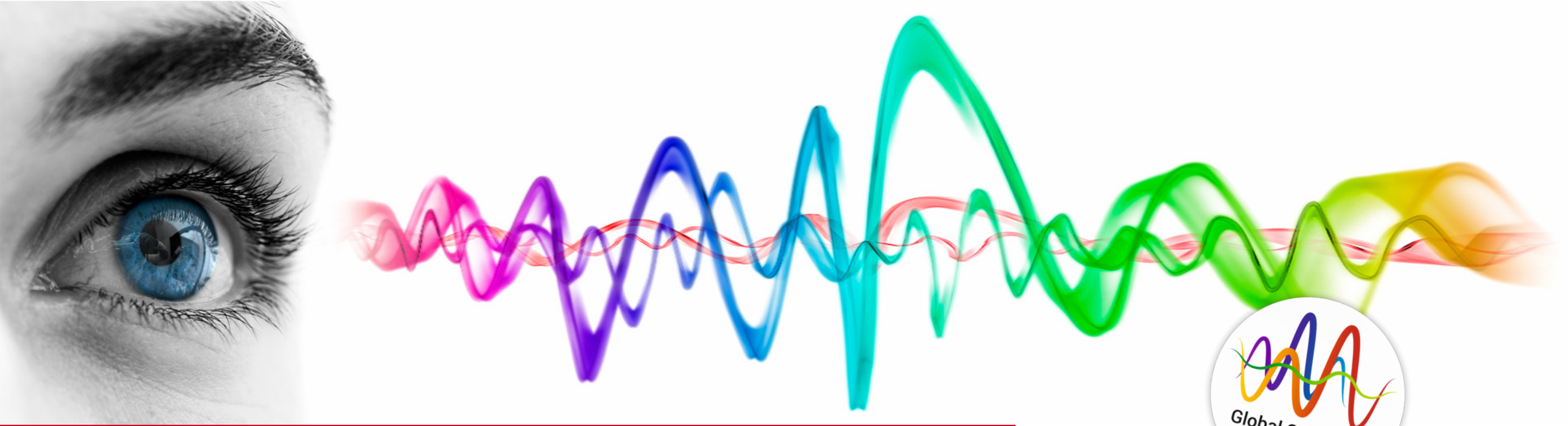
Colibrex
Smart Drone Solutions



Global Spectrum Experience

CEPT Workshop on Spectrum for Drones / UAS

Spectrum as a key issue in both drone operation and drone surveillance

Content

- Introduction about LS telcom / Colibrex and our drone activities
- Overview about drone-based RF measurements
  (as point of interest for spectrum managers)
- Impact of drones on frequency spectrum
- Practical experiences on connectivity during drone operation
- Spectrum issues for drone traffic management / drone surveillance
- Conclusion

Colibrex
Smart Drone Solutions

Software, Hardware, Planning Services, Consultancy & Training for Optimal Spectrum Use

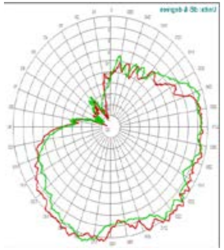
LS telcom
Smart Spectrum Solutions

25 YEARS Innovation for a Wireless World

Colibrex
Smart Drone Solutions

Colibrex is the Subsidiary of LS telcom dedicated to Drone Activities

- Tower inspection and antenna pattern measurement
- Airborne Spectrum Monitoring
- NavAids (ILS/VOR) and Radar Inspection Drones



- Drone licensing and management systems (UTM / U-Space)

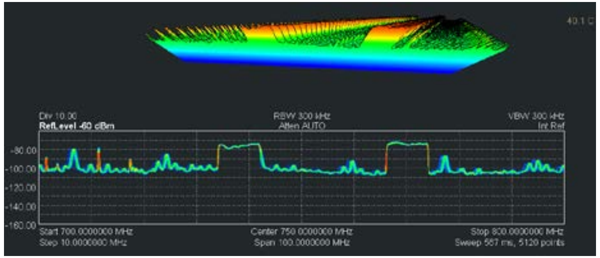
UVS International
UAV DACH
Global UTM Association

