**20(1), pp.1-63, 2022** **ISSN 1334-4684**

# INTERDISCIPLINARY DESCRIPTION OF COMPLEX SYSTEMS

## Scientific Journal

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Scientific Journal

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INDECS, volume 20, issue 1, pages 1-63, year 2022
Published 21st February 2022 in Zagreb, Croatia
Released online 21st February 2022

**Office**

Croatian Interdisciplinary Society
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Published bi-monthly by *Croatian Interdisciplinary Society* (http://idd.hr) as online (ISSN 1334-4676) and printed (ISSN 1334-4684) edition. Online edition, http://indecs.eu, contains freely available full texts of published articles. Printed by Redak d.o.o. (HR) in 50 pieces.

Journal INDECS is financially supported by Croatian Ministry of Science and Education.

Content of the journal INDECS is included in the DOAJ, EBSCO, EconLit, ERIH PLUS, Ulrich's and Web of Science Core Collection.

INDECS publishes original, peer-reviewed, scientific contributions prepared as reviews, regular articles and conference papers, brief and preliminary reports and comments to published articles. Manuscripts are automatically processed with the system Comet, see details here: http://journal.sdewes.org/indecs.

The accessibility of all URLs in the texts was checked one week before the publishing date.

# LETTER TO THE READERS

Dear readers,

this issue of the journal INDECS marks the beginning of the publishing of the jubilee volume. Main reason why this journal publishes scientific contributions for almost two decades is your continuous interest in its content, seen on the one hand in submission of high quality manuscripts, and on the other hand in your reading of that content.

In order that the articles published convey as much information as is possible, and of the highest possible quality, the boards of the journal continuously reflect, modify and adapt the procedures governing manuscript processing and other procedures that are not directly seen, as well as the journal format in order to make the information processing easier.

Among these procedures, let me as first emphasise here the more and more rigorous criteria for accepting a manuscript within the review process. However, a significant increase in the number of the submitted manuscripts as observed within the last several years eventually brought about larger number of published articles. As a consequence of that, starting with this volume, a journal INDECS will be published six times annually, i.e. bimonthly. Secondly, let me emphasise that with this volume format of the journal is slightly changed.

Further changes in the format and other procedures governing manuscript processing are left for further issues of this volume.

Cordially,

Zagreb, 28th January 2022 Josip Stepanić

# LIST OF REFEREES

The following scholars, listed in alphabetic order of their surname, refereed manuscripts for the journal INDECS in 2021:

Ana Aleksić
Nijaz Bajgorić
Ivan Balabanić
Soumya Banerjee
Tine Bertoncelj
Navneet Bhalla
Erik Brezovec
Mirjana Cizmesija
Oscar Claveria
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Ema Demšar
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Hinko Wolf
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Vatroslav Zovko
Berislav Žmuk

Cordially,

Zagreb, 28th January 2022

Josip Stepanić

# EDITORIAL: SMART CITIES RESEARCH HIGHLIGHTS AND FUTURE TECHNOLOGY TRENDS

**Lectori benevolo salutem,**

In 2020 we organised the fifth Smart Sustainable and Safe Cities Conference. In recent years this event has become a tradition in Óbuda University and a Safety and Security doctoral school. This conference is an overview of the technology trends driving Smart Cities related to infrastructure such as 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 thematic issue of INDECS examines the design and research philosophy of complex systems such as smart cities and the developments related to these technologies.

The urban structures and technological advances presented in this thematic issue support the goals of sustainable development in communities, where these intelligent and smart systems will cover all aspects of life.

Some of the topics discussed include, for example, smart city application development,

WI-FI 6, smart city solutions, information security management, wireless networks, smart transport, smart healthcare, smart cars, critical infrastructures, smart mobile device, and systems. The relationship between various research topics and some emerging, sustainable and safe city implementations will also be presented.

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

The selected manuscripts will publish two thematic issues of INDECS. In this issue:

**Borsos** and **Berek** in their article name *Challenges of LoRaWAN technology in smart city solutions* approach present how their own surveys show that the vast majority of these devices are related to smart city applications.

According to research 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.

In the next article: *Smart cars as a solution for overpopulation* by **Pisarov**, analyses the impact of Self-driving cars would be the solution for overpopulated cities, where citizens will have fast, comfortable, economical, safe, and secure vehicles at their disposal, which allow them to effortlessly reach their destinations on time.

Self-driving cars are definitely part of the intelligent transport system of smart cities.

**Lusková** and **Leitner** in their article named *Societal vulnerability to electricity supply failure* examine the possibility of providing a coherent way to clarify the primary causes of disruption of large-scale electricity supply and their impact on the functioning of society, focusing on the vulnerability of urbanized large settlements - urban agglomerations - in the event of long-lasting blackout disturbances.

The energy sector is considered to be one of the most important critical infrastructure networks significantly entering into ensuring the functional continuity of the smart city.

**Bálint**'s article presents the C*omposition of an automated attendance register of students by security cameras, as part of the smart city* presents a solution to how security cameras should be upgraded by expanded intelligence to greatly facilitate the administration in schools and to have a positive influence on safety.

To guarantee safety represents a serious issue in smart cities what's more one of the pillars of a smart city.

The article by **Mester** *Smart mobility solutions in smart cities* brings a new twist on the way we think about intelligent transport.

**Albininé Budavári** and **Rajnai** in their article named *The energy importance of additional information* explore benefits through the example of an online game, that a considerable amount of extra data can be transferred due to the possible negligence from the part of the tax side of the data transfer.

*Exploratory factor analysis for identifying CIEDs patients' concerns during the COVID-19 pandemic in Europe* the article by **Dobai, Iantovics, Paiu** and **Dobreanu** articles aims to investigate a solution based on the use of autonomous social agents to optimize the complex manufacturing processes in the framework of Industry 4.0.

*How safe is your smart city?* the article by **Papp** describes how we can manage public safety by transforming the city environment in a proprietary way.

There are many problems in cities from virtual threats, crimes to the epidemic, but in smart cities, we can find good solutions to these problems.

The aim of the present thematic issue is to offer researchers an opportunity to extend their existing scientific relationship 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.

The majority of these studies focus on smart cities, and they can be successfully implemented in various areas of developing sustainable and safe communities all over the world.

Cordially,

Budapest, 30th December 2021

Guest editors:
Daniel Tokody
Gyula Mester

*Interdisciplinary Description of Complex Systems* 20(1), 1-10, 2022

# CHALLENGES OF LORAWAN TECHNOLOGY IN SMART CITY SOLUTIONS

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DOI: 10.7906/indecs.20.1.1
Regular article

*Received:* 27 November 2020.
*Accepted:* 20 June 2021.

## ABSTRACT

A number of technological application factors can be highlighted in smart city solutions, where small data and long-range transmission are of primary consideration. These include monitoring energy consumption, operating a smart waste management system, monitoring, and tracking traffic, having smart parking systems, monitoring public lighting, and even detecting various malfunctions. Such smart city systems use IoT technology for data collection. An essential aspect of urban solutions is to ensure the coverage of large areas, both outdoors and indoors, low energy consumption, as well as modularity and mobility. LPWAN technologies can meet these conditions. LPWAN technologies include LTE-M, NB-IoT, LoRaWAN, and Sigfox. Using LoRaWAN technology can be the right solution for these cases. As with any application, it is crucial to clarify the challenges of the application with LoRaWAN. The present study addresses the categorization of LoRaWAN devices and the challenges of technology in smart city solutions. LoRaWAN products used in smart city solutions can be grouped according to several aspects. This article deals with the creation of classifications that facilitate further testing. Smart city application challenge studies are applied to the specified categories. The challenges of the solutions cover several areas. These include technological aspects, aspects of specifications, and aspects of the nature of the application. Another area represents the information security aspects, which is, however, not addressed by this invention. Based on these aspects, the article describes the challenges of LoRaWAN technology in smart cities.

## KEY WORDS

LoRa, LoRaWAN, smart city, applications, device categories

## CLASSIFICATION

ACM: B.4

JEL: L63, L96

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## INTRODUCTION

If we consider IoT trends, they show that there are a lot more IoT devices than predicted. Based on 2019 data, there are 9,5 billion IoT assets, compared to the estimated 8,3 billion. The number of IoT devices could reach an estimated 28 billion by 2025 [1]. Surveys show that the vast majority of these devices are related to smart city applications. Researchers among the ten most relevant trends are also among the smart city solutions in 2020 [2]. LoRaWAN is also one of the IoT, LPWAN communication technologies [3].

LoRaWAN technology is wireless, low-power, long-range radio communication that works reliably even in weak signal propagation conditions [2, 4]. Because of these properties, they are preferred for use in smart city solutions. With the help of LoRaWAN devices, which are connected to the network, large areas, especially cities, can be easily covered. The following conclusion addresses LoRaWAN devices that are suitable for smart city solutions. The grouping of smart city solutions and areas is possible from several aspects. Six core areas can be distinguished: environment, life, people, mobility, economy, and government [5-7]. These include, for example, trackers, consumption meters, environment sensors, and parking sensors with LoRaWAN technology.

LoRaWAN communication is one of the most significant technologies used in smart city solutions. This is shown by the presence of available LoRaWAN networks in 162 countries [8]. Numerous research and development projects deal with LoRaWAN due to its topicality. An important aspect when applying a new technology is the set of requirements and challenges it has to meet and the issues it may need to solve. Each technology has its own limitations that need to be considered in such studies; this is also true for LoRaWAN. In addition, similar, competing LPWAN technologies also present challenges. The LoRa Alliance is responsible for the LoRaWAN specification, which is constantly being developed, improved, and upgraded with newer versions [8, 9]. These specifications also raise some issues. The application environment of a LoRaWAN solution (indoor, outdoor, fixed, mobile) presents additional challenges. In addition, it is important to highlight that certified LoRaWAN products can be categorized by functionality. The categories contribute to research and findings.

The structure of the article is as follows: The introduction is followed by a description of LoRaWAN technology. Next is a summary of the grouping of certified LoRaWAN products, as well as the significant challenges arising from the technology, followed by a discussion of the aspects of LoRaWAN specifications. The challenges posed by the nature of the application are also summarized. The review ends with a conclusion, which includes the possibility of additional study areas.

## BASICS OF LORAWAN TECHNOLOGY

LoRaWAN network technology is based on LoRa technology developed by Semtech [4, 10]. The first issued tool appeared around 2013-2014. The name LoRa is an abbreviation of ‘long-range’, which refers to the long data transmission distance that the technology is capable of. The LoRa Alliance was founded in 2015 to regulate the network operation of this technology [11]. The essence of the technology is to be able to build large-scale wireless networks, even in unfavourable field conditions, all with low energy consumption. Considering that we are talking about IoT technology, we must not forget about mobility and that it is possible to establish secure two-way communication. The standard, which is continuously updated by the LoRa Alliance, allows developers and users flexible networking and use. The essential features of LoRa and LoRaWAN communications related to the topic are highlighted.

The long range of LoRa technology is due to the use of special frequency modulation, called chirp spread spectrum (CSS) modulation. The LoRaWAN specification defines the lower two layers of the OSI model: the physical layer and the MAC sublayer of the data link layer; and the application layer. Communication in Europe takes place at 868 MHz and 433 MHz, but 868 MHz is typical. Communication is two-way, with multiple channels. The devices are characterized by low power consumption; 10-year operating time is also available with a button cell. The data transmission distance in the city is a few kilometres, but it can be up to 10-15 km in less populated areas. The data transfer rate is relatively low, at a maximum of around 50 kbps. During communication, the messages are encrypted. The communication uses AES-128 encryption [11, 12].

The features can be summarized as:

- chirp spread spectrum (CSS) modulation,
- 868 MHz and 433 MHz frequencies in Europe,
- wireless radio two-way communication,
- low consumption,
- 1 % transmission time,
- low consumption,
- 10-15 km bridgeable distance,
- 0,3-50 kbps data transfer rate,
- AES-128 encryption,
- star-of-stars network topology.

Network participants include end-devices, gateways, the network server, and application servers [12]. Communication between nodes and gateways takes place via LoRa. The connection between a gateway, a network server, and an application server is IP based. Nodes are usually simple devices equipped with LoRaWAN communication capability and some sensors. Gateways are connected to end-devices. There can be multiple nodes and gateways within a network. Gateways, in addition to network end-nodes, communicate with network servers. The application server and the network server are connected to each other and can be physically present on one device. The network server is responsible for monitoring and managing the network format. The application server decodes the data and displays it in a way that the user can understand. Depending on usage, multiple applications can be connected to a network. This classic network architecture is based on the 1,0 specification; other LoRaWAN specifications may result in a different network architecture [13-16].

Nodes can be divided into three classes according to their operation mode: Class A, Class B, or Class C. In all three cases, two-way communication is supported. Class A operation is optimized for consumption, with Class A devices having the lowest power consumption. Class A devices can only receive messages after they are sent, after which they open two reception windows. It is possible to send messages to the end-devices from the network server side at any time, but they can only be received after the end-device transmission period. Class B nodes operate with extra, scheduled reception windows in addition to the previous ones. In the case of Class C devices, no waiting time is to be expected; they are capable of continuous reception. This type has the highest consumption. There are uplink and downlink messages regarding the direction of data communication. An uplink message transmits from the end-device to the network server; the downlink message's direction is the opposite. The uplink message can be an unconfirmed data message or confirmed data message [12].

Identifiers and keys are used during network communication. The most significant of these are the following. Device Address is a 32-bit identifier used to identify devices [12]. This ID is unique within each network and is part of the messages. Also worth mentioning the

Network Session Key and the Application Session Key, which are 128-bit AES encryption keys for encrypting and decrypting data and messages [12]. The connection procedure is essential for the network operation of the nodes. This can be ABP (Activation by Personalization) or OTAA (Over-the-Air Activation) [12, 17]. In the case of ABP connection mode, a request is received from the end-devices to the network server once before starting the network operation. If the IDs and keys match, the connection is established. In OTAA connection mode, after a successful connection, a handshake connection is established between the nodes and the network server. The keys are exchanged continuously, ensuring a much more secure connection [17].

## GROUPING OF CERTIFIED LORAWAN PRODUCTS BY FUNCTIONALITY

The LoRa Alliance is responsible for the certification of LoRaWAN products. The number of certified devices published on their website was 177 at the time of writing the review [18]. If LoRaWAN products are categorized, additional tests can be performed. Besides, it is necessary to describe the specific categories. There are eight categories based on the function categorization of certified LoRaWAN devices. These are as follows:

- module: a PCBA card, a basic circuit set that complies with the LoRaWAN specification and features long-range, low-power, bidirectional, wireless communication. The LoRaWAN module is not a finished product, and it is the main chip of LoRaWAN application development and finished product production [18, 19],
- development board: a printed circuit board that fundamentally contains a LoRaWAN module and the necessary additional logic associated with it, used for learning and prototyping [18, 20]. The LoRaWAN development board can include a microcontroller or can be connected to microcontroller development boards via a typical connection line,
- sensor node: a finished product which consists of three central units: a sensor unit, a processing unit and a LoRaWAN module [18]. The sensor node can detect specific changes in the environment, react to them and transmit the processed data over the LoRaWAN network [21, 22],
- actuator node: a finished product which consists of three central units: an actuator unit, a processing unit and a LoRaWAN module [18]. The actuator can make a specific change in its environment [23], depending on the messages received on the LoRaWAN network,
- sensor interface unit: a finished product which consists of three central units: a sensor connection, a processing unit and a LoRaWAN module. The sensor interface unit connects to sensor devices [18]. It can collect data from them and then transmit the data on the LoRaWAN network after processing [24],
- meter interface unit: a finished product which consists of three central units: a standard meter connector or a standard communication interface, a processing unit and a LoRaWAN [18]. The meter interface unit can be connected to consumption meters and can collect data from them and then transmit them on the LoRaWAN network after processing,
- tracker: a finished product which consists of three central units: a locating unit, a processing unit and a LoRaWAN module [18]. The tracker is suitable for tracking persons/animals/objects, and the location data are transmitted via the LoRaWAN network [25],
- tester: a complex device that monitors and diagnoses the LoRaWAN network parameters, especially for end-devices and gateways. Another feature may be RF power testing. [18]

It is also possible to create categories according to other logic. By this logic, the ninth group would be gateways, but there is no authentication procedure for these. The formed groups can be further divided into subgroups according to further aspects. Table 1 shows the grouping of LoRaWAN products by functionality [18]. There may be devices with properties that fit several groups. In these cases, the main functionality applies.

**Table 1.** Categorization of certified LoRaWAN devices [18].

| Category | Module | Development board | Sensor node | Actuator node | Sensor interface unit | Meter interface unit | Tracker | Tester |
|---|---|---|---|---|---|---|---|---|
| **Number of devices** | 33 | 15 | 83 | 3 | 6 | 24 | 11 | 2 |

For a smart city, the additional findings apply to the following categories: sensor node, actuator node, sensor interface unit, measuring interface unit and tracker. These categories represent a total of 127 different products. The study does not consider devices that use LoRaWAN technology but are not on the list of certified devices. These devices can be directly or indirectly part of smart city solutions.

