GSM Passive Coherent Location: Signal Processing and Applications

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Agenda

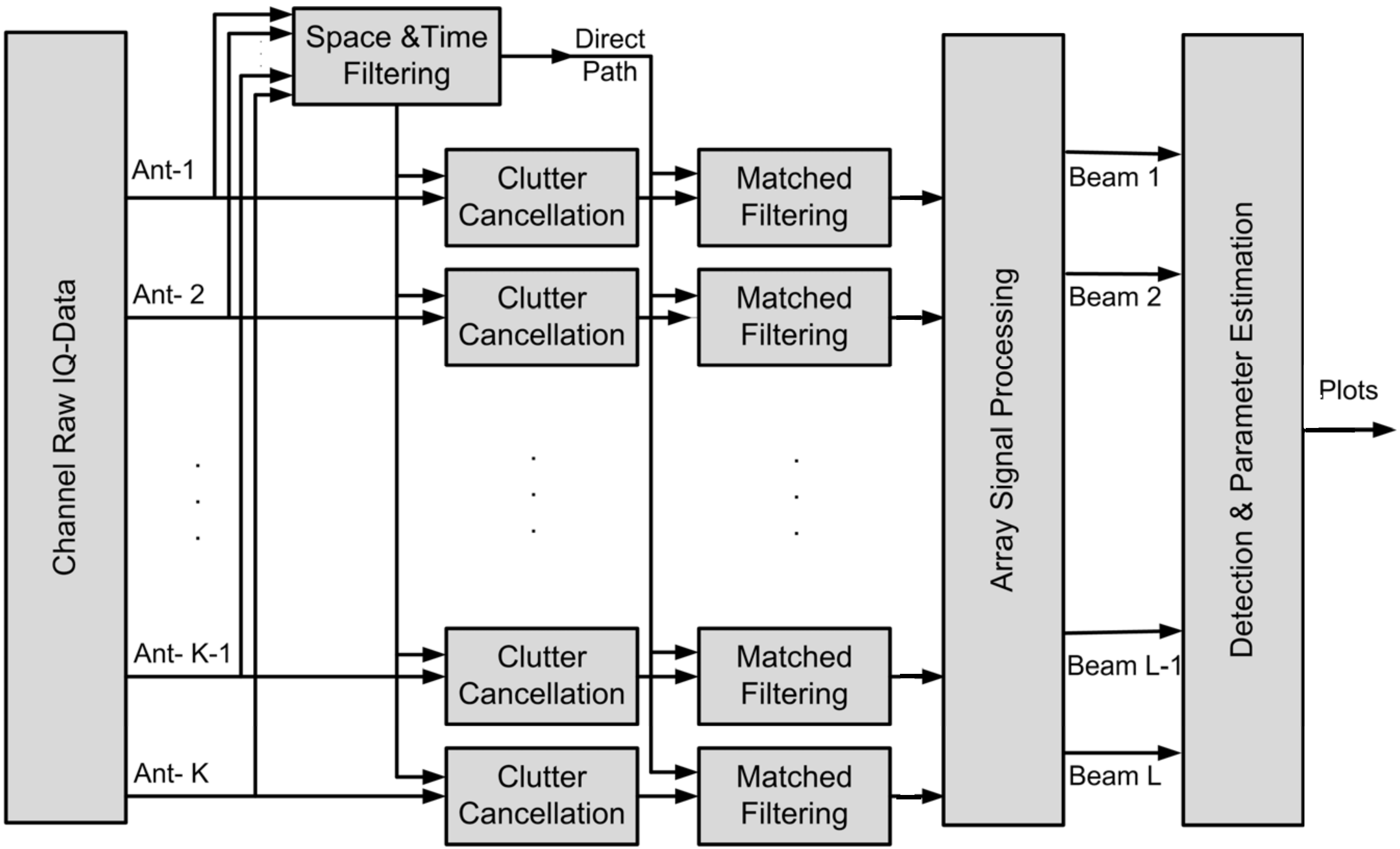
- Introduction
- Detection of Unmanned Areal Vehicles
- GSM-PCL on SDR-Platform: Real Time Capability
  - System Development
  - First Experiments
- Passive Radar for Increased Safety in Air Traffic
- Track-before-Detect for GSM-PCL
- Conclusions and Future Work

Introduction

GSM Passive Radar Demonstrator: GAMMA-2

- Two blocks of 8 Vivaldi elements
- Simultaneous and coherent reception of 16 analogue channels (20 MHz - 3 GHz, BW = 30 MHz)
- Digital data reduction and filtering (DDC)
- Up to 8 DDCs can be collected (BW = 200 kHz)
- Signal processing and tracking on hybrid CPU/GPU systems

