Aeronautical Data Quality - A New Challenge for Surveyors

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Key words: surveying, work flow management, aeronautical data quality, International Civil Aviation Organisation (ICAO), Eurocontrol

SUMMARY

The International Civil Aviation Organisation (ICAO) introduced some years ago their standards and recommended practices, which related also to digital terrain and obstacle data. To achieve compliance with these standards the states had to introduce new work flows for the data capturing and the storage of these data. Eurocontrol, which represents the Member States of the European Organisation for the Safety of Air Navigation took over the responsibility to introduce these standards and implement them for the European airspace. These standards are covering an enormous range of stakeholders, from those who plan a project to those who are responsible for the data capturing, i.e. from the planer to the surveyors and the data base managers. In the future the data related to these standards will have the same importance for the air traffic like the digitized road network for car navigation systems, but with much higher safety relevance.

The legal frame is given in the European Regulation 73/2010, where the Aeronautical Data Quality (ADQ) is defined, also the special data format AIXM (Aeronautical Information Exchange Model), which will guarantee a loss free transformation of all spatial and non-spatial data including the meta information.

The aeronautical data chain contents the integrated aeronautical data package (NOTAM, e.g.), digital obstacle data, digital terrain data and airport terrain data. In the production of all such data the surveyor is involved and has to deliver the information complaint with the standards.

The paper will describe the challenges for different data capturing methods to achieve the compliance with the ADQ standards and data formats. Till now no surveying work flow for geographical data capturing is fulfilling such requests. ADQ will have influence on the suppliers of surveying systems, the service providers, the concerned GIS applications and the data base structures.

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INTRODUCTION

With the annex 15 of the Convention on International Civil Aviation in their series of International Standards and Recommended Practices the International Civil Aviation Organisation (ICAO) set a cornerstone in Aeronautical Information Services (AIS) already in the year 2010 (ICAO, 2010a). It should influence most of the stakeholders in the AIS business worldwide in the coming years to achieve Aeronautical Data Quality (ADQ).
To achieve compliance with these standards the European Union published the Commission Regulation (EU) 73/2010 (EU, 2010) and the member states of the European Organisation for the Safety of Air Navigation (Eurocontrol) asked this organisation for support and guidance in this challenging topic related to technical, institutional and especially implementation aspects. Eurocontrol established several working groups and published in the meantime some manuals and specifications (see e.g. EUROCONTROL, 2011, 2012, 2013). The timeline for implementation of the regulation is very demanding and started already 01.07.2013 going till 30.06.2017, when all data must be ADQ compliant.
So the aim of this paper is to make especially the community of surveyors aware of these ongoing processes in their own field of activities. Workflows and data management have to be adopted to fulfil these regulations. It is not the typical aspect of accuracies, which is challenging in the processes, than rather aspects of the data integrity, consistency, reliability and assurance.

AERONAUTICAL DATA QUALITY

The aeronautical data quality (ADQ) differentiates in between the data originators, the states which are running the AIS or AIM (Aeronautical Information Management) and the end users (see figure 1). Among the data originators one will find the surveyors and the national geographical institutes. The states are responsible for their aeronautical databases like the Aeronautical Information Packages (AIP) or the NOtices To AirMen (NOTAM) which is in most states under the process of conversion from analogue to digital media. For example there is the European AIS Database (EAD), which is the aeronautical information system of Eurocontrol. And finally on the end user side we will have the airlines, pilots, other airspace users as well as the ground segments like other states, flight briefing providers or air transportation system providers. The interface between these 3 groups is defined by the Aeronautical Information Exchange Model (AIXM), see the following chapter.
The surveying discipline is mainly involved in the capturing and maintenance of digital obstacle data, digital terrain data and airport terrain data. The typical content like the geometrical objects, their attributes and the links to the metadata are described in the ICAO document 9881 called "Guideline for Electronic Terrain, Obstacle and Aerodrome Mapping Information", (ICAO, 2009).
The ADQ is now demanding structured electronic data in a defined quality (accuracy,

resolution and integrity, see EUROCONTROL, 2013) starting with the data originator, e.g. the surveyor. All these data must be delivered without any loss of quality to all participants on time. Every step in the work flow process and all involved persons or authorities have to be documented and verified. For example the responsible surveyor, the used equipment including the respective calibration report, the date and time of operations, the project designation including its work order. The used software, datum and reference information must be electronically documented already during the field works. The aeronautical data chain starts normally with the surveyors, goes via the airport organisations to the related authorities and ends up with the national air traffic control organisations. The complete process chain must be ADQ compliant.

