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Ecological Air Tourism in the System of Environmental Engineering

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Abstract. The study considers the role of ecological aviation tourism as a direction of the national and world economy, reveals the interpretation of the concept of «ecological aviation tourism», its main types and investigates the conceptual provisions on which this type of tourism is based. Passenger and freight traffic for the period 2019-2021 is considered and it is determined that against the background of lifting or easing of anti-epidemic restrictions by many countries and the success of the vaccination process, there was a gradual increase in demand for air transport services, especially during the «active» tourist season, which contributed to an improvement in the air transport market. According to statistics for 2021, the number of passengers transported by domestic airlines was 9348.1 thousand passengers, which is almost 95% more than in 2020 and 68.2% of the volume of the «pre-pandemic» 2019. The article analyzes air pollution by harmful substances from aircraft engines, which make up 87% of all civil aviation emissions. The article considers the "European Green Course: opportunities and threats for Ukraine" was considered, which defines 10 main goals for improving the environmental efficiency and sustainability of airlines at the global level.

1. Introduction

The aviation industry creates a million jobs, transports billions of passengers, and makes a significant contribution to the global economy. Aviation is one of the most important technological breakthroughs in history. Despite the constant challenges facing airlines, the industry is finding new solutions in the field of environmental protection. This is where environmental engineering comes in, which involves the design, development, operation and use of cost-effective methods and measures to minimise pollution and risk both for human health and the environment.

After the total suspension of air traffic in 2020, transportation is gradually being restored. According to statistics, aviation employs 65.5 million people worldwide, including 10.8 million jobs such as parts and component manufacturers. More than 4.5 billion passengers were transported by airlines worldwide in 2019 and received a total revenue of 550 billion dollars [1].

The implementation of the principles of sustainable development makes ecological air tourism more and more relevant every year. This goal has found its realization in the development of ecological aviation tourism, which will allow preserving the environment and reducing anthropogenic pressure on the natural environment. That is, ecological air tourism is a sustainable ecologically balanced tourism, the description of the development of ecological air tourism in the system of ecological engineering is relevant.



2. Theoretical framework

The studies of the ecological state of the planet as a whole remain open and relevant even today. In the conditions of information and technical development, humanity suffers from excessive pollution of the environment - air, water and land resources. Not least civil aviation poses a real threat to the atmosphere, it concerns emission pollution and the creation of "holes" in the ozone layer.

According to studies [3], the operation of air transport is characterized by noise and emissions of various substances. The high flight altitude of the aircraft allows combustion products to diffuse into the atmosphere and spread over a larger area.

Studying the study [4], it should be noted that there is an urgent need to improve the environmental properties of aviation fuel by improving its quality. The environmental characteristics of fuel can be improved by reducing the content of sulphur, aromatic substances (especially benzene), resins, olefins and lead. And by adding appropriate additives, such as ionol.

After numerous experiments, the authors concluded that Ukraine's transition to Jet A fuel is associated with the rational use of petroleum products that do not change the environmental characteristics of the fuel unless changes are made to the combustion chamber.

With the endless growth of people's attention to the environment and the growing awareness of environmental protection, ecological air tourism has become more and more common, which has led to many environmental, socio-economic problems in air tourism. [5-8].

The purpose of the article is to reveal the modern concept of ecological air tourism, the development of the basic principles of aviation ecotourism in the system of environmental engineering.

3. Results and discussion

The current economic situation makes it possible to position the tourism industry as the most important sector of the national and world economy, characterized by high incomes and intensive development. The reasons for the high profitability and growth rates of the tourism industry are the high demand for various types of travel and the profitability of tourism products and services. In most countries of the world, the tourism industry helps to stimulate not only economic, but also the social functioning of the region and ensures an increase in revenues to the state budget [9].

One of the most promising areas of tourism is ecological tourism in the system of environmental engineering, which represents a form of sustainable tourism focused on visiting natural territories relatively untouched by anthropogenic influence.

The development of ecological air tourism is due to the presence of a number of factors, which are a combination of natural and anthropogenic factors (Fig. 1).

