OBSTACLE DATA FORMAT SPECIFICATIONS

Status
Software Version 4.04 (June 03, 2008)

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1. Welcome to FLARM

This document provides information how to deliver obstacle data to FLARM Technology, and what data is available for FLARM and compatible systems. The data will be converted by FLARM Technology into a binary OBS-format to be used in the device. This document does not describe the detailed database development process for obstacle warnings according to EUROCAE ED-76 / RTCA DO-200A ("Standards for Processing Aeronautical Data", September 28, 1998).

The document assumes you are familiar with the basics of geographical formats, datum, geoids and projections. If you are not, please do not work on obstacle data, as the data used must be as precise as possible.

The most recent version of this specification document is available on www.flarm.com
You can also subscribe to a developer email news-list in order to get first-hand information on the topic: https://lists.flarm.com/mailman/listinfo/user-list_flarm.com
A list of frequently asked questions can be found on www.flarm.com/support/faq/index.html

Please let us know about your products and designs that use FLARM's NMEA stream.

Suggestions to improve this document may be sent to info@flarm.com.

You might also consider the following documents:

- ICAO amendment 33 of annex 15, ruling electronic terrain and obstacle data as part of aeronautical information services, to be enforced from November 2008 / 2010
- RTCA DO-291 (July 29, 2004) "Interchange Standards for Terrain, Obstacle, and Aerodrome Mapping Data"
- RTCA DO-276A (August 3, 2005) "User Requirements for Terrain and Obstacle Data"

2. Working Principle

FLARM utilizes position and movement information obtained form an integrated 16-channel GPS and an embedded barometric sensor. The future flight path of the glider is predicted and transmitted over low-power short-range radio as a very short digital message once a second. These messages are almost at the same time received by other FLARM units within the range and then compared with their own predicted flight path. Likewise the own flight path is compared with the stored fixed obstacles in the area (e.g. cables, antennas, aerial railways, …). If in either of the cases a dangerous approximation is determined, then FLARM warns the pilot of the possibility using its computation of the current most dangerous object. Warnings are shown via a buzzing sound and on a bright multi-LED display indicating the direction and danger level of the intruder. Directional advice is given in the horizontal and vertical plane.

In addition, the GPS and collision data are transmitted as serial data to be used in other applications (e.g. PDA, external user interfaces). Several manufacturers of glider avionics and PDA software have committed to utilize FLARM data in their applications.

FLARM's range is subject to the antenna installation in the aircraft but usually is around 2 km, by far sufficient even for high speed flying. Alarms and the three alarm levels are issued depending on the forecasted time to impact, not a geometrical distance. The first alarm level is usually issued 16 to 18 seconds prior to impact in case of traffic or obstacles. Alarms are highly selective, i.e. they are only issued when there is imminent danger. In an additional information mode, the pilot can be informed about other aircraft even when not posing any elevated danger. FLARM is designed to handle up to 50 aircraft inside its range and will experience graceful performance degradation with more aircraft in range.

FLARM applies for the radio communication between the units a proprietary patent- and copyright-protected protocol. It is not public, but FLARM Technology offers a license contract where it is accessible in the form of a compatible core design ready for integration into 3rd party systems. These systems are officially declared as FLARM-compatible. Any non-licensed use, dissemination, copying, implementation or reverse engineering of the FLARM radio communication protocol, the FLARM hardware and software or parts of it is forbidden by law and will be prosecuted. FLARM is a registered trademark and can not be used without license.

3. Design Philosophy

FLARM cannot warn reliably in all situations. FLARM does not issue collision avoidance advice. FLARM can only warn of aircraft that are equipped with FLARM or a compatible device or of obstacles stored in its database. The use of FLARM does not allow a change of flight tactics or pilot behavior. It is the sole responsibility of the user and pilot in command to decide upon the use of FLARM. FLARM Technology cannot be held liable under any circumstances.

