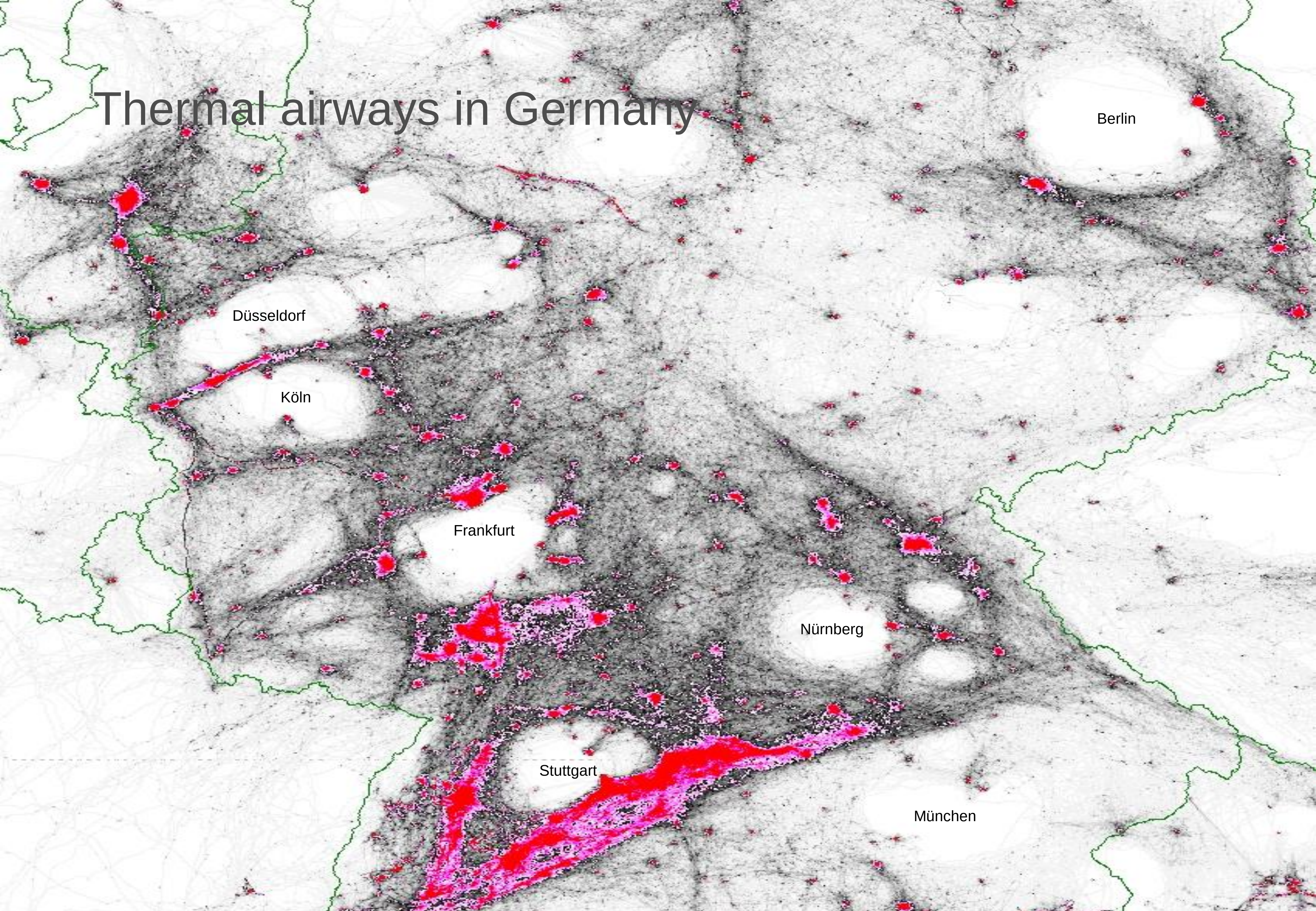
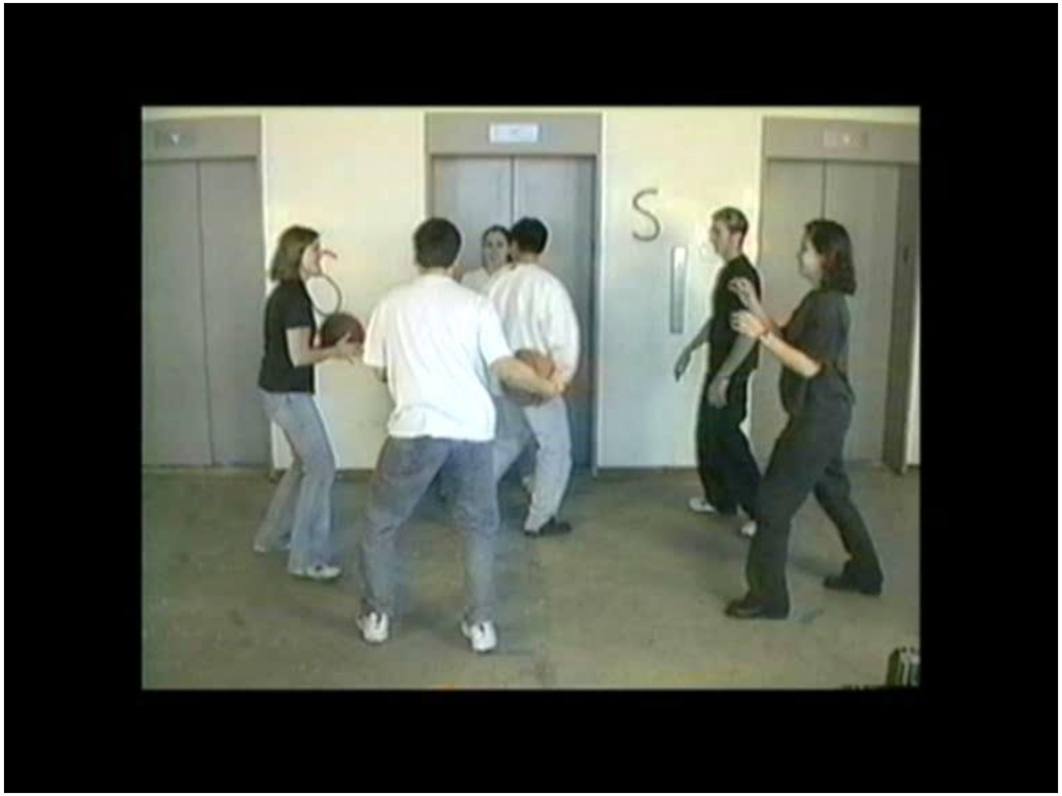
FLARM and PowerFLARM: Past, Present and Future

