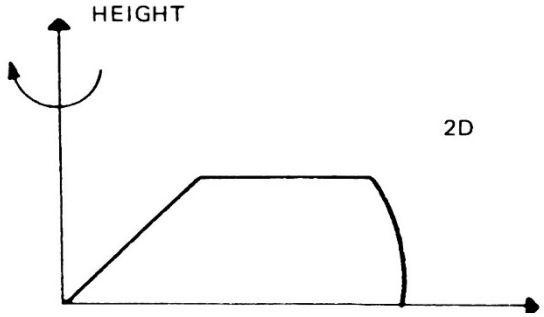
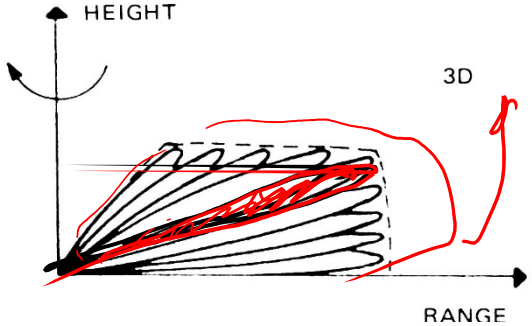
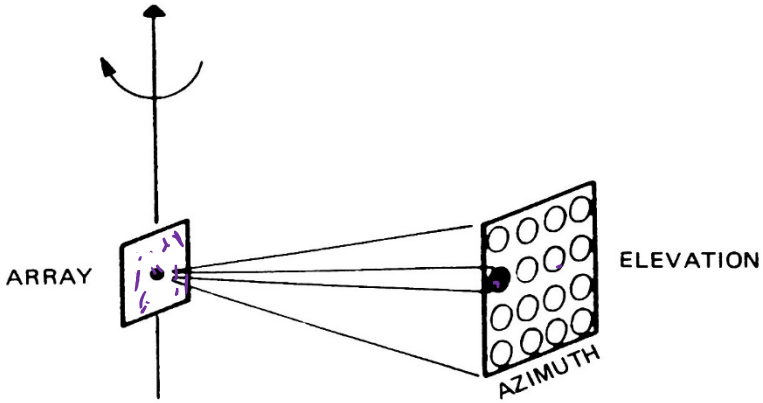
Multifunctional Array Radar

Classification of Radar Systems

- **2D Radar** (Rotating)
  - Fan beam
  - Range, Azimuth
  - Track-While-Scan (TWS) at the same search update rate
- **3D Radar** (Rotating)
  - Pencil beam
  - Range, Azimuth, Elevation
  - Stacked/electronically scanned beams
  - Dwell time management on elevation plane
- **Multifunction Array Radar** (Fixed or Rotating)
  - Range, Azimuth, Elevation
  - Dwell time management on azimuth and elevation planes
  - Single/Multi-beam
  - Multifunction capability
  - Highly adaptive to the environment (dynamic allocation of radar resources)





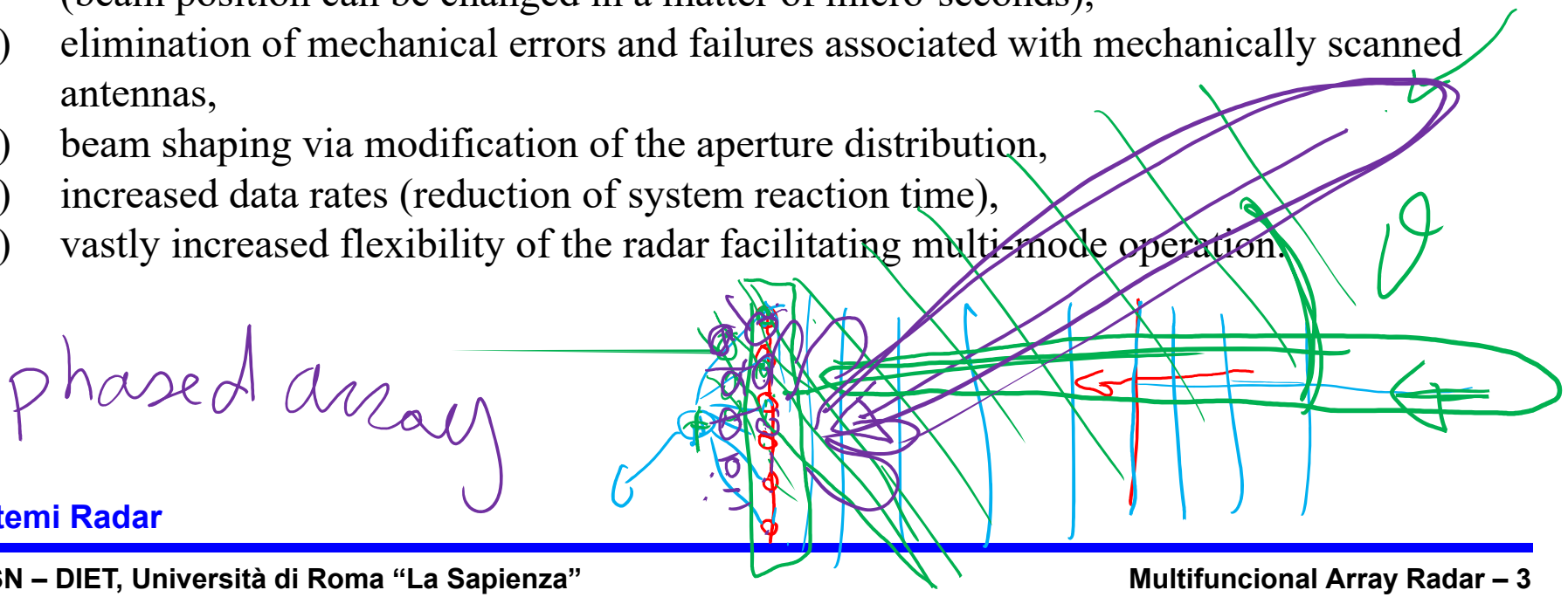


Advantages of Electronic Beam Steering

With electronic scanning, the radar beams are positioned almost instantaneously and completely without the inertia, time lags, and vibration of mechanical systems.

The specific benefits of electronic scanning include:

1) virtually instantaneous positioning of the radar beam anywhere within a set sector (beam position can be changed in a matter of micro-seconds),
2) elimination of mechanical errors and failures associated with mechanically scanned antennas,
3) beam shaping via modification of the aperture distribution,
4) increased data rates (reduction of system reaction time),
5) vastly increased flexibility of the radar facilitating multi-mode operation.