## TECHNOLOGICAL ASPECTS OF THE CHALLENGES

Considering the challenges of LoRaWAN technology, the following three main issues can be highlighted: competing technologies, technological limitations and network operation. Closely related to these are the aspects of the specifications, which are discussed in a separate section. LoRaWAN technology belongs to LPWA networks; there are many other technologies in this area. If we highlight two major LPWAN technologies – Sigfox, and NB-IoT – the LoRaWAN technology performs below regarding the following features. The properties of the three technologies are summarized in Table 2.

**Table 2.** LoRaWAN, Sigfox, NB-IoT properties [3, 12, 26, 27].

| | LoRaWAN | Sigfox | NB-IoT |
|---|---|---|---|
| **Modulation** | CSS | BPSK | QPSK |
| **Frequency** | 868 MHz – ISM | 868 MHz – ISM | LTE-licensed |
| **Private network** | Allowed | Not allowed | Not allowed |
| **Maximum data rate** | 50 kbps | 100 bps | 200kbps |
| **Maximum payload** | 12 bytes | 243 bytes | 1600 bytes |
| **Data direction** | Limited bidirectional | Bidirectional | Bidirectional |
| **Message number** | Unlimited | 40 daily | Unlimited |
| **Maximum range** | 15 km | 40 km | 20 km |
| **Interference immunity** | Very high | Very high | Low |
| **Encryption** | AES 128 | Not supported | LTE encryption |

The maximum data rate of LoRaWAN technology is not the lowest, at 50 kbps. The length of the payload is 1600 bytes for NB-IoT and 243 bytes for LoRaWAN. It belongs to the middle field in terms of range (5-15 km). It is outstanding that LoRaWAN technology is actively immune to interference and uses AES-128 encryption during communication; the adaptive data rate is implemented, and built-in positioning is used. These technological characteristics affect the areas of application. It should be emphasized that a great advantage of LoRaWAN technology, compared to similar technologies, is that private networks can be implemented with it. The private network avoids dependence on the service provider. Also, the cost of LoRaWAN network equipment and the spectrum is the lowest.

Some of the technology limits measured above have been presented. LoRaWAN end-devices implement at least Class A operation options, in addition to which Class B and C operations are optional [13]. The operation mode is vital in the case of bi-directional communication. Class A operation results in the nodes being able to receive only for a limited time after transmission. This way, messages sent to the end-device only arrive after the transmission period of the end-device, which can reduce the application areas. This problem does not exist for Class C operation. Communication takes place at 868 MHz or 433 MHz in Europe, in the ISM band [13]. As a result, the transmission time is also limited.

The classic LoRaWAN network consists of end-devices, gateway(s), network- and application server(s) [13]. End-devices communicate with servers through gateways. It follows that the gateway is the weakest point in the network. There can be multiple gateways in a network, which increases the robustness of the communication. In addition to the implementation of private networks, it is also possible to use a service provider network and a network service.

The conclusions to be drawn for smart city solutions are as follows. This technology is not the right choice in cases:

- at high data rates,
- in case of transmission of large data,
- in case of transmission of large amounts of data,
- continuous two-way communication is essential,
- and any combination thereof.

In the case of collecting small measurement data that needs to be transmitted continuously but at infrequent intervals, this technology can be the right choice. A typical area of application is consumption metering. Unfortunately, developers also have to deal with changing user needs. Previously, it was appropriate to have meter readings taken monthly. In the case of a consumption meter with wireless communication, there are demands that users want to see the data continuously. Comparing the monthly meter readings with the continuous data provision, this seems unreasonable. Of course, the technology allows data to be provided more frequently than monthly.

## ASPECTS OF THE CHALLENGES RELATED TO LORAWAN SPECIFICATIONS

The LoRa Alliance is responsible for LoRaWAN specifications and certification. Newer specifications are issued mainly for improvements, to correct bugs, and for clarifications [28] The specifications include everything that the LoRaWAN devices and networks must comply with. Compared to the 1,0 specification published in 2015, the next version (1.0.1) was released in early 2016 [12, 14]. This version mostly includes spelling corrections and clarifications. The next version, 1.0.2, was released in mid-2016 with some minor changes and fixes [15]. Subsequently, specification 1.1 was released in 2017, which resulted in significant changes [15]. In addition to clarifications, it contained several functional modifications. The changes that appeared were related to the following areas: frame counters, device classes, activation modes, keys and server structure. Version 1.0.3 was released in 2018 and took over the parts for Class B devices from Specification 1.1. Previously, Class B (beacon) operations could only be encountered on a theoretical level [13].

**Table 3.** Number of smart city LoRaWAN devices in terms of specifications [18].

| LoRaWAN specification | 1.0 | 1.0.1 | 1.0, 1.0.2 | 1.0.2 | 1.0.3 | 1.1 |
|---|---|---|---|---|---|---|
| **Number of devices** | 6 | 38 | 0 | 82 | 1 | 0 |

Due to several innovations in the 1.1 specification, it is not popular with developers and operators. It is less understandable compared to the 1.0.x series [28]. If we look at the comparison tables (Table 3 and Table 4), it turns out that most of the products that meet the 1.0.2 specification are in all categories. Only one product meets the latest specification (1.0.3). Of course, the specifications are backwards compatible with each other. The conclusion is that using the latest specifications can avoid bugs and misunderstandings that can be found in older versions. It is recommended to use the 1.0.3 specification.

**Table 4.** Number of smart city LoRaWAN devices in terms of specifications and classification [18].

| Specification | Sensor node | Actuator node | Sensor interface unit | Meter interface unit | Tracker |
|---|---|---|---|---|---|
| **1.0** | 5 | 0 | 0 | 1 | 0 |
| **1.0.1** | 22 | 1 | 2 | 7 | 6 |
| **1.0 and 1.0.2** | 0 | 0 | 0 | 0 | 0 |
| **1.0.2** | 55 | 2 | 4 | 16 | 5 |
| **1.0.3** | 1 | 0 | 0 | 0 | 0 |
| **1.1** | 0 | 0 | 0 | 0 | 0 |

## ASPECTS OF THE CHALLENGES OF THE APPLICATION NATURE

Due to the nature of the application, we can group the devices according to several aspects. One way of grouping comes from the place of use. According to this, we can distinguish two groups: indoor devices and outdoor devices. Also, it should be mentioned that there are devices that are used both indoors and outdoors. Based on the installation of the devices, two groups can be distinguished: fixed installation and mobile. These groupings are shown in Table 5 [29].

The examined device groups cover several smart city application areas. In the sensor node category, there are mostly simple sensor devices such as a temperature meter, a humidity meter, a light sensor, an air pollution meter, and a soil moisture meter. These devices can be used both outdoors and indoors, mostly with a fixed installation. These statements are also valid for sensor interface units. The actuator node category includes mainly devices related to lighting control; they can be indoor and outdoor and have a fixed installation. The metering interface units are mostly water consumption meter-, gas meter-, and electricity meter interfaces; this means that there can be both indoor and outdoor versions with fixed installation. Trackers are mostly used for outdoor positioning, but some devices are used indoors. Trackers are specifically for mobile applications.

In the case of outdoor equipment, physical protection should be provided, and it is important to take weather factors into account. The physical protection is not specifically a LoRaWAN technology issue; the technology is less sensitive to external disturbances and environmental factors. However, for mobile applications, device movement can be a problem. In other words, the movement of the device causes a change in the radio parameters, so it is recommended to turn on the adaptive data rate (ADR) when the device is not in motion, which often happens in mobile applications [13].

As LoRaWAN end-devices are mainly battery-operated, special attention must be paid to monitoring the supply voltage and selecting the appropriate battery. Also, different antennas may be required for the same products, depending on the installation [17].

**Table 5.** Categorization of certified LoRaWAN smart city devices by applications [29].

| | Sensor node | Actuator node | Sensor interface unit | Meter interface unit | Tracker |
|---|---|---|---|---|---|
| **Typical applications** | Temperature measurement, humidity measurement, motion detection, light intensity measurement, soil moisture measurement, consumption measurement, parking sensor | Lighting control | Temperature measurement, humidity measurement, motion detection, light intensity measurement, soil moisture measurement | Electricity consumption measurement, water consumption meter, gas consumption meter, heat quantity measurement | Person tracking, vehicle tracking, package tracking, animal tracking |
| **Indoor/ Outdoor** | Indoor/ Outdoor | Mostly indoor | Indoor/ Outdoor | Indoor/ Outdoor | Mostly outdoor |
| **Installation** | Mostly fixed | Fixed | Mostly fixed | Fixed | Mobile |

## CONCLUSION

It is not news that there are many products in smart city solutions that use LoRaWAN technology. These products can be generally used for a wide variety of purposes, but especially, for data collection tasks. The technology also makes it possible to create private networks, which further increases its use. In addition to the current use cases, new directions are conceivable, which no longer provide a convenience function, but become necessary. In light of all this, there is a need for technology-related studies, measurements, and analyzes.

The study examined products that have LoRaWAN certification. The certified devices were categorized into eight groups, of which five groups were further examined: sensor node, sensor interface node, sensor interface unit, measuring interface unit and tracker. Of the application challenges, three main groups were identified: technology aspects, specification aspects and application nature aspects. The study does not address information security aspects. It can be stated that LoRaWAN technology also has several positively outstanding features compared to competing technologies. In addition, there are technology limitations (data rate, payload size, limited receive- and transmit time) that limit the scope of applicability. The results of the classification based on the LoRaWAN specification show that most of the certified devices conforming to the 1.0.2 specification. There is only one product that meets the 1.0.3 specification. A challenge is to meet the latest specifications for LoRaWAN smart city devices and complete the authentication process. For the application, the outdoor/indoor devices and the challenges of the installation method were identified. From a technological point of view, the main focus is on mobile applications, as they have to meet regularly changing environmental and radio parameters.

Future research work can be pursued in several directions. The areas currently considered can be further examined about the identified groups. Newer certified LoRaWAN products and new specifications should also be considered during reviews. The area of investigation aspects can be expanded with information security issues, examining this for network participants. By expanding the study areas and aspects, we can get a more comprehensive picture of the challenges related to LoRaWAN smart city solutions. If we know the challenges, recommendations can be made for LoRaWAN smart city applications.

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# SMART CARS AS A SOLUTION FOR OVERPOPULATION

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DOI: 10.7906/indecs.20.1.2
Regular article

*Received:* 30 January 2021.
*Accepted:* 11 November 2021.

## ABSTRACT

The latest citizen census data shows that the world's largest cities experienced a population growth last year. As migrations continue, cities will need to work harder and more efficiently to keep up with the impact of the growing population. Because of this, smart cities will set standards in major metropolitan areas around the world.

Self-driving cars would be the solution for overpopulated cities, where citizens will have fast, comfortable, economical, safe, and secure vehicles at their disposal, which allow them to effortlessly reach their destinations on time with the help of the 5G network.

The next mobile revolution is upon us, with autonomous vehicles heralded as a new element of road traffic. Using cameras and sensors to process road and traffic data in real-time, these vehicles also exchange information with each other and traffic infrastructure, relieving the driver of numerous tasks. Therefore, besides improving the safety of road traffic, autonomous vehicles will bring significant changes to the society we know today.

## KEY WORDS

autonomous vehicles, smart cities, overpopulation, IoT, car sharing

## CLASSIFICATION

ACM: 10002951

JEL: O18

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## A DEFINITION OF AUTONOMOUS DRIVING

The word ‘automobile’ originates as a blend of the Greek autòs, which means ‘self’ or ‘personal’, and the Latin mobilis, meaning ‘mobile’. The idea behind this portmanteau was that the carriage, or more accurately, the vehicle is now mobile without horse-power.

However, the author failed to recognize that the absence of horses meant an irrevocable loss of autonomy. Trained and dressed, horses learned themselves (auto-learning) to avoid obstacles on the road, and there were countless cases of ‘autonomous drives’ when a horse returned a carriage safely home, even in the night, fog, or adverse weather conditions, if the driver was indisposed to continue the journey. Without governance, horses would at least bring the carriage to a safe-mode, grazing their fill of grass on the roadside. Contemporary efforts of the automotive industry are directed to recover some of the lost autonomy and in many ways, rise above this historic example.

Using a special perception of Kant’s theory, autonomy is defined as “self-determination within a superordinate (moral) law”. In autonomous vehicles, people override the moral law by programming the vehicle’s behaviors and responses. This way, the vehicle needs to make continual decisions about what to do in traffic, within the boundaries and specifics of the regulations and prohibitions with which it was coded.

### WHAT MAKES A CAR SMART?

Autonomous vehicles are based on a three-phase design, known as ‘sense-plan-act’ which is used in many robotic systems. However, instead of performing a series of simple tasks, autonomous vehicles need to navigate complex and dynamic driving environments. To achieve this, smart cars are equipped with a range of sensors, cameras, and radars that collect raw data from the surrounding environments. This data is then processed, while the software recommends the appropriate driving actions and responses [1-5].

### CONNECTIVITY IS THE KEY

With the current population growth rates, it is estimated that by 2050, congestion and commute times are expected to increase three times, costs of transportation four times, and carbon emissions up to five times the current level. The only viable solution is to transform the traditional city concept into a smart city, where connectivity and automated mobility provide an invisible underlying infrastructure. Apart from empowering local governments to take part in innovative solutions, offering nation-level financial aid, and embracing new technologies, one of the critical changes in developing smart cities is the advent of autonomous driving technology, Figure 1.

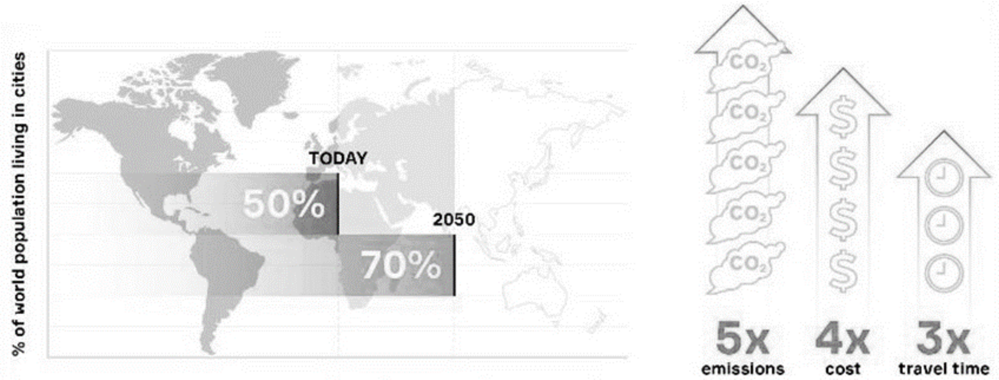


**Figure 1.** Percent of population living in cities [1].

The autonomous driving infrastructure includes everything from traffic cones to roadside sensors and smart signage. In smart cities of the future, connectivity is going to be more important than the fuel that vehicles use. Spearheading the smart city revolution, autonomous vehicles will bring a whole palette of sensors and IoT devices, while the advanced 5G network will enable them to receive, process, and transmit virtually unlimited amounts of data to modern urban environments. Experts argue that 5G might be the missing piece that will make efficient autonomous vehicles possible. The network is claimed to be up to a hundred times faster than 4G, and by 2024, it is expected to be used in 40 % of the world, Figure 2.

Recent analyses show that autonomous vehicles are capable of cutting urban travel time by a third and reducing greenhouse emissions by two thirds. For crowded metropolises of today, this means a reduction of vehicles for almost 30 %. Perhaps the more pressing issue of parking spaces would also be reduced by a staggering 40 %.

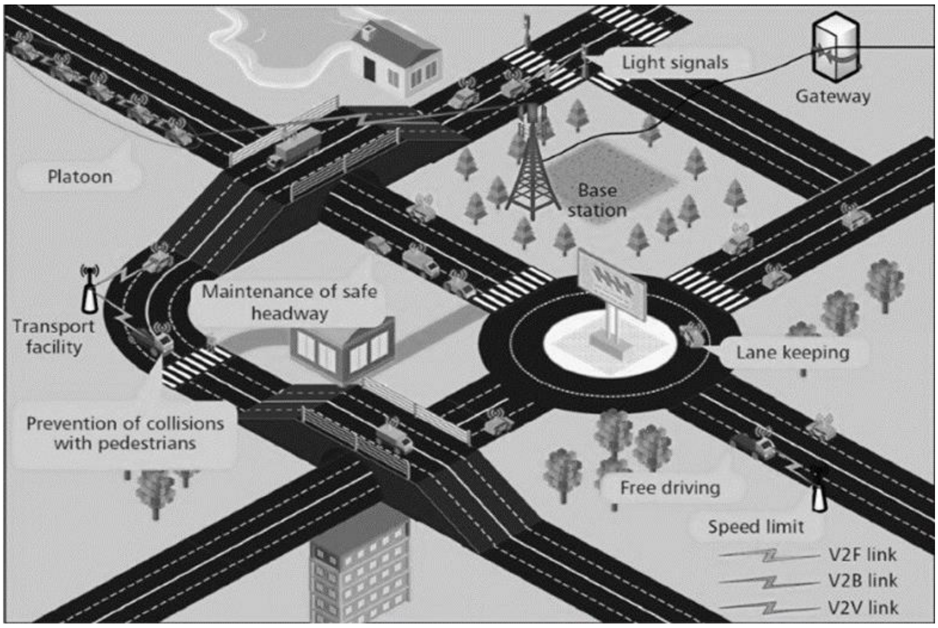


**Figure 2.** Smart city infrastructure [2].

## AUTONOMOUS DRIVING AND CONGESTION

Even the behavior of a single driver can have a dramatic impact on hundreds of cars, making it more difficult to manage traffic. While the attempts to analyze and correct the traffic patterns that lead to congestion began as early in the 1930s, it was not until recently that scientists developed simulation techniques and advanced algorithms to create more realistic visualizations of traffic flow. In experiments conducted by Alexandre Bayen, Director for the Institute for Transportation Studies and the Liao-Cho Professor of Engineering at the University of California at Berkeley, which included several dozens of cars in a small-scale closed circuit, a single autonomous vehicle could eliminate traffic jams by moderating the speed of every car on the road [6-11].

