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# Component B

## Rapid data collection and integration

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# Operative framework

- Rapid characterization of inhabited (urban) areas for risk assessment and Emergency Limit Condition (CLE)

- **Exposure**: spatial distribution of residential buildings & critical buildings
- **Vulnerability**: simplified, scalable fragility models
- **Monitoring**: building health monitoring for pre-event characterization and co-seismic damage detection
- **Site Effects**: fast assessment of local amplification and sub-soil characterization
- **Response**: Post-event rapid damage assessment

# Emergency Limit Condition (CLE)

Critical buildings

Emergency Areas (concentration)

Emergency Areas (recovery)

Link infrastructure

Access infrastructure

**Possibly Redundant !**

Source: *Italian Civil Protection Dept.*

# Data collection overview

Information already available or promptly provided by authorities

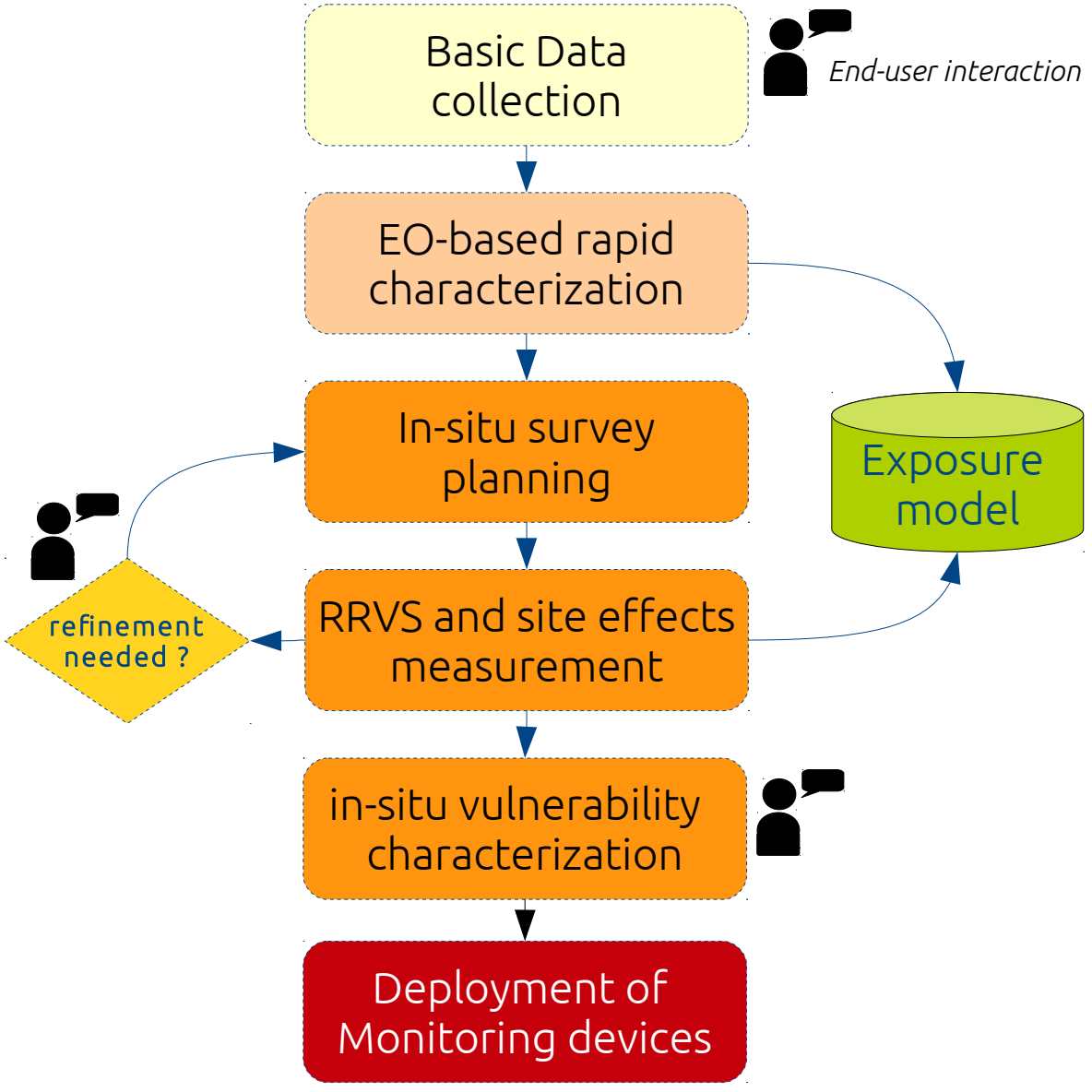
Rapid characterization by medium-res satellite imagery

Optimization based on information distribution and end-user constraint

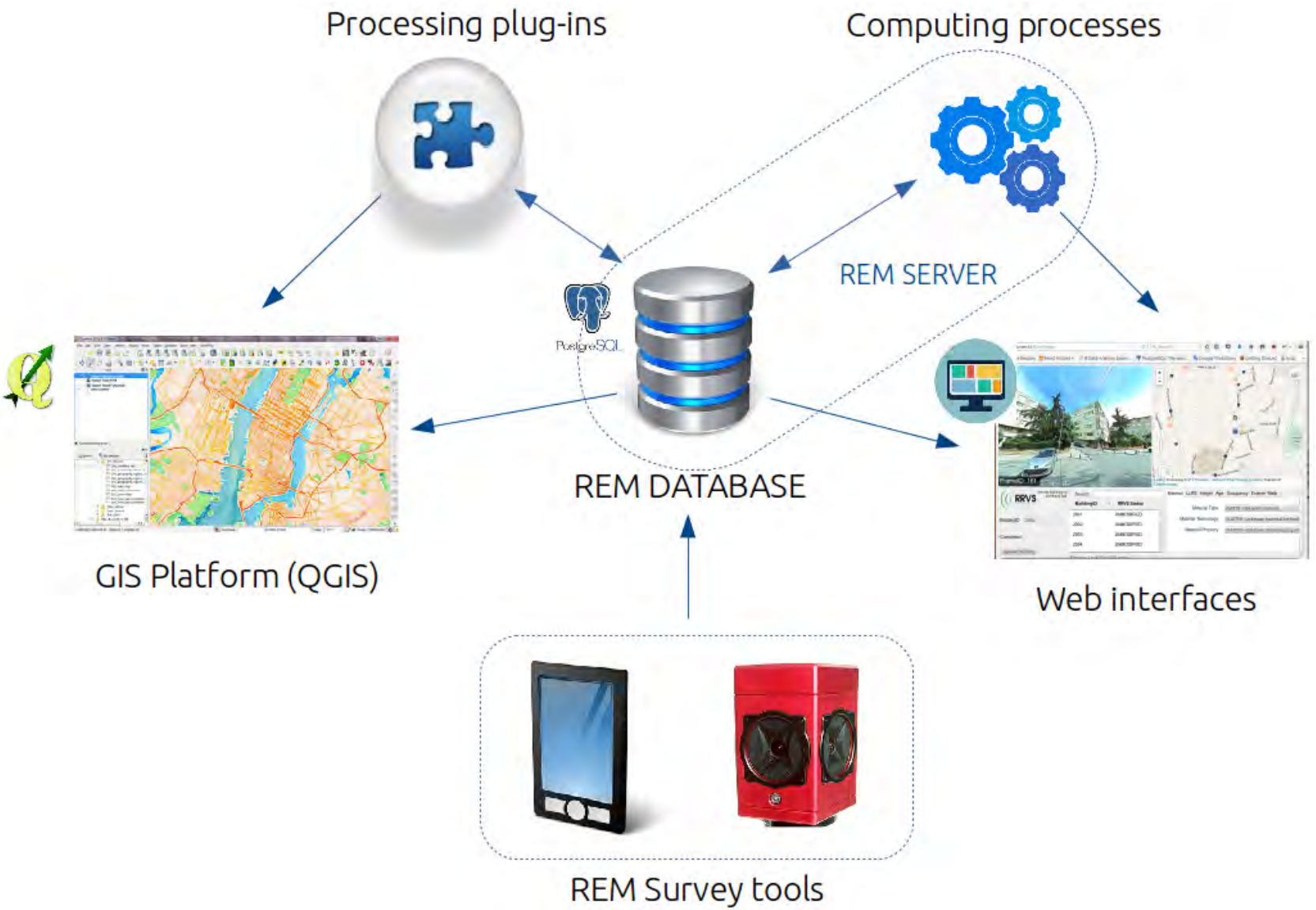
Rapid remote visual screening and first assessment of site effects

