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Mgr Katarzyna Nikorowicz-Zatorska
Lotnicza Akademia Wojskowa
e-mail: k.zatorska@law.mil.pl

Municipal land use development policy as a factor inducing spatial disorientation in aviation

Polityka zagospodarowania przestrzennego miasta jako czynnik wpływający na dezorientację przestrzenną w lotnictwie

Abstract

Recently the aviation industry is growing faster than it was forecasted. Polish airport mostly have their origins in early 20th Century, and most of them were constructed for military purposes. Over the time the airports were developed within the given area without anticipating limitations of urban space. Presently, spatial development of most airports is seriously hindered due to dynamic expansion of urban development. It has reached the point where both the airport and the city suffocate each other's territorial expansion.

Cohabitation of urban space and airports creates a threat of the phenomenon of spatial disorientation. The present article discusses the problem faced by pilots experiencing spatial disorientation which is a threat to aviation operations safety. In fact, most cases regarding spatial disorientation are provoked by incoherent spatial management and the airport location within the physical space. Conclusions are drawn based on the research carried out where pilots with different backgrounds and levels of experience expressed their opinions on the causes of spatial disorientation related with the location of the airport in the urban area.

Key words:
municipal land use development, aviation, spatial disorientation, illusions in aviation, airport, aviation operations safety.

Streszczenie

Obecnie przemysł lotniczy rozwija się szybciej niż wcześniej prognozowano. Polskie lotniska najczęściej były budowane na początku XX wieku i większość z nich została stworzona do celów wojskowych. Plany lotnisk były opracowane na danym obszarze bez uwzględniania ograniczeń w przestrzeni miejskiej. Obecnie zagospodarowanie przestrzenne większości portów lotniczych jest poważnie utrudnione ze względu na dynamikę ekspansji rozwoju obszarów miejskich. Znajdujemy się obecnie w sytuacji, w której zarówno lotniska, jak i miasta blokują sobie nawzajem możliwości rozwoju.

Współistnienie przestrzeni miejskiej i lotnisk stwarza zagrożenie zjawiskiem dezorientacji przestrzennej. Artykuł omawia ten problem, z którym borykają się często piloci, ponieważ dezorientacja przestrzenna może stanowić zagrożenie dla bezpieczeństwa operacji lotniczych.

Wnioski wyciągane są na podstawie przeprowadzonych badań, w których piloci o różnym pochodzeniu i z różnym poziomem doświadczenia wyrazili swoje opinie na temat przyczyn przestrzennej dezorientacji związanych z lokalizacją lotnisk w obszarach miejskich.

Słowa kluczowe:
rozwój obszarów miejskich, lotnictwo, dezoriantacja przestrzenna, lotniska, bezpieczeństwo operacji lotniczych

The origin of the problem

We are nowadays witnessing some serious environmental problems concerning cohabitation of the airport and the city (Cohen & Coughlin, 2008). The essence of the problem is rather ambiguous and cannot be considered in isolation from its economic and social backgrounds. Construction of the airport should facilitate the growth of the region and provide a legitimate window on the world. Nonetheless, running such an investment also brings operational issues and creates a conflict of interest of all parties involved.

The most problematic is the fact of airports situated in the neighborhood of residential areas. To understand the present situation one should go back to early days of aviation, somewhere around 1925–1930. Polish airports were mostly constructed first as military airfields before World War 2. At that

time they were located outside cities, near military barracks, however within a reasonable distance from the downtown (Pędziwiatr, 2010). Over the years, the economic development implied extension of city borders, leading to the merging of the urban space with the areas of the airports. At the same time, technological development, globalization and commercialization of air transport services induced the need for bigger, more modern airports with larger bandwidth capacity. This resulted at an impasse, where an airport facility cannot be expanded anymore because it comes across the picket fences of the residential areas. In these conditions neither airport can be extended, nor the local community can enjoy benefits of the fully operational airport.