In larger simulations, the research showed that once their number rises to 5-10 % of all cars in the traffic, they can manage localized traffic even in complex environments, such as merging multiple lanes of traffic into two or navigating extremely busy sections.

## REDUCED NUMBER OF CARS

Autonomous driving technology is expected to reduce the number of cars on the road, the number of car movements, and the parking space requirements. Although this was partially achieved through car sharing, driverless cars would contribute by reducing car movements. New autonomous vehicles could also offer shared rides, however, if a large number of non-drivers decides to purchase their own autonomous cars, city cores will be congested with autonomous cars with far less capacity than public transports. This means that smart cities need to put more effort into increasing the efficiency of the number of people transported per hour, and not on autonomous vehicles as a single solution [12-14].

## FASTER COMMUTING TIMES

The idea of bringing smart infrastructure and autonomous vehicles together is to improve the quality of life for citizens and help them navigate their urban environment in a faster and safer way. Deployed as an essential component of smart technology, the Internet of Things (IoT) enables different objects and systems to communicate with each other using wireless internet connection. The IoT will have a huge role in automated driving systems, as it is used to relay important traffic messages, provide real-time energy consumption, and to communicate with other driverless vehicles.

With smartphone applications for autonomous car-sharing, millions of people could avoid being packed like sardines in trains and buses every morning, only to get stuck in hour-long traffic jams. By interacting with digital road signage and mobile apps, autonomous vehicles would receive data on delays, traffic jams, and even accidents in real-time, so they can adjust their routes to reach the destination faster. With an integrated parking grid system, the driverless vehicle could navigate straight to the nearest vacant spot, eliminating both the emissions and cruising times, which add to the local traffic [15].

## ECONOMIC AND ENVIRONMENTAL BENEFITS

With a widespread car autonomy, it is expected that car ownership will become less common. As long as the seamless service is provided, owning a car may not be as important. According to RethinkX think tank, driverless cars will be fleet-owned, perhaps even by their manufacturers. They also predict that by the year 2030, the demand for new cars will drop by 80 %. This conclusion is based on an estimate that the use of autonomous cars will increase at least tenfold, which means fewer vehicles on the road. When it comes to autonomous cars, fossil fuels are not as practical as electric power, and the new infrastructure needed to charge electric batteries and the associated technology will create many jobs for the increasing population. In this sense, smart cars will contribute to the general effort to limit the use of fossil fuels and adopt greener forms of transport with minimal carbon emissions (Fig. 3.).

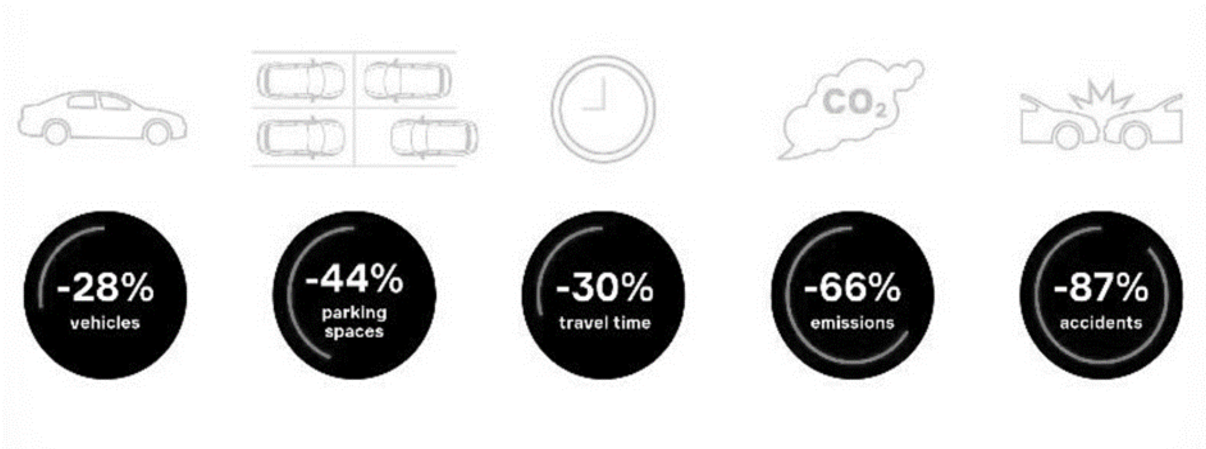


**Figure 3.** Economic and environmental benefits [3].

## CONCLUSION

By investing in more systems that are able to communicate with autonomous vehicles through IoT platforms, smart cities would be able to solve upcoming issues even before they become problems, helping to allocate resources in such a way that maximizes the effectiveness of autonomous vehicles in reducing traffic, emissions, and in increasing road safety for all participants.

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*Interdisciplinary Description of Complex Systems* 20(1), 16-26, 2022

# SOCIETAL VULNERABILITY TO ELECTRICITY SUPPLY FAILURE

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DOI: 10.7906/indecs.20.1.3
Regular article

*Received:* 31 May 2020.
*Accepted:* 15 November 2021.

## ABSTRACT

Today's modern society depends on a number of infrastructures to operate. Failures in these systems cause significant economic impacts and can also endanger people's lives and health. Due to the high importance of these infrastructures, they've received increasing attention in recent years and are referred to as critical infrastructure. Critical infrastructure in the energy sector is considered to be one of the most important infrastructure networks significantly contributing to ensuring the functional continuity of the society. Its importance is also perceived in terms of interconnections and correlations with other critical infrastructure sectors as well as in terms of electricity interconnectivity in Europe, as in the interconnected European system the effects are spreading across the systems of all single country transmission system operators very quickly. For these reasons, the European Union considers this sector to be strategic and of European importance.

The aim of this article is to clarify the primary causes of the disruption of large-scale electricity supply and their impact on the functioning of society, focusing on the vulnerability of urbanized large settlements – urban agglomerations – in the event of long-lasting blackout disturbances. It contains a presentation of the importance of electricity for society, the definition, and the analysis of the causes of disruption to large-scale electricity supply continuity, consequences of a large-scale blackout on community functioning and its basic functions, and current knowledge on the vulnerability of large urban agglomerations to long-term disruption of electricity supply and possible solutions.

## KEY WORDS

electricity infrastructure, disruption of large-scale, blackout, society, vulnerability

## CLASSIFICATION

JEL: K32, O13, Q40

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## INTRODUCTION

Modern society and sustainable technological progress are increasingly dependent on a continuous and reliable supply of electricity. Electricity supply is key to the basic needs and functioning of human society. If the supply of electricity is interrupted or significantly reduced, there is a risk of a reduction in economic and social activities, a threat to property, but often also to human health and life.

The electricity sector is of irreplaceable strategic importance in every society and, as it is necessary for the safe and reliable operation of other vital infrastructure, it is included among the key sectors of critical infrastructure. Critical infrastructure is an asset, system or part thereof that is necessary to maintain the basic functions of society, health, protection, security, quality of life of the population from an economic and social point of view, and whose disruption or destruction would have serious consequences for not being able to maintain these functions [1].

A specific feature of the electricity infrastructure is the fact that in the event of its disruption and subsequent interruption of electricity supply, the impacts on the external environment of the electricity system may be much higher and more unfavorable than the equipment damage itself or the losses of revenue for undelivered energy. This fact is reinforced by the interconnections and correlations of the electricity sector with other sectors of critical infrastructure, as well as various other sectors. Electricity systems in Europe form a complex system and possible disruption or damage to interconnected energy networks can affect a large number of people, endanger their health and lives, cause an adverse environmental impact and cascade effect of the interconnected systems.

## CAUSES OF LARGE-SCALE ELECTRICITY SUPPLY DISRUPTION

Disruption of large-scale electricity supply occurs in the case of a significant and sudden shortage of electricity or endangering the integrity of the electricity system, its security and the reliability of operation throughout the country, the defined territory or part of it [2]. If the whole electricity system or a significant part of it finds itself without voltage, there is a negative event called blackout. On a practical level, blackout represents a large-scale disruption of electricity supply to a large number of customers over a period of time.

European legislation according to EU Regulation 2017/1485 defines blackout as the state of the electricity system when all or part of the transmission system is out of operation. A blackout failure occurs if at least one of the following criteria is met:

1. loss of more than 50 % of demand in the concerned Transmission System Operator’s control area,
2. total absence of voltage for at least three minutes in the concerned Transmission System Operator’s control area, leading to the triggering of restoration plans [3].

The primary causes of disruption of large-scale electricity supply are failures of any of the subsystems of the electricity infrastructure, which consist of:

- Energy sources (power plants).
- Transmission and distribution systems.
- Controller information and control systems.

Power plants may be out of operation mainly due to [2]:

- direct damage to certain manufacturing equipment (due to technical failure, material error, neglect of maintenance, natural disaster, intentional attack, …),

- malfunction of the control system,
- improper controller action or manipulation (failure of a human factor),
- disintegration of the electricity grid supplied by the power plant,
- lack of fuel or other operating materials.

Transmission and distribution systems are particularly vulnerable to [2]:

- direct damage to a certain line element,
- malfunction of the control system or the automatic protections,
- improper controller action or incorrect handling,
- malfunction of technology, damage, failure of human factor,
- an imbalance between supply and demand in the system exceeding a certain threshold etc.

Controller information and control systems are forced to interrupt their function due to[2]:

- direct damage to certain elements of the system,
- incorrect function of system elements – data distortion, incorrect data evaluation, deficiencies in SW equipment, etc.,
- failure of the human factor,
- intentional overloading of the system,
- external attack – cyber attack and many others.

The transmission system of the Slovak Republic is dimensioned so that it is able to handle the failure of any one critical element, and that a simple failure is relatively easily eliminated. Thus, a large outage of the volume of transmitted electricity due to the collapse of the power system usually occurs with the synergy of several causes, acting at the same time. A frequent cause of cascading power outages is natural factors, such as strong storms, extreme winds, landslides, icing on power lines, forest fires, etc. A significant threat to the electricity system is also the human factor – intentional/unintentional activity resulting in a negative event, as well as wrong decisions in the operating the system.

In the conditions of the Slovak Republic, outages in the supply of electricity occur rather sporadically, especially during storms, snow calamities, floods or accidents on the transmission system or during its local overload. However, it can be argued that many serious outages were prevented mainly due to the robust and well-dimensioned transmission system.

## IMPACTS OF LARGE-SCALE ELECTRICITY SUPPLY DISRUPTIONS ON SOCIETY

If various preventive or operational interventions fail to prevent the interruption of electricity supply, a failure occurs. Critical infrastructure entities that necessarily need electricity for operation are usually equipped with spare sources (generators, backup sources, etc.).

However, back-up electricity sources will be kept in operation by critical infrastructure operators for only a few hours. The situation becomes critical if there is a long-term outage.

The magnitude and extent of the effect and impacts of the power outage in the affected area depend on several basic factors [4], as shown in Figure 1.

Disruption of large-scale electricity supply causes the emergence and development of a crisis situation – a state of emergency – not only among consumers, but also a threat to the protected interests of the state. The effects of blackout on the critical infrastructure sectors and other sectors of the economy may be as follows:

Industry – termination of operations in industrial enterprises can cause serious paralysis of the national economy with significant economic losses.

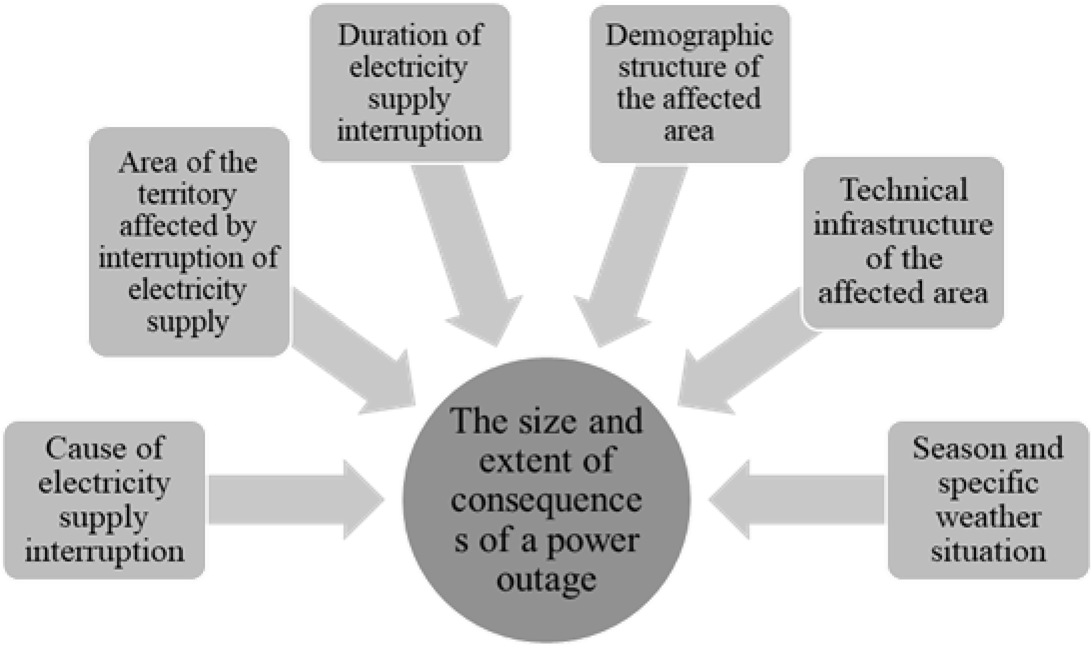


**Figure 1.** Factors influencing the magnitude and extent of the consequences of a power outage.

Gas industry – interruption of natural gas transmission and distribution due to a malfunction of technical equipment dependent on electricity.

Oil and petroleum products – malfunction of pumping equipment, termination of oil transportation and production of petroleum products, limited fuel stocks.

Communication and information systems – total failure of all ICT systems depending on the size of the capacity of stand-by power supply system.

Transport – malfunction of traffic lights and electrical interlocking devices, malfunction of petrol stations, standing electric traction vehicles, standing underground metro system, significantly limited railway transport, stopped air traffic [5].

Water and atmosphere – malfunction of drinking water treatment equipment, malfunction of pumps, paralyzed function of releasing water from tanks, regulation of water flow in rivers, wastewater treatment and sewerage, non-functional meteorological service.

Healthcare – only basic outpatient care will be provided by general practitioners without the possibility of using any devices dependent on electricity (diagnostic devices), limited operation of hospitals and hospital facilities, limited capacity of stand-by power supply systems, termination of production of medicines and medical supplies, etc.

Public administration – a significant reduction of most functions, e.g. payment of social benefits and pensions, possible problems in prisons, in the judiciary. Crisis departments of state administration and self-government should be prepared for a full function in the given conditions [6].

Banking and financial sector – impossibility to make payments, cash points malfunction.

Post – malfunction of technical devices dependent on electricity, e.g. sorting facilities, termination of postal services.

Food and agriculture – lack of some foods e.g. due to non-functional mills, bakeries, slaughterhouses, meat and poultry processing plants, reduced milk production, termination of ventilation systems in large farms, termination of refrigeration and freezing equipment.

Emergency survival of the population – includes measures for emergency supplies and emergency accommodation. Emergency supplies will focus on the supply of minimum meals, minimum doses of drinking water and the provision of other basic needs to persons affected by an emergency, e.g. heat supply and basic health care [7].

The effects of the long-term blackout on individual sectors of the economy so far have serious social and economic consequences which vary considerably depending on whether they take place in large cities and urban agglomerations or in rural settlements.

Compared to urban settlements, rural settlements are able to ensure a certain energy and food self-sufficiency and survive for a certain period of time with the basic needs provided. In contrast, large urban agglomerations have a specific structure and a higher complexity of institutional and functional links, which make their inhabitants highly vulnerable to power outages. The key factors that make large cities and agglomerations more vulnerable include, in particular, the high concentration of population and the interconnected system of urban critical infrastructure, the disruption of which can cause e.g. lack of water, food, heat and thus cause a widespread state of emergency and later also social unrest destabilizing the standard functioning of institutions and the lives of people in big cities.

## VULNERABILITY OF LARGE CITIES IN THE EVENT OF A BLACKOUT FAILURE

The electricity system of the Slovak Republic ranks among the internal systems due to its location in the European energy infrastructure. It is an electrically compact unit connected via the so-called cross – border lines (400 kV and 220 kV) to the electricity systems of most neighboring countries (Poland – 2, The Czech Republic – 5, Hungary – 2, Ukraine – 1) [8].

