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Tendencies of Air Navigation Charges Caused by Changes in Geopolitical Situation

Dr.sc.ing Monta Aleksandra Lacane [1]
[1] Latvian National Defense Academy

Abstract
The situation in air traffic flows and collection of air navigation charges (ANC) has changed since February 24, 2022, when Russia invaded Ukraine, especially in countries bordering or located close to conflict zone, also Riga Flight Information Region (FIR).
The aim of this research is to analyze flight parameters, which affect a number of ANC collected by air navigation service provider (ANSP) SJSC "Latvijas Gaisa Satiksme". Using the results, it would be possible to state market tendencies in Riga FIR caused by changes in geopolitical situation, and suggest what issues should be taken into account in initial and continuation training of air traffic controllers so that changes in air traffic flow would not affect level of safety in the ANSP.

Keywords: Aeronautical charges, Riga Flight Information Region, Russian- Ukrainian War.

1. Introduction

There is a quote by J. R. R. Tolken "Look up at the sky, there is a light, a beauty up there, that no shadow can touch!". Air transport is probably the fastest way to reach distant destinations and the views from above have caught people's eyes since 1903, when the first flight was committed. But is there any shadow covering the beauty of blue skies, which does not allow you to fly for free? This shadow is called air navigation charges (ANC). What does it involve and how the situation has changed since February 24, 2022, when Russia invaded Ukraine and the situation with air traffic flows and ANC collection changed rapidly in countries bordering or located close to conflict zone, as well as Riga Flight Information Region (FIR)?

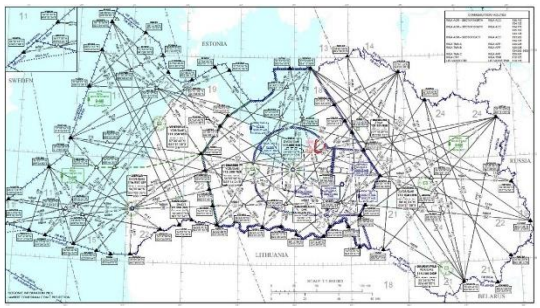

Figure 1. Riga Flight Information Region Upper Airspace chart. [4]

The aim of this research is to analyze each flight parameter, which affects the amount of ANC collected by air navigation service provider (ANSP) SJSC "Latvijas Gaisa Satiksme". Using the results, it would be possible to state air navigation market tendencies in Riga FIR caused by the changes in the geopolitical situation. The research is based on descriptive and inferential statistical analysis to identify the main affecting parameters, as well as causal analysis has been used. After the identification of patterns of the main manipulating data sets, trends, and relationships have been set using statistical techniques.

2. Literature Review

2.1 Definition of Aeronautical Charges (ANC)

Air navigation charges are defined as charges for air navigation services (ANS). The term air navigation services in accordance with International Civil Aviation Organization's (ICAO) document 9161 "Manual on Air Navigation Services Economics" [1.] includes air traffic management (ATM), communications, navigation and surveillance systems (CNS), meteorological services for air navigation (MET), search and rescue (SAR) and aeronautical information services/aeronautical information management (AIS/AIM). These services are provided to air traffic during all phases of operations (approach, aerodrome, and en-route) [2].

2.2 Definition of Airspace Concerned

Airspace is a portion of an atmosphere controlled by a country above its territory, including its territorial waters, and it may be further subdivided

into various areas and zones, including those with restrictions on flying activities or complete prohibition of flying activities. Article 1 of the Convention on International Civil Aviation, with regards to sovereignty of Airspace states, that every State has complete and exclusive sovereignty over the airspace above its territory. [3] A part of airspace, which is served by Latvian ANSP consists of airspace above the territory of Latvia, as well as a part of airspace, which in accordance with international treaties is delegated to the Republic of Latvia. The Riga FIR Upper Airspace chart is shown in figure 1.

