

PAPER • OPEN ACCESS

## Strategizing for sustainable development of transport systems in the safety dimension

To cite this article: Yu Kharazishvili *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **915** 012025

View the [article online](#) for updates and enhancements.

You may also like

- [Ensemble forecasting method](#)  
V A Ivanyuk and A D Tsvirkun
- [Neural network-based probability forecasting method of aviation safety](#)  
Zhu Zheqi, Ren Bo, Zhang Xiaofeng *et al.*
- [Evaluating skill of BMKG wave model forecast \(Wavewatch-3\) with observation data in Indian Ocean \(5 – 31 December 2017\)](#)  
R Kurniawan, H Harsa, A Ramdhani *et al.*



The Electrochemical Society  
Advancing solid state & electrochemical science & technology

### 241st ECS Meeting

May 29 – June 2, 2022 Vancouver • BC • Canada

Extended abstract submission deadline: Dec 17, 2021

Connect. Engage. Champion. Empower. Accelerate.  
**Move science forward**



**Submit your abstract**



# Strategizing for sustainable development of transport systems in the safety dimension

Yu Kharazishvili<sup>1</sup>, D Bugayko<sup>2</sup>, V Lyashenko<sup>1</sup>, V Sokolovskiy<sup>3</sup> and V Baranov<sup>4</sup>

<sup>1</sup> Department of Regulatory Policy and Entrepreneurship Development, Institute of Industrial Economics of the National Academy of Sciences of Ukraine, 2 Maria Kapnist Street, Kyiv, 03057, Ukraine,

<sup>2</sup> National Aviation University, Institute of International Cooperation and Education, Liubomyra Huzara ave. 1, Kyiv, 03058, Ukraine,

<sup>3</sup> Department of tourism and aviation activities, Flight Academy of National Aviation University, 1 Dobrovolsky Str., Kropyvnytskyi, 25005, Ukraine

<sup>4</sup> Department of management and economics, Flight Academy of National Aviation University, 1 Dobrovolsky Str., Kropyvnytskyi, 25005, Ukraine

E-mail: yuri\_mh@ukr.net

**Abstract.** The article conducted a study on approaches to the strategy of sustainable development of transport systems on the example of air transport in Ukraine. The shortcomings of the main tool of their strategy, namely the methods of classical forecasting, which limit its application, are revealed. The methods of forecasting based on expert judgment and classical methods of forecasting containing congenital pathology of errors are considered. Therefore, long-term factors and trends are identified, which remains a classic forecast, rather than building long-term forecasts of the national economy. To implement the stage of strategic planning of transport systems used the concept of sustainable development, which includes stages of identification through integrated assessment in the measurement of safety and strategy by defining goals, building the desired trajectory and decomposition of integrated indices through adaptive control methods of management theory. Three scenarios for the development of air transport in Ukraine have been developed: realistic - 3.8%; optimistic - 7.0% and balanced - increase in gross value added (GVA) by 11.7% with scientific substantiation of quantitative values of indicators and key macroeconomic indicators, which guarantees the desired trajectory of sustainable development, and monitoring their implementation determines the effectiveness of public policies and actions.

## 1. Introduction

Strategic safety management of transport systems is an effective tool in the process of ensuring sustainable development of the economy as a whole and the industry in particular. Strategic aviation safety management is carried out at three hierarchical levels: global, regional and national.

At the global level, strategic aviation safety management is implemented by the International Civil Aviation Organization (ICAO). ICAO develops Standards and Recommended Practices for 193 member states. They are set out in 19 Annexes to the Convention on International Civil Aviation (1944 Chicago Convention). Annex 19 “Safety Management” (ICAO, 2013) [1] is devoted to the development of a global aviation safety management system.



ICAO's strategic goals are closely linked to 15 of the 17 UN Sustainable Development Goals. The organization fully seeks to work closely with States and other UN bodies to support the relevant goals (UN, 2019) [2]. Ukraine is a full member of the UN and ICAO and fully complies with the Standards and gradually implements the Recommended Practices of organization. With a view to global strategic civil aviation safety management, ICAO is implementing a Global Aviation Safety Plan (GASP). On June 14, 2019, the ICAO Council approved the third edition of the GASP for 2020-2022 (ICAO, 2019) [3]. This document identifies global strategic directions for aviation safety and forms the basis on which to develop and implement regional, sub regional and national plans for the implementation of the plan, thereby ensuring harmonization and coordination of activities aimed at improving the safety of international civil aviation (ICAO Assembly, 2019) [4]. The GASP defines a strategy for continuous improvement, which includes the goals of states to be achieved through: implementation of effective aviation safety control systems, implementation of state aviation safety programs (SSP), development of improved aviation safety control systems, including proactive risk management (ICAO, 2019) [3]. Global Strategic Aviation Safety Management is the key to creating a global international aviation safety system. Its main advantage is the implementation of a global approach to aviation safety through implementation at the regional and national levels.

At the regional level, strategic aviation safety management in the context of sustainable development is implemented within the mandate of leading regional organizations in the field of aviation. In the European region, the leading role in ensuring a harmonized level of safety and sustainable development of civil aviation is played by the European and North Atlantic Bureau ICAO (Paris), the European Aviation Safety Agency (EASA), the European Civil Aviation Conference (ECAC), the he European Organization for the Safety of Air Navigation (EUROCONTROL). In order to regionally implement the ICAO Global Aviation Safety Plan, each region must prepare a Regional Aviation Safety Plan. In 2020, the second edition of the European Regional Aviation Safety Plan (EUR RASP) was published. EUR RASP uses the EU safety risk management process in the interests of all 55 European countries. This means that the identification and assessment of safety issues, the development of mitigation measures and the measurement of their effectiveness provide some feedback, which can then be used to reduce the systemic and operational safety risks present in the European Aviation System (ICAO/EASA , 2020) [5]. The European Aviation Safety Plan for 2020-2024 (EPAS) is the main medium-term document that provides a comprehensive and transparent framework for safety management at the regional and national levels, supporting the goals and objectives of the Global Aviation Safety Plan (GASP) (EASA, 2019) [6]. Ukraine is a full member of the European Civil Aviation Conference (ECAC) and the European Air Navigation Safety Organization (EUROCONTROL), but is not a member of the European Aviation Safety Agency (EASA) and the EU, with the status of an associated state. Despite the fact that Ukraine systematically implements European norms and regulations in the process of harmonization of basic aviation legislation, this creates certain restrictions at the regional level. Thus, the main implementation of the Aviation Safety Management Strategy of Ukraine in the context of sustainable development is carried out at the national level.