The basic strategy of system recovery after a blackout failure is also based on this fact – voltage recovery from neighboring transmission systems. This option is preferred by transmission system operators mainly for the purpose of regaining a stable voltage of the order of minutes. If such a possibility is not available, the control centre of the transmission system proceeds according to the standards for ensuring the restoration of power supply from small backup power plants capable of so-called start from darkness.

From the point of view of the topology of the electricity network, the ‘open-all’ strategy is most often used. This means that all switches in the affected area are turned off either automatically or manually. By switching them off, a state is reached in which the controller bases the system renewal solution on clearly defined input conditions. The controller then solves the restart of the power plant units and their continuous loading by gradually connecting other elements of the transmission system. The following priorities are usually respected:

1. own consumption of nuclear power plants,
2. own consumption of system conventional power plants,
3 capital or the most important city of the affected area,
4. other urban and industrial agglomerations,
5. other consumers.

Renewal of the operation of the distribution system is possible only after the renewal of the operability of the transmission system (or its parts). The distribution system operator is responsible for restoring the power supply to the distribution system.

The standard of renewal of electricity distribution after its interruption is to ensure the renewal of supplies to the offtake or handover point of the local distribution system operator within the time limits up to:

- 18 hours in the distribution system network with a voltage level up to 1 kV,
- 12 hours in the distribution system networks with a voltage level above 1 kV [9].

Any power outage (even a short-term one) is registered almost immediately by all persons in the affected area. Such a negative event will have more serious effects in areas with a higher concentration of inhabitants, such as large cities or industrial agglomerations. It is in such densely populated agglomerations that the unavailability of basic services and important operational systems and services with time causes a state of panic and chaotic behavior and decision-making, Figure 2.

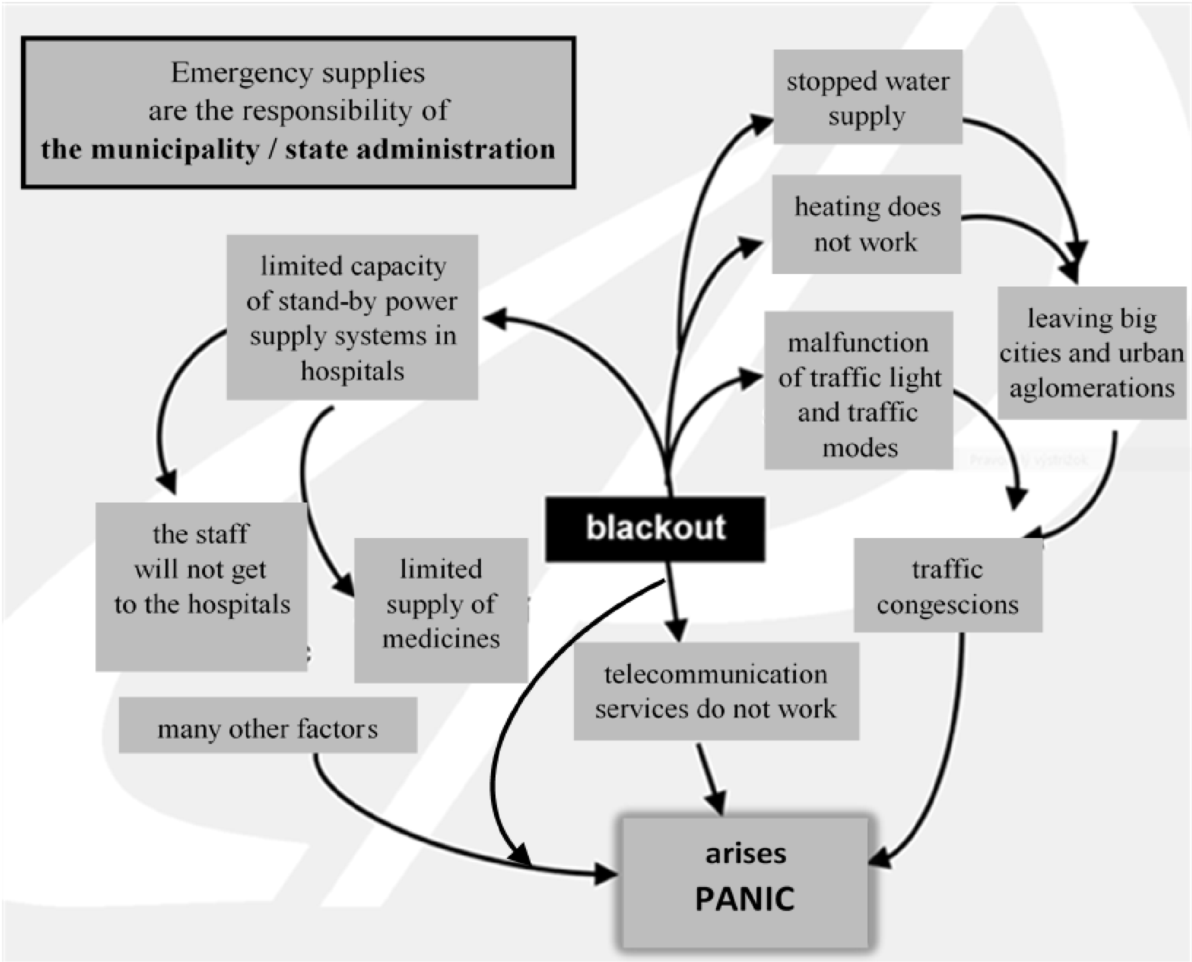


**Figure 2.** Influence of blackout on basic services and occurrence of panic or chaotic behavior.

In the event of a blackout failure, it will not be possible to use almost any technology that is directly dependent on the electricity supply and is not simultaneously backed up by alternative energy sources (e.g. diesel generators, batteries, backup UPSs, etc.).

In the first phase of the outage (in the order of seconds, minutes) the following will not work:

- all devices that need to be connected to the electricity network for their operation,
- ordinary lighting (in households, public buildings, street lamps, ...),
- security devices for buildings (electric opening of doors, garage doors, etc.),
- traffic signaling devices (traffic lights, signaling at railway crossings, variable traffic signs, etc.),
- cashpoint machines and at the same time it will not be possible to make purchases in stores with electronic sales records (barcode scanning, card payments, etc.),
- most petrol stations,

- public transport, which is directly dependent on electricity supplies (trains, metro, trams, trolleybuses and others).

In the second phase of the outage (in the order of units of hours) problems will arise in areas such as:

- drinking water supply,
- gas and heat supply,
- signal failures of mobile operators,
- malfunction of data networks (Internet), data centers, etc.,
- waste collection and much more.

In the later stages (order of tens of hours) there will be other serious problems in the area:

- supplies (food, medicines, fuels, etc.),
- communications (limited access to verified information),
- functioning of individual offices and other institutions,
- security (violation of public order, looting, theft, etc.).

As a result of the failure of electricity supply, people can get stuck for example:

- in lifts (if they are not equipped with special backup sources),
- in public transport (especially trainsets on electrified lines),
- in traffic jams (due to a malfunction of traffic signaling devices).

Other significant impacts of blackouts on the operation of the system include:

- restrictions on the availability of information,
- congestion of telephone networks (it will be very difficult to establish contact with close relations),
- overload of emergency lines and unavailability of units of the Integrated Rescue System,
- limited operation of hospitals (only urgent operations performed, etc.),
- limited possibilities to ensure hygienic standards (non-functioning water and waste, perishable food, etc.),
- limited possibility to buy food and water,
- limited purchase of fuel,
- limited possibilities in providing heating,
- increased risk of fires (emergency lighting with candles, etc.),
- impossibility of employment and school attendance (most buildings and production facilities will be closed),
- limited possibility of transport (limited use of public transport, lack of fuel in motor vehicles, etc.)

The limit of the standard of renewal of electricity supply to end consumers (within 18 hours) also corresponds relatively well with the results of EU foreign research projects within the PASR call – Preparatory Action on Security Research [10] After about 18 hours, the situation changes from serious to critical, Figure 3.

In case of a national blackout, with a typical daily load (not the maximum) of the Slovak electricity system at the level of approximately 9000 MW, the situation according to Figure 3 could become catastrophic after about 7 hours after the blackout.

In terms of the reliability of the entire electricity supply chain, the risk management system often addresses the question of where it is appropriate to invest in proactive preventive measures (system backup, island solutions, ...) to reduce risk and where it is sufficient to leave mitigation only to the implementation of reactive activities that respond to the occurrence of a crisis event.

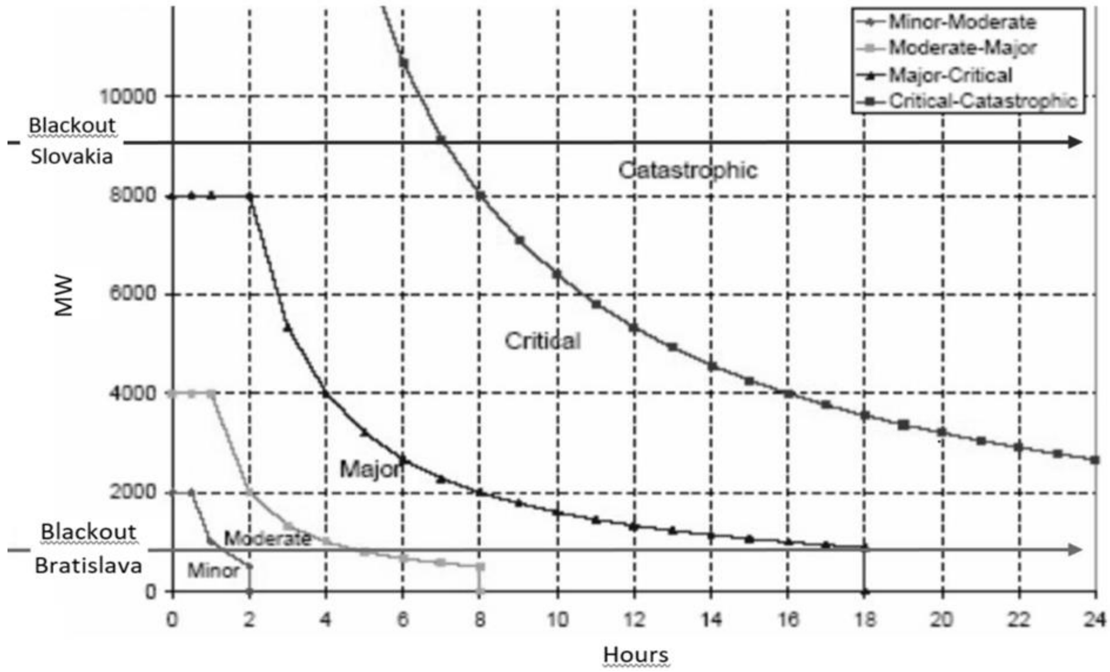


**Figure 3.** Criticality of the situation depending on the extent and duration of the power failure.

The interoperability of crisis management (supplier and municipality) with the risk management process [11] in the area of supplying vital commodities (apart from electricity, heat, drinking water, natural gas and others) also plays a role in this decision, Figure 4.

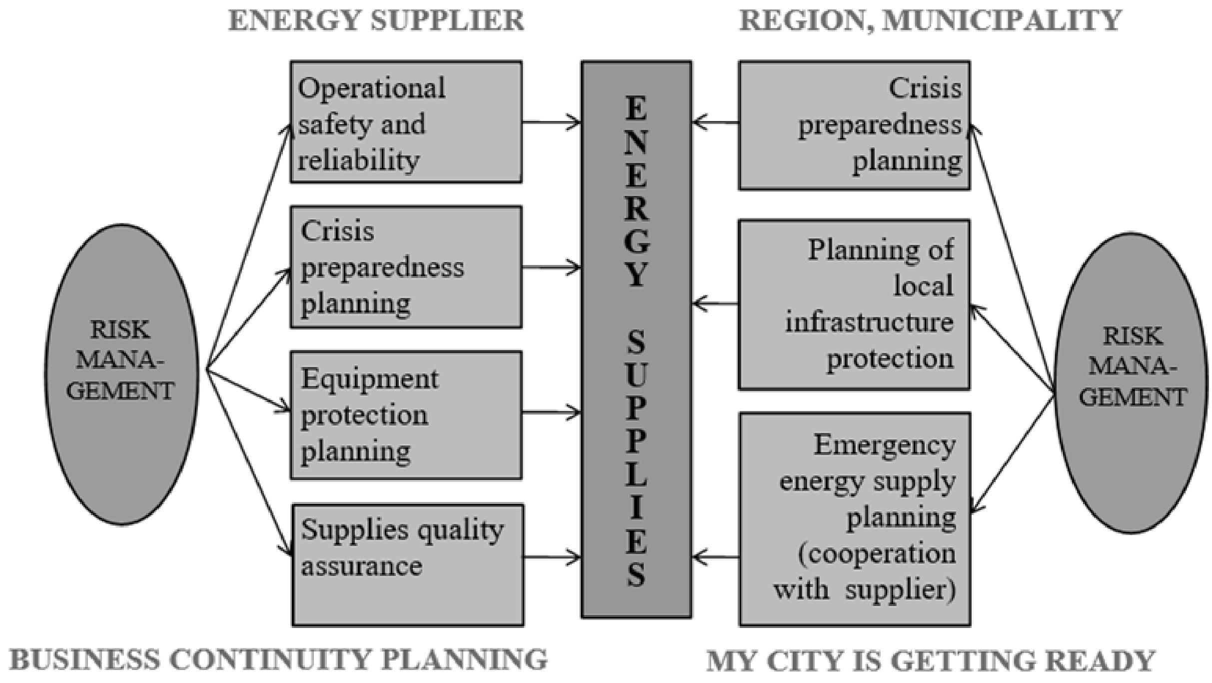


**Figure 4.** Ensuring interoperability of crisis management and risk management.

Within the recovery plans of a transmission or distribution system, in practice it is impossible to predict how a potential outage will develop, or what will be a point of disruption. A blackout is usually the last phase of a complex event and the result of a series of several events that is almost impossible to define in advance.

The process of recovery of the electricity system is generally based on three principles:

- ensuring the ability to ‘start from the dark’ on selected generators (the ability of the power source to go into operation in a situation where the distribution network has lost voltage – in most cases provided by diesel generators),
- voltage recovery in the transmission system using available generators (heating plants, back-up power plants, etc.) or from neighbouring transmission networks, including resynchronization of individual island operations (island operation = part of the electricity system that operates locally and is not connected to the synchronously operating electricity system),
- gradual restoration of power supply in distribution systems and restoration of electricity supply to other customers.

At present, the most preferred preventive and proactive measure against the negative effects of large-scale blackout in large cities is the implementation of the so-called public crisis island operations (CIO), which enable the implementation of emergency electricity supply. The recovery would take place in smaller parts. Relatively small ‘energy islands’ would be created for the supply and distribution of electricity around some power plants or towns, which would be gradually interconnected [12].

Local urban crisis island networks, usually supplied by municipal heating plants, can play an important role in emergency situations in order to safeguard the protected interests of the state or large and important agglomerations. Sources of the distribution system, which are additionally equipped with the so-called black start, in addition to island operation for emergency power supply, can also be used to restore the operation of the electricity system after the blackout, mainly to start and ensure the own consumption of some system power plants. Such a solution should certainly belong to the basic functionality of currently developed and tested intelligent energy networks – i.e. the Smart Grids [13, 14].

It is recommended to increase the energy security of large cities according to [12]:

- build control systems and interconnections ensuring island power supply of all agglomerations with more than 50 000 inhabitants,
- implement effective tools to prevent the spread of faults and a controlled transition to island subsystems and ensure an independent ability to start from the dark of individual island solutions,
- in the area of the development of distribution systems, to ensure their ability to work in island operations in the medium term in the event of a breakdown of the transmission network and to ensure at least the minimum level of electricity supply required for the population and for critical infrastructures,
- ensure the elaboration / updating of territorial energy concepts of self-governing units and large cities (over 50 000 inhabitants) so that they are aimed at ensuring the functionality and reliability of island operations in emergency situations
- create conditions for the involvement of heating plants in the creation of territorial concepts and the determination of their role in island solutions of a specific area in emergency situations.
- link the content of measures to increase the preparedness and resilience of energy infrastructures of large cities with the content of economic measures for crisis situations [15],
- pay attention to the preparation of alternative variants of the functioning of energy systems so as to ensure at least the most necessary energy supplies to priority customers,
- support the construction of stand-by power supply of electricity,
- work closely with regional government and suppliers of energy commodities,
- support research and innovation in the field of local (island) subsystems and their activities to ensure at least a minimum level of electricity supply to the affected area and to maintain the functionality of local critical infrastructure.

## CONCLUSIONS

The increasing number of crisis situations threatening the stability of the operation of the electricity system, such as natural disasters, but possibly also intentional terrorist attacks, make electricity and related critical infrastructure significantly vulnerable, because they can cause a situation called blackout. Energy security is one of the most important factors necessary for maintaining the functions of the state as well as the functions of territorial self-governments, the protection of the lives, health and property of the population in the full sense of the word.

