S2VSE - SYSTEM AND SERVICE VOLUME SIMULATION ENVIRONMENT

SEBASTIAN BERNHARDT, FLORIAN EISELBRECHER

23.10.23 HELSINKI

DLR

Galileo Kompetenzzentrum

Galileo Kompetenzzentrum

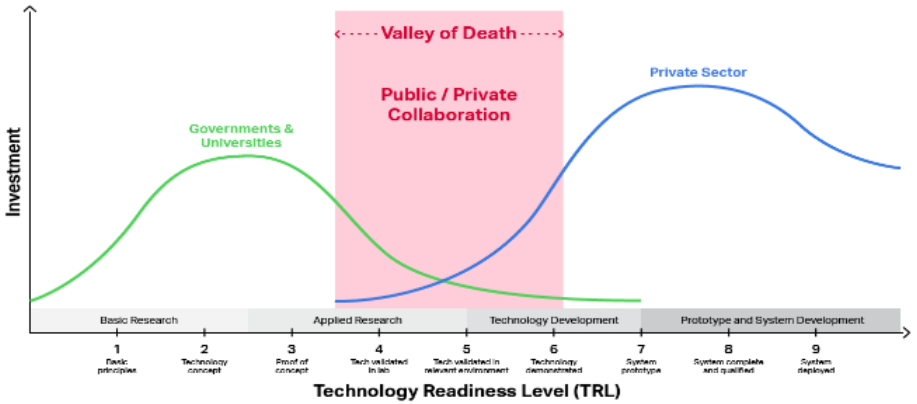
FOR A PRECISE AND SAFE FUTURE

DLR

Galileo Competence Center

Goals

- Evaluate the design of future systems
- Identification of future key technologies
- Identification of the most effective upgrades or modifications to existing satellite navigation systems
- Assessment of the significant value technologies can have
- Assessment of market potential of technologies
- Bridge the gap between research and industry



GK in numbers:

- Founded on 28th June 2019
- Fully established by 2024
- Planned number of employees 120-150

Galileo Kompetenzzentrum

Galileo Competence Center

Goals Performance Analysis and Simulation

- Analysis of existing GNS - Systems (focus on Galileo) and services via
  - Assessment of user requirements
  - Evaluation of current system performance
  - Evolution of existing concepts
- Simulation, analysis and validation of new technologies and subsystems
- Conception of new architectures to support the development of Galileo and future generations of EGNOS, including their services

Galileo Kompetenzzentrum

S2VSE - SYSTEM AND SERVICE VOLUME SIMULATION ENVIRONMENT

DLR

Galileo Kompetenzzentrum

System & Service Volume Simulation Environment

General Objectives

Modular and flexible simulation and performance analysis tool for space, ground and user applications

- Reproduction, analysis and study of current and future GNSS structures and operational scenarios
- Evaluation of the system performance under different conditions and influencing factors (constellations, propagation effects, technologies, ...)
- Assessment and prediction of Key Performance Indicators (KPIs: accuracy, integrity, coverage, continuity and availability)

Galileo Kompetenzzentrum

System & Service Volume Simulation Environment

Module Design

- Each module is based on one or multiple libraries, both parts are implemented in **Python**
- Both the module and the library functions are unit tested using **PyTest**
- Technical documentation for each function is automatically generated using **Sphinx**
- All modules are kept under version control with **Git**

System & Service Volume Simulation Environment

Module Overview

Modules (ca. 100) are separated into three categories:

- Core functionalities (50%)

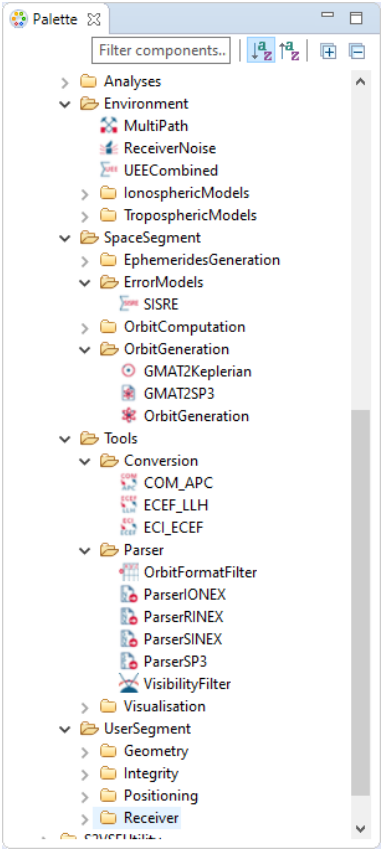
Core functionality includes conversions, error models, integrity, orbit generation, parser, receiver grid generation and more

