Interdisciplinary Description of Complex Systems 16(3-A), 333-341, 2018

ACCURATE RADIOFREQUENCY IDENTIFICATION TRACKING IN SMART CITY RAILWAYS BY USING DRONES

Péter Miksa Hell* and Péter János Varga

Óbuda University, Doctoral School on Safety and Security Sciences
Budapest, Hungary

DOI: 10.7906/indecs.16.3.5
Regular article

Received: 8th May 2018.
Accepted: 31st August 2018.

ABSTRACT

Smart traffic is one of the key pillars of a smart city infrastructure. In the near future, more and more automated shipping systems are going to be used, eliminating the human factor as a possible source of error. In other words, safe operation of automated systems is one of the most important tasks. The direct supply of smart cities and their industrial facilities is best served by road and rail freight and passenger transport. The spreading of laws and automated systems reduces the number of accidents, but it does not completely eliminate it. With regard to the railway disasters that have occurred in recent years, we have observed that the time between the accident and the start of the rescuing process and repair is one of the most important factors for a successful operation. The localization of railway accidents is often difficult or time-consuming due to field conditions. This time can be greatly reduced by a drastic system that helps the work of disaster relief agencies and conscripts. Trolleys and tankers are nowadays equipped with an RFID (Radio Frequency Identification) transponder to keep track of shipment movement. In this article we investigate what kind of assistance could a drone equipped with RFID reader and navigation infrastructure provide in case of a traffic accident or a disaster situation, with particular regard to the dangerous goods transported on a fixed track. The goal is to develop the application of a modern and innovative technology that can make a smart city more secure.

KEY WORDS

drone, RFID, railway, communication, disaster situation, dangerous goods

CLASSIFICATION

JEL: L63, L92

*Corresponding authors, η: hell.peter@kvk.uni-obuda.hu, –;
Óbuda University, Tavaszmező u. 15-17., H – 1084 Budapest

INTRODUCTION

Railway accidents are still happening today. Their number has declined in recent years, but according to statistics, it is still high. Figure 1 shows the number of the evolution of European accidents between 2010 and 2016 [1]. When it comes to disasters, one of the most important factors is to obtain the information that necessary to start a professional rescue.

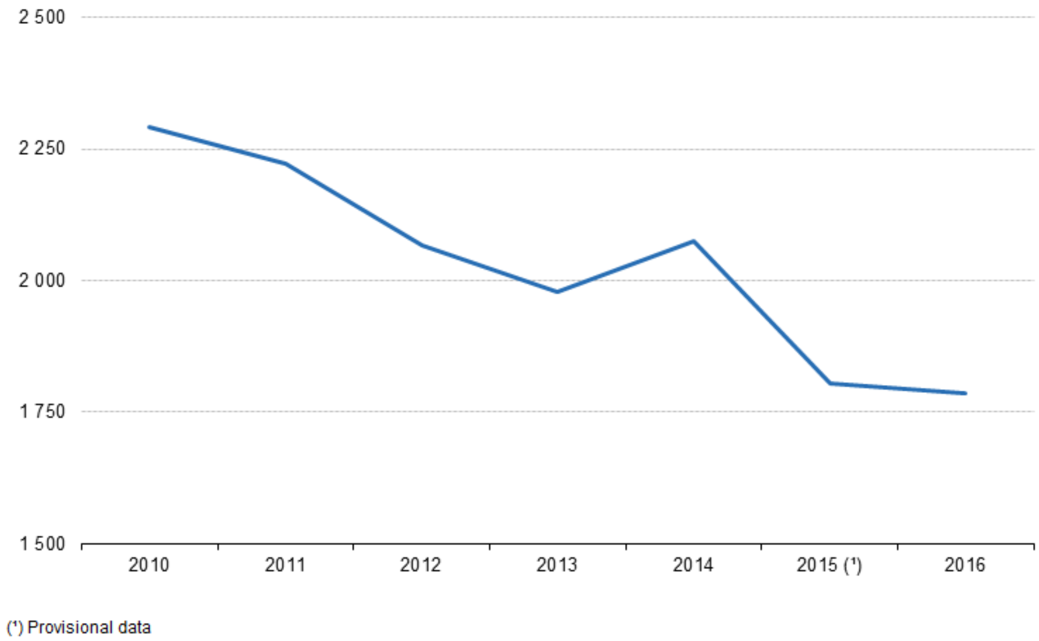

Figure 1. Number of rail accidents in the EU, 2010-2016 [1].