selection of representative structures and In-situ structural characterization

Deployment of sensor network and start of real-time monitoring



# The REM Platform



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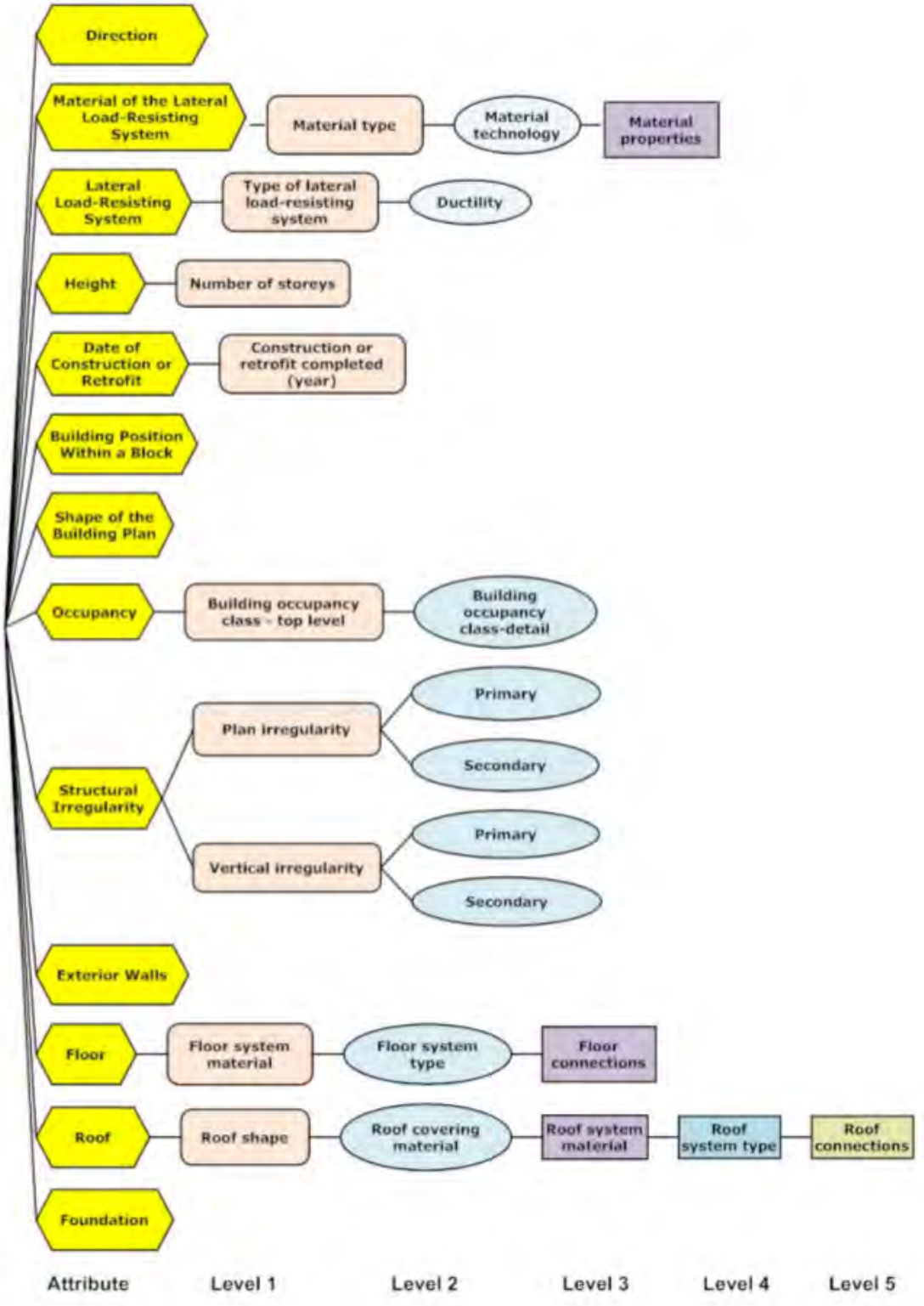
# The GEM Physical Taxonomy



# Taxonomy

- **Faceted taxonomy: GEM**

| ID | Level 1 (L1) | ID | Level 2 (L2) |
|---|---|---|---|
| | **Material type** | | **Material technology** |
| MAT99 | Unknown material | | |
| C99 | Concrete, unknown reinforcement | | |
| CU | Concrete, Unreinforced | | |
| CR | Concrete, Reinforced | | |
| | | CT99 | Unknown concrete technology |
| | | CIP | Cast-in-place concrete |
| | | PC | Precast concrete |
| | | CIPPS | Cast-in-place prestressed concrete |
| | | PCPS | Precast prestressed concrete |

Level 1 detail

Level 2 detail

An example of a **Level 1** detail (CR = concrete, reinforced) and a **Level 2** detail (e.g. CIP = cast-in-place concrete)

# Multiple Hazards Extension


**NOTE:** Experimental extension of REM taxonomy to floods is available

# Consequence Taxonomy

| $DI_{HRC}$ | HRC | HAZUS 1999 [17] | VISION 2000 [18] | FEMA 273 [19] | EMS98 [20] | MSK [2] | AIJ [5] | ATC-13 [7] | ATC-21 [21] | EPPO [22] |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | None | No damage limit state | | | | | | | | |
| 10 | Slight | Slight damage | Fully operational | Immediate occupancy | Grade 1 | D1 | Light | Slight | Gre Tag | |
| 20 | Light | | | | | | | Light | | |
| 30 | | | Operational | | Grade 2 | D2 | Minor | | | |
| 40 | | | | Damage control | | | | Moderate | | |
| 50 | Moderate | Moderate damage | | | Grade 3 | D3 | | | Yellow Tag | Yellow Tag |
| 60 | | | Life safe | Life safe | | | Moderate | | | |
| 70 | | | | | | | | Heavy | | |
| 80 | Extensive | Extensive damage | Near collapse | Limited safety | Grade 4 | D4 | Major | | | |
| 90 | | | | Collapse prevention | | | | Major | Red Tag | Red Tag |
| 100 | Partial Collapse | | Collapse | | | | Partial collapse | | | |
| | Collapse | Collapse limit state | | | | | | | | |

