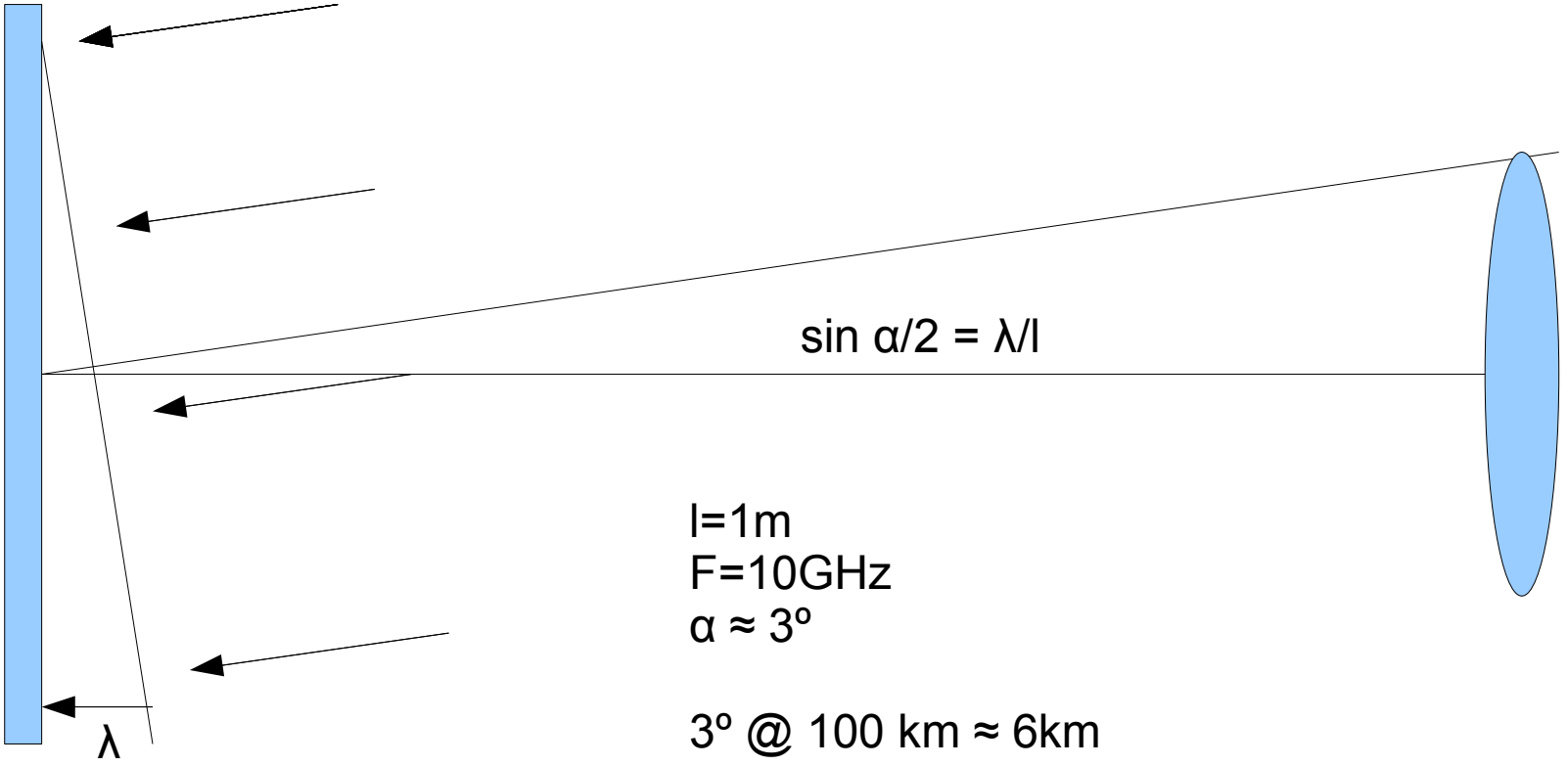
Advanced RADAR techniques

- 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

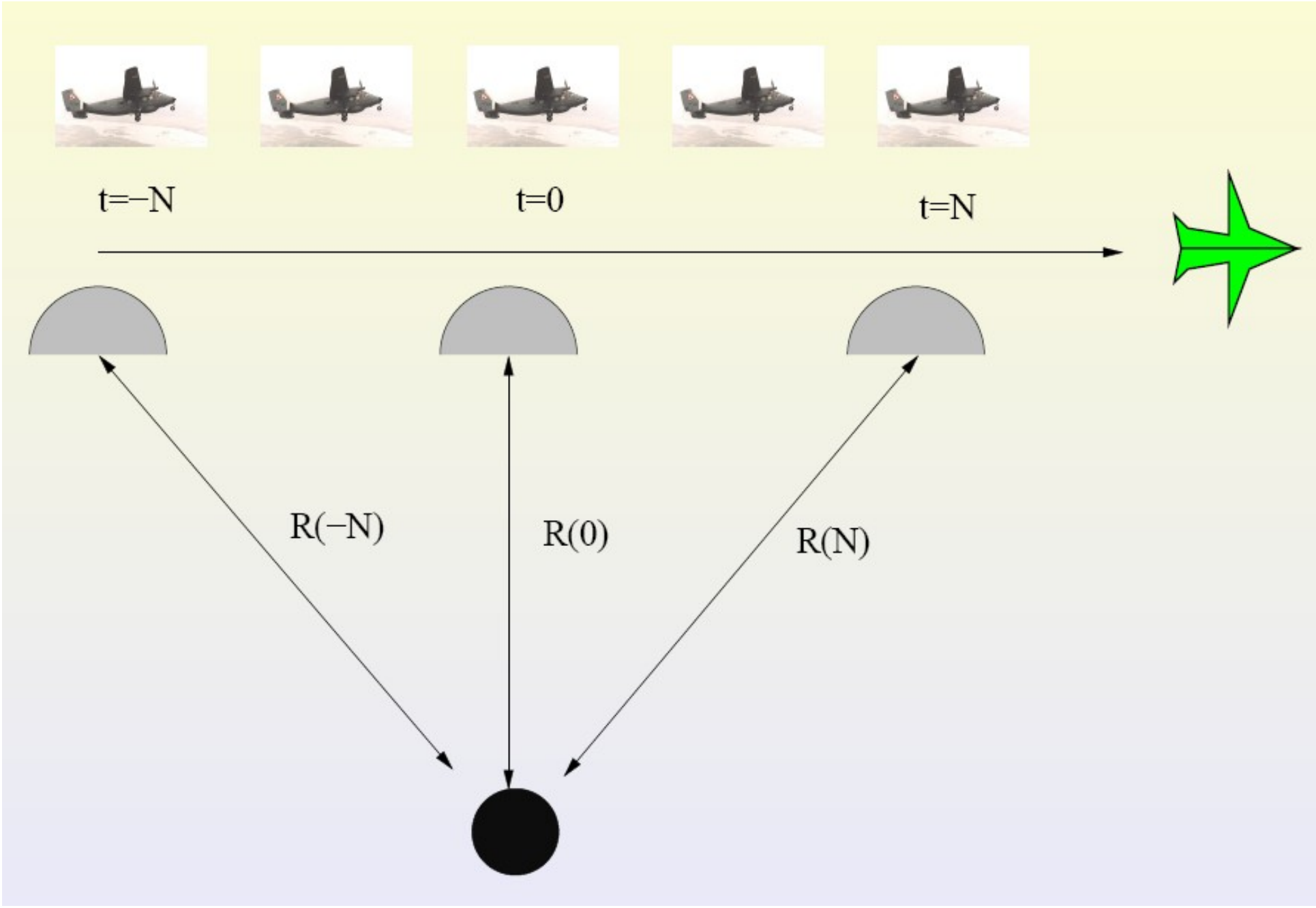


l=1m
F=10GHz
α ≈ 3º

3º @ 100 km ≈ 6km

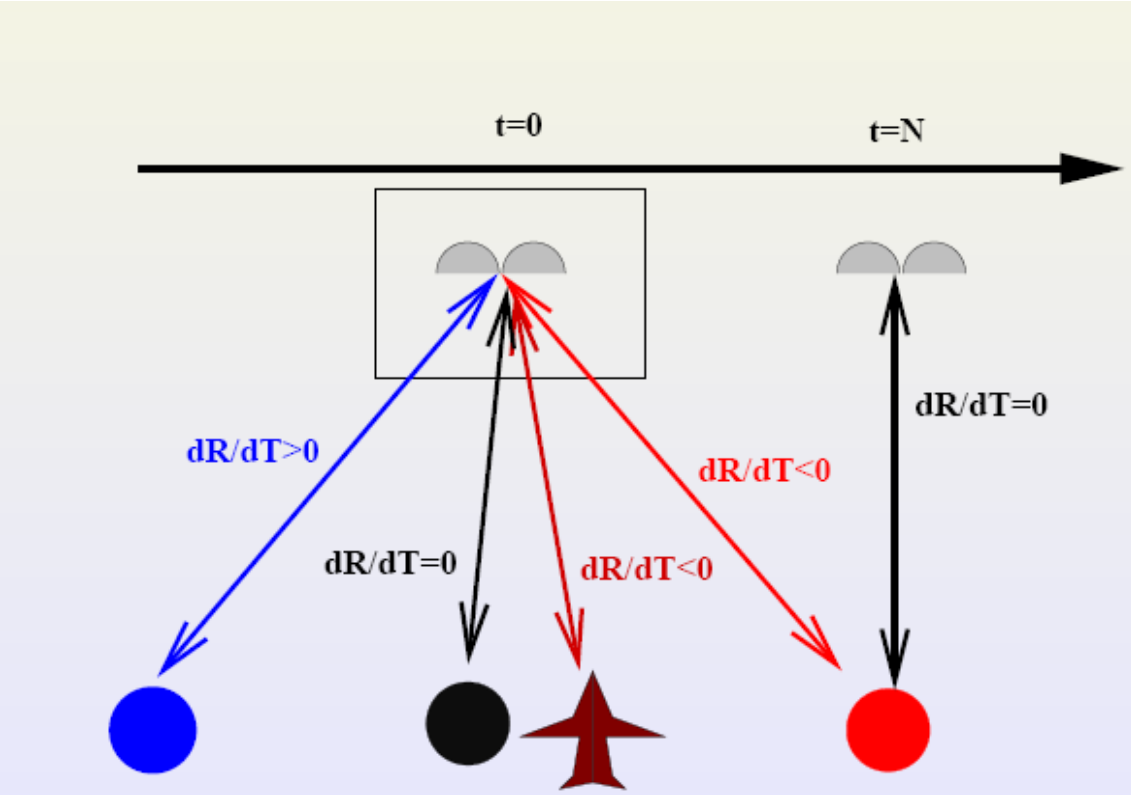