FLARM Technology GmbH, Baar

Thermal airways in Germany

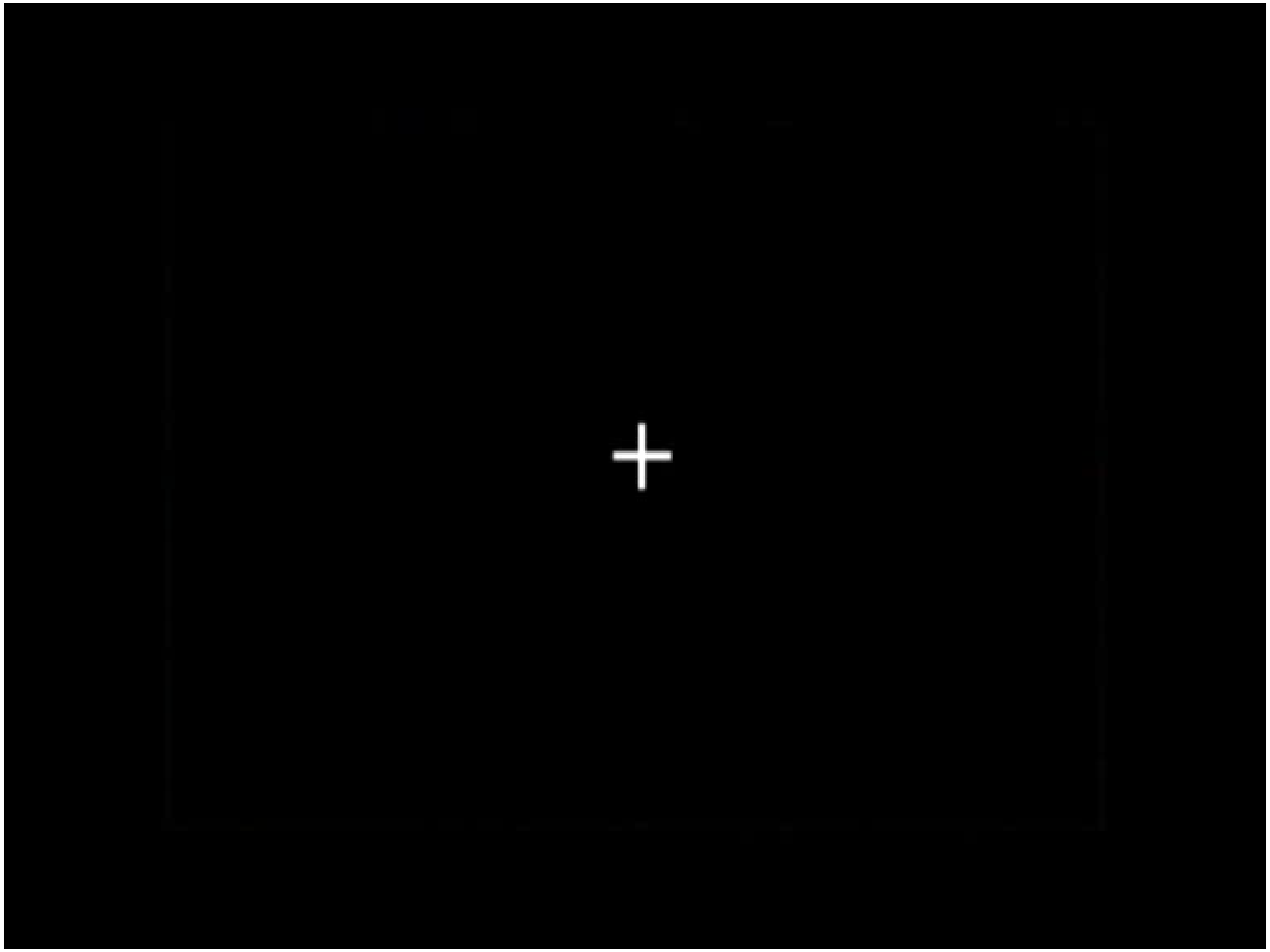


What we see (1)



http://www.youtube.com/watch?v=vJG698U2Mvo

What we see (2)



Where’s the danger?

‘… the physical limitations of the human eye are such that even the most careful search does not guarantee that traffic will be sighted.’

Australian Transport Safety Bureau

The problem it solves

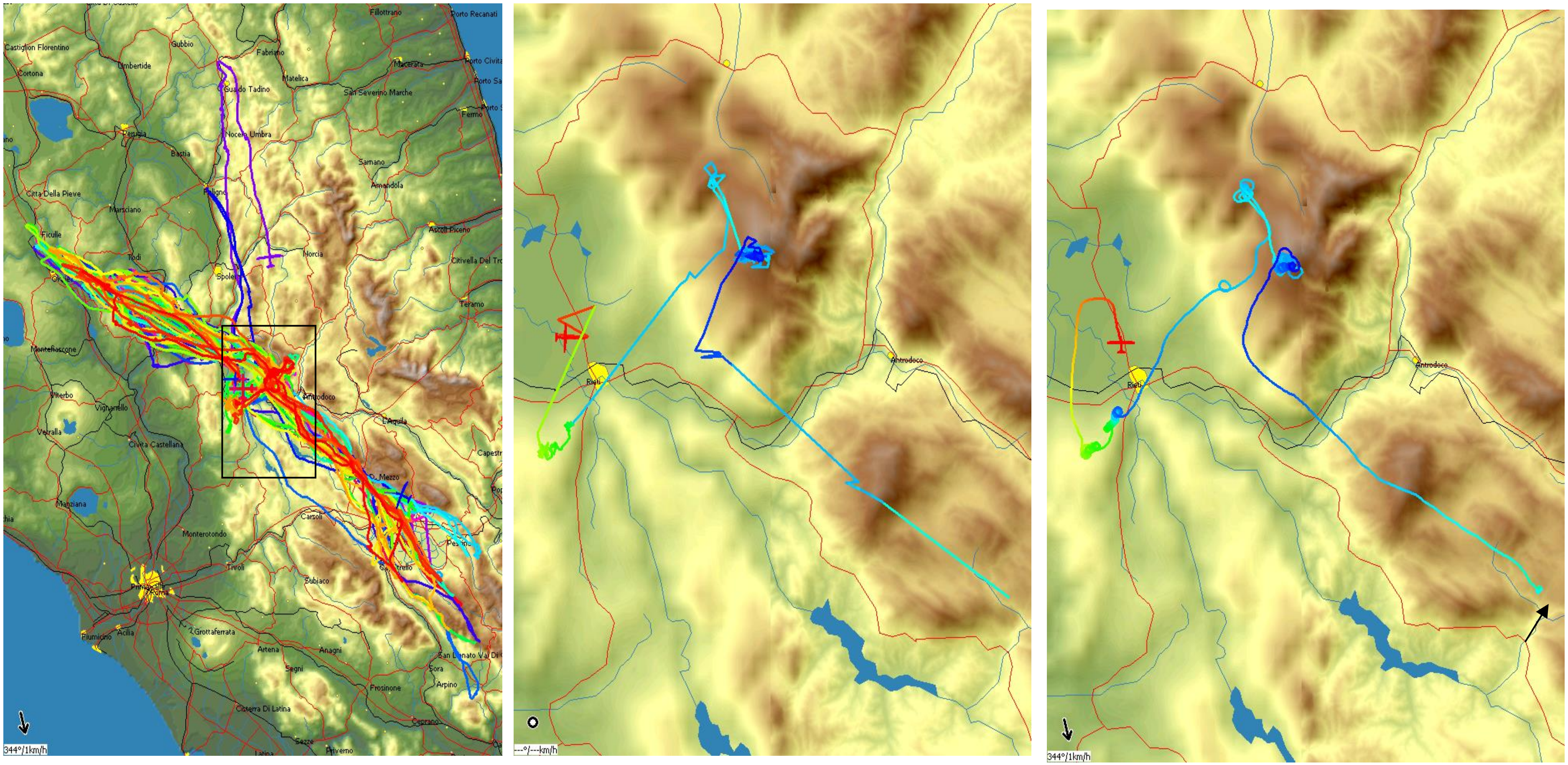
- Zell am See (AT), Aug 28, 2011: **A Cessna C150 and a Super Dimona collide, four fatalities**.
- Donzdorf (DE), Sep 6, 2011: **A paraglider and a glider collide,** no fatalities.
- Mount Swansea (CA), Sep 3, 2011: **Two gliders sharing a thermal collide, two fatalities**.
- Frankfurt (DE), Dec 8, 2012: **A Regent and a Saratoga collide, eight fatalities.**
- Kaiserslautern (DE), Mar 4, 2013: **Airprox between EMB-505 and C177,** no fatalities. Embraer TCAS failed to alert, PowerFLARM alerted the Cessna pilot.
- Kempten (DE), May 15, 2013: **A Cessna and a Katana collide, two fatalities.**
- Birrfeld (CH), June 6, 2013: **A glider and a Mooney collide,** no fatalities. Mooney was not FLARM equipped.

Since the introduction of FLARM in 2004, there have been only an handful of mid-airs where both aircraft have a FLARM installed. In most of these cases, the accident investigation revealed that one device was **not switched on**, had **no antenna** installed or didn't work for other reasons (E.g., Stemme vs. ASH25 near Samedan, April 2007).

