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Flexible Broadband Radio Communication for airborne disaster relief operation

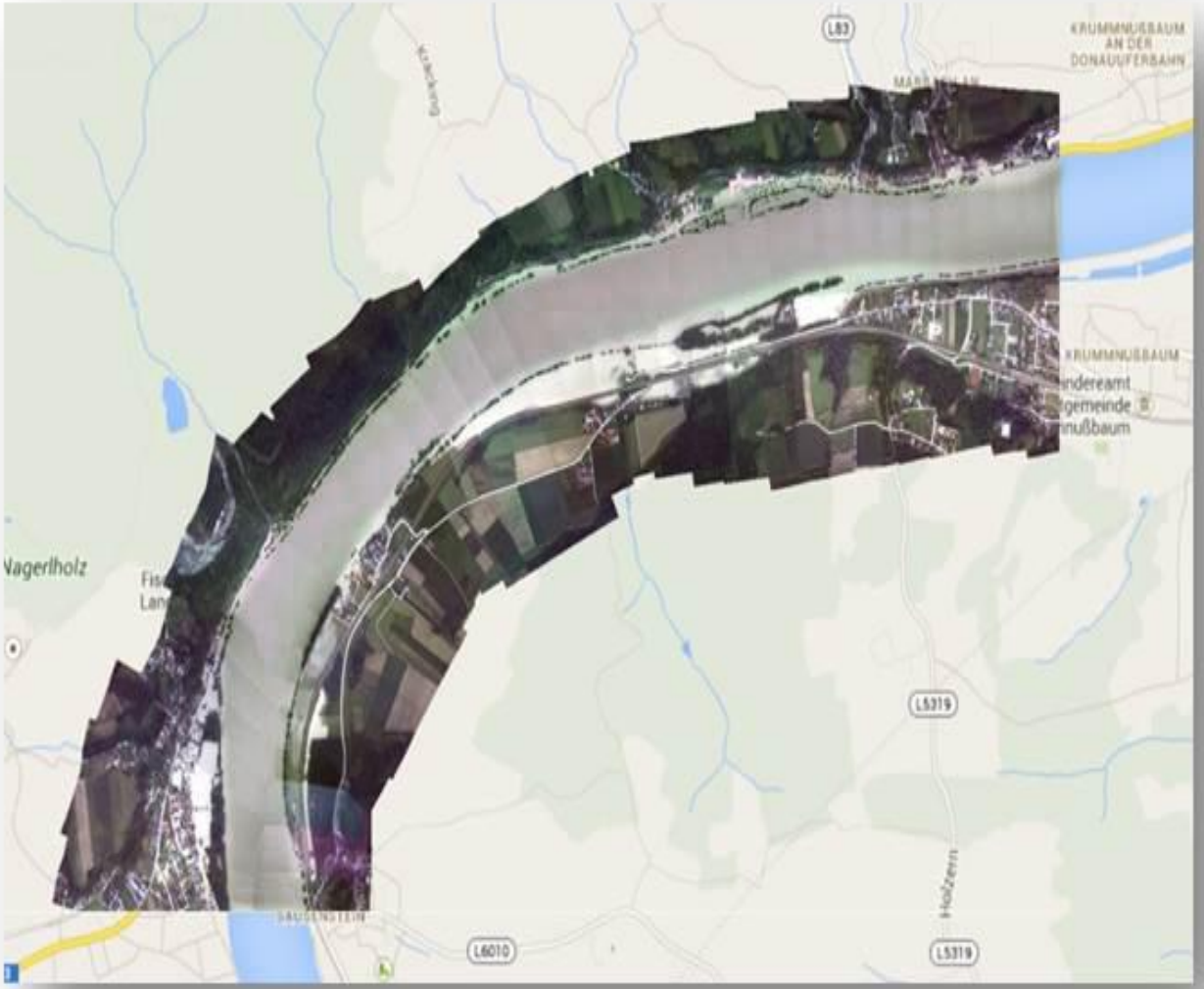
2015, PSCE conference, 27th and 28th May, Graz

