

ICAS Workshop, September 11-12, 2017

Intelligent and Autonomous Technologies in Aeronautics - Software  
Engineering and Unmanned Aerial Systems

# Integrating drones into civil air traffic - challenges and concepts

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# Content

- Drones and applications
- Airspace and users
- Concepts for airspace integration of civilian drones
- Conclusions

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# Unmanned Aircraft



ZHAW UMARS



Amazon Prime Air



Prox Dynamics PD-100 PRS 'Black Hornet'



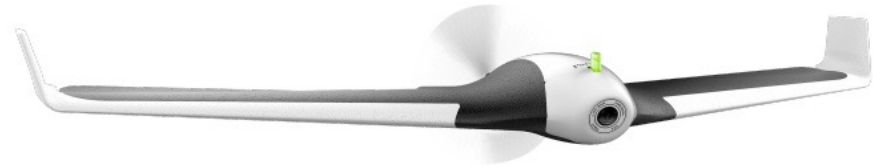
Northrop Grumman RQ-180



# Toys develop into professional tools



GoPro KARMA



Parrot DISCO FPV



DJI Mavic Pro

- Size: 85 mm x 85 mm x 200 mm folded
- Span (engine to engine): 335 mm
- Weight: 750 gram
- Maximum radio distance: 7 km
- Maximum endurance: 27 minutes
- Maximum airspeed: 64 km/h
- Camera: 4000 x 3000 pixels
- price: \$1000

[Video](#)

# Swiss Federal Rail Service SBB using drones to predict debris avalanches

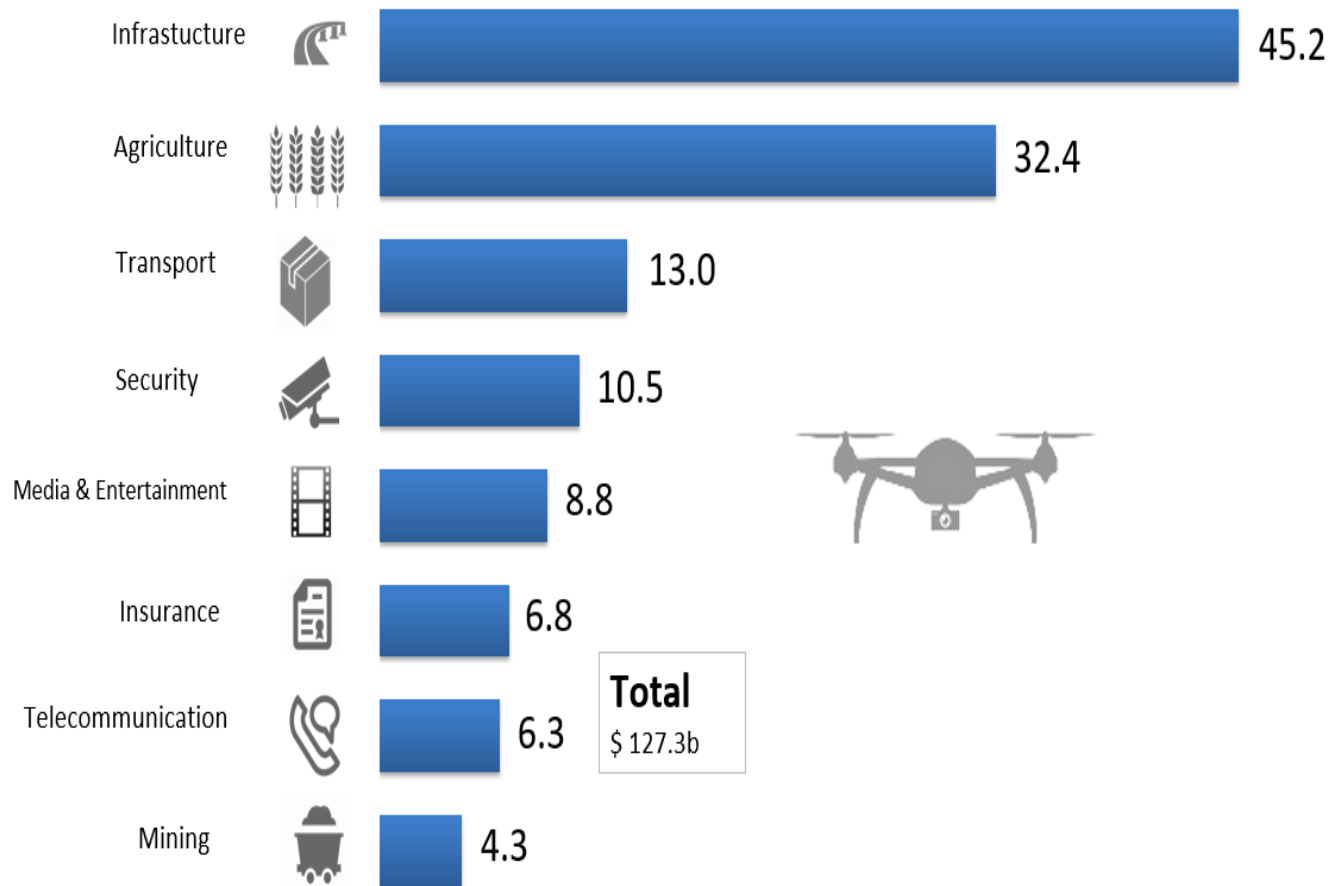


Source: [Drohnen helfen der SBB](#), NZZ 24. August 2017 / SRF [Video](#)

# Unmanned Aircraft: Civilian applications and market volume

## The Industries Where Drones Could Really Take off

Value of drone powered solutions to industries in 2015 (billion U.S. dollars)



