[EN-I-077] Geo-Informatics Platform for Aviation

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Abstract: To respond the increasing demand of air transportation, airspace utilization and air traffic management will have to be more optimized and take into account real time situation dynamically. In order to achieve these goals, the system should be able to synergize the information with the analysis and optimization algorithm seamlessly. However, this still not the case for general air traffic operations nowadays, where most of the information still not integrated together or being recorded separately in non-digital format. Even though there are initiatives to use Aeronautical Information eXchange Model (AIXM) as a standard for the data, there is still not so many algorithms or visualization tools that link all of these information and algorithms coherently.

In this work, we had developed a platform, in the framework of Geo-Informatic System for AVIAtion (GISAVIA) project, that allows the users to collect, process, and analyze both static and dynamic information as well as connecting with the optimization algorithms efficiently. The proposed platform also enables the user to visualize multiple sources of information and results in 3D and 4D. In this article, we show the information, tools, and applications that are implemented for Thailand civil aviation on this platform, i.e. aeronautical information, eTOD data collection and visualization, navigation aid coverage analysis tool, conflict detection algorithm, and terrain and obstacle analysis tool.

Keywords: GIS, Platform for Civil Aviation, Data Visualization, Post analysis, Air traffic simulation

1. INTRODUCTION

To maintain at least the same level of safety and system efficiency while air traffic demand is continuously increasing, the air traffic management system must improve its efficiency by modernizing the system in various domains. Currently, there are several projects aiming to modernize the air traffic management system such as the Next Generation air transportation system (NextGen) in the U.S. and the Single European Sky ATM Research (SESAR) in Europe. In these future air transport management context, wide range of analysis and optimization algorithms such as trajectory planning algorithm, dynamic airspace management algorithm, sequencing algorithm for departure and arrival, and automatic conflict resolution have been proposed and implemented.

Aeronautical information (such as air route structure, location and characteristic of air navigation instruments, dangerous, prohibited, and restricted airspace, etc.) and geo-information (such as terrain and obstacle data) are one of the most important information. They are necessary for development of analysis, optimization, and automation tools, in order to ensure safety and efficiency of civil air transport [1,2]. This information is used in all activities related to civil aviation from design and planning phase (e.g. for airspace design, procedure design, and navigation aid infrastructure assessment) to operational phase (e.g. flight planning, trajectory optimization, and traffic control).

To the author's knowledge, there is still not so many platform and visualization tools that link all of the aeronautical information and these algorithms and tools coherently.

In current operation, this information is stored in a paper-based format or in a format that cannot be directly integrated with other tools. Moreover, existing data management and optimization tools still visualize the data and results in two-dimension format which are not easy to interpret by the user/decision maker.

In this paper, we present an extension of a geo-information platform for aviation presented in [3]. The proposed platform allows the user to seamlessly integrate aeronautical information with analysis and optimization tools, then visualize all the data in a more intuitive manner to facilitate the users / decision maker and let them analyses the traffic more efficiently.

The proposed platform is currently being developed in the framework of Geo-Informatic System for AVIAtion (GISAVIA) project. In this paper, we show the information, developed tools, and applications that are implemented for Thailand civil aviation on this platform.

The following of this paper is organized as follows. Section 2 describes the overall structure of the platform. Section 3 demonstrate implementation of the platform using Thailand's geo-information and aeronautical information. Finally, conclusion and perspective for future works are discussed in Section 4.

2. Geo-information platform for aviation

The overall structure of the proposed platform is presented in Fig. 1. It consists of three main modules as follows.

- **Data**. The data to be integrated into the platform includes static *data* such as geo-information (digital terrain model (DEM) and obstacle data), aeronautical information (e.g.\ airport location, waypoint location, routes, airspace sector boundary, navigation aid instrument position, etc.) and *dynamic data* such as air traffic data, weather information, etc.
- **Analysis and optimization tools.** The platform allows the user to connect with any analysis and optimization tools. In this paper, we present tools that has been developed for air traffic analysis tool, trajectory planning, obstacle and terrain assessment, navigation aid assessment tool.
- **Visualization tool.** This module integrates the above-mentioned modules and visualize the information in 3D and animation format.

The system architecture of the proposed platform is illustrated in Fig. 2. This web-based platform consists of web-server and client sides. On the web-server, imagery (raster) and vector geo-information is stored in *GeoServer*, which is an open source server platform designed especially for geospatial data. On another hand, additional aeronautical information and dynamic data (i.e. daily or near real time air traffic data) is stored in a separate database which connects directly with air traffic analytical tools. All of these modules are linked directly with *Cesium*, a virtual globe map engine, such that on the client part, the user can interact with the system (upload, download data, execute analysis and optimization tool) and visualize the data through any web browser.