According to the provisions of Annex 19 "Safety Management" to the Convention on International Civil Aviation (Chicago Convention 1944), ICAO at the national level Strategic Aviation Safety Management is implemented within the State Safety Program (SSP). As of the first quarter of 2021 in Ukraine, this area is regulated by the Civil Aviation Safety Program of Ukraine, which was approved at the meeting of the Aviation Safety Council of the State Aviation Service of Ukraine on March 27, 2018 (Aviation Safety Council of the State Aviation Service of Ukraine, 2018) [7]. The program has an ICAO-compliant structure. However, its main drawback is the level of its signatories. Unlike most countries in the world, where this program has been approved at the level of the Legislature (Parliament), in some cases the Cabinet of Ministers or, at least, the National Security and Defense Council. In Ukraine, it is published at the CAA regulatory level. So the basis of this program is the resource provision of air transport safety of the state. Only when the program receives real government support is it possible to argue about its effectiveness. Currently, the issue of development and approval

of the State Program on Air Transport Safety on the basis of Standards and Recommended Practice of the International Civil Aviation Organization (ICAO) is included in the Program of Activities of the Cabinet of Ministers of Ukraine. However, according to the declared indicators of the Civil Aviation Safety Program of Ukraine of the State Aviation Service, by 2021 the country must ensure 100% implementation of the State Aviation Safety Program, which as of the 1st quarter of the year does not actually exist. This is a significant risk of strategic aviation safety management, which may adversely affect the results of the next ICAO audit.

Air transport of Ukraine is an integral part of the national transport system. Therefore, its sustainable development must meet the industry-wide strategic goals and objectives. On May 30, 2018, the Order of the Cabinet of Ministers of Ukraine №430-r approved the National Transport Strategy of Ukraine for the period up to 2030. The implementation of the National Transport Strategy is to ensure the sustainable development of the transport sector of the economy. The Strategy includes five priority areas, namely: development of effective public administration in the transport sector; provision of quality transport services and integration of the transport complex of Ukraine into the international transport network; ensuring sustainable financing of the transport complex; increasing the level of safety in transport; achieving urban mobility and regional integration in Ukraine. Among its strategic initiatives, air transport occupies a special place. In order to develop passenger air transportation, it is proposed to continue certification for compliance with safety and security requirements at airports in Ukraine; ensure compliance of airport certification and airworthiness testing procedures with the provisions of EU directives; address the lack of funding needed to support infrastructure development; to continue the process of harmonization of national legislation with the EU; create conditions for the promotion of new air carriers, first of all, low cost models; systematically implement the policy of liberalization of the aviation market. In order to develop cargo air transportation, it is proposed to ensure investment and development of modern multimodal airports - hubs focused on service, including cargo air transportation; develop and implement a program for the development of air cargo; provide appropriate funding for the development of air cargo terminals and infrastructure (Cabinet of Ministers of Ukraine, 2018) [8].

The development of airports and their infrastructure is the cornerstone of sustainable development of air transport and aviation logistics. This direction is given serious attention by the state. Thus, on February 24, 2016, the Resolution of the Cabinet of Ministers of Ukraine № 126 approved the State Target Program for the Development of Airports for the Period up to 2023. The main objective of the Program is to ensure sustainable development of air transport and its infrastructure, implementation of global and regional standards for the national airport system, development of transit and transfer traffic, increase the efficiency of state property management. Expected results of the Program: increase of air passenger traffic to the level of 24.3 million passengers by 2023; increase of airports capacity twice; reduction of time for ground handling of each aircraft to 35-40 minutes; doubling the transit potential; development of public-private partnership and non-aviation activities of airports; creation of favorable conditions for Low Cost airlines, creation of additional jobs places (Cabinet of Ministers of Ukraine, 2016) [9].

Ukraine is one of the unique ten countries that have a full cycle of development, serial production, operation, maintenance of aircraft, as well as an extensive system of training and retraining of aviation professionals. Thus, the development of domestic aircraft construction is a strategic priority for the country's development. On November 11, 2020, the Order of the Cabinet of Ministers of Ukraine № 1412-r "On approval of the Concept of the State target scientific and technical program for the development of the aviation industry for 2021-2030" was issued. (Cabinet of Ministers of Ukraine, 2020) [10]. In fact, the government updated the provisions of the Strategy for the Revival of Domestic Aircraft Construction for the Period up to 2022, introduced by the Order of the Cabinet of Ministers of Ukraine dated May 10, 2018 № 429-r and extended its implementation until 2030 (Cabinet of Ministers of Ukraine, 2018). The purpose of the Strategy is to restore the stable development of the aircraft industry and ensure the profitability of high-tech production of aircraft in Ukraine [11]. The action plan of the Strategy envisages modernization and production of passenger and transport aircraft

of the Antonov family, Mil propellers, unmanned aerial vehicles, import substitution of components. Comprehensive implementation of the Strategy will contribute to the technical re-equipment of production facilities of aircraft companies, the creation of modern centers of basic maintenance, repair of Ukrainian-made aircraft and certification of aircraft according to international standards [10, 11]. Among the priorities of innovative measures in the air transportation market is the creation of a state regional airline and equipping its fleet of Antonov family aircraft of its own production.

