eTOD: State of Affairs

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Overview

- Content

  – The need for eTOD

  – Regulatory situation

  – Technical situation

  – Conclusions

The need for eTOD

- eTOD data are needed for a number of applications:

  - procedure design (including Engine Out Standard Instrument Departure (EOSID) design)

  - Terrain Avoidance and Warning Systems (TAWS), for Helicopters (HTAWS)

  - takeoff performance analysis

  - Vertical Situation Displays (VSD)

  - Synthetic Vision Systems (SVS)

  - en-route mapping

  - finding landing zones, e.g. Helicopter Emergency Medical Services (HEMS)

  - descent profile analyses, e.g. to determine emergency oxygen requirements

  - radio wave propagation analyses (radar, VHF, etc.)

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Regulatory situation: history

- ICAO decided to go digital with obstacle and terrain information at a Divisional Meeting in 1998.

- RTCA and EUROCAE developed User Requirements for Terrain and Obstacle Data (DO-276A and ED-98A) in 2002.

- In 2004, Amendment 33 to ICAO Annex 15 incorporated those eTOD requirements.

- Amendment 36 to Annex 15, released in 2010, foresaw major revisions to the eTOD requirements to reduce implementation costs.

- In 2013, Amendment 37 to Annex 15 contained minor eTOD changes and added AMDB (Aerodrome Mapping Database) requirements.

- The Final Report of the ICAO EANPG/58 (28 November to 01 December 2016), Appendix V – Deficiencies related to eTOD Area 1 and Area 4 in the list of AN Deficiencies, listed the countries not providing electronic terrain and obstacle data for Area 1 and not providing obstacle data for Area 4 as having Air Navigation Deficiencies.

Technical situation: AIXM

- Eurocontrol and the FAA have jointly developed the Aeronautical Information Exchange Model (AIXM) to exchange eTOD obstacle data and other aeronautical information.

- AIXM version 1.1 was released in 1998.

- AIXM version 5.1 has been available since February 2010. It contained updates to inter alia facilitate the encoding of Digital NOTAMs.

- AIXM version 5.1.1 was released in May 2015.

- Since 2012 a Change Control Board with international participation has governed the development of AIXM.

Technical situation: airborne applications

- Most airborne systems (e.g. Terrain Avoidance and Warning Systems (TAWS), Vertical Situation Displays (VSD), Synthetic Vision Systems (SVS), and en-route mapping) will not utilize AIXM to store and process eTOD obstacle data.

- To enable the use of eTOD data in airborne systems, ARINC is developing a new set of technical specifications:

    – Terrain Database: ARINC Project Paper 813 will define encoding formats for terrain databases that can be loaded directly into airborne systems.
    Note: Today the primary terrain data sources for these systems are enriched SRTM (Shuttle Radar Topography Mission)datasets that were acquired by the Space Shuttle mission STS-99 in February 2000.

    – Obstacle Database: ARINC Project Paper 815

    – XML Encoding and Compression: ARINC Specification 814

    – All these specifications are not mature and only available as drafts.

- First plans exist to use AIXM data in EFBs to optimize takeoff and landing performance.

http://www.aviation-ia.com/aeec/projects/adb/

Sferion Synthetic Vision & Obstacle Warning

WorldDEM as foundation layer

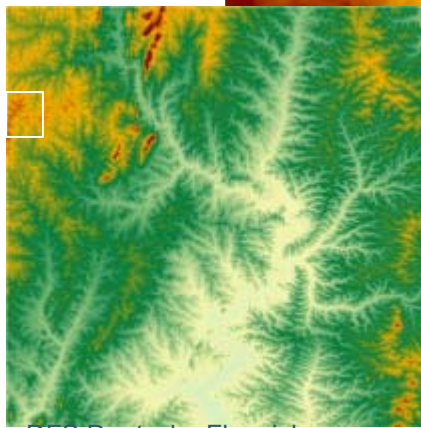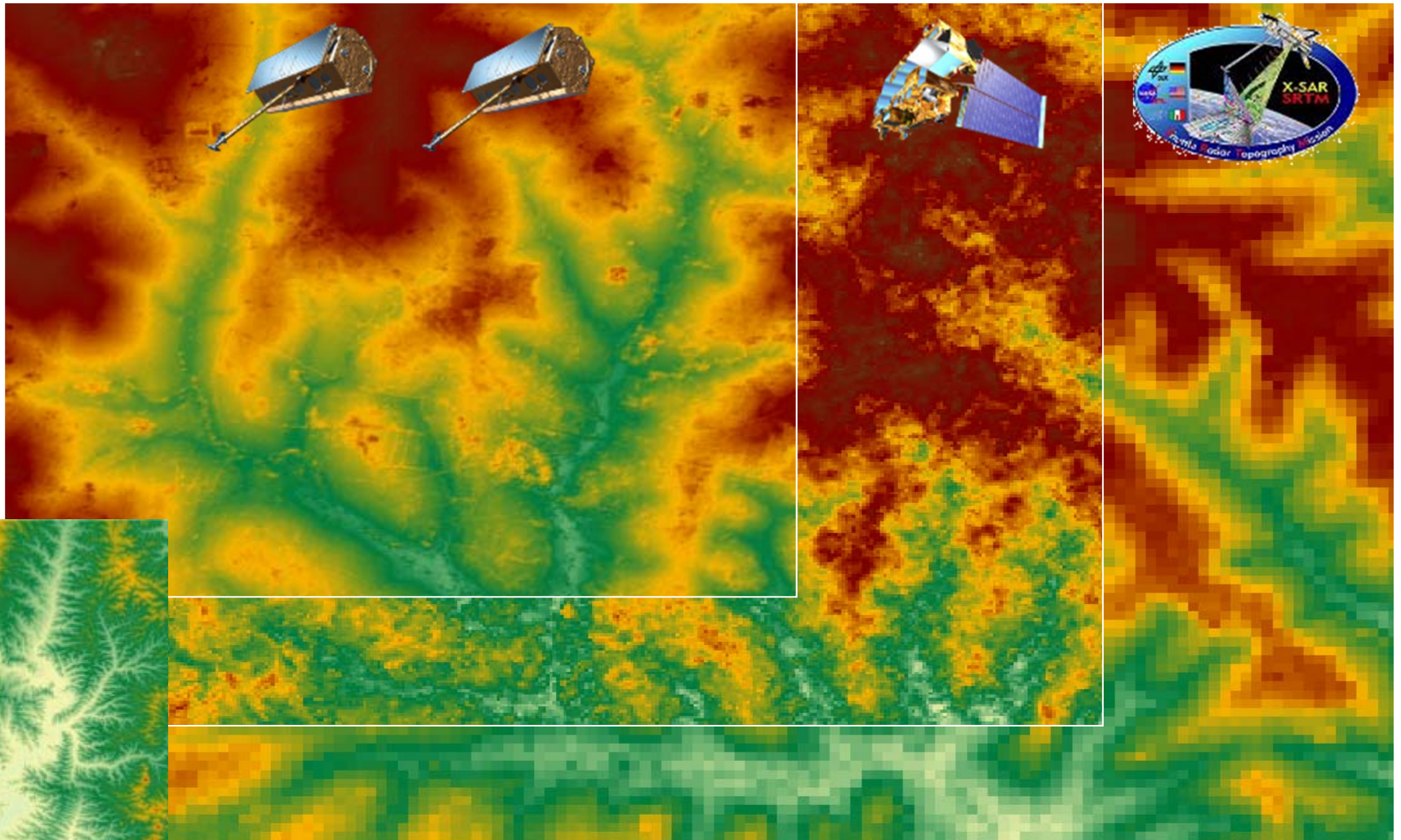# Example: SVS based on WorldDEM for bad weather conditions

