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Central transport hub: Analysis of ground and airspace environments

Tomasz Nowoczyn[1], Mariusz Specht[2*]

[1] Department of Aviation, Polish Air Force Academy, ul. Dywizjonu 303 35, 08-521 Dęblin, Poland
[2] Department of Transport, Gdynia Maritime University, ul. Morska 81-87, 81-225 Gdynia, Poland
* Corresponding author's e-mail: m.specht@wn.umg.edu.pl

ABSTRACT

The planned central transport hub (CPK – Centralny Port Komunikacyjny) is a response to the dynamic increase in the number of air transport operations in Poland and the region of Central and Eastern Europe. Like any other airport in the world, the modern international hub will operate in a local environment. Its surroundings will undoubtedly exert an impact on the air traffic using the airport. Hence, this article aims to analyse the surroundings on the ground and in the airspace. As part of the study, the topography and land use in the immediate and wider surroundings of the CPK were analysed, the main obstacles for landing and taking off aircraft were determined, and the airspace structure of this region of Poland was characterised. Based on the research carried out, it can be concluded that the surroundings of Poland's future largest airport are conducive to its uninterrupted and efficient operation on a 24/7/365 basis. The lack of major obstacles (both on the ground and in the airspace), which is particularly noticeable to the east and south of the CPK, favours the flexible adaptation of navigation procedures in such a manner that maintains a balance between efficient and economical traffic flow of aircraft and the environmental impact of air transport. The least design freedom is expected in the eastern and north-eastern directions. At this point, it is essential to pay attention to highly urbanised areas, restricted airspace zones, and strict nature reserves. Nevertheless, it is entirely possible to connect the CPK to the country's airway network in these directions. To summarise all the aspects mentioned, it can be concluded that the surroundings of the CPK will not have a negative impact on the future functioning and implementation of the strategic objectives of the airport component of the project. It is possible to implement a sustainable transport development strategy that involves minimising the negative impact of aircraft traffic operating from the CPK while ensuring its cost-effectiveness, ergonomics and safety.

Keywords: central transport hub; airport; airspace; navigation procedures; aircraft; air transport.

INTRODUCTION

Over the past decades, the world has seen the rapid development of air transport [Barnhart C. et al., 2012; Gössling S., Humpe A., 2020; Rocha L.E.C., 2017; Wandelt S., Sun X., 2015; Zanin M., Lillo F., 2013]. Its unique characteristics, including transport speed and a high level of safety compared to the other means of transport, have resulted in aircraft dominating longer-distance passenger transport [Barnett A., 2010; Sippel M., 2010; Stimpson J.P. et al., 2014]. According to the annual publications and forecasts of the International Air Transport Association (IATA), air transport has continued to become increasingly accessible over the years. Many factors influence this, the most important of which is the level of society's affluence, closely linked to the region's general level of economic development. Accessibility and affordability are also not insignificant. In this respect, the popularity of air travel has been boosted by airlines operating under a low-cost business model, which minimise their operational costs, and, while offering a wide range of chargeable additional services, sell tickets at very low prices that are affordable for many passengers [Button K., 2012; Majerová V., Jirásek M., 2013; Vidović A. et al., 2013].

Year after year, the fundamental measure of air transport, namely the number of passengers carried, continues to rise globally [IATA, 2025]. Furthermore, this increase exceeds forecasts. This is particularly evident in the recovery period following the COVID-19 pandemic, which severely impacted this transport sector [Borucka A. et al., 2022; Kallbekken S., Sælen H., 2021]. According to IATA estimates, the economic situation preceding the COVID-19 sanitary restrictions was expected to be regained by 2024. The overall number of passengers carried had already equalled the 2019 figure a year earlier, i.e., in 2023 [IATA, 2024].

Over a broader period, the dynamic growth of the air transport market has been evident in the Central and Eastern Europe region since the beginning of the 21st century. This was mainly contributed to by the political opening after the fall of the Iron Curtain and the political reforms carried out in these countries in the last decade of the 20th century, the rapid economic development associated with them, as well as the expansion of the European Union and the Schengen Area [Button K., Drexler J., 2007; Grosche T. et al., 2007; Jankiewicz J., Huderek-Glapska S., 2016]. This growth was most evident between 2012 and 2023. When comparing the number of air passengers dispatched in 2012 with the exact figure in 2023, most of the countries concerned recorded at least a 50% increase. Some countries have managed to double this rate (Croatia, Poland, and Romania), while others have achieved a 200% increase (Bosnia and Herzegovina, North Macedonia, and Serbia). Interestingly, despite this development, the number of air journeys per citizen remains lower than that in Western European countries. By comparison, in 2023, the figures were 1.367 for Poland, 1.206 for Romania, and 1.263 for Serbia. In the same year, Germany achieved 2.198 flights per citizen, France 2.355, and the Netherlands (an extreme case) 4.006. This shows, above all, the enormous potential of the Eastern European market [Eurostat, 2024].

Poland is among the leaders in economic development in the region, and the processes described above took place in its air transport sector. Currently, there are fifteen commercial airports in Poland, which dispatched a total of 50,155,337 passengers in 2023 [Eurostat, 2024]. This means that, at present, Poland is the eighth country in the European Union in terms of the number of passengers dispatched [Eurostat, 2024]. For many years, Warsaw Chopin Airport (International Civil Aviation Organization (ICAO): EPWA) has been the largest airport in Poland, dispatching 35.4% of all domestic air passengers in 2023 [GUS, 2024]. At the same time, it is Poland's only hub that offers a large number of continental and intercontinental connections. The capital's airport, however, has a serious problem, as its development is restricted due to its location within the urban limits of Warsaw. The lack of physical space for expanding the terminal buildings and aprons, as well as altering the geometry of inefficient, intersecting runways, results in significant capacity problems. Considering the strategic importance of this airport within the country's air transport structure, it represents an obvious hindrance to the further development of the transport sector in Poland. This also entails the risk of limiting the growth of air transport and, consequently, a reduction in the flow of capital, personnel and information to and from Poland.

To address these problems, a concept has been developed for a completely new hub airport for Poland and the Warsaw metropolitan area, i.e. the Central Transport Hub [Blachut J., 2019; Duliński W., 2025; Węgliński B., 2019]. Not only is the new airport intended to take over the current tasks from the Warsaw Chopin Airport and maintain the upward trend in air transport development at an annual growth rate of 3-4 million passengers handled, but also to help increase the market share of LOT Polish Airlines for it to become a primary European carrier.

The implementation of the CPK's strategic goals will undoubtedly be supported by the appropriate location and establishment of navigation procedures, which will ensure the optimal and safe flow of aircraft using the airport. However, to achieve this, the airport surroundings need to be presented and characterised in the first place. This article will focus on delivering a detailed analysis of the future airport's operating environment on two levels:

1. On the ground – by focusing on the environmental impact of aircraft at the ground level, as well as on the local inhabitants of the area in the vicinity of the investment project, and the physical hazards to aircraft traffic.
2. In the air – by focusing on the airspace structure within the area under investment, and on the navigation procedures in place at other airports of the region.

The entire analysis can assist in shaping the CPK navigation procedures based on the principle of sustainable development, i.e., adapting optimal aircraft flight routes to the surroundings and minimising the adverse impact of air transport on the environment.

MATERIALS AND METHODS

The current state of Warsaw's aviation infrastructure

Warsaw is a city located in the central-eastern part of Poland, covering an area of 517.2 km^2 and with a population of 1,861,599. Considering the entire metropolitan area, it is inhabited by approximately 2.5 million people [GUS, 2024]. Currently, Warsaw's commercial air traffic is handled by three airports: the Warsaw Chopin Airport (ICAO: EPWA), the Warsaw Modlin Airport (ICAO: EPMO), and the Warsaw Radom Airport (ICAO: EPRA).

