Synthetic Aperture Radar

LECTURE 7

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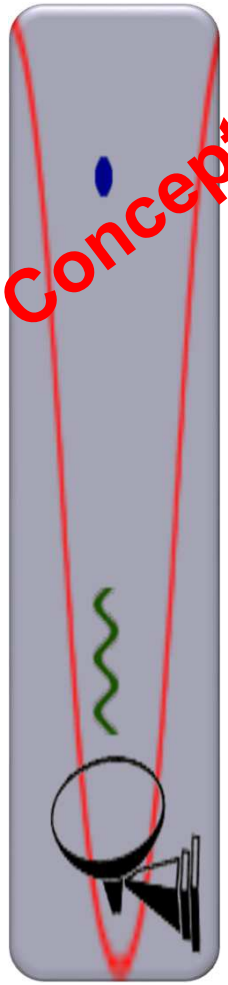
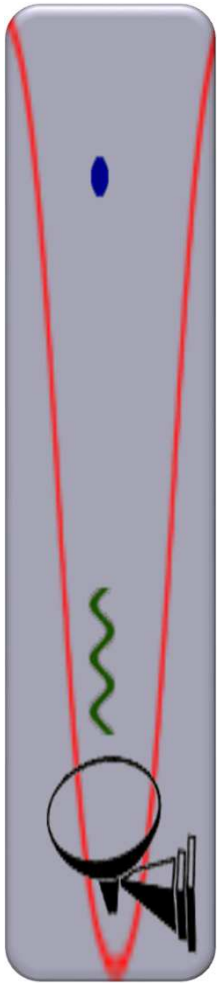
Concept of Coherence