Merge of database with sensor data for combined synthetic view

SFERION Avionic with WorldDEM
30.06.2015 - 02.07.2015, Helicopter Days Bückeburg

Satellite DEM: Ivory Coast, Bouaké Region

WorldDEM(0.4"≈12m)   ASTER(1"≈30m) SRTM90(3"≈90m)
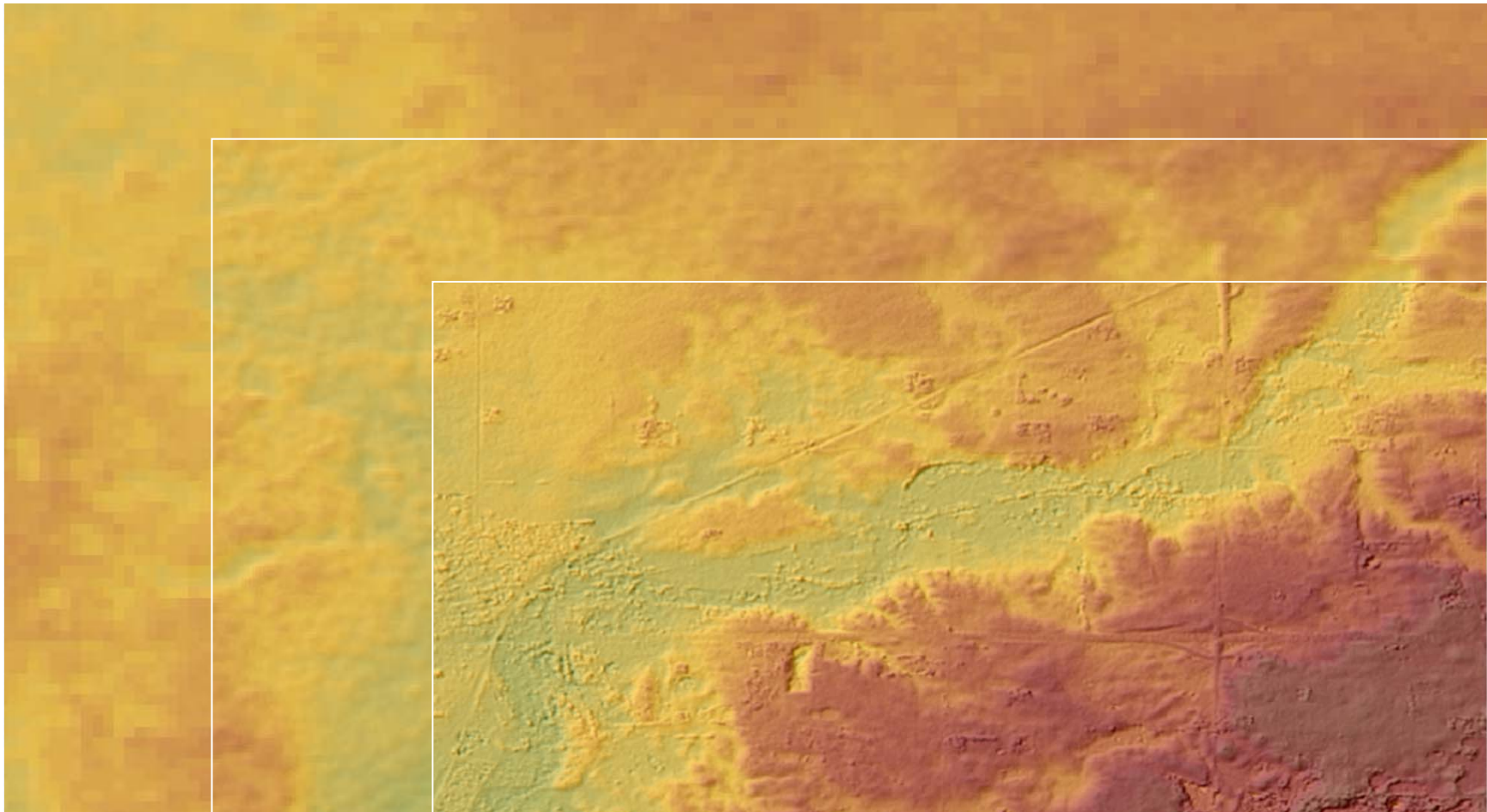
Terrain comparison
WorldDEM - level of detail

