Knowledge system support for flight planning process

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Abstract. *The article deals with an ontology approach to flight planning process. The rules and documents associated with them differ in individual countries, so a knowledge system based on ontology can help to interpret and understand information and its interconnection in the airspace legal domain.*

Keywords

Ontology, Topic Maps, knowledge system.

1. Introduction

The world's navigable airspace is divided into three-dimensional segments, each of which is assigned to a specific class. Most nations adhere to the classification specified by the International Civil Aviation Organization (ICAO). Individual nations also designate *Special Use Airspace*, which places further rules on air navigation for reasons of national security or safety. Although the classification is the same, there are many rules connected with using the airspace classes that differ among countries. This puts a great amount of pressure on pilots planning their trips across different countries to understand the differences between countries' airspace rules. Wrong understanding of the differences in using the airspace can lead to a fatal accident or serious penalty fee for not respecting airspace rules in that concrete country.

The flight planning process requires searching, finding and understanding of high amount of information; for the pilot, the rules and airspaces are subject to change every year. So a tool that would help them to manage this information would be very helpful.

Airspace overview

On March 12, 1990, ICAO adopted the current airspace classification scheme. The classes are fundamentally defined in terms of flight rules and interactions between aircraft and Air Traffic Control (ATC). Some key concepts are:

- Separation: Maintaining a specific minimum distance between an aircraft and another aircraft or terrain to avoid collisions, normally by requiring aircraft to fly at set levels or level bands, on set routes or in certain directions, or by controlling an aircraft's speed.
- Clearance: Permission given by ATC for an aircraft to proceed under certain conditions contained within the clearance.
- Traffic Information: Information given by ATC on the position and, if known, intentions of other aircraft likely to pose a hazard to flight.

The classifications adopted by ICAO are:

- Class A: All operations must be conducted under Instrument Flight Rules (IFR) or Special Visual Flight Rules (SVFR) and are subject to ATC clearance. All flights are separated from each other by ATC. Class A airspace starts at FL 180 or 18000ft to FL 600 or 60000ft. And also must change from the local altimeter to 29.92 inHg or 1013.2 mb.
- Class B: Operations may be conducted under IFR, SVFR, or Visual flight rules (VFR). All aircraft are subject to ATC clearance. All flights are separated from each other by ATC.
- Class C: Operations may be conducted under IFR, SVFR, or VFR. All flights are subject to ATC clearance. Aircraft operating under IFR and SVFR are separated from each other and from flights operating under VFR. Flights operating under VFR are given traffic information in respect of other VFR flights. From the primary airport or satellite airport with an operating control tower must establish and maintain two-way radio communications with the control tower.
- Class D: Operations may be conducted under IFR, SVFR, or VFR. All flights are subject to ATC clearance. Aircraft operating under IFR and SVFR are separated from each other, and are given traffic information in respect of VFR flights. Flights operating under VFR are given traffic information in respect of all other flights.
- Class E: Operations may be conducted under IFR, SVFR, or VFR. Aircraft operating under IFR and SVFR are separated from each other, and are subject to ATC clearance. Flights under VFR are not subject to ATC clearance. As far as is

practical, traffic information is given to all flights in respect of VFR flights.

- Class F: Operations may be conducted under IFR or VFR. ATC separation will be provided, so far as practical, to aircraft operating under IFR. Traffic Information may be given as far as is practical in respect of other flights.
- Class G: Operations may be conducted under IFR or VFR. ATC separation is not provided. Traffic Information may be given as far as is practical in respect of other flights.

Classes A-E are referred to as controlled airspace. Classes F and G are uncontrolled airspace.

Table 1 provides an overview of the above-mentioned classes and specifications for each of them.

