The objective of this miniproject is to relate time-varying arrangements of scatterers and shadowing objects to the effects imposed on a signal propagating through the channel. The details are outlined below. For this project you may form a group of up to 4 members, and the tasks should be assigned as follows:

- One person will develop the Monte Carlo sampling routines appropriate to the different distributions described and plot histograms that show, qualitatively, that the appropriate distributions are actually being obtained. These histograms should include at least as many samples as are requested for each distribution, as described below.
- One person will incorporate the samples from the distributions, as described below, to develop a time-varying impulse response equation that describes the channel.
- Two persons will use the time-varying impulse response equation to evaluate: 1) delay spread, 2) frequency selective fading, and 3) the impact on a baseband pulse, as described below.
- All members will contribute to compile a report with the requested results.

**Problem description**

The problem should be divided into fast-fading and slow-fading (or shadowing components), where the fast fading component can be generated to have the form:

\[ V_{\text{fastfading}} = \sum_{i=1}^{N} a_i \left( \frac{e^{-jkr_{i2}}}{r_{i2}} \right) e^{-jkr_{i1}} \left( \delta(t - \tau_i) \right), \]

where \( r_{i1} \) is the range from the mobile to the \( i^{th} \) scatterer, \( r_{i2} \) is the range from the \( i^{th} \) scatterer to the base station antenna, \( a_i \) is the scattering strength of the \( i^{th} \) scatterer, and \( \tau_i \) accounts for the delay from the mobile to the base station, including the path to and from the \( i^{th} \) scatterer. The shadowing term, \( S \), will be included as a multiplicative term to adjust the amplitude of the fast fading component. That is, the overall impulse response can be represented as

\[ IR = KS V_{\text{fastfading}}, \]

where \( K \) is determined by antenna and transmit power parameters. Note that both \( S \) and \( V_{\text{fastfading}} \) are functions of time due to the time-varying nature of the channel.

**Generation of the fast fading component**

We will assume there are 10 scatterers responsible for the fast fading. These are assumed to lie in the same horizontal plane as the mobile antenna, and they all lie at a radius of 150 m from the mobile. The azimuthal distribution of these scatterers is selected according to a uniform distribution.
tion over the entire 360° in azimuth. The strength of each of the scatterers is to be selected from a Rayleigh distribution with mean of $\sigma = 3 m^2$. This will form one expression for $V_{\text{fastfading}}$ that is valid for 1 second. Each second you are to replace the scatterers by sampling the uniform distribution (10 times) and the Rayleigh distribution (10 times). You will repeat this process 1000 times, since the entire simulation is to be for 1000 seconds. For each arrangement of scatterers you will obtain 1 sample of the received signal, i.e., the sampling rate will be 1 second.

**Generation of the slow fading (shadowing) component**

It is assumed that the shadowing component is due to a knife-edge obstacle that blocks (or influences) the fast fading component paths between the transmitter and receiver. The obstacle ground position varies from 200m to 1500m from the mobile according to a uniform distribution. Obstacle height varies according to a Gaussian distribution with mean of 70m and standard deviation of 30m. You will sample these distributions only once for every 60 samples of the fast fading, i.e., every 60 seconds, except at the beginning where 2 samples will be obtained. The obstacle position and height will vary every sample (every second) according to the difference between two consecutive samples of the distributions, so that the height and position of the obstacle change linearly to the new values (indicated by the second set of samples) over a period of 60 seconds. You will use these values to determine the shadowing component (only magnitude effects) every second.

In this way the total time-varying impulse response is determined for a period of 1000 seconds.

**System parameters**

- Transmit antenna gain 3 dB
- Receive antenna gain 0 dB
- Mobile transmit power 100 mW
- Operating frequency 2 GHz with bandwidth of 10 MHz
- Ground range from mobile antenna to fixed station antenna is 3 km

**Requirements (deliverables)**

- a report describing the approach used
- histogram plots and qualitative statements on goodness of fit
- impulse response plots at several different times
- plot of fading for a CW signal for at least one-fourth of the 1000 second interval
- plot of average delay spread
- plot of average spectral response over the designated bandwidth
- comparison of transmitted and received (baseband) pulses of width 20 microseconds at several different times