DREPT INTERNAȚIONAL

CZU: 341.226
https://doi.org/10.52277/1857-2405.2021.4(59).07

MECHANISMS AND LEGAL INSTRUMENTS TO ENSURE AIR ROUTE SAFETY

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SUMMARY

The legal regulation of ensuring the safety of air traffic in general and of air routes in particular is one of the main concerns of specialists in the field of public international law. The principles and objectives, structure and organization of airspace for safe and efficient operation by analyzing the procedures for the formation and operation of air routes are the subject of this article.

Airspace areas with special legal status are an important element of airspace regulation and the process of ensuring air route safety. The analysis of the normative provisions that contribute to ensuring the security of air routes, the risks and threats on the safety of these routes and the mechanisms for preventing and combating them are a priority for specialists in the field of international air law.

Key-words: *international air law, air routes, air traffic safety, special status areas.*

MECANISMELE ȘI INSTRUMENTELE JURIDICE DE ASIGURARE A SECURITĂȚII RUTELOR AERIENE

SUMAR

Reglementarea juridică a asigurării securității traficului aerian, în general, și a rutelor aeriene, în special, constituie una dintre preocupările de bază ale specialiștilor din domeniul dreptului internațional public. Principiile și obiectivele, structura și organizarea spațiului aerian în vederea exploatării sigure și eficiente prin analiza procedurilor de formare și exploatare a rutelor aeriene constituie obiectul de studiu al prezentului articol.

Zonele din spațiul aerian cu statut juridic special constituie un element important al reglementării spațiului aerian și a procesului de asigurare a securității rutelor aeriene. Analiza prevederilor normative care contribuie la asigurarea securității rutelor aeriene, riscurile și amenințările asupra siguranței acestor rute, mecanismele de prevenire și combatere a acestora sunt o prioritate pentru specialiștii în domeniul dreptului internațional al aerului.

Cuvinte-cheie*: dreptul internațional al aerului, rute aeriene, siguranța traficului aerian, zone cu statut special*

The legal principles are the most general and important norms that determine the behavior of law subjects, which represent a criterion for the legitimacy of all other norms and form the basis for the creation of new norms in the studied field. At the same time, the possibility of dividing such principles into basic and branching principles should be considered. According to the theory of law, the basic principles are those that directly reflect the legal content and determine the organization of the legal system as a will, raised to the level of law [38, p.110].

As for the principles of the international air law branch, this matter has not been sufficiently developed by legal science. Some authors acknowledge the existence of such principles, others refrain from highlighting them.

An analysis of the relevant legislation and international treaties allows us to distinguish the branch principles from the area we are examining in the field of air traffic management.

They include the following:

a) national air traffic management;
b) air traffic safety;
c) structuring the airspace in order to use air traffic safely and efficiently;
d) a unified air traffic management system, cooperation with adjacent competent entities or bodies (including foreign states) in air traffic management;
e) priorities established in the use of airspace on the axis: state – legal person – natural person.

The interaction of these principles is a theoretically difficult problem, which admits a significant element of subjectivity. They must interact with each other so that, first of all, the safety of flights (human life), then the security of the state, then the commercial and other interests of any entity using airspace are ensured. Recognition of these principles is an imperative requirement to ensure compliance with the rules in this area.

An appropriate assessment can have a direct impact on the decision of the competent authorities, not only with regard to the use of airspace, but also with regard to air traffic management. It should also be considered that the principle of ensuring the safety of international civil aviation in its two aspects: technical and social has developed and received universal recognition in international aviation law. Both aspects can be ensured by respecting the legal rules of air traffic management.

In the process of establishing the rules for the operation of ships by the state:

- due attention must be paid to the safe navigation of civil aircraft [3, art 3(d)];
- air navigation facilities must be provided for the safety and efficiency of air communications [3, art. 15];
- the flight of an unmanned aircraft must be controlled in such a way as to exclude a danger to civilian aircraft [3, art. 8];
- appropriate measures must be taken if airports or air navigation facilities are insufficient for the safe operation of international air services [3, art. 69].

In accordance with bilateral air services agreements, States undertake to provide meteorological, radio and technical services for flights, air traffic control, to report in a timely and accurate manner information on airport capacity and flight routes under the responsibility of their competent authorities; and ensure that aircraft comply with the requirements imposed on international flights for safe navigation, etc.

