Advances in Forestry Control &
Automation Systems in Europe

MONITORING LOGISTICS OPERATIONS OF THE FOREST BASED SUPPLY CHAIN IN (NEAR) REAL-TIME UTILIZING HARMONIZATION APPROACHES:

a Case Study from Austria

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Motivation

- Market penetration of Sensors is increasing

„obvious“ sensors

… but also

i.e. citizens as sensors (Goodchild 2007)

Motivation

- Market penetration of Sensors is increasing
- Number of proprietary systems and data models handling sensor data

Trimble FORESTRY

PONSSE

… and many more!

Open Issues:

- **Sharing data between those proprietary systems?**
- **Monitoring the status of the forest supply chain in real-time?**

Sensor Data & Spatial-temporal Domain - a Standardization Issue?

- Due to the **high number** of **different** available **proprietary systems**, **data models** and **sensor data transmission techniques** it seems **difficult** to **integrate** each part of the FSC in **one "system".**

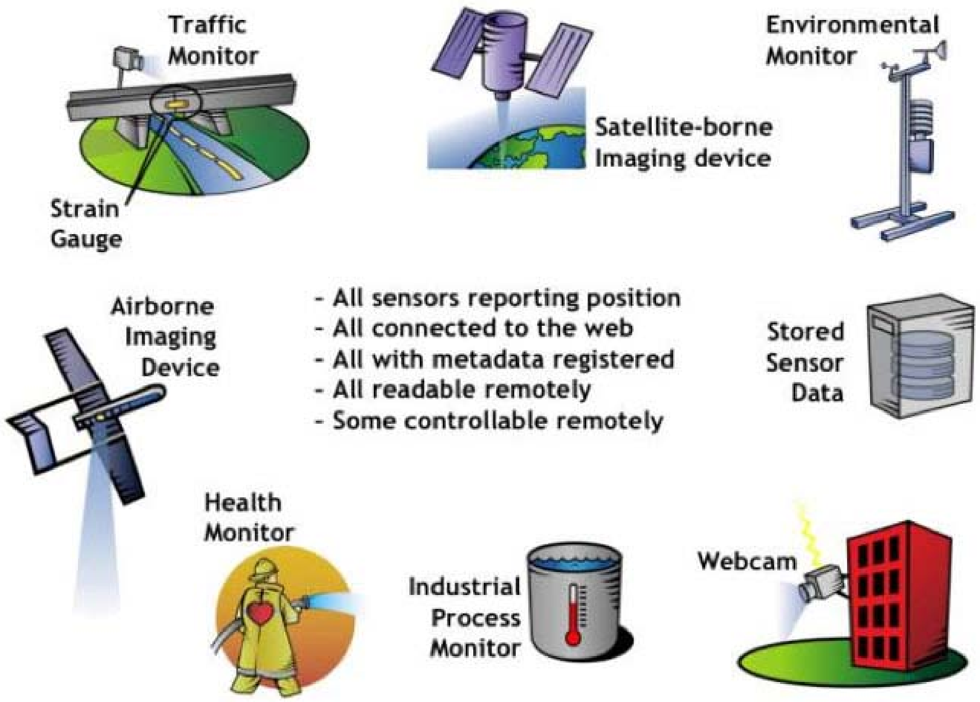
- In order **to integrate** different proprietary systems, we need to think about **standardization strategies** in order to **integrate sensor data** right from the start.
- As the FSC deals with **agents** that **are moving** in **space and time**, any standardization approach needs to take **spatial and temporal dimension** into account.
- Integrating sensors involves **semantic understanding of the sensors** (Bröring et al. 2011a, Bröring et al. 2011b, Janowicz et al. 2010, Kuhn 2009, Kuhn et al. 2014)

Sensor Data & Spatial-temporal Domain - a Standardization Issue?

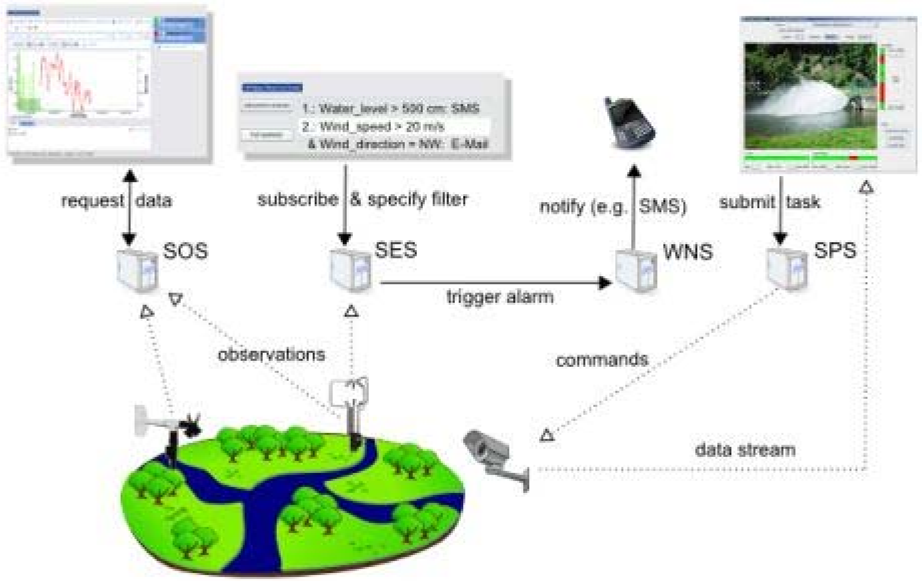
Approach for integrating real-time sensor data:

