Project 2

Project Rules:

1. This project is to be done individually.
2. Each student must develop his/her own code and submission material
3. The code needs to be written in either Matlab, or Python.
4. The student must submit a written report with plots and explaining what each plot means and the assumptions employed
5. The report/code will not be graded on efficiency, style, or writing quality, but both should be clear enough to be reasonably understandable.

Objective: To explore, and understand range Doppler map formation.

Problem 1

Consider a RADAR system with a pulse width of 50 μs. The RADAR transmits a linear frequency modulated waveform (LFM) and employs stretch processing. The LFM signal sweeps a bandwidth of 150 MHz. The range swath of interest is 1500 m. The RADAR is on an aircraft with the following initial position $P_{RDR} = \begin{bmatrix} -3 & 10000 & 304.8 \end{bmatrix}$ m. The velocity of the aircraft is $V_{RDR} = \begin{bmatrix} 150 & 0 & 0 \end{bmatrix} \frac{m}{s}$. The RADAR employs a PRF of 7500 Hz and a CPI of 40 ms. The receiver noise figure is 3 dB, temperature is 290 K.
Assume the following:

1. RADAR Peak transmit power of 10 dBW
2. All targets will have an RCS of 15 dBsm
3. Transmit and Receive antenna gain of 20 dB each
4. Assume no system, or atmospheric losses

Tasks:

- Determine the requires sampling frequency at the mixer output.
- Produce the received signal per pulse for cases A and B (described below) at both 1 GHz and 10 GHz
- Produce the range Doppler map for both cases at a center frequency of 1 GHz and 10 GHz

- Plot each RDM and note the squint angle for each case
- Comment on the scatterer presentations in the RDM for each case
- Hint: A received data sample can be modeled in the following manner $y(n) = \sqrt{P_r}x_{signal}(n) + x_{noise}(n)$, where $x_{noise} = \sqrt{\frac{\sigma^2}{2}}[x_{noise,real} + jx_{noise,imag}]$. Recall x_{noise} is distributed $CN(0, \sigma^2)$

Recall a stretch processor multiplies the received signal by a reference chirp given by

$$S_{ref}(t) = e^{j2\pi F_c(t-t_o)}e^{j\pi\frac{\beta}{\tau}(t-t_o)^2} \tag{1}$$

which relates the target delay t_d to a reference range R_o. The reference range is usually the distance to a center reference point (CRP). For this project, assume the reference range is updated per pulse. This means that you will have a reference range of the form $R_o(m) = ||P_{RDR}(m) - CRP||$ where m is the pulse index. An example of this is given in the Matlab script DBSExample.m located in the **Lecture 21** folder in D2L.
There are two target layout cases. The scatterers (5 for this project, each represented by a row in the matrix) are laid out in the following arrangement (xyz coordinates):

$$L = \begin{bmatrix} -100 & -100 & 0 \\ -100 & 100 & 0 \\ 100 & -100 & 0 \\ 100 & 100 & 0 \\ 0 & 0 & 0 \end{bmatrix} \tag{2}$$

These scatterer locations are all relative to a CRP. When simulating the data, the target locations will be offset by the CRP location. Meaning, that for a particular case $L_{Tgt} = L + CRP$

1. Case A: $CRP = \begin{bmatrix} 10000 & 0 & 0 \end{bmatrix}$
2. Case B: $CRP = \begin{bmatrix} 0 & 0 & 0 \end{bmatrix}$