Analysis of Small Aircraft Types and their Accidents in the Czech Republic

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Abstract

The share of investigated small aircraft accidents in all air accidents in the Czech Republic is 1/3. The analysis was carried out within the project of the Ministry of the Interior – Simulation of the Firefighters Interventions during Air Accidents. The first objective of the analysis was to create a catalogue of all types of small aircraft operated in the Czech Republic and to determine the number of these aircraft according to the types in selected categories. The second objective was to analyze the accidents of small aircraft that have occurred in the Czech Republic during the last 12 years and to bring forth the results which are important from the point of view of firefighters' interventions.
KEY WORDS: *small aircraft, ultralight, accidents, aircraft register, ECCAIRS*

1. Introduction

The catalogue of small aircraft types is part of an extensive project based on the assignment of the Ministry of the Interior of the Czech Republic (further only MI Project) of Simulation of Firefighters Interventions during Air Accidents MV-55820-16/VZ-2017. The purpose of the MI Project is to create a complex e-learning software to use in firefighters' training. It includes a training program and a simulator of air accidents interventions. It mainly concerns research in the area of flammability of materials used on small aircraft and spreading of fire, combustion fumes and smoke. The results of this research will mainly be used for optimization of firefighters' training and their intervention during air accidents. A design of a training centre is also part of this project. The outcome of this project will also fulfil an intermediate goal of the National Safety Research Program 2016 - 2021 BV III/2-VZ.

The analysis of air accidents which was carried out is also part of this MI Project. The goal of the research was to process the data about air accidents of small aircraft and bring forth conclusions which will be meaningful for firefighters' interventions. For the purpose of this research, small aircraft are considered airplanes which MTOM (Maximum Take-off Mass) does not exceed 2000 kg. Some categories of aircraft, e.g. Unmanned Aircraft Systems were excluded from the MI Project because they are insignificant from the firefighters' point of view. The limit of MTOM is set by the instructions for the MI Project, which is rather extensive. With regard to the volume of activities and the complexity their processing it was necessary to select only 1 segment or homogeneous group.

Reasons for focusing on small aircraft with MTOM ≤ 2000 kg:

- The group represents sufficiently large sample and yet is does not exceed the tolerable limits for quality results to complete the goals of the MI Project.
- Most small aircraft do not exceed MTOM of 2000 kg.
- The principal reason why to pay attention to accident rate of small aircraft is their share in all air accidents in the Czech Republic. Accidents of small aircraft make up 1/3 of all accidents in the Czech Republic (see Table 1).
- 60 % of all the aircraft in the group up to 2000 kg (2017) are in the administration of LAA; Sport Flying Devices (SFD) are not subject to single European regulation.
- The airports are certified in accordance with Annex 14 of ICAO, or with Reg. (EU) No 139/2014 as amended. Airports of category 1 and 2 primarily intended for operation of aircraft in general aviation according to visual flight rules are not required to provide permanent firefighters' service. There are 88 such airports registered in the Czech Republic and there are 94 areas for operating Sport Flying Devices.

Table 1

Accidents in civil aviation in the Czech Republic

	2010	2011	2012	2013	2014	2015	2016	2017
Number of accidents in commercial air transport								
Total	1	0	0	0	0	0	0	0
Fatal accidents	0	0	0	0	0	0	0	0
Number of people killed	0	0	0	0	0	0	0	0
Number of accidents in general aviation								
Total	88	81	73	81	91	79	77	91
Fatal accidents	6	11	8	9	9	8	15	5
Number of people killed	9	14	12	9	11	8	18	7
Number of small aircraft accidents All categories defined by the project with MTOM ≤ 2000 *kg*	40	25	22	29	30	33	29	41

[1, ECCAIRS database]

2. An Overview of the Present Solution of the Problem

The accident rate of small aircraft is a hot topic and it is necessary to deal with it. Based on the data stated in Table 1 the number of air accidents in general aviation is not insignificant [2]. The related research can focus e.g. on detailed analysis of accident causes and pay special attention to the improvement of the situation including an innovative plan for compliance checks or a design of a system for improvement of general readiness of private aircraft pilots (the necessity and importance of scheduled maintenance, pre-flight preparation and navigation briefing, weather influence, psychological readiness and a level of experience).

