Monika KARDACH*, Marta MACIEJEWSKA**

THE RISK ASSESSMENT OF A SIGHTSEEING FLIGHT IN UNCONTROLLED AIRSPACE

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The intensive growth in the popularity of recreational aviation as a means of spending free time can cause an increase in the number of unwanted events in general aviation (GA). Thus, it is advisable to examine the safety of aerodromes and their nearest surroundings. The article deals with a risk analysis for a sightseeing flight, starting with and ending at a model aerodrome. A comprehensive analysis showed 67 hazard sources in the analysis area, of which 16 hazards were defined. Three out of sixteen hazards were assigned to the unacceptable category (according to the Risk Score Method). It was a mid-air collision, detachment of the aircraft's elements in the air and a ground collision. For every hazard other than those acceptable, actions aimed at risk reduction were recommended. Moreover, the risk should be monitored at every stage of the operation.

Keywords: risk assessment, General Aviation, Risk Score

1. INTRODUCTION

According to Annex 6 of the International Civil Aviation Organization, General Aviation Operation is an aircraft operation other than a commercial air transport operation or an aerial work operation (ICAO, 2010). On the other hand, a different definition can be found on the website of the Polish Ministry of Infrastructure; General Aviation (GA) covers all air traffic (private and commercial) excluding scheduled and military flights (Majchrzak, 2012). There are 42 small airports adapted for GA traffic, entered in the register of civilian airports in Poland (Fig. 1).

* PhD student, Poznan University of Technology, Faculty of Civil and Transport Engineering, ORCID: 0000-0002-8768-303X, ResearcherID: U-7838-2018.
** PhD student, Poznan University of Technology, Faculty of Civil and Transport Engineering, ORCID: 0000-0003-1547-2257, ResearcherID: U-7719-2018.

Thirty-one of them are managed by the Polish Aeroclub. The register of civilian airports is carried out by the Civil Aviation Authority. General Aviation aerodromes can be separate units or a part of larger airports (e.g. GA terminal at Warsaw Chopin Airport). It is difficult to accurately determine the volume of GA traffic in Poland, due to the fact that during flights in uncontrolled space there is no obligation to submit operational flight plans (plans for safe operation of air operations prepared by operators taking into account factors such as aircraft performance, other than operational restrictions and expected conditions on the itinerary and airports to be used (EASA, n.d.)) or radio contact with air traffic services. Some approximate values can be obtained on the basis of connections with the flight information service (FIS), which, however, are not mandatory and not every pilot, for various reasons, contacts them.

Fig. 1. The map of registered aerodromes in Poland. Source: “lotniska.dlapilota.pl”

One of several risk definitions states that the risk is a combination of the probability of hazard activation in an unwanted event and the damages caused. The risk can be reduced by elimination of hazard sources acting on the receiver of exposures (Klich, 2011). To do so, some safety systems and risk management are needed. Risk management consists of two basic elements: risk assessment and responding to the risk (Gill, Kadziński, Kalinowski, 2011). The article focuses on risk assessment as a connection of risk analysis, estimation and evaluation. There are many methods of risk assessment. One of them is Risk Score. The risk is estimated in four steps, based on three parameters. The steps are:

1) characteristic of the hazard area,
2) the identified hazards’ list,
3) risk estimation (based on (1)):

$$R(z_k) = \prod_{i=1}^{3} r_i(z_k) \quad (1)$$

where: r_1 – risk component corresponding to the criterion of damage resulting from the hazard activation (S), r_2 – risk component corresponding to the probability criterion (P), r_3 – risk component corresponding to the exposure criterion (E),

4) risk evaluation.

The level of damage (S) is assessed according to the data in Table 1. The level of probability is assessed according to Table 2. The level of exposure is assessed according to Table 3.

Table 1. The damage levels in the Risk Score method

Damage level (S)	**Estimated losses**	**Human losses**	**Material losses**
100	serious catastrophe	many mortal victims	> 30 M PLN
40	catastrophe	a few mortal victims	1–30 M PLN
15	extra large	one mortal victim	0,3–1 M PLN
7	large	serious injury	30–300 K PLN
3	medium	absence from work	3–30 K PLN
1	small	first aid	< 3 K PLN

Source: Górska, 2012.

