

6th International OMNeT++ Workshop

# The CNI Open Source Satellite Simulator based on OMNeT++

**Brian Niehöfer, Sebastian Subik and Christian Wietfeld**

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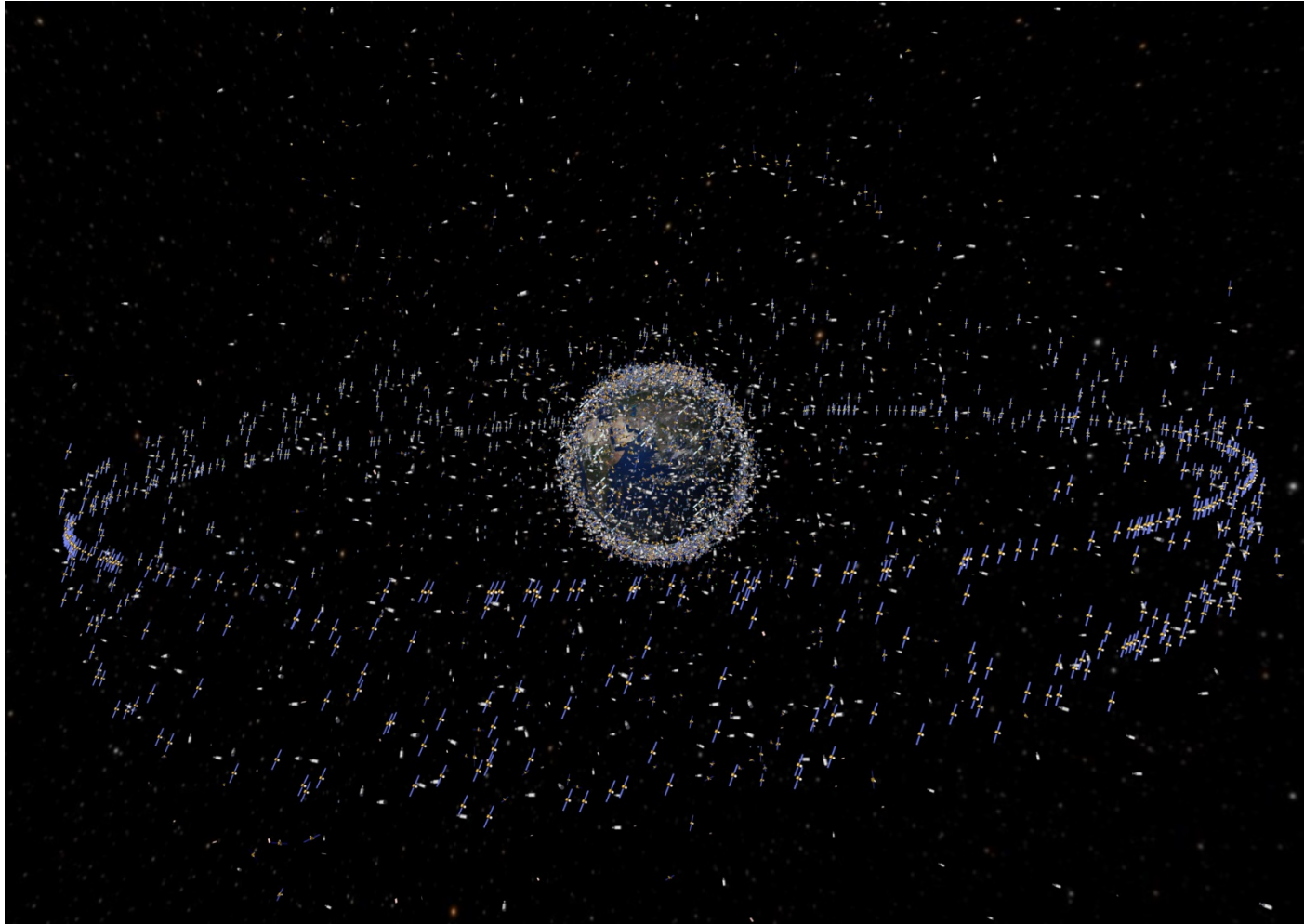


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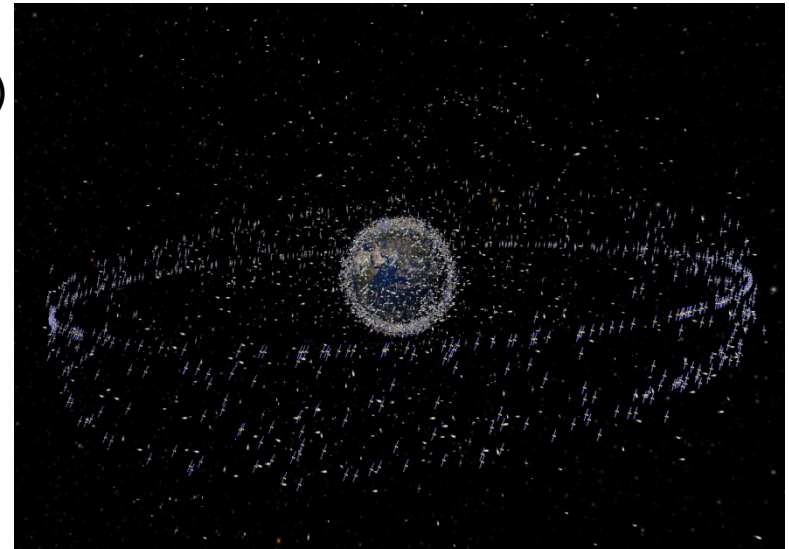
## Basic Motivation