Furthermore, local residents tend to contest the development of the airport infrastructure, arguing that its expansion entails health issues (Aydin & Kaltenbach, 2007; Brook et al., 2010; Babisch & Van Kamp, 2009; Huss et al., 2010), ground movement (Schwab et al. 1985; Short et al. 2014; Weiszer, Chen & Stewart 2015), noise, pollution (Fidell & Silvati, 1991; Girvin, 2009; Visser & Wijnen, 2001; Postorino & Mantecchini, 2016) and another factor, very harmful for the human beings — radiation. It's a textbook example of NIMBY (ang. not-in-my-backyard) social phenomenon, where people admit that an airport is an important infrastructural investment and they are aware that it upgrades the local market, gives economic and social opportunities and theoretically boosts the growth of the entire region, but still they don't want to have it in the proximity of theirs homes (Ahlfeldt & Maennig, 2011).

The complexity of the issue requires a multidisciplinary approach and heavily concerns the problem of flight operations safety, which should be considered in the context of human safety on the ground and in the air.

Generally speaking, it can be assumed that the airport infrastructure is designed to ensure the safety of passengers, employees and the local population during flight operations. Knowing that the growing air transport sector requires more and more space in result of using ever-larger aircraft to carry more and more passengers and goods, more buffer zone should be designed to separate residential areas from the airport. At present, this is almost unenforceable, due to the fact that most of the Polish airports are already squeezed into urban areas.

Municipal land use development policy

To find the roots of the present problem, one should also take a look at the Polish municipal spatial policy. In the Polish legal system, the law regarding the airline industry, including construction of the airports, is voted on the national level. However, the implementation of the law provisions is delegated to the local level. This structure is absolutely correct and reflects the principles of the separation of powers, however it generates a financial issue for the municipality. In most cases it provokes delays in the airport investments and, in consequence, some system inertia.

Local authorities are also responsible for municipal land management. Their legal duty is to establish the local spatial development plans (in Polish: Miejscowy plan zagospodarowania przestrzennego [MPZP]) and, in absence of MPZP, a study on the conditions and directions of spatial development [Study]. The legal procedure is lengthy, complicated and time consuming. This is another ground zero for system inertia. Polish land management policy can be considered as quite chaotic which can be explained to a certain extent by the prolonged period of systemic transformation and lack of the sustainable real estate management culture. Under the former political system, shortages of land resources around main cities weren't a real concern and the consumer demand for land was limited. Whereas certain law provisions concerning spatial management were in force, when needed they it could be easily changed. Also, the perception of buildings from the point of view of aesthetics or functionality have changed substantially.

After 1989, most of the previous laws concerning land management remained in force until 2002, when the validity of then-in-force MPZPs expired. In practice, the majority of the territory of Poland was deprived of guidelines until the new MPZP was approved. This resulted in many unfavorable changes in the way the land was used, the lack of order or harmonization of urban space development and planning mistakes made or rooted in that period. It took years to cover the blanks on the Polish territory map with new MPZP, and without them it was possible to impair the planning spatial order.

The above-mentioned above contributed to planning impasse, leading to irreversible effects of airports neighboring with residential areas. In simple words; expansion of the city and the urbanization of suburban areas were ahead of the spatial development legislation. This situation cannot be reverted now. The only way to alleviate the negative effects of "wild" urbanization now is to change the functions of the properties in the vicinity of airports by systematic purchase of land parcels and transformation of their functions or zoning.

Flight operation safety

Cohabitation of the airport and the residential areas causes issues to the safety of flight operations. As mentioned above, flight operations safety applies to ground-based operations as well as those in the air. The aviation industry shall have, as its primary objective, the safety of passengers, crew, ground personnel and general public in all matters related to safeguarding against actual, potential or and anticipated threats. This means that the major issue related directly to aviation is the matter of safety. However, unfavorable terrain or inappropriate use of land around the airport is a factor that can cause a threat to the safety of flight operations.

Improper land management in the vicinity of the airport can provoke two types of threats: imminent hazard to the aircraft and the spatial disorientation affecting pilots.

