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Preparing the Visual Approach Chart using GIS Technology - Tirana Airport Case Study

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Abstract: ***This paper presents analysis and display of the Visual Approach Chart for Tirana Airport prepared using GIS technologies for flight operation purpose according to Annex 4 ICAO [ICAO – International Civil Aviation Organization, Annex 4 - Aeronautical Charts, https://www.icao.int]. To accomplish these objectives, the following steps have been taken: Analysing Annex 4 ICAO; Initiating an aeronautical information (AIS) exchange language model database AIXM; Field surveying of obstacles using GPS and TS; Analysing obstacles and dominant obstacles; Taking in consideration and analysing other hazards to flight operation. The paper concludes that this map should be monitored for any feature change. Every change should be reflected in database. The software ArcGIS Aviation is a very good tool to analyze and create a Visual Chart for the Airports purposes.***

Keywords: Visual Approach Chart, Airport, GIS

1. Introduction

A visual approach is conducted on an IFR [IFR – Instrument Flight Rules, Doc. 4444, ICAO] flight plan and authorizes a pilot to proceed visually and clear of clouds to the airport. The pilot must have either the airport or the preceding identified aircraft in sight. This approach must be authorized and controlled by the appropriate air traffic control facility [Doc. 4444 – Procedures for Air Navigation Services (PANS) - Air Traffic Management ICAO].

CVFPs [CVFP - Charted Visual Flight Procedure] are charted visual approaches established for environmental/ noise considerations, and/or when necessary for the safety and efficiency of air traffic operations. The approach charts depict prominent landmarks, courses, and recommended altitudes to specific runways. CVFPs are designed to be used primarily for turbojet aircraft. When conducting visual approaches, pilots are encouraged to use other available navigational aids to assist in positive lateral and vertical alignment with the runway.

Contracting States shall (according to Annex 15 ICAO) [ICAO Annex 15 – Aeronautical Information Service], when so specified, ensure the availability of charts in whichever of the following ways is appropriate for a particular chart, or single sheet of a chart series. Providing a visual approach map was a critical issue concerning the visual flight operation at Tirana Airport in Albania.

Aeronautical Information Service (AIS) is a service established within the defined area of coverage responsible for the provision of aeronautical data and aeronautical information necessary for the safety, regularity and efficiency of air navigation. The object of the aeronautical information service (AIS) is to ensure the flow of aeronautical data and aeronautical information necessary for global Air Traffic Management (ATM) system safety, regularity, economy and efficiency in an environmentally sustainable manner. The role and importance of aeronautical data and aeronautical information changed significantly with the implementation of area navigation (RNAV); performance-based navigation (PBN); airborne computer-based navigation systems; performance-based communication (PBC); performance-based surveillance (PBS); Data link systems and satellite voice communications (SATVOICE). [ICAO Annex 15 – Aeronautical Information Service] Corrupt, erroneous, late, or missing aeronautical data and aeronautical information can potentially affect the safety of air navigation.

This paper analyzes the aeronautical and geospatial features of the Visual Approach within Tirana Airport (LATI) and the procedure for creation of visual approach chart with data and information determined by Annex 4 ICAO. First of all, Annex 4 ICAO specifications for Visual Approach Chart, which determine the structure of data and information that are influencing on the creation of map, are analyzed.

On the other hand the geospatial and the aeronautical features of the Tirana Airport visual approach were analyzed. There is paid special attention on the terrain and obstacles dataset of the given area. For the analysis and map display of 3D terrain models and obstacles related to flight, there are used accurate data from authorized source (ASIG [https://geoportal.asig.gov.al], IDS [IngegneriadeiSistemihttps://www.idscorporation.com] and Enav [https://www.enav.it]). This is one of the most demanding geospatial analysis tasks since incorrect resulting positions can lead to incorrect flight operation and thus lead to nasty consequences in the assessing the behaviour of a flight operation (track), which might cause human casualties and material damage.

2. Methodology

Visual Approach Chart is a mandatory map determined by Annex 4 ICAO in the group of essential maps an airport should have, as an operational requirement. The preparation of this map for the first time in Tirana Airport passed through main phases: (1) Collecting and analyzing of terrain and obstacles datasets; (2) Collecting and analyzing of geospatial and aeronautical features; (3) Creating an Aeronautical Information Exchange Model (AIXM) database; (4) Visualizing the final GIS map; (5) Safety assessment of new chart implementation, for impact leads in flight operation within Tirana Airport.

