GFZ Helmholtz-Zentrum Potsdam

HELMHOLTZ ASSOCIATION

SIBYL

# Component B

# Rapid data collection and integration

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# Data collection overview

Information already available or promptly provided by authorities

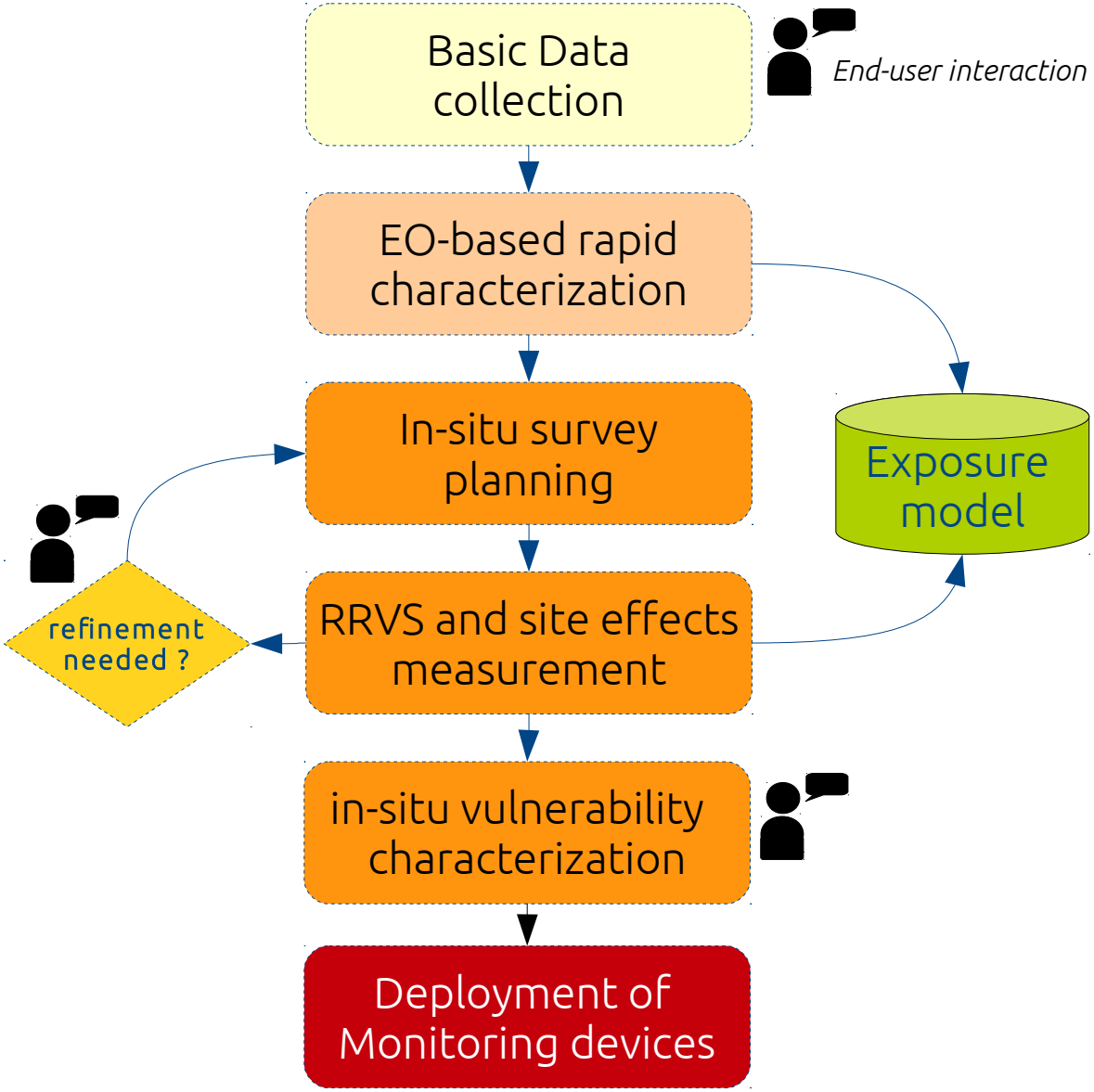
Rapid characterization by medium-res satellite imagery

Optimization based on information distribution and end-user constraint

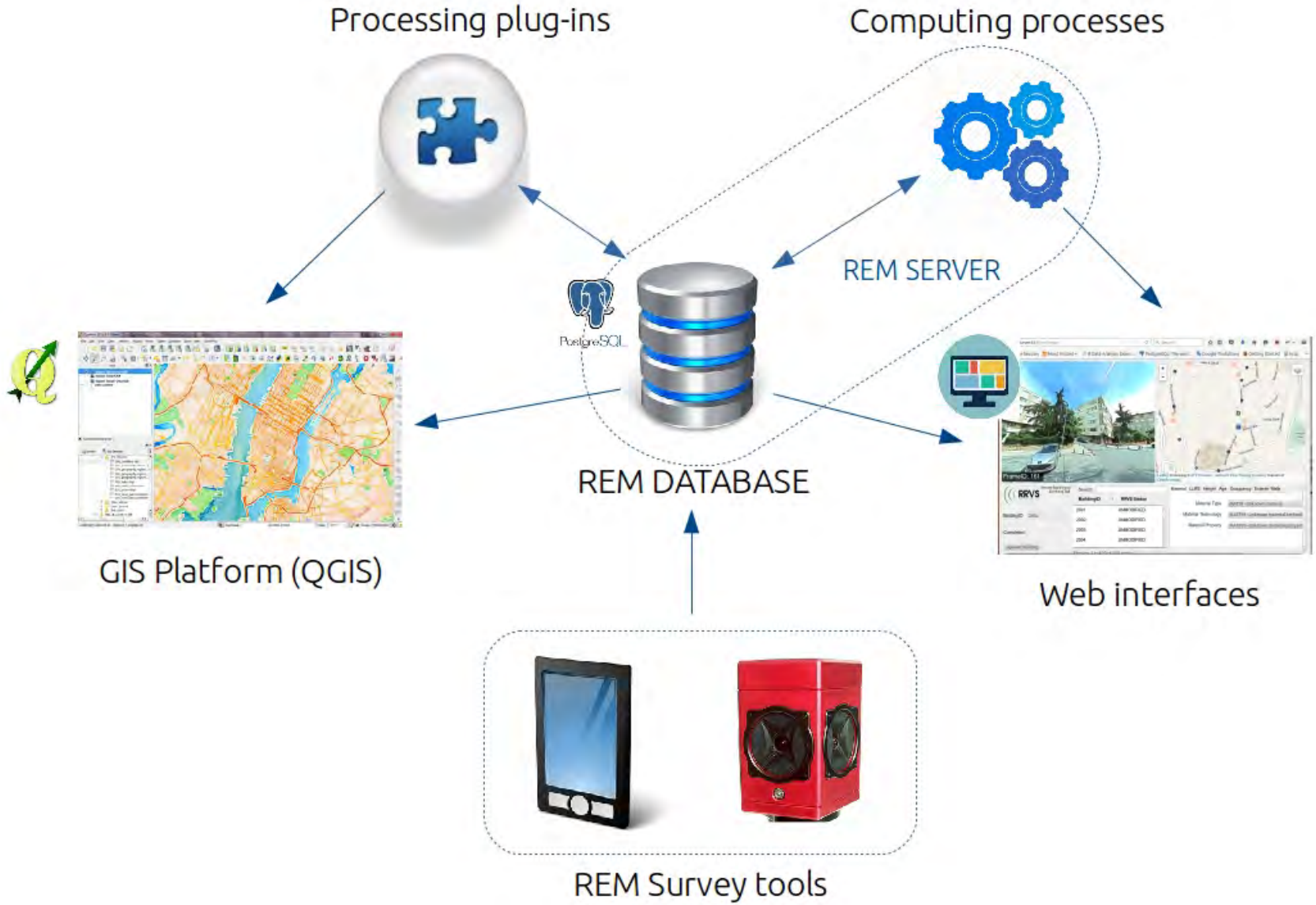
Rapid remote visual screening and first assessment of site effects

selection of representative structures and In-situ structural characterization

Deployment of sensor network and start of real-time monitoring

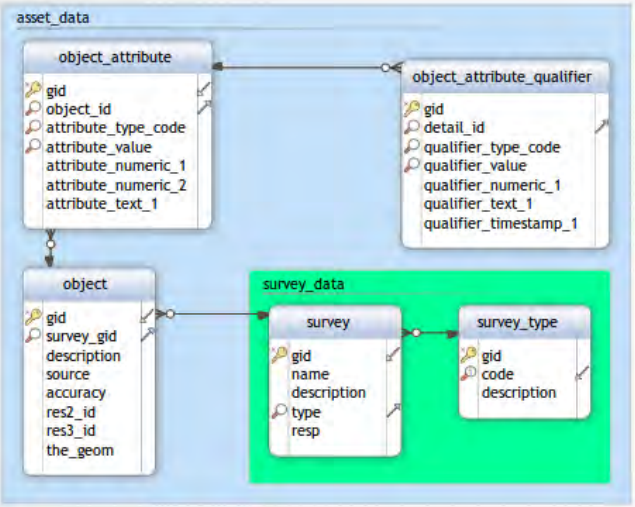


# The REM Platform

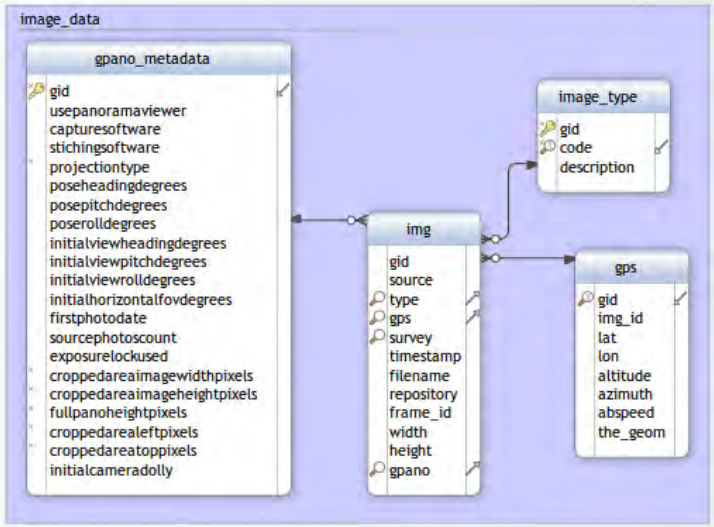


# REM Database Schema

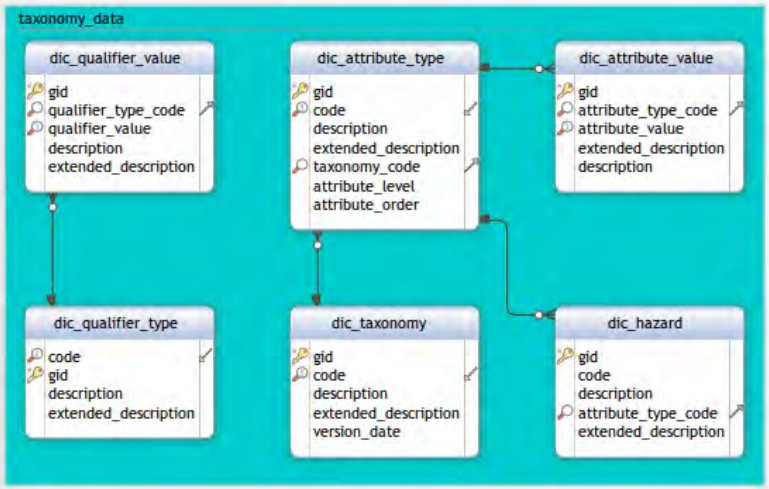
Assets




Images



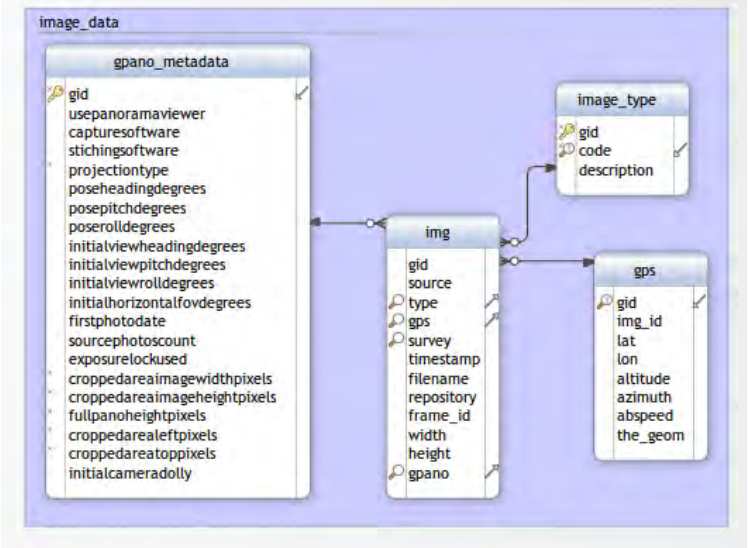

Taxonomy




...

