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ANALYSIS OF INTERNAL SOURCES OF HAZARDS IN CIVIL AIR OPERATIONS

Summary. International air law imposes an obligation on the part of transport operators to operationalize risk management, and hence develop records of hazards and estimate the level of risk in the respective organization. Air transport is a complex system combining advanced technical systems, operators and procedures. Sources of hazards occur in all of these closely related and mutually interacting areas, which operate in highly dispersed spaces with a short time horizon. A highly important element of risk management is therefore to identify sources of danger, not only in terms of their own internal risks (the source of threats and activation of threats within the same transport organization), but also in the area of common risk (sources of threats beyond the transport system to which the activation of the hazard is related) and external risks (sources of threats outside the transport system). The overall risk management of a transport organization should consider all three risk areas. The paper presents an analysis of internal sources of threats to civil air operations and the resulting main risk areas. The article complements a previous paper by the same authors entitled "Analysis of external sources of hazards in civil air operations".

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1. INTRODUCTION

Risk and safety management in practice is often implemented by examining the causes of incidents and accidents, identifying critical initiating events, estimating the risks associated with them, and establishing corrective and preventive actions. Polish and European air law, for practical reasons, has narrowed the number of categories to three events: accident, incident and serious incident [3, 4]:

1. "Accident" refers to an occurrence associated with the operation of an aircraft: in the case of a manned aircraft, this takes place between the time any person boards the aircraft with the intention of flying until such time as all such persons have disembarked; or, in the case of an unmanned aircraft, this takes place between the time the aircraft is ready to move with the purpose of flying until such time when it comes to rest at the end of the flight and the primary propulsion system is shut down. In either case, an accident will occur when:
   (a) a person is fatally or seriously injured as a result of:
   - being in the aircraft; or
   - being in direct contact with any part of the aircraft, including parts that have become detached from the aircraft; or
   - being direct exposed to jet blast, except when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew; or

   (b) the aircraft sustains damage or structural failure, which adversely affects the structural strength, performance or flight characteristics of the aircraft, and would normally require major repair or replacement of the affected component, except for engine failure or damage, when the damage is limited to a single engine (including its cowlings or accessories), propellers, wing tips, antennas, probes, vanes, tyres, brakes, wheels, fairings, panels, landing gear doors, windscreens, the aircraft skin (such as small dents or puncture holes), minor damage to the main rotor blades, tail rotor blades, landing gear, or damage resulting from hail or bird strike (including holes in the radome); or

   (c) the aircraft is missing or completely inaccessible.
2. "Incident" refers to an occurrence, other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operation.
3. "Serious incident" refers to an incident involving circumstances that indicate that there is a high probability that an accident occurred, associated with the operation of an aircraft: in the case of a manned aircraft, this takes place between the time any person boards the aircraft with the intention of flying until such time as all such persons have disembarked; or, in the case of an unmanned aircraft, this takes place between the time the aircraft is ready to move with the purpose of flying until such time when it comes to rest at the end of the flight and the primary propulsion system is shut down.

For statistical purposes, "fatal injury" means an injury sustained by a person in an accident, which results in his or her death within 30 days of the date of the accident.

Analysing safety levels made on the basis of reports of civil air operations in 2003-2009, records on incidents kept by the Civil Aviation Authority and reports of the State Commission

on Aircraft Accidents Investigation (2,973 reported events) (see Fig. 1) allows us to identify the main groups of hazards. As can be seen from the data, 1,009 causes of the events were classified as involving a "human factor", which accounts for 34% of all events. Meanwhile, 936 events, or 31% of the total, were classified as resulting from a "technical factor". Steadily increasing is the number of reported incidents involving an "environmental factor": in 2003-2009, 618 of these kinds of hazards occurred, representing 21% of all events. Other factors are: "organizational factor" (179 events or 6%), "cancelled investigation/discontinued cases" (112 or 4%) and "unidentified", i.e., an event for which the data are insufficient for it to qualify under any specific group (119 or 4% of the total) [2].