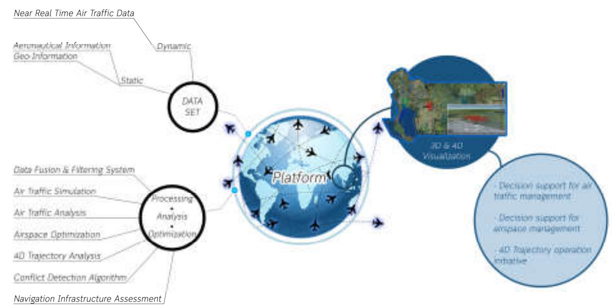

Figure 1 Geo-information platform for aviation.

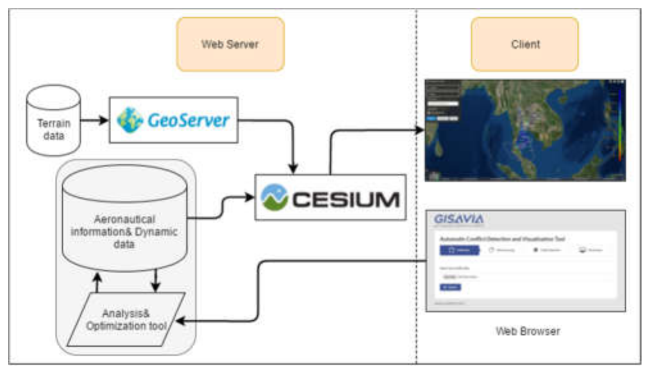

Figure 2 System architecture.

3. Analysis and Optimization modules

This section describes analysis and optimization modules that have been developed and implemented on the platform.

3.1 **Air traffic analysis module.** This module has been developed as a post analysis tool. Currently, it consists of two main functions.

3.1.1 *Conflict detection module.* Conflict is a situation when horizontal and vertical separation between aircraft are less than given limitations. To ensure safety of aircraft traveling from origin to destination airport, the air traffic management regulation requires aircraft to be vertically separated by at least N_v = 1,000 feet and horizontally separated by N_h = 3 nautical miles for aircraft operating in the terminal maneuvering area (TMA) and by N_h = 5 nautical miles for aircraft operating in the en-route environment [6]. One can consider that each aircraft has a bounded and closed reserved block of airspace defined by a three-dimension cylinder, as shown in Fig. 3, in which other aircraft are not allowed to enter.

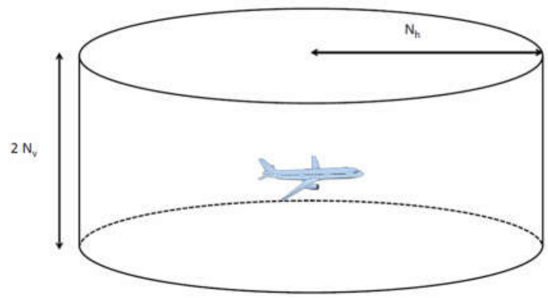

Figure 3 Protection volume.

In real-time operation, the air traffic controller has conflict alert system that alert the controller when two aircraft has high chance to be in conflict. However, in some air traffic management system, there still lack of tool to record air traffic data and perform post-analysis for safety management.

The proposed conflict detection module relies on an algorithm presented in [7]. It allows the user to upload collected air traffic data (from radar or Automatic Dependent Surveillance – broadcast: ADS-b). Then, it detects any violation of separation standard between aircraft in the terminal maneuvering area and en-route airspace, visualize the results in 3D and animation format, as well as generate conflict reports.

3.1.2 Air traffic density. This module determines density of traffic in each en-route airspace during each operating hour. It allows the user to detect peak hour and peak density, in order to plan efficient airspace usage and management strategy.

3.2 Navigation aid coverage analysis tool. This tool determines coverage of navigation aid equipment such as VHF omnidirectional range (VOR) and distance measuring equipment (DME) at different altitude from the ground, taking into account terrain and obstacle data.

3.3 Terrain and obstacle data analysis tool. For flight safety, terrain and obstacle in the airspace has to be identified and limited. When planning for airport and aerodrome, information about locations height and shape of the terrain and obstacle has to be taken into consideration. This tool aims at analyzing effects of terrain and obstacle near by the airport. It allows the user to automatically create the obstacle limitation surface [5]. It detects any terrain and obstacle that penetrates this surface and visualize the result in 3D.

4. Platform implementation

The proposed platform has been implement as a web-based tool and tested with data and information of Thailand civil aviation.

