Modern Environmental Science and Engineering (ISSN 2333-2581)
Januzry 2021, Volume 6, No. 1, pp. 39-45
Doi: 10.15341/mese(2333-2581)/01.07.2021/006
Academic Star Publishing Company, 2021
www.academicstar.us

Comparison of ICAO Airport Obstacle Databases by ETOD's Obstacle Limitation and Collection Surfaces

Zsolt Bagdi[1], and Gábor Bakó[2]
1. Erenfield Consulting Ltd., Hungary
2. Interspect Ltd., Hungary

Abstract: Aviation safety at airports of all countries is a maximally expected factor, which over time should not only be maintained at the same level, but should be increased and adapted to the continuous development of the aviation sector. The technologies that are available to us in this age contribute greatly to this. For example electronic Terrain- and Obstacle Data Collection (eTOD). The process is based on a type of aerial remote sensing from fixed-wing aircraft. With the help of in-flight point cloud and geoinformatics software, strictly defined terrain- and obstacle data can be organized into databases, the format of which is regulated by international standards and documents, according to which the obstacle database can be used internationally. These datasets are needed not only because they are required by law, but also because they form the basis for the design of various flight procedures and make a major contribution to safe aviation.

Key words: eTOD, obstacle, Photogrammetry, airport, ICAO, AIP, OLS

1. Introduction

All airports in ICAO (International Civil Aviation Organization) member states have to comply with a large number of regulations. By this I mean, for example, the existence of physical equipment, the quality and painting of taxiways, aprons and runways, and last but not least, the handling of obstacles in and around the airport [1, 2]. An obstacle can be a fixed or mobile object. Think about the fact that there are many airports that have a main road or railroad line next to their fence. High vehicles currently running in the area of the extended runway centerline can be obstacles [3-6]. Fixed objects do not require special explanation. For example trees, buildings and the terrain [7-11]. Without aerial remote sensing, it would not be possible to meet the current requirements, as hundreds of square kilometres need to "scan" and collect all the obstacles [12].

In the present research, the databases resulting from the survey of Debrecen International Airport. During the work, we collected obstacles in the 10 and 15 km radius from runway strip and the Airport Reference Point (ARP) in accordance with international legislations [13-16] (Table 1). Therefore, data collection that meets the challenges of the future is of great importance [17]. The application of the point cloud generated by the flights and the application of the developed special method resulted in the collection of about 5,500 obstacles in the area into a database, which provided orders of magnitude more accurate data to the AIS (Aeronautical Information Services) compared to previous and independent databases. A number of terrain- and obstacle data were collected that could not have been assessed with terrestrial geodetic survey, relying on our field experience. In this way, surveying an area of nearly 320 km^2 would result in a number of complications. Examples include covering objects,

Corresponding author: Zsolt Bagdi, Ph.D. student; research areas/interests: earth sciences. E-mail: zbagdi92@gmail.com.

measuring obstacle peaks that are not visible from the ground. The optimal solution is the combined use of aerial remote sensing and subsequent field geodetic methods.

Table 1 Terrain data numerical requirements in all areas [18].

	Area 1	Area 2	Area 3	Area 4
Post spacing	3 arc seconds (approx. 90 m)	1 arc second (approx. 30 m)	0.6 arc seconds (approx. 20 m)	0.3 arc seconds (approx. 9 m)
Vertical accuracy	30 m	3 m	0.5 m	1 m
Vertical resolution	1 m	0.1 m	0.01 m	0.1 m
Horizontal accuracy	50 m	5 m	0.5 m	2.5 m
Confidence level	90%	90%	90%	90%
Integrity classification	routine	essential	essential	essential
Maintenance period	as required	as required	as required	as required

2. Methodology

The field of research was the already mentioned Debrecen International Airport. The airport is located in the southern part of the city (ARP WGS 84 coordinate: 472920N 0213655E). Obstacles were collected within a radius of 10 and 15 km from the reference point and runway strip. The point cloud was made from this area.

