



# FIG Working Week 2024

19-24 May

Accra, Ghana

Your World, Our World:  
Resilient Environment  
and Sustainable  
Resource Management  
for All

*Presented at the FIG Working Week 2024,  
19-24 May 2024 in Accra, Ghana*

## Session TS03D

# New Approaches for Data Acquisition Visualization & Interaction

**We start at 14:30**

**Please get a set of headphones**

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## Interactive planning of GNSS monitoring applications with Virtual Reality

Peter Bauer

Institute of Engineering Geodesy and Measurement Systems (TU Graz, Austria)

Project Assistant



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General Authority for Surveying  
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**AWARD WINNER**

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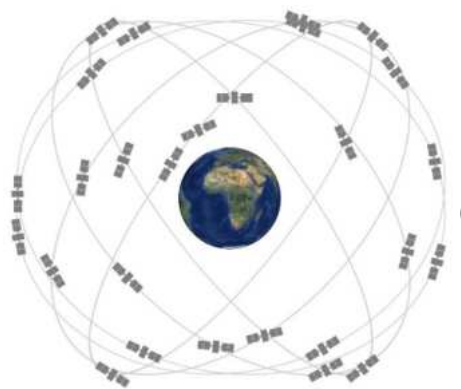
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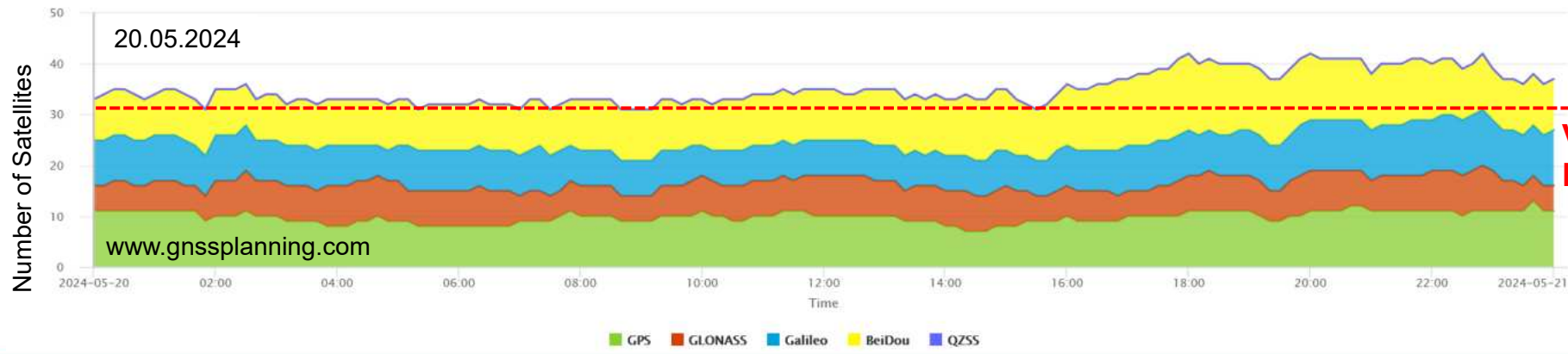
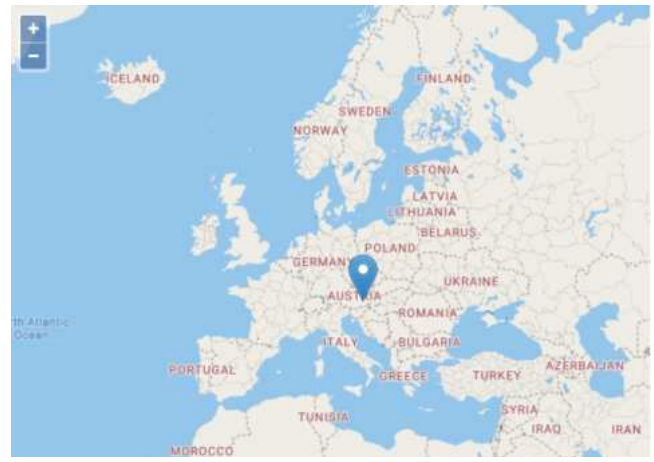
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## Is there a need for a more detailed measurement planning?

Current state: Well-equipped space segment (20.05.2024)



- GPS: 31 x
- GALILEO: 25 x
- GLONASS: 24 x
- Beidou: 46 x



Visible Satellites > 31  
RTK~ 3-5 cm





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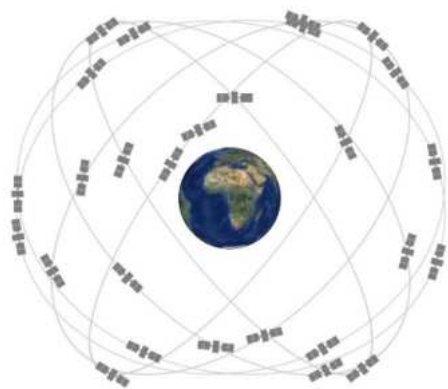
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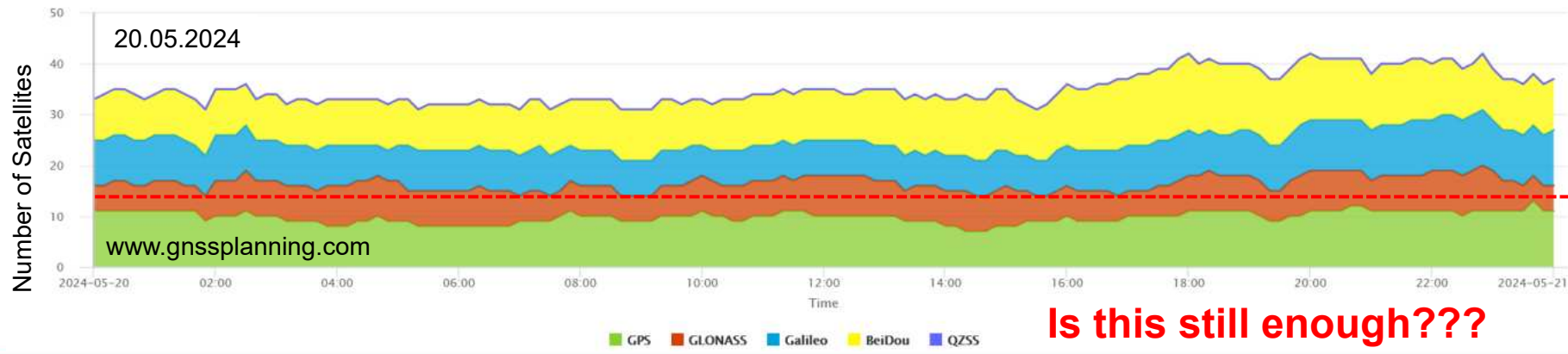
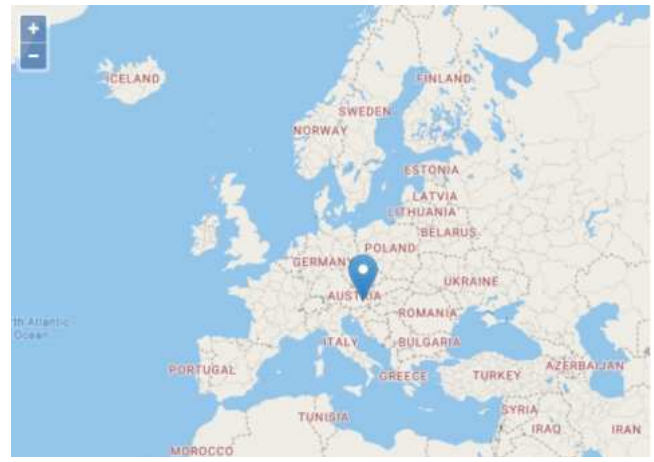
## Is there a need for a more detailed measurement planning?

