

Wireless Networking Technologies Lab 5

LEO Satellite pass using WiFi

Telecommunication Networks (TKN)

Begin: 17.06.2026, 08:00

Submission: **30.06.2026 23:59**

Introduction

In this lab, the LEO scenario will be extending to actually support a full pass of the satellite around earth. We will start with the Matlab example of simulating a LEO satellite pass. Based on the previous lab, adapt the scenario to use WiFi as the communication protocol. This lab further extends the simulation to support free space path loss and calculate the correct transmit power for reception. Lastly in this lab, Doppler pre-compensation will be applied to examine its effects.

Common Simulation Parameters

Unless a task states otherwise, use the baseline configuration in table 1. Use the same random seed and stopping rule when comparing curves.

Parameter	Baseline value
NTN link	NTN-TDL-C channel, LEO altitude 600 km, carrier frequency 2.4 GHz
Wi-Fi link	SISO EHT-MU single-user packet, 20 MHz, MCS 3, APEP 1000 B, 1 TX and 1 RX antenna
Satellite	eccentricity 0, inclination 90, right ascension of ascending node 42, argument of periapsis 32, trueAnomaly 0, orbit propagator two-body-keplerian

Table 1: Baseline simulation parameters.

Task 1

In this task, you will simulate a full pass of the satellite.

1. Adapt the scenario to simulate a pass of the satellite over a mobile station that is placed directly on top of the HFT building at Einsteinufer 25. Use the lab begin date as start time and simulate two hours of satellite movement with a sample time of 30 seconds.
2. Create a distance over time plot, where the distance is the distance to the satellite.
3. Create another plot with elevation angle over time.

Task 2

This task extends the simulation to support free space path loss.

1. Begin by normalizing your signal to have a power of 0 dB. This normalization step is done with the power of the STF. We assume that all powers are now set to dBm values.
2. Next, include the free space path loss in your channel model. Set the transmit power to 20 dBm as in ordinary WiFi and simulate a satellite run. Plot the receive power over time at the receiver.
3. A typical WiFi node has a receive sensitivity of -85 dBm, meaning that is the minimum power where a signal is detectable. How does this compare to the receive power? What is the distance a WiFi transmission can reach with the normal transmit power?
4. Calculate the transmit power that is needed in order to successfully receive WiFi frames from the satellite? For actual reliable reception of WiFi frames, a receive power of at least -75 dBm should be aimed for.
5. The transmit amplifier is limited to 30 dB gain, how much antenna gain is needed to achieve a successful reception?

Task 3

In this task, we will examine the satellite movement in more detail.

1. Given the previously set transmit power, plot the receive power at the station over time. During which time period is a reception possible?
2. Consider the curvature of the earth and plot if the satellite is visible to the ground station over time.
3. Finally, create a Doppler shift over time plot. Can the Doppler shift be used for localization in this case?

Task 4: Research Task – Doppler Pre-Compensation

In this task, we want to apply Doppler pre-compensation to our transmitted waveform. Use the above scenario but with a short simulation time of only 10 minutes. In these 10 minutes a total of 1000 packets should be transmitted, uniformly distributed over the simulation duration. Disable pilot tracking in the receiver.

Concept

Assume the channel introduces a Doppler shift f_D . Without pre-compensation, the receiver observes approximately

$$r(t) = h(t)s(t)e^{j2\pi f_D t} + n(t).$$

With ideal pre-compensation, the transmitter sends

$$s_{\text{pc}}(t) = s(t)e^{-j2\pi \hat{f}_D t},$$

where \hat{f}_D is the predicted Doppler shift. The receiver then observes

$$r(t) \approx h(t)s(t)e^{j2\pi(f_D - \hat{f}_D)t} + n(t).$$

If $\hat{f}_D \approx f_D$, the residual CFO is small.

Experiments

1. Run a PER sweep with the SNR vector 0:1:40 dB without precompensation.
2. Repeat the same sweep with ideal pre-compensation.
3. Repeat the sweep with imperfect pre-compensation, for example with prediction errors of 10, 100, 1000, and 5000 Hz.
4. Compare the maximum usable carrier frequency with and without pre-compensation.
5. Discuss how much residual CFO the 802.11be receiver can tolerate after pre-compensation.
6. What information is required to pre-compensate Doppler at the transmitter and how can it be obtained?

Submission

Your submission should be a zip file with the following:

1. A PDF report with all findings, figures, parameter settings, and answers to the tasks listed above. Every figure must have axis labels, units, legends where needed, and a short interpretation.
2. All code needed to reproduce your results.