The largest of these, and also the largest airport in Poland, is the Warsaw Chopin Airport, located within the administrative boundaries of the city in its south-western part. The distance to the capital city's inner centre is 8 km. The airport itself is one of the few in Poland with two runways: RWY (runway) 15/33 (a length of 3,810 m) and RWY 11/29 (a length of 2,680 m), both constructed from asphalt concrete. It is home to the largest passenger terminal in Poland and three piers with a total area of 110,038 m^2 [PANSA, 2025a]. In the southern part of the airport, there is a cargo terminal that is Poland's largest (in terms of its surface area and transhipped air cargo). Additionally, there is a general aviation (GA) terminal and a military section, currently used by the 1st Aviation Transport Base aviation unit. The northern part of the airport is where hangars are located, and one of them, owned by LOT Polish Airlines, is used for aircraft maintenance. The airport premises also house the headquarters of the Polish Air Navigation Services Agency (PANSA). Furthermore, there are air navigation aids: a very high frequency omnidirectional radio range/distance measuring equipment (VOR/DME) "OKC" radio beacon, category II instrument landing system (ILS) for RWY 11, and category IIIa systems for RWY 33 [PANSA, 2025a].

There is no doubt that the largest airport in Warsaw is among the most important ones in the country, if not the most important. Thanks to accounting for 35% of all passengers dispatched and 46% of total air freight processed in Poland [CAA, 2024], the airport has been a key element in the country's air transport network for many decades. As the air transport service market is expected to continue developing, it is appropriate to take a closer look at its future, as well as the issue of capacity limits. A natural measure to increase an airport's capacity is to expand it. In the case of Warsaw Chopin Airport, however, this is particularly challenging, primarily due to its location. In 1934, the airport was inaugurated outside the area of Warsaw's urban developments. Over the past ninety years, the processes of suburbanisation and natural urban development have resulted in the airport area being surrounded by residential buildings in Warsaw's districts of Okęcie, Ursynów, and Włochy. In addition, one of the country's key thoroughfares, namely Expressway S2, which is part of both the East-West trade and transport route and the Warsaw ring road, runs in the immediate vicinity. Another issue is the permitted number of daily operations, which, due to the city's location, is determined by noise restrictions. Currently, there are 560 operations performed during the day (between 06:00 AM and 10:00 PM), and only 24 Quota Count points [Malinowski Ł., 2025] are to be used at night (the number of these points is determined by the noise emitted by aircraft, with the louder units receiving more points). In practice, this prevents the airport from operating on a 24/7/365 basis. These limits can only be changed by issuing a new environmental approval, which is not impossible. Still, considering the need to maintain the acoustic ecological standards, it would be challenging to increase them substantially. In addition to the factors mentioned above, the capacity of the Warsaw Chopin Airport is also restricted by:

- the runway layout – the intersecting runways prevent the performance of parallel operations,
- the terminal space – the building is not expandable and has limited space for passengers; moreover, there is no possibility of increasing the capacity of the luggage logistics system by expanding the handling space and the length of conveyor belts,
- no space for larger aprons and additional taxiways (in fact, the only facility that can be built in the airside area is the so-called south pier), an extension of the aircraft parking area along

taxiways Echo 1 and Echo 2 at the expense of the storage and fuel depot areas.

Due to the limited possibilities for infrastructural expansion at Warsaw Chopin Airport, alternative measures were necessary to prevent capacity-related problems. It seemed like a simple solution to transfer some of the air traffic to other airports. The problem is that, until 2012, such a facility did not exist in the Warsaw metropolitan area. An attempt has, therefore, been made to adapt one of the former military airports to the needs of handling passenger traffic, and the choice fell on the town of Nowy Dwór Mazowiecki. This is how the modestly-sized Warsaw Modlin Airport (ICAO: EPMO) was created. On the site of a former military complex, located approximately 35 km northwest of the inner centre of the capital city, a small airport terminal and a parking apron with thirteen parking spaces have successfully been built. The airport has one RWY 08/26 runway with a length of 2,500 m [PANSA, 2025a].

The entire concept of the Warsaw Modlin Airport has been designed with low-cost carriers in mind. The aim was to commission an airport that would be more attractive to this type of airline than the Warsaw Chopin Airport: with lower fees, located further away from the city, with a simple taxiway network to minimise time on the ground and a small number of airport-related services. This model quickly attracted one carrier, which had a monopoly on regular air connections for almost the entire period of the airport's operation. The Irish company Ryanair, being the one in question, has achieved a position that, over the years, has enabled it to negotiate incredibly favourable financial conditions for using the Warsaw Modlin Airport. This has contributed, first, to the airport itself generating annual losses, and second, to the lack of development of any competition in the form of other airlines. The entry threshold for the Warsaw Modlin Airport is exceptionally high, and any additional capacity is immediately used by one dominant carrier. This situation prevents the implementation of the plan to transfer all low-cost traffic and a large part of the charter traffic from Warsaw Chopin Airport to Warsaw Modlin Airport.

Upon recognising the failure of the original plan to relieve the burden on the main Warsaw airport, the Polish government decided to implement another alternative. In 2015, a civilian airport was opened in Radom, located approximately 90 km south of Warsaw, by converting a former military airport. Its primary intended purpose was to provide services to the southern part of Mazowieckie Voivodeship and the entire Świętokrzyskie Voivodeship. According to the original plans, the Radom Sadków Airport (ICAO: EPRA) was intended to operate similarly to most regional airports in Poland, i.e., the majority of connections would be operated by low-cost airlines. However, it quickly became apparent that this had not brought the expected success. During the initial months of operation (September-December 2015), only 467 passengers were dispatched. Throughout 2016, 8,965 passengers were sent, and this number remained constant in 2017 and 2018, with 8,965 and 9,903, respectively [CAA, 2024]. This means that in the "most successful" year, an average of 27 passengers were dispatched per day. These are disastrous figures that do not ensure the airport's profitability. Given these circumstances, a quick decision was made to change the strategy for the Radom Airport. In 2018, the state-owned company Polish Airports S.A. became the airport operator. The concept of a regional airport was abandoned in favour of a new airport to relieve the burden on Warsaw airports, which was not necessarily intended exclusively for low-cost carriers. The first step in that direction was to change the name from the Radom Airport to the Warsaw Radom Airport. In May 2019, the process of replacing the old air terminal building with a new one was initiated, and the runway was extended by 500 m to a length of 2,500 m. Thanks to these modifications, the Radom Sadków Airport has gained the capability to efficiently handle several models of wide-body long-haul aircraft (e.g. B787). The modernisation plan centred on the construction of an airport with modern facilities and low operating costs for carriers, which would compensate for its distance from the capital city's centre. All construction works were completed in the first quarter of 2023, and the airport itself was commissioned on 27 April 2023. However, a significant problem emerged at the very beginning, namely the COVID-19 pandemic. The year 2023 was still characterised by the post-pandemic reconstruction of the air passenger transport market, which the sanitary restrictions had heavily damaged. During this period, most of the world's airlines were undergoing the process of financial regeneration. They were not inclined to open new connections, especially to and from destinations like Radom Airport, which appeared unlikely to generate sustainable profits. This does not mean, however, that not even a single aeroplane took

off from the Radom Airport runway throughout 2023, as the state-owned carrier, LOT Polish Airlines, offered a helping hand. As time went by, new charter carriers started to appear on the Radom Airport apron. The highest number of routes was initiated in the fourth quarter of 2023 and at the turn of 2023. Finally, the year 2023 closed with a total number of 104,770 passengers dispatched, which was the second-worst result in Poland [CAA, 2024]. Nevertheless, this is a record-breaking figure for the Radom Airport itself.

To summarise, there are currently three airports providing services to the Warsaw metropolitan area: Warsaw Chopin Airport (ICAO: EPWA), the Warsaw Modlin Airport (ICAO: EPMO), and the Warsaw Radom Airport (ICAO: EPRA). In 2023, all of them collectively dispatched a total of 21,976,911 passengers, accounting for 42.07% of all passengers in Poland [CAA, 2024]. The estimated maximum capacities of the airports are as follows: 22 million passengers for EPWA, 3.5 million for EPMO, and 3 million for EPRA. Therefore, the total capacity of all the capital city's airports amounts to approximately 28.5 million passengers [CAA, 2022]. This means that in 2023, the limit of physical handling capacity was dangerously approached. The consequences of this situation include the failure to allocate new slots to airlines and to open new connections, as well as delays caused by an excessive number of passengers and inefficient aircraft handling on the ground. All this contributes to a significant reduction in the competitiveness of Warsaw airports, hindering the upward trend in the industry. Considering the importance of airports, this represents a substantial threat to the country's entire air transport sector.