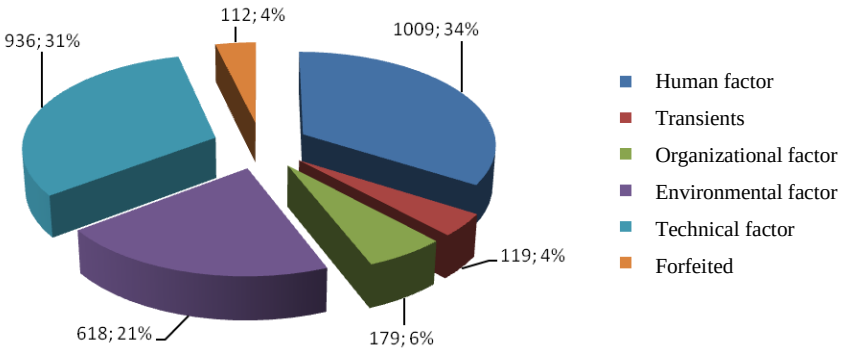

Fig. 1. Classification of aviation events (safety investigations) in 2003-2009 according to specific groups of causal factors [2]

The data show that, during the analysed period, the number of safety investigations increased more than four times: from 175 in 2003 to 702 in 2007. This increase relates specifically to incidents in the categories of "human factor" (from 31 to 106), "environmental factor" (from four to 100) and "technical factor" from 30 to 200 events. The number of events in the category of "organizational factor" is maintained at a constant level. The above analysis shows that the number of reported incidents is constantly increasing. This is due to increased awareness of the role of reporting in the management of aviation safety, which is highly important from the point of view of flight safety because it allows for appropriate preventive measures to be taken in order to avoid incidents in the future [2].

Causes in the category of "human factor" only refer to the crew. However, aspects of this category can also refer to technical, environmental and organizational areas. For instance, factor H2 ("lack of qualifications") may be a consequence of deficiencies in training or standards, controls and audits. Similarly, H5 ("inability") may be a consequence of deficiencies in safety management or standards, controls and audits [1]. Within the "human factor" category, there are five groups of causes [1]:

H1 - intentional conduct
H2 - lack of professional qualifications
H3 - errors in communication
H4 - procedural errors
H5 - inability

Figure 2 shows the classification of the different groups of causes of events reported in 2005-2009. As can be seen from the data, of the 626 incidents reported in this period, 339 were categorized in the "procedural errors" group, which accounts for 53% of all events.

Furthermore, 201 events or 32% were classified into the category of "no qualifications", 48 or 7% as "errors in communication", 39 or 6% as resulting from "intentional conduct" and 10 events or 2% of the total assigned to "inability" [2].

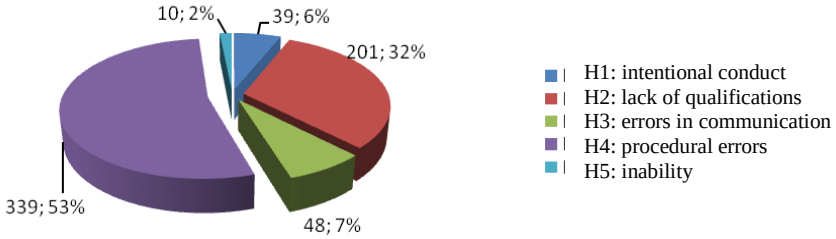

Fig. 2. Summary of events in 2005-2009 for the "human factor" groups of causes [2]

The groups of causes in the "technical" category refer specifically to systems and components of specific aircraft in terms of their airworthiness and efficiency. In this category, there are 12 groups [1]:

T1 - serious engine failure, engine fire
T2 - damage to the engine, malfunction, alarm fire, damage to the balloon
T3 - chassis and tyres
T4 - control systems
T5 - structural damage
T6 - fire, smoke (cabin crew, passenger, in the hold)
T7 - unauthorized modification, non-genuine spare parts
T8 - equipment and radio equipment (avionics)
T9 - design and manufacturing errors
T10 - autopilot
T11 - damage of the system
T12 - other

