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Conference Paper · October 2017

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2nd International Symposium on Fuzzy and Rough Sets (ISFUROS 2017)

Development and New Technologies for the Management of the Panamanian Airspace, challenges and possible solutions

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Abstract: Panama faces significant challenges in copying with an increment on air travel through its airspace and terminals, thus generating a great need for modeling and managing possible solutions for its airspace. This paper presents a preliminary approach for the implementation of a laboratory specialized in modeling and management of Panamanian airspace. Objectives, possible research areas, and key actors, have been identified.

Keywords: Air space, Panama, modeling,

1. Introduction

Flying is more popular than ever before. Although once a luxury that only a privileged few could afford, air transport has become a veritable form of mass transit over the last few decades.

Because of becoming a mass transit system, the sky is never completely clear. Every minute of the day-morning or afternoon-there are about 11,000 airplanes, somewhere in the world. In the year 2014 the 100,000 daily flights were surpassed (an average of 102,465, versus an average of 99,700 in 2013). In that same year, 1,397 commercial lines used 273 billion liters of fuel, operating from 3,864 large airports, moving 2,790 million passengers on 49,871 routes[1]. In 2016 the airlines will transport globally 3.6 billion

[1] http://static.hosteltur.com/web/uploads/2013/09/Volando_hacia_el_futuro_cuatro_tendencias_que_dominaryAn_en_2015.pdf

passengers. That represents an increase of about 800 million on traffic figures of 2011 and will put increasing pressure on the air transport industry[2].

In addition, the growth of the economy and the status of Panama as an increasingly important hub between North and South America, makes the flow of passengers of the international airport of Tocumen, the main port of entry, achieving during the last years an important increase of flights and airlines[3].

Given the importance of an efficient air transport system, it is necessary to recognize the different aspects that this entails. For example, in many countries airports, despite being recognized as a key infrastructure for a country's economic and social development, have difficulties in managing their resources in real time.

The complexity in airport management appears when a large number of operations are concentrated in a short period of time, which must be addressed simultaneously, where it is necessary to share the maximum number of possible resources to reduce costs without harming the quality of service. The management of runways and taxiways should be made considering not only the requested operations by the airlines, but also the changes in the scheduled hours due to delays or the condition of the terminal, which may make it difficult for passengers or their baggage to be on time at the boarding gates, where a small disturbance on the scheduled activities can spread quickly and affect the rest of the planned operations in a cascade effect (Rios, 2017).

Finally, it is necessary to investigate and understand all aspects of air traffic management, based on a review and, if necessary, a complete rethinking of methodologies that allow the navigation of airplanes, through the introduction of new efficient methodologies, and the development of new technologies for airport airspace management in real time, through concepts such as Airport Collaborative Decision Making (A-CDM), which aims to improve the operational efficiency of all airport operators by optimizing the utilization of resources, which should lead to reduce delays, and to increasing the predictability of events during the progress of a flight. The ultimate objective is to achieve safer, more efficient, competitive and sustainable air transport (Rios, 2017, Dutary, 2017).

The main objective of this document is to present the establishment and development of a center for the management, at all levels, of the air space and Air Traffic Management

[2] http://logistics.gatech.pa/en/assets/airports/tocumen

[3] http://www.tocumenpanama.aero/panama-ciudad-pty/terminal-2

(ATM) in Panama. It is expected to position this center as a reference in training in the field of air space management, so that it can participate in projects of specialized professional training, research and technology transfer with companies in the aeronautical sector, users of airspace and with institutions and organizations in the region, among others.

2. Literature Review.

Sustained growth in the aviation industry has put considerable strains on the resources of air transport systems. As an example, air traffic movement in the Latin American region is expected to grow by more than 6% over the next 20 years, with more than 3,000 new aircraft, while traffic at Tocumen Airport in Panama will double by 10 years (Ley, 2017, Dutary SA, 2017). This has resulted in an increase in flight delays, airport congestion, extreme resource use, and a decrease in safety and air movement effectiveness (Bertsimas & Gupta, 2016).

Aircrafts fly in airspaces that belong to an official network of air routes. Airspace is divided into different regions, of which two are those that are interested in air flow management: the airspace of the terminals and the space between these terminals (Fondacci & Goldschmidt, 1998). This space between terminals is divided into sectors with a maximum capacity equivalent to the rate of aircraft allowed to enter the sector, which tend to be saturated if they are sectors of high demand.

