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IDENTIFICATION OF CAUSES FOR AIR EVENTS

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Abstract

The article describes methods applied to identify causes of air events in the polish aviation. According to statistics a human error is the main factor both military and civil aviation accidents. The causes of the accidents are usually referred as "pilot error". Methods used during the investigation process allow finding other failures than crew unsafe acts like: preconditions for unsafe acts, unsafe supervision and/or organizational (management) influence. Those findings allow the investigators take corrective action not only to mishap crew but also to the whole system including procedures, training, regulations and even aviation law. The air incident/accident investigation is a very complex undertaking, since the gathering of the evidence gives rise to considerable practical and methodological difficulties. They result from the fact that any air event investigation attempt is a process of investigating into a more or less traceable dynamic situation. Notifiable accidents, i.e. ones with the aircrew killed and the aircraft severely damaged, create exceptional difficulties in collecting information needed. Such being the case, the source materials prove only a fragmentary evidence to be then completed with indirectly gained data.

Keywords: *aviation, air events, human error, aviation accident investigation, causes of aviation accidents*

1. Introduction

According to the international law and Polish aviation law, investigation into any air event is aimed at finding the causes thereof and making then recommendations to ensure flight safety. The sole and only objective of the air incident/accident investigation is to prevent such events in the future. The uncompromising attitude in tracing the event back, i.e. how it happened and for what reasons shall be the most fundamental feature of the process of investigating every and single air event. The following methods are used correctly to identify causes of air events that have occurred in the polish aviation:

- the James Reason's theory,
- the SHELL model,
- the chain of errors.

2. The James Reason's theory – the effect of a human error upon causes of air accidents

The effect of a human factor upon causes of air accidents is perfectly well explained with the James Reason's theory, who claims that safety within any system depends on the following factors [5]:

- Strategy of performing actions at high management level,
- Actions at low management level,
- Factors conducive to making errors,
- Actions performed by the aircrew,
- Lack of defences/safeguards to support the aircrew.

According to this theory, if factors hazardous to safety arise at every above-mentioned stage of activity and are not eliminated on time, an accident occurs. A model of how an air accident arises,

according to James Reason, has been presented in Fig. 1. In the presented model, latent hazards may be present at all stages of activity to reveal themselves in some specific circumstances only. For instance, e.g. decisions taken at high level of management to reduce health requirements, give up requirements for some specific predispositions, or make some savings on aircrew-training costs may drastically translate into severe hazards to flight safety, under extreme conditions of the aircrew performing their duties, with the workload considerably exceeding their capabilities. On the other hand, improper behaviour/actions by aircrews and/or lack of suitable defences/safeguards can, but do not have to, bring about unfavourable effects. A systematic approach to solving problems of flight safety most fully reflects the (huge) amount of factors that directly or indirectly affect the occurrence of an air accident.