Table 2. The probability levels in the Risk Score method

Probability level (P)	**Characteristic**
10	very probable
6	quite possible
3	practically possible
1	unlikely
0.5	sporadically possible
0.2	possible to think about
0.1	theoretically possible

Source: Górska, 2012.

Table 3. The exposure levels in the Risk Score method

Exposure level (E)	**Characteristic**
10	constant
6	every day
3	once a week
1	once a month
0.5	once a year

Source: Górska 2012.

After calculating the risk value (R) according to the simplified formula R = SEP, the risk level is assigned to one of the five groups (Table 4).

Table 4. The damage levels in the Risk Score method

Risk level (R)	Risk level name	Preventive actions
$R \leq 20$	negligible	a control is recommended
$20 < R \leq 70$	low	a control is needed
$70 < R \leq 200$	important	an improvement is needed
$200 < R \leq 400$	high	an immediate improvement is needed
$R > 400$	very high	stopping work is recommended

Source: Górska, 2012.

In order to grade the risk acceptance level, its evaluation is necessary. The categories of risk related to risk levels from the Risk Score method are presented in Table 5 below.

Table 5. Risk categories in the Risk Score method

Risk level	Risk category
Negligible Low	acceptable
Important	tolerable
High Very high	unacceptable

Source: Górska, 2012; Jamroz et al., 2010.

Risk assessment methods differ from each other in their use of different thematic categories, readability and the difficulty of using and interpreting the results. The method chosen to assess the risk of a sightseeing flight should be tailored to the specifics of flight operations. It should be comprehensive, compact, allow for taking into account a large number of factors, be easy to interpret, provide the expected level of accuracy, and not exceed the assumed time and technical possibilities. Therefore, taking into account all of the above-mentioned arguments, the Risk Score method will be the most appropriate method to achieve reliable results in the risk assessment of a sightseeing flight.

2. A DESCRIPTION OF THE ANALYSED AREA

2.1. Pilot's characteristics

For the needs of the article, it was assumed that the aircraft is controlled by a model pilot. He is a man between 25 and 35 years of age, has a valid PPL (A)

Private Pilot License, which is the first step in the career of an aircraft pilot and the most common pilot licence in Poland (Urząd Lotnictwa Cywilnego – Raport). A person holding such a license may perform the duties of the first or second pilot on daily, non-commercial flights, on single-engine, piston aircraft with a maximum take-off weight of up to 5700 kg, without receiving remuneration. A person wishing to obtain a license (through an examination at the Civil Aviation Authority) must be at least seventeen years old and hold a first-class or second-class medical certificate (Rozporządzenie Ministra Transportu, Budownictwa i Gospodarki Morskiej w sprawie licencjonowania personelu lotniczego, 2013). It is assumed that the pilot has 350 hours of flight at the time at Cessna 172 and 200 hours at Cessna 182 in the aeroclub from which the analysed flight takes place. The pilot knows Polish and English fluently in speaking and writing (ICAO level 4), which entitles him to fly flights within the European Union. The pilot is not authorized to perform night flights of VFR, IFR flights, or to pilot multi-engine airplanes. The pilot is in constant training, sightseeing flights are performed once a week.

2.2. Aircraft's characteristics

The aircraft selected to perform the flight operation, during which the risk level will be assessed, is a single-engine metal biplane with a retractable landing gear and a 235 HP Lycoming O-540-J3C5D engine with a maximum weight of 1406 kg. It can take 4 people on board (1 pilot and three passengers). The wings have a rectangular trapezoidal outline and are supported by Duralumin single braces. The darts and flaps are metal. The cabin is covered, you can enter it through two door openings. The chassis is three-wheeled. It is equipped with pilot-navigational instruments, transmitters, VHF receivers, a radio compass and a Garmin G1000 avionics set. The aircraft belongs to the aeroclub operating from the model airport. The plane is handled by licensed mechanics. Among 37 aeroclubs in Poland which can train PPL(A) pilots, only one doesn't have a Cessna airplane (150, 152 or 172) on which the model aircraft was based, thus the parameters were selected.

2.3. Aerodrome's characteristics

The model airport, under which the analysis was carried out, is an aerodrome located on the territory of the Republic of Poland. It is located near a city where a big airport is located (serving around 3 million passengers per year). The magnetic declination of the aerodrome is 2°E. The airport has a grass runway measuring 750 m × 100 m. At the airport, VFR air traffic is allowed. Sightseeing flights by aircraft, balloons, and gliders are organized. It is assumed that the aeroclub has the necessary certificates for all types of business. At the aeroclub there is also a parachute, modelling and paragliding section. At the airport there is a gas station on which Avgas 100LL fuel is available, and Aeroshell W-100 oil as well.