Thus, we can conclude that the issues of strategic aspects of air transport safety and its sustainable development are given serious attention at the global, regional and national levels. The unresolved part of the problem, according to the authors, is the need for research to reach the level of strategic vision of the safety management of sustainable development of air transport, as well as in the development of effective tools for its implementation at the national level. It is obvious that the safety of air transport directly depends on its economic and technological development, aviation infrastructure, social and environmental component. That is, the safety of air transport is a component of the system of sustainable development of air transport. Therefore, a systematic study of sustainable development of air transport in the safety dimension, development, approval at the highest state level of such a program and its corresponding resource provision in the medium term is a necessary condition for entering the trajectory of sustainable development of Ukraine's national air transport system. The strategic vision of the safety management of sustainable development of air transport involves first solving the problem of identifying the current level of sustainable development in the safety dimension, and then strategizing for a given perspective with a scientific justification of the desired values of indicators and macro indicators. The aim of the authors is to implement at the national level the strategic management approach, which based on data analysis (Strategic Data Driven Decision Making). This article is devoted to the solution of the problem of strategizing for sustainable development of transport systems in the safety dimension (on the example of air transport of Ukraine).

## 2. Results

Solving the challenges of introducing a scientifically sound development strategy for each country in the context of dynamic changes in the global economic space and increasing the degree of openness of economies are the most important tasks for today. States need to ensure technological leadership in priority areas, creating new high-paying jobs and supporting the state - economic (sustainable) development on an innovative basis. This formulation a priori provides for three components of development: social, environmental and economic, the balanced development of which is one of the first among the main challenges of development of territories and communities at all levels. The basis of sustainable development both at the state level and at the regional and local levels is the harmonization of economic, social and environmental components. Systematic coordination and balance of these three components and on this basis introducing of the development strategy is a very difficult task [12].

One of the main tools for fulfilling the tasks is foresight, which, according to UNIDO, is a system of methods for expert evaluation of strategic projects of socio-economic and innovative development, identification of technological breakthroughs, the ability to order a return to the economy and society in the middle and long-term [13]. Another successful formulation is provided by American researcher Ben Martin, who defines foresight as a systematic attempt to assess the long-term prospects of science, technology, economics and society to identify strategic research directions and new technologies that can bring the greatest socio-economic benefits [14]. The use of foresight gradually changed from technological, market-oriented to socio-economic and strategic [15,16], i.e. integrated into the strategic management system of the firm.

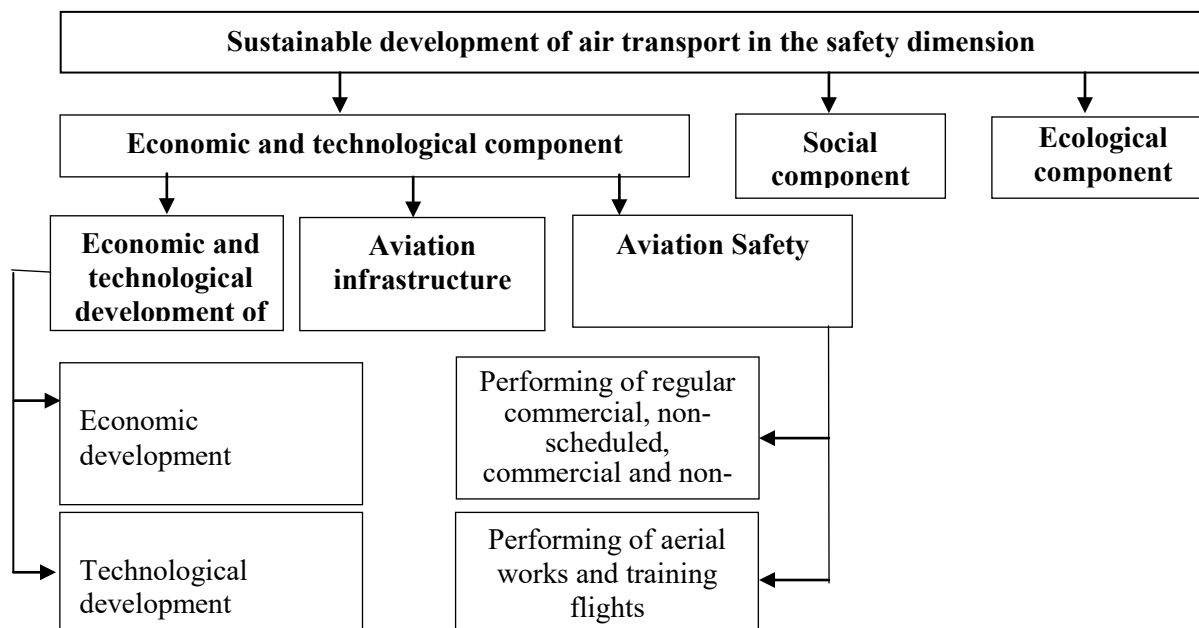
On the other hand, foresight is characterized as a process, i.e. foresighting "... the process involved in a systematic attempt to look into the longer-term future of science, technology, the economy and society with the aim of identifying the areas of strategic research and the emerging of generic technologies likely to yield the greatest economic and social benefits "[17, p. 96].

The advantage of foresight is a special technology of forming priorities for the development of various spheres of society in order to mobilize the largest number of participants to achieve qualitatively new results in the development of the country, region and community. That is, it is expressed in a much more comprehensive approach than traditional forecasting.

Unfortunately, expert assessments are full of subjectivity, do not rule out fundamental errors, reflect the inability to offer something adequate and are the last hope, like a straw for the drowning man. "... Known approaches to the classical prediction of the dynamics of integrated indices using polynomials discredit economic and mathematical modeling in general and deplete the complexity of such a multidimensional concept as sustainable development or economic security. The use of the SWOT- analysis method can be considered a step necessary to determine the strategic directions of development, but not enough to substantiate quantitative strategic assessments of the future. It is obvious that classical forecasting methods based on correlation-regression analysis are inappropriate here. First, forecasting provides a continuation of existing trends for the future; secondly, it always contains an error; thirdly, it is necessary to know how the components and indicators of sustainable development should change in order to achieve the desired state of development" [18, pp. 9-10].