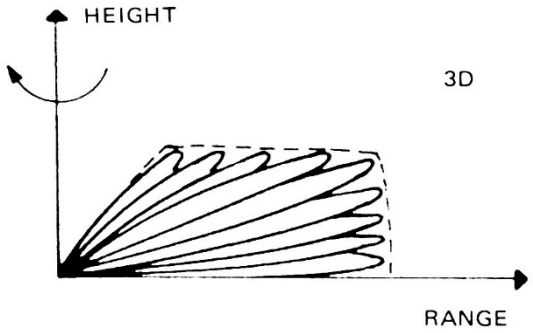


3D Radar

$$t_{DWELL} = \frac{\theta_B}{360} T_{SCAN}$$

$$\theta_B = Azimuth\ beamwidth$$

$$\Delta t = \sum_{1}^{N} t_i$$



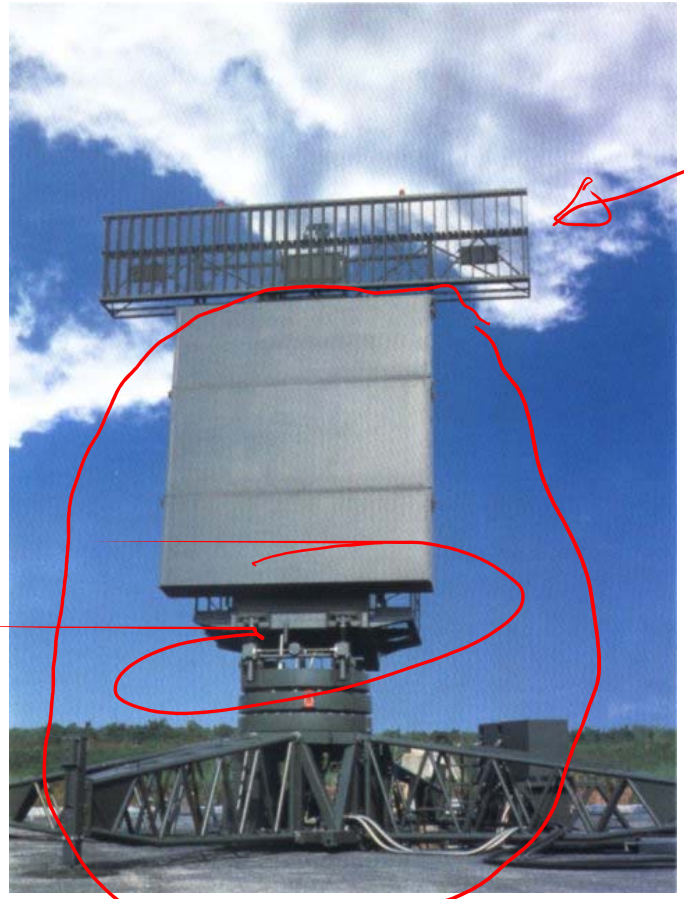
N = number of beams necessary for the elevation coverage

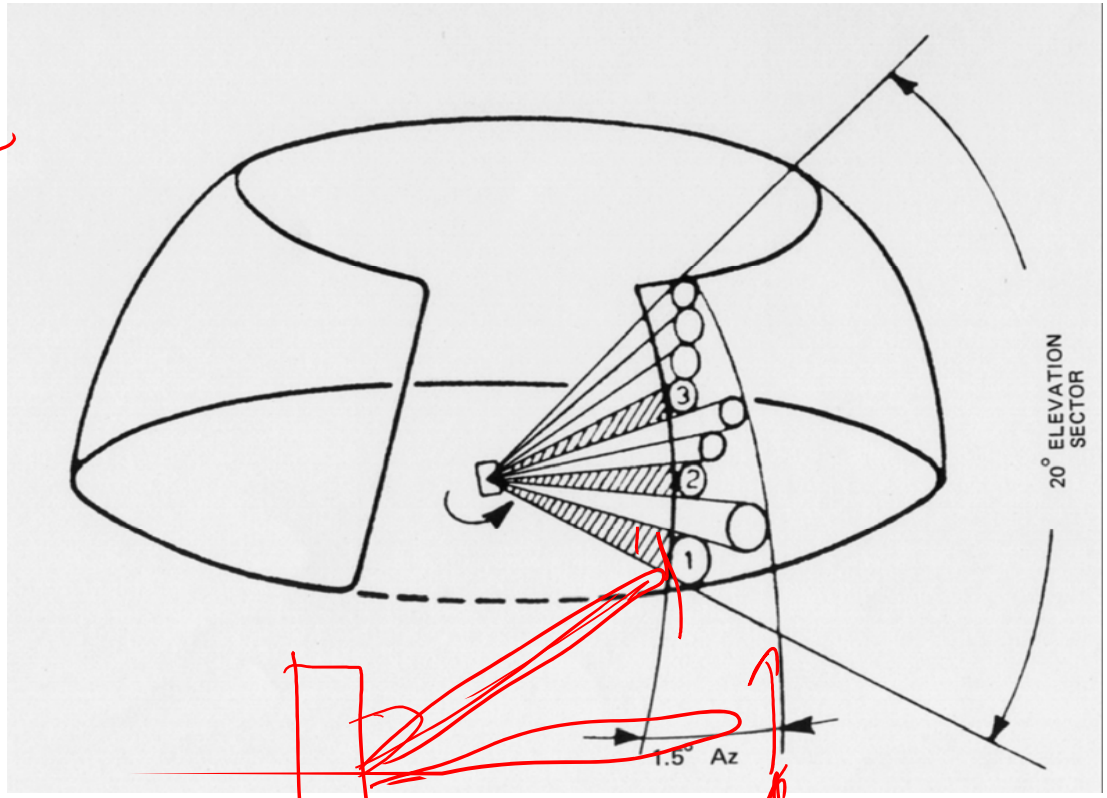
t_i = dwell time necessary for the i-th beam

$t_{DWELL} = \Delta t$

If t_{DWELL} is less than Δt multibeams (simultaneous beams) solution is necessary.

3D Radar example: RAT-31 SL



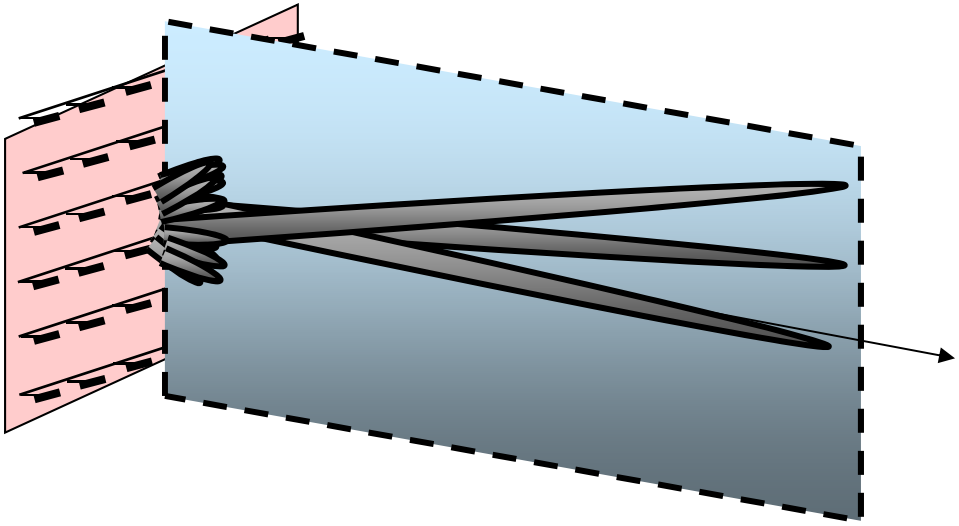


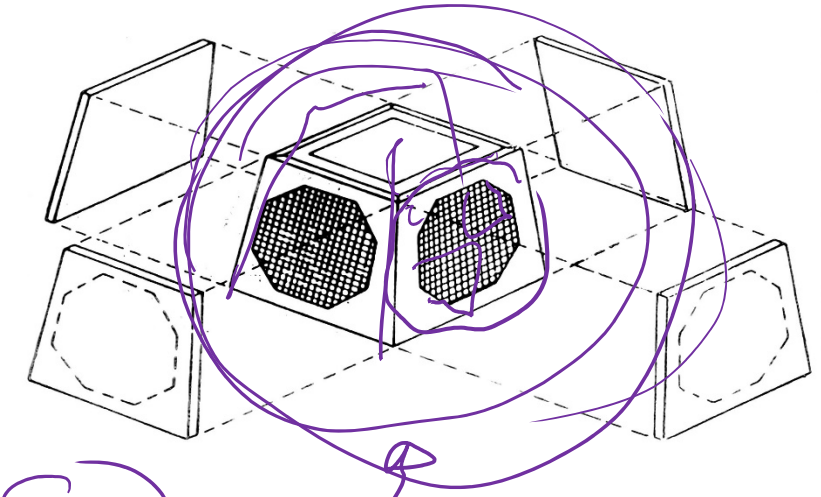
- S-Band phased array, effective up to a range of 450 km
- multiple simultaneous independently phase controlled pencil beams that provide flexibility in scanning and very high data rate (Elevation scanning 0° to 20°; Rotation speed: 6 r.p.m)
- Each beam provides monopulse altitude measurements