2.1 Scientific Approach

The accident rate of small aircraft has not been the usual matter of scientific research. It is a very specific topic. In order to carry out more thorough research which would bring meaningful results it is necessary to complete the air accidents statistics with another set of data. It is always necessary to supplement scientific results with another set of relevant data and to find connection between these two groups in order to attain valuable output.

We provide an overview of scientific research papers which dealt with more than just statistics of air accidents. The research in these articles pays attention to specific series of accidents and they analyze their causes. Analysis of general aviation crashes in Australia using the human factors analysis and classification system: The authors state that general aviation accidents make up 70-90 % of all accidents and 85 % of these were caused by human factor. They analyzed 169 air accidents using a system of classification of human factors in order to clarify human failure causing air accidents in Australia. The final findings of the research show that there was greater probability that the crew will make a mistake based on their skills and decision-making process when they were not personally well prepared, when there were some physical or mental limitations or they were experiencing unfavourable state of mind. [3] Fatal aviation accidents in Lower Saxony from 1979 to 1996: The authors were investigating all fatal air accidents which happened in Lower Saxony between the years 1979 and 1996. Their research was based on autopsy information of 68 out of the total of 154 casualties. The autopsy was performed on 39 out of 73 pilots involved. Some autopsies have brought information which can be considered relevant cause of accident, such as gunshot wound, traces of alcohol or medical drugs in blood and previous illness. Based on the findings the authors emphasize the need for an autopsy of all casualties of air accidents, especially the pilots, because they consider it as the only reliable method which can reveal all factors contributing to the accident. [4] In the article Why airplanes crash: causes of accidents worldwide, the results of the detailed investigation of the causes of 700 fatal accidents that took place between 1990 and 2006 in passenger commercial air transport were presented. In conclusion, the authors summarize the fact that the groups of causes of air accidents and their share in the total number of accidents vary considerably according to different regions of the world, according to different types of air services and by different category of aircraft. [5] The Australian Transport Safety Bureau has published a scientific article Australian aviation accidents involving fuel exhaustion and starvation. The study examines the overall accident rate and contributing factors to fuel-related accidents between 1991 and 2000. [6] We have not found a topic similar to ours in any scientific articles. The information which is available concerning air accidents is usually in the form of statistics.

2.2 Authorities – their Scope of Activity and Source of Data

To carry out a research it is necessary to have relevant data at your disposal. The MI Project focuses on firefighters' interventions. After the aircraft have been categorized it was necessary to define the individual types

of small aircraft which are operated in the Czech Republic. We obtained this data in cooperation with Czech aviation authorities: Air Accidents Investigation Institute (AAII), Light Aircraft Association (LAA) and Civil Aviation Authority (CAA) of the Czech Republic. The data presented in freely accessible documents published by these authorities was not sufficient that is why we submitted an official application for information, which was granted.

The AAII is a government authority which is in charge of investigation of air accidents and serious incidents in civil aviation. The AAII keeps a statistics of air accidents, it is responsible for their filing and for sending information into European database ECCAIRS (European Co-ordination Centre for Accident and Incident Reporting Systems) and to ICAO (International Civil Aviation Organization). By means of survey outputs and analytical activities the AAII is instrumental in improving safety besides others by drafting safety recommendations. These are then handed over to CAA, to related civil aviation entities and to SRIS – Safety Recommendations Information System (European Central Repository for Safety Recommendations in Aviation). It is the CAA that carries out the administrative proceedings concerning aviation safety – it applies appropriate measures to ensure and improve safety of air traffic. The LAA is an organization authorized by the Ministry of Transport (MT) to carry out state administration for Sport Flying Devices (SFD) [7]. The Ministry of Transport executes the administrative proceedings for the SFD group.

AAII publishes information about accidents in civil aviation in their Annual Reports. It also publishes an annual Czech Republic Civil Aviation Report. It regularly issues Bulletins of Foreign Accidents - information about accidents involving aircraft with Czech registration mark, which happened in abroad. It carries out Flight Safety Meetings based on the ICAO Annex 13 regulation. Presentations as well as other related documents from these meetings are released on the AAII website. You can also find Final Reports of Accidents there (available only in Czech language).

The LAA publishes information about accidents in their annual reports as well as in a magazine called Pilot, which they issue. Up to date numbers of SFDs and progress of newly registered SFDs in a particular year are stated directly on the website in the 'Statistics' bookmark.