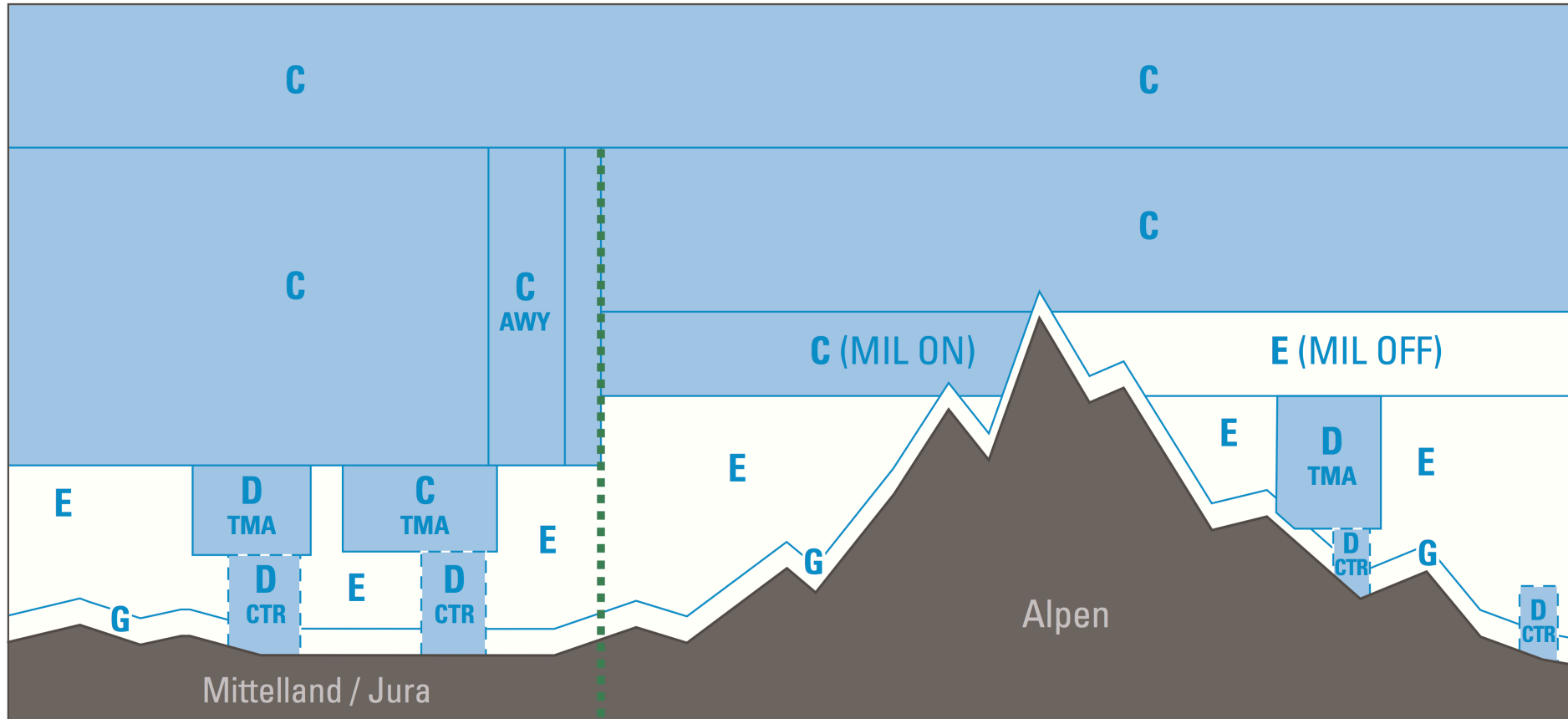
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# Airspace structure of the FIR Switzerland