Sistemi Radar

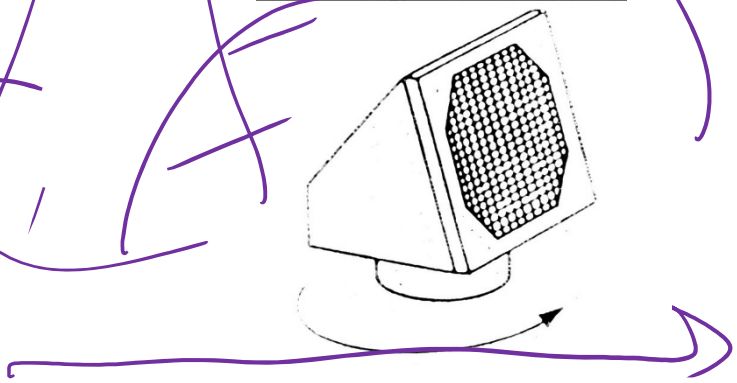
http://www.selex-si.com/

Planar Array





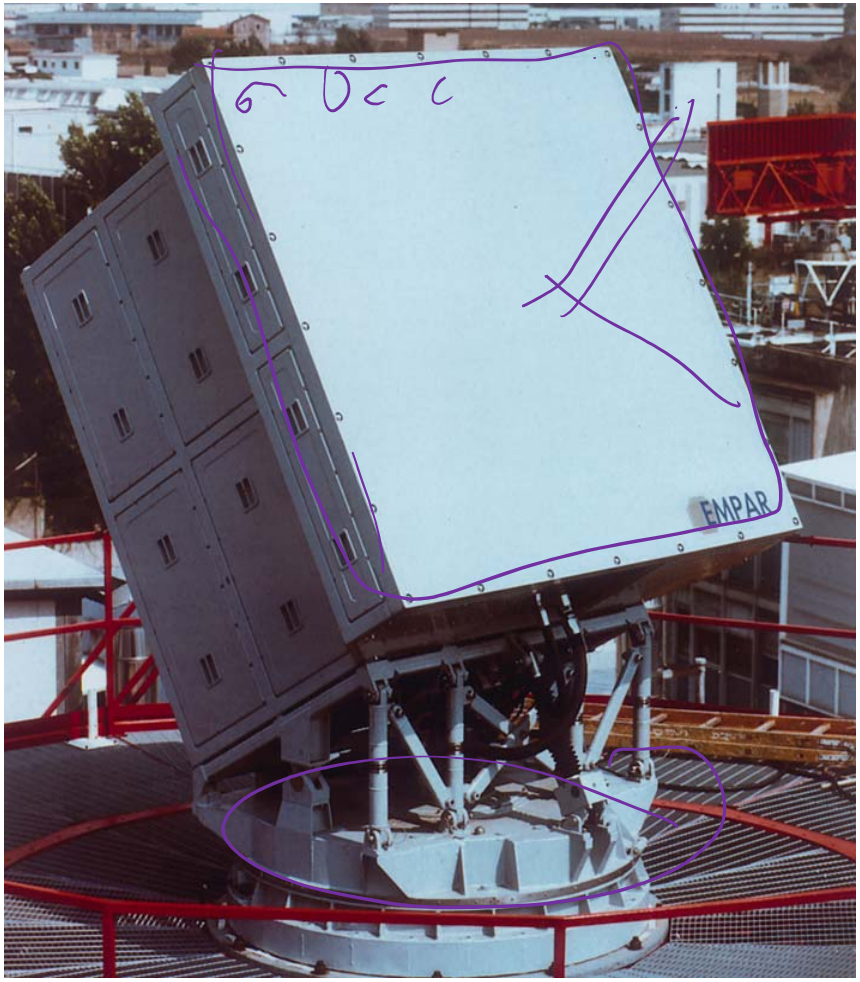
- **Fixed vs rotating**
  - complete adaptability to operational environment
  - simpler time management
  - cost, weight and dimensions much higher



EMPAR (I)

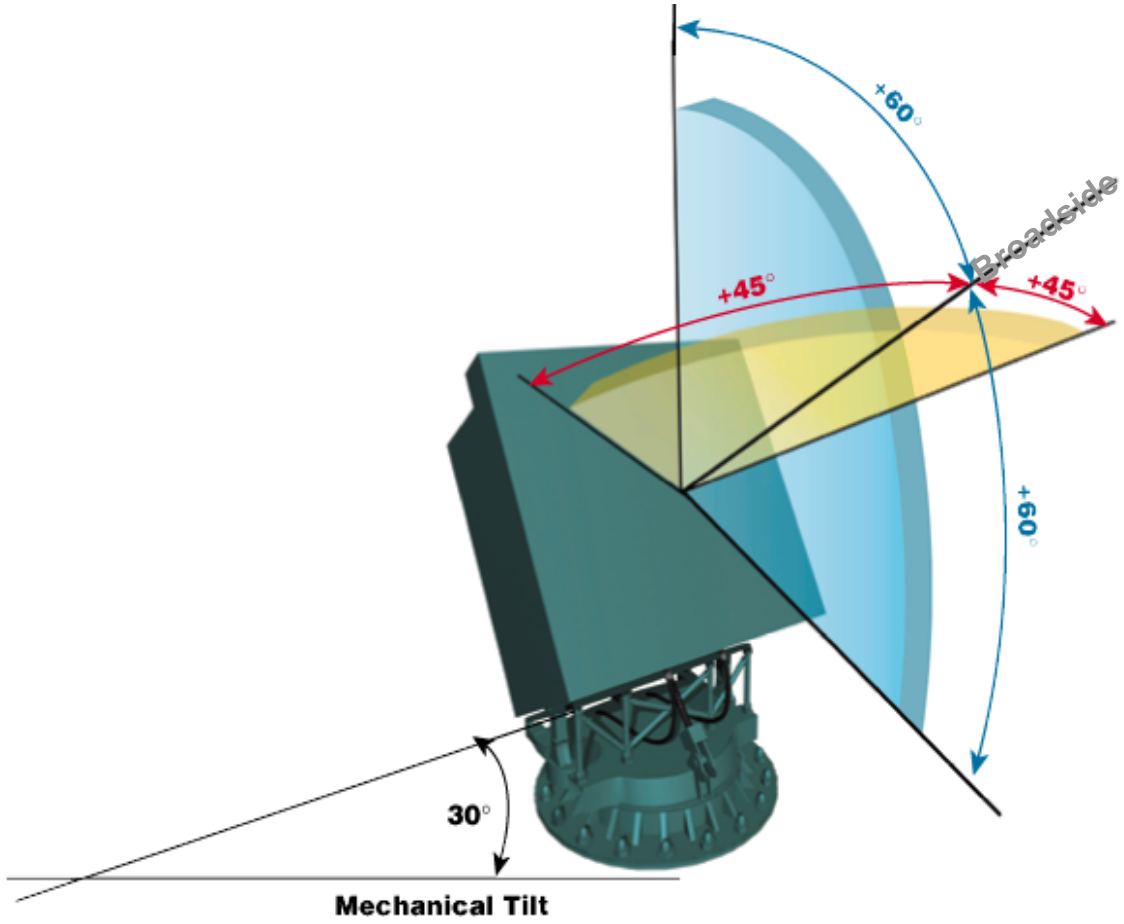
European Multifunction Phased Array Radar (EMPAR)

