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A STUDY OF AVIATION INCIDENTS INVOLVING MILITARY AIRCRAFT

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Abstract

This paper presents a flight safety analysis over the past a dozen or so years. The analysis was mostly conducted on the basis of statistical data recorded by units responsible for flight safety in the Armed Forces of the Republic of Poland. The first part of the paper presents a brief historic outline and basic flight safety-related definitions. It also describes basic elements of flight safety formulated by the International Civil Aviation Organisation, ICAO. It presents theories providing reasons for the occurrence of aviation incidents and[1] *the role of a human factor in flight safety and at the same time makes known so called James Reason's Model that explains why aviation accidents occur. In addition, it includes a few examples of the occurrence of serious accidents caused by the human factor. It also emphasises the importance of the system of aviation-related events reporting and investigation and the planning of preventive actions to be taken. The paper also stresses the need to change the way of thinking about aviation accident prevention, where the most important questions are not what or who, but why and how. The second part of the paper presents flight safety analysis in the Armed Forces for the previous year.*

Keywords: *aviation accident investigation, aviation-related events*

1. Introduction

Thanks to the structural and technical development of aviation technology, flying has become safer and safer. Nevertheless, accidents[2] still happen and will continue to happen. Therefore, it is of material importance to carry out an on-going analysis of their causes and to work out relevant preventive measures aimed at avoiding them or minimising their consequences.

The first flight took place on 17th December 1903. Five years after this epoch-making event[3], Sub-Lieutenant Thomas E. Selfridge was killed in an airplane crash, and the second pilot, Orville Wright, suffered serious bodily injuries. Several years later, in 1909, three pilots were killed and in 1913 already about twelve.

At the beginning of the previous century airplanes were far from perfect and pilots did not know much about physical phenomena occurring during the flight. It is difficult to claim that any system errors were made at that time. In the fifties of the previous century, accidents and crashes were mainly caused by aircraft structure referred to as a technical factor. In the seventies however, for

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[1] Aviation-related event - an aviation accident or incident. Depending on their consequences, aviation-related events are divided into categories, types and classes. Flight Safety Manual..., op. cit., p. 12.

[2] Aviation accident - an event associated with aircraft operation which takes place between the time when any person boards the aircraft with an intention to fly until all the persons on broad disembark the aircraft and during which any person has suffered at least serious bodily injuries or the aircraft has been damaged, or its structure has been destroyed, or the aircraft has disappeared and has not been found, and its official search has been terminated, or the aircraft is located in a place which cannot be accessed. *Flight Safety Manual...***,** op. cit., p. 11.

[3] Airplane crash - an aviation accident in which a crew member or other person on board of the aircraft died, suffered bodily injuries resulting in death or was deemed to have been lost upon completion of the search. Definitions of basic terms. *Flight Safety Manual of the Armed Forces of the Republic of Poland.* Warsaw 2004, p. 9.

a change the so-called human factor was mostly to blame. Although the scope of crew responsibility had been changing with time and flight organisation not always kept up with fast advancements in the aviation technology, humans remain the weakest link in the chain of aviation-related events.

On the other hand, a well-prepared aircraft crew decreases the risk of an occurrence of an aviation-related event in difficult, sometimes unavoidable situations. Citing examples form the area of civil aviation does not mean that the same problems are encountered in the military aviation or public order services. Each type of aviation fulfils its own unique tasks, which brings about differences in detailed areas of flight safety risks. One thing, however, is certain, one must utilise the experience gathered within the entire set of different types of aviation.

2. Basic concepts

There are many possible associations with the term flight safety (Fig. 1), such as[4]:

- lack of serious accidents and incidents (an opinion held by travellers),
- lack of threats, i.e. factors that cause or may cause damage,
- attitude adopted by employees of aviation organisations towards dangerous actions and conditions,
- avoiding errors,
- compliance with regulations.

Fig.1. Elements of the flight safety system according to the ICAO

On the other hand, in the Flight Safety Manual for the Air Force of the Armed Forces of the Republic of Poland flight safety is defined as a situation when a commander executes their plans exercising full control over any risks that may affect the course of aviation tasks fulfilment.

In both definitions, flight safety is referred to as a possibility to have full control over safe fulfilment of aviation tasks. However, the passage from the military instruction may be interpreted in such a way that one person, i.e. the commander is responsible for the entire flight safety system in a given unit. This interpretation does not reflect the reality and exempts from responsibility many other persons who should feel responsible for proper functioning of the flight safety system. One can perceive as an ideal a situation when all members of the Air Force personnel take care of flight safety and try to prevent negative phenomena and mitigate the risk.