OpenGeospatial Consortium Sensor Web Enablement (SWE) Initiative (OGC 2015) with according standards (partly ISO standards):

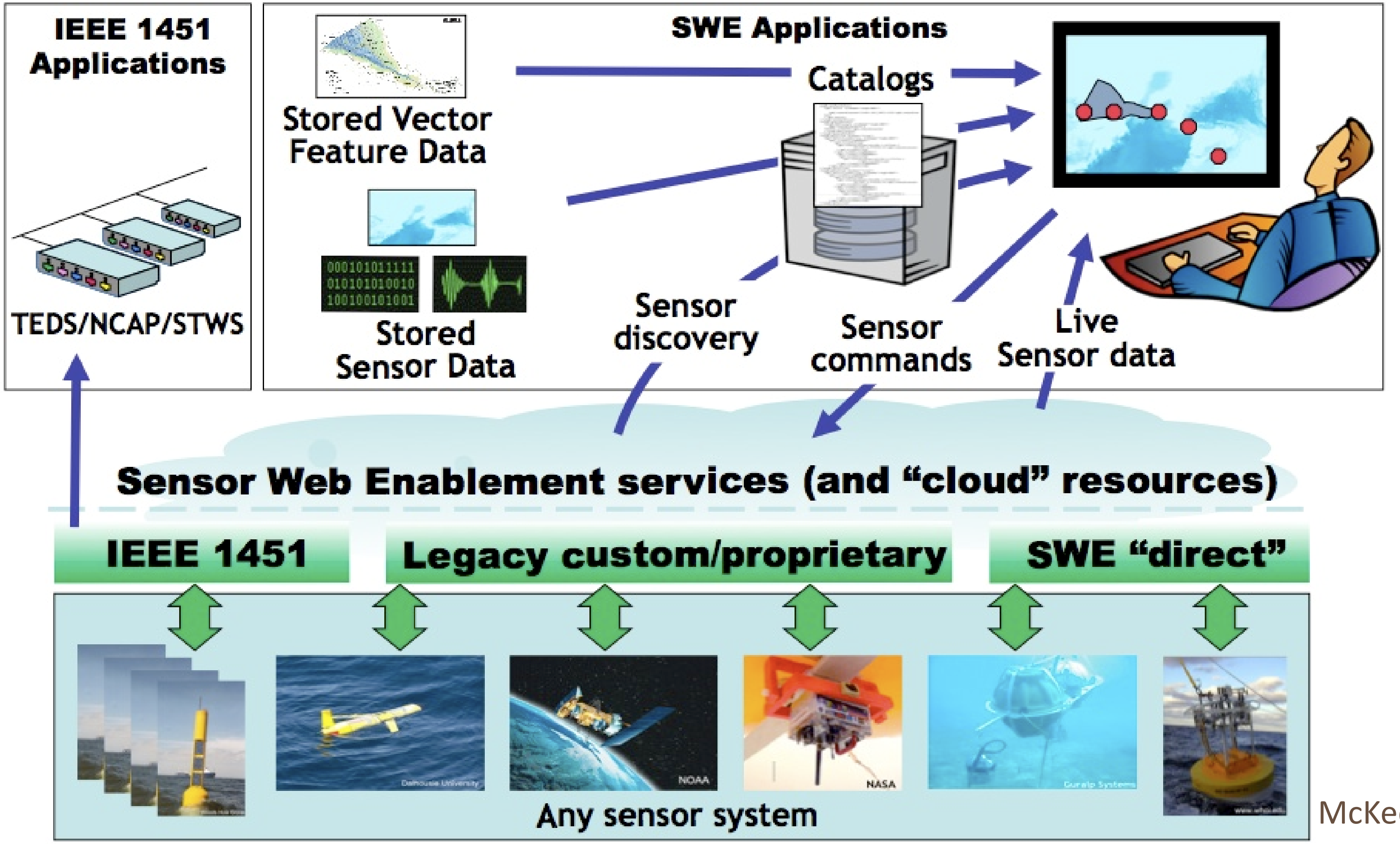
- Sensor Observation Service (SOS)
- Sensor Model Language (SensorML)
- Observations and Measurements (ISO 19156)
- …



http://www.opengeospatial.org/domain/swe


1.: Water_level > 500 cm: SMS
2.: Wind_speed > 20 m/s
& Wind_direction = NW: E-Mail
request data
subscribe & specify filter
notify (e.g. SMS)
submit task
SOS
SES
WNS
SPS
trigger alarm
observations
commands
data stream