It has been shown that the biggest threat to community life in large agglomerations is a longer-lasting blackout that can destabilize the operation and paralyze the basic functions of a city or an important industrial agglomeration. In the event of a prolonged power outage, it is not possible to meet basic physiological needs, such as heat, water and food, nor is it possible to sufficiently maintain public order. However, if the distribution networks in larger cities are able to work in the so-called emergency island operations powered by, for example, municipal heating plants, the overall negative impact of a blackout on the affected area and its functions will be significantly reduced.

## ACKNOWLEDGMENT

This work has been supported by VEGA grant No. 1/0371/19 named “Societal vulnerability assessment due to failure of important systems and services in electricity sector” and the FP7 project No. 608166 “Risk Analysis of Infrastructure Networks in response to extreme weather”.

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*Interdisciplinary Description of Complex Systems* 20(1), 27-36, 2022

# COMPOSITION OF AN AUTOMATED ATTENDANCE REGISTER OF STUDENTS BY SECURITY CAMERAS, AS PART OF A SMART CITY

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DOI: 10.7906/indecs.20.1.4
Regular article

*Received:* 30 January 2021.
*Accepted:* 12 November 2021.

## ABSTRACT

The safety of students represents a serious issue in smart cities. The present research aims to find a solution to how security cameras should be upgraded by expanded intelligence to greatly facilitate the administration in schools and to have a positive influence on safety issues. As security cameras have been developed for surveillance, the mentioned features should be further improved. The cameras installed in hallways and classrooms are possibly capable of face detection and recognition, as well as for headcount. It is recommended that these solutions be expanded by the possibility of registering attendance. If a camera can recognize a student, an attendance register may be composed, so it would be possible to determine who is attending classes regularly and who is not. The data received in this way could periodically be sent to teachers by the system. The composing of attendance registers is a privilege of access control systems; however, this is fairly inconvenient in educational institutions. Hypothetically, the surveillance camera system represents the most adequate choice for a passive, personal identification, as in this case, an active contribution is not necessary.

## KEYWORDS

security camera, deep learning, attendance register of students

## CLASSIFICATION

APA: 4000

JEL: I29, O33

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## INTRODUCTION

Granting the security of students in a smart city is imperative. Taking city residents and their need for student accounts is key when it comes to creating smart cities [1].

To achieve the daily state in which students feel secure on the premises of an educational institution, up-to-date security solutions are to be implemented. The fast evolution and extended use of ICT has deeply affected the knowledge management [2].

Smart cities are unimaginable without modern security solutions. By the implementation of up-to-date camera systems, students' security may be guaranteed, and trespassers could be kept out.

The cameras featuring artificial intelligence may provide help in face detection, face recognition, and headcount, and may utilize deep learning. With the simultaneous implementation of these capabilities, it will be possible to compose an attendance register by security cameras.

Being part of smart cities, the composition of an automatic attendance register by security cameras may provide great help for teachers, as their daily administrational burden may be lessened this way.

## SPECIFICATIONS OF SECURITY CAMERAS

There are numerous types of security cameras. The resolution of modern cameras is at least of HD-class, e.g. of 1280×720 pixels, and in the case of full HD, of 1920×1080 pixels. Some of these features even higher resolution: 4K, of 3840×2160 pixels, while the professional level, high-tech gadgetry is characterized by 8K resolution of 7680×4320 pixels. Besides resolution, another important parameter of security cameras is the image repetition frequency, which is given in units called frame/second (fps). Typical fps-parameter values considering cameras are: 25, 50, 60. It is highly recommended that the fps and resolution values are inversely proportional, so good shots are rarer than normal resolution values.

Furthermore, the parameter of bit rate is also worthy to mention, the average being between 10 and 100 Mbit/s. Camera imaging must also be tied to the decisive factor of illumination. With an average camera, the illumination of 0,5 lux is sufficient, whereas, in the case of a camera monitoring a schoolyard, this parameter can be lower, as low as even 0,01 lux. The cameras employing infra-red technology are capable of quality shots even in pitch dark [3].

## SPECIFICATIONS OF SECURITY CAMERAS FACE DETECTIONS AND RECOGNITION

While face detection and recognition may represent an easy task for a human being, it is a complex and cumbersome process for security cameras. The development of the technology ensures that cameras are reaching ever higher image resolution, so they can identify faces with increasing precision [4].

Facial biometry represents the most commonly accepted biometric identification process these days. It is utilized in many fields, like on border crossings or at police departments. Frauds, however, do everything in their power to thwart the identification, or rather, to be misidentified. Modern camera systems try to use this meta-data efficiently and to minimize the possibilities for error [5].

One of the most implemented methods is to record the facial images from two different perspectives, as an input image. The deep information may be proofed by this method, as the high-quality 2D printed fake images may be filtered out this way [6].

In the case of a video-surveillance system, it must be firstly determined on what part of the individual frames human faces appeared (if these appeared at all). Then, with the extraction of suitable characteristics, a person is identified, based on an existing database of images. Besides the efficacy of recognition, processing speed is also a significant practical requirement [7].

A human face, by itself, represents an agglomeration of information, from which the person's age, sex, and emotional state may be derived. However, to utilize the data gained, it is worth to assign the task of recognition to artificial intelligence, as early as within the security camera system itself. This represents a fairly complex image-processing task. To obtain the mentioned meta-data (sex, age, hair color), statistical learning algorithms are commended (Support Vector Machine) [8].

Successful face recognition requires fulfillment of numerous conditions, thus, it represents a more complex task for the processors mounted in the cameras or recording units (DVR, NVR) than just 'simple' face detection.

Security camera technologies utilizing facial recognition are gaining ground ever-increasingly on the premises of universities. Formerly, cameras were installed on these premises for safety reasons, while today, the behavior of students and their emotions may be increasingly surveyed [9]. The object of the survey may be to identify the emotional states of the students, such as anger, depression, sadness, and happiness [10].

## HEADCOUNT

Just a couple of years ago, technology in cameras, capable of efficient headcount was non-existent, as developers tried to count persons with systems featuring only single cameras. These systems often mistook other objects, identifying them as humans, so the information was inaccurate. The most serious problem with systems featuring only single cameras is that they lack a three-dimensional perspective, so it is impossible to examine how tall is the given person or the object. This means, that the system may identify all sorts of lifeless objects – from shopping carts to baby carriages – as humans. The problem is exaggerated if the visibility changes and even shadows may be counted as persons [11].

The most dynamically developing field of science in our age is artificial intelligence – and Deep Learning as a part of it. It gets an ever more important role in the world of security technology. This technology is capable of 'learning' based on the data provided, and it is becoming more and more accessible, being able to support a wide variety of security tasks directly or indirectly.

The headcount, attempted by systems utilizing traditional cameras were often aggravated by factors influencing accuracy, like unfavorable lighting conditions, shadows, or objects carried across the point of surveillance. The dual-lens head counting camera features two optical devices, and a Deep Learning algorithm, so it provides a highly accurate student headcount. Furthermore, it has a decisive advantage versus the camera algorithms, as it may learn continuously, by data obtained from the outside world. This means that the longer the camera has been operating, the 'smarter' it will become [12].

## DEEP LEARNING

Deep Learning is a method of machine learning by which models can be constituted more accurately than by the former ones. As machine learning exists in Neural Networks, by the analogy of living organisms, there are machines capable of learning. Through machine learning, a machine – the learning system – gains information from its environment, improving its capacities [13].

The cameras capable of composing attendance registers, by all means, must feature artificial intelligence. The processing of metadata is possible by cameras featuring the deep learning function. The more metadata a camera acquires through its machine learning process, the fewer mistakes it will commit, and the output values will be more accurate. The most important metadata may come from the students' attire and hairdos.

The attire, worn at a given moment, may greatly aggravate identification, as also may increase the possibility for error. Such may be a hat and a scarf in winter, or sunglasses in summer. By the implementation of artificial intelligence, the factors preventing identification may decrease, as the camera learns to identify these 'aggravating' factors. An important element of machine learning may be the recognition of students' hairdos, as it has frequently happened that a person had sometimes shorter, and sometimes long hair. This may cause a serious problem for a machine.

In the case of security camera systems, artificial intelligence means the recognition of perpetual alterations, variations.

## COMPOSITION OF ATTENDANCE REGISTERS BY SECURITY CAMERAS

Face recognition is an operation based on a black and white list. Students' mugshots may be stored on the camera system's hard disk, thus, the system becomes capable of identifying the students. In case when the system does not find a match, an alarm is switched on, as there is a possible intruder, trying to access an area from which he/she is denied.

Access control systems are most suitable for the composition of attendance registers. This is not their specific feature, but this may change rapidly. These days, cameras possess such specific abilities and artificial intelligence by which these tasks may be completed. The composition of an attendance register can be utilized in education extensively. As a first step, the mode of image processing would have been chosen. This may happen by a centralized or by a decentralized method.

In the case of the centralized method, the intelligence is built into the network's recorders. In this case, the images are examined in NVR, so the system may operate with any kind of IP camera, lowering the costs, and avoiding copyright infringement. Its drawback is the need for bandwidth, so the network is more encumbered, as the whole image data must be sent to the recorder, while the factual recording happens only in case of movement.

If the image processing of the camera is implemented with a decentralized method, the camera includes intelligent software, and the analysis happens before the forwarding of the image data. Therefore, the need for bandwidth decreases, the network is not encumbered very much, and the needed storage space is reduced, as data is sent only when there is an event happening [14].

As a second step, the cameras should be programmed to recognize which subject is taught in which classroom. This would be easily achieved by entering the time-table. The list of subjects taught may be defined in the cameras' database. This data may be expanded with the list of lecturers and teachers, to send them the attendance register from the camera system. If needed, even the mugshots may be forwarded with the attendance register in predefined time intervals to a given IP address.

As a further step, the list of students, along with their mugshots could be recorded. The camera would recognize the students and could compose an attendance register with the date and time of attending the classes. The system's complete operation is shown in Figure 1.

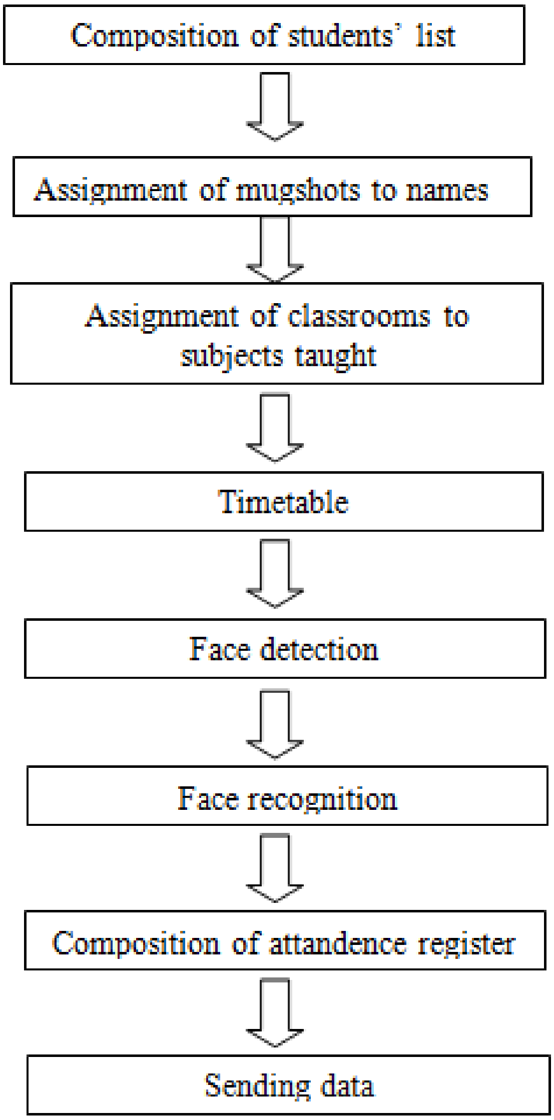


**Figure 1.** The model of a camera system capable of composing a students' attendance register.

## THE MOST IMPORTANT STAGES OF AN ATTENDANCE REGISTER COMPOSING CAMERA SYSTEM'S DESIGNING PROCESS

Before the practical realization, even during the phase of designing, numerous difficulties and problems emerged. The up-to-date cameras feature high pixel density, so they generate oversized data quantities. Thus, it is expedient to choose the best possible video compressing solution. These days, the most used compression procedure is the MJPEG, the H.264, and the H.265 standards.

To achieve a successful establishment of an attendance register composing camera system at universities, it is advised to deploy a security camera in front of each auditorium. In the case of larger educational institutions, this means numerous cameras implicitly. Therefore, during the building up of the system, it is expedient to foresee a deployment of 24 cameras. Table 1 shows the primary computation of the data quantity, generated by the attendance register composing camera system consisting of 24 cameras.

**Table 1.** Primary computation concerning the data quantity, generated by an attendance register composing camera system consisting of 24 cameras.

| Resolution | Compression | Cameras | Days | Hours | Bandwidth | Disk Space |
|---|---|---|---|---|---|---|
| 1,3MP (HD) | Without compression | 24 | 5 | 12 | 16Gbit/s | 497TB |
| 1,3MP (HD) | MJPEG | 24 | 5 | 12 | 873 Mbit/s | 24TB |
| 1,3MP (HD) | H.264 | 24 | 5 | 12 | 145 Mbit/s | 4016GB |
| 1,3MP (HD) | H.265 | 24 | 5 | 12 | 130 Mbit/s | 3613GB |
| 2MP (1080p) | Without compression | 24 | 5 | 12 | 27 Gbit/s | 787TB |
| 2MP (1080p) | MJPEG | 24 | 5 | 12 | 1,35Gbit/s | 38TB |
| 2MP (1080p) | H.264 | 24 | 5 | 12 | 230 Mbit/s | 6354GB |
| 2MP (1080p) | H.265 | 24 | 5 | 12 | 177 Mbit/s | 4904 GB |
| 10 MP | Without compression | 24 | 5 | 12 | 135 Gbit/s | 3811TB |
| 10 MP | MJPEG | 24 | 5 | 12 | 6,6 Gbit/s | 185TB |
| 10 MP | H.264 | 24 | 5 | 12 | 1,1 Gbit/s | 31TB |
| 10 MP | H.265 | 24 | 5 | 12 | 858 Mbit/s | 24TB |

As it can be seen, from the computation in the present table, the number of days spent with education has been strictly observed, as the lectures on the faculties usually take place in a time period from Mondays to Fridays. Furthermore, the cameras presumably record 12 hours a day at best, so data has been taken accordingly. Based on the preliminary computation, it may be stated that the implementation of the codec H.265 seems to be the best solution.

## THE CHOICE OF THE SECURITY CAMERAS BASED ON MEGAPIXELS

These days, the most common security cameras feature resolutions of about 1,3MP to 10MP. The higher the resolution of a camera, the more details its recording conveys. For educational institutions, the mentioned progress may mean both advances and drawbacks. The more precise identification and zoom-in capability with a minimal decay in picture quality, through a greater resolution, would mean an advantage. The overly great quantity of generated data may mean a hindrance, because of its storage and processing representing a serious task for the NVR (Network Video Recorder) unit, and for the security cameras.

Therefore, during the design, 3 types of cameras were chosen, all participating in the testing of the online attendance register composing system. These were cameras featuring 1,3 MP-s, 2 MP-s, and the most modern one with 10MP-s of resolution. The mentioned camera types were included because of the significant differences in resolution. While the camera featuring 1,3MP-s of resolution is characterized by cost-effectiveness, the camera capable of 10MP-s of resolution represents the absolute pinnacle of development. The cost-effectiveness, or rather the best price/value rate is recommended to be observed in the case of universities.

So, before the tests began, three camera types had been chosen. All of these utilized the compression process of standard H.265, in favor of lessening of the data quantity in question.

## EXPERIENCES GAINED DURING THE REALIZATION IN PRACTICE

The practical testing was completed in a period of six weeks. Each camera type had an allotted testing period of 2 weeks. The cameras all possessed artificial intelligence and could perform all important analytic functions, such as facial detection, facial recognition, headcount, and black and white-listing.

The testing of the cameras included 57 university students, during the cold, winter months, with the testing of all the cameras subsequently. This was necessary, to avoid significant changes in dressing and hairdo of the persons in question, as the opposite would influence the efficiency of the cameras tasked with identification. If some of the cameras were tested in the winter, and some in the summer, the accuracy of the identification would suffer greater deviations, negatively influencing the exactness of the measuring. Therefore, the primary aim was the provision of nearly identical conditions. The facial recognition completed on the students was influenced by numerous negative factors. One of these was overlapping, as in case of many students, during the entering the lecturing hall, some individuals were overlapped by others. The identification was further encumbered by the fact that some students wore glasses or scarves, thereby covering some facial details which, if not covered, would aid in efficient identification.

During the deployment of the cameras, special attention had to be directed towards the ambient light conditions. One of the cameras was deployed incorrectly, therefore the light conditions and the shadows greatly hampered the task of the artificial intelligence of the camera in question. In practice, this meant that the facial recognition capability of the camera deteriorated, and it was not capable of the efficient identification of the students.