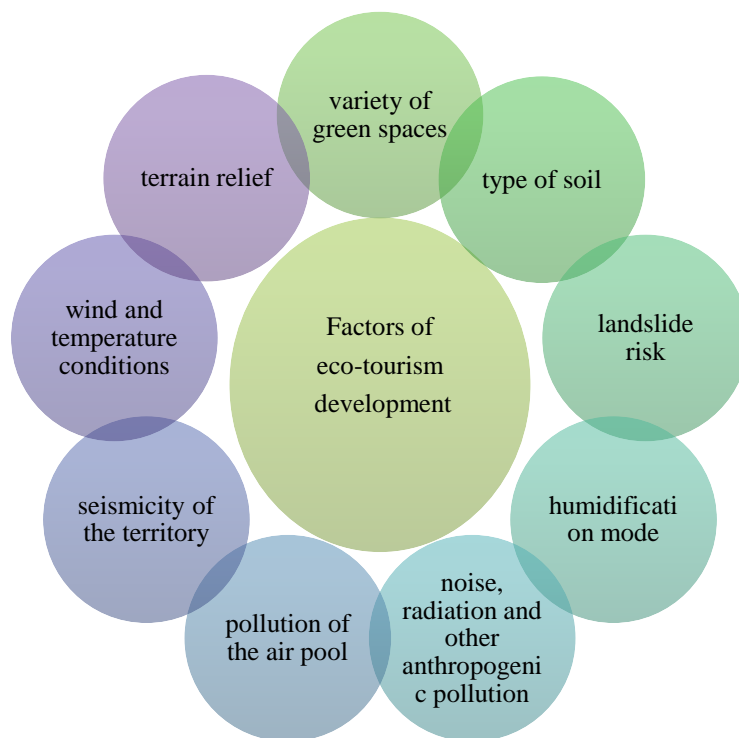


Fig. 1. Factors of environmental development

Ecological tourism in the system of environmental engineering includes such forms of tourist activity as agritourism, mining and recreational tourism, in some cases - health and wellness tourism, historical and local history tourism, ethno-ecological tourism, green tourism, air tourism and other types of tourism [12].

Agritourism is a relatively new area with high development potential. This type of tourism includes tourism in rural areas, hunting tourism, and equestrian tourism. The development of agricultural tourism, which involves tourists staying in rural areas on farms and cottages, is most typical for Western Europe, the USA, and countries with high rates of agricultural land development. The advantages of this type of eco-tourism are the absence of any costs for infrastructure, resources, and comfortable stay of tourists in the presence of established hospitality traditions in the host region.

Hunting tourism, which includes hunting for game animals, birds and fish, is a fairly developed form of ecotourism.

In regions with appropriate natural conditions, mountain recreational tourism is a fairly developed area, including mountain tourism, ski tourism, mountaineering, snowboarding and other types of tourist activities.

The environmental focus of health tourism can be seen in regions that have a health resort base in environmentally favourable and sometimes even unique areas, such as mineral water deposits.

The study of various aspects of historical interaction between humans and nature is devoted to historical and local history tourism, which involves tourist products and services related to visiting cultural and historical sites, including urban planning objects, historical, architectural and cultural monuments [13].

Ethno-ecological tourism involves the study of the life of certain ethnic groups, their origin, language, culture, territory of residence, demographic characteristics, and the peculiarities of building relationships with the natural environment in real time. First and foremost, we are talking about small ethnic groups living in harmony with the natural world.

In recent decades, tourism and recreation have become one of the leading sectors of the global economy, and are a crucial part of the national economy and a source of wealth for many countries around the world. In today's globalised world, the ability to move quickly is an urgent need and a key condition for the functioning of these areas. Aviation transport connects different cities and continents, thereby contributing to the functioning of tourism. Therefore, one of the types of tourism is air tourism.

For Ukrainian airlines, 2001 was the first year of gradual recovery after the decline in indicators in 2020, caused by the consequences of the Covid-19, related restrictions.