To be discussed

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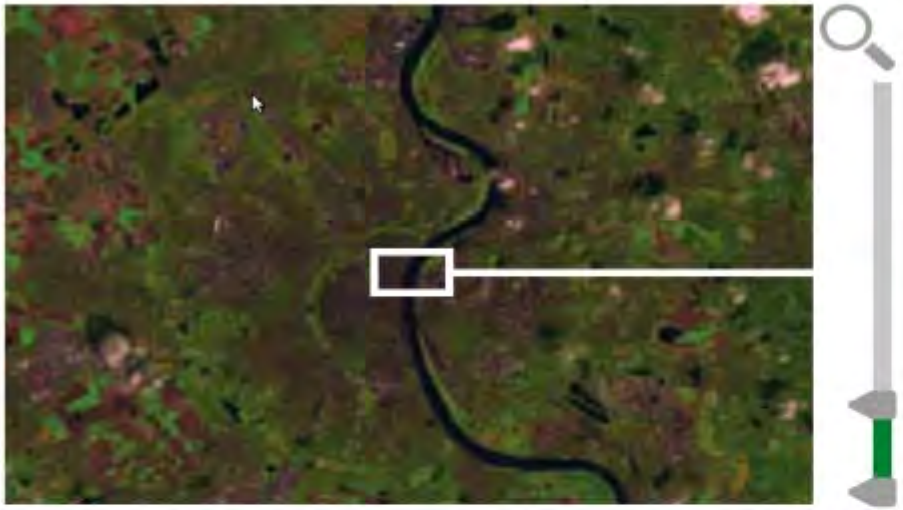
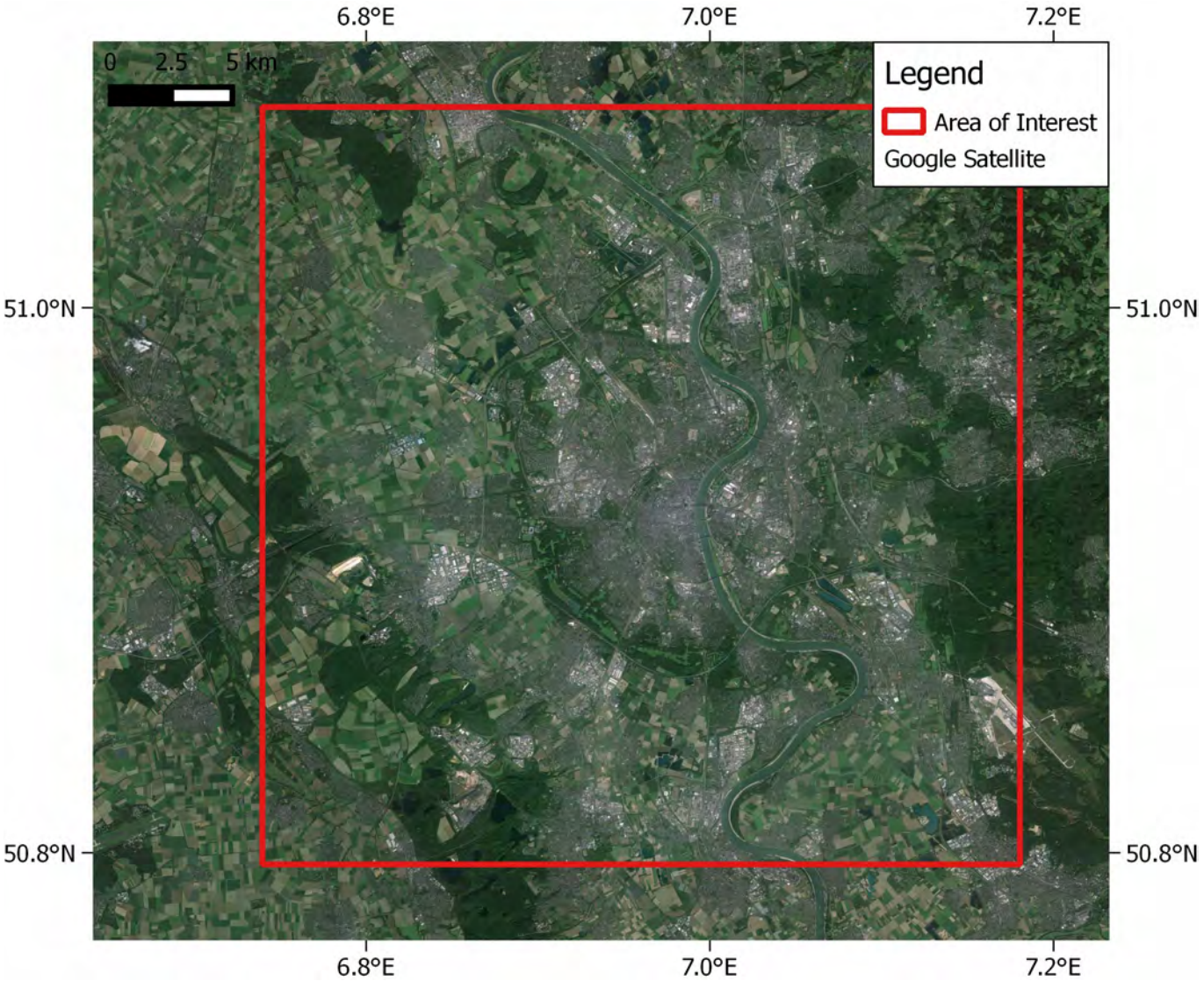
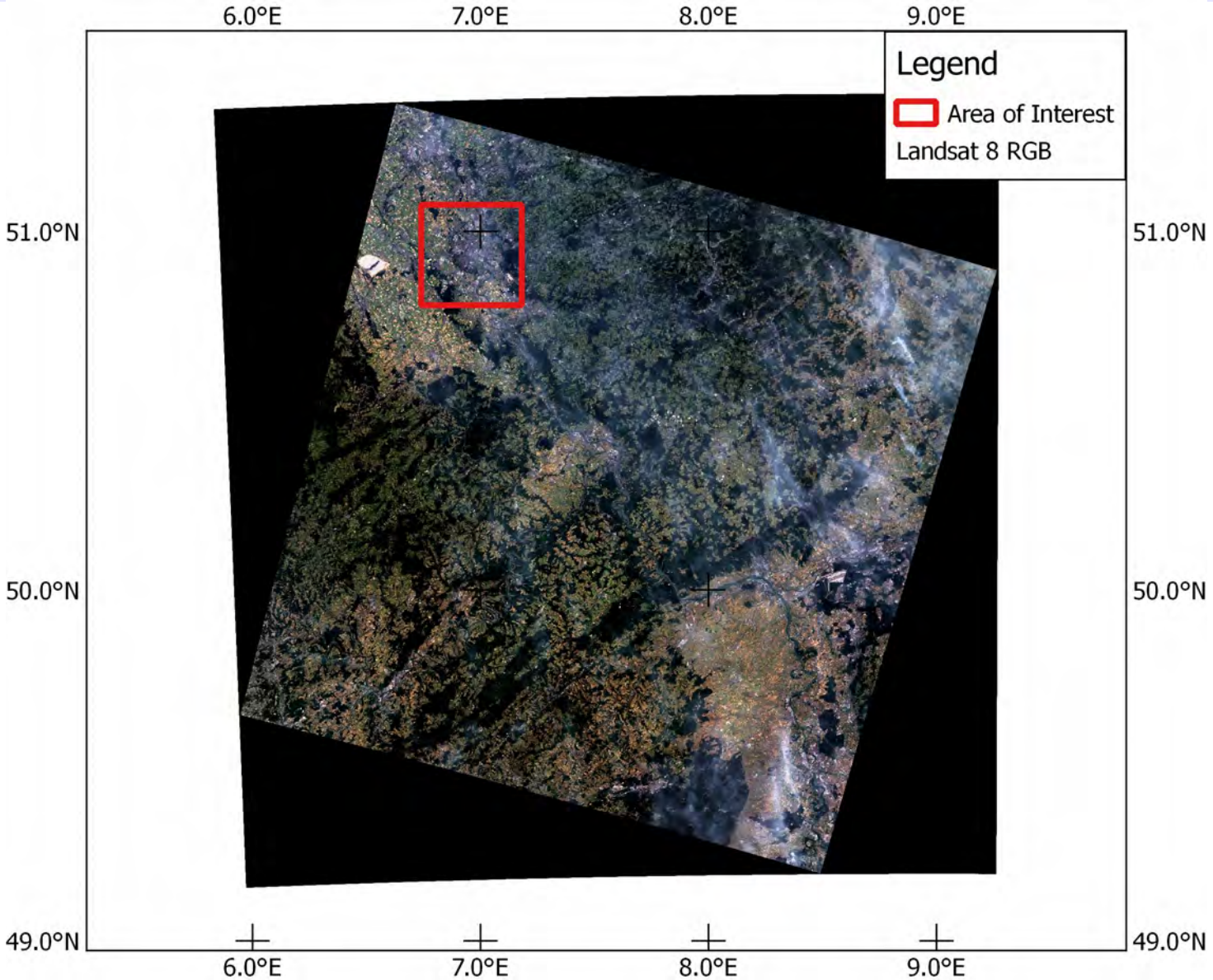
# Multi-spectral stratification



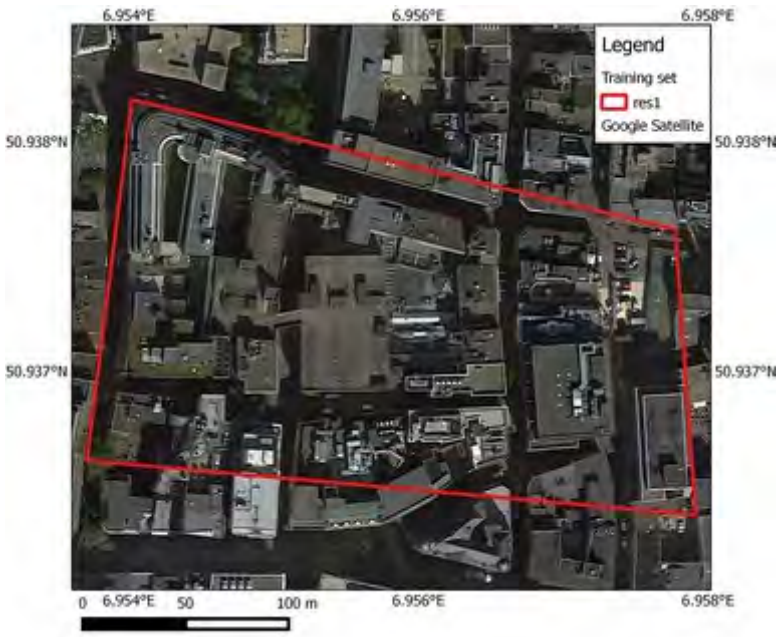
# Multi-spectral stratification: SATEX-plugin