We had to meet the required numerical requirements defined in the ICAO documents (accuracy, resolution, integrity). The area is divided into several smaller components. The division of the area is determined by the runway of the airport. In the direction of the approach, i.e. in the spatial angles in the extension of the runway centreline, the classification of obstacles is based on stricter altitude requirements, as aircraft fly regularly over these areas. "Areas" perpendicular to the runway centreline, i.e., lateral, allow data collection based on other criteria. In the case of Debrecen, the terrain conditions of the approach areas from the north-eastern runway threshold adversely shaped the obstacle data collection process. This is due to the rise of the terrain. The initial height of the obstacle surfaces above each area is fixed and the surfaces themselves are not terrain-following. Therefore, as the raising the mean sea level elevation of the terrain, the number of objects increased in large numbers. Thus, this resulted in the inclusion of more than 5,500 obstacles in databases. Some surfaces — airport specific — can extend up to more than 10 kilometres and most of them continue to rise as the distance increases. At the southwestern runway end, after the initial height of the surface, we managed to collect only a few obstacles. This is explained by the decrease in the elevation of the terrain. Thus, the height of the objects were not reached the height of the surfaces, so they were not exceed them.

For aerial data collection, we used a fixed-wing aircraft to which we mounted a special camera device. The images and the point cloud were taken in February 2018, when the amount of irradiation was sufficient to apply aerial photogrammetry. We managed to complete the professional flight of the area of more than 300 square kilometres in two days in constant consultation with the AFIS (Aerodrome Flight Information Service) services. Aerial photogrammetry over the extended circular area (Fig. 1) required special aircraft control, which was performed by a professional pilot.

More than 20 areas and more than 20 surfaces were edited in GIS software. As a result, we received more than 30 databases containing the collected terrain- and obstacle data, as well as uploading databases whose contents identify potentially dangerous objects in the areas. According to our pre-assessed information, the airport staff handled the obstacles even in the pre-collection period with maximum safety. Yet during the research and work, the data of the objects intersecting the defined surfaces had to be provided to the Aeronautical Information Services. Another very important fact is that in the smaller area with a radius of 10 km, it is not enough to survey an airport, but the second largest city in Hungary is located in it. Debrecen, with its almost entire area, belonged to the zone where we have to generate point cloud and then filter it professionally (Fig. 2). Filtering results in points remaining above the surfaces, so we were able to work with them and evaluate terrain- and obstacle objects and their metadata (Fig. 3).