Current state: Well-equipped space segment (20.05.2024)



- GPS: 31 x 
- GALILEO: 25 x 
- GLONASS: 24 x 
- Beidou: 46 x 

Support of the instrument



Visible Satellites > 14

Is this still enough???



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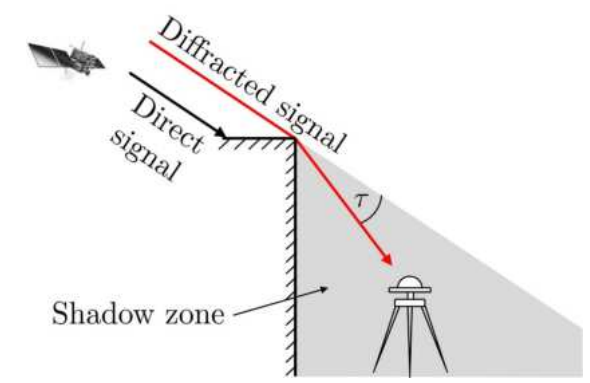
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How much  
satellites  
remain?

## Further constraints for high accuracy

- Avoidance of specific satellites (e.g. retiring / unhealthy)
- Avoiding diffracted signals



Florian Zimmer (PhD thesis)

Here, sophisticated simulations are necessary!

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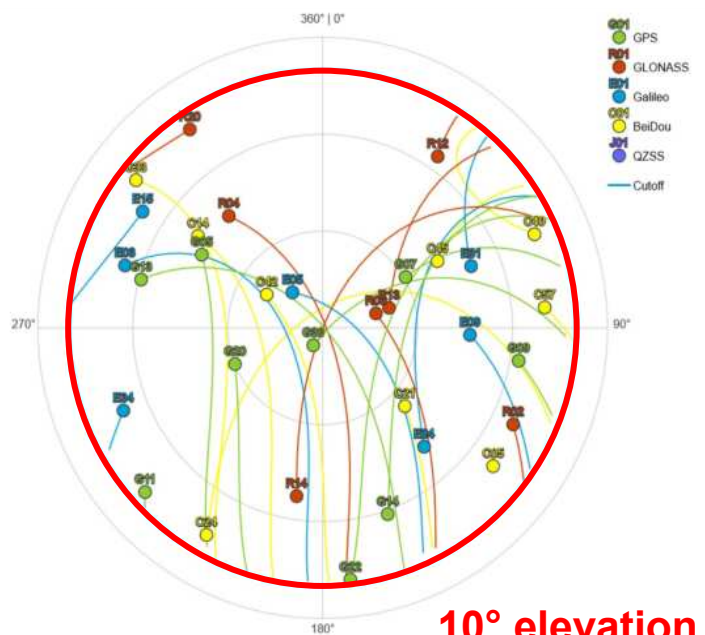
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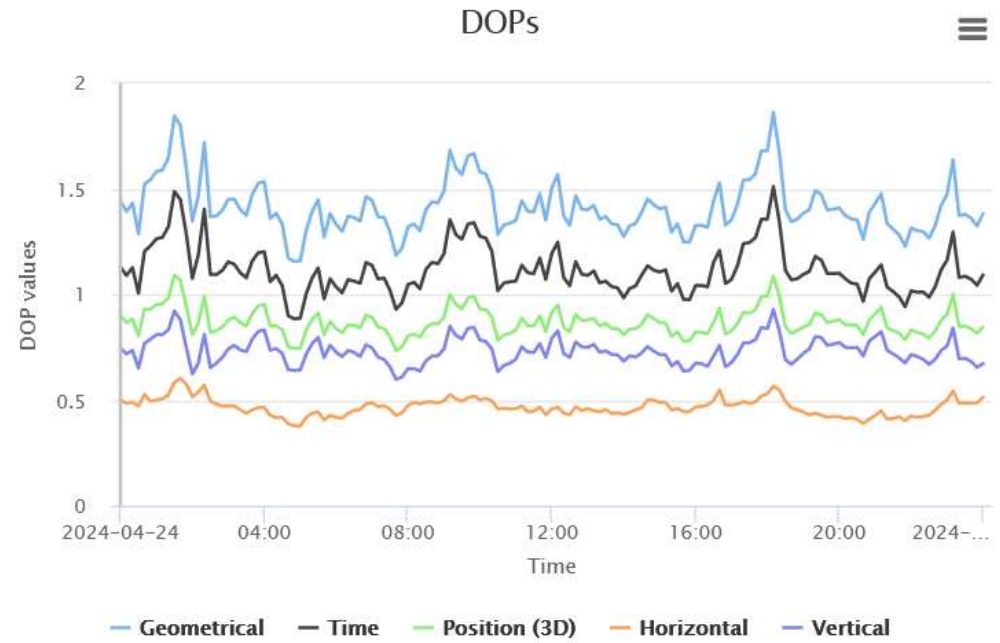
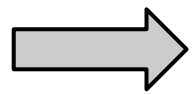
## GNSS planning

State of the art

- Skyplot and estimation of PDOP values



10° elevation mask to avoid ground refraction



[www.gnssplanning.com](http://www.gnssplanning.com)



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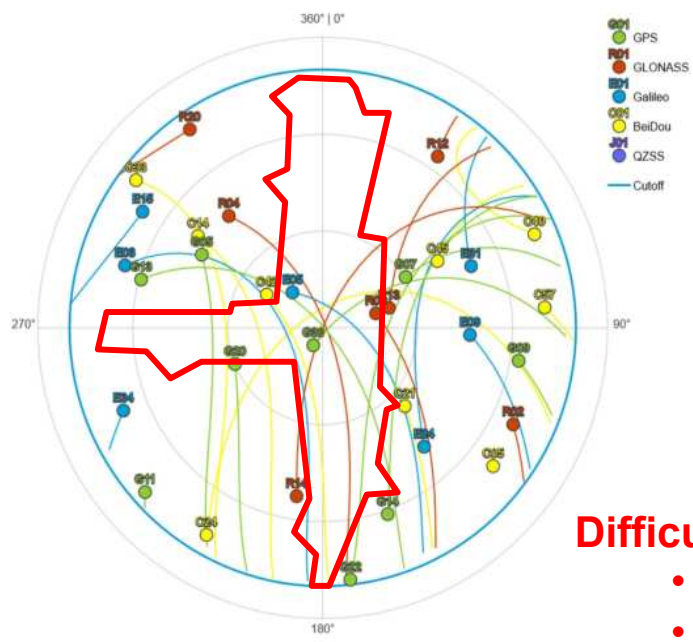
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## GNSS planning

State of the art

- Customised Sky-masks

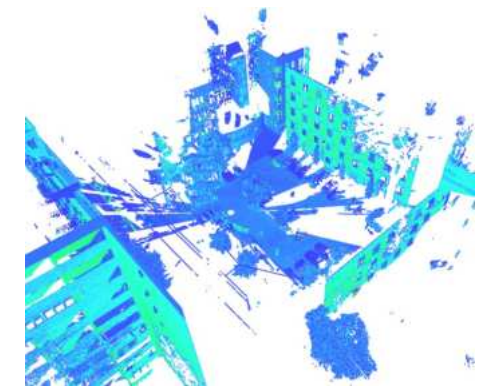


360° camera



Youtube.com (City of Graz)