Table 1. Analysis of the functioning of the Ukrainian aviation industry in 2020-2021 [14]

	Units measurement	in total			including international ones		
		2020	2021	% 21/20	2020	2021	% 21/20
Activities of airlines							
Transported passengers	thousand people	4797,5	9348,1	194,9	4287,7	8622,3	201,1
including on regular lines	-,-	1788,1	3322,7	185,8	1284,6	2608,9	203,1
Completed passenger kilometers	billion pas. km	10,1	18,7	185,1	9,8	18,4	187,8
including on regular lines	-,-	3,1	5,6	180,6	2,9	5,2	179,3
Commercial flights have been made	thousand	45,3	74,0	163,4	35,3	59,9	169,7
including on regular	-,-	20,4	34,4	168,6	11,8	21,9	185,6
Dispatched and arrived aircraft	thousands of units	94,0	152,4	162,1	69,0	117,6	170,4
including on regular lines	-,-	58,6	96,2	164,2	41,7	71,7	171,9
Passenger flows	thousand people	8664,5	16221,0	187,2	7628,9	14753,8	193,4
including on regular lines	-,-	5643,5	10172,7	180,3	4627,2	8738,3	188,8
Mail cargo flows	thousands of tons	52,2	63,2	121,1	51,5	62,5	121,4
including on regular lines	-,-	40,8	52,5	128,7	40,4	51,9	128,5

In 2021, 28 Ukrainian airlines performed passenger and cargo transportation, making a total of 74,000 commercial flights (compared to 45.3 thousand flights in 2020) (Table 1) [14].

In 2021, as many countries lifted or eased anti-epidemic restrictions and the vaccination process was successful, there was a gradual increase in demand for air transport services, especially during the «active» tourist season, which contributed to an improvement in the air transport market. According to statistics, in the reporting year, the number of passengers carried by domestic airlines amounted to 9,348.1 thousand, which is almost 95% more than in 2020. and 68.2% of the volume of «pre-pandemic» 2019.

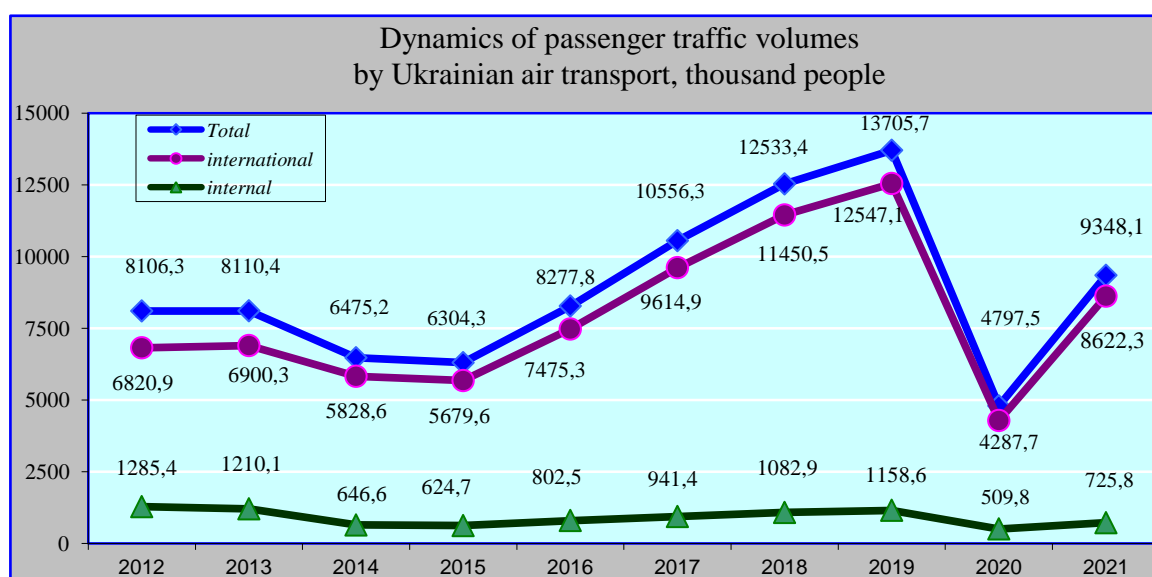


Fig. 2. Dynamics of volumes of passenger transportation by air transport of Ukraine, thousand people

In 2021, 16 Ukrainian airlines operated passenger services, with four leading airlines accounting for almost 93 per cent of the industry's total: UIA, SkyUp, Azur Air Ukraine, and Windrose. It should also be noted that the fifth position in terms of passenger traffic was taken by Biz Airline, which started operating flights in March of the reporting year (Fig. 2) [15].