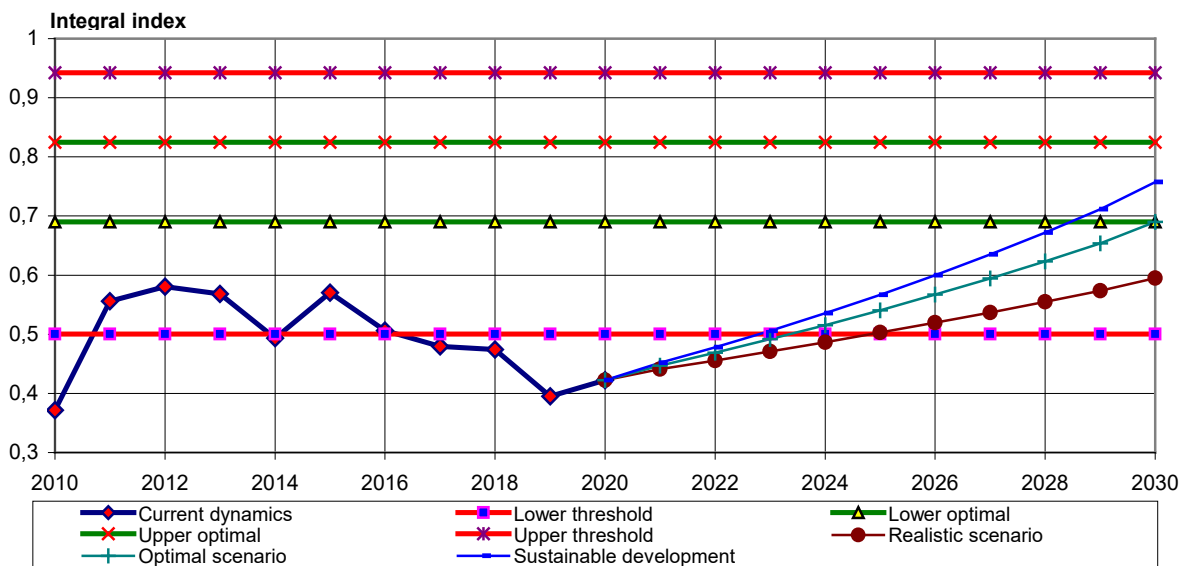
Speaking in mathematical language, the use of foresight is a necessary condition, but not enough. That is why most of the developed strategies in Ukraine have a declaratory character without scientific substantiation of strategic guidelines through the declaration of necessary measures such as: providing, increasing, creating, forming, updating, implementing, improving, involving, developing.

The starting point of strategizing and the necessary data is the structure and system of indicators (Fig. 1), a multifactor hierarchical model of integrated convolution of air transport (1) [20] and the dynamics of the integrated index of the security object in comparison with the integrated threshold values (Fig. 2) [20].



**Figure 1.** Hierarchical structure of subordination of components of sustainable development of air transport [20].

$$\left\{ \begin{aligned}
 I_{SD\_AT,t} &= I_{econ\_tech}^{a_{1,t}} \cdot I_{soc}^{a_{2,t}} \cdot I_{ecol}^{a_{3,t}}; P_i = \prod_{j=1}^4 p_{ij}^{b_{ij}}; p_{ij} = [p_{thres.,ij}^{low}; P_{opt.,ij}^{low}; P_{opt.,ij}^{upper}; P_{threshr.,ij}^{upper}]; \\
 I_{econ\_tech,t} &= I_{ec-tech,t}^{a_{1,t}} \cdot I_{av.inf ras t}^{a_{2,t}} \cdot I_{av.secur,t}^{a_{3,t}}; \\
 I_{ec-tech,t} &= I_{econ,t}^{a_{1,t}} \cdot I_{tech,t}^{a_{2,t}}; I_{econ,t} = \prod_{i=1}^5 z_{econ,t}^{a_i}; I_{tech,t} = \prod_{i=1}^5 z_{tech,t}^{a_i}; \\
 I_{av.inf ras,t} &= \prod_{i=1}^5 z_{av.inf ras,t}^{a_i}; \\
 I_{av.secur,t} &= I_{flights,t}^{a_{1,t}} \cdot I_{work,t}^{a_{2,t}}; I_{nozemu,t} = \prod_{i=1}^5 z_{flight,t}^{a_i}; I_{work,t} = \prod_{i=1}^5 z_{work,t}^{a_i}; \\
 I_{soc,t} &= \prod_{i=1}^5 z_{soc,t}^{a_i}; \\
 I_{ecol,t} &= \prod_{i=1}^3 z_{ecol,t}^{a_i};
 \end{aligned} \right. \tag{1}$$



**Figure 2.** Dynamics of the integrated index of the level of safety of sustainable development of air transport with strategic goals [20].