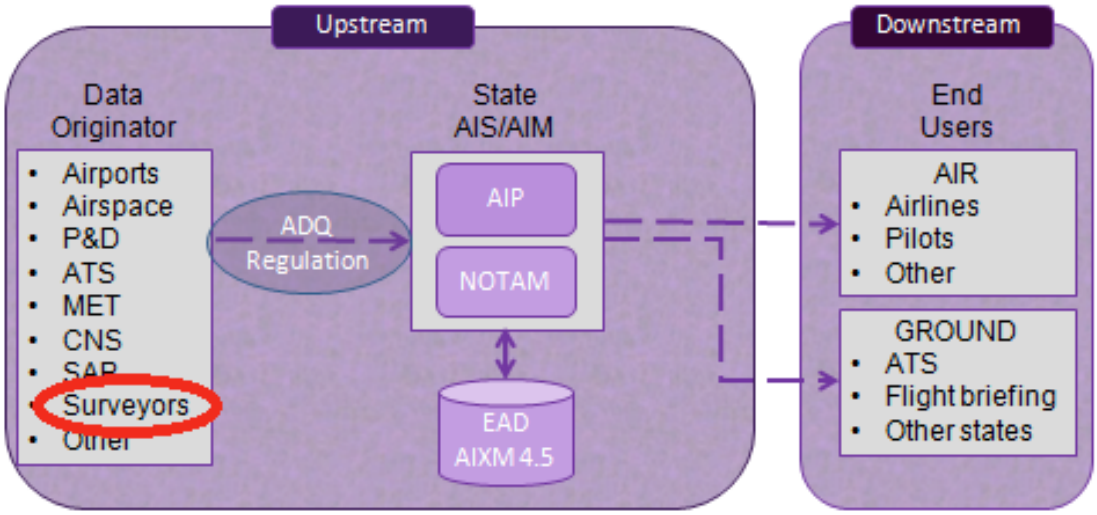

Figure 1: ADQ Regulations (see GROUPEAD, 2013)

AERONAUTICAL INFORMATION EXCHANGE MODEL

In paragraph 5 of the Commission Regulation (EU) 73/2010 (EU, 2010) the data exchange of all aeronautical data and information is defined. Based on this the Eurocontrol Specification for Aeronautical Information Exchange (AIX) were defined (EUROCONTROL, 2012). The latest version of the data model is AIXM 5.1. Here it is mentioned that the specification is designed to enable interoperability between the different actors of the aeronautical data chain, through the standardized encoding and the distribution in digital format of the aeronautical information/data. To achieve compliance with the ADQ the AIXM 5.1 has to follow some rules, for instance:

- a common data set shall be provided by using the Unified Modeling Language (UML) or by using a feature catalogue
- a data set for aeronautical information has to include a temporality concept (time slice objects) that enables modeling the evolution of a feature and its properties during the feature lifetime. This means the time has to be recorded as a 4th dimension of the data set.

- the use of a geographical information - spatial schema, i.e. points, curves and surfaces.
- the recording of all kind of metadata information

For the data encoding the Extensible Markup Language (XML) shall be used. For geographical data the Geographical Markup Language (GML) has to be applied, which is an XML grammar. Standard GIS software like ArcGIS (ESRI), Geomedia (Intergraph) or Bentley Map (Bentley Systems) should provide these formats.

```
<group name="RunwayPropertyGroup">
   <sequence>
     <element name="designator" type="aixm:TextDesignatorType"
nillable="true" minOccurs="0"/>
     <element name="type" type="aixm:CodeRunwayType" nillable="true"
minOccurs="0"/>
     <element name="nominalLength" type="aixm:ValDistanceType"
nillable="true" minOccurs="0"/>
     <element name="lengthAccuracy" type="aixm:ValDistanceType"
nillable="true" minOccurs="0"/>
     ...
     <element name="associatedAirportHeliport"
type="aixm:AirportHeliportPropertyType" nillable="true" minOccurs="0"/>
     ...
     <element name="areaContaminant" type="aixm:
RunwayContaminationPropertyType" nillable="true" minOccurs="0"
maxOccurs="unbounded"/>
     <element name="annotation" type="aixm:NotePropertyType" nillable="true"
minOccurs="0" maxOccurs="unbounded"/>
   </sequence>
</group>
```