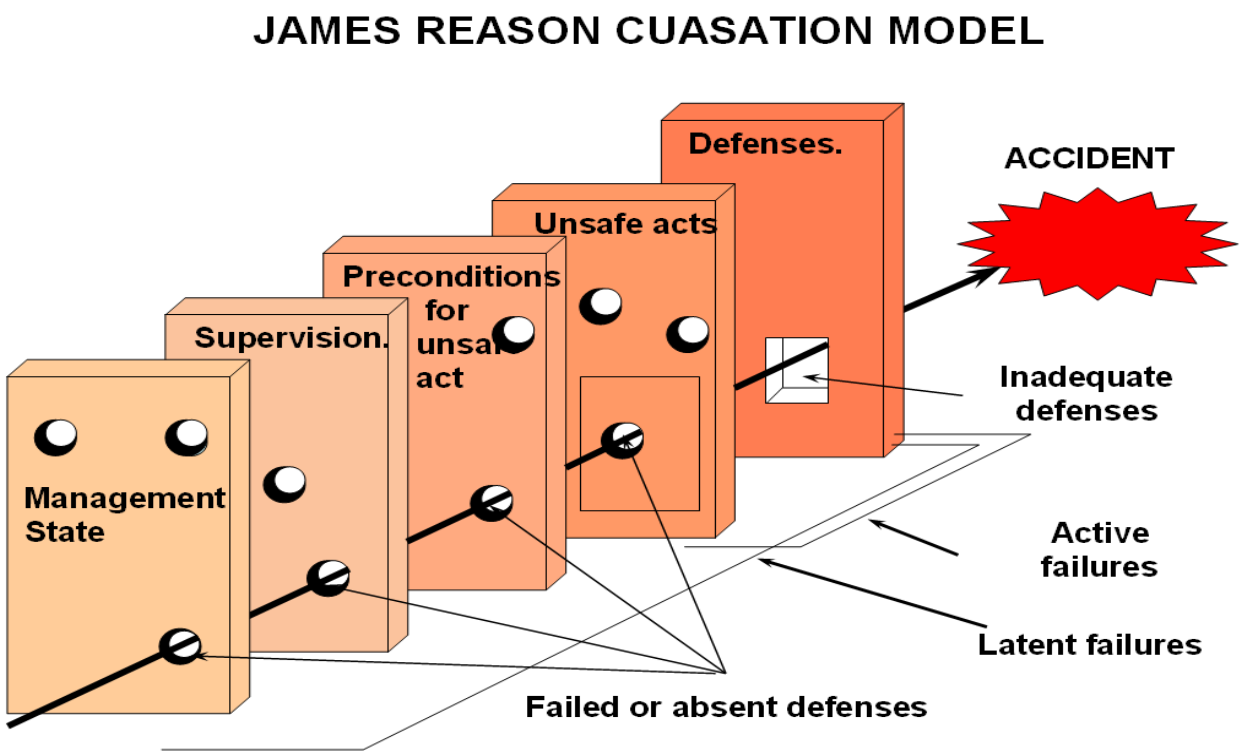

Fig. 1. A model of how an air accident arises, according to James Reason [5]

There are four levels of causes of air events dependent on human actions [5]:

1. Causes due to improper actions taken by the aircrew,
2. Preconditions conducive to improper actions by the aircrew,
3. Improper command/supervision, and its negative effect upon the aircrew,
4. Improper management and its adverse effect upon the improper command/supervision and/or actions taken by the aircrew.

Actions taken by the commanding/managing staff may considerably contribute to causes of accidents or circumstances conducive to the occurrence thereof. Deficiencies in the scope and way of performing actions by the managing staff may be classified into the following categories: insufficient/unsatisfactory supervision/control, improper flight planning, the already known deficiencies left uneliminated, violations of supervision/control dedicated rules. The primary responsibility of the managing staff is to create conditions conducive to successful accomplishment of an operation. The managing staff, irrespective of the level, has to prepare manuals, instruction/training curricula, manage the subordinate personnel and show reasons for the undertaken actions. The managing staff is responsible for proper education/training of the personnel, proper organisation of labour, and an atmosphere in a given organisation.

Lack supervision/control or improper activities in this field lead to actions inconsistent with the procedures in force, the application of procedures inconsistent with safety rules, etc. Lack of supervision/control over the level of training and education of aircrews may prove conducive to hazards due to errors made by crewmembers or their poor skills in coping with specific situations.

No response to problems in a given organisation usually makes them intensify, or gives grounds for routine deviations from prescribed procedures, which may become bad habits, or constant decrease in quality of performed operations. This may refer to problems such as errors in documentation or procedures, excessive risk taken by aircrews, failure to notice in time that flight safety tends to deteriorate or no/poor response to incidents/accidents.

The improper planning can result in the increased workload upon aircrews, lack of time to get well prepared for a mission, mismatched aircrews, the planning of operations that remain beyond capabilities of a given aircrew, etc. All these factors may, in turn, prove conducive to excessive fatigue, making errors, and hence, increased risk.

