Basic questions

1. Explain the basic idea of synthetic apertures.
2. Explain how range resolution is signal dependant.
3. How does the cross-range resolution depend on the antenna size?
    a. for real apertures.
    b. for synthetic apertures.
4. How does the cross-range resolution depend on the range?
    a. for real apertures.
    b. for synthetic apertures.
5. Explain the Doppler effect.
6. Given a C-band radar with antenna length of 1m that generates LFM-chirps of 100 MHz bandwidth at 6 GHz, what are the range and cross-range resolutions at a distance of 10 km? What would be the expected resolutions with a synthetic aperture (stripmap mode)?
7. What is the difference between layover and foreshortening in SAR images?

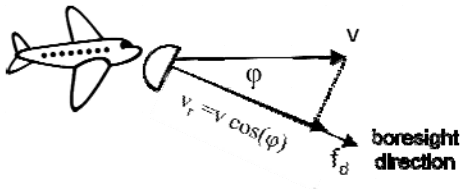
Doppler effect

We have seen that the Doppler frequency shift can be expressed by:

$$f_d = \pm\frac{2v}{c}f_0$$

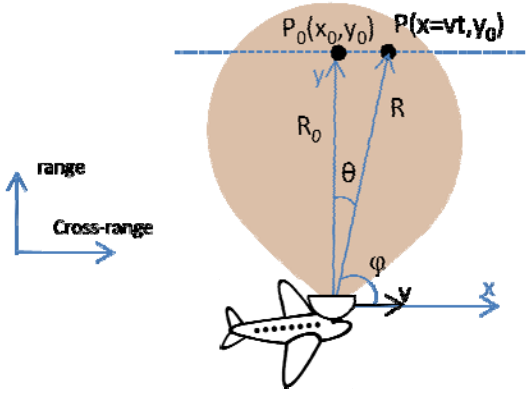
Note that this formula is only valid for objects whose relative velocity are in the direction of the radar main beam (antenna boresight). In a general case, the Doppler shift is proportional to the radial velocity, which is the velocity component in the direction of the radar:

$$f_d = \pm\frac{2v_r}{c}f_0 \pm \frac{2v\cos(\varphi)}{c}f_0$$



Hence, the magnitude of the Doppler shift is maximum when the target is travelling directly towards or away from the radar and equal to zero (regardless of the velocity) when it is crossing orthogonally to the radar boresight. This last configuration is typical of SAR systems.

We will analyze the 2D geometry depicted on the following figure.



1. The point P is moving parallel to the flight path. Express the range R of point P as a function of R_0 and t.
2. Show that if $vt << R_0$, the range can be expressed as:

$$R(t) \approx R_0 + \left(\frac{v^2}{2R_0} \right) t^2$$

3. Express the phase and Doppler shift of the received signal from point P. What is the relation between Doppler shift and time (hint: $\phi(t) = 2\pi \frac{2R(t)}{\lambda}$)?
4. Assuming that the radar is the C-band radar of question 6, flying at a constant speed of 140 $m.s^{-1}$, what would be the maximum and minimum Doppler shift for a path length limited to 400m (+/- 200m from P_0). Sketch the evolution of the Doppler shift as a function of x.
5. What would be the achievable Doppler and cross-range resolution for this configuration?

Image interpretation

Analyse this SAR image. What distortion effects do you see?