FLARM, if professionally installed and serviced, virtually eliminates the risk of mid-air collisions.

flarm

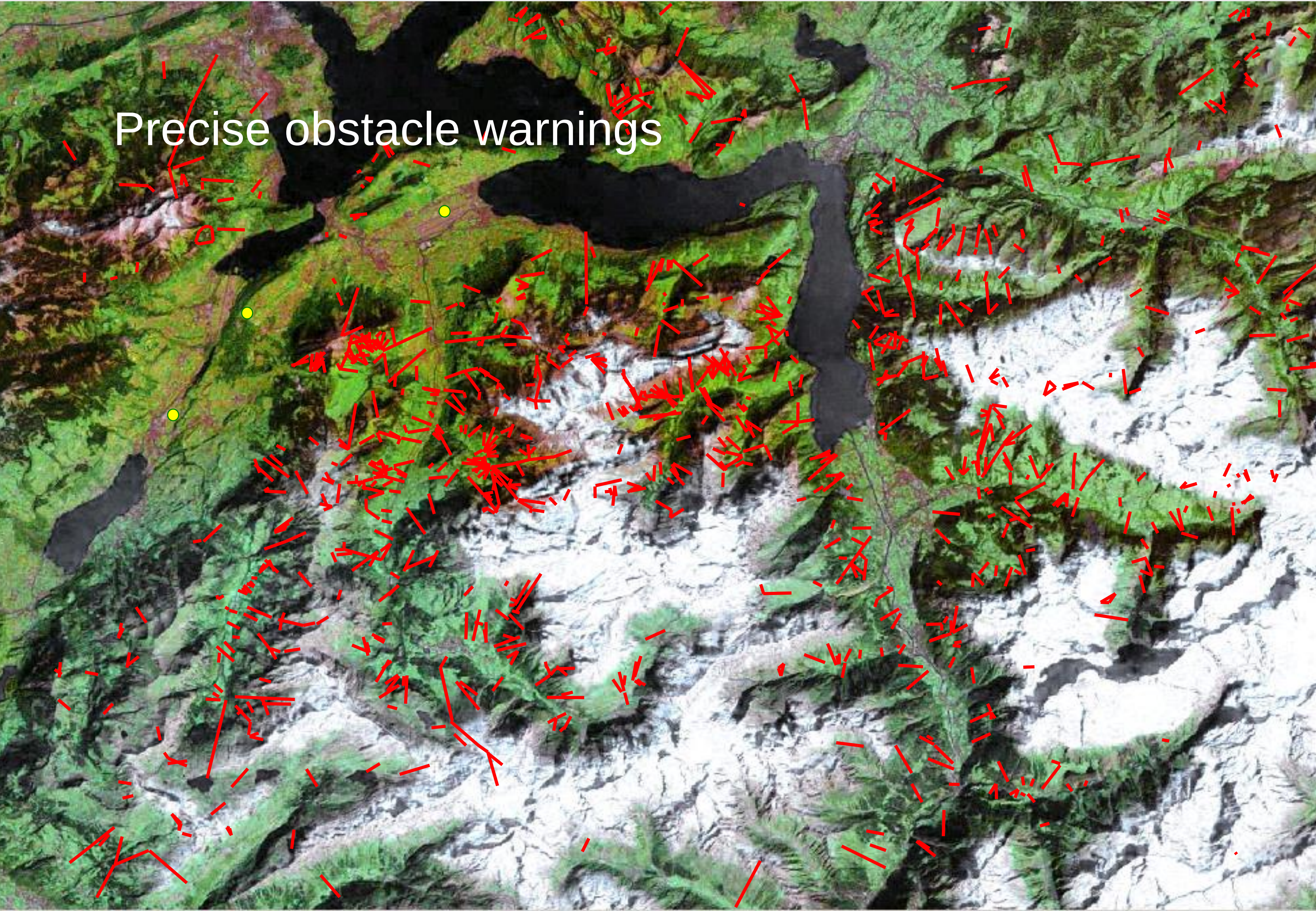
Additional benefit: Search and Rescue



all 50 traces

synthetic reconstruction

wreckage data

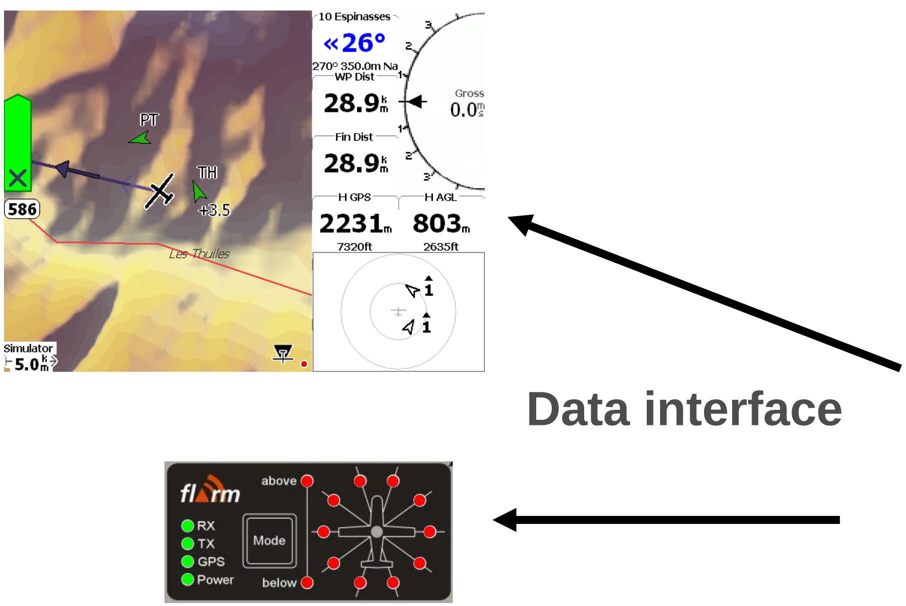

Precise obstacle warnings

How it started: EASA DOA-POA-MOA, 2004

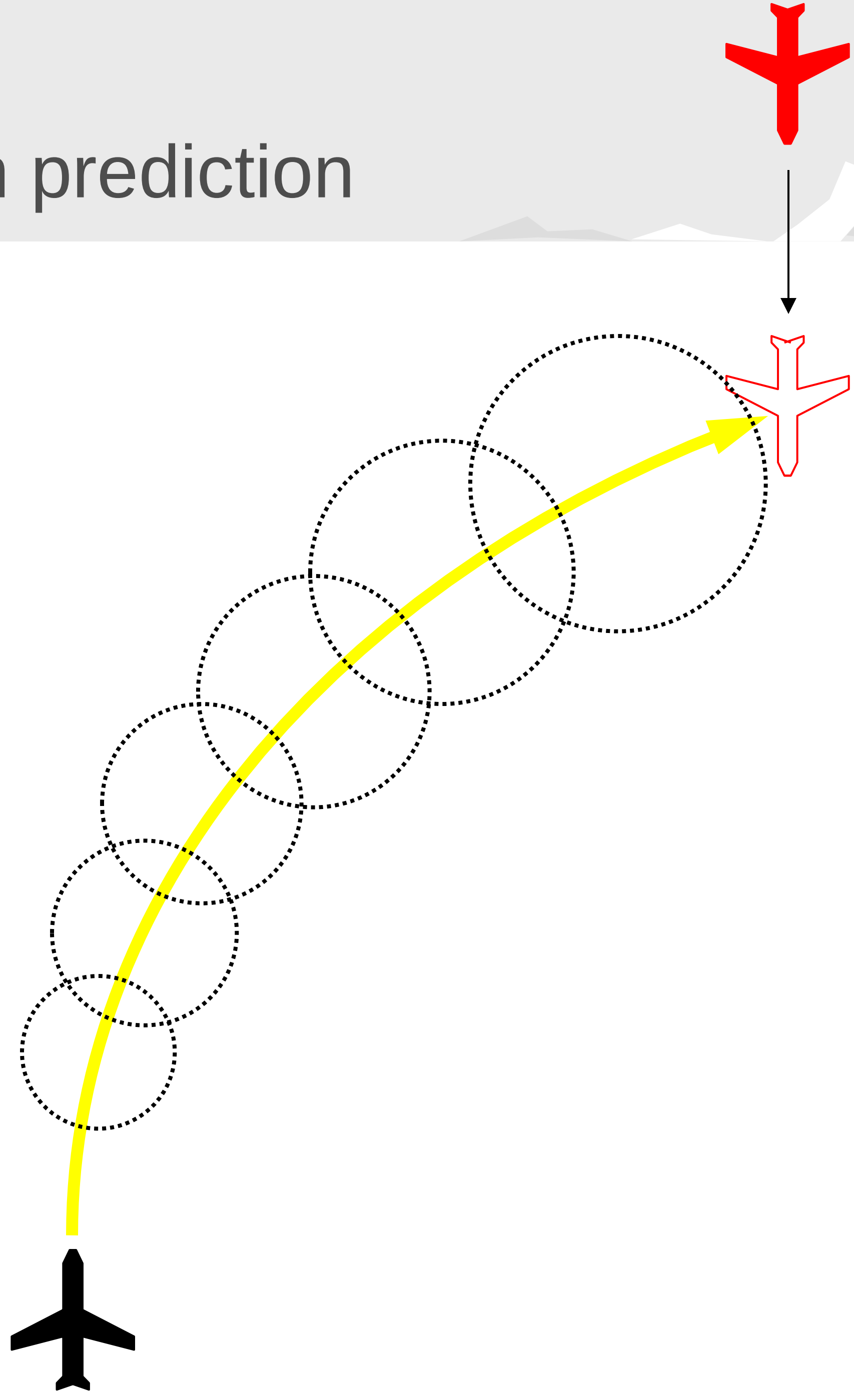
How it works

Ingredients
- Short range broadcasting
- CPU (8bit RISC), forced S/W update
- Memory (2 MBytes)
- User interface
- Data interface based on standard protocols

Service
- Traffic monitoring and alarms (ADS-B)
- Obstacle alarms
- Flight logger
- Other in-flight gadgets
- Ground based services



Motion prediction



Acft / acft

- adaptive 3d flight path prediction with calculated accelerations in all dimensions
- turn rate derived from current and filtered past GPS ground track, indication is relative to this
- climb/descent rate assumed constant
- adaptive vertical, horizontal and time safety margin
- typically <5m horizontal data error (GPS / DGPS, no SBAS)
- typically <12m vertical data error (GPS / DGPS, baro adjusted, no SBAS)