*British Broadcasting Corporation, [www.bbc.com/](http://www.bbc.com/)*

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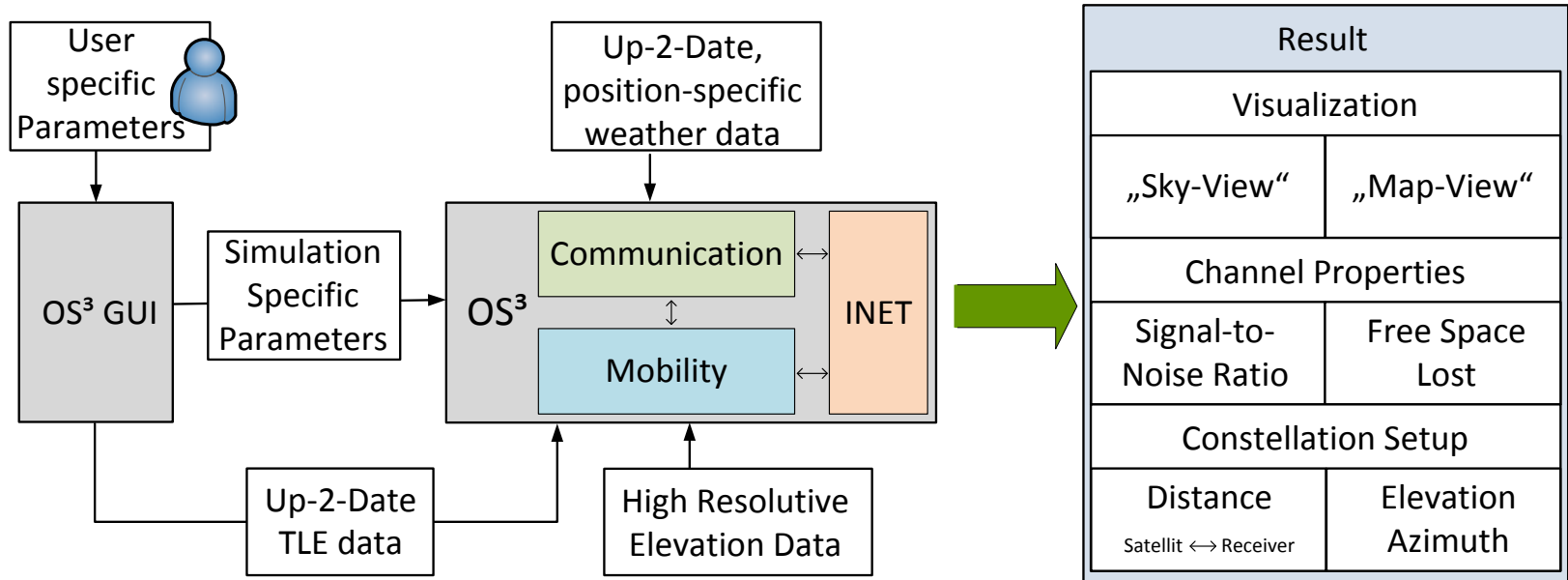
- Actual status: ~2000 active satellites
  - Excl. ~19.000 pieces of debris (>5cm)
  - >30 civil fields of application with its own recommendations
    - Research
    - Navigation
    - Communication
    - Disaster Monitoring
    - Military
    - Geodetic
    - ...
  - High costs for experimental measurements or even In-Orbit Validation Failures
- Demand of a **accurate and adaptable** tool chain for a **simulation-based** modeling and evaluation process