The ICAO Assembly and Council are constantly focusing on these matters, which have been repeatedly addressed by the Security Council and the UN General Assembly. The international significance of this matter also serves as an argument in support of the analyzed principle [44, p.139-172]. The general obligations of States Parties in respect of the 1944 Chicago Convention with regard to civil aviation safety would not be fulfilled if the more general principle of ensuring the safety of international air navigation were not applied.

In this context, many authors consider that the existence of the principle of ensuring the safety of international air navigation in international law is indisputable.

Even if the position in relation to the existence and theoretical recognition of this branch principle is not unanimous, the need and importance of ensuring the safety of air navigation is indisputable.

Air transport is one of the many networked systems on which human societies depend, as well as in telecommunications, transport, electricity, water, etc. [26, p. 209–221] These infrastructures, in particular air transport, have helped to move the organization of the global economy from “space” to “flow space” [13, 594 p.]. This change may lead to a new organization of global space around a “network of world cities” [30, p. 497-511]. The current geography of transport is shaping and is shaped by the network evolution of large cities, mostly connected by the air transport network [27, p. 46–52; 31, p. 319–337; 25, p. 26–36].

Therefore, the global economy is increasingly dependent on network-based infrastructures, which can be described as a set of physical entities located on the surface of the earth. The functionality of these entities can be described as a set of nodes and routes that connect them[17, p. 88–112]. One of the mentioned infrastructures is the air transport network, which can be represented schematically as a flight network. The nodes of the flight network are airports, which are connected when a direct flight is scheduled between them [36, p. 5–21].

The organization of airspace is designed to determine the optimal conditions (permissive and prohibitive) for use. The establishment of the airspace structure in this respect is the basis for all subsequent regulations of the practical use of airspace. The structure of airspace is understood as a set of areas, corridors and other elements delimited by height and territory, ensuring the planning and coordination of airspace use, direct control of aircraft flights, safety and regularity of air traffic [45, p. 167].

When establishing the structure of airspace, the geographical and politico-administrative limits, flight characteristics, terrain relief, availability and characteristics of technical means, dynamic characteristics and characteristics of air and ground navigation and flight equipment of aircraft, particularities of legal status of land objects etc. are analyzed.

Assessing the soundness of air transport networks when faced with random errors and intentional attacks is therefore an important issue in the field of transport geography study. There is a growing concern in the transport geographical community about understanding the operability and functionality of critical infrastructure systems [28, p. 63–68], such as the severely disrupted air transport network.

The investigation of complex networks began with the purpose of defining new concepts and measures that allowed to characterize the topology of real networks. The result was to identify the principles of real networks statistical properties. To address the complexity of the network structure, several types of networks have been defined and studied. Some examples of networks are weighted networks (i.e. weighted link networks) [7, p. 47–52] and space networks (i.e. link networks that depend on the Euclidean distance between nodes) [8, p. 915–921].

The approach of studies in this field has changed due to progressing analysis of complex networks. Currently, the main interest is to investigate the dynamic behavior of networks. The concepts of robustness, resilience, dynamic collective synchronization or propagation processes are offered in response to the needs caused by this new scenario [9, p. 175–308].

The airspace is generally divided into upper airspace and lower airspace. In addition, the airspace is divided into air traffic service areas, within which there are control areas, control areas of the air (nodal) hub and aerodrome, airways, aerodrome areas (take-off, landing, areas aerobatic waiting areas), entry and exit corridors for aircraft arrival and departure, test flight areas, explosion areas, firing, etc.[43, p. 15].

All this applies to controlled airspace. As a result, the rest of the airspace is uncontrolled and only flight information and emergency notification services are provided. Within this type of space, counseling routes are usually allocated to counseling areas, which together constitute the counseling airspace. In addition, the airspace is divided into flight information regions, where flight information and emergency assistance services are provided [3, p. 2.5.2.1]. There are three types of flight information regions: in the lower airspace, in the upper airspace, and that combine the upper and lower airspaces [45, p. 151].

Peculiar attention should be paid to restricted areas in airspace. States have the right, in order to ensure the safety of air traffic and to coordinate the flights of aircraft with other activities in the airspace [3, art. 9 (a)], to establish zones of exclusion and zones of flight restriction. States established such areas just before the 1944 Chicago Convention and the 1919 Paris Convention [46, p. 39-56].