Besides these resources, we have also applied for more data from state authorities of civil aviation. We have issued a very specific application to the AAII which was submitted in accordance with Reg. (EU) No 376/2014 on the Reporting, Analysis and Follow-up of Occurrences in Civil Aviation, Annex III – Request for Information for the European Central Repository (ECCAIRS). Based on this application we obtained data about air accidents.

The CAA and LAA provided us with data concerning the number of aircraft listed in Aircraft Registers, which they administer, based on our request for information in accordance with Act 106/1999 Coll., on Free Access to Information. Our set of data thus included information from Central Registry ECCAIRS, data from the Aircraft Register of the CAA and from the Aircraft Register of the LAA.

3. Methodology

The first and fundamental step we had to take was to determine aircraft categories which belong in this project. They are the aircraft with a defined MTOM. These aircraft can be listed in two registers in the Czech Republic; in the Aircraft Register of the CAA or in the Aircraft Register of the LAA. The Aircraft Register of the CAA (AR LAA) is a registry for aircraft (with the exception of SFD) which are operated by natural persons who have permanent residency or legal persons that have their headquarters in the Czech Republic. The SFDs are listed in the Aircraft Registry of the LAA (AC LAA). The LAA has been appointed by the Ministry of Transport of the Czech Republic to carry out state administration for the SFDs since 2010. Based on the Section 84, Letter e) of the Civil Aviation Act the LAA administers the registry of SFDs, which are owned by natural persons who have permanent residency or legal persons that have their headquarters in the Czech Republic.

3.1 Categorization

We have included these categories of aircraft in the research:

AR CAA: ELA1 (European Light Aircraft, category 1), ELA2 (European Light Aircraft, category 2), Gliders, Powered Gliders, LSA (Light Sport Aircraft), and Helicopters. The categories ELA1, ELA2, LSA are specified in the Reg. (EU) 748/2012 and in Reg. (EU) 1321/2014. Helicopters are specified by the EASA CS-27 regulation (European Aviation Safety Agency: Certification Specifications for Small Rotorcraft). Balloons, Airships and Unmanned Aircraft Systems are not part of this research because they do not pose a risk based on the objectives of the MI Project and they were not included in the simulations of firefighters' interventions.

AR LAA administers SFDs: Microlight Sport Aircraft, Microlight Gliders, Microlight Gyrocopters, Microlight Helicopters and ELSA (Experimental Light Sport Aircraft). All these categories are specified in the Czech Ministry of Transport Decree No. 108/1997 Coll., Section 24. ELSA makes up its own category. They are aircraft 51 % or more of which are built by amateurs or non-profit associations of amateurs for their own purposes and without any commercial objectives. This category, which is in the administration of LAA, increased the limit of MTOM

from 450 kg to 600 kg in 2010. Hang Gliders, Paraglides (including their powered types), and Centre of Gravity Shift Controlled Aeroplanes were excluded from the research. The reason was their structure which, as opposed to the other categories, poses a low risk of complications during rescue teams interventions and there is lower level of danger for infrastructure (including critical infrastructure).