2.3 Calculation of ANC

The charges for ATM, air traffic control (ATC) service are calculated by using a definite formula. Procedures for the Determination and Collection of the Charges for the Air Navigation Services Provided by the State Join Stock Company "Latvijas Gaisa Satiksme" are defined in accordance with Section 28, Paragraph 1 of the "Law on Aviation". It determines that the charge for en-route air navigation service in Riga FIR and in the airspace delegated to the Republic of Latvia in accordance with international treaties (hereinafter- Riga FIR, as shown in figure 1), shall be calculated, using the following formula [5]:

R= t x d x p, where: (1)

R- the charge for en-route air navigation services;

t- unit charge rate in Riga FIR.

In accordance with Articles 3.2(e) and 6.1(a) of the Multilateral Agreement Relating to Route Charges of 12 February 1981 (hereinafter – Agreement) [6] the calculation of the unit charge rate shall be examined and approved by the enlarged Commission (hereinafter– Commission) of the European Organization for the Safety of Air Navigation. [4]

d- 1/100 part of the distance covered within the Riga FIR. The distance factor of the route charge for a specific flight depends on the actual route flown as recorded by Network Manager; [4]

p- aircraft weight factor, which is calculated as a square root of a quotient, that is obtained by dividing by 50 the number of metric tons of the maximum take-off mass of the aircraft referred to the certificate of airworthiness, in the flight instructions or another similar official document. [4]

There are specific flights, which in accordance with Chapter 3, Article 9(1) and 9(2) of Commission Regulation (EC) No 1794/2006 of 6 December 2006 [7.] shall be exempted from the charging system, consequently- such flight are not considered in this research:

- flight performed by aircraft, the maximum authorized take-off weight of which is less than 2 metric tons;
- flights in accordance with visual flight rules (VFR) and mixed IFR (Instrument Flight Rules)/VFR flight in parts of airspace, where a charge for VFR flights is not applied;
- search and rescue flights authorized by the appropriate competent body;
- military flights performed by military aircraft of any country;
- training flights performed exclusively for the purpose of obtaining a licence;
- flights performed exclusively for the purpose of checking or testing equipment used or intended to be used as ground aids to air navigation;
- humanitarian flights authorised by the appropriate competent body;
- customs and police flights. [7]

3. Research Methodology

3.1 Research design

This research has been done by using quantitative methods of research. The author attempts to give answer to the previously described question- what are the main factors affected by the changes in the geo-political situation in the region that affect the collection of aeronautical charges and how they have changes recently and moreover- what shall be done by the corresponding ANSPs to keep their staff qualified enough.

In accordance with Sis International Research quantitative research is a well-structured way how to collect and analyze information obtained from different sources or information which describes different parameters. Quantitative research includes computation, mathematical and statistical tools to derive results.

3.2 Data used in research

Research is based on data obtained form Latvian Air Navigation Services Provider. All necessary data has been obtained from data bases used by the company and it is derived from flight plans filled in

by airlines before the flight. An official request for such data which is of a restricted nature had been sent to the company and had been received after approval of the request. Data used in analysis includes:

- Flight number;
- Departure aerodrome;
- Destination aerodrome,
- Type of aircraft used;
- Registration number of aircraft;
- Maximum take-off weight of aircraft;
- Entry point in Riga FIR (waypoint via which aircraft entered Riga FIR);
- Exit point of Riga FIR (waypoint via which aircraft left Riga FIR);
- Distance flown in Riga FIR.

Results of statistical data has been used to find out to what extent each parameter affects changes in aeronautical charges collected by the ANSP. Consequently, as air traffic intensity is closely related to safety issues and also to training of air traffic controller, a table of suggestions has been also created which should be taken into account in initial and continuation training of air traffic controllers.

