HUMAN FACTOR AS A THREAT IN AIR TRANSPORTATION OF HAZARDOUS MATERIALS

Abstract

While considering the issue of air transport safety, great attention should be paid to projects related to air transport of hazardous materials, which constitute an increasingly important role in the global air transport. The author of this article undertook an analysis of the chosen aspects of security aiming at the minimization of risks occurring during the transportation of hazardous materials. Nevertheless, the main subject of research is a human factor and its impact on the possibility of occurrence of flight events involving dangerous substances and objects. As a result of the analysis, the main causes of flight events caused by air transport participants were indicated and discussed.

Keywords: air transport, hazardous materials, human factor, incidents in air transport, ICAO Technical Instructions.

Introduction

Over the centuries humanity has noticed a steady development of means of transportation caused by economic and geographic requirements, as well as the development of technical knowledge. The nineteenth century became a breakthrough period in terms of vehicles technical advancement, as a result of the introduction of steam engines (and later combustion engines) to power motor vehicles. At that time, the first locomotives were constructed, enabling transportation of people and freight by rail. In addition, in the late nineteenth century, Carl Benz built his first car, and the Wright Brothers construct a plane, to propel which the combustion engines were utilized¹.

Since that moment, a very rapid progress in the development of technical means of transportation has occurred. Air transport appeared to quickly perceived as the fast way of peoples’ transport and cargo services. As a result, it became one of the most recognizable and a developed mean of transport. Following a huge interest in this type of transport, a number of aircraft in the sky was rapidly increasing, causing the intensification of air traffic and growing the possibility of occurrence of events, which could affect safety of transported people and cargo. The main causes of threats in aviation occurring at that time, are also present nowadays, and include: dependence on the airport infrastructure,

weather conditions, technical advancement of aircraft and support offered by the air navigation services.

Bigger and faster aircrafts used on a large scale across airspace, contribute to a significant increase of risks leading to an increase of the number of plane crashes. Growing danger in the air transport requires undertaking the actions reducing the possibility of events’ occurrence. However, the actions are even more necessary when we consider air transportation of hazardous materials. Air transport of chemicals, radioactive substances or biological infectious agents poses a threat in two areas. Firstly, such materials create a danger through their physicochemical and infectious properties, secondly, an airplane accident will result in the distribution of substances over a wide area, resulting in the contamination of environment and inhabitants. Therefore, the transportation of hazardous materials requires the use of special security guidelines conveying the issues such as: a design of packaging, proper marking of containers, routines for loading and storage in the aircraft, cargo security and production of transport documentation.

Transport of dangerous goods by air constitutes a huge threat to people’s life and health as well as a surrounding environment. The actions undertaken in order to minimize the existing risks include a number of projects which aim at reducing the possibility of occurrence of flight events involving dangerous substances and objects. The current air transport legislation (regulations, instructions, etc.) contains a code of conduct which includes the possibility of existence of incidents involving hazardous materials. Nevertheless, the recognition of safety issues is very limited, mainly reduced to the technical approach containing numerous procedures. The author of this paper intended to expand the perception of the problem related to the effects of human errors on the safety of air transportation of hazardous materials. The task undertaken by the author, in the most general terms, includes the indication of reasons (on the basis of the conducted analysis) for the occurrence of flight events involving dangerous substances and objects.

The importance of legal solutions in air transportation of hazardous materials

The issue of ensuring security in air transport is recently one of the major problems faced by air carriers, nevertheless, among a total mass of aircraft cargo, it is transportation of hazardous materials that deserves great attention. This is due to a huge threat to human life, health and environment, which may appear as a result of unfortunate events. What is more, it should be emphasized that nowadays it is possible to notice a very rapid increase in the volume of transported cargo posing a danger to the environment. Risks associated with the transport of hazardous materials are subject to continuous research and legislative work which aim at developing standards and recommended procedures for dealing with hazardous substances and objects. As a result, the main aim is to minimize the level of risks associated with air transport of dangerous goods. However, an enormous scale of the existing risks in this area means that despite a practical application of appropriate regulations, instructions and legislation, the process of creating regulations for the transport of hazardous materials is not and will never be completed. Because of the above reason, it becomes very important to examine the activities recently undertaken to improve the level of safety of the transport of materials which threaten human life.