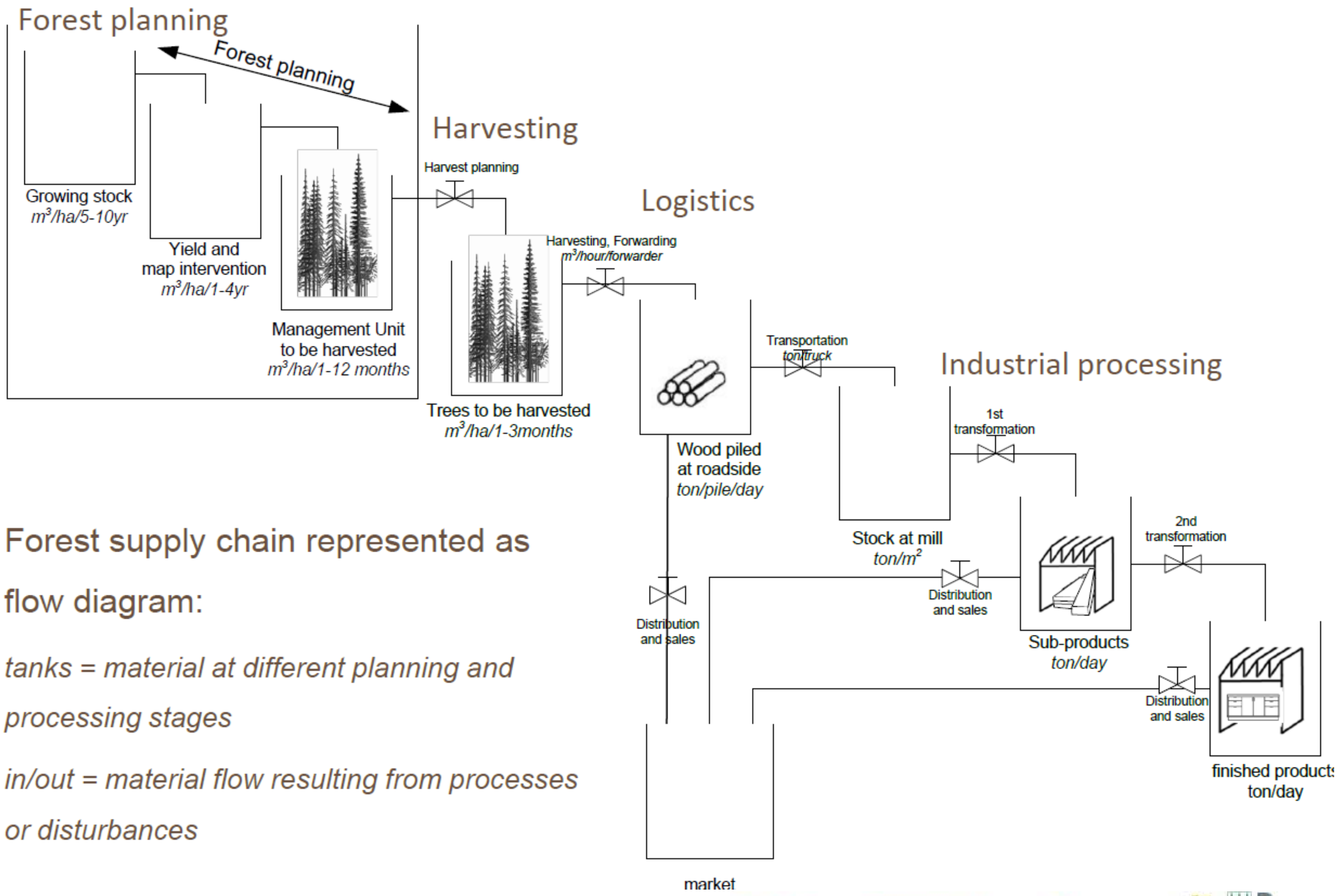
Sensor Data & Spatial-temporal Domain - a Standardization Issue?



McKee (2011)

Integration of Sensor Data in MBC

Model-based Control Overview



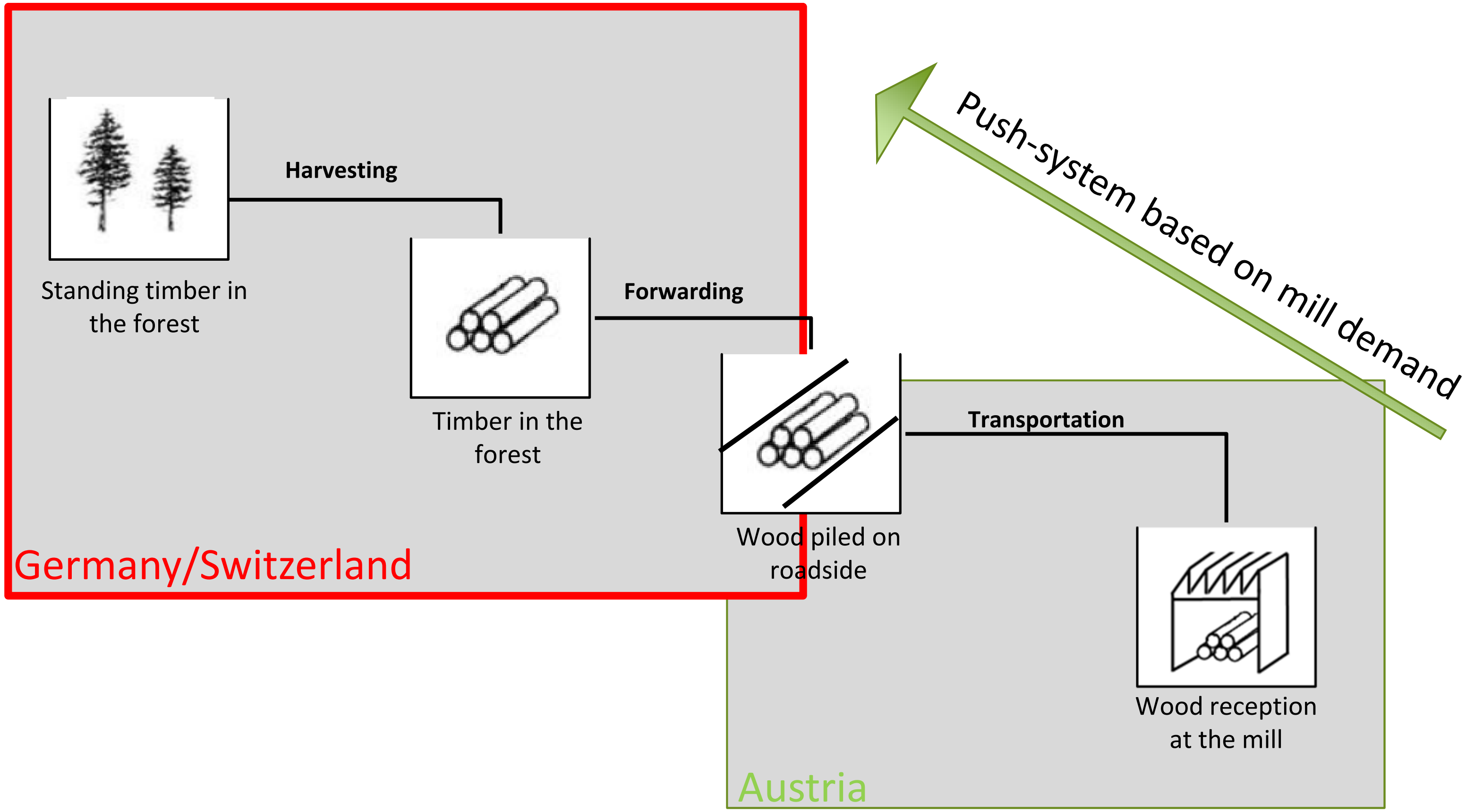
Forest supply chain represented as flow diagram:

tanks = material at different planning and processing stages

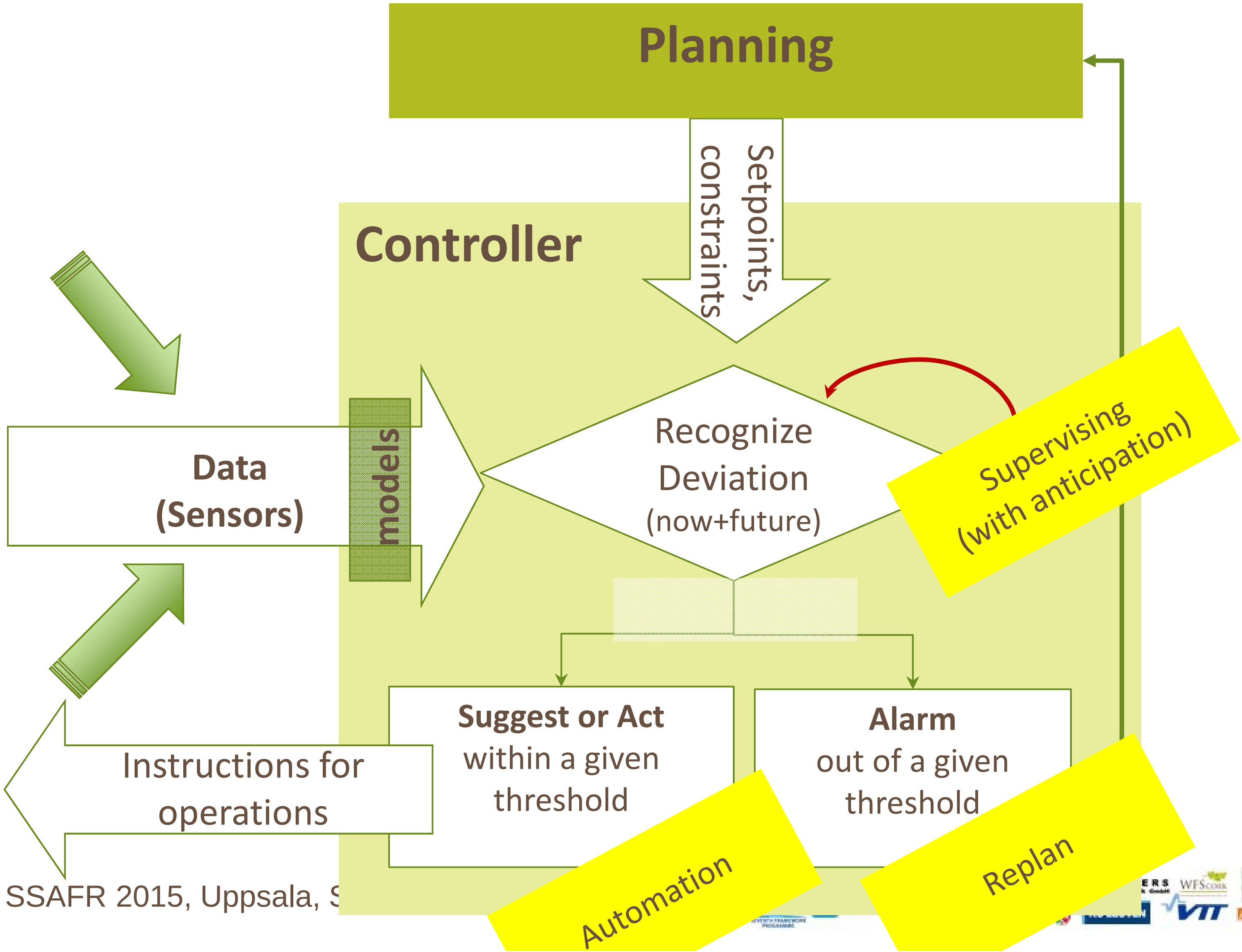
in/out = material flow resulting from processes or disturbances