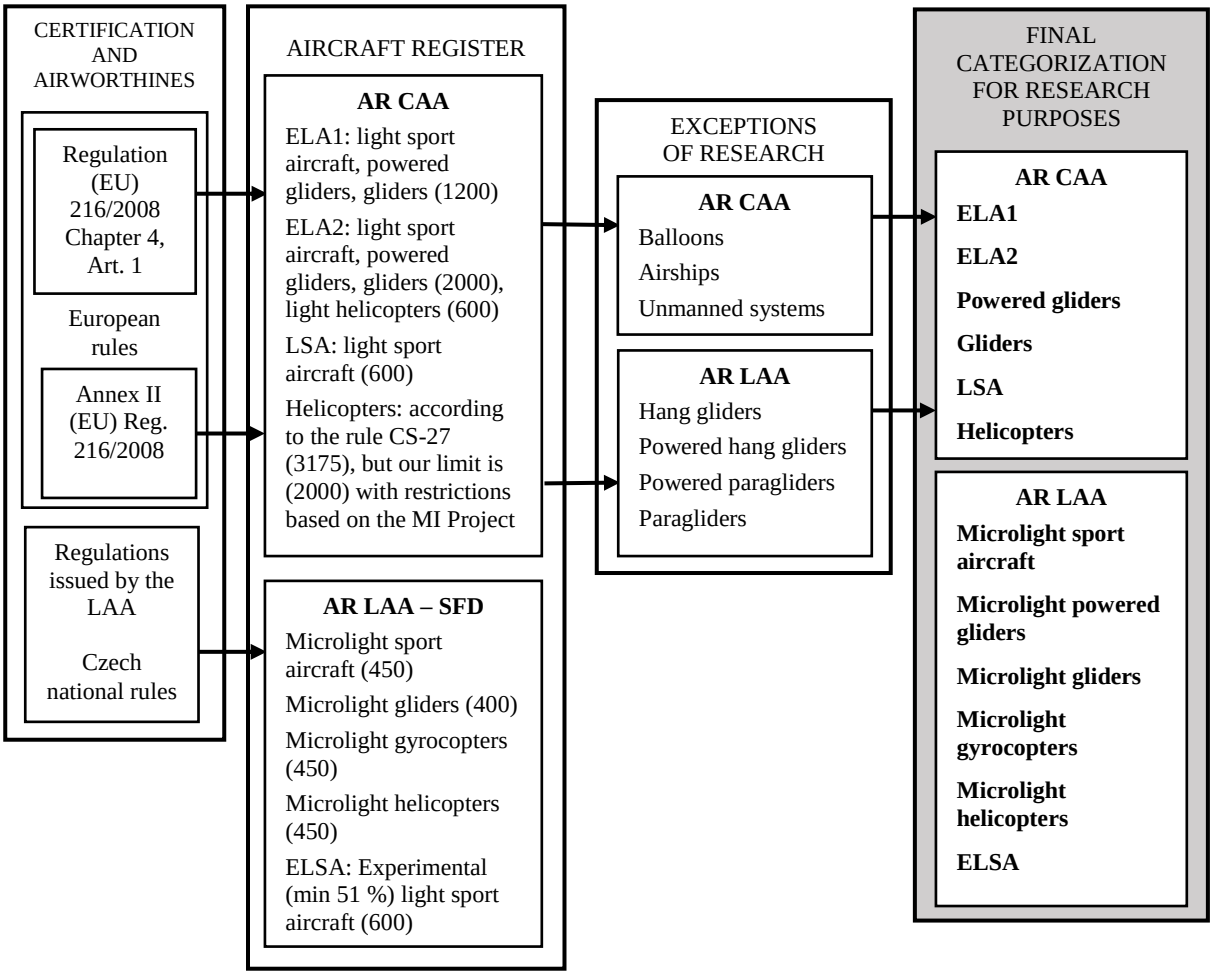

Fig. 1

Methodology of aircraft categorization
(NUMBER) – maximum take-off mass, kg
[AR CAA, AR LAA]

3.2 Types of Aircraft and their Number

There were 5605 aircraft, which could be included in the MI Project, listed in the aircraft registers. There were 2202 aircraft in the AR CCA and 3403 aircraft in the AR LAA. The largest category is Microlight Sport Aircraft, which comprises of 3057 aircraft (54 types). The second largest group is Gliders which total number is 1042 (88 types). Other large categories are Aircraft ELA1 and ELA2 with a total of 859 aircraft (94 types). We have defined all the corresponding types of aircraft for the individual categories and the number of aircraft of each type. Based on this information a catalogue of small aircraft types was compiled. Further work within the MI Project will deal with specification of all types of aircraft to be used for simulation of firefighters' interventions (technical description, capacity, position of fuel tanks, etc.).

Table 2

An example of the small aircraft types catalogue

Glider	Pcs.
L 13	211
VSO 10	135
Standard Cirrus	105
ASW 15	61
VT 116	44
L 23	44
ASTIR CS	33
ASW 19	32
VENTUS	23
NIMBUS	20
TWIN ASTIR	18
DISCUS CS	17
K7	14
VT 16	14
ASW 20	12
DG-100	12
DG-200/17	11
HPH Glas. 304	11
L 33	11
LS 3	11
Bergfalke	10
GROB SAILP.	10
LS 1-f	10