2.1 Collecting and analyzing of terrain and obstacles datasets

Prior to visual approach chart, the obstacles survey for Tirana Airport areas was held. Obstacles are all fixed (whether temporary or permanent) and mobile objects, or parts thereof, that: (a) are located on an area intended for the surface movement of aircraft; or (b) extend above a defined surface intended to protect aircraft in flight; or (c) stand outside those defined surfaces and that have been assessed as being a hazard to air navigation.

For aerodromes regularly used by international civil aviation, obstacle data should be provided for Areas 2b, 2c and 2d for obstacles that penetrate the relevant obstacle data collection surface specified as follows[1]:

(a) Area 2b: an area extending from the ends of Area 2a in the direction of departure, with a length of 10 km and a splay of 15% to each side. The Area 2b obstacle collection surface has a 1.2% slope extending from the ends of Area 2a at the elevation of the runway end in the direction of departure, with a length of 10 km and a splay of 15% to each side;

(b) Area 2c: an area extending outside Area 2a and Area 2b at a distance of not more than 10 km from the boundary of Area 2a. The Area 2c obstacle collection surface has a 1.2% slope extending outside Area 2a and Area 2b at a distance of not more than 10 km from the boundary of Area 2a. The initial elevation of Area 2c shall be the elevation of the point of Area 2a at which it commences; and

(c) Area 2d: an area outside the Areas 2a, 2b and 2c up to a distance of 45 km from the aerodrome reference point, or to an existing TMA[2] boundary, whichever is nearest. The Area 2d obstacle collection surface has a height of 100 m above ground; except that data need not be collected for obstacles less than a height of 3m above ground in Area 2b and less than a height of 15 m above ground in Area 2c (Fig. 1).

[1] ICAO Annex 15 - Chapter 10. Electronic terrain and obstacle data

[2] TMA – Terminal Maneuvering Area

The obstacle limitation surfaces (OLS) are created using ArcGIS for Aviation Modules[3], as specified in Annex 15, ICAO. The result for Tirana airport is shown in *Fig.2*

After field survey, the obstacles that belongs to OLS or/and in flight areas or/and flight procedures for LATI[4] were analyzed for surface penetration or/and impact in any surfaces mentioned above, using ArcGIS technology. All obstacles from field survey that fulfil the criteria above, are stored in a layer, with the attributes as specified in Annex 15 and Doc. 10066 - Pans AIM ICAO, *Obstacles.* Part of table of attributes of obstacles that fulfilled the criteria in our project is shown in Figure 3 below.

The quality and loyalty of the elevation model of the terrain depends of the data which are collected, i.e. on the numerical requirement of areas, but also on the way of interpretation and visualization of the 3D model. In this paper were applied different techniques of the data structure. There are used different methods for visualization and 3D modelling of the visual approach area and creation of the GRID, terrain dataset and TIN model. Terrain data are taken from two authorized source: IDS[5] point lidar and ASIG[6]. Both of these models fulfilled the numerical requirement presented on doc 10066 Pans AIM ICAO, Terrain data numerical requirements table.