Minnesota
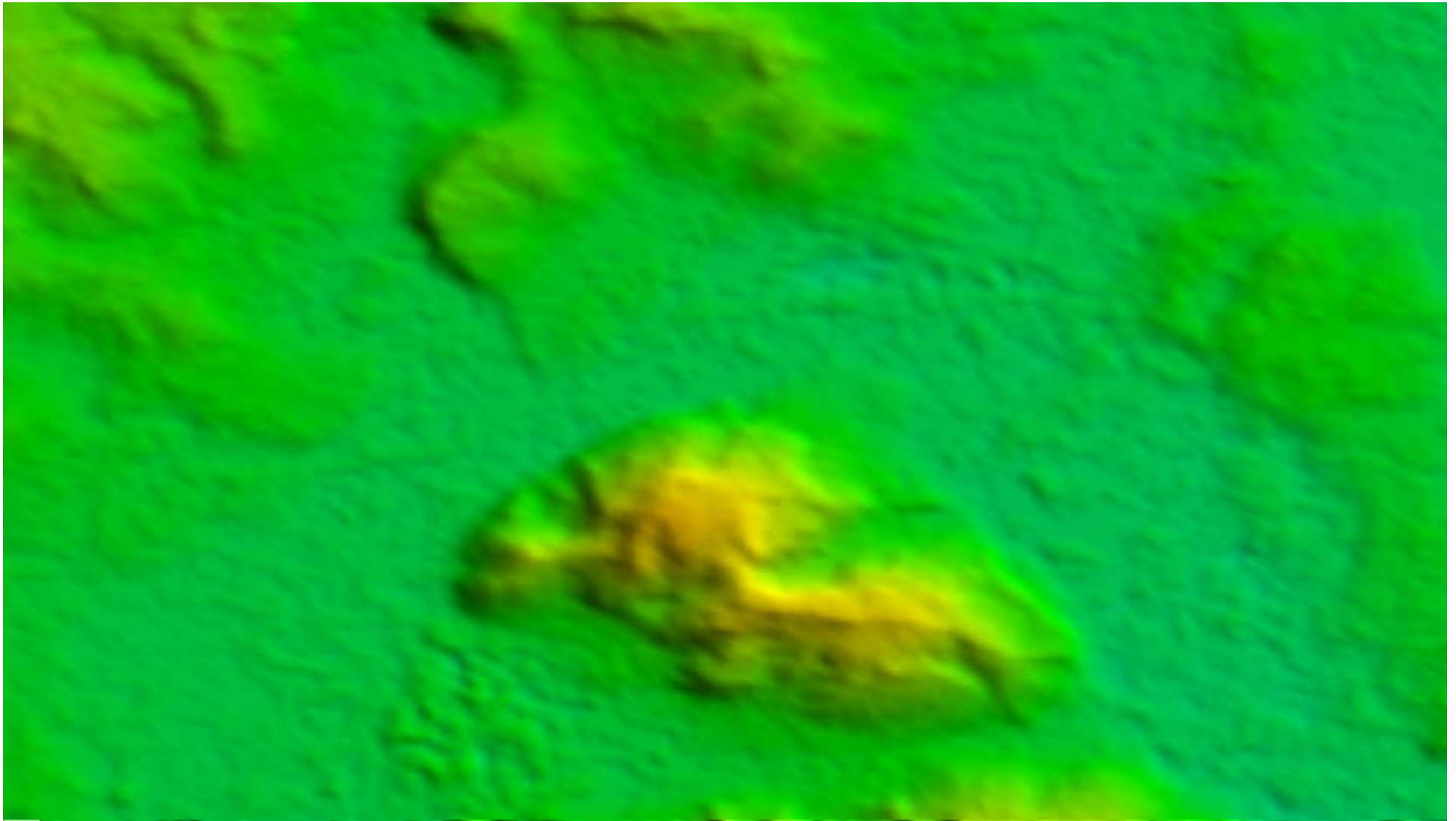**N47W097**

SRTM90   SRTM30   WorldDEM

Terrain comparison

Oxford, United Kingdom

WorldDEM ICAO Annex 15 Chapter 10 compliance with numerical requirements

- Using commercially available datasets to comply with some eTOD requirements is a possibility:

Attributes	Area 1 - The State	WorldDEM Compliance	Area 2 - Terminal	WorldDEM Compliance
Terrain Database Post Spacing	3 arc seconds	y	1 arc second	y
Vertical Accuracy	30 m	y	3 m	partially (for ~90% of airports worldwide)
Vertical Resolution	1 m	y	0.1 m	y
Horizontal Accuracy	50 m	y	5 m	y
Confidence Level	0.9	y	0.9	y
Data Classification Integrity Level	Routine (1×10^{-3})	y	Essential (1×10^{-5})	y
Maintenance Period	As required	regional update**	As required	regional update**
Coverage	State (global)	y	45 km	y