SAR image

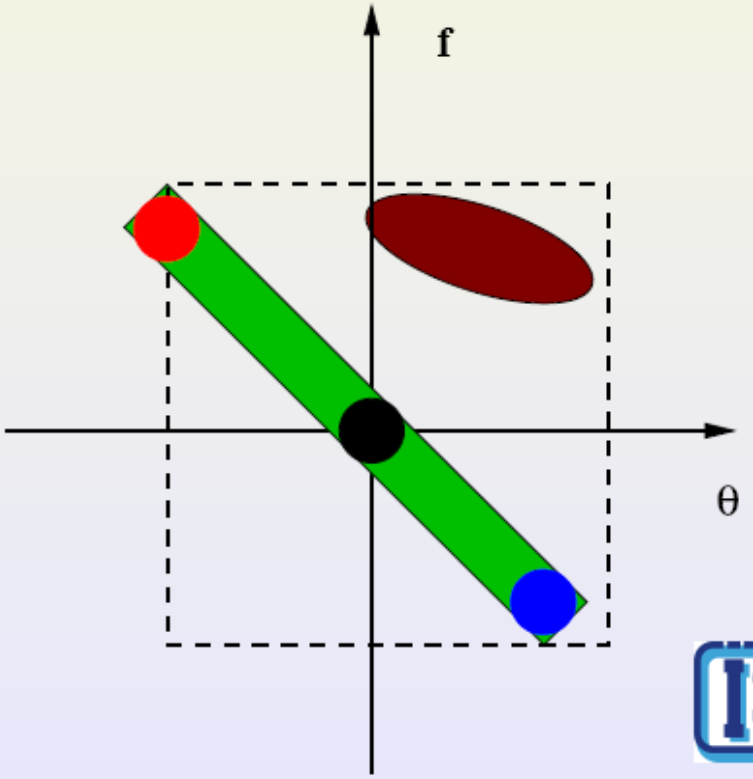
SAR technique



SAR – angle & Doppler

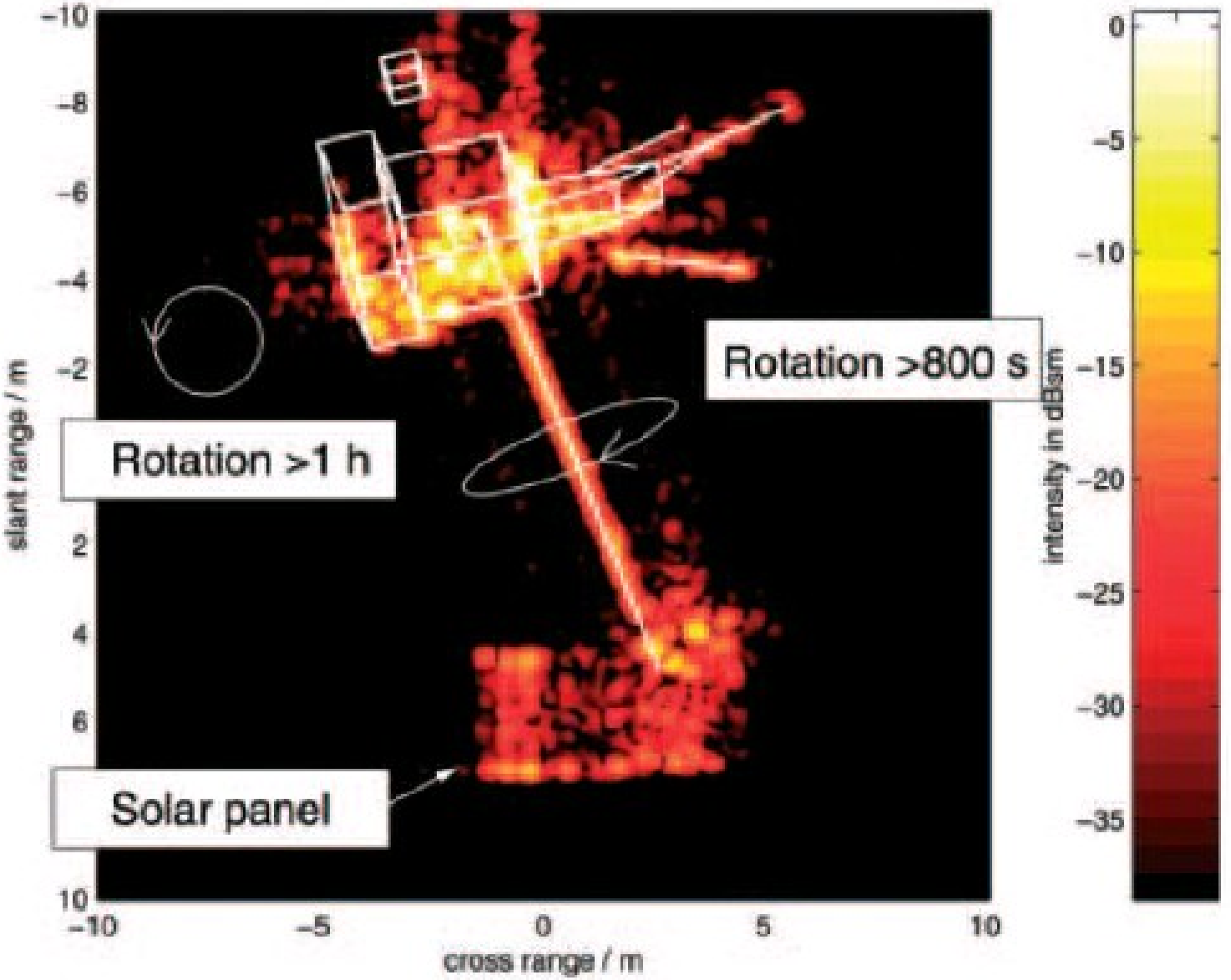
- SAR – Earth surface mapping
  - Doppler frequency changes with angle
  - Low-pass filtering = unfocused SAR (one filter for all distances)
  - Matched filtering = focused SAR (filter changes with distance!)
- STAP/GMTI – moving target detection with SAR
- SAR combined with Direction of Arrival = STAP (N antennas, 2D processing!) -> GMTI