4. Finding and Discussions

4.1 Analysis of Parameters Affecting Amount of ANC Collected by ANSP

Since Latvia is a Member State of Eurocontrol, the collection of route charges is done through Central Route Charging Office (CRCO) in Brussels, Belgium. CRCO runs an effective and centralized system, which ensures that the charges, essential to the funding of European air traffic management system, are handled with care. In accordance with Eurocontrol's Information Circular No 2022/01 on January 1, 2022 [8.] the CRCO started the billing and collection of en-route charges also on behalf of Ukraine as from November 1, 2021.

Latvian ANSP SJSC "Latvijas Gaisa Satiksme" collects aeronautical data, which is recorded by the company's air traffic management software. Table 1 gives an example of a few records:

Table 1. Sample of aeronautical data used in research

Flight	*Departure aerodrome*	*Destination*	*Type*	*Registration number*	*MTOW*	*Entry Point*	*Exit Point*	*Distance flown*
AAA22P	*UUWW*	*EHAM*	*F900*	*OOFFE*	*22*	*OPOKA*	*NINTA*	*592*
BBB522	*EGLL*	*RKSI*	*A359*	*HL8078*	*268*	*EVONA*	*NETNA*	*188*
CCC541	*RKSI*	*EDDF*	*A388*	*HL7625*	*560*	*SOKVA*	*GARSO*	*321*

- *Flight*- it is a callsign of an airline, which mostly consists of three letters indicating an airline and numbers indicating flight number;
- *Departure aerodrome*- an airport that is approved by ICAO and has an official designator, which consists of four letters as stated in ICAO's Doc 7910- Location Indicators; [9]
- *Type*- aircraft type in accordance with ICAO Doc8643- Aircraft Type Designators; [10]
- *Registration number*- official registration number of aircraft as shown in its technical documentation;
- *MTOW*- maximum take-off weight of aircraft as shown in the certificate of airworthiness;
- *Entry point*- a radio navigation point, a waypoint via which aircraft enters Riga FIR;
- *Exit point*- a radio navigation point, a waypoint, via which aircraft leaves Riga FIR;
- *Distance flown*- a distance covered within the Riga FIR.

Table 2. Results of aeronautical data analysis- average values in observed period and percentage against year 2019

	Number of flights (1)	Against 2019 (2)	Average dist, km (3)	Against 2019 (4)	Average MTOW, t (July) (5)	Against 2019 (6)
2019	302048		210.245		202.56	
2020	134841	-55.36%	204.442	-3%	186.42	-8%
2021	168667	-44.16%	199.458	-5%	200.49	-1%
2022	114120	-62.22%	107.7855	-49%	177.36	-12%

For instance, airline AAA2P (to protect airline's privacy, the callsigns shown have been changed) entered Riga FIR at 06:07 UTC. Aircraft F900 (Dessault Falcon 900) departed from UUWW (Vnukovo International Airport in Moscow) and flew to EHAM (Amsterdam Airport Schiphol). MTOW of aircraft 22 metric tons. In Riga FIR it followed route OPOKA-NINTA, and covered 592km in this airspace.

In research statistical data are compared to year 2019, when traffic intensity in Riga FIR was the highest. Time period observed is from March to July from 2019 until 2022, also to compare the effect of the war on air traffic, as well as the effect of Covid-19 pandemic, which in Riga FIR started in March 2020.

4.2 Results obtained in analysis

Table 2 (column (1)) shows a total number of aircraft recorded each year from March to July from 2019 until 2022. The analysis shows, that total number of flights has reduced even by 62.22% in the observed period, giving the greatest drop in traffic in April 2020 -81.9%, which was the result of Covid-19 pandemic restrictions, and -44.79% in April 2022, the main cause of which was the change in geopolitical situation. From May, 2022 until July the decrease was slightly less, because of increased demand of air transport for summer vacations. From these values we can see, that aircraft movement in Latvia was more badly affected by the pandemic in summer 2020 than in summer 2022.