Luftraumklassierung und -struktur

Classification et structure de l'espace aérien



Source: Skyguide [VFR-Guide](#) page 112

# Airspace users

## Aviation operations today

**NO DRONES**



Source: European Commission



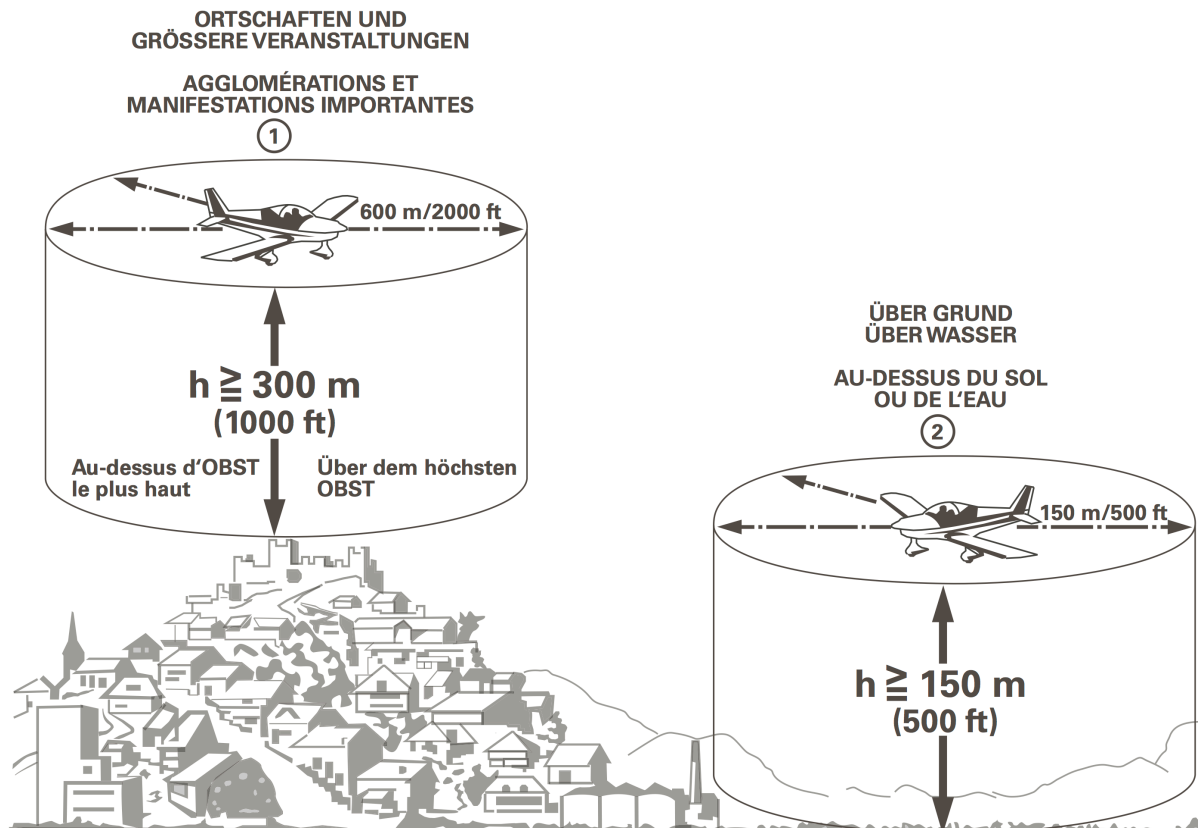
Source: European Commission

# Visual Flight Rules (VFR): Minimum altitude

## Mindestflughöhen über Grund Hauteurs minimaux de vol



gilt als Motorflugzeug  
est considéré comme avion



Source: Skyguide [VFR-Guide](#) page 96



# Visual Flight Rules (VFR): Ridge soaring rules

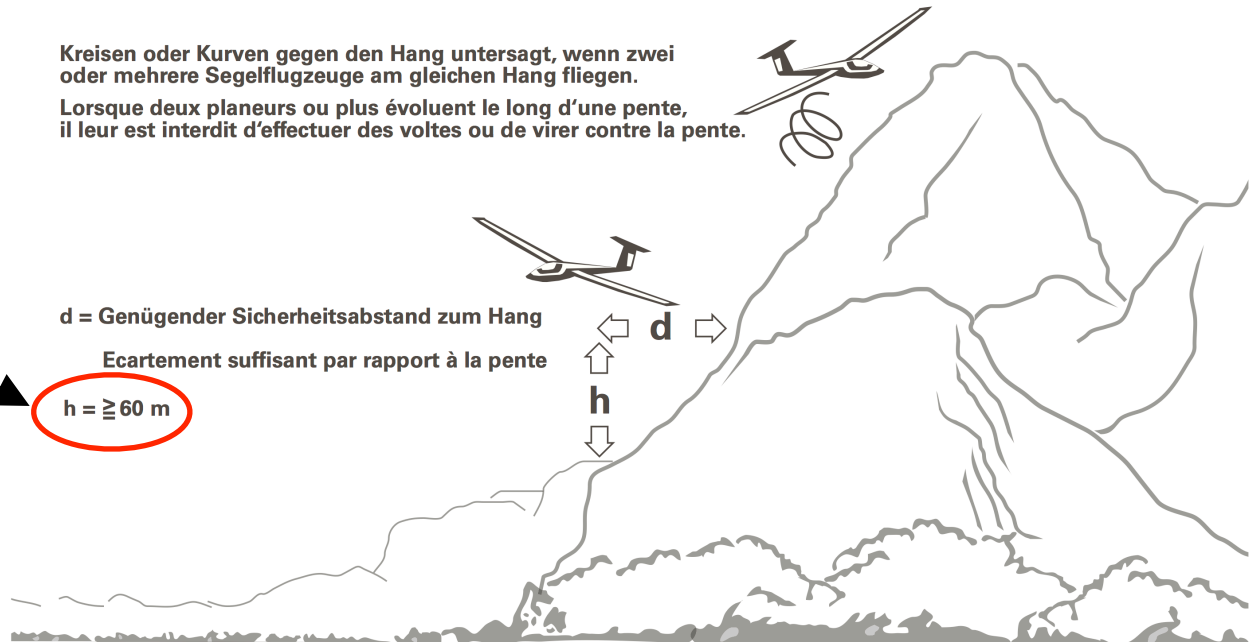
## Hangflugregeln Règles pour le vol de pente

Minimum altitude  
above Ground:  
**60 metres = 200 ft**

Kreisen oder Kurven gegen den Hang untersagt, wenn zwei  
oder mehrere Segelflugzeuge am gleichen Hang fliegen.  
Lorsque deux planeurs ou plus évoluent le long d'une pente,  
il leur est interdit d'effectuer des voltes ou de virer contre la pente.

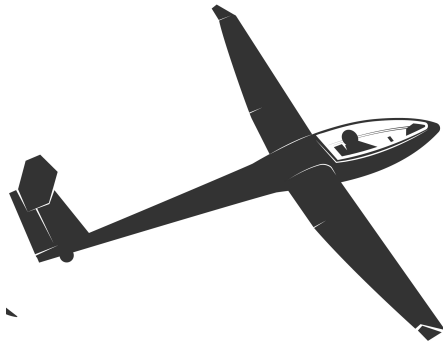
d = Genügender Sicherheitsabstand zum Hang  
Ecartement suffisant par rapport à la pente