Measurements etc.

# REM Database Schema



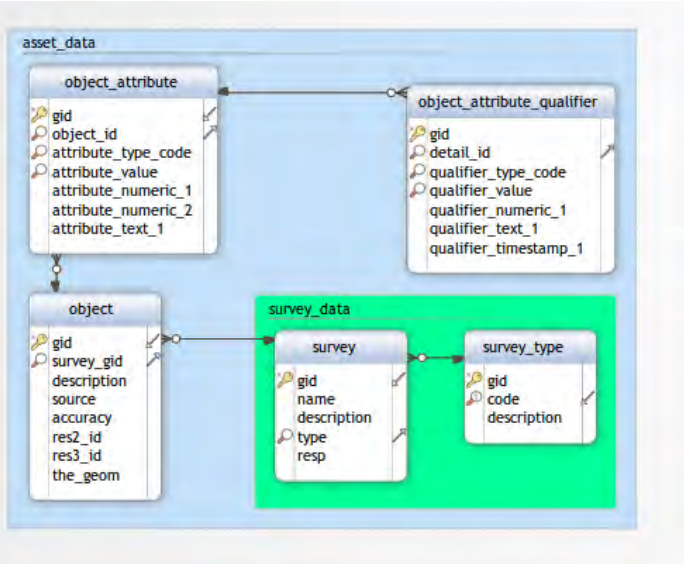

Images

Standard
Panoramic
Omnidirectional

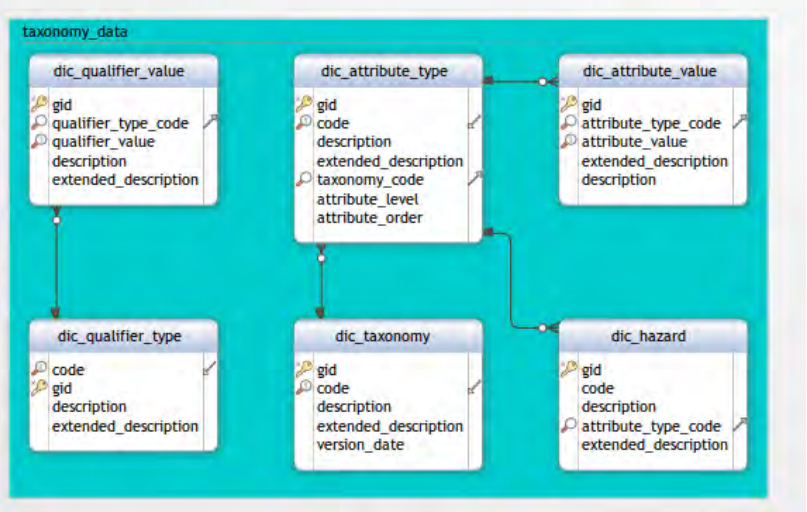
Pre-event / post-event

# REM Database Schema

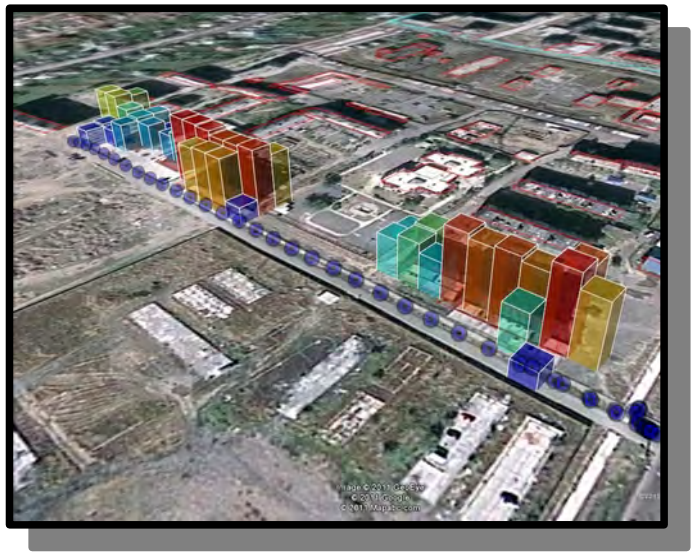
Assets



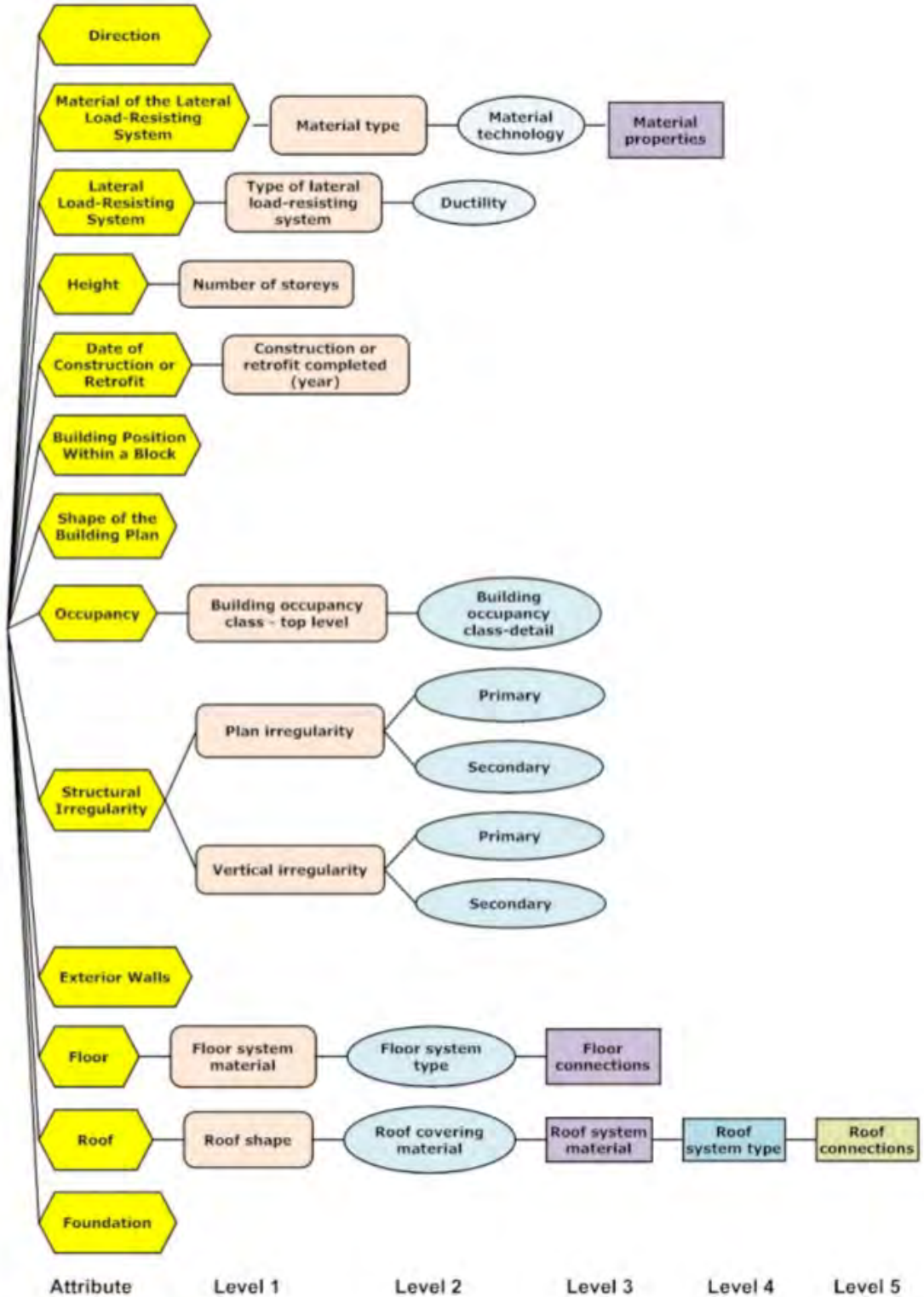

Taxonomy




Objects+
Attributes+
qualifiers



# 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

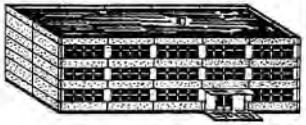
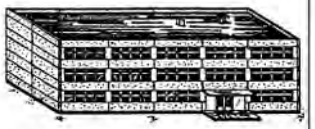
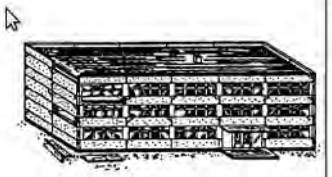
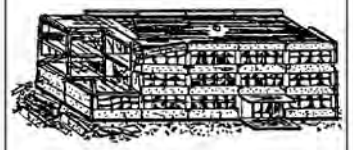
| $DI_{HRC}$ | HRC | HAZUS 1999 [17] | VISION 2000 [18] | FEMA 273 [19] | EMS98 [20] | MSK [2] | AIJ [5] | ATC-13 [7] | ATC-21 [21] | EPPO [22] |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | None | No damage limit state | | | | | | | | |
| 10 | Slight | Slight damage | Fully operational | Immediate occupancy | Grade 1 | D1 | Light | Slight | Green 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 | | | | |
| 90 | | | | Collapse prevention | | | Major | Major | Red Tag | Red Tag |
| 100 | Partial Collapse | | Collapse | | | | Partial collapse | | | |
| | Collapse | Collapse limit state | | | | | | | | |