- warnings at 18 / 12 / 8s prior to impact
- absolute distance minima in addition to time to impact

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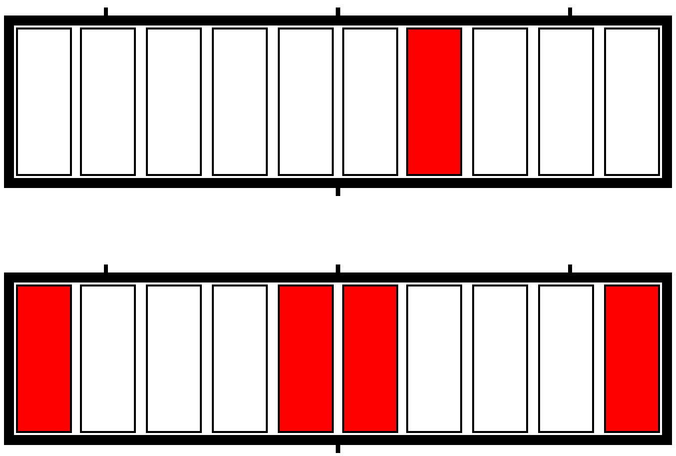
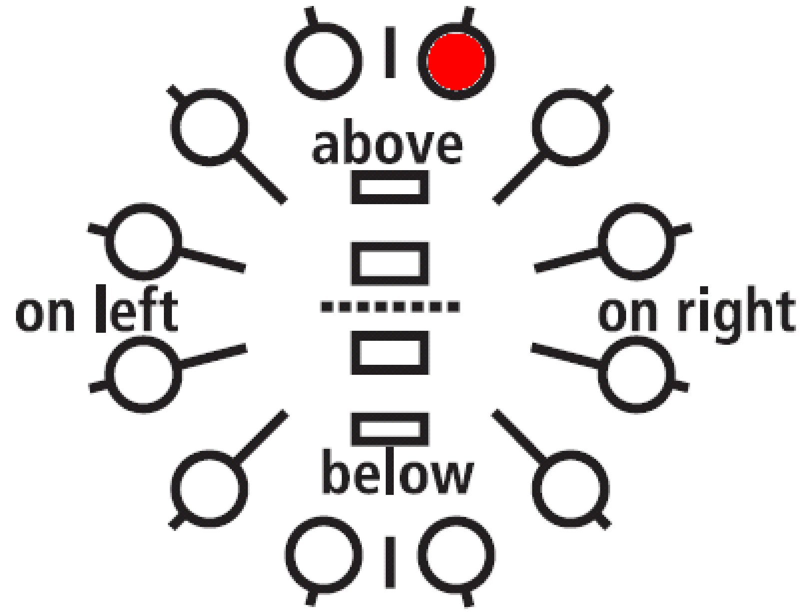
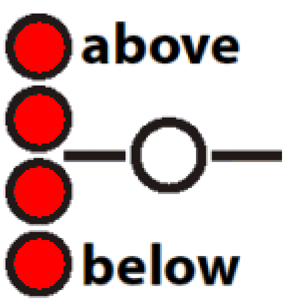
User interface options





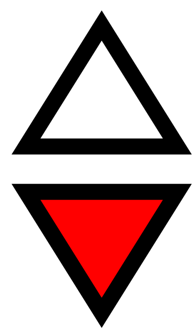


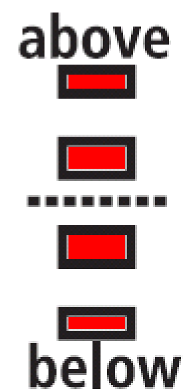
ambrüf

nitschi

up

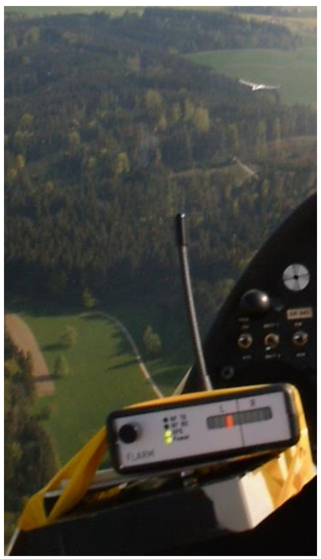
down





How it continued: Design iterations

Prototype: 2003



Prototype: 2004

• Y-Lynx RF

First generation
2004/2005

• Nordic RF
• wide VDC

Second generation
2005/2006

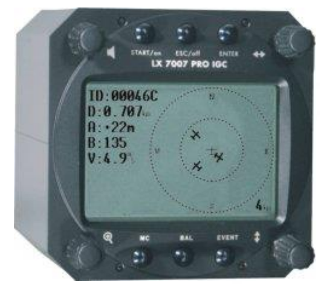
• Baro
• Vertical indication
• Clock
• New CPU
• Second RS232 output
• Polycarbonate housing

Third Generation
2006/2007

• Compass rose
• Bicolor LEDs
• SD card
• ESD protection

Compatible devices

- RF Development (Australia)
- LX Navigation (Slovenia)
- Garrecht Avionik (Germany)
- Triadis (Switzerland)
- Artronic (Switzerland)
- Butterfly Avionics (Germany)
- Flytec (Switzerland)
- Ediatec (Switzerland)
- …



