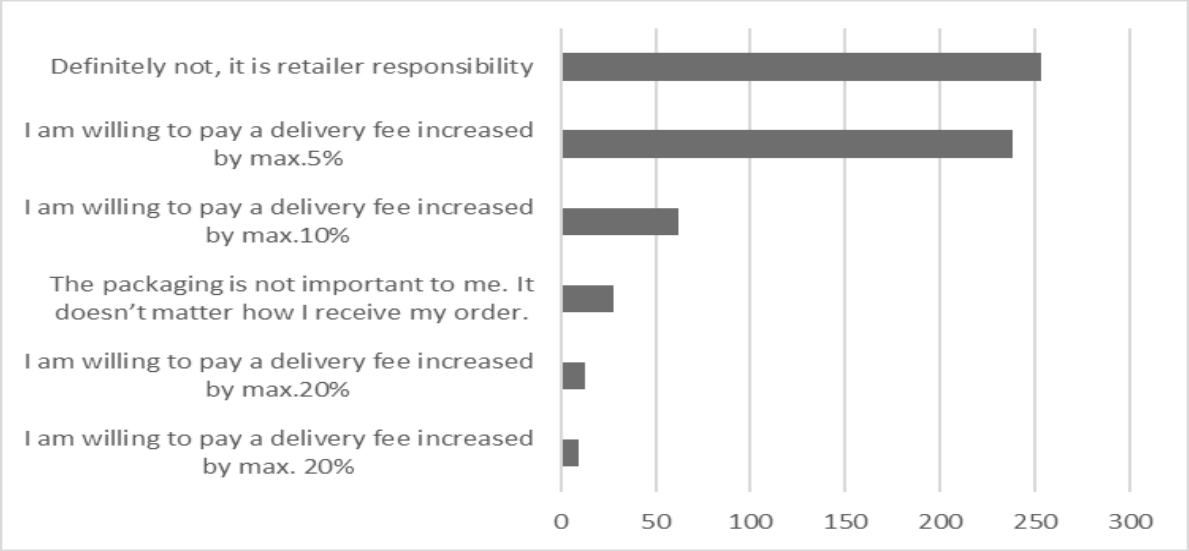

Figure 3. Importance of environmentally friendly packaging.

The question on the importance of reusable packaging obtained a mean score of 4,6 on the Likert-scale, which is a high result. The 1,6 standard deviation is higher than the previous results, therefore the opinions on this topic are more divergent. 409 respondents gave preference to recycled paper boxes.

CONCLUSIONS

The primary analyses performed on this subject are suitable for analyzing the defined hypotheses. It is evident that consumers are increasingly conscious about the environment, however the desire to do something about the environment does not seem to be widely supported in practice in their daily activities. Consumers are generally unwilling to make financial sacrifices for the environment. The vast majority think that the duty of protecting the environment falls on someone else, therefore the costs incurred should be covered by others. Table 2. shows the results.

Table 2. Summary of results.

	Hypothesis	Database and methods	Results
H_1	Environmentally friendly packaging is important for customers who shop online; therefore, they tend to accept higher costs.	Field research evaluated by statistics methodology.	Rejected.
H_2	An environmentally friendly fleet is important for customers; therefore, they tend to pay higher delivery fees.	Field research evaluated by statistics methodology.	Rejected.

H_1: environmentally friendly packaging is important for customers who shop online; therefore, they tend to accept higher costs.

Considering the performed analyses this hypothesis is rejected: even though environmental protection is important for customers, the responsibility is attributed to the service providers. Thesis: even if environmentally friendly packaging is important for online shoppers, they are not willing to incur higher costs.

H_2: an environmentally friendly fleet is important for customers; therefore, they tend to pay higher delivery fees.

This hypothesis has been rejected: although an environmentally friendly fleet is important to customers, the responsibility is primarily attributed to the trader. Thesis: an environmentally friendly fleet is important for customers, however, they are not willing to pay higher delivery fees.