Michael Schmidt

Motivation

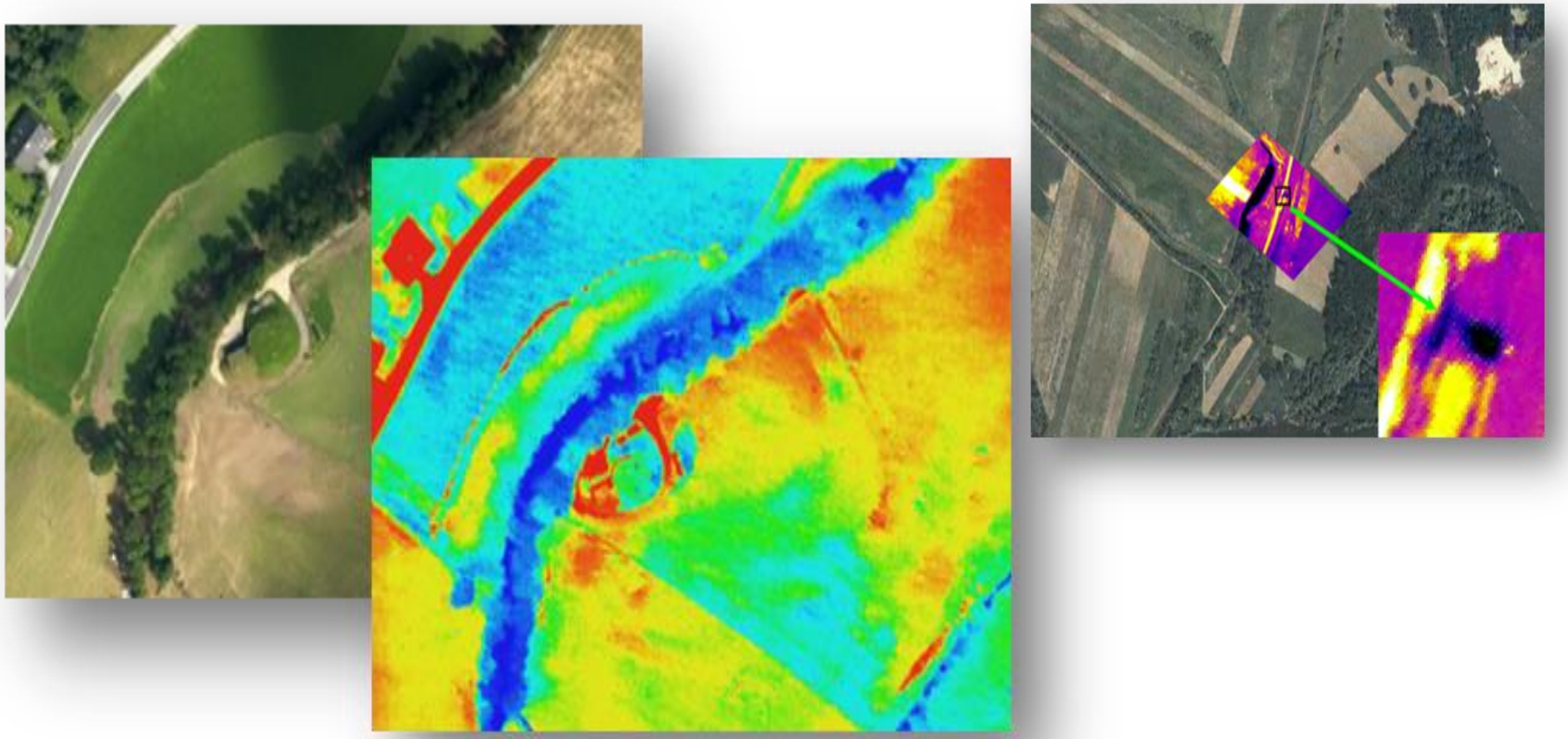
Near real time assessment of disaster areas with airborne sensor data