To be discussed

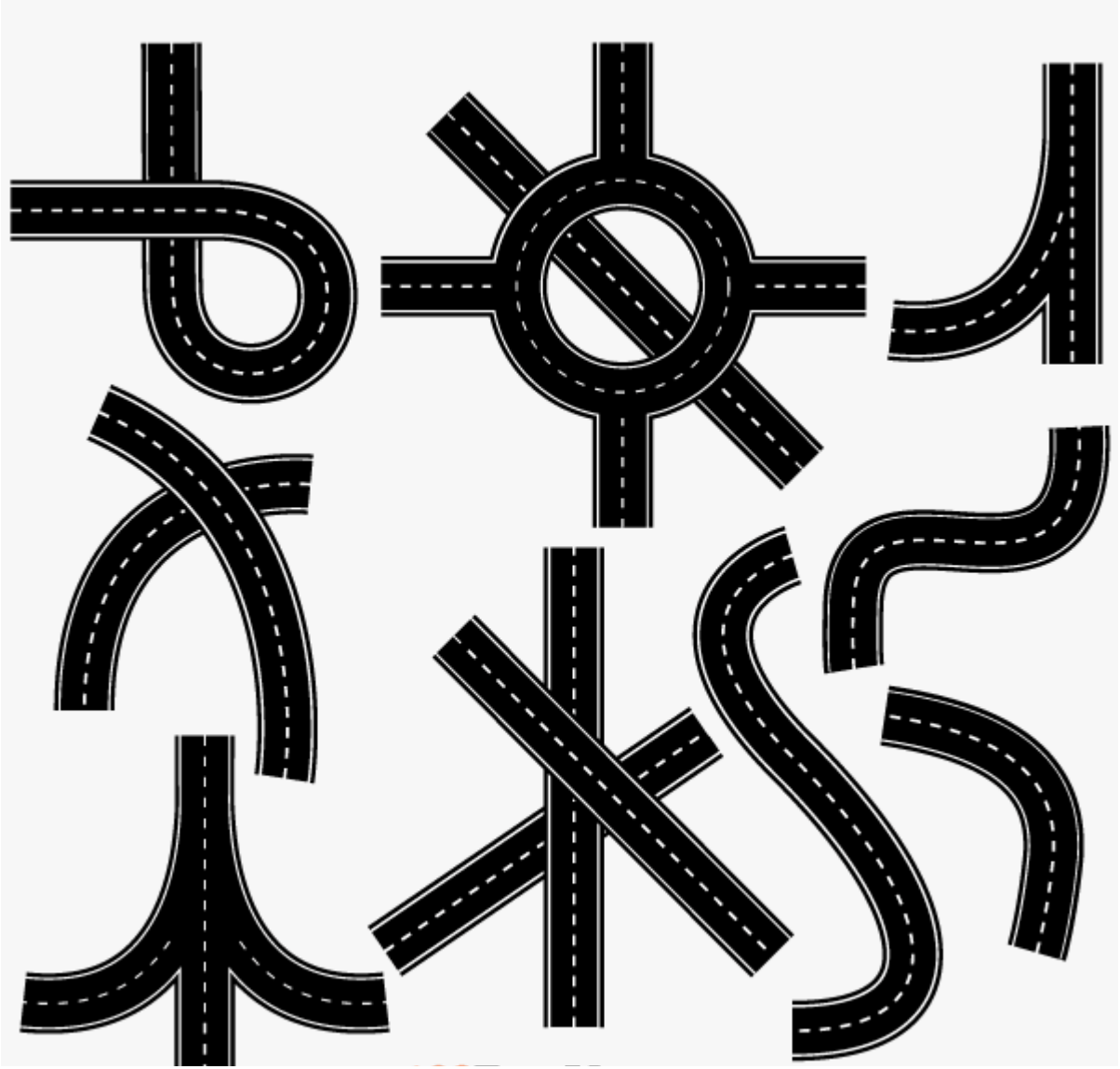
# Consequence Taxonomy

| Classification of damage to masonry buildings | |
|---|---|
|  | **Grade 1: Negligible to slight damage (no structural damage, slight non-structural damage)**<br>Hair-line cracks in very few walls.<br>Fall of small pieces of plaster only.<br>Fall of loose stones from upper parts of buildings in very few cases. |
|  | **Grade 2: Moderate damage (slight structural damage, moderate non-structural damage)**<br>Cracks in many walls.<br>Fall of fairly large pieces of plaster.<br>Partial collaps of chimneys. |
|  | **Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage)**<br>Large and extensive cracks in most walls.<br>Roof tiles detach. Chimneys fracture at the roof line; failure of individual non-structural elements (partitions, gable walls). |
|  | **Grade 4: Very heavy damage (heavy structural damage, very heavy non-structural damage)**<br>Serious failure of walls; partial structural failure of roofs and floors. |
|  | **Grade 5: Destruction (very heavy structural damage)**<br>Total or near total collapse. |

EMS-98

| Classification of damage to buildings of reinforced concrete | |
|---|---|
|  | **Grade 1: Negligible to slight damage (no structural damage, slight non-structural damage)**<br>Fine cracks in plaster over frame members or in walls at the base.<br>Fine cracks in partitions and infills. |
|  | **Grade 2: Moderate damage (slight structural damage, moderate non-structural damage)**<br>Cracks in columns and beams of frames and in structural walls.<br>Cracks in partition and infill walls; fall of brittle cladding and plaster. Falling mortar from the joints of wall panels. |
|  | **Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage)**<br>Cracks in columns and beam column joints of frames at the base and at joints of coupled walls. Spalling of conrete cover, buckling of reinforced rods.<br>Large cracks in partition and infill walls, failure of individual infill panels. |
|  | **Grade 4: Very heavy damage (heavy structural damage, very heavy non-structural damage)**<br>Large cracks in structural elements with compression failure of concrete and fracture of rebars; bond failure of beam reinforced bars; tilting of columns.<br>Collapse of a few columns or of a single upper floor. |
|  | **Grade 5: Destruction (very heavy structural damage)**<br>Collapse of ground floor or parts (e. g. wings) of buildings. |

# Infrastructure Taxonomy



Syner-G

Hazus

...

To be discussed

# Example: Emergency Limit Condition (CLE)

Critical buildings

Emergency Areas (concentration)

Emergency Areas (recovery)