Most often violations of rules by the managing staff are as follows: giving permission to perform operations without suitable qualifications, or training, or required equipment, exceeded limits on the work time, etc.

3. The SHELL model

The SHELL model by Hawkins can be considered the basis for the interpretation of human (i.e. pilot-made) errors as factors underlying interactions of each of the SHELL components. It gives good grounds for the explaining, controlling and predicting errors [3]. Fig. 2 shows a graphic form of the flight safety model according to Hawkins. Interactions of each of the model-included components are given consideration in the SHELL model (Fig. 3).

The L-H (human being – aircraft) interactions can be considered from five different aspects [3]:

- interactions that depend, among other things, on the cockpit equipment, ergonomic conditions (man-machine interactions), adjustments to human's features, and others,
- sources of information on the aircraft, accessibility, accuracy, readability thereof, uniformity, etc.,
- automatic control systems, whether the aircrew understand how to use them properly,
- aircraft warning systems, uniform and reliable signals, procedures, Traffic alert- and Airborne-Collision Avoidance warning Systems (TCAS, ACAS),
- principles of operation in the field of maintenance oriented at the aircraft itself (as a whole), systems, devices/instruments, circuits, etc. following the so-called check-lists, precision of operating them, knowledge and observance of principles of operating on-board equipment, making correct use of the operational documentation.

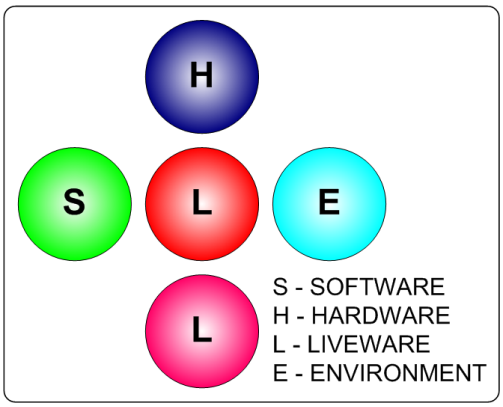

Fig. 2. Systemic concept of flight safety model according to Hawkins

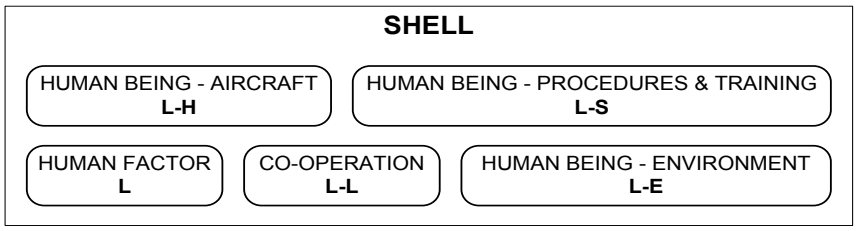

Fig. 3. Interactions in the SHELL model

Air accidents may be caused by disturbances in aircrew – aircraft, or servicing staff - aircraft relationships.

In the case of the L-S interface (human being – procedures and training) considered are interrelations between a human being on the one hand, and on the other hand, his/her level of training/education and applied procedures, and their probable contribution to causes of air accidents.

The live ware (L) and its contribution to causes of air accidents are considered from five different aspects [3]:

- Physical: pilot's height, weight, level of training acquired, fit, strength, age,
- Physiological: immunity to diseases, health, the way of life, resistance to hallucinations, resistance to fatigue,
- Psychological: ability to act or lack of it, plan of activity, the way of making decisions, attention divisibility, predispositions, personal attitude, emotions,
- Knowledge and experience: the scope of professional knowledge, flying experience, personal experience,
- Workload: schedule of the day, work time, shift work, leisure, jet lag.