In aviation, nothing is completely safe, and it is not possible to completely eliminate all risks. However, the whole energy needs to be devoted to mitigate the risk to the lowest reasonable level. In addition, it is unacceptable to create an impression that no matter what is done accidents have happened and will happen, which could be a justification for the denying or neglecting of the law, recommendations or rules. Neither the most sophisticated aviation technology nor the more and more complex tasks will make it possible to work out all the possible threat scenarios and because of that, each element of the flight safety system must be perfected and improved on an on-going basis.

4 Safety Management Manual. Civil Aviation Authority 2009, p. 2-1.

Another important thing is the system of reporting and investigating aviation-related events and working out of preventive actions. The way of thinking about preventing aviation accidents must change, and it is indeed for slowly changing. It is more important to answer the questions why and what then what and who. Domestic legal regulations do not make it easier to develop the system of reporting information about aviation-related-events. Support for the program *Just Culture,* i.e. voluntary reporting of aviation-related events (Reporting Culture) without being punished that has been launched in recent years in the civil and military aviation can be found in the European Union doctrine. It stipulates that: without prejudice to the criminal law provisions, member states refrain from initiating proceedings *in connection with* unintentionally caused aviation-related events about which they have found out only because these events have been reported in accordance with the national program of mandatory reporting, which however does not apply to cases of gross negligence[5].

Polish aviation law[6] is not that favourable though. Article 212 point 1 of the Act stipulates that: any person who while flying an airplane:

- violates the air traffic-related provisions applicable in the area where the flight takes place,
- crosses the border without the required permit or in violation of the terms of the permit,
- violates, imposed on the basis of Article 119 section 2 of the Act, bans on or limitations of flights in the Polish airspace introduced by reason of military necessity or public safety,
- contrary to Article 122 of the Act does not follow the orders issued by bodies in the state in which the flight takes place or orders received from their national aircraft to land at a designated airport or calling for other actions to be taken by the crew,
- is liable to a penalty of deprivation of freedom of up to 5 years.

Point 2 further stipulates that: a perpetrator who acts involuntarily is liable to a fine, a penalty of limitation of freedom or deprivation of freedom of up to one year.

These legal regulations of Article 212 of the Act Aviation Law, to the extent to which it establishes criminal liability of aviation crews for violating air traffic rules, theoretically exclude a chance that such events will be reported, within both the mandatory and the voluntary system.

3. Heinrich's pyramid

Originally created for the purposes of work safety, it quickly became applied to studying the likelihood of the occurrence of aviation accidents (Fig. 2). Each accident (the top of the pyramid) is a consequence of numerous errors and omissions in flight organisation and compliance with procedures which if stopped at an early stage could have prevented a tragic incident. Failure to stop the chain of errors and omissions will sooner or later lead to a serious incident or accident. Proper analysis should begin at the base of the pyramid and should focus on the number of events reported. The International Civil Aviation Organisation (ICAO) mathematically estimated the number of events of a given class, i.e. incidents, accidents, serious accidents, which is most likely to result in the occurrence of a crash.

Fig. 2. Heinrich's Pyramid

5 EU Directive 2003/42: regulates the European Aviation Safety Agency (EASA) – Article 16 of EASA Basic Regulation (216/2008).

6 The Act of 3 July 2002 - Aviation Law, Dz.U. [Journal of Laws] of 2012, no. 0 item 993.

4. The Swiss cheese model

James Reason, professor of psychology, who deals with a broadly defined safety theory, claims that the occurrence of several favourable factors leads to an accident (Fig. 3). One element is not enough.