Aeronautical information such as airport locations, TMA boundary of each airport, en-route airspace sector, airspace class, boundary of each special used airspace (dangerous, restricted, and prohibited area), domestic route, international route, and area navigation (RNAV) route are obtained from the aeronautical information publication (AIP) [5] through website https://www.caat.or.th/. These information are then digitized and integrated into the platform. Example of visualization of these information in three dimensions are illustrated in Fig.4 and Fig. 5.

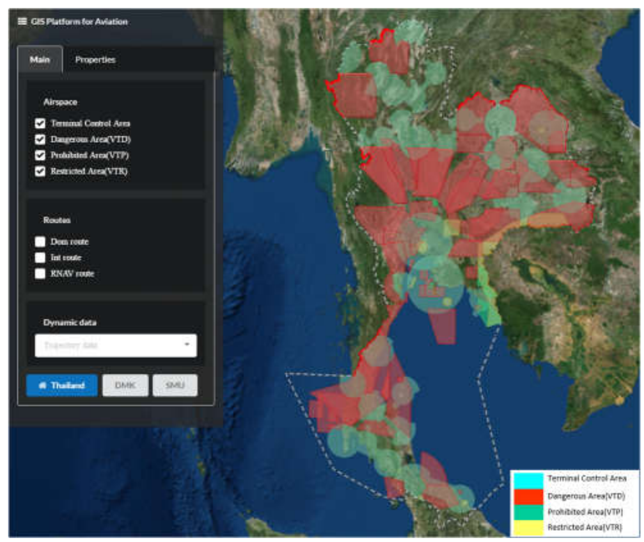

Figure 4 Airspace boundary display on GISAVIA platform.

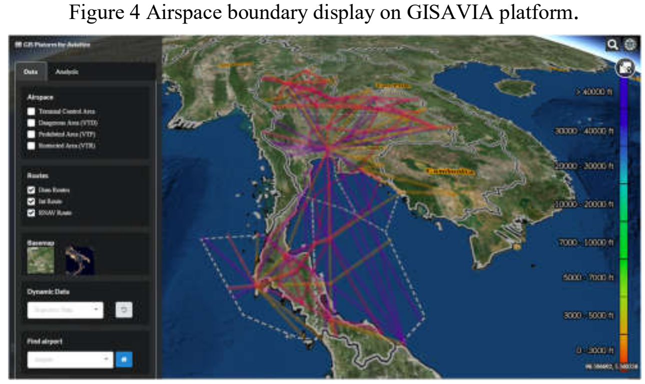

Figure 5 Air routes display on GISAVIA platform.

Air traffic data are obtained from ADS-b databased distributed through community-based receiver network such as https://opensky-network.org/ and www.flightradar24.com. In order to integrate these dynamic data into the platform, their format are transformed into JSON format. These data are store in the database. The platform allows us to visualize and playback this dynamic data as well as integrated it to other analysis tools. Example of air traffic data over the Thai airspace is shown in Fig. 6 and Fig 7. One can notice in Fig.7 the interaction between different usage of the airspace and the air traffic.

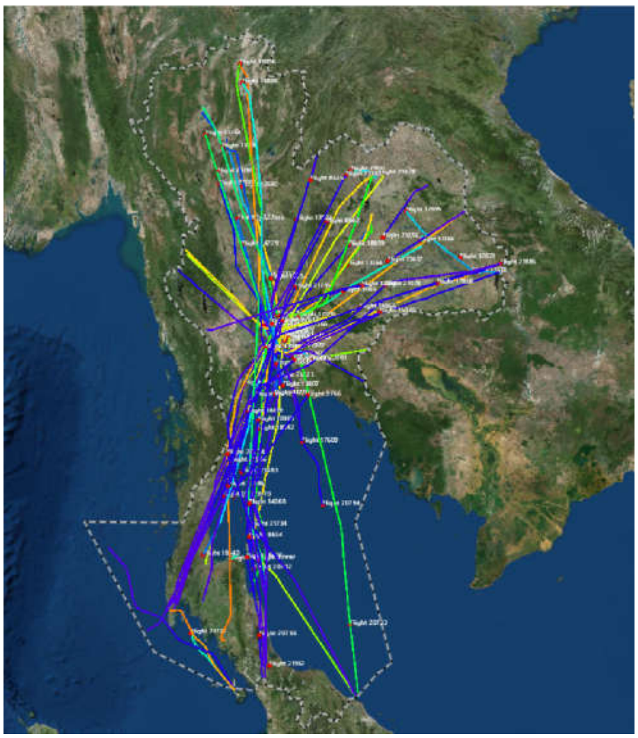

Figure 6 Air traffic over the Thai airspace.