According to the 1944 Chicago Convention, such areas must be of a reasonable size and location so as not to unnecessarily impede air navigation. Description of prohibited areas and information on possible changes to them, States establishing such areas must inform other States and ICAO.

An aircraft that has disrespected the restrictions established for the exclusion zone or the flight restriction zone is considered to be an infringer. In accordance with article 9 of the Chicago Convention, this aircraft is required, at the request of the authorized air authority of the state whose rules are being disrespected, to land as soon as possible at any specified airport in that state [3, art. 9 (c)]. In sovereign airspace and in airspace over the territorial sea, a prohibited or restricted area may be declared uniquely or permanently. Flights in such an area are not, in principle, prohibited. The decision on a case-by-case basis is made by the commander of the aircraft concerned [45, p. 124].

Persons intending to fly in such an area should first coordinate their actions with the authorized state bodies which provide the necessary data, "in order to minimize interference with the normal operation of flights and, at the same time, to avoid the danger for aircraft" [3, p. 2.17.1].

Some special areas reserved in the airspace for military maneuvers, demonstration flights and temporary flights may also be established [4, p. 3.3.2.3]. A number of states have declared significant areas of airspace over the high sea adjacent to their territory as areas with a special permanent regime. These states include: USA, Canada, Spain, Italy, France, Japan, Philippines, South Korea. Such areas are called differently: the air defense identification zone, the air security zone [4, p. 3.3.4.], but their essence is the same.

These areas reach a width of 200 and 300 nautical miles from the same limit from which the width of territorial waters is measured. Despite the fact that these areas have a relatively old origin and their legal regime is respected by foreign aircraft, some experts in the field have questioned the legality of establishing these areas for several decades [39, p. 101-127].

This approach is controversial because some states that establish such areas with varying degrees of restriction and special status argue their position by the need to ensure national security in general and the security of their borders in particular, and, as long as this custom is not implemented and respected by the overwhelming majority of states, this fact generates consistent impediments in terms of respect for the principle of sovereign equality of states and freedom of airspace use.

In this sense, the Air Code of the Republic of Moldova establishes: „The national airspace includes:

a) the air traffic space representing the part of the national airspace where the aeronautical activity is allowed, as well as the lands destined for takeoffs and landings, regardless of the affiliation and the nature of the flight activity;

b) the reserved areas representing the portions of the national airspace intended for military aeronautical activities, school aeronautical activities, aeronautical sports, testing and approval of aircraft, utilitarian and similar, as well as other activities established by specific regulations;
c) regulated areas consisting of dangerous areas, restricted or prohibited areas, as well as conditional airways and areas of joint activity in the state border area" [1, art 4 (3)].

The Romanian legislation defines:

a) hazardous area – restricted airspace as a defined volume of airspace within which hazardous flight activities may be performed within specified time intervals;
b) restricted area – the airspace located above the land surface or territorial waters of a state within which the flight of aircraft is restricted in accordance with specified conditions;
c) prohibited area – the airspace located above the land surface or territorial waters of a state within the flight of aircraft is prohibited [2, art. 1, p. 43].

Also, in the airspace of Russia, aerodrome areas are defined, in some cases combined in air hubs, take-off and landing areas, restraint areas, acrobatics areas, restricted areas and flight restriction areas. The history of the last two areas dates back to 1912 and 1914, when the corresponding documents declaring the forbidden areas were issued in Russia [46, p.10-12].

The air code of the Russian Federation states that the airspace of today's Russia includes areas, zones and routes of air traffic services (airways, local airlines, etc.), areas of airfields and air hubs, special areas and routes of aircraft flights, restricted areas, hazardous areas (landfills, blasting operations and others of this type), restricted areas on aircraft flights and other elements of the airspace structure established for the implementation of activities in airspace. The structure of the airspace is approved in accordance with the procedure established by the Government of the Russian Federation [40, art. 15].

Such areas „must be of a reasonable size and location so as not to unnecessarily impede air navigation" [3, art. 9].

Examples of establishing similar areas are known in other areas. These are: exclusive economic zones in the coastal areas of the high sea, security zones of 500 meters around installations, structures, artificial islands at sea. "Aviation safety zones" may also be recognized as legitimate on the basis of established customs. Some authors considered it appropriate to create "adjacent air zones" by analogy with the corresponding maritime zones. In this case, the concept of functional airspace, which is established for the performance of any type of activity in airspace, may be applicable [22, 1340 p.].

