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Improving Air Safety in the Context of Terrorism

Nowadays it does not take much time to hear about some new terror attack against an airplane. All these mid-air incidents should have the effect of a wake-up call for security agencies and those working in the field of explosive detection. The terrorist groups continue to explore innovative ways to get bombs onto passenger aircrafts either by cheating the detection systems or by recruiting insiders. In the developed world at most airports the detection systems are working effectively, therefore there it is very hard for terror organizations to take bombs onto airplanes, but many airports in the world have either not deployed these technologies yet, or they do not provide the necessary training for their operators. The terror organizations prefer popular places, building or public transport vehicles where they can have a large number of victims. Train stations, bus stations, airports, aircrafts, sport arenas and music venues are usually among the main targets.
Keywords: mid-air explosion, explosive detection, passenger security screening, terrorism, human management, operator training, experts, air safety

Analysis of attacks

At first let us have a look at the frequency of acts of attacks by decades via the analyses from the beginning till nowadays. Figure 1. shows that in the decades of the 30's, 40's and 50's the number of terror attacks were negligible. We need to take into consideration that a successful attack against aircrafts can cause more people's deaths and all those human lives are irreplaceable. In the decades of the 60's, 70's, 80's the number of onboard bomb attacks increased exponentially. In the examined more than 80 years 71% of all on board bomb attacks happened in the last 30 years' period.

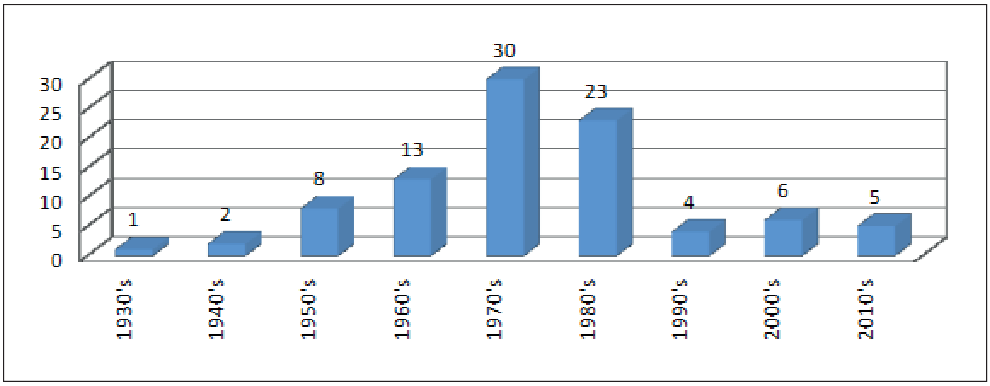

Figure 1. The frequency of acts of attacks by decades

We examined 92 events from the year of 1933 till nowadays. From the 92 occasions the terrorists achieved their goal 56 times. There were at least 2854 lethal victims and more than 124 people injured. The professional reaction in the beginning was that airports needed a stricter system of security screening. But they started to handle the problem only in the decade of the 70's when the number of terror attacks started to increase. Improvement showed mainly only in the 90's. It was the attacks of the 11th September 2001 that had the biggest impact on airport security screening. Because of these occasions the airport security procedures changed a lot [2][4].

Security areas at airports

In terms of safety we may group the airport areas into a number of categories (Fig. 2.). If we go to an airport we arrive at the land side which is protected least of all. Land side is a public place which consists of the departure and arrival hall. After we cross the security screening which is located in the security restricted area (abbreviation "SRA") we arrive at the air side. The air side is closed from the public. It is a guarded area only visited with permission which can be a either a boarding pass or a worker's special airport identity card. The air and land side border is where for example the passenger security screening may take place. The gates to get through are usually equipped with some sort of security screening. The air side can be surrounded also by a fence. The Security Restricted Area is a special place in the airport (for example Hold Baggage Checking System) where for the entry a permission is necessary. In the air side we can find the private area (abbreviation "PA", in the figure) for example the air traffic control tower [3][5][7].