Among the existing legal regulations concerning the safety of air transportation of hazardous materials, the most important is Annex 18 to the Convention on International

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2 D. Kucharek, Organizacyjno - ekonomiczne czynniki funkcjonowania PAŻP w systemie bezpieczeństwa narodowego, WOSP, Dęblin 2015, p. 28.

Civil Aviation (Chicago Convention, 1944) and the associated Technical Instructions for the Safe Transport of Dangerous Goods by Air (ICAO Technical Instructions). In addition, air carriers utilize the regulations regarding transportation of dangerous goods in the international air transport (IATA Dangerous Goods Regulations), which are called "field manual" of ICAO Technical Instructions, as they are almost the exact translation of first document.

Currently, air transport of hazardous materials fulfils all of the above regulations, nevertheless they define only procedural provisions of carriage. Numerous procedures developed in the institutions dealing with air traffic, as well as the existence of numerous books and articles in the field of aviation safety, could indicate that there is no need for further exploration of issues related to threats within the air transport. However, it should be emphasized that the environment in which aviation operates, is constantly changing in terms of technology, economy, quality and quantity. Therefore, the issue of safety and security in air transport, including transportation of hazardous materials, becomes a process that must be subject to constant monitoring. Moreover, there is a need for a constant analysis and assessment of the factors affecting the safety of air transport. The conducted analysis should include the assessment of an impact of process management on the safety of performing flights, system operation in this area and an impact of the surrounding on entire implementation of projects related to air transport. A further assessment should investigate a whole system of air transportation of hazardous materials in order to indicate the poorest links.

**Human factor as a threat in transport of hazardous materials**

The danger involved in transport of hazardous materials is a significant problem for cargo carriers. In the history of air transportation, often errors associated with human factors, in particular the failure to comply with the procedures for transport of hazardous materials, resulted in tragic plane crashes. One of the many reasons that lead to unfortunate consequences, is the possibility of occurrence of uncontrolled chemical reactions during transport. The list of hazardous materials includes, for example, substances which, under favourable environmental conditions, for instance, by release of oxygen, can contribute to the combustion of other material, automatically begin a fire, and damage or destroy the transported cargo and means of transport. Despite implementing regular updates to the procedures contained in the ICAO Technical Instructions, monitoring the procedures of transportation and introducing better security systems used in packaging, tragic accidents still occur.

A large number of projects which should be performed concerning transportation of hazardous materials, may increase the possibility of flight events involving dangerous substances and materials. In the above situation, it is necessary to conduct systematic research in order to analyse the functioning of air transport in terms of conditions related to transport of hazardous materials. What is more, ensuring the safety of air transport is the

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4 Annex 18 contains a number of standards and recommended practices that apply to Contracting States; the main ones are to:
- achieve compliance with the Technical Instructions;
- have inspection, surveillance and enforcement procedures;
- record and investigate dangerous goods accidents and incidents;
- have penalties for violations of legislation.

5 Nowadays, all the model requirements are based on the United Nations guidance, which is contained in: the United Nations Recommendations on the Transport of Dangerous Goods; and the International Atomic Energy Agency Regulations for the Safe Transport of Radioactive Material. The Recommendations now include the IAEA requirements for radioactive materials and have been reformatted as model regulations.
most crucial objective of flight performed in airspace. For this reason, all institutions involved in the operation of air transport, are aiming at achieving and maintaining a high level of safety regardless of the existing economic, environmental or social conditions\(^6\).

The necessity of use of specific procedures in transportation may be neglected, nevertheless their usefulness can be confirmed by emphasized some of the air plane crashes which occurred in the past, whose causes were associated with transportation of hazardous materials on board. Few examples from the aviation history (some of them included casualties) can be presented in order to confirm the existence and types of threats\(^7\).

