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

- 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.
- 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.
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

![Data interface](image1)

![Broadcast](image2)
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
User interface options

- above
- nitschi
- below

- up
- down
How it continued: Design iterations

Prototype: 2003
- Y-Lynx RF

Prototype: 2004
- Y-Lynx RF
- First generation 2004/2005
  - Nordic RF
  - Wide VDC

- 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)
- …
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

<table>
<thead>
<tr>
<th>Situation</th>
<th>Head-on</th>
<th>Converging</th>
<th>Head-on, circling</th>
<th>Circling, opposite direction</th>
<th>Circling, same direction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Human</strong></td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><strong>FLARM</strong></td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>-</td>
</tr>
</tbody>
</table>
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: 362D91B1.IGC
Pilot: undefined
Radio ID: DF03AE
Recorder: PowerFLARM-IGC
HW Type: 1.0
FW Vers: 3.00
Stealth: OFF

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

Top View

4 km
8 km
12 km

good data
insufficient data
no data
cut of bound
Prior art: Primary surveillance radar (PSR)

1. Rotating antenna emits radiation
2. Aircraft reflects
3. Antenna receives reflection
Secondary Surveillance radar (SSR) + Transponder (XPDR)

1. Ground station interrogates on 1030MHz.
2. Transponder A/C/S replies on 1090MHz with squawk or altitude.
3. Ground station receives squawk or altitude.
0. ATC assigns a temporary squawk.
Presentation of PSR

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

Weather radar

Traffic radar
Presentation Secondary Surveillance Radar (SSR)

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

Transponder detector (a.k.a. PCAS)

- 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.

Transponder detector (a.k.a. PCAS) works by receiving XPDR replies from other aircraft. It depends on a radar ground station or TCAS. Distance information is obtained from signal strength. The system provides crude or no directional information and provides altitude from mode C replies.
ADS-B: FLARM for air traffic controllers

1. Aircraft determines its position using GPS.

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

3. Ground (ATC) receives broadcasts and synthesizes situational image.
Position/altitude broadcast, similar to FLARM

TIS-B
Traffic Information System Broadcast

FIS-B (Weather etc.)
Flight Information System Broadcast

ADS-R
ADS Re-Broadcast

ADS-B system environment

Data fusion

SSR, met, etc. data feed
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