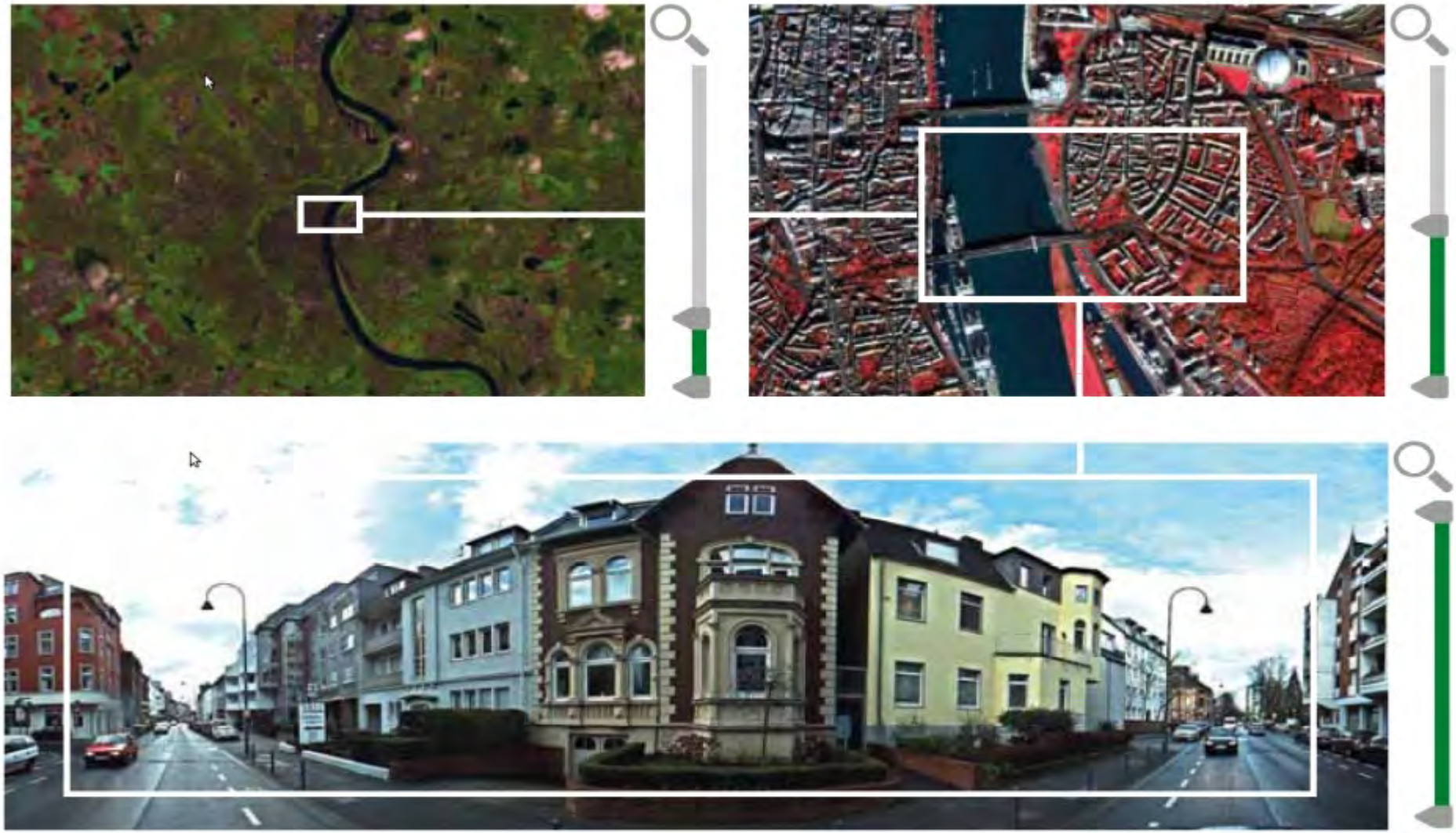
Link infrastructure

Access infrastructure

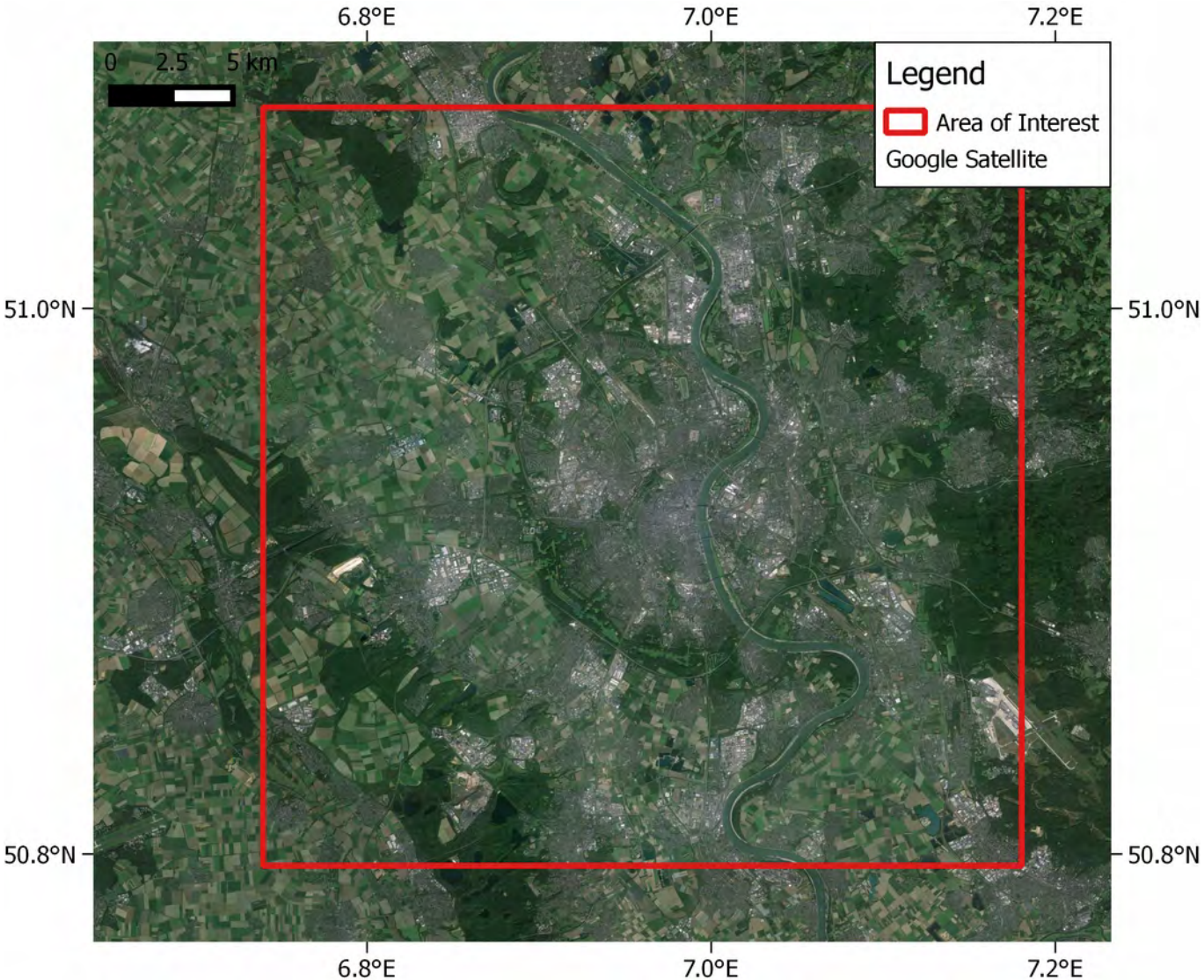
**Possibly Redundant !**

Source: *Italian Civil Protection Dept.*

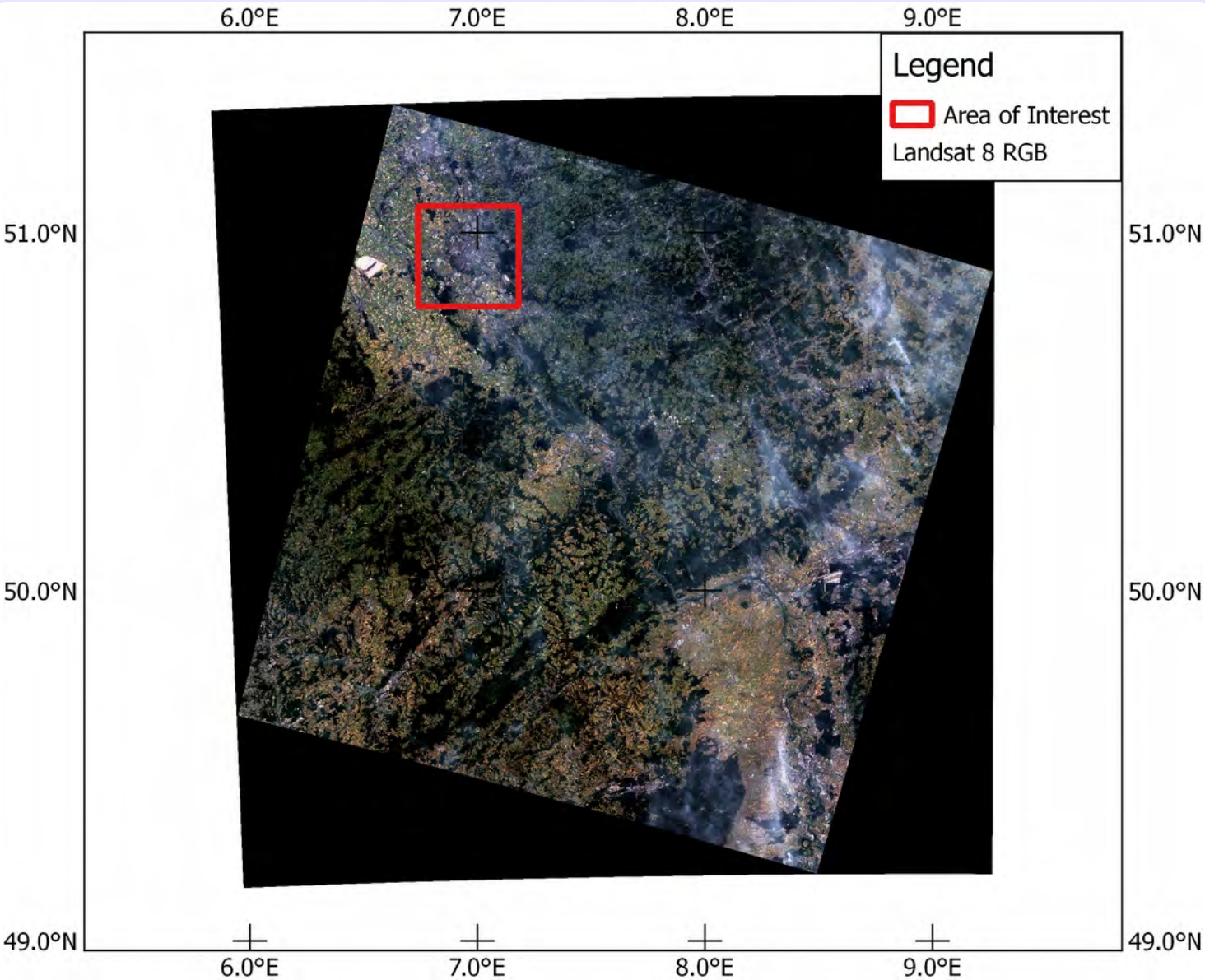
# Multi-spectral stratification



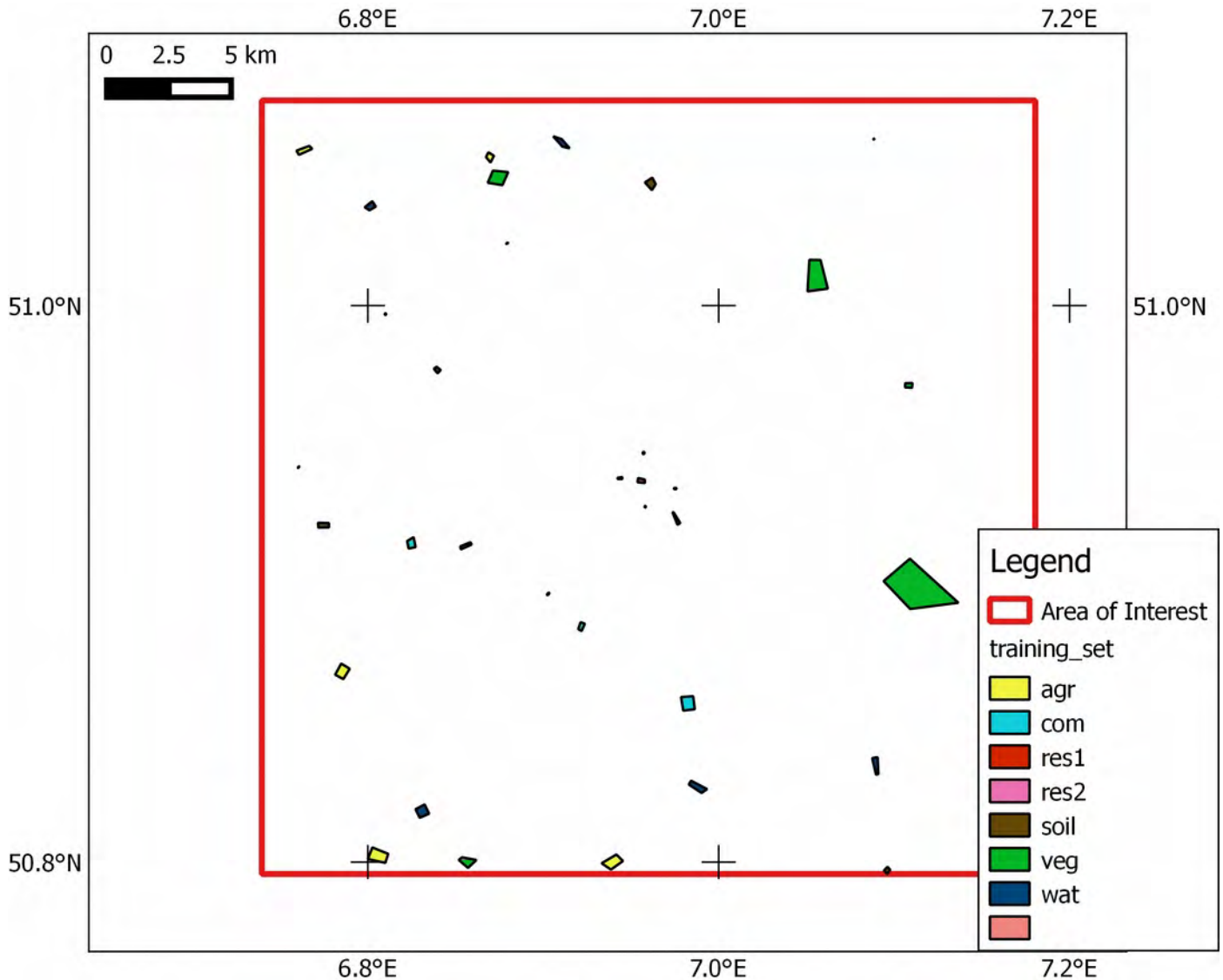
# Multi-spectral stratification: SATEX-plugin