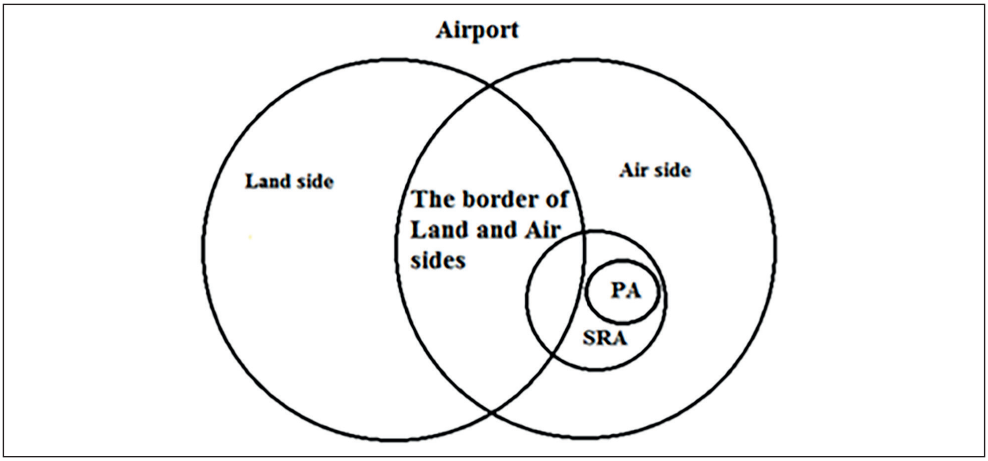

Figure 2. The airport's security zones [3]

The sensors

Sensors are used in order to collect information by way of any technological solution providing measurable data. The purpose of the sensor is to respond to some kind of an input resembling a physical feature (quantity, property or condition) and to convert it into a measurable electrical signal (voltage, current) which is compatible with electronic circuits. These output signals may be described in terms of amplitude, frequency, phase, or digital code. They can also be further transmitted, filtered and processed. Sensors are also known as energy converters [6][14][15][16][17]. They create the connection (input-output characteristic function or transfer characteristic function) between the environment and the system (i.e. the electric devices) by transforming the external impacts into electric impulses. Their output signals can be either analogue or digital.

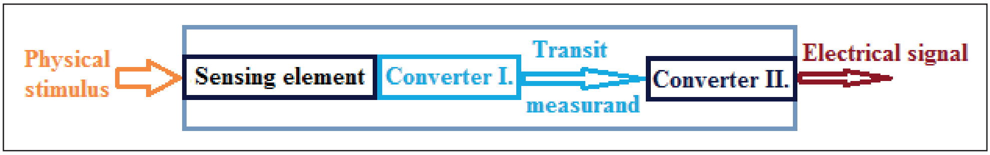

Figure 3. Simple sensor, "indirect measurement" [9]

It can be described as:

$$S = f_{(s)}$$

where: S – is the output signal, s is the stimulus, and $f_{(s)}$ $f_{(s)}$ – represents the functional relationship.

$$S = C + ms.$$

where: C – is output value at a stimulus value of zero and m – is constant of proportionality (sensitivity).

This relation should be (1) linear or nonlinear, (2) single valued or not, (3) one-dimensional or multi-dimensional (single input, single output; multiple inputs, single output). It is in most cases quite difficult to describe mathematically and often it must be defined with the help of calibration data, frequently only defined by a portion of the range of the device.

Only few sensors exist that are truly linear, at least a small non-linearity is always present. Thus, we should calculate the nonlinear sensor's response by the handling of approximated transfer functions:

$$S \approx A\left(1 + ks + \frac{k^2}{2!}s^2 + \frac{k^3}{3!}s^3 + \cdots\right) \text{(1)}$$

where: A – is a parameter, and k – is the power factor [16][17].

Based on the signal processing methodology used, there are three types of sensors: simple sensors (Figure 4.), integrated sensors (Figure 5.) and intelligent sensors (Figure 6.). If we look for the measurand (stimulus) but it is not possible to transform it into an electrical signal, we need to transform it into a transit measurand, called "indirect measurements", (Figure 3.).

The intermediate quantity must be transformed into primary electrical quantity and in this progress different physical effects can take place. For example, a chemical sensor may have a part which converts the energy of a chemical reaction into heat (Converter I.) and another part (Converter II.), a thermopile, which converts heat into an electrical signal. If we do not need this "Converter I", we can do a "Direct Measurement", as we can see on Figure 4. Direct measurement (the use of direct sensors) employs such physical effects that convert energy directly and generate or modify electrical signals. In an integrated sensor (Figure 5) there is an electronic evaluation module for processing the primary electronic signal, which in addition amplifies the signals and provides for the necessary compensation for sensor drifts.