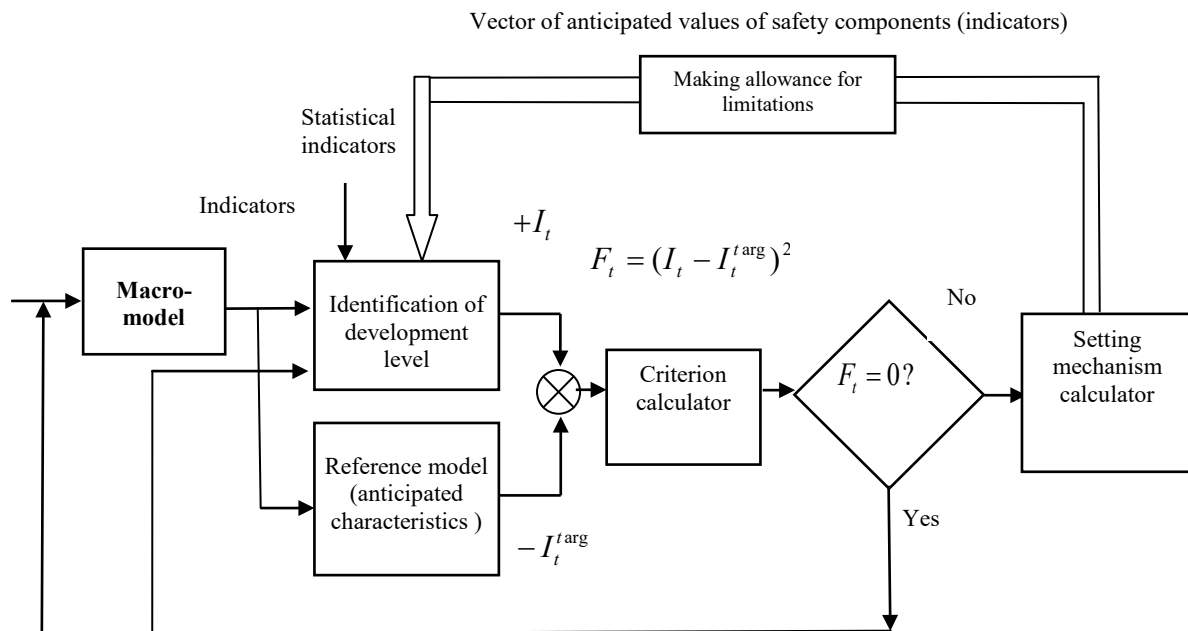
Determining the boundaries of safe existence - the vector of threshold values: lower critical, lower threshold, lower optimal, upper optimal, upper threshold, upper critical, determines the setting of strategic goals and the necessary strategic development scenarios. A pair of optimal values determine the "homeostatic plateau", within which there are the best conditions for the functioning of the system and feedback [21], because the criterion of sustainable development is the average value of "homeostatic plateau" [18, p. 195], which determines the following targets and relevant strategic scenarios:

1. Realistic - reaching the average level between the lower threshold and the lower optimal values.
2. Optimistic - reaching the level of the lower optimal value (entering the optimal zone of the EU states).

3. Scenario of balanced sustainable development - reaching the level of average optimal value (homeostatic plateau) - the criterion of sustainable development.

Desired trajectories of strategic development can be built according to different laws: linear, exponential, S-logistics curve and others depending on the horizon of strategic forecasting and realistic conditions of economic growth. Therefore, by 2030, the desired trajectory of strategic development is built on an exponential trajectory.

The approach to sustainable development strategy used differs significantly from classical forecasting methods, which a priori contain a congenital pathology of errors due to the principle of forecasting "the past determines the future". Instead of this principle, it is proposed to use the principle "the future is determined by the trajectory into the future". The construction of the desired trajectory of development determines the knowledge of integrated indices in each year of prediction, which allows by decomposing integrated indices to scientifically substantiate the desired values of components and indicators of sustainable development. This decomposition of integral indices is proposed to be carried out by the method of adaptive regulation from the theory of control (Fig. 3) [18].



**Figure 3.** Generalized Scheme of Adaptive Control System with a Reference Model [18].

For the practical application of the strategy of strategy, the standard procedure "Strategy" in the programming language C ++, developed by the author of the proposed method of substantiation of strategic guidelines [18], which implements an adaptive method of regulation with a short feedback cycle (without macro model). Long feedback mode is used for in-depth research.

The reference to the standard procedure "Strategy" is as follows:

$$F_{\min} = \text{strategy}(P, f, n_1, n_2, x, f_{zad}, p_{\max}, p_{\min}, eps, func), \tag{2}$$

- where:  $F_{\min}$  – the resulting error of the decision;
- $P$  – vector of normalized indicators of the integrated index, from which the strategy begins - the original vector of the required values of indicators that correspond to a given value of the integrated index);
- $f$  – the initial value of the integral index;
- $n_1$  – initial number of the indicator;



- $n_2$  – end number of the indicator;  
 $f_{zad}$  – set value of the integrated index;  
 $p_{max}$  – vector of normalized maximum values of adjusting indicators;  
 $p_{min}$  – vector of normalized minimum values of adjusting indicators;  
 $eps$  – given solution error;  
 $func$  – a pointer to the function called to calculate the optimization criterion.

The initial vector of normalized indicators, the original vector of normalized required values of indicators, as well as the initial vector of required values of indicators in natural (physical, natural) units through the use of the inverse normalization procedure are used for further calculations of macro indicators in each year of the future trajectory. The calculations give the following dynamics of strategic values of components and their indicators according to certain development scenarios (Table 1-2).

**Table 1.** Assessment of strategic guidelines of integrated indices of sustainable development of air transport.

<i>Component of development</i>	<b>2021</b>	<b>2022</b>	<b>2023</b>	<b>2024</b>	<b>2025</b>	<b>2026</b>	<b>2027</b>	<b>2028</b>	<b>2029</b>	<b>2030</b>
<b>Realistic scenario</b>	0,4371	0,4524	0,4681	0,4845	0,5014	0,5189	0,5370	0,5557	0,5751	0,5951
Economic and technological component	0,4318	0,4433	0,4558	0,4693	0,4836	0,4989	0,5151	0,5322	0,5502	0,5692
Social component	0,1853	0,2016	0,2185	0,2360	0,2541	0,2728	0,2921	0,3119	0,3322	0,3533
Ecological component	0,7387	0,7458	0,7536	0,7621	0,7713	0,7813	0,7919	0,8034	0,8156	0,8287
<b>Optimistic scenario</b>	0,4470	0,4688	0,4916	0,5155	0,5406	0,5670	0,5946	0,6235	0,6538	0,6899
Economic and technological component	0,4366	0,4542	0,4737	0,4951	0,5185	0,5438	0,5710	0,6001	0,6310	0,6636
Social component	0,1921	0,2163	0,2417	0,2683	0,2961	0,3251	0,3552	0,3865	0,4191	0,4525
Ecological component	0,7417	0,7526	0,7650	0,7788	0,7942	0,8113	0,8299	0,8504	0,8726	0,8964
<b>Sustainable balanced development</b>	0,4515	0,4779	0,5059	0,5355	0,5668	0,5999	0,6350	0,6722	0,7115	0,7573
Economic and technological component	0,4414	0,4627	0,4850	0,5084	0,5330	0,5587	0,5857	0,6140	0,6436	0,6744
Social component	0,1968	0,2283	0,2649	0,3073	0,3565	0,4135	0,4797	0,5565	0,6456	0,7489
Ecological component	0,7418	0,7515	0,7613	0,7712	0,7812	0,7914	0,8017	0,8121	0,8227	0,8465