In accordance with the approved schedule, 9 domestic air carriers (including the new airline Biz Airline) operated regular flights to 42 countries of the world. The number of passengers transported by Ukrainian airlines during 2021 doubled compared to the previous year and reached 2,608.9 thousand people. The number of passengers carried on international regular flights of Ukrainian airlines increased by 6.2 percentage points to 75.2% [16].

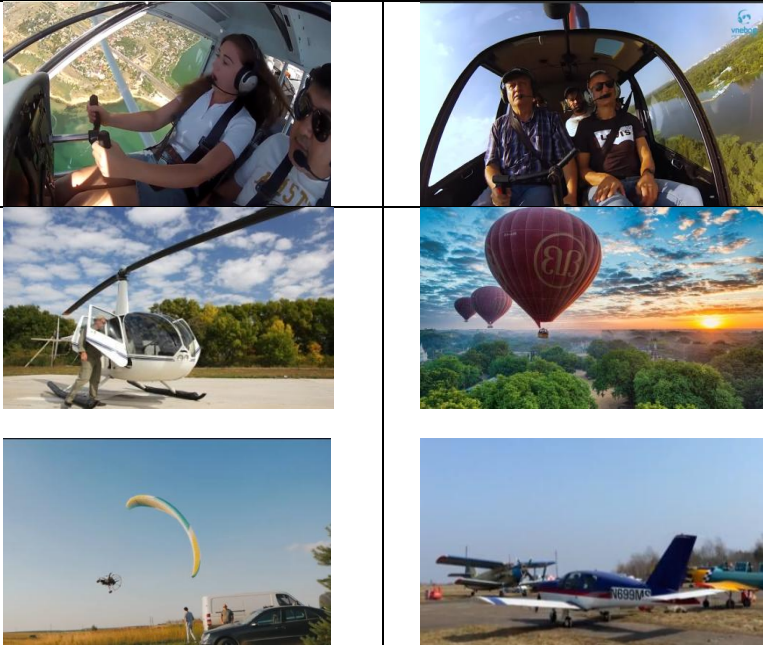
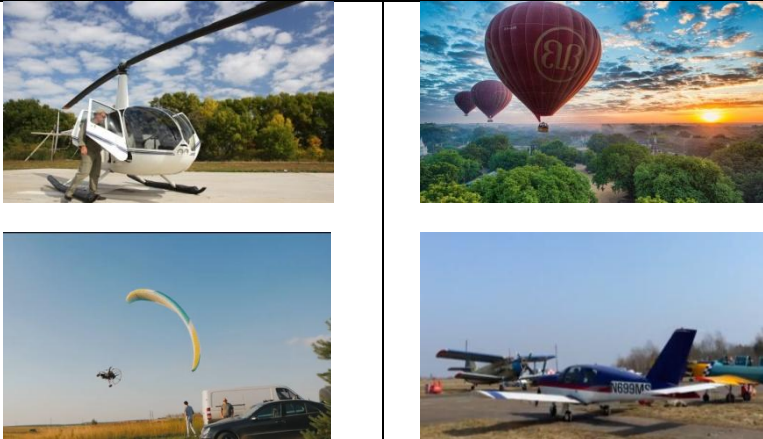
Thus, regular flights to Ukrainian airports from 34 countries of the world were carried out by 29 foreign airlines, including four new ones (Cyprus Airways, the air carrier of the Republic of Cyprus, Flynas of Saudi Arabia, Eurowings, Ryanair UK). The volume of international scheduled traffic carried by foreign airlines increased by 83.4 per cent to 6096.8 thousand passengers, which is 70 per cent of the total volume of regular passenger transportation between Ukraine and the world [17].

Aviation tourism is becoming more and more widespread every day, and the aeroplane has become a commonplace for many people.

Aviation tourism is an entirely new area of tourism that allows anyone to travel by becoming a pilot of an aircraft or other air transport. Aviation tourism has developed significantly in recent decades. Aviation tourism is extremely popular in many countries in Europe, America and Australia.

