

Combining micro UAV based mobile video imagery and virtual globes – a test case for future sensor web capabilities

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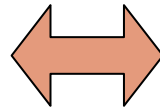
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Vision: Monitoring the Real World in a Virtual Globe Environment

1. Monitoring real-world events in a virtual world → Virtual Monitoring
2. Superimposing the real and virtual world → Augmented Monitoring
= research goals of the ViMo (Virtual Monitoring) project

Mobile geosensors (real world)



Virtual globes (virtual world)



Outline

- 1. Small UAVs – The ideal future Geosensor Platforms?**
- 2. Virtual Globes – Live before and after Google Earth ...**
- 3. OGC's Sensor Web Enablement (SWE)**
- 4. The i3D Virtual Globe Technology**
- 5. Geosensor Support in i3D – Test Cases for future SWE Capabilities**
- 6. Conclusions and Outlook**

Small to medium UAVs – a booming new technology



Mini and micro UAVs

- mini: less than 30 kg
- micro: 1 to few kg
- legally operational as 'model aircrafts'
- GPS/INS flight control
- configurations:
 quadcopters, fixed wing, helicopters
- propulsion: various,
 increasingly electrical

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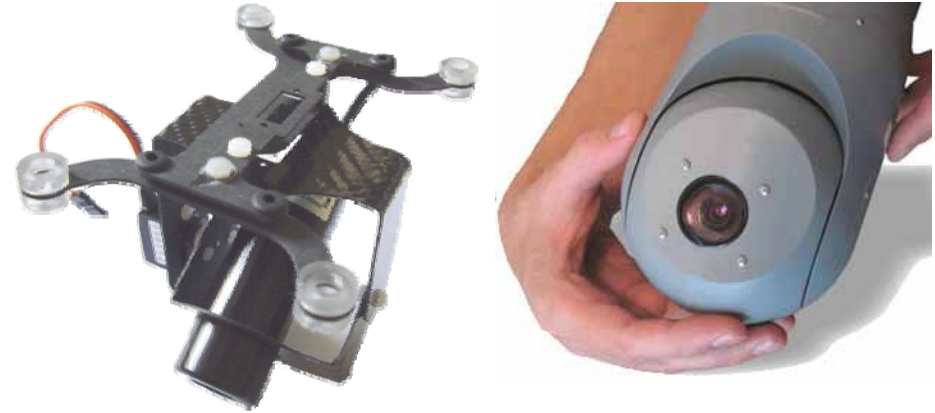
Small UAVs – Light-weight Imaging Payloads

=> micro UAVs < 400g (!)

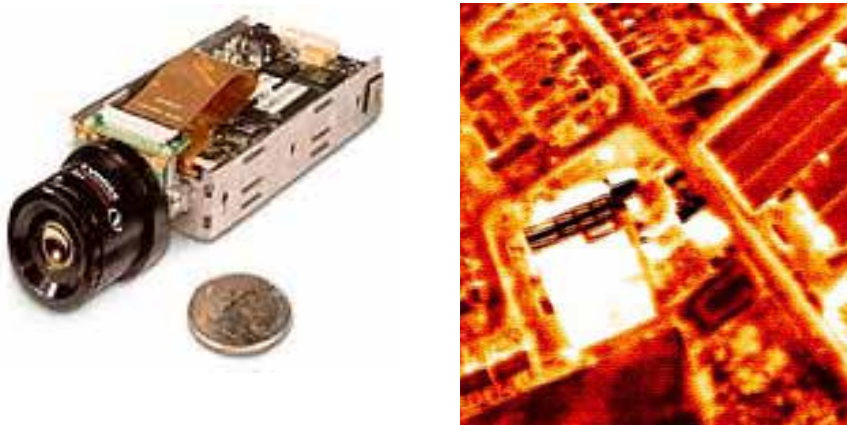
Still Imaging Sensors



Video Sensors



Thermal Infrared Sensors (TIR)



Multispectral Sensors (MSMS of FHNW)



Micro UAVs

Example: microdrones md4-200

VTOL operation with autonomous flight attitude control

- GPS, IMU, barometer, magnetic compass

Battery powered (min. 20' flying time per battery load)

Max. takeoff weight < 900g

Payload < 250 g

Payload: interchangeable image sensors

- video, RGB, thermal IR

Integrated data link (video & flight attitude data)



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Virtual Globes



i3D Virtual Globe Technology (FHNW)

Current virtual globe technologies

- e.g. Google Earth, Microsoft Virtual Earth or NASA World Wind

Features

- streaming of (very) large terrain data sets
- strong support for POI (& 3D objects)
- integration with web search technologies

Not (primarily) designed for ...