As shown in figure 1, each region of the air space between terminals generate a series of challenges, effects over the performance of the air space system and impacts on the business.

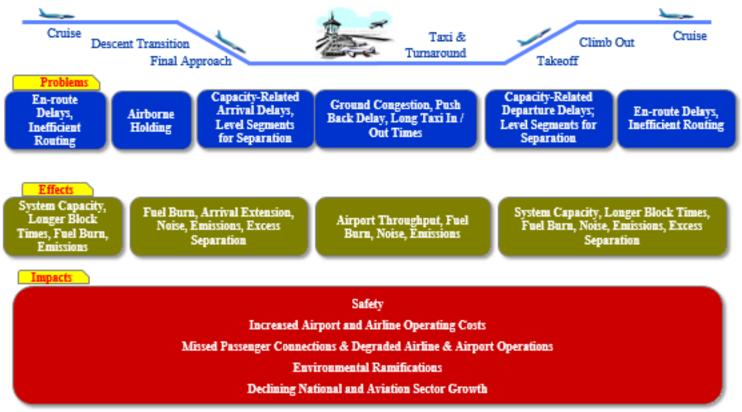


Figure 1. Airspace management and optimization, constraints and impacts (Ley, 2017).

As seen, in managing and optimizing airspace, it is necessary to consider several elements that make the combinatorial complexity of the problem to increase. On one hand, there are those stochastic elements that do not allow deterministic definition of parameters that describe the operations of an aircraft: takeoff, ascent, level flight, descent and landing. These stochastic elements are often exogenous to the flight management system; climate, operational problems in the final destination, mechanical problems, etc. On the other hand, there are those elements that define the flight plan of the aircraft: heading, route and height, which are defined according to the sectors in which the airspace is divided. Finally, there are those elements that govern the behavior of terminal space, such as schedules, flight saturation, entry and exit of aircraft, boarding, and fuel loading, among others (Fondacci & Goldschmidt, 1998).

The traffic and airspace optimization models should then consider aspects of collaborative decision making between the different entities involved in these operations: air traffic, airlines, airport administration, and flight control and ground services. Consideration should be given to aspects such as capacity and occupation of the sectors, conflict analysis, and workload for control centers, flight plans, meteorological services and air operators (Sherali, Staats, & Trani, 2006) and the free flight paradigm presented by Sherali, et al (2002), which allows airlines to dynamically develop better and more effectives air routes without several of the constraints currently presented.

Ley (2017) presents the perspective of the Systems of Systems approach to analyze the safety, efficiency, capacity and interoperability of airspace. As seen in figure 2, an Air Space Ecosystem that considers the complexities of the different stakeholders involved in the airspace components, with the airplane as the center of the system. Systems Systems theory (SoS) explains the concept of a highly complex system, where there are multiple subsystems that interact coordinately within a single system[4].

First of all, it is the Air Space, where it is necessary to consider the design processes of such space, air traffic management and the optimization of the routes in real time among other aspects. On the other hand, airlines have to design based on their flight operations, maintenance operations, crews and fleets.

[4] http://rs.ieee.org/component/content/article/9/77-system-of-systems.html

The air terminal is another element of importance, since it must coordinate the movement and operations in the ramp and tracks, optimization of arrivals and departures, optimization in the handling of doors, etc.