Firstly, in November 1973, Boeing 707-321C, Pan American World Airways airline transported from New York to Glasgow 24 tons of cargo, of which nearly 7 tons were chemicals. During the flight, pilots felt smoke in the cockpit, which thickened, preventing the crew from operating the aircraft. The plane was sent to the airport in Boston, where it crashed during a landing approach. A direct cause of the crash, during which three pilots died, was the most probably a leaking nitric acid.

Another incident which took place in May 1996 was one of the most tragic aviation accidents which have been ever recorded. The disaster, which caused the death to 110 passengers and crew members, was associated with the transportation of dangerous goods by a passenger plane. The accident occurred shortly after a take - off from the airport in Miami. The crew lost the ability to control the aircraft due to a lack of power supply necessary for on - board equipment. The DC9 aircraft owned by the ValuJet Airlines crashed in the swamps near the airport. The investigation revealed that the cause of the accident was a fire that damaged electric installations in the luggage compartment of the aircraft. Ignition of the fire was due to improper security of oxygen generators belonging to the ValuJet Airlines\(^8\).

In February 2006, similarly to the previous example, the accident occurred on the board of freight plane DC8 belonging to a shipping company the UPS during flight to Philadelphia. While the approach to land, crew reported smoke and fire in the cargo compartment. Fortunately, a short distance from the airport and a small amount of fire saved the plane. The crew managed to land and emergency services immediately took charge of extinguishing the fire. The investigation presented no clear causes of the fire, although the evidence indicated that the fire could occur as a result of a chemical reaction that took place in lithium-ion batteries carried on that plane.

In September 2007, Boeing 747 (cargo) owned by a shipping company the UPS, performing flight from Dubai to Cologne has crashed. The first signs of danger occurred shortly after a take-off when the pilots received a signal from smoke detectors about the appearance of smoke in the cargo space. The plane immediately turned around, however, about 17 km from the Dubai International Airport, the machine hit the ground. The crash killed two members of the crew. As a result of the investigation, it has been found that a direct cause of the disaster were large amounts of lithium-ion batteries, transported together with other flammable materials\(^9\).

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\(^7\) *Air Accident Investigation Report*, Uncontained Cargo Fire Leading to Loss of Control Inflight and Uncontrolled Descent Into Terrain General Civil Aviation Authority of the United Arab Emirates, Dubai 2010, p. 204.


\(^9\) *Air Accident Investigation Report*, op. cit., p. 204.
Table 1. Number of events which causes were associated with transportation of hazardous materials on board in the USA between 1990 and 2012.

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<tbody>
<tr>
<td>Air Transport</td>
<td>297</td>
<td>1 419</td>
<td>1 294</td>
<td>1 400</td>
<td>1 460</td>
</tr>
<tr>
<td>Road transport</td>
<td>7 296</td>
<td>15 063</td>
<td>12 652</td>
<td>12 810</td>
<td>13 241</td>
</tr>
<tr>
<td>Rail transport</td>
<td>1 279</td>
<td>1 058</td>
<td>749</td>
<td>745</td>
<td>662</td>
</tr>
<tr>
<td>Water transport</td>
<td>7</td>
<td>17</td>
<td>105</td>
<td>71</td>
<td>70</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8 879</td>
<td>17 557</td>
<td>14 800</td>
<td>15 026</td>
<td>15 433</td>
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The cases of unfortunate aircraft events mentioned above, belong to the most tragic in the last half-century. Nevertheless, air accidents are rare, despite a growing number of aircrafts carrying hazardous materials. Instead, incidents and serious incidents are more frequent and least dangerous. The information on the number of incidents in transport of hazardous materials is presented in the Table 1. It includes all air events that happened between 1990 and 2012. As a result of recording all incidents regarding different means of transportation, conducted by the US Department of Transportation (DOT), an overall upward trend in the number of incidents in transportation of hazardous materials can be observed. Between 1990 and 2012, the number of incidents connected with hazardous materials nearly doubled. According to the data in the Table 1, most of the incidents and their largest range concerned road transport. Undoubtedly, this situation is an outcome of enormous quantities of hazardous materials transported by road vehicles.