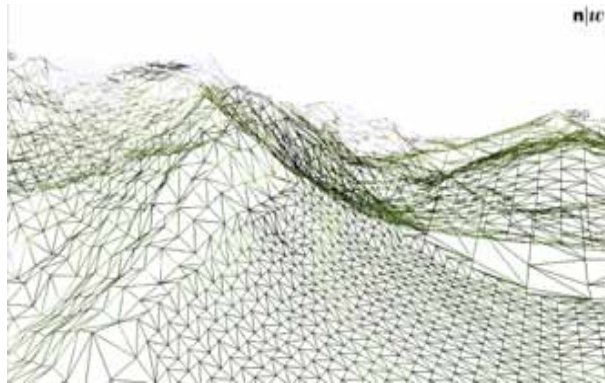
- dynamic or real-time content
- collaboration scenarios

Virtual Globes – Typical Contents

Points of Interest



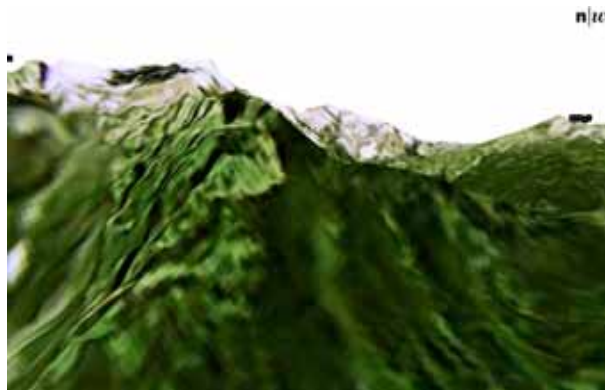
DEM digital elevation models



3D objects



Ortho imagery



Multimedia objects



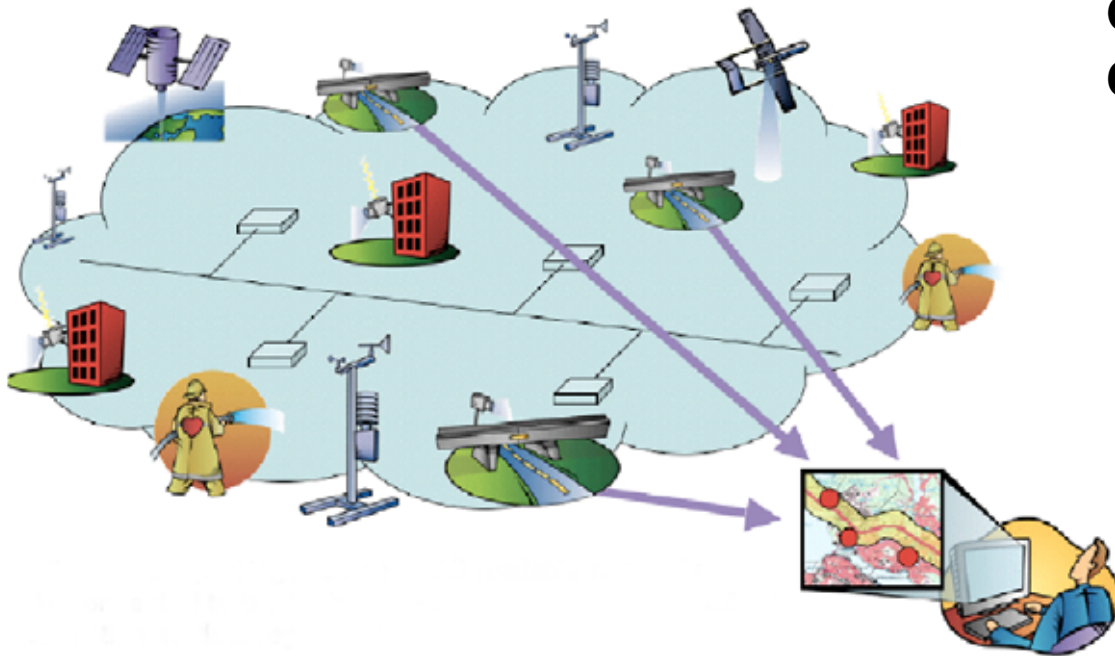
Virtual Globes – Live before (and after?) Google Earth