Smart development aims to provide an integrated solution to the problems of urban life, but it also brings a number of new problems along, which should also be addressed. The creation of smart cities attracts the infrastructure development of its industrial facilities. The use of new technologies not only offers opportunities but also raises security issues. Therefore, all options should be taken into account in the design, installation and operation of such systems. The latest digital technologies should be applied to existing, but well-functioning systems.

The aim of the research is to create a drone system that would reduce the time of the exploration of accidents. The spread of drones for different target tasks is emerging. The smart city concept provides an opportunity to create an infrastructure that can use such tools in special, even life-saving cases. Researching this area can help the use of drones in disaster recovery.

Theoretical and practical implementation of the research is underway. This includes assessing the possibilities of using target drones in a disaster situation and the possibility of using the prepared drone. Practical test measurements are ongoing with experts in disaster prevention.

PRESENTING AND DEFINING THE TERMS USED IN THE RESEARCH

The following terms and concepts are of fundamental importance to understand this topic.

- Hazardous Substance: Any solid, liquid or gaseous substance of which the manufacturing, handling, storage, transport usage can produce infectious, poisonous, irritating, flammable, explosive, corrosive or harmful substances, or other harmful substances such as steam, mist, or radioactive radiation, and may thus endanger the health of those who come into contact with it or damage property. The transport of dangerous substances and hazardous waste is governed by international conventions (Basel Convention): RID for Rail transport; ARD for road transport and AND for waterway.

- RID – Regulation on International Carriage of Dangerous Goods: The European Convention on the International Carriage of Dangerous Goods by Rail. It is co-ordinated with ADR and UN-numbers (UN-ID) in the Act LXXX of 2011.
- ADR – *Accord Dangreuses Route*: European Agreement on the International Carriage of Dangerous Goods by Road. It was established in 1957 in Geneva. Hungary joined ADR in 1979.
- ADN – The European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways: The European Agreement on the International Carriage of Dangerous Goods by Inland Waterways was established in 1941. European states consider this to be the guiding principle for inland waterway navigation.
- UN numbers: An internationally recognized identification number issued by the United Nations (UN) Expert Committee for the identification of certain chemicals or groups of compounds. On hazardous material vehicles, the hazardous orange board plays a role in alerting other road users to the danger of dangerous goods being transported, and on disaster response units to provide essential information during an accident or an emergency. That is why the correct marking of the vehicle is a very important aspect. Irregular vehicle marking may have unforeseeable consequences. The hazard number is also known as the Kemler number. The orange warning sign is divided into two parts. The upper part contains the danger number and the lower part contains the material number.
- UAV – Unmanned Aerial Vehicle or drone: Remote controlled (RC) aircraft. The nowadays fashionable ‘drone’ expression has been given to this device after its beelike buzzing voice. Drones were initially military targets, but they became involved in civilian development with the advancement of technology. Regarding the purpose of their civil use, the main areas are hobby, film production, parcel delivery, scientific research, law enforcement, and military duties.
- RFID – Radio Frequency Identification: Technology used for automatic identification and data transmission, the core of which is to store and transmit data using RFID tags or transponders and a reader. The reader and the label do not have to physically contact each other. The reading distance depends on the tag and the reader, and can vary from a few centimeters to several tens of meters. The RFID tag can be fixed, glued or embedded in the object to be identified. This can be an object, component, creature, or a system to be identified.

An example of an alloy of systems is a railroad or rail network within the transport sector. Installed sensor systems may already be able to optimize the current traffic situation without human intervention or send feedback to the central supervisor. But such a complex infrastructure can only be an element of smart cities, smart industrial facilities, where, besides the ease and order of living, security also plays a major role. Railway accidents can occur not only in cities, where it is easy to carry out rescue processes, but also in the open, difficult to reach track between municipalities. The RID by Rail stipulates the UN numbers (United Nations numbers) labeling for transport and storage of cargo containing dangerous goods [2]. If these *labels* are visible, and not damaged, then the goods are easily identifiable. However, in the event of an accident, the labels could become damaged or end up in non-visible, inaccessible places due to vehicle and cargo damage. Identifying the leakage of hazardous materials from damaged packaging and tankers is a much more complicated task from then on. Identification of unidentified hazardous chemical substances is currently carried out with special instruments but in many cases they cannot be transported to the site with a drone due to the physical parameters (mass, geometrical extension) of these instruments [3]. The most important factors in the event of such accidents are time, rapid analysis and rescue. Therefore, the implementation of a different method for the identification of damaged goods and cargo can be of great help in the future. In Europe, there is currently no uniform tracking system for trains. The tracking is mostly limited to locomotives, not to rail wagons. Therefore, in the case of such accidents, it is difficult to pre-assign important backup-enhancing such as the exact type of accident and its spatial extent. It is difficult to determine the type and quantity of the damaged materials that are released from packing units. The method of study does not analyze the chemical and physical properties, but reads the RFID chip information placed in the cargo that contains cargo-specific data [4]. In this research, we investigate how a radio frequency RFID reader system mounted on a drone and the infrastructure for identification can provide assistance in an accident or a disaster.