LOD model



on-site scan

Difficult integration into current software:

- No single software environment
- Often manual workflows

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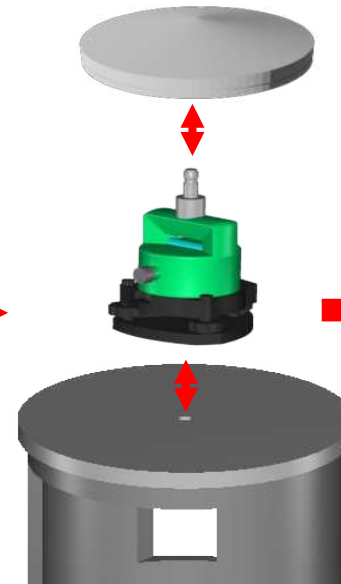
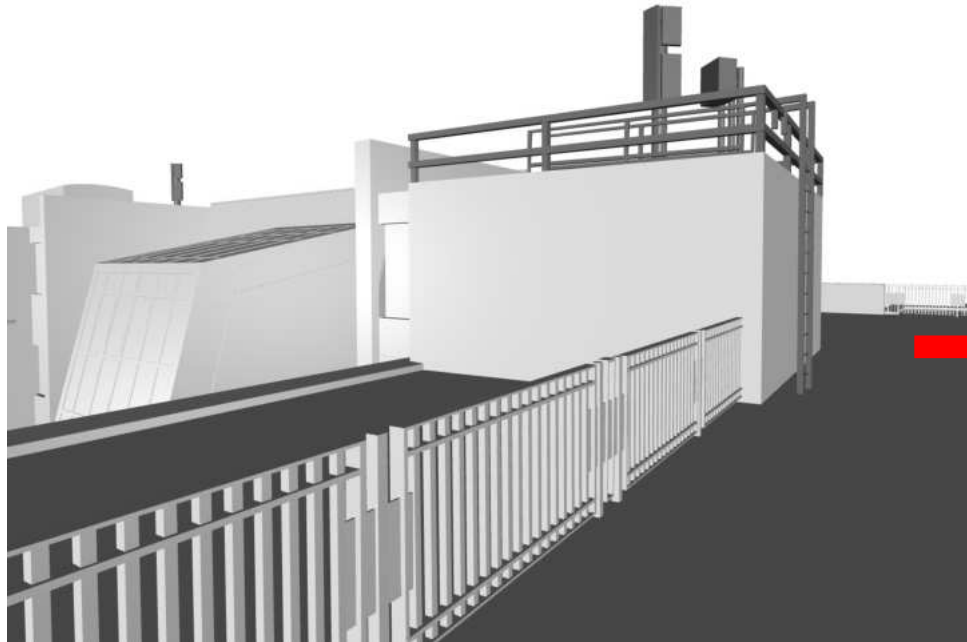
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## GNSS planning

**Aim: Interactive simulation in a single 3D environment**



**No commercial geodetic simulation provided the required functionality...**

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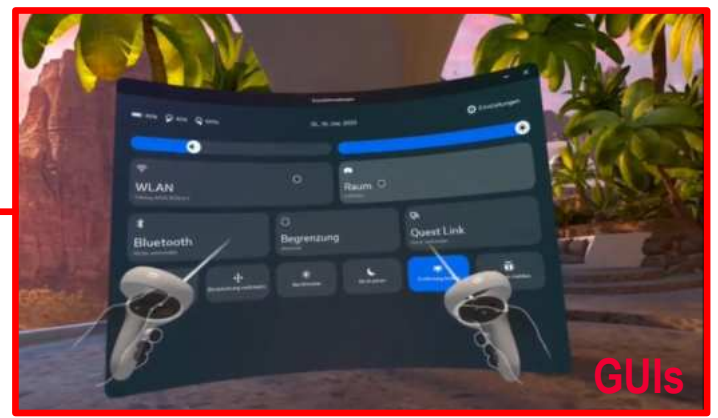
## Entertainment sector

### Game Engines

- Sophisticated 3D coding environments for the creation of video games



<https://github.com/topics/ray-tracing>



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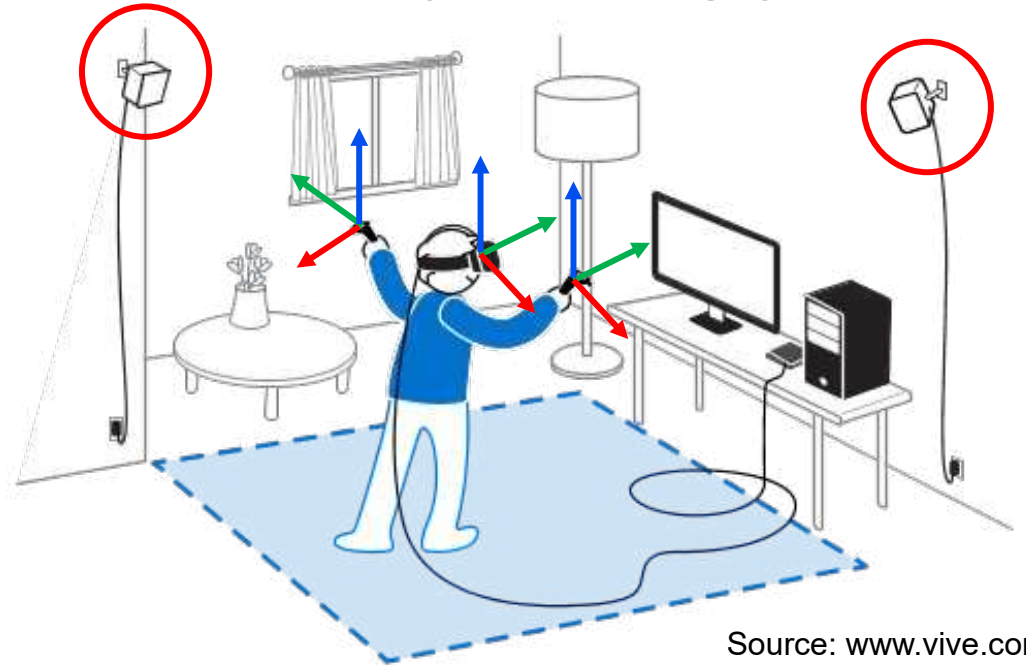
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## Virtual Reality

### Visualisation and interaction with 3D Data

- Position and orientation of all components (controllers and HMD) is tracked by a positioning system



Source: [www.vive.com](http://www.vive.com)