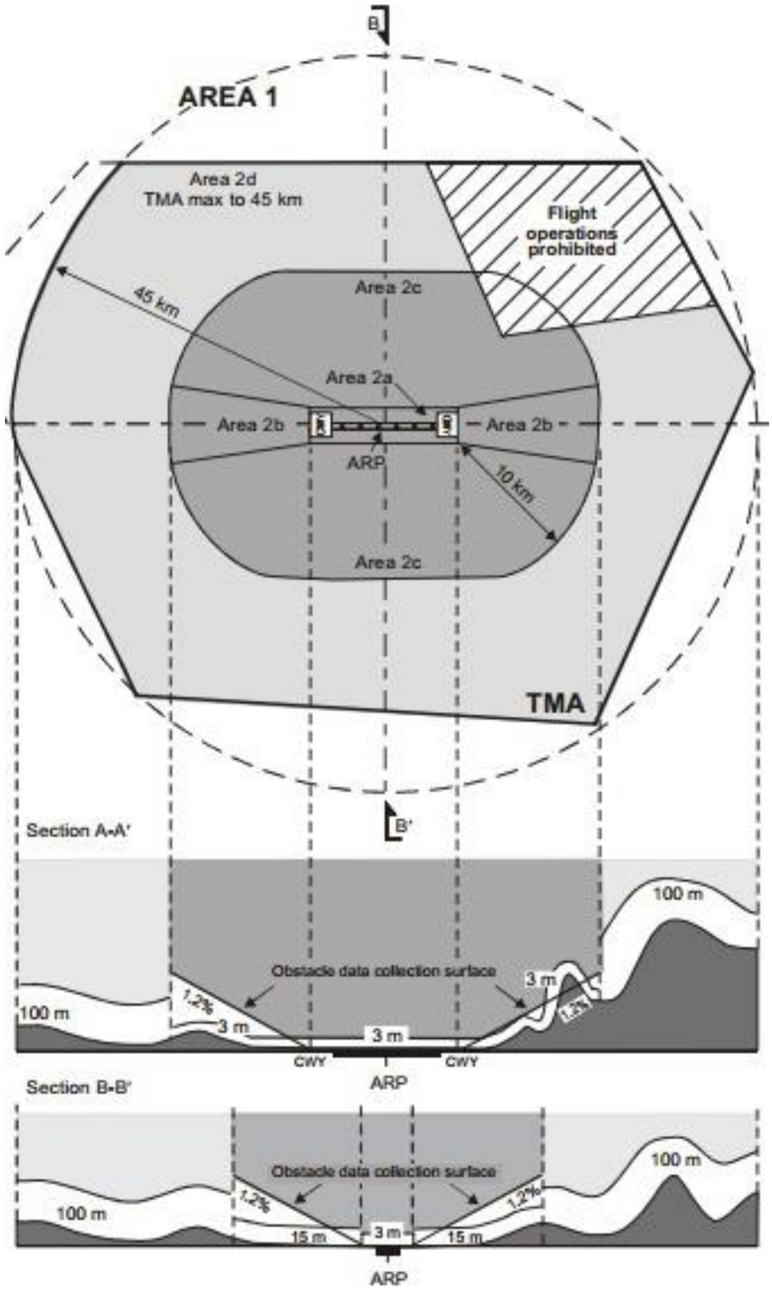

Fig. 1 Some airport specific area in the 10 and 45 km radius zone [19].

Fig. 2 An urban detail of the point cloud obtained during the work [20].

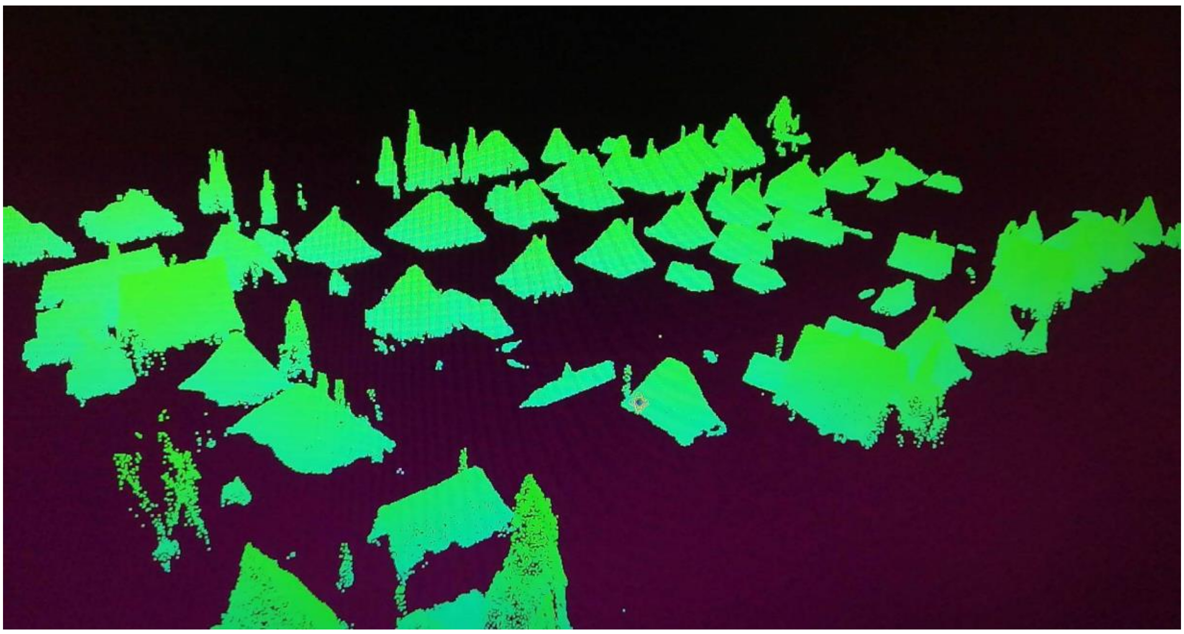

Fig. 3 A state of point cloud after cutting in software that reflects the presence of obstacles [20].

