



Zentrale Stelle
für Informationstechnik
im Sicherheitsbereich



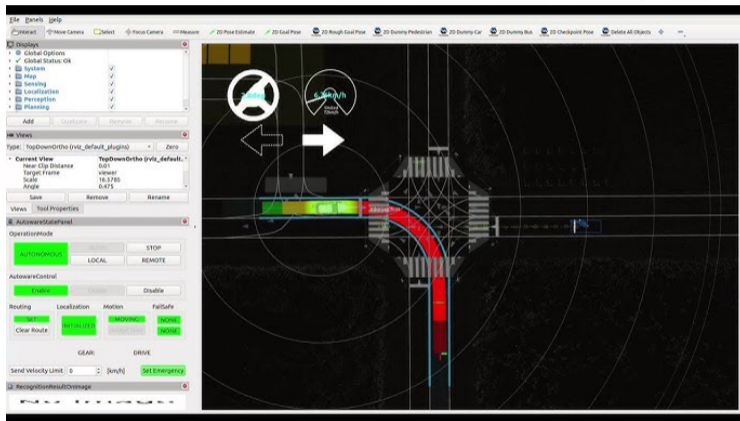
ZITiS

GNSS Spoofing Simulator

Tobias Reichel, IARIA CROSS-SEC, April 20, 2026

State of the Art

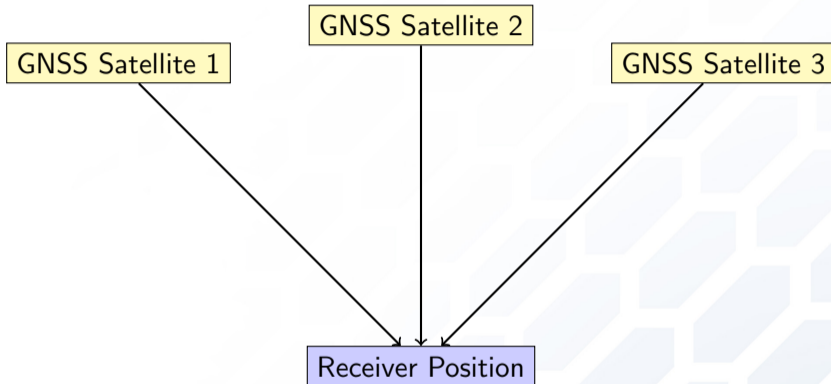
Complex Realistic Location Simulation with and without Spoofing



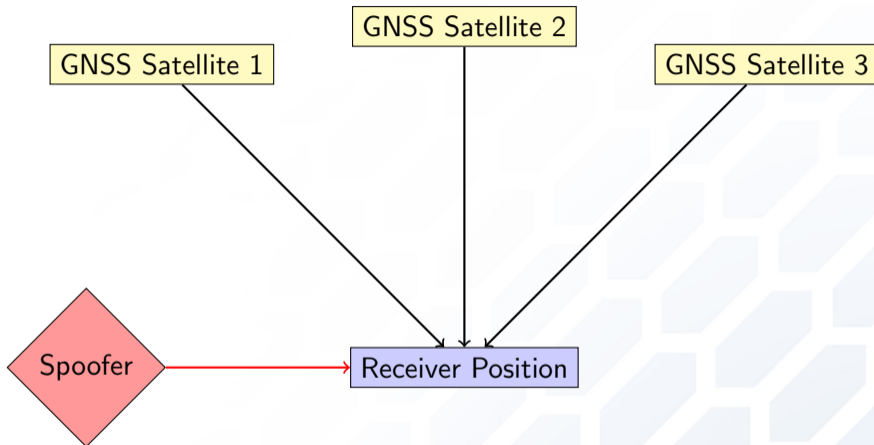
Simulation of the Satellite Signals in NMEA and Rinex Format without Spoofing

```
$GPRMC,000054.00,A,0003.3108943,N,00001.2219070,W,216.13,93.22,180502,0.0,E,A*1C
$GPGGA,000054.00,0003.3108943,N,00001.2219070,W,1,07,1.0,204.046,M,0.000,M,0.0,*6A
$GPGSV,2,1,07,01,19,284,44,03,28,219,50,08,22,348,47,10,16,031,49,1*6C
$GPGSV,2,2,07,16,87,169,57,21,25,316,51,26,47,155,54,,,,,1*54
$GPRMC,000055.00,A,0003.3040910,N,00001.1603140,W,233.18,96.39,180502,0.0,E,A*1B
$GPGGA,000055.00,0003.3040910,N,00001.1603140,W,1,07,1.0,201.894,M,0.000,M,0.0,*6C
$GPGSA,A,3,01,03,08,10,16,21,26,,,,,2.3,1.1,2.0,1*27
$GPGSV,2,1,07,01,19,284,44,03,28,219,50,08,22,348,48,10,16,031,48,1*62
$GPGSV,2,2,07,16,87,169,57,21,25,316,52,26,47,155,53,,,,,1*50
```