### Various applications beyond gaming





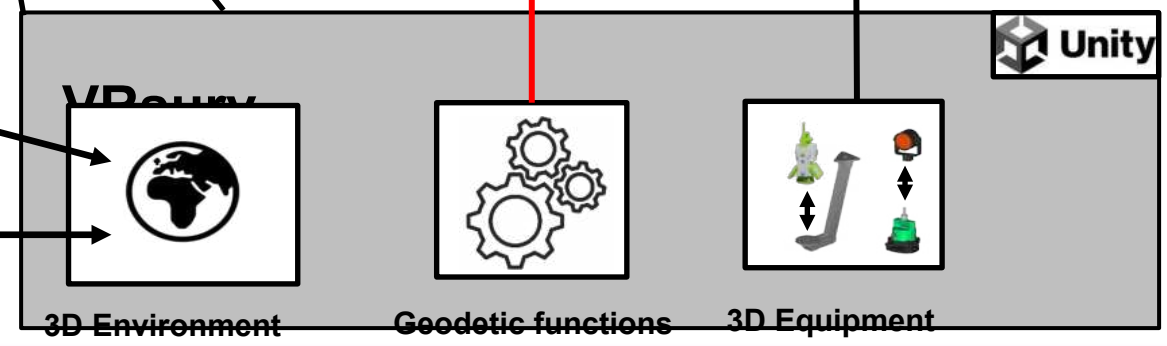
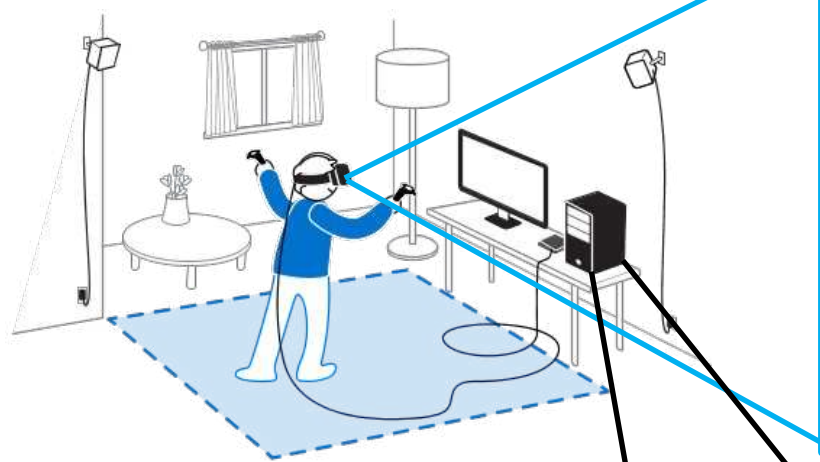
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## VRsurv (Unity)



## GNSS Integration

GNSS Observation Simulator Version 1.0

Import model for mask computation:

Central point in model (WGS84)

Latitude (N°)	Longitude (E°)	Height (m)
<input type="text" value="47"/>	<input type="text" value="13"/>	<input type="text" value="1900"/>

Import satellite constellation:

**TU Graz IGMS** Institute of Engineering Geodesy  
TU Graz  
Steyrergasse 30/II, Austria  
(c) Peter Bauer

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## Monitoring in alpine areas



GNSS monitoring of the dam

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## Monitoring in alpine areas





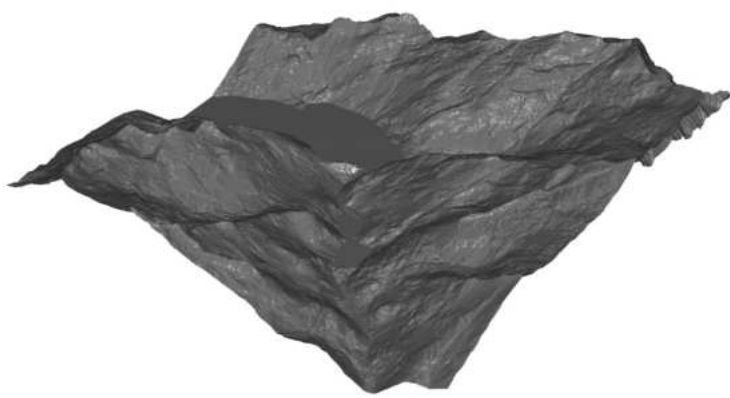
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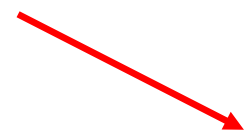
## 3D data foundation



National digital terrain model (1 m x 1 m, publicly available)



High resolution dam geometry from operator (drone survey)



3D environment for the simulation in Unity

How accurate is the 3D computation?



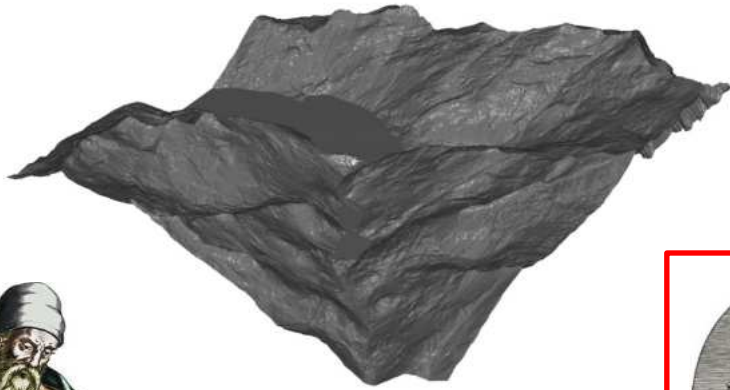
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## 3D data foundation



Euklid



Mercator

National terrain model  
relates to a transversal  
Mercator projection and  
earth curvature is  
removed



This is a problem for real 3D investigations!  
Also does the DTM have an uncertainty of 0.5 m





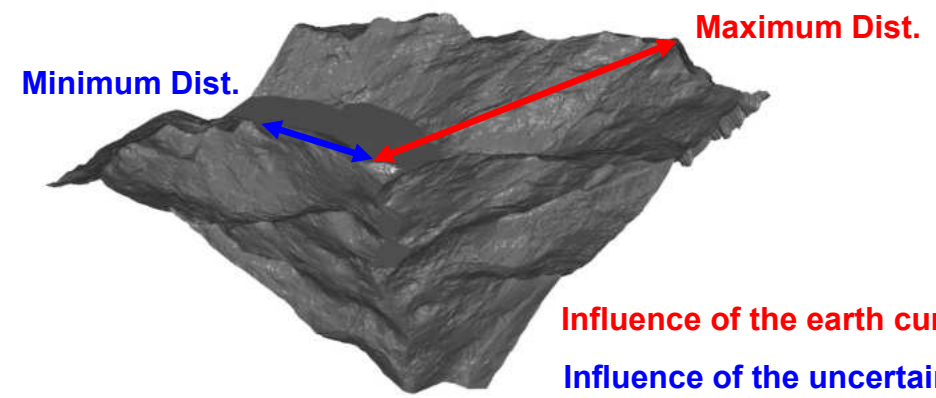
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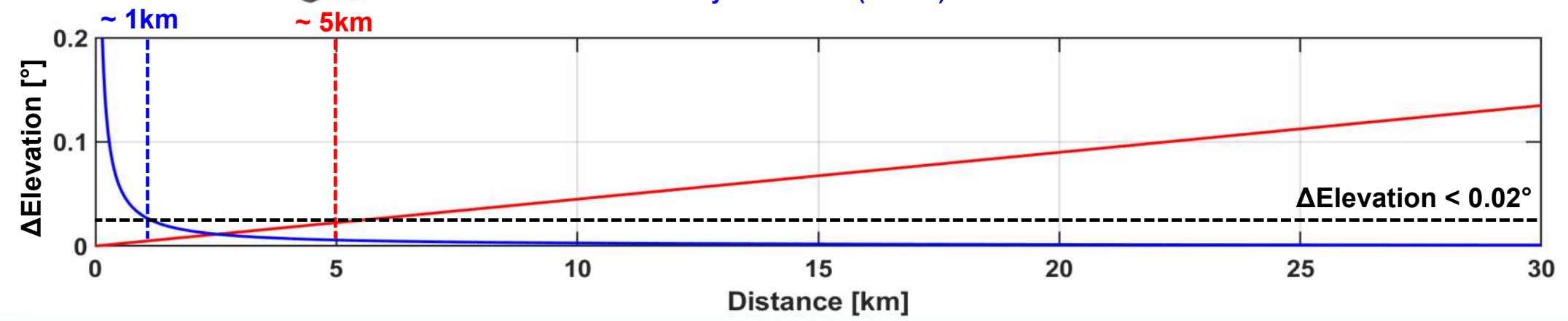
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## 3D data foundation