The concept of the central transport hub

Maintaining the continuous development of the air transport sector is a crucial aspect of the functioning of modern, developed countries. Air connectivity is the basis for the efficient flow of people, as well as personnel, technologies, and investments. Suppose Poland aspires to join the group of the twenty strongest economies in the world and remain among them. In that case, it must ensure that its communications are at an appropriately high, global level. This, however, is not guaranteed by the existing infrastructure, which is inevitably approaching its capacity limits. According to forecasts by the Polish Civil Aviation Authority (ULC), the number of passengers is expected to continue to increase by 3–4 million per annum over the next two decades [CAA, 2022]. Continued investments in the airports in Modlin and Radom appear to be only a partial solution. In addition, Warsaw lacks sufficient potential in terms of traffic generated for the multiport variant, i.e., a model of multiple airports with similar characteristics operating in parallel, as is the case, for example, in London, New York, Paris, or Tokyo.

The expansion of the Warsaw Chopin Airport to a satisfactory level is physically impossible. The problem of the airport being unable to develop due to its location near urban buildings is not unique to Warsaw Chopin Airport on a global scale. A procedure commonly applied in such a situation is to build a new, larger airport located further away from the city. In recent years, this has been achieved, for example, in Istanbul, where a brand-new international hub (ICAO: LTFM), located approximately 35 km from the city's inner centre, was commissioned in 2018. It replaced the Istanbul Atatürk Airport (ICAO: LTBA), located within the city limits, with only the cargo and GA terminals retained on it. Previously, such situations occurred in the 1990s, for example in Seoul, with the Incheon International Airport (ICAO: RKSI), which relieved the burden on the Gimpo International Airport (ICAO: RKSS), in Hong Kong, with the Hong Kong Kai Tak International Airport (ICAO: VHHX), replaced by the Hong Kong International Airport (ICAO: VHHH), and in Denver, with the Denver International Airport (ICAO: KDEN) replacing the Stapleton International Airport (ICAO: KDEN). All the aforementioned airports have achieved commercial success and have become significant hubs in the global air transport network. A similar solution has also been suggested for Warsaw. The first of such plans appeared as early as 1971 [Ministry of Infrastructure of the Republic of Poland, 2003]. At that time, the implementation of the project was halted due to the economic and political situation in the Polish People's Republic. The topic, however, resurfaced after systemic reforms, with a 2003 report clearly stating that the construction of a new central airport was in line with Poland's air transport mission. Several years later, in 2010, the Ministry of Infrastructure commissioned a comprehensive analytical study on a central airport for Poland. The study was developed by a consortium of foreign companies, including

PriceWaterhouseCoopers (PwC), MKmetric Gesellschaft für Systemforschung (MKm), Oliver Wyman Consulting (OWC) and Deutsche Flugsicherung (DFS). The study includes forecasts for the economic and demographic development of Poland and the region, as well as projections for air traffic growth and the development and structure of the aviation market. It also analyses costs and potential profits for the new airport, and proposes a business model. Furthermore, the study examined the impact of this investment project on Poland's existing regional airports. Extensive simulations, in-depth analyses and the development of different variants, both pessimistic and optimistic, lead to a clear conclusion: "*(...) abandoning the construction of the Central Transport Hub would pose a significant risk to the development of air transport in Poland. Considering all the aforementioned criteria, the consortium recommends choosing the variant involving the construction of a new central airport hub for Poland*" [PwC, MKm, OWC, DFS, 2025]. An action plan was proposed as well. Despite such an unequivocal recommendation, no construction-related decisions were taken, which was most likely due to the unstable financial situation of LOT Polish Airlines.

The project was eventually revived in 2017 when the Council of Ministers adopted a resolution approving and implementing the investment project. The project was also expanded to include a railway component, which involves the construction of a high-speed rail network that converges at the central airport, which has been aptly named the Central Transport Hub [Council of Ministers of the Republic of Poland, 2017]. Since then, it has become a nationwide project aimed not only at building a new airport for the Warsaw metropolitan area but also at modernising the railway transport network throughout the country. The so-called "railway spokes", in their ultimate form, were intended to allow passengers to reach Warsaw and the CPK within a maximum of 120 minutes from most Polish metropolitan areas, as well as to help reduce the problem of transport-related social exclusion and infrastructural inequalities between the eastern and western parts of the country. The assumed operating speeds, in the order of 250 km/h, were intended to provide an ideal balance between travel time and construction and maintenance costs, and to enable the involvement of Polish rolling stock manufacturers.

Since the end of 2017, the preparation work has accelerated significantly. The ultimate location has been selected, and several geological surveys and meteorological measurements have been conducted. A business plan has also been developed. Notably, the project received an environmental permit at the end of 2023 and a location decision at the turn of 2024. The current plan is to build an international air hub with an annual capacity of 40 million passengers (with a modular expansion option) and an ICAO 4F category, enabling it to handle all types of aircraft currently in use, including the Airbus A380 and larger units [Horonjeff R., McKelvey F.X., 2010]. As of today, the project is planned to be commissioned in 2032 [CPK, 2025].

The location of the Central Communication Hub

Any design work related to transport infrastructure requires a prior thorough analysis of the exact location of the project. As previously determined, the Central Transport Hub is not a new project; therefore, over the years, many potential locations have been identified as suitable for implementing this investment project. The first specific proposals were brought forward in 2003 and included Modlin, Mszczonów, Nowe Miasto nad Pilicą, Radom, Skierniewice, Sochaczew, and Wołomin [Ministry of Infrastructure of the Republic of Poland, 2003]. The main criterion considered at the time was location, which was intended to ensure both efficient access to the centre of Warsaw and the airport's unwavering, future-oriented development. When reviewing further analyses regarding the selection of a location for the new airport, it is worth examining a report compiled in 2006 by the Spanish consortium Ineco Sener. The report rejected many of the previously proposed locations (Modlin, Nowe Miasto nad Pilicą, Radom, Sochaczew, and Wołomin) due to unsuitable terrain, a lack of expansion possibilities, or excessive nuisance to local inhabitants and the protected natural environment. Instead, it identified Mszczonów as the most suitable location, while also suggesting that Baranów be considered [Siłka P., 2009]. Baranów is a village located 36 km from the centre of Warsaw and is the seat of a rural commune of the same name. The village, located on the Warsaw-Łódź line, is expected to gain even more importance with the commissioning of one of Poland's main thoroughfares, the A2

Motorway, in its immediate vicinity Due to the extensive, flat plains of the Mazowsze Region, characterised by low population density, the lack of environmentally protected areas, and the Central Railway Route (CMK) junction, located approximately 5 km to the south, this proposal has become extremely attractive.

On 7th November 2017, the Council of Ministers passed Resolution No. 173/2017 on the Adoption of the Investment Preparation and Implementation Concept: Solidarity Airport – Central Transport Hub for the Republic of Poland, which included, e.g. the final choice of location. The following prerequisites were considered [Council of Ministers of the Republic of Poland, 2017]:

- Prerequisite 1: The integration of rail and air traffic into a single transport hub to ensure intermodality through free access to the backbone of the country's rail network, both existing and planned lines, with a particular emphasis on the integration of meridional and latitudinal connections.
- Prerequisite 2: Securing the land requirements – a guarantee of uninterrupted development for at least several decades, which means securing an estimated 3,000 ha of free land, which includes the construction of the entire airport infrastructure along with space for its future expansion. In addition, it would be advisable to secure approximately 1,500 ha for the development of the so-called Airport City, i.e. public utility and investment buildings related to the airport itself, approximately 100 ha for the construction of a logistics centre, and a restricted use area of no less than 6,000 ha.
- Prerequisite 3: Appropriate location about Warsaw and Łódź – the adaptation of the transport infrastructure to the distribution of mobility generators and the acceptance of location in the centre between the Warsaw and Łódź metropolitan areas. The travel time from Warsaw to the new airport should be no more than 25 minutes by train and 35 minutes by car, which implies that it should be located at a distance of no more than 40 km from the inner centre of the capital city. One of the goals should be to maintain transport accessibility at a level as close as possible to that currently exhibited by the Warsaw Chopin Airport.
- Prerequisite 4: Environmental prerequisites – lack of physical terrain constraints, low population density, and lack of Natura 2000 nature conservation sites near the airport, providing the possibility for operation on a 24/7/365 basis.