# Multi-spectral stratification



# Multi-spectral stratification

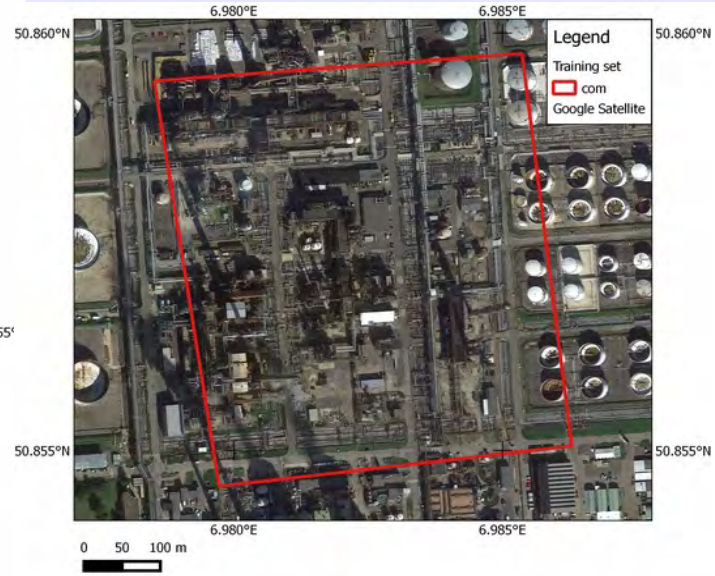



Training

7 classes
5 ex/class

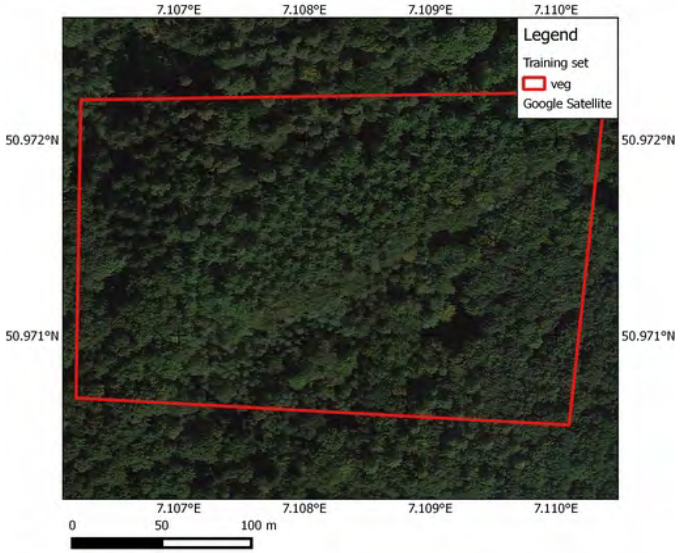
# Multi-spectral stratification

Soil


Commercial
Industrial

Vegetation

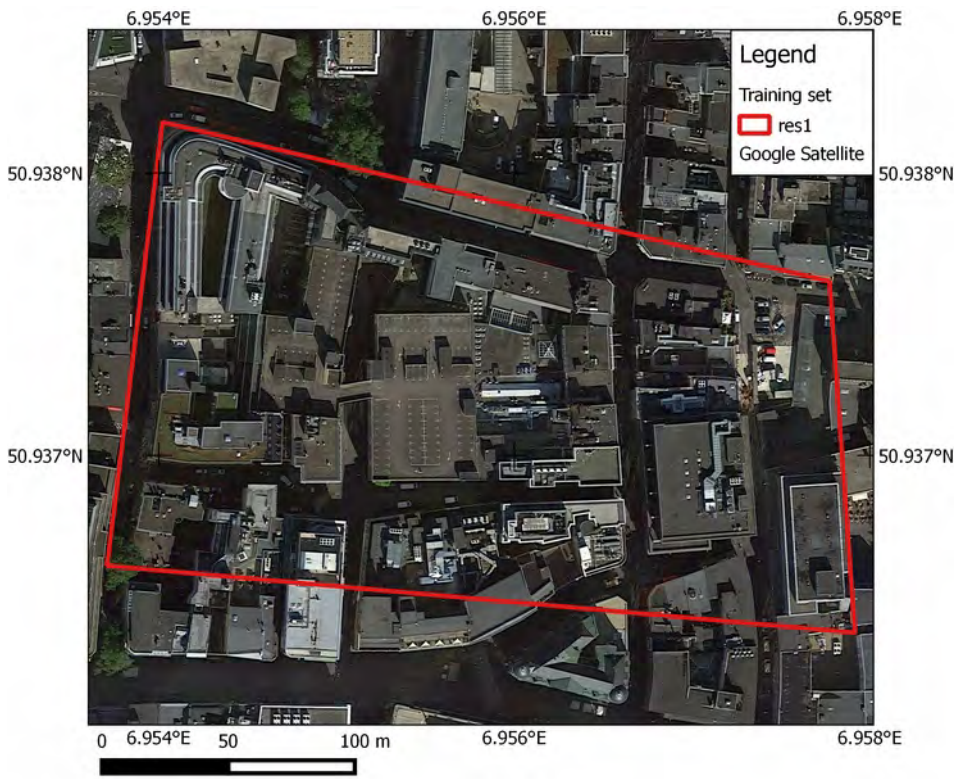


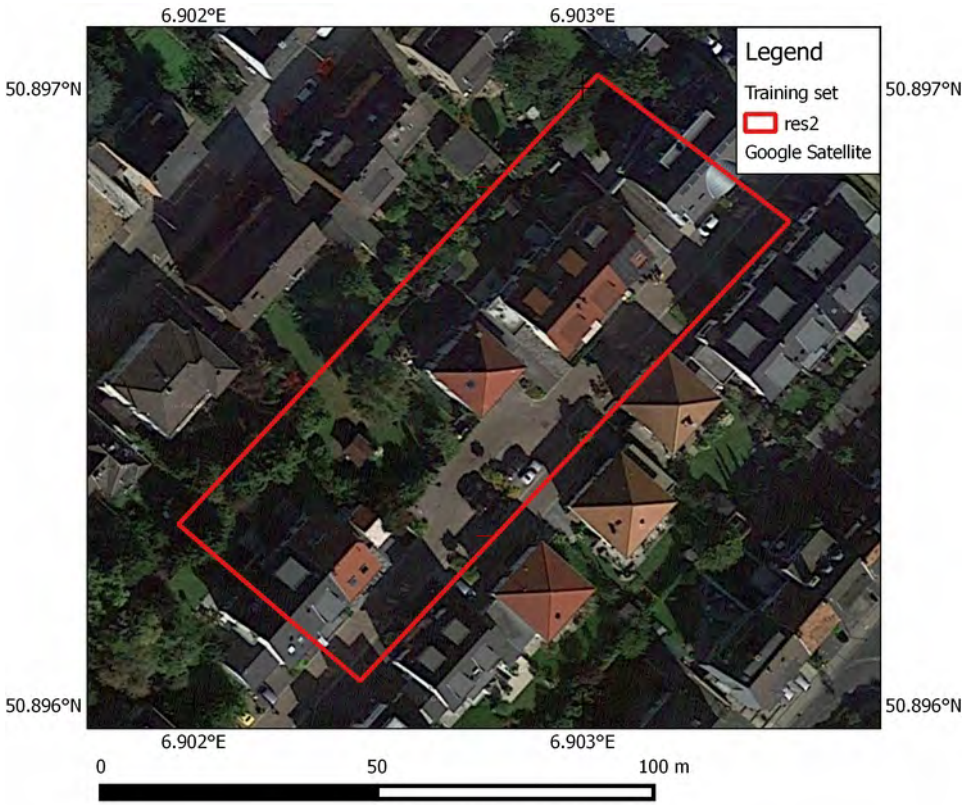


Water

Optical, Very High resolution (Google Maps)

# Multi-spectral stratification



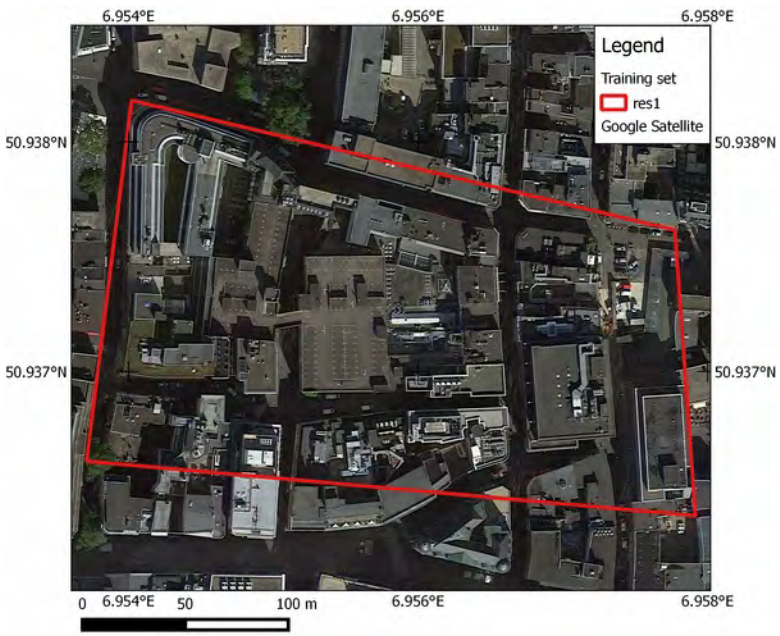




Res1 – high density

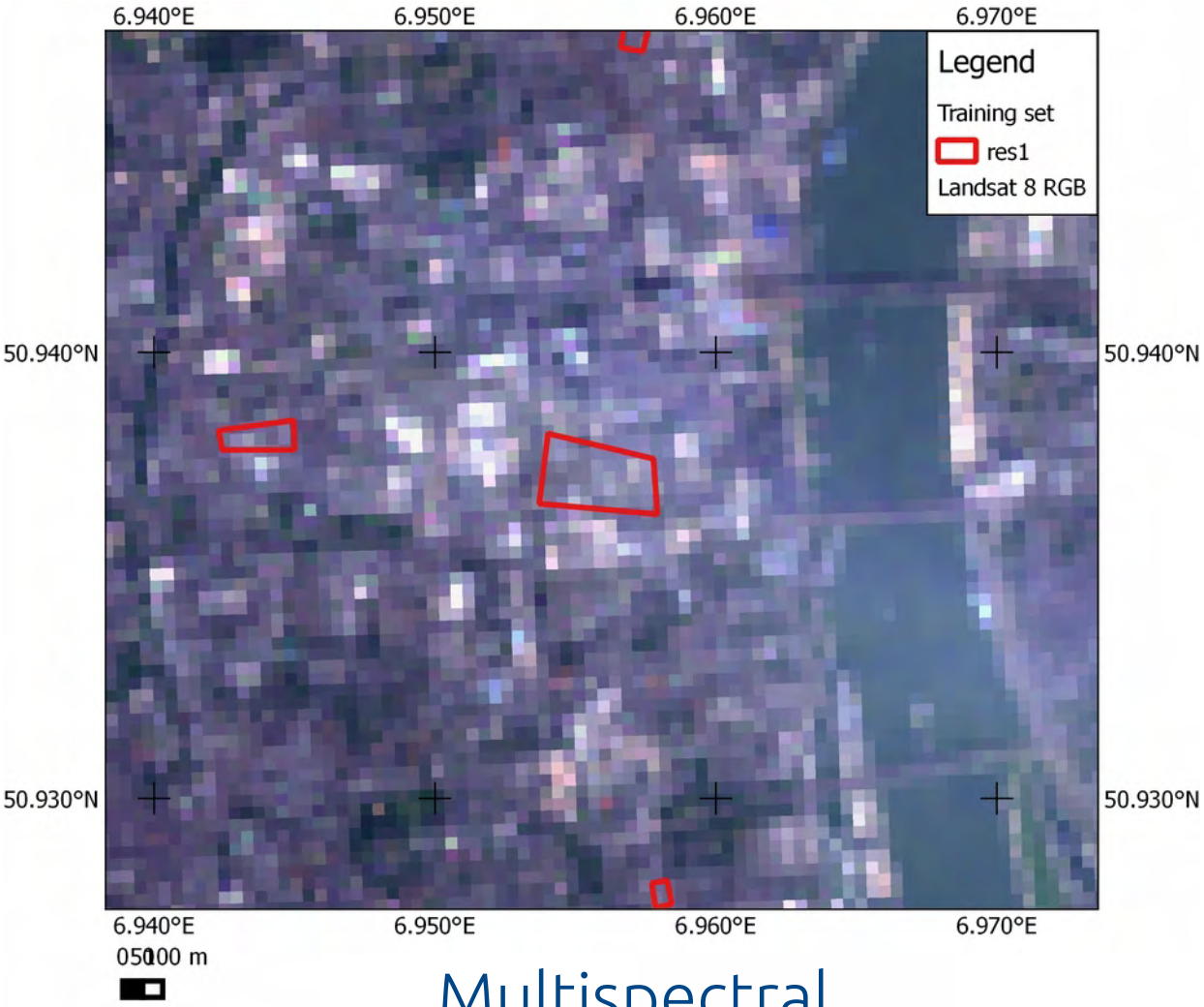
Res1 – low density

Optical, Very High resolution (Google Maps)