To summarize the result, we are able to recognize that as online shopping is continuously increasing, in parallel customer expectations are also higher. As the younger generation has started to order online, they are very sensitive to green solutions. The basic requirements of delivery on time, driver helpfulness, product quality and good prices are no longer enough to provide excellent service to online customers. To avoid losing market position, the e-retailer should provide an ecologically friendly solution without requesting an extra fee from customers which is a challenge for all players.

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USE OF DRONES IN LOGISTICS: OPTIONS IN INVENTORY CONTROL SYSTEMS

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ABSTRACT

New and promising technologies are constantly emerging in the transport and logistic sector. These technologies provide new and effective opportunities in the supply chain. The application of autonomous mobile robots, automatization, artificial intelligence, and unmanned aerial vehicles is not the distant future. We can create more efficient, secure, precious, and rapid solutions with the help of the UAVs' properties like the size, the mobility, the functionality, the capabilities, and the development possibilities. Modern technology and development make them teachable and programmable, furthermore we can develop independent decision-making mechanisms into the solutions. They can have a powerful image and data acquisition, as well as analysis capabilities. There is great potential in this technology. It can reorganize the future supply chains. Businesses can increase their solutions' cost-effectiveness, speed, accuracy, and safety in different areas like billing, inventory, transportation, and workforce productivity. We provide a summary of the UAVs in this article. We demonstrate the spread, the usability, the challenges, and the opportunities of this technology in the transport and logistic sector. Within that, we present more about the usefulness of inventory.

KEY WORDS

unmanned aerial vehicles, legislation, drones in logistics, intralogistics, inventory

CLASSIFICATION

JEL: L86, L93

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PREAMBLE

The Unmanned Aerial Vehicles (UAVs), also known as drones, are no longer the future. The purpose of this article is to demonstrate the multiple usages of drones, with the focus on the logistics sector, more specifically in inventory systems. We provide insight into a wide range of applications, news and trends through the UAVs' history and evolution. This gives us a better picture of challenges and opportunities in the present and future. Nowadays drones are highlighted because of the military utilization. However, in terms of their usage there are non-military UAVs as well. It is important to mention that technical and technological progress of non-military drones comes from the military utilization.

Like all emerging technologies, UAVs have many negative prejudices and fears, especially because of military origin and usage. These issues and concerns relate primarily to the capabilities, the limits of the technology, the incomplete regulatory environment and the safe operation. Privacy and security concerns (such as tracking) are common problems as well. But if we take these issues aside, we can admit that the non-military drones can be used in many sectors. Furthermore, cross-sector usage can also work well.

In this article we focus on the close and short-range UAVs, but because of their technical abilities and limits we do not investigate the mid-range and endurance ones. Our goal is to have a look at the cutting-edge technologies and automation enhancements in the face of global challenges in the logistic sector. We also investigate the field of logistics utilization. The main focus is the role in supporting intralogistics systems and within that the solutions of the in-stock inventory automation. To the better understanding of the UAVs' inventory and stock management solutions we did an in-depth interview with a startup called Aeriu.

The technology, related developments and regulatory environment is undergoing continuously and changing significantly. It is the reason why this technology, the related products and services can be examined in the short term.

THE SPREAD AND FORECASTS OF THE UAVS

The term "Unmanned Aerial Vehicle" can be used for any aircraft that does not carry a human being. These devices can be controlled independently or they can fly based on a pre-programmed flight plan. With the help of remote access they can achieve more complex tasks and they can be integrated with automation systems. When we talk about drones we need to differentiate the Unmanned Aerial Vehicles (UAV), the Remotely Piloted Aircraft Systems (RPAS) and the Unmanned Aircraft Systems (UAS). In this article, the term 'drone' will be used for all of them.

Their first appearance is due their usage in the military, but at the same time these devices are already widely adapted in the commercial sector. They have a broad spectrum and a wide range of adaptation in civil life. Companies have seen many opportunities to utilize this technology. There are many R&D projects in this topic. UAVs can be adopted in many sectors like agriculture, transportation, construction, logistics, industry, public security, governmental use, etc..

As *Figure 1* shows the growth and economic potential of unmanned aircraft is continuously increasing according to global drone market forecasts. The background of this trend is the multiple usage and adaptability.