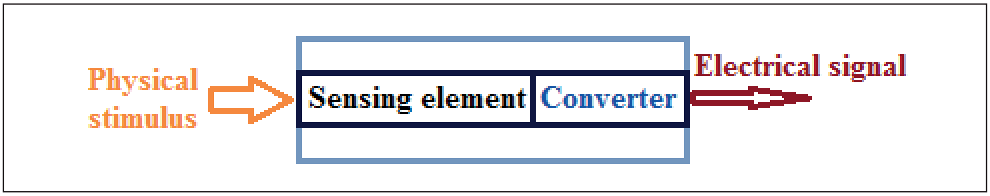

Figure 4. Simple sensor, "Direct Measurement" [9]

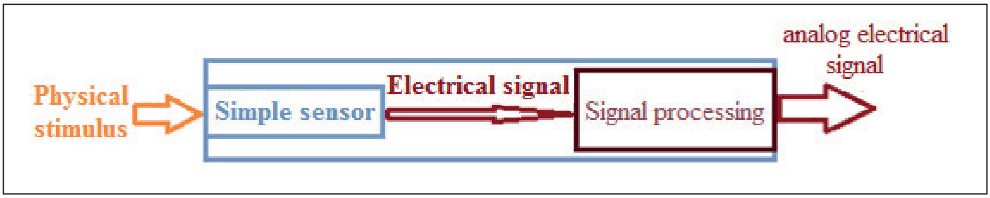

Figure 5. Integrated sensor [9]

Integrated sensors can filter the interfering signals, linearize the signals, fit the measuring range and normalize the output signals. For processing the digital signal, we should transform the analogue output signals to digital signals which is made by the A/D converter (Figure 6.).

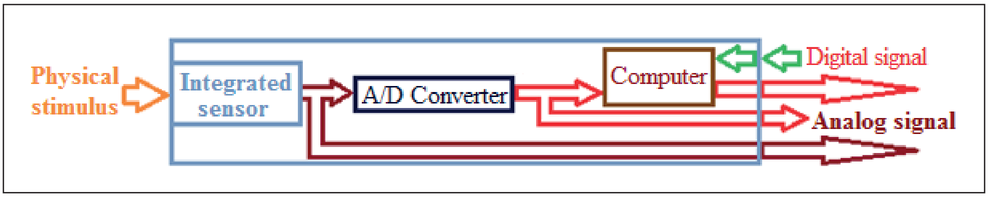

Figure 6. Intelligent (smart) sensor [9]

Since the invention of microelectronic components, the digital evaluation unit (microcontroller) is integrated with the sensors [8]. Sensor classification schemes depend on their purpose. Various other classification methods are used in the current literature [6][8][14][15][16][17]. They can be based on the type of the signal displayed, the interrelationship between procreation of output signals the type of the outer (peripheral) energy resource needed for the operation (passive and active), the type of the selected reference (an absolute sensor, a relative sensor), or the type of the measurand (stimulus) [6][8][9][14][15][16][17].

The measuring systems

Sensors are generally part of larger complex systems including signal conditioners, memory devices, data recorders, etc. The systems could be for example: measurement systems, data acquisition systems, or process control system, etc. The sensor's place in a device could be inside or outside, but it is always a part of the data acquisition systems, Figure 7. shows a block diagram of a data acquisition and control device.

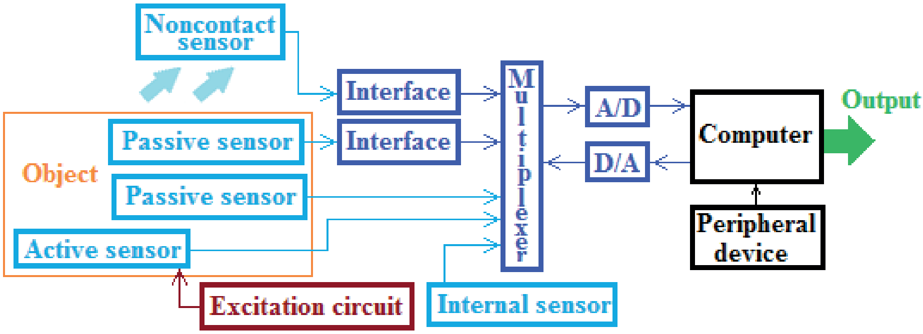

Figure 7. Positions of sensors in a data acquisition system [9]

An object can be anything, such as: an unmanned aerial vehicle, atmosphere, or human, or explosive devices (improvised explosive devices, IEDs), baggage, or liquid, drugs. Any material object could become a subject of some kind of a measurement system. Data are collected from objects by sensors. Some of them (passive sensors and active sensor as we can see in the Figure 7.) are positioned directly on or inside the object. Noncontact sensor perceives the object without a physical contact, for examples: a radiation detector and a IR camera. The internal sensor serves a different purpose. It monitors internal conditions of a data acquisition / control system itself. Some sensors cannot be directly connected to standard electronic circuits because of output signal formats. They require the use of interface devices. Depending on the complexity of the system, the total number of sensors could vary from one to many thousands (a drone or space shuttle).