Attributes	Area 3 - Aerodrome	WorldDEM Compliance	Area 4 - CAT II/III	WorldDEM Compliance
Terrain Database Post Spacing	0.6 arc seconds	y	0.3 arc seconds	n
Vertical Accuracy	0.5 m	n	1 m	n
Vertical Resolution	0.01 m	n	0.1 m	n
Horizontal Accuracy	0.5 m	n	2.5 m	n
Confidence Level	0.9	*	0.9	*
Data Classification Integrity Level	Essential (1×10^{-5})	*	Essential (1×10^{-5})	*
Maintenance Period	As required	regional update**	As required	regional update**
Coverage	Aerodrome	y	CAT II/III	y

Helicopter operational improvements by database improvements

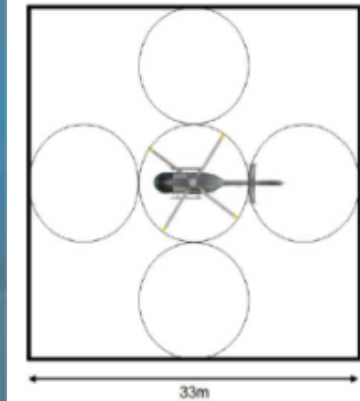|	Current terrain and obstacles numerical data requirements	Proposed terrain and obstacles numerical data requirements	Factor of Improvement / Consequence
Post spacing **Terrain horizontal acc.** **Terrain vertical acc.** **Obstacle horizontal acc.** **Obstacle vertical acc.**	DTED1 – 90m +/- 50m +/- 30m +/- 50m +/- 30m	DTED2 – 30m +/- 5m +/- 3m +/- 16m +/- 7m	Factor 6 Factor 100 Factor 10 Factor 9 Factor 4.3
Minimum off-airport landing area size to consider for landing safely an EC145-T2 H/C, HEMS operations from database information	135m x 135m	67m x 67m	Factor 4 / Ease of landing area detection or selection
NAVD page obstacle display, minimum range selected: 0.5NM	Uncertainty area around obstacle position is a small circle	Uncertainty area is reduced to a point, so already optimal	Factor 9 / Accuracy in line with display capability
DMAP page obstacle display, minimum range selected: 0.1NM	Uncertainty area around obstacle position is a medium circle	Uncertainty area around obstacle position is a small circle	Factor 9 / Accuracy in line with display capability
SVS – case 1 **(terrain at 5NM)**	Dx +/- 1° Dy +/- 0,35° Errors part 13%	Dx +/- 0,89° Dy +/- 0,31° Errors part 1,5%	Factor 1,1 Factor 10
SVS – case 2 **(terrain at 800m)**	Dx +/- 2,54° Dy +/- 1,16° Errors part 55%	Dx +/- 1,28° Dy +/- 0,64° Errors part 10%	Factor 2 Factor 5,5
SVS – case 3 **(terrain at 300m)**	Dx +/- 5,3° Dy +/- 2,36° Errors part 69%	Dx +/- 2° Dy +/- 1° Errors part 19%	Factor 2,6 Factor 3,5
HTAWS forward timing	Warning timing reduced by 10% (1s)	Warning timing reduced by 3% (300ms)	Factor 3 / Less impact on Warning timing => safer
HTAWS vertical buffer increased by accuracy (worst case)	248ft	173ft	Factor 1.4 / False alerts nuisances reduction
HTAWS vertical buffer reduced by accuracy (worst case)	5s of descent flight (52ft)	13s of descent flight (127ft)	Factor 2.5 / Passing from "unsafe" to "situation in line with regulations"

Rationale: landing zones

Figure 13: HEMS operational minimum landing area for an EC145

Helicopter emergency medical services (HEMS) operations

Terrain and obstacles:
- eTOD Area 1 accuracy requirement: 50m
- Desired accuracy: 16m

- The landing area to be searched for, which also has to be free of obstacles, is reduced by factor 4.

→ reduction of pilot workload
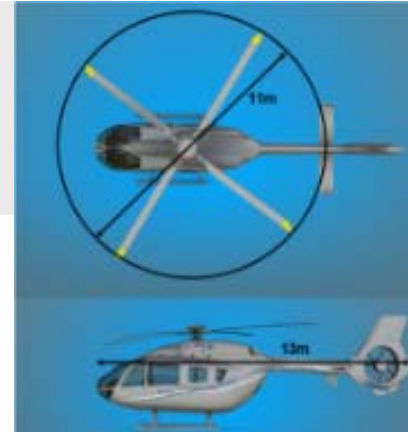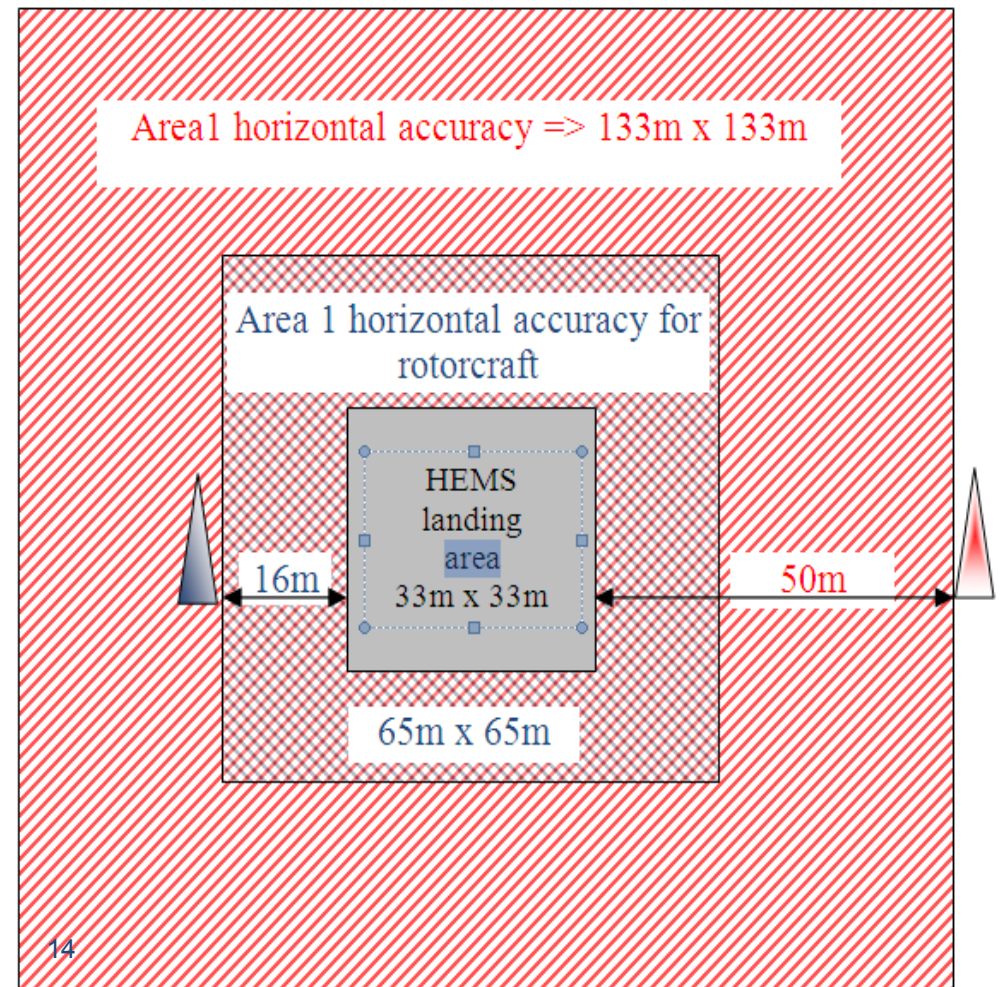→ increased situational awareness