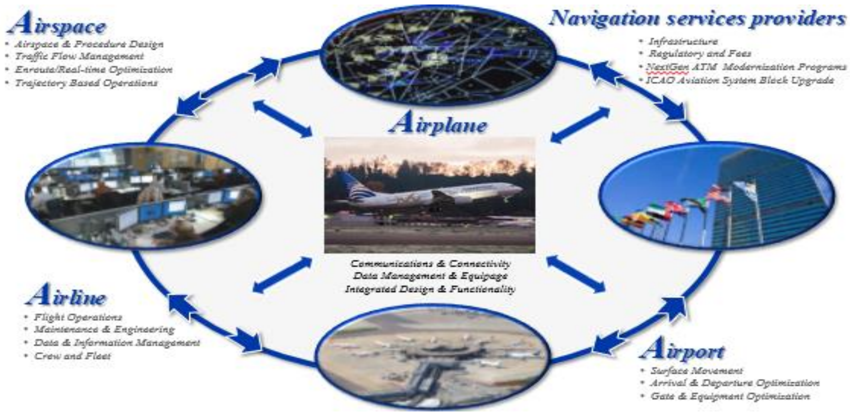
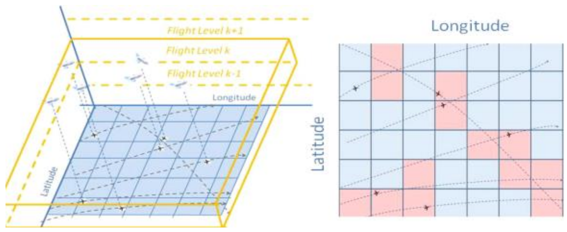


Figure 2. The Eco-System perspective (Ley, 2017)

Finally, there are providers and regulators of air navigation services, with their regulatory aspects, infrastructure, modernization and updating programs, among others. All these systems must be in constant communication and with complete connectivity with the aircraft, which must have sufficient functionality and ability to be constantly integrated with all these elements.

The analysis of the spaces between terminals has a computationally complex approach since it is necessary to consider a 4D space-time analysis, considering route, trajectory, height and the dynamic aspect of the movement of the aircraft as seen in figure 3 (Nosedal, Piera, Solis, & Ferrer, 2015).



(a) (b)

Figure 3. (a) 4D trajectories and (b) macro-mapping and concurrence events in a sector (Nosedal, et al, 2015)

In addition, it is necessary to develop tools to determine, in real time, as well as in the medium and long term, the minimum separation distance between the aircrafts in the sectors that are part of the air space between terminals. The tool should take information such as the volume of the sector, the number of aircraft crossings and the routes and trajectories, as well as the number of aircraft and their speeds, in order to generate traffic scenarios that meet the constraints and objectives defined by the analysts (Ghoneim & Abbass, 2016).

Moreover, the modeling of terminals and airports will allow the development of tools to analyze flight frequencies, aircraft service and systems management in order to alleviate terminal congestion, which in turn helps to mitigate airspace congestion (Vaze & Barnhart, 2012), to plan operations under critical conditions (Jacquilla & Odoni, 2015), to optimize the allocation of spaces such that it will be possible to meet the time objectives and minimize congestion (Churchill, y otros, 2013), and to study the queues on taxiways that increase aircraft congestion and delays in operations (Simaiakis & Balakrishnan, 2016). Finally, it will allow to model the optimal allocation of gates for efficient operation (Steuart, 1974) the optimal configuration of runways and taxiways (Bertsimas, Frankovich, & Odoni, 2011), or to perform an economic and operational analysis of the role of the dominant hubs in the air operating system (Bilotkach & Pai, 216).

Panama is showing a deterioration in its airspace traffic system. Figure 4 (Silvera, 2017) shows the area and complexity of its airspace and traffic. Due to an increment in traffic to and from Panama, with new routes and more traffic overflying the country, a series of issues have to be investigated, such as that the configuration of some routes dates back to several decades, all routes are bidirectional, and high concentration of traffic in some control points and routes, among them

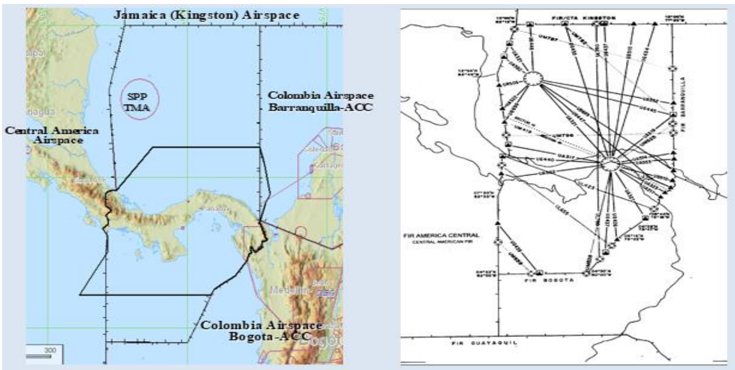


Figure 4. Panama Flight Information Region (Silvera, 2017)

According to the Civil Aviation Authority of Panama (Silvera, 2017) that the number of operations in Tocumen have increased from a little over 136,000 in year 2014, to near 146,000 in 2016. Table 1 shows the operations in terminals (TMA) and overflights in

Panama Flight Information Region (FIR), that shows and increment over 12% in the total number of operations in Panama, from 2014 to 2016.