**$h \geq 60 \text{ m}$**



Source: Skyguide [VFR-Guide](#) page 97

# Gliders below 500 ft AGL

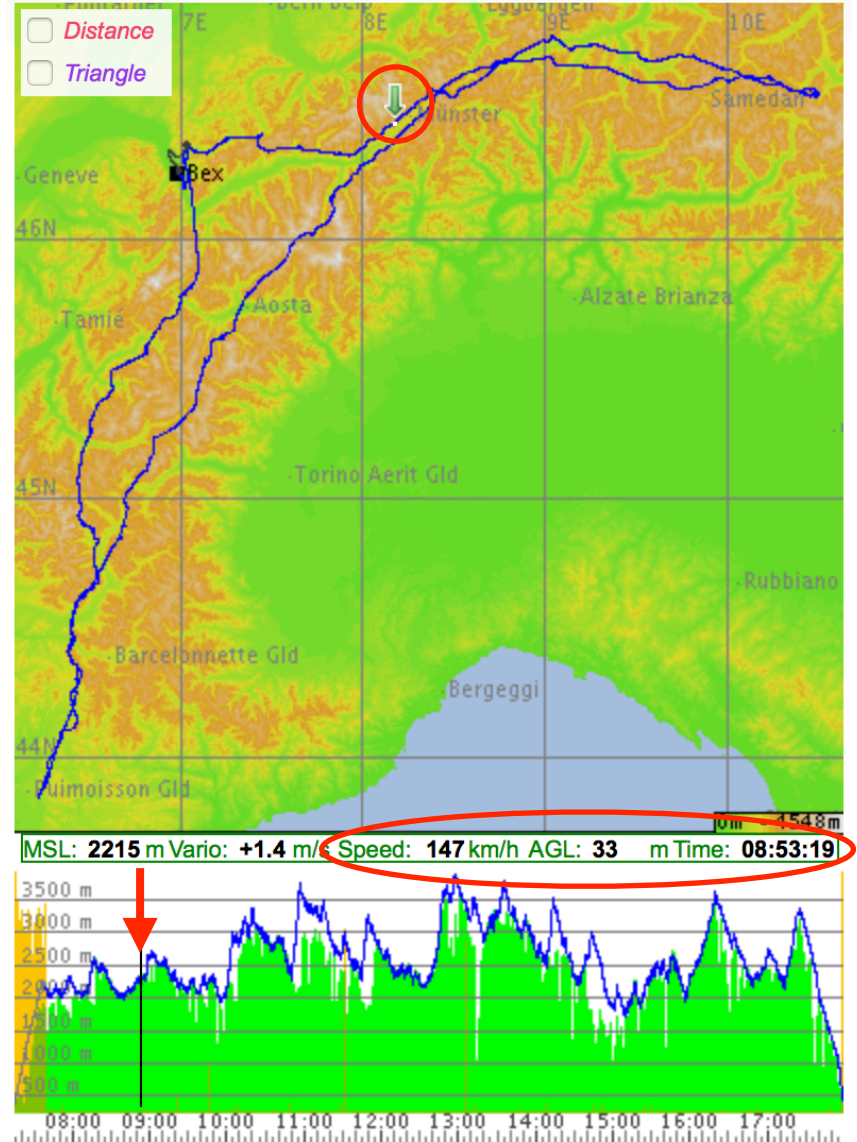


Time: 08:53:19 UTC

Altitude above Ground Level (AGL): **33 m**  
= **108 ft**

Airspeed: **147 km/h**

Source: [OLC Gliding](#)



# Paragliders below 500 ft AGL

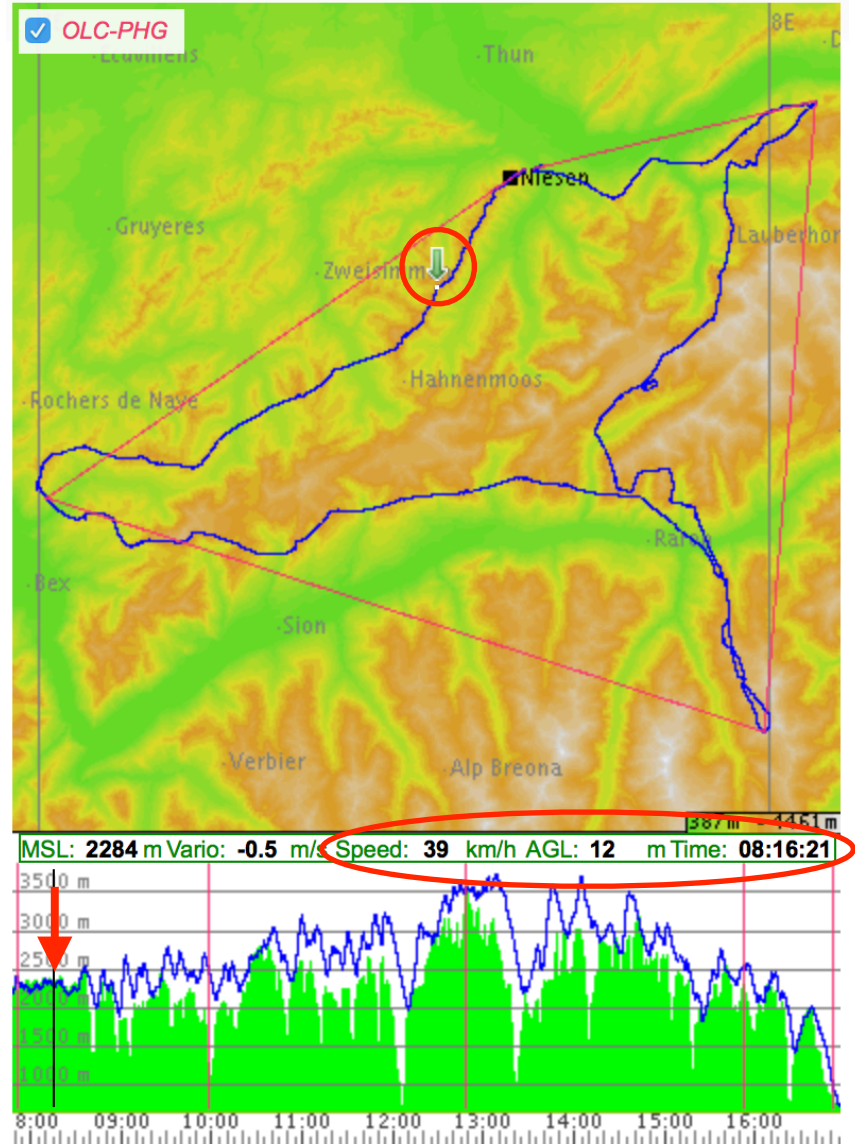


Time: 08:16:21 UTC

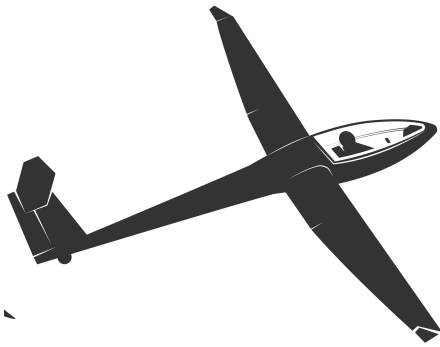
Altitude above Ground Level (AGL): **12 m**  
= **40 ft**

Airspeed: **39 km/h**

Source: [OLC ParaHangGliding](#)