Integration of Sensor Data in MBC

Model-based Control Overview



Integration of Sensor Data in MBC



(Near) Real-Time Sensor Data Collection

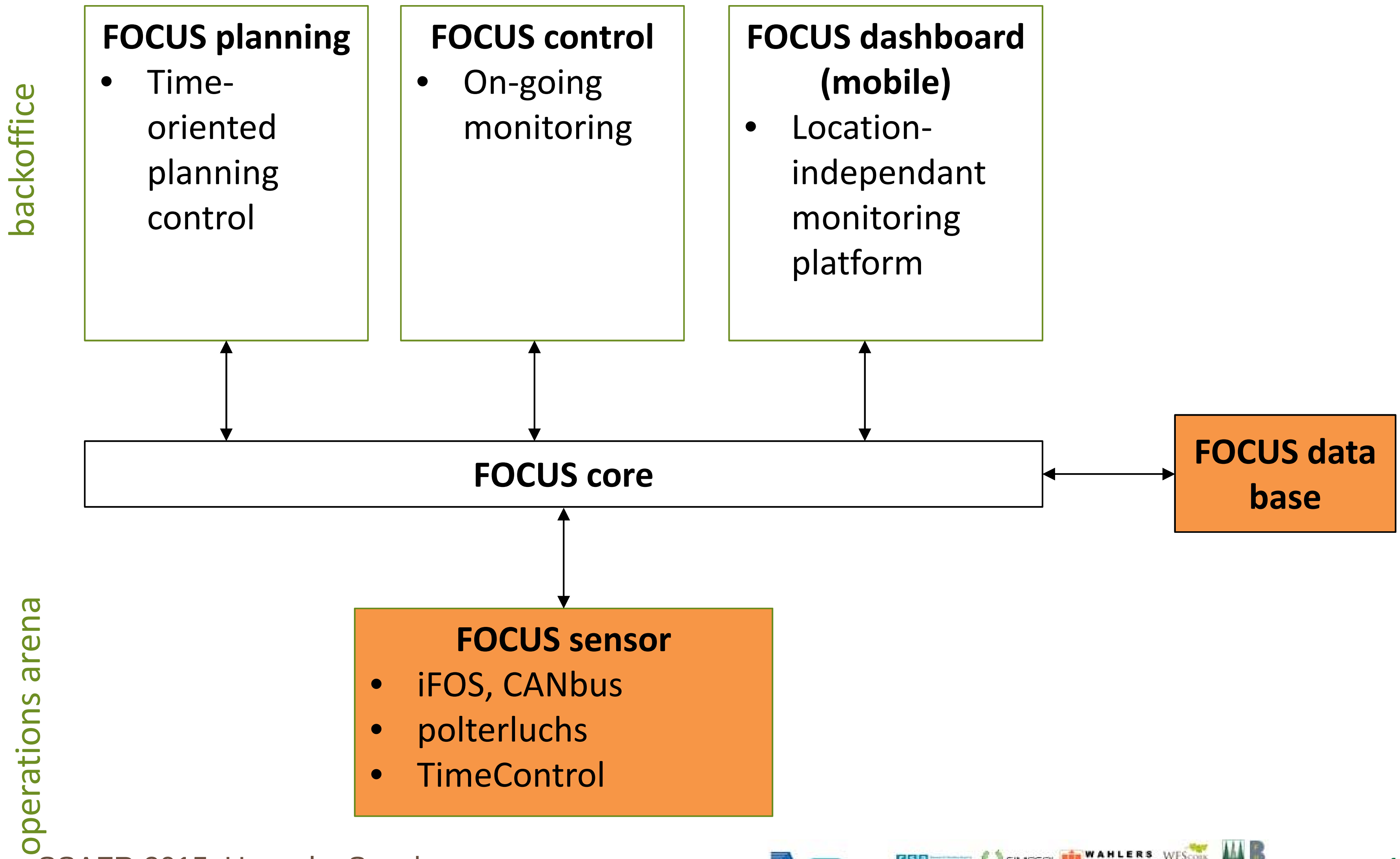
Approach

In order to collect real-time data of Wood Trucks we need the following data:

- Position
- Truck engine status of the truck (velocity, RPM, weight ..)
- additional attributive data
- Data collection employing the Sensor Web and standardized OGC Sensor Observation Services (SOS):
  - Collection of (any) measurement data in a standardized way
  - Storage of sensor data in a harmonized data-structure to:
    - Query sensor data
    - Parallel sensor requests
    - Providing of data in a standardized way (WFS, WMS)