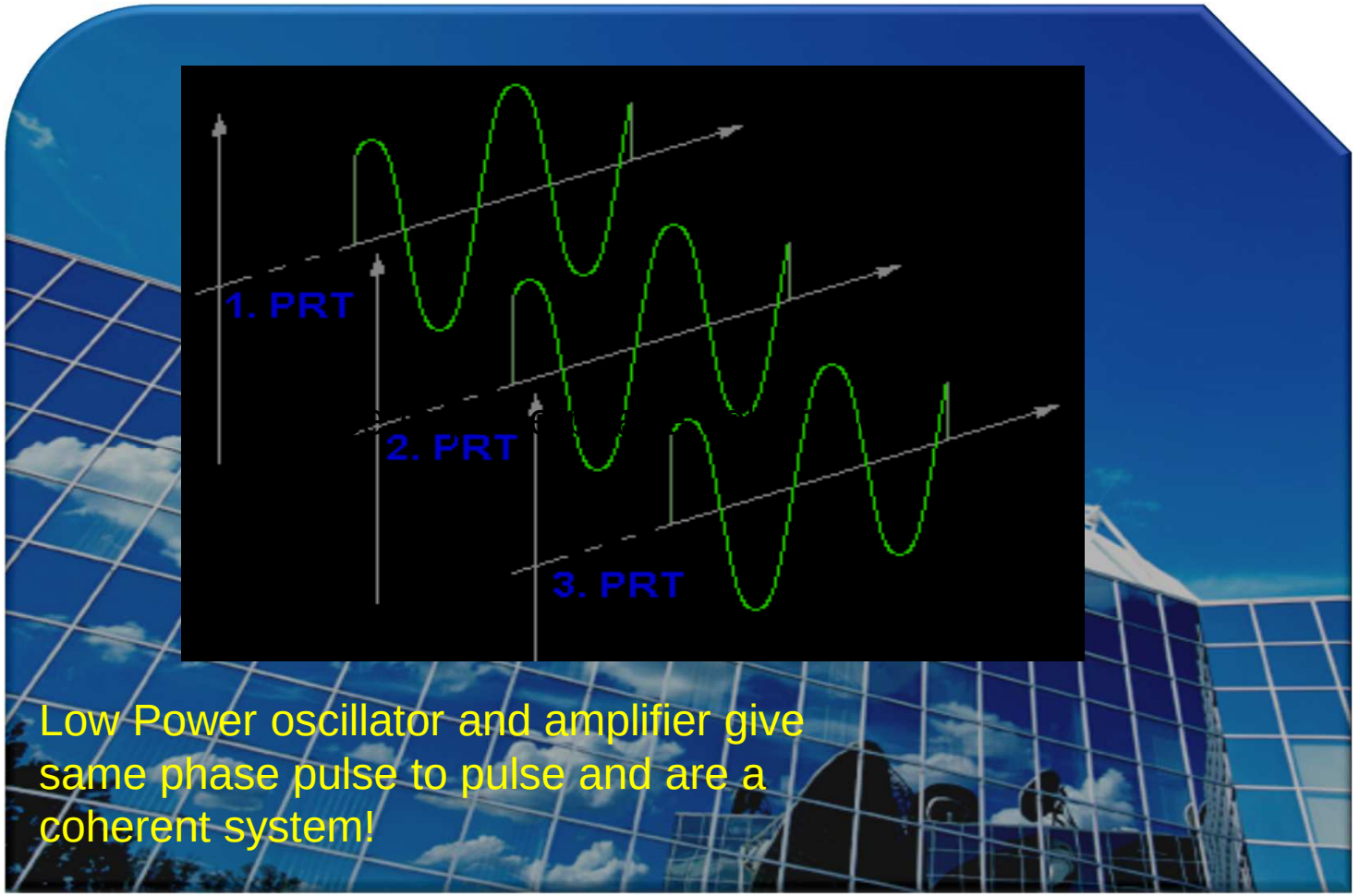


What is Coherent Radar?

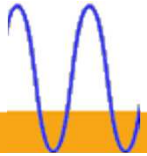
- The transmitted pulse's of coherent radar have all defined phase angles to a reference.
- Whether a radar set is coherent or non-coherent always depend on the transmitter.
- As a transmitter different systems are used in radar.

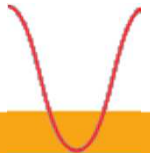
PULSE TO PULSE PHASE COHERENCE



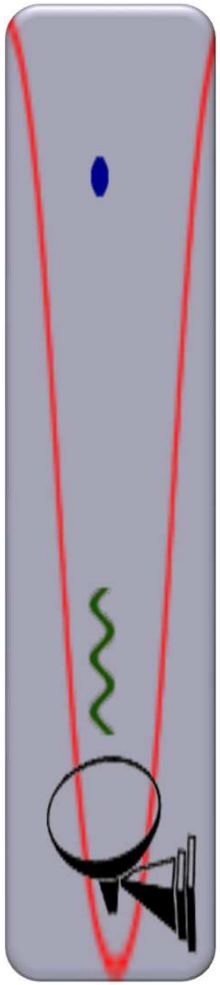


Low Power oscillator and amplifier give same phase pulse to pulse and are a coherent system!