In the aviation industry it is a well-known fact that most of the incidents, serious incidents or accidents happens during the take-off or landing operations. These are the phases of the flight when the aircraft is most fragile and fully exposed to the environmental factors. During the take-off procedures the aircraft uses its maximum power and any changes in its configuration can lead to a disaster. During the approach and landing procedures the aircraft slows down to the maximum safe speed at low altitudes and again, any changes provoked by the external factors can contribute to the impossibility of taking the aircraft out of a dangerous situation. The most unfavorable factors which can lead to a disaster are: high buildings, including chimneys and antennas, trees, shrubs, birds or flock breeding, landfills, farmlands, intense sources of light or smoke, sources of radio or electromagnetic waves, etc.

The above-mentioned factors tend to induce adverse conditions for the flights safety. One of the factors most critical to the safety of flight operation is wind. Any change in wind direction or intensity (wind speed) during take-off or landing procedures can lead to potentially precarious situations. High buildings, trees or shrubs change the direction of wind. Worse still, they visually alter the pilot's perception of the real altitude. Trees or shrubs growing on the area beneath the approach path optically shortens the distance between the aircraft and the ground, resulting in higher approaches.

Another factor that affects the safety of flight operations, and results from improper land management of the area in the proximity of the airport, is the presence of birds. Birds are mainly attracted by human clusters, fields, landfills and flock breeding, because of easy access to food and water sources. And birds are extremely dangerous to operating aircrafts at low altitude.

The sources of smoke or intense light can impair pilot's vision. Highway lights may be perceived as the runway or taxiway lights. Radio or electromagnetic waves interfere with the aircraft instruments.

Summing up, the presence of the residential areas in the vicinity of the airport create a hazard to the safety of flight operations. Good practice would be to expand the buffer zone to keep the airport operational area as sterile as possible to safeguard the passengers, crew, ground personnel and general public against hazards faced by the flight operations. Unfortunately, such prevention measures are impossible, due to the lack of land in the proximity of the airport to create an extended obstacle free area, which drives a vicious circle.

Spatial disorientation in aviation

Spatial disorientation (SD) is the consequence of presence of the illusions in aviation. SD should be comprehended as a situation where a pilot has a false image of the position, motion and position of the aircraft in space relative to the ground surface and the gravitational vertical of the reference system. This can be caused by somatogyral and somatogravic illusions. Illusions are brought on by sensory inputs which do not always accurately reflect the movement of the aircraft (Kirkham, Collins, Grape, Simpson & Wallace, 1978). An overview of the mechanism underlying the creation of illusions is beyond the scope of this article. In the table (Table 1) below the brief reminder of the nature of the illusions that could be identified in aviation is presented.

The above-outlined (Table 1) illusions and SD factors common in the aviation are, in the great majority, caused by the external terrain references. The latest statistics show that the major factor causing accidents in aviation is "human factor", sometimes wrongly equated as "pilot error". This broad category also includes a large portion of accidents caused directly by previously mentioned vestibular illusions (Beaty, 1995).

It is impossible to entirely remove SD as the cause of incidents, serious incidents or accidents, but its contribution can be minimized through appropriate training1 , pilot's self-consciousness and sustainable and responsible land management in the vicinity of the airport.

The goal of the study

The purpose of the research was to find the answers for the following questions: Are pilots

Table 1
Vestibular illusions in aviation

Vestibular illusions	General description	Types
Somatogyral illusions	Illusions involving the semicircular and somatogyral canals of the vestibular system of the ear. They primarily occur under conditions of unreliable or unavailable external visual references and result in false sensation of rotation.	The leans The graveyard spin The graveyard spiral Coriolis illusion Vertigo
Somatogravic illusions	Illusions caused by linear acceleration. These illusions involving the utricle and saccule of the vestibular system are most likely under conditions with unreliable external visual references.	The head — up illusion The head — down illusion Elevator illusion Oculoagravic illusion Visual illusions Upsloping terrain/runway Downsloping terrain/runway Narrow or long runway Wide runway A black — hole effect The autokinetic illusion False visual reference illusion Vection illusion Fog and reduced visibility Ground lighting illusion White — out