DRONES USED IN DISASTER RELIEF

Drones (UAVs) were originally designed to be unmanned vehicles for military use. The development of civil aircraft has been accelerating in the last decade and its scope has also widened. Its management and orientation capabilities have grown dramatically thanks to the rapid change in microelectronics, while the performance of the devices has also increased, enabling them to be deployed in newer areas. The use of drones for security and disaster recovery must be distinguished from hobby use, as its advantages are unquestionable [5].

In Europe, disaster prevention agencies possess a number of specialized drones. Among others, they play a major role in flood protection, such as helping to determine the extent of the flooded area, the location of possible critical points and the availability of escape routes. They also play a useful role in the fire brigade, for example in the case of forest fire, the size of the fire can be quickly assessed. The typical equipment for these devices includes a high resolution camera, a thermal camera, or an air component sensor, a gas sensor, and a radiation meter [6, 7].

During the research, we examined several devices currently in retail [8]. Most small-sized (less than 5 kg of self-weight) drones are not capable of performing special tasks. Because of their stability due to their take-off mass, they cannot transmit other measuring instruments or sensors beyond the base camera. In most cases, the implementation of disaster protection tasks is carried out in non-ideal visibility and weather conditions, so only high-end drones with high performance, more stability, higher payloads, higher take-off weights of up to 8 to 10 kg and more reliable navigation are convenient. Drones capable of doing such tasks are usually small series mass devices or individually assembled devices, which are much higher in price than a hobby drone, but still are of a magnitude more favorable than a helicopter carrying out similar tasks. Not to mention the operating, maintenance costs and the education of people handling them [9].

RFID TECHNOLOGY

The RFID contactless system for identifying information is one of the most dynamically developing communication technologies today. We use such systems for access control systems, bankcard payment (Paypass), or toll payment systems for lorries. The procedure uses radio signal transmission for data exchange. When identifying hazardous goods, the basic idea is that the object to be identified contains a transponder element capable of storing information of the goods so that they can be identified [10].

The RFID active transponder, shown in Figure 2, is a mechanically strong, robust, weather-resistant and corrosive, highly refractory unit. It also ensures the operation of wagons. For more reliable identification, transponders can be placed on several sides (side, bottom, top) of rail tankers. This will increase read access.

It is possible to place a microcontroller on the side of the railway wagon, tanker, or container, or on the cargo to store the data needed for the identification of the transported material. It should also contain the antenna required for the radio link. The other unit of the RFID system is a reader mounted on the drone as shown in Figure 2. The readings would be transmitted via a radio channel to the evaluating experts [11].

The reading distance between RFID readers and transponders depends on the type of system. The current readout of active transponders and high gain antennas is currently a few tens of meters, but this distance increases with the development of technology, which further increases the efficiency of the system.