Colibrex
Smart Drone Solutions

Principle

Use of a drone (UAS) specially adapted with

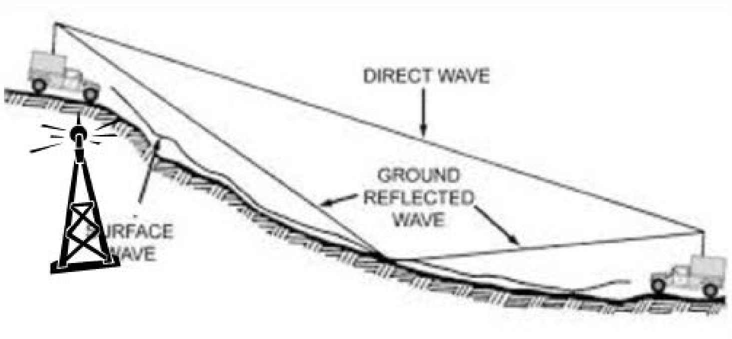
- dedicated measurement sensor & data processor (incl. real-time download)
- high resolution flight positioning and orientation
- autopilot capabilities
- calibrated measuring antennas
- specific software for data analysis
- specific RF shielding



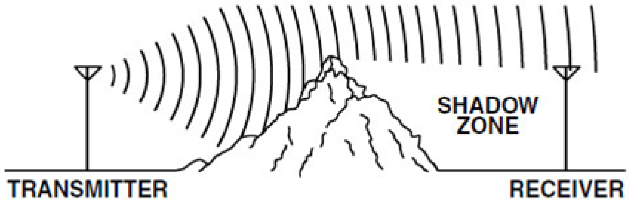
Colibrex
Smart Drone Solutions

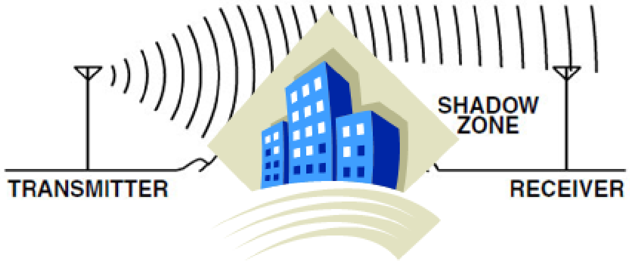
Primary Advantages of Measuring “in the air”

1) To avoid / reduce ground reflections



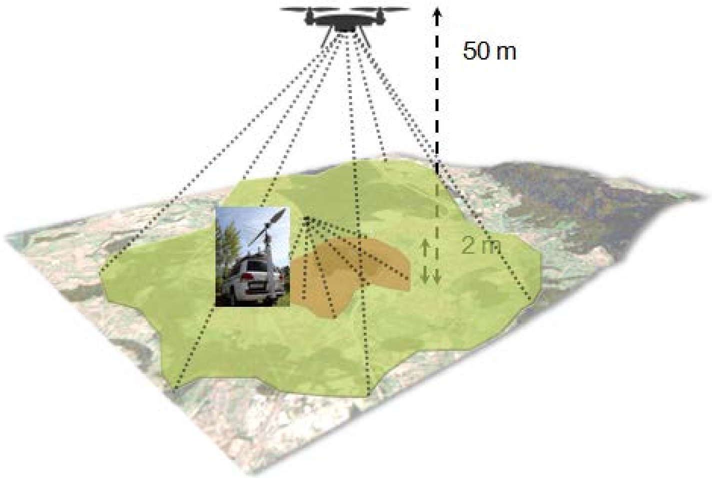
2) To capture signals only available at a certain height



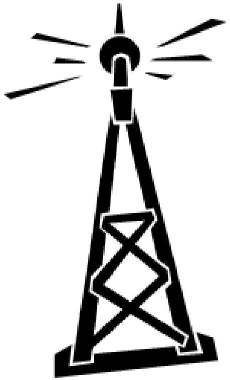


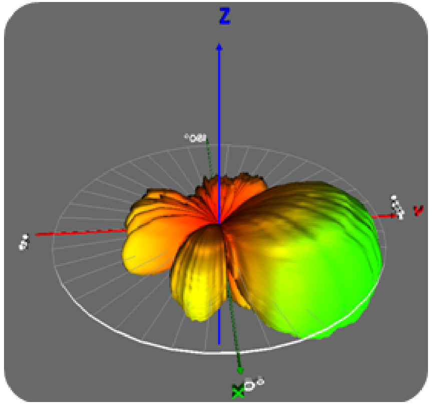
Primary Advantages of Measuring "in the air"