4. General Format Specification

The data format is a file with values separated by the semicolon character "`;`". Each record ends with a CRLF. The first line is a header line. The column order is free but must be used consistently over the file.

The subsequent lines are for the points. Each line represents one point. A point is a three dimensional coordinate. An obstacle object consists of one or many points. Each object must have a unique descriptor. Each point of the same object must have a sequence number, starting with 1. In one object, the sequence number must be unique. This is also required for objects made from only one point. The sequence number describes the order in one object. All the points from the same object must be together in the file in the order of the sequence number.

5. Field Specification

<table>
<tr><th>Header label</th><th colspan="4">Required</th><th>Definition</th></tr>
<tr><td>DESCRIPTOR</td><td colspan="4">x</td><td>String, must be unique per object.
Example: 205-ZH-11358</td></tr>
<tr><td>SEQNUMBER</td><td colspan="4">x</td><td>Integer, starts with 1 up to number of points per object. Single-point objects must carry SEQNUMBER=1.
Example: 7
Meaning: This is the 7^{th} point of object 205-ZH-11358</td></tr>
<tr><td>LATITUDE</td><td colspan="4">x</td><td>Point's WGS84 latitude in degrees north.
Example: 46.98765
Meaning: The latitude of the 7^{th} point of object 205-ZH-11358 is 46.98765° North = 46°59.259' North = 46°59' 15.54" North ≈ 46°59' 16" North</td></tr>
<tr><td>LONGITUDE</td><td colspan="4">x</td><td>Point's WGS84 longitude in degrees west.
Example: -6.98765
Meaning: The longitude of the 7^{th} point of object 205-ZH-11358 is 6.98765° East = 006°59.259' East = 006°59' 15.54" East ≈ 006°59' 16" East</td></tr>
<tr><td>GND_AMSL</td><td></td><td></td><td>x</td><td></td><td>Point's bottom height (=where it touches the ground) in m above mean sea level (=geoid).</td></tr>
<tr><td>GND_WGS84</td><td></td><td></td><td></td><td>x</td><td>Point's bottom height (=where it touches the ground) in m above WGS84 ellipsoid.</td></tr>
<tr><td>OBST_AMSL</td><td></td><td>x</td><td></td><td></td><td>Point's top height in m above mean sea level (=geoid).</td></tr>
<tr><td>OBST_WGS84</td><td>x</td><td></td><td></td><td></td><td>Point's top height in m above WGS84 ellipsoid.</td></tr>
<tr><td>OBST_ALTGND</td><td></td><td></td><td>x</td><td>x</td><td>Point's vertical dimension in m
= OBST_WGS84 - GND_WGS84
= OBST_AMSL - GND_AMSL.</td></tr>
<tr><td>IGNORE</td><td colspan="4"></td><td>Optional column(s), content will be ignored. Can be used several times.</td></tr>
</table>

6. Example

The following non-printing character is used in the example:

┘ stands for the CRLF

Here is the file

```
DESCRIPTOR;SEQNUMBER;LATITUDE;LONGITUDE;GND_AMSL;OBST_ALTGND┘
205-HL-1;1;47.676055;-8.457980;457;20┘
205-HL-1;2;47.675594;-8.459303;457;20┘
205-HL-1;3;47.677357;-8.463332;460;20┘
205-SH-10;1;47.683021;-8.422021;613;25┘
205-SH-10011;1;47.767006;-8.495748;660;65┘
```

The example shows three objects. The first one consists of 3 points and two segments. The other two objects have no horizontal size as they consist only of one point.

7. Undulation Difference Table

This table[1] shows EGM96 geoid mean sea level in meters with respect to WGS84 ellipsoid. Positive values mean that the geoid (i.e. the real sea level) is above the WGS84-ellipsoid, resulting in WGS84-elevations being higher than MSL-altitudes. The maximal value is +65m (60N 030W, south of Iceland), the minimum is -102m (00N 080E, south of India).

