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SOME COMMENTS ON THE AIRCRAFT ACCIDENT STATISTICS

ABSTRACT

This paper investigates flight safety with the use of the flight accident data of the NTBS (US statistics), ICAO, EU and other national sources. The unconventional representation of the statistical data results in an original figure, which needs further analysis and explanations. This paper tries to make a short preliminary discussion, and comments on the resulting figures. It also deals with the results the following projects: (i) Safefly (development and application of innovations in the production of the prototype of a new 4-seats composite aircraft), (ii) development of a 2 seats acrobatic training aircraft supported by the Hungarian National Development Agency and (iii) the EU supported FP 7 project, PPLANE (Personal plane) in which the authors are involved.

Keywords: flight safety, accident statistics, small aircraft

INTRODUCTION

Safety is the condition of being safe; freedom from danger, risk, or injury. From the technical point of view, the safety is set of methods, rules, technologies applied to avoid the emergency situation caused by unwanted system uncertainties, errors or failures appearing randomly.

Flight safety can be evaluated by the accident statistics. The source of the accident data are based on the records of the NTBS (US statistics), ICAO, EU and other national databanks. Accident data can be used in many different forms. One original approach lies in the idea of developing unconventional figures.

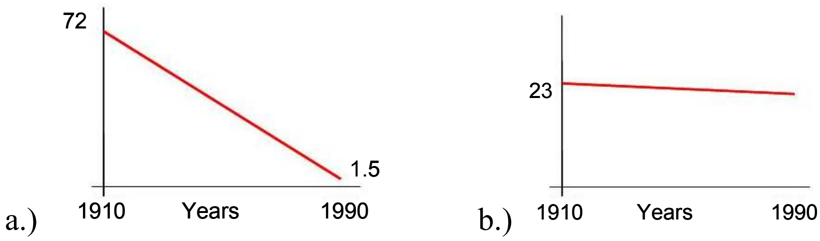

Figure 1. Number of people killed in car accidents for
a. each million miles, b. - for 10 000 driver licence

The main idea comes from the original presentation of the road fatal accident data by Caesar Marchetti, a well-known researcher of the Institute of Applied System Analysis [1]. Earlier, changes in road safety were analyzed and predicted by the application of the Figure 1.a (created by one of the pioneers of the technology forecast Ralp Lenz). This Figure shows that the number of people killed in US automobile accidents for each million miles reduced drastically during the period 1910 -1990. On the other hand, the innovative Figure 1.b, introduced by Marchetti, demonstrates an interesting fact: the number of people killed in car accidents for 10 000 driver license was nearly the constant for the same period.

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The Figure 1.b. demonstrates that all the innovative solutions, applying new safety technologies, has an effect a short time. For example after the deployment of the ABS, drivers learned in a short time that they can keep a smaller break distance.

This paper deals with the analysis of the flight accident data, based on the approach of using using some new, original Figures.

The paper also introduces the results of the investigations performed by the authors in the following projects: (i) Safefly (Development and application of innovations in the production of the prototype of a new 4-seats composite aircraft), (ii) development of a 2 seats acrobatic training aircraft supported by the Hungarian National Development Agency and (iii) the EU supported FP 7 project, PPLANE (Personal plane). The Figures (in form of slides) were presented on the Tel-Aviv Meeting (January, 2010) of the PPLANE project and Safety and Security Sub-group meeting (in Paris, February, 2010) of the EU supported AGAPE (ACARE Goals Progress Evaluation).

1. PRELIMINARY INFORMATION

Flight safety is analyzed by many scientist by the use of statistical data in time-variant forms (like it is shown in Figure 1.a). Some others try to use more general approaches and make some general conclusions. For example, NASA initiating the zero accident project [2, 3, 4] leads to general conclusions: the risk of flight was decreased by a factor of 1:10 before introducing the wide-body aircraft, but which can not be further reduced with the present technical, technological methods [2, 5]. However, the number of aircraft and the number of yearly, daily flights are increasing continuously (Fig. 2.); therefore the absolute number of accident is expected to increase, which might even lead to the vision made by Boeing, in which by 2016/17, each week one large-body aircraft will have an accident. "Given the very visible, damaging, and tragic effects of even a single major accident, this number of accidents would clearly have an unacceptable impact upon the public's confidence in the aviation system and impede the anticipated growth of the commercial air-travel market" [2] .So, new methods like emergency management must be developed and applied for keeping the absolute number of accident on the present level.

