Development of radar systems for UAS

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Overview

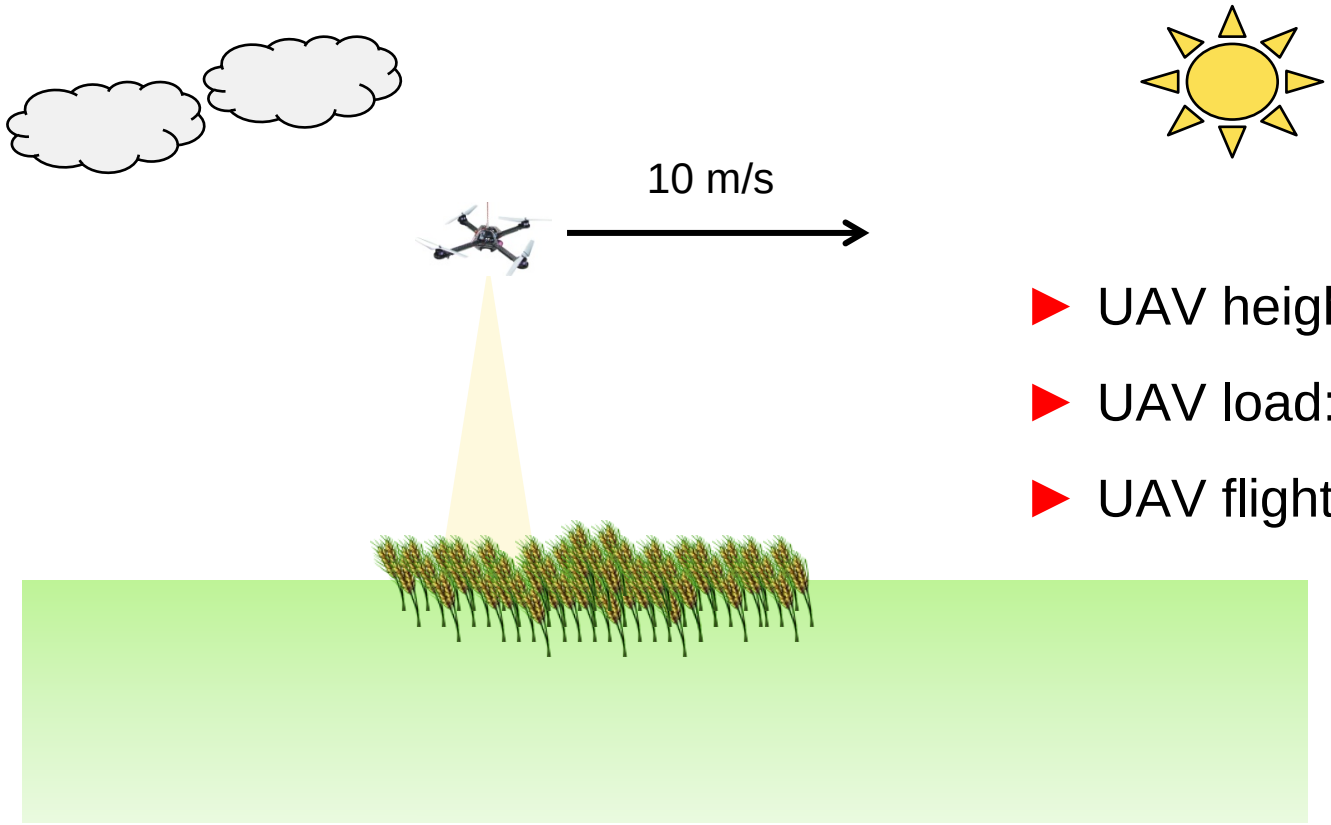
- Flight mission objectives
- Polarimetric soil characterization
- 3D (SAR) radar

Flight mission objectives

- Added value of radar
  - Largely independent of daylight, weather etc.
  - Diffraction, reflection: See „through“ things, e.g. plants
  - System works without calibration, „ready-to-go“
  - Small, light modules that can be integrated with other sensors