- Visualisation (35%)

Visualization modules provide pre-defined graphs and plots

- Utilities (15%)

Utility components provide features to improve the flow of each scenario and the overall quality of the simulation

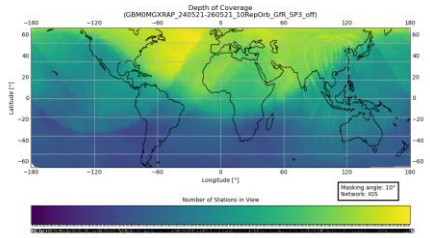


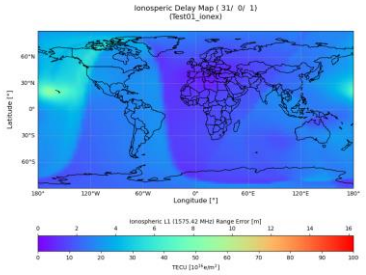
Galileo Kompetenzzentrum

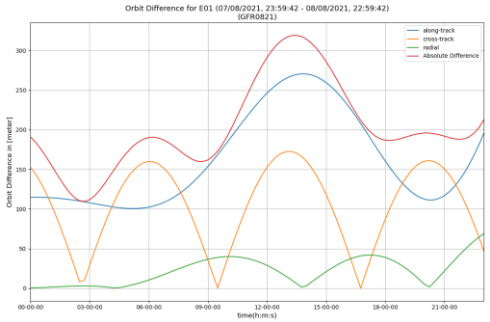
System & Service Volume Simulation Environment

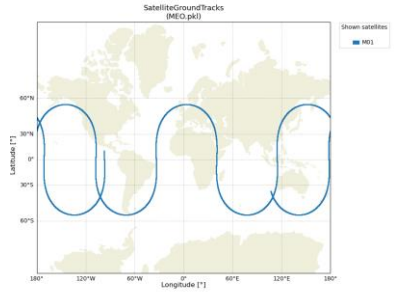
Visualisations

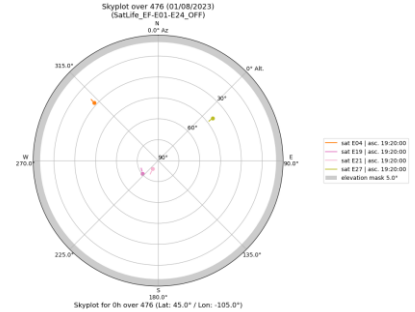
- **D**epth-**O**f-**C**overage (**DOC**)
- **T**otal-**E**lectron-**C**ontent (**TEC**) maps
- Differences in orbit
- Ground tracks
- Sky plots
- Visibility times
- **D**ilution-**O**f-**P**recision (**DOP**), etc.