ELA1	Pcs.
Z 226	76
Cessna 172	70
Z 142	66
Cessna 152	30
Z 526	26
Z 126	24
Cessna F 172	20
L 40	19
PIPER PA28	19
Z 42	17
Cessna F 150	15
Cessna FR 172	14
Z 50	12
Cessna 150	11
Cessna F 152	10

ELA2	Pcs.
Z 37	110
Z 43	48
SR22	34
L 200	26
L 60	16
Cessna 182	11
Z 143	8
Cessna 172	7
PIPER PA34	6
Cessna 210	6

Microlight Sport Aircraft	Pcs.
EV-97	130
Cora/Allegro	121
Zenair CH	112
MiniMax/HiMax	102
TL-2000 Sting/Carbon	94
Tulak	83
D-7 Straton Mini	80
D-8 Straton Moby Dick	71
TL-32 Typhoon	64
Fox/KitFox	64
KP-2U Sova/Rapid/Sk.	63
TL-132/232 Condor	62
TL-96 Star	62
WT 9 Dynamic	62
P-92 Echo/Echo Super	56
LK-2M Sluka	55
Jora	54
Zephyr	53
Samba XXL	43
Lambada UFM	40
TL-3000 Sirius	40
P-220 Koala	36
Bristell UL/ELSA	36

Pcs. – number of aircraft by types in AR in 2017
[AR CAA, AR LAA]

4. Accident Analysis

Based on the Request for Information from the European Central Repository (ECCAIRS) we have obtained data about small aircraft accidents between the years 2006 and 2017. This time frame was determined by the available data from AAII. We have analyzed 304 accidents of small aircraft listed in the aircraft registers of the Czech Republic, which happened in the Czech Republic during the monitored period (2006-2017). There were another 101 accidents of small aircraft which were not registered in Czech databases. They include:

- 59 – accidents of aircraft which were not listed in the Czech registers, but they were produced in the Czech Republic. The accidents happened outside the Czech Republic territory (6 accidents in Germany, 6 accidents in Great Britain, 5 accidents in Poland, 4 accidents do not state the country of registration, 3 or fewer accidents in different countries of the world).
- 22 – accidents happened in the Czech Republic, but the aircraft were not listed in the Czech aircraft registers.
- 20 – accidents happened in the Czech Republic, but the aircraft country of registration was not stated.

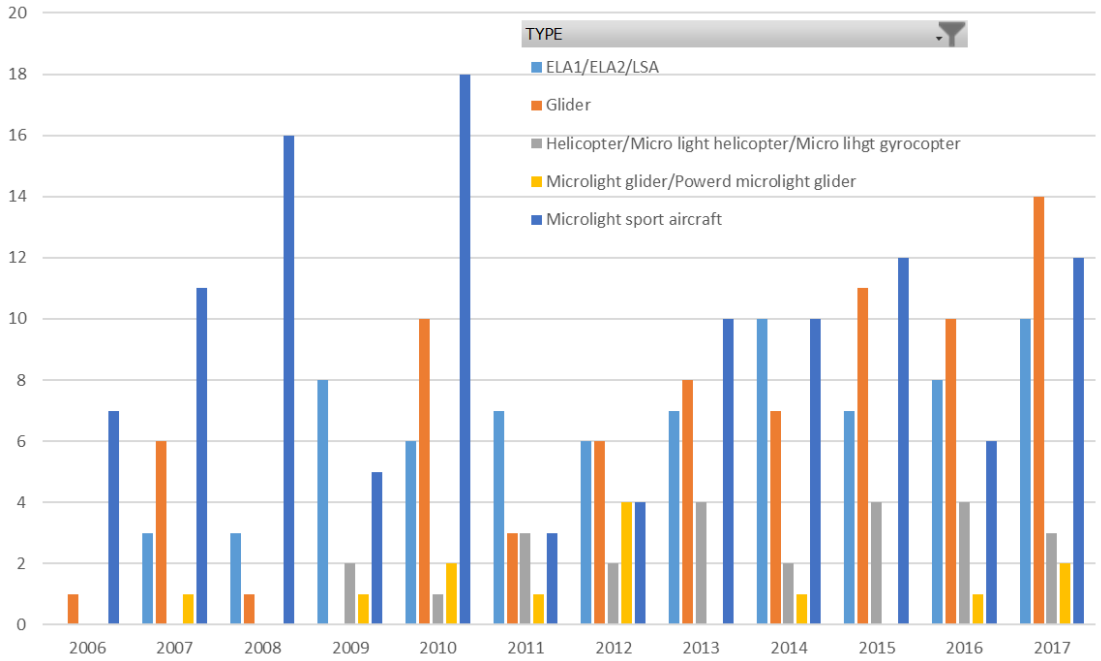

Fig. 2

Yearly number of small aircraft accidents by category
[authors]

