The Need of a High Resolution European Spatial Data Infrastructure for Unmanned Aerial System Mission Planning & Risk Assessment

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Abstract

The concerns associated with the safety of operation of Unmanned Aerial Systems (UAS), or drones, grow together with their increasing popularity. While some data necessary to assess drone mission safety risks are readily available, critical geospatial information such as geolocated detailed nation-wide population density is often absent and has to be derived from alternative data sources, such as those published within the INSPIRE initiative. The absence of readily available comprehensive data often leads to a situation when software tools aimed at the support of drone flight mission planning fail to do it adequately. We present a prototype of a web portal that addresses this issue in Austria by integrating representations of operational zones, nature reserves and aeronautical information to facilitate legally compliant and safe UAS mission planning. Being the most comprehensive UAS flight support tool in Austria at the moment, this portal based on open data sources at the same time reveals certain challenges, such as liability for the accuracy of provided data and lack of the standard approach to data generation, since different methods result in varying limits of UAS operational zones.
Keywords: Unmanned Aerial Systems, UAS Regulations, Specific Operations Risk Assessment (SORA), Air Traffic Management, Drone Mission Planning

1 Introduction

The use of Unmanned Aerial Systems (UAS) at professional as well as recreational level increased tremendously in the last years. The US Federal Aviation Administration expects the UAS fleet to reach six million units by 2021 in the USA alone (Federal Aviation Administration, 2016). In a significantly smaller country like Austria the drone count is estimated to be up to 100,000 units (Der Standard, 2017). The growing number of UAS around the world presents a potential safety risk and is likely to increase the probability of UAS related incidences, especially for urban areas. Therefore, raising awareness of drone mission regulations is an urgent need in many countries, including Austria. Governments address this need with great effort by providing general information related to UAS operation to the public. Some of the successful examples here are “Know Before You Fly” (http://knowbeforeyoufly.org/) in the US, “Drone Rules” (http://dronerules.eu/en/) in the EU, and “Drone Safe” (http://dronesafe.uk/) in Great Britain. Examples of software tools aiming at the support of drone mission planning include multinational “AirMap” (AirMap Inc., 2018), “Drone Assist” (NATS and CAA, 2016) in Great Britain and “DFS-Drohnen App” (DFS, 2017) in Germany.

There exist different approaches and attempts for the safe integration of UAS in the national airspaces worldwide, but basically all UAS regulations follow a very similar risk-based paradigm. UAS mission risk is defined as a function of (1) Maximum Take-Off Weight (MTOW), (2) the population density, (3) the presence of critical infrastructure, (4) environmental protection sites and (5) aviation related zones (e.g. control area around airports, military danger zones, etc.). Civil UAS aviation is currently dominated by visual line of sight (VLOS) operations below 100-150 m. However, there is a strong need from industry (e.g. UAS delivery, infrastructure inspection of transmission lines, environmental monitoring, agriculture) for the beyond visual line of sight (BVLOS) drone operation. This can further increase the UAS operation related risks which are already steadily growing, e.g. in the

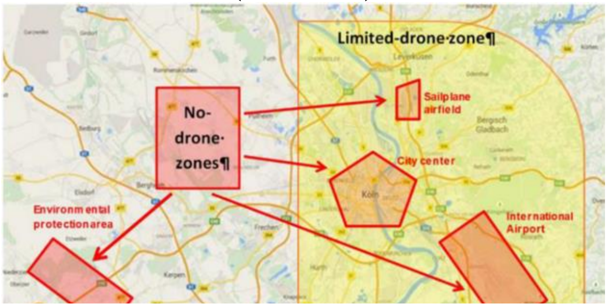
UK there were 29 UAS related accidents in 2015, 71 in 2016, and at least 79 in 2017 (Sage, 2018).

Thus it is critical to develop new UAS-specific Standards and Recommended Practices (SARP) for the future UAS Traffic Management (UTM), which is also stated by the International Civil Aviation Organization: "Unmanned aircraft (UA) are, indeed, aircraft; therefore, existing SARPs apply to a very great extent. The complete integration of UAS at aerodromes and in the various airspace classes will, however, necessitate the development of UAS-specific SARPs to supplement those already existing" (ICAO, 2011, p. 2). We argue that such SARPs have to focus on the framework of defining areas of operation and geofences based on high resolution geospatial data.

2 Framework to support UAS mission planning

Currently a framework of defining areas of operation and geofences for UAS does not exist since general aviation has so far considered large scales (i.e. high detailed map representations) only in a very limited manner (e.g. obstacles in airport entry lanes). This represents a very important difference between general aviation and UAS aviation data and is in our opinion also one of the biggest challenges for any future UTM.