The airspace is under the form of one or more permanent or temporary volumes. In order to control the flow of traffic from airports during take-offs, landings or transits, states create control areas above airports to facilitate these numerous actions. The creation or disposal of these volumes of airspace is decided at the government level. However, given the international nature of air traffic, consultations shall be held between states before taking such decisions. The accessibility of these areas is defined by its characteristics or class.

In the sense of the above, it is important to define the typology of state-controlled airspace areas. Thus, the volumes of airspace controlled by state bodies are:

1. TMA (TerMinal Area). These are space-controlled volumes overlooking medium-sized aerodromes. These include departure, transit and arrival. A TMA can be divided into several smaller blocks, depending on air traffic. S-TMA (Special TerMinal Area) are spaces that have the same functions as the previous ones, only that the control is performed by the military.

2. CTAs (Control Traffic Area). These spaces are in direct contact with the aerodromes. These are often located below a TMA. The CTRs are intended to cover take-off and landing routes and air traffic at the aerodrome.

States also create areas with special status. These areas are created only to prevent or restrict access to aircraft. The purpose is to protect dangerous or strategic targets, such as nuclear power plants or military areas, from any air intrusion. Their size varies from a few square kilometers to an entire region. Their creation is decided for some unilaterally, in which case the international community is informed, and for other areas involving flight restrictions, consultation between different users is necessary.

These areas may be conventionally divided into:

1. „D" dangerous areas. Passing through these areas does not require any prior authorization, as they often do not have their own control body, but they still pose a danger to aircraft. It could be an army maneuvering area or a coastal area. The nature of the hazard and the hours of activity can be found in the supplement to the aeronautical maps. „D" zones may be temporary and are called *Temporary Dangerous Zones (TDZ)*, especially in the case of military exercises. They are used for about a week.

2. „R" zones, regulated. These are areas that are subject to certain conditions. Entry of these areas may be prohibited during business hours, such as low-altitude and very high-speed military flights. They are called *Temporary Regulatory Zone (TRZ)*. This is the case for any international event with the presence of high authorities (G7, the Pope's visit to Rome) or for parachute drop areas.

3. „P" zones, forbidden zones. These areas are closed to civilian and military air traffic. These cy-

lindrical volumes cover strategic areas or objectives, such as nuclear power plants, sensitive industrial objectives, etc.

An important element in the process of ensuring the safety of air corridors is the air transport network, structure, robustness, solidity and flexibility against various risk factors. Thus, the analysis of the topology and robustness of air transport networks is of utmost importance in the process of analyzing and estimating air route safety.

There are different points of view on the network strategies implemented by the airlines. There are studies on the effect on prices resulting from existing connections between airlines [11, p. 1475–1498; 12, p. 573–602] or on the levels of connectivity and competitive position of airports [29, p. 47–53]. Another approach is the analysis of the route network architecture through the complex analysis of the network [36, p. 5–21; 20, p. 7794–7799; 32, p. 712–721].

Some experts in the field [19, p. 381–385] have studied the structure of the airport network around the world, finding that the degree and distribution of centrality between them follows a truncated distribution of the law of power, given that airports have limitations on the number of connections they can provide. To model the real network, the authors used a variant of the models developed and published by de Yook, S.H., Jeong, H. and Barabási, A.L. in 2002 and Barthélemy, M. in 2003 [35, p. 13382–13386]. Both include the standard increase mechanism for adding links between existing nodes. Complex networks are used for the current study of route networks.

This inevitable increase in the number of routes also implies a complex approach to ensuring air traffic safety. Only a model that includes geopolitical constraints, such as the fact that most cities are only allowed to make connections with other cities in the same country, can generate nodes with high intermediation values, as seen in the actual airport network [19, p. 381–385; 20, p. 7794–7799]. With the development of this comprehensive study, the analysis of complex networks began to be used more frequently in the airline industry. In particular, most new studies were undertaken in Italy [18, p. 527–536], India [6, p. 2972–2980], USA [34, p. 87–102] and China [24, p. 50–58].