Thus, the result of the strategic stage is the synthesis of the necessary values of indicators in the dynamics for each year, compliance with which will provide the desired trajectory of sustainable development in the security dimension. A similar approach to strategizing is used in business: "In business, as in game theory and chess, all great strategists start by predicting the future ... Outstanding strategists do not look back to calculate the way forward, but look to the future and count back . This is the hard work of a strategist - not only to determine the destination, but also to set a course there; not just to look into the future, but also to calculate the steps to it and make the necessary changes in time on the way to the desired goal" [22]. Thus, a combination of classical foresighting is proposed to assess the long-term prospects of science, technology, economics and society, strategic areas of research and new technologies, with the methodology of identification and strategy based on the principle "future is determined by the trajectory of the future".

**Table 2.** Assessment of strategic guidelines for air transport indicators at the end of 2030.

<b>Components and Indicators / Development Scenarios</b>	<b>Realistic scenario</b>	<b>Optimistic scenario</b>	<b>Sustainable development</b>
<b>Economical development</b>	<b>0,4347</b>	<b>0,5416</b>	<b>0,6585</b>
- specific weight of air transport GVA in total GVA of transport and communication), % (S);	5,26	5,95	7,55
- level of investment in air transport,% of air transport output (S);	7,8	9,69	13,7
- level of export services of air transport, % of total exports of transport services (S);	28,3	34,92	32
- level of import air transport services, % of total import of transport services (D);	34,22	28,46	22,5
- level of shadowing of air transport,% of official GVA (D);	33,78	29,16	12,5
<b>Technological development</b>	<b>0,5300</b>	<b>0,6109</b>	<b>0,7082</b>
- coefficient of manufacturability of air transport, the share of VDA in output (S);	0,4806	0,50	0,535
- capital utilization ratio (S);	1,226	1,391	1,27
- level of shadow capital load,% of official load (D);	34,36	29,38	8,5
- the level of use of passenger capacity of aircraft (S),%;	64,58	71,63	85
- the level of renewal of fixed assets, (S)%;	6,822	8,06	8,3
<b>Aviation infrastructure</b>	<b>0,6621</b>	<b>0,7471</b>	<b>0,7181</b>
- cargo GDP transport intensity on air transport (ratio of cargo turnover to GDP) (D);	0,0012	0,00095	0,00133
- passenger GDP transport intensity on air transport (ratio of cargo turnover to GDP) (D);	0,0518	0,0333	0,0516
- average distance of cargo transportation (ratio of cargo turnover to volume of cargo transportation) (S);	3485,3	3813,2	3314
- average distance of passenger transportation (ratio of passenger turnover to passenger traffic volume) (S);	1486,1	1716,1	2050
- the ratio of domestic and international air transportations (S);	0,1251	0,1467	0,21
<b>Aviation Safety</b>	<b>0,5613</b>	<b>0,6621</b>	<b>0,6109</b>
Performing of regular commercial, non-scheduled commercial and non-commercial flights	0,5366	0,6433	0,6657
- accident rates (catastrophe) (D);	0,5895	0,4365	0,2015
- accident rates (accident) (D);	0,0	0,0	0,0
- accident rates (serious incidents) (D);	0,0	0,0	0,0
Performing of aerial works and training flights	0,5873	0,6817	0,5429
- accident rates (catastrophe) (D);	6,7649	5,5073	4,6
- accident rates (accident) (D);	6,3611	4,6168	6,1342
- accident rates (serious incidents) (D);	0,0	0,0	0,0
<b>Social component</b>	<b>0,3533</b>	<b>0,4525</b>	<b>0,7489</b>
- level of wages in the output of air transport, Ukraine (S);	0,1374	0,1587	0,29
- level of employment in air transport,% (S);	75,71	77,21	94
- population mobility ratio (S);	0,8575	1,0871	0,9572
- level of official GVA created by shadow wages,% of official GVA of AT (D);	47,17	42,83	6,5
- level of shadow employment,% of official employment (D);	42,26	37,92	10,25
<b>Ecological component</b>	<b>0,8287</b>	<b>0,8963</b>	<b>0,8465</b>
- CO <sub>2</sub> emission level of Ukrainian air transport to GDP (D);	0,2751	0,32	0,32
- the level of emissions of pollutants into the atmosphere (D);	0,0025	0,002	0,002
- the level of environmental costs of AT (S).	0,1416	0,1496	0,185

<sup>1</sup>The current values of indicators and their threshold values for integral convolution to exclude zero increased by 0.35; 0.35 and 0.41, respectively, to maintain the proportions, followed by a return to natural values in reverse.

<sup>2</sup>The current values of indicators and their threshold values for integral convolution to exclude zero increased by 0.41; 0.41 and 0.41, respectively, to maintain the proportions, followed by a return to natural values in reverse.