In 2017, only five potential locations were still under consideration: Baranów, Babsk-Skierniewice, Mszczonów, Sochaczew, and Żyrardów (Międzyborów-Jaktorów). Only one of them satisfied all the prerequisites set, and it was the commune of Baranów. Therefore, by the decision of the Council of Ministers, this location was ultimately designated as the area for the implementation of the airport component of the Central Transport Hub.

Not only is the selected location attractive for Warsaw and Łódź, but it also enables efficient integration into the future high-speed rail network, which implies the efficient implementation of the entire CPK plan, including the airport and a modern rail network for the whole of the country (Figure 1).

RESULTS

After presenting the assumptions, concept, and location of the capital city's new airport, we can move on to analysing the surroundings of the planned project, which will focus on two areas. The purpose of the ground analysis is to determine the characteristics of the topography at the CPK location, identify natural terrain obstacles, and locate any objects that are potentially dangerous to aircraft. The analysis of airspace, in turn, provides the basis for marking out flight routes. Its division should be considered, paying special attention to permanently prohibited, dangerous, or restricted zones. What should also be considered is the course of existing navigation procedures at the neighbouring airports.

Analysis of ground-level surroundings of the Central Transport Hub

The primary objective of characterising the site and identifying potential construction obstacles is to ensure appropriate horizontal and vertical separation during the design phase, as outlined in safety guidelines [ICAO, 2022]. This involves a thorough understanding of the terrain and surrounding features that may pose risks to aircraft operations or interfere with construction planning and execution.

An analysis of hypsometric maps (Figure 2) provides valuable insights into the topography of

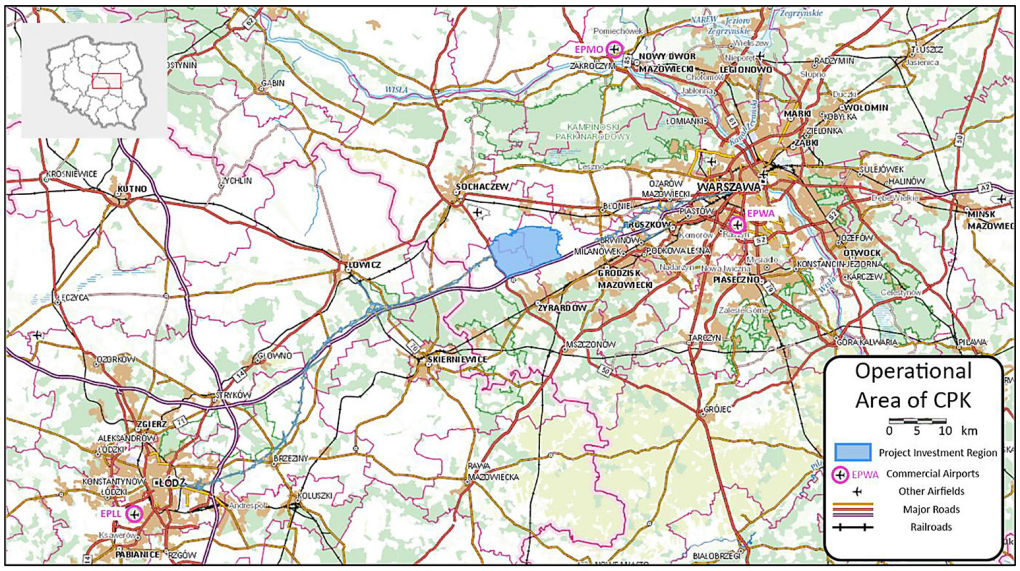

Figure 1. Operational region of the central transport hub, the location of the investment area

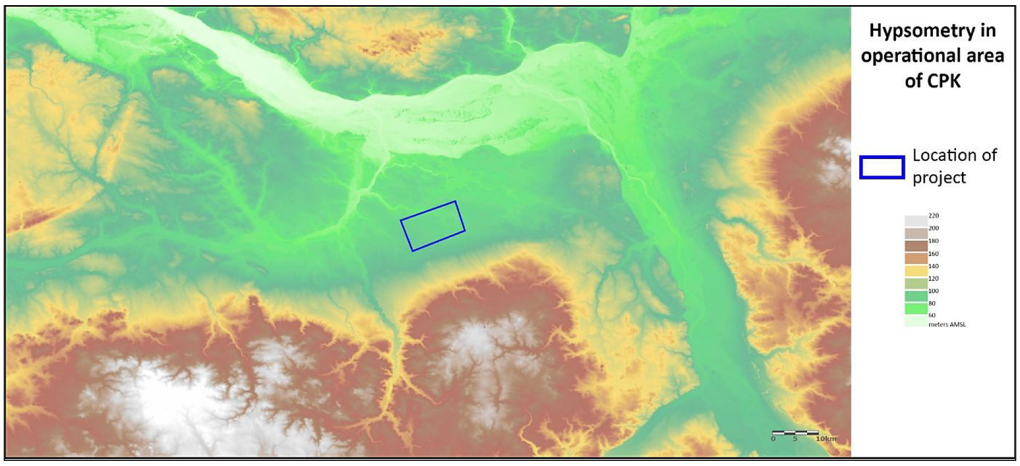

Figure 2. Topography within the CPK operating areas on a coloured hypsometric scale

the Baranów commune, situated in the Central Masovian Lowland, within the Warsaw-Berlin Urstromtal, a formation formed during the Pleistocene glaciations. The area is mainly flat, with gentle hills formed by the accumulation of fluvioglacial sediments and the erosion caused by waters from the Vistula River basin. Elevations within a 50 km radius of the proposed airport range from 60 m to 250 m above mean sea level (AMSL). The lowest areas are found to the north and northeast, along the valleys of the Vistula and Narew rivers. To the west lies the shallow Bzura River valley and its tributaries, where terrain elevation remains below 200 m AMSL. The highest elevations are in the south and southwest, where the northern edges of the Rawa and Piotrkowska Uplands rise to between 200 and 250 m AMSL. Within the airport's designated investment area, elevations range from 90 to 100 m AMSL.

Natural objects that pose a hazard to aircraft, especially during operations performed close to the ground, include trees (a risk of collision under limited visibility conditions) near the area prepared for the construction of the investment project, as well as forest-free farmland and meadows. The Bolimów Landscape Park, located approximately 6 km south-west of the airport, is a significant wooded area that poses a potential physical hazard to air traffic. In addition, when designing the landing and take-off procedures, attention should be paid to individual trees and groves located near the future airport, along the extension of the runway axes, and in protected zones.

One of the significant hazards to aircraft during operations in critical flight phases is the presence of high-rise artificial structures. These include:

- high-rise buildings,
- radio, TV and GSM network masts,
- wind turbines,
- power lines,
- building cranes (of a temporary nature).