FlyTec

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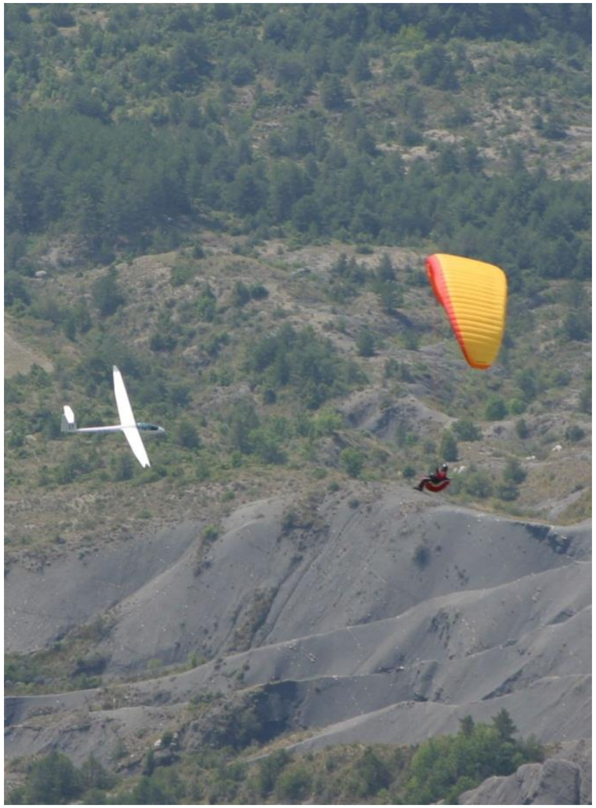
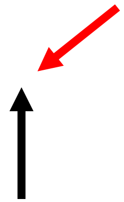
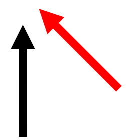
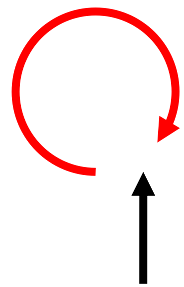
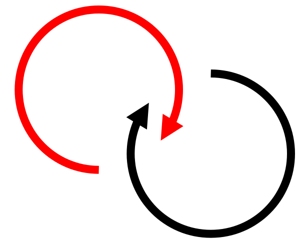
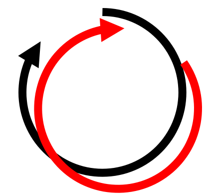
Compatible FLARM modules for paragliders

- “Passive” FLARM.
- Sends out position on FLARM RF frequency.
- Warns the glider/power plane pilot.
- Does not warn the paraglider/delta pilot.

- Small, cost-effective and low-power:



How it performs

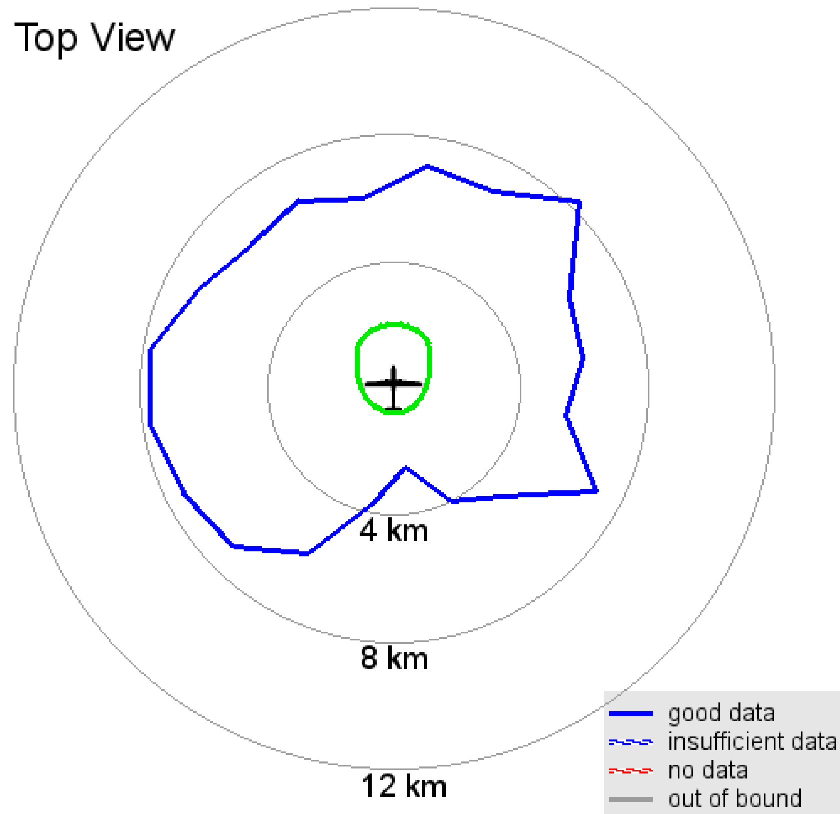
					
Situation	Head-on	Converging	Head-on, circling	Circling, opposite direction	Circling, same direction
Human	+	-	+ --	-	+
FLARM	++	++	++ +	++	-

Radio performance

FLARM / POWERflarm Radio Range Analysis

The green area is the minimum recommended range for speeds up to 200km/h
The blue area is the average receive range of the submitted flightdata

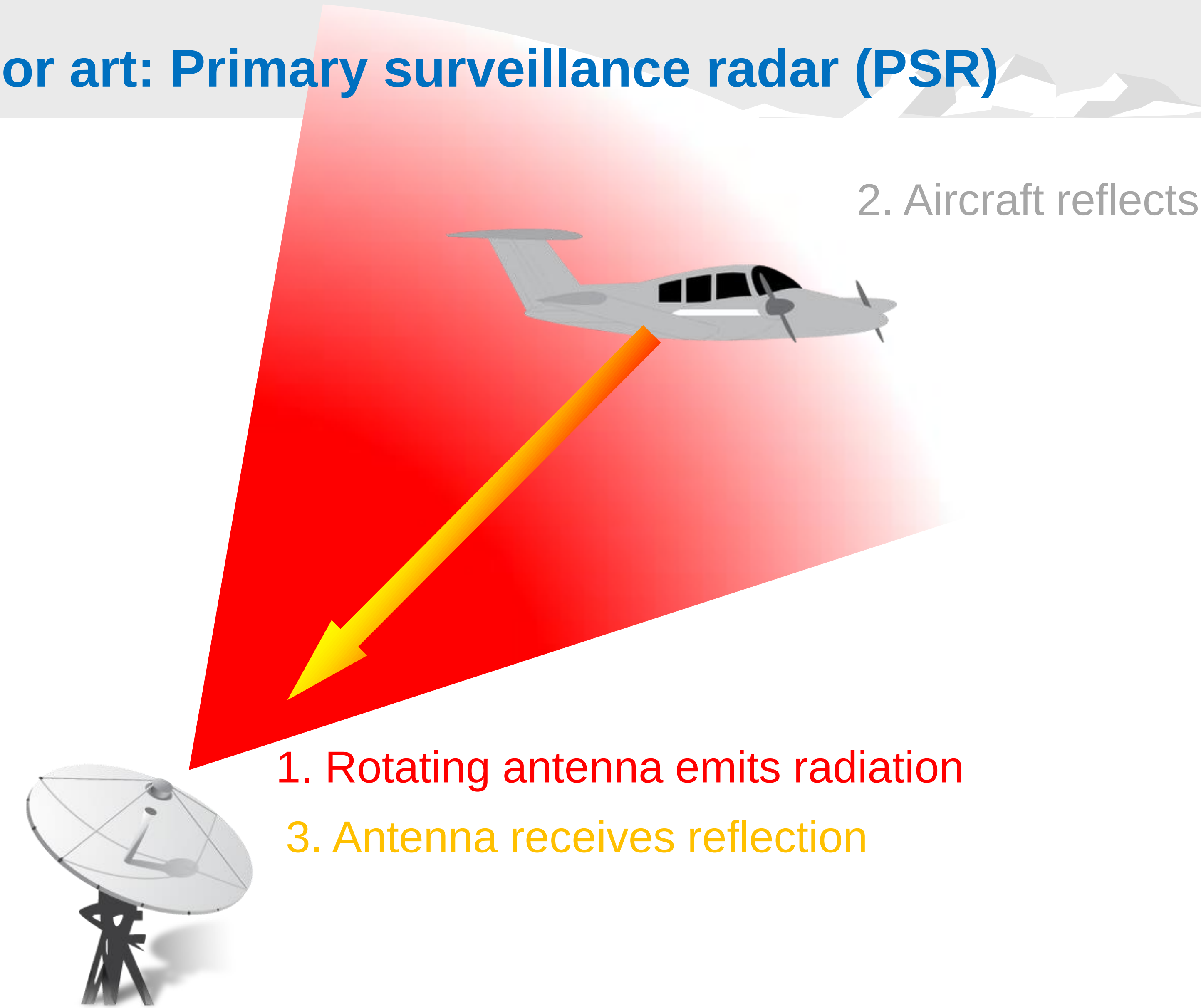
```
File     : 362D9IB1.IGC
Pilot    : undefined
Radio ID: DF038E
Recorder: PowerFLARM-IGC
HW Type  : 1.0
FW Vers  : 3.00
Stealth  : OFF
```