Output electrical signals of the sensors are fed into a multiplexer, which is a gate. Its function is to connect sensors one at a time to an analogue-to-digital (A/D) converter if an output signal of the sensor is an analogue signal, or directly to a computer if a sensor produces digital signals. The computer controls a multiplexer and an A/D converter for the appropriate timing. The system contains some peripheral devices (such as: a data recorder, a display, an alarm etc.) and a number of components, which are not shown in Figure 7. These could be filters, sample-and-hold circuits, amplifiers, and so on [6][7][9][14][15][16][17].

Passenger security devices and methods at the airport

Cabin luggage and check-in luggage are the two types of bags. Both of them are checked by different X-ray machines. At the check-in desk the drop-off baggage is taken from the passengers, and those bags are checked by an automatically Hold Baggage System (Figure 7).

Figure 8. Checked baggage security system [1]

The hold baggage is checked by X-ray devices, explosive detection and explosive trace detection machines. All types of luggage can be checked by hand also.

These instruments are used in airport passenger security screening, they encounter the passengers: scanning equipment (hand luggage); metal detector gates; liquid testing machines; trace detection devices; hand-held metal detector; and other control devices.

X-ray detection machines

Larger electronic devices (for example: laptop, tablet, iPad, camera, and all other devices with big density) must be removed from our hand luggage. These electronic devices should be put in a tray, then it goes throw the X -ray detection device on a conveyor belt.

The hand luggage is scanned by hand, X-ray equipment and explosive detection devices. If the security staff find something looking dangerous in the bag, they separate the bag from the passenger and check it with their own hands.

Metal detector gate (Walk Through Detector)

At passenger control people need to remove all their accessories, belts, shoes which contain a large amount of metal, they need to empty their pockets, take off their coats and pullovers. After this process they can walk through the metal detector gate.

Liquid Testing Equipment

Liquids are substances such as aerosol, gel, cream, lotion, spray, toothpaste, jellies, beverages, drinks, alcohol, soup, syrup, perfume and the materials of similar composition. These liquids need to be placed on a tray separately from the bag. Another machine called EMA (electromagnetic fluid analyser) searches for liquids, in which there is a unit detecting explosives and traces of explosives.

Trace Detection Instruments

With these devices passengers are examined who have walked through the metal gate. Large objects cannot be placed into the X-ray machine like strollers, wheelchairs and walking sticks. Instruments detecting and disarming explosive devices are also used in addition to advanced tools detecting and analysing drugs.

Hand-held metal detection equipment

If the metal detector gives a signal, passengers need to be checked with a hand-held metal detection device. In addition to the devices listed above there are other devices inspecting package and other shipment, for example: mail and small parcel inspection X-rays; X-ray cargo inspection; container and vehicle scanners; airport check-in facilities; portable X-ray equipment; millimetre-wave machines [1][3][4][7][10][12][18].

The people side of airport security

A key problem with modern security systems is that it does not matter how high-level technology they use, how complex they are, there is always a weak point "built in" them. This weak point is the operator. It may be a commonplace, but without proper selection, development and motivation of the people running them, no safety system can be run so that it brings true safety for the public.

Training operators has the primary aim of maximising safety. This means that it is not only and exclusively about the use of certain technical equipment – it also has to affect human behaviour. Any programme of security team education has therefore got to contain much more than technical operations training – it has to help internalise skills (and even develop capabilities) necessary to improve alertness, situation analysis skills, reaction times, etc. Practically, an effective operator training, even if its main concern may be technological improvement, improves also all other aspects of critical situation recognition and handling. In other words, it is a complex crisis management training, tailored to, for example, airport security systems operators.