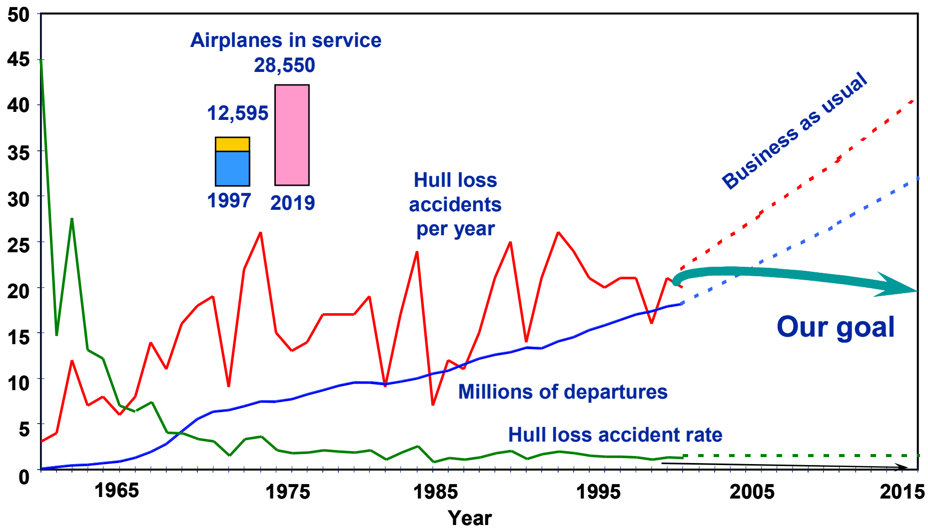

Fig.1.: The NASA zero accident project [3]

The aircraft accident statistics make clear the well-known facts [6, 7, 8]: the longest part of the flight (with about 50 - 80 % of flight time) is the cruise phase, which only accounts for 5 - 8 % of the total accidents and 6 - 10 % of the total fatal accidents (Fig. 3.) The most dangerous phases of flight are the take-off and landing.

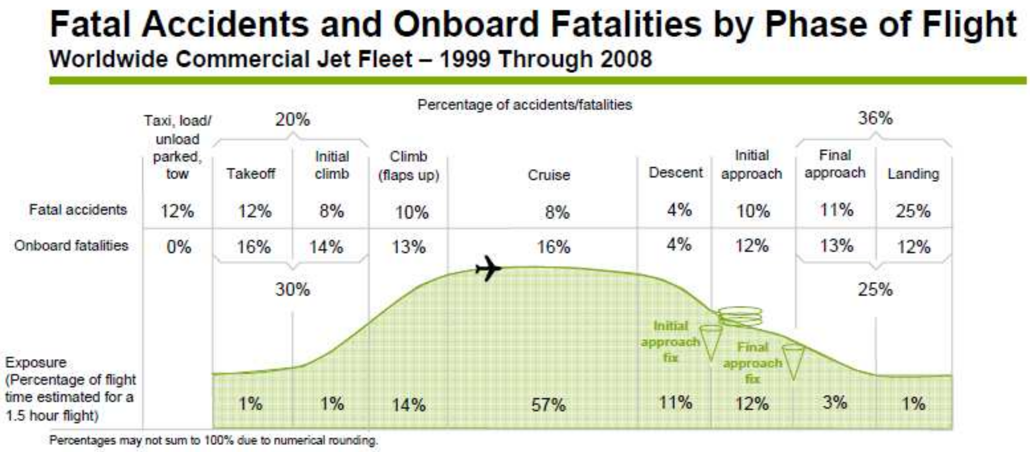

Fig. 3. Percentage of flight accidents related to the different flight phases [7]

This fact results to an interesting and important conclusion: the different air transportation modes (e.g. commercial, general aviation) should have approximately the same flight risk; or at least the same accident rate for the number of flights.