3) To enlarge the captured area



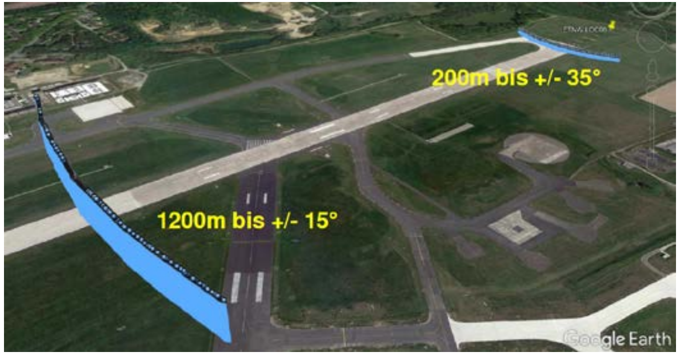
4) To enable multi-points / volumetric capture of signals





Customer Advantages of Using Drones as Alternative to Solutions with Antennas on Masts

Costs and difficulty to erect (mobile) masts at > 10m and at the desired position



Colibrex
Smart Drone Solutions

Drones are „Radio Stations“ in the Sky !

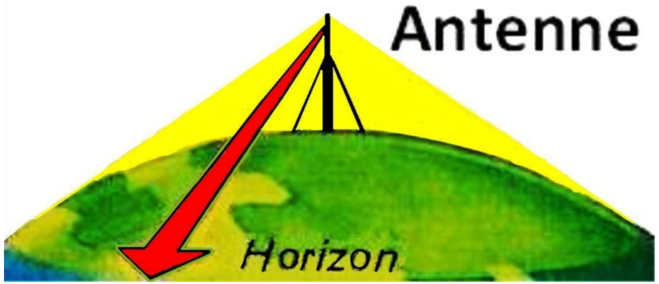
- Command and control frequencies (UAS)
- Remote payload control
- Audio signal distribution (payload)
- Video signal distribution (payload)
- Payload sensor data (several)
- Payload identification (parcels)
- UAS beacon / Drone-ID (identification)
- Radar sensors (anti collision)

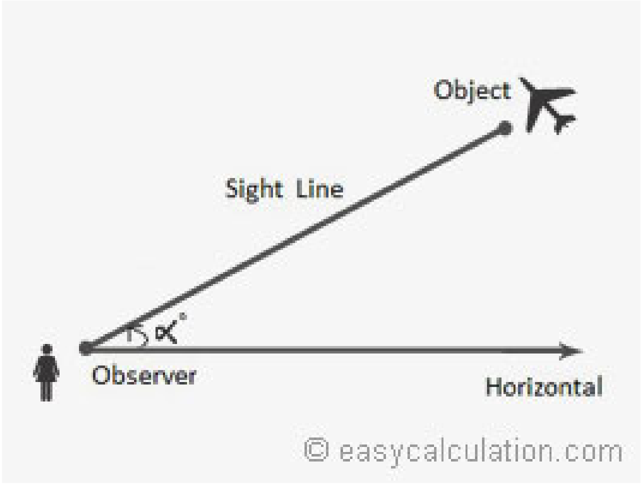
Colibrex
Smart Drone Solutions

Due to their Altitude, Drones have a wide Coverage Area and Impact on the Spectrum Usage

Horizont in km = 4 * SQR (Meter over ground)

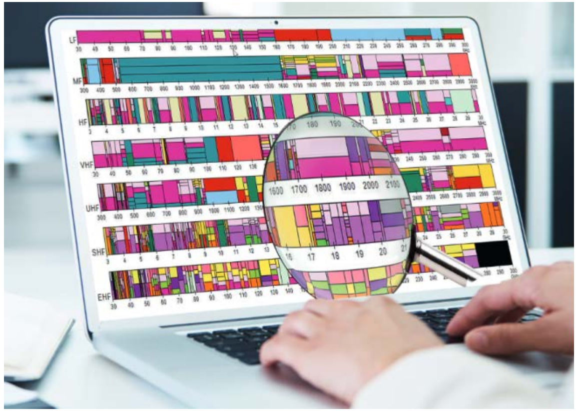
- UAS height 5 Meter = 9 km horizont
- UAS height 50 Meter = 28 km horizont
- UAS height 500 Meter = 90 km horizont