# Gliders and Paragliders below 500 ft AGL

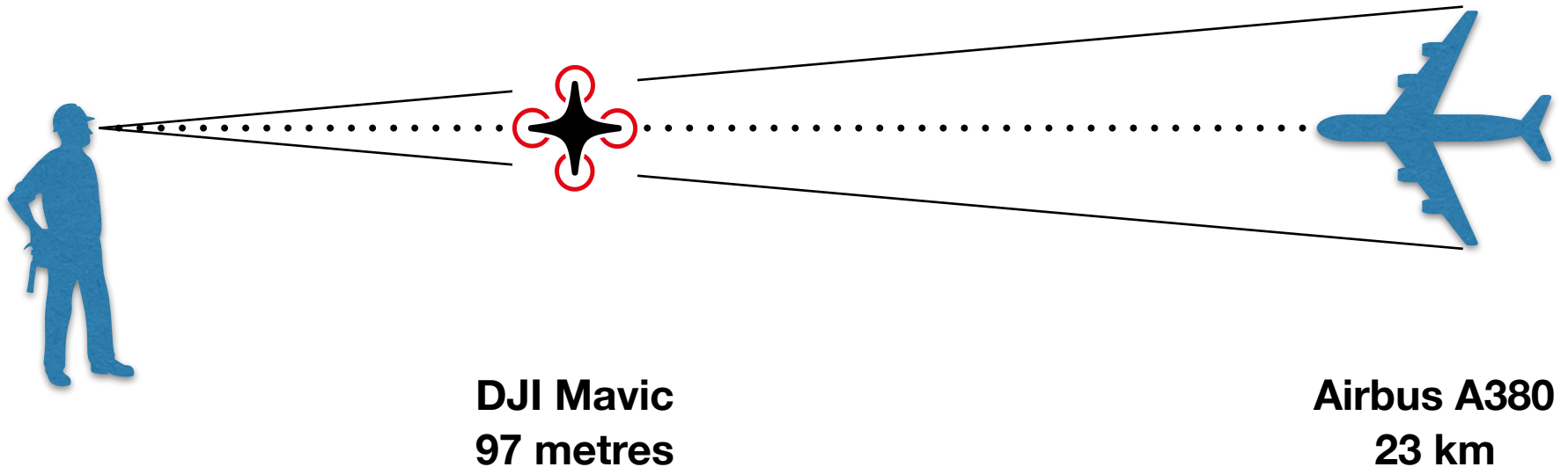


How do these guys avoid a collision?

The answer is: **See & Avoid**

# Visual Flight Rules (VFR): See & Avoid

Usable visual acuity: 3 arc minutes = **0.05°**



Calculated maximum viewing distance



# Instrument Flight Rules (IFR): Separation by Air Traffic Control

Communication and coordination with Air Traffic Control (ATC) in all phases of the flight.



Air Traffic Controller

**Voice only!**



Airbus A380 Cockpit



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# Swiss FOCA: Rules for drone operations




Bundesamt für Zivilluftfahrt  
www.bazl.admin.ch



Federal Office of Civil Aviation .....

**When is the use of  
multicopters allowed –  
and when is it prohibited?**

.....

 Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra  
Swiss Confederation

Bundesamt für Zivilluftfahrt BAZL  
Office fédéral de l'aviation civile OFAC  
Ufficio federale dell'aviazione civile UFAC  
Federal Office of Civil Aviation FOCA



# Swiss FOCA: Rules for drone operations

## Operation without the need for a permit



Remote controlled multicopters with a total weight of less than 30 kilograms and in permanent direct eye contact of the "Pilot"



Multicopters on model airfields and operated by participants in air shows



Multicopters on open ground and in populated areas without gatherings of people (groups of more than two dozen people). Always observe the principle of protection of privacy and never operate a drone in a nature conservation area.  
-> (See RPAS Map)

## Operation requiring a permit



Multicopters controlled with video goggles and without a second "pilot" in permanent direct eye contact



Multicopters with a total weight of more than 30 kilograms



Multicopters within a radius of less than 100 metres around gatherings of people outdoors, except at public air shows and on designated airfields for flying model aircraft



Multicopters operated within a radius of less than 5 kilometres around airfields / airports, and at an altitude higher than 150 metres above ground level in air traffic control zones; here the necessary permit has to be obtained from the airfield manager or air traffic control  
-> (See RPAS Map)



Please observe any other applicable cantonal or municipal restrictions and temporarily restricted airspace (e.g. above Davos during the World Economic Forum).

RPAS Map: [www.bazl.admin.ch/karte-rpas](http://www.bazl.admin.ch/karte-rpas)  
Further information: [www.bazl.admin.ch/rpas](http://www.bazl.admin.ch/rpas)

## Contact


E-mail: [rpas@bazl.admin.ch](mailto:rpas@bazl.admin.ch)

# Remotely-Piloted Aircraft Systems (RPAS)















# Swiss FOCA: RPAS Map

 Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra  
In collaboration with the cantons

Search for a place or add a map:

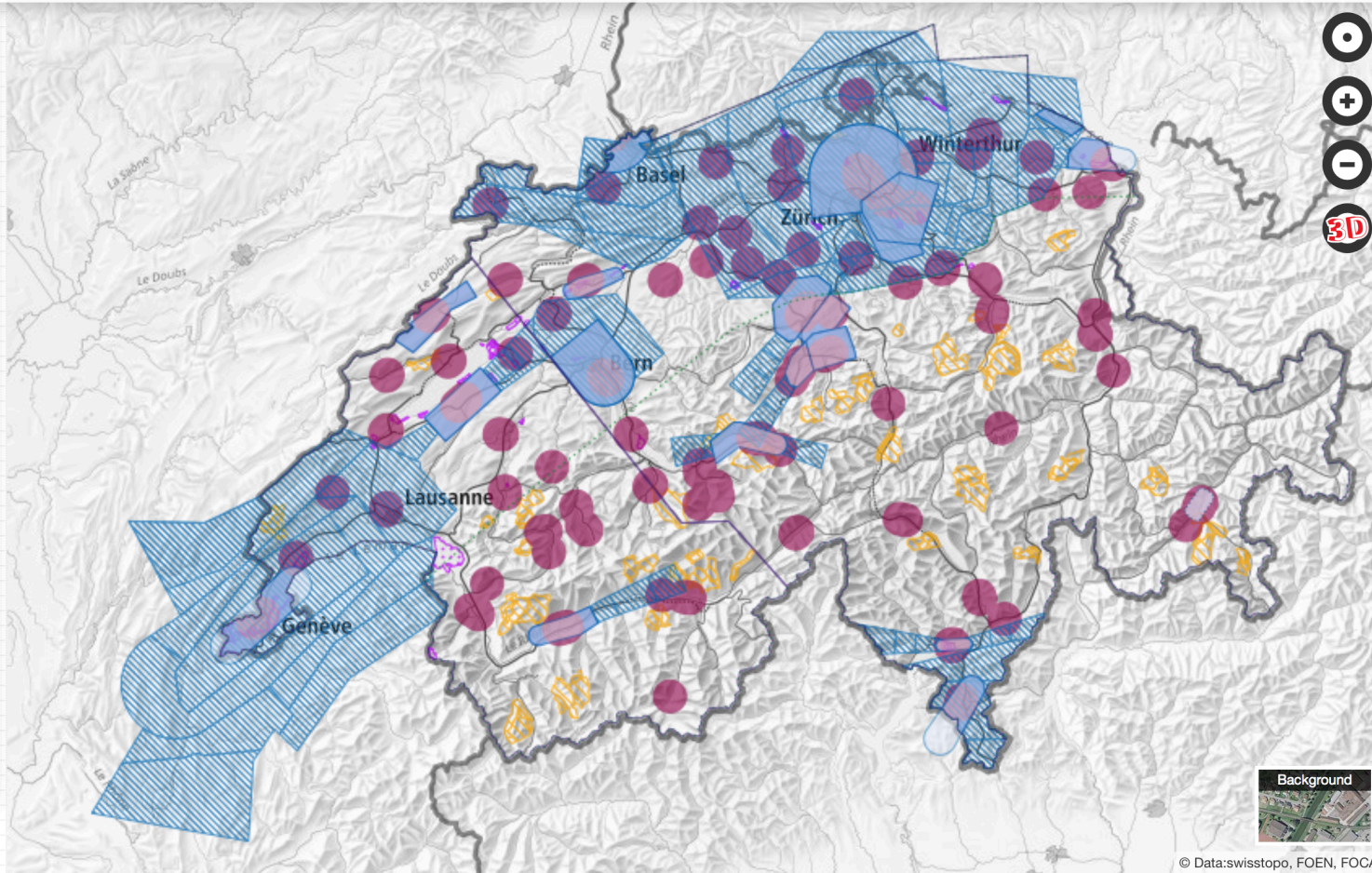
[Full screen](#) [Report problem](#) [Help](#) [Mobile version](#) [DE](#) [FR](#) [IT](#) [EN](#) [RM](#)

- ▶ Share
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- ▶ Advanced tools
- ▶ Aviation Change topic

- ▼ **Maps displayed**
- Aeronautical Chart ICAO 
  - Glider Chart 
  - Airspaces - FIR 
  - Airspaces - CTA 
  - Airspaces - FIZ 
  - Airspaces - CTR 
  - Airspaces - TMA 
  - Restrictions for drones 
  - Swiss game reserves 
  - Water & migrant bird reserves 

Looking for more maps?

▶ Close menu



50 km

CH1903+ / LV95  Coordinates (m): 2°51'557, 1°22'2396

© Data:swisstopo, FOEN, FOCA

[Download data](#) [Copyright & data protection](#)

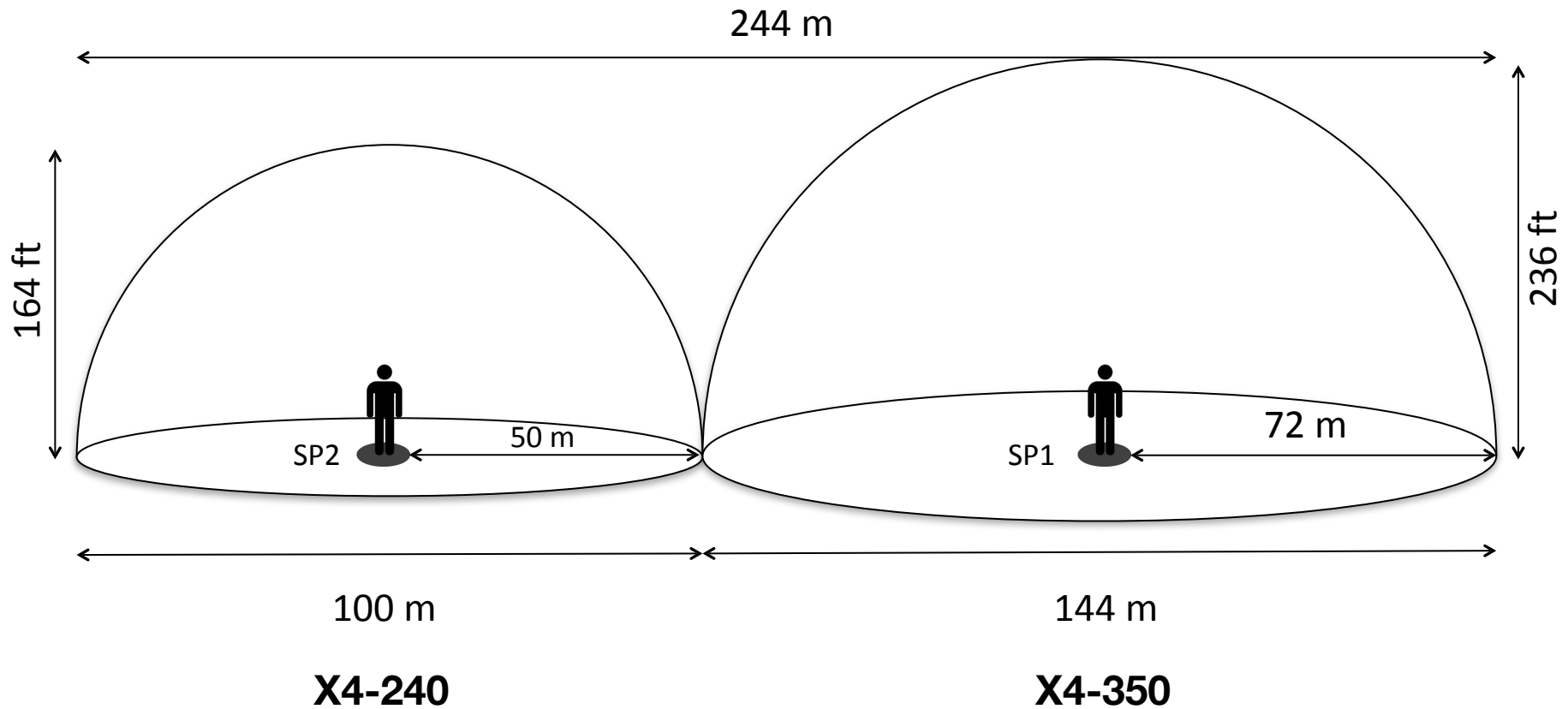
# Drone operation in Visual Line of Sight (VLOS)