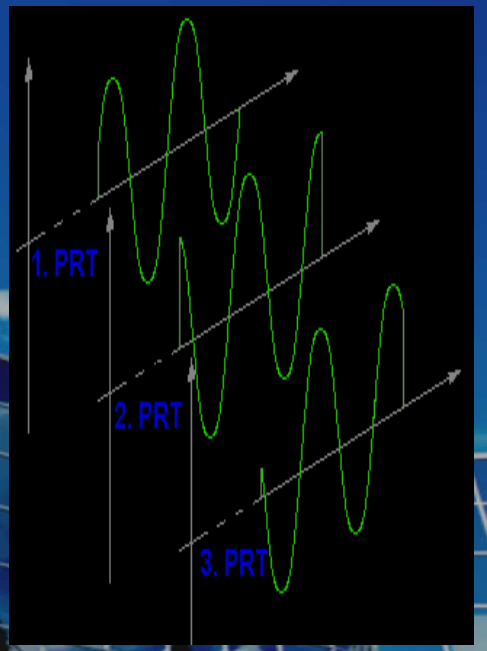


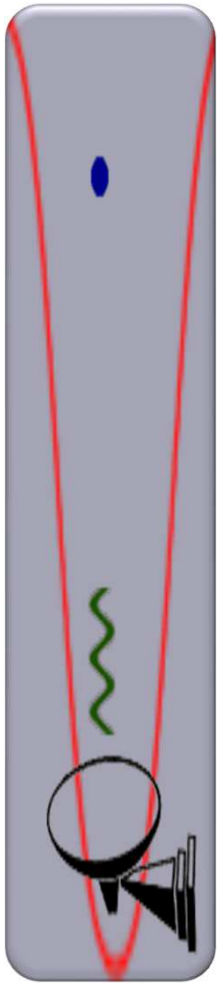


NON-COHERENT RADAR PROCESSING

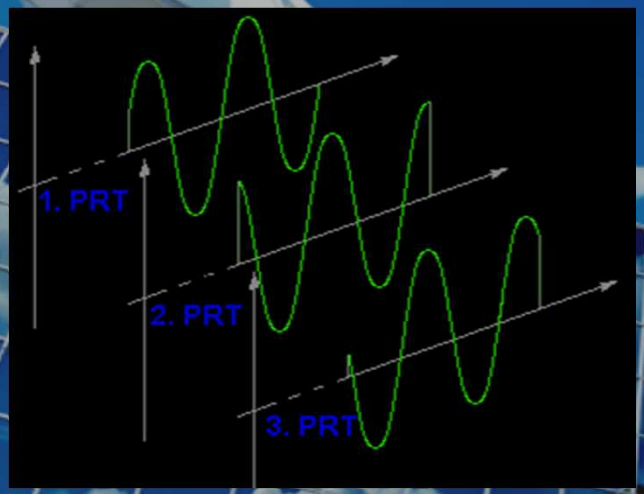


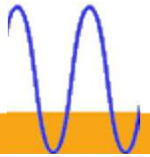
- One of the transmitting systems is the POT (Power Oscillator Transmitter) which is self oscillating.
- When such a device is switched on and off as a result of modulation by the rectangular modulating pulse, the starting phase of each pulse is not the same for the different successive pulses.
- The starting phase is a random function related to the start up process of the oscillator.

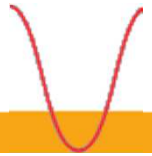




Self oscillating transmitter gives random phase pulse to pulse and is not coherent!

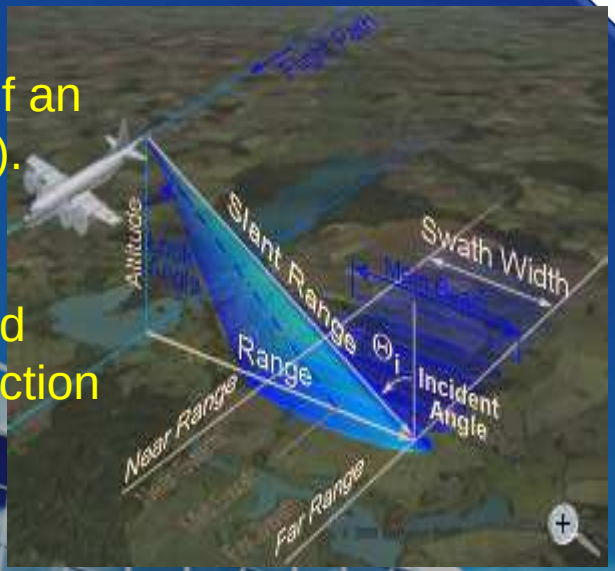






SIDE LOOKING AIRBORNE RADAR (SLAR)

- The platform (aircraft or satellite) of an side-looking airborne radar (SLAR).
- The microwave beam is transmitted obliquely at right angles to the direction of flight illuminating a swath.
- Range refers to the across-track dimension perpendicular to the flight direction, while azimuth refers to the along-track dimension parallel to the flight direction.

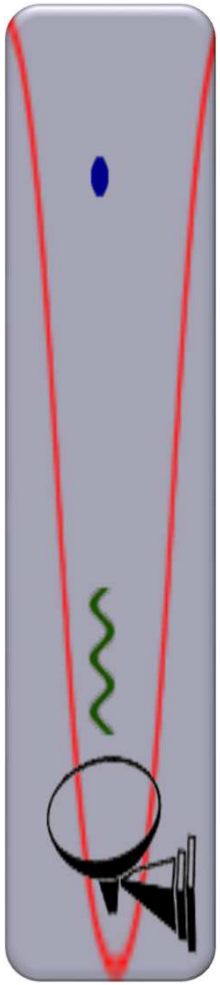


SIDE LOOKING AIRBORNE RADAR (SLAR)

The SLAR is a real aperture radar primarily. This requires a reasonable large antenna for adequately angular resolution. The azimuth resolution, Ra, is defined as

H is the height of the antenna, (height of the airplane)
L is the geometric length of the antenna,
λ is the wavelength of the transmitted pulses, and
θ is the incidence angle