Table 1. Total Flight Operations in Panama (Silvera, 2017)

Year	2014	2015	2016	% increase from 2014
Tocumen operations	136,851	141,593	145,830	7%
Other airports (TMA)	92,068	109,585	109,628	19%
TMA Operations	215,838	250,778	255,458	18%
Overflights	60,467	67,880	67,680	12%
Total Operations FIR Panama	289,386	318,658	323,138	12%

3. Project objectives and goals.

The main objective of the project is the creation of a Laboratory for the Development of Technology and Practices for the Management of the Air Space in Panama (LabGea). This laboratory will have the task, among others, of developing simulation models to evaluate the benefits and limitations of real-time management and decision-making policies at different types of airports. Due to the high dynamic complexity of these systems, as a first step, it will be necessary to clearly define the scope of work of the optimization models. That is, if the stakeholders propose to concentrate only on the airspace of the terminal, the space between terminals, or the terminal itself, and all the elements associated with them, in order to be able to define the scope and characteristics of the modeling activities.

The laboratory will investigate the development of new decision support tools to improve flight operations and integrate them into ground operations. Transfer activities and continuous education will also be carried out with agreements and collaboration projects with the main companies, institutions, training centers and international agencies. For that purpose, it will have simulation laboratories, analysis and modeling units, specialists in aeronautical systems development, among others, to evaluate, validate and verify new technologies and processes developed locally and internationally and their applicability in the regional aeronautical sector.

The training and education center will contribute to form professionals that will work in the implementation of collaborative processes for integrated operations and decision making at regional airports and air traffic control centers, considering the complex behavior of these systems and the emerging behaviors that arise due to transitions of the air airspace context.

The laboratory working areas would be, among others:

- Airport management
- Administration, use, modeling and simulation of airspace
- Modeling and simulation of airport systems
- Economic analysis of airport operations
- Navigation technology
- Multidisciplinary area for projects and works related to the subject, but not within the aforementioned.

The Laboratory will begin with a Pilot Project for the formulation and calibration of an Optimization Model of the Panamanian Air Space, specifically oriented to the Operation of the International Airport of Tocumen, Marcos A. Gelabert and Panama Pacific and the international routes that share the Panamanian. The basic concept for this specific project is that it will make possible to specify the requirements of external specialized support, identify and concentrate the national specialized human resource and establish a mechanics and organization of joint work, focused on a specific and clearly defined objective.

4. Main stakeholders

Para la implementación de este proyecto se requiere la participación y contribución de algunos actores clave, entre ellos:

- The National Secretariat of Science, Tecnology and Innovation of Panama (SENACYT)
- Technological University of Panama (U. T.P.)
- International Civil Aviation Organization (ICAO):
- Civil Aeronautical Authority of Panama (AAC)
- Tocumen, S.A
- Copa Airlines

- Otros actores:
  - University of Texas, Arlington College of Engineering[5]
  - IATA[6]
  - Barcelona Cluster of Aeronautical Sciences at the [7],
  - Jeppesen Aerospatial Services[8].
  - El Laboratorio de diseño de sistemas aeroespaciales de Georgia Tech Laboratory for aersopatial systems design[9].

Conclusions

As seen in the document, the justification of LabGea is widely explained. The rapid increment on the use of airways around the region is causing extreme saturation of air terminals and the airspace, decreasing security aspects, service to customers and airline increment of costs. The idea of this Laboratory is to have a facility that will be a regional reference as a center for research and solutions for different agencies, organizations, corporations and university around Central America, North of South America and the Caribbean.

Acknowledgement: The authors want to acknowledge the iMODA Network (Red Iberoamericana de Investigación en Modelos de Optimización y Decisión y sus Aplicaciones http://imoda.ugr.es/web/) for the support to write and present this paper.

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