Classic Stripmap SAR

- SAR azimuth antenna length L_0 and azimuth resolution δ_0 related by

$$L_0 = 2\delta_0. \tag{1}$$

- View δ_0 as a function of required beamwidth (for wavelength λ),

$$\Theta_0 \approx \frac{\lambda}{L_0} = \frac{\lambda}{2\delta_0}. \tag{2}$$

- Required spatial sampling is δ_0 which means, for platform velocity v_s, we need a PRF of

$$f_p = \frac{v_s}{\delta_0}. \tag{3}$$

- To minimize δ_0, minimize L_0 which maximizes Θ_0.

Maximize azimuth beamwidth

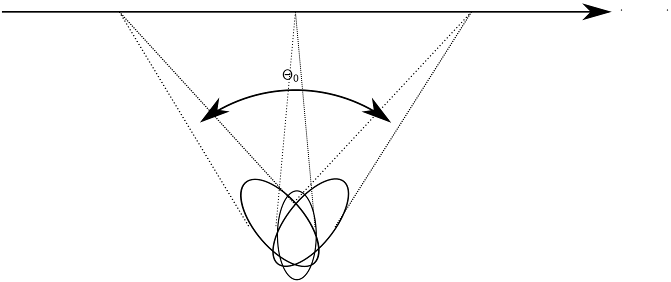


Figure: Spotlight mode to increase range of look angles.

- It's not the beamwidth but the fact that the target/scene is viewed from a wide range of azimuth angles.
- A wide beamwidth is one way to achieve this.
- Spotlighting (mechanical or electronic) is another

Approach

- Divide total beamwidth into M parts

$$\Theta_M = \frac{\Theta_0}{M} = \frac{\lambda}{2M\delta_0}. \tag{4}$$

- Each part needs an antenna of length

$$L_M = 2M\delta_0, \tag{5}$$

- and a PRF of

$$f_p = \frac{2v_s}{\lambda}\Theta_M = \frac{2v_s}{L_M} = \frac{v_s}{M\delta_0}, \tag{6}$$

- Arrange a set of antennas of length L_M in the azimuth direction and change the beam direction from pulse to pulse

Five channel example with ideal PRF

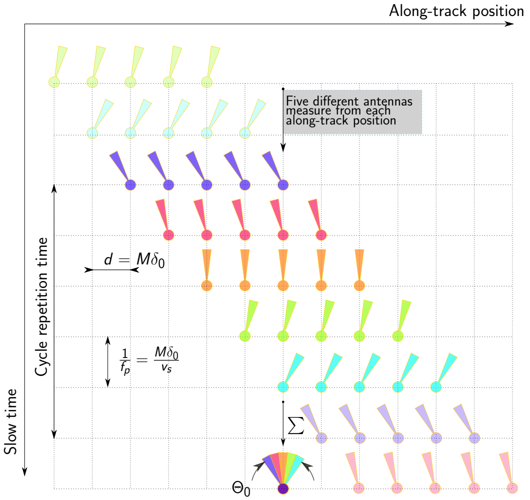


Figure: Five channel example. Circles denote the phase-centre location while the angle denotes the direction of the Tx and Rx patterns.

Azimuth antenna configuration

- Arrange a set of subarrays in the along track direction as illustrated.
- Two-way phase-centre separation will be $d = M\delta_0$
- With each subarray of length $2M\delta_0$, the total array length is

$$L = ML_M = 2M^2\delta_0. \tag{7}$$

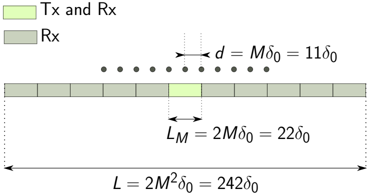


Figure: Antenna Lengths to achieve desired resolution for an example 11 channel system for a desired resolution of δ_0.

Example antenna lengths

Table: System parameters for $\delta_0 = 0.1$m and $v_s = 7500$m/s. The swath is the simply related to the time between pulses without consideration of pulse length and margins.