1997/98	Founding of Skyline Software Systems und Viewtec	2004	Google buys Keyhole NASA launches World Wind
2000	Founding of GEONOVA (FHNW)	2005	Launching of von Google Earth Leica launches Virtual Explorer Microsoft buys GeoTango
2001	"Flight through Switzerland" (GEONOVA): for the 1st time entire country interactively & 3D in the WWW Founding of Keyhole	2006	Microsoft launches Virtual Earth (as a virtual globe) IGN (Fr) launches GéoPortail (3D)
2003	Founding of 3D GEO (HPI Potsdam) and GeoTango (York University) ESRI launches ArcGlobe (ca.)	2008	Many European pioneers in virtual globe technologies have seized to exist (GEONOVA, Viewtec etc.)

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OGC's SWE – The missing Link between Geosensors and Virtual Globes?



OGC Sensor Web Enablement (SWE) – Components of the SWE Framework

- Observations & Measurements (O&M)
- Sensor Model Language (SensorML)
- TransducerML (TML)
- **Sensor Observation Service (SOS)**
- Sensor Planning Service (SPS)
- Sensor Alert Service (SAS)
- Web Notification Service (WNS)

Research Questions

- SWE access from Virtual Globe Environm.
- SWE suitable for mobile geosensors?
- SWE suitable for mobile video imagery?

Sensor Observation Service (SOS)

(Status 02/08: Draft Implementation Specification)

The key component of OGC's SWE

- Standard web interface for requesting, filtering, and retrieving observations and sensor system information
- Intermediary between client (e.g. Virtual Globe) and
 - an observation repository or
 - a near real-time sensor channel

Profiles and supported requests

- Core: GetCapabilities, DescribeSensor, GetObservation
- Transactional (optional): RegisterSensor, InsertObservation
- Enhanced (optional): GetObservationById, GetResult, GetFeatureOfInterest, GetFeatureOfInterestTime, DescribeFeatureType, DescribeObservationType ...

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i3D – Virtual Globe Technology



Features

- 3rd generation geovisualisation engine developed at FHNW
- spherical rendering on WGS-84 ellipsoid
- highly optimised for current generation GPUs

Content Streams

- for terrain, imagery, POI and 3D objects (e.g. city models)
- over the network or from local drives
- support for very large terrain and imagery data sets

Extensible Architecture

- various extension mechanisms / powerful API

i3D – Demo



i3D – Emerging and Future Content Types of Virtual Globes

Thematic cartographic objects

- required for information visualisation & analysis
- important in combination with geo sensor data
- open research area ...



Sensors and actors

- for sensor platforms, sensors and observations
- (near) real-time, kinematic, animated
- actors = users within collaborative environment