Figure 3 shows the classification of the different groups of causes of events reported in 2005-2009. As can be seen from the data, of the 436 incidents reported in this period, 96 were related to "accessories and radio", representing 22% of all events. Meanwhile, 79 events or 18% were classified under the "chassis and tyres" category, and 66 or 15% were classified as "other", i.e., damage not included in groups relating to specific causes. For "engine damage", there were 58 events or 13% of the total, whereas "damage to hydraulic systems" represented 54 events or 13% of the total. "Other" or "design errors" accounted for 24 events or 6%, "serious engine failure" for 23 events of 5%, "structural failure" for 15 events or 4%, "control systems" for seven events or 2%, and "fire, smoke" or "autopilot and flight management systems" for five events or 1% of the total [2].

The groups of causes in the "organizational factor" category refer to flight safety management systems in the workplace organizational unit of aviation. In this category, there are 12 groups [1]:

O1- security management
O2 - training system
O3 - standards, controls and audits

O4 - operation of cabin crew
O5 - operation of ground handling
O6 - technology and equipment
O7 - operational planning
O8 - change management
O9 - selection system
O10 - service and maintenance
O11 - shipping, forwarding
O12 - other

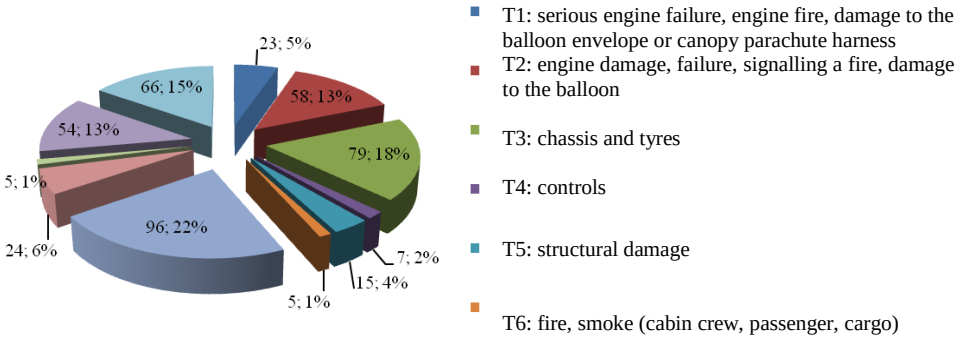

Fig. 3. Summary of events in 2005-2009 for the "technical factor" groups [2]

Figure 4 presents the individual group causes of air events reported in 2005-2009. As can be seen from the data, of the 138 incidents reported in this period, 90 were related to "maintenance", which makes up 65% of all events. Meanwhile, 19 events or 14% were classified under the category of "operation of ground handling", 12 events or 9% under "standards, inspections and audits", and 11 events or 8% under "training system". A further three events or 2% of the total could be classified under "operation of cabin crew" or "other" [2].

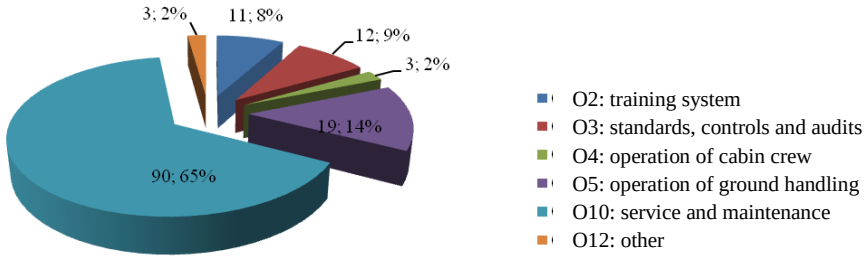

Fig. 4. Summary of events in 2005-2009 for the "organizational factor" groups [2]

Groups of causes in the "environmental factor" category refer to the physical world, in which flights are made by particular aircraft, and to equipment infrastructure that is necessary to ensure flight safety. In this category, there are eight groups [1]:

E1 - meteorological
E2 - air traffic management, radio communication or air traffic confusion
E3 - birds, animals and other objects
E4 - airport services and ground handling
E5 - communication, navigation and surveillance aids
E6 - protection (transport security)
E7 - supervising the application of the rules
E8 - other

Figure 5 shows the classification of the different groups of causes reported in 2005-2009 [2].

