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Quality as the basis of flight safety

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Original article

Abstract

The speed of technological development during the twentieth century was fully reflected in the aviation world, whether it was in terms of aircraft development systems for controlling air traffic or flight control systems. The fast pace of change continues today. Obviously, aircraft reliability and complexity have extremely improved for years, but nearly all accidents in civil aviation in recent memory have been the result of human error. At the early stage of aviation development the human factor (HF) share in total reasons of aviation accidents was 20 per cent, later it increased fourfold and currently it makes up about 80 per cent. It turned out, that the human in the system "Human – Aircraft" is the most unstable, the most unreliable and the weakest link: humans may make mistakes, moreover, the human has the right to be mistaken. No doubt, human errors preventing system must be worked out. The challenge is to make flying safer. It will be discussed below.

Keywords

- flight safety
- human factor
- aviation accidents
- aircraft
- aircraft maintenance
- maintenance organization

Authors contributions

A – Preparation of the research project
B – Assembly of data for the research undertaken
C – Conducting of statistical analysis
D – Interpretation of results
E – Manuscript preparation
F – Literature review
G – Revising the manuscript

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Introduction

Despite the fact that civil aviation is recognized as safe, public opinion is vastly shaped by the rate of aviation accidents, especially catastrophic ones. Immense moral and material damage led out flight safety indicators to obtain both state and international significance [1]. What is worthy of attention, the aviation accidents absolute index continues its rise even though the flight safety relative index demonstrates sustained tendency of improvement. Aviation accidents are unavoidable at present and in foreseeable future, since even "Airworthiness Standards" requirements envisage the possibility of occurring disastrous or emergency situations during flight.

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The objective is to minimise such occurrences within the operational life of an aircraft. Nevertheless, the "AC-Flight Crew" system has a determinative value in defining flight safety, because imperfections of the transport system (which materialize in variable factors making flight more insecure) take aim at the flight crew whose professional competence plays a crucial role in provision of flight safety. Thereby, the human factor [2–4] emerged into a highly important factor of the flight safety maintenance. Doubtlessly, preventive inspection initiatives aimed at identifying systematical errors in the aircraft operational performance preserve its relevance [5].

Equally important are the processes that ensure safety across the entire aviation lifecycle—from design and production [6] through technical maintenance, traffic management and aviation personnel management. Compliance with standards and regulations [7,8], fully integrated with safety requirements, is also critical.

Data and methods

The human factor, in the context of the aircraft-related operations, establishes principles utilized in research and technical development/ production, air traffic management, professional education. Actually, human factor oversight means creating such working conditions for physically suitable and well-trained personnel which would eliminate commitment of functionally hazardous human-caused mistakes compromising flight safety. This includes:

- provision of access to up-to-date documentation that is necessary for scheduled works;
- provision of fully operational technical gear required to carry out duties;
- creation of appropriate labor conditions including weather protection;
- close cooperation between supervisors and an ordinary staff member.

Also, it is utterly important to ensure that the complexity of work fully corresponds with the personnel`s qualification/competence. It means:

- full-scale education for personnel at institutions which have valid accreditation and exist under EU regulations of aviation industry;
- acquiring CAA licenses and authorization for performing aircraft -related services.

Even minor disregard for standards of educational process might result in recurrent mistakes committed during aircraft maintenance. Areas of aviation law which regulate services of aircraft maintenance companies and airworthiness control companies require creation and permanent workability of the quality management system. Personalized as quality control managers and independent auditors, system carries out continuous monitoring in order to investigate and prevent actions which go against official requirements (including those dedicated to the human factor) before they might be capable of inflicting damage. As always, the entire system efficiency incumbents upon the personnel, and its professional competence. For current moment, regrettably, no unified educational standards or authorization procedures exist for such personnel. Cases of personnel-caused aviation accidents (by experienced, well-trained and highly motivated personnel) aren't rare in the working routine. This generally happens in companies with poor safety culture, which do not adequately cultivate a sense of responsibility. This culture is vertically (hierarchically) configured and based on mutual trust and respect, intolerance toward safety rules violation. As the saying goes: "Cleanliness is not about cleaning, but about not littering"—prevention is better than cure. Applied in the context of aviation, flight safety is not solely ensured by quality control but also by conscientious performance of duties.