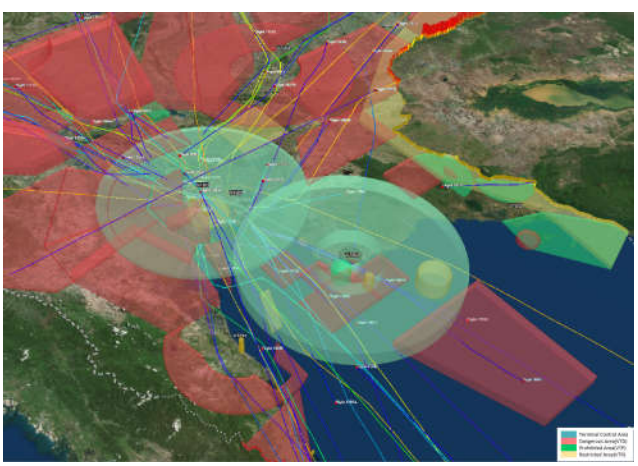

Figure 7 Air traffic over the Thai airspace with information of airspace boundary.

The air traffic density analysis is tested with one-day air traffic data crossing the Thai en-route airspace consisting more than 2,000 flights. The en-route airspace is divided into 8 sectors as illustrated in Fig 8. Example of analysis results is illustrated in Fig. 9.

Figure 8 En-route airspace sector in Thai airspace.

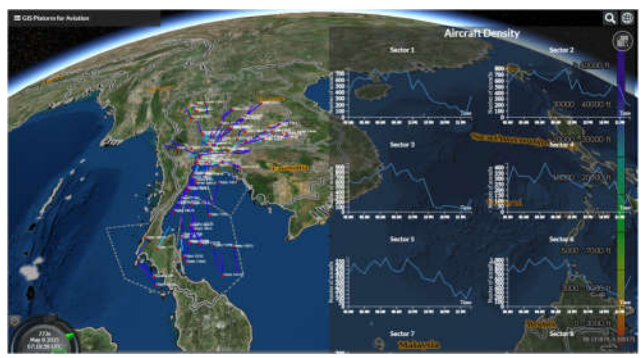

Figure 9 Air traffic density in each en-route sector.

Fig. 10 illustrates example of terrain and obstacle analysis around Samui airport. One can observe the terrain that penetrates the obstacle limitation surface. In order to generate the obstacle limitation surface, the user simply has to specify the runway threshold. Then, the tool will generate the surface according to ICAO annex 14 automatically.

In order to test the air navigation aid coverage analysis tool, we implemented and tested it with a DME station located near Samui airport. The coverage analysis result is presented in Fig. 10. One can observe that the radio signal of the DME is blocked by the terrain around the station.

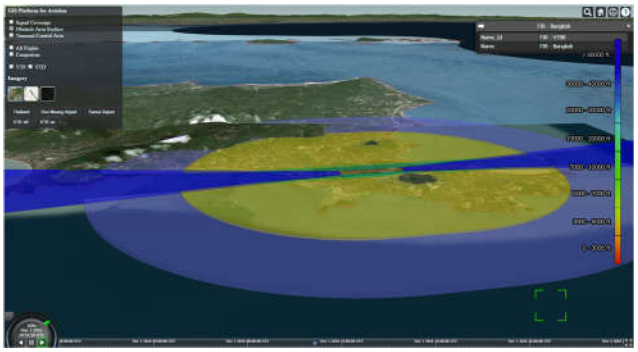

Figure 10 Terrain analysis around Samui airport.

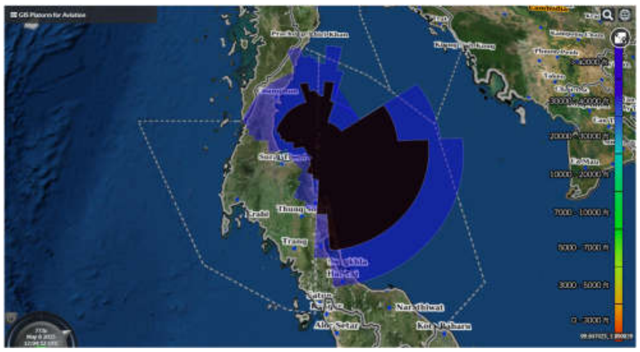

Figure 11 Example of DME coverage around Samui airport.

5. Conclusions

In this paper, we presented development progress of a geo-information platform for civil aviation that is being developed in the framework of GISAVIA project. The proposed platform allows the user to seamlessly integrated geo-information data with analysis and optimization tools. Then, visualize the information and result in 3D (x,y,z) and 4D (x,y,z,time). This platform enables the user to access information, analyze, and optimize air traffic and airspace management. This will enable the user to cope with increasing air traffic demand by managing and optimizing the system more dynamically.

The platform was implemented with Thailand's geo-information. Several analysis modules such as conflict detection, air traffic density, radio navigation aid coverage and automatic terrain and obstacle analysis have been developed and tested.

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