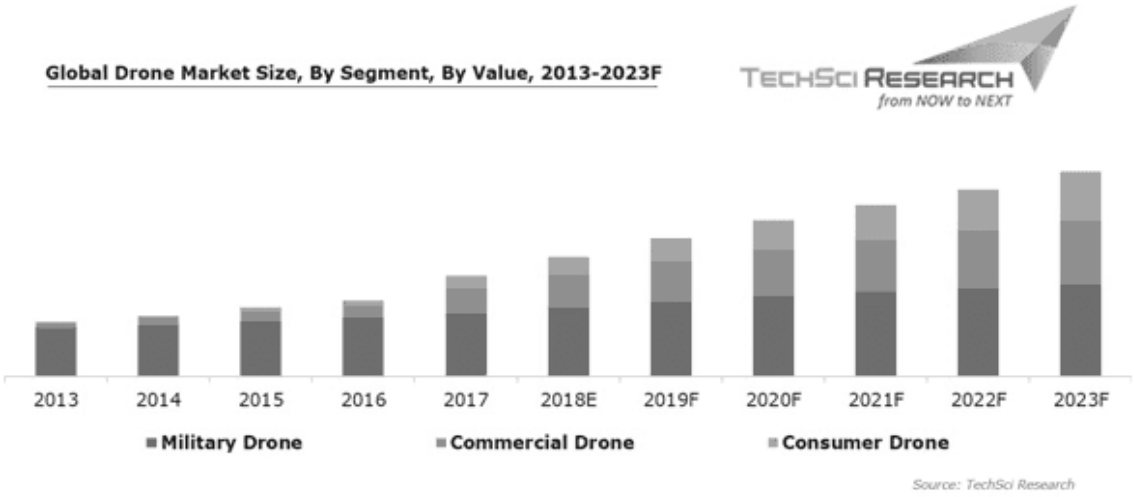

Figure 1. Global Drone Market Size 2013-2023.

The progression of the technology and the new adaptations of the commercial UAVs will increase as the trade of drones. The evolution of regulatory policies and directives has a good effect on the market growth.

REGULATION

The elaboration and the existence of the regulatory environment and the cross-border norms play a key role in the spread and usability of UAVs. Legislation is influenced by several factors and it has some concern as well. There is a wide range of difference among national and intercontinental regulations, meanwhile the harmonization is difficult. This is the main problem both in the European Union and globally. There are some other major regulatory problems like aviation regulation and security issues. General air traffic has become congested and overloaded with the spread of drones and their utilization in many sectors.

The UAVs had controlled and limited access to airspace based on previous aviation regulations. However the airspace became too crowded despite these rules. This particularly affects the big cities. Drones have become disturbing factors for other airspace users like aircrafts. However, uncontrolled drones are and can be a serious security issue. There is a pressing need to modify the airspace usage limitation for these devices. They have to integrate with other users in the airspace. But such modification is not easy. These regulations and integration processes must be enforceable and innovative.

The motion of drones in airspace and their traffic control has another problem: these devices move fast anywhere in multiple directions, unlike other means of transport. In this case there is no limitation as guided land transport has the rails or road traffic has drive-ways. Therefore any malfunction could pose a serious security risk. To make safe operation and usage possible not only airspace regulation is needed, but other factors need close attention as well.

The level of security, malfunction protection and manufacturing technology of the drones must meet serious requirements. These factors can also avoid accidents like crashes of the UAVs. Beyond technical and usage issues we also have to pay attention to data protection problems. The drones are suitable for observation with the connected cameras and sensors. There is an urgent need to regulate this issue. Like all evolving technologies, drones are very risky when it comes to cybersecurity as well. Malicious actors can sabotage and use them to support their own agenda. It can be seen that

drone regulation is a very complex issue. There was and there is a need for a comprehensive package which includes identification, tracing, traffic management and operation as well .

The European Union has introduced a number of laws and regulations over the past few years. Such as the Regulation (EU) 2018/1139 of the European Parliament and of the Council (4 July 2018) on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations.