Area1 horizontal accuracy => 133m x 133m

Area 1 horizontal accuracy for rotorcraft

HEMS landing area 33m x 33m

16m

50m

65m x 65m

Rationale: HTAWS (Helicopter Terrain Awareness and Warning System) accuracy

- HTAWS generates proximity alerts for terrain and obstacles.

- Due to its higher resolution and accuracy, WorldDEM allows more accurate collision warnings to be triggered.

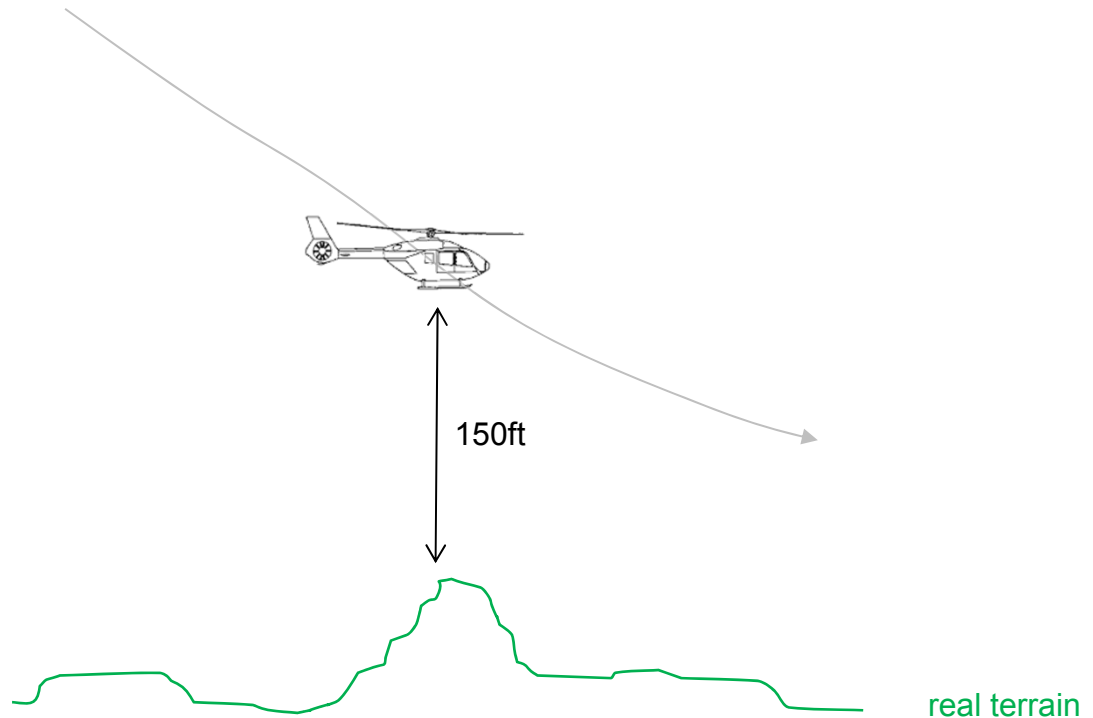- Redundant system (with on-board sensors)
