L-Band Mobile-Satellite Uplink Interference to GPS: Measurements and Simulations

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BACKGROUND

GPS primarily operates in the L1 band (1575.42 MHz), while its upper adjacent band (1610–1660.5 MHz) is allocated to the Mobile-Satellite direct-to-device (D2D) uplink communication. As D2D transmitters increase, their aggregate out-of-band emissions (OOBE) could affect GPS receivers, highlighting the need to assess coexistence.

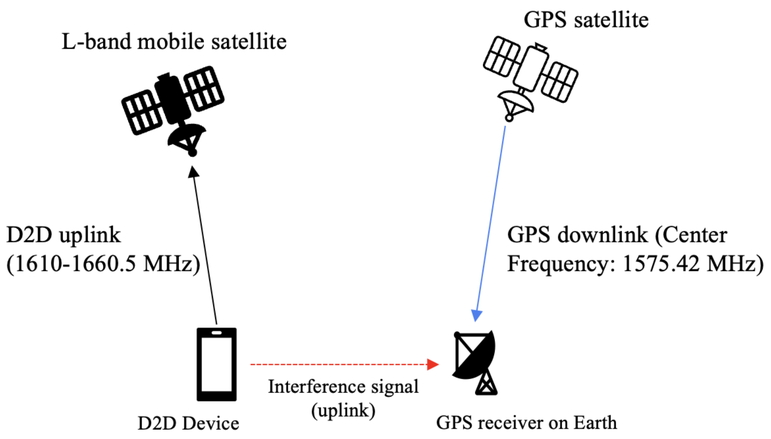


Figure 1 Illustration of potential interference from L-band D2D uplink on GPS receivers

RESEARCH QUESTIONS

- How to model aggregate interference under realistic conditions?
- How to evaluate the potential impact on GPS receiver performance?

METHODS AND MATERIALS

1. **Aggregate Interference Modeling**

- Record and calibrate the OOBE from an Iridium D2D transmitter to obtain accurate single-interference data.

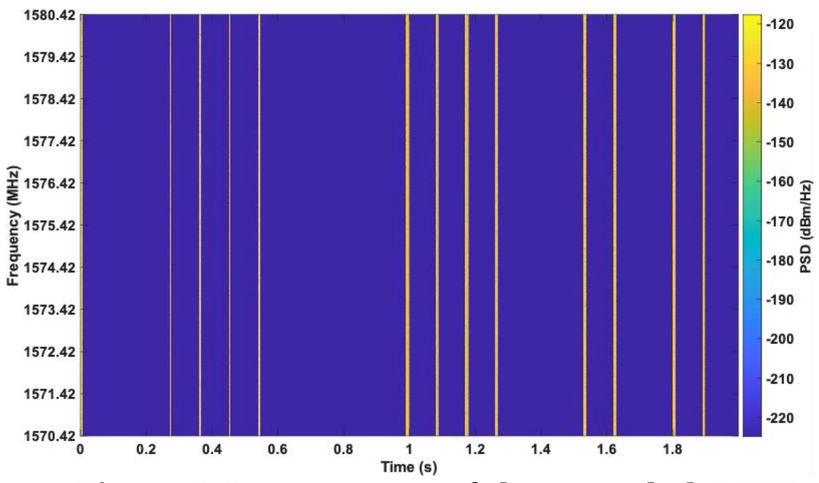


Figure 2 Spectrogram of the recorded OOBE in the GPS L1 band after calibration

- Model the spatial distribution of transmitters within an annular region using a homogeneous Poisson point process (HPPP) with varying inner radius and λ (device density).
- Synthesize the aggregate interference based on the recorded calibrated OOBE data and the modeled transmitter distribution.

METHODS AND MATERIALS - CONTINUED

2. **GPS Signal Generation and Receiver Design**

- Generate a multi-satellite GPS L1 baseband signal.
- Design a software-defined multi-channel GPS L1 receiver based on GNSS-SDR software.