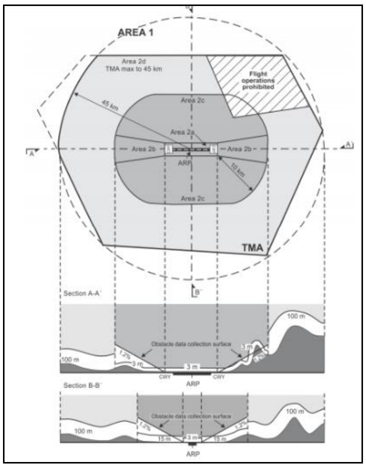


Figure 1: Obstacle data collection surfaces Area 1 and Area 2

[3] https://www.esri.com/en-us/arcgis/products/arcgis-aviation-airports

[4] LATI – ICAO name for Tirana Airport

[5] IDS - https://www.idscorporation.com/

[6] ASIG - https://geoportal.asig.gov.al/

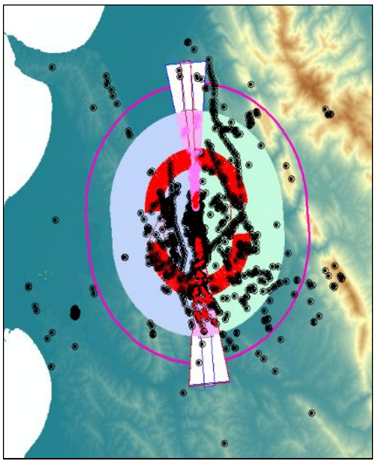
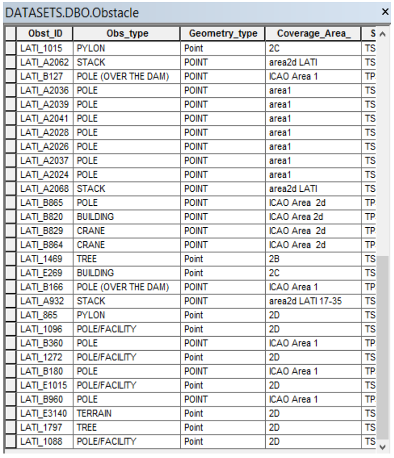


Figure 2: Obstacle data collection surfaces and obstacle limitation surfaces for Tirana Airport



DATASETS.DBO.Obstacle

Obst_ID	Obs_type	Geometry_type	Coverage_Area_	S
LATI_1015	PYLON	Point	2C	TS
LATI_A2062	STACK	POINT	area2d LATI	TS
LATI_B127	POLE (OVER THE DAM)	POINT	ICAO Area 1	TP
LATI_A2036	POLE	POINT	area1	TS
LATI_A2039	POLE	POINT	area1	TS
LATI_A2041	POLE	POINT	area1	TS
LATI_A2028	POLE	POINT	area1	TS
LATI_A2026	POLE	POINT	area1	TS
LATI_A2037	POLE	POINT	area1	TS
LATI_A2024	POLE	POINT	area1	TS
LATI_A2068	STACK	POINT	area2d LATI	TS
LATI_B865	POLE	POINT	ICAO Area 2d	TP
LATI_B820	BUILDING	POINT	ICAO Area 2d	TP
LATI_B829	CRANE	POINT	ICAO Area 2d	TP
LATI_B864	CRANE	POINT	ICAO Area 2d	TP
LATI_1469	TREE	Point	2B	TS
LATI_E269	BUILDING	Point	2C	TS
LATI_B166	POLE (OVER THE DAM)	POINT	ICAO Area 1	TP
LATI_A932	STACK	POINT	area2d LATI 17-35	TS
LATI_865	PYLON	Point	2D	TS
LATI_1096	POLE/FACILITY	Point	2D	TS
LATI_B360	POLE	POINT	ICAO Area 1	TP
LATI_1272	POLE/FACILITY	Point	2D	TS
LATI_B180	POLE	POINT	ICAO Area 1	TP
LATI_E1015	POLE/FACILITY	Point	2D	TS
LATI_B960	POLE	POINT	ICAO Area 1	TP
LATI_E3140	TERRAIN	Point	2D	TS
LATI_1797	TREE	Point	2D	TS
LATI_1088	POLE/FACILITY	Point	2D	TS

Figure 3: Table of attribute of obstacles

First of all in this project, a terrain dataset (Fig. 4)and TIN (Fig. 5) is created from ASCII file, which is created from lidar points, and then as a final result a raster from lidar points using ArcGIS 3D spatial analyst and raster analysis (Fig. 6). The other DTM raster used in analysis is taken from state authority ASIG. Then after, we compared both DTM raster since the quality and loyalty of the elevation model of the terrain is very important to this project. In the same time we also checked if base elevation measured from field survey corresponds to raster elevation. The differences in [cm] were insignificant and acceptable according to doc 10066 Pans AIM ICAO, Terrain data numerical requirements table. The software and software solutions ArcGIS is used to import data process and create 3D terrain models