During the testing of the attendance register composing system, it was proven that the cameras featuring artificial intelligence need some time to learn. The longer a camera had been operating, the higher efficiency it achieved. The cameras' efficiency in operation is shown in Table 2.

**Table 2.** The cameras' efficiency of identification [15].

| Groups of resolution | Accurate identification of students during week 1 | Accurate identification of students during week 2 |
|---|---|---|
| 1,3 MP (HD) camera | 43 | 51 |
| 2 MP (HD) camera | 46 | 52 |
| 10 MP camera | 51 | 55 |

As it can be clearly seen, the cameras were operating more efficiently than during the week before. The cameras were learning continuously, so the efficiency of the recognition improved significantly by the end of the testing period. Based on the results of the research, it may be stated that the camera featuring a resolution of 1,3 MP-s, initially identified the students at a 75 % rate, while during the second week, it correctly identified them at an 89 % rate. The camera featuring a resolution of 2 MP-s, could initially reach an efficiency of 80 %, while during the next week it operated at the efficiency rate of 91 %. Last, but not least, the camera featuring a resolution of 10 MP-s could initially reach an efficiency of 89 %, improving gradually to 96 % in the end [15].

## EMPIRICAL RESEARCH

During the empirical research, the lecturers' opinions were examined, concerning the online attendance register composing system based on security cameras. During the examination of the empirical research, as typical means of measurement in pedagogy, inquiries were utilized. The received data were analyzed with the help of the program named SPSS.

**Table 3.** Distribution of the lecturers per institutions ($n$ = 70).

| Country | Facilities | Number of lecturers |
|---|---|---|
| **Serbia** | University of Novi Sad Hungarian Language Teacher Training Faculty, Subitca | 15 |
| | College of Vocational Studies for the Educational of Preschool Teachers and Sports Trainers | 18 |
| | Singidunum University Beograd – Information Technology | 21 |
| | Singidunum University Beograd – Department of Economics | 16 |
| **Total number of teachers, *n*** | | **70** |

## HYPOTHESIS

It may be presumed that the lecturers are open to new technological solutions, so they would gladly utilize the online attendance register composing camera system during their lectures.

The composition of the attendance register represents an important part of lecturers' duties. The lecturers compose an attendance register of the students present on their lectures. Thus, it is expedient to automatize such a routine, daily task as part of a smart city. Following this concept, the teachers were asked if they found the new, attendance register composing solution useful in aiding their day-to-day activities. The received answers were presented in Figure 2.

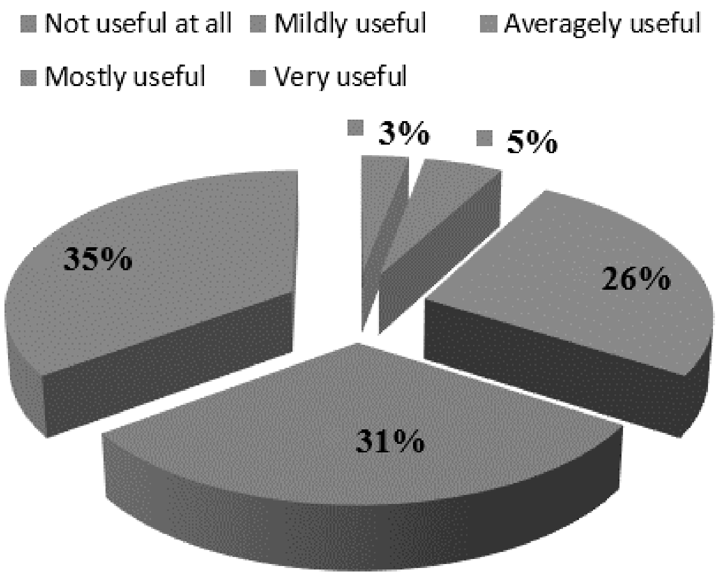


**Figure 2.** In your opinion, could a camera system capable of composing attendance registers be useful at the universities? ($n$ = 70).

The specificity of the educationalists' work is that faculty lecturers continuously compose new, more modern lectures to be taught to their students. The lecturers' work requires creativity and open-mindedness, so it may be presumed that the educationalists would gladly utilize an attendance register composing solution based on a camera system during their day-to-day activities.

Answering the question, about having the possibility of utilizing an attendance register composing system based on a security camera system, or a paper-based solution, the majority of the lecturers stated that they would utilize the first possibility ($p$ = 0,075), independently from universities. The received answers are shown in table 4.

**Table 4.** If there was a possibility, would you utilize a students' attendance register composing system or would you choose the paper based solution during your day-to-day activities? (*n* = 70).

| Facilities | Automated electronic attendance register composing system | Paper-based attendance register |
|---|---|---|
| University of Novi Sad Hungarian Language Teacher Training Faculty, Subitca | 54 % | 46 % |
| College of Vocational Studies for the Educational of Preschool Teachers and Sports Trainers | 65 % | 35 % |
| Singidunum University Beograd – Information Technology | 63 % | 37 % |
| Singidunum University Beograd – Department of Economics | 69 % | 31 % |

Based on the teachers' answers, it may be stated that the hypothesis has been proven, by which, the teachers are open towards new technical solutions, so they would gladly utilize in practice the camera system composing online attendance register during their lectures.

## CONCLUSION

A sufficient level of safety in the educational institutions of smart cities cannot be reached without modern security cameras. To lessen the administrative encumberment of lecturers, it is advisable to equip the camera systems with the function of composing an attendance register. Thus, the existing level of safety may be increased, and very broadly speaking, the paper-based attendance registries could be replaced with automated digital attendance registries.

To achieve this, the camera system must feature a deep learning function. Based on a substantial quantity of metadata, the system could learn to recognize the errors of identification arising from the encumberments, thus, a type of reliable and efficient camera system could be attained, with the point of recognizing the students with the fewest errors possible, as well as sending the attendance register to a predefined, teachers' and lecturers' email address periodically.

The research uncovered that through artificial intelligence, the cameras were learning continuously. It may be stated that by the end of the testing period, the cameras' efficiency had improved significantly, concerning the identification of students.

As part of the empirical research, it was determined that the teachers, included in the present research, may utilize a camera system composing online attendance registers in practice if the possibility were given.

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*Interdisciplinary Description of Complex Systems* 20(1), 37-43, 2022

# SMART MOBILITY SOLUTIONS IN SMART CITIES

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DOI: 10.7906/indecs.20.1.5
Regular article

*Received:* 28 August 2020.
*Accepted:* 30 January 2021.

## ABSTRACT

A flying electric car in the smart city is a type of personal air vehicle that provides door-to-door transportation by both ground and air. In this article, we review the latest developments in flying cars. The autonomous flying car detects and evaluates the environment, uses digital technologies to control and navigate itself without collision, travels in space, can take off and land (VTOL), and uses electric propulsion. Today, several companies are developing flying cars: Terrafugia, Aero Mobil, Volocopter, Lilium, Hyundai, Uber, Bosch. Many prototypes have been built in the last years using a variety of flight technologies and some have true VTOL performance.

## KEY WORDS

smart mobility solutions, smart cities, flying electric cars, VTOL, Terrafugia TF-X

## CLASSIFICATION

ACM: C.0, H.1.0, K.6.4

JEL: D85

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## INTRODUCTION

The use of Smart Mobility Solutions in Smart Cities is not only a development but a revolution itself. These days, it seems like everyone is building their own electric vertical take-off and landing (VTOL) flying car. The autonomous flying car detects and evaluates the environment, uses digital technologies to control, navigate itself without collision, travels in space, is able to take off and land and uses electric propulsion.

A flying electric car in the smart city is a type of personal air vehicle that provides door-to-door transportation by both ground and air. We observe the movement, kinematic and dynamic of flying robot cars in two coordinate systems, one is tied to the ground and the other to the flying car.

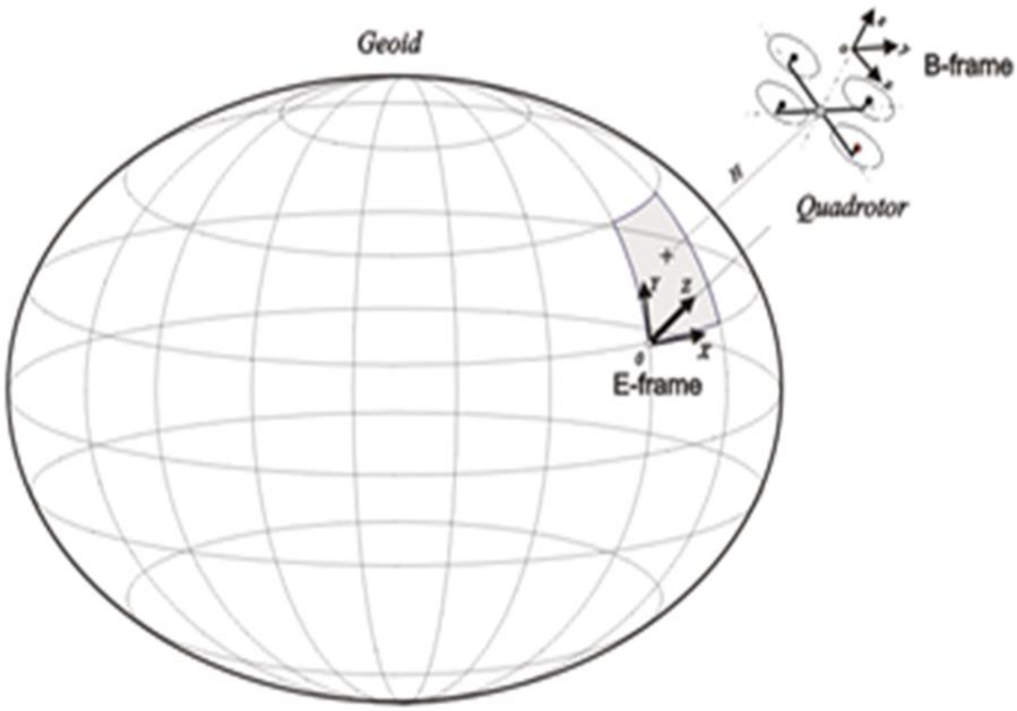


**Figure 1.** Two coordinate systems to observe the movement, kinematic and dynamic of flying cars.

Today, several companies are involved in the development of flying cars:

- AeroMobil,
- Volocopter,
- Lilium,
- Hyundai,
- Uber,
- Bosch,
- Terrafugia.

AeroMobil [1] is a Slovakian technology start-up, it has presented a concept for the eVTOL upgrade AeroMobil 5,0, which is being developed for air taxi operations. The AeroMobil 5,0 is a concept four seat flying car designed for door-to-door flying.

Volocopter [2] is the electric air taxi pioneer leading the way in building up the ecosystem for urban air mobility.

The VoloCity is the air taxi for the smart city. The VoloCity will become the first commercially licensed Volocopter, developed according to the high standards and requirements of the European Aviation Safety Agency (EASA). The intensive testing programme has shaped the innovative design and outstanding overall performance of the VoloCity. Quiet, safe, and comfortable, the VoloCity engenders Urban Air Mobility.

Lilium [3] is developing a revolutionary on-demand air taxi service that is powered by the all-electric, vertical take-off and landing Lilium Jet. Lilium, a Munich-based startup building their own urban air mobility electric vehicles. Lilium will look to use its jet in an air taxi service ferrying people around cities.

Hyundai and Uber are also developing air taxis [4], shown in Figure 2. Hyundai’s aerial taxi would be able to take off and land vertically, accommodate four passengers and cruise at up to 322 km/h, fully electric with a range of 96 km. Hyundai and Uber team up to debuted new flying taxis at CES 2020.


**Figure 2.** Hyundai’s future mobility vision in smart cities.

Bosch is developing a universal control unit and sensors for self-driving air taxis.

In this article, we review the latest developments in flying cars (Terra Fugia TF-X). Many prototypes have been built in the last years using a variety of flight technologies and some have true VTOL performance [5-18].

## TERRAFUGIA TF-X FLYING CAR

Terrafugia is a leader of the mobility revolution. They are executing a multi-step strategy to make air transportation a part of everyday travel. Terrafugia have a flying road electric vehicle. Terrafugia announced the TF-X, a plug-in hybrid tilt-rotor vehicle that would be the first fully autonomous flying car. Terrafugia is a Chinese-owned company headquartered in Woburn, Massachusetts, USA [19].

In our opinion, today the Terrafugia TF-X flying car is the best solution, as it is a fully autonomous flying car [20]. The TF-X is designed to be able to lower their rotors, allowing the vehicle to also operate as a road vehicle.

The main data of the Terrafugia TF-X flying car are as follows: maximum speed: 322 km/h, 805 km range, vertical take-off and landing (VTOL), four seats.

The following figures, Figure 3-6, show the road traffic of the Terrafugia TF-X flying car as a wheeled road vehicle and in flight.


**Figure 3.** The Terrafugia TF-X flying car comes out of the garage.


**Figure 4.** The Terrafugia TF-X flying car is driven on wheels.

**Figure 5.** The Terrafugia TF-X flying robot car stops and takes off.

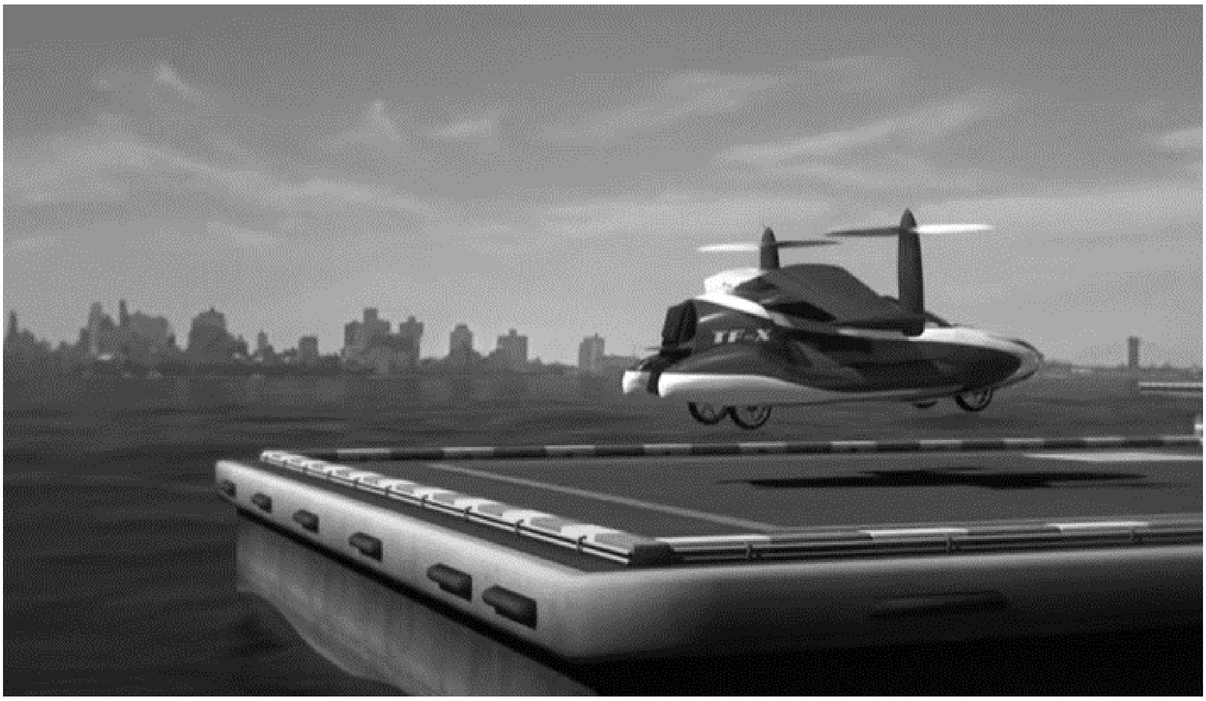


**Figure 6.** The Terrafugia TF-X flying robot car lands and reaches its destination.

The US Federal Aviation Administration (FAA) has granted Terrafugia special permission to carry out in-air tests of its TF-X flying car. The American flying car company Terrafugia has been a clear leader in the development of flying cars.

Recently, Terrafugia unveiled its newly designed TF-X flying car with much sleeker body and VTOL system. it is the nearest we have gotten to a realistic flying car. Now, thanks to FAA’s permission. Terrafugia is allowed to start testing the prototype of its flying car.

## CONCLUSIONS

The present article has reviewed the latest developments in flying cars.

The autonomous flying car detects and evaluates the environment, uses digital technologies to control, navigate itself without collision, travels in space, is able to take off and land (VTOL) and uses electric propulsion.

Today, several companies are developing flying cars: Terrafugia, Aero Mobil, Volocopter, Lilium, Hyundai, Uber, Bosch. Many prototypes have been built in the last years using a variety of flight technologies and some have true VTOL performance.

Terrafugia is a leader of the mobility revolution. The Terrafugia TF-X flying car is the best solution, as it is a fully autonomous flying car. The TF-X is designed to be able to lower their rotors, allowing the vehicle to also operate as a road vehicle.

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*Interdisciplinary Description of Complex Systems* 20(1), 44-49, 2022

# THE ENERGY IMPORTANCE OF ADDITIONAL INFORMATION

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DOI: 10.7906/indecs.20.1.6
Regular article

*Received:* 18 July 2021.
*Accepted:* 15 September 2021.