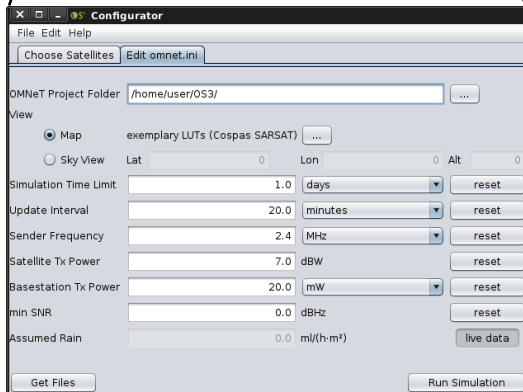
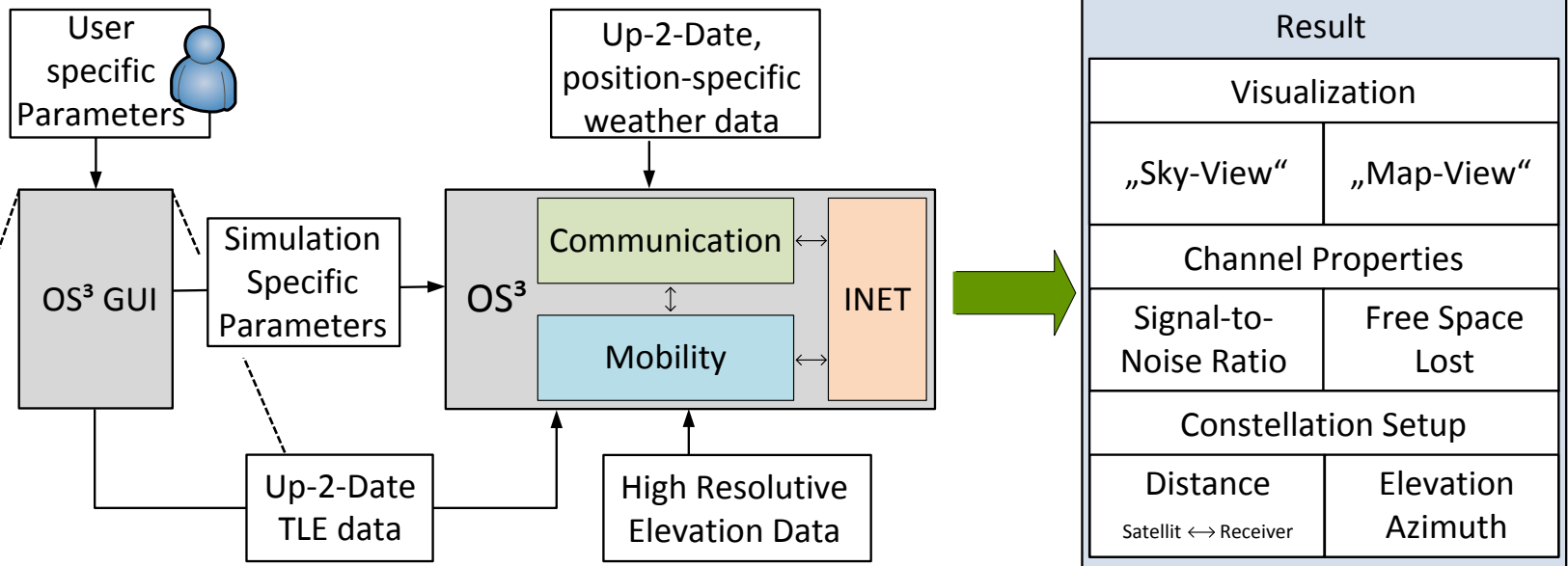
## OS<sup>3</sup> in comparison to existing satellite frameworks

Name	Comment
<b>Galileo System Simulation Facility (GSSF)</b>	<ul style="list-style-type: none"> <li>• Mainly provides global coverage analyses for Galileo</li> <li>• Missing flexibility to analyse other satellite systems</li> </ul>
<b>Multiscale Satellite Simulation Environment (MSSE)</b>	<ul style="list-style-type: none"> <li>• Foundation of OS<sup>3</sup></li> <li>• Mainly design for simulating Galileo or GPS formations</li> <li>• Complex handling</li> <li>• No protocol stacks included</li> </ul>
<b>Satellite Navigation Radio Channel Signal Simulator (SNACS)</b>	<ul style="list-style-type: none"> <li>• Open-Source</li> <li>• Primally focussed on GNSS signal generation</li> <li>• Not adaptable for other satellite aspects/scenarios</li> </ul>
<b>Open-Source extensible spacecraft simulation and modeling (Open-SESSAME)</b>	<ul style="list-style-type: none"> <li>• Open-Source</li> <li>• Simulation of spacecraft dynamics</li> <li>• No protocol stacks or additional functionalities</li> </ul>