Geo-referenced information

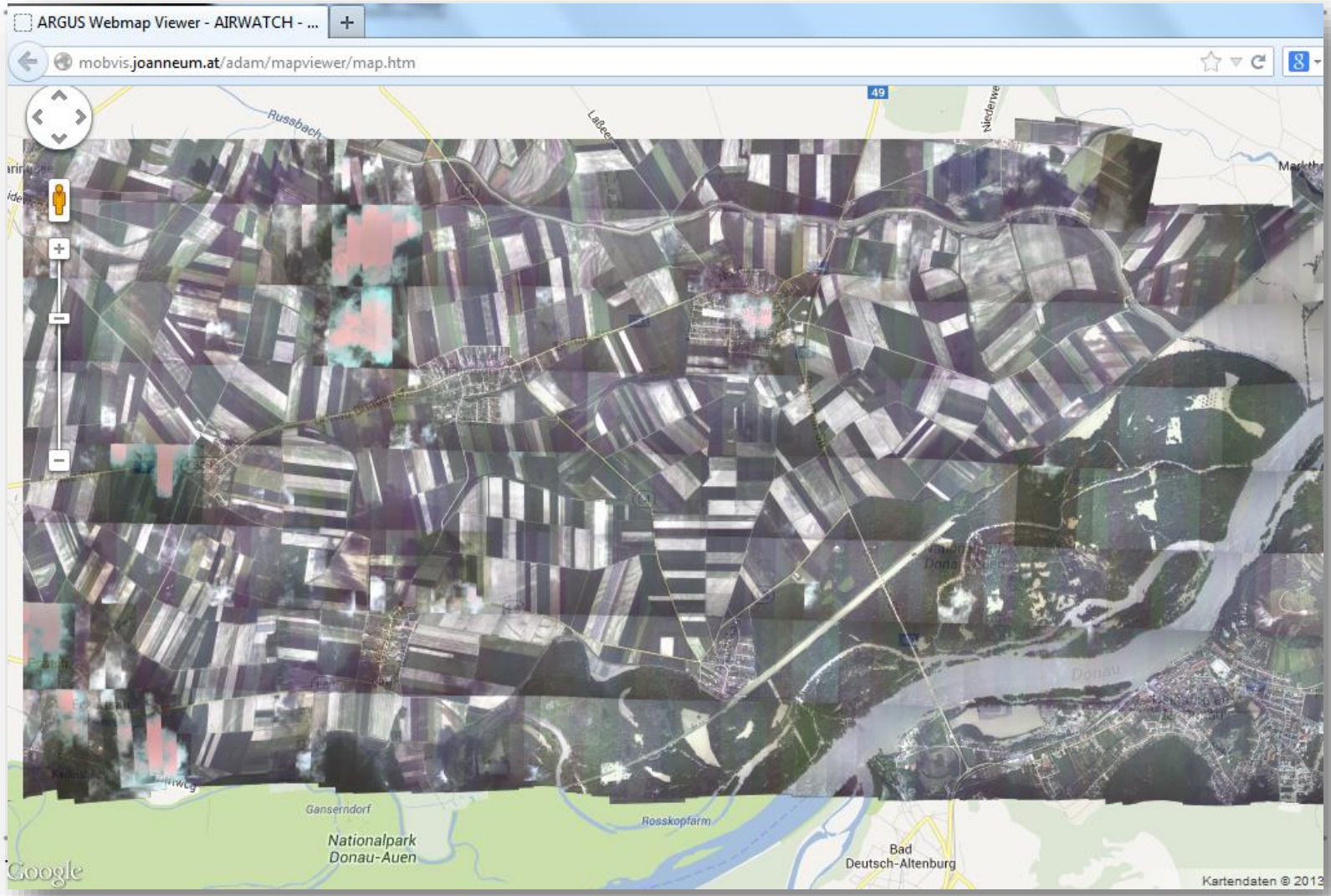


Sequence of 40 RGB images, superimposed on Google Earth

Multi Sensor



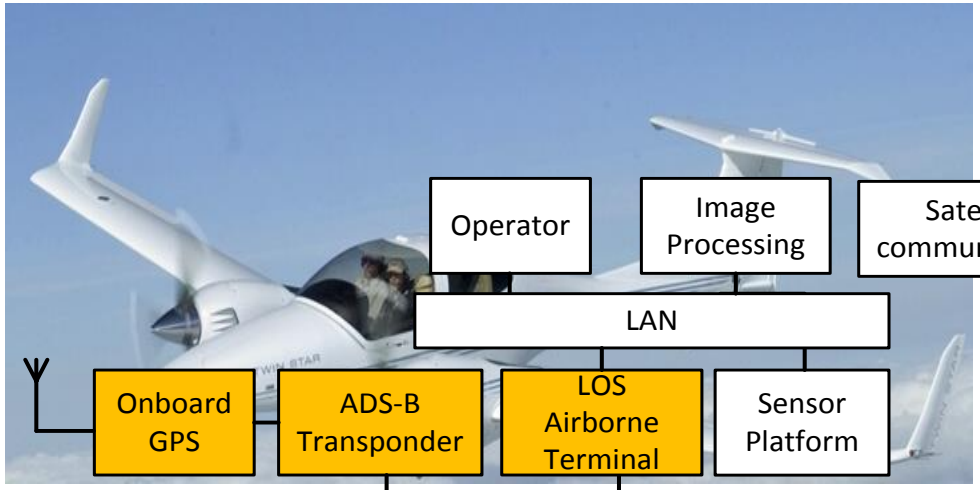
Wide coverage area



Additional Motivation

- Adaptive mission processing
- Cost effective solution
- Suitable for small planes

Architecture



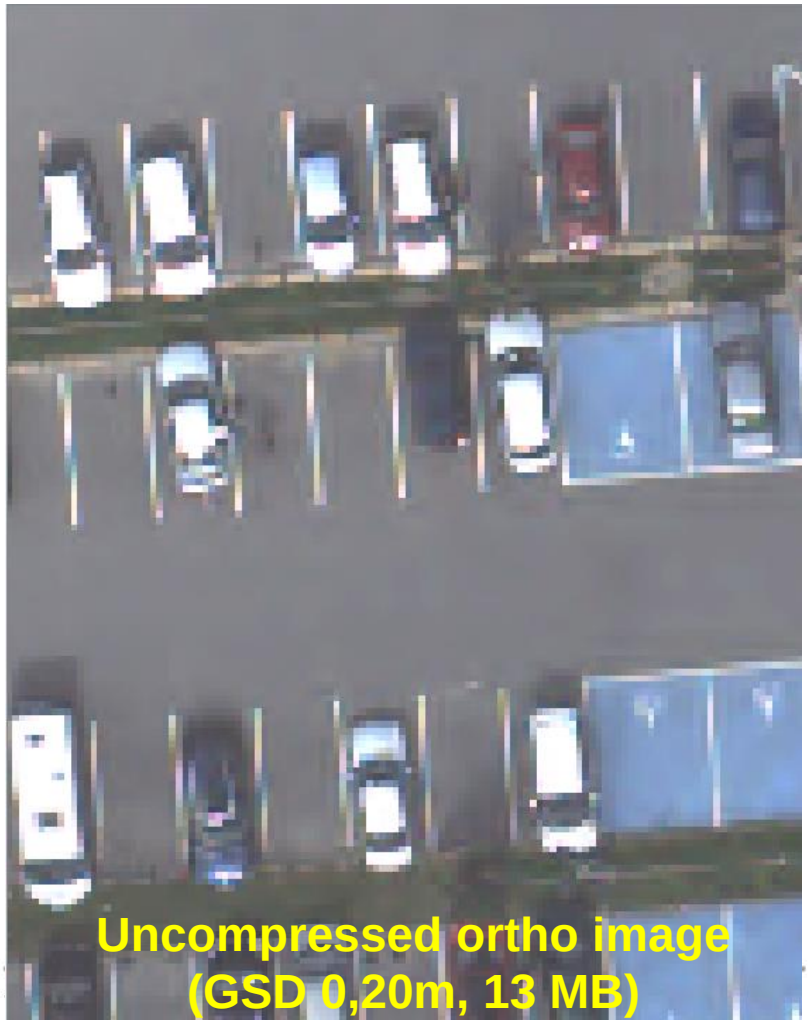
TOC

- Requirements
- Frequencies
- Access system
- Link budget
- Hardware solution
- Multi ground station
- Tracking system of the antenna
- Satellite link

Requirements

- Optical / thermal images with a ground resolution of 10cm/40cm, @700m
- Return link for: ACK, Monitoring and control of the on-board equipment and communication to the on board operator , < 500KBit/s
- compressed by a factor 10 to 30 results in up to 8 Mbit/s ; Images every 4 second