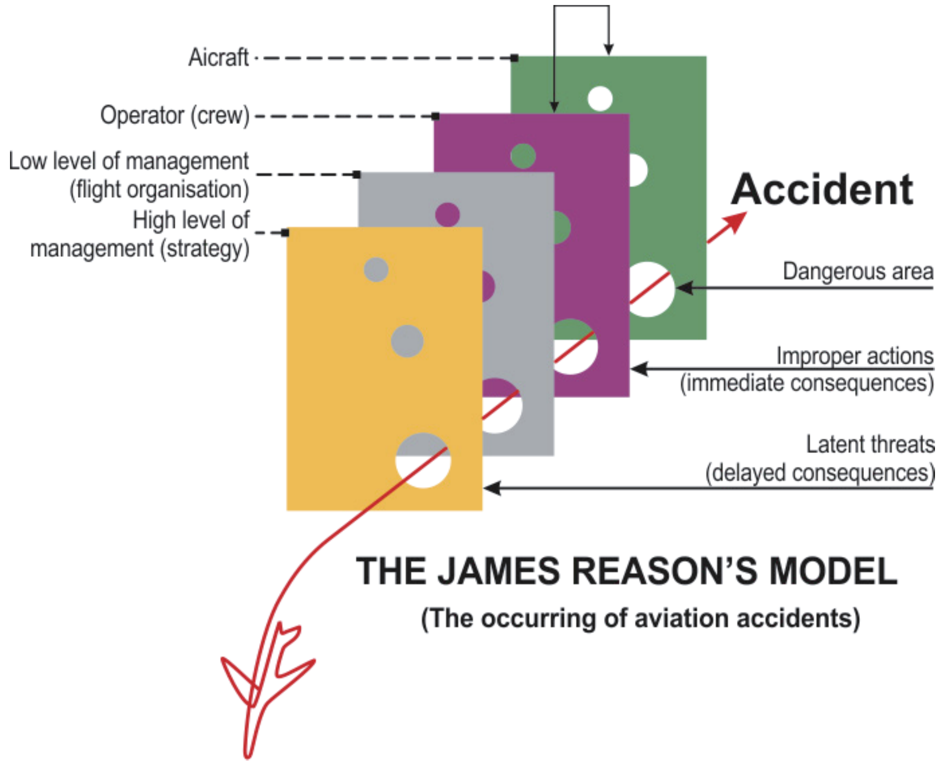

Fig. 3. Factors contributing to the occurrence of aviation-related events – so called Swiss Cheese Model[7]

Errors made at the high and low level of management lead to delays and are usually visible in hindsight. On the other hand, irregularities in the work of an operator or aircraft bring about immediate consequences in the form of an aviation-related event. The James Reason's model, often referred to as the Swiss Cheese Model, has holes in the slices, which are seen as equivalent to weaknesses in particular parts of the system. They are permanent, differ in size and are located in various positions. The system as a whole generates errors when all the holes in each slice align, which leads to the creation of so-called trajectory of accident opportunity. A pilot's error (corrected) or a serious breakdown of equipment (noticed) should not lead to a tragedy if they occur separately, however they can activate subsequent negative events. According to the James Reason's concept, an accident is a sum of connections between activators and latent conditions.

5. A human being as the weakest link

To begin with contemporary aviation means complex technology and automated systems for aircraft steering. More and more often, the pilot becomes an operator or even a supervisor of first-class systemic technical solutions. When an abnormal situation occurs, the pilot usually receives an acoustic and visual signal, which obliges them to act.

It seems that this solution has nearly completely eliminated any risk of events. However, international flight safety statistics show that 70% of aviation accidents are caused by the pilot

[7] O. Truszczyński: Czynnik ludzki w zdarzeniu lotniczym [The Human Factor in the Aviation-Related Event]. Polski Przegląd Medycyny Lotniczej [The Polish Journal of Aviation Medicine], pp. 25-29, Warsaw 2003.

(crew). In a situation, other that the programmed one, the same systems that faultlessly steer the airplane provides the crew with so many pieces of information that under time pressure the crew is not always able to make optimum decisions. The situation becomes even worse when the pieces of information start to overlap which leads to a change in the conditions.

It often happens that after aviation-related events crew experience is analysed. In the deadliest accident in civil aviation, taking into account the number of fatalities, which occurred in 1977 in Tenerife, the captain flying renowned KLM airlines Boeing 747 who caused the accident was the most experienced pilot in the company.

In October 2009 the crew of Airbus A320 carrying 144 passengers ignored controller's calls and missed their destination airport by 240 kilometres as they were pre-occupied with matters unrelated to the flight. The incident was simply a result of carelessness. The pilots were experienced and had all the licences.

In July 2013 an Asiana Airlines Boeing 777-200ER crashed while landing at the San Francisco airport. Among the crew, there were pilots with over 12 and 9 thousand hours of flight experience, but one of the pilots had merely 43 hours of flight experience on this type of aircraft.

One may ask if it should be the case that the plane crashes although crewmembers comply with the rules of aircraft operation, properly use approach plates and checklists. Maybe in contemporary aviation it is the knowledge of the law and rules as well as skilful use of aviation technology (cockpit equipment) that are the most important, whereas experience should be rated third.