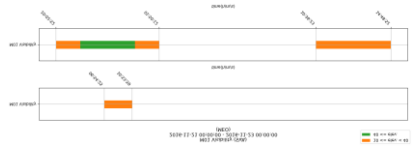










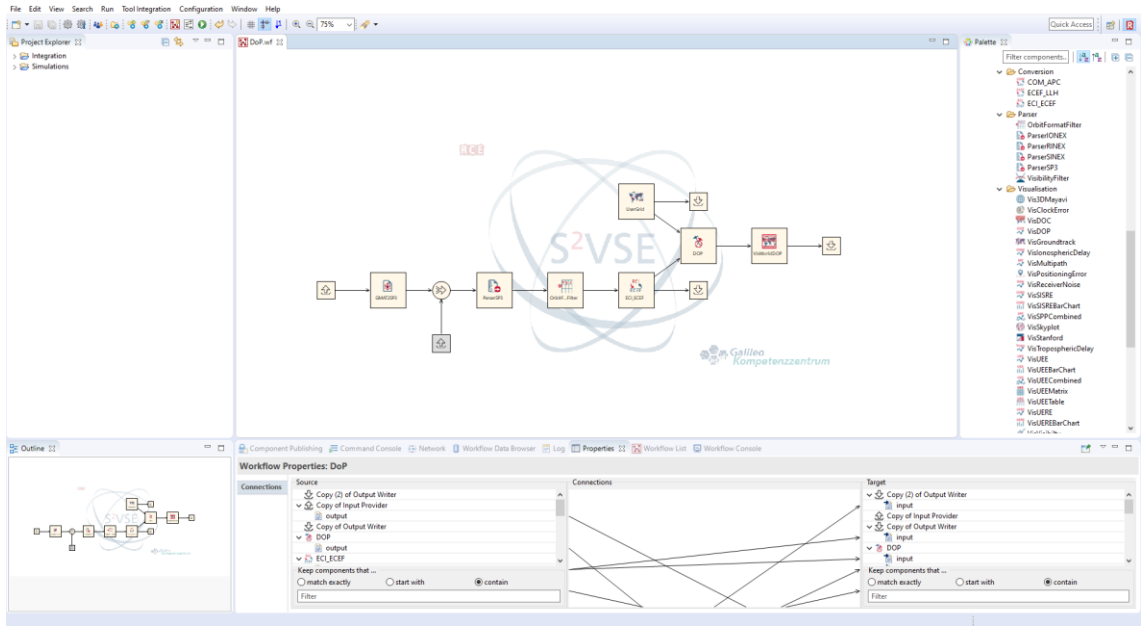


Galileo Kompetenzzentrum

System & Service Volume Simulation Environment

Simulation environment: Remote Component Environment (RCE)

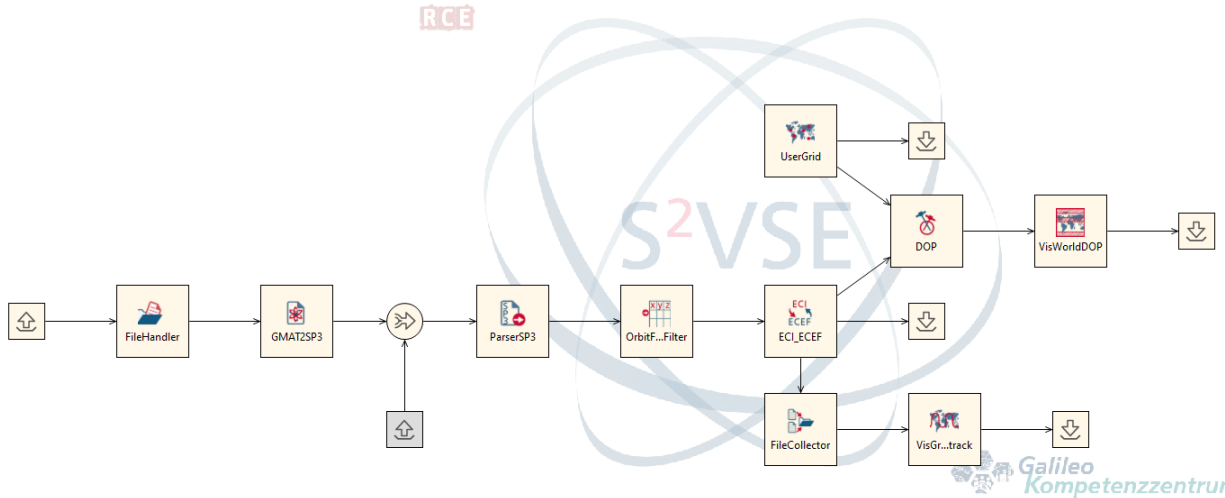
- Developed by DLR's Institute of Software Technology (SC)
- Open source Java software based on Eclipse Editor
- Enables simulation module distribution and remote execution



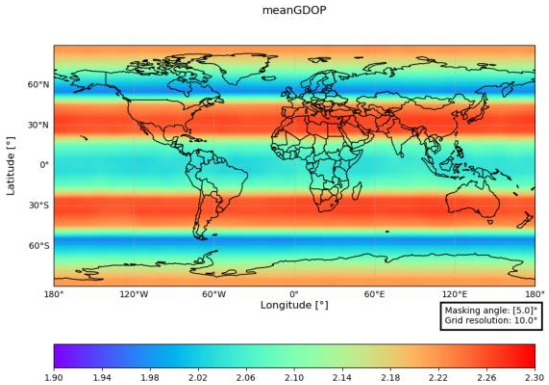
System & Service Volume Simulation Environment

KPI: Dilution-Of-Precision (DOP)

- Dependent on the satellites in the line of sight of the receiver
- Geometry between satellites in correlation to the receiver impacts the position error
- Input: Receiver positions and satellite orbits