## ABSTRACT

The cornerstone of the Smart City conception is the application of an advanced info-communication infrastructure. One of the main tasks of info-communication systems is the transmission of information. During transmission, however, not only the data representing the required information is transmitted, but also extra data. According to the receiver-side monitoring aspect of the communication, this involves some additional information. This additional information can be examined in many ways. The aim of the present study is to investigate the energy significance of additional information. During the investigation, the appearance of additional information is represented with an older Internet game. This game provides an opportunity to detect the incorporation and decoding of extra data. The study is then based on the energy balance modeling of the systems to point out the nature of the energy problems of such supplementary information.

## KEYWORDS

infocommunication, additional information, social engineering, energy model, energy importance

## CLASSIFICATIONS

ACM: H.1.1, J.4, K.4

APA: 4010

JEL: 039

PACS: 01.70.+w

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## INTRODUCTION

The basis of the implementation of the systems related to the storage, processing and transmission of information is the infocommunication infrastructure [1, 2]. In the practical transmission of information, not only the absolutely necessary information is transmitted. Usually, additional information is displayed next to it. In public communication, the information is not always sent to a specific person or object. Therefore, the additional information can be obtained by anyone. In this way, the additional information facilitates the unsolicited acquisition of the information and later its use [3-6]. At the same time, the energy problem of handling information in practice also appears to have a connection with additional information. To model the energy consequences, the problem is approached from the point of the control theory, and the systems are examined according to their energy balance. The components used for modeling are defined on a philosophical basis for universal usability [7-11]. Thus, the modeling procedure is multidisciplinary and can be generally used in RDI [12-17] and education [18-20], and in legal regulations [21, 22] each in its territory.

This study presents the role of additional public information in the possibility of obtaining information and in the practical handling of information [23] through the example of an internet game. The Open Source Information Acquisition (OSINT) is one element of the social engineering information acquisition palette, among others [24]. The conscious planning of information management is also important due to its sensitive use. This design should include the energy requirement of handling additional information, and it should also limit the possibilities of intentionally reducing deduplication procedures, by taking into account unnecessary redundancy [1, 2]. Based on the analysis of the game, the study also points out that the additional information can be a very significant part of the transmitted information set. This is, among other considerations, one of the major drivers of the growing energy demand of systems and of the big data effect.

## ADDITIONAL INFORMATION

The communication can be formulated with the additional information on the receiving side: the additional information is the information that appears next to the content that is intended to be conveyed, and from a certain research aspect, it represents an added value [23].

Through the example of an older online game, it was shown that in addition to the intentionally disclosed information, the transmitted data carries additional information for the receiving party. More specifically, it showed an example of incorporating additional information and decoding it. The game proceeded as follows: based on the selfies made by toy dolls from different geographical locations, players had to guess where the dolls were [23]. A photo montage related to the game is shown in Figure 1.

The evaluation of the game revealed that players were able to find the location within half an hour, usually based on the landscape and the construction details in the selfie's background. But some additional information that had not originally been requested was also decoded: they were able to establish, among other things, the manufacturer of the dolls, the vintage or the originality of their clothing. They also provided information about the owner's attachment to toys. Thus, it became certain that the additional information could be decoded from many more aspects than originally planned [23].

**Figure 1.** Photo montage from the online game.

## ENERGY MODEL

The additional information can be examined from several aspects. This is an examination of energy problems, and the amount of data is proportional to the energy required to deal with it. Therefore, the examination is made in terms of the amount of data representing the additional information. For modeling, it is worth calling the general energy model for help [9].

The general energy model is based on philosophical foundations. It adapts the abstract categories of human thinking. These categories are Object, Property, and Relationship. The energy equivalents of these are Transformation, Storage and Transmission. The system model is accordingly based on three types of basic elements. The energy balance shows that some of the energy flowing into the system from the outside is stored and the rest is radiated out of the system. Meanwhile, the energy can be transformed [9]. The general model is shown in Figure 2.

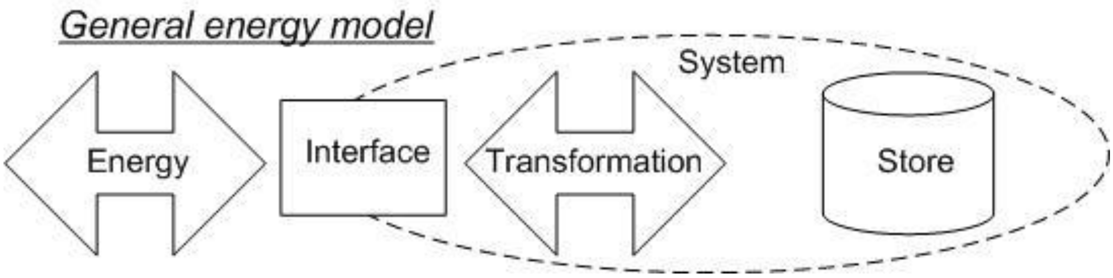


**Figure 2.** Energy model.

## ENERGY IMPORTANCE

To explore the energy problems, it is worth starting from the energy balance formula (1) of the aforementioned system model.The formula (2) corresponding to the other initial condition is the energy demand formula, which expresses the amount of required and added energy.

$$E(in) = \text{delta } E(store) + E(out), \tag{1}$$

$$E(all) = E(need) + E\ (add). \tag{2}$$

Since the two formulas represent independent test aspects, the simple (3) and elaborated form of the formula derived from the matrix of the two formulas can also be given (4).

$$E(in/all/) = \text{delta } E(store/all/) + E(out/all/), \tag{3}$$

$$E(in/need/) + E(in/add/) = delta\ E(store/need/) + delta\ E(store/add/) + E(out/need/) + E(out/add/). \quad (4)$$

Formula (4) can be decomposed into two equations: to a formula representing the aspect of the energy required (5), and to a formula representing the added energy (6).

$$E(in/need/) = delta\ E(store/need/) + E(out/need/), \quad (5)$$

$$E(in/add/) = delta\ E(store/add/) + E(out/add/). \quad (6)$$

The identical form of formulas (1) (5) and (6) shows that the energy problems in the handling of additional information can be included in the same system of aspects as in the case of general information handling problems. This is a logical conclusion, since the abstraction of information takes place through the interpretation of data. Accordingly, the additional information must be stored, so it binds excessive processing capacity, and it requires additional bandwidth.

## SUMMARY

In order to implement the smart city concept [25-29], it is essential that its implementation is based on a high-availability, long-term, sustainable, and reliable infocommunication infrastructure [1, 2]. The main purposes of infocommunication systems are data storage, processing and transmission [1]. During data transmission, more data is transferred than is required. This is not just due to intentional redundancy.When transferring media materials, a much larger amount of extra data is added to the data representing the useful information.

The present study has shown, through the example of an online game, that a considerable amount of extra data can be transferred due to the possible negligence from the part of the tax side of the data transfer [23].The receiving side can interpret the data in several ways, so this data can contain additional information. In published data streams, the decoding of this additional information is a form of information acquisition (OSINT) that is part of the technical palette of social engineering [24]. Furthermore, the study has shown, using the energy modeling of systems, that the additional information has the same energy problems as useful information. Accordingly, the additional information must be stored, an additional processing capacity and extra bandwidth is required. This need must be taken into account when designing systems. Given that much of the amount of the data generated is a media stream in which significant extra data is present, the additional information also plays a significant role in the rapid increase in the energy demand of systems, as well as in the big data effect.

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*Interdisciplinary Description of Complex Systems* 20(1), 50-56, 2022

# EXPLORATORY FACTOR ANALYSIS FOR IDENTIFYING CIEDS PATIENTS' CONCERNS DURING THE COVID-19 PANDEMIC IN EUROPE

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DOI: 10.7906/indecs.20.1.7
Regular article

*Received:* 14 May 2021.
*Accepted:* 11 November 2021.

## ABSTRACT

The current COVID-19 pandemic affects healthcare worldwide. Patients living with cardiac implantable electronic devices (CIEDs) are at high-risk to experience emotional distress and severe COVID-19 symptoms. Assessing their mental and physical health condition during the pandemic is crucial. An online questionnaire consisting of 45 multiple-choice questions regarding the patients' emotional and physical status was completed by 210 CIEDs participants. On the eligible 184 responses, a principal axis factoring (PAF) multivariate analysis was performed, which is part of the Exploratory Factor Analysis (EFA) class, frequently used in healthcare research. The considered variables in the PAF were CIEDs patients' concerns related to: device functioning, having received a shock (if ICD), the possibility to receive a shock (if ICD), access to medical care, reaching physicians, access to medication, getting infected by SARS-CoV-2, the health of caretakers, the health of their loved ones. However, one of the most difficult tasks in PAF is the selection of an appropriate number of factors. We proposed three rules to be considered, the verification of: the Kaiser criterion, the Cattell's Scree test, and the cumulative variance (to explain at least 60-65 %). After the number of factors had been established, we proposed a final verification, the Monte Carlo Parallel Analysis. Two factors were identified, subsequently defined as "Healthcare-related concerns" and "Fear of COVID-19 disease", which explained 75.56% of the cumulative variance. The factors highlight the need for accurate medical information provision, patient education, and support to improve healthcare during the pandemic.

## KEY WORDS

exploratory factor analysis, SARS-CoV-2, cardiac implantable electronic devices, healthcare-related concerns, Industry 4.0

## CLASSIFICATION

JEL: I10

PACS: 02.50.-r, 12.40.Ee.

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## INTRODUCTION

Worldwide, both physical and mental health has been affected by the current COVID-19 pandemic [1]. Cardiac implantable electronic devices (CIEDs), such as pacemakers, implantable cardioverter-defibrillators (ICD), cardiac resynchronization therapies, are standard of care in life-threatening arrhythmias, and device implantation rates show a yearly increase [2, 3]. Individuals living with CIEDs not only have multiple underlying diseases, but also experience quality of life changes [4-6]. These patients are vulnerable to get severe COVID-19 symptoms and to develop emotional distress. Therefore, an online purpose designed questionnaire was developed to assess their physical and mental health condition during the pandemic.

In the current paper, a multivariate analysis based on a principal axis factoring (PAF) was performed focusing on CIEDs patients' concerns related to: device functioning, having received a shock (if ICD), the possibility to receive a shock (if ICD), access to medical care, reaching physicians, access to medication, getting infected by SARS-CoV-2, health of caretakers, health of patients' loved ones. PAF is part of the Exploratory Factor Analysis (EFA) class, which is frequently used in healthcare research [7-10].

One of the most difficult problems in EFA lies in the identification of the optimal number of factors [11-14], as an inappropriate number of factors may lead to imprecise conclusions. A previous paper [15] highlighted the importance of the total cumulative variance explained by the factors in the establishment of the appropriate number of factors. It was proved that, at least, a threshold value of cumulative variance should be explained by the extracted factors, considering the specificity of the research. Based on the mentioned previous research, and on a thorough scientific literature review, we propose three rules to be considered in selecting the best-fitted number of factors, as well as an additional rule, for verification purposes, of the selected number of factors.

## MATERIAL AND METHOD

A purpose-designed questionnaire containing 45 multiple choice questions was created to assess CIED patients' mental concerns and physical health condition during the COVID-19 pandemic. The questionnaire was completed online, anonymously and voluntarily by 210 CIEDs patients from the outpatient care of the Institute for Cardiovascular Emergencies and Transplant and by international patients, as part of online support groups mainly from the USA, UK, Hungary, Canada. Eighteen participants were excluded due to contradictory responses. The final data analysis included 184 responses.

The varimax method for rotation in EFA was proposed by Kaiser, which is one of the most frequently used methods of rotation [16]. PAF was performed, applying the varimax orthogonal rotation method focusing on the concerns of the respondents. Initially, the study included 9 variables (Var): Var1- device functioning, Var2- having received a shock (if ICD), Var3- the possibility to receive a shock (if ICD), Var4- access to medical care, Var5- reaching physicians, Var6- access to medication, Var7- getting infected by SARS-CoV-2, Var8- health of caretakers, Var9- health of their loved ones.

A preliminary study excluded Var3, Var9 due to their low variability. Further communality analysis excluded Var1, Var2, and Var8. The exclusion of Var2 and Var3 is explained theoretically by the fact that these concerns may arise only for patients with ICD, not for every CIED patient assessed in the current study. PAF was performed on the remaining variables: Var4, Var5, Var6, Var7.

Based on an in-depth study of the scientific literature, and considering the results of the research mentioned anteriorly [15], we suggest the following three rules to determine the number of extracted factors:

- rule 1): the total explained variance to be at least 60 %-65 % – established since none of the variables passed the normality assumption,
- rule 2): the extracted eigenvalues to be at least 1, criteria proposed by Kaiser [16],
- rule 3): visual interpretation of the Scree plot, called as Cattell's Scree test [17].

Parallel analysis (PA) was proposed by Horn, named as the Monte Carlo simulation method, useful to determine the number of factors, which should be extracted in EFA [18]. One of the reasons that it is less utilized in research is due to the fact that it requires heavy computational resources. However, we propose a Monte Carlo Parallel Analysis as an additional verification step, after establishing the appropriate number of factors.

## RESULTS AND DISCUSSION

The eligible 184 responses were registered from geographically different points of the world, mainly from Europe (Romania, Hungary, UK, Ireland, Switzerland, Slovakia, Spain) and the USA; all respondents were patients living with cardiac implantable electronic devices.

Table 1 presents the correlation coefficient (r) matrix, and the corresponding significance (sig) of each correlation. Values below 0,05 (sig<0,05) indicate significant correlation.

**Table 1.** Correlation coefficients between all variables; * indicates a significant correlation.

| | **Var4** | **Var5** | **Var6** | **Var7** |
|---|---|---|---|---|
| **Var4 r (sig)** | 1 (-) | 0,468 (~0) | 0,474 (~0) | 0,049 (0,26) |
| **Var5 r (sig)** | 0,468 (~0)* | 1 (-) | 0,509 (~0) | -0,093 (0,1) |
| **Var6 r (sig)** | 0,474 (~0)* | 0,509 (~0)* | 1 (-) | 0,154 (0,02)* |
| **Var7 r (sig)** | 0,049 (0,26) | –0,093 (0,11)* | 0,154 (0,02)* | 1 (-) |

Table 2 presents the obtained eigenvalues, variance explained by each prospective factor, and the total cumulative variance explained. Corresponding to Rule 3, the Scree plot was created, which is a line plot showing the eigenvalues of factors used to determine the number of factors to retain in PAF (Fig.1). Based on this visual interpretation and on Rule 2 (the eigenvalue of each selected factor must be at least 1) two factors were chosen. Furthermore, during this process the total cumulative variance explained by the two selected factors (marked with * in the table) was 75,56 %, as presented in Table 2.

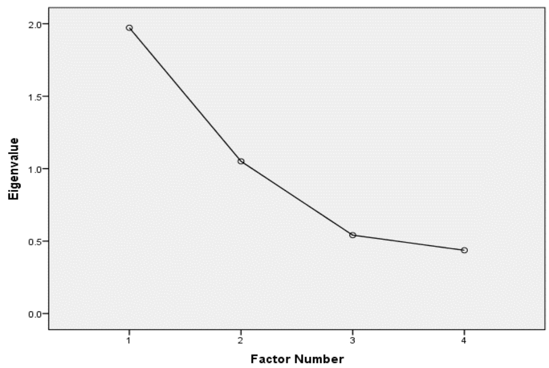


**Figure 1.** The Scree plot presented based on the representation of the obtained eigenvalues.

**Table 2.** The obtained eigenvalues and variance explained.

| Factor | Initial Eigenvalues | | |
|---|---|---|---|
| | Eigenvalue | % of Variance | Cumulative % |
| ***Factor1** | 1,97 | 49,3 | 49,3 |
| ***Factor2** | 1,05 | 26,26 | 75,56 |
| **Factor3** | 0,54 | 13,52 | 89,08 |
| **Factor4** | 0,43 | 10,92 | 100 |

Table 3 presents the result of the Bartlett's Test of Sphericity (BTS). BTS indicates significant findings. We suggest BTS application at the 0,05 significance level. The obtained small value of the significance, ~0 (0<0,05), indicates that the factor analysis can be applied on the considered data. Furthermore, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) was applied. KMO should indicate non-significance. We suggest KMO application at the 0,05 significance level. The obtained result was 0,636 (0,636>0,05), which indicates an appropriate application of the exploratory factor analysis.

**Table 3.** Bartlett's Test of Sphericity.

| | |
|---|---|
| **Approx. Chi-Square** | 129,28 |
| **df** | 6 |
| **Sig** | ~0 |

Table 4 presents the communalities: initially and after extraction. All variables are appropriate as their communality values after the extraction is greater than the threshold (0,263).

**Table 4.** The obtained communalities.

| Variables | Initial | Extraction |
|---|---|---|
| **Var4 (access to medical care)** | 0,295 | 0,393 |
| **Var5 (reaching physicians)** | 0,353 | 0,641 |
| **Var6 (access to medication)** | 0,361 | 0,610 |
| **Var7 (getting infected by SARS-CoV-2)** | 0,064 | 0,263 |

Table 5 shows the results of the two identified factors. Variables loaded with the absolute value lower than 0,3 were removed. Low values were considered as redundant.