Class	Controlled	IFR	SVFR	VFR	ATC Clearance	Separation	Traffic Information
A	Controlled	Yes	Yes	No	Required	Provided for all flights	N/A
B	Controlled	Yes	Yes	Yes	Required	Provided for all flights	N/A
C	Controlled	Yes	Yes	Yes	Required	Provided for all IFR/SVFR	Provided for all VFR
D	Controlled	Yes	Yes	Yes	Required	Provided for IFR/SVFR to other IFR/SVFR	Provided for all IFR and VFR
E	Controlled	Yes	Yes	Yes	Required for IFR	Provided for IFR/SVFR to other IFR/SVFR	Provided for all IFR and VFR where possible
F	Uncontrolled	Yes	No	Yes	Not Required	Provided for IFR/SVFR to other IFR/SVFR where possible	Provided where possible
G	Uncontrolled	Yes	No	Yes	Not Required	Not provided	Provided where possible

Tab. 1. Airspace classes and their specifications

1.1 Use of airspace classes

Each national aviation authority determines how it uses the ICAO classifications in its airspace design. In some countries, the rules are modified slightly to fit the airspace rules and air traffic services that existed before the ICAO standardization. As an example we can take differences in Germany and Australia

In Germany, Classes A and B are not used at all. Class C is used for Airspace above Flight Level (FL) 100 (or FL 130 near the Alps) up to FL 660. The airspace is divided into *lower airspace* below FL 245 and *upper airspace* above FL 245.

- *Class A* is not used.
- *Class B* is not used.
- *Class C* is used for controlled zones above and around airports and airspace above FL 100 (or FL 130 near the Alps) up to FL 660.
- *Class D* is used for controlled zones or above and around airspace class C designated zones where CVFR is not necessary.
- *Class E* is used for airspace between usually 2,500 ft (760 m). AGL (around airports 1,000 ft (300 m). or 1700 ft. AGL) and FL 100.
- *Class F* is used for IFR-Flight in uncontrolled airspace.
- *Class G* is used below 2,500 ft (760 m) AGL (around airports below 1,000 ft (300 m) AGL, then rises via a step at 1,700 ft (520 m) to 2,500 ft (760 m) AGL)

Australia has adopted a civil airspace system based on the United States National Airspace System (NAS):

- *Class A* is used above FL 180 along the populated coastal areas, and above FL 245 elsewhere.
- *Class B* is not used.
- *Class C* is used in a 360° funnel shape in the Terminal Control Zones of the major international airports, extending up to the base of the Class A, generally at FL 180 over these airports. It also overlays Class D airspace at smaller airports.
- *Class D* is used for the Terminal Control Zones of medium sized airports, extending from the surface up to 4,500 feet (1,370 m). Above this, Class C airspace is used, although generally only in a sector, and not 360° around the airport.
- *Class E* is used along the populated coastal areas, from 8,500 feet (2,590 m) to the base of the overlying Class A or Class C airspace.
- *Class F* is not used.

Class G is used wherever other classes are not - almost always from the surface to the base of the overlying Class A, C, D or E airspace.

1.2 Special Use Airspace

A number of “special use” airspace areas exist for various usage. It means that certain activities have been confined to those areas of airspace. Limitations are placed on aircraft operations in the areas which are not a part of the activity. These are:

- Prohibited areas
- Restricted areas
- Warning Areas
- Military Operations Areas
- Alert Areas
- Controlled Firing Areas
- Military Training Routes
- Air Defense Identification Zone
- Temporary Restricted Areas

2. Information support

The core of the knowledge system that would handle the airspace classification is composed of ontology and a method that can describe this ontology. The airspace knowledge system in general is based on the concept of three processes:

- find information;
- understand information;
- use information.

The airspace system shares the concept of the knowledge system philosophy. Knowledge system is focused on data, information and knowledge that are created, shared and used. Data create a representation of reality. Information shows data in associations and consequences. Knowledge is appropriate and early presented information. Knowledge system creates new layers that contain information relevant to user requests. Both worlds (airspace system and knowledge system) use a principle of shared knowledge.

Technology used in knowledge system must support the processes bellow:

- search adequate information on demand;
- deliver the right information in right place in sufficient time;
- analyze information to disclose a new association;
- organize information structure to get readable navigation.