Elwin Edwards, theorist who conducted research in the field of safety, in 1972 worked out a model that makes it possible to analyse the actions of humans (the pilot, the crew) and their interactions with other elements of the environment.

A few years later, this theory was modified by another scientist – Frank Hawkins. In the Shell model (Fig. 4) of utmost importance are relations between the pilot (the Liveware Centre) and four other elements rather than between these elements. The relations are of the following type:

- the human factor – the equipment (L H). A relation between a human being and technology (car, equipment),
- the human factor – the software (L S). A relation between a human being and the system that supports human being's actions, such as computer software, checklists, publications, manuals, etc.,
- the human factor – the human factor (L L). Relations between the pilot and the crew, air traffic controllers, technical staff. It also includes relations between employees and the management (commanders) and atmosphere at work,
- the human factor – the environment (L E). Relations between internal and external environment. Internal environment means the workplace, lighting, noise, temperature. External environment means for example visibility, dangerous weather conditions.

Fig. 4. The Shell Model: S – software, H – hardware, E – environment, L – liveware[8]

The above discussed types of environment also comprise resting, sleeping, financial situations,

8 http://aviationknowledge.wikidot.com/

etc., which makes the saying that a pilot flies in the same way as he or she lives of essential importance here.

The model presented shows a complexity of human actions in the flight safety system. The important thing is that its elements must fit with one another. In practice, other models and theories are used as well, for example the Teppo Haakonson flight safety model (determining capabilities of the pilot during in-flight situations), the William T Singleton model (flight safety optimisation), the theory of Karl Marbe (the idea of accident proneness), the theory of P. Rippon (accident-prone personality).

6. Analysis in three stages

The flight safety analysis is a process, which consists in studying the characteristics and causes of the occurring aviation-related events and relations between them in a given training situation and period in order to determine potential threats and work out effective preventive measures. The aim of the analysis is to show how flight safety was shaped in the process of aviation task organisation and fulfilment. Analysis is conducted because situations that exist before aviation tasks are assigned need to be examined on an on-going basis[9].

This analysis is carried out in at least three stages. The first stage of the analysis focuses on what happened, the second aims at determining the main threat zones, while the third one defines preventive measures. If the preventive measures are to be effective the analysis of flight safety must be carried out on a continuous basis and using one of the theories of flight safety. A detailed flight safety analysis is often presented in accordance with the Ishikawa[10] diagram, created by Kaoru Ishikawa and referred to as 5M. The following particular elements are analysed in the model:

- man – selection (psychophysical characteristics), ability to take action (skills, stress resistance), personality traits,
- media – lack of protection against natural phenomena, weather conditions, (the base of the cloud, visibility, temperature, winds, precipitation), operating areas (local conditions, bird activity, vegetation, obstacles, time of the day), work conditions (cooperation between crew members in the cockpit, vibration, noise, pollution), airport infrastructure (type and condition of runway, runway inclination, foreign objects on the runway and taxiways),
- machine – structure (aircraft reliability, performance and ergonomics), service (availability of time, tools, spare parts), logistics (supply of consumables, cost of maintenance), technical documentation (clear, unambiguous procedures, availability of documentation),
- mission – (clear, defined, feasible) objective of task fulfilment, task fulfilment as a result of mutual impact of elements of the model,
- management – effective management of aviation organisation personnel, proper staff selection, clear rules of promotion, emphasis on learning proper procedures that are in force in a given aviation organisation.

7. Flight safety in 2013

The level of flight safety is mainly determined on the basis of the number of the most serious aviation-related events, i.e. serious accidents that involve bodily injuries or death or complete destruction or damage to the aircraft.

Intensity with which serious accidents happen is determined by means of so-called serious accident indicator (WWc), expressed using the relation:

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9 Flight Safety Manual... *op.cit., p. 36.*

10 http://pl.wikipedia.0rg/wiki/D1agramJshikav/y#lstota_metod_diagramu_lsh i kawy. 3.09.2013.

$$WW_c = \frac{Wc}{N} \cdot 100000, \qquad (1)$$

where:
Wc – number of serious accidents,
N – total flying time.

Only one serious accident happened in military aviation last year, while the serious accident indicator line shows an upward trend in flight safety (Fig. 5).