Flight mission objectives

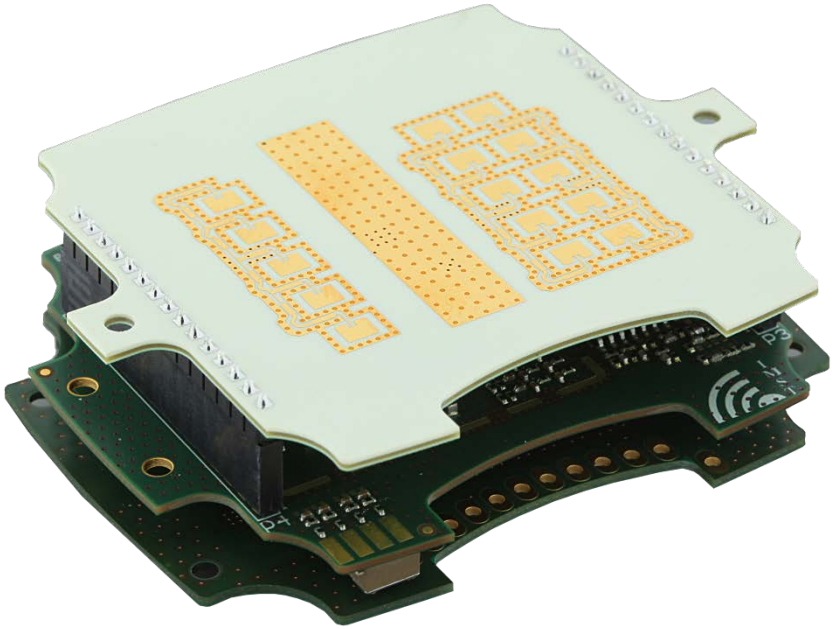
- Typical flight mission



- UAV height: 25 m
- UAV load: < 1 kg
- UAV flight time: 20 min

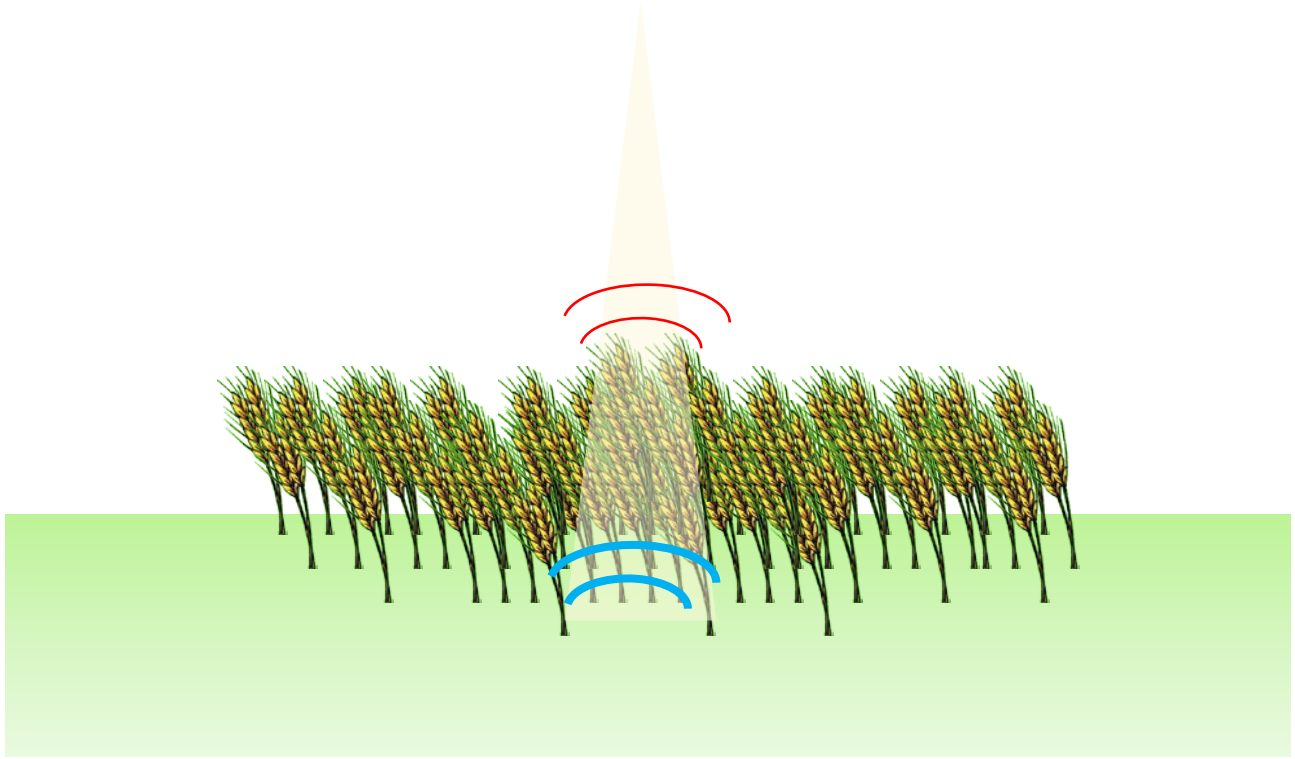
Flight mission objectives

- Plant height estimation
  - Use IMST‘s 2-channel radar
  - Reflection from plant top