Figure 2: Example of an XML Schema Group (RunwayPropertyGroup) in AIXM 5.1 (see EUROCONTROL, 2010)

```
<complexType name="RunwayTimeSliceType">
 <complexContent>
  <extension base="aixm:AbstractAIXMTimeSliceType">
   <sequence>
    <group ref="aixm:RunwayPropertyGroup"/>
    <element name="extension" minOccurs="0" maxOccurs="unbounded">
     <complexType>
      <sequence>
       <element ref="aixm:AbstractRunwayExtension"/>
      </sequence>
      <attributeGroup ref="gml:OwnershipAttributeGroup"/>
     </complexType>
    </element>
   </sequence>
  </extension>
 </complexContent>
</complexType>
```

Figure 3: Example of dynamic feature (runway) with TimeSlice property in AIXM 5.1 (see EUROCONTROL, 2010)

ADQ AND SURVEYORS

For all data capturing and updating of terrain, obstacle and aerodrome data the surveyor is

involved. In the AIS terminology this is called ETOD (electronic terrain and obstacle data). In figure 4 you can find an aerodrome obstacle chart as an example from the Aeronautical Information Package (AIP) and in figure 5 an aerodrome obstacle chart.

The necessary surveys are based on the World Geodetic System 1984 (WGS 84) as the horizontal reference system and the Earth Gravitational Model 1996 (EGM 96) as geoid model for the height reference system or any convenient geoid model relative to the mean sea level via EGM 96 with the corresponding metadata and transformation information. For the temporal reference system of the aeronautical data the Gregorian calendar and the Co-ordinated Universal Time (UTC) shall be used. Any data transformation has to be recorded in the metadata information. The planimetric coordinates have to be delivered in the geographic coordinate system (latitude and longitude) in decimal of degrees format (DD.dd). The necessary accuracies to be achieved and further regulations for the different surveying methods can be found in ICAO, 2010b and especially in EUROCONTROL, 2013. The content of the data to be surveyed, .i.e. the features can be found in ICAO, 2009.

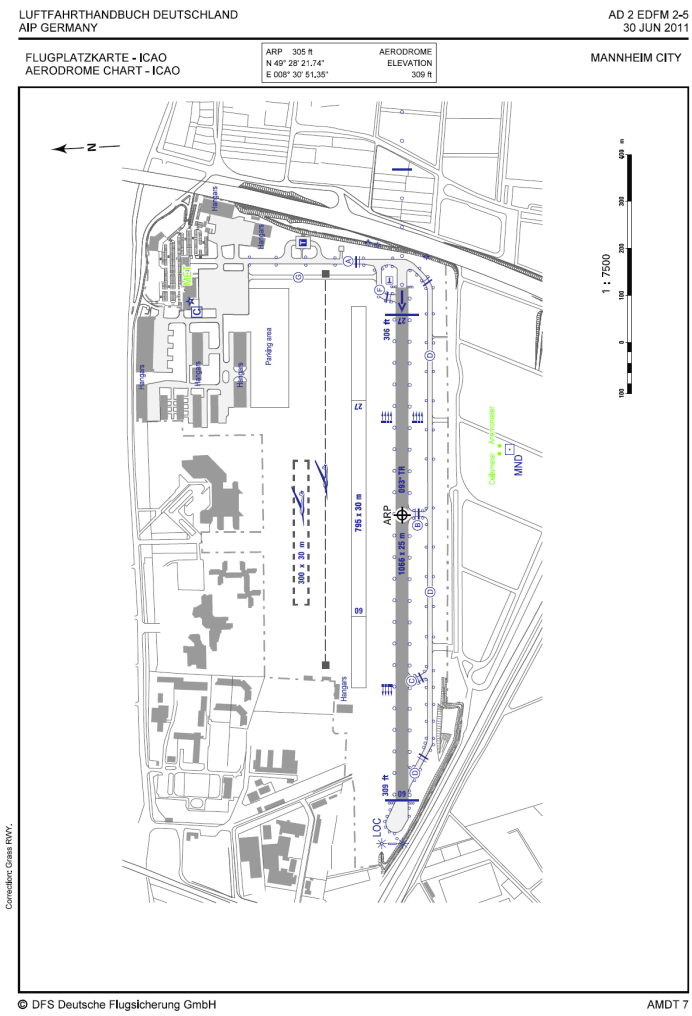

Figure 4: Aerodrome chart, DFS AIP Germany

The ADQ is now demanding, that any interaction with aeronautical data or information has to be electronically recorded including the actor by himself. Interaction means any action, which may affect the quality of the aeronautical data and information, including amendments and approvals. This also demands an electronic work flow management from the incoming order to the surveyor's office till the delivery of AIXM data. Most of the existing office software products for surveyors are not assisting such a work flow management, even the data capturing software is not enabled for it. Just the suppliers of GIS software like ESRI with ArcGIS for Aviation or Bentley Systems with Bentley Map Airport Data Model have already adopted their database structures to the new AIS standards. A prototype for aerodrome mapping databases based on Geomedia (Intergraph) can be seen at ROBIN et al., 2011. But even these applications are normally designed more for the use of the database as for an efficient data capturing procedure, which is ADQ compliant.