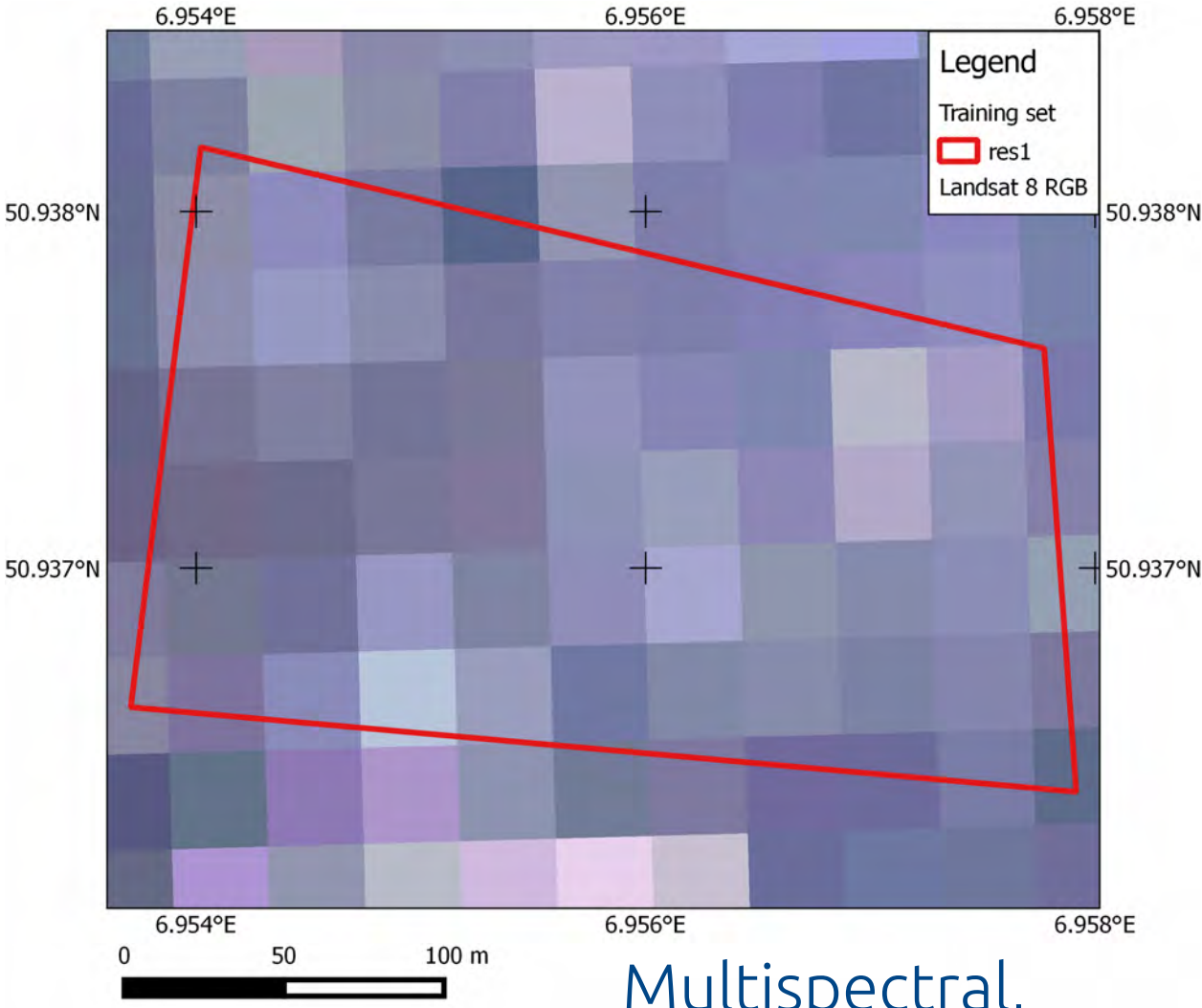
# Multi-spectral stratification



# Multi-spectral stratification




Optical, Very High resolution



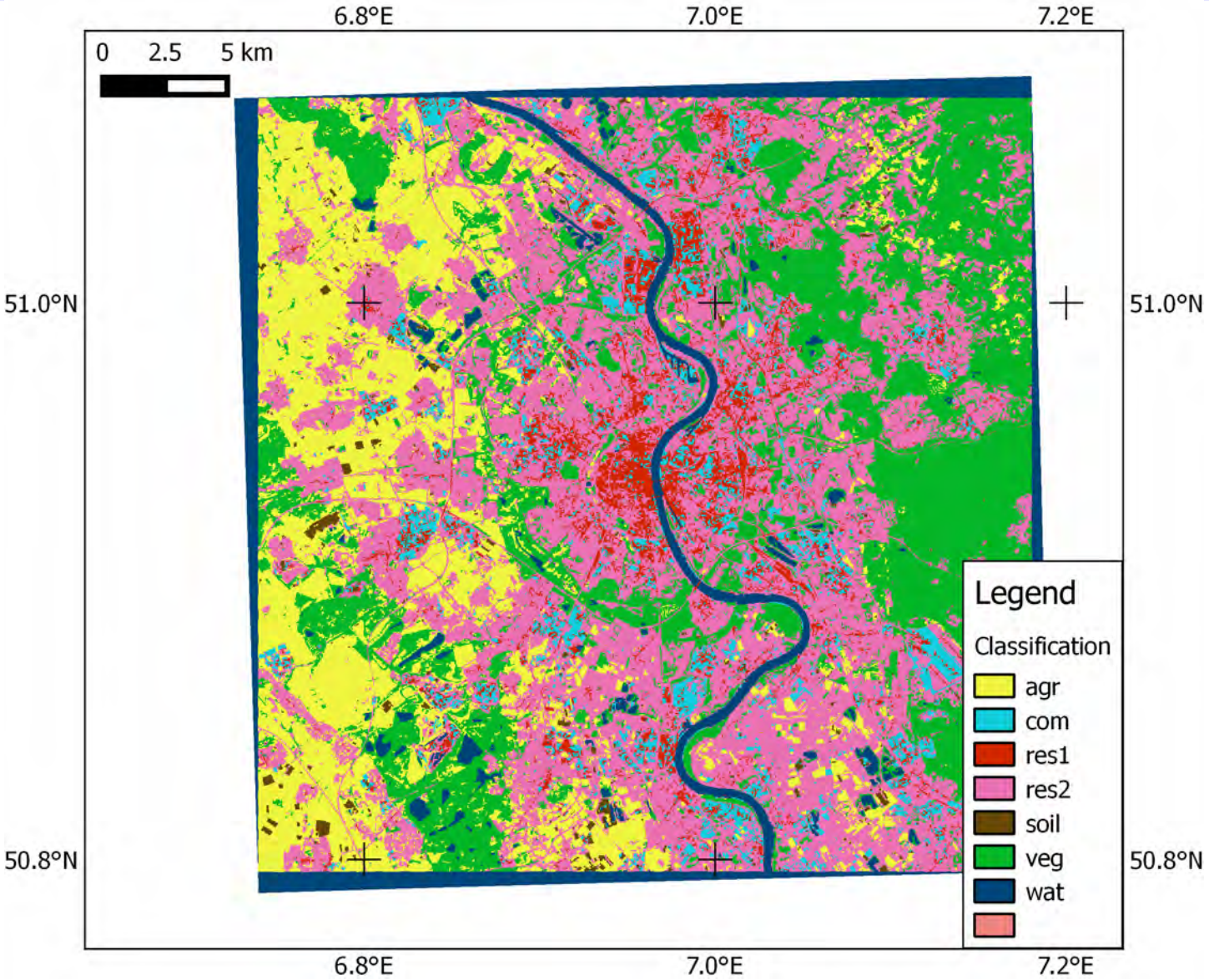

Multispectral, medium-resolution

Res1 – high density

# Multi-spectral stratification

## Supervised Classification

(Support Vector Machines)