This approach eliminates existing shortcomings and provides new opportunities not only to identify long-term factors and trends, but also the scientific Performing the procedure of "denormation" - the transition from dimensionless indicators to macro indicators in natural units using the method of rationing in reverse order and making assumptions about future values of GDP and GVA of transport and communications in general, we obtain strategic values of key macro indicators (Table 3).

**Table 3.** Assessment of strategic benchmarks of key macro indicators of air transport at the end of 2030.

Indicator / Scenarios	2020	Realistic scenario	Optimistic scenario	Sustainable development
Output, UAH billion	25,848	65,053	85,039	121,274
Nominal GVA, UAH billion	11,838	31,269	42,558	64,882
Average annual growth rate of GVA, %	-40,0	3,8	7,0	11,6
Capital investments, UAH billion	1,3	5,073	8,237	16,615
Exports of services, billion dollars USA	1,25	3,628	5,25	5,653
Imports of services, billion dollars USA	0,4	0,8363	0,8024	0,7347
Volume of shadow airborne forces, UAH billion	4,855	10,563	12,412	8,11
Freight turnover, billion, tkm	0,2648	0,4137	0,3964	0,6633
Passenger turnover, billion pass. km	13,7	17,77	13,82	25,89
Flight performance:				
Number of disasters per 100,000 flight hours.	1,0	1,497	1,0144	0,5768
Number of accidents per 100,000 flight hours.	0	0	0	0
Number of serious incidents per 100,000 flight hours.	0	0	0	0
Execution of aerial works and training flights:				
Number of disasters per 100,000 flight hours.	2	1,5542	1,1712	1,1744
Number of accidents per 100,000 flight hours.	2	1,4614	0,9818	1,1261
Number of serious incidents per 100,000 flight hours.	0	0	0	0
Effective demand for labor, mln. persons.	0,0079	0,00927	0,0093	0,0113
Nominal salary, UAH / month.	21000	65989	99607	213213
Shadow wages, UAH billion.	2,6	5,7165	7,066	1,6346
Total shadow intermediate consumption, UAH billion.	7,5	14,28	16,11	5,78
CO2 emissions, thousand tons.	320	303,5	480,6	732,6
Volume of pollutant emissions, thousand tons.	4,179	2,778	3,0	4,579
Volume of environmental investment, UAH million.	28,77	92,09	136,1	224,3

The obtained strategic values of indicators and key macro indicators are a reference point for the implementation of sustainable development strategy scenarios, the dynamics and scope of which can be used to assess the level of strategy implementation and the effectiveness of government policy [28].

### 3. Conclusions

One of the main tools for solving problems of introducing a science-based development strategy is foresighting - a system of methods for expert evaluation of strategic projects of socio-economic and innovative development, identifying technological breakthroughs, the ability to order a return to the economy and society in the medium and long term. Thus, the prediction includes methods that have been developed in various scientific fields. They reflect work on predicting the desired rather than the future. The advantage of foresight is a special technology of forming priorities for the development of various spheres of society in order to mobilize the largest number of participants to achieve qualitatively new results in the development of the state, region, community.

Unfortunately, most of the methods used are based on expert assessments (Delphi method, expert panels, SWOT analysis, brainstorming) which are full of subjectivism and do not exclude fundamental errors. Methods of classical forecasting (economic-mathematical modeling, regression analysis, extrapolation, simulation), based on the principles of "the past determines the future", a priori contain a congenital pathology of errors because in most cases the future is not a continuation of the past, but acquires completely different forms.

Thus, the classical prediction remains the definition of long-term factors and trends in the national economy. Therefore, in anticipation, the emphasis is on quality results. Speaking in mathematical language, the use of foresight to strategize is a necessary condition, but not enough. That is why most of the developed strategies in Ukraine have a declaratory character without scientific substantiation of strategic guidelines through the declaration of necessary measures such as: providing, increasing, creating, forming, updating, implementing, improving, involving, and developing. This approach does not allow controlling the development process and influencing its dynamics.

Given the above, the strategic vision of safety management of sustainable development of transport systems involves first solving the problem of identifying the current level of sustainable development in the safety dimension, and then - strategizing for a given perspective with scientific justification of desired values of indicators and macro indicators. Thus, the identification allows obtaining the dynamics of integrated indices in comparison with the integrated threshold values, which determines the current level of sustainable development and makes it possible to perform the stage of constructing the desired trajectory of development. Further application of the strategy - decomposition methodology of integrated indices of sustainable development with the help of adaptive control methods from the theory of management, allows obtaining the dynamics of components and indicators of the transport system, the provision of which meets the selected objectives.

Thus, the combination of classical foresight to assess the long-term prospects of science, technology, economics and society, strategic research and new technologies, with a methodology of identification and strategy based on the principle "future is determined by the trajectory of the future", eliminates existing shortcomings and provides new opportunities for identification of long-term factors and tendencies, as well as scientific construction of the desired future - i.e. the creation of a tool for strategic foresight.

The application of such a strategy tool allowed to obtain strategic scenarios for sustainable development of air transport in Ukraine until 2030: realistic - 3.8% increase in GVA, optimistic - 7.0% increase in GVA, balanced sustainable development - 11.6% increase in GVA with scientific quantitative substantiation of indicators and strategic guidelines of key macro indicators of air transport, the monitoring of which allows to objectively determine the effectiveness of government policy.

### References

- [1] ICAO 2013 Annex 19 to the Convention on International Civil Aviation. Safety Management ICAO 999 (University Street Montréal Quebec Canada H3C 5H7 First Edition) p 44
- [2] UN 2019 Resolution adopted by the General Assembly (UN) on 25 September 2015 A/RES/70/1 Transforming our world: the 2030 Agenda for Sustainable Development.