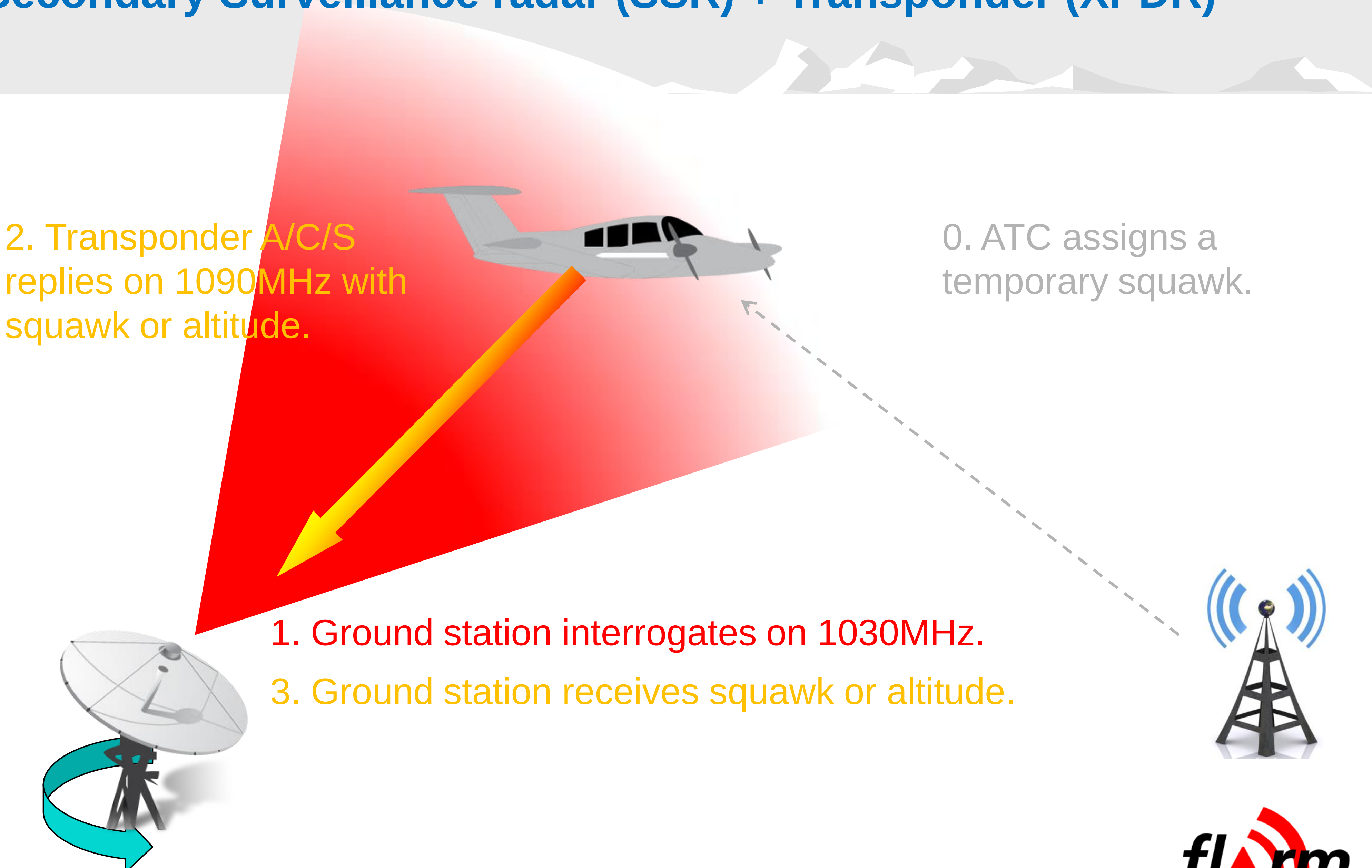

```
Total points: 2507
Average distance: 6467m
Maximum distance: 25532m
```


data processed on Tue, 04 Jun 13 10:03:13 +0200

Prior art: Primary surveillance radar (PSR)



Secondary Surveillance radar (SSR) + Transponder (XPDR)



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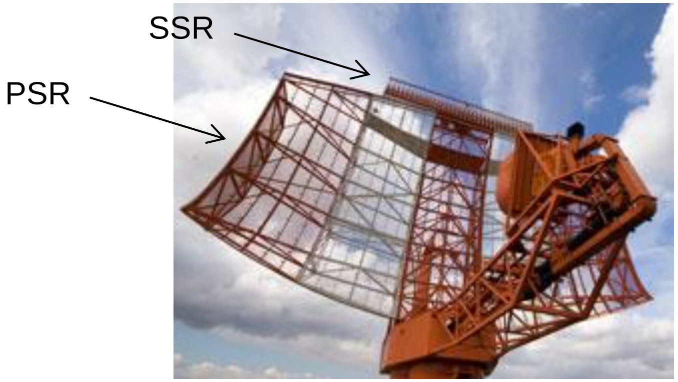
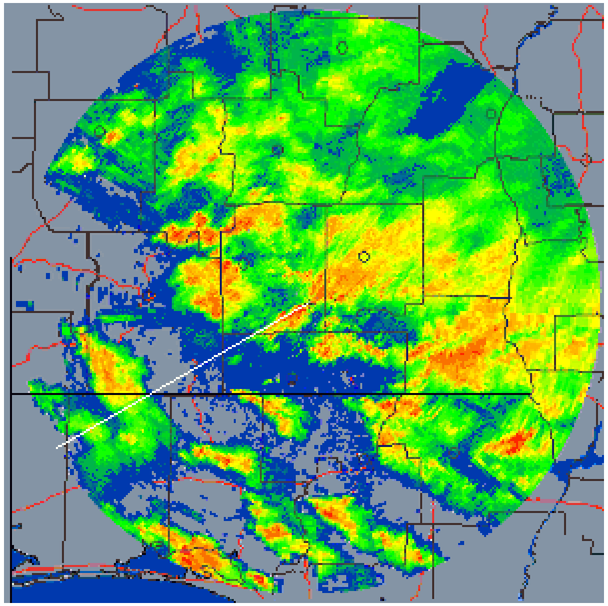
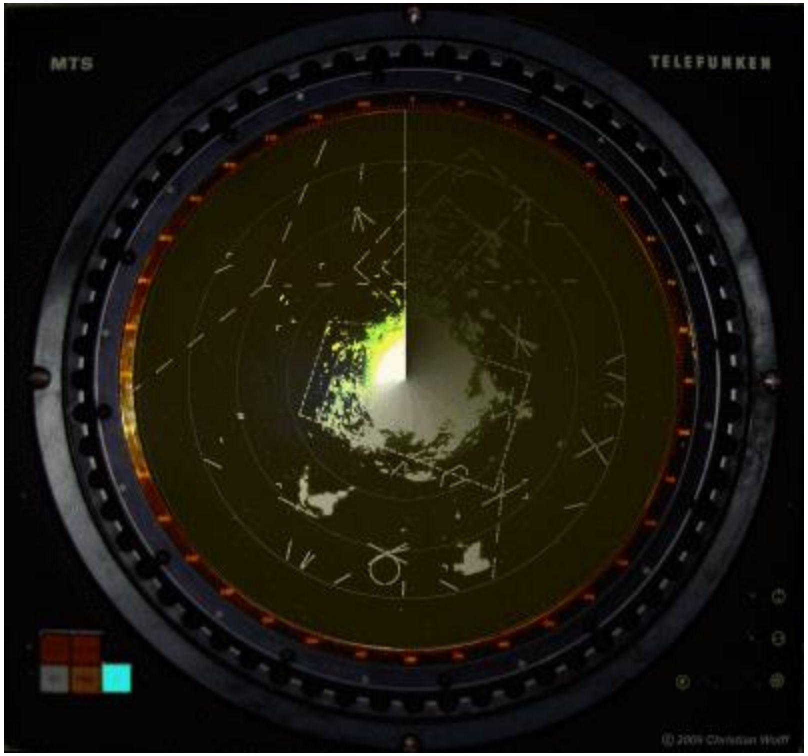
Presentation of PSR



Synthetic 2D image based on antenna rotation angle and signal delay antenna-aircraft-antenna.