Figure 1: ‘No-drone zones’ and ‘limited-drone zones’ map (EASA, 2015)



A legally compliant and safe UAS mission planning is a very high resolution spatial task that requires accurate and up-to-date situational information about the area of operation. At the moment each nation in the EU has either no or its own regulations for UAS below 150 kg MTOW, whereas European Aviation Safety Agency (EASA) is responsible for certification and flight permissions for heavier UAS. The EASA proposal A-NPA 2015-10 (EASA, 2015) that is currently in discussion introduces different areas of operation for UAS below 150 kg depending on the population density (e.g. “City Center”), no-drone and limited drone zones (Figure 1) that should be implemented as “geofences”. A geofence in this context represents the demarcation of a physical area and can be expressed in machine-readable form by coordinates.

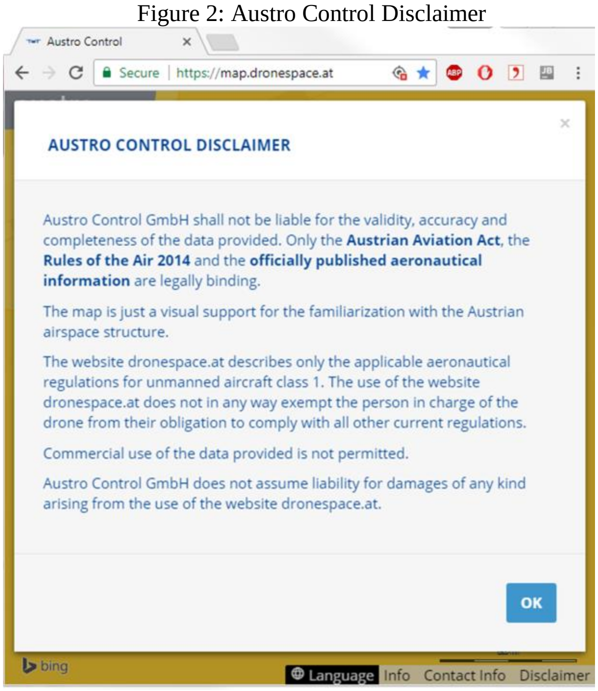
Since January 1st 2014 Austrian legislation defines four areas of operation for UAS depending on the building and population density as (I) undeveloped, (II) uninhabited, (III) populated and (IV) densely populated since 2014 (Table 1). These areas of operation are described only in a narrative form without any spatial map-based delineation (Luftfahrtgesetz BGBl. Nr. 253/1957 (NR: GP VIII RV 307 AB 318 S. 40. BR: S. 128.), 2017). The combination of 4 areas of operation considering population density with the UAS MTOW represent a risk-based approach for definition of 4 UAS categories A, B, C and D. The overall approach here is: “the heavier the UAS is and the higher is the population density, the more demanding are the requirements in terms of technical airworthiness of the UAS and the expertise and skills of the UAS pilot in order to receive an official operational approval.

Table 1: UAS license category in Austria in dependence of areas of operation and MTOW

	Area of operation			
MTOW upper limit	I undeveloped	II uninhabited	III populated	IV densely populated
5 kg	**A**	**A**	**B**	**C**
25 kg	**A**	**B**	**C**	**D**
150 kg	**B**	**C**	**D**	**D**

The legally described crisp boundaries of the operational zones are of great importance as UAS are licensed for specific operational areas and license violation may result in fines up to €22,000. Austrian mobile apps and web portals “Drohnen-Info” (Der Standard, 2017) and “Drone Space” (Austro Control, 2017) that should support drone mission planning, provide no information concerning the areas of operation. Furthermore, the validity, completeness or accuracy of the available data is not guaranteed (Figure 2). Thus such tools cannot be considered reliable from the drone pilot point of view.

Figure 2: Austro Control Disclaimer



Source: https://map.dronespace.at, Accessed 13.02.2018

Thereupon we see a strong need for a scientifically based extraction and reliable map representation of risk related operational zones. Its innovative contribution to UTM is a web portal prototype that provides an integrated map-based representation of information relevant for the UAS mission planning, including information related to aviation (AIP, 2017), nature protection sites and four areas of operation calculated based on the building density.

The key foundation of the web portal is a geospatial "*Drone Zone Model*" derived from available up-to-date high quality trusted geodata sources (e.g. address locations, road network, airport control zones, danger areas). These data are provided by the Austrian public administration and the aviation control authority within the Open Government Data (OGD) initiative and the European INSPIRE Geodata Infrastructure directive.