- EMPAR is a multifunction radar, operating in G-band
- Rotating passive phased array
- Constrained feeding network
- Radiation aperture: 1.5x1.5 m
- Rotation speed: 60 rpm
- Electronic scan angle
  - ± 45° azimuth
  - ± 60°elevation
- Pin diode phase shifters: 2160
- Linear (vertical) polarization
- First side lobe level: < -35dB
- Number of beams in transmission 1 (Σ)
- Number of beams in reception: 8 (Σ, ΔAZ, ΔEL, 4L, SLB, SLC 4)
- Angular measurement: monopulse



EMPAR (II)

- Multifunction capabilities are performed in the full hemispherical volume thanks to the scan-off possibility of the beam



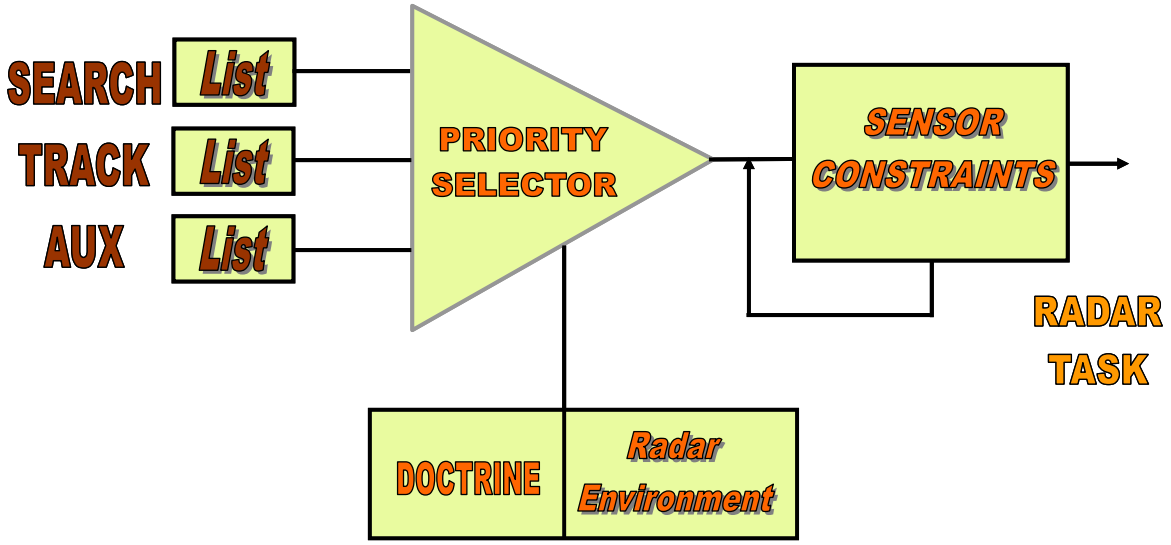
Multifunction Radar (I)

- Flexible signal and data processing
- Resources management

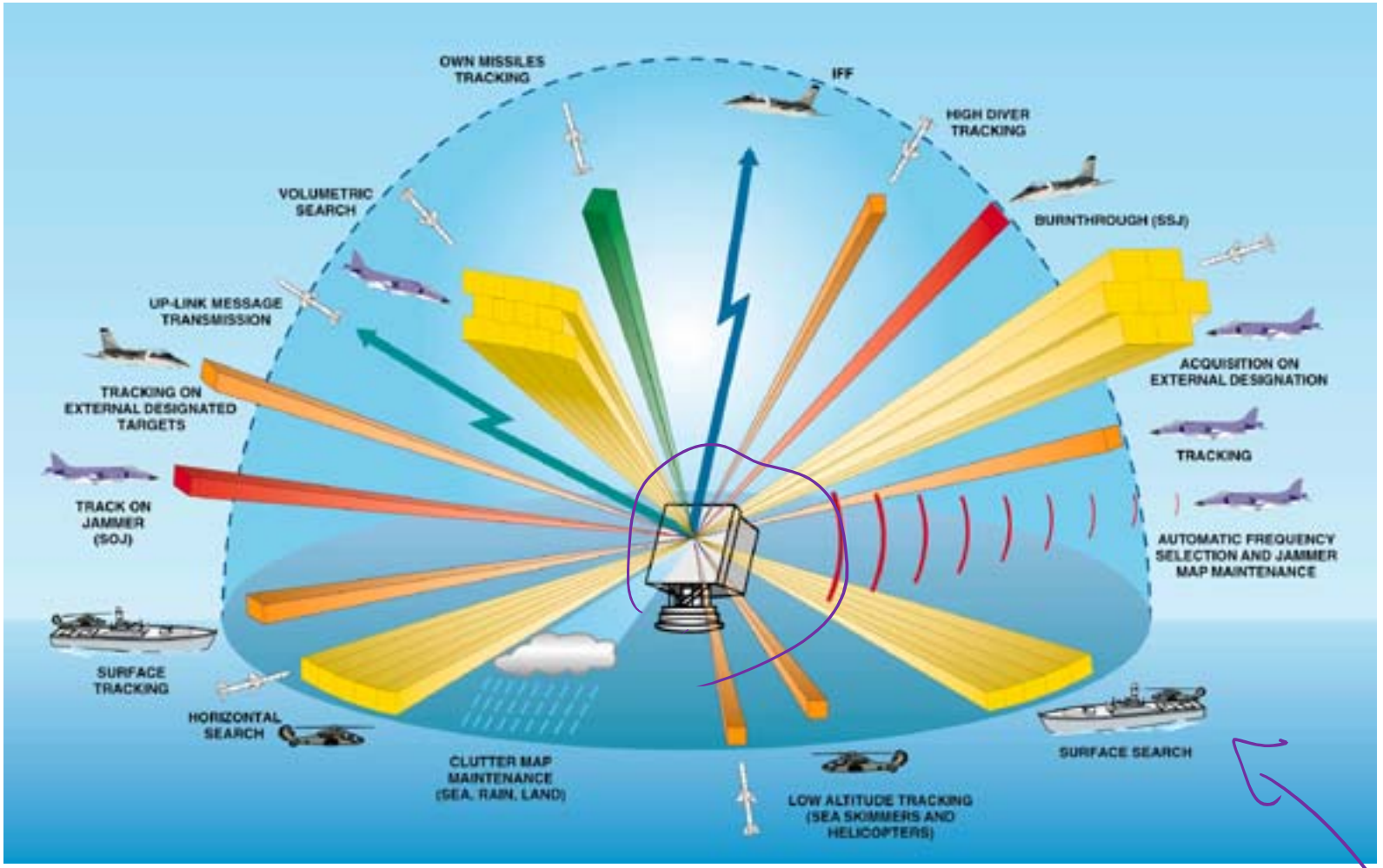
Radar Management Computer

- Scheduling of radar activities
- Commands for radar units
- Dedicated Processing of detections
- Monitoring of performance