Signal Processing Scheme in GAMMA-2

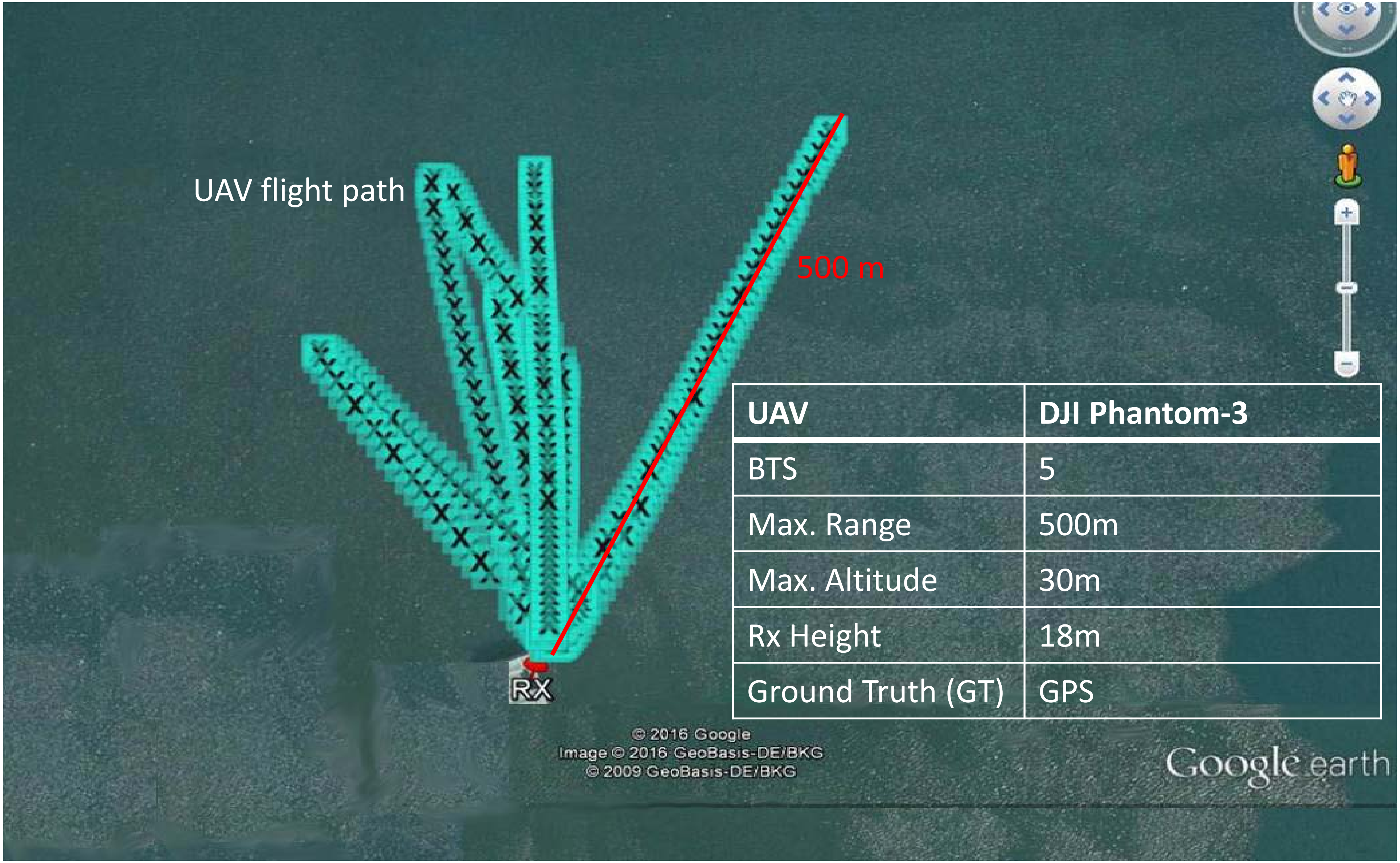


UAV-Detection

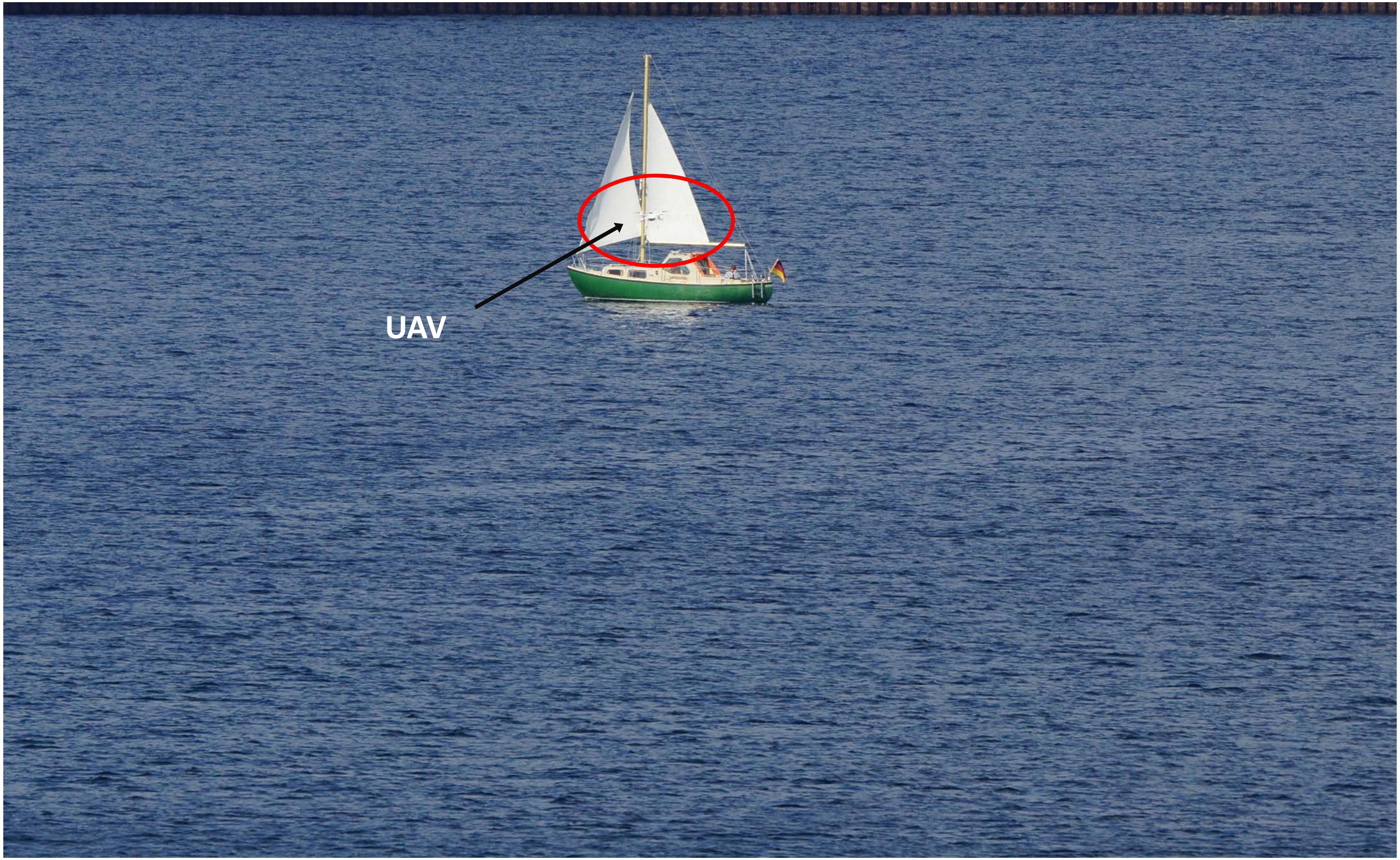
UAV-Detection: Motivation

- Technological progress and miniaturization of electronic components lead to small affordable consumer grade UAV (unmanned aerial vehicles)
- Widespread available UAV pose a possible threat
- Detection of these UAV is therefore of high interest