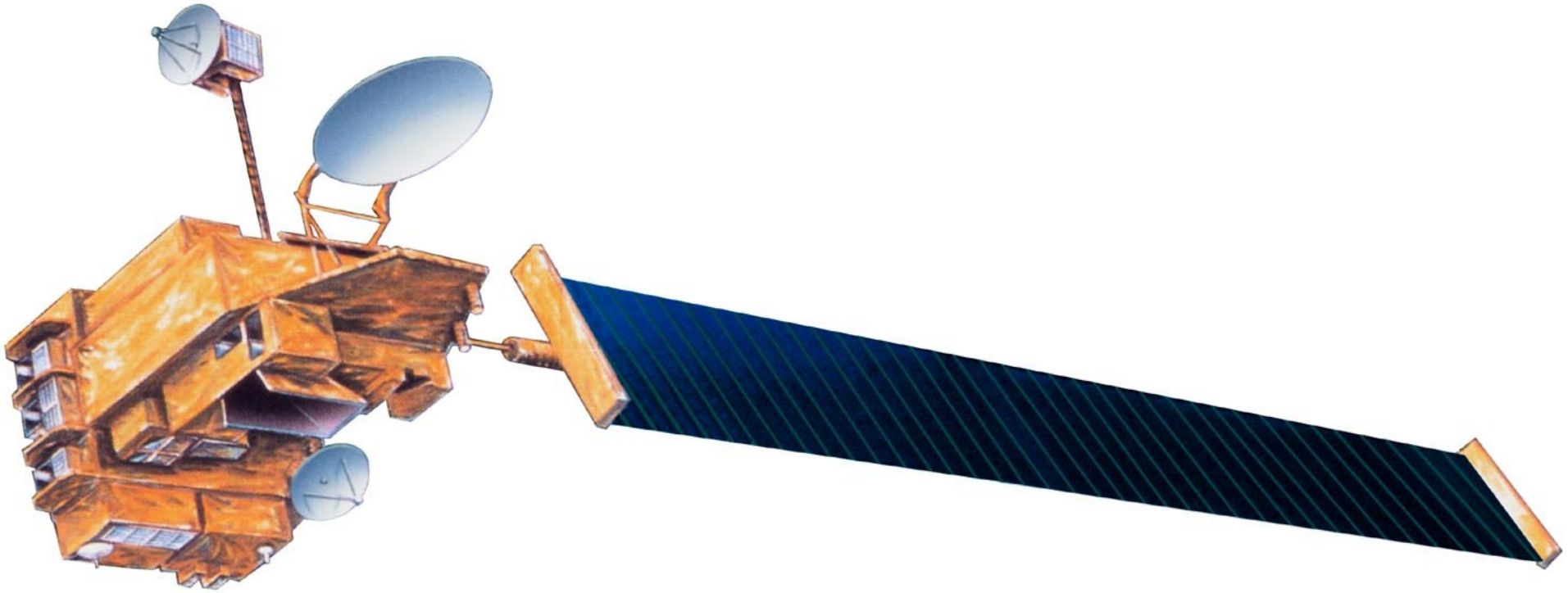
ISAR

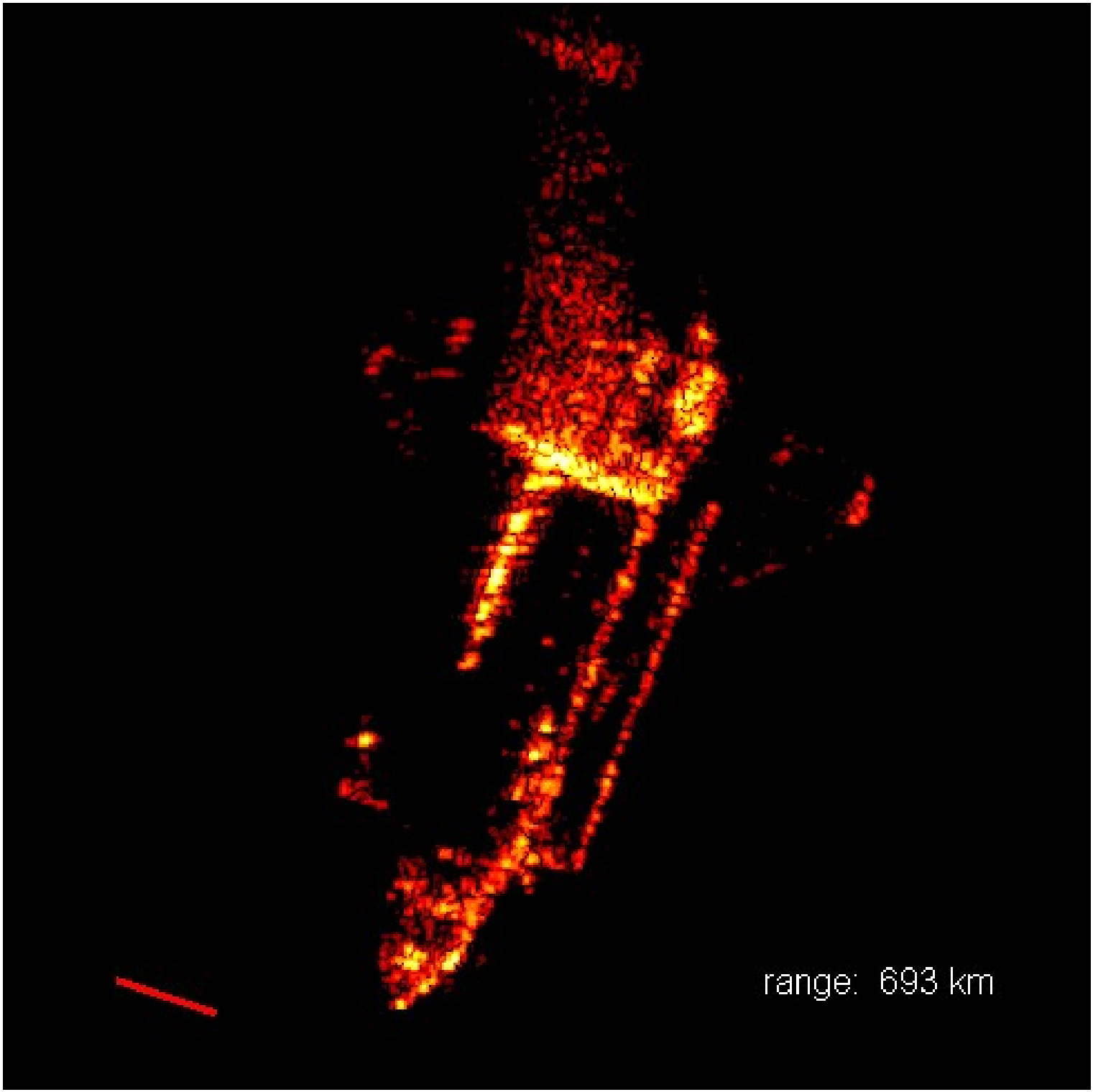
- Inverse SAR
- imaging a moving (e.g. rotating) object: ship on waves, rotating satellite, aircraft in turn
- TIRA: 34m antenna for sattelite imaging