On 26 June 2018, the Council also adopted a new proportionate and risk-based rule. This allows the EU aviation industry to grow and become more competitive. Furthermore, the European Commission adopted EU-wide rules (EU) 2019/945) on 12 March 2019, which specifies the technical requirements for drones. The Regulation is in line with the previous European Union Aviation Safety Agency (EASA) Regulation. It sets out important principles regarding security and personal data protection.

These new regulations and common rules will also encourage increased investment and innovation in this sector.

DRONE UTILIZATION AREAS

Drones can be used in many areas. These devices have changed a lot since their release. The market offers many variants with many specifications today. Generally the most important election aspects of these vehicles are the price, size, weight, effective ranch, battery time and the service that they provide. Different sectors can have different priorities:

1) Energy and infrastructure
   These sectors typically need long distance capability to monitor the infrastructures like roads and wires. UAVs can reduce the cost of the control process. One solution can be the pre-programmed route. In certain cases, experts can take closer measurements to achieve better analysis accuracy.
2) Agriculture / Nature reservation / Environmental protection
   Drones can be used to control and monitor the previous category. The more accurate data gathering becomes possible by using these devices. Also the control of the animals and plants can become easier.
3) Construction industry
   We can use drones to improve work processes in many different ways in this industry such as territorial analysis of the building areas, aerial photography, data gathering and refinement of design work. UAVs can provide a more cost-effective solution for controlling, monitoring or support of construction work. Furthermore, there may be other usage of construction monitoring and control.
4) Security, critical care, disasters
   UAVs with cameras and sensors are excellent for special cases. They can be used to detect disasters and security incidents, as well as to information transfer. It makes the response for incidents and decision-making more effective.
5) Cartography, photography, film industry
   We can make significant cost savings in these sectors by using drones. This technology makes possible the usage of better and wider viewing angles, better focusing performance and new viewpoints.
6) Transport, logistics
   At the transport and logistics sector there are many possibilities to use UAV technology such as delivery, inspection, inventory. etc.. The following chapter gives a better overview of this specific sector.

DRONES AT LOGISTICS

UAVs can be used in many different ways at the transport and logistics sector because of the integration into and with each other. The devices that can be used here are those that can work with small cargos or without them. They are best to integrate new logistics applications and services into existing and new systems. The load and battery capacity is key when it comes to the consideration of usage of drones in these sectors.

In this article, the utilization area will not be presented fully. Focus will be given to the applicability of the drones in intralogistics. We would like to provide an introduction to each application. Within the areas of use we will discuss and examine their practical application and experience whey will give in the inventory system (Figure 2). To carry smaller packages is another important area of usage of drones. We will revisit that topic later in this article.

The reform of delivery methods is expected. This is closely related to the increase in demand. The UAVs can significantly facilitate the access of the crowded beehives at the cities. This solution is expected to play a major role in the future, although transportable cargo and the battery is a problem here as well. The potential of UAVs can be the same as conveyors and wires.

Figure 2. Drone supported inventory.

In an intralogistic environment, we should focus on areas where drone usage has a significant positive impact on efficiency. Possible areas are cost-effectiveness or replacement of human resources. These can make the process more economical. In our opinion, drones and related smart applications can not replace the human resources today. However, the complex tasks entrusted to them can free up human capacity, even so a complete decision-making process can not be replaced. Human responsibility will remain important in the following recovery areas, although most of the tasks can be done automated with a help of drones:

1. inventory,

Inventory and its control is typically an application area where drones have been proven to be effective. The primary condition of such solutions is the proper position of the cargos, collectors and pallets. Because of the usability of the associated identification marks, tags, barcodes, etc. have to be scannable by the drones. The modification of the storage system and the routes are not

necessary. This kind of preparation does not interfere with material transport. The only criteria is drones have to be customizable and integrable to the given system. They need to have reading, recording and data transmitter capability and applicable cameras. The right controlling algorithms of drones are also important. Such solutions already exist, like Exesee or Aeriu, which we will introduce later in this article.