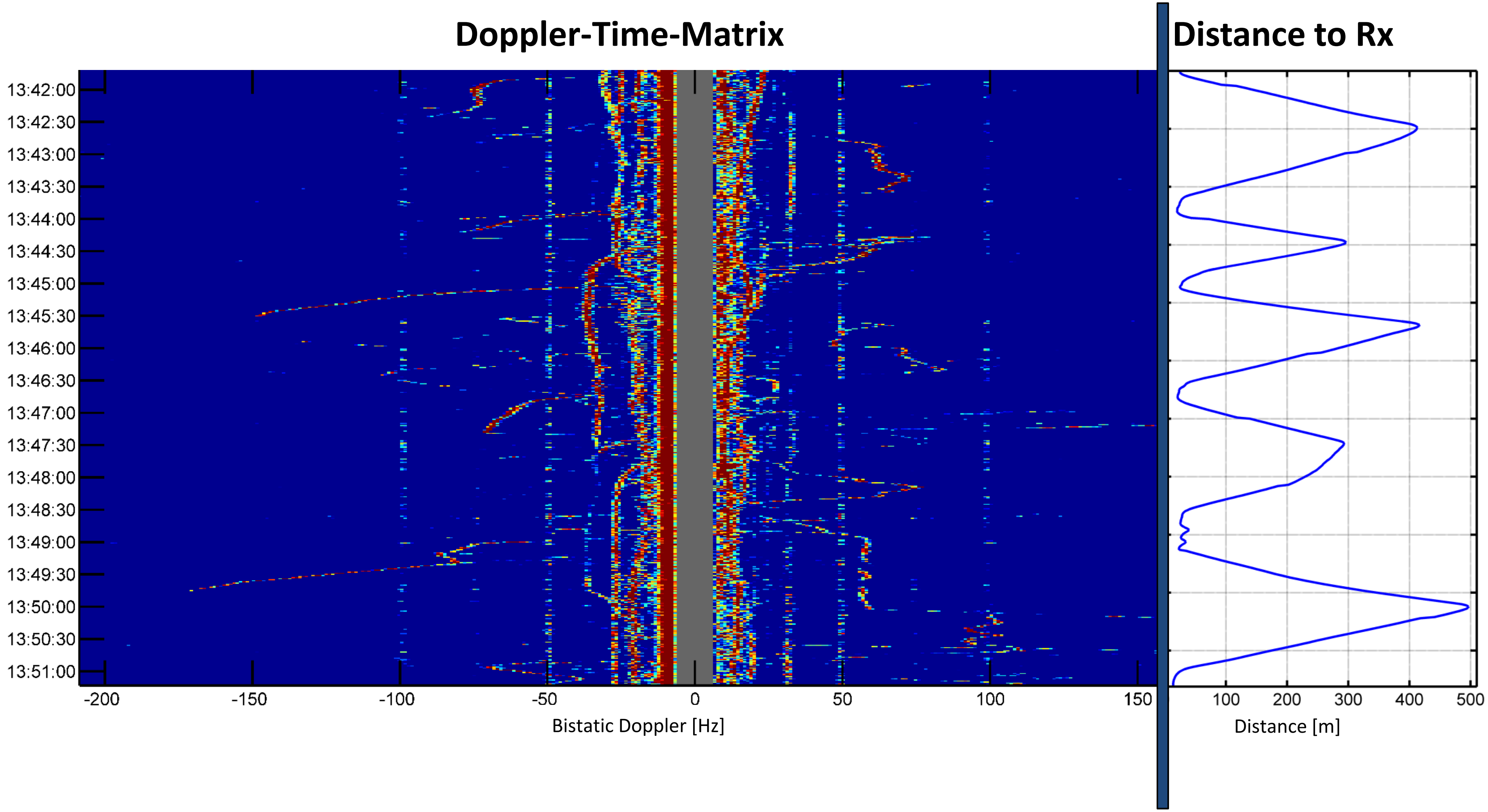
- Conduct and evaluate first experiments to examine if GSM based PCL could contribute to the detection of small consumer grade UAV



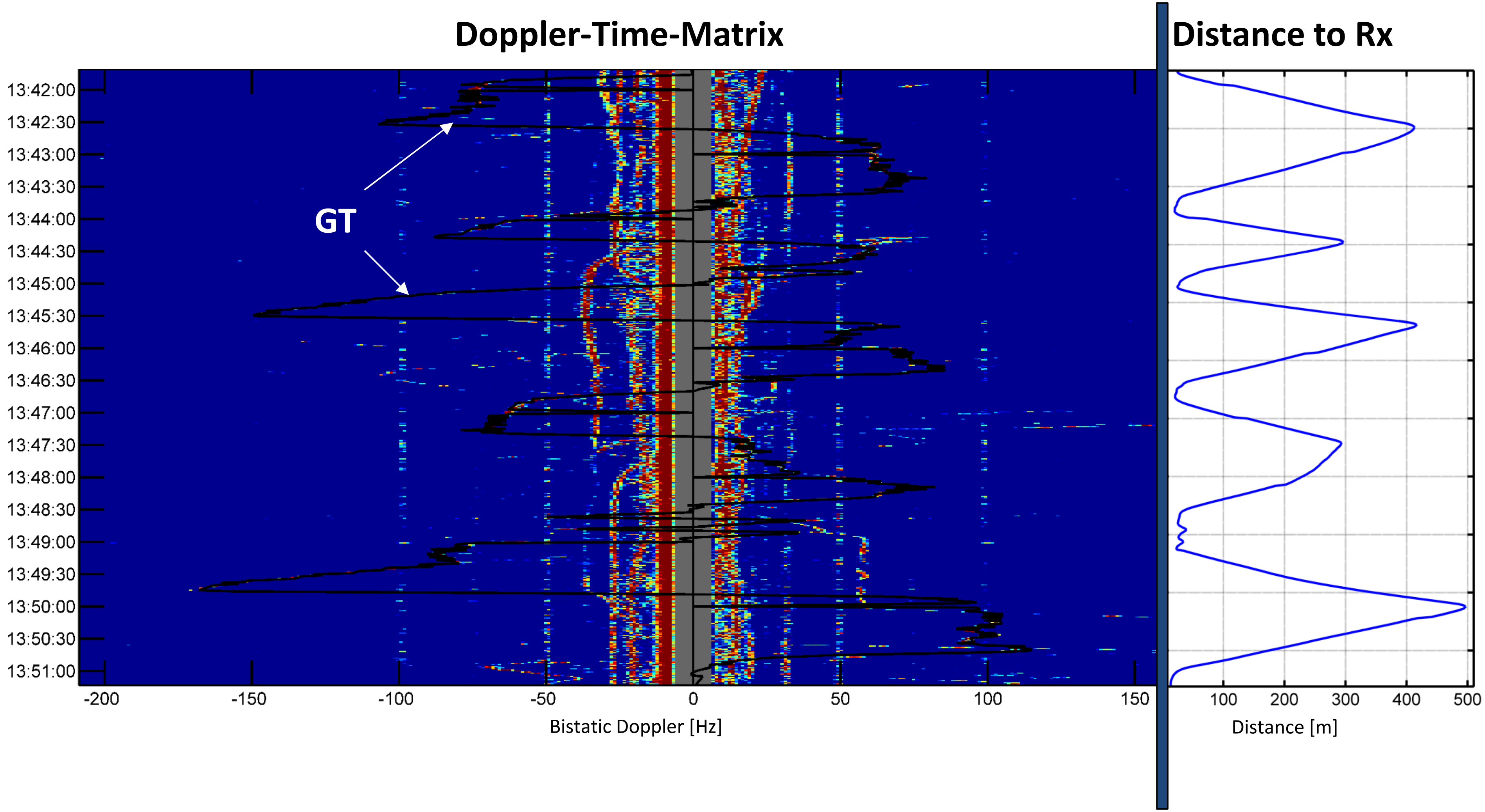
UAV	DJI Phantom-3
BTS	5
Max. Range	500m
Max. Altitude	30m
Rx Height	18m
Ground Truth (GT)	GPS