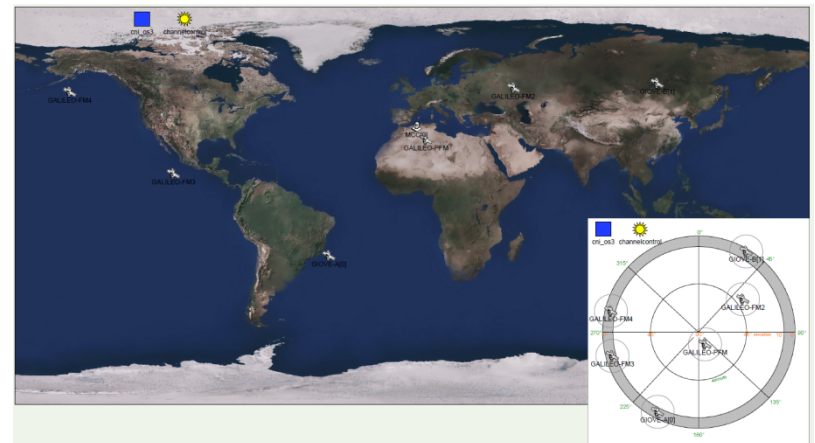
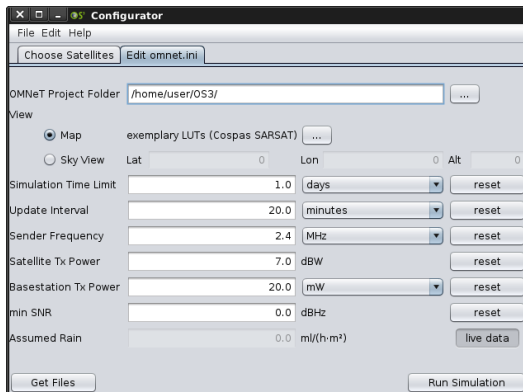
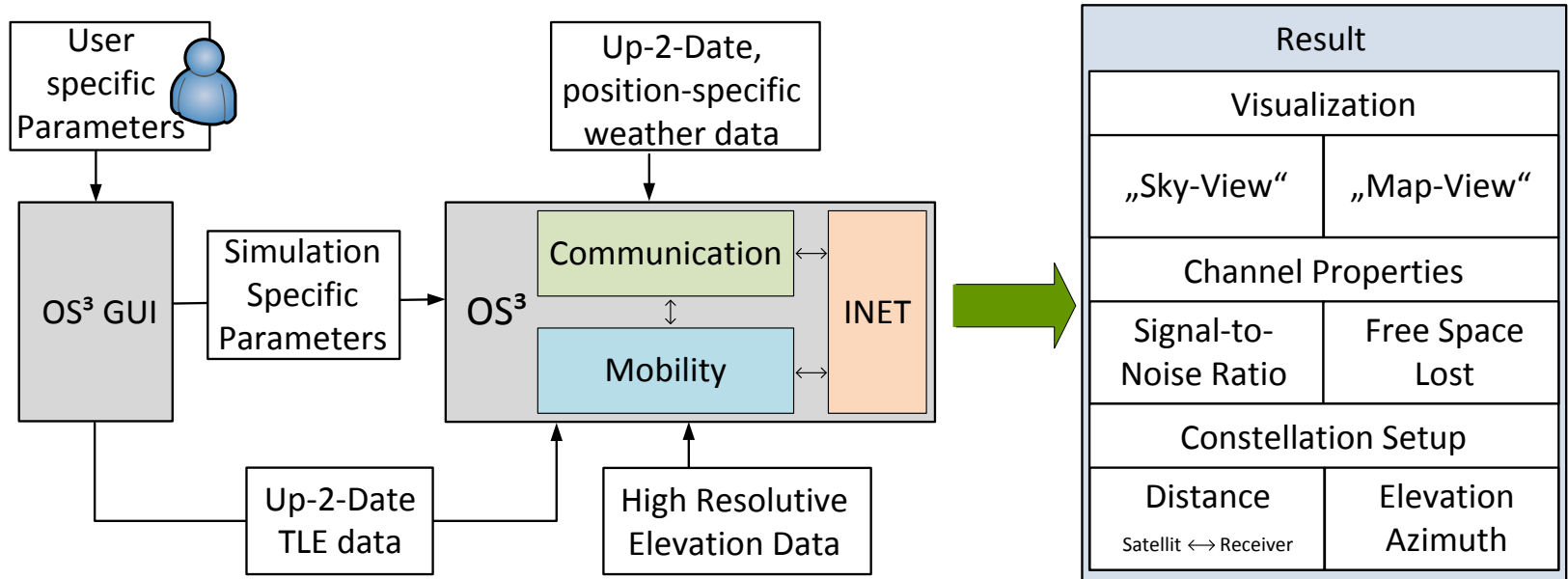
# OS<sup>3</sup> Simulation Architecture