In table 2, column (5) reveals average distance of aircraft flown in Riga FIR from 2019 until 2022, also from March to July. From the results and comparison to the year 2019 (table 2, column (6)), we can see that the average MTOW of aircraft has reduced, the lowest value -12% given in 2022. Usually, heavier aircraft is used for cargo flights. Air traffic flow in Riga shows that rather often airlines from Far East, also China, which before February 2022, used Western part of Riga FIR on their way to/ from Western Europe to China, Japan or other countries in that region, and they also crossed Russian Federation airspace on their way, entering it via Estonia. Because of the sanctions introduced by European Unit, this air traffic flow with the heaviest aircraft, changed, also Western Europe airlines do not use Russian airspace for transit. In order to get a better picture of this situation, air traffic was analysed also by type of aircraft. The results are shown in Table 3.

Table 3. Example of results of aeronautical data analysis in Riga FIR by type of aircraft

	March				**April**			
Aircraft type	Number of flights	Against total, %	Against 2019, %	Average MTOM	Number of flights	Against total, %	Against 2019, %	Average MTOM
Total	12995	-	-41.31	-	13505	-	-44.79	-
A20N/ A21N	519	3.99	265.49	76.38	677	5.01	134.26	75.19
A319	500	3.85	-62.60	69.11	474	3.51	-66.09	68.65
A320	1122	8.63	-57.14	74.31	1247	9.23	-58.91	74.27
A321	570	4.39	-68.70	87.6	877	6.49	-55.35	87.68
A388	0	0.00	-100.00	0	0	0.00	-100.00	0
B733	4	0.03	-99.14	62.62	0	0.00	-100.00	0
B738	2296	17.67	-4.73	74.83	2475	18.33	-7.23	75.1
B744/ B748	204	1.57	-72.51	415.12	101	0.75	-85.91	411.77

In fact, air transport is used not only for passengers, but also for cargo aircraft. Unfortunately, ATM system of Latvian ANSP does not allow to distinguish between passenger and cargo flights, moreover, in terms of ANC collection, there is no difference. But despite that, by analysing MTOW of aircraft, it would be possible to determine, whether airlines fly less (as from results stated in previous paragraph), but use heavier, thus bigger, aircraft, which can carry more passengers or cargo, of they fly less and are forced to use even lighter aircraft, which in terms of ANC collections would be the worst scenario.

One of the most widely used cargo aircraft is the Boeing 747-400 (B744) and its upgraded modification 747-800 (B748). The average MTOW of B744/748 (these two modifications have not been analysed separately, consequently, it had not been considered that typically B748 is heavier than B744) in Riga FIR in 2019 was 414.54 tons, but in 2022 was 413.98. Here it is seen, that changes in MTOW of this type of aircraft are not significant. In fact, the average MTOW of aircraft has reduced significantly since April 2022.

The number of aircraft Boeing 744/748 has reduced by 72.51% in March 2022, and by 90.57% in June 2019. There is another super heavy aircraft, which can carry even more than 600 passengers, Airbus A380, which is the first fully double-deck aircraft in civil aviation. It had been used before also in Riga FIR, but there are no records about Airbus A388, the average MTOW of which is 560 tons, in Riga FIR since March 2022.

Airbus company has introduced new modifications of the most often used civil aircraft A320 family- Airbus A320 Neo and A321 Neo. The number of aircraft Airbus A320Neo has increased by 265.49% in March 2022 and by 107.76% in July 2022 compared to 2019, which is a sign of an upgraded fleet of airlines. The most widely used aircraft in 2022 is Boeing 738 (20% of total flights in July 2022) and Airbus A320 (9.64% in July 2022), which are typical middle-range passenger air carriers.