However, a large increase in the number of incidents in air transport should be stressed, since in the analysed period it raised from 297 in 1990 to 1 460 in 2012. A significant increase in the number of incidents in transport of hazardous materials cannot be explained only by expansion of carrying capacity and the number of freight planes, which transport hazardous substances and objects. The biggest impact on the number of recorded incidents have stringent obligations imposed on operators that require them to inform the institutions responsible for the safety of air transport even about the smallest event. For example, according to the ICAO Technical Instructions, the operator must inform competent authorities of any finding of undeclared or incorrectly declared dangerous goods in cargo or mail. The operator must also report any cases of detection of hazardous materials in the check-in luggage or baggage located in the close surrounding of the passengers or crew members. 

However, in recent years, the number of events recorded in aviation has not undergone rapid changes (see Table 1). This is confirmed by the UK Civil Aviation Authority, which claims a constant number of incidents reported in the UK. The observed changes occur only because of the causes that directly affect the occurrence of incidents.

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On the basis of recorded notifications, the fundamental causes of incidents in air transport of hazardous materials were categorised. In the percentage terms, they are as follows\textsuperscript{11}:

- undeclared/misdeclared - 40%
- packaging errors - 10%
- spillages/leakages - 10%
- mishandling/misleading - 15%
- passenger originating - 25%

Following the analysis regarding the causes of events in transport of hazardous materials by air, the investigation on the areas of responsibility was also conducted. It should be noted that the above enumerated reasons for the occurrence of incidents, resulted mostly from the mistakes made by a human factor. This statement is supported by the results, which clearly indicated that the recorded air events, in percentage terms, were caused by:

- shippers - 50%
- operators - 25%
- passengers - 25%

The conducted analysis indicates the causes of incidents and demonstrates the areas of responsibility, clearly illustrating that a lack of a declaration for transporting dangerous materials, was the most common reason for the occurrence of incidents. On the other hand, the fact that shippers were mainly responsible for incidents, only indicates their important role in organizing transportation of hazardous materials. The shippers are responsible for proper preparation of cargo for transport which involves: using packaging appropriate to the threat posed by cargo, marking package (packaging, transport container), organization of cargo protection and preparation of documents’ transport. A high responsibility leads to the possibility of making errors which are then classified as airline incidents. Moreover, the significant role of passengers in initiating situations should be noted. Such accidents are also classified as incidents involving hazardous materials. A high overall impact of passengers is a direct result of their huge number of passengers, combined with low awareness of the risks involved, and sometimes even disregard of the applicable procedures.

**Conclusion**

The analysis of the causes of the events in transport of hazardous materials, allows for a more complex visualization of conditions influencing the occurrence of hazards in air transport. For substances which properties create a threat to human health and life as well as the environment, transport provides the opportunities for an uncontrolled discharge into the surrounding. During transportation of hazardous materials, a high possibility of packages, packaging or transport containers (used for transportation of chemical, biological or radioactive materials) leakage might occur. As a result of the analysis of the factors which have the greatest impact on the safety of air transport of hazardous materials, it is possible to indicate a wide range of threats that may contribute to the occurrence of aviation events.

Referring to the entire analysis in this article, the author indicated the cause of the error made by a human factor, in terms of the actions undertaken to reduce the number of flight events involving hazardous materials. Among the reasons that may occur, it is the human error, which has the greatest influence on the formation of threats and leads to incidents or even accidents involving hazardous materials. This refers to unintentional behaviour of flight crew and passengers as well as people responsible for the safety of flight operations and people involved in aviation security. What is more, terrorist attacks using chemical, radioactive or biological infectious agents have a significant influence on events in aviation. Therefore, despite technological development of airplanes and packaging used for transportation of hazardous materials, the main action as a result of which the level of air transport safety will be systematically raising, should be aimed at increasing skills, awareness and competence of the human factor.

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