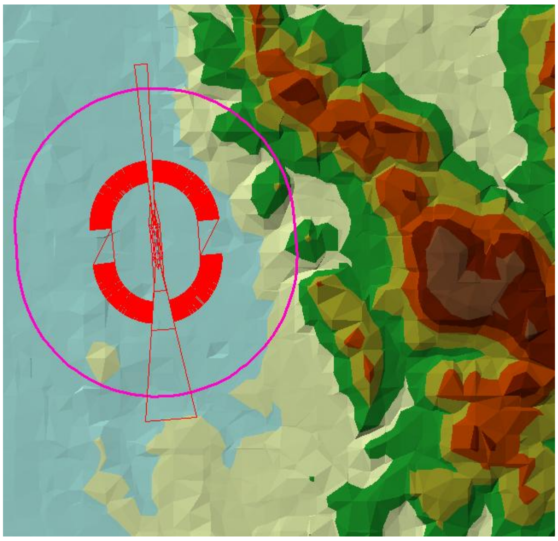


Figure 4: Terrain dataset created from lidar point

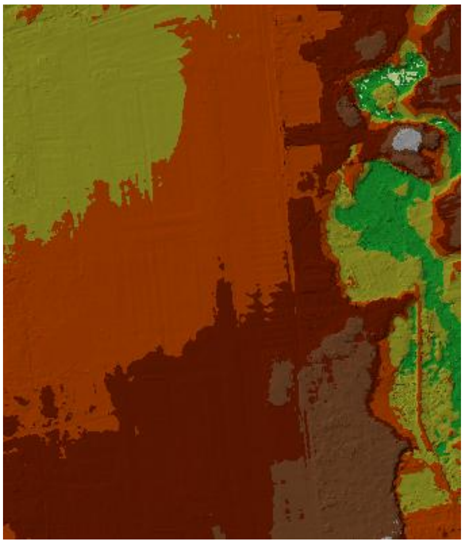


Figure 5: TIN created from lidar point

2.2 Collecting and analyzing geospatial and aeronautical features

The Visual Approach Chart unlike from other aeronautical charts integrates two main groups of features; (a) geospatial features; and (b) aeronautical features.

(a) Geospatial Features: Relief shall be shown in a manner best suited to the particular elevation and obstacle characteristics of the area covered by the chart. This was an issue since Albanian territory varies from below sea level to approximately 1800m above sea level. The presentation of relief is made in a manner that the pilot can easily distinguish from map when a hill, even not a high hill, will appear. To solve this major issue, two layers of terrain are used combined in this project, to achieve the final display. First were hill shade layer created to emphasize terrain slope (Fig. 7) and the other layer (Fig. 8) contain classified terrain values of area of interest.

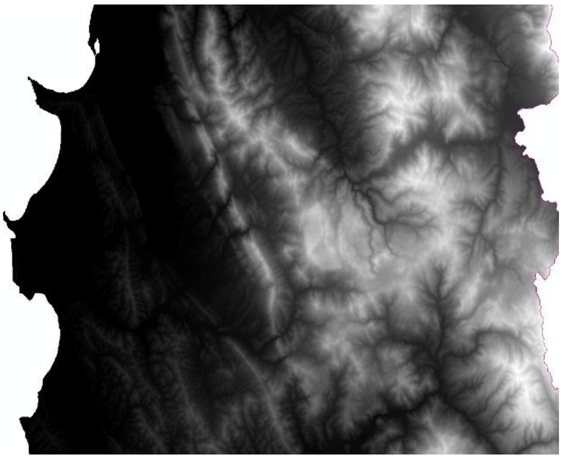


Figure 6: DTM Raster created from lidar points

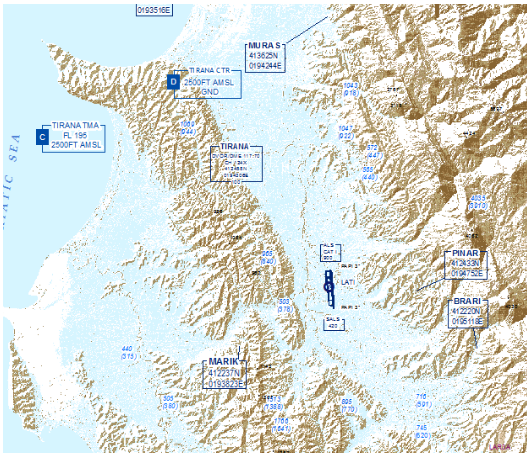


Figure 7: Hill shade Layer

The software and software solutions ArcGIS is used to process, analyze and display 3D terrain models

