Advanced RADAR techniques

- SAR + GMTI
- ISAR
- IfSAR (InSAR)
- GPR
- Noise radar
- Passive radar (coherent + radiometric)

Secondary radars and similar systems:
- IFF
- AIS
- ILS
Antenna size and beam width

\[ \sin \frac{\alpha}{2} = \frac{\lambda}{l} \]

\( l = 1 \text{ m} \)
\( F = 10 \text{ GHz} \)
\( \alpha \approx 3^\circ \)

\( 3^\circ \ @ \ 100 \text{ km} \approx 6 \text{ km} \)
SAR technique
SAR – angle & Doppler

- SAR – Earth surface mapping
  - Doppler frequency changes with angle
  - Low-pass filtering = unfocused SAR (one filter for all distances)
  - Matched filtering = focused SAR (filter changes with distance!)
- STAP/GMTI – moving target detection with SAR
- SAR combined with Direction of Arrival = STAP (N antennas, 2D processing!) -> GMTI
• Inverse SAR
• imaging a moving (e.g. rotating) object: ship on waves, rotating satellite, aircraft in turn
• TIRA: 34m antenna for satellite imaging
TIRA radar image of ADEOS with overlayed wiregrid model and the results of intrinsic motion and damage analysis.
Should be like this...
range: 693 km
IfSAR (InSAR)
ex:SRTM mission

add third dimension to SAR
Two antennas -> phase difference
SRTM: 60m boom
Ground Penetrating Radar

- Check before you dig...
- De-mining

Technology:
- As LF as possible (penetration)
- ... as WB as possible (depth resolution)
- SAR (along-track resolution)
- ground bounce and multi-bounce problems
Noise radar

- Noise can fill wide band = good resolution
- Pin-type autocorrelation function = low ambiguity
- Long integration time possible
- Good compatibility
- Nonspecific signal = low probability of intercept (LPI) = covert operation

Problems:
- near-far echo
- moving target (Doppler, stretch)
- computational complexity
Daventry experiment (passive radar)

Two receiving aerials fed into a sensitive mobile receiver connected to an oscilloscope. The equipment had been rigged inside a van to detect any echoes that were bounced back from the aeroplane. After careful adjustment, the results were dramatic; 'blips' appeared on the screen at distances of up to eight miles.

The BBC had a powerful short-wave transmitter Station near Daventry, the Empire Radio Station, with a power output of 10 kW. The wavelength was 49m and the continuous beam was about 30 degrees wide and with a 10 degree elevation. Hadley Page Heyford bomber made a number of passes at differing altitudes from 6000 ft down to 1000 ft.

26th February, 1935
Arnold Wilkins (as operator), A.P. Rowe and Robert Watson Watt.

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Passive radar (coherent)

- Uses audio/tv/cellular *transmitters of opportunity*
- Correlation receiver (two antennas)
- Problem with direct signal & near/far
- Direction finding – more receivers (or more transmitters)
Radiometric techniques (totally passive)

- Natural thermal emission of the scene (passive)
- Noise-like illuminator (active)
- Millimeter wavelengths (good resolution)
  - Concealed weapon detection (CWD) - even non-metallic objects (ceramic weapons and potentially plastic explosives) can be detected
- Detection of immigrants in soft-sided vehicles
DOA (ESM) systems

- Direction Of Arrival – measuring objects own transmission
- locate emitters by triangulation (angles) or multilateration (TDoA – Time Difference of Arrival)
  --> multisite operation!
- „Kolchuga” (UA), „Vera” (CZ)
IFF (SSR)

Identification Friend or Foe (mil.)
or Secondary Surveillance Radar (civ.)

- To shoot or not to shoot?
- Who is it?
- Radar equation \(\frac{1}{R^4}\) vs. \(\frac{1}{R^2}\)
- Altitude measurement problem

Technology: transponder, 2- channels

- 1030 MHz interrogation
- 1090 MHz reply

Required for all the aircrafts flying above some limit.
B-68. Interrogator krótkiego zasięgu zamontowany na przenośnej wyrzutni przeciwlotniczych pocisków rakietowych.
IFF with prim. radar
IFF Modes

• Mode 1: 64 codes, (mil ATC): type of aircraft or mission
• Mode 2, (mil ATC) 4096 "tail numbers"
• Mode 3/A (civ. ATC - squawk code):
  • instrument flight rules – unique A/C codes.
  • G/A A/C under visual flight rules - common code 1200.
• Mode C: aircraft altitude (usually alt.with 3/A)
  • special codes for emergency/hijack etc.
• Mode S ("selective")
  • Duplex data link
  • More flight params sent down
• ADS-B (Automatic Dependent Surveillance – Broadcast)
  – reply w/o question
AIS

Automatic Identification System

- VHF (156-162 MHz)
- GPS/GLONASS position, course, maneuvering – every 2 to 10 s (underway), 3 min (anchor)
- various status info (cargo, destination) - every 6 min
- more accuracy, more info than radar
- incl. safety-related messages
• safe landing under bad visibility
• modulation depth
• 108-112 MHz