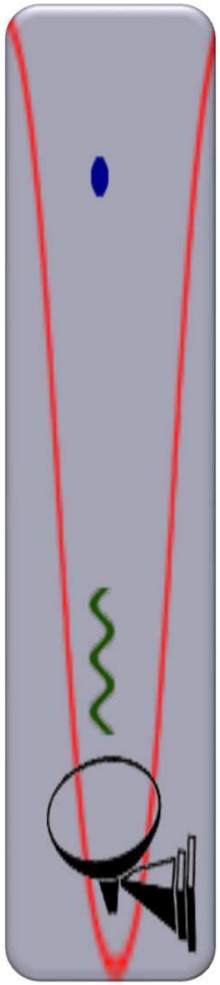
$$R_a = \frac{H \cdot \lambda}{L \cdot \cos\theta}$$



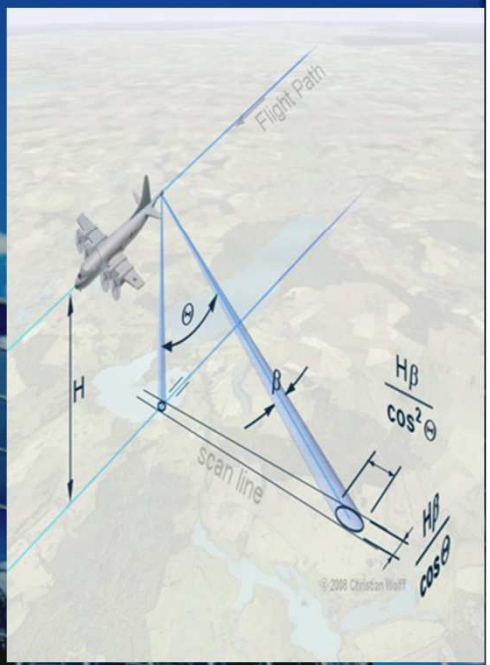
- The equation shows, that with increasing altitude decreases the azimuthal resolution of SLAR.

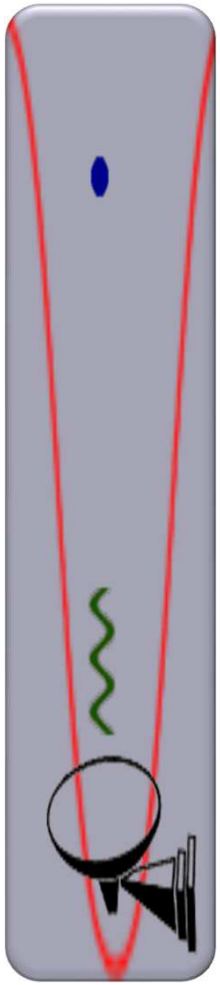
$$R_a = \frac{H \cdot \lambda}{L \cdot \cos\theta}$$

- A very long antenna (i.e., large L) would be required to achieve a good resolution from a satellite



- Synthetic Aperture Radar (SAR) is used to acquire higher resolution.
- The size of the ground resolution cell increases on the side of the nadir as the distance between radar platform and the ground resolution cell increases.
- This means that the ground resolution cells are larger towards the edge of the image than near the middle. This causes a scale distortion, which must be accounted for.





- At all ranges the radar antenna measures the radial line of sight distance between the radar and each target on the surface. This is the slant range distance.
- The ground range distance is the true horizontal distance along the ground corresponding to each point measured in slant range. The cross-track resolution, Rr, is defined as:

$$R_r = \frac{c_0 \cdot t_p}{2 \sin \theta}$$

c_0 is the speed of light
t_p is the pulse duration of the transmitter, and
θ = incidence angle

$$R_r = \frac{c_0 \cdot t_p}{2 \sin \theta}$$

$$R_a = \frac{H \cdot \lambda}{L \cdot \cos \theta}$$

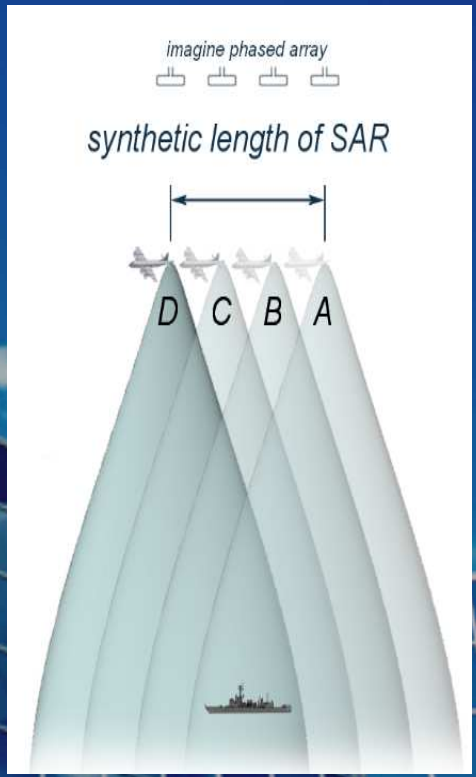
For an SLAR with the following characteristics:
λ = 1 cm,
L = 3 m,
H = 6000 m,
θ = 60°, and
tp = 100 ns,
has got a resolution of
Ra = 40 m and
Rr = 17.3 m

Note: The same SLAR on a platform in a height of 600 km would achieve an azimuth-resolution of Ra = 4000 m.