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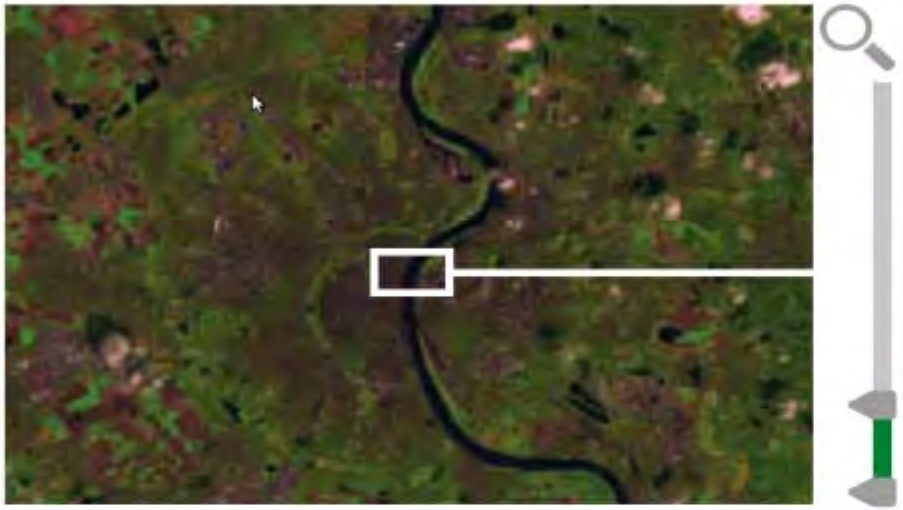
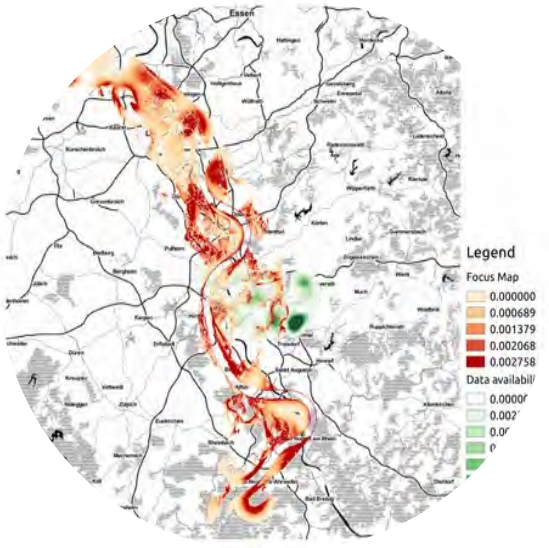
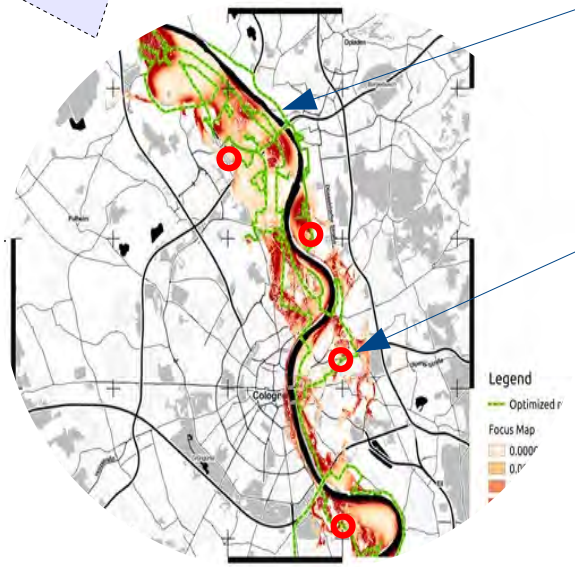
# In-situ survey planning



# In-situ survey planning




Extent and quality of available information are Combined with application priorities and constraints (also based on end-user consultation) to plan the Optimal arrangement of sampling points and the path for RRVS and field measurements

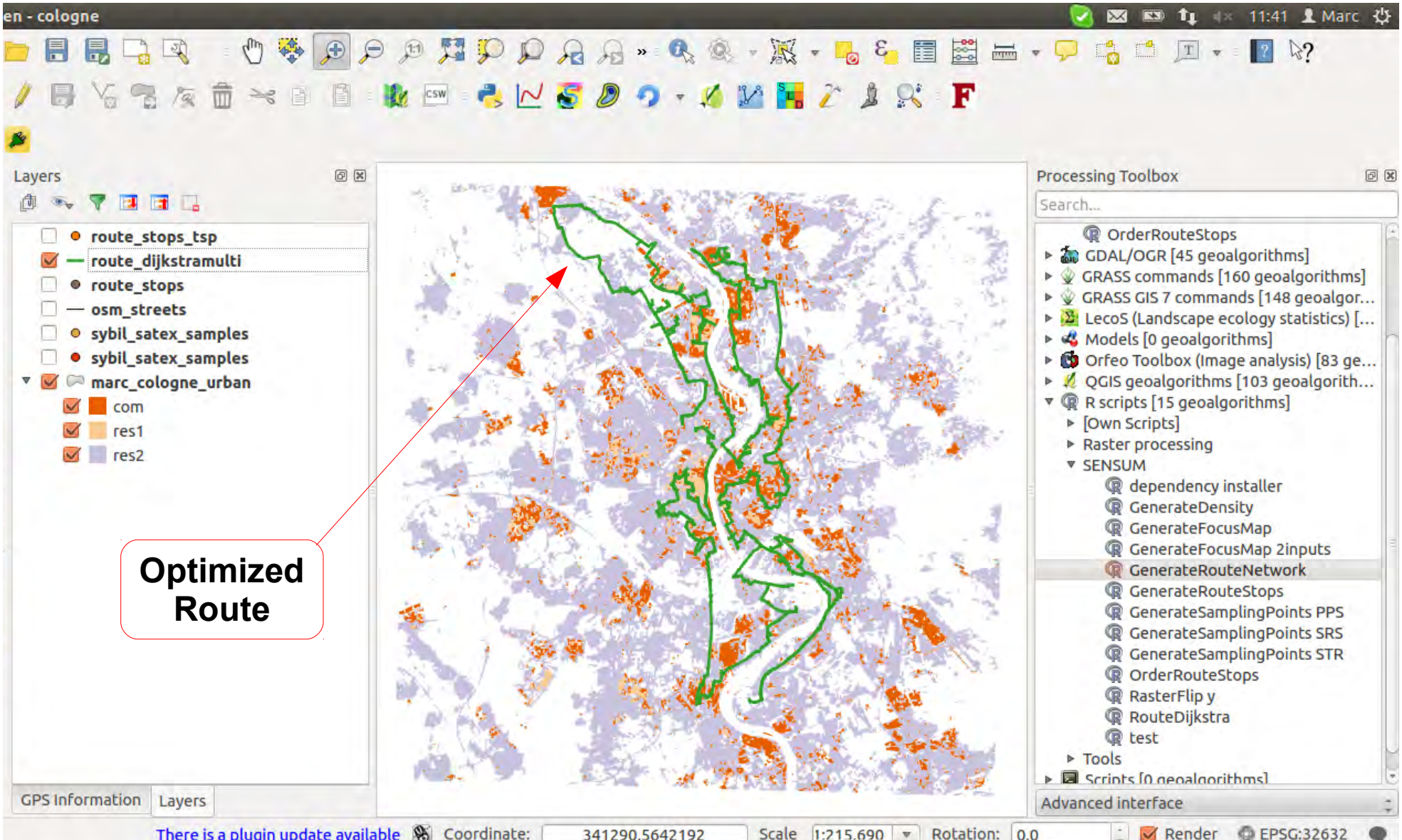



Route for mobile Mapping activity

Array locations for site-effect assessment

Planning and screening Procedures can be iterated for Incremental refinement of the Exposure / vulnerability model