Table 4. Example of results of aeronautical data analysis: changes in use of aircraft types (proportion of a particular aircraft type in respect to total amount of aircraft), year 2022

	March 22	April 22	May 22	June 22	July 22
	% of total				
Aircraft type	-41.31	-44.79	-41.13	-39.14	-40.56
A20N/A21N	265.49	134.26	163.32	115.9	107.76

A319	-62.6	-66.09	-67.99	-54.16	-59.63
A320	-57.14	-58.91	-52.05	-49	-50.21
A321	-68.7	-55.35	-40.66	-53.79	-24.6
A388	-100	-100	-100	-100	-100
B733	-99.14	-100	-100	-98.31	-99.49
B738	-4.73	-7.23	-2.91	4.1	5.19
B744/B748	-72.51	-85.91	-88.92	-90.57	-89.2

In order to have a better understanding of changes, the data from Table 4 have been visualized in Figure 2.

From here we can see that changes have shown a proportional tendency for all types of aircraft considered in the analysis. There are three types of aircraft- A20N/ A21N, A319 and A320, the number of which in Riga FIR has increased since July 2021.

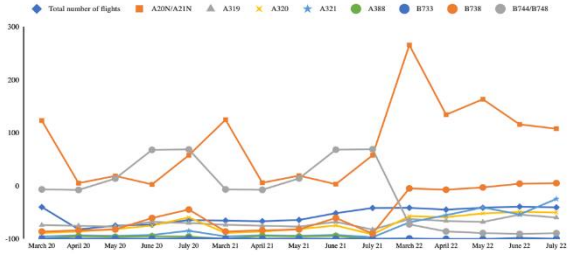

Figure 2. Changes in use of aircraft types (proportion of a particular aircraft type in respect to total amount of aircraft), year 2022

5. Conclusion and Further Research

The research reveals that the geopolitical situation has changed the average distance flown by aircraft in Riga FIR. As from table 2, column (3), it was 107.79 km in 2022, which has been reduced by 49% compared to 2019, because there is almost no traffic on a way from waypoint NINTA to IGORO (figure 3, purple line), 611 km, and OPOKA- NINTA (figure 3, green line), 592 km, which are the longest routes in Riga FIR. In July 2019 1723 aircraft followed these routes, in July 2020 and 2021- 268 and 294 aircraft, which is by 84% less compared to 2019, but in July 2022- none, a reduction by 100%. In 2020 average total distance flown had reduced only by 3%, in 2021 by 5%. These changes in 2022 are caused by sanctions introduced by European Union on February 27, 2022, which prohibit all aircraft owned, chartered or operated, or otherwise controlled by citizens of the Russian Federation. There are more aircraft in international waters

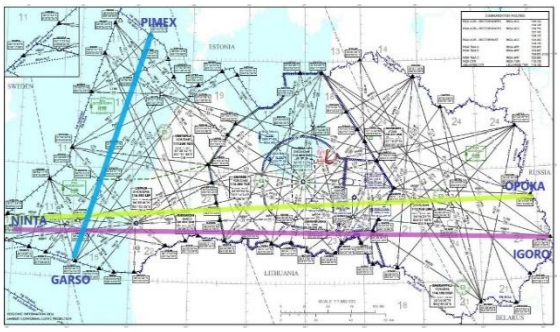

Figure 3. Changes in the main traffic flows in Riga FIR because of changes in geopolitical situation against year 2022.

flying to or from Kaliningrad area via waypoints PINIX (PIMEX), PIVAX, GARSO to or from Russia (figure, blue line). This direction air traffic has become more complex, as Kaliningrad Airport is located close for FIR boundary. This means, that aircraft going to or from Kaliningrad, cross Riga FIR in changing vertical profile, which increases workload for air traffic controllers significantly.

The analysis shows, that the total number of flights in Riga FIR has reduced even by 62.22% in the observed period, giving the greatest drop in traffic in April 2020 -81.9%, which was the result of Covid-19 pandemic restrictions, and -44.79% in April 2022, the main cause of which was the change in geopolitical situation. From May 2022 until July 2022 the decrease was slightly less because of increased demand of air transport for summer vacations. From these values we can see that aircraft movement in Latvia was more affected by the pandemic in summer 2020 than in summer 2022 by changes in geopolitical situation.