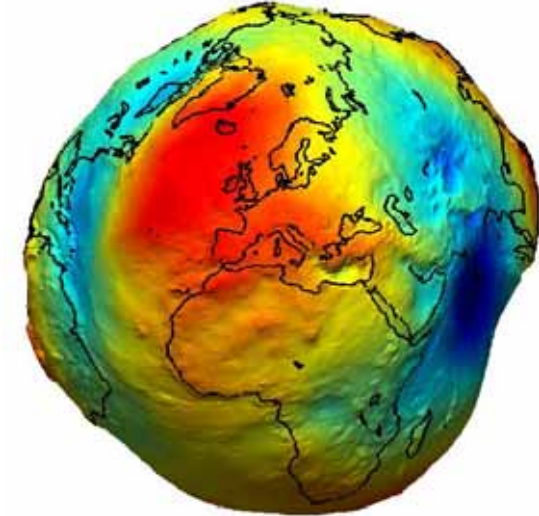
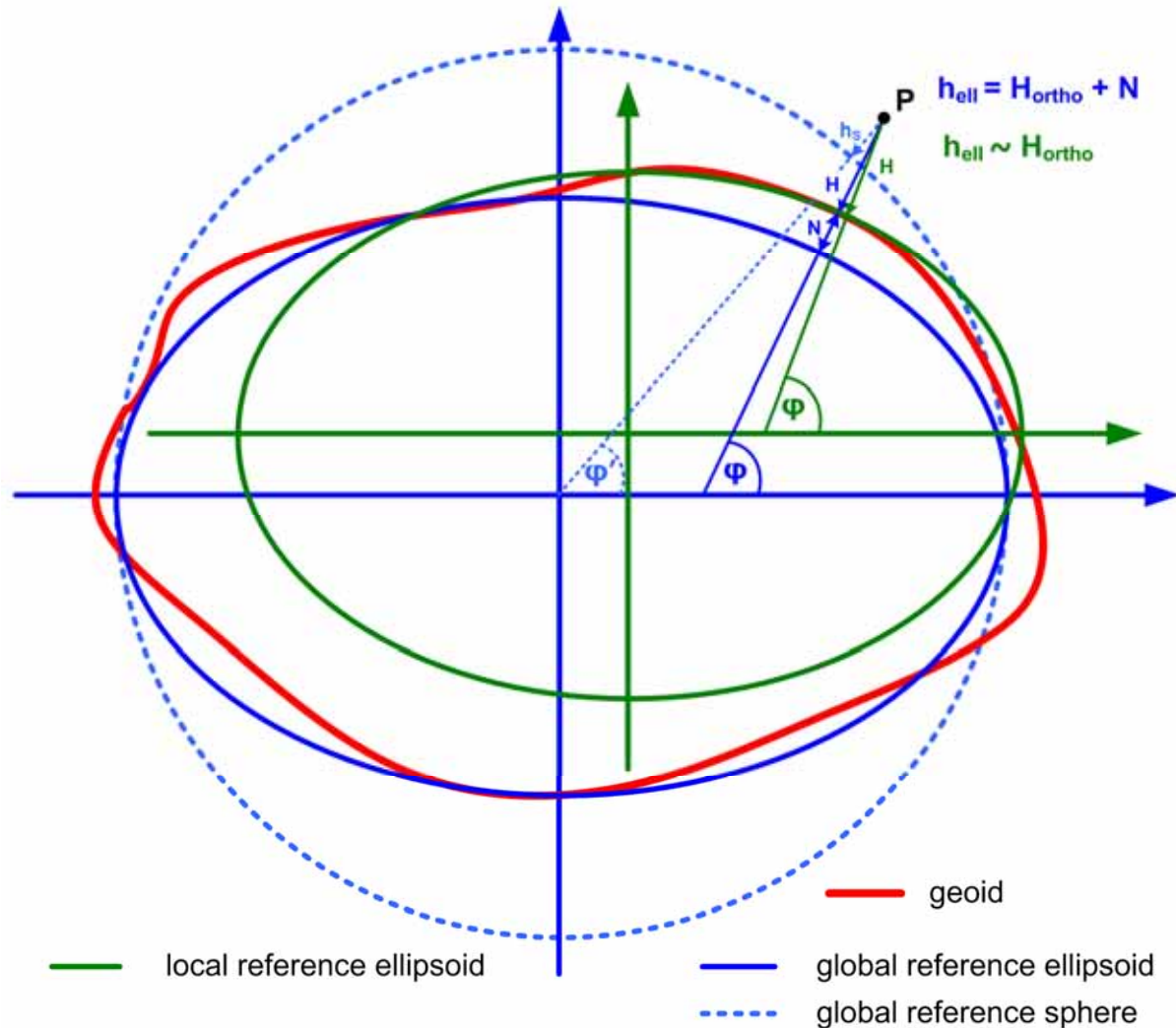


Georeferenced (video) imagery

- designed for integrating imagery in 3D landscape:
- augmented views or
- overlays in 3D scene



i3D – Geodetic Reference Systems



Geodetic Reference Systems in Virtual Globes

A key issue when ...