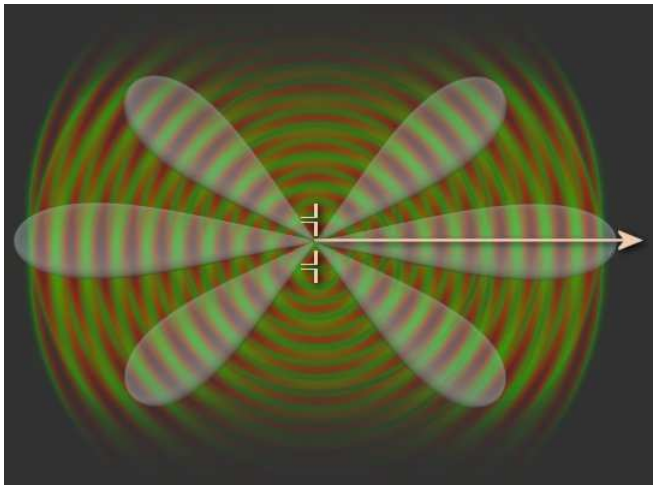
A Synthetic Aperture Radar (SAR), or SAR, is a coherent mostly airborne or spaceborne sidelooking radar system which utilizes the flight path of the platform to simulate an extremely large antenna or aperture electronically, and that generates high-resolution remote sensing imagery.

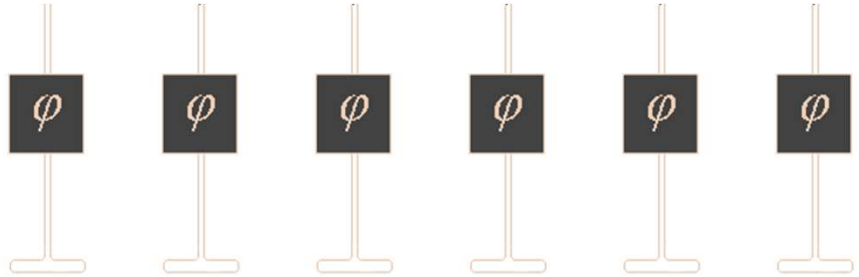
How does SAR works?

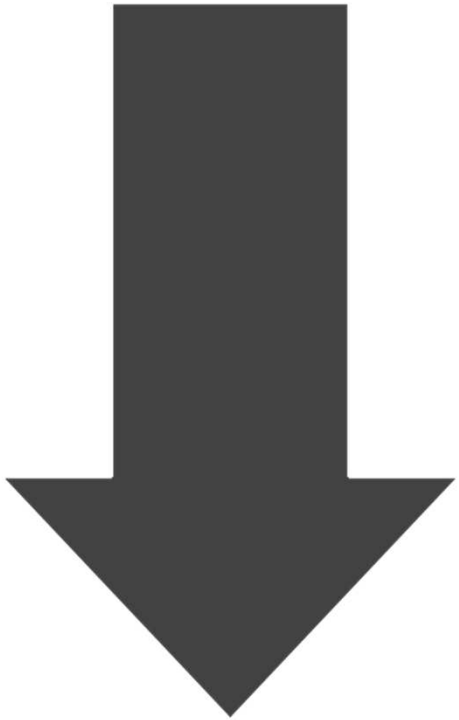
- As a target (like a ship) first enters the radar beam, the backscattered echoes from each transmitted pulse begin to be recorded.
- As the platform continues to move forward, all echoes from the target for each pulse are recorded during the entire time that the target is within the beam.
- The point at which the target leaves the view of the radar beam some time later, determines the length of the simulated or synthesized antenna.
- The synthesized expanding beamwidth, combined with the increased time a target is within the beam as ground range increases, balance each other, such that the resolution remains constant across the entire swath.



Two antenna elements, fed with the same phase







Fed with different phase shift