2.4. Airspace's characteristics and external factors

The Polish airspace is divided into controlled and uncontrolled space (Rozporządzenie Ministra Infrastruktury w sprawie struktury polskiej przestrzeni powietrznej oraz szczegółowych warunków i sposobu korzystania z tej przestrzeni, n.d.). The Polish information region of FIR Warszawa includes airspace over the Polish land area, internal waters and the territorial sea (Polish airspace), and this space over the high seas (Baltic Sea) where Polish air traffic services (ATS) operate under international agreements. The airspace is controlled by a space in which all air traffic services are provided with air traffic control in accordance with the ICAO space classification. The controlled space in FIR Warszawa is classified as a class C or D space, while the uncontrolled space has a G class. Uncontrolled space covers the air space from ground level (GND) to FL095 besides the control zones (CTR) and airport traffic zones of military airports (MATZ). The sightseeing flight in question is taking place in G space. The regulations divide flight procedures into: Visual Flight Rules (VFR) and Instrument Flight Rules (IFR) flights. VFR flights must be carried out in compliance with the strictly defined rules regarding weather conditions VMC (Visual Meteorological Conditions) and the manner of performing such flights. It is unacceptable to lose the visibility of the ground. In flights according to the IFR procedure, the indications of on-board instruments are used. An IFR flight can be performed with good visibility, however, it is also allowed to perform such flights in IMC (Instrument Meteorological Conditions), meaning conditions in which it is not possible to obtain sufficient external visual references. In aeroclub flights VFR flights are performed more often – hence their selection for further analysis.

The external factors taken into consideration include: weather conditions, time of the operation, wildlife, third person activity (drones, laser, other aircraft pilots, industrial pollution).

3. RISK ASSESSMENT

3.1. Hazard sources identification

In order to obtain information on hazard sources during flight the following were used, among others: engineering knowledge, brainstorming, conclusions from reports on aviation accidents or incidents, checklists. To make a checklist, the analysed area was divided into several groups in order to make it clear and easier to analyse. The source of hazards during the flight may be influenced by: the pilot, the technical condition of the aircraft, the location and parameters of the aerodrome, as well as external factors (Kadziński, Gill, Pruciak, 2011; Merkisz et al., 2013). It was assumed that the groups on the hazard sources checklist about the occurrence of hazard sources are the following:

- Pilot,
- Aircraft technical state,
- Aerodrome,
- External factors,
- Airspace and Air Traffic Services.

O.n.	Hazard sources checklist	Answer	
		YES	NO
1	Is it possible that the flight takes place in icing conditions?		✓
2	Can the pilot's health condition be a source of his inadequate behaviors?	✓	
3	Is there a possibility that the pilot had a break in flying, which caused the loss of some of the acquired skills or habits?		✓
4	Is the equipment of the aircraft compatible with Minimum Equipment List (MEL)?	✓	
5	Is it possible that the flight takes place at night?		✓
6	Is it possible that the Pitot's probe is covered during the flight?	✓	
7	Is there a certainty that the pilot and the passenger have a parachute?		✓
8	Is it possible that after refueling the pilot will not change the fuel switch position from "right" or "left" to "both"?	✓	
9	Is there a possibility that will be a fire in the cabin?	✓	
10	Is it possible that the surface of the runway is in poor condition (wet, overgrown with grass)?	✓	
11	Is there a high-traffic airport nearby?	✓	
12	Is there any certainty that the pilot has checked AUP?		✓
...	...		

Fig. 2. Selected fragment of the hazard sources checklist. Own study

The identification of hazard sources was based on a list of control questions. This was done by highlighting the answers to individual questions contained in it. A fragment of the list of control questions with answers is presented in the figure below (Fig. 2) (Gill, Kadzinski, Kalinowski, 2011).

Selected hazard sources are presented in Table 6. Hazard sources occur when the answers to the questions coincide with the colour selected in the checklist, i.e. one in which the affirmative answer generates a hazard.