Un-compressed vs. Compressed Ortho Image



Uncompressed ortho image
(GSD 0,20m, 13 MB)

Compressed ortho image
(GSD 0,20m, 1,2 MB)

Requirements

- High frequency agility from 1,9 to 6 GHz because of different national regulations and license costs
- Range at > 30km with line of sight
- High spectral efficiency
- Small antenna and low weight for the airborne unit
- Bidirectional IP Interface
- Satellite link directly from the plane for wide coverage areas and fast response

- Requirements
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Frequencies

- High frequency agility from 1,9 to 6 GHz because of different national regulations and license costs
- 1900-1920 MHz and 2010- 2015MHz (CEPT)
- Other candidates: 2070-2110 MHz and
- 4400-4516 MHz
- 5080 MHz
- 5,8 GHz Japan

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Access System

- FDD: - two frequencies are necessary!

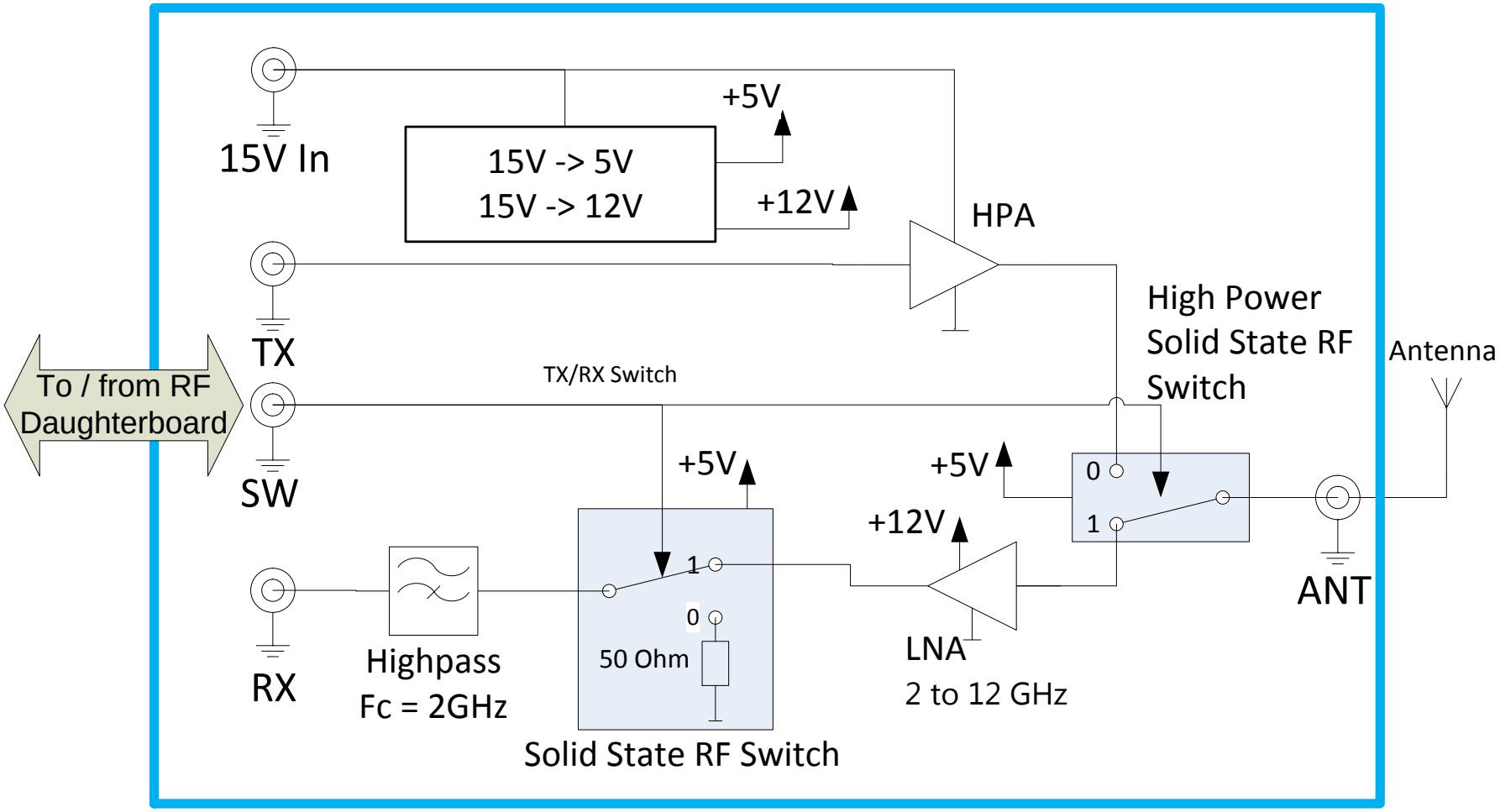
  + simple front end

- TDD: + single frequency !