  - Reflection from soil



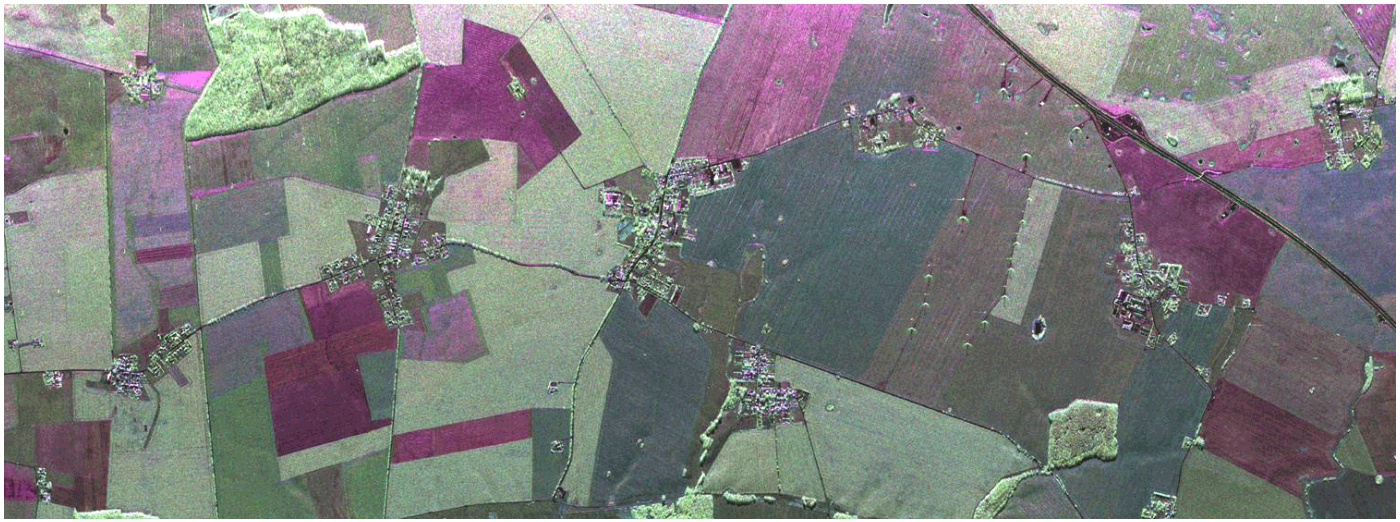
Flight mission objectives

- Plant height estimation



Flight mission objectives

- Polarimetry
  - Well known from satellite systems
  - Characteristic for types of vegetation
  - Can we transfer this to small RPAS?