Ontology is a core of a designed knowledge system. It defines a correct and exact interpretation of individual themes. It creates universal language in the problem domain and enables saving our knowledge. Ontology can be created by ontology languages or by Topic Maps. Ontology languages, for example Ontology Web Language (OWL) [1], are designed to formally depict the problem domain in pre-defined way, based on the XML standard. It can be used to identify new relations and consequences in the problem domain that were hidden before. OWL can be also easily processed by computers and the process of searching new associations can be automated.

Topic Maps is an alternative way to interpret knowledge but it was originally optimized for human interactive work. Topic Maps are designed to interpret knowledge, not to search a new one.

The main concept of Topic Maps is based on:

- Topic (theme) – alias for the subject that we want to represent in the computer. One topic represents only one subject.
- Subject – part of the real world that is depicted by theme.
- Instance – internal attribute of theme that is stored directly in Topic Maps or external attribute that is connected to external source via http.
- Association - expresses the relation between topics. It can have a type and number of instances.

Basic ontology model created in Topic Maps is composed of two layers [2]. The first one is information and the second one is a knowledge layer. The knowledge layer contains topics and associations and information layer contains all relevant documents and resources related to area of interest. Construct instance can be used to connect these two layers. Thus, the interconnection between topic and relevant resource is created.

Topic Maps were created in Ontopoly software. In this software the topics that represent the airspaces and countries were created, the association between these topics represents the rules defined by ICAO standards. There internal occurrence connected with topics that describes details about the topic. Věta nedává smysl The external occurrence represents the documents or links to external sources connected with the topic. As an example, there is a country topic on Figure 1.

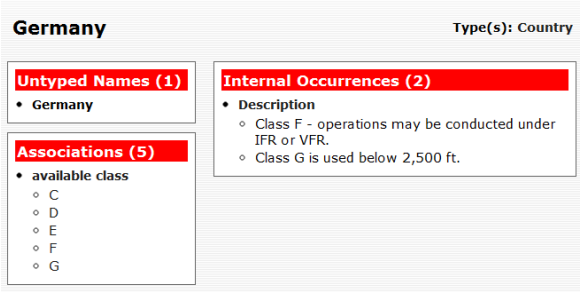

Fig. 1. Germany topic detail

As can be seen from Figure 1, Germany has no association with class A and B airspace as it is specified by the ICAO rules. The overview of the topics can be inspected in Omnigator software. The associations are visualized as a colored graph. The associations of the topics are clearly visible and can help with understanding the situation. The example can be seen on Figure 2.

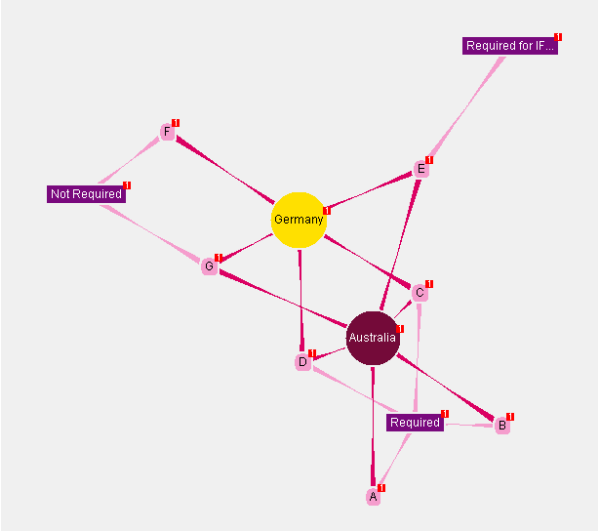

Fig. 2. Topics and associations visualized as a graph

Conclusion

Using an ontology approach and tools such as Topic Maps could help pilot with understanding the airspace classes and rules of using them among different countries and can be helpful when planning the flight. The use of ontology when working with a high amount of documents and rules can simplify the process of information gathering. Visualization of that data in forms of graph can speed up the understanding of relationship among several data sources and documents with defined rules.

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