UAV

Experiment Results for BTS-3: No GT



Experiment Results for BTS-3: With GT



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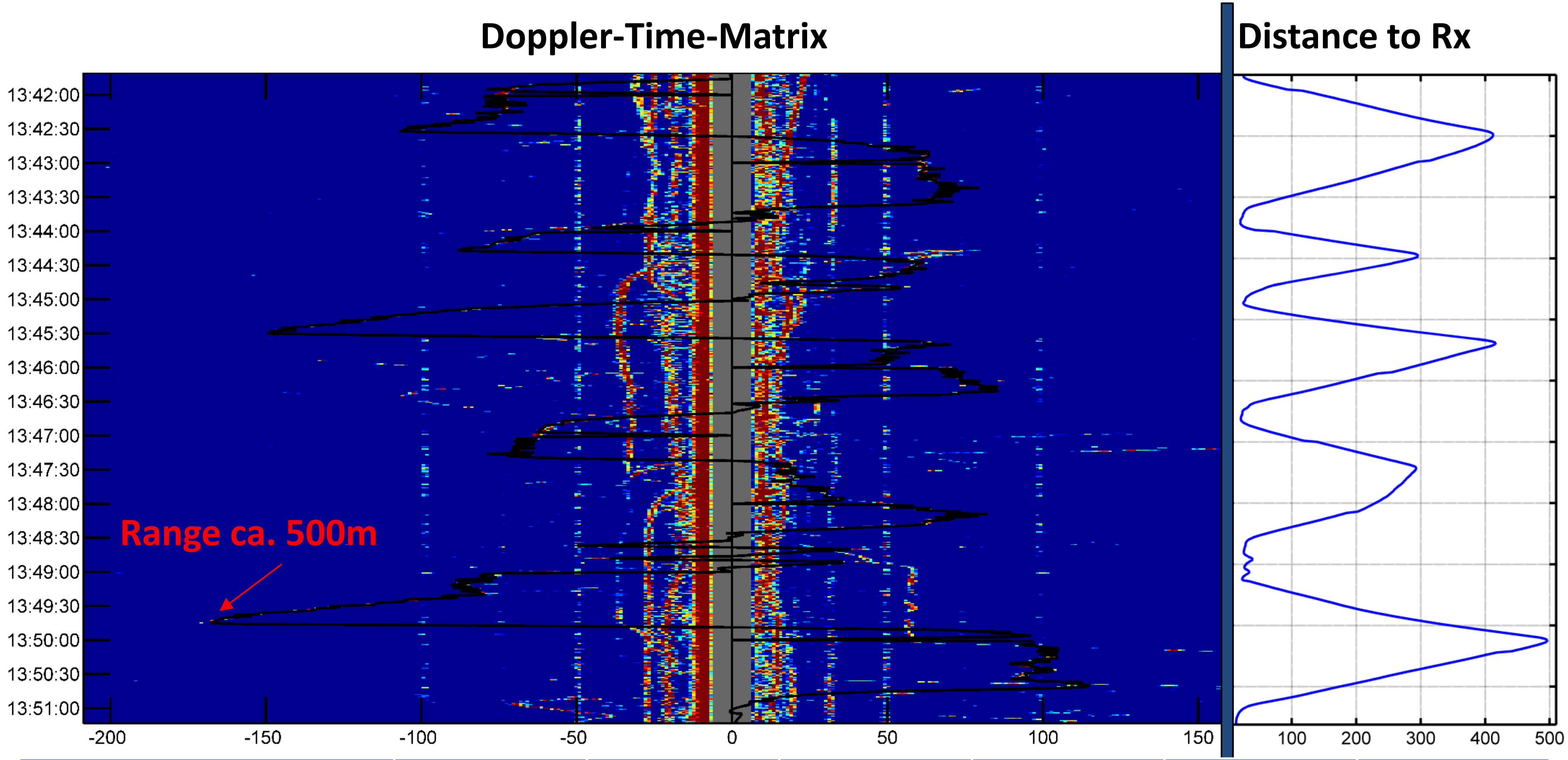
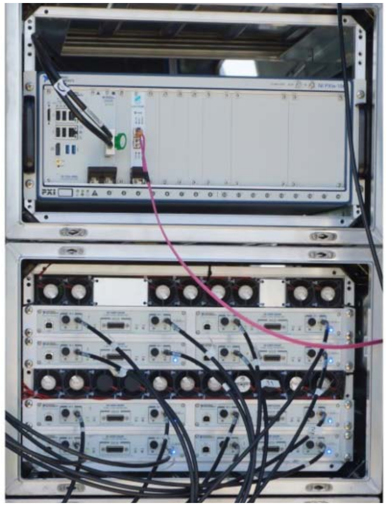


BTS	1	2	3	4	5	All
Tag Indicator [%]	30	17	70	49	65	85

GSM-PCL on SDR-Platform: real time capability

Fraunhofer FKIE

Phase-aligned SDR Receiver



SDR:

8 x NI USRP 2954

Controller:
NI PXIe-1085

Daughterboard
UBX

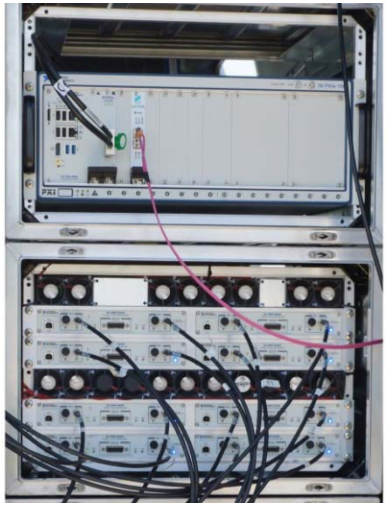
FPGA
Kintex 7-410T

Timing
OctoClock

Connection
CPS-8910

Streaming
ADQ10GBE

Phase-aligned SDR Receiver



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USRP - Universal Software Radio Peripheral

- NI USRP 2954 / Ettus x310 UBX Daughterboard

Daughterboard

- Frequncy range10 MHz to 6 GHz
- Bandwidth160 MHz
- Noise figure 5 dB to 7 dB
- Gain range 0 dB to 37.5 dB