On the other hand, the investigation of the accident causes (Fig. 4.) demonstrates that about 70 - 80 percent of the accidents are caused by human factor and nearly 50 % of them are initiated by the pilots.

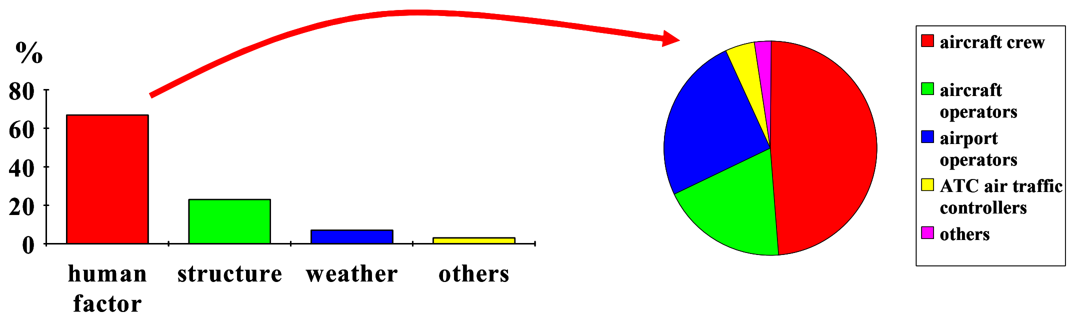

Fig. 4. Causes of flight accidents

More generally speaking, the investigation of the accident statistics shows that [8, 9, 10]

- aircraft accidents are generated by the complex effects of structure features, peculiarities of the pilot, air traffic and the surroundings;
- as usually the accidents are induced by 3 - 6 different failures or errors;
- the probabilities of the second, third and the following errors are depending on the previous errors and might even be 30 - 80 times higher;
- the special distribution at the left or right hand side of the empirical density functions related to the system characteristics plays a deterministic roles in the accidents;

- the inaccurate calculation and modelling of the common failures (principally independent failures or errors appearing at the same time) might result in the under evaluation of the risks.

Another interesting conclusion: the human factor is a most important contributing factor to flight accidents. Therefore, the flight risk of small and personal air transport must be nearly the same as the risk of the commercial flights. The difference might be caused by less training, or less practice.

Finally and another interesting figure published by the EASA (Fig. 5.): in Europe, the fatal accident rate, as fatalities per 10 million flights, has increased since 2003, but reason of this fact has not explained yet.

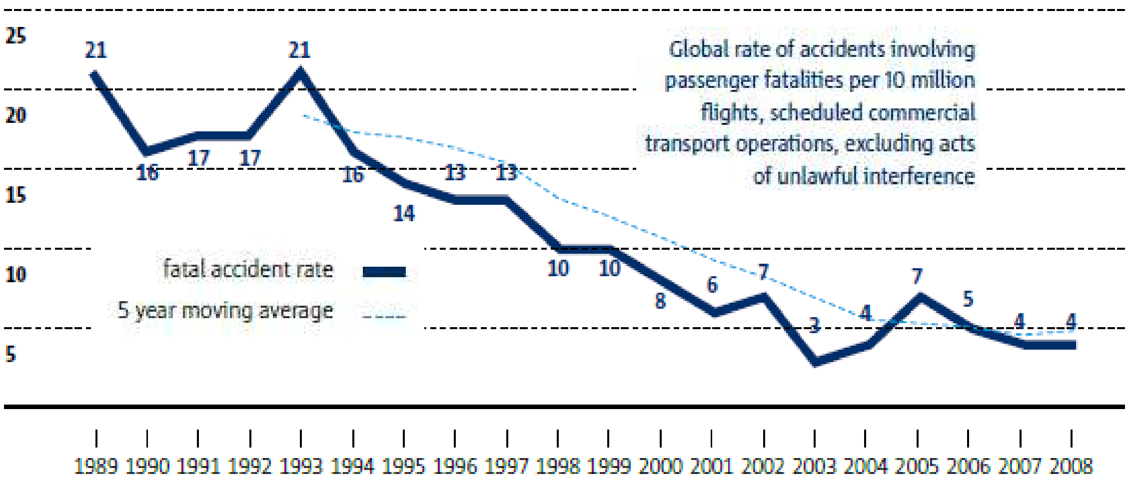

Fig. 5. Characterisation of the European accident statistics [11]