2. commission,

In case of commission we also need smart devices that can replace human resources. This work can be done faster and more effective with drones instead of human beings. The homogeneous warehouses can be rendered inhomogeneous. In this case drones are also equipped with transportation or grasping add-on besides reading, recording and data transmitter capability. Using multiple devices in the same time is possible similarly as at inventory usage. However, we have to keep in mind that these devices can crash with each other. As we can see, there is a huge potential in this application as well. The challenge here is the stability and strength of the transport mechanism besides the carrying and battery capacity. There are other automated solutions such as portal robots. These can be competitors of drones.

3. delivery,

We already mentioned delivery and shipping out of stock. There is a huge market interest in this area. Depending on the specific need not just indoor devices can be used but the wild range of drones. In this case, it is possible to carry out an autonomous transport task based on GPS coordinates. These drones must be endowed with the appropriate artificial intelligence and they have to have integrated sensors and image recognition solutions as well. The carrying and battery capacity is a serious challenge here. There are other problems that we have to solve here such as unattended control, recognition of the environment, flight control and changing weather conditions. In this case delivery primarily means the delivery within the warehouse and delivery from storage complexes to depots or other landfills. It can also mean getting to the end user. This area of utilization requires even more technological development.

4. working day sampling.

This is a statistical metric of a sift utilization rate. It shows the observation of devices, operators, machines at a factory, a warehouse or other facility from time to time. Using this metric we can optimize our processes because we can easily and more effectively reduce the waiting time for different tasks. To be integrable with the available systems the drones have to be equipped with on-board cameras, reading and transmitting units [9].

DRONES IN INVENTORY - THE HUNGARIAN STARTUP, AERIU

The control of inventory is one application of drones. It can make the process easier and faster. We can find workable and proven solutions at many international companies from Africa, Singapore, US, France and Hungary. It means practical experience and measurable results are available from the field of utilizing drones in logistics. Proven results in measuring its effectiveness are accessible. We conducted a personal interview with Gergely Ellenrieder, the CEO of Aeriu. Aeriu is an international startup from Hungary. They are active in this sector. Gergely answered our questions and shared his experiences with us.

Auriu is a software development company with a revolutionary product. They operate with man-driven drone(s) in a warehouse environment. It is able to scan and read the ID on pallets and products while flying in “S” shape. The software can be controlled via an iOS-based Iphone .

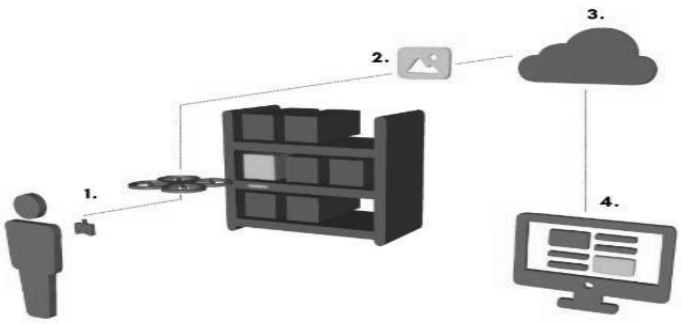

Figure 3. Principle of operation.

As can be seen in Figure 3, the data captured by the drone is transmitted to a synchronized cloud. It makes the information available to the application's users. Aeriu mostly focuses on software development. That is why they do not need to develop their own drone. Their solution is able to work with any commercially available device. The customer doesn not need to buy new hardwares, because Aeriu can operate with drones purchased for other purposes earlier. The solution of Aeriu is easy-to-implement, and it can be use and maintain simply. This is Aeriu's unique value proposition comparing to their competitors. They provide full service to their customers. They also give advice and technical expertise besides the software itself. After assessing the customers unique storage environments and endowment they optimize the software, the devices and other necessary resources [11].

The company was established by five young IT professionals in 2017. After the idea and initial thoughts, they thoroughly investigated the warehousing and logistics environment. They realized there are many problems with traditional manual inventory. Inventory with forklifts is a very slow process when accident prevention rules are followed. Furthermore, a manpower-controlled forklift was slow and the operator had to overcome serious maneuvering obstacles. The number of people working as a forklift operator has decreased, but their inventory job had to be done. Using modern solutions seemed like a sustainable approach that can provide a faster, more efficient, and more secure inventory. The founders firstly collected a wide range of information about the challenges and needs of the corporates - and they figured out what the real problem was [11].