# Sampling and Routing - III



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# MOMA – Mobile Mapping

# MOMA – Mobile Mapping

Omnidirectional Camera

Battery

Acquisition unit

Navigation system

MOMA mounted On a car

# MOMA – Mobile Mapping

**Omnidirectional (radial or equirectangular) Projection**



**Perspective (central) Projection**

# RRVS Remote Rapid Visual Survey

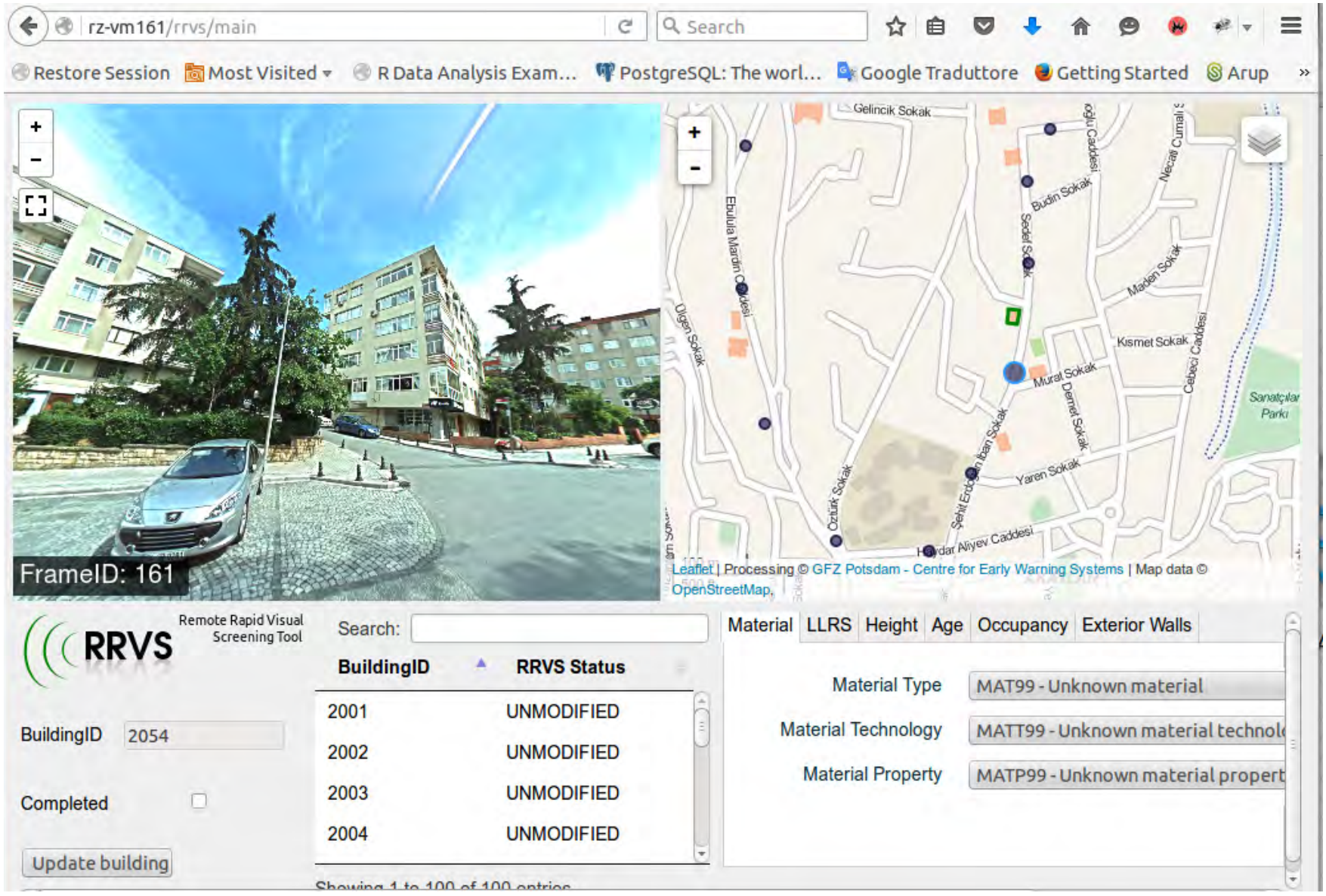
## Preliminary screening

**Remote Inspection**

## Selected direct screening

**Direct Inspection**

# RRVS Remote Rapid Visual Survey

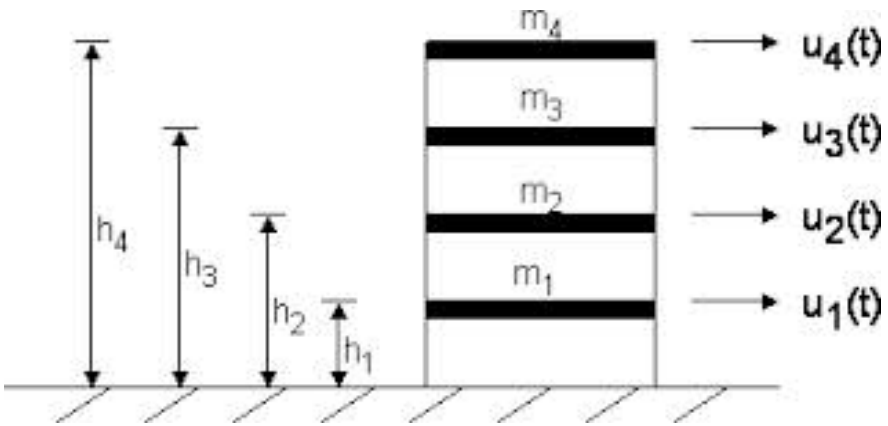


# *In-situ* vulnerability characterization

in-situ data collection about the structure, geometry, materials, soil and environment using Non-Destructive Testing (NDT), dynamic measurement techniques and a topological engineering model for vulnerability assessment

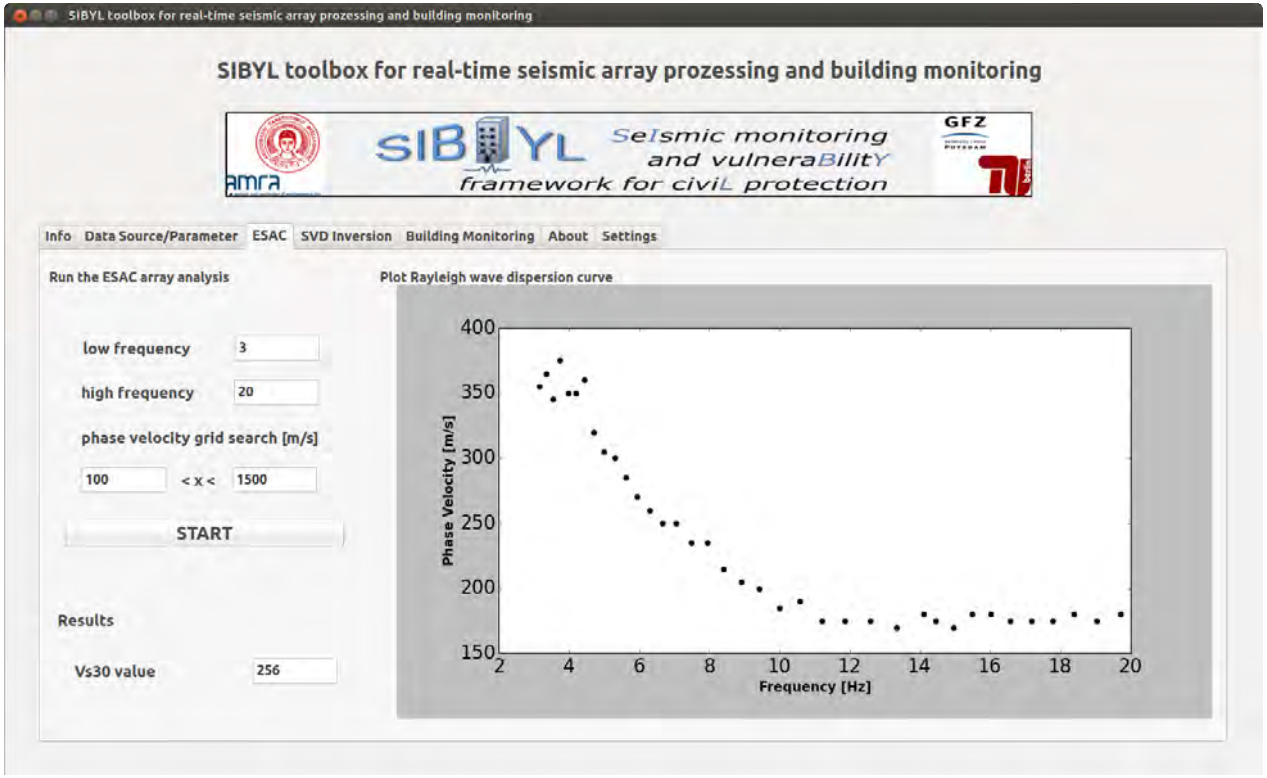
Connect to: **TASK C**
low cost in-situ building vulnerability assessment