2.1 Representations of UAS operational zones

In order to demonstrate the ambiguity and real world consequences of the narrative definition of UAS operational zones based on settlement density, we used different high resolution geodata sources for the "simple" representation of buildings in the City of Villach, Austria.

Applying different geospatial analysis techniques we derived representations of building density which can be used as indicator for the settlement density or population density. Building density and therefore representations of the areas of operation vary depending on the choice of geodata source and geospatial analysis method.

In order to illustrate the problem we analyzed the individual perceptions of densely populated space within a group of local students and combined their "mental maps" into a single representation using Villach as a representative example of a small European city (Figure 3). We expect here any drone mission operator to develop his/her own subjective spatial perception for the narratively defined areas of operation.

Figure 3: "Mental Map" experiment representing the different individual spatial perceptions of densely populated areas in Villach, Austria

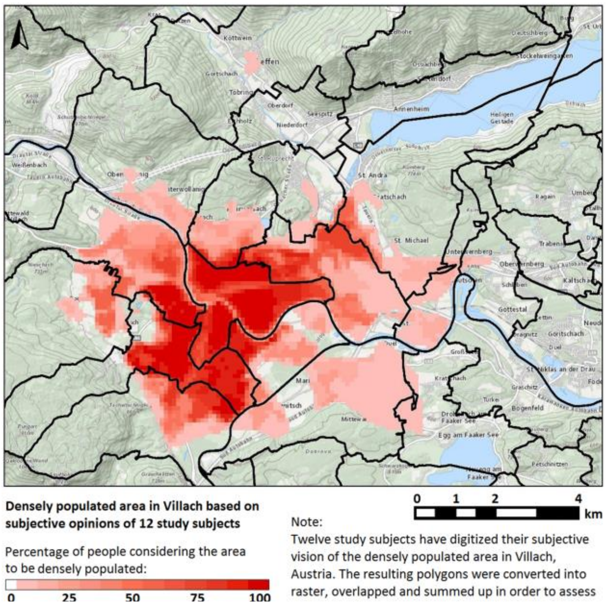


Figure 4 shows the distribution of the number of buildings per regional statistical units (i.e. 100 x 100m). In order to evaluate the area of a building in contrast to an address-based point location, we calculated the building coverage ratio per hectare using areal building footprint representations (Figure 5).

The comparison of the building/population density derived within these different approaches shows that the settlement density estimates greatly varies depending on the chosen methodology, and one approach has to be chosen to avoid ambiguity in the classification of operational areas. Subjective assessment of densely populated areas does not necessarily reflect the actual distribution of buildings and the associated settlement and population density, and thus it cannot ensure compliance with any legal drone operation regulation.

Figure 4: The number of buildings per regional statistical unit (100 x 100m) in Villach, Austria

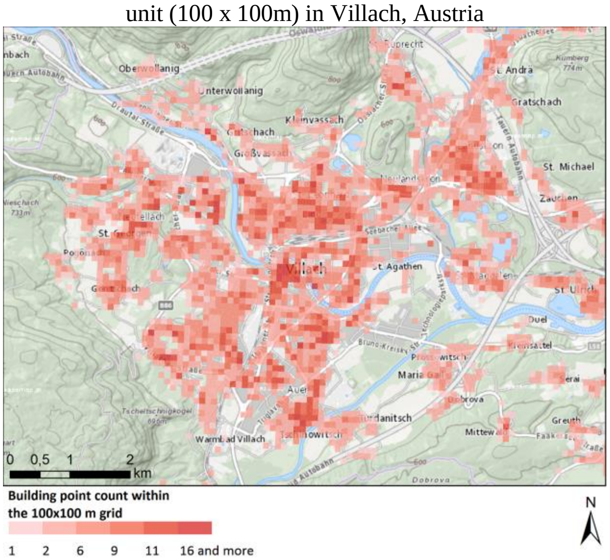
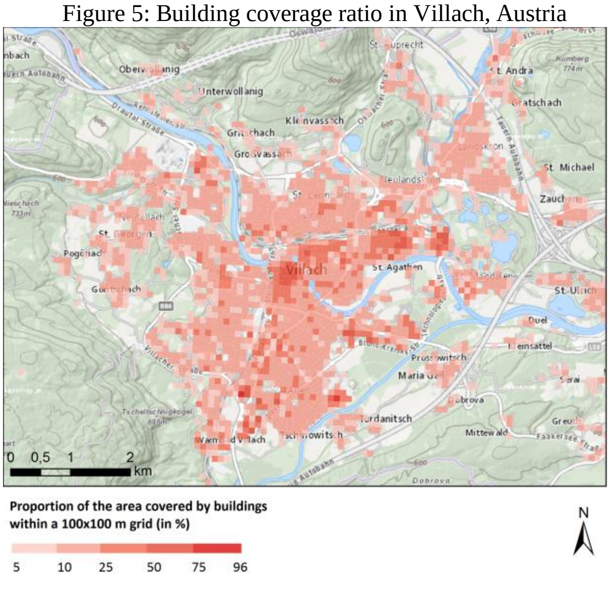