The main issues with forklift-used inventory were the shortage of manpower, problems of the monotonous work, slowness, inaccuracy and hazardous working environment. Furthermore, the chance of making mistakes was also very high, not to mention the fact: inventory of forklifts requires at least two people. E-commerce and the change of the market environment are putting an increasing amount of pressure on storage systems. Speed and cost-effectiveness are increasingly important. Aeriu started to test their new solution at Waberer's, Nestle and Hell.

According to Aeriu, using drones makes the time spent on inventory become 50 % faster. Drones can scan a pallet of barcodes in about 8 to 10 seconds. This means if we use 2 drones and they do the inventory work for at least 6 hours, approximately 3 000 pallets can be accurately captured without an error. Initially, it was difficult to convince companies that inventory with drones can be a safe and fast solution in tight indoor warehouses. However, after tests and comparative analysis, it became clear that the security risk is much lower. Moreover, the videos captured by drone cameras capture additional relevant information as well, which can be analyzed. Such as permissive waste can be monitored or quality defects in products and storage systems can also be detected. A machine learning algorithm can prevent potential threats, too [11].

The company promises their solution makes inventory 50 % faster, 99-100 % greener and safer, and about 20 % cheaper. For the time being, the drones must be controlled by humans. In order to handle the Aeriu software correctly, employees need to participate in a 16 hours long training. Their services are available in several packages as of now (Figure 4).

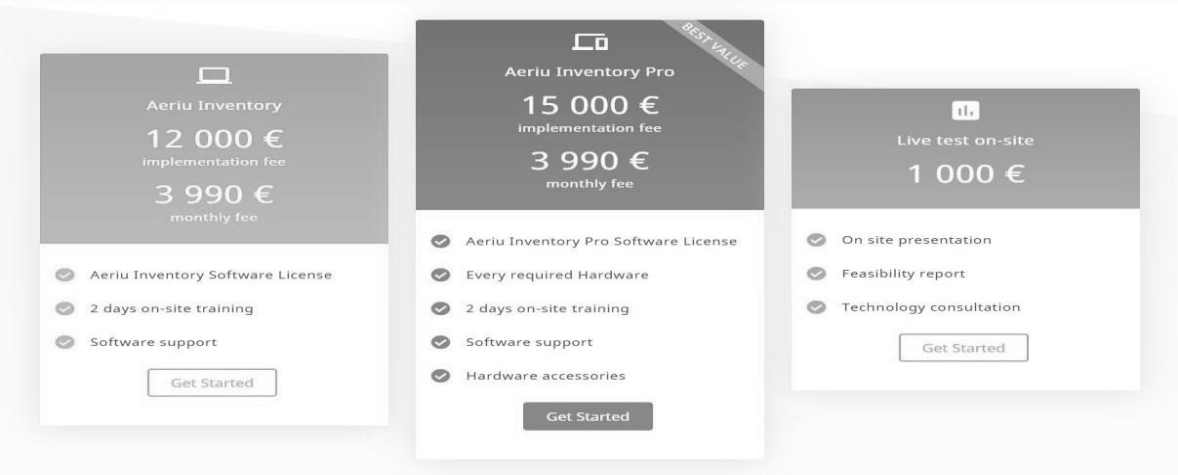

Figure 4. Aeriu packages and pricing.

The Aeriu system can be fully customized and integrated to the customer’s existing systems. In addition, custom upgrades and devices are also available. They use implementation and monthly fees. As drones are not developed by Aeriu they cooperate with Duplitec Ltd. They are DJI's official partner in Hungary. That is why they can be replaced immediately if the customer's drones fail. The first customer of Aeriu was IKEA in Hungary. Here they use the company's products to carry out the inventory work [11].

At the end of 2019, Aeriu was invited to Milan (Italy) by a multinational company, RGIS. They deal with inventory as their main activity around the world. RGIS has ordered the full service package. Such inquiries and concluded contracts show that there is a need of Aeriu’s services [11].