Co-operation between aircrew members and all who participate in the flight (the L-L interaction) is given consideration from four aspects [3]:

- Communication: verbal, in writing, visual signals, between aircrew members, with other aircraft, with the air traffic control, phraseology,
- The CRM/TRM (Crew Resource Management) – aircrew co-operation, formal procedures, information transfer, crew members match,
- Supervision: operational, in the course of training, taking care of quality, standards,
- Rules and regulations in force – procedures, regulations, inspections, audits.

The L-E (human being – environment) interaction is given consideration from four aspects [3]:

- Physical: airport/airfield, air navigation service, information, weather, work environment,
- Psychological: satisfaction, morale, manners, family problems,
- Functioning of the organisation: the set forth objectives, interrelationships, staff, HR policy,
- Workload: excessive workload, time pressure.

4. The chain of causes

Investigation into each and any of air events should be started with reconstruction of particular links of the 'chain of errors', which at the same time is the 'chain of causes'. The 'chain of errors' is a term that describes errors in human-performed actions as effects of a series of coincidences that result in an incident/accident. Since any chain shows no more strength than its weakest link, removal of that weakest link could potentially prevent the accident, or reduce the probability that the accident occurs, or possibly reduce the effects.

Figure 4 presents an example of a chain of errors reconstructed in the course of investigating into causes of one of air accidents. The problem was initiated with erroneous weather forecast. Then, information on weather conditions getting worse did not reach the Flight Operations Control

Service, and some organisers made no account of this information. Thus, decision was made to fly another flight. After completion of the operation, the aircrew decided to execute the landing procedure, despite weather conditions getting ever worse. The flight operations dispatcher did not divert the aircraft to an alternate airfield despite the fact weather conditions were at that time worse than airfield minima. Such decision was not taken after the first missed approach. Another approach – the aircrew members did not co-operate, responsibilities were not assigned to individual crewmembers in the cockpit (no CRM). All these factors resulted in an excessive descent rate and finally, in ground collision. Improper actions were also taken by the landing controller, who did not take a decision to abort the landing even though the aircraft had exceeded the minimum permissible altitude for both the aircraft and the airfield [6].

Fig. 4. An example of a chain of errors

Reconstruction of the 'chain of errors' is nothing more but an initial stage of the air accident investigation that allows to find causes of the event in the range of actions taken by humans engaged in a given air operation. The chain of errors may start, depending on the event, with organisational or maintenance problems, disturbances of flight resulting from changes in the environment, incorrect decision, violation of procedures or flight rules. It may comprise many other factors as well.

One has to find what impact upon the occurrence of particular components (links) in the chain of errors had the system components such as the aircraft, the environment, procedures, the training system, the management and other ones. One should also find why human errors arose, why the aircrew made their errors under given conditions: what was the impact of circumstances generated by other people in the 'chain of safety' upon the aircrew?

6. Conclusions

Air incident/accident investigation is very complicated. Reconstruction of the course of the event and determination of causes of its occurrence demand many-months' intensive work of experts in many and various fields of science. The air accident investigation is often based on fragmentary, not always fully reliable data. Finding the reasons for a given event to occur proves thus even more difficult. According to Polish civil law (legal system) currently n force, based on the final report issued by the State Commission on Aircraft Accident Investigation, the court is to decide whom/what factors to blame and to what extent particular persons engaged in the event are responsible for the accident. Each cause identified by the State Commission on Aircraft Accident Investigation has to be well evidenced and well grounded. It has to be evident from the thorough investigative process, in particular, from the course of flight, conducted analyses, procedures, rules and regulations in force, and the law. While investigating an air event, there is a natural need to

find that one and only cause, and the cause is expected to be closely related to this very flight, without searching for other reasons, e.g. related to organisational factors, management and supervision practices, etc. This tendency proves, however, disadvantageous from at least two aspects: preventive actions to be undertaken, and flight safety. Application of the above-discussed methods enables air accident investigators to conduct complex analyses of causes of the occurrence of air events. Precise identification of all causes of a given air event allows, in turn, implementation of systemic solutions in the field of flight-safety-improving preventive measures and actions.

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