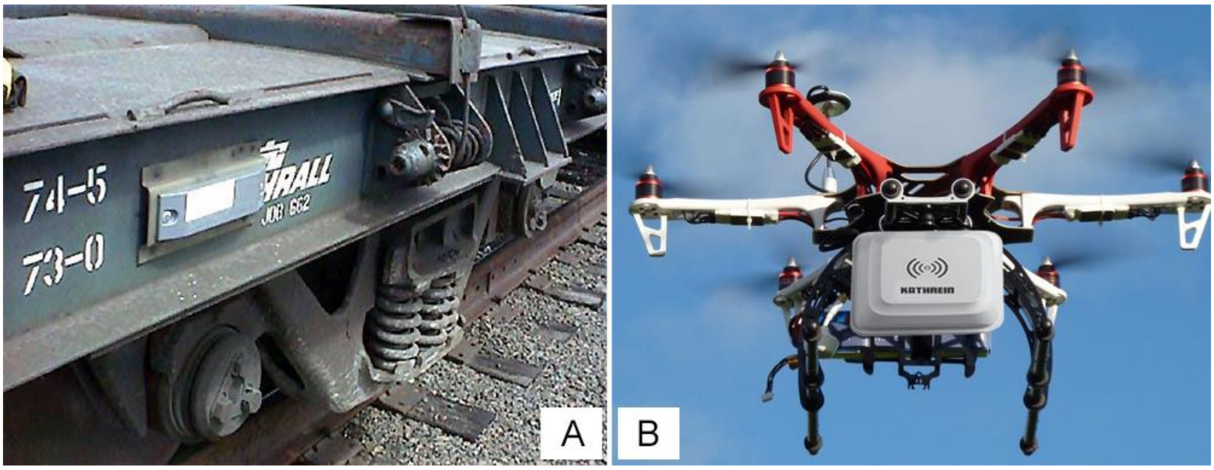

Figure 2. A railcar mounted with an RFID transponder (left) [12] and a drone mounted with an RFID reader (right).

In the event of an accident, the vehicle often suffers a serious damage or the visibility may be inadequate, so the UN numbers on the cargo and other data may not be visually legible. RFID identification allows one to read vehicle and cargo data from a safe distance. The data would be sent to the rescue control bodies by the drone, who may begin to devise the backup strategy with the necessary information, and prepare protective equipment, and neutralizing and disinfecting devices [13]. The basic structure of the RFID system is shown in Figure 3.

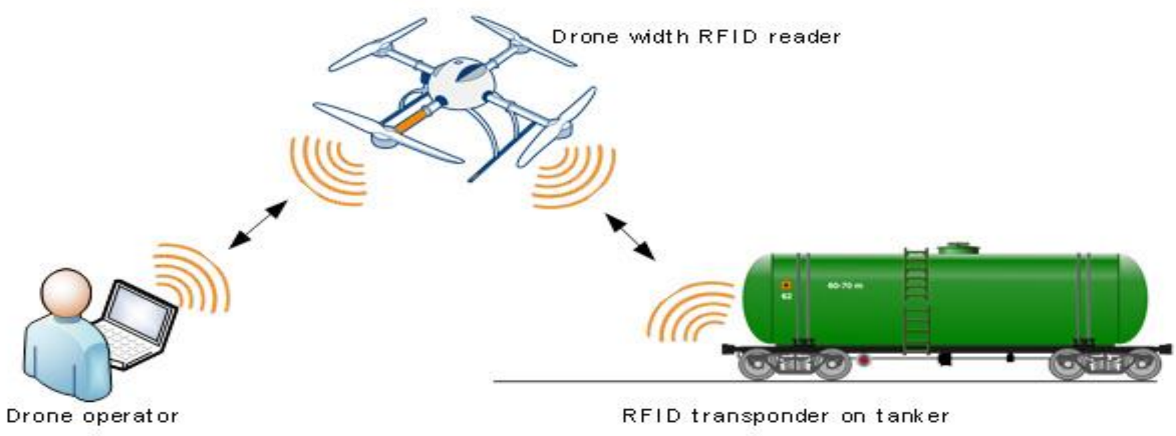

Figure 3. Theoretical structure of a RFID reader system mounted on a drone.

CHOOSING THE RIGHT DRONE FOR THE TASK

Safe operation of a drone is influenced by many factors. These include:

- the geometry of the drone, its own mass, its maximum take-off mass,
- remote control (communication) type and range,
- power supply required for operation, flight time,
- weather and environmental conditions.

The geometrical size of the drone and the take-off mass are related to stability. An aircraft specially designed for a disaster protection tasks is from 8 kg to 10 kg. It is easy to transport, manageable and is safe and stable in a wind speed of up to 50 km/h, with a 65 km/h wind gust. The communication distance between the drone and its pilot can be several kilometers without causing any technical problems, but according to the law there has to be a direct view of the flying device. Regarding the usability of the system, two parameters are determinative: the transportable mass and the sufficient power for the desired distance. The ground must be securely covered by the drone back and forth, and on-site tasks must be carried out, which means additional running time. To do a quick job, the RFID reader antenna on the deck must be able to read from 8 m to 10 m away from the transponder [14]. Determining the reading distance depends on one hand on the compliance of the safe object approach distance and the speed of the drone and the response time of the reader transponder. The reading (object approach) distance can be calculated from the jamming and spreading of the train cars involved in the accident. It is from about 8 m to 10 m in length, compared to the size of a wagon. Larger reading distance requires a larger geometric size and weight antenna system, which also requires higher power consumption. The average reading distance of RFID systems ranges from a few centimeters to some ten centimeters. Larger reading distance is only available from a few manufacturers. Figure 4 shows the comparison of important parameters – with regards to the reading process – of Kathrein RFID readers. The geometric size of reading antennas is within the applicable size limit. Horizontal and vertical opening angles are on average 50°, which in practice means that if a drone equipped with an RFID reader is at a previously defined safe 8-10 m distance away from a transponder-mounted wagon, the scan (sweeping) range is about 10 m radius area. The read-only requirements are met by all three readers, but only the WIRA 7070 is suitable for the weight limit and the power consumption of the antennas.