2. GENERAL AVIATION - PART OF CIVIL AVIATION

Several European and national projects deal with the development of the general and personal air transportation system. Nowadays, the technology is ready to develop new economic [12] and environmental friendly aircraft that will be used by less-skilled pilots renting or owning the aircraft [13, 14]. The EU EPATS (European personal air transportation system) project [15] predicts that in 2020 about 50 million flights pro year will be performed by small aircraft. Such rapid development needs about 150 000 - 180 000 new small aircraft in Europe [15]. Therefore, a new safety philosophy [14] must be created for the small aircraft operation. The new personal transportation system needs changes in all the existing general aviation system, including development of new net of small airports [14] and air transport management system [16].

The European commission has recognized the important future of the new small aircraft transportation system and call up the attention on its required development [17].

Nowadays, general aviation (GA) is a large part of civil aviation. In 2005, for example, 215 837 aircraft, about 91 % of US operated civil aircraft belonged to the GA [18]. 211 940 GA aircraft were, so called, active as it shown in Figure 6.

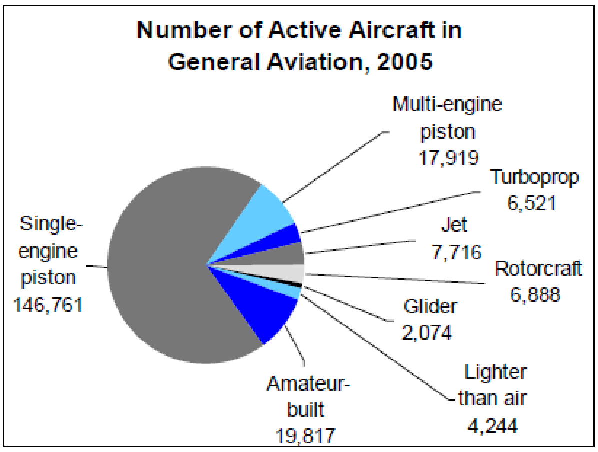

Fig. 6. Distribution of US GA per aircraft type [16]

With accordance to the statistical data related to the year 2001 [19]:

- more than 18 000 landing facilities nationwide served US GA including heliports, lakes, dirt landing strips in remote areas as well as general airports near urban regions and even large airports used by commercial air carriers,
- GA used from one-person "ultralights" and powered parachutes with extremely limited range and payload capabilities to helicopters, seaplanes, antiques, fabric-and-wood biplanes, "homebuilt" experimental airplanes, the ubiquitous four-seat single-engine airplane, twin turboprops, and large and small business jets,
- the aircraft were operated by 600 000 certified pilots and served 77 % of all air traffic with transporting approximately 180 million passengers, in different aircraft sizes, for business and personal reasons,
- US GA accounted for over 637,000 jobs, with nearly $20 billion in annual earns and its direct and indirect economic impact is exceeded to be $102 billion, in different aircraft sizes, for business and personal reasons,
- as it was estimated, 65% of all general aviation flights were conducted for business and corporate travel,
- commercial, non-scheduled flights (charters) as a component of GA, with more than 22,000 pilots flew some 14,700 aircraft for this industry segment.

The aircraft are operated by GA and airlines with using different practices that result to different accident rates [20].

The GA has about 10 - 35 times greater accident rate (accident per 100 000 flight hours) than the commercial flights (Fig. 7.). However the fatal accident rate of GA is only about 2,5 - 3 times greater than the same rate for the commercial carriers.

The GA accident rates are very depend on the type of operation (Fig. 8.). The corporate and executive aircraft operating by professional pilots are involved into the accidents not more often than the airlines aircraft (Fig. 8.).

Leading causes of pilot-related fatal accidents in 2006 [21] were:

- maneuvering: 25.0 %
- descent/approach: 19.0 %,

- weather: 14.8 % and
- takeoff/climb: 14.4 % from the GA total accidents.