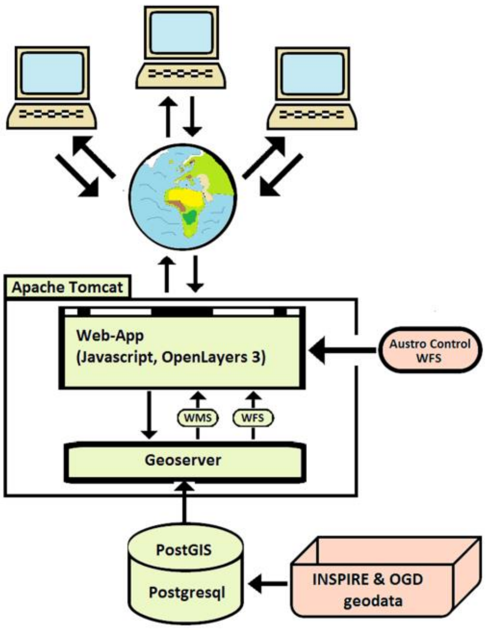
Figure 5: Building coverage ratio in Villach, Austria



2.2 Drone Zone Austria

As a proof-of-concept we developed the web portal prototype "Drone Zone Austria" (www.dronezoneaustria.at) being the first fundamental step to support a holistic risk based drone mission planning approach. A unique feature of the "Drone Zone Austria" map is that it integrates three key spatial data sources for whole Austria, namely: (1) areas on operation based on the nation-wide high resolution building density information and derived by a transparent spatial analysis procedure; (2) relevant aeronautical information provided by Austro Control GmbH and (3) nature reserves. The architecture of the "Drone Zone Austria" web portal is given in Figure 6. The web application is written in JavaScript and exploits OpenLayers 3 for geodata representation. The data is served by means of the local Geoserver implementation (v.2.10) and Austro Control Web Feature Service. The Geoserver implementation relies on a PostGIS 2.3.3. database (PostgreSQL v.9.6.5) that contains preprocessed INSPIRE and open government geodata. Apache Tomcat 8.5.20 implementation is used is a web server.

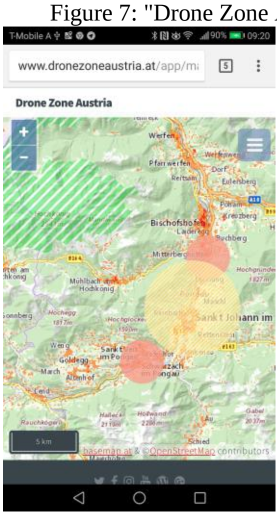
Figure 6: Architecture of the "Drone Zone Austria" web portal prototype



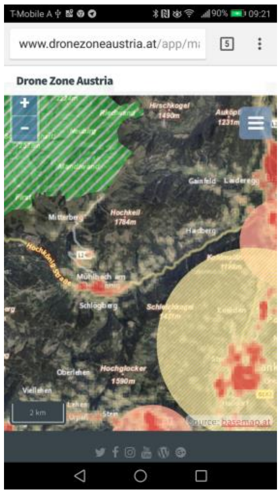
The detailed list of all utilized data sources is available to users in a corresponding portal section. There is a possibility to toggle individual data layers or to input the drone license category and weight to automatically receive a map-based representation of restrictions matching these input data. Identification of the zones occurs through symbology and in a form of pop-ups induced on a mouse click. They provide the type and the name of the zone, and for the nature protection areas they additionally reference webpages of local environmental protection authorities. With the use of their contact data one can get up-to-date information on drone use limitations in the corresponding area, which can be time-dependent (e.g. bird nesting season). To facilitate pilot's orientation, relevant spatial background information is available in several forms: high resolution orthoimages and a street map provided by the Web Map Tile Service of *basemap.at*, plus OpenStreetMap data. Basemap.at is a high-performance web basemap published under an OGD license. It is based upon up-to-date and detailed data provided by the nine Austrian federal states and their partners.

Due to its responsive design, "Drone Zone Austria" can be accessed from a mobile device as well as from a desktop or laptop. Figures 7 and 8 provide an impression of user interface of the web portal and its functionality. The project is in the final stage of development and the prototype will be officially released be the end of April 2018.