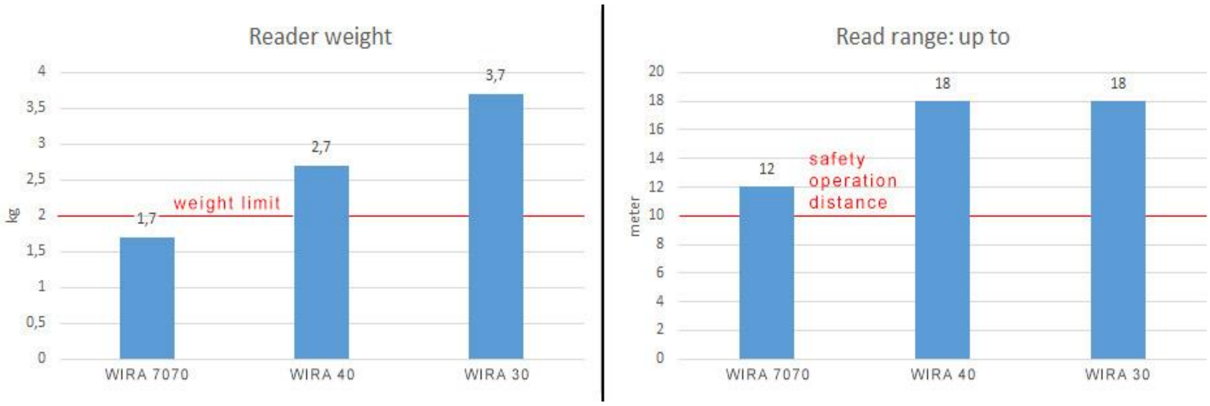

Figure 4. Parameter limits for selecting the RFID reader [15] (authors' edit of https://www.kathrein-solutions.com/datasheets).

The category of drones to perform the task was determined based on the previously described technical requirements and parameters. Henceforth we chose XYRIS 6 type hexacopter manufactured by VespaDrones for the planned test measurements [16]. The basic self-weight of the drone (frame structure, control and navigation equipment, FPV camera, motors, etc.) is 6 kg [17]. The maximum safe take-off mass defined by the manufacturer is 9,5 kg, therefore the deck-mounted RFID reader and accessories (controller, communication unit) should not exceed 3,5 kg. The manufacturer's recommended maximum flight speed is 50 km/h. Based on the test flights and calculations, the flight time was 25 minutes with an average speed of 30 km/h without load. This time was reduced drastically to 15 minutes once the device was loaded with 3 kg of measuring equipment, thus considerably reducing the flying distance. Figure 5 shows the flight values of the drone without load and under load.

Based on the measurement and computational results, a drone built with test-measuring RFID readers is suitable for carrying out the task. By increasing the reading distance or scanning speed, the workflow can be accelerated, but based on test measurements, the incorrect readout rate of the transponders also increases. Also, the number of missed transponders increases due to the reader-transponder response time.

Figure 5. Driving distance with the RFID system (left) and without it (right).

CONCLUSION

Drones have so far had an unquestionable role in disaster relief. Safe operation for a smart city is a must for secure infrastructure, so drone-mounted RFID technology can be of extraordinary significance. If we take into account, based on the current measurements and calculations, that the drone has to perform tasks at the destination site, it can be established that, in addition to the present technical construction, the distance between the drone and the drone pilot cannot be greater than 2-3 km. This distance is not great, if the site is hard to approach by walking or by taking a public road than it can be reached up to a quarter hour earlier with the drone, significantly affecting the rescue result. Test measurements show that the system works at the principle level. Flight parameters of the drone and RFID technology, such as distance or operating time can be increased. The drone-mounted RFID system still requires further improvements, but it can provide undeniable help in quickly identifying hazardous substances. By applying this technology, measures can be taken sooner, with fewer human resources involved.