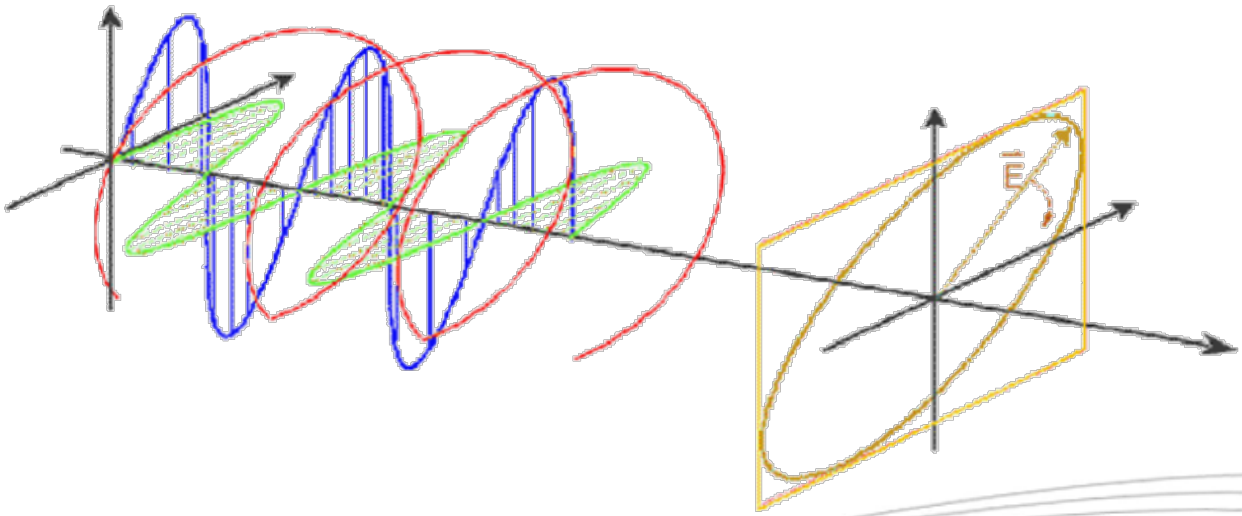
Source: DLR

Flight mission objectives

- What is the challenge for a radar system?
  - Greatest difference to optical system: Pixel size
  - Radar antenna opening angle is one of the most important parameters for flight missions on small RPAS
  - Typical values: 30 deg to 60 deg
  - Smaller opening angles → antenna gets too large or too heavy
  - Use multichannel data to decrease pixel size
- Smart Inspectors objective: Create an 8 channel radar capable of SAR processing

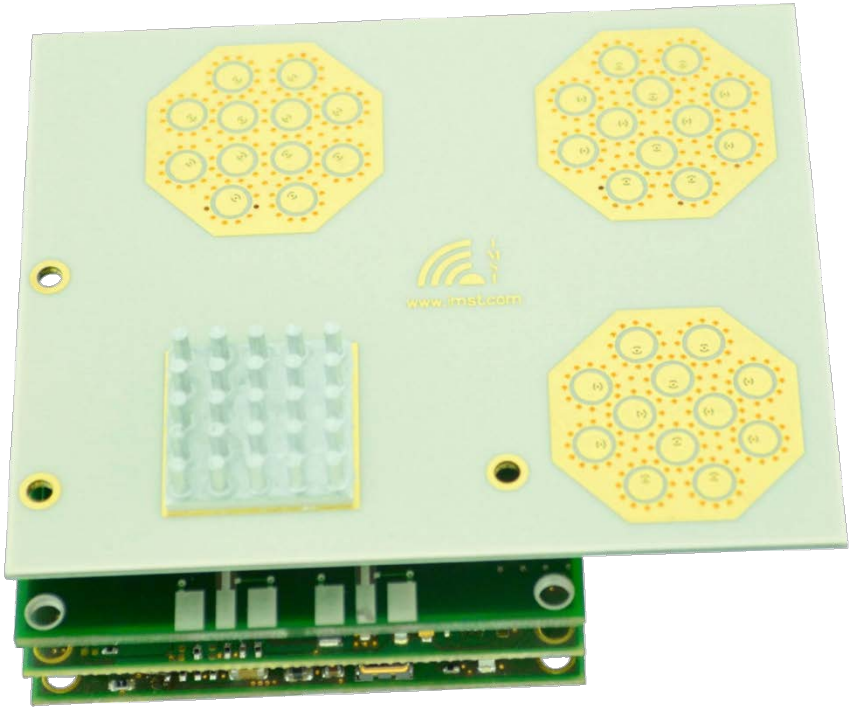
Polarimetrical characterization

- Electric field is approximated as a planar wave
- Travels in z-Direction
- On each xy plane along the z-axis, the field will cause an electric force
- This direction (over time) is called polarization