TIRA radar image of ADEOS with overlayed wiregrid model and the results of intrinsic motion and damage analysis

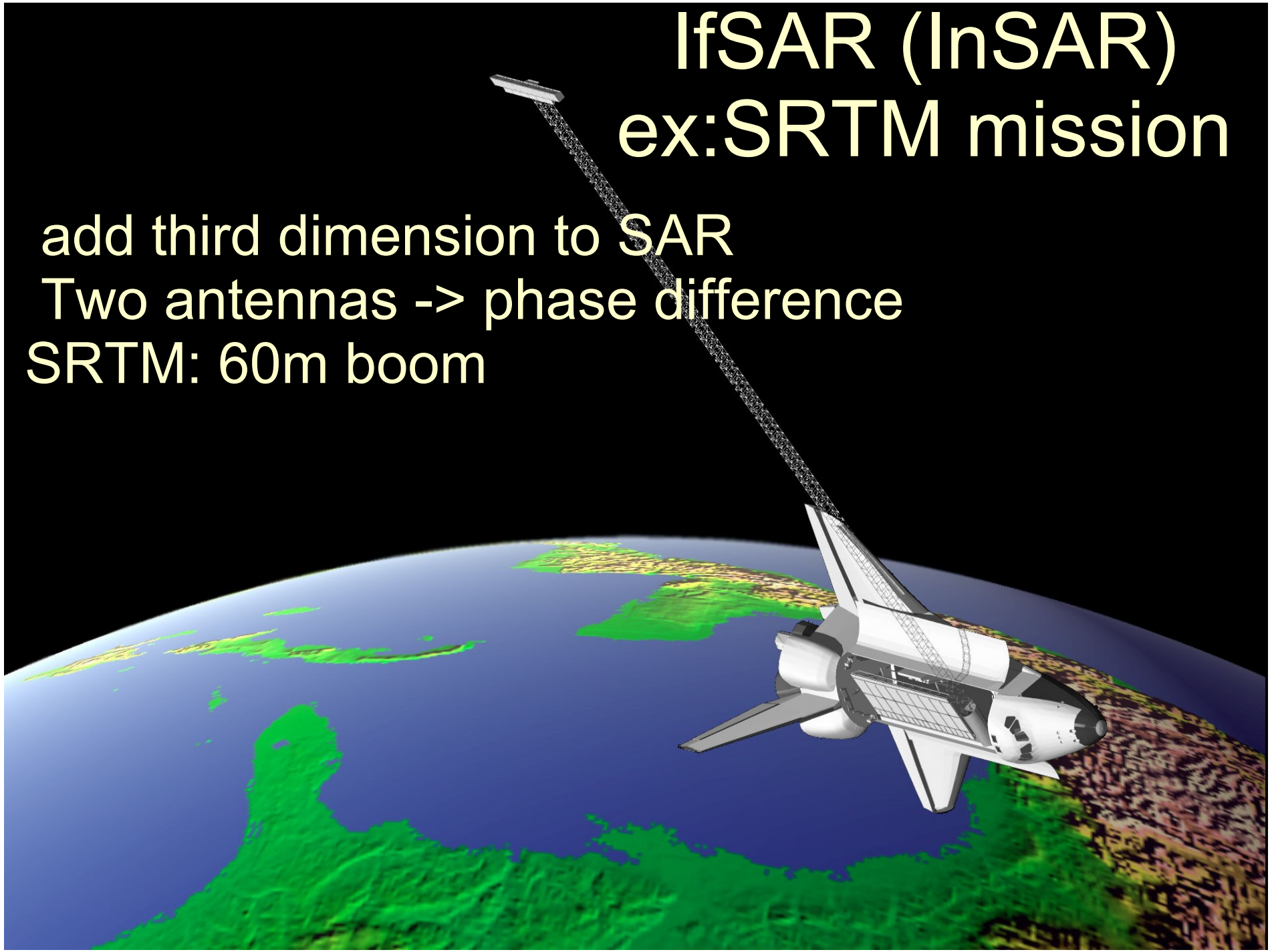
Should be like this...