- integrating geosensors
- in particular 3D geosensors

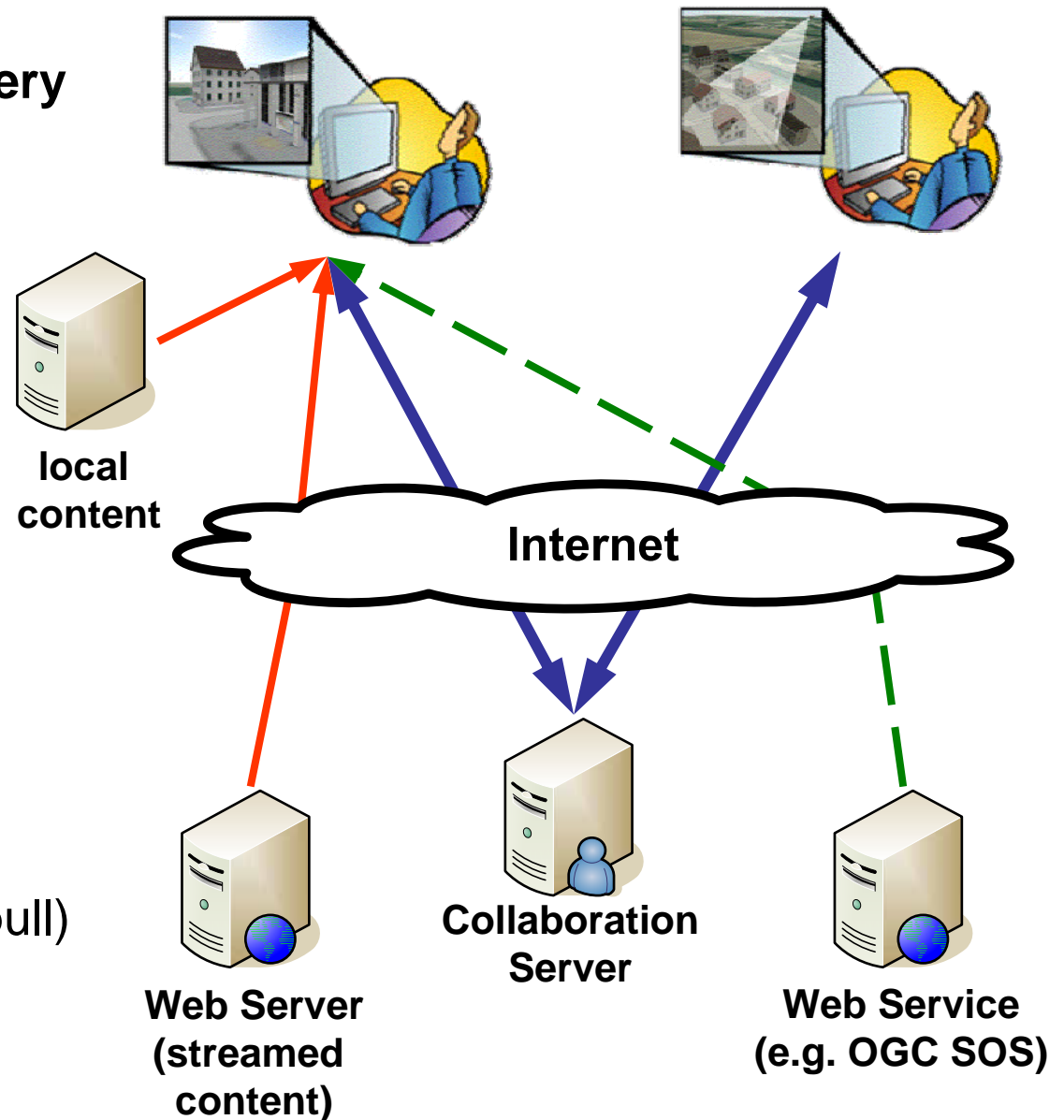
i3D – Content Channels & Delivery

Content Channels

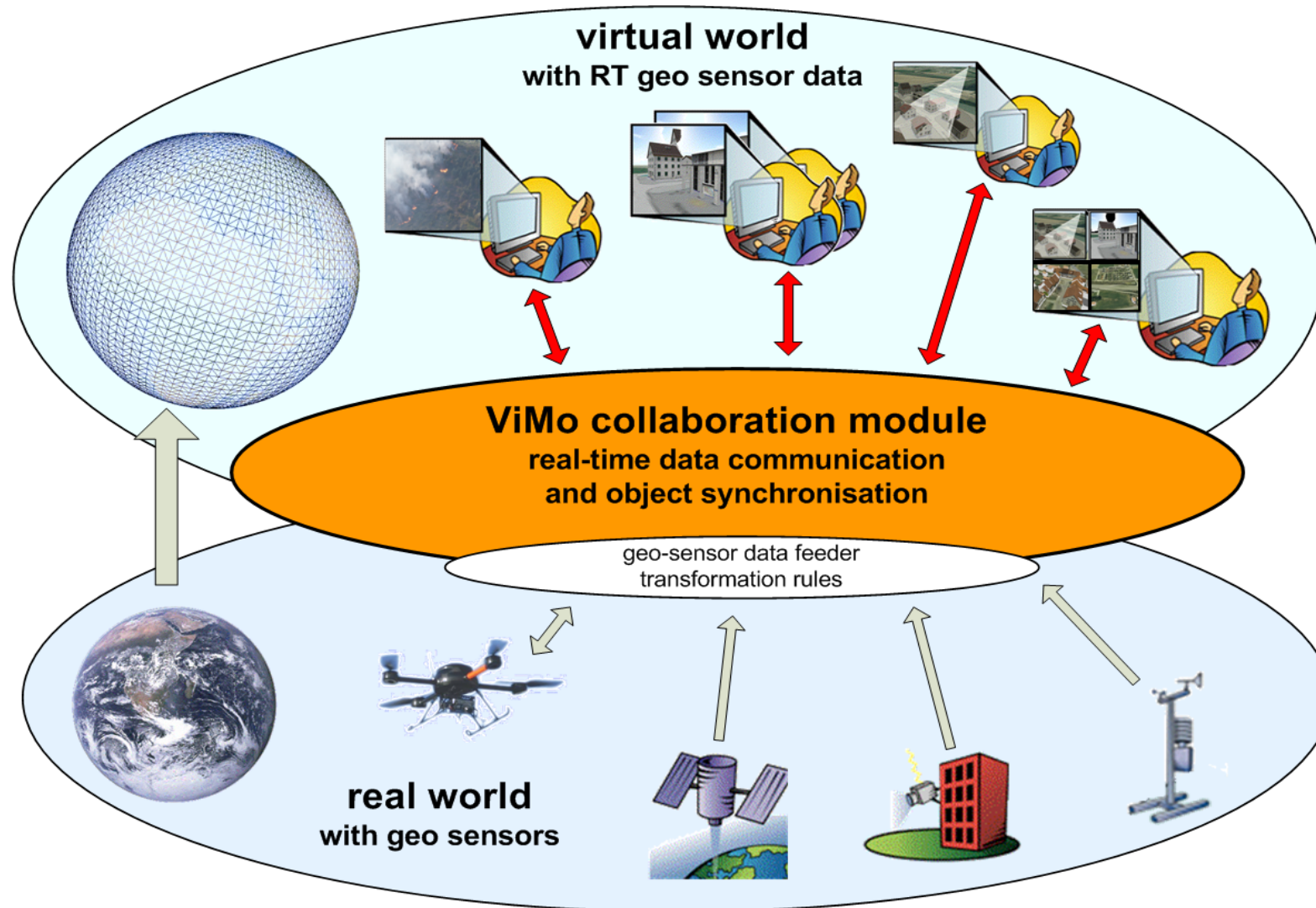
- Static / fixed content
- **Streamed content**
- **Content services**
- **Synchronised content**

Content Delivery Types

- Pull
- Push
- Object synchronisation (push/pull)