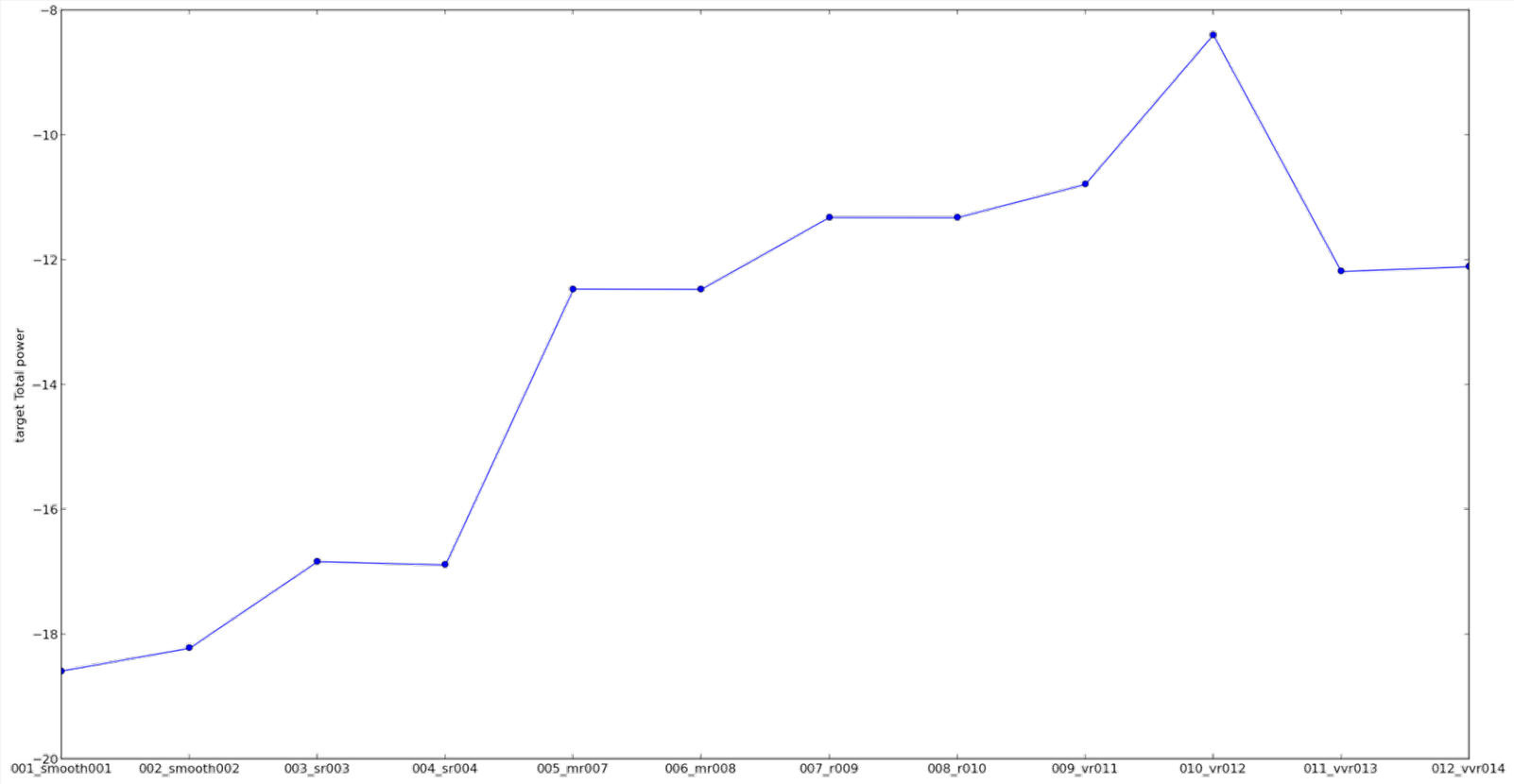
Polarimetrical characterization

- Creating a polarimetry radar
  - Send in right-hand circular polarization, receive in right- and left-hand