Aeriu plans to conclude additional domestic and international contracts. They want to expand into the region and Europe and also hit international markets such as the US and Canada. Product development will not stop, and they are working on team and services extension. Achieving autonomous flight is also a development plan. For the time being, they are still thinking about indoor usage [11].

SUMMARY

Unmanned aerial vehicles and drones are expanding into new areas and new market segments. As a matter of fact, the increasing proliferation of assets has changed the market itself. There are new technologies, developments, new services and applications for such devices. Current forecasts suggest that drone recovery will cut a larger slice of the global market. The utilization areas are numerous. Drones can be applied in several sectors both indoors and outdoors. The transport and logistics sector is also taking advantage of the opportunities that are offered by unmanned aerial vehicles.

This technology is going through an immense amount of improvements, however, it faces lots of challenges as well. The creation of a safe and identifiable usage of the drones in the airspace is also a major regulatory challenge. Legislators have made progress in many areas to create a better regulatory environment, but there are still regional and global issues which need to be resolved. The main problems are the safe technical and physical parameters, the identifiability, the security of the extracted data and airspace control. There are issues with the battery capacity that cause a short range of the UAVs. In addition to these basic challenges, the design of vehicles suitable for transport is also a challenge. Furthermore, we have to find a way how we can use drones in the

security and control sector. Using them in different integrated systems can be a dual perspective. While it can cause the elimination of lays, on the other hand, it can solve a shortage of labor.

Drones have been investigated primarily for use in the transportation and logistics sector in this article. The usage of these devices was examined at intralogistics, because measurement results are already available mainly in indoor use and the regulatory environment is also better. We have introduced effective, fast, accurate, and secure applications for inventory and its control system. We have also examined their opportunities and major applications. We conducted a personal interview with the Hungarian startup, Aeriu to gain better understanding about the practicalities of using UAVs. They have provided inventory solutions with drones. The received information has confirmed what we had known so far. The use of drones in logistics gives measurably more effective results.

The used technologies and the direction of developments offers many opportunities not only for the transport and logistics sector but also for many other sectors. The transportable drones will bring improvements and new applications with the help of integration. The usage of machine learning and artificial intelligence can also lead the developers into new dimensions. Better regulation environment and the improvement of technical parameters and capabilities may cause a reform of the use of drones in the market.

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MANUSCRIPT PREPARATION GUIDELINES

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ABSTRACT Concisely and clearly written, approx. 250 words.

KEY WORDS Not more than 5 key words, as accurate and precise as possible.

CLASSIFICATION Suggest at least one classification using documented schemes, e.g., ACM, APA, JEL.

TEXT Write using UK spelling of English. Preferred file format is Microsoft Word. Provide manuscripts in grey tone. For online version, manuscripts with coloured textual and graphic material are admissible. Consult editors for details.

Use Arial font for titles: 14pt bold capital letters for titles of sections, 12pt bold capitals for titles of subsections and 12pt bold letters for those of sub-subsections. Include 12pt space before these titles.

Include figures and tables in the preferred position in text. Alternatively, put them in different locations, but state where a particular figure or table should be included. Enumerate them separately using Arabic numerals, strictly following the order they are introduced in the text. Reference figures and tables completely, e.g., "as is shown in Figure 1, *y* depends on x …", or in shortened form using parentheses, e.g., "the *y* dependence on *x* shows (Fig. 1) that…", or "… shows (Figs. 1-3) that …".

Enumerate formulas consecutively using Arabic numerals. In text, refer to a formula by noting its number in parentheses, e.g. expression (1). Use regular font to write names of functions, particular symbols and indices (i.e. sin and not *sin*, differential as d not as *d*, imaginary unit as i and not as *i*, base of natural logarithms as e and not as *e*, x_{n} and not x_n). Use italics for symbols introduced, e.g. $f(x)$. Use brackets and parentheses, e.g. {[( )]}. Use bold letters for vectors and matrices. Put 3pt of space above and below the formulas.

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