i3D – Collaboration Framework



i3D – Collaboration Framework

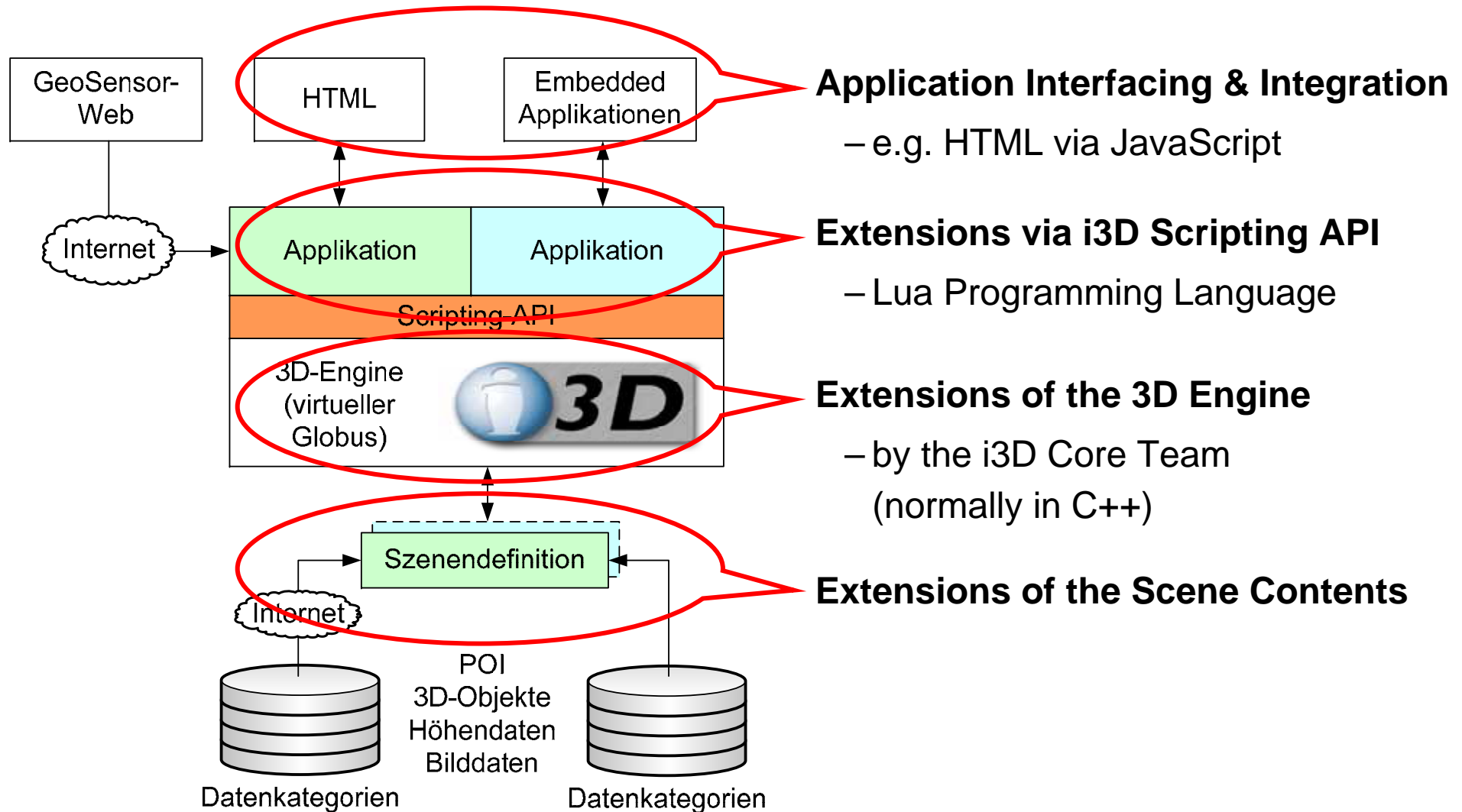
Main requirements and features

- user authentication and collaboration sessions
- secure real-time communication for large numbers of users
- collaborative geospatial environment (shared virtual globe)
- additional communication channels (e.g. chat, video and voice)

Communication Framework

- built on top of RakNet network engine (C++ UDP network library)
- components: ViMo Session Server, ViMo Connection Broker, ViMo Client
- ViMo Connection Broker enables NAT punch-through

i3D – Extensible Virtual Globe Technology



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Geosensor Support in i3D – Test Cases and Application Scenarios

OGC Sensor Observation Service

- Test case: integration of airport weather service via SOS

Virtual Tracking – Integration of mobile Geosensors

- Test case: real-time and post-mission integration of GPS loggers

Virtual Monitoring

- Monitoring real-world events in a virtual environment

Augmented Monitoring

- Superimposing the real and virtual world

Integration of Airport Weather Data using OGC SOS

Base data

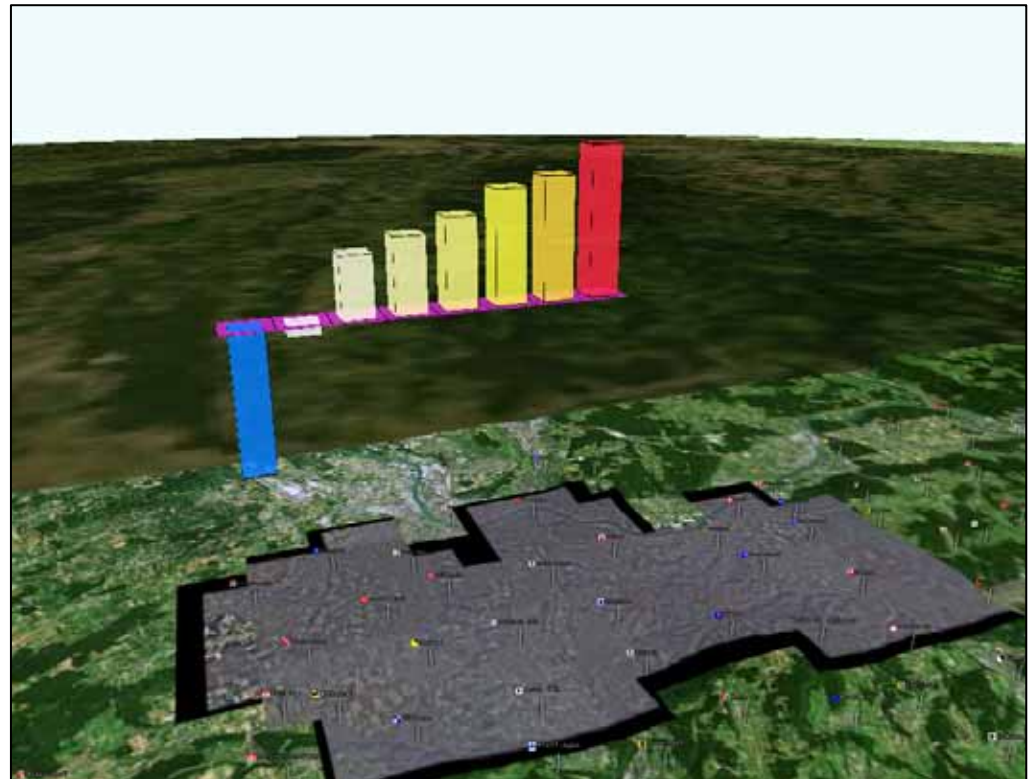
- global airport weather web service
- access via www.geonames.org