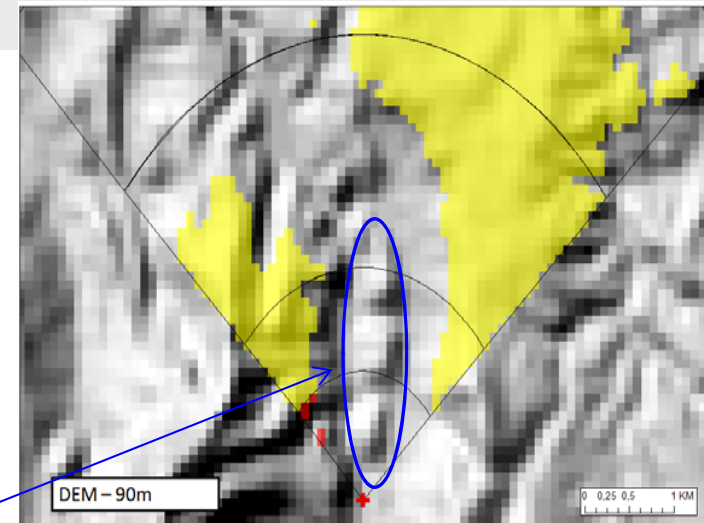
HTAWS based on SRTM90 versus WorldDEM12
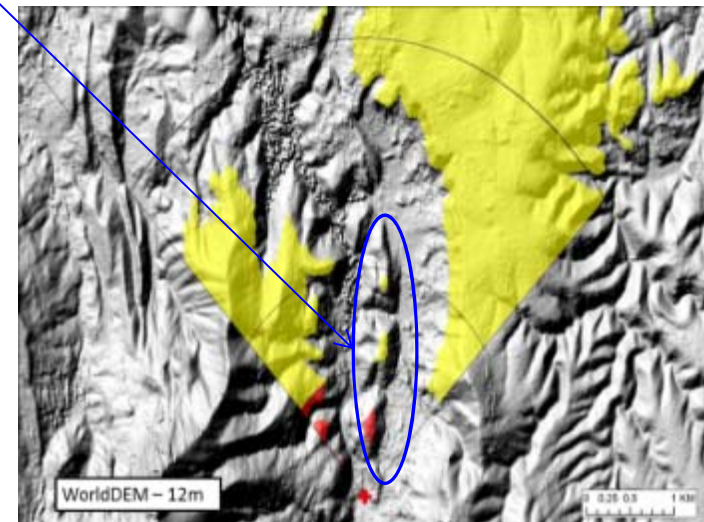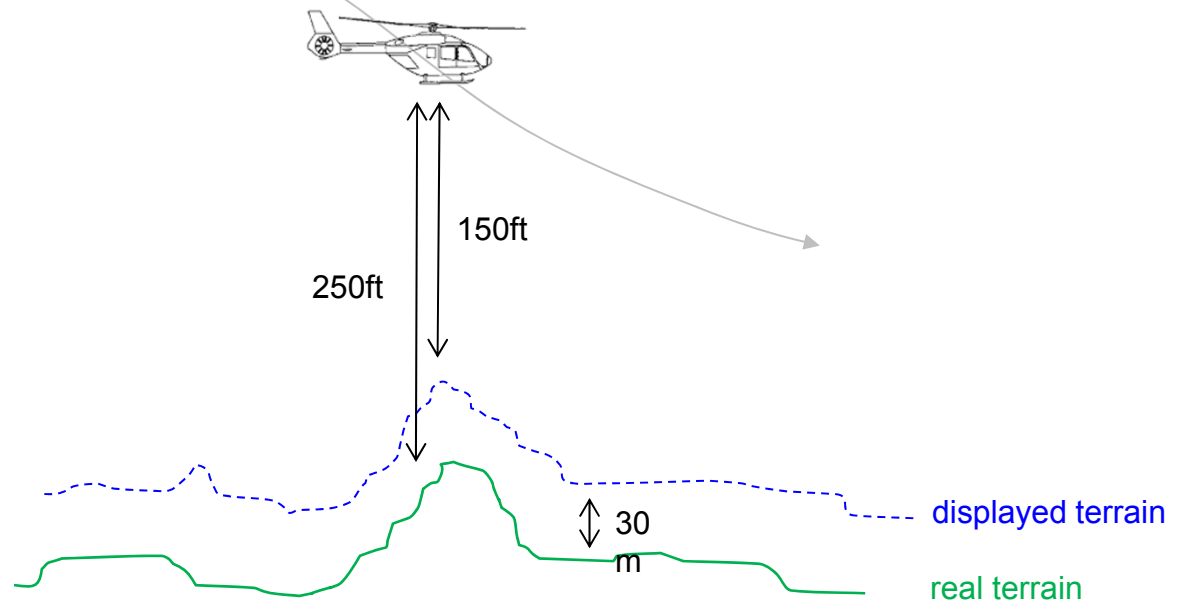
Rationale: HTAWS accuracy

Scenario

- Descent flight with 600ft/min
- HTAWS vertical buffer: 150ft
- Accuracy 100ft (>30m) actually

150ft

real terrain

Rationale: HTAWS accuracy

Scenario

- Descent flight with 600ft/min
- HTAWS vertical buffer: 150ft
- Accuracy 100ft (>30m) actually