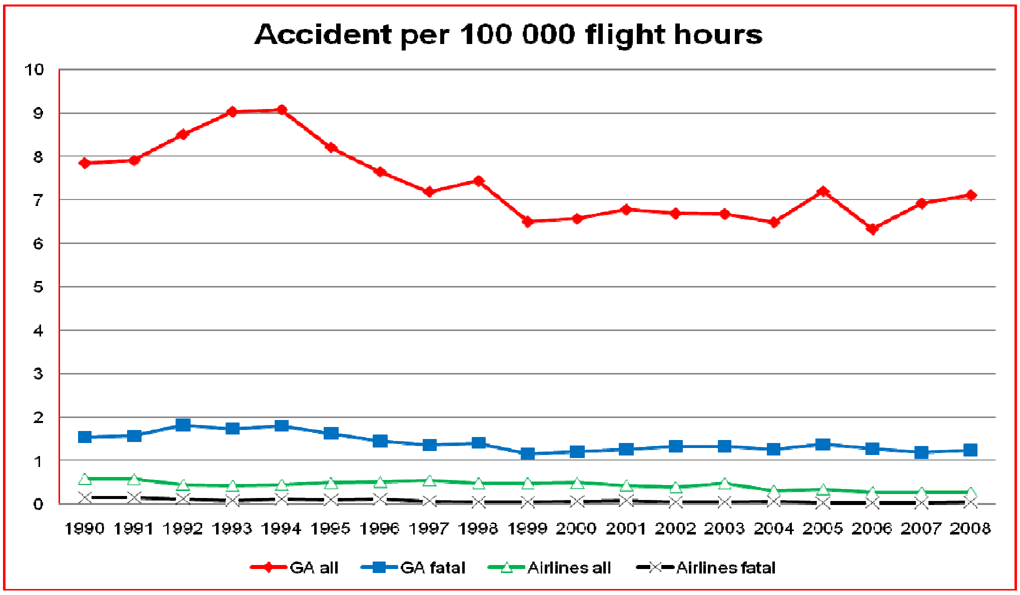

Fig. 7. Comparison of GA and airlines accident and fatal accident rates [19]

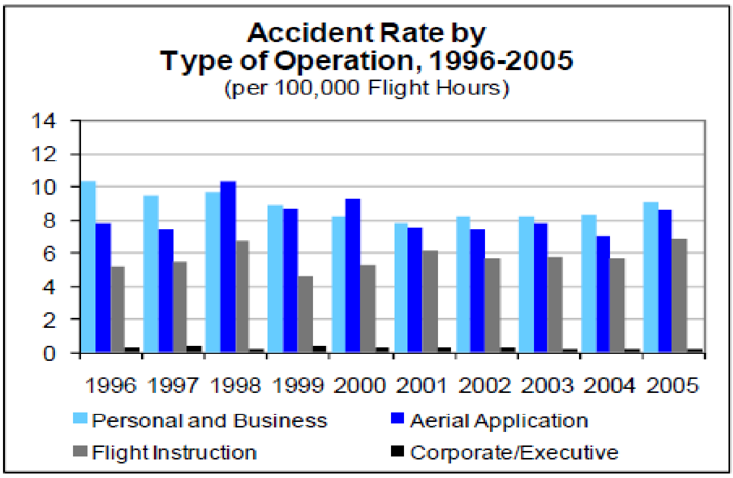

Fig. 8. US GA accident rates [18]

According to the AOPA (Aircraft Owners and Pilot Association) Air Safety Foundation statistics (Table 1.) [21], in 2006, the GA business flights served more than 15 % of the total GA flight hours, but caused only 2.8. % of the total accident and 5.5. % of the total fatal accidents. The higher ration in the fatal accidents can be explained by the use of larger and faster aircraft operated by business GA. The accident ratio of executive/corporate flights is similar to the business flights.

Data of Table 1. shows that *more than 70 % of GA accidents and fatal accidents are caused by personal pilots, while they flew less then 50 % of total flight time.*

These results are expected by people and experts, because GA aircraft are operated by licensed but so called less-skilled pilots in uncontrolled areas and at the small airports having limited services.

On another hand, if the human factor is the most important factor causing the accident, then the difference between the GA and commercial aviation should be high. Therefore, the GA accident statistics needs further investigations using the original point of view.