**Table 5.** The obtained Rotated Factor Matrix.

| | Factor | |
|---|---|---|
| | **1 "Healthcare-related concerns"** | **2 "Fear of COVID-19"** |
| **Var4 (access to medical care)** | 0,77 | |
| **Var5 (reaching physicians)** | 0,73 | |
| **Var6 (access to medication)** | 0,62 | |
| **Var7 (getting infected by SARS-CoV-2)** | | 0,51 |

According to the additional verification step, we performed the Monte Carlo Parallel Analysis (PA) with the following parameters: number of variables: 4; number of subjects: 184; and number of replications: 1000. Table 6 presents the obtained results: in the first column the Eigenvalue, in the second the Random Eigenvalue (RE) and in the last one the Standard Deviation (SD).

The obtained simulation result indicates the extraction of two factors as follows: the eigenvalue of the first factor should be at least 1,153, and the next factor should have at least the eigenvalue of 1,042. According to Table 2 the eigenvalue of the first factor is 1,972, which is a higher value than 1,153 obtained by PA. The eigenvalue of the second extracted factor is 1,051 that is higher than the value 1,042 obtained by PA. Therefore, the results of PA confirm the correctness of extracting the two factors.

**Table 6.** Results of the Monte Carlo Parallel Analysis.

| Eigenvalue | RE | SD |
|---|---|---|
| 1 | 1,153 | 0,045 |
| 2 | 1,042 | 0,032 |
| 3 | 0,96 | 0,036 |
| 4 | 0,844 | 0,054 |

Factor 1 was loaded with Var5, Var6, and Var7, indicated in column 1, with the values of 0,772, 0,773, 0,624. All these variables, access to medical care, medication, and contact physicians, are vital components of an appropriately working healthcare system. Thus, Factor 1 was defined as “Healthcare-related concerns”, to emphasize that CIEDs patients worry about their basic medical care, which is currently affected by the COVID-19 pandemic. Individuals living with CIEDs are part of a vulnerable group of chronic patients. Providing them accurate information about healthcare is crucial, as they have to attend follow-up visits on a regular basis, in order to check device functioning and prevent health deterioration [6]. Multiple studies show that emotional support and patient education improves quality of life; with the recent rapid digital transformation in healthcare, cardiologists, electrophysiologists, and physicians in training can provide online and/or telephonic support to high-risk patients adding practical and psychological benefits [19-21].

Factor 2 was loaded with Var7, with the value of 0,512, indicated in column 2 of Table 5. This factor was defined as “Fear of COVID-19”. The fact that Factor 2 has only one component underlies Var7’s independent and major effect on the respondents’ life, which is consistent with medical literature. COVID-19 independently influences mental health, which might be due to the fear of getting infected by SARS-CoV-2, and to the daily media coverage and misinformation on social media. Platforms providing misinformation should be removed and official sources should provide and disseminate information about preventive measures for everyday life with cardiac devices and healthcare assistance during times of a pandemic [1, 22, 23].

## CONCLUSION

Our study described a multivariate analysis called PAF, part of the EFA class, which is frequently used in healthcare research. PAF was performed on CIEDs patients’ concerns during the COVID-19 pandemic. In order to extract the optimal number of factors, which is one of the most difficult problems in EFA, we considered three principal rules, and an additional step to verify the correctness of the number of factors.

The two extracted factors were explained by 75,56 % of the cumulative variance. Factor 1 was defined as “Healthcare-related concerns” and Factor 2 as “Fear of COVID-19 disease”, which highlights the current concerns of CIEDs patients. Consequently, the need for accurate medical information provision, patient education and support are emphasized in order to improve healthcare during the pandemic.

The Social Network of Machines (SOON) project aims to investigate a solution based on the use of autonomous social agents to optimize the complex manufacturing processes in the framework of Industry 4.0. In the current article we performed an experimental study on the collected data of CIEDs patients. The approach was based on statistical modeling. As a future research, the statistical modeling presented in the current paper together with other methods of data science and artificial intelligence will be applied for industrial data analysis available in the framework of the SOON project.

## ACKNOWLEDGMENTS

This study was developed in the framework of the CHIST-ERA program supported by the Future and Emerging Technologies (FET) program of the European Union through the ERA-NET Cofund funding scheme under the grant agreements, title: Social Network of Machines (SOON). This research was supported by a grant of the Romanian National Authority for Scientific Research and Innovation CCDI-UEFISCDI, project number 101/2019, COFUND-CHISTERA-SOON, within PNCDI III.

We would like to thank the "Advanced Research in Information Technology" Research Center (CARIT) and the Electrophysiology Team of the Emergency Institute for Cardiovascular Disease and Transplant (IUBCvT) Targu Mures for their support.

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*Interdisciplinary Description of Complex Systems* 20(1), 57-63, 2022

# HOW SAFE IS YOUR SMART CITY?

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DOI: 10.7906/indecs.20.1.8
Regular article

*Received:* 3 April 2020.
*Accepted:* 31 December 2021.

## ABSTRACT

As far as I am concerned, not at all, and I am going to show why! When most people hear the expression 'Smart City', they associate it with a future city where thousands of sensors are installed and connected with each other and the central computer-based unit. Other groups of people think of the smart city as represented by high quality and future visionary high-end instruments and electric cars. However, the smart city is based on an interaction between city systems, public safety, health, education, and citizens' services. This cooperation makes the city a healthier, safer place for people to live in. Nowadays, public safety is of paramount importance like energy management, smart transport, or building automation. In this article, I am going to describe how we can manage public safety by transforming the city environment in a proprietary way. I use the principles of Crime Prevention Through Environmental Design for redesigning the city environment.

## KEY WORDS

smart city, CPTED, crime prevention, public safety, smart systems

## CLASSIFICATION

ACM: 10003752.10010070

JEL: O39

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## INTRODUCTION

The global population is currently more than 7 billion and is predicted to top out around 10 billion. Today, more than half of all people in the world live in an urban area. By mid-century, 70 % of the world's population will be living in cities covering less than 2 % of the Earth's surface [1, 2]. The challenges of cities are changing rapidly. This raises many issues: pollution, infrastructure access, traffic congestion, mobility, safety, clean drinking water, waste management and the health of residents are only a few examples. The massive population is overburdening services. Poverty and crime are still far too high. In many cases, cities concentrate too many people on small areas and the overpopulation results in a high degree of indifference, impersonality and isolation. The focus of transforming the urban environment should be on the individual, the community and the environment [3]. How can we handle this high degree of urbanization and how does it affect our future?

## A SMART CITY

The development of the built area and combination of new technologies such as the Internet of Things and Artificial Intelligence offer a multifaceted solution: the smart city or intelligent city. The Internet of Things allows you to analyze your environment and make real-time adjustments to improve productivity and efficiency. This efficiency can be felt throughout the city from a more efficient power grid to optimized traffic and seamless connectivity [4, 5].

Based on these we can create the definition of the smart city: Smart cities are safe, green and hyper-connected cities, technologically equipped to improve the lives of their residents. "The purpose of an intelligent city or Smart City is to create a standardised, cooperative structure by the integration of subsystems" [6].

At this point, an important question arises: "what is the difference between an intelligent city and a smart city?" A lot of people think these two terms are synonyms. They differ according to me. Here is my definition of these concepts [7]:

- "the primary objective of the intelligent city is to promote the integration of various subsystems in order to be able to cooperate with each other in a coherent way. "The different types and different functions of these subsystems help each other, which affects the operation of the entire infrastructure" [6].
- "Smart city is an intelligent city in which services can be exploited by users in a maximal way"[8].

"Smart City should enable every citizen to engage with all the services on offer, public as well as private, in a way which best suits his or her needs. It brings together hard infrastructure, social capital including local skills and community institutions, and (digital) technologies to fuel sustainable economic development and provide an attractive environment for all"[7].

"The principle of subsidiarity may be applied at the introduction of a new intelligent system. According to this principle, problems must be solved where they emerge, so higher-level intervention is only necessary if the problem cannot be solved on its level and it would interfere with the operation of the entire network"[8]. "The use of the word 'ambient' refers to the fact that the architecture that this technology utilizes allows the devices to continually monitor their own systems and the systems surrounding them with the help of sensors and measurements at a local level – where it is needed. Certain authorized elements may also intervene in operating mechanisms. At the same time they are also able to inform the elements in higher 'evolutionary' positions, and if necessary, send them warnings or alerts.

Each element of the system operates autonomously, but they work in dynamic cooperation. For example, sensors of the system can work this way"[8].

As the population grows and traffic jams get more common, some cities end up with a higher crime rate. This affects everyone: business owners, tourism and, of course, families. Big changes often require a comprehensive look. In this article, I am going to take a broad approach describing how to provide the citizens with a lasting sense of security. Instead of just responding to occasional demands, stakeholders came up with a long-term plan. Big changes do not happen overnight. While cities continuing to grow and citizens' expectations increasing, we shall reconsider how cities are built and run. According to my research, a Smart City must have decentralized systems with shared logic. These systems provide real-time data, relying on which the law enforcement officials are informed on ongoing events straight away as they take place. Hot information enables the dedicated body to take preventive measures before the damage becomes extensive [9].

## LIVABLE CITY

Why is the city so attractive? Because the City is the highest level of organization form of human settlement. The physical and functional factors that meet the individual needs the most effective way are concentrated here.

What makes a city fine? Perhaps, the best answer to this is that the people who live there feel that way and they are willing to make sacrifices for it. But this concept requires more than doing modernization or 'getting smart'. We have to make the city livable. The city is for people who live there, its task is to serve the inhabitants as much as possible. All initiatives must be subordinated to this principle.

What makes a city livable? In a livable city, the residents feel good and safe. The basis of our existence is safety, without this, we cannot imagine a well-functioning community. All the residents, and communities – e.g. family, street, district – have a basic need to feel safe in the physical space around them which is called a built environment. This safety is provided by the absence of fear of crime, clean and tidy neighbourhoods, transparent parks, illuminated recreational spaces, clear traffic signals and predictable and reliable transport. With all these, the city can create communities in which people can take responsibility for their environment and their neighbourhood. This can form the basis of a higher standard of living and a more structured society [10].


**Figure 1.** Maslow's hierarchy of needs [11].

Safety is one of the most essential motivation factors for humans, located in the second level of Maslow's hierarchy of needs stated that people are motivated to achieve certain needs and that some needs take precedence over others.). When we talk about Smart City, we mean a city which not only helps peoples' everyday lives with the design of technological, IT and environmental equipment. It is also a place where public spaces, parks, homes, buildings, streets or neighbourhoods are designed to provide the maximum safety for the residents using a demonstration of quantitative and qualitative changes in crime. Needless to say, technology will play a central role. Urban and rural areas are evolving to cater to changes in technology while presenting new opportunities for improved Public Safety. Connectivity and the overall experience for residents and visitors, city officials are specifically tasked with the challenge of providing safe and secure settings, network connectivity, reliable and sustainable power, modern living and working conditions and ultimately a seamless and data-driven operating environment. Creating a safe, secure city requires preparing for a wide variety of challenges from protecting critical infrastructure to mitigating the risks of terrorism and cyber-attacks. Deploying a 24/7 crime prevention and Public Safety strategy is essential to proactively maintain safety while also allowing emergency professionals to respond quickly in a crisis situation. According to many academic sources and, in addition, to my own experience, I have developed the following definition of Liveable City. A Livable City is a level of urbanization that uses smart city's innovative technology to enhance community services as well as it uses Environmentally Sensitive Crime Prevention to increase the safety feeling of the residents. These two parts of the design process create economic opportunities that improve the city infrastructure, reduce costs (maintenance costs) and resource consumption and increases civic engagement. Let me take a few moments to discuss the potential high-level planning steps for developing a Smart City. A smart city is not a single or small collection of projects. Ideally, a smart city begins with a vision [12, 13]. It's essential as a first step because it will guide every decision that comes next. The truth is that, when you have a long-term vision, big changes can happen right before your eyes.

## HOW CAN WE DESIGN A SAFER SMART CITY

The answer ... is not just one thing. No single solution can fix everything. We need connected systems and collaborating teams, greater intelligence to discover the unseen [14].

The focus of transforming the urban environment should be on the citizens, the community and the environment. We can meet this requirement if the redesign of the neighbourhoods or built-up areas serve the needs of the city dwellers. One of these demands – even if many people are not aware of this – is the emergence of human communities. The careful urban planning that focuses on safety and livelihoods should strive to divide the built environment into smaller units, despite the large masses of people, where the chances of human observant communities remain.

Our built environment is the space in which we are continuously interacting. Our communication is often unnoticeable. When we walk down the street, sit down in a park, come to a plaza or park our car, we perceive the environment at all moments from which conscious and unconscious conclusions are drawn. It is important that we grab all the tools which can form the environment (rather than the individual's permanent but constantly changing framework) in a way that it provides us with a sense of security at all times. The presence or lack of a subjective sense of security is fundamental to our behaviour and attitudes towards other members of society, our environment and our living space. I use the principles of Crime Prevention Through Environmental Design (CPTED) for redesigning the city environment. These are 'natural surveillance', 'access control', 'territoriality', 'activity support' and 'management and maintenance'. These principles are based on continuous monitoring of the number of crimes and other economic and social data. Measuring data is very important for us. It helps to make decisions in good shape. It is very important to the government, mostly for security related issues.

What is CPTED? It is defined as a "multi-disciplinary approach for reducing crime through urban and environmental design and the management and use of built environments. CPTED strategies aim to reduce victimization, deter offender decisions that precede criminal acts, and build a sense of community among inhabitants so they can gain territorial control of areas and reduce opportunities for crime and fear of crime" [15]. Its directives include adjusting the height and quality of fences, improving public lighting, maintenance of streets and buildings, controlling and damping traffic, providing people with information about their environment, marking boundaries of land and private and public spaces, use of security systems, and development of natural oversight and community control.

The basic concept is to create a built environment which includes spaces, streets, and residential parks that are less liable to invite committing crimes. Where we experience clean, bright, transparent spaces, tidy, maintained parks and other community service areas. There is a need for zones, districts, and neighbourhoods where functions and people mingle, thus avoiding sleeping quarters. The goal is to control urbanization and to keep the human dimension in mind.

In order to live in our environment, and in our built environment in particular, which provides us adequate living space and quality, many other factors affecting the environment must be reconsidered. These include colours, space shapes, illumination, and proper usage of vegetation. It may not be sufficient to state that the community can do its best to prevent crime, but it must be facilitated by creating the right environment to enhance the community's natural need to protect it in the first place [15-17].

## INTERVENTIONS POINT

Crime and harm are the most common human activities which are often discovered through human intervention. The current highly centralized and human-based smart city systems are not capable of signalling emerging disaster situations early due to their reliability. As a result, response can only be given with a lag.

When applying environmentally sensitive crime prevention, nine intervention points are identified. These points help to determine the applicability of the principles and the methods that mutually support each other. Since we cannot find two identical areas or problems, the solutions given to them are not uniform. It is more important to have a set of criteria which we can start applying. Let's review these intervention points [10]:

1. Mix of people: in this intervention point we are going to design or redesign city areas whose role is to build social relationships, e.g. pedestrian streets, public spaces, etc.
2. Mix of functions: it is very important for an area to be alive as much of the time as possible. It is therefore necessary to combine functions such as trade and culture or other services and non-industrial workspaces such as large shopping malls.
3. Social control: as we have seen, the role of the community in crime preventionis much greater than we would expect. There is a major need to strengthen social cohesion and develop community functions.
4. Define space: as I stated earlier, environmentally sensitive crime prevention only works if it is focused on a well-defined area. The task is to increase community control by subdividing the area into the appropriate 'size'.
5. Lighting: for community control to function properly, the 'protected area' must be made visible and this can only be done with artificial lighting at certain times of the day.

6. Protection: we are not able to implement community control at every point of the area, so we need to optimise (centralise) surveillance, deter ‘intruders’ or make it difficult for them to operate.
7. Management: the built environment, even a relatively durable construction is constantly decaying and being worn out. If we do not maintain it from time to time, it will create negative effects that are more difficult to eliminate. For example: “One unrepaired broken window is a signal that no one cares, and so breaking more windows costs nothing” [18]. This is the broken window theory. “The broken windows theory states that visible signs of disorder and misbehavior in an environment encourage further disorder and misbehavior, leading to serious crimes. The principle was developed to explain the decay of neighborhoods, but it is often applied to work and educational environments” [18].
8. Information: it is essential that a person feels uncomfortable and depressed in an area which they are unfamiliar with. It is important to inform and to help citizens to navigate in the built environment.
9. Urban design: Prevention is more effective than ‘rubble clearance’, so if it is possible, we have to prepare the citizens for the right usage of the area.

## CONCLUSIONS

I have argued in this that those smart cities which did not focus on environmentally sensitive crime prevention are not safe enough. The prophylaxis requires a complex approach in which setting priorities is important but pluralism in the methods is just as essential. The future will focus most likely on cities where, depending on the urban citizens, the population and crime rate will continue to increase. Urban design must put much more emphasis on the principles of environmentally sensitive crime prevention.

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