It is recommended that all approach, arrival, and departure paths bypass these obstacles, which means that none of them should be in the way of the procedure or within its protection zone. Where this is not possible, it is necessary to provide sufficient obstacle clearance. The PANSA publishes information on permanent structural obstacles (type, location and height) and updates them in the monthly editions of the Aeronautical Information Publication (AIP) [PANSA, 2025a]. They can also be found on the annually published ICAO aeronautical charts. As they contain information on the airspace from ground level (GND) to FL090, their primary purpose is to provide information for pilots performing visual flight rules (VFR). Still, the information they contain can also be used for this analysis [PANSA, 2025a]. Thanks to these publications, it is easy to identify objects that are likely to affect the traffic of aircraft operating from the CPK. The obstacles on those charts are grouped into six categories: general obstacles, high-rise buildings, chimneys, masts, towers, and wind turbines. Each of them has a unique magenta-coloured pictogram, assigned in the proper location of an obstacle. Next to each one, two high values are expressed in the column. The first one above is the elevation above mean sea level of an obstacle or the highest obstacle within a group (height of the object and terrain elevation). The second one below, shown in brackets, is height above ground level – height of the object itself. The exact coordinates of localised obstacles are also mentioned in the AIP VFR published by PANSA.

However, not every object specified above is classified as an aeronautical obstacle. Many of them are not included in aeronautical publications because of their very low impact on flying aircraft (low height of an object, location in inaccessible areas). In terms of effects on the CPK project, we must consider one more object, not mentioned in AIP – the chimney of the former sugar refinery in Guzów village. Its locus in the near vicinity of the project site will have a profound impact on future, critical aircraft operations. Since there are no sources about the height of the chimney in existence, we must perform the measurements ourselves. To examine its height, we used an inclinometer situated exactly 100 m away. The information about ground level elevation above mean sea level was extracted from the National Geodetic Service – geoportal.gov.pl.

After all, we can specify seven significant objects, which can be classified as dangerous for aircraft operating at CPK. Their list is provided in the table below (Table 1).

Another element of the ground analysis is to identify densely built-up areas and environmental protection areas. Power-driven aircraft, which make up the vast majority of airborne vehicles, generate thrust force through the combustion of

Table 1. Aeronautical obstacles for the central transport hub

Obstacle type	Height above ground level	Location coordinates	Description
Chimney	1,119 ft (821 ft)	52°10'31.7"N, 20°44'33.7"E	Chimney of Pruszków CHP Plant
Mast	1,495 ft (1,105 ft)	52°04'21.6"N, 20°53'02.2"E	Mast of RTCN Warszawa-Raszyn in Łazy
Wind turbines	1,144 ft (563 ft)[1]	51°59'11.0"N, 20°31'06.8"E and 51°59'19.4"N, 20°31'16.5"E	Wind turbines of a wind power plant in Mszczonów
Mast	823 ft (460 ft)	52°00'58.3"N 20°13'57.9"E	Mast of the RON radio transmitter in Skierniewice-Bartnice
Chimneys	819 ft (402 ft)[1]	51°58'47.1"N, 20°10'26.9"E and 51°58'30.7"N, 20°10'12.9"E	Two industrial chimneys in Skierniewice
Mast	639 ft (347 ft)	52°06'59.5"N, 19°56'36.8"E	Mast of RCN in Łowicz
Chimney	522 ft (194 ft)[2]	52°07'00.7"N, 20°19'59.8"E	The old chimney belonged to the former sugar refinery in Guzów

Note: 1 – the height of the highest obstacle in the group is provided; 2 – no information in aeronautical publications provided, authors' measurements.

petrol or aviation kerosene in their engines. Naturally, this process inevitably involves emissions of exhaust gases and disturbing noise. The marking out of areas with high population density, as well as strictly protected areas, at this stage will enable the establishment of future procedures in a manner that minimises the adverse environmental impact of air transport.

The emission levels are mainly determined by the type and power of the drive unit, as well as the number of units. Less efficient piston and propeller turbine engines are more economical and generate less noise than turbojet and turbofan engines. Additional noise is also generated by the air resistance of an aircraft, which can be increased in the take-off and landing configuration by the extension of airbrakes, control surfaces, flaps, landing lights, and slots.

Aeronautical designers strive to reduce the aforementioned negative aspects of flight. Each new generation of aircraft brings improvements in engine performance and reliability, as well as reductions in fuel combustion and the intensity of noise generated. Currently, further improvement of these characteristics is one of the most significant challenges for air transport. In the future, the carbon footprint is planned to be reduced by introducing engines powered by alternative fuels, e.g. biofuels or hydrogen. It should be noted, however, that the process of replacing older machines with new ones is lengthy. Even today, we can still encounter units developed in the 1970s that are still in widespread use. This particularly applies to the cargo flight market, where aircraft like the MD-11, B767 or B757 are still in use. This means that the universal procedures for aeroplanes still have to consider the strict environmental regulations established many years ago.

By the category assigned to the CPK, older generation aircraft, i.e. those for which the application for a type certificate was submitted between 6th October 1977 and 1st January 2006, will also be able to operate from the new airport [Horonjeff R., McKelvey F.X., 2010]. In an extreme case of a four-engine aeroplane with a take-off mass greater than or equal to 345,000 kg, the perceived noise level of the flight pass can be as high as 106 effective intensity level (EIL) dB [ICAO, 2017]. The perceptible value decreases with distance. Still, even intensities half as low as those mentioned above can have an adverse impact on health, especially mental health, in the long term [Goines L., Hagler L., 2007]. It is, therefore, reasonable to identify densely populated areas in the vicinity of the CPK (Figure 3):

- Warsaw (with its western districts being particularly exposed) – a population of 1,861,599,
- localities situated along the line of Żyrardów–Grodzisk Mazowiecki – total population of approximately 200,000,

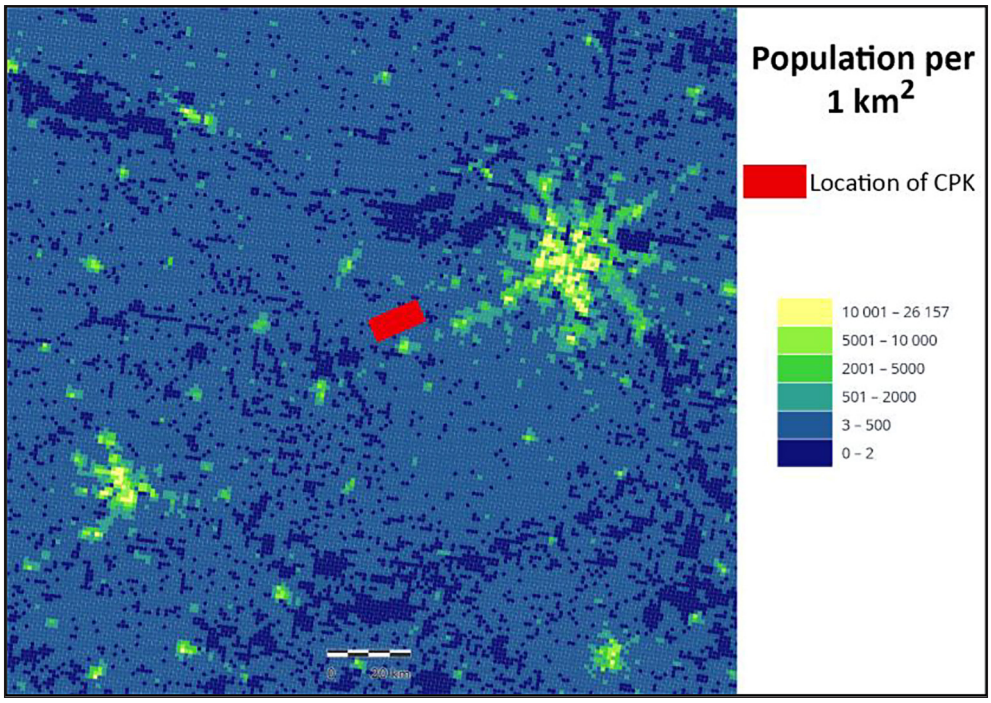

Figure 3. Population density in the CPK region

- Skierniewice – a population of 45,184,
- Sochaczew – a population of 33,698,
- Nowy Dwór Mazowiecki – a population of 28,654,
- Łowicz – a population of 26,099,
- Grójec – a population of 16,758,
- Mszczonów – a population of 6,024.