- [3] ICAO 2019 Doc 10004 Global Aviation Safety Plan 2020-2022. <https://www.icao.int/safety/GASP/Documents/Doc.10004%20GASP%202020-2022%20EN.pdf>
- [4] ICAO Assembly 2019 - 40th Session Technical Commission Agenda Item 28: Aviation safety and air navigation policy. A Comprehensive Strategy for Aviation Safety: Endorsement of the Updated Global Aviation Safety Plan. A40-WP/51 TE/5 14/6/19
- [5] ICAO/EASA 2020 EUR Regional Aviation Safety Plan 2020-2022. [https://www.icao.int/EURNAT/EUR%20and%20NAT%20Documents/EUR%20Documents/EUR%20RASP/EUR%20RASP%202020-2022\\_EN.pdf](https://www.icao.int/EURNAT/EUR%20and%20NAT%20Documents/EUR%20Documents/EUR%20RASP/EUR%20RASP%202020-2022_EN.pdf)
- [6] EASA 2019 European Plan for Aviation Safety (EPAS) 2020-2024 European Union Aviation Safety Agency (EASA). [https://www.easa.europa.eu/sites/default/files/dfu/EPAS\\_2020-2024.pdf](https://www.easa.europa.eu/sites/default/files/dfu/EPAS_2020-2024.pdf)
- [7] Aviation Safety Council of the State Aviation Service of Ukraine 2018 Program of Safety in the Field of Civil Aviation of Ukraine.
- [8] Cabinet of Ministers of Ukraine 2018 Order of May 30, 2018 № 430-r “On approval of the National Transport Strategy of Ukraine for the period up to 2030” [http://publications.chamber.ua/2017/Infrastructure/UDD/National\\_Transport\\_Strategy\\_2030.pdf](http://publications.chamber.ua/2017/Infrastructure/UDD/National_Transport_Strategy_2030.pdf)
- [9] Cabinet of Ministers of Ukraine 2016 Resolution of February 24, 2016 № 126 “About the statement of the State target program of airports development for the period till 2023” <https://zakon.rada.gov.ua/laws/show/126-2016-%D0%BF#Text>
- [10] Cabinet of Ministers of Ukraine 2020 Order of November 11, 2020 № 1412 “About approval of the Concept of the State target scientific and technical program of development of the aviation industry for 2021-2030” <https://zakon.rada.gov.ua/laws/show/1412-2020-%D1%80#Text>
- [11] Cabinet of Ministers of Ukraine 2018 Order of May 10 2018 № 429-r “Some issues of national aircraft construction” Ukrainian <https://www.kmu.gov.ua/nps/deyaki-pitannya-vitchiznyanogo-aviabuduvannya>
- [12] Sustainable development of regions of Ukraine. 2009 science. (K. : NTUU "KPI") p 197
- [13] Kryukov S, 2010 Foresight: The Forecast For The Formation Of The Future. Terra Economicus. Vol 8 **3(2)** 7-11
- [14] Martin B, 1995 Technology Foresight in a Rapidly Globalizing Economy SPRU Science and technology (Policy research, University of Sussex)
- [15] Peter Schwartz. 2011 "Innovation - the Pledge of Stability During Crisis" Foresight-Russia Foresight, CyberLeninka; Federal State Autonomous Educational Institution of Higher Education "National Research University Higher School of Economics" **5 (4)** 1-49
- [16] Shevchenko L, 2019 Strategic foresight: Managing The Future. Law and Innovation **3 (27)**
- [17] Cuhls K, 2003 From Forecasting to Foresight Processes – New Participative Foresight Activities in Germany. Journal of Forecasting **22**
- [18] Kharazishvili Y, 2019 Systemic Security of Sustainable Development: Assessment Tools, Reserves and Strategic Implementation Scenarios (Institute of Industrial Economics, National Academy of Sciences of Ukraine: Kyiv Ukraine) 304
- [19] Leondes C, Aoki M, 1965 Modern Control Systems Theory; McHraw-Hill: New York, NY,USA.
- [20] Bugayko D, Kharazishvili Y, Kvilinskiy O, 2021 Systematic Approach Determining The Level Of Security Sustainable Development Of Aviation Transport: Indicators, Level. Journal Of European Economy **1** 161-178
- [21] Van Gigch J, 1978 Applied General Systems Theory (Harper & Row: London, UK\_
- [22] Kusumano M, Joffy D, 2018 Strategies of geniuses. The five most important lessons from Bill Gates, Andy Grove and Steve Jobs. (Kharkiv: Book Club "Family Leisure Club") p 256
- [23] Hutsaliuk O, Koval V, Tsimoshynska O, Koval M and Skyba H 2020 Risk management of forming enterprises integration corporate strategy. TEM J. **9(4)** 1514-1523

- [24] Hutsaliuk O, Yaroshevska O, Shmatko N, Kulko-Labyntseva I, Navolokina A, Stakeholder approach to selecting enterprise-bank interaction strategies. *Problems and Perspectives in Management* 2020 **18(3)** 42-55
- [25] Kostetska K, Khumarova N, Umanska Y, Shmygol N and Koval V 2020 Institutional qualities of inclusive environmental management in sustainable economic development. *Manag. Syst. Prod. Eng.* **28(1)** 15-22
- [26] Tsimoshynska O, Koval M, Kryshchal H, Filipishyna L, Arsawan WE and Koval V 2021 Investing in road construction infrastructure projects under public-private partnership in the form of concession. *Nauk. Visnyk Natsionalnoho Hirnychoho Universytetu* **2** 184-192
- [27] Yankovyi O, Hutsaliuk O, Tomareva-Patlahkova V, Shmatko N, Kabanova O, Rud Y 2020 Comprehensive forecasting of interconnected socio-economic indicators as a methodological basis for adopting optimal management. 2020 International Conference on Decision Aid Sciences and Application (Sakheer, Bahrain, 8-9 November 2020). Institute of Electrical and Electronics Engineers
- [28] Chorna M, Filipishyna L, Nord G, Tkachenko S and Velychko K 2019 Formation of analytical support for the management of economic and environment safety of organizations. *J Secur Sustain Issu* **8(3)** 413–22.