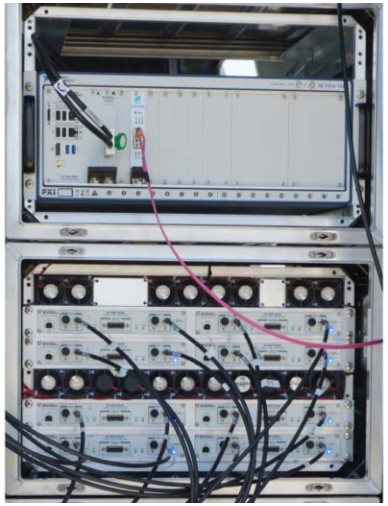
ADC

- Maximum I/Q sample rate 200 MS/s
- 14 bit Analog-to-digital converter (sFDR 88 dB)

FPGA

- Kintex 7 -410T
- Clock Rate 200 MHz
- Streaming Bandwidth per Channel (16-bit) 200 MS/s

Phase-aligned SDR Receiver



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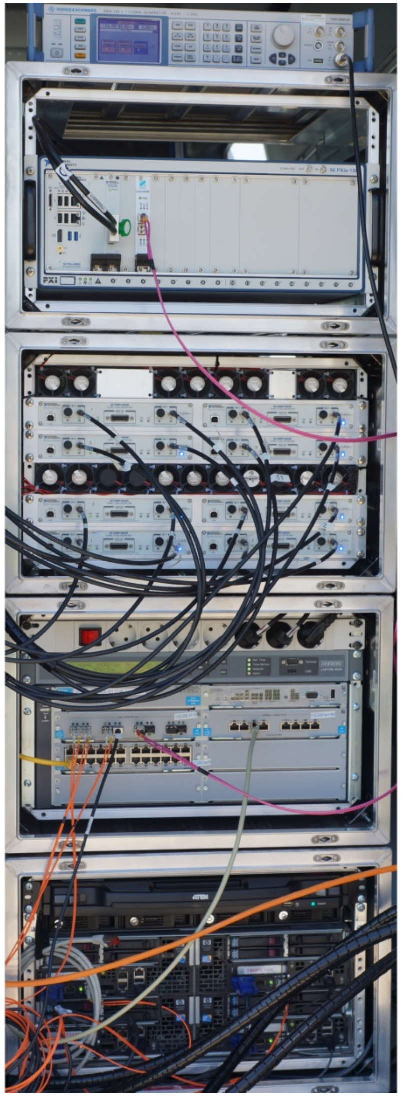
Phase-aligned SDR Receiver: Multi USRP System



Controller

- NI PXIe-1085 (12 GB/s Systembandbreite)
- NI PXIe-8880 Embedded-Controller
- NI PXIe-8384 2. Generation MXI-E-x8-Interface
- SD Devices ADQ10GBE PXIe 10 Gigabit Ethernet

Timing

- OctoClock-G
- 8-Way 10 MHz and PPS Distribution
- Frequency Accuracy <1 ppb
- PPS Accuracy 50 ns

Interface

- CPS-8910
- Upstream ports One Gen 2 x8 PCI Express
- Downstream ports Eight Gen 1 PCI Express x4

Phase-aligned SDR Receiver

Daughterboard
- LNA
- Direct Conversion
- Quadrature demodulation

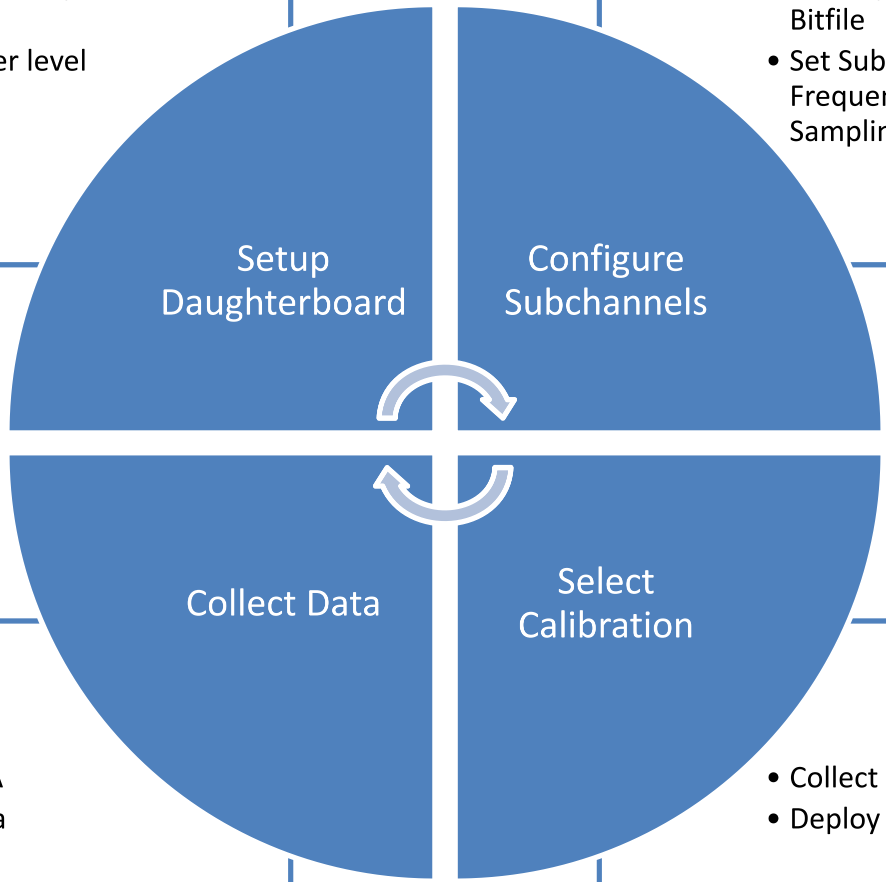
FPGA
- Impairment correction
- Subband extraction
- Calibration

Host Controller
- DMA FIFO
- Streaming 10 Gbe

Phase-aligned SDR Receiver

- Access Frequency range
- Adjust power level

- Select prebuild FPGA Bitfile
- Set Subchannels Frequency and Samplingrate



Reconfigure Receiver at any Time

- Frequencyrange
- Number of Subchannels
- Bandwidth of Subchannels
- Calibration Scheme

- Invoke DMA
- Stream Data

- Collect Data
- Deploy on FPGA

Outlook: Use FPGA GPIO for RF Switches to select antenna Input (Back to back Antennas or suited for different Frequency range)