Air traffic flow in Riga shows that rather often airlines from Far East, also China, which before February 2022, used Western part of Riga FIR on their way to/ from Western Europe to China, Japan or other countries in that region, and they also crossed Russian Federation airspace on their way, entering it via Estonia. Because of the sanctions introduced by European Unit, also this air traffic

flow with heaviest aircraft, changed, also Western Europe airlines do not use Russian airspace for transit. But furthermore, there are more flights from waypoint PINIX-PIVAX-GARSO, which are used by Russian aircraft to reach Kaliningrad. This new traffic flow increases air traffic controllers' workload significantly because of changing vertical profile of aircraft over international waters (High Seas). Consequently, controllers need to adapt to new traffic patterns to which they are not used, they need training as well, to keep the level of safety in the region the same.

The average MTOW of aircraft in Riga FIR has reduced, the lowest value -12% giving in 2022. Average MTOW of B744/748 aircraft in Riga FIR in 2019 was 414.54 tons, but in 2022 was 413.98. Here it is seen, that changes in MTOW of this type of aircraft are not significant. Average MTOW of aircraft has reduced significantly since April 2022, reaching even -17%.

Table 5. Factors to consider in training of air traffic controllers in case of serious changes in number of aircraft handled by air traffic services unit or sector

Factors affected	Possible solutions	Factors to consider by training unit or ANSP
Decreased workload for air traffic controllers	Increased minimum hours required on simulator to renew ATCOs licence (stated by ANSP)	- Number of aircraft in one simulator run (exercise); - Content of simulator exercises; - Changes in air traffic flow; - Changes in air traffic complexity and conflict solutions
Increased fatigue and boredom in ATCOs	Rostering	- Duration of shifts; - Organization of on-duty and off-duty time in a shift; - Methods to keep ATCOs focused all the time during shifts
Lack of personnel (ATCOs, instructors, competence assessors etc.)	Consider number of personnel required at the moment, in short and long term	- Opportunities to provide high quality on-the-job training; - Necessity to adjust numbers of hours for practical training on simulators and on-the-job training (OJT) - Necessity to adjust training methods (especially OJT)

The number of aircraft Boeing 744/748 in Riga FIR has reduced by 72.51% in March 2022, and by 90.57% in June 2019. There super heavy aircraft Airbus A380, had been used before also in Riga FIR, but there are no records about Airbus A388, the average MTOW of which is 560 tons, in Riga FIR since March 2022.

The number of aircraft Airbus A320Neo has increased by 265.49% in March 2022 and by 107.76% in July 2022 compared to 2019. This is a sign of an upgraded fleet of airlines, which allows to save some resources.

The most widely used aircraft in 2022 are Boeing 738 (20% of total flights in July 2022) and Airbus A320 (9.64% in July 2022), which are typical middle-range passenger air carriers.

Due to the factors mentioned above, there is a sharp loss of revenue of ANS provider in Riga FIR, even showing a reduction by more than 30%.

Changes in the geopolitical situation in the region have changed not only the number of aeronautical charges collected by each ANSP in the affected region, but also have revealed additional questions seeking answers. First, aviation is about safety, as well as air navigation. To maintain the previous level of safety or to become even safer, ANSPs are forced to deal with additional factors, such as training of personnel. Air traffic controllers are trained in accordance with EASA Regulation 2015/340, which also states requirements for continuation training- the one which is continuously accomplished after ATCOs license is obtained. Such training shall be considered necessary to include additional training because of the reduced amount of air traffic in FIR. The reduced number of aircraft in FIR naturally affects a person's ability to stay focused long time, it

introduces additional problems connected with stress and fatigue.

Consequently, the most affected FIRs in the region are forced not only to deal with financial resources affected by the geopolitical situation, but also with human factors of ATCOs and other personnel. This research data can be used for further study cases in order to identify regions, countries or maybe also airlines, which contribute the most to increase or decrease in number of aeronautical charges collected. This could also reveal other most affected regions- both in a positive way and in negative.

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