M	L_M **m**	L **m**	f_p **Hz**	**Swath (slant-range Km)**
1	0.20	0.20	75000	2.00
3	0.60	1.80	25000	6.00
5	1.00	5.00	15000	10.00
7	1.40	9.80	10710	14.00
9	1.80	16.20	8330	18.00
11	**2.20**	**24.20**	**6810**	**22.00**
13	2.60	33.80	5760	26.00
15	3.00	45.00	5000	30.00

Signal processing

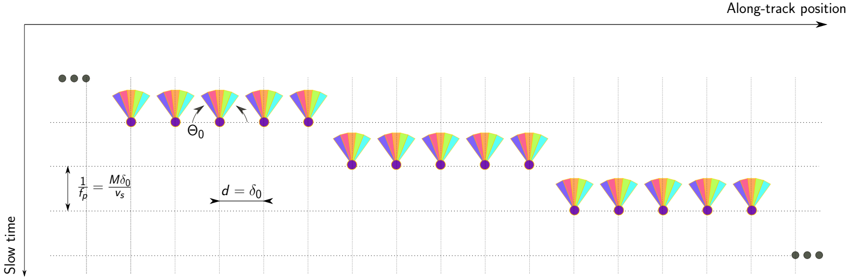


Figure: Equivalent HRWS system.

- Have to generalize to non-ideal PRFs.
- Similar approach to non-uniform sampling for HRWS mode.
- Number of samples grows as $1/\delta_0^2$ in both azimuth and range.
- Developed a wavenumber processing approach
  - Based on paramterisation by arclength
  - Generalised Stolt interpolation

Simulation

Table: Simulation parameters

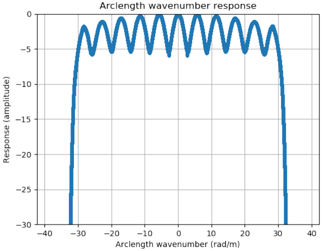
mode	f_p Hz	L m	L_M m	M	Swath km	f_0 GHz	B MHz
40 cm	4500.00	20.0	4.0	5	16.5	9.65	374.74
30 cm	5000.00	21.4	3.6	6	13.5	9.65	499.65
25 cm	5142.86	24.4	3.5	7	12.7	9.65	599.58
20 cm	6428.57	19.6	2.8	7	7.5	9.65	749.48
12 cm	7500.00	24.0	2.4	10	4.5	9.65	1249.14
10 cm	8181.82	24.2	2.2	11	3.0	9.65	1498.96

- swath width has been computed in the slant-range.

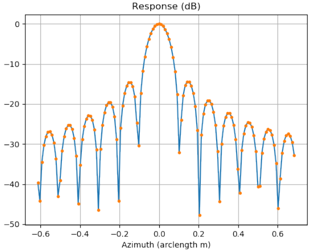
$$\text{Swath}(f_p;\tau_p) = (1/f_p - 2 * \tau_p) * \frac{c}{2} \times 90\% \tag{8}$$

- τ_p is the pulse duration, selected as $\tau_p = 50 \times 10^{-6}$ s.
- 10% margin incorporated.

Processed signal



(a) 10 cm mode.



(b) Azimuth cross-section of 10cm mode.

Figure: Reconstructed signals in azimuth wavenumber domain.

PSF

- Over the wider azimuth range, one observes a different generation of sidelobes with a peak rising to around -18dB.
- A Doppler weighting could suppress these at the expense of resolution.

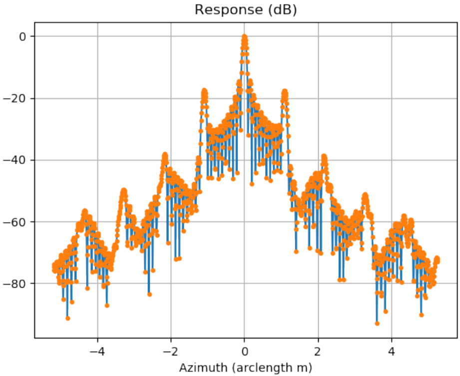


Figure: Azimuth cross-section of 10cm mode.

NESZ

Table: Computed NESZ

Mode	f_p (Hz)	**NESZ** (dB)
40 cm	4500.00	-30.9
30 cm	5000.00	-29.8
25 cm	5142.86	-29.7
20 cm	6428.57	-29.2
12 cm	7500.00	-25.5
10 cm	8181.82	-30.2