.SP3 Satellite

Influence of the earth curvature on the elevation mask  
Influence of the uncertainty of the DTM (~0.5 m) on the elevation mask





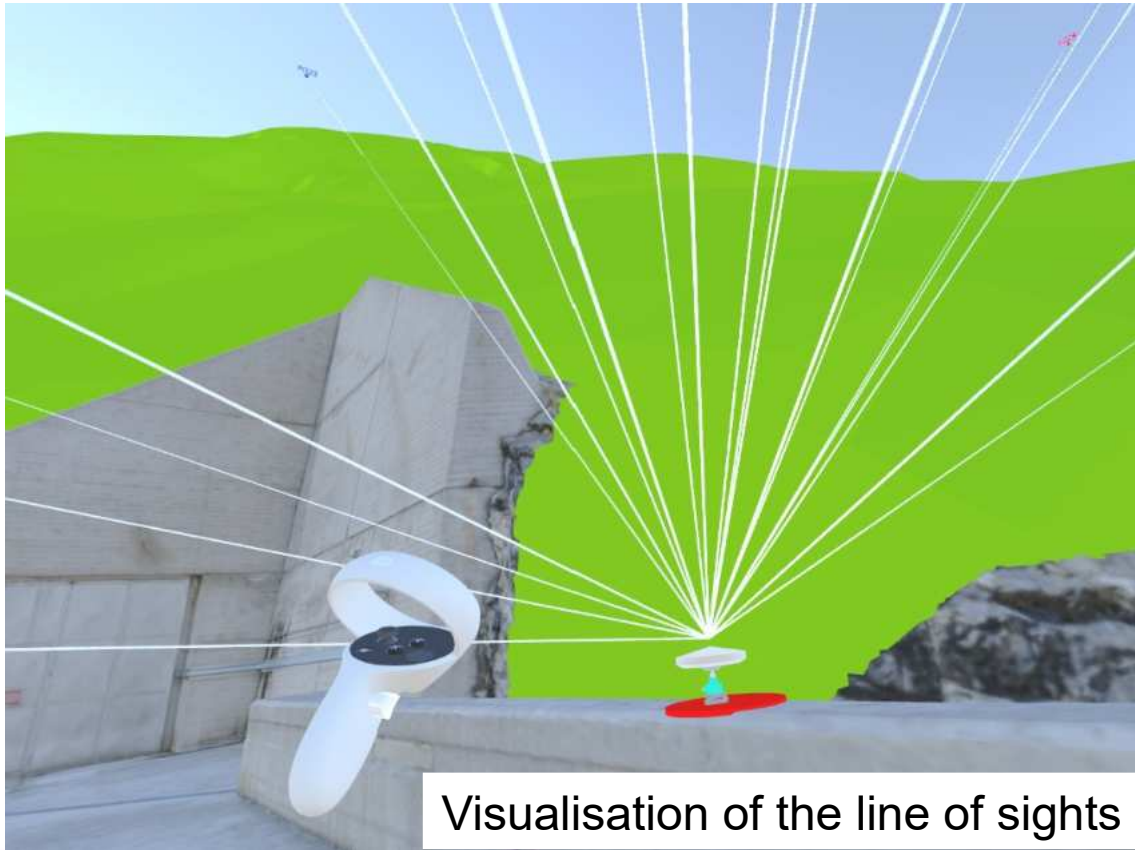
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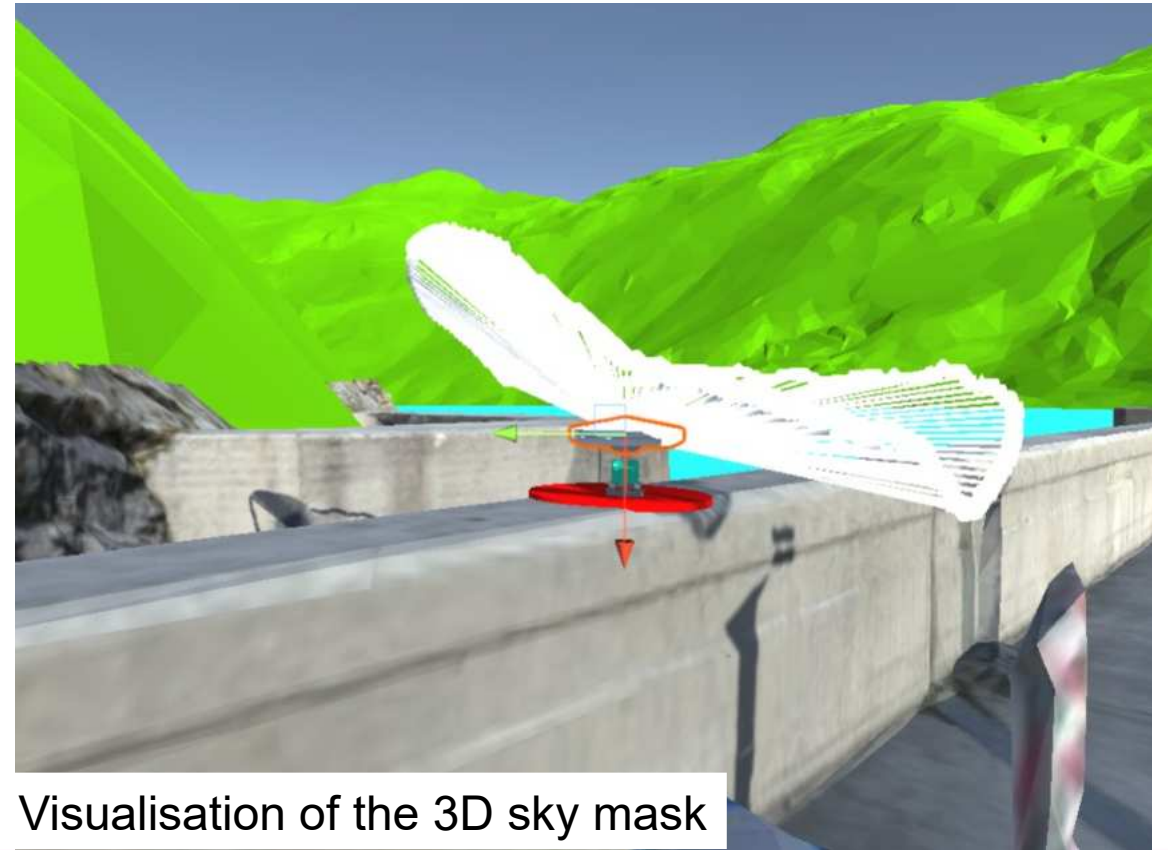
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## VR simulation