**Deliverable DC1** (M18, TU-BERLIN):
Guidelines for the building assessment procedure and short-term monitoring

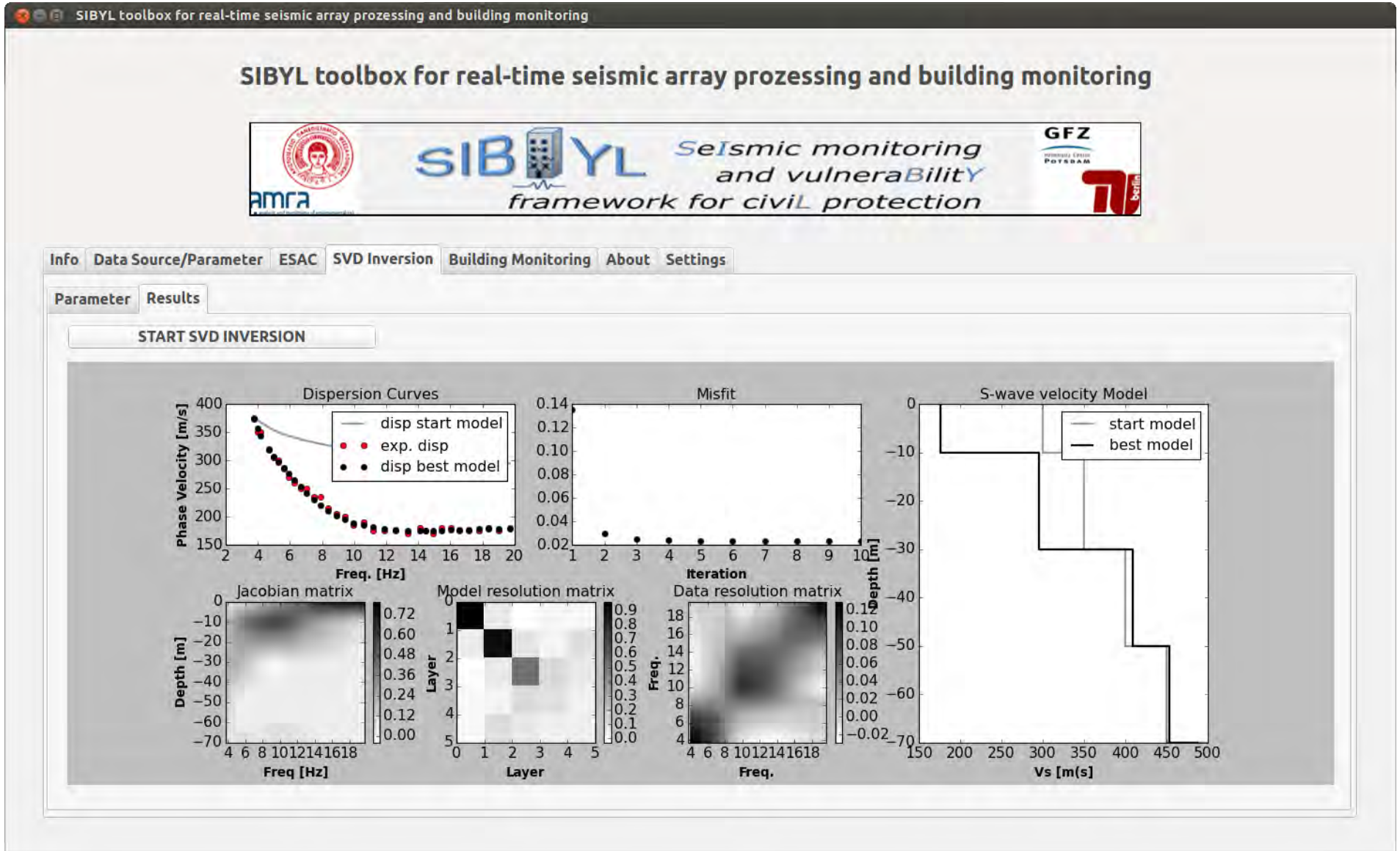



# Deployment of monitoring devices

Deployment of MP-Wise mesh network
For rapid assessment of local amplification effects

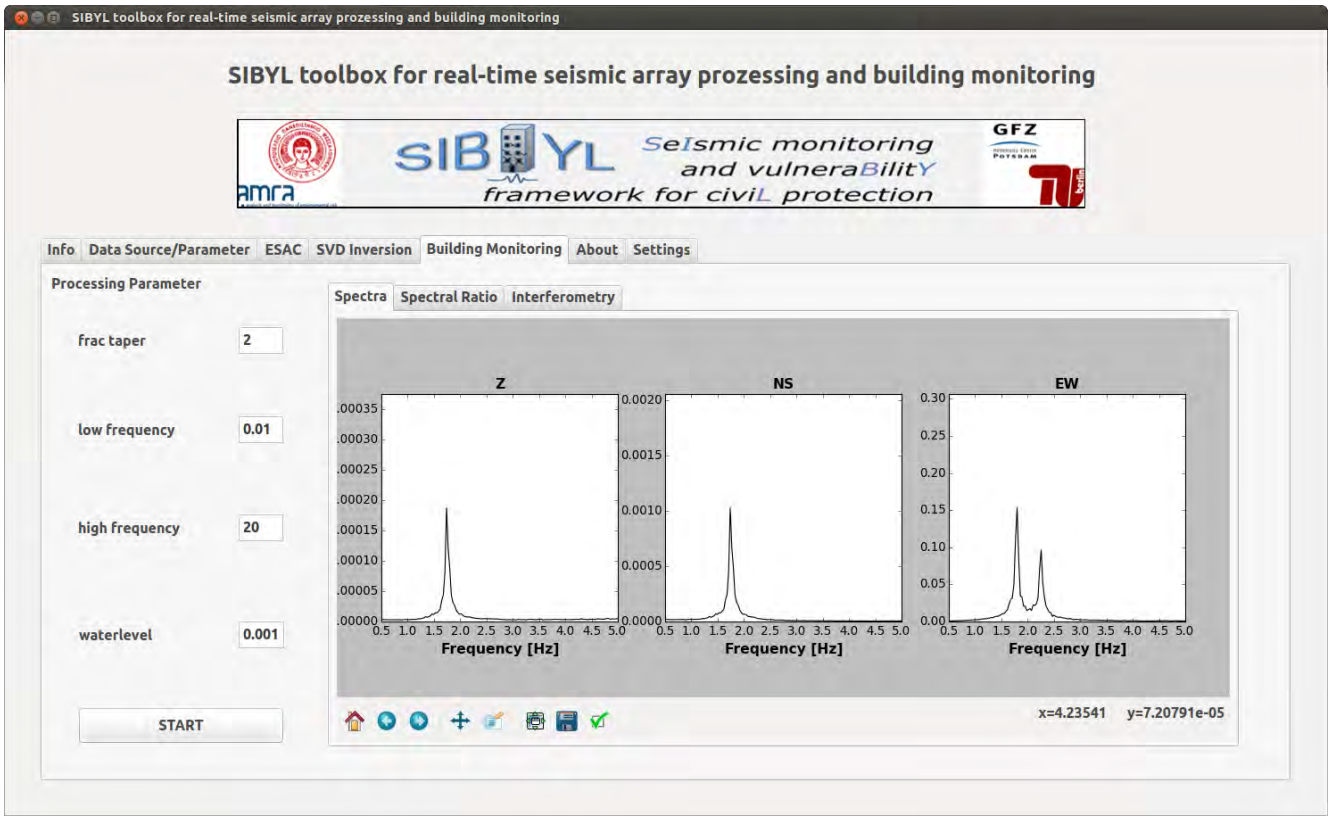



# Deployment of monitoring devices

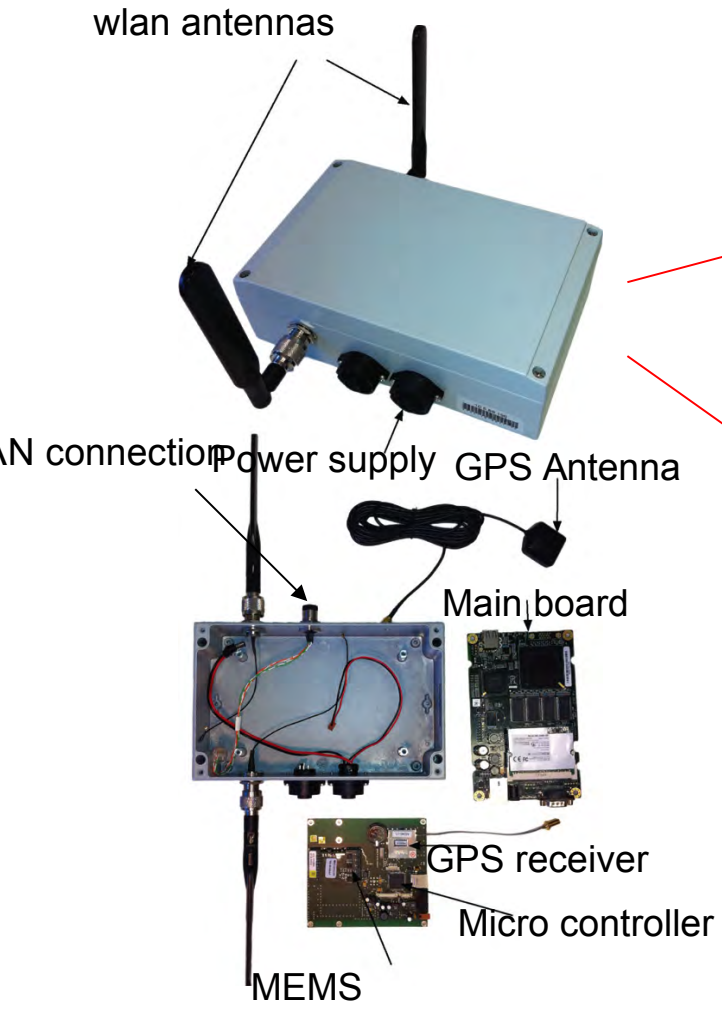


# Deployment of monitoring devices

Installation of GFZ-wise monitoring network
In the selected structures, based on preliminary exposure/vulnerability model and considering end-user priorities and requirements