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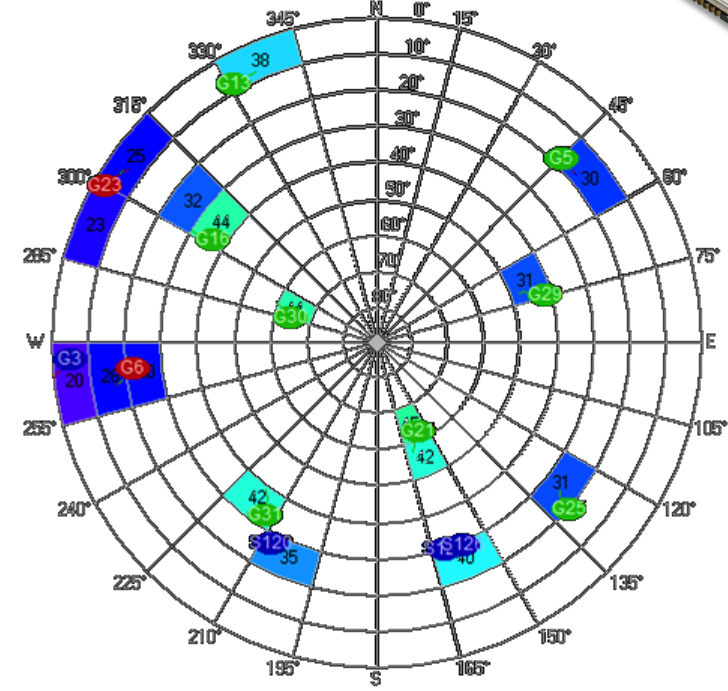
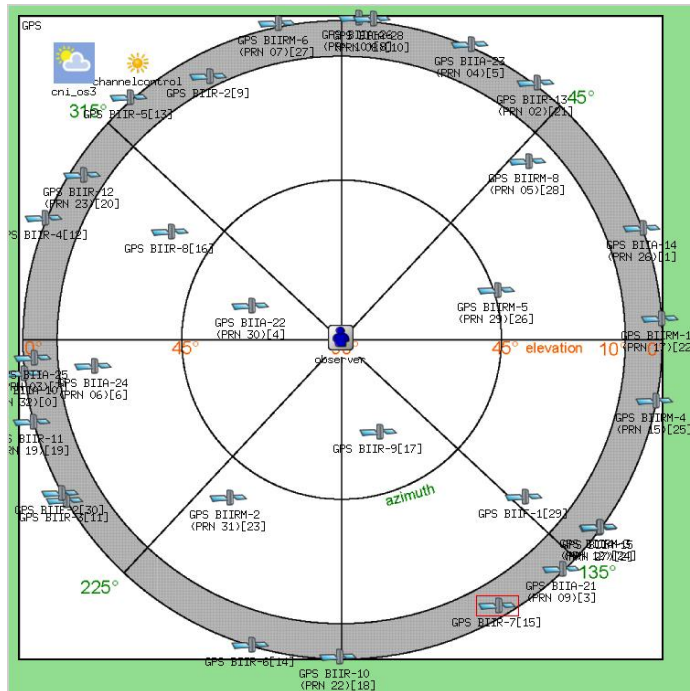




# Qualitative Satellite Position-Accuracy Estimation

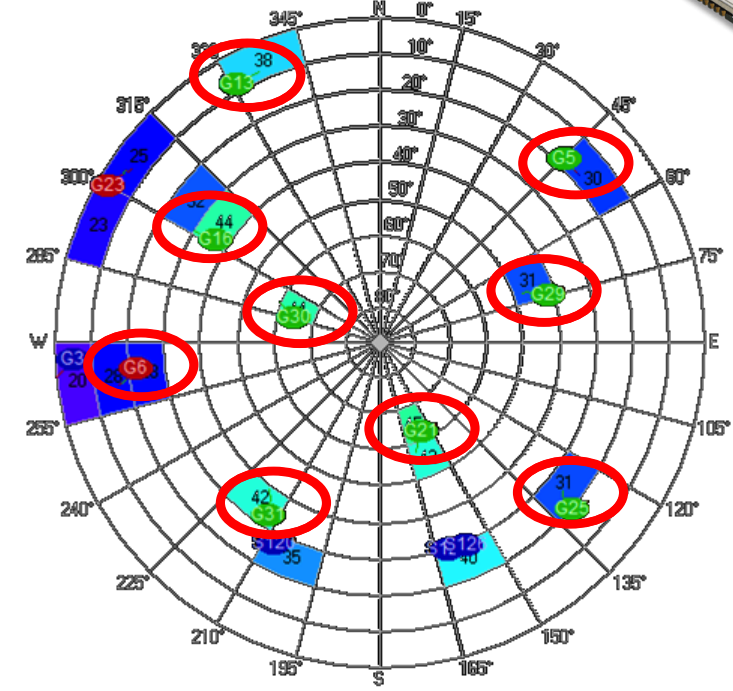
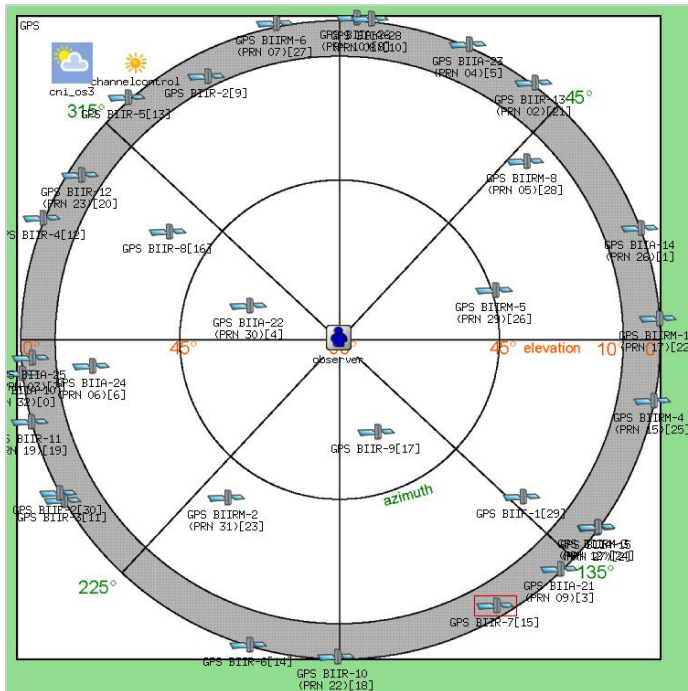
- Comparison between **OS<sup>3</sup>** and commercial **high-end GPS receiver**
  - u-blox evaluation kit *6T-EVK*
  - Sky-View mode (Elevation/Azimuth visualization)
  - u-blox position and measurement-time/s within OS<sup>3</sup> validation setups