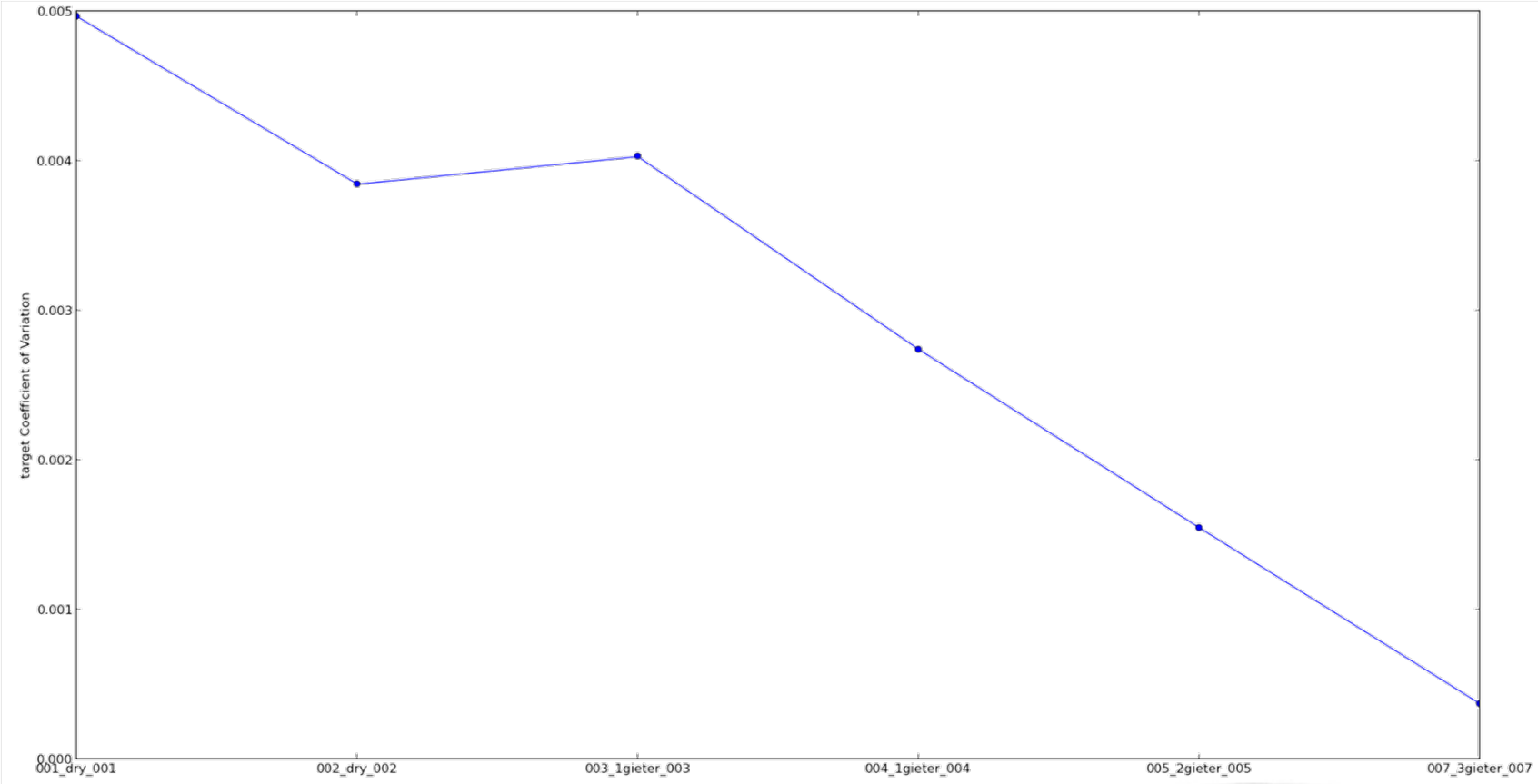
Polarimetrical characterization

- Soil roughness – Total power parameter



Polarimetrical characterization

- Soil moisture

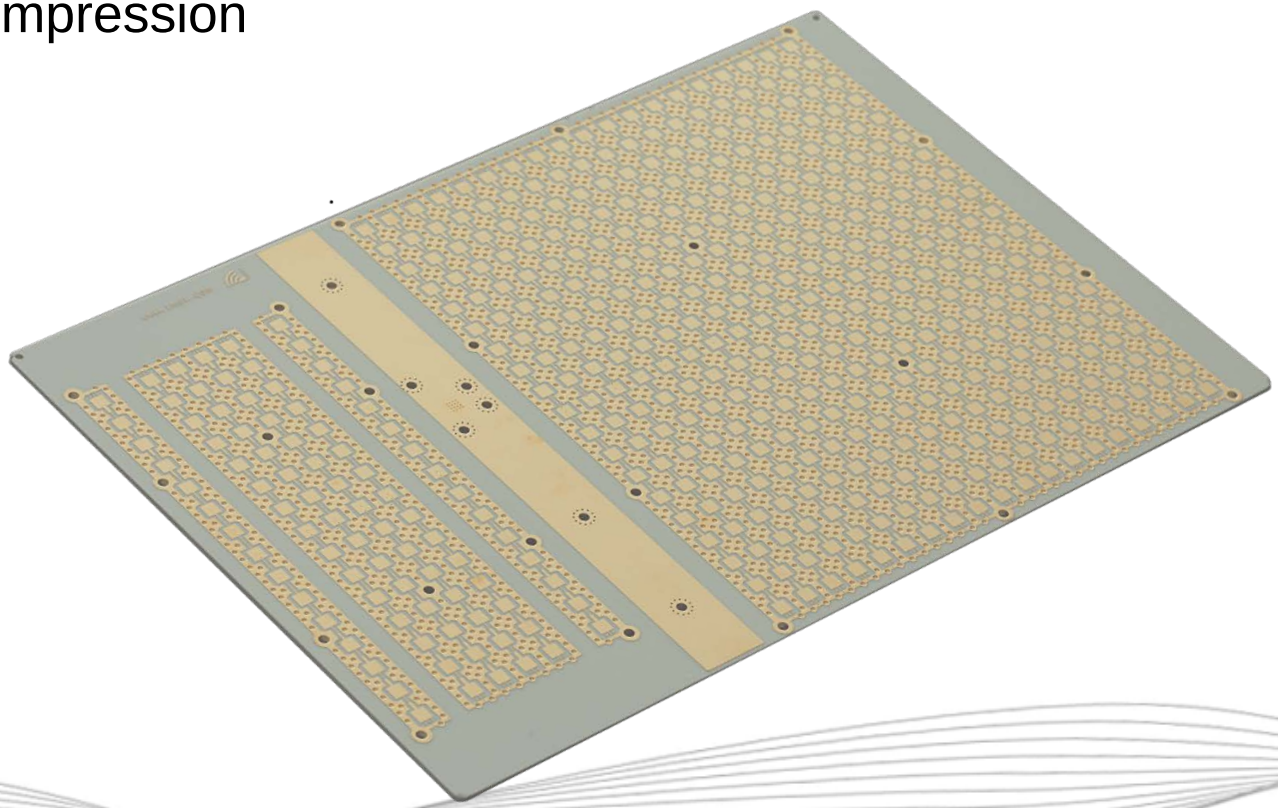


Polarimetrical characterization

- Work is still in progress
  - Radar hardware is ready
  - Software / Analysis scripts are ready
  - First test on different soils were performed
- Coming next:
  - Methodical acquisition of test data
  - Optimization of target tracker
  - Evaluation of polarimetric parameters
  - Integration into RPAS

3D (SAR) radar

- Multichannel radar solution
  - 8 complete receivers / downconversion channels
  - Multi-Core processing unit for online FFT processing / data compression



3D (SAR) radar

- Implement a „Digital Beam Former“
  - A virtual antenna beam is steered over the surface
  - 8-channel system: virtual antenna beam width is smaller (factor 8) than the individual channel (here: ~ 7,5 deg)
  - Needs extensive calculation power
  - Offline processing is planned as a first step

3D (SAR) radar

- Increased flying height possible
  - Polarimetry radar: 30 deg beamwidth
    - 25m height, 10 m/s, 20 min
    - 168 000 m² covered, 14 m beamwidth on ground
  - 3D (SAR) radar: 7,5 deg beamwidth
    - 100 m height, 10 m/s, 20 min
    - 1 256 637 m² covered, 13.1 m beamwidth on ground
    - Or: Scan area x 2, scan resolution x 4

3D (SAR) radar

- Synthetic Aperture Radar (SAR)
  - Increases resolution even further
  - Theoretically not limited
  - Requires stable flight plattform or exact knowledge of flight path
  - Complex method, will not be adressed within Smart Inspectors

3D (SAR) radar

- Currently work on the system is still in progress
  - Hardware is finished
  - Multi-core firmware is being developed
  - Calibration schemes are researched
- Planned:
  - First test flights on RPAS

Thank you for your attention!