Radar Scheduling



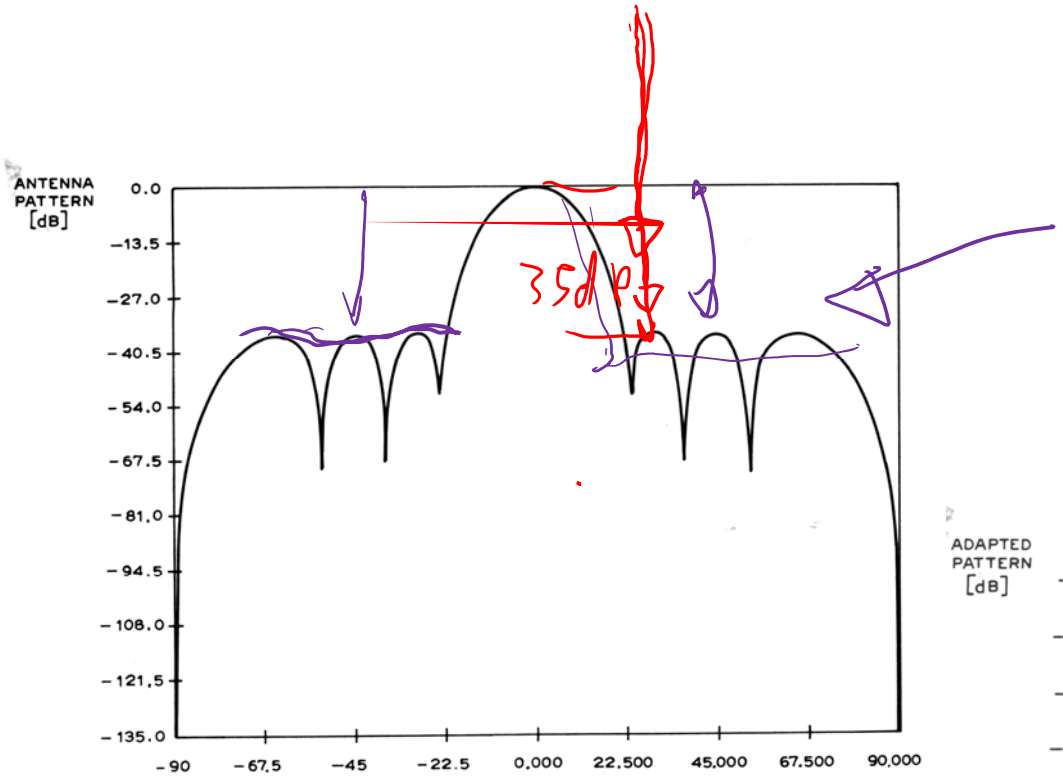
Multifunction Radar (II)



KEY

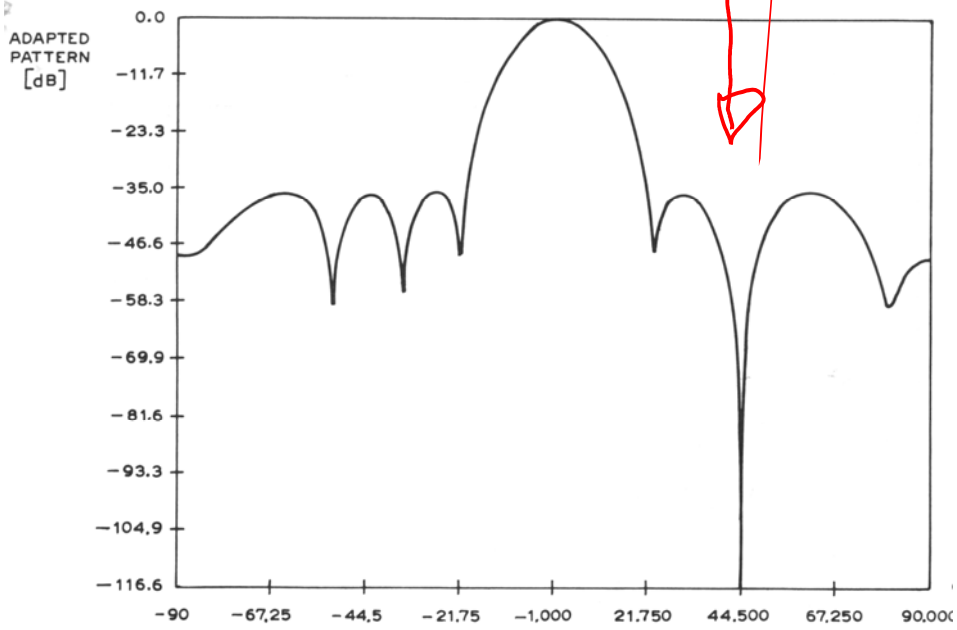
- TRACKING
- ANTI-JAMMING
- OWN MISSILE CONTROL
- SEARCH TASKS
- IFF

Nulling the jammer Direction of Arrival (DOA)



quiescent pattern

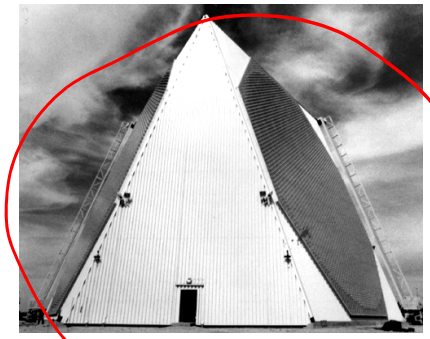
adapted pattern



Wideband phased arrays

- S-BAND
- 4000 EL/PER ANTENNA
- NO. MAN.: 234 ANTENNAS
- 936,000 EL. TOTAL
- LOCKHEED MARTIN

AEGIS SPY-1

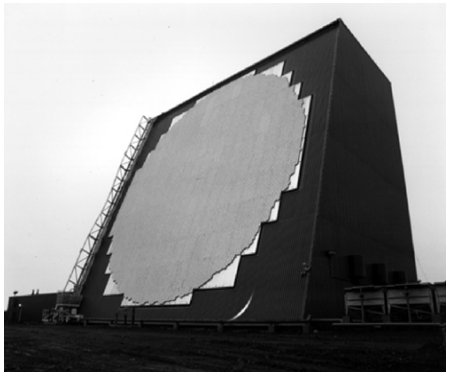


- UHF (420-450 MHZ)
- NO. T/Rs/FACE: 1,792
  EL./FACE: 2,677
- NO. MAN.: 4
- TOTAL NO. T/R MODULES MANUFACTURED >14,336
- DIAMETER: (72 FT/102 FT)
- RAYTHEON

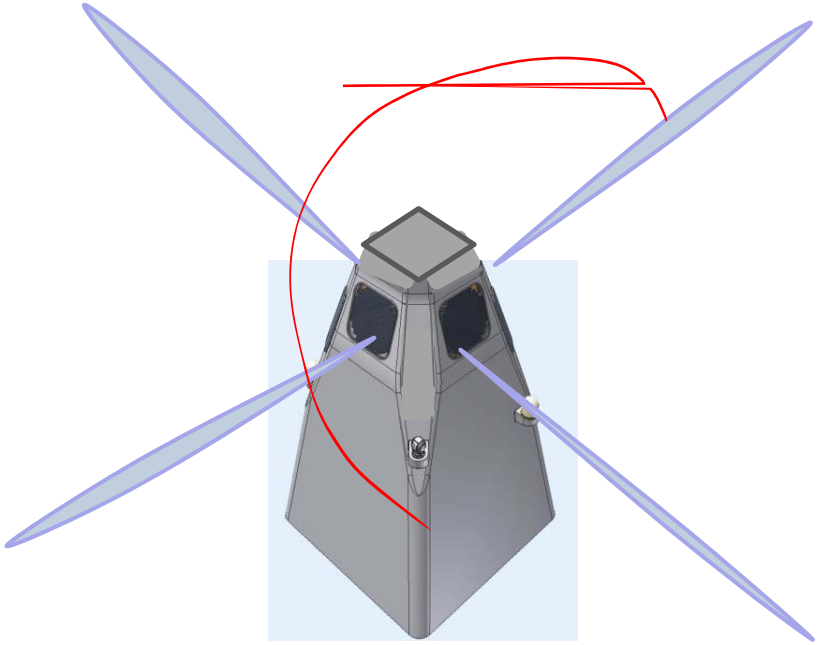
(BROOKNER, SCI. AM, 2/85)