# SOSEWIN - node

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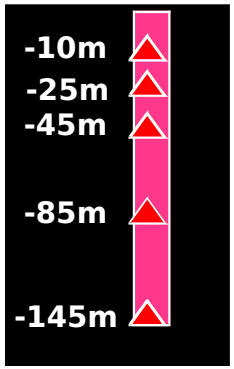
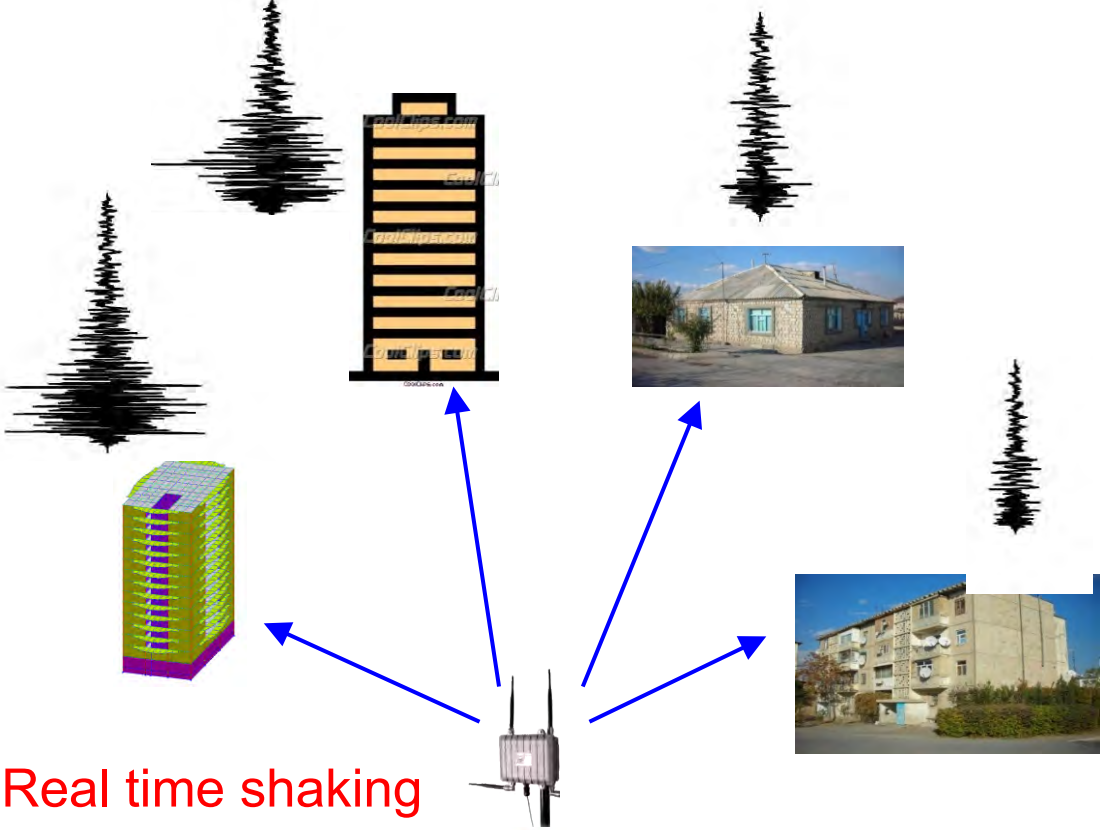



## Early warning

Shaking+damage **Forecasted on the node!**



## Real time shaking forecast

**Real time damage detection**

**Aftershock hazard**: take actions independent from models of aftershock rate

**Cumulated damage effect**: from building monitoring to incremental damage assessment, to updated vulnerability models

## Aftershock sequence

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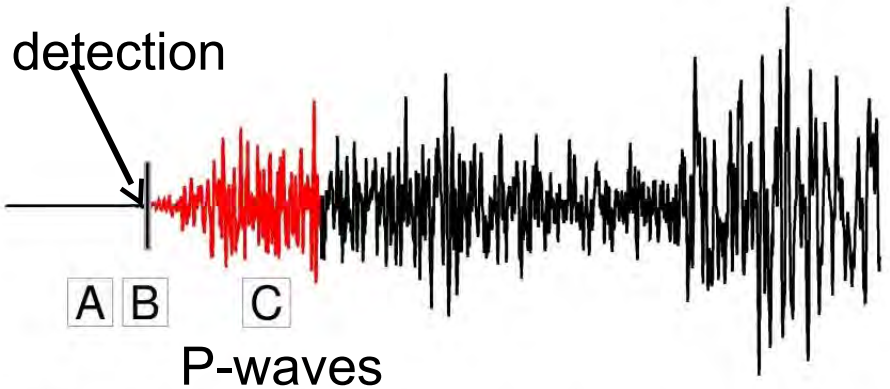
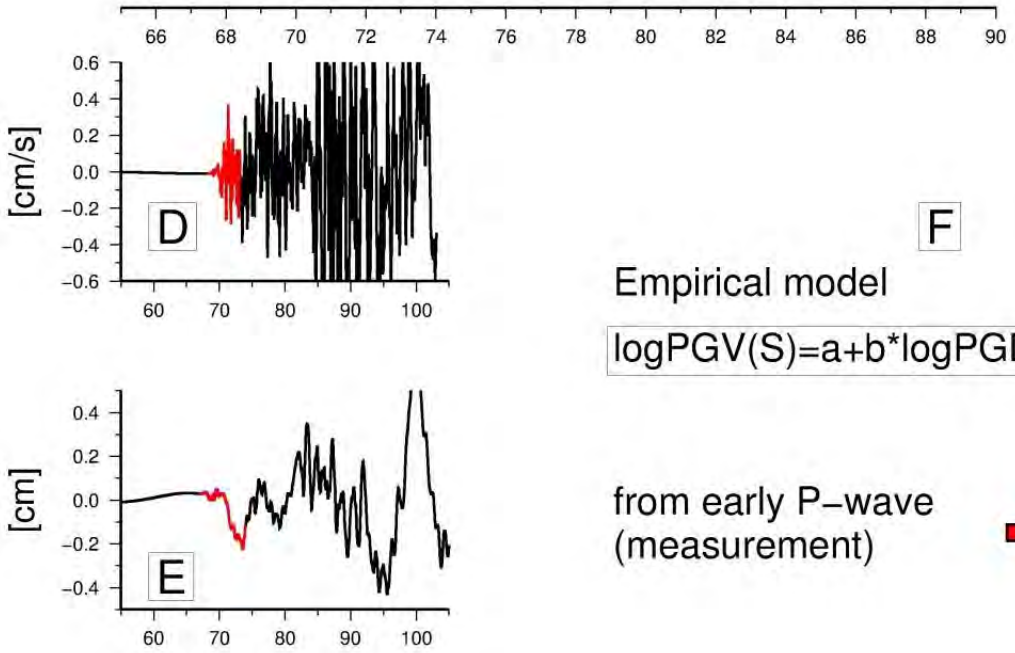
Real-time acceleration

Event detection




P-waves

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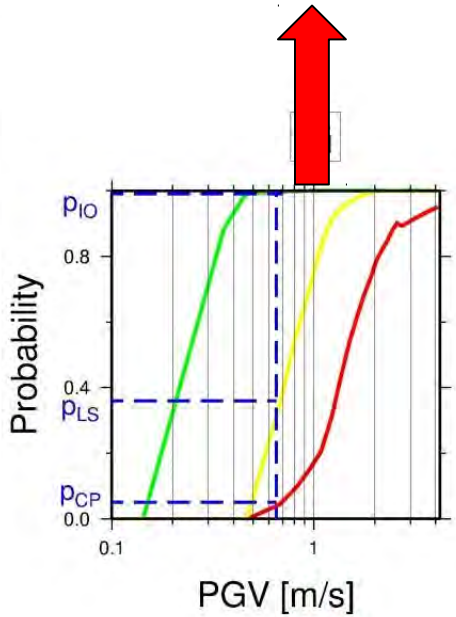
Empirical model

logPGV(S)=a+b*logPGD(P)

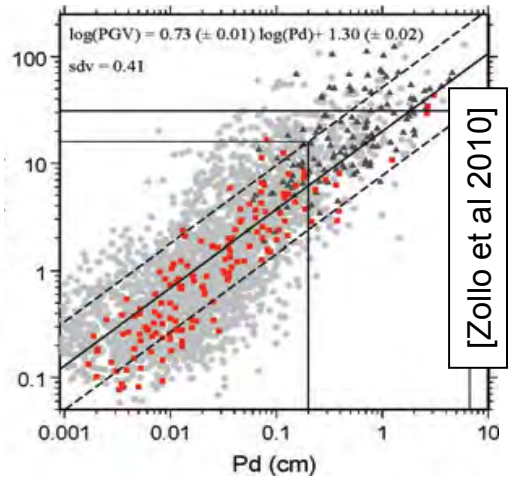
from early P–wave (measurement)

to S–wave (prediction)

Alert protocols based on PGV thresholds & expected damage levels [ movie]




Alert protocols based on PGV thresholds




Peak Displacement over 3s P-wave

# Outlook and Conclusions

- Software can be cloned from GFZ git-hub repository:

- REM-DB-schema: github.com/GFZ-Centre-for-Early-Warning/REM_DBschema
- REM-SATEX: github.com/GFZ-Centre-for-Early-Warning/REM_satex_plugin
- REM-routing: github.com/GFZ-Centre-for-Early-Warning/REM_optimized_routing
- REM-RRVS: github.com/GFZ-Centre-for-Early-Warning/REM_RRVS

- Current license: BSD3 (to be discussed)

- Participation to development is welcome !

# Outlook and Conclusions

- REM provides a useful, efficient platform for information collection, integration and analysis
- The use of modular, extensible taxonomy is geared towards multi-hazard, systemic assessment
- Mobile mapping as part of a multi-stage environmental analysis, to be integrated with direct visual screening and in-depth in-situ analysis
- **Next**: incremental exposure (and vulnerability) modelling
- **Next**: integration with real-time structural monitoring