The flying testbeds of the ZHAW Centre for Aviation

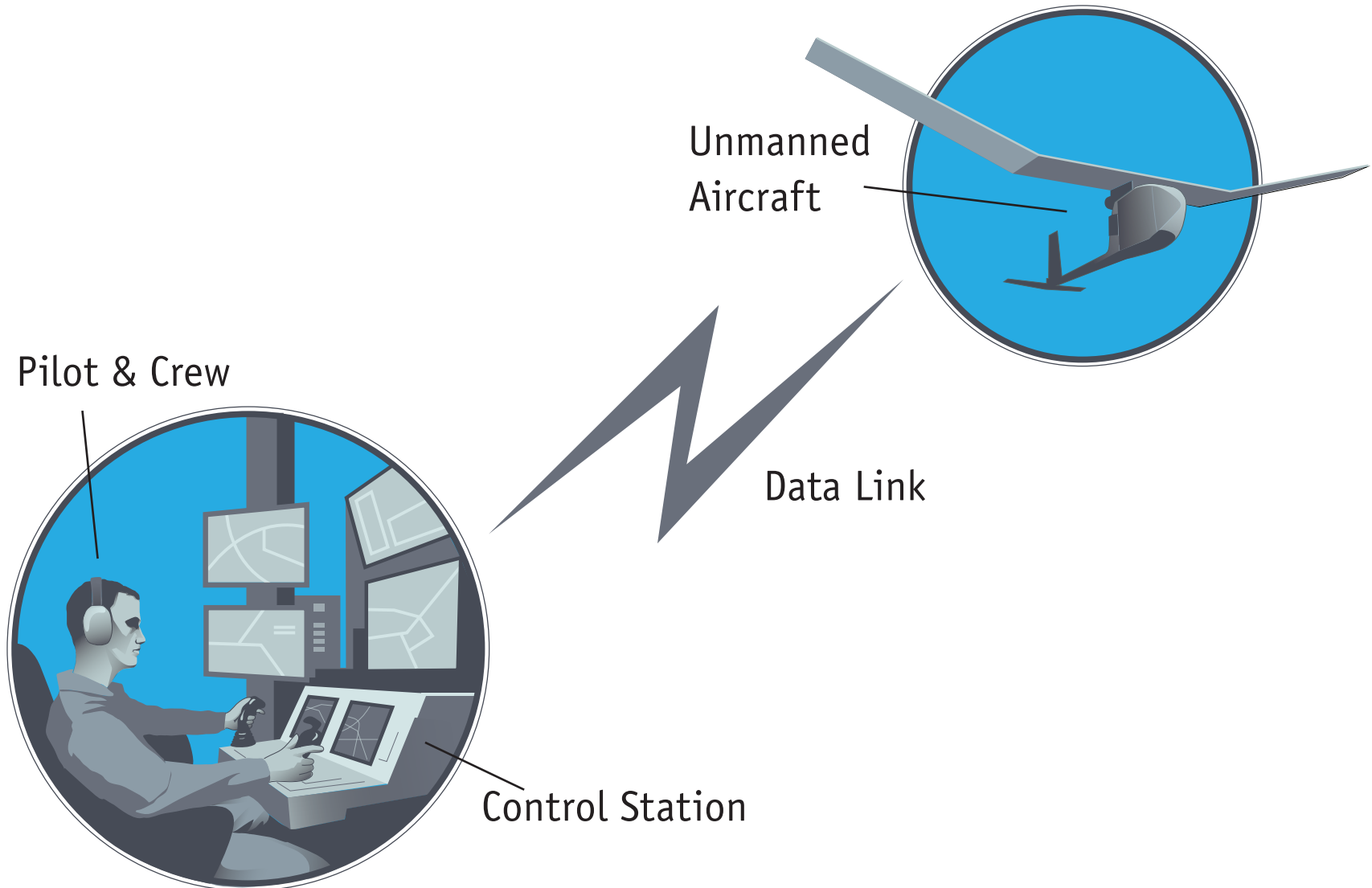
# Drone operation in Visual Line of Sight (VLOS)

Flight test results for maximum VLOS range:



VLOS operation has a very limited range.  
This excludes a lot of professional drone applications.

# Drone operation Beyond Visual Line of Sight (BVLOS)



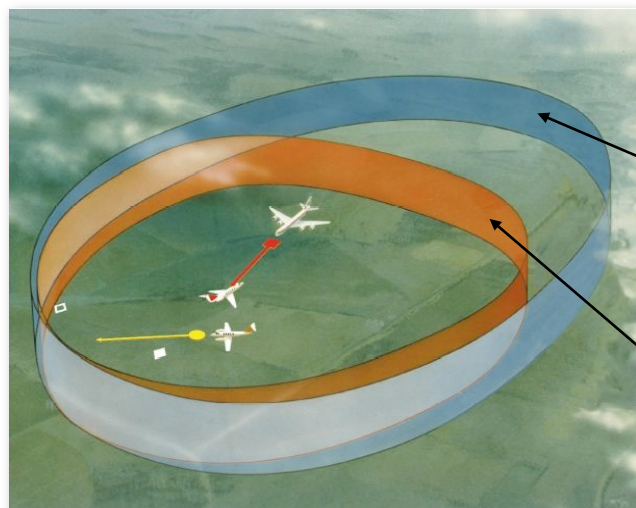
# BVLOS operation in controlled airspace: The challenge of voice communication

- **Scenario 1:** Voice between Remote Pilot (RP) and ATC Controller. Data link between RP and drone.  
**feasible**
- **Scenario 2:** ATM shifts from voice communication to data link communication.  
**only a long term scenario**
- **Scenario 3:** Drones with speech recognition.  
**speech recognition still has high error probability**
- **Scenario 4:** A separate Unmanned Air Traffic Management (UTM) for drones.  
**ATC needs systems and procedures to merge UTM with classic ATM.**



# Detect & Avoid in controlled airspace: Airborne Collision Avoidance System (ACAS)

## Traffic Collision Avoidance System (TCAS)



Traffic Advisory (TA)

Resolution Advisory (RA)

TCAS II



TCAS Display [Allied Signal]

- If traffic separation by ATC fails, TCAS is the last resort to avoid collision.
- TCAS commands only vertical evasion manoeuvres.
- TCAS equipment does not fit into small drones.