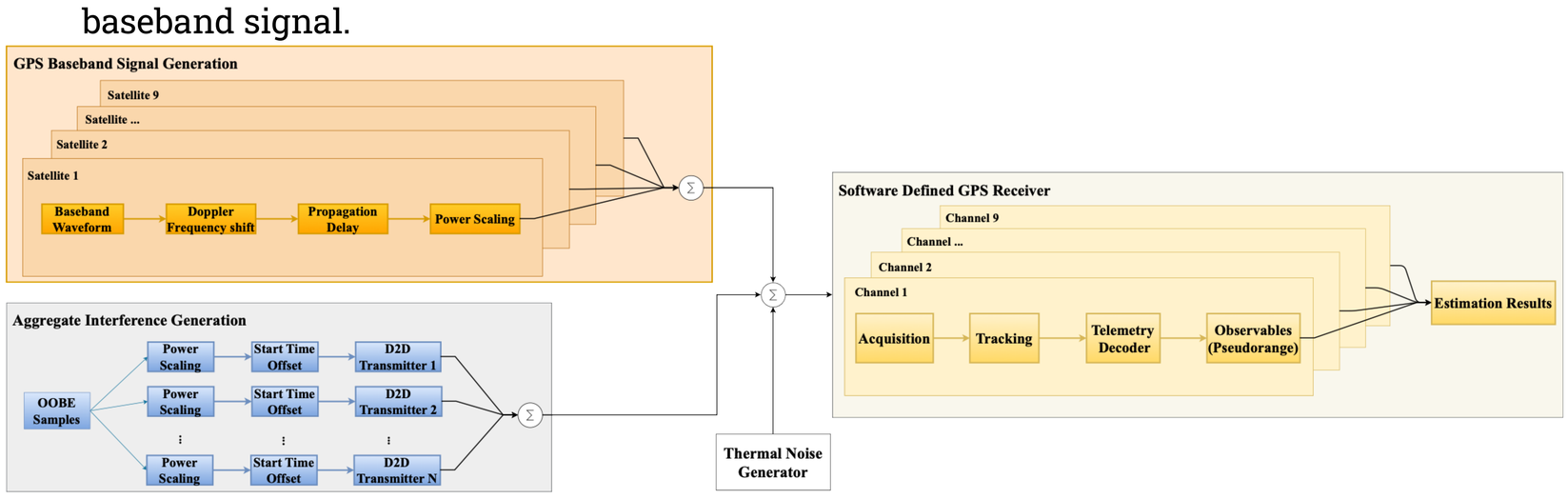
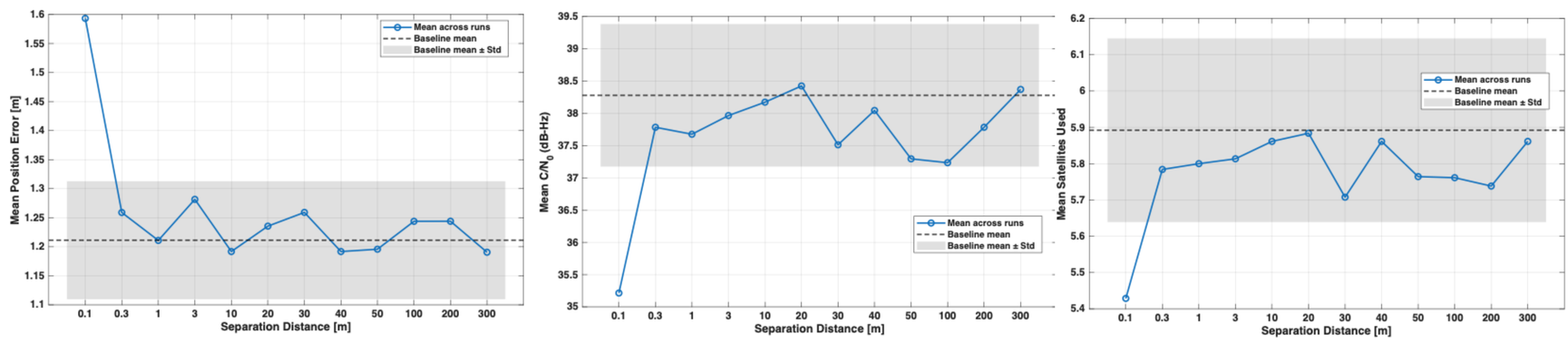


Figure 3 Simulation framework illustration

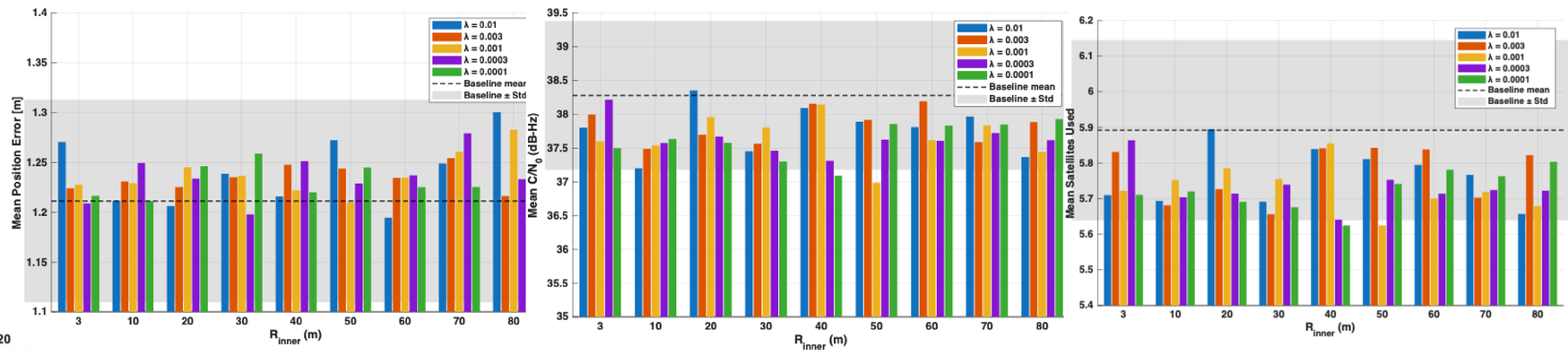
RESULTS



(a) Mean position error vs. separation distance

(b) Mean number of satellites used vs. separation distance

(c) Mean C/N_0 vs. separation distance



(d) Mean position error vs. inner radii and λ

(e) Mean number of satellites used vs. inner radii and λ

(f) Mean C/N_0 vs. inner radii and λ

Figure 4 Simulation results for mean position error, mean number of satellites and mean C/N_0 : (a)–(c) single-transmitter scenario; (d)–(f) multiple-transmitter scenario

KEY TAKEAWAYS

1. For single transmitter scenario, a separation of 0.3 m keeps all three metrics within safety region.
2. For aggregate scenario, metrics remain within the safety region with only marginal, nonmonotonic excursions, indicating that the impact of aggregate interference on GPS receivers is limited within the simulated parameter range.

ACKNOWLEDGEMENTS

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REFERENCES

[1] National Telecommunications and Information Administration. "Impact of L-Band MSS Direct-to-Device Operations on GPS." Federal Register." Request for comment, December 27, 2024.
[2] C. Fernández-Prades et al., "GNSS-SDR: An open source tool for researchers and developers," ION GNSS Conference, 2011.