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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

Northrop Grumman RQ-180

Prox Dynamics PD-100 PRS 'Black Hornet'

Dr.-Ing. Peter M. Lenhart, ZHAW
Toys develop into professional tools

- **GoPro KARMA**
  - 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

- **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
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[Video]
Swiss Federal Rail Service SBB using drones to predict debris avalanches

Source: Drohnen helfen der SBB, NZZ 24. August 2017 / SRF Video
The Industries Where Drones Could Really Take off
Value of drone powered solutions to industries in 2015 (billion U.S. dollars)

- Infrastructure: $45.2b
- Agriculture: $32.4b
- Transport: $13.0b
- Security: $10.5b
- Media & Entertainment: $8.8b
- Insurance: $6.8b
- Telecommunication: $6.3b
- Mining: $4.3b

Total: $127.3b
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Airspace structure of the FIR Switzerland

Source: Skyguide [VFR-Guide] page 112
Airspace users

Aviation operations today

Source: European Commission
Airspace users

Future aviation operations

YES DRONES

20,000 m
TELECOMMUNICATIONS
RELAY TO REMOTE AREAS

11,000 m
CARGO
FILMING
FARMING
INSPECTIONS

4,000 m

150 m

Source: European Commission
Visual Flight Rules (VFR): Minimum altitude

**Mindestflughöhen über Grund**
Hauteurs minimales de vol

1. **ORTSCHAFTEN UND GRÖSSERE VERANSTALTUNGEN**
AGGLOMÉRATIONS ET MANIFESTATIONS IMPORTANTES

- **h ≥ 300 m**
(1000 ft)
- Au-dessus d’OBST
le plus haut
- Über dem höchsten
OBST

2. **ÜBER GRUND ÜBER WASSER**
AU-DESSUS DU SOL OU DE L’EAU

- **h ≥ 150 m**
(500 ft)

Source: Skyguide [VFR-Guide](#) page 96
Visual Flight Rules (VFR): Ridge soaring rules

Minimum altitude above Ground:
60 metres = 200 ft

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
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°

DJI Mavic
97 metres

Airbus A380
23 km

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

Voice only!

Airbus A380 Cockpit

Air Traffic Controller
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Swiss FOCA: Rules for drone operations

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

Contact

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RPAS Map: www.bazl.admin.ch/karte-rpas
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Remotely-Piloted Aircraft Systems (RPAS)
Swiss Confederation: Map of RPAS no-flight zones
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:

- **SP2**
  - 50 m
  - 164 ft
  - 100 m
  - X4-240

- **SP1**
  - 72 m
  - 236 ft
  - 144 m
  - X4-350

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

Several terms used in this document are defined below as a common point of reference:

Unmanned Aircraft (UA): A device used or intended to be used for flight in the air that has no onboard pilot. This device excludes missiles, weapons, or exploding warheads, but includes all classes of airplanes, helicopters, airships, and powered-lift aircraft without an onboard pilot. UA do not include traditional balloons (see 14 CFR Part 101), rockets, tethered aircraft and un-powered gliders.

Crewmember [UAS]: In addition to the crewmembers identified in 14 CFR Part 1, a UAS flight crew member includes pilots, sensor/payload operators, and visual observers (VO), but may include other persons as appropriate or required to ensure safe operation of the aircraft.

Unmanned Aircraft System (UAS): An unmanned aircraft and its associated elements related to safe operations, which may include control stations (ground, ship, or air-based), control links, support equipment, payloads, flight termination systems, and launch/recovery equipment. As shown in Figure 1, it consists of three elements:

1. Unmanned Aircraft
2. Control Station
3. Data Link

National Airspace System (NAS): The common network of U.S. airspace—air navigation facilities, equipment, and services; airports or landing areas; aeronautical charts, information and services; rules, regulations, and procedures; technical information; and manpower and material. (see Figure 2)

Next Generation Air Transportation System (NextGen): According to the FAA’s Destination 2025, (2011): “NextGen is a series of inter-linked programs, systems, and policies that implement advanced technologies and capabilities to dramatically change the way the current aviation system is operated. NextGen is satellite-based and relies on a network to share information and digital communications so all users of the system are aware of other users’ precise locations.”

Figure 1: The UAS and Flightcrew Members

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.
Traffic Collision Avoidance System (TCAS)

- 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.
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.