Frequency Bands Used for Drone Operation

- WiFi / WLAN (2.4 / 5.8 GHz)
- ISM (433 MHz / 868 MHz / 920 MHz)
- Public Bands (27, 35, 40, 41, 43, 72 MHz)
- GSM Bands (900 / 1800 / 2100 MHz)
- LTE Bands (800 MHz / 1600 MHz)
- Amateur Bands (145 / 435 / 1275 MHz)
- GNNS frequencies



Colibrex
Smart Drone Solutions

The Future with Drone Operation Using Mobile Connected Frequencies

- Especially with 5G offering improved data rate and low latency, mobile operators are looking how to connect drones via mobile networks (drones as „IoT“ devices ?)

Qualcomm Technologies released the results of over 1,000 drone test flights where drones used existing 4G LTE commercial mobile network connections. Acc. to Qualcomm the results are good and show that drones can rely on this type of connection, even at 400 feet and even beyond visual line of sight (BVLOS). Some key points:
-Very strong signal availability at higher altitudes
- Successful handover and lower frequency of handover events
- Comparable coverage to ground mobile devices (SINRs)

Further analysis are for sure necessary...

- Many frequency bands can basically be considered: 700 MHz, 800 MHz, 850 MHz, 900 MHz, 1800 MHz, 1900 MHz, 2,1 GHz, 2,3 GHz, 2,6 GHz
- Interference between mobile services and other types of services in adjacent bands is possible - so steps shall be taken to mitigate these issues

Colibrex
Smart Drone Solutions

The Future with Drone Operation using Mobile Connected Frequencies

- Compatibility studies are normally conducted to assess the risk of interference and, where necessary, also outline measures to reduce the interference risks to acceptable levels (e.g. recommending emission masks)
- Existing compatibility studies for mobile bands have focused on terrestrial mobile use cases – not mobile-connected drones operating in the air at altitude. It may be necessary to conduct new compatibility studies to assess the interference risks presented by drones as well as potential remedies.
- In addition, a number of mobile bands which may be of interest for connecting drones are allocated to mobile ‘except aeronautical mobile’. This may have certain regulatory reper-cussions on mobile operators who wish to use these frequency bands for drone operations, unless it is determined whether use of drones is classified as an aeronautical service

Colibrex
Smart Drone Solutions

Ensuring Safe and Continuous RC of the Drones

- Frequency-hoping RC ensures good performances under „normal“ conditions
- In certain areas, 2,4GHz links can be disturbed by stronger signals in the same frequency range (e.g. microwave links, military communications around 2,2...2,4 GHz; primary use – „no claim for distortion-free use“)
- The authorized power level of 2,4 GHz RC is not enough to cover certain applications
- „RC-booster“ represent a good solution but are not everywhere authorized
- 2,4GHz link can be relatively easy to jamm or to hack

Compliance tables power levels in different regions

Band	Location	Maximum Output Power	Maximum EIRP	Geographic Location	Compliance Document
ISM 2.4-2.483Ghz	Indoor and Outdoor	1000mW	4000mW*	USA	FCC 15.247
ISM 2.4-2.483Ghz	Indoor and Outdoor	100mW	NA	EUROPE	ETS 300-328
UNII 5.15-5.25Ghz	Indoor only	40mW	160mW	USA	FCC 15.247
UNII 5.25-5.35Ghz	Indoor and Outdoor	200mW	800mW	USA	FCC 15.247
UNII 5.15-5.35Ghz	Indoor only	NA	200mW	EUROPE	ETS 300-328
UNII 5.725-5.825Ghz	Indoor and Outdoor	800mW	16000mW	USA	FCC 15.247
UNII 5.470-5.725Ghz	Indoor and Outdoor	NA	1000mW	EUROPE	ETS 300-328
UNII 5.725-5.825Ghz	Indoor and Outdoor	NA	25mW	EUROPE	ETS 300-328

*For point to multipoint point applications, the 3 to 1 rule applies for point to point links.