The air transport network is the result of the route network aggregation of all airlines. The analysis of the current literature that studies air route networks as complex networks allows the establishment of different dimensions or levels of study characterized by different units of analysis. Therefore, given that each level has different characteristics and properties, three levels of study are proposed:

1. The global route network;
2. The network of air alliances;
3. A certain network of airlines.

The different levels not only represent different network sizes in the number of nodes (airports) and connections (routes), but also different approaches. The study of the global route network – analyzes the competitive environment for airlines and the general framework of air transport development. Due to the size of the global route network and the fact that it is a spatial network, it should be analyzed both globally and regionally. The literature contains examples of both global [20, p. 7794–7799] and regional [6, p. 2972–2980] analyzes.

The analysis of the global route networks soundness may be of interest to decision-makers whose purpose is to increase the security of the air transport network, allowing the detection of critical airports to prevent major network crashes, which can have a significant impact on the global economy. For example, Wilkinson, S.M., Dunn, S., and Ma, S. [33, p. 1027–1036] studied the impact of the eruption of the Icelandic volcano Eyjafallajökull on the global transport network, and Chi L.P. and Cai X. [14, p. 2394–2400] analyzed the resistance of the American airport network to errors and attacks. Thus, global air transport networks are the result of several layers of airline routes.

Participation in alliances may contribute to improving the strength of the network for member airlines through the resulting code-sharing agreements. The network of an airline alliance is the network of routes operated by its members and the routes of other airlines with which they have code-sharing agreements.

Therefore, airline alliance networks are also multilayered, as they represent an aggregation of airline networks, but have not been developed in any study using complex networks, although airline alliances have been extensively studied in the literature on air transport management [11, p. 1475–1498; 12, p. 573–602].

This level represents the structure of the alliance network of airlines and allows us to determine the properties of an organizational network. Analyzing the robustness of airline alliances networks may be of interest to airline and alliance management. Increasing the reliability and security of air networks and alliances may help these organizations to maintain and increase their long-term profitability. Finally, the classification into different levels will allow linking the characteristics for each level and studying the effects and relationships between them.

The literature on the dynamic behavior of air transport networks, although limited, has focused on the study of robustness. The chinese authors Liu, H., Hu, X.B., Yang, S., Zhang, K. [24, p. 495–505], used robustness in applying the genetic algorithm to optimize an airline's route network. Lacasa, L., Cea, M. and Zanin, M.[23, p. 3948–3954] made a more detailed study of the blocking transition phenomena in the European route network. More recently, Fleurquin, P., Ramasco, J.J. and Eguiluz, V.M [16, p. 1-6] have analyzed the problem of delayed propagation in the US airport network, and the authors Zhang, H.t., Yu, T., Sang, J. and Zou, X. [37, p. 590–599] applied a model that quantitatively describes and reproduces the real airport network.

The air traffic is part of a dynamic environment, where airports and routes may be temporarily closed for various reasons, such as weather events, security alerts, strikes or terrorist attacks, etc., which lead to high costs for airlines and states. For example, in 2010, the strike of air traffic controllers in Spain is estimated to have cost airlines $ 134 million, while snow and strikes cost EasyJet £ 31 million in the same year.

The alternative for airlines, depending on the cause of the failure, could be to look for a replacement route for their customers, using the routes of other airlines or to wait for the route or airport to be operational again. The analysis of soundness in air transport may assess the effect of errors (eg. bad weather) or attacks (eg. terrorism) on a route network. The robustness study allows the assessment of the ability of networks to avoid failure when some of its components are damaged [9, p. 175–308]. In this way, we can analyze the resistance of the network, tolerance to attacks and congestion caused by any failure.

All these technical aspects provide the necessary information for prospecting various scenarios in which air traffic safety could be affected. The ultimate goal of these studies remains to ensure the security of civil aviation.

Analyzing the soundness of business networks (i.e. companies or alliances) could influence decisions to open new routes or negotiate new code-sharing agreements. On the other hand, the analysis of the soundness of route networks in a specific region would contribute to better decision-making in the development of state policies in the field of air route safety. For example, European decision-makers may be interested in finding out which airports are most important in maintaining stable air communication. It may also be known which airports outside Europe could pose a problem for the flow of their air routes.

As the current literature is mainly focused on the development of the complex network, studies to date have used the global air route network as a special case of a complex network. As the aviation route network can be appropriately modeled and characterized as a complex network, it can be argued that it is time to apply complex network analyzes to aviation organizations: alliances and airlines.