Overall, air transport can have a negative impact not only on the population exposed to nearby aircraft operations daily, but also on the environment. The natural environment is also vulnerable to the negative aspects of its operation. Regarding flora and fauna, three areas affected by air transport can be identified: the acoustic environment, air quality, and direct physical hazards. The first of these concerns wildlife and is identical to the problem of protecting the public against noise described above. It should be emphasised that the impact of high noise levels and their effects vary depending on the species, with the most significant impact being exerted on animals with a range of sensitivity and audible frequencies similar to, or greater than, those of humans, namely birds and mammals. When comparing humans to wild animals, the impact of human-generated noise (which includes the sounds generated by aircraft) can cause severe disturbances. These include elevated stress levels as well as behavioural disorders and hearing loss. Their adverse effects include, e.g., the avoidance of certain areas by animals, their reluctance to settle, eating disorders, reluctance to reproduce, social problems, impaired recognition of danger, the disappearance of self-preservation instinct and, consequently, greater exposure to predator attacks [Erbe C., Thomas J.A., 2022].

The second problem is air pollution, which affects both fauna and flora. Aircraft with a drive unit generate combustion products. Ground operations, as well as take-off and landing operations, together account for approximately 10% of all exhaust gases emitted during the entire flight. Still, they have a greater impact on the local environment on the ground, particularly at large airports. In addition to carbon dioxide and carbon monoxide, exhaust gases from aircraft engines contain sulphur oxides (SOx), nitrogen oxides (NOx), hydrocarbons (HC), particulate matter (PM) and carbon black. At high concentrations, all of them can lead to respiratory disorders, neoplasms, and even death in both humans and animals. A change in the air composition also alters the ecosystem. For example, the presence of sulphur compounds can cause the dieback of susceptible plants, which, in the long term, disrupts the entire food chain in a particular area [Rupcic L. et al., 2023].

The third aspect of the environmental impact of air transport is the hazard arising from the physical presence of an aircraft in the air, which primarily affects birds and flying mammals. It is worth emphasising at this point that this is a two-way hazard because a collision between an animal and an in-flight aircraft almost always results in the death of the animal and is likely to cause severe mechanical damage to the machine. Such incidents during critical flight phases can be hazardous, as evidenced, for example, by the accident of US Airways Flight 1549, when an A320, after taking off from New York's LaGuardia Airport (ICAO: KLGA), collided with a flock of Canadian Geese at an altitude of 2,800 ft. The collision caused damage to the blades and the core of two engines, which, at that flight stage, meant the need for an emergency landing on the Hudson River [NTSB, 2010]. In this case, there were no fatalities, which, unfortunately, is not always the case. According to Federal Aviation Administration (FAA) estimates, more than 305 aircraft were destroyed in animal strike accidents in the United States alone between 1990 and 2022, resulting in a total of 464 fatalities [FAA, USDA, 2023].

For the reasons mentioned above, we can summarise that bypassing nature conservation areas when establishing airport-related procedures has two basic purposes: to minimise the adverse impact of air transport on the natural environment and to ensure the safety of aircraft themselves. Therefore, we must focus on existing environmental protection areas in Masovia. In the case of the CPK, attention should be paid to the following areas, summarised in Table 2.

Airspace analysis around the central communication hub

Poland's airspace is subject to the division standards as established by the ICAO. This means that it is divided into controlled (A, B, C, D, E) and uncontrolled (F, G) zones. There are seven airspace classes, which differ in the methods used to ensure separation, accessibility, and the type of air traffic control service, as well as visibility-related restrictions, speed limits, and the requirements for maintaining radio communication [ICAO, 2018]. The basic classification of

Table 2. Environmental protection areas within the CPK operational area

Name	Location in relation to the CPK	Description
Kampinos National Park	15 km north-east	National Park, one of the world's UNESCO biosphere reserves, is a Natura 2000 area. A total of 5000 ha is strictly protected, and 28,000 ha are actively protected areas. The place of bird nesting, as well as the habitats of endangered species.
Bolimów Landscape Park	5 km south-west	Many strictly protected reserves and Natura 2000 areas are birthplaces for approximately 130 bird species.
Nadarzyński and Sękociński Forest	25 km east	Two forests within the Warsaw agglomeration, as well as several protected reserves.
Młochowski Grąd and Młochowski Łęg Nature Reserves	25 km south-east	A total of 24 ha is in strict protection reserves. Protection of 130-year-old trees.
Skulski Las i Skulskie Dęby Nature Reserves	23 km south-east	347 ha of protective areas in total. Nesting places for many bird species.
Radziejowice Forest	13 km south	Forest areas with present endangered flora.
Chojnów Landscape Park	45 km south-east	11.5 ha in total of strictly protected areas. Endangered flora present.

airspace in Poland is based on the division into two zones: an uncontrolled zone of class G, from GND to FL095, and a controlled zone of class C, from FL095 to FL660 [PANSA, 2025a]. In the airspace divided in this manner, local areas of different courses can be identified. The zones, characterised in this way, have their horizontal and vertical boundaries. The most common example of this is the controlled areas surrounding controlled airports, which enable the organisation of air traffic and communication with aircraft of classes lower than FL095. In civil aviation, two such airspace elements can be distinguished:

- control zone (CTR) – a controlled zone of an airport, which includes airspace controlled outside the controlled area, which stretches from the land or water surface to a specified upper limit.
- terminal control area (TMA) – a controlled zone of an airport (or a junction), which includes part of the controlled area usually established at the intersection of airways in proximity to a single airport or several (junctions) airports.

The primary task of both the elements above is to establish separate areas subject to greater control by the ATC, thereby increasing safety within the airspace around the airport and ensuring the provision of the appropriate type of air traffic service. It should be emphasised that all instrument flight rules (IFR) airport-related procedures must be performed in their entirety in controlled zones (Figure 4). Therefore, in the case of the CPK, it will be necessary to change the structure of Warsaw's airspace by adding a CTR zone belonging to the new airport and creating or modifying the existing TMA zone.

Examining the information published by PANSA in the AIP, one can identify the appropriate TMA and CTR zones currently present in the CPK region's airspace [PANSA, 2025b].

Other permanent zones separated from the basic division of Poland's airspace include P

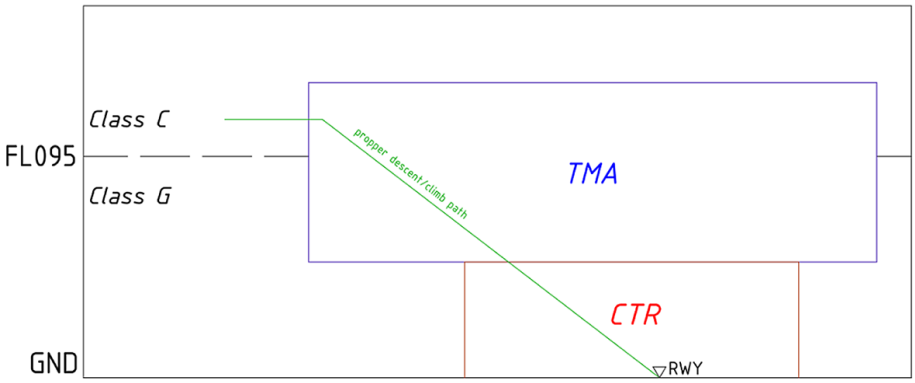

Figure 4. Diagram of the proper aircraft descent/ascent in Poland's airspace

(Prohibited) zones, D (Dangerous) zones and R (Restricted) zones [PANSA, 2025c]. The performance of air operations in them includes: completely prohibited (P zone); permitted, provided that the aircraft meets specific technical standards (R zone) or permitted with special attention paid to the dangers present in it (D zone). It is prohibited to carry out airport-related navigation procedures through these zones, as it may expose aircraft to danger. These zones may result, for example, from the location of industrial plants that emit flammable gases, which are likely to undergo a sudden reaction in jet engine chambers, military training areas, or areas designated for environmental protection. By browsing the current (January 2025) data published by the PANSA, one can determine the following airspace areas [PANSA, 2025a] (Table 3) (Figure 5).