(Near) Real-Time Sensor Data Collection

FOCUS platform solution for the pilot case



(Near) Real-Time Sensor Data Collection

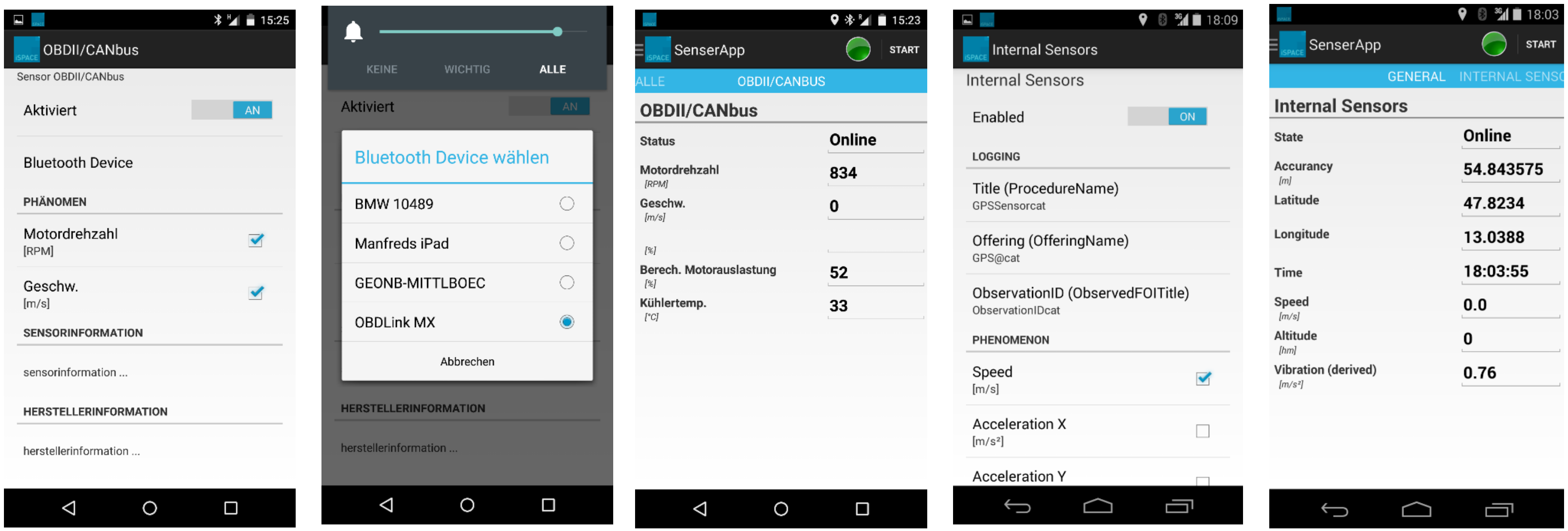
Collecting truck position and engine status information

- **Collecting truck position and engine-status in near real-time**
  - Combines **vehicle sensor measurements** with **vehicle location & time** using the GNSS of a mobile device
  - Transmit combined measurements in a standardized way to be used by the FOCUS architecture over IP (local app-caching supports temporary offline status)
  - **Interoperability support** - OGC SOS Transactional Standard 2.0
  - **Vehicle sensor data collection:**
    - Starting Point: Collect sensor data via **OBDII/CANbus** via Bluetooth (ELM327)
    - **WWH-OBD** (ISO 27145) standard
      - New heavy-duty vehicles must conform to the requirements of the Euro-VI emissions standard starting in 2014. Thus, vehicle manufacturers are obligated to implement a WWH-OBD capable diagnostic system
    - **Sensors** of the **mobile device** and derived indicators

(Near) Real-Time Sensor Data Collection

Mobile Phone App :: Collecting Data

- Screenshots of the Android App
  - Connect to OBDII/WWH-OBD
  - Use internal sensors of the mobile phone
  - Send the collected data via IP to the OGC SOS Server live (or stores the data if no Internet connection is available and sends data as bulk message)



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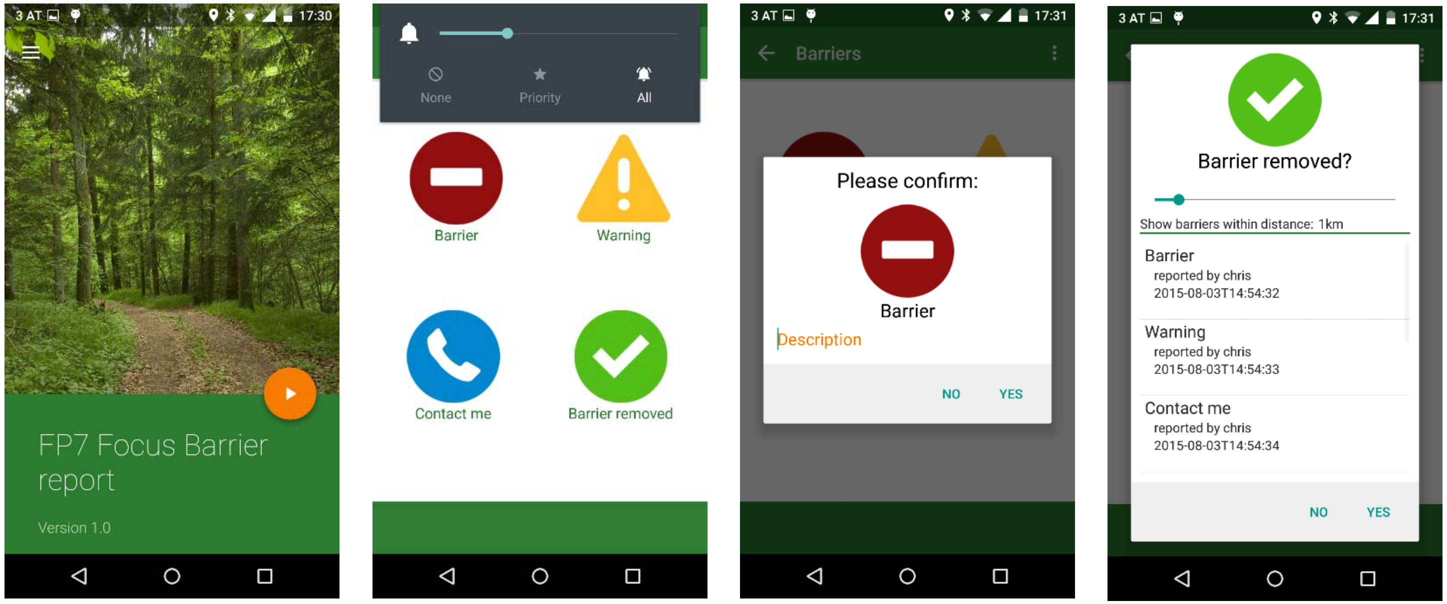