- Case 1: distance to terrain 250ft → false alarm

150ft

250ft

30 m

displayed terrain
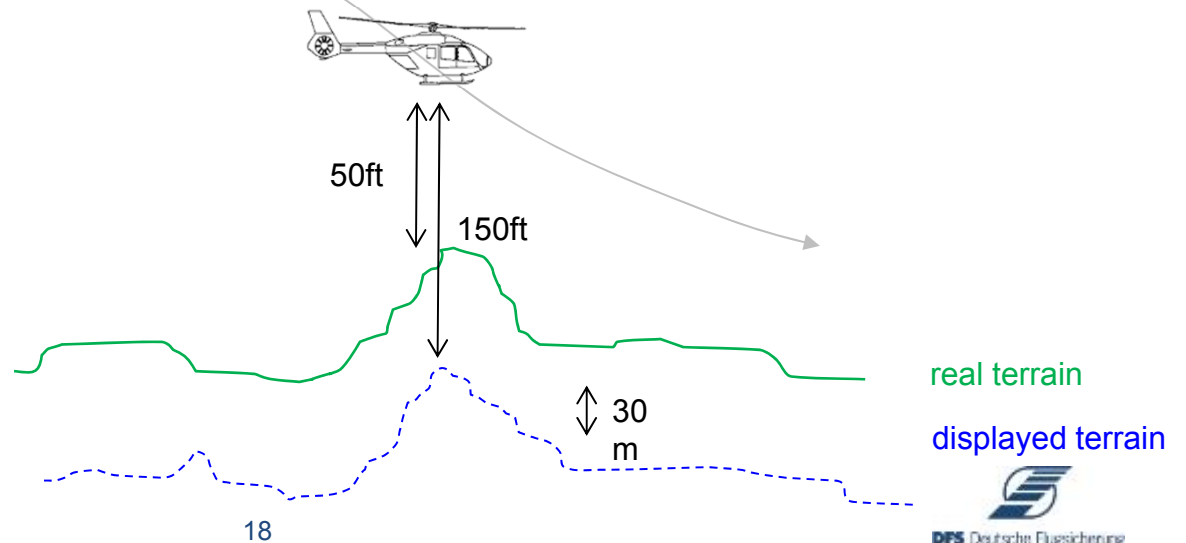
real terrain

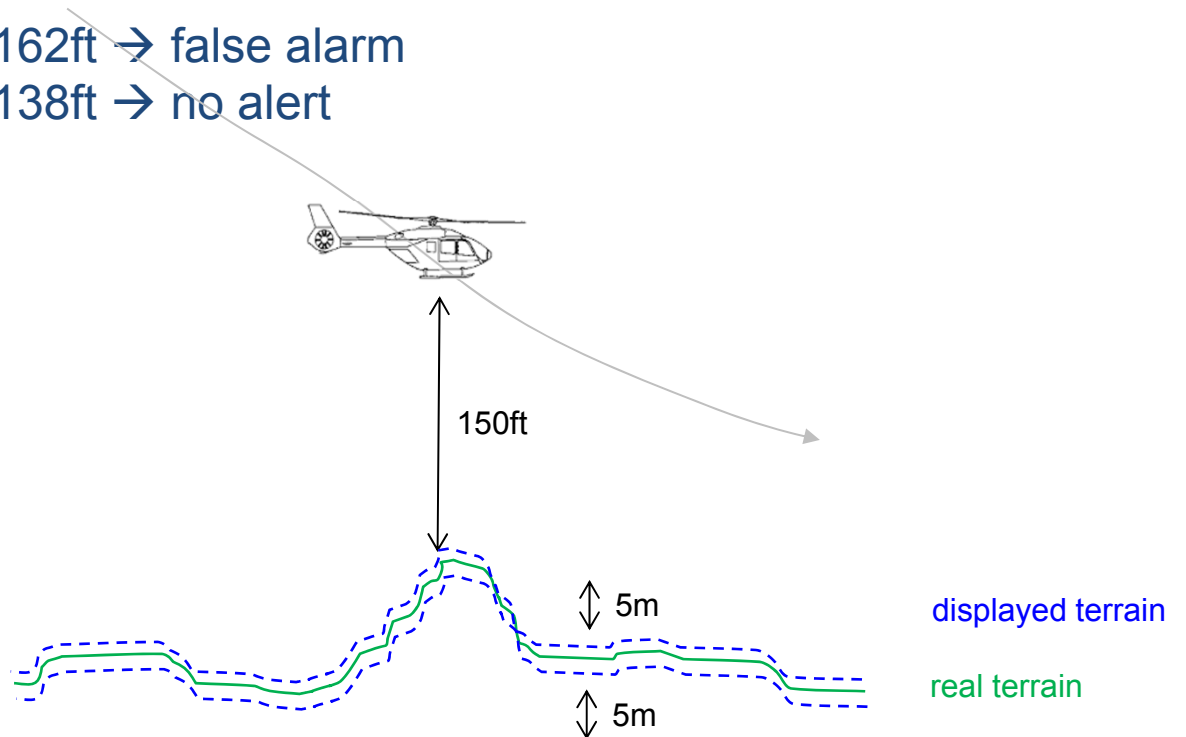# Rationale: HTAWS accuracy

Scenario

- Descent flight with 600ft/min
- HTAWS vertical buffer: 150ft
- Accuracy 100ft (>30m) actually

- Case 1: distance to terrain 250ft → false alarm
- Case 2: distance to terrain 50ft → no alert