The final stage of this analysis will be to establish collision avoidance navigation procedures for the airports neighbouring the CPK. It has previously been determined that, to achieve commercial success for the entire project, it would be necessary to close down the existing Warsaw Chopin Airport (ICAO: EPWA). The area of this airport is situated within the strict urban boundaries of Warsaw, near its centre, making it extremely attractive for developing a new residential and commercial district. For the purposes of this paper, it will therefore be assumed that Warsaw Chopin Airport would be entirely closed for air traffic, which entails the elimination of all associated aeronautical procedures. It should be noted that this assumption is hypothetical and used solely for the purpose of this analysis. The final decision regarding the closure of EPWA has not yet been confirmed at the political or economic level. This means that, at this point, we should take a closer look at the IFR procedures of three regional airports: Nowy Dwór Mazowiecki (ICAO: EPMO), Radom (ICAO: EPRA), and the Łódź Airport Central Poland, formerly known as Łódź Lublinek Airport (ICAO: EPLL), located approximately 80 km southwest of the CPK. Based on the Polish AIP, the following navigation procedures can be distinguished [PANSA, 2025a] (Figures 6 and 7).

All of the procedures above are radio navigation procedures, which means that their performance requires appropriate aircraft equipment, namely Global Navigation Satellite System (GNSS) antennas and VOR/DME receivers integrated with the aircraft systems. Due to the inaccuracy of these instruments, procedures also have primary and secondary protection zones, in addition to the designated paths and vertical restrictions at individual points. The paths shown in the diagrams are the central axes of wider zones, the cross-sectional diameter of which is usually 10 NM (nautical mile) but can be up to 16 NM (en route width) [ICAO, 2022].

In addition to the standard instrument departure (SID) and standard terminal arrival (STAR) procedures for neighbouring airports, it is worth reviewing the broader aspects of Poland's airspace structure. Air traffic in Poland is conducted along strictly defined air corridors that connect individual navigation points. The SID and STAR procedures start or end precisely at this point. Each airway has its unique name comprising a letter and one, two or three digits. Two types of them are distinguished: one-way and two-way. Additionally, each of them has its operational altitude range, reaching a maximum of FL660. Marking out and managing airways in Poland is the responsibility of the PANSA. In the documentation it makes available, one can find a comprehensive list of these, along with a detailed description of their course and characteristics [PANSA, 2025a].

DISCUSSION

The surroundings of an airport have an impact on its functioning, primarily in the context of the traffic of aircraft using the airport. Both analyses showed the operational environment of Poland's future airport hub.

As regards the characteristics of the topography around the CPK location, it can be concluded that it is not a mountainous area. The hilly terrain can affect the shape and complexity of landing, departure and arrival procedures. Consequently, this has a negative impact on the operational efficiency of the entire airport. Examples of such airports include Innsbruck Airport (ICAO: LOWI) in Austria and Paro International Airport (ICAO: VQPR) in Bhutan. In addition, in extreme cases, special training is also required for the crew in the field of performing take-offs and landings at a particular airport. The location of the CPK in an area with previously specified characteristics will have no negative impact on its construction or future operation, nor will it require operators to incur additional operating costs. The flat stretches of land and the lack of terrain obstacles provide a

Table 3. Restricted airspace zones within the CPK operational area

Type of zone	Official identification name	Vertical boarders	Description
P (Prohibited)	EEP19 Włocławek	GND – 2,700 ft	Nitrogen processing plants, the presence of flammable suspensions
	EPP7 Płock	GND – 3,000 ft	Płock oil refinery, the presence of flammable suspensions
	EPP21 Warszawa II	GND – 2,000 ft	Warsaw downtown is a concentration of high-rise buildings
	EPP9 Warszawa	GND – 1,000 ft	Government administration buildings
	EPP10 Świerk	GND – 2,700 ft	Nuclear reactor at the Nuclear Research Centre
	EPP18 Emów	GND – 2,700 ft	Government administration buildings
	EPP28 Kozienice	GND – 1,300 ft	Kozienice coal power plant, the presence of flammable suspensions
	EPP1 Pionki	GND – 3,500 ft	Ammunition factory, the presence of flammable suspensions
	EPP3 Puławy	GND – 5,000 ft	Nitrogen processing plants, the presence of flammable suspensions
	EPP14 Skarżysko Kamienna	GND – 5,000 ft	Ammunition factory, the presence of flammable suspensions
	EPP29 Legionowo	GND – 1,000 ft	Government administration buildings
R (Restricted)	EPR12 Kampinoski Park Narodowy	GND – 3,800 ft	Environmental protection area, prohibition of powered aircraft flights
	EPR42 Sochaczew	GND – 3,500 ft	Sochaczew-Bielice airport region
	EPR41 DORSZ	GND – 700 ft	Military administration buildings, no flights allowed without authorisation
D (Dangerous)	EPD30Z Rembertów (Zielonka)	FL195 – FL300	Protective zone of a military training ground, structure for flight planning purposes, active together with zone EPD30
	EPD30 Rembertów (Zielonka)	GND – FL296	Military training ground zone, flights prohibited without authorisation when active
	EPD36Z Jagodne	FL095 – FL115	Protective zone of a military training ground, structure for flight planning purposes, active together with zone EPD36
	EPD36 Jagodne	GND – FL115	Military training ground zone, flights prohibited without authorisation when active
	D-Rembelszczyna	GND – 2,100ft	Gas compressor station, possibility of flammable suspensions in extreme cases
	D-Wloclawek	GND – 1,200ft	Gas compressor station, possibility of flammable suspensions in extreme cases
	D-Wronow	GND – 2,300ft	Gas compressor station, possibility of flammable suspensions in extreme cases

wide range of freedom in adapting future operational procedures for the airport.

The total number of specific aviation obstacles is relatively low. Of those listed in Table 1, the chimney in Guzów, which is located in the immediate vicinity, should be given the most attention. If no appropriate and safe separation can be ensured during the landing approach, it may become necessary to demolish the chimney. In the second instance, the focus should be on the structures located slightly further away from the airport itself, in particular the chimney of the Pruszków CHP plant and the Łowicz longwave transmitter mast, as they are located at a distance at which aircraft using the CPK will maintain a lower altitude.

It follows from the ground-based part of the analysis that the occurrence of the environmental and noise protection areas represents the most significant limitations in aircraft traffic. This is particularly the case to the east of the CPK, where one of the most densely populated and urbanised areas of the country, namely the Warsaw metropolitan area, is located. Protection against aviation noise should be considered when marking out the airport navigational procedure routes. An additional impediment in this case is the presence of strictly protected areas, particularly extensive stretches