Ballastkasten Seaterflüsse  
Mindestzuladung im vorderen Sitz  
66 kg  
101 kg

winter  
m/s  
150

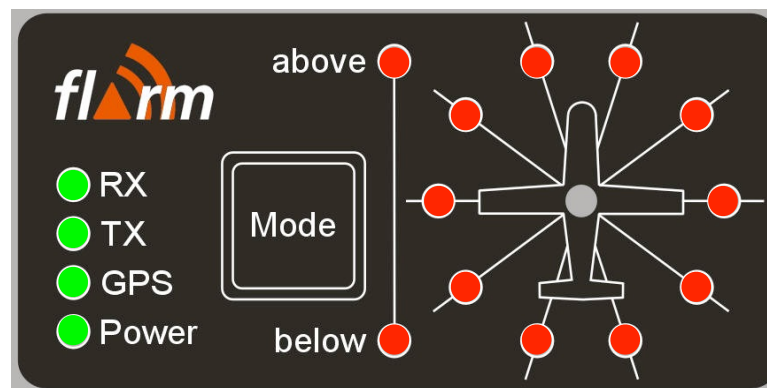
winter  
km  
1000

120  
150  
km/h

338  
10

3  
2  
1  
0  
9  
8  
7  
6  
5  
4  
3  
2  
1  
0

# Detect & Avoid in uncontrolled airspace: Flight Alarm (FLARM)



- **RX (Receive):** illuminates if traffic is within range, **requires GPS reception**
- **TX (Send):** illuminates when transmitting own position, **requires GPS reception**
- **GPS:** illuminates during GPS reception, **blinks 1-3 minutes when device is started**
- **Power:** illuminates, if voltage is sufficient; blinks if voltage is low, shuts off below 8.5V

- FLARM is a Collision Warning System (CWS) not a Collision Avoidance System.
- FLARM is not certified.
- FLARM is not mandatory for VFR flight.

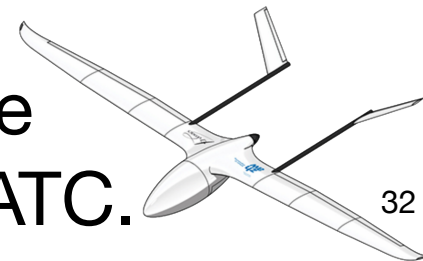
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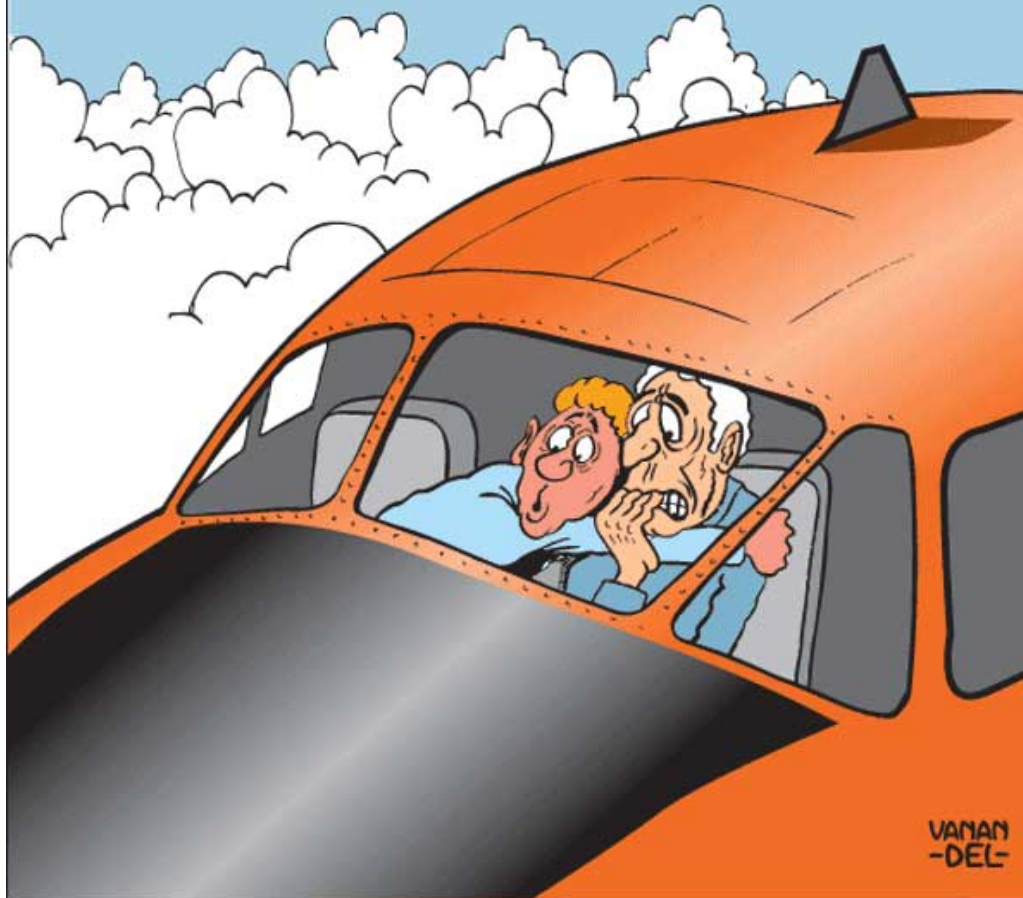


# Conclusions

- VLOS operation has a very limited range which excludes a lot of professional drone applications.
- There is VFR traffic below 500 ft AGL! Expect it to be fast (gliders) and vulnerable (paragliders), if you fly your drone there.
- Pilots do not (want to) „see & avoid“ drones, drones have to „detect & avoid“ other air traffic.
- BVLOS operation in uncontrolled airspace needs a certified (!) Detect & Avoid system which equals or excels „See & Avoid“ of VFR aircraft.
- BVLOS in controlled airspace needs voice communication or an UTM managed by ATC.



## COMPUTERIZED AVIATION



WHAT IS IT DOING NOW...?