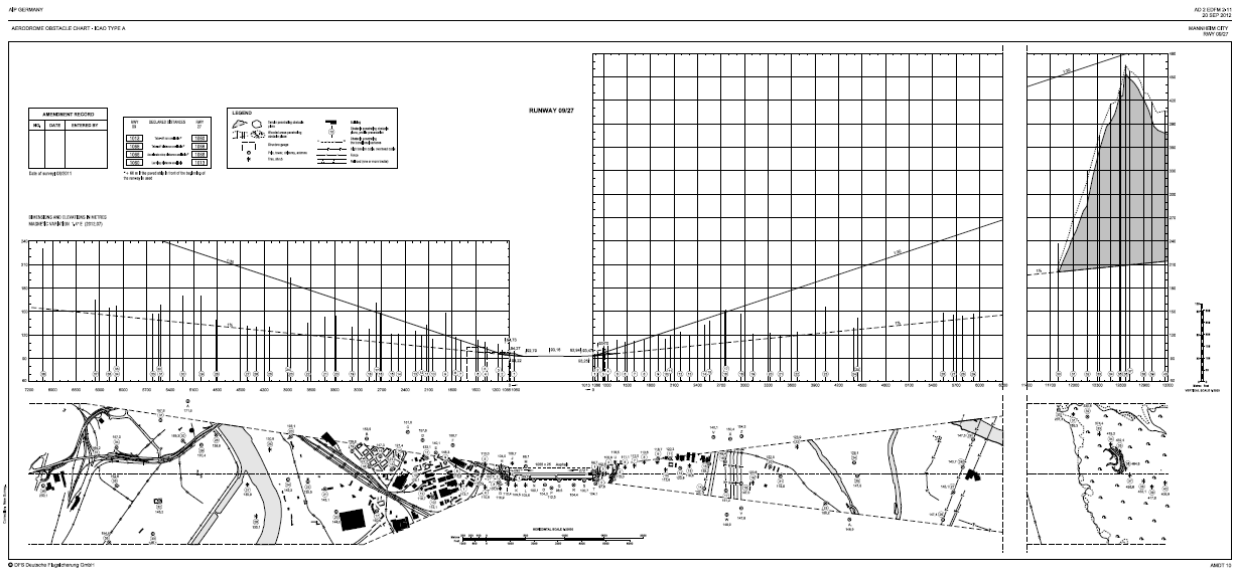

Figure 5: Aerodrome obstacle chart, DFS AIP Germany

An essential part of the ADQ standards are beside the geometric and attribute information a variety of metadata to be delivered and handled by the data originator like:

- the originator of the data by himself
- any amendments made to the data
- the persons or organisations, that have interacted with the data and when
- details of any validation and verification of the data that has been performed
- any actual calibration report
- for geospatial data:
  - the earth reference model used
  - the coordinate system used
- for numerical data:
  - the statistical accuracy of the measurement or calculation technique used
  - the resolution (digits)
  - the confidence level as required by the ICAO standards
- details of any functions applied, if data has been subject to conversion/transformation

Some of the metadata information can be seen in table 1. There you can see typical information for different data capturing methods the surveyors are using. The information shown gives an idea about the complexity to handle all the information parallel to the capturing or updating process, no information should be lost and a complete history of all actions has to be documented and approved.

	Meta data information											
Data capturing method	date	time	data originator	organisation	data request or link to document	used hard- and software	calibration or link to calibration report	horizontal reference system	vertical referenz system	accuracy	confidence level	etc.
terrestrial survey	x	x	x	x	x	x	x	x	x	x	x	
photogrammetry	x	x	x	x	x	x	x	x	x	x	x	
LiDAR aerial	x	x	x	x	x	x	x	x	x	x	x	
LiDAR terrestrial	x	x	x	x	x	x	x	x	x	x	x	
mobil mapping (multi sensor)	x	x	x	x	x	x	x	x	x	x	x	
digitization	x	x	x	x	x	x	x	x	x	x	x	

Table 1: Metadata information for different data capturing methods surveyors are using