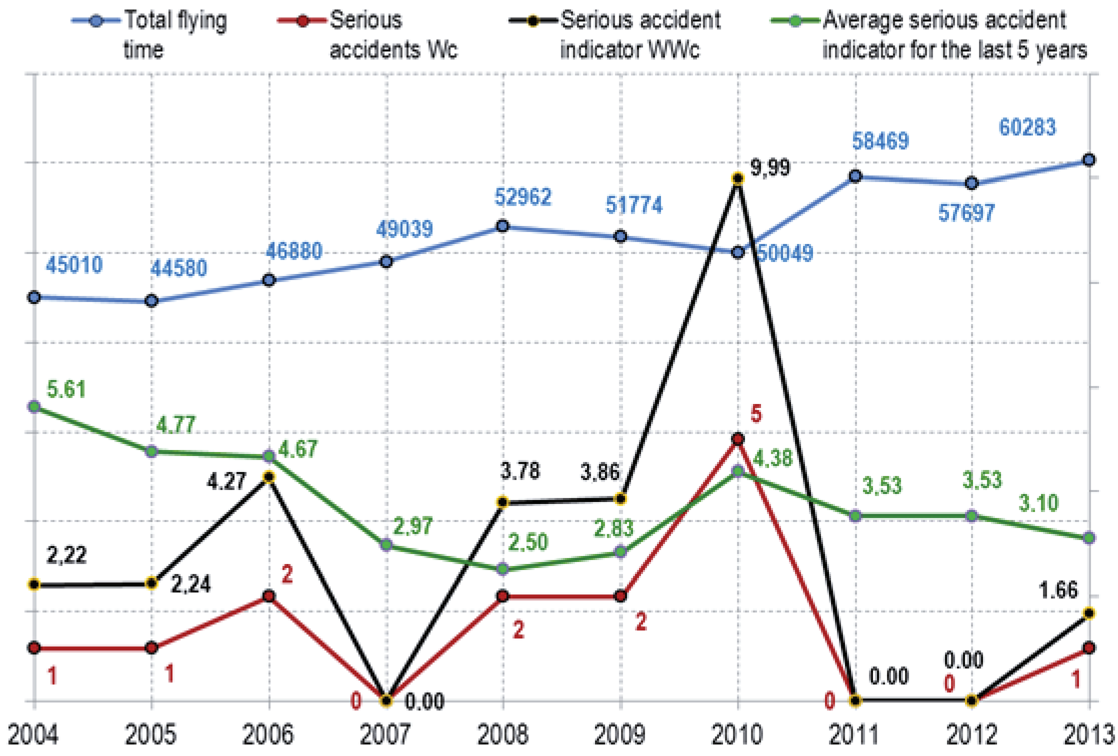

Fig. 5. Serious accident indicator in the air force[11]

In 2013, the serious accident indicator was at the level of 1.66, which means that it was significantly below the average for the last 10 years (2.8) and also below the average for the last 5 years (3.79). In 2013, the Polish Air Force completed nearly all training tasks and had a flying time of 60,283 hours.

Aircraft efficiency is measured by average flying time per incident. A significant decrease of this indicator has been noted in case of TS-11 "Iskra", C-295M Hercules aircraft and W-3 "Sokół" helicopter. A decrease in flying time per event may be an indicator of high unreliability of aviation equipment. On the other hand, it may be a proof that the staff exercises great effort to identify threats relating to a given type of aircraft (increase in the number of incidents) and immediately take preventive measures, which is the right direction.

Working out better and better diagnostic methods in objective flight control laboratories makes it possible in many cases to diagnose an aircraft defect at an early stage. Most aviation-related events and operating problems are a result of human mentality and the extent to which a human being is prepared to fulfil a given task. Insufficient preparation in aviation activity leads to violations and endangers flight safety. Therefore, the human factor contribution signalled at the beginning is so important for the evaluation of flight safety as well as the efficiency of preventive measures.