As can be seen from the data, of the 544 incidents reported in this period, 333 were related to "birds, animals and other objects", which makes up 52% of all events. Meanwhile, 62 events or 12% were classified under the "air traffic management, radio communication or air traffic confusion" category, 37 events or 7% under the "meteorological" category, 40 events or 7% under "other", 36 events or 7% under "airport services and ground handling", 11 events or 2% under "protection" and 15 events or 3% under "communication, navigation and surveillance aids" [2].

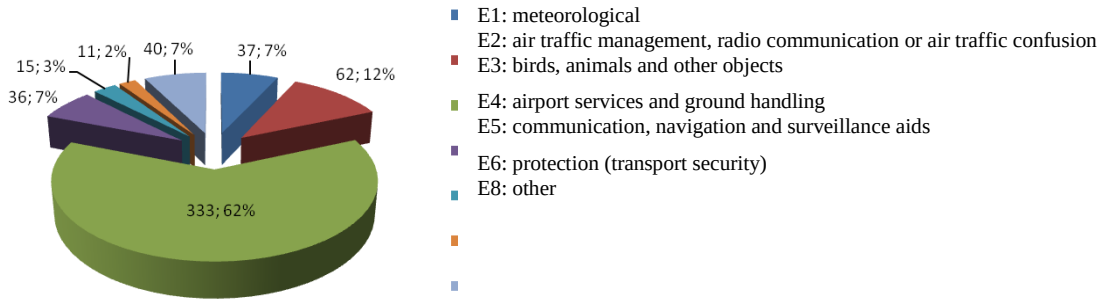

Fig. 5. Summary of events in 2005-2009 for the "environmental factor" groups of causes [2]

In the model process approach, risk management in aviation is related to a cycle comprising the following steps: the identification of sources of threats, developing areas of risk, risk assessment, the communication of risks within and outside the organization, corrective and preventive actions, and monitoring changes in security. The primary purpose of active safety management strategy involves constant monitoring and obtaining knowledge on the basis of a variety of information, which may highlight threats and signal the appearance of early symptoms of potential problems relevant to safety (including the analysis of flight events or safety investigations). As such, the aforementioned approach could be a useful basis from which to identify the source of hazards that pose a potential threat to flight safety.

2. SOURCES OF INTERNAL HAZARDS IN CIVIL AIR OPERATIONS

A registry of external hazards and the corresponding risk areas has previously been published by the Department of Aviation Technologies at the Silesian University of Technology. In order to maintain compatibility with the classification of hazard sources, the publication set out divisions on the basis of possible group effects of hazards in accordance with [1], as well as a group headings relating to causes of hazards in civil air operations (Table 1) and the possible scenarios involving a combination of hazards (Table 2).

Tab. 1

Internal sources of hazards in airports

Human factor (H)	
Intentional (HI)	16. Mental illness 17. Alcohol 18. Drugs and stimulants 19. Bravado
Unintentional (HN)	10. Panic 11. Fatigue 12. Inadequate training 13. Lack of sufficient experience 14. Ignorance of procedures 15. "Burns" professional 16. Errors in communication 17. Low awareness of hazards 18. Failure to communicate threats
Technical factor (T)	6. Unauthorized access to the ground-based facilities 7. Unauthorized access to the aircraft 8. Errors in the construction of technical measures 9. Accumulation of flammable substances 10. Unsuitable means of screening 11. Failures of computer systems 12. Ergonomic positions 13. Improper repair 14. Improper inspections 15. Errors in the construction of technical measurements
Environmental factor (E)	9. Stress 10. Social environments 11. Errors in the work of handling companies 12. Inadequate maintenance of the state of the runway, signage or information
Organizational factor (O)	6. Lack of operational procedures 7. Errors in operating procedures 8. Errors in training programmes 9. Errors during loading 10. Errors during refuelling 11. Errors in security controls 12. Insufficient monitoring processes 13. Errors in crisis management 14. Lack of control and threat assessments 15. Improper planning 16. Inadequate funding 17. Political situation 18. Lack of legal regulations