Table 1. GA accident statistics depending on the types of operation.

Type of Operation	Percent of Flying (2006)	Percent of Total Accidents (2006)	Percent of Fatal Accidents (2006)
Personal	48.2	71.5	71.8
Instructional	20.1	13.3	7.7
Aerial Application	4.6	4.3	3.3
Business	15.1	2.8	5.5
Positioning	*	1.7	2.2
Ferry	*	0.5	0.7
Other Work use	0.8	0.8	1.8
Aerial Observation	3.0	0.6	1.1
Executive/Corporate	4.0	0.7	0.4
Other/Unknown	4.2	3.8	5.5

3. SPECIAL INVESTIGATION ON GA ACCIDENT STATISTICS

The pilot skills can be divided into two different classes. Hard skills means that the pilot know all the regulations, rules, technologies required for safe operation, have enough information about theory of flight, performance and system characteristics of used aircraft, operational conditions including the airport, weather, etc. limitations, rules and technologies of using the airspace and can fly (define the flight plan, use flight the procedures, control the aircraft work with communication and information systems) safely. On the other hand, human personal characteristics define the soft skills, which means that the pilots know everything required to have hard skills (that are evaluated during flight tests - examination for licensing), but due to their actual psychophysical and mental conditions, their own habits, they are not flying are it would be required. They do it because they have limited practice, limited knowledge about the risks and emergency situations, believe in their ability more, than it would be reasonable.

Less-skilled pilots are pilots having right licenses, but less practice or less information about the flight conditions flight situations, making false decisions, over evaluating their own ability or they are simple negligent.

The Figure 9. demonstrates the very complex role of soft skills. For example, it might surprise experts, but *in each tenth GA accidents are caused by pilots having a total flight time of more than 10 000 hours.* According to the investigations of the NTSB [18] from the 1626 accident pilots whom total flight experience data are available, 48% were pilots with a total flight time of 1,000 hours or less [18]. Even more interesting, the *pilots having less than 200 flight hours are took part in 17 % of the accidents. It is a logical fact, 88 % of these accidents were happened with a single piston engine aircraft.*

Using the approach described in the introduction (see Fig. 1.) to investigate accident statistics, another surprising result appears (Fig. 10.).

The commercial pilots are 3 times less involved in the accidents and fatal accidents than the GA pilots. While the accidents per 1000 pilots are decreasing, the fatal accident per 1000 pilots scattering around the nearly constant values.

The detailed investigation of the curves of the Figure 10. resulted to two interesting hypotheses:

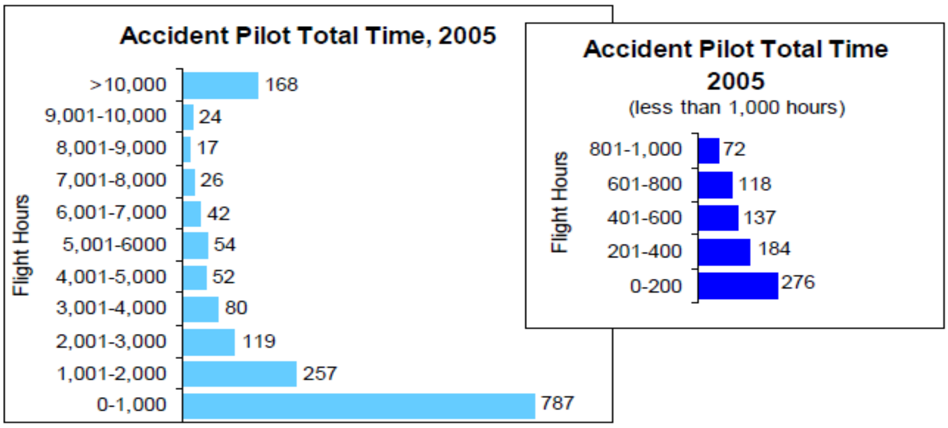

Fig. 9. The distribution of experience among accident pilots

- the fatal accidents per 1000 pilots partly characterizing the role of pilots (because the human factors) in the fatal accidents are nearly the same for GA and airlines with taking into account that the airlines' aircraft are piloted by crew including at least two pilots, while the GA aircraft are controlled as usually by one pilot, and the airlines' pilots supported by different services e.g. line up operation, air traffic control.
- the number of fatal accidents per 1000 pilots - as a function of calendar time - is slowly decreasing because the human intelligence is generally slowly, but increasing, which has a positive influence on the human situation awareness and reaction time.