# Multi-spectral stratification



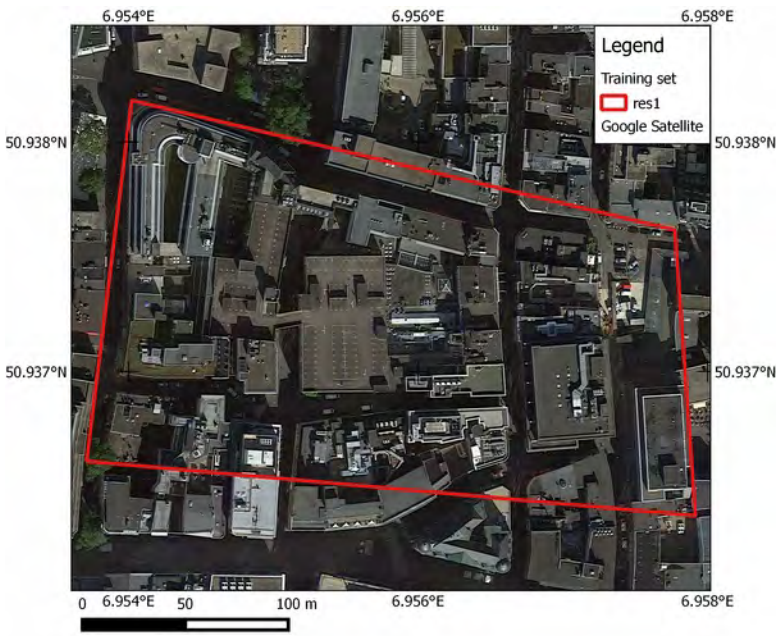

Optical, Very High resolution



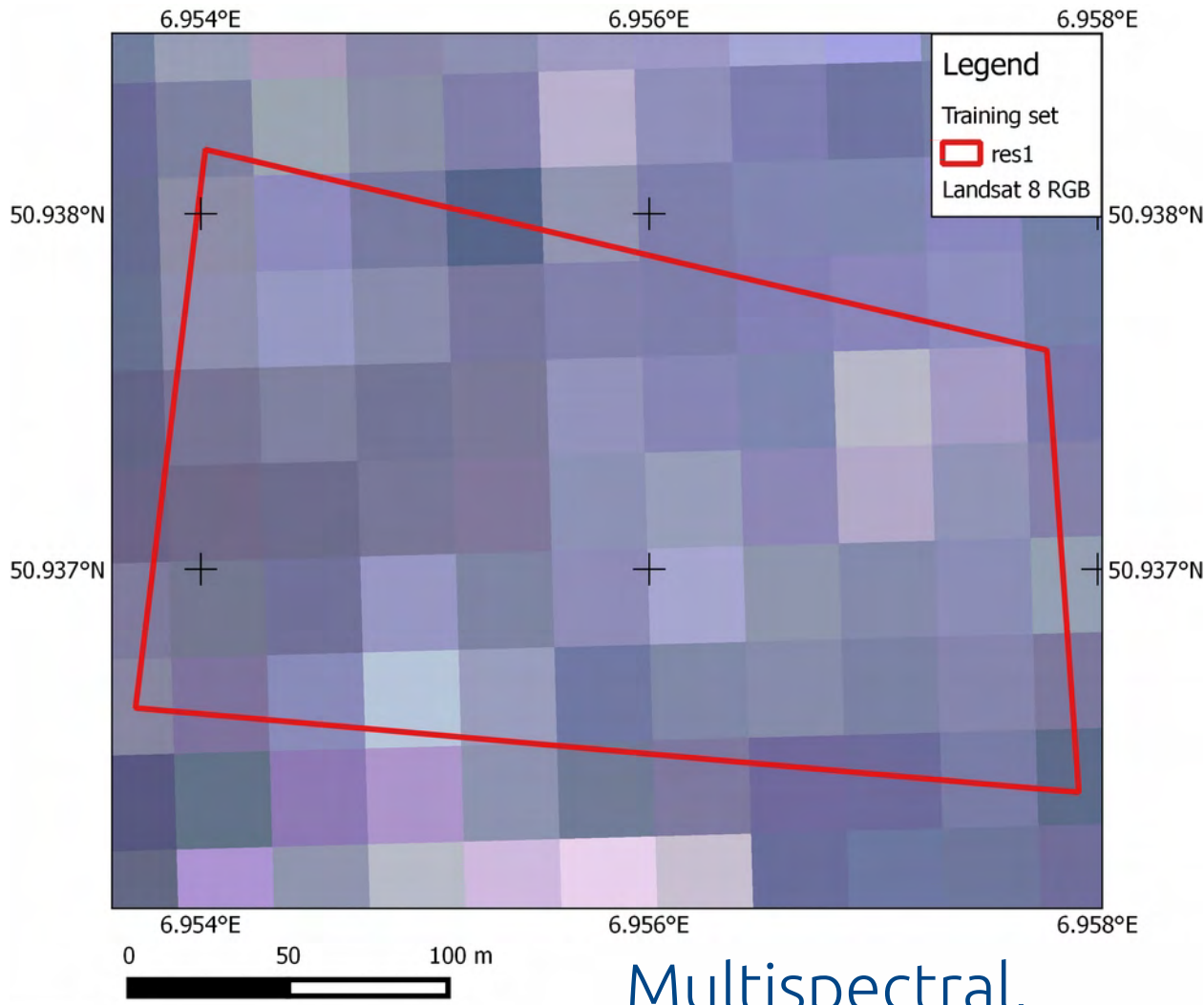

Res1 – high density

Multispectral, medium-resolution

# Multi-spectral stratification




Optical, Very High resolution



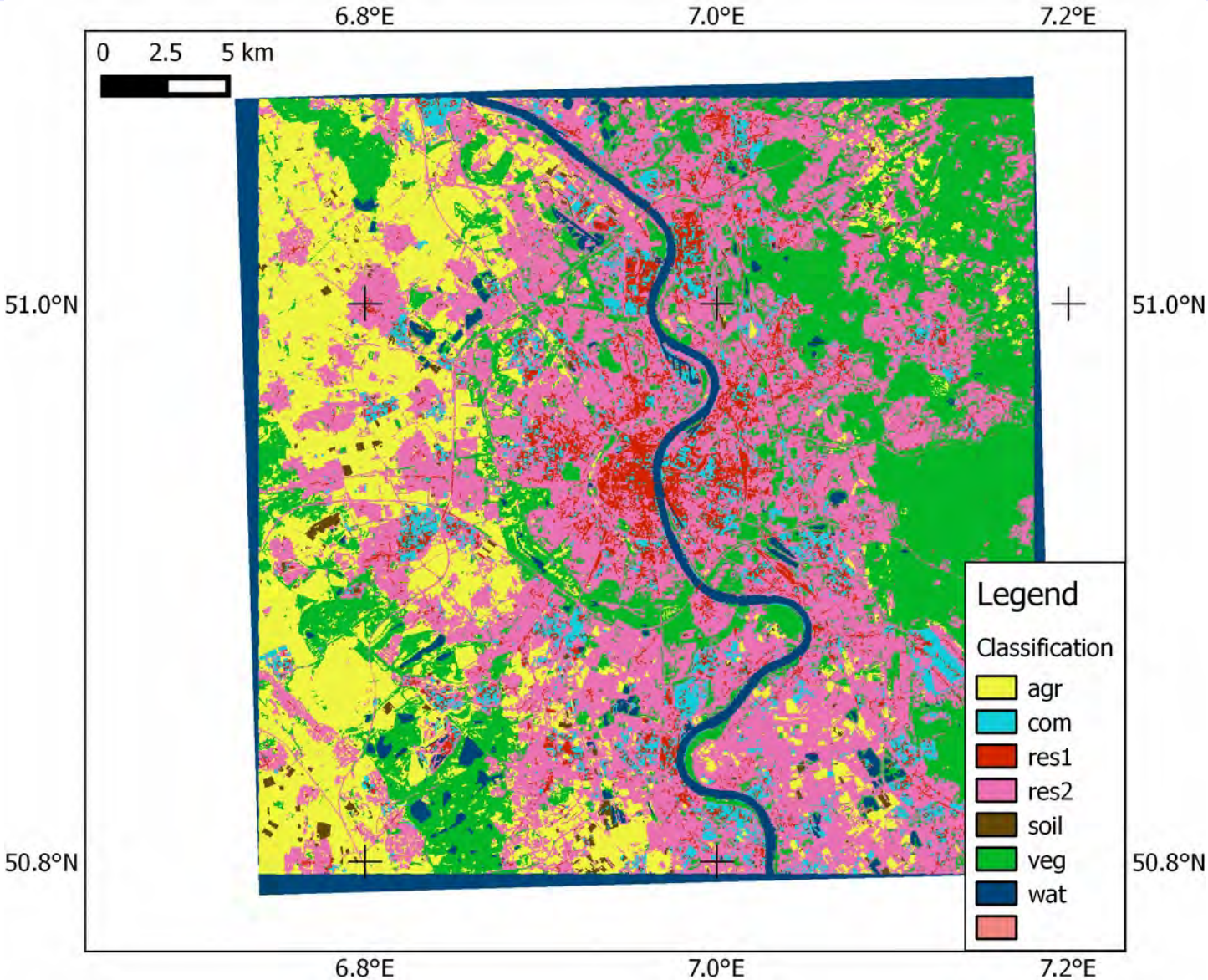

Multispectral, medium-resolution

Res1 – high density

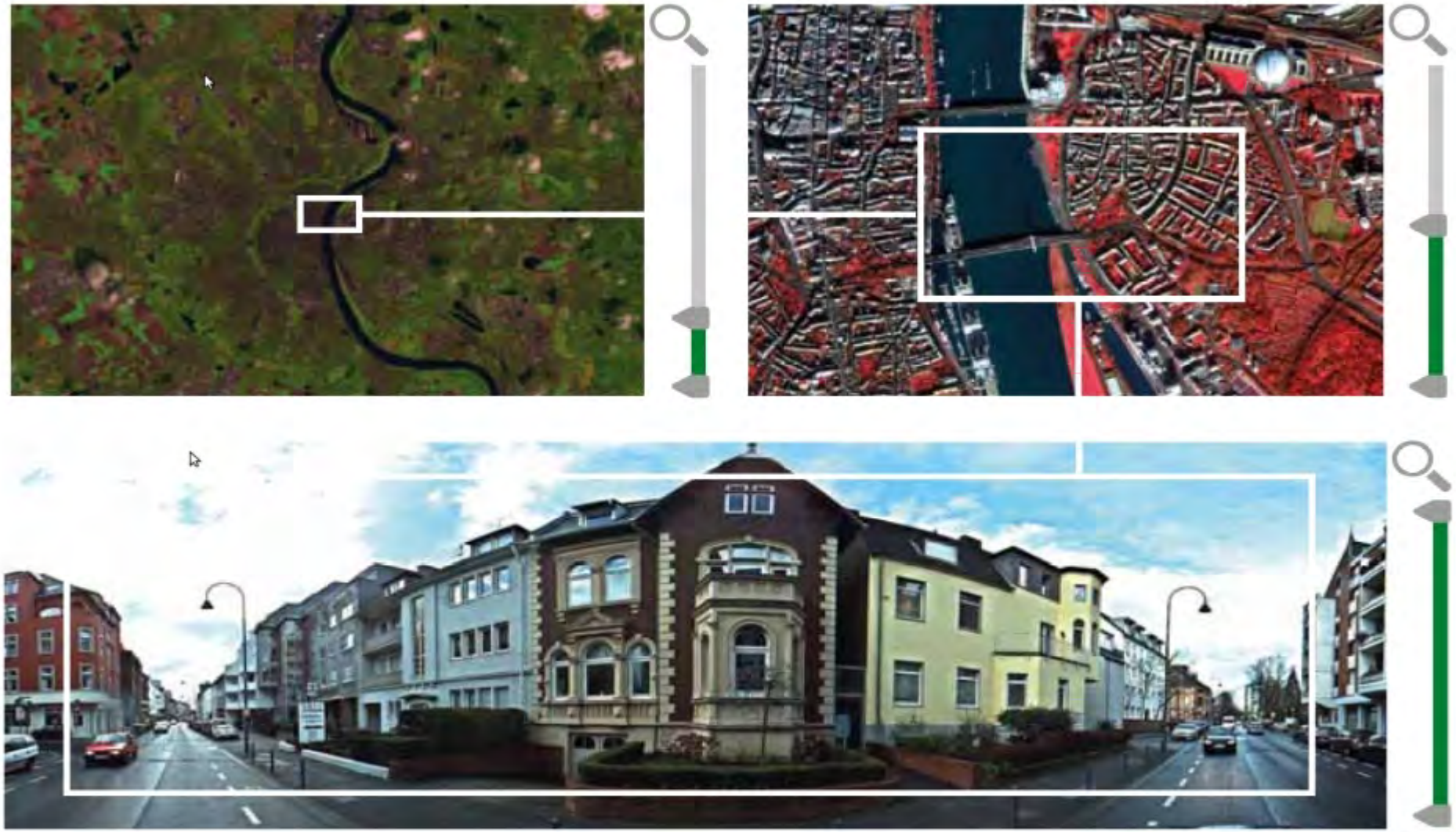
# Multi-spectral stratification

Supervised Classification

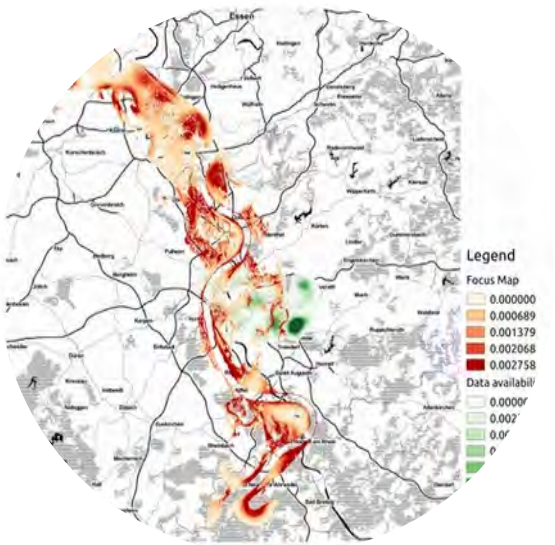
(Support Vector Machines)