We have combined some related categories for better clarity. The Microlight Sport Aircraft (114), Gliders (74), ELA1/ELA2/LSA aircraft (75) and Helicopters (2000)/Microlight Helicopters/Microlight Gyrocopters (25) had the highest accident rate in the monitored period of 2006 - 2017. The specific category of Heli/Gyrocopters shows that on average there were 2 accidents per year in the past 12 years. In 2017 there were 41 accidents of small aircraft in total which was the highest number during the monitored period.

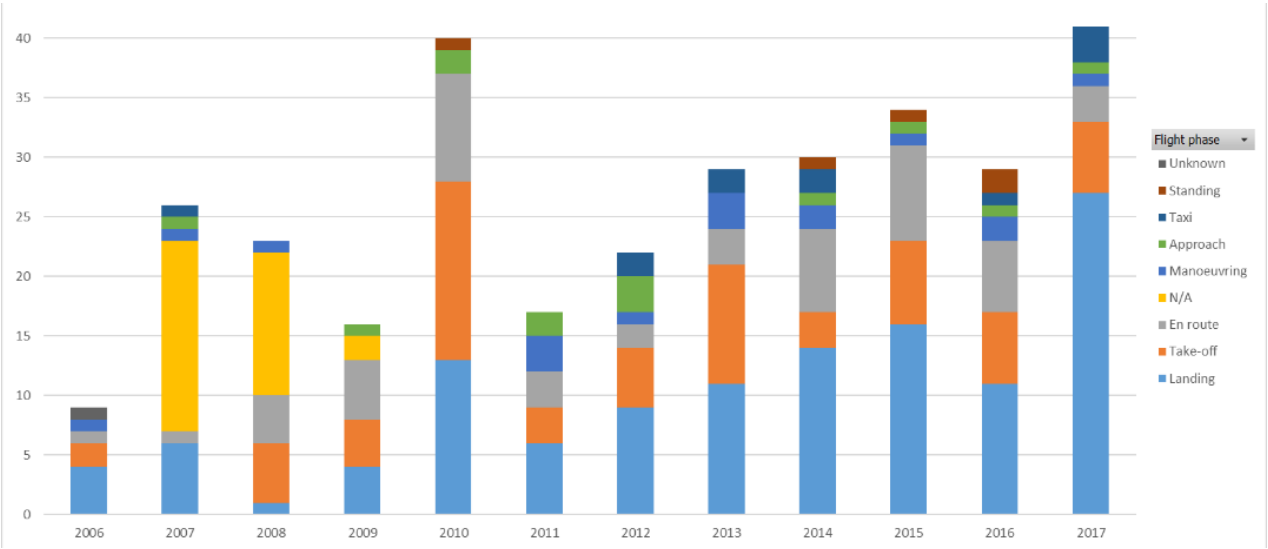

Fig. 3

Small Aircraft Accidents by Flight Phase
[authors]

Based on the analysis of accidents according to the flight phase we can say that accidents which happened while still at the airport or nearby during so called critical phases (Taxi, Take-off, Departure, Approach, Landing) make up a significant number. Using this information, we have defined critical area – airport areas and their surroundings, especially near urban and residential areas [8, 9]. A map of critical areas significant for firefighters' interventions will be created in the following research.

Fig. 4

Emergency events in residential areas
[10, 11]

The accident analysis confirmed that there is correlation between the most numerous types of aircraft in the aircraft registers and the types with the highest number of accidents. The most numerous types of aircraft in the registers have the highest number of flight hours and they are also at the top of the accident statistics charts. Critical groups of aircraft were determined based on confirmation of this link. Using the data from ECCAIRS each type of aircraft, which had an accident in the past 12 years, was assigned the actual number of investigated accidents of that type. By means of the aircraft catalogue we matched each type with the number of aircraft listed in the registry. Comparing these two sets of data we have defined a total of 18 critical groups of aircraft.