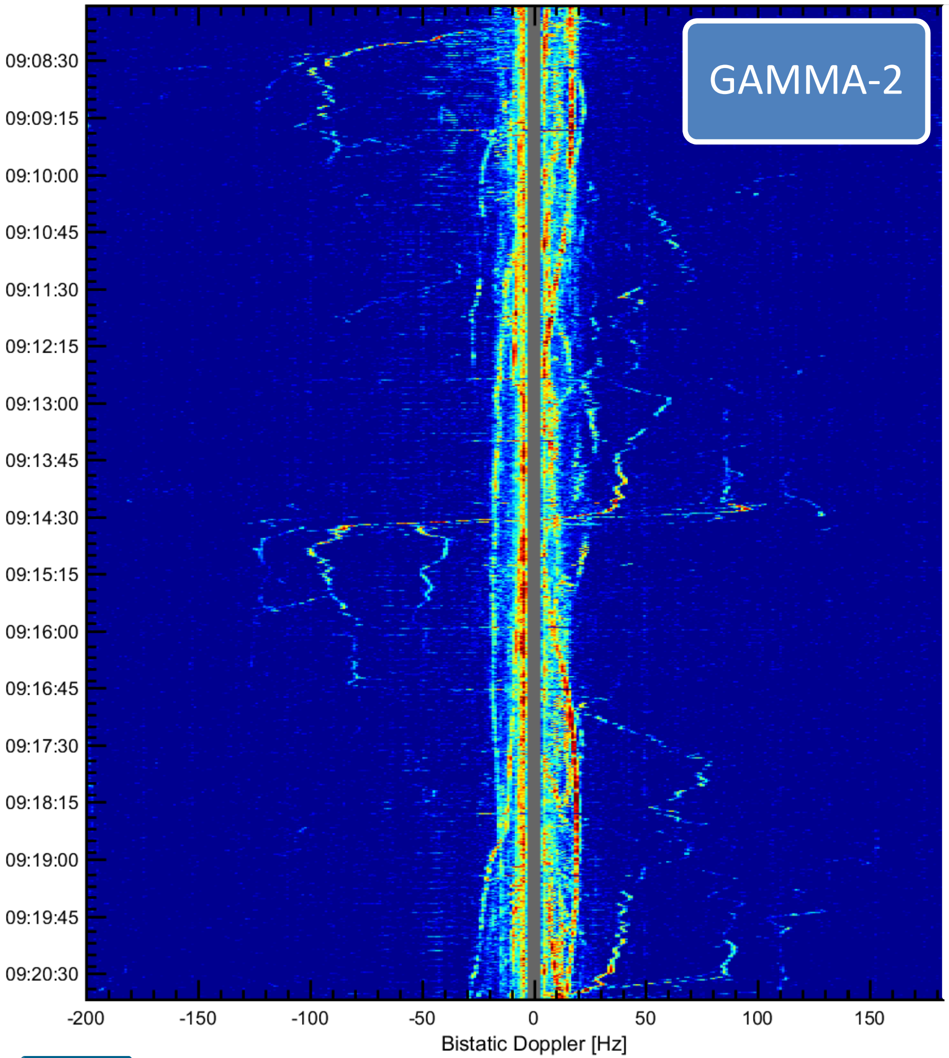
First experimental validation of SDR based PCL system

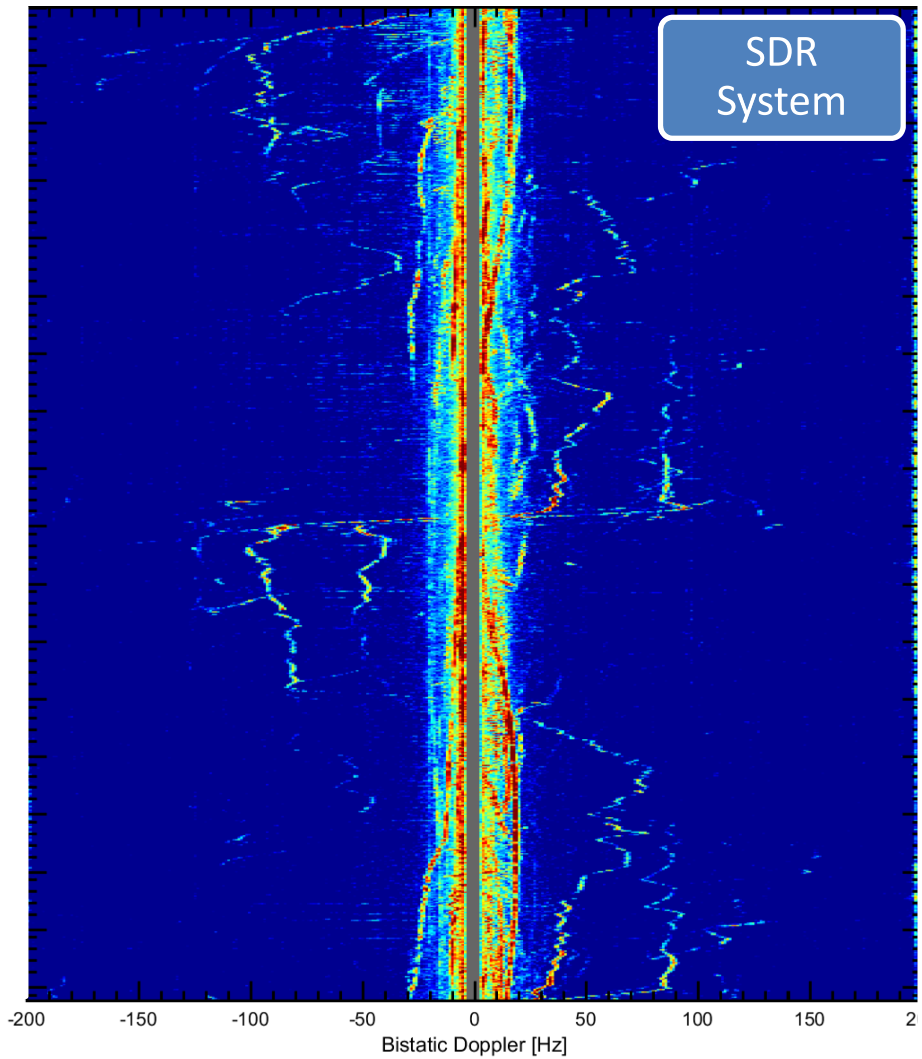
- Conduct experiments in a coastal region
- 2 cooperative small boats provide GT
- 6 illuminating GSM BTS
- Divide 16 element ULA into two 8 element ULA to operate both systems simultaneously
- Compare systems using Doppler-Time-Matrix of signal processing results

GAMMA-2

SDR System

First experimental validation of SDR based PCL system: Time-Doppler-Matrix of BTS 5 for both systems