Source: own study based on Federal Aviation Administration (FAA website…)

aware of aviation threats related to illusions and spatial disorientation? Can pilots' experience protect them against illusions and spatial disorientation? Is the area in the vicinity of the Polish airports organized in line with the provisions of Polish air law? Pilots' voice and point of view are very important in the discussion about the safety of the flight operations. As "human factor" is the dominant reason of aviation incidents, serious incidents and accidents, the nature of the problem should be examined also from the "above the ground" perspective. Pilots are the primary operators of the aircraft and they are responsible for the flight safety from the off — blocks time until the moment when the aircraft stops moving under its own power. Because of this professional responsibility, it is important to find out whether, according to their opinion, the land use management in the proximity of the airport enhance or affect the safety of the flight operations, and whether pilots recognize the necessity to reorganize the areas neighboring the airports in order to improve the safety of the flight operations in Poland.

The survey was conducted among airplane pilots, irrespectively of their sex, age or professional affiliation, to find the correlation sought. Also, an open question was foretold in the survey, in which pilots were asked to indicate Poland's airports least-friendly in terms of the safety of flight operations.

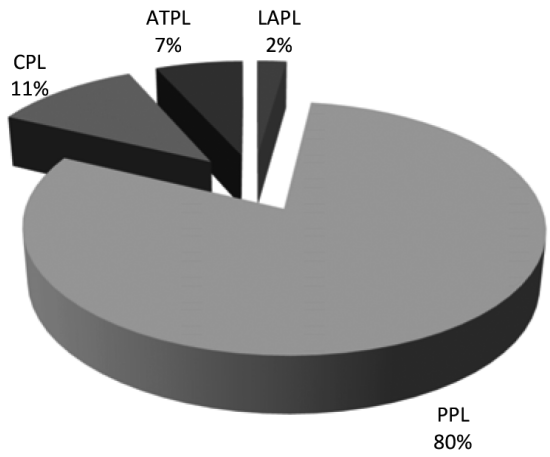
Research findings

The structural characteristics of respondents is presented on the Graph 1. The most numerous group is constituted of the PPL(A) holders.

Among the totality of respondents who holds PPL(A), 20% has less than 70 hours of total flight time. This is a very modest score. These pilots have just completed their basic training and the majority of their flight time consists of cockpit shared time with the experienced flight instructor responsible for the flight safety. Due to lack of experience which results from a small number of flight hours, it is rather likely that the responses from that group might not be representative. In the group of pilots with less than 70 hours of total flight time, only 22% did admit they ever experienced any type of illusion. However, 50% of the same group avowed to experience spatial disorientation at least one time during their flying careers. This result might stem from a misunderstanding what illusion and SD are, and from miscomprehension of the relation between the two. Quite significantly, a lot of pilots, regardless of their flying experience, believe that SD is simply getting lost, deviating from the path, or even losing the aeronautical chart or map (sic!).

P.A. Craig (2013, p. 3), the precursor of research on the human factor in aviation, put forth the thesis that pilots who's total flying time is between 50 and