[11] developed independently on the basis of data from the Flight Safety Department of the Polish Air Force

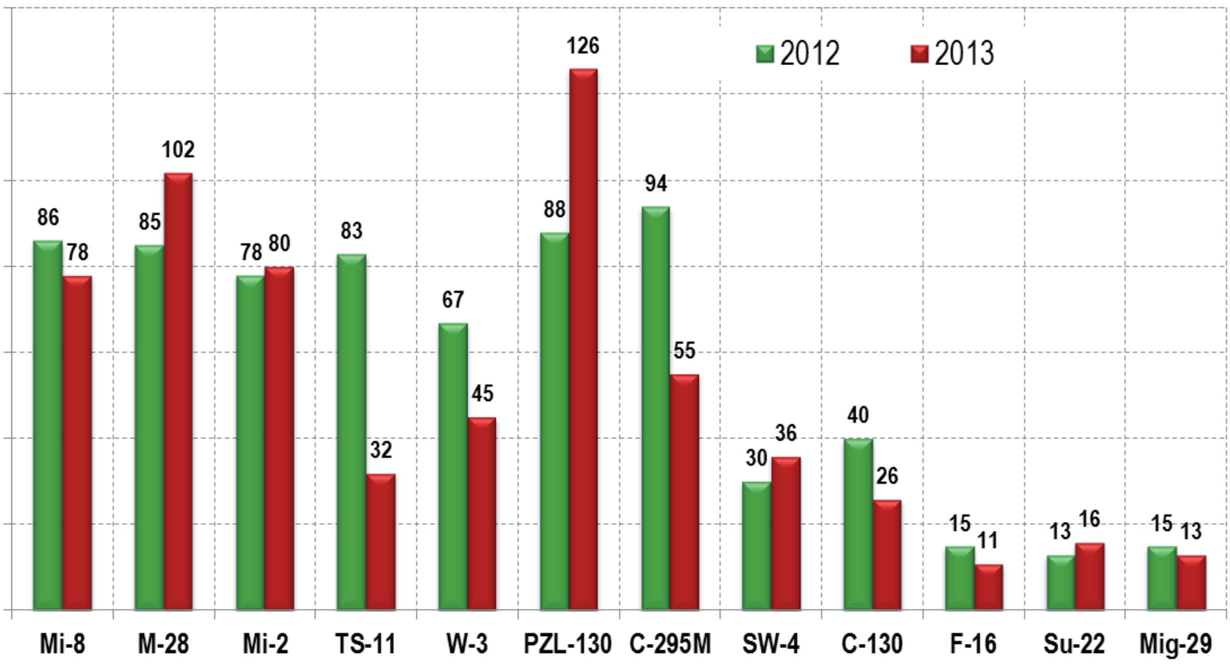

Fig. 6. Average aircraft flying time per aviation-related event [12]

Statistical analysis of aviation-related events that occurred in aviation units of the Types of Armed Forces in 2013 show that 79 events occurred in the area dependent on the unit personnel and one of the them was classified as "unruly behaviour, intentional violation by the crew of aviation regulations or conditions of tasks fulfilment (D). The other 33 events were classified as an error connected with the piloting technique, an incorrect decision taken by a crew member in the situation at hand*"* (B), subsequent 28 events were classified as "improper operation, use of the aircraft, devices or equipment by the crew in a manner contrary to the instructions (E), one event was a result of poor psychophysical condition of a crew member, namely disturbance of their psychophysiological processes which limited them from taking action or made them unable to take action (M). Five events were classified as improper technical handling of the aircraft consisting in improper work organisation or performance by engineering and aviation personnel or failure to comply with regulations concerning direct technical servicing of the aircraft (T), seven as inadequate in-flight supply of materials and technical support (ZM) and the other two as inadequate at-height rescue protection or improper handling of rescue equipment by staff appointed for this purpose" (W) – Fig. 7.

The number events caused by the human factor noted in 2013 was greater than in 2012, when 78 events of this type were noted. The most frequent in the group of dependent events were human errors, both among the crew, technical personnel as well as flight protection services. Errors in piloting that occurred, and were detected in the course of analysis of objective flight control materials were characterised by short-term and relatively insignificant deviations from the required standards and mainly resulted from similarity of parameters specified in training programs and parameters imposed by aviation equipment manufacturers. Precise objective flight control devices usually register the flight and the pilot has a limited possibility to detect deviations using less precise flight and navigation instruments, often at complicated stages of the flight. Some of these events were due to improper distribution of attention during the flight or improper cooperation between numerous crewmembers, which was reflected in the proposed and introduced prevention measures.