In fact, even the operative level modular training scheme should have a multi-level structure. In the core there may be a relatively simple drill to brush up some operational know-how or a key process or the use of a new tool or system, but it has to be followed by layers of behaviour programming. The topics to include for re-thinking and re-working are therefore to follow a scheme like the following:

1. Why? – What is the aim and objective of the drilled process?
2. Where? – Where to do the process? Which is the best possible place for it? Can it be done at one single place or also at multiple sites parallelly? Is it necessary to have a fixed place or can it occasionally be done at various places? Does the place need to be prepared or can it be done ad hoc practically anywhere?
3. What time? – Is any time of the day appropriate or are there limitations? Is there any sequential limitation to executing the process or motion in question? How much time is necessary to do it?
4. How? – What is the proper (technically appropriate, safe etc.) way to execute it?
5. Who? – Who should do it? Is one person enough? Can it be done without endangering alertness, reducing the level of vigilance, etc.? How many people are needed to form a team in order to do it professionally AND safely? Who should NOT do it?

Such trainings, if held regularly, have to follow a scheme in order to train not only the "operator-side" of the co-worker but also the "security officer-side"; not only the individual skills but also task sharing and team behaviour; not only manual skills, but also thinking. All this should be done in an integrated way so that all the complex knowledge does not fall apart; and it should be done in a comprehensive way so that everybody be aware what the role of a motion or process, or a person or team is in the functioning of the security system. Only so is it possible to think in an operation-wide security development system that may aid also the solution of managerial concerns such as recruitment, motivation, organizational culture, identity and image, and employee loyalty – an aspect of the management of security organizations that is of primary importance. Therefore, we can state that practically all aspects of airport and air flight human resources management have an effect on – and they work also for the improvement of – the security and safety of co-workers and clients, uniformed and civilian staff, visitors and travellers.

An international airport is a great place for developing and improving safety and security tools, systems and methodologies for air transportation, but what we can learn there can also be adapted to the use of other organizations. For the managers not only know-how and experience is of primary importance at a post directly involving safety and security matters, but also an attitude of alertness, a quasi-paranoiac thinking. This attitude enables them, on the one hand, to identify even those risks that are not evident, do not seem to be very likely, or do not seem to be very dangerous in themselves, and, on the other hand, it helps them identify how such elements would strengthen each other when built together in a complex crisis situation. Such risk-alertness may be developed and improved by applying various methodologies such as systems thinking [19][21], crisis management planning [20], and in simulations [9][11][13][19][20][21].

Conclusion

In our article we show how many terror attacks happened in the last 80 years. At least 56 fatal cases, 2854 people were killed and at least 124 people were injured. We presented the structure of an airport security, its operating principles, technical characteristics, place and methods of their application. Further development of today's technology is justified because known explosives or explosive devices cannot be detected 100% confidence. Unfortunately, experience has shown how successful the acts of terrorism in the world are. Therefore, safety systems developers must continuously improve. Research on safety systems must deal with the psychological examination of passengers but it is not cost-effective.

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A légiutas-biztonság fejlődése a terrorizmussal összefüggésben

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Manapság gyakran hallani repülőgépek ellen elkövetett terrortámadásokról. Az ilyen légi incidensek hatására sokan ráébredtek, hogy szükség van biztonsági szervezetekre és olyan szakszemélyzetre, amely a robbanóanyag-felderítés területén tudna dolgozni. A terrorista csoportok folyamatosan keresik az újabb és újabb módját annak, hogy hogyan juttassanak a repülőgépek fedélzetére robbanóanyagokat: kijátszva az ellenőrző rendszereket vagy beépített/megfenyegetett belső emberek segítségével. A fejlett világ repülőterein hatékonyan működő detektáló rendszerek vannak, így ott nagyon nehéz dolguk van a terror szervezeteknek, hogy bombát helyezhessenek el a repülőgépek fedélzetén, de a világ számos repülőterére még nem telepítettek veszélyes anyagok detektálására alkalmas biztonsági rendszereket vagy még nem biztosították a szükséges képzést a berendezéseket üzemeltetők számára. A terrorszervezetek számára kedvelt célpontok a nyilvános helyek, a tömegközlekedési eszközök, ahol az áldozatok száma várhatóan nagy less: vasútállomások, buszállomások, repülőterek, repülőgépek, sportarénák és a zenei helyszínek is általában a főcélpontok közé tartoznak.

Kulcsszavak: utasbiztonsági ellenőrzés, terrorizmus, humán menedzsment, operátorok kiképzése, légiutas-biztonság