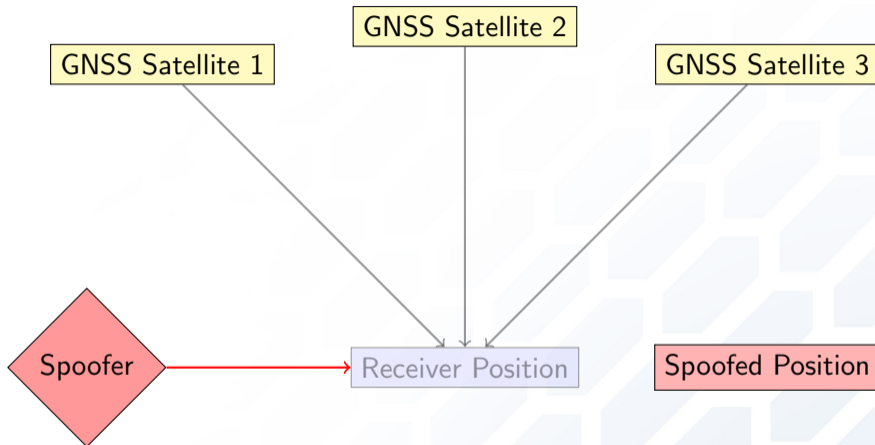
GNSS Spoofing Basics



GNSS Spoofing Basics



GNSS Spoofing Basics



Problem

- ▶ GNSS Spoofing is a malicious attack but no open source simulator exist
- ▶ Need for realistic GNSS Spoofing data for anti spoofing mechanism or forensic investigation research
- ▶ Hardware simulations nowadays are expensive
- ▶ Typical setups require permissions or shielding cables/tents

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- ⇒ Solution: Complete Software side Simulation

Simulation Setup

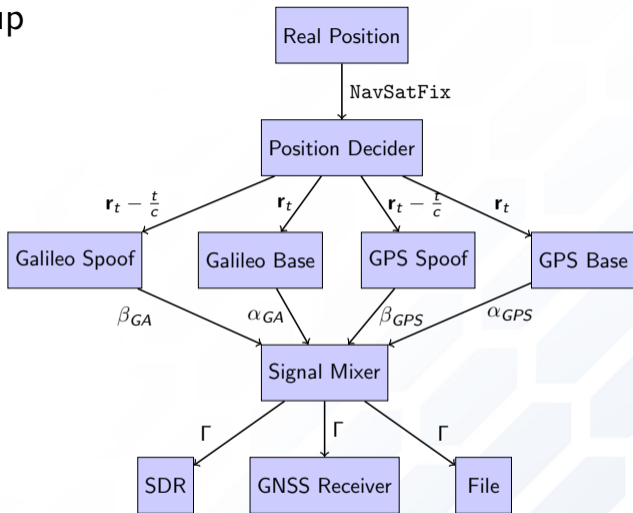


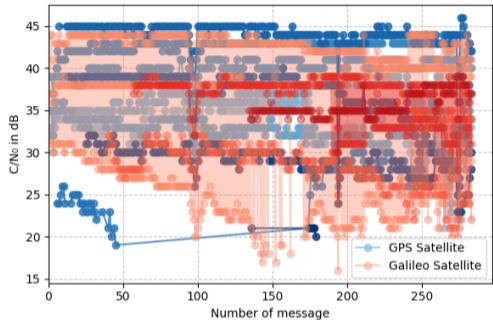
Figure: Systematic Overview of the GNSS Spoofing Simulation Set Up.