3. Results

Preliminary surveys using non-aerial data collection methods have shown that the use of terrestrial geodetic survey alone does not guarantee the safe collection of obstacles. The work, which lasted more than 5 months, resulted in thousands of terrain- and obstacle objects being added to the database. Managing these is a very responsible job, as these databases form the basis of the designed flight procedures. Compliance with accuracy, resolution, and other numerical requirements could also be achieved with parallel work: remote sensing and terrestrial survey.

Using a lateral overlap of 40% between bands and 70-90% forward overlap between photos and a spatial resolution of 3, 5, 7.5, 10 cm, the applied technology was tested on a sample area of 0.5 km^2 and 0.4 km^2. The fixed-wing aircraft operated in the speed range of 220-340 km/h and altitude range of 640-860 metres [20].

During the research, most of the work was with collection surfaces. Their editing and assigning required serious attention. The cutting of the point cloud gave the points to be examined that are an obstacle in the area of the airport. Multiple metadata is attached to an obstacle during research. For example: obstacle type, height, absolute height, antenna height (if any), WGS-84 coordinate (multiple for large extent), type of markings, paintings and lighting according to ICAO.

The obstacle limitaion surfaces were also assigned during the process. These surfaces required the most attention during the work. They require less stringent regulations. Therefore, the obstacle that also exceeds this surface due to its height has already been considered a potentially dangerous obstacle to flight. Aeronautical Information Services and Aviation Authorities also pay special attention to these type of obstacles.

There are several surfaces in the OLS (Obstacle Limitation Surface) database. For example: approach surface(s), conical surface, inner horizontal surface, transitional surface(s), take-off climb surface, inner-transitional surface, balked landing surface, inner approach surface(s), outer horizontal surface. Of these, approach surfaces are also particularly important. When an aircraft lands, it descends at a certain angle, where the speed is low and it all happens at low altitudes. The closeness of ground obstacles is critical for an aircraft. The sub-databases of these surfaces contain the obstacles that have been analyzed. This is because an obstacle that exceeds a relevant obstacle limitation surface can easily be an object that could be a potential hazard to flying. Further investigation is needed for the presence of an obstacle markings. Painting an obstacle, use of flags and obstacle lightings. The results of our research confirm that without choosing an optimal remote sensing method, databases are likely to be incomplete. A previous survey independent of us resulted in the 9 obstacles that were included in preliminary databases. In contrast, the combined method of terrestrial survey and aerial remote sensing generated the 276 obstacle objects that were collected under the obstacle limitation surfaces. The difference is significant (Table 2). It can be stated that high-resolution photogrammetric evaluation and the combined method (automated and manual aerial photogrammetry and control terrestrial survey) can be considered the most reliable method, in addition to the fact that the use of this technology in such areas is currently economical and time-efficient.

Table 2 Comparison of databases of obstacle limitation surfaces that are the subject of independent previous and current research.

Obstacle Limitation Surfaces	Previous databases (piece)	Current databases (piece) (aerial photogrammetry + terrestrial survey)
Approach surface(s)	5 obstacle	34 obstacle
Conical surface	1 obstacle	6 obstacle
Inner horizontal surface	2 obstacle	37 obstacle
Transitional surface(s)	1 obstacle	36 obstacle
Take-off climb surface	-	156 obstacle
Inner transitional surface	-	2 obstacle
Balked landing surface	-	0 obstacle
Inner approach surface(s)	-	5 obstacle
Outer horizontal surface	-	0 obstacle

(In case the "-" sign is marked in the table, the database of the given surface was not reported.)

More than 20 different surfaces are easily interchangeable. This is due to the fact that ICAO has defined several surfaces over an area. It has separate surfaces for obstacle collection, limitation and protection.