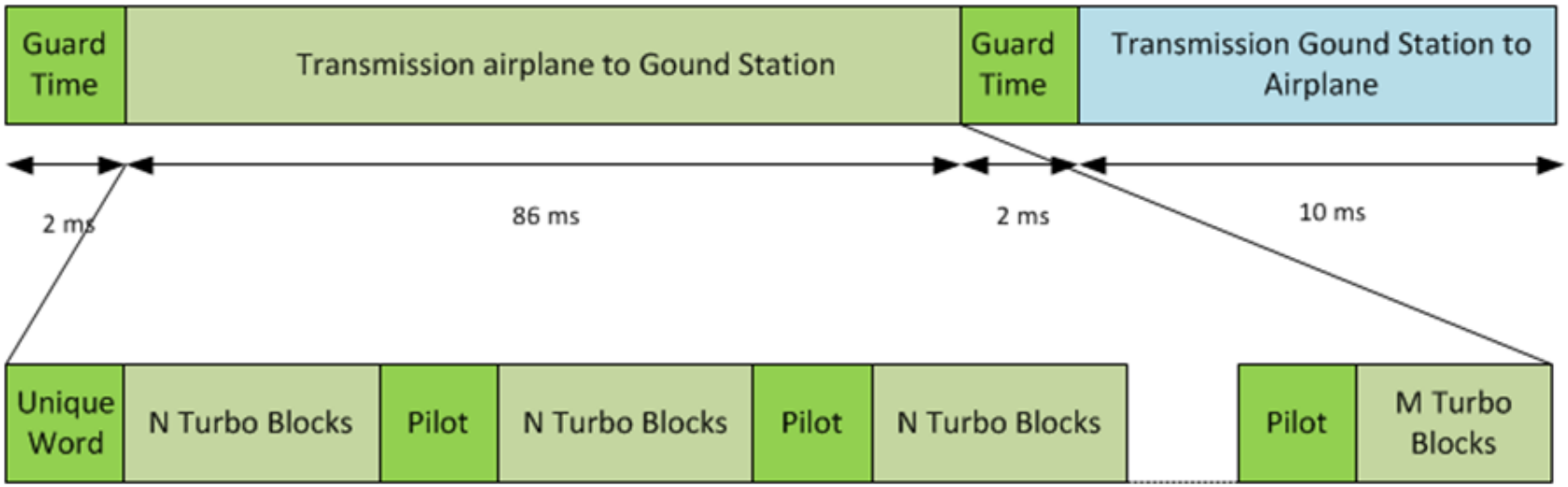
  + Up / downlink BW variable

  – circulator (difficult because of wide band demand); Switch required. (isolation!)

TDD front end



TDD framing structure



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Link Budget

Frequency	1,9 GHz to 6 GHz; Circular
3dB-Bandwidth	10,8 MHz
Channel filter roll-off	0,35
Duplexing	TDD
Modulation scheme	QPSK
Transmit Antenna Gain	0dB
Tx Power P1dB	31 dBm
FEC	Duo-binary Turbo code
Coderate	4/5
Margin	5,7dB
Rx Antenna Gain	24 dB
Maximum downlink data rate	8 Mbit/s
Maximum uplink data rate	0,5 Mbit/s
Maximum Distance	30 km

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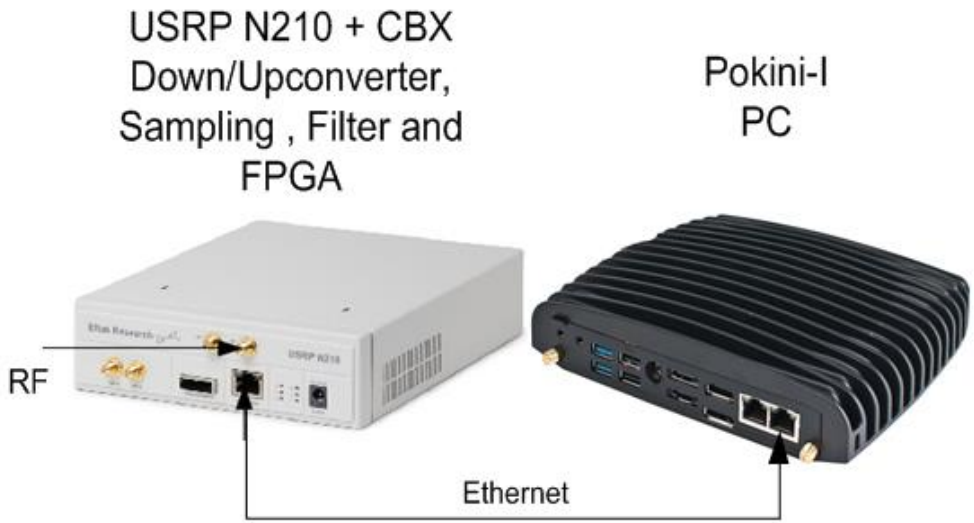
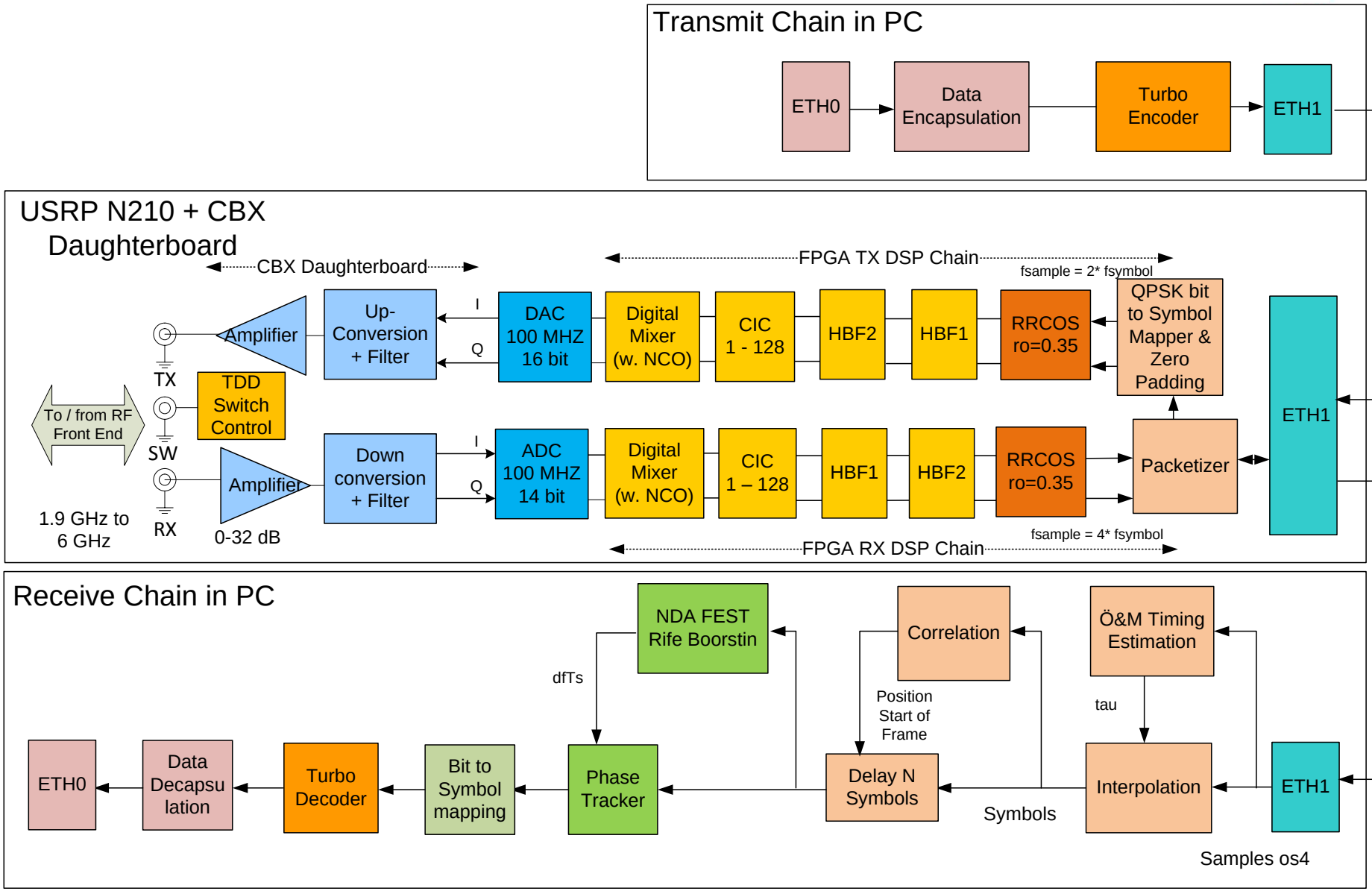
Hardware solution from Ethernet to RF