EASTERN HEMISPHERE

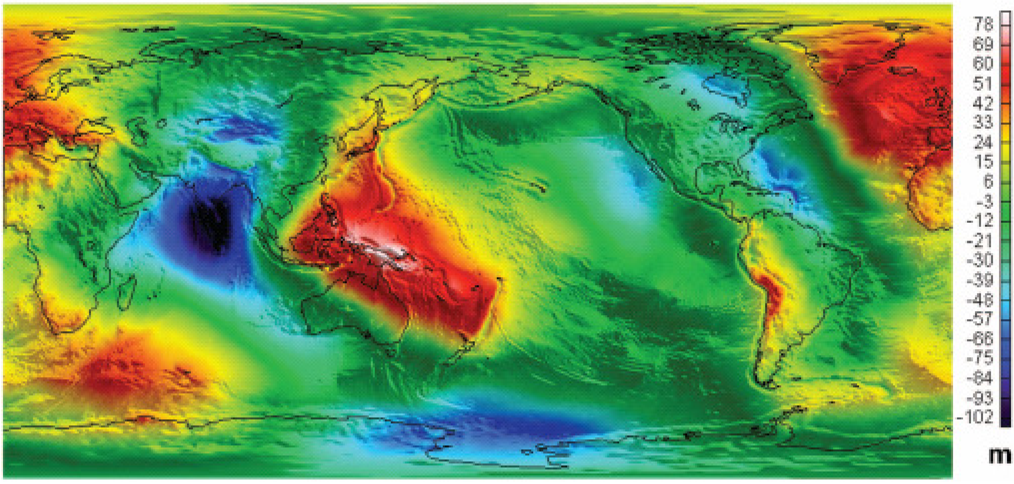
	0	010E	020E	030E	040E	050E	060E	070E	080E	090E	100E	110E	120E	130E	140E	150E	160E	170E	180E	
90N										13										
80N	33	34	28	23	17	13	9	4	4	1	-2	-2	0	2	3	2	1	1	3	Northern Hemisphere
70N	51	43	29	20	12	5	-2	-10	-14	-12	-10	-14	-12	-6	-2	3	6	4	2	
60N	47	41	21	18	14	7	-3	-22	-29	-32	-32	-26	-15	-2	13	17	19	6	2	
50N	47	48	42	28	12	-10	-19	-33	-43	-42	-43	-29	-2	17	23	22	6	2	-8	
40N	52	48	35	40	33	-9	-28	-39	-48	-59	-50	-28	3	23	37	18	-1	-11	-12	
30N	36	28	29	17	12	-20	-15	-40	-33	-34	-34	-28	7	29	43	20	4	-6	-7	
20N	31	26	15	6	1	-29	-44	-61	-67	-59	-36	-11	21	39	49	39	22	10	5	
10N	22	23	2	-3	-7	-36	-59	-90	-95	-63	-24	12	53	60	58	46	36	26	13	
Equator	18	12	-13	-9	-28	-49	-62	-89	-102	-63	-9	33	58	73	74	63	50	32	22	
10S	12	13	-2	-14	-25	-32	-38	-60	-75	-63	-26	0	35	52	68	76	64	52	36	Southern Hemisphere
20S	17	23	21	8	0	-10	-11	20	-40	-47	-45	-25	5	23	45	58	57	63	51	
30S	22	27	34	29	14	15	15	7	-9	-25	-37	-39	-23	-14	15	33	34	45	46	
40S	18	26	31	33	39	41	30	24	13	-2	-20	-32	-33	-27	-14	-2	5	20	21	
50S	25	26	34	39	45	45	38	39	28	13	-1	-15	-22	-22	-18	-15	-14	-10	-15	
60S	16	19	25	30	35	35	33	30	27	10	-2	-14	-23	-30	-33	-29	-35	-43	-45	
70S	16	16	17	21	20	26	26	22	16	10	-1	-16	-29	-36	-46	-55	-54	-59	-61	
80S	-4	-1	1	4	4	6	5	4	2	-6	-15	-24	-33	-40	-48	-50	-53	-52	-53	
90S										-30										