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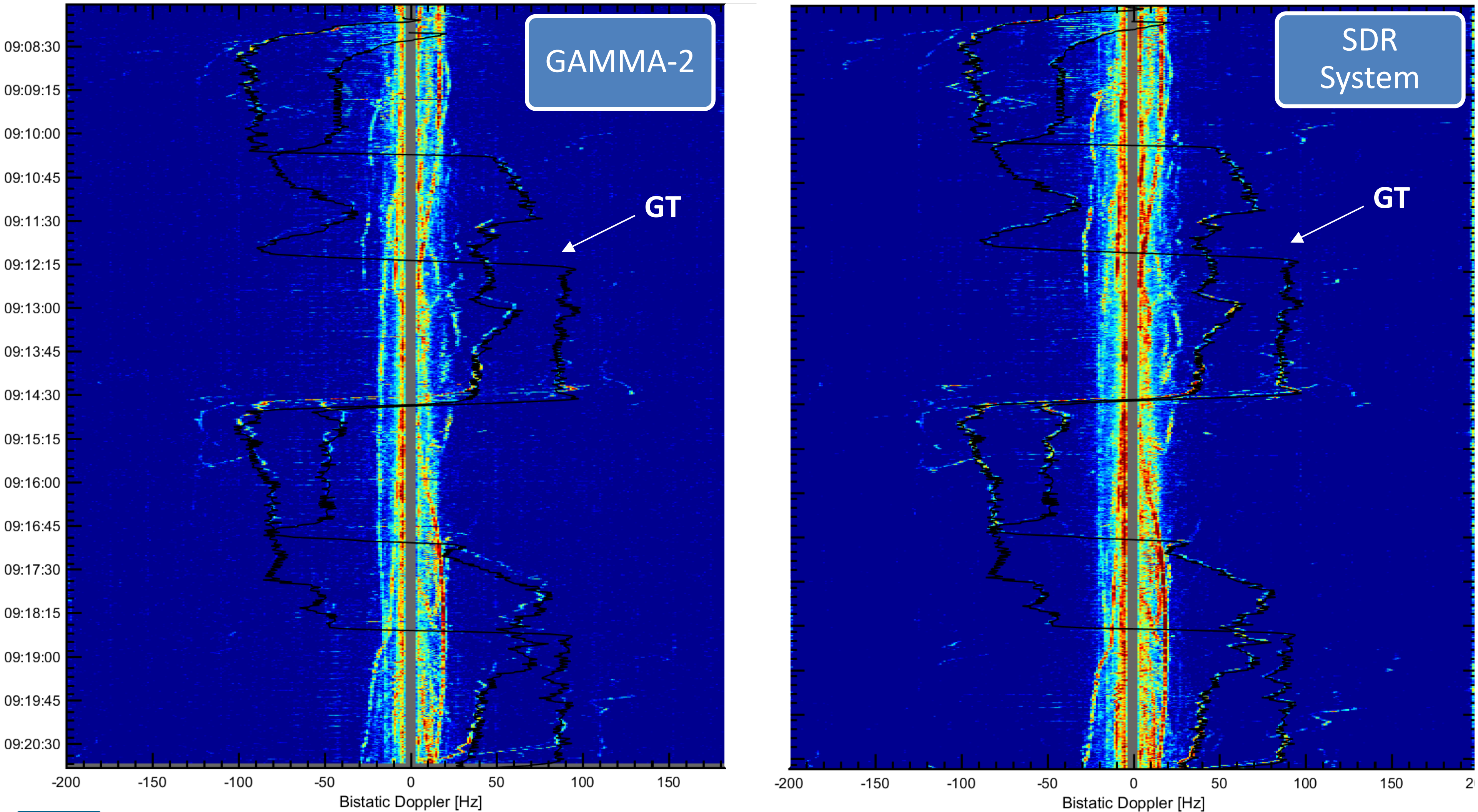


Passive Radar for Increased Safety in Air Traffic

DFS Deutsche Flugsicherung

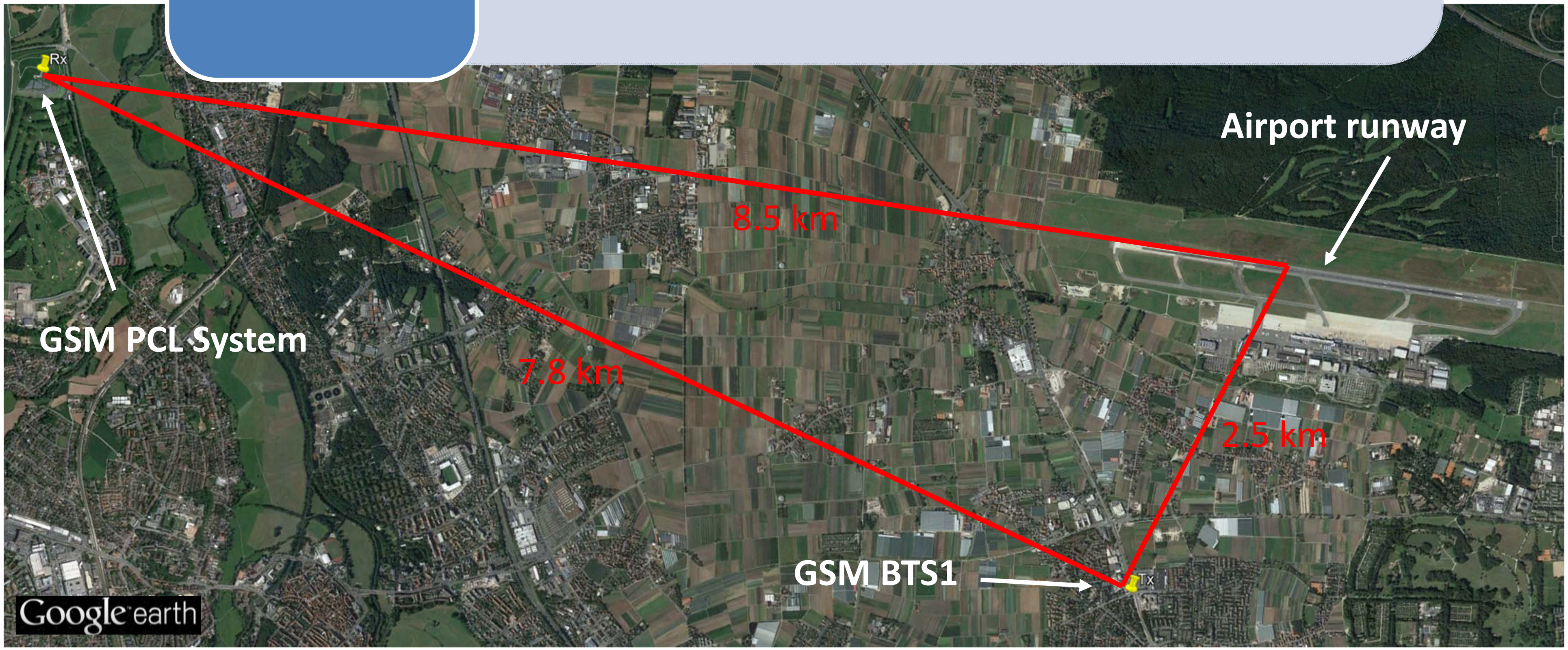
HENSOLDT Detect and Protect.