Aviation tourism is a type of tourism based on flights on light aircraft, such as hang gliders, paragliders, motor gliders, motor paragliders, etc. An important advantage of light aircraft is their low speed, which allows you to safely view architectural monuments and picturesque corners of nature from the air (Table 2) [18].

Table 2. Areas of air tourism

Air tourism destinations	
<p>Extreme recreation. When a tourist is going to sit at the controls of a plane or fly a helicopter, paraglider or other aircraft on their own.</p>	
<p>Charter holidays. The purpose of such a holiday is to visit as many tourist destinations as possible in a short time. Aviation equipment is used exclusively as a means of transport, without extreme bias. As for the aviation vehicles themselves, they can be: an aeroplane, a helicopter, a paraglider, a hot air balloon.</p>	
<p>The purpose of of air tourism</p>	<p>satisfying the interests of citizens to be involved in aviation culture, knowledge and activities in accessible and mass forms inherent in ultralight aviation; expanding the scope and capabilities of traditional tourism, making fuller use of the specific capabilities of ultralight aircraft; solving the relevant statutory and programme tasks of air tourism.</p>
<p>Tasks of air tourism</p>	<p>flights with air tourists on excursion routes; professional orientation of young people to aviation specialities, initial training of observer pilots, operators, navigators and candidates for flight training; involvement of the population in new forms of socially useful leisure activities; promotion of air tourism and air excursions using light aircraft as a new type of aviation activity and services for the mass consumer.</p>

Currently, anyone with sufficient funds can fly any type of aircraft. Such a flight program includes a pre-agreed route and destination.

In recent years, aviation tourism has been actively developing in various parts of the country, facilitated by a large number of airfields and aircraft, and, of course, the potential of the land [13].

Aviation tourism is becoming one of the real incentives for tourism development in regions.

Light aircraft can also be useful for social tourism, such as tourism for the disabled. Many people who are unable to move around on their own could take to the skies in such aircraft and in a short time see areas inaccessible not only from a wheelchair but also to an ordinary pedestrian or car tourist.

Aviation tourism is the best investment in human health, new and unforgettable impressions [9].

The human dream of flying became realisable after the advent of the aeroplane, and tourism has since moved to a qualitatively new level. But in addition to being on board this aircraft, many people dream of taking the pilot's seat. To do this, it is not necessary to change your specialisation. You can arrange an unforgettable holiday where, after a special briefing, you can sit down and fly.

Light aircraft have always been very popular for air tourism. But recently, military aircraft have begun to attract a lot of interest. For example, one of the German companies (Alpha Travel) has started to provide military equipment. It offers to fly on a legend of the Second World War – an aircraft called Junkers. The program consists of several stages:

pilot training on these simulators for professionals.

flying on lightweight types of aircraft.

flying at the helm of a military combat vehicle.

It is especially interesting that there are only 5 such aircraft in the world that are in good condition after the events of many years ago. Therefore, all those who want to fly on Junkers military equipment are not random people.

In Ukraine, the following types of aircraft are offered to fly: AN-2; Yak; SK-12 Orion. The latter is a seaplane, meaning it can both fly and stay on the water. That is why flying on it costs five times more than on ordinary tourist aircraft. Piloting an aircraft or being part of its small crew is a lot of fun and saves a lot of time [16].

As far as this type of transport is concerned, helicopter flights are often cheaper than air travel. In post-Soviet countries, you will be offered to fly the following helicopter models: R-44; AS-355; twin-engine: U, MI and AS. An MI-8 helicopter can accommodate up to 22 people, but in this case, the visibility of the flight will be minimal. Therefore, if you use a helicopter exclusively as a means of transport, this option is quite suitable, because it is also the most cost-effective. But if you are going on an aerial tour, choose a helicopter with a capacity of 3 to 5 people. Such a tour will cost three times more, but you will get much more emotions from it.

This type of holiday is most suitable for lovers of outdoor activities and romance. This type of recreation is considered to be extremely romantic and spectacular, and is safe for human life. But while in many countries ballooning is already generating considerable revenue for businesses, Ukraine is only just becoming aware of this opportunity and creating certain initial organisational conditions.