[12] developed independently on the basis of data from the Flight Safety Department of the Polish Air Force

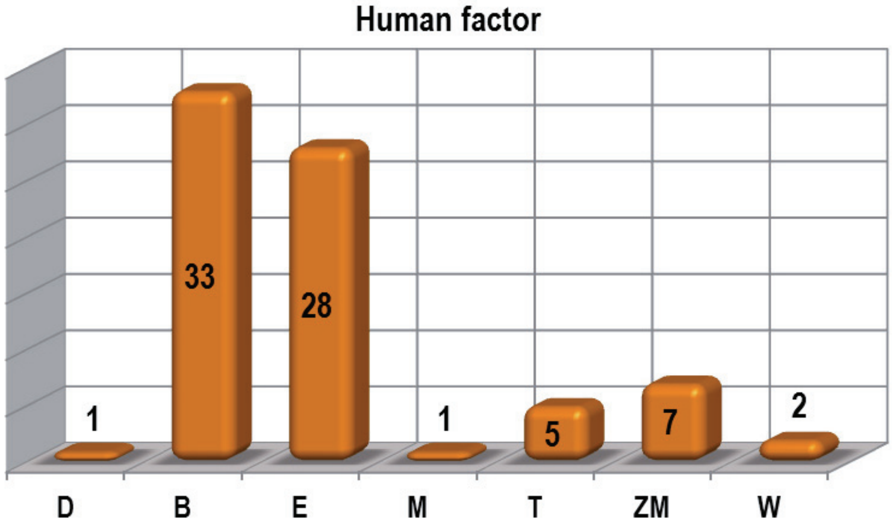

Fig. 7. The human factor in aviation-related events in 2013 by class13

Main factors contributing to the frequency of incidents in the group of events independent of the human factor include above all operation of airplanes, which are near the end of their useful life (Su-22, TS-11 aircraft and Mi-2, Mi-8, Mi-14 and Mi-24 helicopters).

Most events, over 41.5% (771 incidents) were classified as "IT" – other technical problems. These events most often occur on aircraft equipped with complex electronic system software. Problems of this type are usually eliminated by restarting the software or resetting the device. It has happened many a time that the devices, which developed failures in flight, operate faultlessly when checked by Aviation Engineering Services staff on the ground, which makes it significantly more difficult or even impossible to find the reason for failure and, at the same time, to decide on appropriate preventive measures.

Another large group are incidents connected with technical wear and tear (TZ), which constitute over 36.6% of all events (1 serious incident and 679 incidents). Investigation of this type of events shows that they are most often caused by premature wear and tear of units and devices.

Quite a large group (38 events) includes events classified as belonging to the reason group *incidents involving birds and animals* „Z", which proves that previously used methods of avoiding this type of events, need to be verified and modified. Birds caused most damage, whereas three events were a direct consequence of roe-deer invasion onto airport working platforms.

Seven events were classified as belonging to the group *unexpected entrance of the aircraft in the zone of dangerous weather phenomena* "P". Six of them were a result of the icing up of aircraft elements, which may be evidence of cursory analysis of weather reports by the crew or improper operation of airport weather centres.

8. Conclusions

The statistical result makes it possible to draw a very optimistic conclusion that in terms of flight safety year 2013 must be deemed one of better periods in the aviation activity of the Polish Air Force. In addition, it continues a downward trend in the number of aviation-related events, while of utmost importance is the fact that it was possible to avoid a significant number of serious accidents in military aviation of the Armed Forces of the Republic of Poland (1 serious accident).

Flight safety structures have been improved, a complex system of analysis and evaluation of flight safety for the aviation of the Armed Forces of the Republic of Poland – Turawa has been

[13] developed independently on the basis of data from the Flight Safety Department of the Polish Air Force

implemented and further developed.

Preventive measures have been properly defined and effectively introduced, thus we may hope for obtaining similar flight safety indicators in the years to come.

The need to carry out precise and very detailed statistical analysis of aviation-related events from the point of view of preventive measures and flight safety has been confirmed.

References

[1] *Decision No. 363/MON of 3 December 2013 on bringing into use "The Air Traffic Instruction of the Armed Forces of the Republic of Poland"*, IRL, 2013.
[2] *EU Directive 2003/42: regulates the European Aviation Safety Agency (EASA)*, Article 16 of EASA Basic Regulation, 216, 2008.
[3] *Flight Safety Manual of the Armed Forces of the Republic of Poland*, Warsaw 2004.
[4] *Safety Management Manual,* Civil Aviation Authority, 2009.
[5] The Act of 3 July 2002 – Aviation Law. Dz.U. [Journal of Laws], No. 0, item 993, 2012.
[6] http://pl.wikipedia.or6/wiki/Diagram_lshikawy#lstota_metod_diagramu_lshikawy, 2013.