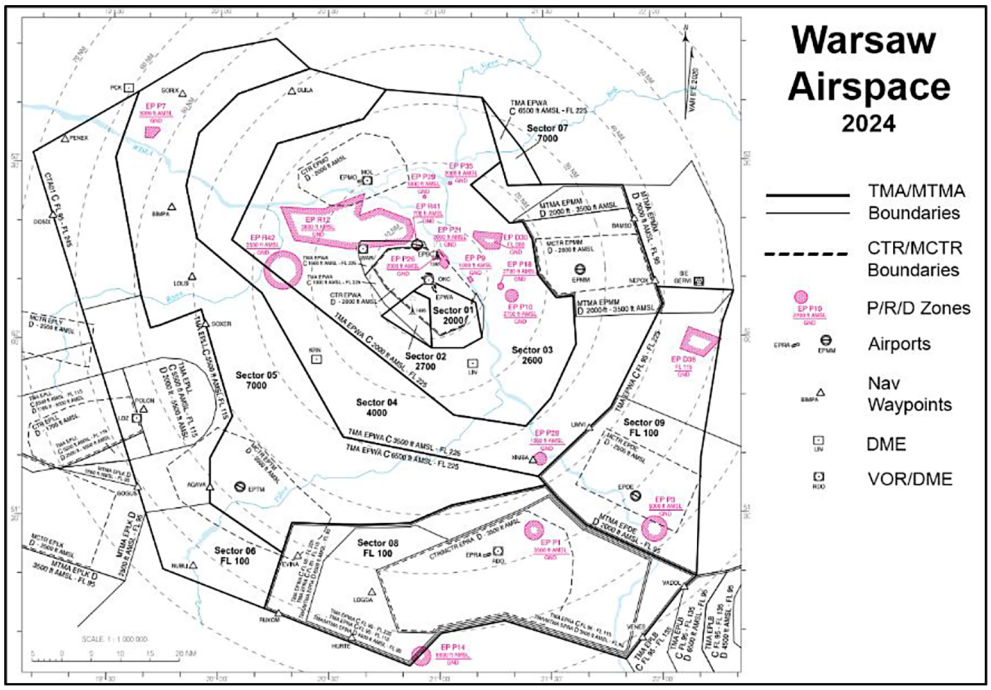

Figure 5. A map of Warsaw's airspace

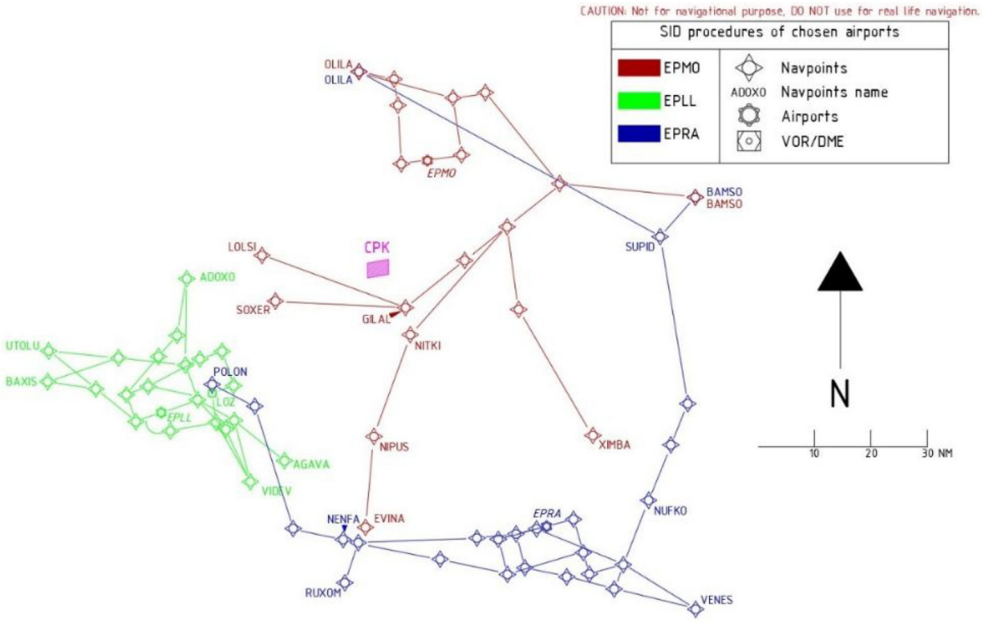

Figure 6. Diagram of departure SID procedures for the EPRA, EPMO, and EPLL airports (CPK investment area shown in magenta)

of the Kampinos National Park and the Bolimów Landscape Park reserves, situated near the airport.

Compared to other regions of Poland, the airspace structure in this area is rather complicated. The large number of airports in the area results in the concentration of CTRs and the division into sizable TMAs. There is no doubt that if another airport is built, the layout of the Warsaw-Łódź airspace will change as well. However, from the perspective of the CPK's functioning, an even greater problem may be posed by the concentration of navigational procedures at other airports in the region, which are intended to operate in parallel (EPLL, EPMO, and EPRA).

Regarding the presence of airspace zones with restrictions, there is a significant number of them within the CPK operational area. This is primarily due to the concentration of industrial plants,

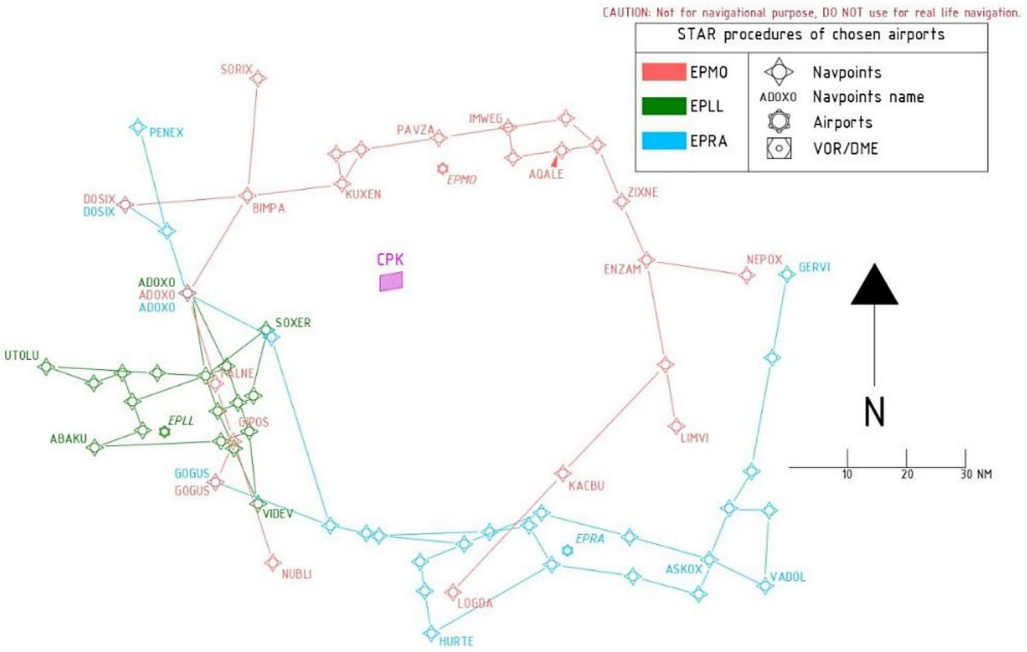

Figure 7. Diagram of arrival STAR procedures for the EPRA, EPMO, and EPLL airports (CPK investment area shown in magenta)

critical state infrastructure, and government administration buildings. It should be noted, however, that most of these zones are small in terms of surface area, have low altitude restrictions, and sometimes overlap with the previously established environmental protection areas or densely populated areas. Therefore, in this respect, particular attention should be paid to the D zone of two military training grounds located east of the Vistula River (EP30, EP30Z, EP36, and EP36Z), as they have a large area and a wide range of vertical boundaries.

CONCLUSIONS

The established location of the Central Transport Hub favours the achievement of the basic economic assumptions of the entire project. Based on the analysis conducted, it can be concluded that the surroundings of the new, largest airport in Poland are conducive to its uninterrupted and efficient operation on a 24/7/365 basis. The lack of major obstacles (both on the ground and in the airspace), favours the flexible adaptation of navigation procedures, maintaining a balance between efficient and economical aircraft traffic and the environmental impact of air transport. The least design freedom is expected in the eastern and north-eastern directions. At this point, it is essential to consider highly urbanised areas, restricted airspace zones, and strict nature reserves. Nevertheless, it is entirely possible to connect the CPK to the country's airway network in these directions. To summarise all the aforementioned aspects, it can be concluded that the surroundings of the CPK will not have a negative impact on the future functioning and implementation of the strategic objectives of the airport component of the project. It is possible to implement a sustainable transport development strategy, i.e. minimising the negative impact of aircraft traffic operating from the CPK while ensuring its cost-effectiveness, ergonomics and safety.

Finally, it should be emphasised that similar studies and analyses need to be carried out in the future. Airports themselves share the same characteristics as the infrastructure of other means of transport, i.e., long implementation and operation times. Over several years of construction and operation, the surrounding environment is likely to undergo significant changes. The most dynamic changes may occur within the airspace structure and in the context of increasing the urbanisation level of the Warsaw metropolitan area (considering the investment attractiveness and the continuous, positive balance of migration for this region of the country). The key to the smooth and sustainable development of the project, as well as ensuring the cost-effectiveness and safety of air traffic, is to monitor changes taking place in the airport's operational area.

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