Graph 1
Analysis on the respondents' characteristic2

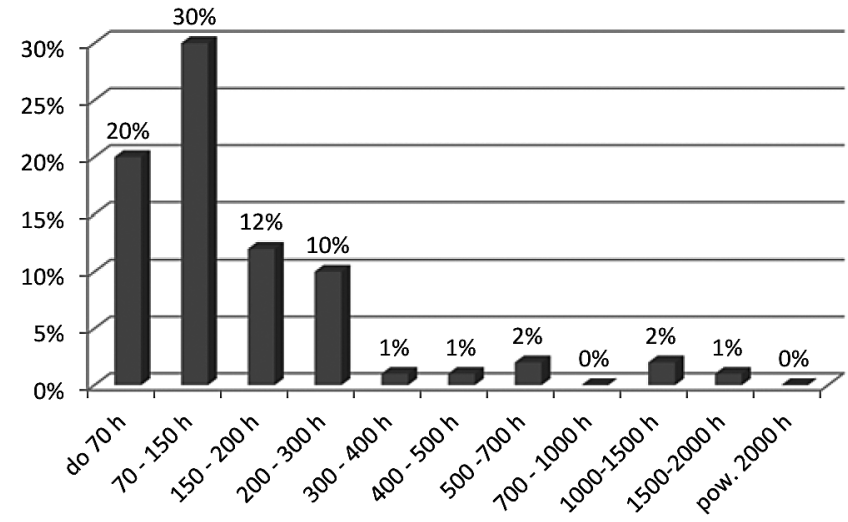


Source: Source: own elaboration based on the own study

The Graph 3 represents the totality of flying time of CPL(A) and ATPL(A) holders who took part in the research. These two type of license are awarded to professional pilots in commercial airline transportation. The minimum flying time is 200 hours to became CPL(A) or ATPL(A) frozen license holder. It can be easily seen that CPL and ATPL pilots are well past the killing zone.

It can be assumed that experience, practice and flying skills keep these pilots out of the killing zone. However, according to the results of the research, their experience doesn't make them immune to experience illusions or SD. Only 9% of CPL(A) and 6% of ATPL(A) holders admitted they had experienced illusion at least once in their careers. Moreover, only 3% of CPL(A) and ATPL(A) holders confessed to having faced SD. Comparing the statistics regarding PPL(A) holders, it seems like pilots' self-awareness in relation to hazards in aviation decreases with the growing number of hours flown. On the other hand, its' a desired case that

Graph 2
Total flight time of PPL(A) holders



Source: Source: own elaboration based on the own study

350 hours, are in the so called killing zone, during which unseasoned aviators are likely to commit lethal mistakes. Knowing the statistics, where the human factor is the leading cause of accidents in aviation, it seems alarming that so many unexperienced pilots deny the impact of illusions and SD on safety of the flight operations.

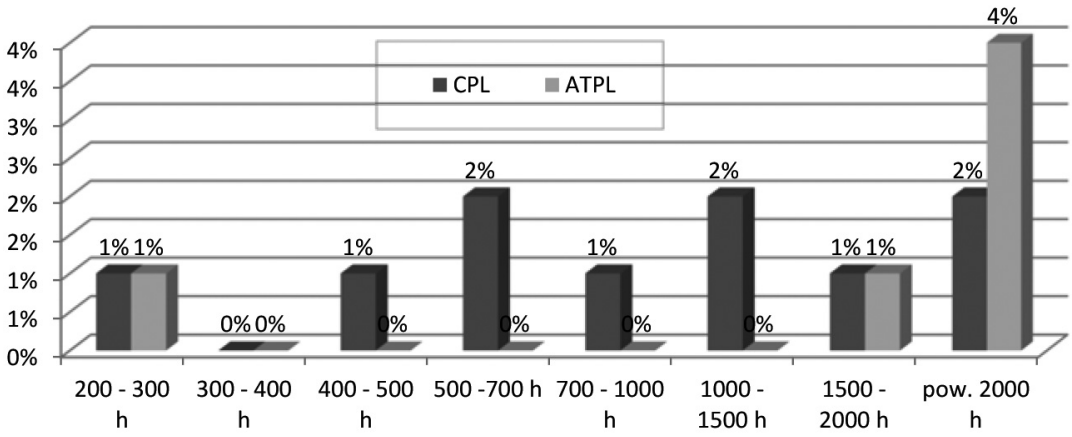
From the above graph 2 it can be learnt that the majority of PPL(A) holders, which are basically the most numerous group among pilots, are in the killing zone. Because of this fact, it is extremely alarming how remote awareness regarding SD they reveal.

junior pilots are aware of dangers in aviation regarding SD and not completely trustful of their skills, so they may be more sensitive in general.

Another important objective of the research was to check the pilots' knowledge regarding the relationship between the occurrence of SD and the land use management in the vicinity of airports. Survey questions and pilots' answers in this matter are summarized in the Table 2 below.