PAVE PAWS (AN/FPS-115)

- L-BAND (1175-1375 MHZ)
- BANDWIDTH: 200 MHZ (16% BW)
- POWER:
  PEAK: 15.4 MW
  AV. 0.92 MW
- DIAMETER: 95 FT
- NO. EL.: 15,360 ACTIVE
  34,746 TOTAL

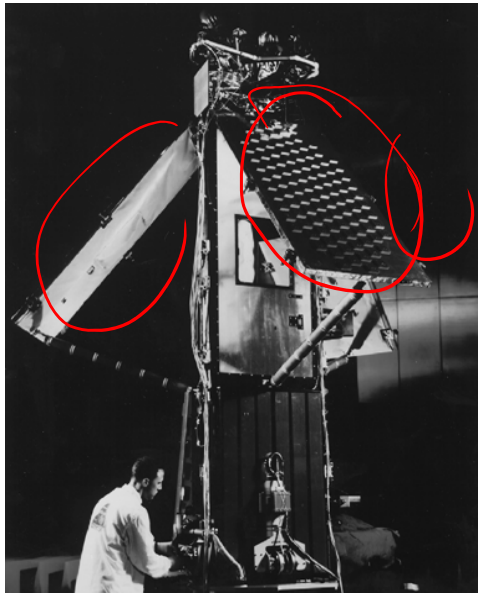


COBRA DANE (AN/FPS-108) (BROOKNER, '88)



IRIDIUM Phased Array

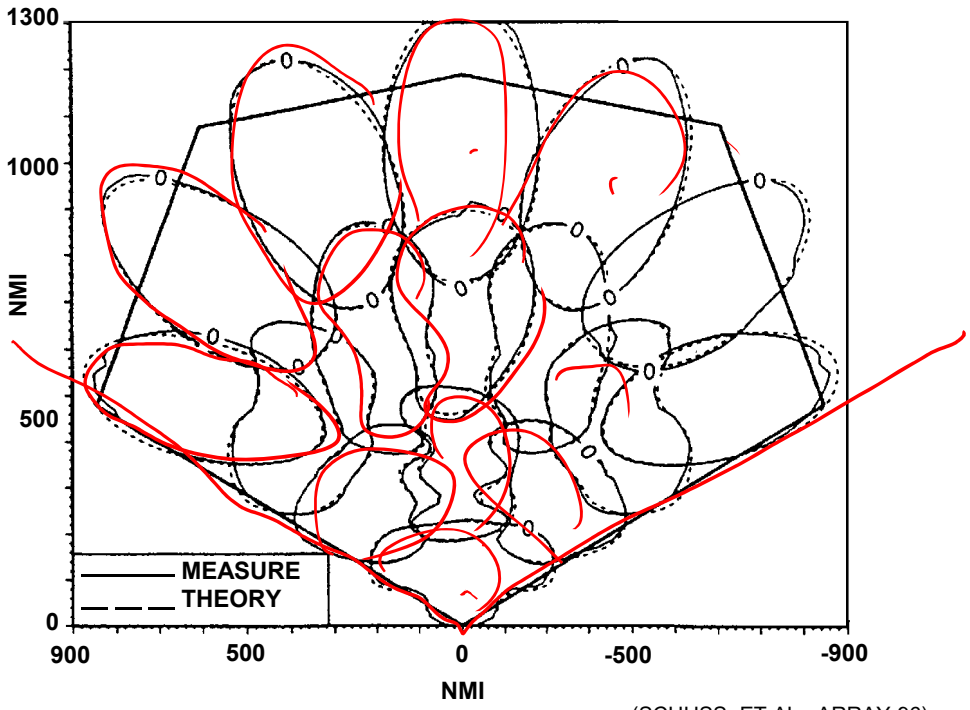
IRIDIUM®: THREE L-BAND MMIC ARRAY PANELS DEPLOYED ON BUS



- REVOLUTIONARY COMMERCIAL GLOBAL SATELLITE PERSONAL COMMUNICATION SYSTEM
- NO. T/Rs: >100/ANT.
- NO. ANT. /SAT.: 3
- NO. SATS.: 66
- TOTAL NO. T/Rs/CONST. : >19,800
- NO. BEAMS/PANEL: 16

(BLACK, ELECT. PROGRESS, FALL '75)

AN ARRAY ANTENNA with ACTIVE, MMIC, MULTIBEAMS, MICROSTRIP-PATCH ELEMENTS, SPACEBORNE, COMMERCIAL, LARGE PRODUCTION.



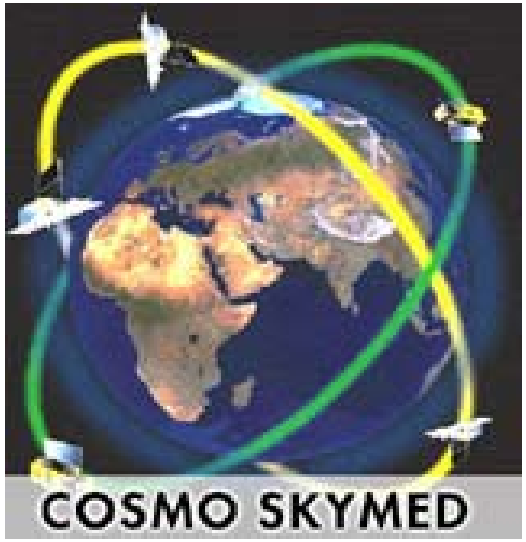
(SCHUSS, ET AL., ARRAY-96)

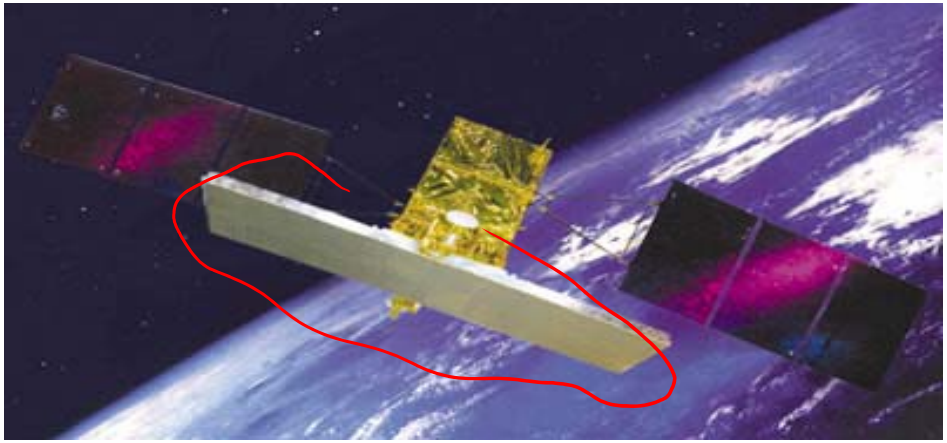
GROUND FOOTPRINTS OF 16 BEAMS

Space-Based Radar Systems (I)