Figure 7: "Drone Zone Austria" on a mobile device

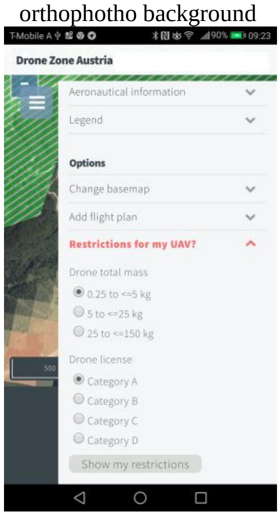


(a) Areas of operation, aviation related zones and a nature reserve



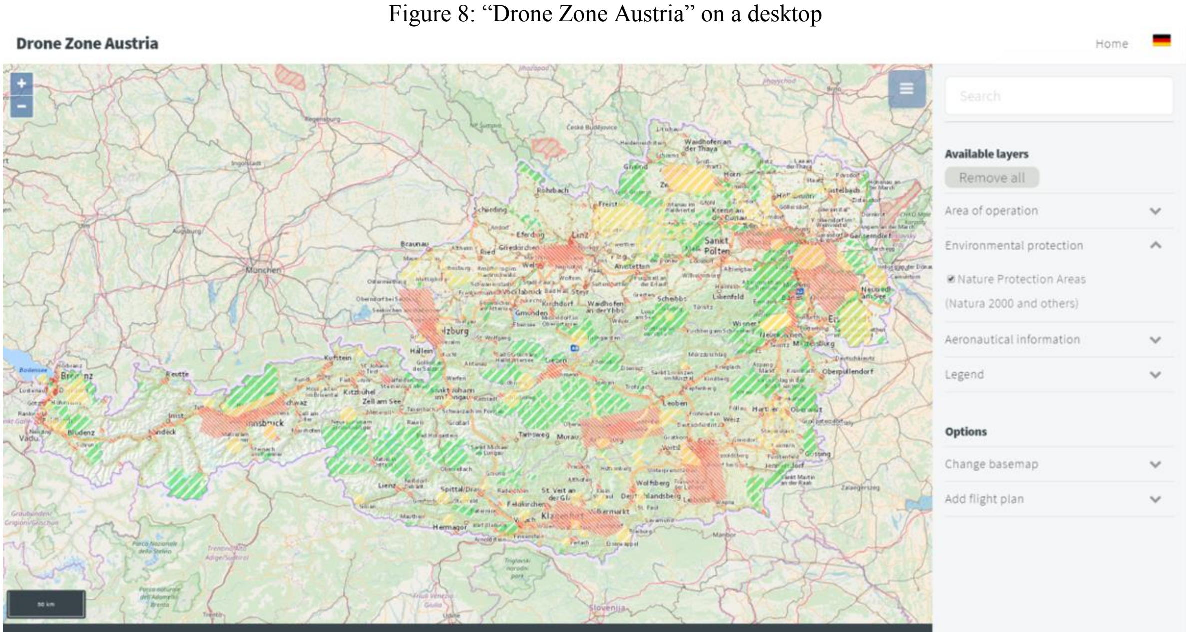
(c) Integrated mission planning support with an orthophotho background

(c) A nature reserve identified with a pop-up



(c) Request of the specific UAS mission restrictions

Figure 8: "Drone Zone Austria" on a desktop



3 Conclusions

We have demonstrated the generic problem of a high variation in potential settlement density representations using Austria as a case study. Nevertheless, the same issues are of high relevance for the upcoming EU wide unified regulations for UAS with a MTOW of less than 150kg (EASA 2015). The resulting areas of operation shows very clearly the complexity of the issue and its huge impact on UAS mission planning. Our research results indicate that there is an urgent need for UAS-specific SARPs that regulate definition, demarcation and publishing of the UAS operation relevant zones not only for Austria but for the entire EU to fully support a risk based mission assessment in a machine readable form. The proposed web portal prototype represent a scientific proof of concept how safe drone mission planning can be supported by high resolution geodata, spatial aggregation methods and a web service based architecture. An important issue in this context is the clarification of who must to be in charge of providing such trusted, validated and legally approved spatial information. This remains up to date an open issue. In order to facilitate safe and legally compliant UAS risk-based mission planning, a spatial data infrastructure is necessary for national aviation authorities and UAS operators as well. Current existing spatial data infrastructures like the INSPIRE directive (Infrastructure for Spatial information in the EU; http://inspire.ec.europa.eu/) for the EU and the OGD Initiatives (Attard et al., 2015) provide promising opportunities and a framework for utilizing high quality geodata for risk-based UAS mission planning in the EU.

4 Acknowledgements

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