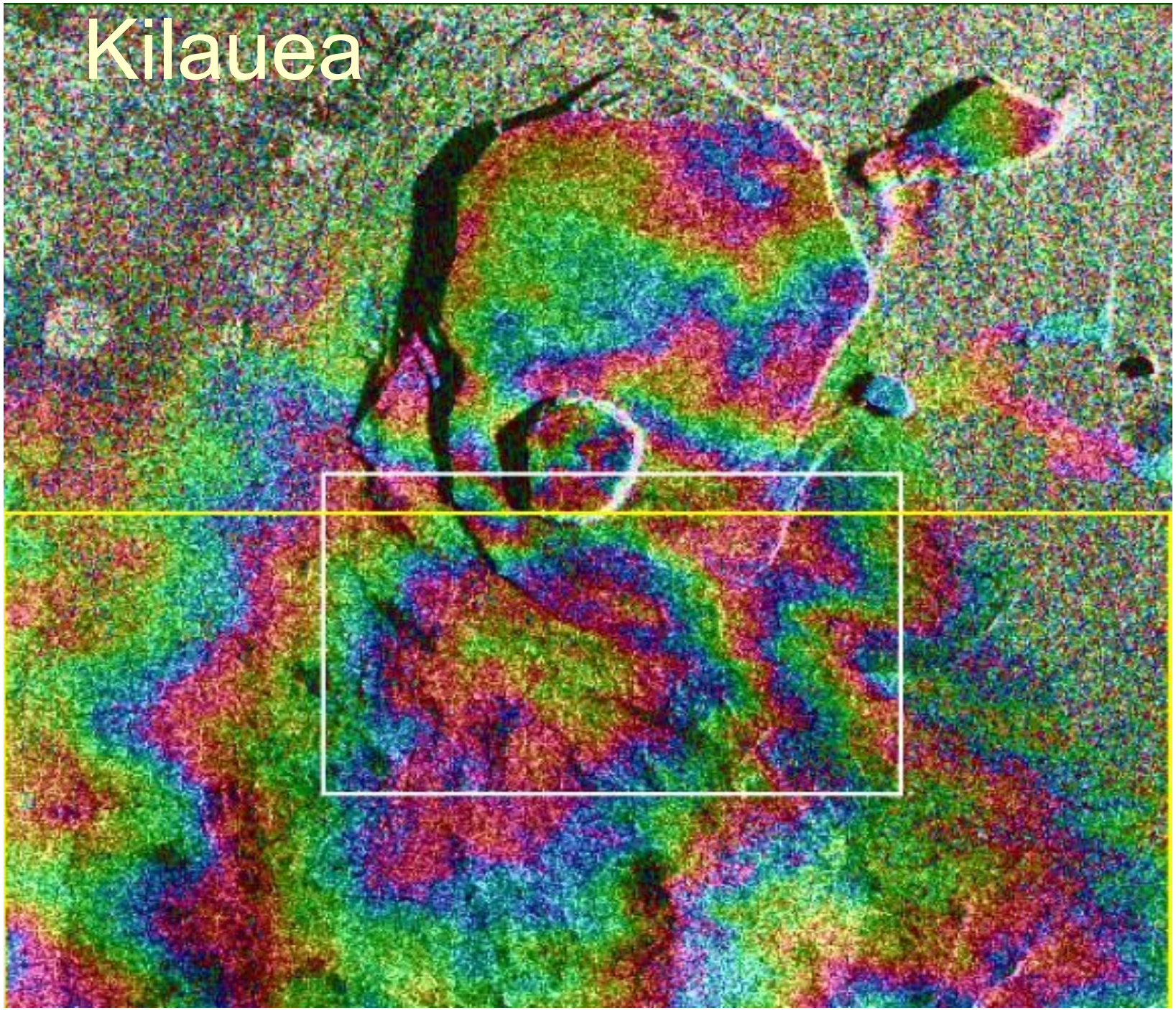



range: 693 km

IfSAR (InSAR)
ex:SRTM mission

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




Kilauea

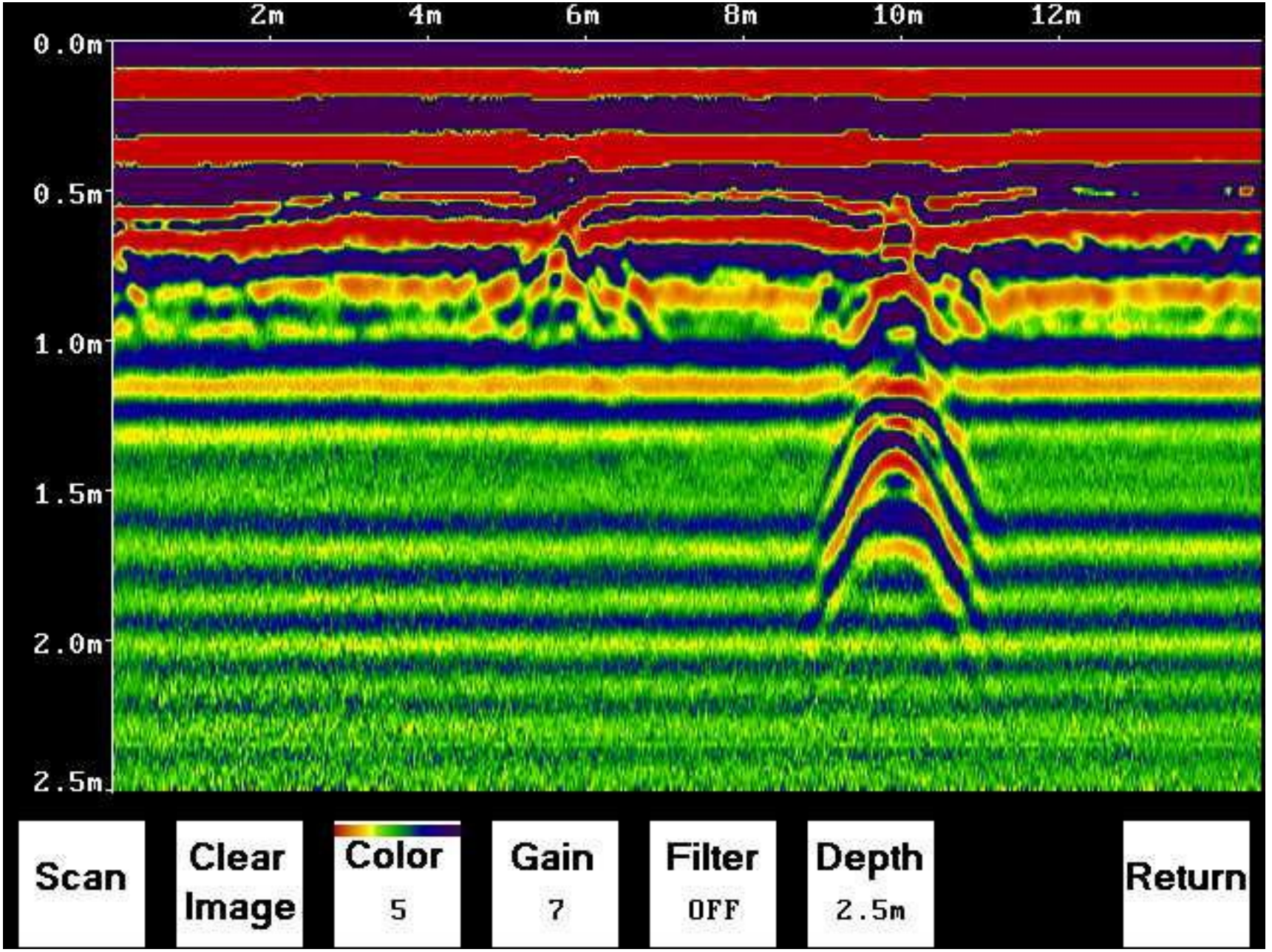
Ground Penetrating Radar

- 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

GPR image

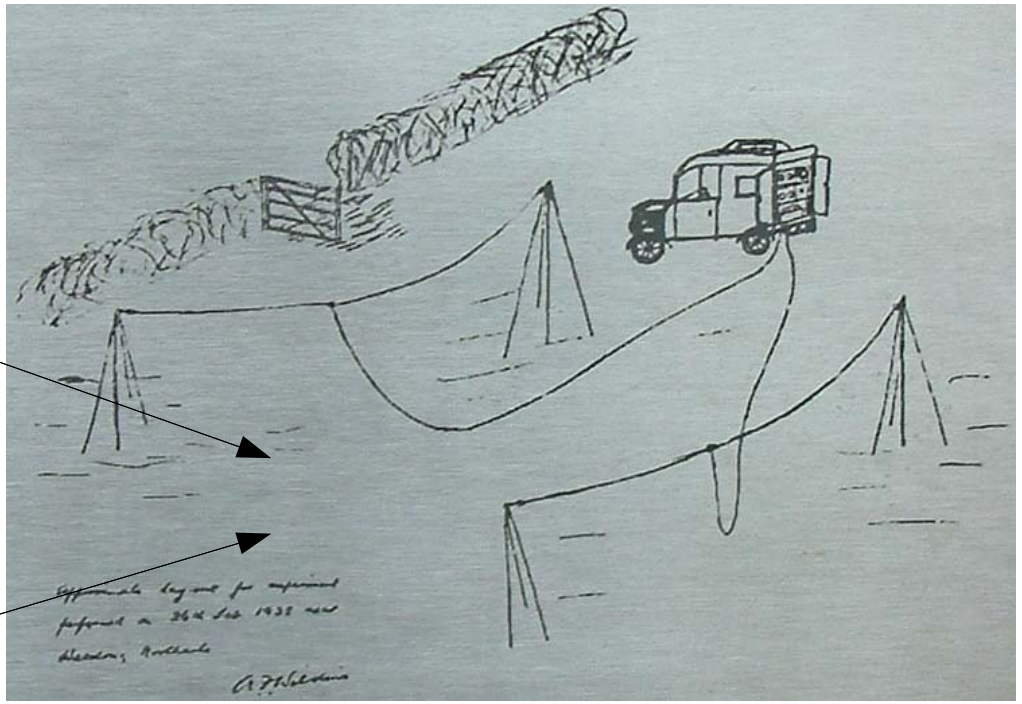

2m
4m
6m
8m
10m
12m
0.0m
0.5m
1.0m
1.5m
2.0m
2.5m
Scan
Clear Image
Color
5
Gain
7
Filter
OFF
Depth
2.5m
Return

Noise radar

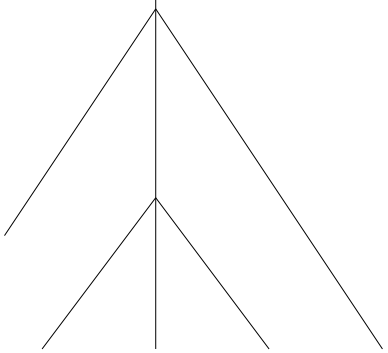
- Noise can fill wide band = good resolution
- Pin-type autocorrelation function = low ambiguity
- Long integration time possible
- Good compatibility
- Nonspecific signal = low probability of intercept (LPI) = covert operation
- Problems:
  - near-far echo
  - moving target (Doppler, stretch)
  - computational complexity

Daventry experiment (passive radar)

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.