Table 6. Hazard sources identified on the basis of a checklist

Nm.	Hazard sources identified on the basis of a checklist
2	Inadequate behaviour of the pilot caused by his health condition
6	Uncovering the Pitot's probe before flight
7	Lack of the parachute in aircraft equipment
8	Wrong fuel switch position
9	Fire occurrence in the cabin
10	Poor condition of the runway surface
11	Flight in controlled airspace without permission
12	Pilot's failure to recognize the AUP

Own study.

3.2. Hazards' recognition

According to the risk management algorithm, after identifying the hazard sources, they should be assigned to the hazards they generate. An individual hazard can come from only one or from several sources. When they occur simultaneously, it is enough to have one source to activate the hazard. The identification of some hazards is presented in Table 7.

Table 7. The examples of hazards defined on the basis of hazard sources

Hazard sources	Hazards	Unwanted events
Lack of fastened seatbelts <22> Use of great strength <3> Pilot's haste <16> Changing flight parameters as a result of unconscious action <21> Performing dangerous manoeuvres <24>	hazard of hitting objects	broken/dislocated limbs, bruises
Fire in the cabin <9> Engine's fire <45> Wings' fire <49>	hazard of fire effects	burns, inhalational poisoning, death
Not knowing the flight route <14> Lack of flight plan <15> Wrong fuel switch position <8> Not enough fuel <79> Lack of parachute <7>	hazard of forced non-engine flight	material losses caused by damage to the aircraft, breakage, injury, dislocation of the limb of the pilot and/or passenger

Own study.

3.3. Risk estimation and evaluation

For each of the hazards defined earlier variables were assigned, referring to: the level of damage generated by the activation of hazard (S), exposure to hazards (E), and the probability of damage (P). Below is an estimation of the risk during a sightseeing flight. For hazards with a risk category other than "accepted", actions have been proposed to reduce the risk level, e.g.:

1) Hazard of hitting objects:

Variables	S = 1 E = 3 P = 3
Calculation of risk value	R = 1*3*3 = 9
The risk level	negligible
Risk category	acceptable
Proceeding against risk	caution required

2) Hazard of separation of aircraft elements in the air

Variables	S = 40 E = 2 P = 3
Calculation of risk value	R = 40*2*3 = 240
The risk level	high
Risk category	unacceptable
Proceeding against risk	avoiding rush, inaccuracy, routine, checking the sobriety of the pilot before every flight, confirmation of pre-flight procedure by a third party

Variables after risk reduction	S = 40 E = 1 P = 1
Calculation of post risk value	R = 40*1*1 = 40
The risk level	low
Risk category	acceptable
Proceeding against risk	caution required

The risk assessment above is only a sample of the performed work. The whole analysis included: 93 questions in the checklist, 67 identified hazard sources, 16 hazards defined and the creation of a summary table. To facilitate the interpretation of the results, a three-color scale was used in the table, in which green indicates the acceptable level of risk, yellow means tolerable level and red – unacceptable (Table 8). Corrective actions have been recommended for the unacceptable risk levels.

Table 8. Risk assessment of a sightseeing flight with the Risk Score method before and after risk reduction

No.	Hazard	Before risk reduction					After risk reduction				
		S	E	P	R	Risk cat.	S	E	P	R	Risk cat.
1	Hitting objects	1	3	3	9	acceptable	–	–	–	–	–
2	Consequences of fire	7	1	3	21	acceptable	–	–	–	–	–
3	Consequences of electric shock	7	0.5	0.5	1.75	acceptable	–	–	–	–	–
4	The nervous system's overload	3	3	6	54	acceptable	–	–	–	–	–
5	Vision overload	3	2	1	6	acceptable	–	–	–	–	–
6	Mid-air collision	40	3	3	360	unaccept.	40	1	1	40	acc.
7	Collision with obstacle	40	2	1	80	tolerable	40	1	0.5	20	acc.
8	Detachment of aircraft's components in flight	40	2	3	240	unaccept.	40	1	1	40	acc.
9	Detachment of aircraft's components on the ground	7	6	3	126	tolerable	7	3	3	63	acc.
10	Forced gliding	3	1	0,5	1,5	acceptable	–	–	–	–	–
11	Accident during take-off	15	2	3	90	tolerable	7	2	1		acc.
12	Accident during landing	15	3	3	135	tolerable	15	2	1		acc.
13	Piloting errors	100	1	0,5	50	acceptable	–	–	–	–	–
14	Forced landing in the field	7	1	3	21	acceptable	–	–	–	–	–
15	Ground collision	40	1	6	240	unaccept.	40	1	1		acc.
16	Lack of immediate medical rescue	40	0.5	0.2	4	acceptable	–	–	–	–	–