This is an adventure that allows you to feel like you're in free flight, feel the adrenaline and soar high above the ground. Any time of the year is suitable for such a flight. The only limitation may be a strong wind with a speed of more than 8m/s or rain. Most often, flights take place with an instructor, but if you already feel experienced and confident in the air, you can take permission to take to the skies on your own. To do this, you need to complete a special course of theoretical and practical training. It's nothing complicated, but you'll enjoy flying much more afterwards.

Such flights are simply unforgettable, because they resemble a journey through the clouds. There are the following rules for such tourism: wind no more than 3m/s; no thunderstorms or precipitation; in summer, you can fly only 2-3 hours before sunset or in the first 2-3 hours after sunrise; in winter, you can fly while it is light outside and the air temperature is not lower than 13°C; a balloon basket usually accommodates 2-4 people; there are no weight restrictions. Such flights are safe and beautiful.

The balloon business can be developed in two directions: tourism and advertising. At the moment, balloonists receive the main dividends from the latter. Free ballooning has been used for tourist purposes, but now this niche is unoccupied and very attractive for investment.

Ukraine has all the conditions for the formation of free tourist ballooning, especially natural ones. Places such as the Carpathians, the cities of Kyiv and Lviv, which are beautiful historical sites, Kamianets-Podilskyi (with the possibility of flying under the bridge), Askania-Nova, etc. are considered promising. Today, there are 20 hot air balloons in Ukraine (for comparison, there are 6,000 in Germany and 400 in the Netherlands) [20].

A nice bonus of aviation tourism is the opportunity to jump with a parachute from an aircraft or any vehicle. This way you can add new unforgettable emotions to your holiday.

Aircraft pollute the atmosphere by emitting harmful substances from aircraft engine exhaust gases.

Gases produced by aircraft engines make up 87% of pollution from civil aviation [22]. There are such components of aircraft engine gases that pollute the atmosphere [23]: sulphur oxides SO_x; nitrogen oxides NO_x; carbon monoxide CO; hydrocarbons that have not been fully combusted, HCU; aldehydes; soot.

The ecological version of the summation of gaseous substances makes it possible to determine the percentage of a particular substance in the total mass of emissions of standardised gaseous substances (Fig. 3) [24, 25].

When a plane takes off, about 50% of emissions containing heavy metals are dispersed in the area around the airport. The rest is first in the air, then settles on the ground.

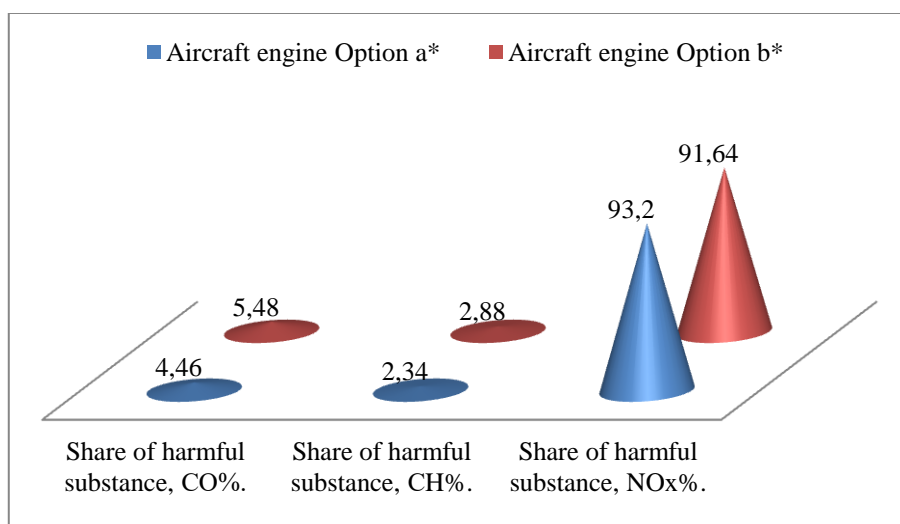


Fig. 3. The share of individual harmful substances in the total mass of emission at a level of increase of P100 by 10

* ICAO standards [24]:

- for engines, the first serial sample of which was produced on or before December 31, 1995, as well as for engines, individual copies of which were produced on or before December 31, 1990;
- for an engine type or model of which the first serial example was produced on or before December 31, 1995, and of which a specific copy was produced on or before December 31, 1990.