WESTERN HEMISPHERE

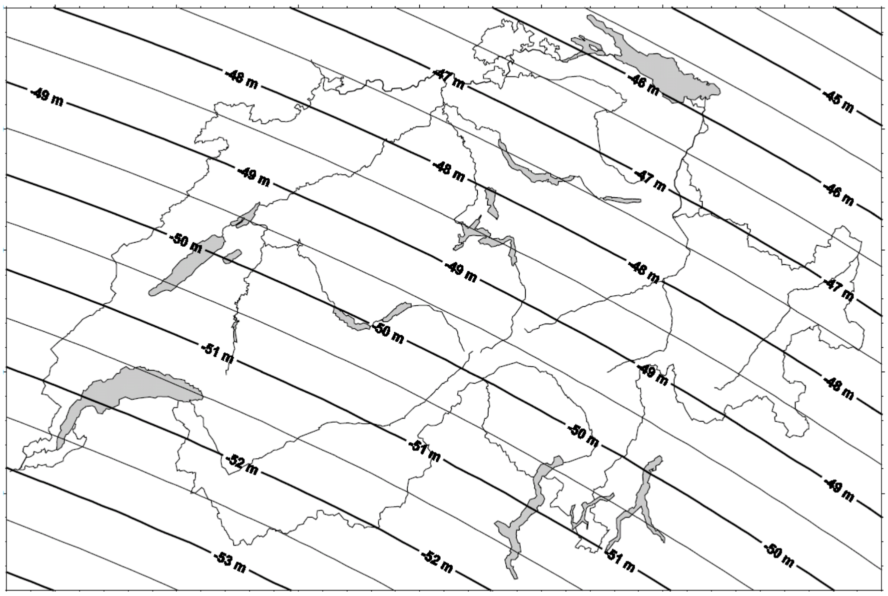
	0	010W	020W	030W	040W	050W	060W	070W	080W	090W	100W	110W	120W	130W	140W	150W	160W	170W	180W	
90N										13										
80N	33	34	33	34	31	27	19	11	9	5	1	3	-1	-3	-3	-3	-2	1	3	Northern Hemisphere
70N	51	58	61	50	47	37	24	3	-19	-25	-27	-24	-14	-7	-3	-1	1	2	2	
60N	47	57	60	65	49	29	6	-21	-42	-46	-39	-30	-14	1	13	10	17	9	2	
50N	47	59	62	63	45	24	-12	-26	-40	-35	-22	-18	-16	-19	-11	1	8	8	-8	
40N	52	51	52	59	33	2	-26	-35	-33	-34	-26	-16	-21	-34	-31	-20	-13	-10	-12	
30N	36	44	34	31	17	-17	-40	-51	-32	-26	-22	-29	-42	-40	-28	-15	-8	-5	-7	
20N	31	31	25	17	-9	-32	-48	-45	-20	-10	-9	-34	-47	-39	-23	-7	7	10	5	
10N	22	33	17	3	-16	-42	-41	-11	1	3	-10	-29	-38	-28	-11	2	11	12	13	
Equator	18	20	12	3	-18	-27	-15	10	14	-3	-14	-20	-23	-12	1	13	17	16	22	
10S	12	14	4	-9	-13	-18	4	32	1	-9	-11	-8	-10	-8	-1	6	11	22	36	Southern Hemisphere
20S	17	13	0	-5	-6	-5	20	35	9	-1	-3	-2	-5	-11	-9	0	10	27	51	
30S	22	15	12	4	-8	4	16	32	9	1	-4	-7	-10	-13	-8	-2	5	22	46	
40S	18	24	21	6	-6	-2	15	23	8	-1	-7	-10	-12	-12	-12	-7	1	6	21	
50S	25	27	20	10	3	3	13	14	6	-2	-8	-10	-10	-15	-17	-16	-18	-18	-15	
60S	16	17	22	24	21	20	20	10	-2	-10	-16	-22	-23	-26	-30	-32	-37	-43	-45	
70S	16	12	6	2	4	5	4	1	-6	-16	-25	-31	-38	-44	-49	-55	-61	-60	-61	
80S	-4	-8	-12	-16	-19	-21	-23	-24	-26	-26	-29	-38	-38	-42	-48	-52	-55	-54	-53	
90S										-30										