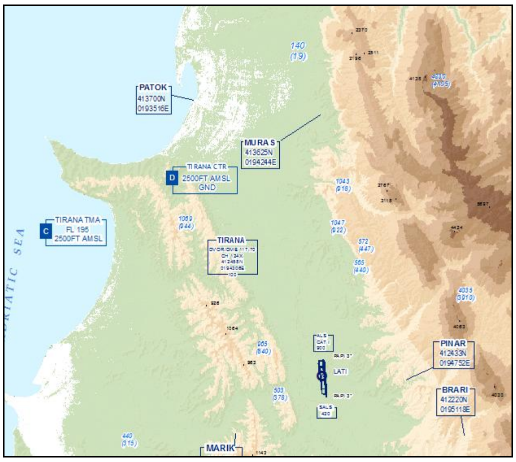


Figure 8: DTM raster with classified values symbology

Contours are generated from DEM every 1000 feet and spot elevations are carefully selected. To analyze and display the spot elevations 1st order point of vertical system of Albania are collected from state authorized source[7] and analyzed. On the other hand, from the topographic map 1:25000 peaks are digitalized with their elevation column according to topographic maps. After that we created a feature dataset with peaks and analyzed them based on DTM we created before adding a new elevation column.

To close the peaks issue, we send it to another state authorized source to verify and validate elevation. After theirs evaluation they added a new elevation column. The differences were acceptable, but the chosen height value is the highest value of three columns with height analysis. For safety flight reasons the way we display elevations in this map is to the next highest foot. Also, the value of certain spot elevations/heights in relation to both mean sea level and aerodrome elevation are given.

According to Annex 4, ICAO, natural and cultural landmarks shall be shown (e.g. bluffs, cliffs, sand dunes, cities, towns, roads, railroads, and isolated lighthouses). In this map also are represent the castles, Dajti cable car and transmission lines. Geographical place names should be included only when they are required to avoid confusion or ambiguity. Also very important to visual flights and air orientation are shore lines, lakes, rivers and streams which shall be shown.[8]

(b) Aeronautical features: Area of visual approach chart is designed in an area bigger than Controlled Traffic Region (CTR) to provide the smooth transition from/to another flight phase. A control zone, or CTR in aviation is a volume of controlled airspace, normally around an airport, which extends from the surface to a specified upper limit, established to protect air traffic operating to and from that airport. Also restricted areas, aerodrome and heliports are displayed. The pilot enters the CTR through entry points which are created in ArcGIS, verified for their accuracy and resolution according to doc 10066 Pans AIM ICAO and displayed in map as shown in Fig.9

2.3 Creating an Aeronautical Information Exchange Model (AIXM) database

The objective of the Aeronautical Information Exchange Model (AIXM)[9] is to enable the provision in digital format of the aeronautical information that is in the scope of Aeronautical Information Services (AIS). The AIXM is based on Geography Markup Language (GML) and is one of the GML Application Schemas which is applicable for the Aeronautical domain. In order to meet the requirements of this increasingly automated environment, AIS is moving from the provision of paper products and messages to the collection and provision of digital data.

The AIXM supports this transition by enabling the collection, verification, dissemination and transformation of digital aeronautical data throughout the data chain, in particular in the segment that connects AIS with the next intended user. The Aeronautical Information Conceptual Model (AICM) is a conceptual model of the aeronautical domain. It describes the features and their properties (attributes and associations) within the domain. The conceptual model is designed using the Unified Modelling Language (UML)10.

[7] Institute of Geography and Military Infrastructure

[8] Annex 4 – Aeronautical Charts, Chapter 12

[9] https://www.aixm.aero/

[10] https://www.aixm.aero - AIM, AICM and AIXM Introduction

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The AIXMXML Schema is an exchange model for aeronautical data and a concrete implementation of AICM. It is an implementation of the Conceptual Model as an XML schema. Therefore, it can be used to send aeronautical information to others in the form of XML encoded data, enabling systems to exchange aeronautical information. Diagram tree of main features[11] is shown below in Fig.10.