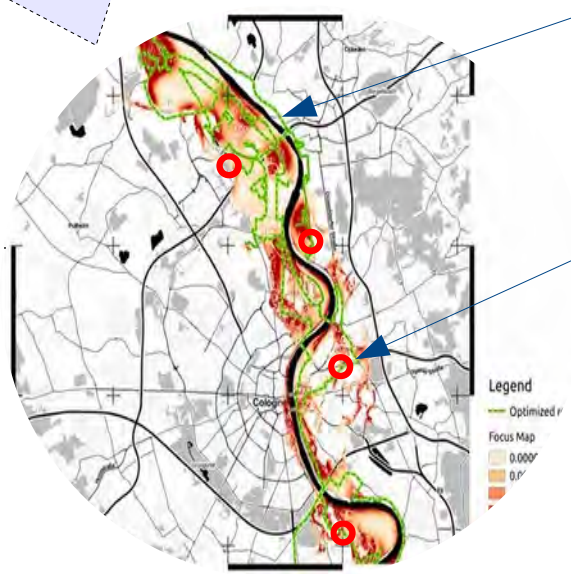
# In-situ survey planning



# 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

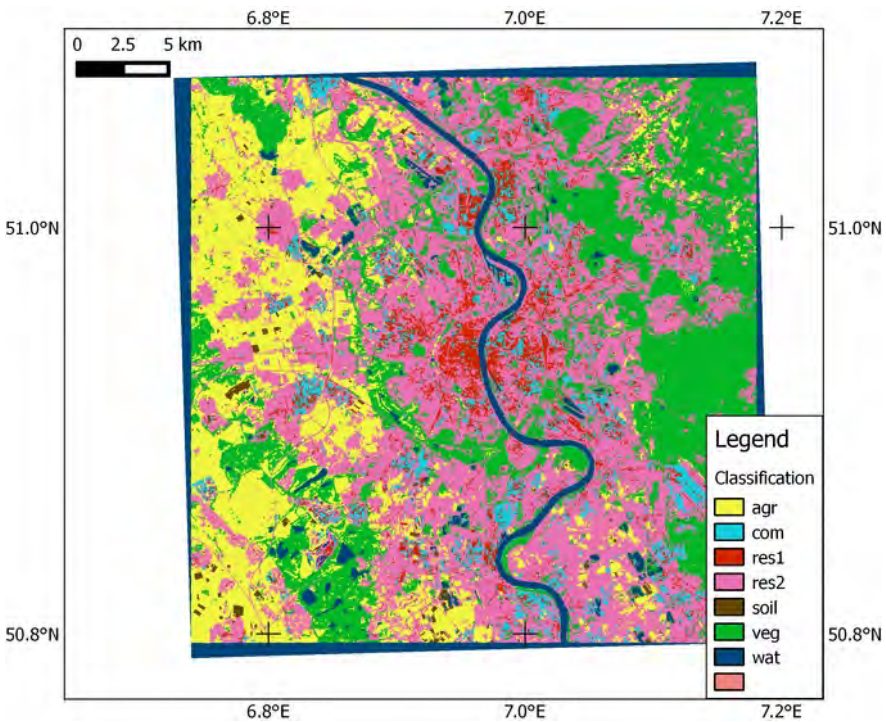
## Stratified Sampling

$$\theta = \theta(v) : estimator\ of\ v$$

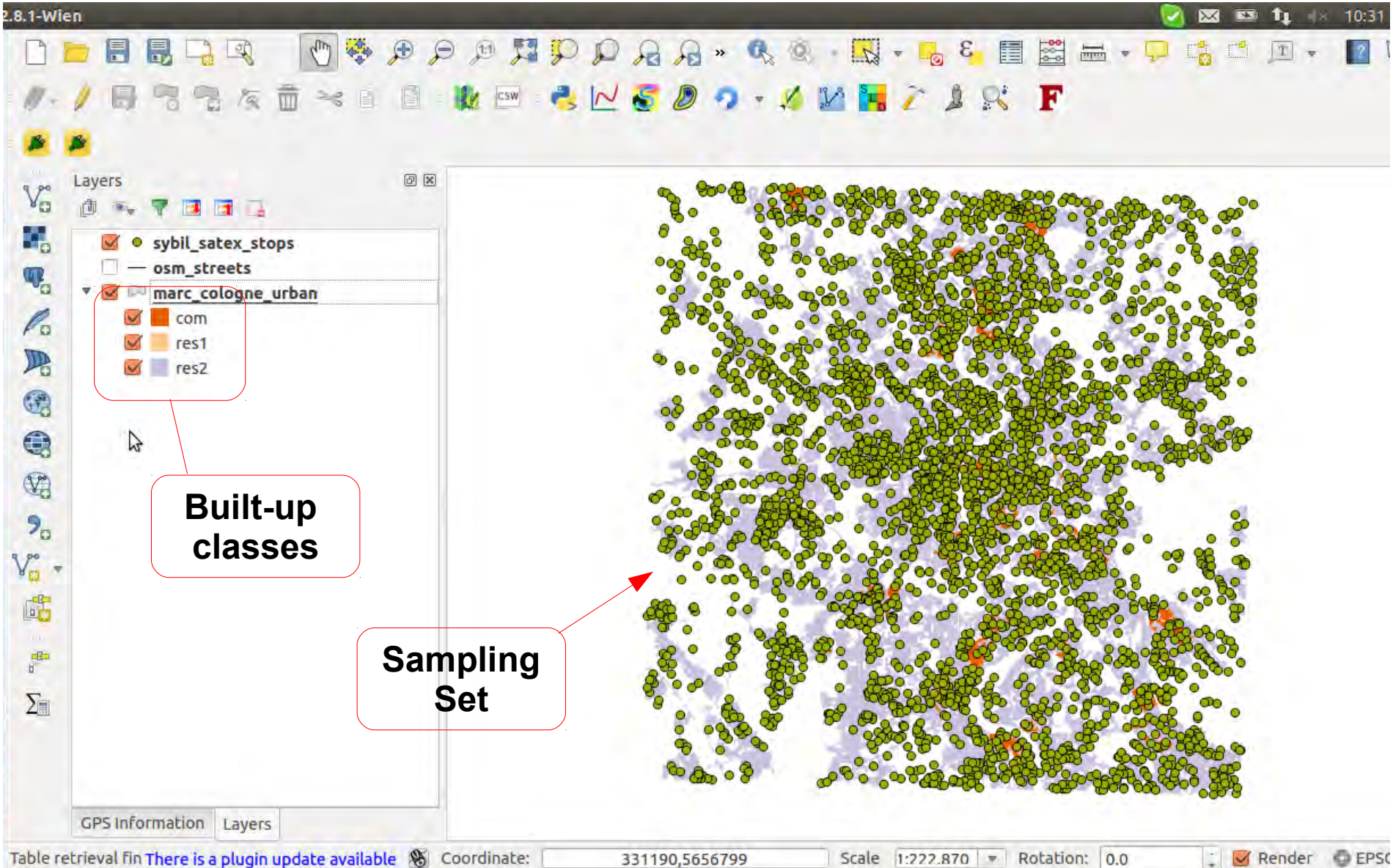
$$W_s = \frac{N_s}{N},\ N = \sum_{s \in S} N_s$$

$$E(\bar{\theta}_{st}) = E\left(\sum_{s \in S} W_s \bar{\theta}_s\right)$$

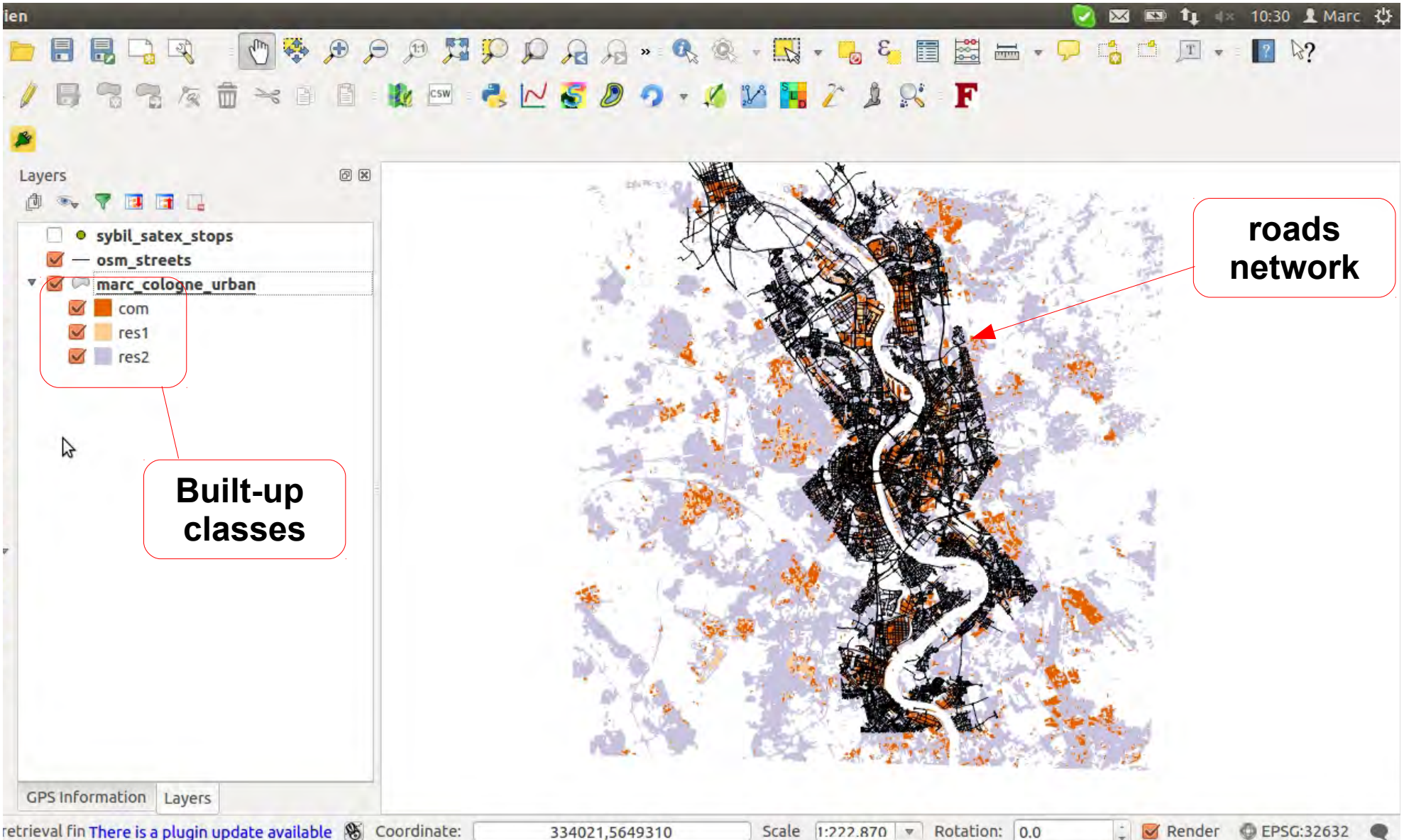
$$\boxed{Var(\bar{\theta}_{st})} = \sum_{s \in S} W_s^2 \boxed{Var(\bar{\theta}_s)}$$