(Near) Real-Time Sensor Data Collection

OGC SOS Service 2.0 – with defined semantics

- The SOS has defined semantics for describing, storing and querying spatio-temporal measurements

Term	Description
Feature of interest (FOI)	The ~ represents the geoobject who is subject to the measured values and is measured by sensors. The FOI is usually the means of locating (geocoding) the measuring points, i.e. the geoobject has coordinates (for example latitude, longitude and altitude). It depends very much on the project and must be chosen depending on the task at hand.
Observation	An ~ gives a measurement (result) for the property (Phenomenon) of an object under observation (FOI). The value itself is generated by a sensor or by procedures (procedure). Furthermore, the phenomenon was detected at a particular time (sampling time) and generated the value at a particular time (Result Time). Often these two time values are consistent, so in practice the sampling time is used as the time of observation.
Offering	An ~ is a logical grouping of observations that are related to each other, which are jointly offered by a service.
Phenomenon	A ~ is a property (physical quantity) of a geoobject. Examples are air temperature, wind velocity, pollutant concentration of the atmosphere, reflected radiation in certain frequency band, et cetera.
Procedure	A ~ produces the measured value of an observation. This can be done by reading a sensor, or a numerical simulation process.
In situ	~ is the Latin term for "on the spot."

(Near) Real-Time Sensor Data Collection

OGC SOS Service 2.0 – with defined semantics

- The SOS has defined semantics for describing, storing and querying spatio-temporal measurements
- SOS uses XML encoding for transmitting and and retrieval of sensor data

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InsertObservation_truck150520.xml

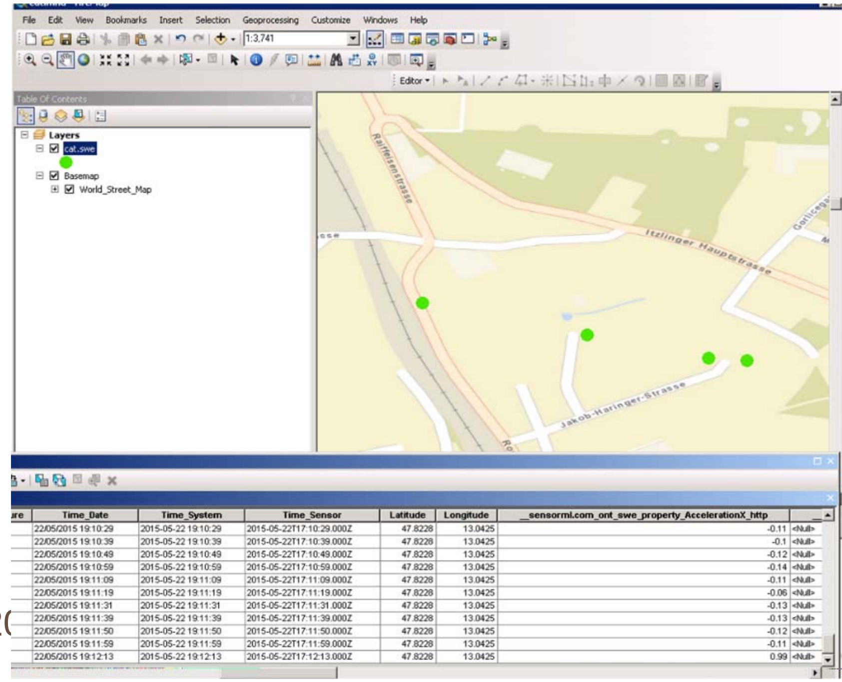

```xml
<sos:observation>
 <!-- for each observation use a uuid as identifier (just for internal database use) -->
 <om:OM_Observation gml:id="IDceff5087-17da-1346-6685-316a33681d16"> <!-- IDa7655d8d-9b80-4fc3-bddd-2d247b3622f8 -->
  <om:type xlink:href="http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_Measurement" />
  <om:phenomenonTime xlink:href="#phenomenonTime"/>
  <om:resultTime xlink:href="#phenomenonTime" />
  <om:procedure xlink:href="http://ispace.researchstudio.at/sensor/ispace_s50_01/procedure/GPSSensor/" xlink:title="GPSSenso
  <om:parameter>
   <om:NamedValue>
     <om:name xlink:href="http://www.opengis.net/def/param-name/OGC-OM/2.0/samplingGeometry"/>
     <om:value xsi:type="gml:GeometryPropertyType">
       <gml:Point gml:id="ID377456f9-0fde-40d8-8b13-fbad5e8d9603"> <!-- IDa7659d8d-9b80-4fc3-bcdd-2d287b3644f6 -->
         <gml:pos srsName="http://www.opengis.net/def/crs/EPSG/0/4326">50.1213933 8.6153626</gml:pos>
  </gml:Point>
     </om:value>
   </om:NamedValue>
  </om:parameter>
  <om:observedProperty xlink:href="http://sensorml.com/ont/swe/property/AccelerationX" /><!--25/C1-->
  <om:featureOfInterest xlink:href="#ID377456f9-0fde-40d8-8b13-fbad5e8d9603"/>
  <om:result uom="mpers2X" xsi:type="gml:MeasureType">-0.207</om:result>
 </om:OM_Observation>
 </sos:observation>


<sos:observation>
 <om:OM_Observation gml:id="ID55b267d7-24de-4261-2d19-454274357b3j"> <!-- IDa7655d8d-9b80-4fc3-bddd-2d247b3622f8 -->
  <om:type xlink:href="http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_Measurement" />
  <om:phenomenonTime xlink:href="#phenomenonTime"/>
 <om:resultTime xlink:href="#phenomenonTime" />
```