Analyzing the topology of these networks may help to observe the way in which the own networks and alliances of the airlines are composed, allowing the evaluation of their characteristics and their influence on these companies. These developments may be of vital importance at all levels of study, from airline-focused studies to those focusing on the general political environment.

Only a systemic analysis of all types of route networks may effectively contribute to ensuring the safety of air routes in particular and to building a higher level of flight safety in general.

The concept of „use of airspace" is broader than the concept of „air traffic". The second refers to the first as part of the whole or as specific to the general. The Air Code of the Russian Federation defines the use of airspace as: „activities in which various material objects (aircraft, missiles and other objects) are moved into the airspace, as well as other activities (construction of tall structures, activities during which electromagnetic and other radiation occur, the release of substances into the atmosphere that affect visibility, blasting operations and others of this type), which may pose a threat to air traffic safety" [40, art. 11 (1)].

The rule contained in the article 11 of the Air Code of the Russian Federation does not have a general meaning, but a specific one: only in terms of air traffic management. This rule conceptually focuses on ensuring the safe use of airspace "taking into account the specific needs of the air traffic system" [42, p. 33].

It is also necessary to understand the legal content of the term "airspace user". According to the codified legislation of the Russian Federation, this means citizens and legal persons, entitled accordingly to carry out activities for the use of airspace [40, art. 11 (2)]. Although the notion of "users" in this case does not mention the state itself and the constituent entities of the Russian Federation, this is undoubtedly implicit, and the Air Code of the Russian Federation states: „All users of airspace have equal rights of use" [40, art. 13 (1)].

For comparison, the Romanian Air Code defines air traffic as an ensemble of aircraft that, at a given time, are flying in a given airspace or operate on the maneuvering surface of an aerodrome and operational air traffic as all movements of civil aircraft and carried out in accordance with national regulations other than those complying with the procedures of the International Civil Aviation Organization [2, art. 1].

The Air Code of the Republic of Moldova defines exactly these two notions in the same way and establishes that airspace users are operators of aircraft operated in general air traffic.

An increased knowledge of the topology of the airline network would allow a more complete assessment of the influence of different airports on the robustness of the global network and their impact on the connection of different regions.

It can be seen that there have been no studies on complex networks at this level, while alliances and code-sharing agreements have been studied through other approaches [11, p. 1475–1498; 12, p. 573–602].

It is therefore interesting to study the topology of what could be considered „mega-carriers" in the same way that it existed in the study of airlines. The analysis of the route network of alliances may provide a lot of information about the position of its members in such networks. By analyzing the topology of existing routes, how these alliances are built and evaluated may be determined, among other things, whether membership in an alliance increases the robustness of the airline's route network.

For example, if alliance members were selected only to increase the total range of their routes, and code-sharing agreements between its members would only be on routes not operated by them (i.e. complementary routes), the alliance would not provide robustness of its members. At the same time, members do not close similar routes and arrangements are made for code-sharing on routes operated by airlines (i.e. redundant routes), it can be seen that robustness increases as well as relevant benefits. This would only be an example because these characteristics depend on various network attributes and actually contribute to increasing the security level of the air route.

Theoretical developments around complex networks contribute to the understanding of a large number of phenomena, from social networks, economy and communication to financial and IT markets. The knowledge obtained regarding the topology of real complex networks allowed the application of robustness analysis techniques in the light of the errors and attacks faced by a network [10, p. 309–320; 5 p. 378–382].

Conclusion. It is up to the national legislature to define as clearly as possible the notions of airspace, air route, airspace user and the exact establishment of the rights, obligations and algorithm for exercising the freedoms of action of these entities, to perform this task in strict accordance with international principles and trends in the field of civil aviation regulation, which revolve around the imperative to ensure the security of service providers and their direct beneficiaries.

Ensuring air route security as an inherent part of the complex structure of instruments and people that ensures the rapid and safe movement of a growing number of people and quantities of goods in practice is one of the main priorities not only of the competent bodies, but also of intergovernmental and non-governmental structures that aim at achieving the safe use of airspace.

Currently, the creation and management of air routes cannot be effectively achieved by means of a national regulatory structure alone. The specificity of the structure and management of airspace requires governments to cooperate in order to ensure the stability, robustness and security of both air routes in particular and of all air traffic in general.

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