Visualisation of the line of sights



Visualisation of the 3D sky mask

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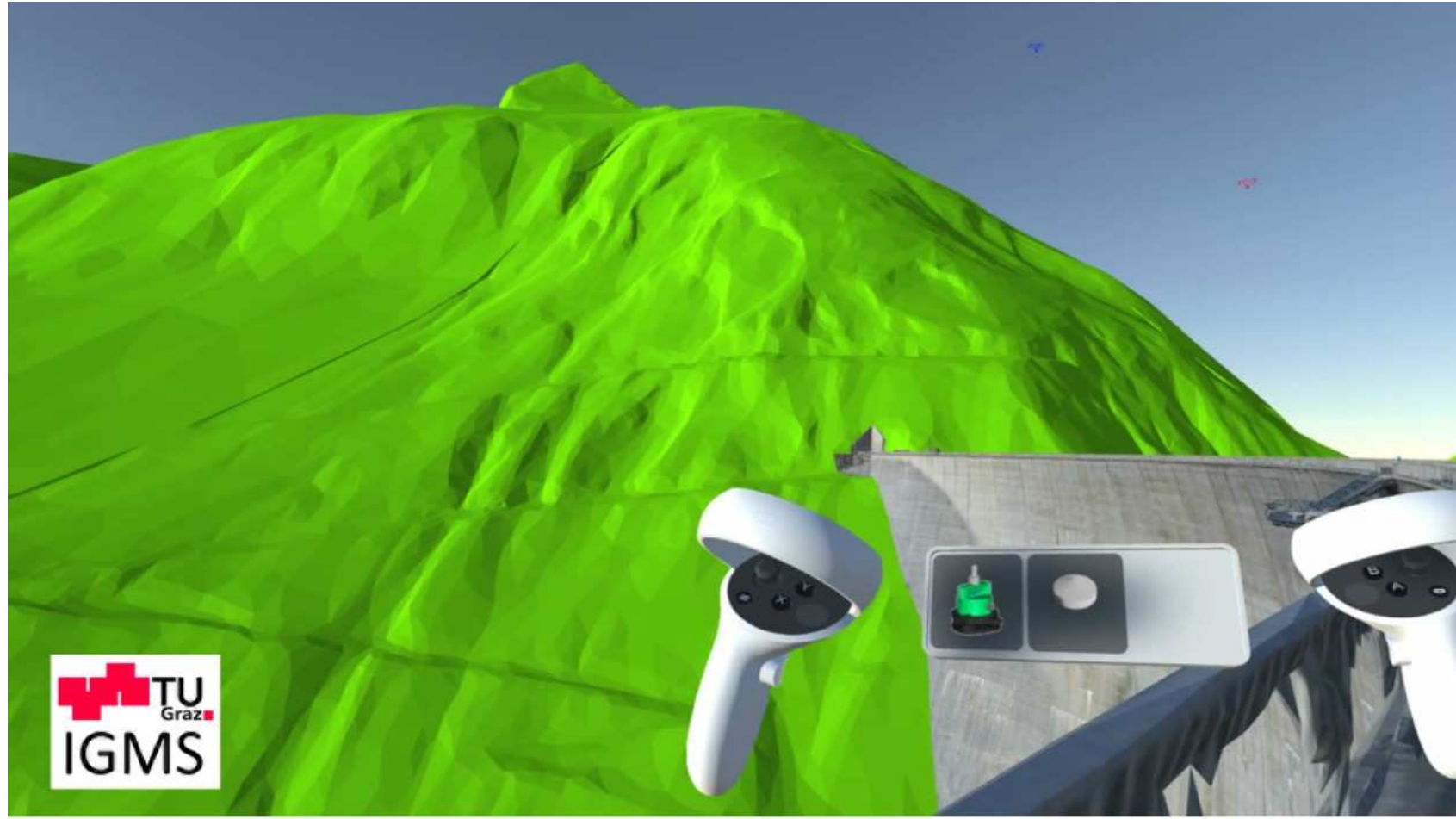


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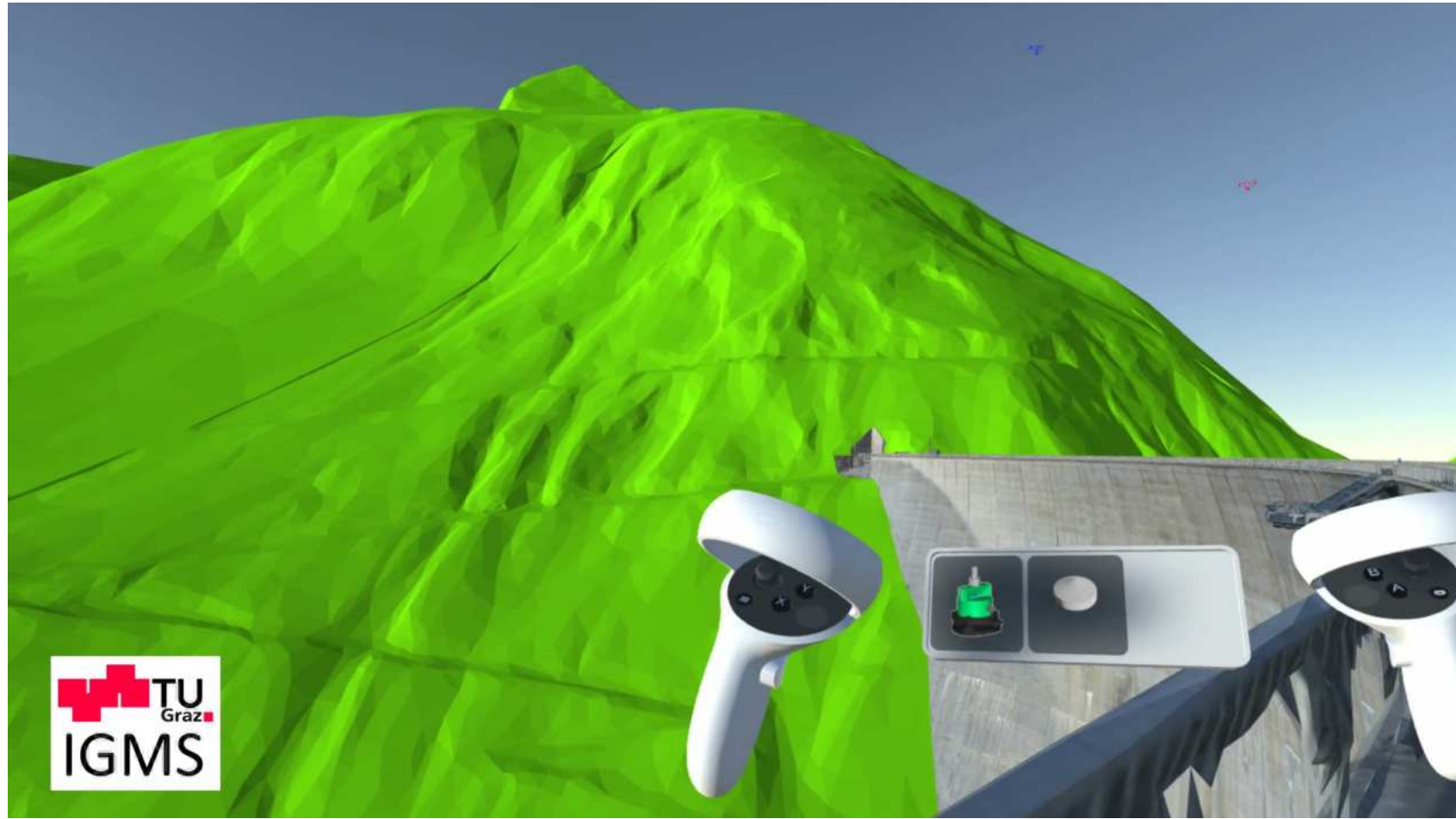