50ft

150ft

30 m

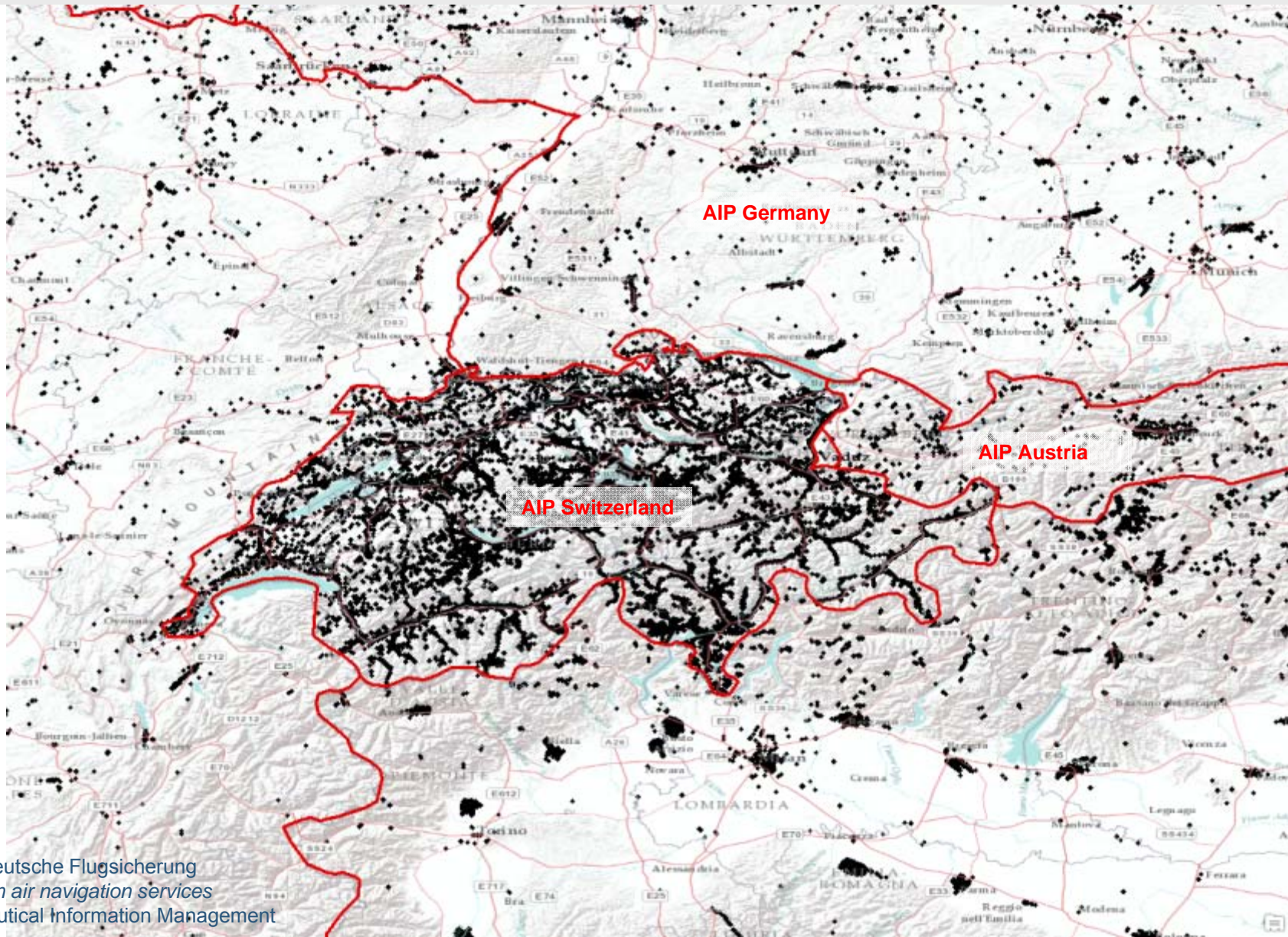real terrain

displayed terrain

Rationale: HTAWS accuracy

Scenario

- Descent flight with 600ft/min
- HTAWS vertical buffer: 150ft
- 12ft (4m) with WorldDEM

- Case 1: distance to terrain 162ft → false alarm
- Case 2: distance to terrain 138ft → no alert

150ft

5m

5m

displayed terrain

real terrain

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3D obstacle AIP data

AIP Germany

AIP Austria

AIP Switzerland

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German air navigation services
Aeronautical Information Management

Technical issues: procedure design / airline systems

- The sheer amount of eTOD obstacle data overwhelms current ANSP and airline procedure design systems (LTBA, Istanbul Atatürk Airport is shown here).

- Coding inconsistencies between different eTOD implementations exist.

- Business rules, coding guidelines, reference implementations, and verification tests are required.

Technical issues: AIXM I

- Despite its long development history (ongoing since 1998), a number of issues prevent the effective exchange of AIXM data:

  – Mapping rules to convert AIXM to the ARINC obstacle data formats do not exist. Therefore, it is difficult to make AIXM data available for airborne applications.

  – The AIXM standard is too permissive; there is practically no interoperability so that data exchanges are only possible after major bilateral coordination between the exchanging parties.

  – The underlying business rules are neither finalized nor mandatory.

  – Incremental updates of AIXM datasets are currently not supported, in particular due to the lack of harmonized UUIDs (Universally Unique Identifiers) throughout the data chain. Due to this shortcoming, additional effort to track changed information in new datasets is required.

Technical issues: AIXM II

– No reference implementations and certification tests for AIXM implementations by different vendors exist that would ensure the required level of interoperability across the industry.

– The development of coding guidelines has only begun. Additional resources are required.

– As the Digital NOTAM concept is not fully mature and harmonized UUIDs are a pre-requisite to its implementation, the use-case obstacle NOTAM cannot be implemented at this time.

– The Digital NOTAM Event Specification required for the implementation of Digital NOTAM is neither complete nor mature.

– Due to the verbosity of AIXM datasets, AIXM files are very large (about 500 MB for Frankfurt Airport). This paired with the current inability to provide incremental updates can lead to problems when uncompressed AIXM files have to be transmitted over narrow-band connections.

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Technical issues: terrain data

- At present SRTM/ASTER terrain data are predominantly used in avionics

- SRTM/ASTER data:

  - are available free of charge

  - are often outdated

  - have a low resolution and a high error potential

- Higher resolution data cannot yet be processed by most avionics systems

- Problems with State-provided terrain data:

  - lack of harmonization between national datasets (lack of homogeneity)

  - quilting of data at borders

  - different data formats

The aeronautical data chain is outdated and broken

Conclusions

- eTOD is still immature and not all operational requirements are met by today's regulatory requirements.

- A major issue are the disparate, uncoordinated development efforts by different stakeholder groups.

- Another major issue is the inability to exchange data between stakeholders. This is caused by excessively permissive specifications and the lack of congruence and coherence between standardization activities.

- Other industries have solved these coordination, standardization, and data exchange issues a long time ago.

- The aviation industry needs to fix eTOD and to improve the underlying structures, i.e. harmonization, standardization, and certification.

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Performance

Safety

Customer orientation

Core business

Adaptability

Internationalisation

Environment

Technology

Employee focus

Thank you for your attention!

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