Weather radar



Traffic radar

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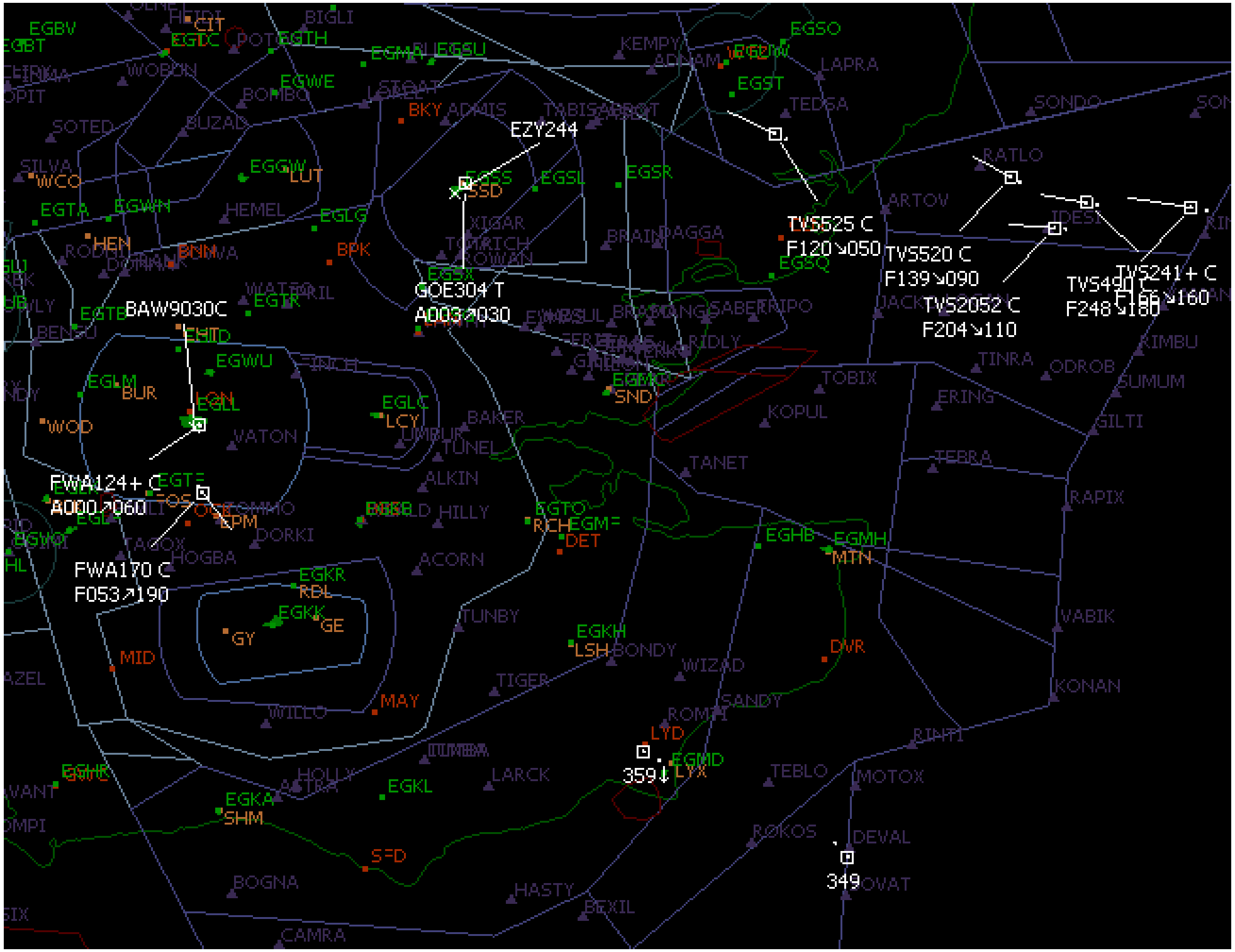
Presentation Secondary Surveillance Radar (SSR)

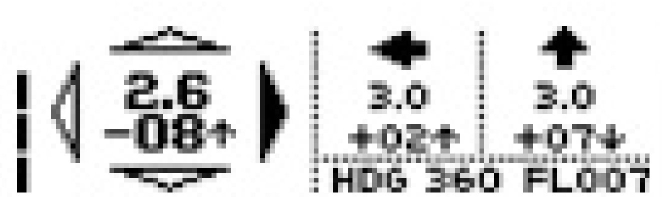


London area

Synthetic image based on antenna angle, signal delay, squawk and altitude.

Air traffic controllers see a synthesized image based on current and past SSR data and flight plan information.

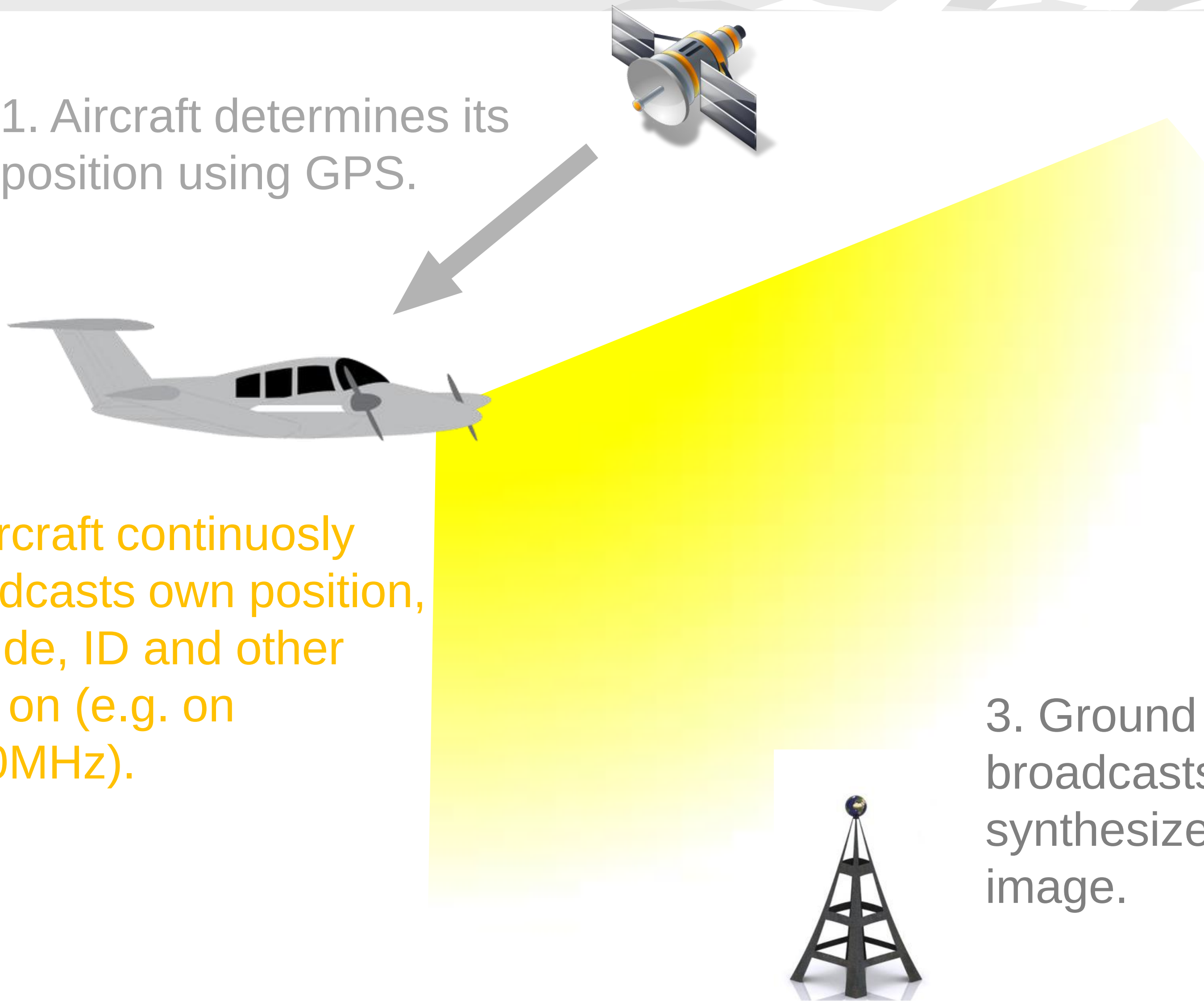
Transponder detector (a.k.a. PCAS)



- Primary target at my 3 o'clock.
- Distance 2.6NM.
- 800ft lower, climbing.
- I'm flying HDG 360 at FL 007.