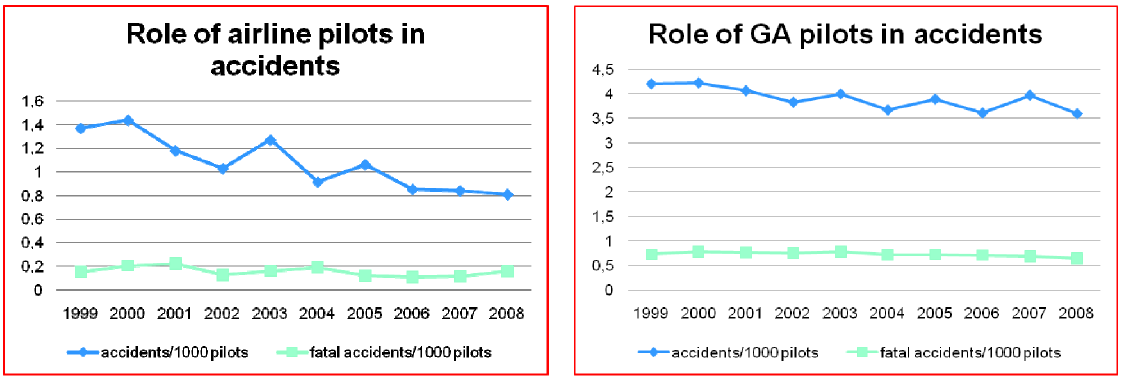

Fig. 10. Accidents and fatal accidents for 1000 cetified pilots

The Figure 11 shows that *the private pilots take part only two times more accidents than the airlines' pilots, while the GA commercial pilots are involved into the accidents nearly four times more often. With accordance to the accidents per 1000 active pilots indicator, the safest flights are made by student pilots.*

The indicators accidents and fatal accidents per 1000 active certified pilots are not the best and only the indicators characterising the flight risks. However, they call our attention on the so called non-technical aspects of safety. *Society accepts that each year about 2 professional pilots and 5 - 7 non-professional (private and pleasure) pilots will take part in aircraft fatal accidents.*

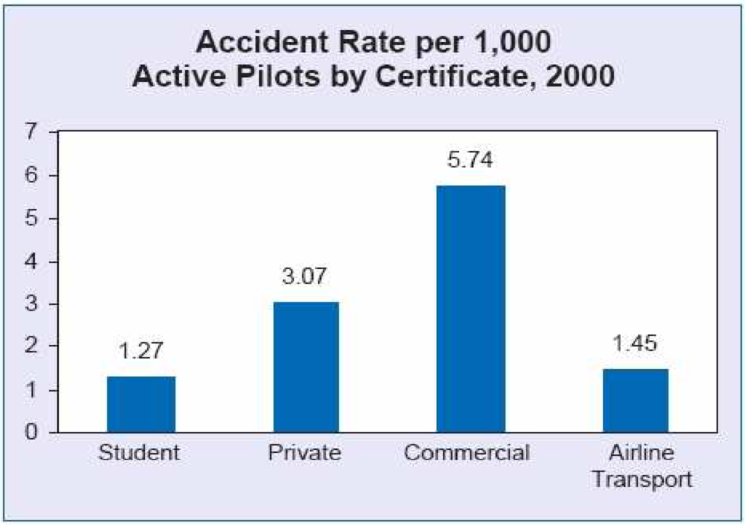

Fig.11 Accidents per different classes of pilots [22]

Principally, the best solution would be that on-board of each aircraft an instructor will be set. This seems as a joke, but it can be made with the development of virtual co-pilots [23], a care-free control system which can always work together with the pilots. Such close to the intelligent system might be based on the horse driving analogy called as H-metaphor [24].