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# Quantitative GPS Signal to Noise Measurements

Comparison of simulative and experimental SNR Determination over time

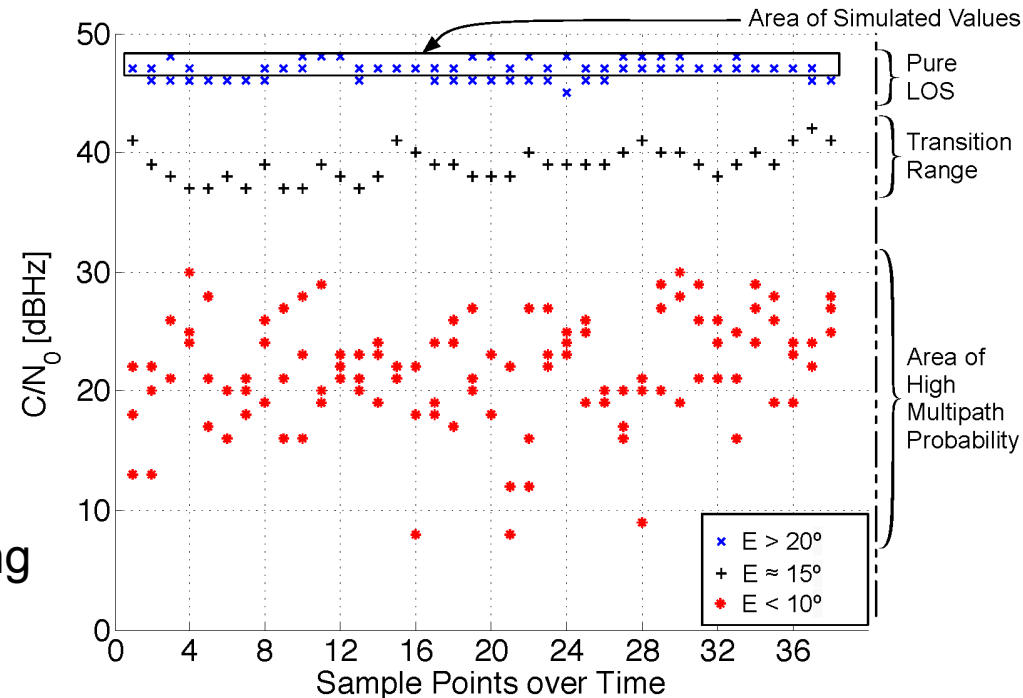
- u-blox evaluation kit *6T-EVK (given antenna and gain setup)*
- Include Multipath effects
- OS<sup>3</sup> was not able to simulate multipath on its own, extension using raytracing already developed in \*
- Separate measurements into 3 classes

\* = B. Niehöfer, S. Lehnhausen, C. Wietfeld. "Combined Analysis of Local Ionospheric and Multipath Effects for Lane-Specific Positioning of Vehicles within Traffic Streams", 6th ESA Workshop on Satellite Navigation Technologies (NaviTech), Noordwijk, The Netherlands, Dec 2012.

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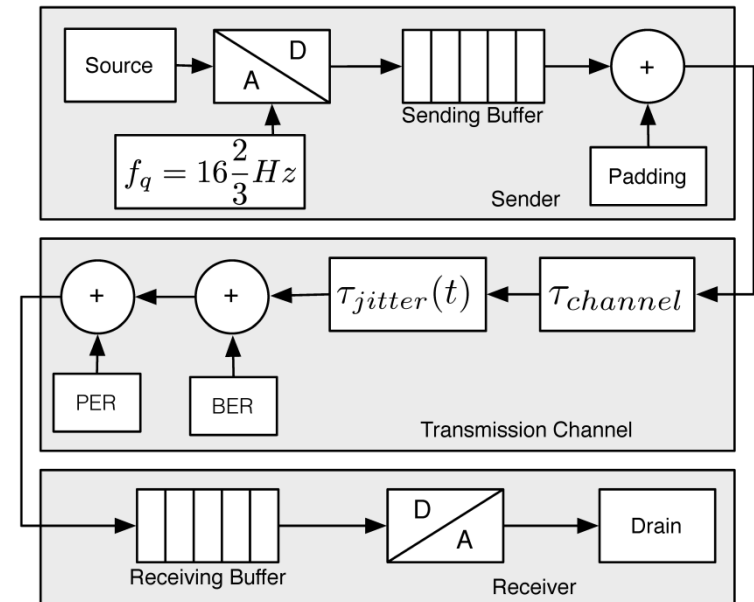
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## Use Case: Voice over Satellite - Implementation