Tab. 2
Identified groups of hazards (own study based on the European Aviation Safety Plan and the Polish Civil Aviation Authority communications)

No.	Group of hazards
1.	Runway incursions
2.	Runway excursions
3.	Mid-air collisions
4.	Controlled flight into terrain
5.	Loss of in-flight control
6.	Controlled airspace violation
7.	Fire, smoke and fumes
8.	Unlawful intrusion into restricted area of the airport
9.	Unlawful intrusion into restricted area of the airport with prohibited items
10.	Placing explosives in facilities and equipment of the airport
11.	Placing explosives on board the aircraft
12.	Hostages in the area of airport
13.	Seizure of aircraft with passengers
14.	Seizure of aircraft without passengers
15.	Landing at the airport with seized aircraft
16.	Acts of sabotage/diversion
17.	Disturbance of public order, vandalism
18.	Disaster unrelated to human activities (weather anomalies)
19.	Damage of technical equipment with consequences

3. SELECTED SOURCES OF HAZARDS IN BRIEF

The groups of hazards as described in Table 2 highlight many possible combinations of hazards sources. All the mentioned groups are conditioned by factors resulting from internal threats. Airports have either a limited or no influence on such threats. Some sources of hazards are described below:

1. HN6: lack of awareness of consequences
Risks arising from the lack of adequate knowledge among passengers about aviation security. An example would be when luggage containing prohibited items left by a terrorist is tampered with by unaware passengers, resulting in a threat generated by their lack of awareness of civil aviation security.

2. HI7: possession of prohibited items
Items that are prohibited from being brought on board the aircraft by passengers in cabin baggage are defined in Annex 4-C of the EU Commission Implementing Regulation 2015/1998 of 5 November 2015, which sets out detailed measures for the implementation of common basic standards on aviation security. The list of prohibited items in this context is attached in Annex 5-B of the aforementioned regulation. In addition, assembled explosives and incendiary devices, which are not carried in accordance with the applicable safety rules, are also prohibited in consignments of cargo and mail.

3. O1: lack of awareness of safety culture
An effective safety culture involves mutual cooperation in order to ensure the highest level of safety. In the case of noticing any risk, threats and hazards should be reported to the appropriate authorities. In the absence of this awareness, the risk of danger increases significantly.

4. T4: design errors in technical equipment and constructions
Defects in technical constructions, equipment (terminal, ATM, conveyor belt, tanks, roofing) may pose a direct threat to aviation. The presence of fuel tanks and other sensitive technical materials at the airport means that mistakes in construction could lead to disaster.

4. CONCLUSIONS

International air law imposes an obligation on the part of transport operators to operationalize risk management, and hence develop recording systems of hazards and estimate the level of risk in an organization. Air transport is a complex system combining advanced technical systems, operators and procedures. Sources of hazards occur in all of these closely related and mutually interacting areas, which operate in a highly dispersed environment with a short time horizon. A very important element of risk management is therefore to identify sources of danger, not only in terms of the internal risk involved (the source of threats and activation of threats within the same transport organization), but also in the area of common (sources of threats beyond the transport system to which the activation of the hazard is related) and external risks (sources of threats outside the transport system). The overall risk in a transport organization should consider all three risk areas. The paper presented an analysis of internal sources of threats in civil air operations and the resulting main risk areas.

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