- Works by receiving XPDR replies from other aircraft.
- Depends on radar ground station or TCAS.
- Distance information from signal strength.
- Crude or no directional info.
- Altitude from mode C reply.

ADS-B: FLARM for air traffic controllers

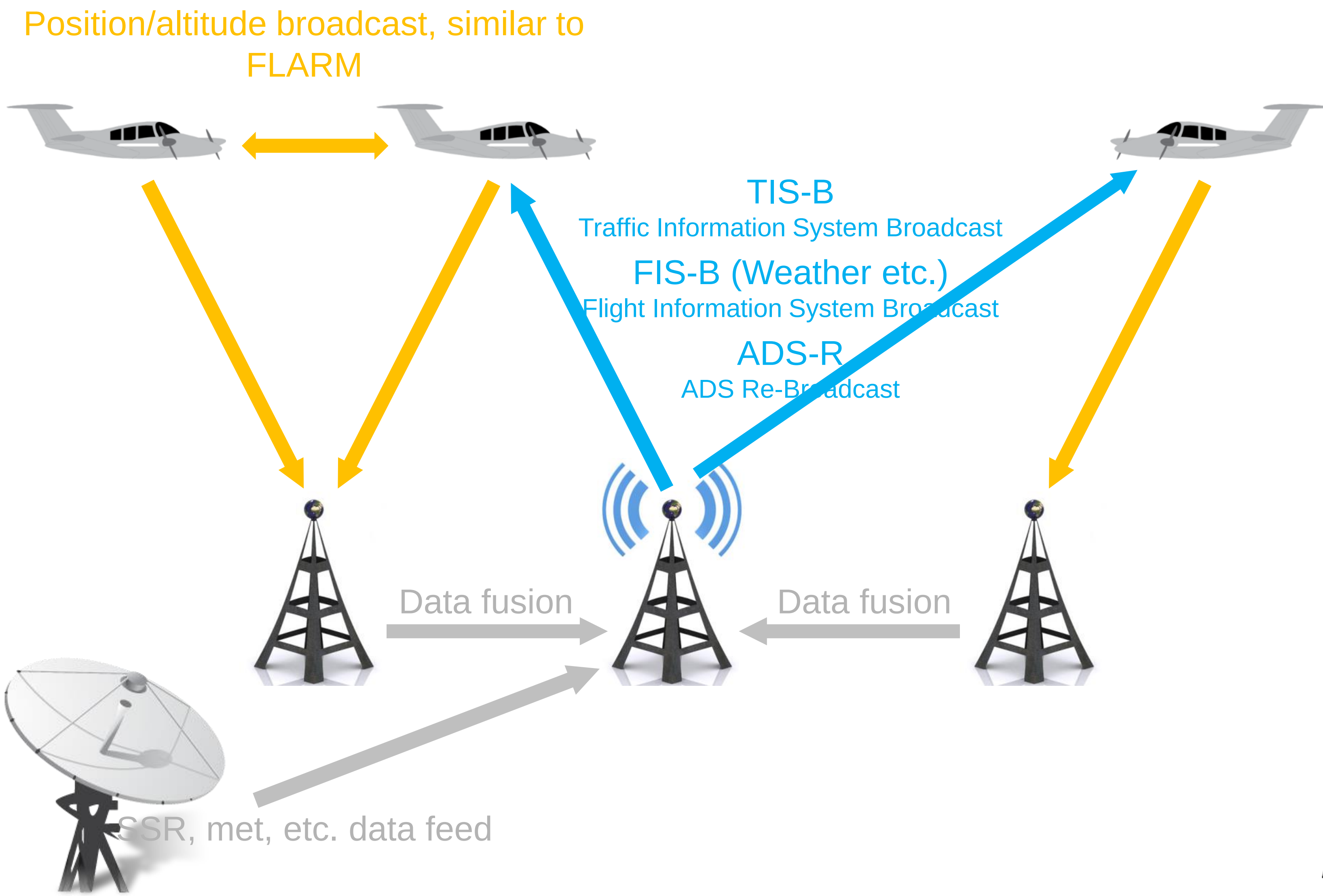


1. Aircraft determines its position using GPS.

2. Aircraft continuosly broadcasts own position, altitude, ID and other data on (e.g. on 1090MHz).

3. Ground (ATC) receives broadcasts and synthesizes situational image.

ADS-B system environment

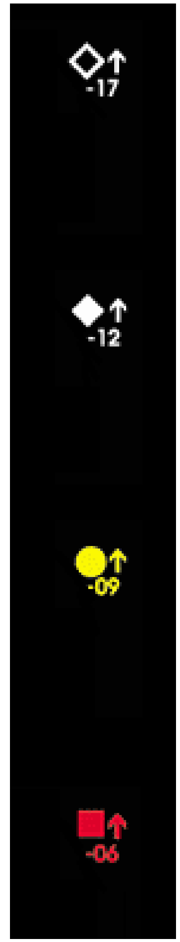


What airliners use: TCAS (Traffic and Collision Avoidance System)

- SSR in aircraft
- On-board computer analyses traffic situation
- Visual display of traffic and threats
- TCAS-II gives vertical resolution advisories
- TCAS only receives Mode C or Mode S/ADS-B

TCO: EUR 50k – 200k

Mandatory for >5.7T or >19 PAX



Non-threat traffic
1700ft lower, climbing

Proximity traffic
1200ft lower, climbing

Traffic Advisory (TA)
900ft lower, climbing
20-45s before closest approximation
«Traffic, traffic»

Resolution Advisory (RA)
600ft lower, climbing
15-35s before closest approximation
«Climb, climb» / « descend, descend»

Put it all together: PowerFLARM!

- Complete FLARM system, plus:
- ADS-B receiver (1090ES)
- Mode S/C receiver
- Intuitive display with FLARM/ADS-B/S/C data fusion.
- A/C power supply or batteries.
- Portable and builtin options available
- New: Works in pressurized cabins (uses pressure altitude from Mode S)
- Price tag: ca. EUR 1800.—
- Simple EASA installation approval if MTOW < 2t

Who‘s using it

- 25’000 units installed worldwide
- Virtually all gliders in central Europe are equipped
- A growing number of PowerFLARM installations in powered aircraft
- A growing number of paragliders
- Many commercial heli operators
- Swiss SPHAIR program (military pilot training) plans to equip the entire basic training fleet

What it is **not**

- FLARM/PowerFLARM is a complement, not a replacement for see-and-avoid
- Not suitable for IFR
- Currently does not support TIS-B
- Intends not to contribute to information overload in the cockpit

Cockpit procedures

- On FLARM/ADS-B alarm (directed target, with bearing):
  - Brief glance at FLARM display to determine bearing to target
  - Make visual contact
  - Take evasive action
- On PCAS alarm (undirected target):
  - Brief glance at FLARM display to determine approximate distance/relative altitude of target
  - Intensify lookout
  - Take evasive action

www.flarm.com

www.powerflarm.aero