Each developed (aviation) engine must pass a series of tests (certifications), including studies on environmental safety, before being put into mass production. That is why the International Civil Aviation Organization (ICAO) has formulated regulations on aircraft engine emissions [24].

A quantitative characteristic of emissions of harmful substances by aerospace engines is the emission index (EI), which shows the number of grams of a given harmful substance emitted into the air when the engine burns 1 kg of fuel. Dimensionality of the emissions index is g/kg. There are Elco, Elcn, Elnox, etc.

ICAO has introduced a standard take-off and landing cycle consisting of the flight of the aircraft starting from the start of the engine to an altitude of 1000 meters and from the moment of landing at an altitude of 1000 meters until the engine stops after the aircraft lands. The dimensions of the ICAO take-off and landing cycle [25] are shown in Figure 4.

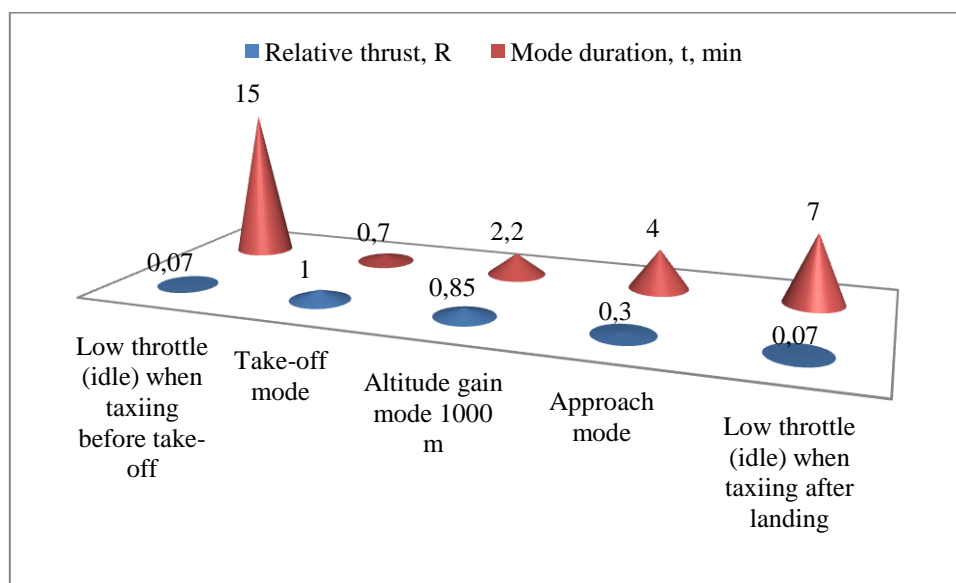


Fig. 4. Average statistical data of take-off and landing of the plane

The values of the relative thrust of engines at the stages of the take-off and landing cycle are average for the global civil aviation fleet, and the values of the duration of the stages are oriented towards large international airports.

The relative engine thrust is determined by the formula [27] (1):

$$R = R / R_0 \quad (1)$$

where: R is the engine thrust in a given mode;

R is the take-off thrust of the engine (maximum thrust in take-off mode).

In response to the global priority to minimise CO₂ emissions, IATA and individual leading airlines, airports and various industry associations are working on developing an environmental policy that improves the environmental performance and sustainability of airlines globally. Ukraine has committed itself to reducing its CO₂ emissions and has already joined the monitoring project CORSIA on reducing CO₂ emissions for International Aviation. IATA supports the development of standard environmental impact policies, helps airlines improve their environmental performance and educates them on how to reduce CO₂ emissions. IATA's main goal is to reduce its net CO₂ emissions by 50% by 2050 compared to 2005 levels. Some manufacturers set an even higher target of zero emissions by 2050 [27, 28].

To overcome the aforementioned challenges, the European Union is looking for ways to reduce emissions by gradually phasing out of fossil fuels and the development of sustainable transport

infrastructure. The EU's goal is to reduce transport emissions by 90% till 2050 and create a climate-neutral continent.