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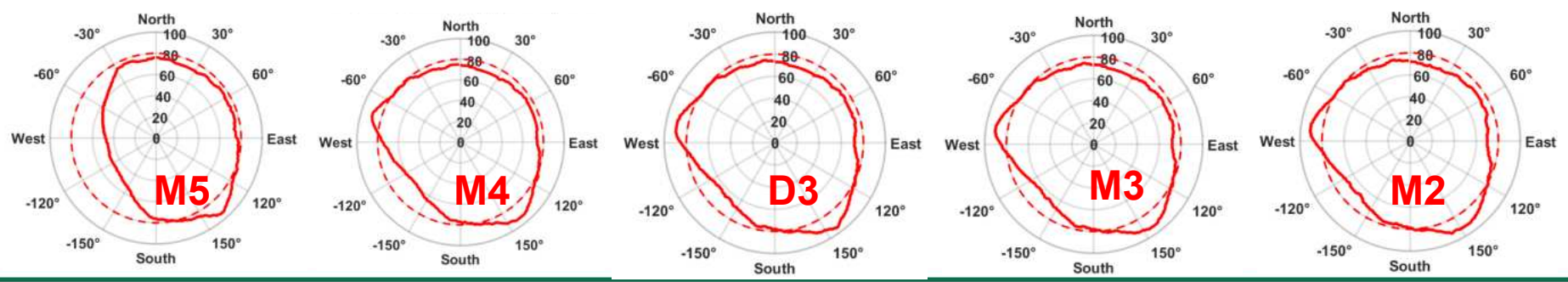
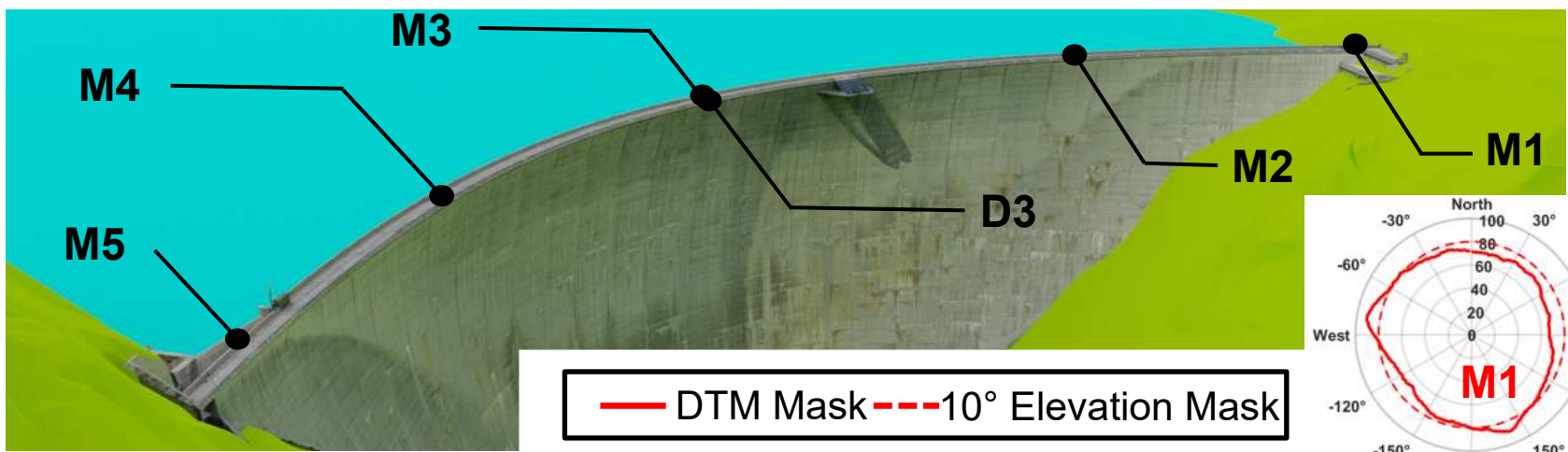
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## Results of the simulation





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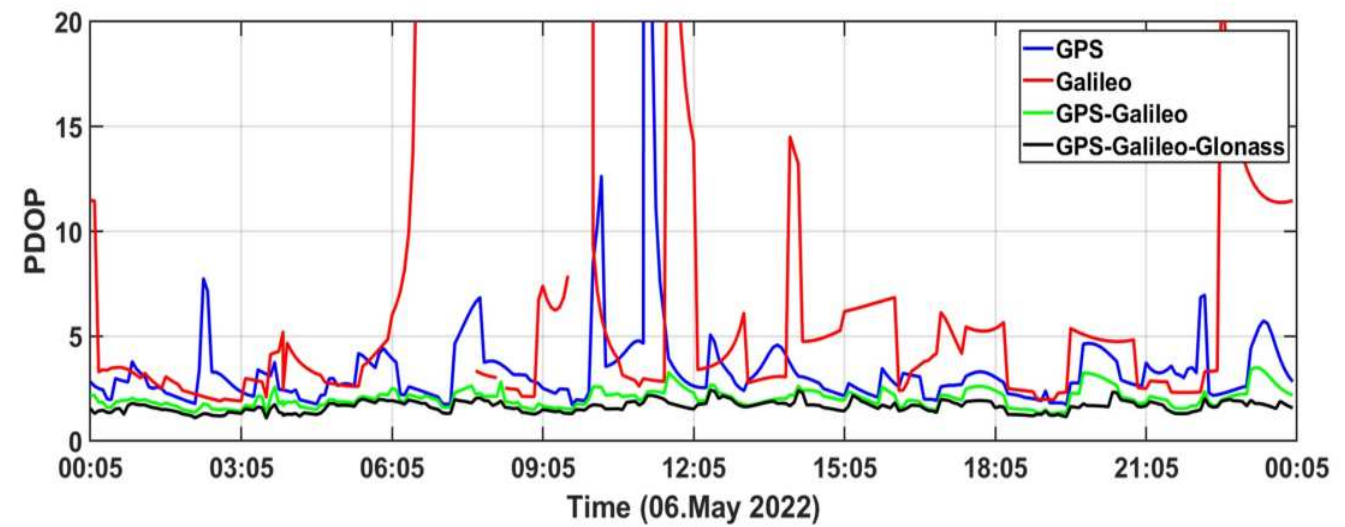
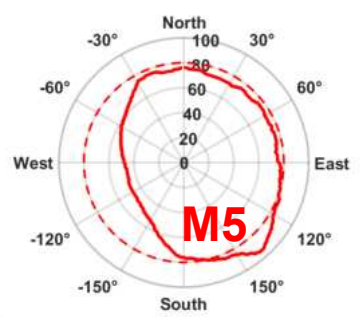
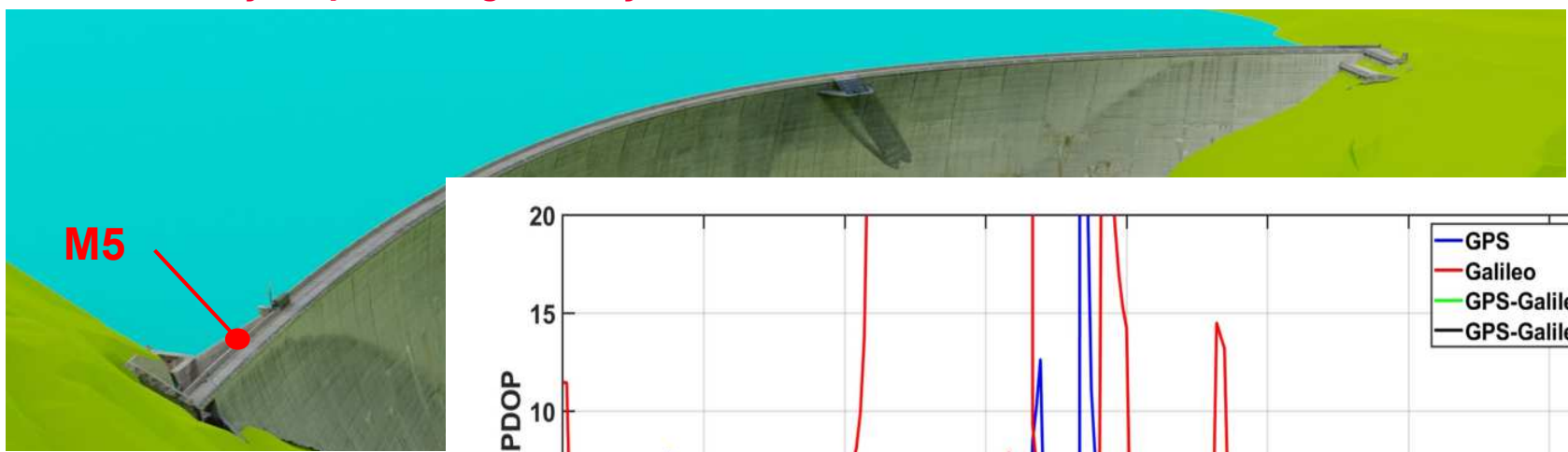
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## Results of the simulation