- Exemplary implementation using OMNeT+  
+
- Demonstrate OS<sup>3</sup>'s:
  - Flexibility
  - Performance
  - Benefit of included features
- Already gained measurements as further validation step
  
- Scenario assumes:
  - Terrestrial networks damages / no core network available
  - Independent cell using satellite link for wide area transmission

## Use Case: Voice over Satellite - Implementation

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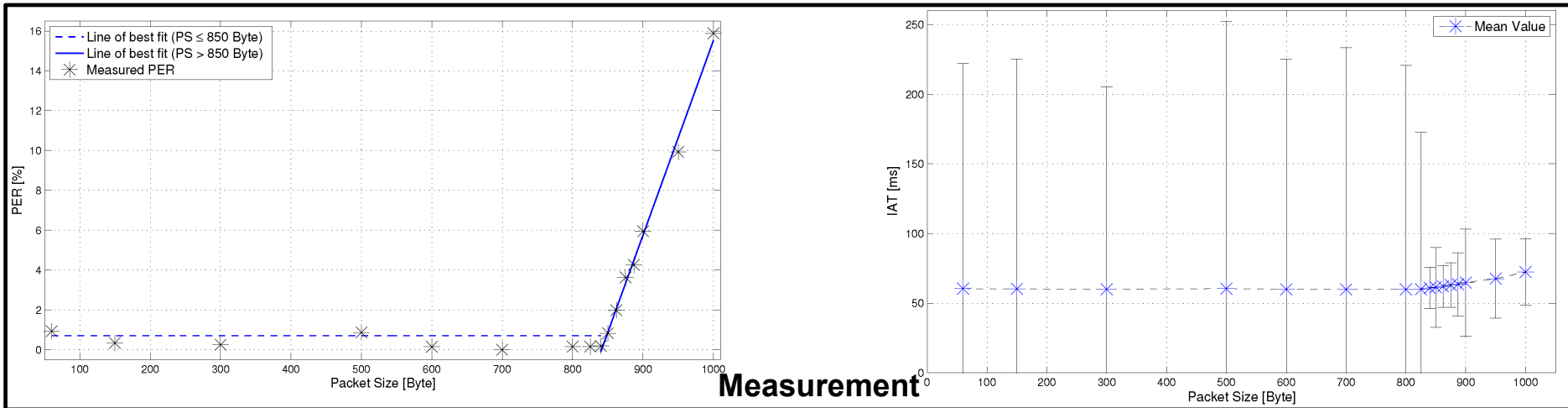


- Scenario assumes:
  - Terrestrial networks damages / no core network available
  - Independent cell using satellite link for wide area transmission
  - Generation and processing of voice packets within independent OMNeT++ simulation
  - Coupled with OS<sup>3</sup> for time-depending SNR estimation
  - Based on SNR → Calculate Packet Error Rate