When examining the approach surfaces following obstacle data collection, we collected 34 obstacles that were immediately included in the Aviation Authority's potentially hazardous obstacle databases (Fig. 5). Obstacles are further examined by their owners and the airport operating companies too.

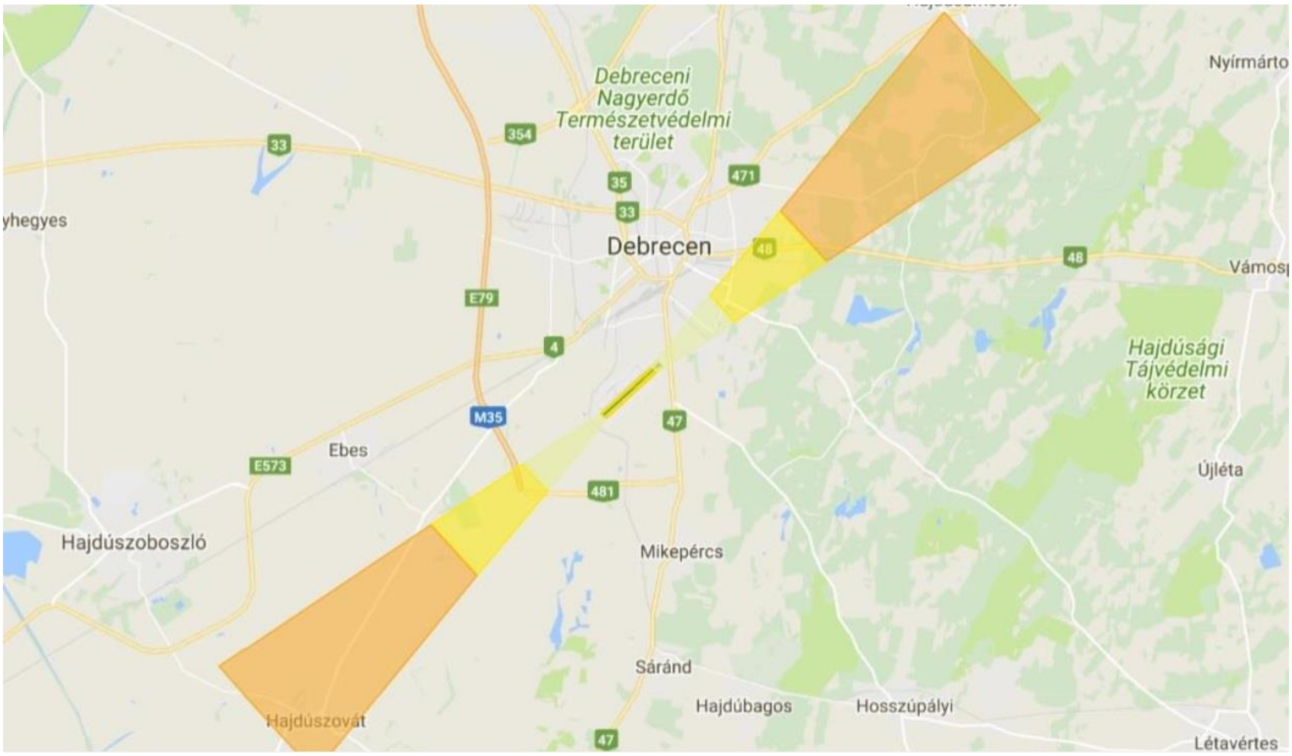

Fig. 5 Sections of Debrecen International Airport's edited approach surfaces, top view on map drawing.

4. Conclusions

With the appropriate weather and irradiation conditions, we are able to survey an area of approximately 350 square kilometres with a 10 cm GSD (Ground Sampling Distance). With a subsonic aircraft (typically 500-1000 km/h), this area can increase to 1000 km^2. Modern digital CMOS (Complementary Metal-Oxide Semiconductor) cameras provide sharp images at relatively high cruise speeds.