Outcomes and discussion

The major method of aviation accidents reduction/reoccurrence prevention is a rigorous investigation. The problem is that aviation accidents investigation theory has not been designed yet. Methods that are used can provide objective results only if the investigator has sufficient experience. Otherwise, investigation may not reveal essential causes of aviation accidents, moreover, further preventive inspections may not guarantee a prevention of aviation accidents, which is based on the same causes. aviation accidents usually take place because of systemic failures, but preventive inspection measures (in case of poorly conducted investigation) take aim at the personnel depending on the level of involvement. The system will continue failing as long as no appropriate corrective measures are applied. What certainly deserves attention due to its relevance—investigation of cases in which the flight safety was compromised, but aviation accidents was avoided due to workmanship of personnel. Such cases occur more frequently than ones which resulted in catastrophe. Investigating causes of analogous incidents is the major source of system failures identification leading to aviation accidents. It is an intricate issue, but manageable, if there is no shortage of experienced investigators. This calls for a specific training system which has not been established yet. The problem needs to be solved. As daily operational activity demonstrates, the development dynamics of aviation accidents are directly associated with personnel performance quality. Aviation accidents are not a sudden occurrence. They emerge as a result of accumulated mistakes that have been made by the personnel over the years and in their entirety finally led to an aviation accident situation that the flight crew lost control of. It can be envisioned as a chain of violations whose links are separately necessary, but not a defining condition of aviation accidents occurrence. These violations, at first glance, seem insignificant, but their quantity determines the possibility of aviation accidents. It reinforces the thesis that there are no trifles in aviation.

Based on the aforementioned information, The "Aviation Accidents Chain Rule" can be stated: "Any, even seemingly insignificant, quality violation in performing work duties might be a self-sufficient link in the chain of violations leading to aviation accidents. "

In general, sustainable development situation over time, taking into account the main parameters, is presented in the form of an algorithm:

$$F_t(\text{L, M, D}) \leq F_{t+1}(\text{L, M, D}) \quad (1)$$

where:

F_t(L, M, D); F_{t+1}(L, M, D)—sustainable development functions; and future development of the function;

L—labor resources or human factor;

M—means of production, skills (artificially created);

D—financial debt or cost order.

The author proposes to introduce a quality assessment system based on a recursive function.

Recursion is sometimes referred to in management science as the process of iterating through levels of abstraction in large business entities. A common example is the recursive nature of management hierarchies, ranging from line management to senior management via middle management. It also encompasses the larger issue of capital structure in corporate governance.

For example, let's use the Ackermann function as a basis for our application. It is based on two variables, each of which can represent a horizontal or vertical hierarchy [9].

If an organization involved in flight safety has a hierarchy tree, then in our example, we can use the values of the variables of such a function: for example, n = 2 for a horizontal slice of the hierarchy and m = 3 for a vertical slice of the hierarchy. In our case, the higher the value of the Ackermann function, the higher the number of errors and collisions in the operation of the entire system as a whole. Quality will be lower, and systemic measures and the introduction of new quality standards will be required to ensure safety.

The Ackermann Function A (3, 2) = 29. In our example, the resulting number is not that large, and this may mean that the hierarchy has not reached such a large size and the Ackerman function number does not have much inertia, which means that the errors will not be so critical; that is, risks exist, but not because of the cumbersome organization in the organizational structure.

Table 1 gives some numbers to determine them without calculations, but at high levels of the hierarchy, astronomically high numbers are expected, which is already something to think about.

Table 1. Selected Ackermann function values

m \ n	0	1	2	3	4
0	1	2	3	4	5
1	2	3	4	5	6
2	3	5	7	9	11
3	5	13	29	61	125

Conclusions

Enhancing work quality in order to increase flight safety can be achieved by:

- enhancing MO (Part-145)/ CAMO (Part-M) functional performance by eliminating systemic failures/ operational mistakes and provision of actual usage of human factor principles;
- improving professional competence/ qualification of quality control personnel;
- increasing personal responsibility for not applying timeouts measures in order to reveal and eliminate systemic failures/ operational mistakes;
- improving quality of aviation accidents investigation through development of investigation theory/ training standards/ authorization procedures;
- increasing senior officer responsibility for the promotion of safety culture;
- enhancing quality control of educational standards/ work authorization procedures for the aircraft maintenance personnel.

Although the numerical example presented is simple, it illustrates how nested management structures may degrade operational quality and influence safety. Rapid growth of the function clearly limits organisational expansion from a safety perspective.

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