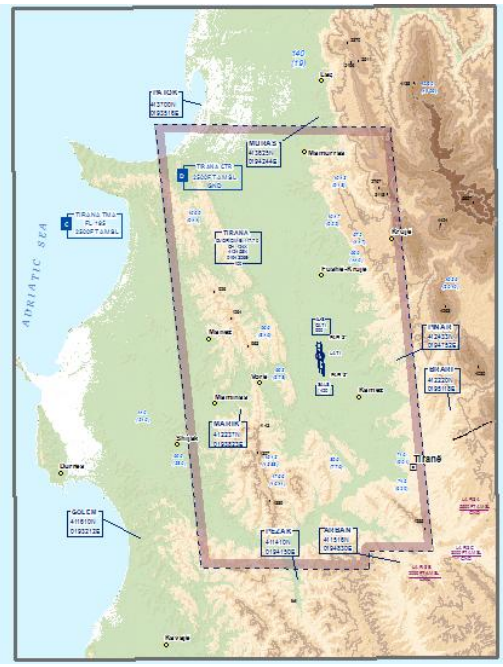

Figure 9: Controlled Traffic Region (CTR) entry points for Tirana Airport – Visual Chart

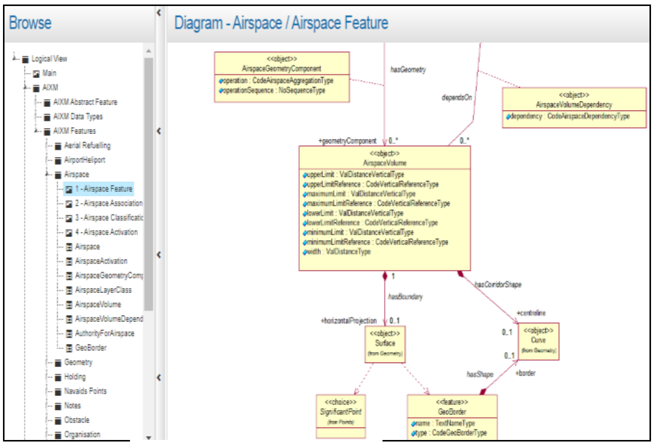

Figure 10: Logical View of AIXM UML navigator diagram tree [**aixm.aero**]

The AIXM database is created using ArcGIS for Aviation and SQL express[12] database technology. Aeronautical data used in this map are transferred in AIXM database, while DTM is in raster format. The database creation and implementation of AIXM is shown below in Fig.11

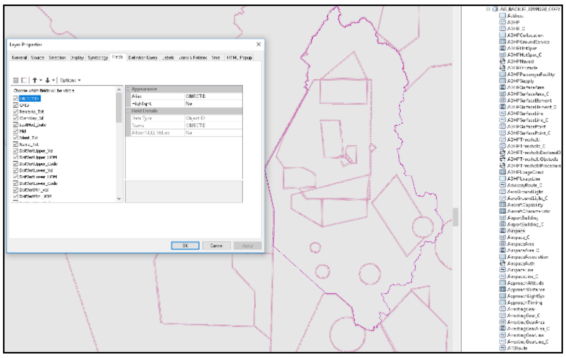

Figure 11: Implementation of AIXM schema into database

2.3 Visualizing the final GIS Map

A final Map must fulfil some very important criteria's as: accuracy, clarity, easy readable for the pilot etc. The presentation of information shall be accurate, free from distortion and clutter, unambiguous, and be readable under all normal operating conditions. Colours or tints and type size used shall be such specified in Annex 4 ICAO[13] and doc 8697[14], that the chart can be easily read and interpreted by the pilot in varying conditions of natural and artificial light. The information shall be in a form which enables the pilot to acquire it in a reasonable time consistent with workload and operating conditions. The presentation of information provided on each type of chart shall permit smooth transition from chart to chart as appropriate to the phase of flight.

The Visual Approach Chart ICAO shall be made available for all aerodromes used by international civil aviation. The units of measurement used to express distances, altitudes, elevations and heights shall be conspicuously stated on the face of each chart.