In the course of our work, it has been proven that the application of applied aerial remote sensing provides orders of magnitude more accurate and larger obstacle databases. The difference between the terrestrial geodetic survey database and the amount of obstacles in the database of the combined (terrestrial survey and aerial remote sensing) collection method is almost 1000 times, and in the case of databases according to obstacle limitation surfaces, it is more than 30 times. As a result of the aerial view, we were able to collect potentially dangerous obstacles that, due to the terrain and cultural conditions, would have been very difficult to collect or, if necessary, would have escaped the attention of the measuring staff. This is unthinkable in the aviation sector, as the aim is to maintain aviation safety and continuously improve it, taking into account both economic and time factors.

Using the common method, the cooperating Erenfield Consulting Ltd. and Interspect Ltd. successfully created the obstacle databases for several airports in Hungary, which was processed and made available by the Aeronautical Information Service in valid international databases.

Acknowledgments

The authors would like to acknowledge all the support from the University of Debrecen, Doctoral

School of Earth Sciences and the staff of Erenfield Consulting Ltd. and Interspect Ltd.

Abbreviations

ICAO	International Civil Aviation Organization
eTOD	electronic Terrain- and Obstacle Data collection
ARP	Airport Reference Point
AIS	Aeronautical Information Services
WGS 84	World Geodetic System 84
AFIS	Aerodrome Flight Information Service
TMA	Terminal Movement Area
CWY	Clearway
GIS	Geographic information system
OLS	Obstacle Limitation Surfaces
GSD	Ground Sampling Distance
CMOS	Complementary Metal-Oxide Semiconductor

References

[1] International Civil Aviation Organization: Annex 15, ICAO, Montreal, Canada, 2018c.

[2] International Civil Aviation Organization: Annex 14, Volume I, ICAO, Montreal, Canada, 2018.

[3] International Civil Aviation Organization: Annex 11, ICAO, Montreal, Canada, 2018.

[4] International Civil Aviation Organization: Annex 5, ICAO, Montreal, Canada, 2010.

[5] International Civil Aviation Organization: Annex 14, Volume I, ICAO, Montreal, Canada, 2018.

[6] International Civil Aviation Organization: Annex 15, ICAO, Montreal, Canada, 2018c.

[7] ICAO Doc 9881, Guidelines for Electronic Terrain, Obstacle and Aerodrome Mapping Information.

[8] ICAO Doc 8126, Aeronautical Information Services Manual, 2003

[9] ICAO Doc 9674, World Geodetic System – 1984 (WGS-84) Manual, 2002.

[10] European Organization for the Safety of Air Navigation: Terrain and obstacle data manual. Eurocontrol, Brussels, 2015.

[11] A. Petrovsky, P. Bosman, P. Green, A. Heerbaart and F. Brenner, *Eurocontrol Terrain and Obstacle Data Manual*, Eurocontrol, Brussels, 2015, p. 140.

[12] International Civil Aviation Organization: Annex 15, ICAO, Montreal, Canada, 2018c.

[13] ICAO Doc 9881 Guidelines for Electronic Terrain, Obstacle and Aerodrome Mapping Information.

[14] *ICAO Doc 9674 AN/946 World Geodetic System – 1984 (WGS-84) Manual* (2nd ed.), 2002.

[15] *ICAO Doc 8126 AN/872 Aeronautical Information Services Manual* (6th ed.), 2003.

[16] *EUROCONTROL Terrain and Obstacle Data Manual*, Edition: 2.2

[17] EUROCONTROL Specification for Electronic Aeronautical Information Publication, EUROCONTROL - SPEC –146, 2015.

[18] International Civil Aviation Organization: Terrain data numerical requirements. Annex 15, Appendix 8, Table A8-1, ICAO, Montreal, Canada, 2018c.

[19] International Civil Aviation Organization: Coverage areas and requirements for data provision. Annex 15, Chapter 10.1, ICAO, Montreal, Canada, 2018a.

[20] Gábor Bakó, Zsófia Szilágyi, Zsolt Bagdi, Zsolt Molnár, Eszter Góber and András Molnár, The GSD dependency of the eTOD photogrammetric survey, *CEAS Aeronautical Journal* 10, doi: https://doi.org/10.1007/s13272-019-00407-z pp. 1-7.