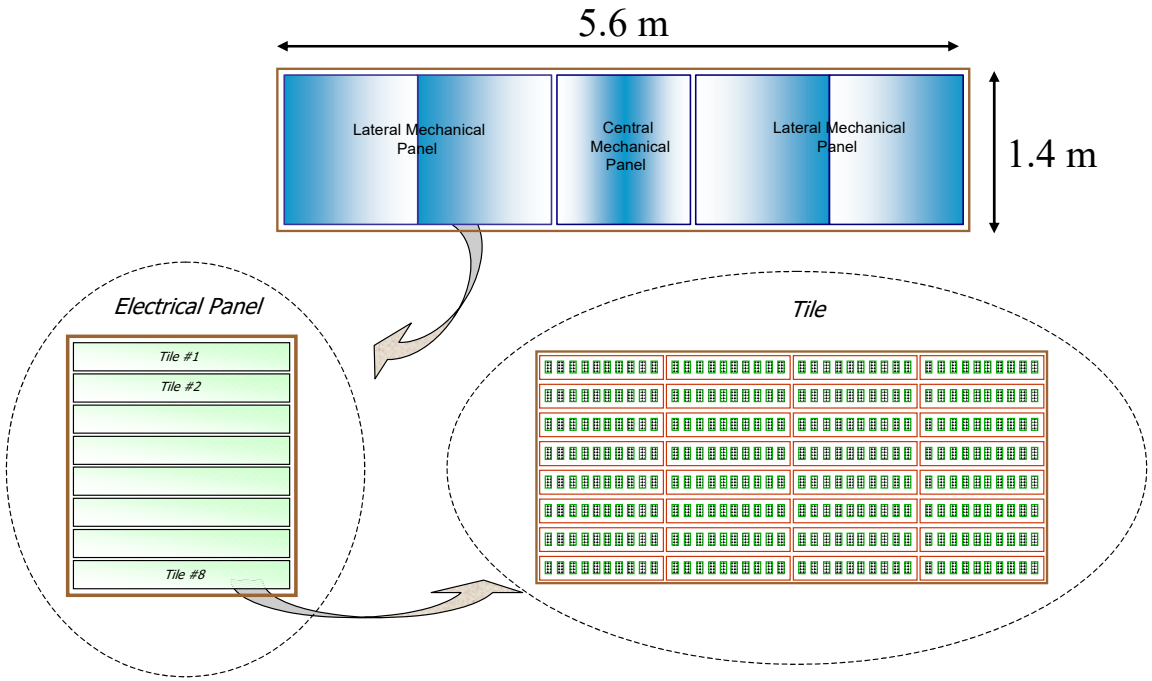
COSMO-SkyMed

COnstellation of Small Satellite for Mediterranean basin Observation



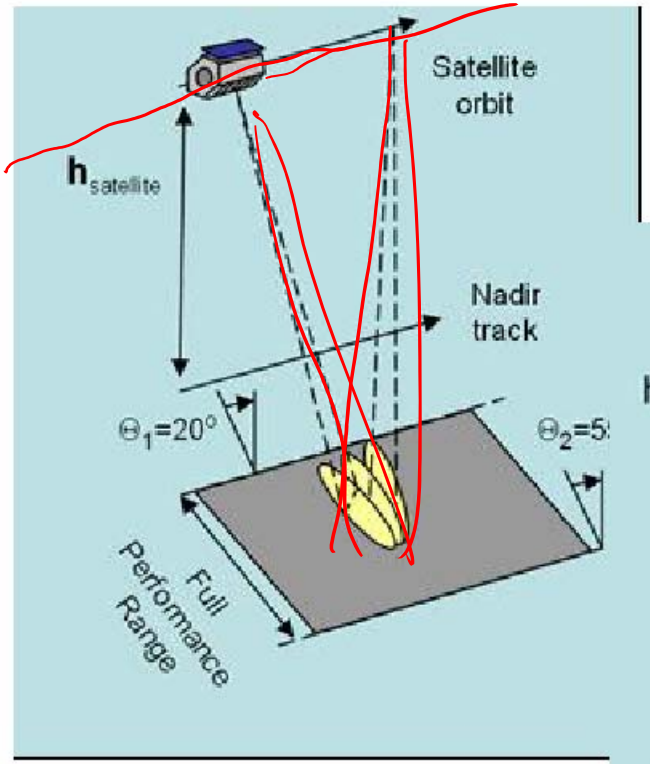


http://www.skyrocket.de/space/

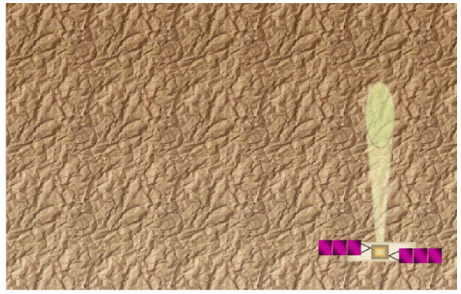


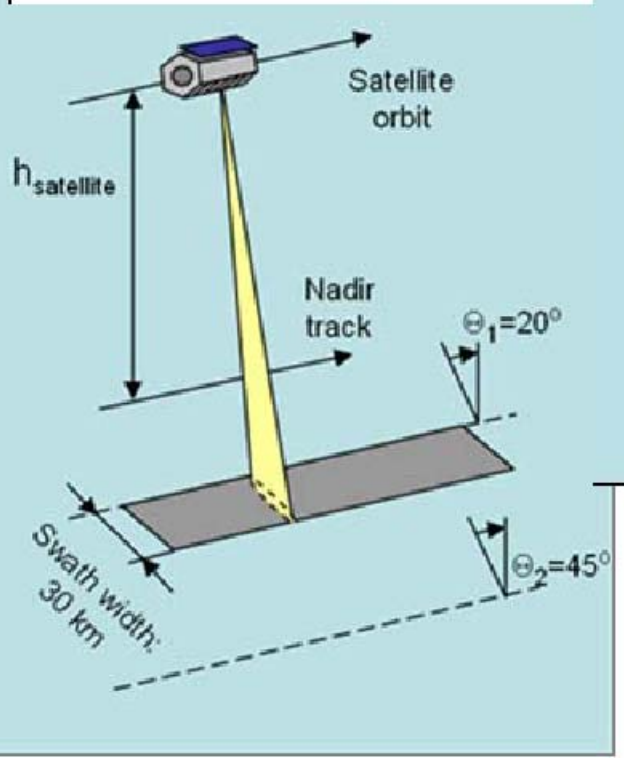
da Workshop Unità Tecnologica Payload RADAR, Roma 18/02/2003, ing. F. Caltagirone
http://www.asi.it/html/ita/news/PresentazionePYRAD1.zip