In aviation charts units used for distance, elevations or altitudes are feet and nautical miles, so conversion scales (kilometres/nautical miles, metres/feet) are provided on the face of the chart. World Geodetic System 1984 (WGS-84) determined by Annex 4 ICAO is used as the horizontal (geodetic) reference system. Published aeronautical geographical coordinates (indicating latitude and longitude) are expressed in terms of the WGS-84 geodetic reference datum. Geospatial data that were not in WGS-84 datum are transformed into WGS-84. The order of chart resolution of geographical coordinates shall be that specified for a particular chart series and in accordance with doc 10066[15].

A conformal projection on which a straight line approximates a great circle shall be used determined by Annex 4 ICAO. In this map data are projected in UTM 34 Zone projection coordinate system.

True North and magnetic variation is indicated in this map and the values shown are those for the year nearest to the date of publication that is divisible by 5, i.e. 2010, 2015, etc. The scale should not be smaller than 1:500 000. The scale of 1:250 000 is used in our chart that fulfils the requirements and covers the LATI visual approach area. The scale is

[11] https://www.aixm.aero/sites/aixm.aero/files/imce/AIXM51HTML/index.html
[12] https://www.microsoft.com/en-us/sql-server

[13] Annex 4 ICAO – Aeronautical Charts, Appendix 2
[14] Aeronautical Chart Manual ICAO (Doc 8697)
[15] Pans AIM ICAO (doc 10066)

sufficiently large to permit depiction of significant features and indication of the aerodrome layout. The map title is identified by the name of the city or town which the aerodrome serves and the name of the aerodrome[16]; TIRANA LATI.

An illustrative photo of the final GIS Map is shown in below in Fig. 12

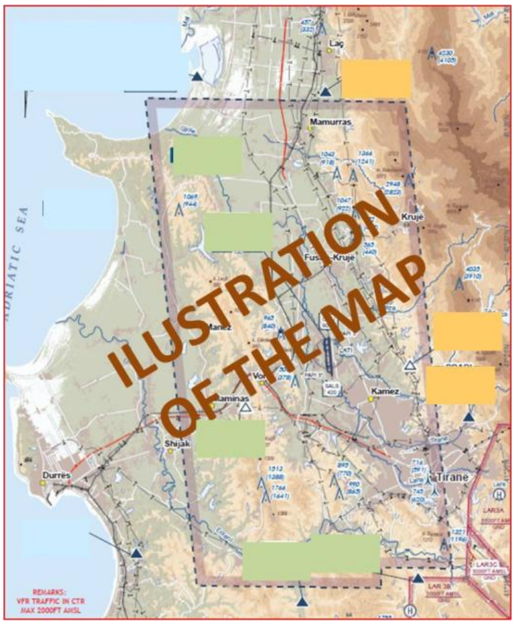

Figure 12: Visual Approach Chart for Tirana Airport

3. Results and Discussions

This paper represents the workload held on creation and visualizing the Visual Approach Chart for Tirana Airport, based on specification of ICAO Annexes and flight operation procedures requirements (as specified before in this document). Concerning the importance of flight operations, several safe and secure steps are taken to collect and analyze the geospatial features terrain and obstacles dataset and the procedure for visualizing 3D terrain models based on available and collected data of the visual approach area.

Considering the ICAO Annex mandatory for their specifications, a Visual Approach chart should be provided for visual approach. At the end of this project, the Visual Approach Chart is provided. The validation procedure includes: First, is presented to the safety management to make a safety assessment that check the impact and risk this map, its data and information provided within represent to air traffic and to flight operations. After that, the map is presented to air traffic ready to use for flight operation purpose.

This is especially interesting for pilots that flight visually and air traffic, but also for other airspace users from other professions. It also closes a topic with Annex 4 ICAO, since this is a mandatory map.

[16] Annex 4 ICAO – Aeronautical Charts, Chapter 12

The map is published in Aeronautical Information Publication and electronically in official website https://albcontrol.al/al/aip/29-Jan-2021-NA/2021-01-29/html/index-en-GB.html

4. Conclusion and Recommendations

The map is used for flight operation purpose, in such a manner that represent the real procedure of visual approach and the features are correctly represented every time are in use.