(Near) Real-Time Sensor Data Collection

Visualization with a GIS

- Geographic Information Systems (GIS) are tools to visualize, manipulate and manage spatio-temporal data – either web-based or desktop-based.
- OGC Sensor Observation Services can be seamlessly integrated in GIS (desktop and web-based GIS via standardized services)



Time_Date	Time_System	Time_Sensor	Latitude	Longitude	__sensorml.com_ont_swe_property_AccelerationX_http	
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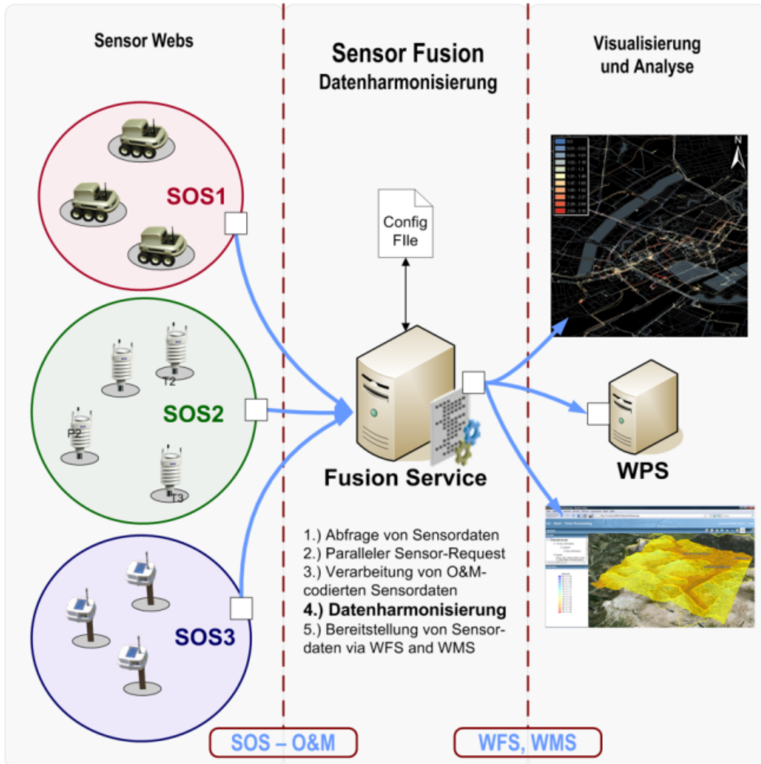
22/05/2015 19:10:39	2015-05-22 19:10:39	2015-05-22T17:10:39.000Z	47.8228	13.0425	-0.1	<Null>
22/05/2015 19:10:49	2015-05-22 19:10:49	2015-05-22T17:10:49.000Z	47.8228	13.0425	-0.12	<Null>
22/05/2015 19:10:59	2015-05-22 19:10:59	2015-05-22T17:10:59.000Z	47.8228	13.0425	-0.14	<Null>
22/05/2015 19:11:09	2015-05-22 19:11:09	2015-05-22T17:11:09.000Z	47.8228	13.0425	-0.11	<Null>
22/05/2015 19:11:19	2015-05-22 19:11:19	2015-05-22T17:11:19.000Z	47.8228	13.0425	-0.06	<Null>
22/05/2015 19:11:31	2015-05-22 19:11:31	2015-05-22T17:11:31.000Z	47.8228	13.0425	-0.13	<Null>
22/05/2015 19:11:39	2015-05-22 19:11:39	2015-05-22T17:11:39.000Z	47.8228	13.0425	-0.13	<Null>
22/05/2015 19:11:50	2015-05-22 19:11:50	2015-05-22T17:11:50.000Z	47.8228	13.0425	-0.12	<Null>
22/05/2015 19:11:59	2015-05-22 19:11:59	2015-05-22T17:11:59.000Z	47.8228	13.0425	-0.11	<Null>
22/05/2015 19:12:13	2015-05-22 19:12:13	2015-05-22T17:12:13.000Z	47.8228	13.0425	0.99	<Null>



Summary & Future Work

- **Monitoring** of the **FSC** actors in **near real-time** with a **sensor cloud** in the course of the **FOCUS FP7 research project** (*Advances in Forestry Control and Automation Systems in Europe*)
  - Due to the high number of different sensor and system vendors, a **multitude** of **proprietary formats/systems** is available – which can hardly be linked in real time.
- **Open Geospatial Consortium** (and ISO) provides **open standards** to describe and transmit sensor measurements (with respect to **spatial and temporal domain**) including open-source reference implementations

  >> **OGC Sensor Web Enablement Initiative**

- To connect with **vehicle sensors**, standards (OBDII and WWH-OBD) are used which are amended with spatial and temporal data.

- Vehicle data can be visualized with **Geographical Information Systems** – desktop or web-based – both by **utilizing standards** (OGC SOS, OGC WMS, …).

Resources

- Bröring, A., Maué, P., Janowicz, K., Nüst, D., & Malewski, C. (2011a). Semantically-enabled sensor plug & play for the sensor web. *Sensors*, *11*(8), 7568-7605.
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