Conclusions and questions that emerged in the process of calculations and measurements raise new promises and suggestions for further research. But it is undeniable that the RFID system seems to be a good solution and can realize the research ideas. During further work, more drones and RFID systems have to be designed and tested to make the system as effective as possible in the work of disaster protection organizations.

ACKNOWLEDGEMENT

The research on which the publication is based has been carried out within the framework of the project entitled "The Development of Integrated Intelligent Railway Information and Safety System" (Application number: GINOP-2.2.1-15-2017-00098).

REFERENCES

[1] Eurostat: *Rail accident fatalities in the EU*.
http://ec.europa.eu/eurostat/statistics-explained/index.php/Rail_accident_fatalities_in_the_EU, accessed 5th May, 2018,

[2] OTIF: *Convention concerning International Carriage by Rail (COTIF) Appendix C – egulations concerning the International Carriage of Dangerous Goods by Rail (RID)*.
https://otif.org/fileadmin/new/2-Activities/2D-Dangerous-Goods/RID_2017_E.pdf, accessed 5th May, 2018,

[3] Šolc, M. and Hovanec, M.: *The Importance of Dangerous Goods Transport by Rail*.
Naše More **62**(3), 181-186, 2015,
http://dx.doi.org/10.17818/NM/2015/SI17,

[4] Kiss Leizer, G.K. and Berek, L.: *The Safety Technology Questions of Wastes Arising in the Course of Catastrophes in the Continental Traffic*.
Műszaki Tudományos Közlemények **5**, 2016

[5] Asghar, K.M.; Safi, E.A.; Khan, U.I. and Alvi, A.B.: *Drones for Good in Smart Cities: A Review*.
https://www.researchgate.net/publication/316846331_Drones_for_Good_in_Smart_CitiesA_Review, accessed 5th May, 2018,

[6] Restás, Á.: *The system and possibilities of training uav pilots for disaster management tasks*.
Bolyai Szemle **24**(3), 157-174, 2013,

[7] Restás, Á. and Dudás, Z.: *Human aspects and special features of uav use supporting disaster mangement*.
Repüléstudomány közlemények **25**(1), 23-45, 2013,

[8] Hell, P.: *Drone protection systems in fesility management*.
Hadmérnök **12**(3), 37-47, 2017,

[9] Rodic, A.; Mester, Gy. and Stojković, I.: *Qualitative Evaluation of Flight Controller Performances for Autonomous Quadrotors*.
In: Pap, E., ed.: Intelligent Systems: Models and Applications. TIEI 3. Springer Verlag, Berlin & Heidelberg, pp.115-134, 2013,
http://dx.doi.org/10.1007/978-3-642-33959-2_7,

[10] Moran, O.; Gilmore R.; Ordóñez-Hurtado, R. and Shorten, R.: *Hybrid Urban Navigation for Smart Cities*.
https://arxiv.org/pdf/1705.01516.pdf, accessed 5th May, 2018,

[11] Kiss Leizer, G.K. and Tokody, D.: *Radiofrequency Identification by using Drones in Railway Accidents and Disaster Situations*.
Interdisciplinary Description of Complex Systems **15**(2), 114-132, 2017,
http://dx.doi.org/10.7906/indecs.15.2.1,

[12] Transcore: *Rail and Intermodal Automatic Equipment Identification*.
https://www.railway-technology.com/contractors/signal/transcore, accessed 5th May, 2018,

[13] Transcore: *RFID and Rail: Advanced Tracking Technology*.
https://www.railway-technology.com/contractors/signal/transcore, accessed 5th May, 2018,

[14] He, W.; He, Y. and Tentzeris, M.M.: *Modeling, design and experimentation of a UHF RFID tag antenna embedded in railway tickets*.
2015 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting. IEEE, Vancouver, 2015,
http://dx.doi.org/10.1109/APS.2015.7305097,

[15] KATHREIN Solutions GmbH: *RFID Readers, antennas.*
https://www.kathrein-solutions.com/products/hardware/rfid-antennas, accessed 5th May, 2018,

[16] Vespadrones: *Drone datashit: XYRIS 6 type hexacopter datashit.*
http://vespadrones.com, accessed 5th May, 2018,

[17] Menouar, H.; Guvenc, I. and Akkaya, K.: *UAV-Enabled Intelligent ransportation Systems for the Smart City: Applications and Challenges*.
IEEE Communications Magazine **53**(3), 2017,
http://dx.doi.org/10.1109/MCOM.2017.1600238CM.