SAR imaging modes

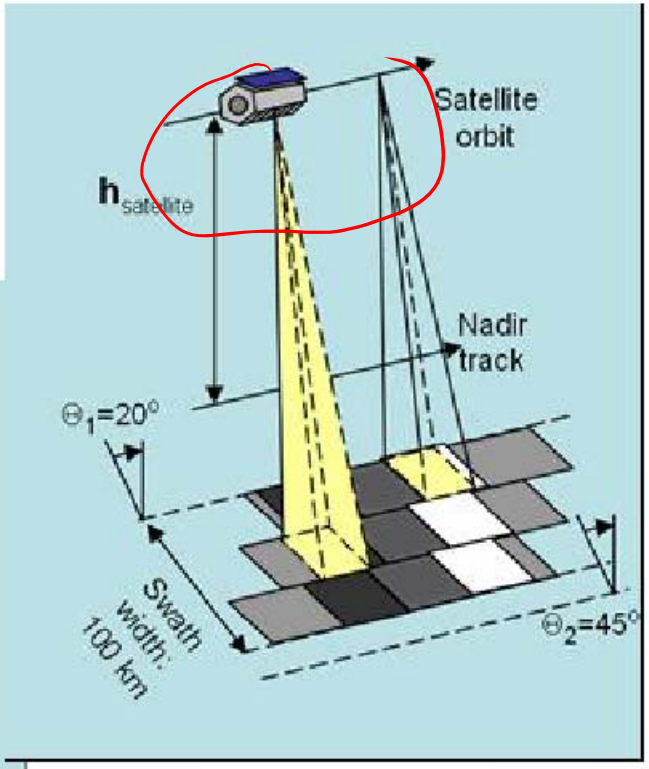


Spotlight





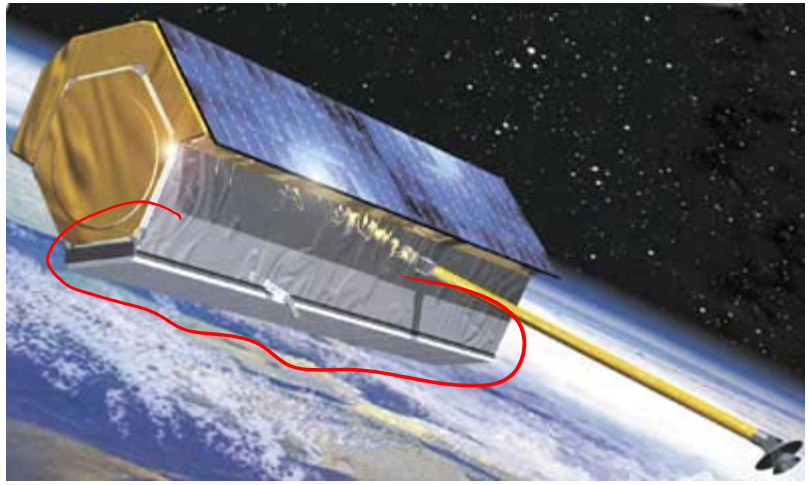
Stripmap



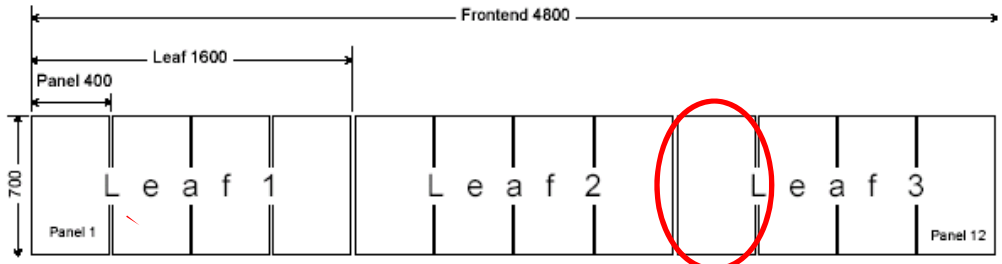
ScanSAR

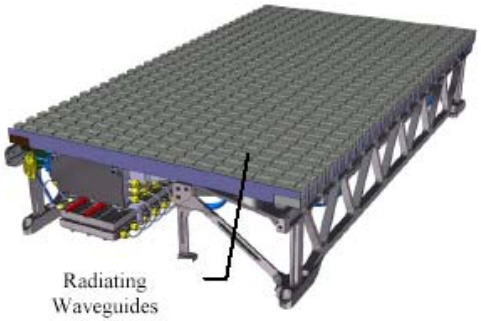
Space-Based Radar Systems (II)

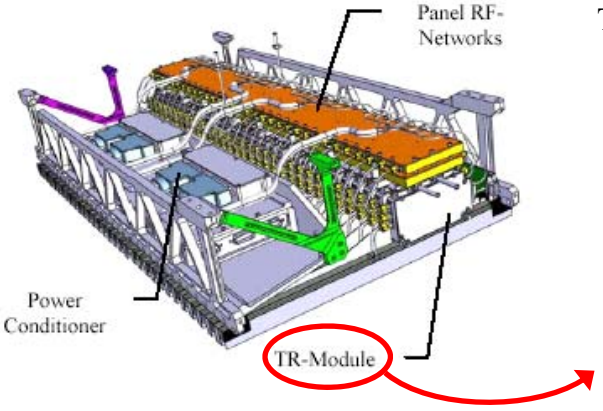
TerraSAR-X



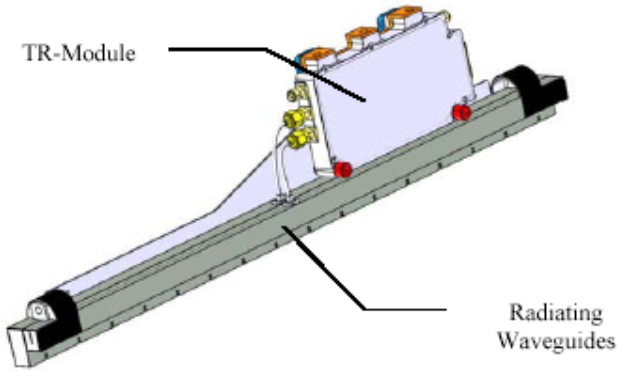
http://www.skyrocket.de/space/







M. Stangl, R. Wernighaus, R. Zahn, (2003), "The TerraSAR-X Active Phased Array Antenna", IEEE Int. Symposium on Phased Array Systems and Technology, Boston, October 14-17, pp. 70-75.

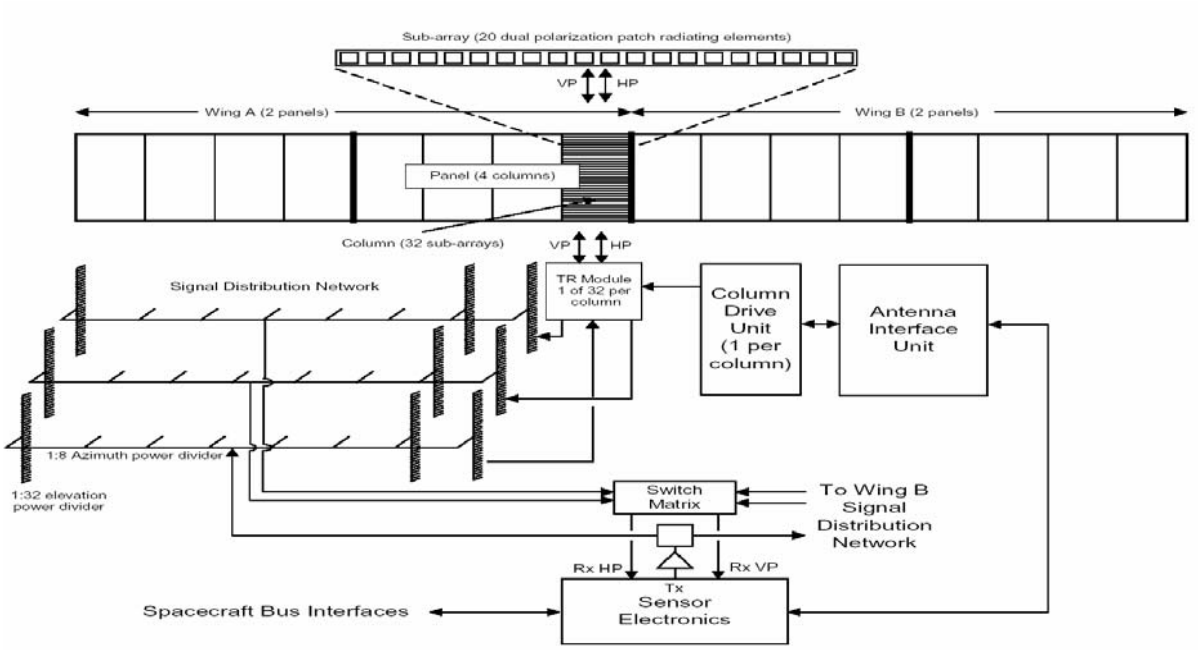


Space-based Radar Systems (III)

Radarsat-2

http://www.radarsolutions.dera.gov.uk/radarsat2.html

Antenna Dimensions: 15m x 1.5m



P.A. Fox, C. Grenier, (2003), "The radarsat-2 synthetic aperture radar antenna phased array error analysis and performance", IEEE International Symposium on Phased Array Systems and Technology, 14-17 Oct. 2003, pp. 247-252