Regarding the compatibility of the land use and the air law, it can be observed that pilot's seniority is positively correlated with the ability to recognize the discrepancy between the letter of the law and the

Graph 3
Total flight time of CPL(A) and ATPL(A) holders



Source: Source: own elaboration based on the own study

Table 2
Survey questions and pilots' answers regarding the interdependencies existing between SD and land use management in the proximity of airports in Poland

Question 1: In your opinion, does the land use management in the vicinity of the Polish airports complies with the air law?				
License type:	LAPL(A)	PPL(A)	CPL(A)	ATPL(A)
Yes	100%	60%	30%	33%
No	0%	21%	20%	17%
I don't know	0%	19%	50%	50%
Question 2: In your opinion, does the land use management in the vicinity of the Polish airports favorably influences the safety of flight operations?				
License type:	LAPL(A)	PPL(A)	CPL(A)	ATPL(A)
Yes	0%	51%	20%	50%
No	50%	43%	70%	50%
I don't know	50%	6%	10%	0%
Question 3: In your opinion, does the land use management in the vicinity of the Polish airports should be reorganized in order to improve the level of the flight operations safety?				
License type:	LAPL(A)	PPL(A)	CPL(A)	ATPL(A)
Yes	100%	57%	80%	33%
No	0%	28%	0%	50%
I don't know	0%	15%	20%	17%

Source: own elaboration based on the own study

actual situation of the Polish airports. However, still a significant percentage of professional pilots cannot clearly identify this relationship, which may be considered disadvantageous. It's interesting that more CPL than ATPL holders assess disapprovingly the surroundings of Polish airports regarding the safety of flights operations. This may be due to the fact that most airline pilots (ATPL) most of their time frequent the controlled airports, while commercial pilots (CPL) often use airports with poorer infrastructure, hence their belief in the necessity to make amendments on Polish airports. Junior pilots (LAPL and PPL) are convinced that land use management in the proximity of the Polish airports adversely affects the safety of the flight operations and that changes are necessary. Besides, use of the uncontrolled airports and poor flying skills raise the bar of difficulty for them.

Conclusions

Despite the fact that leading world aviation organizations such as ICAO, EASA or FAA recognize the impact of land use management in the vicinity of the airports on the safety of flight operations, the problem is not yet obvious to a wider audience, including local authorities whose duty is to lead a sustainable land use management policy. Even more significantly, this still a stranger to pilots community. In relation to the survey carried out, it can be concluded that the majority of pilots do not associate the safety of the aviation operations with the land use management around the airport areas. The relationship between the occurrence of SD and the land development in the proximity of the airports is almost unknown to them.

Furthermore, admitting by pilots that they are subject to experience illusions and SD regardless of their experience, is still the shaming factor in the pilots' enclosed community. Once the relationship between the SD occurrence and accidents in aviation, as a function of the land use management, is fully recognized, pilot training programs shall pay much more specific attention to this issue.

Another factor which contributes to minimizing the seemingly innocuous impact of SD on pilots' professional performance is the well know complacency and relatively high self-confidence observed among pilots, especially senior pilots and those whose totality of flying time is approaching 200 hours.

The fact that, with the increase of number of flying hours under the belt, the level of pilots' awareness about the occurrence of illusions and SD in aviation is lowered, is alarming. Overestimating by the pilots of their craft skills was a cause of great many accidents in aviation.

The pilots' self-confidence sometimes reveals disturbing behaviors which could seriously affect the safety of flight operations and constitute a breach of fundamental knowledge and the nature of the SD phenomenon. One of the respondents stated that the pilot's duty is to fly regardless of the present conditions and the final outcome depends only of the piloting skills. This shows both that the civil aviation has already went a long way, but also how much still needs to be done in terms of safety of the flight operations.

Przypisy/Notes

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[2] LAPL(A) — Light Airplane Pilot License; PPL(A) — Airplane Private Pilot License; CPL(A) — Commercial Pilot License for airplanes; ATPL(A) — Airline Transport Pilot License for airplanes.

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Mgr Katarzyna Nikorowicz-Zatorska

Asystent w Instytucie Logistyki i Organizacji Transportu Lotniczej Akademii Wojskowej.

Mgr Katarzyna Nikorowicz-Zatorska

Assistant at the Institute of Logistics and Air Transport Organization of the Military University of Aviation.