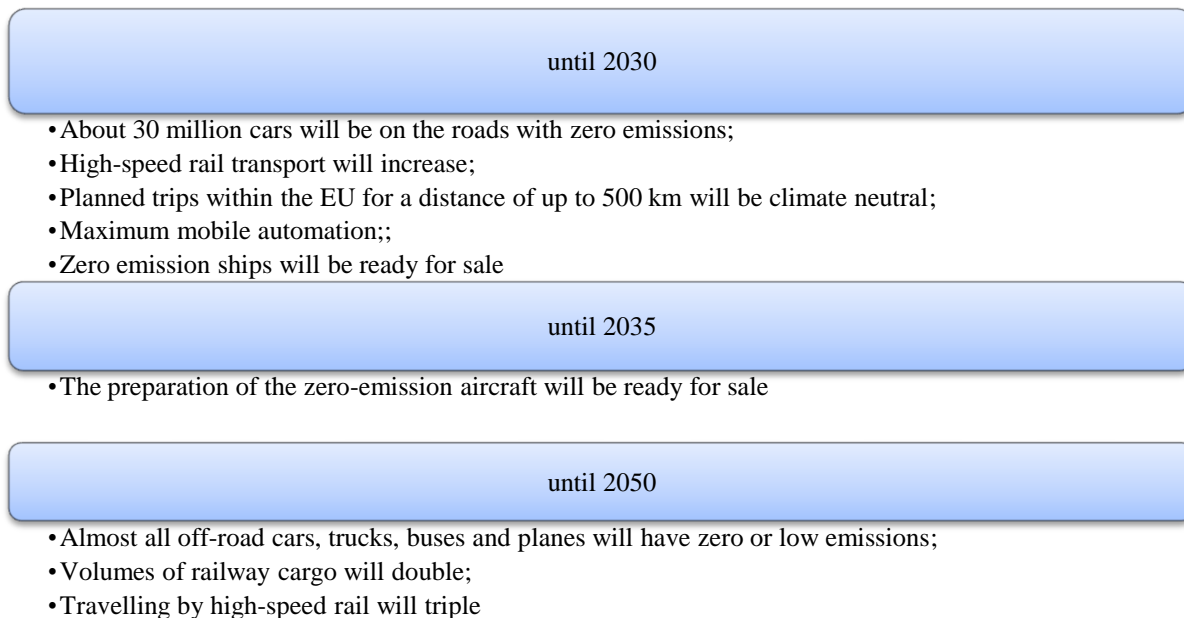


Fig. 5. Key goals of the Mobility Development Strategy

These points are also relevant for Ukraine. Ukrainian potential is very large for the development of public transport and cycling, as well as rail and water transport for passenger and freight transport, and eco-friendly air tourism, so these points from the Strategy can be a guide for Ukrainian cities and the government.

The transport goals and initiatives of the «European Green Deal» are detailed in the EU Sustainable and Smart Mobility Strategy, dated December 2020 (Fig. 5) [30]. This is a European Union (EU) strategic document aimed at transforming Europe's transport system to change transport emissions by 90% till 2050 and increase the resilience of cities to future crises [31].

4. Conclusions

Therefore, the current rapid process of globalization and the adoption of international environmental standards forces airlines to intensify their activities in order to reduce emissions into the environment.

The study analyzed the problem of air pollution by aircraft engines, thereby determining the global and local aspects of the problem. The problem of pollution and how to solve it.

At the meeting, it was determined that the issue of air pollution from aircraft ships must be solved comprehensively. The analyzed methods of reducing air pollution from airplanes relate only to specific problems and do not ensure the reduction of the harmful effects of all factors.

As a result, a comprehensive and simultaneous solution to the problem of improving the environmental performance of aircraft engines was proposed in four directions: chemical, structural, economic, and the introduction of alternative energy sources in air transport.

Summarising all of the above, we note that the functioning of ecological air tourism in the system of environmental engineering can become not only a factor of sustainable development, but also a model of balanced use of natural resources as a valuable factor in the rise of the state, by solving many

urgent and complex problems that exist today in the field of recreational and tourist activities and its development in the territories of nature reserves in Ukraine.

Thus, ecotourism in the environmental engineering system is a vivid example of the combination and balanced interaction of three components - social, environmental and economic.

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