The providing philosophy is described by Moore [22]: "the sentience of a horse in that it is an intelligent vehicle that “sees” the environment, shares its intent with neighboring vehicles, “feels” the flow over its wings, senses its internal health, and communicates with its user. Instead of a user being required to instruct the horse along a specific path, the user is able to provide the ‘intent’ while performing higher level tasks that the horse could never perform effectively. From these perceptions, the sentient vehicle develops an integrated awareness of its situation and autonomously plans and executes a course of action that appropriately satisfies the user’s directives. The resulting vehicle’s capabilities will enable at least automobile levels of safety and convenience, while providing a balance between user control and security."

The H-methafor may go back to far. Safety philosophy of personal aircraft can be based on a simple idea: the aircraft control should be made on the level of difficulty related to driving a car. Such supporting system might include the following features: voice check-list, automatic situation awareness, flight path prediction, avoiding the departure to critical flights, automatic recovery or even switch to full automatic or distance control.

The new solutions are required for the developing the new business personal air transportation system [14, 15, 25].

There is an another hypothesis: air transportation system (including training, regulations, research and developing, production, infrastructure, monitoring and control - ATM, maintenance, services, etc.) has developed, organized and managed by taking into account the risk level accepted by the society (mentioned above).

This hypothesis can be confirmed by the curves of the Figure 12. According to the US accident data and fatal accident ratio, GA and airlines aircraft are approximately the same. That means that the design rules and final structural decision for small and large aircraft are the same.

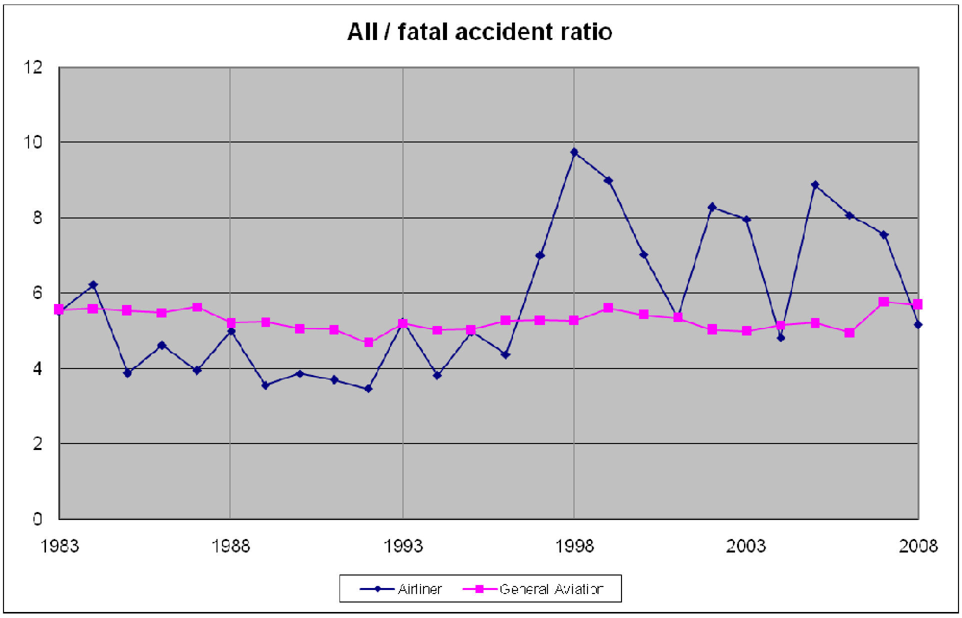

Fig. 12. An original way to compare airliner and GA accident statistics

CONCLUSIONS

The statistics as the statistics of the aircraft accident data, too, can be used in different ways depending on the goal of investigators. This paper introduced and discussed preliminary some original figures representing the aircraft accident data. The goal of investigation is make some conclusions for developing the safety philosophy of the small aircraft "driving" by less-skilled personal pilots.

The main results showed that the general aviation risk depending on the used indicator is much more greater then airlines risk (in case of accident rate per 100 000 flight hours) or nearly the same (in case of applying the indicator fatal accident per 1000 active pilots).

Another interesting result, the accident / fatal accident ration nearly the same for GA and airlines. So the GA and airline operation systems are developed on the same level.

The results described above are the first preliminary results of study that need further investigation and explanation.

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