Would be also possible for solely as-planned geometry!



Combination of GPS and Galileo is mandatory for M5



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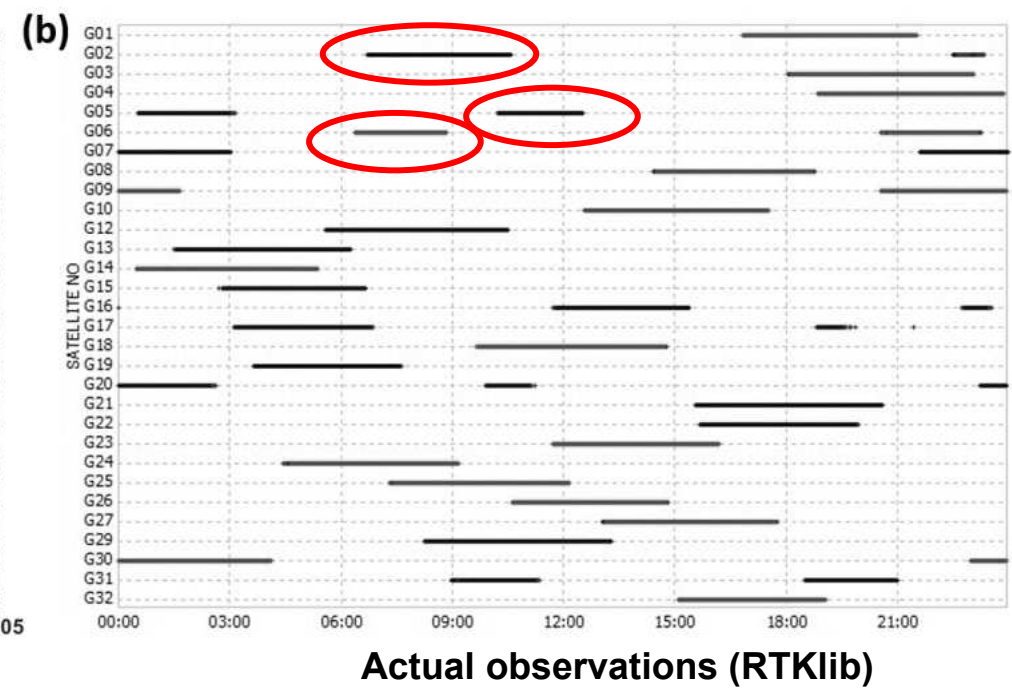
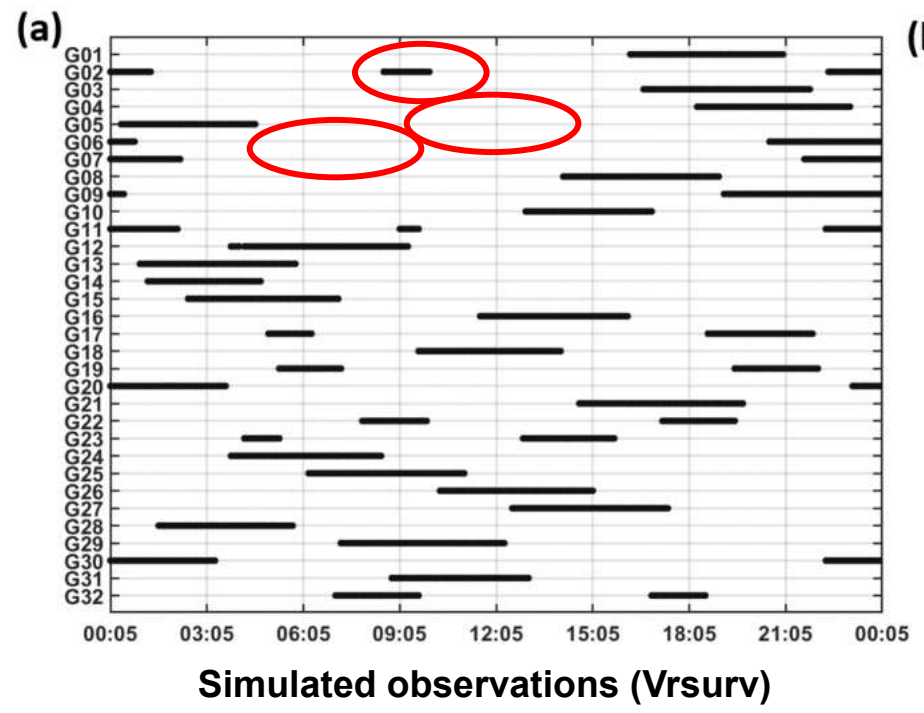
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## Outlook

Results have been validated with real on-site data



Room for further investigations (e.g. multi path)



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## Summary

### Virtual Reality

- Geodetic data integration into game engines is not a problem
- Real-time visualization and data interaction is possible

### 3D environment

- Enable a priori simulation of systematic effects with a new level of detail
- Not only geometry as a parameter (material properties, requirements, costs...)

### GNSS-monitoring

- Satellite visibility can be also simulated for projects, which are under construction

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Contact: [peter.bauer@gmx.at](mailto:peter.bauer@gmx.at)

Thank you for your attention!





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SUSTAINABLE DEVELOPMENT GOALS

International Federation of Surveyors supports the Sustainable Development Goals

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