Validation

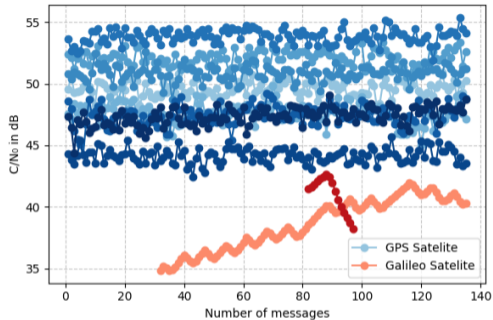
Data Source	Num of mgs	Timestamp	Lat diff	Lon diff	Fix
Original ublox Log	552	14:16:05	0.00002133	0.00002899	5
gnss_sdr α_{GPS}	223	00:13:13	0.00007283	0.00004543	6
gnss_sdr α_{GA}	605	00:02:43	0.00001224	0.00002130	5
gnss_sdr $\alpha_{GPS}, \alpha_{GA}$	2862	00:02:18	0.00012332	0.00011897	7
ublox α_{GPS}	226	No time fix	0.726741	0.586268	1
ublox α_{GA}	-	No time fix	-	-	0
ublox $\alpha_{GPS}, \alpha_{GA}$	231	No time fix	0.000392	0.000271	3
gnss_sdr $\alpha_{GPS}, \beta_{GPS}$	11552	00:00:24	0.000144	39.000095	4
gnss_sdr α_{GA}, β_{GA}	4142	00:01:21	0.006285	20.047235	4
gnss_sdr $\alpha_{GPS}, \alpha_{GA}, \beta_{GPS}, \beta_{GA}$	142	00:01:13	0.777552	34.434319	4
ublox $\alpha_{GPS}, \beta_{GPS}$	178	00:00:35	0.000222	0.001033	0
ublox α_{GA}, β_{GA}	-	No time fix	-	-	0
ublox $\alpha_{GPS}, \alpha_{GA}, \beta_{GPS}, \beta_{A}$	186	No time fix	0.000224	0.000220	0
ublox $\alpha_{GPS}, \alpha_{GA}$ and β_{GPS}, β_{A}	185	No time fix	32.666489	45.748938	0

Table: Comparison of message counts, first timestamp, min-max latitude/longitude differences, and Fix metadata.)

Validation



(a) C/N0 of the test recording.



(b) C/N0 of GPS and Galileo Signal Input.

Figure: Comparison of test recording and simulation with gnss_sdr

- ▶ Only E1B/C Galileo and L1 GPS bands can be simulated
- ▶ Some Anti Spoofing mechanism were triggered by an real receiver
- ▶ Testing with better suited ephemerides files

Citations



- [1] T. Reichel, M. Gerstner, L. Schiller, A. Attenberger, R. Hackenberg, and K. Dološ, “A forensic analysis of GNSS spoofing attacks on autonomous vehicles,” in *Proceedings of the Sixteenth International Conference on Cloud Computing, GRIDs, and Virtualization*, 2025, pp. 32–39.
- [2] gym487, *Gps-sdr-sim-realtime*, 2017, <https://github.com/gym487/gps-sdr-sim-realtime>, Accessed: Feb. 23, 2026.
- [3] H. Sathaye, M. Motallebighomi, and A. Ranganathan, “Galileo-SDR-SIM: An open-source tool for generating galileo satellite signals,” in *Proceedings of the 36th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2023)*, 2023, pp. 3470–3480.
- [4] C. Fernández-Prades, J. I. Arribas, and P. Closas, *GNSS-SDR: An open source tool for researchers and developers*, pp. 780–789, 2011, <https://gnss-sdr.org>, Accessed: Feb. 23, 2026.

Acknowledgments



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