Results



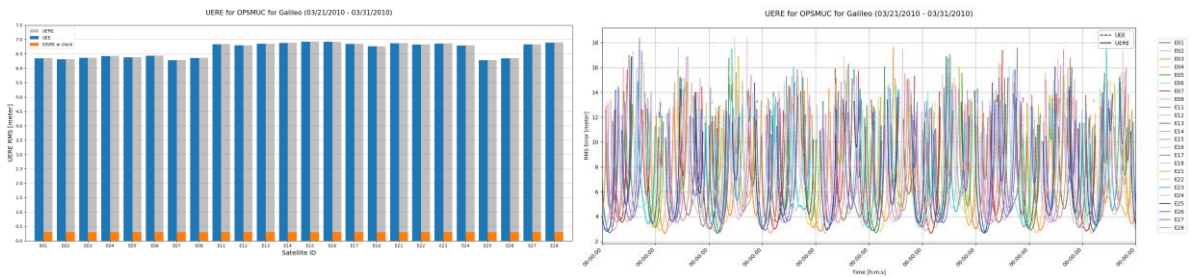
Galileo Kompetenzzentrum

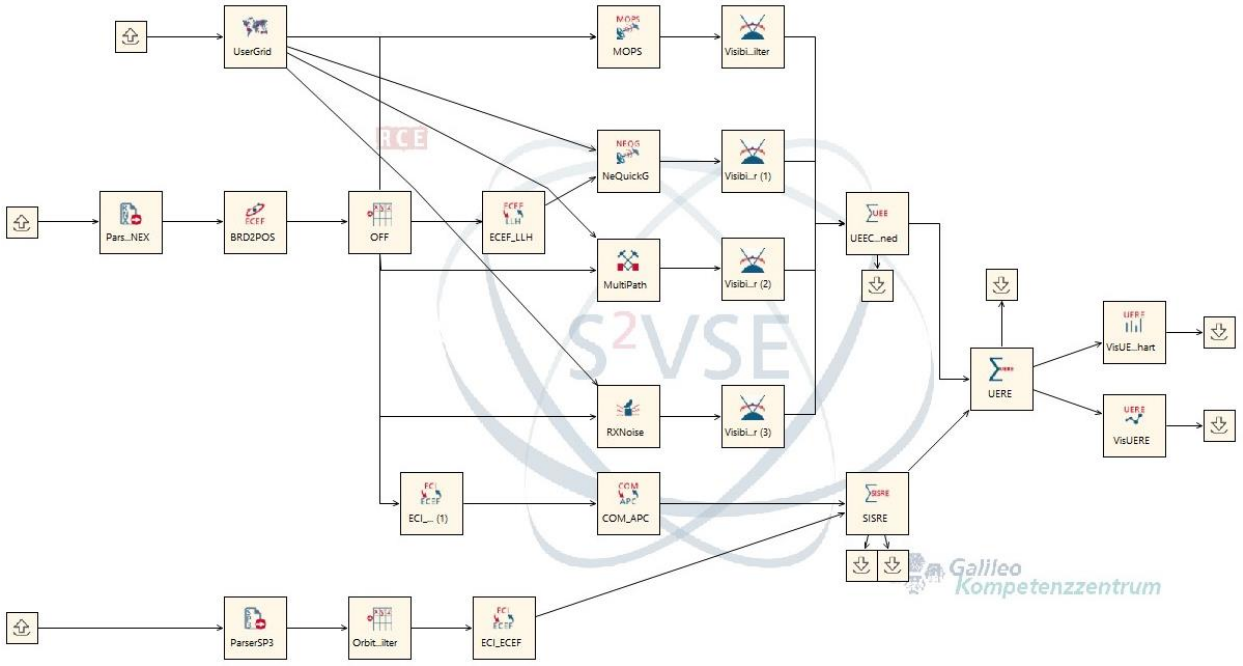
System & Service Volume Simulation Environment

KPI: User-Equivalent-Range-Error (UERE)

- Describes the total error affecting the pseudorange
- Contains Signal in Space Ranging Error (SISRE) and User Equipment Error (UEE)
- Input: Receiver positions, Ephemerids and precise orbits

Results



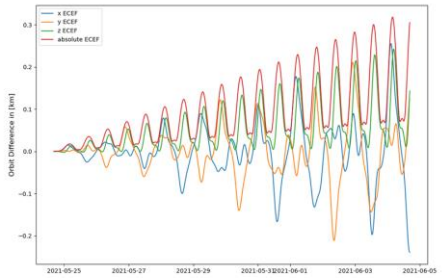


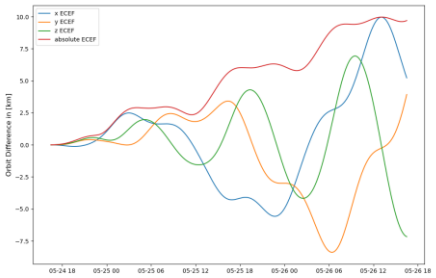
Galileo Kompetenzzentrum

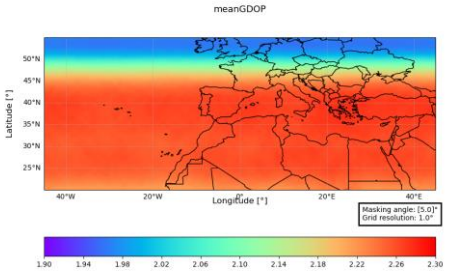
System & Service Volume Simulation Environment