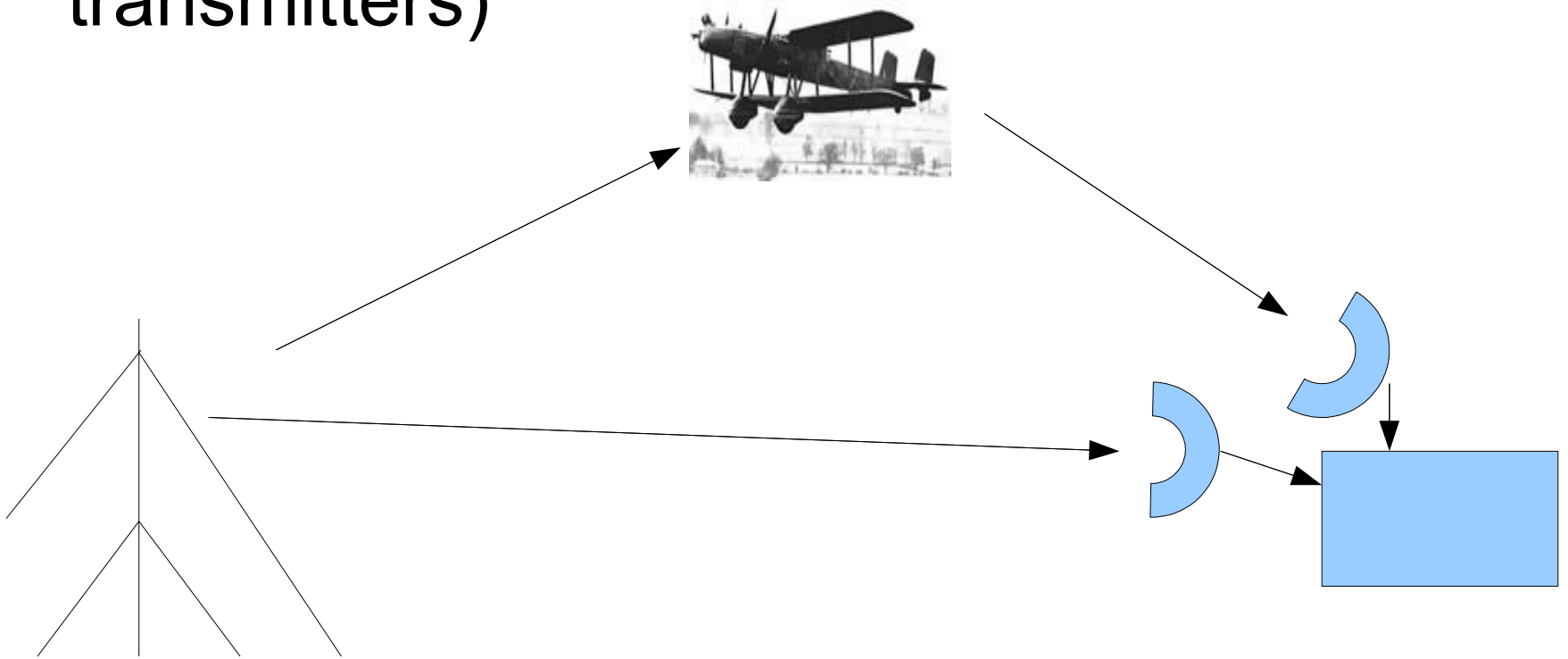
26th February, 1935
Arnold Wilkins (as operator),
A.P.Rowe and Robert Watson Watt.



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.

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 ($1/R^4$) vs. ($1/R^2$)
- Altitude measurement problem

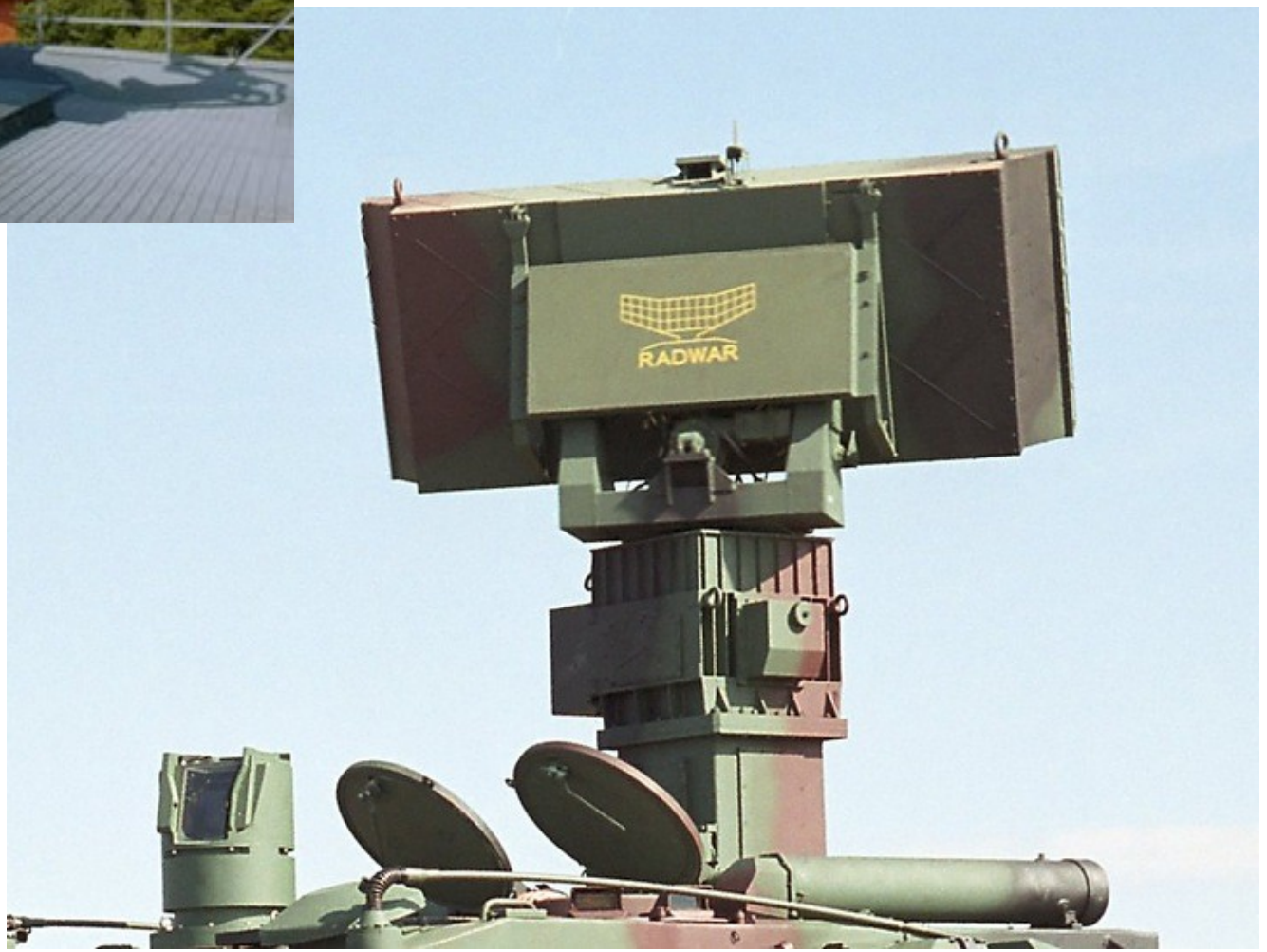
Technology: transponder, 2- channels

- 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

ILS

- safe landing under bad visibility
- modulation depth
- 108-112 MHz