[1] Source: US NIMA Technical Report ref: DMA TR 8350.2 Table 6.1

The following map[2] visualises these differences.



The following map[3] shows these differences in Switzerland with an inverted sign.



8. Design considerations for an obstacle database

Here are some things you should always remember when working with obstacles:

- Take care to have coordinates in WGS84 datum and not any other local polar coordinates, as they look identical.
- Take care not to mix up the sign used for north/south and west/east.
- Take care not to mix up degrees, minutes, seconds, decimal degrees and decimal minutes.
- Take care to use the appropriate altitude information, i.e. do not mix relative and absolute altitudes and do not mix the altitude above the geoid (mean sea level) with the one above the WGS84 ellipsoid. This difference is the undulation (see chapter 7).
- Never use data from sources not known.
- Mark your own modifications.
- Describe exactly where you took the data from, what is the source a.s.f.

[2] Lemoine, F.G., et al., 1998, The development of the joint NASA GSFC NIMA geopotential model EGM96: Technical Paper NASA/TP-1998-206861

[3] Source: swisstopo

When designing or revising your own obstacle database - especially if you happen to be part of an official body to track obstacles (e.g. for AIP-ENR en-route obstacles) - please carefully consider the following issues. The better your data is the more likely someone will use it.

- Do not build a database with one very specific use in mind. The design should be as generic as possible and not be limited to third party use you already know about.
- Do not assume your database is just to prepare the data for printed maps and printed lists of obstacle data.
- Derived and calculated values must be marked, else you loose track of the original data.
- Describe each object as precise as possible; include one or several object classifications with fine granularity.
- Maintain the date when an object was inserted and when it was declared invalid to be able to export only modifications that happened in a defined time interval.
- Store the error levels you expect.
- Verify data entered in your system with reasonable checks; include a DEM (digital elevation model) crosscheck, but be aware that most DEM's have maximal error on mountain tops and ridges, i.e. exactly where the gradient is large.
- If there is specific use for the data, transform the data in an automated post-processing, but do not reduce information inside the database as this is lost information.
- Create a database made out of one or multiple 3 dimensional points connected together, ideally in a 1:1 relationship. The number of points connected in such a chain must not be limited by design. Do not build trees, rather replace trees by series of chains.
- A data point should always be referenced to WGS84 datum and polar projection, even if there is a need to keep track in a datum and projection of local use.
- A data point should always have altitude information referenced to mean sea level (=geoid). You can keep track of the elevation above the WGS84 ellipsoid if you know the difference and if you do not mix them. And be aware that a reference to WGS84 often but not always only relates the horizontal axis (i.e. longitude and latitude), while the vertical information is still MSL (or EGM).
- Store the bottom and the top elevation of any vertical object.
- Keep track of all physically existing points of a combined object, i.e. the poles of a power line between the beginning and the end. Do not just assume that there are some, or a known number of poles. By doing so, make sure that you do 3D mapping, not 2D-mapping, else you will ignore poles on line segments that have no edge / no bending just because of the 2D-projection: there might be an edge in the altitude contour of the line. If you forget that, you'll have line segments inside of mountains.
- Base your database on software that allows filtering, sorting and exporting the data according to user needs. Using MSWord is not a good tool for that. MSExcel can be a good and easy tool if you do not just use it as a word processor; if so, strictly use one line per point. Any database software can be suitable.
- Use a unique numbering for points and objects and keep track of the sequence of points in an object.
- If your data is part of somebody else's data, keep track of the ID's the other system uses to immediately identify duplicates.
- Publish your data so that it is known what you do. Third parties using your data will cause errors to be detected faster.