Transmit Chain in PC
ETH0
Data Encapsulation
Turbo Encoder
ETH1
USRP N210 + CBX Daughterboard
CBX Daughterboard
FPGA TX DSP Chain
fsample = 2* fsymbol
Amplifier
Up-Conversion + Filter
I
Q
DAC 100 MHZ 16 bit
Digital Mixer (w. NCO)
CIC 1 - 128
HBF2
HBF1
RRCOS ro=0.35
QPSK bit to Symbol Mapper & Zero Padding
ETH1
TX
TDD Switch Control
To / from RF Front End
SW
Amplifier
Down conversion + Filter
ADC 100 MHZ 14 bit
Digital Mixer (w. NCO)
CIC 1 – 128
HBF1
HBF2
RRCOS ro=0.35
Packetizer
1.9 GHz to 6 GHz
RX
0-32 dB
FPGA RX DSP Chain
fsample = 4* fsymbol
Receive Chain in PC
NDA FEST Rife Boorstin
Correlation
Ö&M Timing Estimation
dfTs
Position Start of Frame
tau
ETH0
Data Decapsulation
Turbo Decoder
Bit to Symbol mapping
Phase Tracker
Delay N Symbols
Symbols
Interpolation
ETH1
Samples os4

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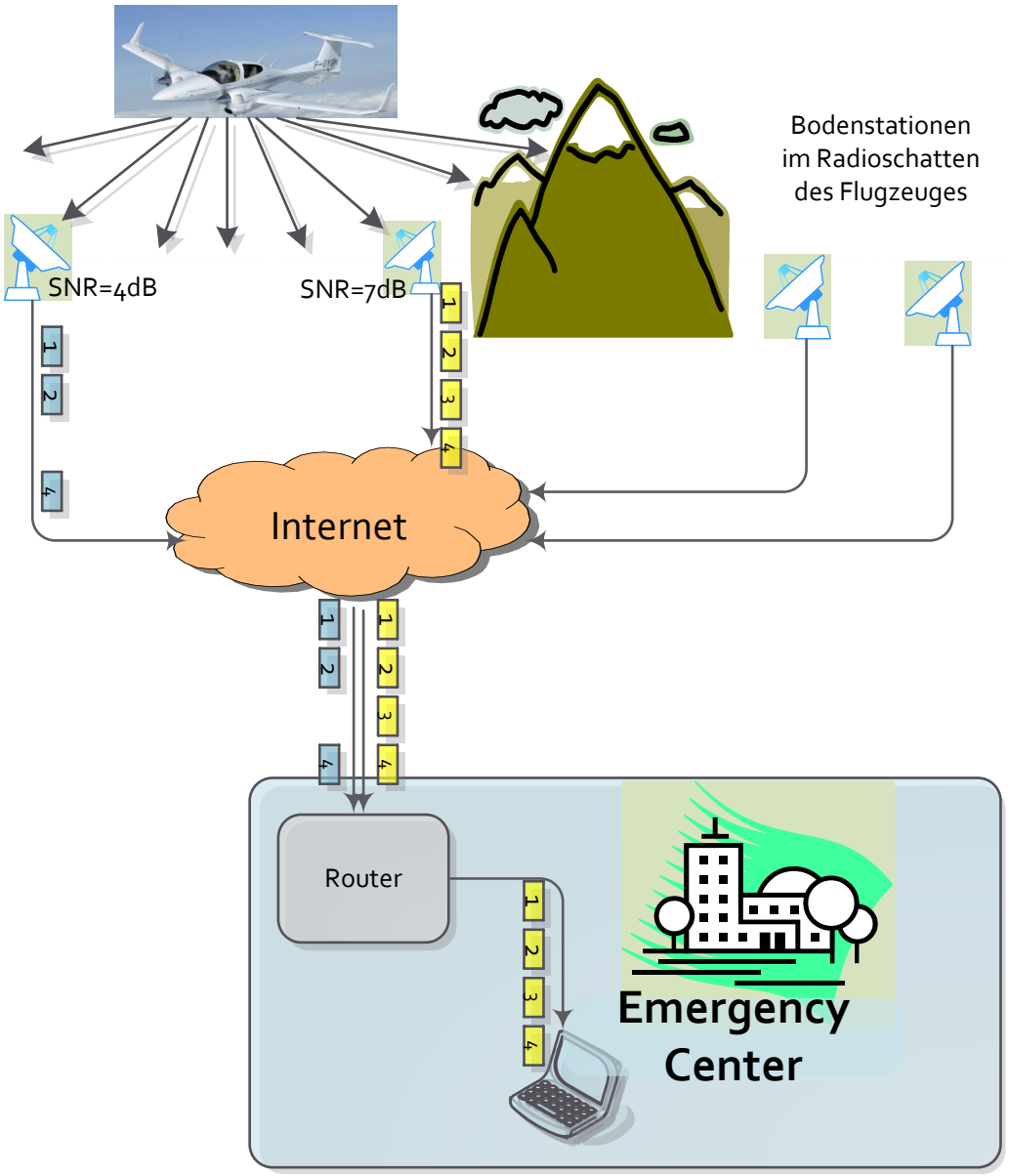
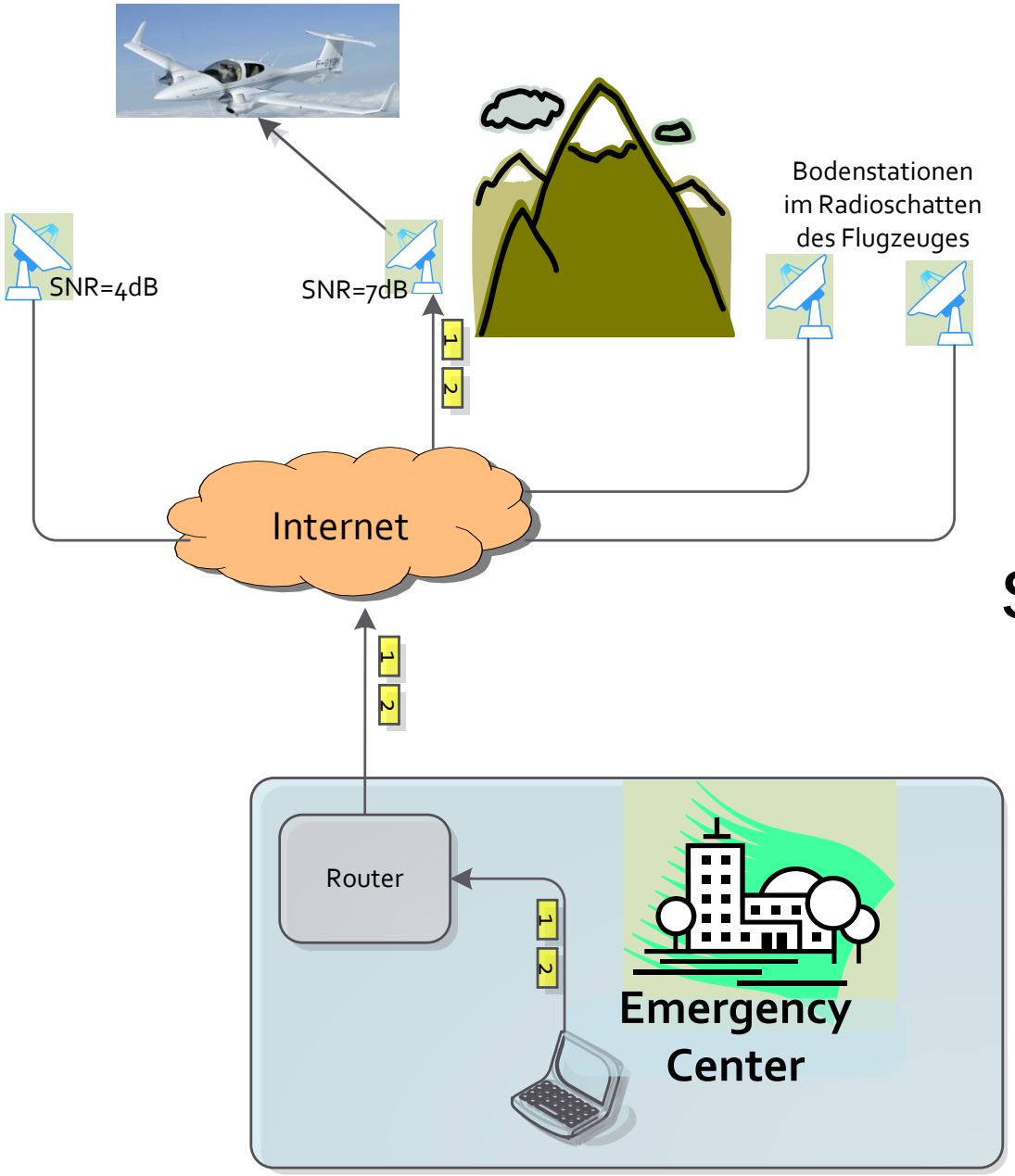