SOS framework by 52°North

- Open Source
- Implements Core Profile of OGC SOS (GetCapabilities, DescribeSensor, GetObservation)

SOS access from i3D Virtual Globe

- Server-side: PHP access to SOS (including data harvesting for SOS)
- Client-side: JavaScript & AJAX (future: direct SOS support by i3D API)



Virtual Monitoring

➔ Monitoring real-world events in a virtual world

Real-time display of sensor position, attitude and FOV in virtual globe

Time-synchronised georeferenced video imagery (acquired with micro UAV)



Test flight with micro UAV, Campus FHNW, Muttenz (CH), Virtual Globe Technology i3D (CTI Project ViMo, FHNW)

Augmented Monitoring

➔ Superimposing the real & virtual world



Augmented video from micro UAV test flight
Campus FHNW, Muttenz (CH)

Georeferenced video stream overlaid with 3D landscape model

- mobile platform for video sensor (UAV)
- georeferencing of video stream
 - GPS time encoding of video stream
 - direct georeferencing (DG) or
 - integrated georeferencing (IG) using 3D landscape model information
 - Eugster & Nebiker, MMT'07
- integrated / superimposed rendering of video and virtual globe (i3D)
- integration of geometric and semantic information from the virtual world

Service-based Geosensor Integration – (Future) Requirements

Wish list for OGC's SWE architecture and specifications:

- **geospatial data types and observations (location etc.)**
- **mobile sensors (e.g. fleet management etc.)**
- **multi-sensor platforms**
- **dynamic sensor platforms (e.g. UAVs)**
- **dynamic sensor orientation (gimbals, stabilisation platforms)**
- **georeferenced imagery and video streams**

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Conclusions

New mobile geo sensors and geo sensor web

- Virtual globe as ideal platform for monitoring & tracking real-world phenomena

Mobile geo sensor support in virtual globes

- Geodetic reference models for (sub-)metre accuracy required
- New content types: sensors, actors, georeferenced imagery and video
- Collaboration functionality for object synchronisation & shared use of VGE

Two generic application scenarios for wide range of applications

- Virtual Monitoring (e.g. object monitoring and tracking)
- Augmented Monitoring (e.g. rapid / real-time mapping)

- **First solve the problem(s) and then start to standardise the solution ...**

Outlook – OGC Geo Video Web Service (GVS) (Status: Discussion Paper)

GVS components

- Video cameras providing video streams and textual data
- Microsoft Windows (?) Media Encoder: MPEG-4 conversion & data encoding
- Microsoft Windows (?) Media Server
- GVS Database
- GVS Web Services
- GVS Client
- Windows Media Player (?)

First step in the right direction, but ...

- no support for camera calibration / interior orientation etc.
- mobile video sensors & GPS/IMU input mentioned but not yet covered

Ongoing and Future Work

Integrated georeferencing

- Automatic image measurements / image to 3D landscape matching
- Streamed 3D contents of virtual globe environment as control information

Move from analog to digital (and HD) video

- development of low-weight video encoders for mini and micro UAVs
- encoding / decoding of sensor position and orientation information
- ...

Collaborative rapid mapping and mission monitoring using small UAVs

- New CTI project 'UAVision'



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