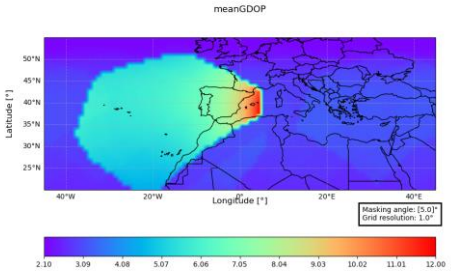
Current Projects

1. Impact of solar radiation pressure and space weather on orbit determination
2. Impact of Satellite End-of-Life on Galileo
3. Constellation generation to compare different constellations in an urban environment



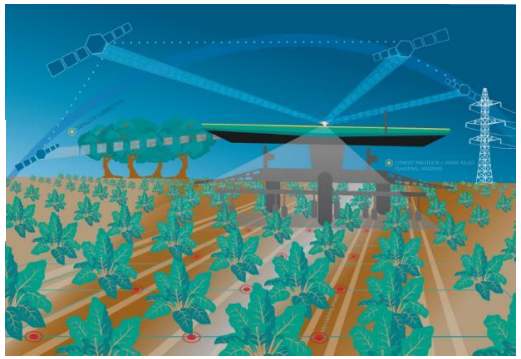


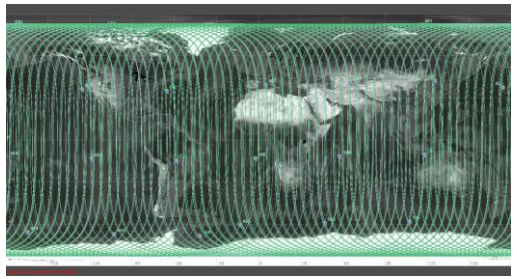


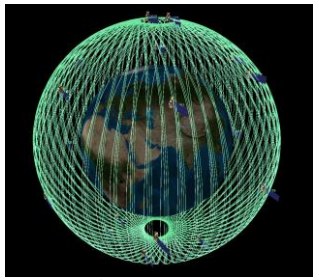


Current Use Cases

Automotive – Precision Farming







Galileo Kompetenzzentrum

System & Service Volume Simulation Environment

Planned Use Cases

- Evaluation of new services and innovative applications
- Use of a customized open module design with individual parameter control

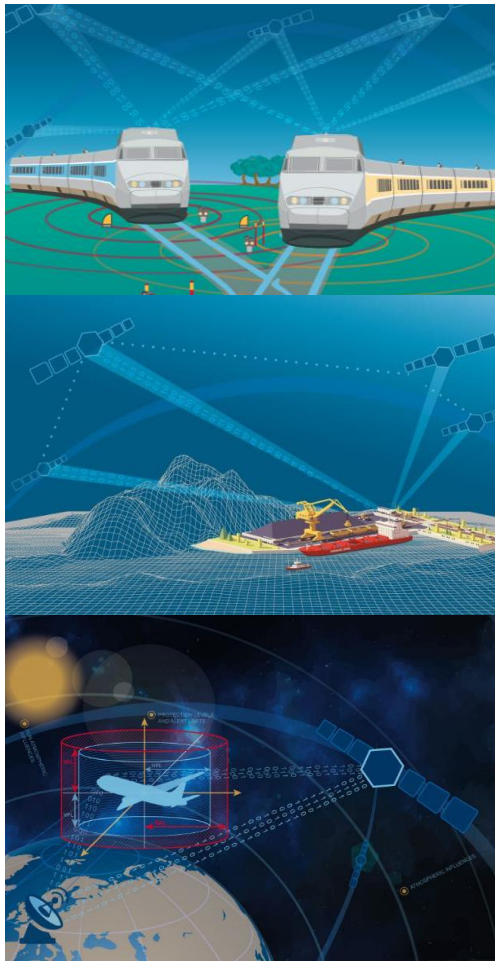
Future Module Development:

- Extended orbit propagation
- Modular position solver
- User equipment simulation
- More environmental models

Rail – Collision Avoidance

Maritime – Docking of a vessel

Aviation – Precision Landing



Galileo Kompetenzzentrum

THANK YOU FOR YOUR ATTENTION

CONTACT: SEBASTIAN.BERNHARDT@DLR.DE

DLR

Galileo Kompetenzzentrum