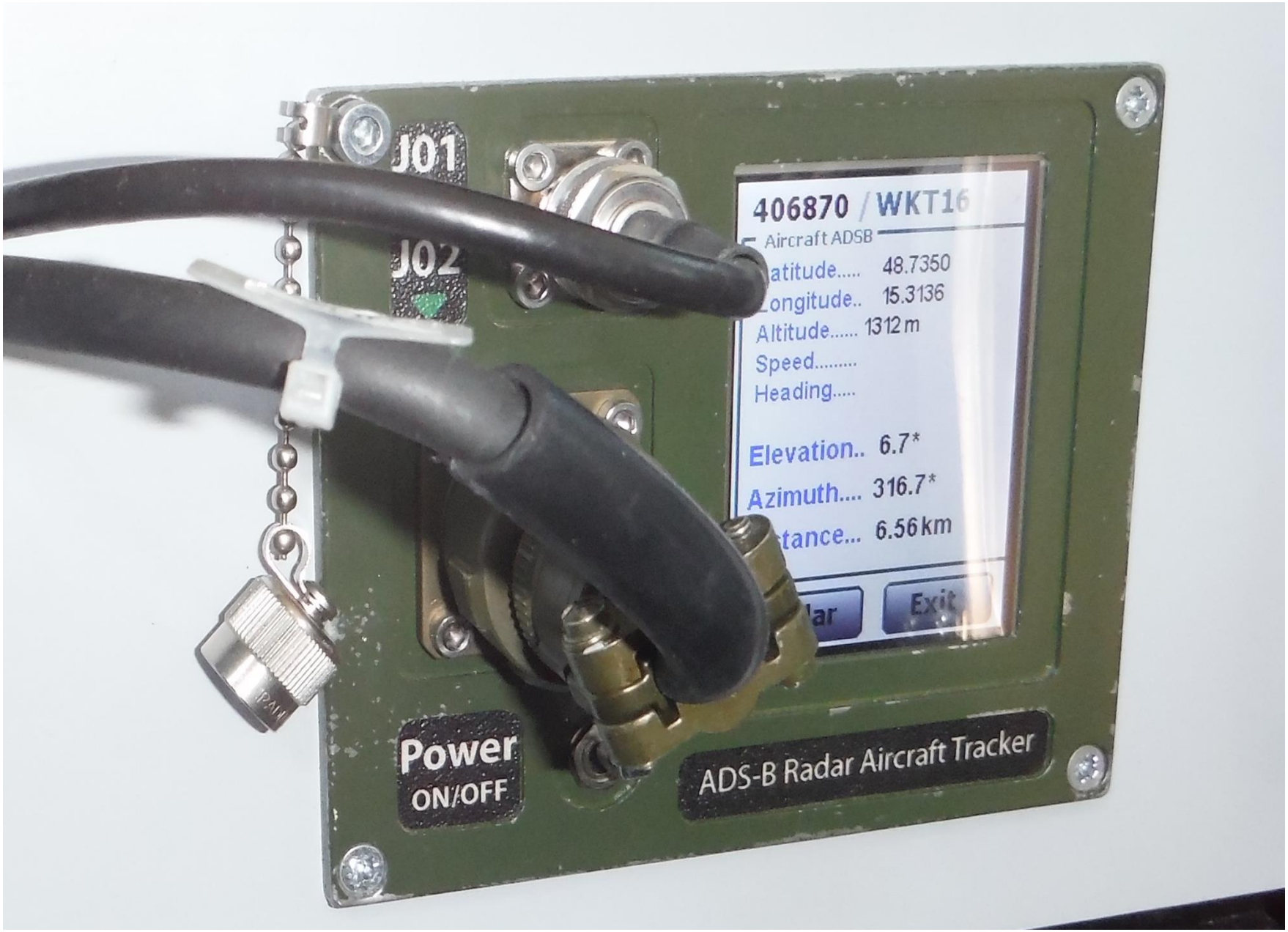
Multi ground station network: forward- link



Multi ground station network: return-link

Tracking System

- Mono-pulse is good but expensive and need first access information (telemetry channel)
- Step track is cheaper then Mono-pulse, less performance but need telemetry channel for first access
- Operation with telemetry channel only (broadcast)
- Using ADS-B information (1090MHz)


J01
J02
406870 / WKT16
Aircraft ADSB
atitude..... 48.7350
ongitude.. 15.3136
Altitude..... 1312 m
Speed.....
Heading.....
Elevation.. 6.7*
Azimuth.... 316.7*
tance... 6.56 km
Exit
Power
ON/OFF
ADS-B Radar Aircraft Tracker

Tracking Antenna

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Satellite connection

- Data-rate up to 1 Mbit/s from the plane to the Internet
- Return up to 4Mbit/s
- Integration in a DA42 was verified

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Summary

- Real time response for disaster management
- Integrated and tested a LOS link from a DA42
- Data-rates verified
- ASDS-B tracking works well
- Satellite link for wide area coverage implemented

The activity was supported by:

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Innovation and Technology

European Space Agency
IAP /ARTES20 Programm

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Thank you for your attention!