Fraunhofer FHR

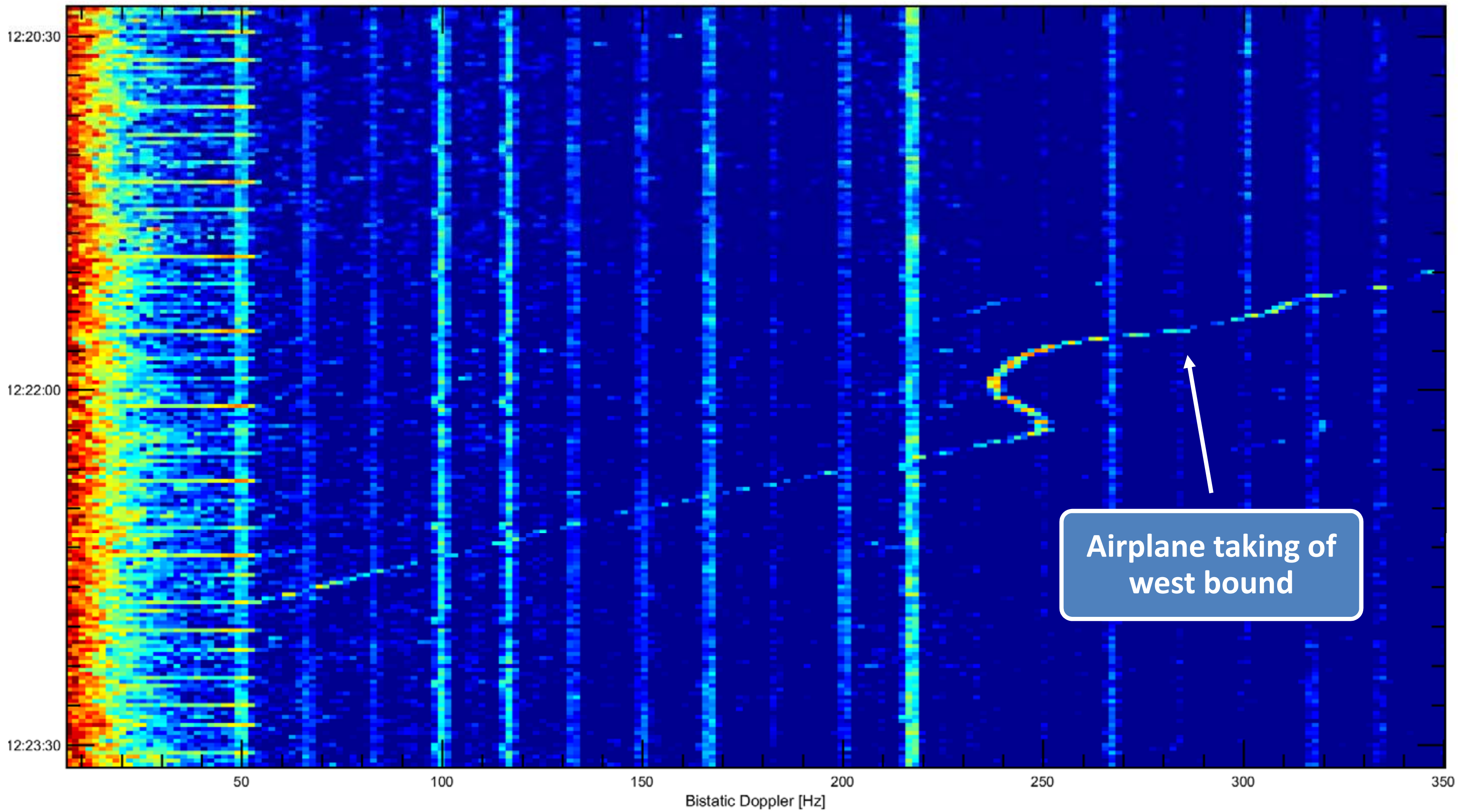
Fraunhofer FKIE

Passive Radar for Increased Safety in Air Traffic

- Experiments in area surrounding Nuremberg Airport
- Two PCL systems using DVB-T(2) (Hensoldt, Fraunhofer FHR)
- One PCL system using GSM (Fraunhofer FKIE)
- Central fusion of signal processing results for target tracking



Passive Radar for Increased Safety in Air Traffic: Time-Doppler-Matrix of BTS 1



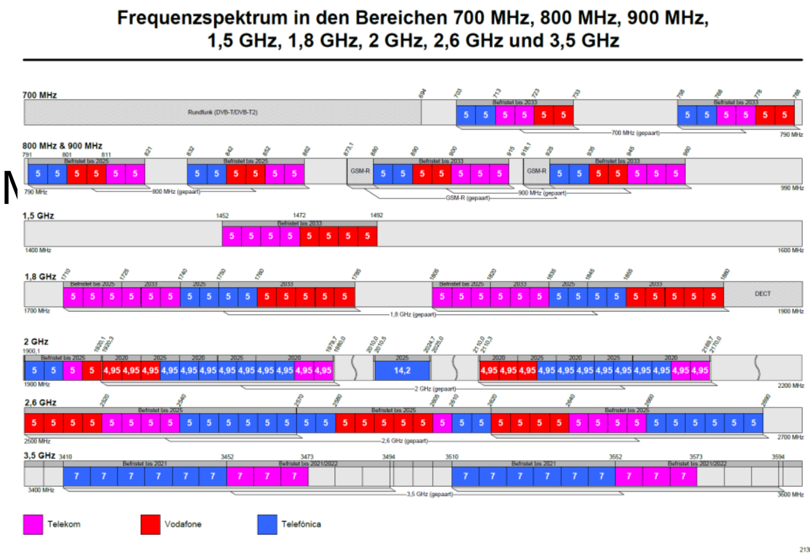
Conclusions and Future Work

Conclusions and Future Work

- Successful detection of agile UAV with GSM based PCL
- Development of a SDR-Based GSM-PCL for real time applications
- Passive Radar for Increased Safety in Air Traffic
- Investigation of TbD-Methods for GSM-PCL: Weak target detection

Phase-aligned SDR Receiver

- Mobile Communication Germany
- 703 – 733 / 758 -788 → 30 MHz
- 791 – 821 / 832 – 862 → 30 MHz
- (873,1)880 – 915 (918,1)925 – 960 → (GSM-R 41,9) 35 MHz
- 1452 – 1492 → 40 MHz
- 1710 – 1785 / 1805 – 1880 → 75 MHz
- 1900,1 – 1920,1 → 20 MHz
- 1920,3 – 1979,7 / 2110,3 2169,7 → 59,4M
- 2010,5 – 2024,7 → 14,2 MHz
- 2500 – 2570 / 2620 – 2690 → 70 MHz
- 2570 – 2620 → 50 MHz
- 3410 – 3494 / 3510 – 3594 → 84 MHz



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