9. Obstacle database sources

The obstacle data available for FLARM is based on a variety of governmental and private data collections plus an extensive data processing performed by FLARM Technology. The processes employed to generate the database have not been certified in accordance with EUROCAE ED-76 / RTCA DO-200A ('Standards for Processing Aeronautical Data', September 28, 1998).

Using the data is at the pilot's own responsibility and risk. Neither FLARM Technology nor any data provider accept any responsibility for the accuracy, completeness or up-to-date status of the data or any direct or indirect damage resulting from using such data. Governmental data sources only collect data which have been reported by those who own, construct or operate constructions which represent an obstacle, and do not check these reports.

In many countries, there are obligations to report objects exceeding a certain height, but enforcing these obligations is difficult. Object data delivered to FLARM Technology for processing is often similar to those obstacles printed in official maps. As there are delays between the erection of an obstacle, its reporting, the data processing and publication, data can be old and wrong.

Data processing by FLARM Technology is done in MathWorks MatLab and includes the conversion of the many different raw source formats, dati and media into one standard with WGS84 latitude, longitude as well as altitude, i.e. is not based on MSL. In addition, altitude is - where missing - amended or - where present - checked with digital elevation models such as DHM25 for Switzerland and the SRTM 3" DEM provided by Consortium for Spatial Information (CGIAR-CSI). A series of conservative data enhancing and enhanced quality checking processes is done. Most source data require interpolation to avoid line objects running below the surface. Linear objects are checked against the segment lengths. All data deliveries are compared against prior deliveries and differences analyzed in detail. Note that single antennae outside of Switzerland and Austria are currently not part of the database.

Once a complete set of data is ready for compilation, a Java application organizes and compresses the data into a multidimensional binary tree optimized for real-time embedded system obstacle data retrieval from the memory and collision assessment, stored in a file format with OBS extention. This allows that independent of the amount of obstacles in the database, the retrieval of the data for those objects around the aircraft's current position is done in a predictable performance. The file contains a series of keys and checksums to ensure both the file's and data content's integrity.

The binary OBS format resulting from this compilation is then uploaded into a FLARM simulation environment and a typical flight test pattern virtually flown to verify the correct operations. In addition, a series of keys and data integrity checksums are verified, also in daily operations by each unit. Furthermore, the OBS file is decompiled and visualized in Google™Earth, where the obstacles and multidimensional binary tree borders are visually crosschecked. If all these checks are passed, the new file is published online.

The file-checksums are checked in the PC-based upload application prior to the upload. The data-checksums are checked by the Flarm-firmware after the upload but prior to upload-confirmation, and then at each boot-process.

The following sources have been used, some periodically, others on an ad-hoc update frequency:

- UHV / Federal Office of Civil Aviation (Switzerland, Jun 02, 2008), copyright by Swiss Confederation
- Austrocontrol (Austria, Jul 06, 2007)
- Land Tirol (Austria, Feb 2005)
- Land Vorarlberg (Austria, Mar 03, 2008)
- Deutsche Flugsicherung / Amt für Flugsicherung der Bundeswehr (Germany, Jan 2007)
- 3rd party private data collection (French Alps, ongoing)
- Service de l'Information Aéronautique de la Direction des Services de la Navigation Aérienne de la Direction Générale de l'Aviation Civile (France, Jul 2007)
- Archivio Numerico Ostacoli al Volo / Centro Informazioni Geotopografiche Aeronautiche (Italian Alps north of 45°30'N or west of 008°00'E, May 29, 2008)
- Slovenia Control, Slovenian Air Navigation Services, Limited (Slowenia, Jul 2005)