4. CONCLUSION

The aim of this article was to analyse and assess the risk during a sightseeing flight in an uncontrolled space. Using the Risk Score method, calculations were made and risk levels were assigned to the relevant categories. Three out of sixteen hazards were assigned to the unacceptable category (collision in the air, separation of aircraft elements in the air and collision with the ground) and four to tolerated categories (accident during take-off and landing, separation of aircraft elements on the ground and collision with terrestrial obstacles). Therefore, it was necessary to determine the risk management strategies in order to reduce it. Actions such as: submitting a flight plan in the absence of such an obligation, frequent cooperation with third parties, avoiding rush and inaccuracy, and checking the sobriety of pilots before the flight were recommended. After risk reduction, all hazards have an acceptable level. Most of the risks are influenced by the accuracy of the human being in the performance of specific activities and norms. For this reason, many of the risk reduction measures proposed are directly related to the pilot. It should be remembered that the work refers to the model airport, which is why the analysis results in actual aerodrome airports may be different. Nevertheless, the risk in aeroclubs should be monitored at each stage.

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OCENA RYZYKA ZAGROŻEŃ PODCZAS LOTU WIDOKOWEGO W PRZESTRZENI NIEKONTROLOWANEJ

Streszczenie

Intensywny wzrost popularności lotnictwa rekreacyjnego może się stać przyczyną wzrostu liczby zdarzeń niepożądanych w lotnictwie ogólnym – General Aviation (GA). Celowe jest więc badanie bezpieczeństwa na lotniskach aeroklubowych i w ich najbliższym otoczeniu. W artykule przedstawiono analizę ryzyka w przypadku lotu widokowego samolotem lekkim, zaczynającego się i kończącego na lotnisku modelowym. Kompleksowa analiza wykazała 67 źródeł zagrożeń w obszarze analiz, a z nich zdefiniowano aż szesnaście zagrożeń. Trzy z szesnastu zagrożeń przypisano do kategorii nieakceptowanej (według metody Risk Score). Była to kolizja w powietrzu, oderwanie sie elementów statku powietrznego w powietrzu i zderzenie z ziemią. W odniesieniu do każdego zagrożenia innego niż akceptowane zalecono działania mające na celu zmniejszenie ryzyka zagrożeń. Poza tym ryzyko powinno być monitorowane na każdym etapie działalności aeroklubu.

Słowa kluczowe: ocena ryzyka zagrożeń, lotnictwo ogólne, Risk Score

Table 8. Risk assessment of a sightseeing flight with the Risk Score method before and after risk reduction

No.	Hazard	Before risk reduction					After risk reduction				
		S	E	P	R	Risk cat.	S	E	P	R	Risk cat.
1	Hitting objects	1	3	3	9	acceptable	–	–	–	–	–
2	Consequences of fire	7	1	3	21	acceptable	–	–	–	–	–
3	Consequences of electric shock	7	0.5	0.5	1.75	acceptable	–	–	–	–	–
4	The nervous system’s overload	3	3	6	54	acceptable	–	–	–	–	–
5	Vision overload	3	2	1	6	acceptable	–	–	–	–	–
6	Mid-air collision	40	3	3	360	unaccept.	40	1	1	40	acc.
7	Collision with obstacle	40	2	1	80	tolerable	40	1	0.5	20	acc.
8	Detachment of aircraft’s components in flight	40	2	3	240	unaccept.	40	1	1	40	acc.
9	Detachment of aircraft’s components on the ground	7	6	3	126	tolerable	7	3	3	63	acc.
10	Forced gliding	3	1	0,5	1,5	acceptable	–	–	–	–	–
11	Accident during take-off	15	2	3	90	tolerable	7	2	1		acc.
12	Accident during landing	15	3	3	135	tolerable	15	2	1		acc.
13	Piloting errors	100	1	0,5	50	acceptable	–	–	–	–	–
14	Forced landing in the field	7	1	3	21	acceptable	–	–	–	–	–
15	Ground collision	40	1	6	240	unaccept.	40	1	1		acc.
16	Lack of immediate medical rescue	40	0.5	0.2	4	acceptable	–	–	–	–	–