# Use Case: Voice over Satellite - Results

PER depending on Packet Size

IAT depending on Packet Size

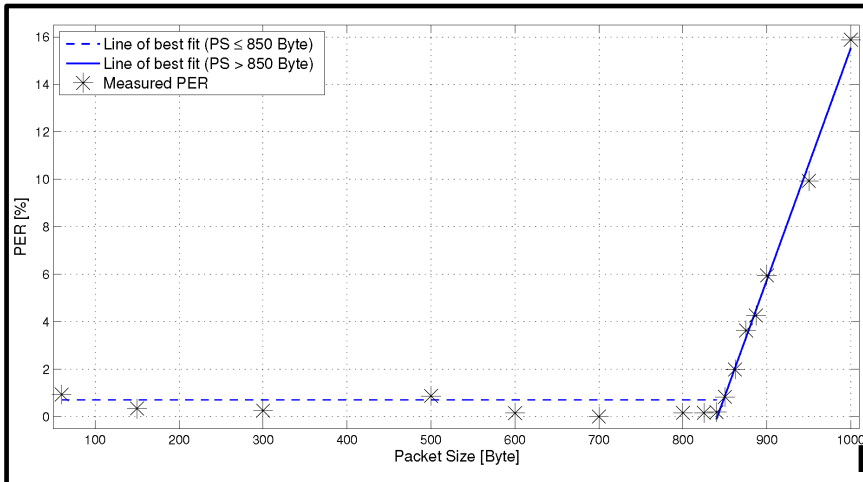




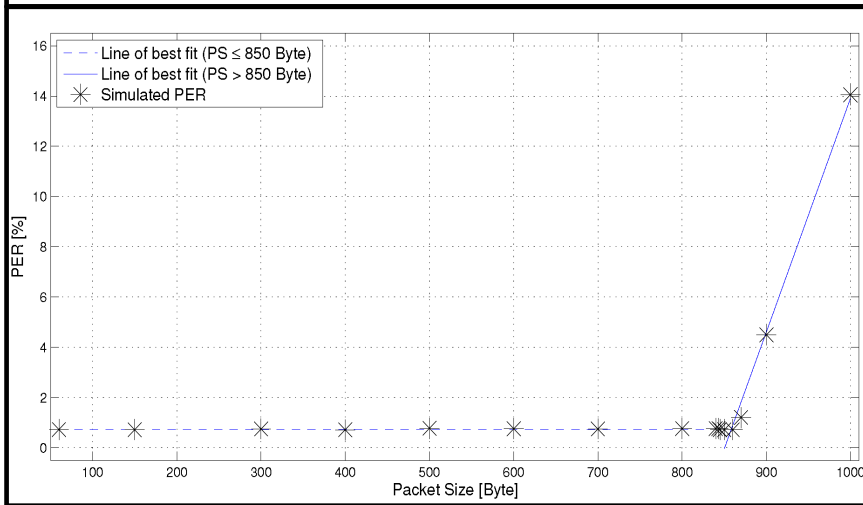
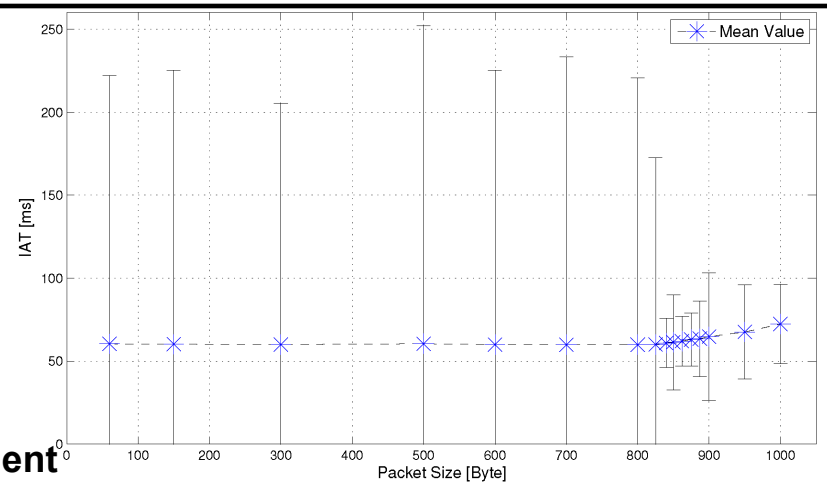
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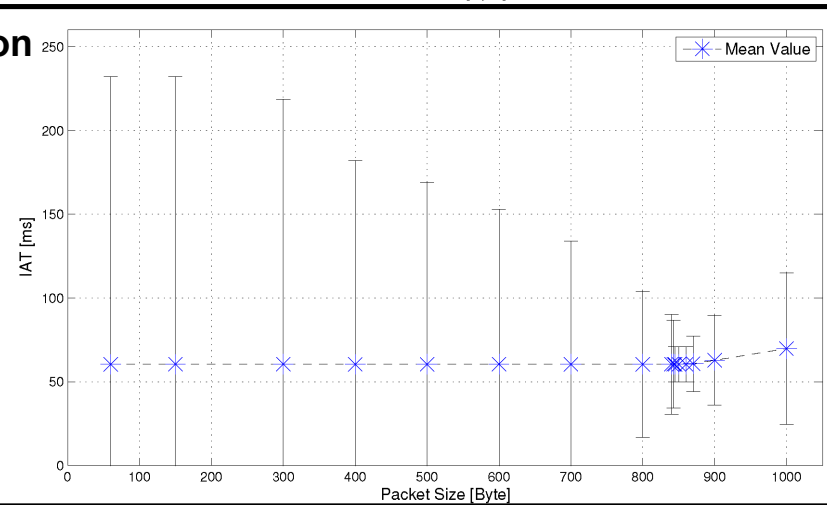
IAT depending on Packet Size



Measurement



Simulation



## The CNI Open Source Satellite Simulator based on OMNeT++

### ■ Objective

- Providing Open-Source Satellite Simulator, supporting:
  - Various existing and future satellite systems
  - Individual extensions and an Integration within OMNeT++
  - Easy Handling, even for non-expert user (OS<sup>3</sup> GUI)

### ■ OS<sup>3</sup> Features:

- NORAD SGP4/SDP4 implementation
- Webservices for realistic and up to date input data (Weather, Satellite movement, Altitude,...)
- Calculation of various channel characteristics
- Configuration of scenario-specific parameters
- Two different visualization methods
- Plattform – independent
- ...

### ■ OS<sup>3</sup> Validation and Use Case

- OS<sup>3</sup> data compared with data from German Aerospace Center (DLR), High-End GPS measurement equipment and own Voice over Satellit experiments
- **All tests confirm accuracy and validity of OS<sup>3</sup> independent from each other**

***OS<sup>3</sup> already available for download: [www.cni.tu-dortmund.de/os3](http://www.cni.tu-dortmund.de/os3)***



**Thank you for your attention**

**Any questions?**

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