Table 3

An Example of the Small Aircraft Types Catalogue

Number of aircraft critical group	Manufacturer	Category	Type	Quantity of accidents (2006-2017)	Number of aircraft in the AR (2017)
1	Let	Gliders	L13/A/AC, L23	27	255
			L33	5	11
2	Let	Powered gliders	L 13 SE/SW	4	60
3	Zlin	ELA1	Z-126, 226, 326, 526, 726	17	138
			Z-50	3	12
			Z-142,242	2	68
		ELA2	Z-43,143	3	56
			Z-37	6	110
4	Orlican	Gliders	VSO-10 Gradient	10	135
			VT-16, 116	4	58
5	Orlican	ELA2	L-60/S	3	16
6	Robinson	Helicopters	R44	9	60
			R22	2	40

[authors]

In Table 3 we present 6 basic critical groups of aircraft stating the category where they belong. In one group, there are stated types or modifications of the type that are comparable in terms of design with the basic type, even if they are represented by a lower number of aircraft in the registry. We consider the each group to be homogeneous. For example L13, L23, L33 can by merged together 32 accidents and the number in the AR 266. Other types of aircraft (all of them being operated) are in the groups of non-critical types of aircraft.

The number of aircraft in the AR is static (as of 2017) and does not take into account the development of amount of registered aircraft in the period we monitored accidents (2006-2017). However, we can state that these types are historically the most operated in the Czech Republic. Deeper research would require additional inputs: the development of the number of aircraft types in AR versus the development of accidents by aircraft type. For MI Project is particularly important the actual sessions and number of operated small aircraft, with the highest probability of accidents.

5. Conclusions and Discussion

We have carried out the first research of this type in the Czech Republic. We have followed the objectives of the MI Project where typology and accidents rate of small aircraft belong. Our research focused on the goals of the MI Project mainly paying attention to firefighters' interventions during air accidents. For this purpose, we have created a catalogue of small aircraft types and determined the number aircraft of each type. Our analysis of accident rate has two major outcomes: definition of critical areas (future map of critical areas) and critical groups of aircraft. These results will become the entry data for further work within the MI Project.

Data is the absolute necessity for any research. In order to analyze accidents the database ECCAIRS and the possibility to consult it for scientific purposes has become a valuable source. We have also experienced very good cooperation with the AAII, CAA and the Ministry of Transport of the Czech Republic. On the contrary cooperation with the LAA was more complicated although it does not fall under the European legislation. In the future, we will also deal with the causes of accidents and their consequences. Human factor plays a major role in aircraft accidents. It often involves breaking of the rules, loss of control, aircraft overload or exceeding the MTOM, underestimating the meteorological conditions (poor visibility, strong crosswind, strong gusts of wind), underestimating the aircraft's technical condition.

This research can be carried out in every European country and in the end all the results can be combined and compared within the entire European Union. We consider the number of aircraft operated as an essential entry information in order to study aircraft accident rate. The number of aircraft accidents itself does not say anything about the accident rate development. The number of aircraft in aircraft registers has also been growing year-on-year. We need to take into consideration another important thing and that is the fact that not all the aircraft in the aircraft registers have a valid Certificate of Airworthiness. It concerns especially SFDs, where for example only 1561 out of 3057 of Microlight Sport Aircraft have a valid Certificate of Airworthiness. This is another factor that influences the air accident rate. The ratio between the number of aircraft with valid Certificate of Airworthiness and those which do not fulfil the requirements for certification of airworthiness is different for every category of aircraft. In the category of Microlight Sport Aircraft there are 51 % of aircraft which have a valid Certificate of Airworthiness (2017). In this context it may seem that the aircraft accident rate is rather high. Therefore, our newest research will deal with the development of the number of air accidents in the context of registered aircraft and the number of valid Certificates of Airworthiness.

Availability of Data and Material

The data needed for this research is not freely available. The basic set of data on air accidents was obtained from the European database ECCAIRS, based on Reg. (EU) No 376/2014, Annex III. The second set of data - types of aircraft registered in air registers and their numbers, was obtained from the Civil Aviation Authority and the Light Aircraft Association, based on Act 106/1999 Coll., On Free Access to Information. In both applications, we specified an exact requirements according to the objectives of the Project.

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