The map should be monitored for any feature change. Every change should be reflected in database and the data should be tracked between versions to notice what have changed. What are expected to change mostly are obstacles related to flight operations.

The software ArcGIS Aviation is a very good tool to analyze and create a Visual Chart for the Airports purposes. It is highly recommended to be used for these purposes.

Because this Map is a very complex one, where geospatial and aeronautical features are integrated together, is necessary a continuously update near future.

5. Acknowledgments

This project and this paper were realized with great contribution, support and well understanding of AIS Director at Alb control Mr.Ilir Zhamo. All data published here have the prior approval of Albcontrol.

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[3] **Eurocontrol** – *Supporting European Aviationhttps://www.eurocontrol.int/*
[4] **ICAO** Annex 4 – *Aeronautical Charts*
[5] **ICAO** Annex 15 – *Aeronautical Information Services*
[6] **AIM ICAO** *Doc. 10066 - Pans*
[7] **ICAO** Doc. 8697 – *Aeronautical Chart Manual*
[8] **eTOD** – *Electronic terrain and obstacles datahttps://www.eurocontrol.int/publication/eurocontrol-terrain-and-obstacle-data-manual*
[9] **ICAO** *Doc. 4444 – Procedures for Air Navigation Services (PANS) - Air Traffic Management* ICAO
[10] **Gilbert Lasnier** "*Understanding ICAO ETOD requirements*".
[11] **ASIG** *State Authority for Geospatial Informationhttps://geoportal.asig.gov.al/*
[12] Institute of Geography and Military Infrastructure *https://www.mod.gov.al/index.php/ministria/struktura-t-vartese/igjiu*
[13] **ArcGIS***for Aviation, Airporthttps://www.esri.com/en-us/arcgis/products/arcgis-aviation-airports/overview*
[14] *https://www.aixm.aero/*
[15] *https://www.microsoft.com/en-us/sql-server*
[16] **IDS** - *https://www.idscorporation.com*

[17] **ENAV***https://www.enav.it*
[18] **AIM, AICM** and *AIXM Introduction https://www.aixm.aero/sites/aixm.aero*
[19] **MEHMETI S.** "*Web Gis Platform For Spatial Data According To Inspire Using Open Source*"
[20] **ICAO***Annex 4 Aeronautical Charts, Chapter 12, Visual Approach Chart ICAO*
[21] **ICAO** – *International Civil Aviation Organization, Annex 4 - Aeronautical Charts, https://www.icao.int*
[22] **eTOD** – *Electronic terrain and obstacles data https://www.eurocontrol.int/publication/eurocontrol-terrain-and-obstacle-data-manual*
[23] **IFR** – *Instrument Flight Rules*, Doc. 4444, ICAO
[24] **ICAO***Doc. 4444 – Procedures for Air Navigation Services (PANS) - Air Traffic Management ICAO*
[25] **CVFP** - *Charted Visual Flight Procedure*
[26] **ICAO** *Annex 15 – Aeronautical Information Service*
[27] **Ingegneria dei Sistemi** *https://www.idscorporation.com*
[28] **Enav***https://www.enav.it*
[29] **ICAO** *Annex 15 - Chapter 10. Electronic terrain and obstacle data*
[30] **TMA** – *Terminal Maneuvering Area*
[31] **IDS** - *https://www.idscorporation.com/*
[32] **ASIG** - *https://geoportal.asig.gov.al/*
[33] Institute of Geography and Military Infrastructure
[34] **Annex 4** – *Aeronautical Charts, Chapter 12*
[35] https://www.aixm.aero/
[36] https://www.aixm.aero - AIM, AICM and AIXM Introduction
[37] https://www.aixm.aero/sites/aixm.aero/files/imce/AIXM51HTML/index.html
[38] https://www.microsoft.com/en-us/sql-server
[39] **ICAO** *Annex 4– Aeronautical Charts, Appendix 2*
[40] **ICAO** *Aeronautical Chart Manual* ICAO (Doc 8697)
[41] **ICAO** *Pans AIM (doc 10066)*
[42] **ICAO** *Annex 4 – Aeronautical Charts, Chapter 12*
[43] **FAA** *Federal Aviation Administration- VFR Charting Products https://www.faa.gov*

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