NEXT STEPS

In our surveyors community there is a very little awareness of the actual situation for ADQ compliant data production and the demands coming from aeronautical information and navigation systems. Even surveying system suppliers are obviously not prepared to adopt their system features to achieve compliance with ADQ based standard workflows. And as in the forgoing chapters mentioned and explained there are several challenges for the surveyors themselves to fulfil the ADQ compliance. It starts with the electronic workflow management, continues with the recording of the metadata and ends with the deliveries in the AIXM compatible data format.
At the moment besides the aeronautical navigation system providers worldwide mainly the international airports and the national air traffic controllers like DFS Deutsche Flugsicherungs GmbH, the Austrian Austro Control GmbH or the Spanish AENA are aware of the situation and started to work on the FAA or ADQ compliance for their workflows and databases. Standard procedures have to be adopted and changed. Also all data originators and not only the surveyors are involved in this evolution process. Not to mention all the existing data, which are not compliant and the necessary information like metadata or transformation procedures, approvals, etc. are not availbale.
Providers of aeronautical databases have already adopted their systems to the new situation, also GIS suppliers are on their way. Experienced service providers like GroupEAD (info@groupead.com) or Blom (info.de@blomasa.com) are aware of the situation and are offering consultancy, training and workflow management in this new field of Aeronautical Data Quality. There should be still a chance for all involved parties to keep the deadline in 3 years from now.

REFERENCES

ROBIN, Ch. et al., 2011: Aerodrome Mapping Database - Entwurf und Modellierung eines Datenbanksystems für Flughäfen, Angewandte Geoinformatik, Salzburg, Austria
EU, 2010: Commission Regulation (EU) 73/2010, Official Journal of the European Union
EUROCONTROL, 2010: AIXM - UML to XML Schema Mapping, Brussels, Belgium
EUROCONTROL, 2011: Terrain and Obstacle Data Manual, Edition 2.0, Brussels, Belgium
EUROCONTROL, 2012: EUROCONTROL Specification for Aeronautical Information Exchange, EUROCONTROL-SPEC-151, Brussels, Belgium
EUROCONTROL, 2013: EUROCONTROL Specification for the Origination of Aeronautical Data Vol. 1 and 2, EUROCONTROL-SPEC-154, Brussels, Belgium
ICAO, 2009: Guidelines for Electronic Terrain, Obstacle and Aerodrome Mapping Information (Doc 9881)
ICAO, 2010a: Aeronautical Information Services, International Standards and Recommended Practices, Annex 15 to the Convention on International Civil Aviation, 13th Edition, Montreal, Canada
ICAO, 2010b: Units of Measurement to be used in Air and Ground Operations, Annex 5 to the Convention on International Civil Aviation, 5th Edition, Montreal, Canada
GROUPEAD, 2013: ADQ4u - Solutions for Surveyors, internal documentation, Madrid, Spain

BIOGRAPHICAL NOTES

Dr. Ralf W. Schroth, born in Berlin in the year 1953, studied Geodesy and Surveying from 1972 up to 1977 at the University of Stuttgart. After the probationary period for the national surveying administration in the Land Baden-Wuerttemberg he got his degree as legal surveyor in 1979.
He worked as a scientific assistant at the Institute for Photogrammetry at the University of Stuttgart under the leadership of Prof. Fritz Ackermann till 1984. There he was active in the fields of research and development, giving lectures in Photogrammetry and adjustment theory, software development for aerial triangulation and photo-reproduction. In 1985 obtaining the degree of Doktor-Ingenieur.
From 1984 till 2008 he has been working with the company Hansa Luftbild in Muenster, where he was acting in different managing positions like as managing director and member of the board of the Hansa Luftbild Group.
Since 2008 Ralf Schroth is working for the Norwegian Blom Group as managing director in Germany and Romania, business development director for central and eastern Europe and organizing the off-shore production at Blom International Operations SRL, Romania.
Ralf Schroth has many years of experiences in business administration and management, project management, Photogrammetry and Geo-Information systems. Already in 1988 he was announced as a member of the management board at Hansa Luftbild GmbH and co-founded an international group of companies. He was also responsible for general contracting projects on the Arabian Peninsula. He was board member in several affiliated companies in Germany and abroad.
Since 1991 he is a lecturer at the University of Hanover for business administration and

management for surveying engineers. In 1997 he got the appointment as honorary Professor from the University of Hanover. From 2004 till 2008 he was also lecturer at the Institute of Geomatics at the Polytechnic University of Barcelona.

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