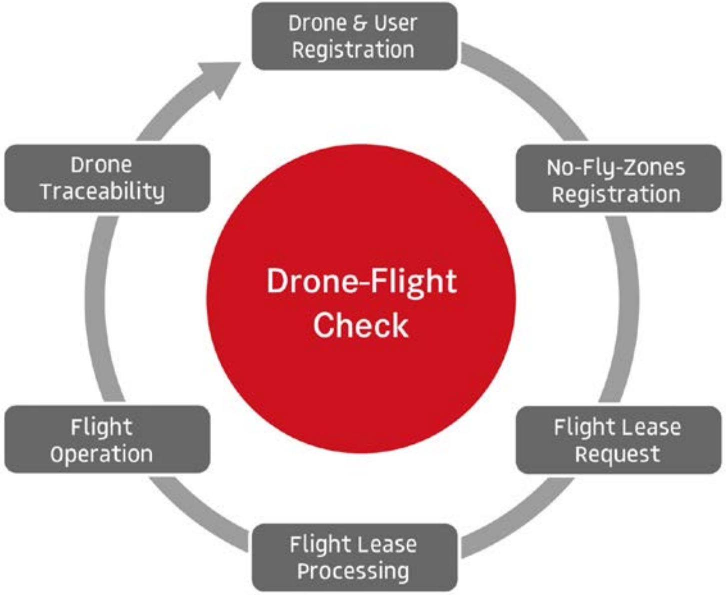
Ensuring Stable Downlink Data Transfer

- Possibilities of downlink are relatively limited and each with some limitations
- 433 MHz & 915 MHz
  - Quality of the receivers/links (consumer electronics...)
  - Subject to interferences, reflections, time-shift
  - Limited datarate (ex: 250kbps with FHSS/TDM on a power up to 20dBm/100mW)
- 5,8 GHz often used for Video Downlink offers good bandwith / datarate capabilities but limited distancerange

Colibrex
Smart Drone Solutions

UTM / U-Space

- Drone management will be absolutely mandatory for a large-scale deployment of drones and for operation in critical environment like airports, cities, ...
- Tracking / Drone traceability is a key element of any drone management system
- The same challenges as described before for drone operation do apply in terms of spectrum use, with very critical issues like
  - Continuous connectivity „everywhere“
  - Secured connectivity, redundancy ?

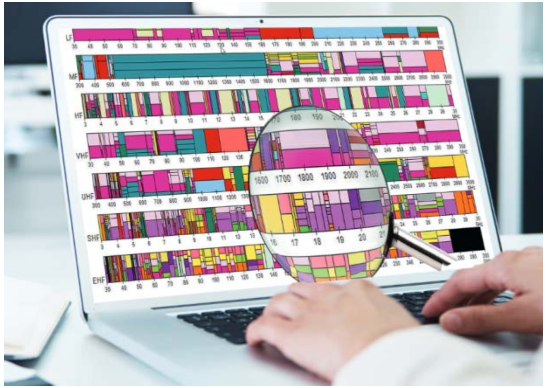


Colibrex
Smart Drone Solutions

Drone-ID Technologies under Consideration

- Proprietary RF-Module
  ☺ Independant from any public network, direct identification/pointing possible
  ☹ Not standardized protocoll, subject to free frequencies
- „Transponder“-like module, e.g. based on ADS-B Technology
  ☺ Could enable integration into aviation tools & flights into controlled airspace
  ☹ Relatively high costs, risk of saturation of controling networks
- GPS-Tracker connected via a 3G/4G-SIM-Module – in future 5G
  ☺ Easy to deploy (similar technologies used for ex. in fleet management)
  ☹ Availability of a continuous coverage not guaranteed ?
- GSM-U (Private network for UAS) based on LTE-M ?
  ☺ Dedicated network based on existing infrastructure
  ☹ Not standardized yet, future development
- IEEE802.11p … and some more proposals

Spectrum-related challenges represent a critical factor for a large-scaled deployment of drones – both in terms of safe operation and drone traffic management



- Drones are „radio stations in the sky“
- Drones being „flying (sometimes heavy) objects“, loss of communication / interferences / hacking can be critical
- Radio links typically used today are not always safe enough; the availability of proper links and number of channels is a question mark for a deployment of a large number of drones
- BVLOS applications and in general the integration of drones into a management / surveillance system request stable and secured long-range connectivity on dedicated frequencies... a real challenge for spectrum managers !

Thank you for your attention

Disclaimer

LS telcom Smart Spectrum Solutions