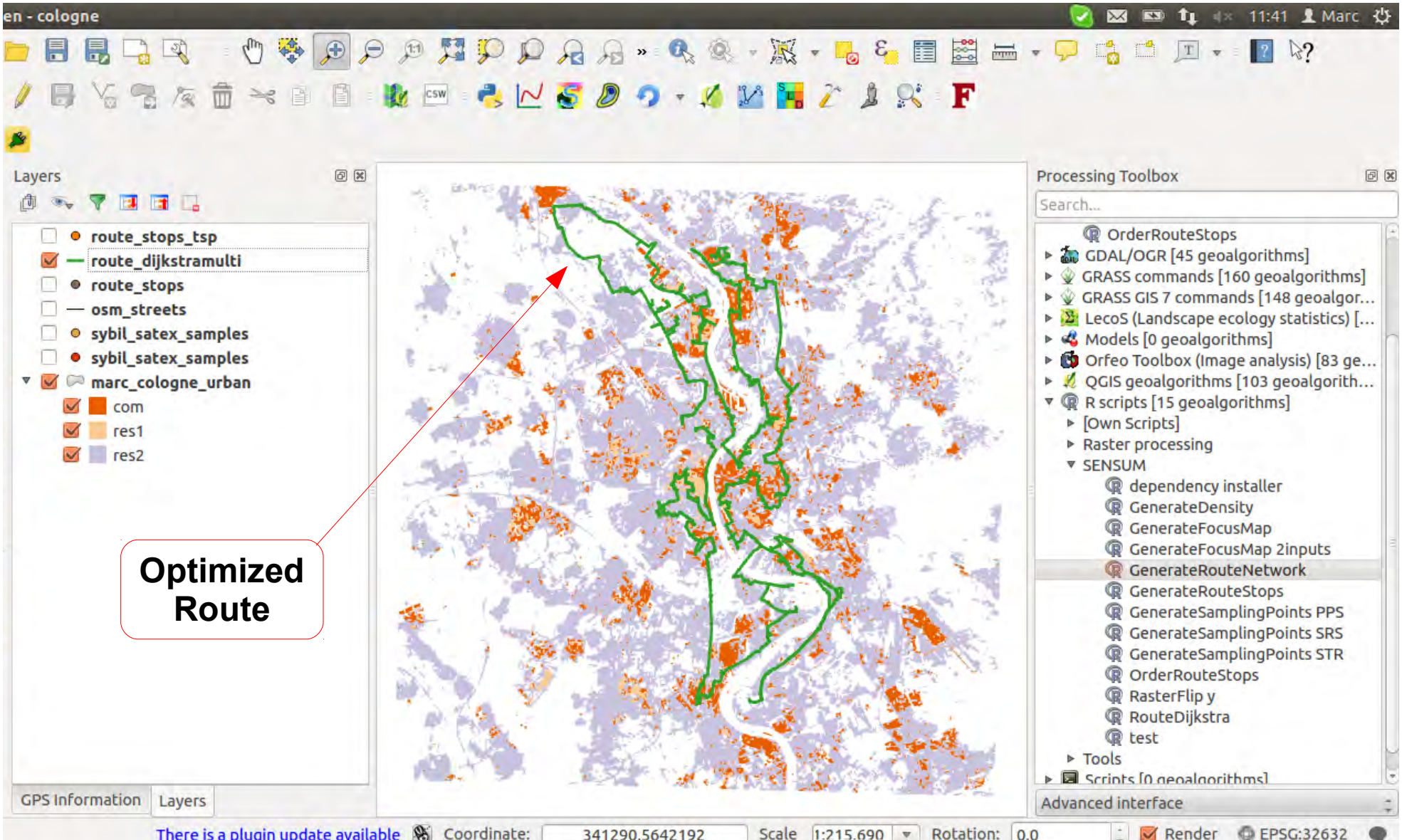
# Sampling and routing - I



# Sampling and routing - II

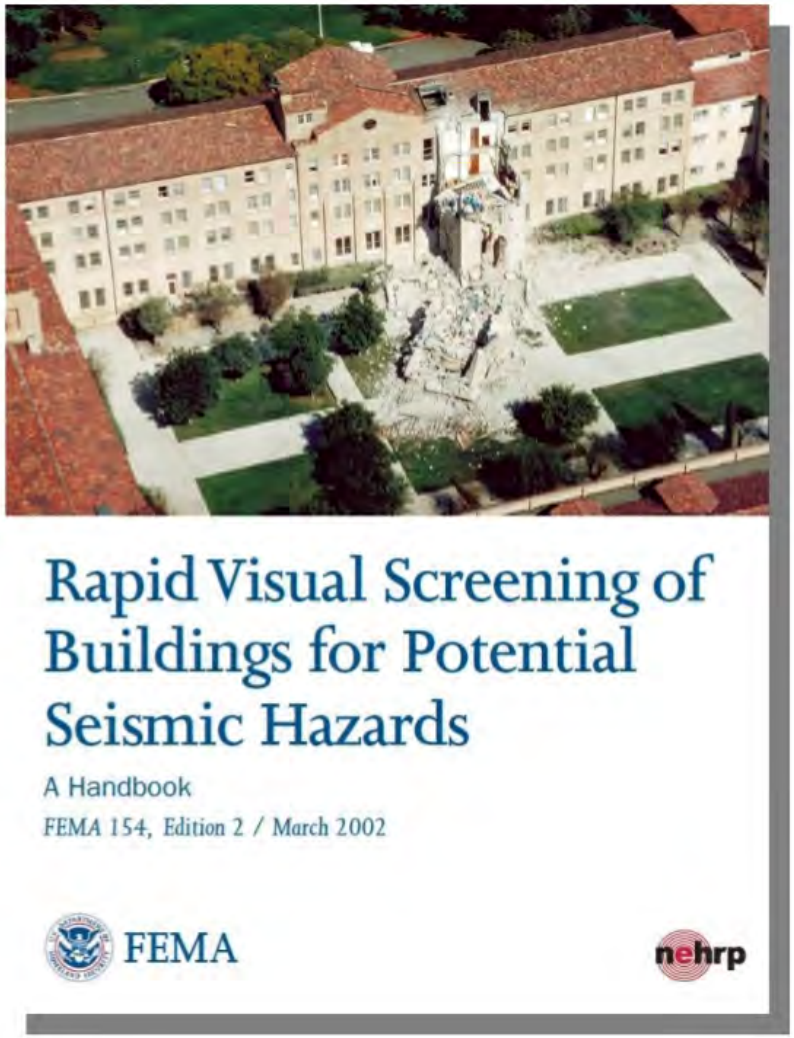


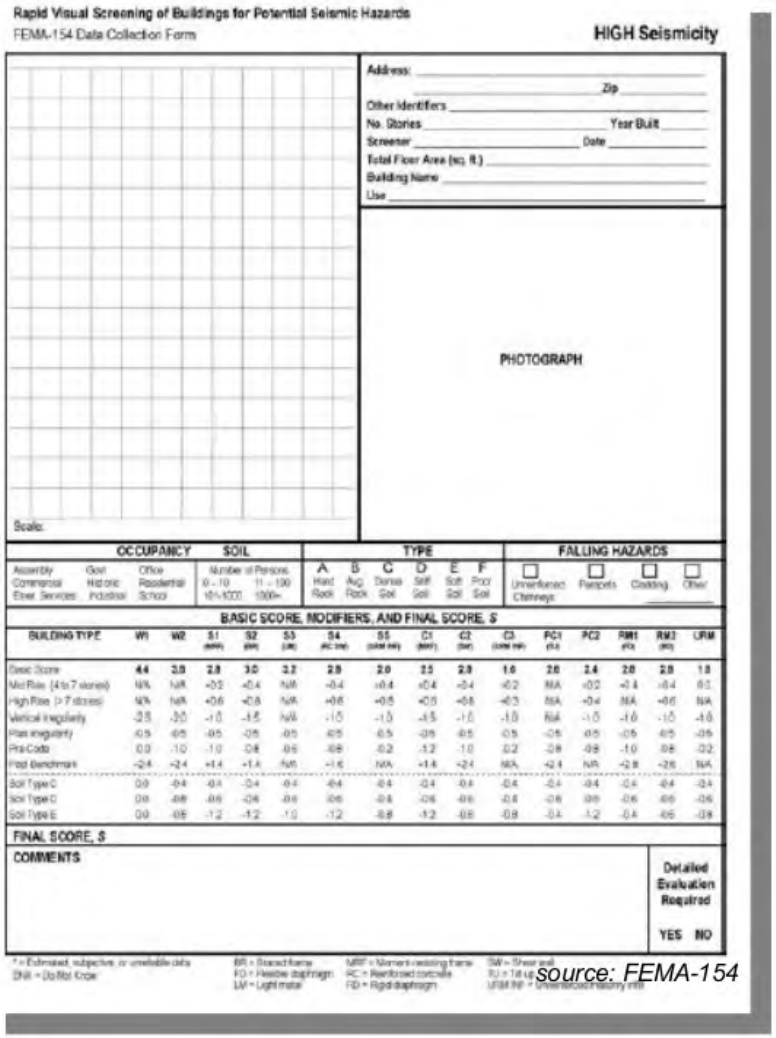
# Sampling and Routing - III



# MOMA – Mobile Mapping

# GFZ-MOMA : Mobile Mapping




source: FEMA-154

# MOMA – Mobile Mapping


Navigation system

MOMA mounted On a car

# MOMA – Mobile Mapping

**Omnidirectional (radial or equirectangular) Projection**



**Perspective (central) Projection**

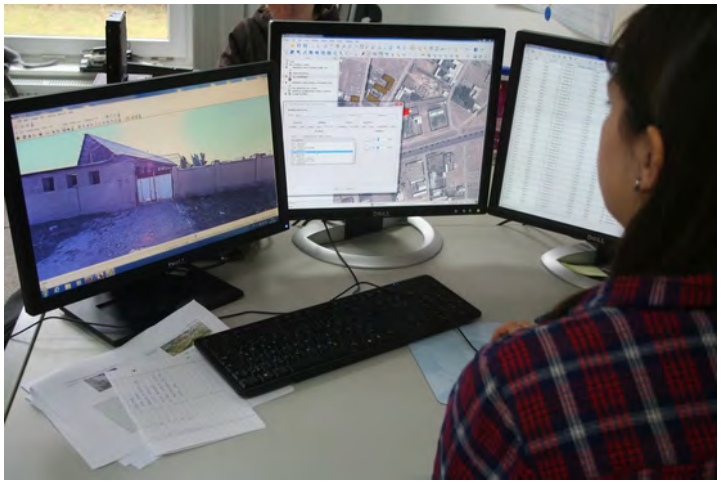
# MOMA – Mobile Mapping


Good weather


Bad weather

# RRVS Remote Rapid Visual Survey

## Preliminary screening



**Remote Inspection**

## Selected direct screening

**Direct Inspection**

# RRVS Remote Rapid Visual Survey

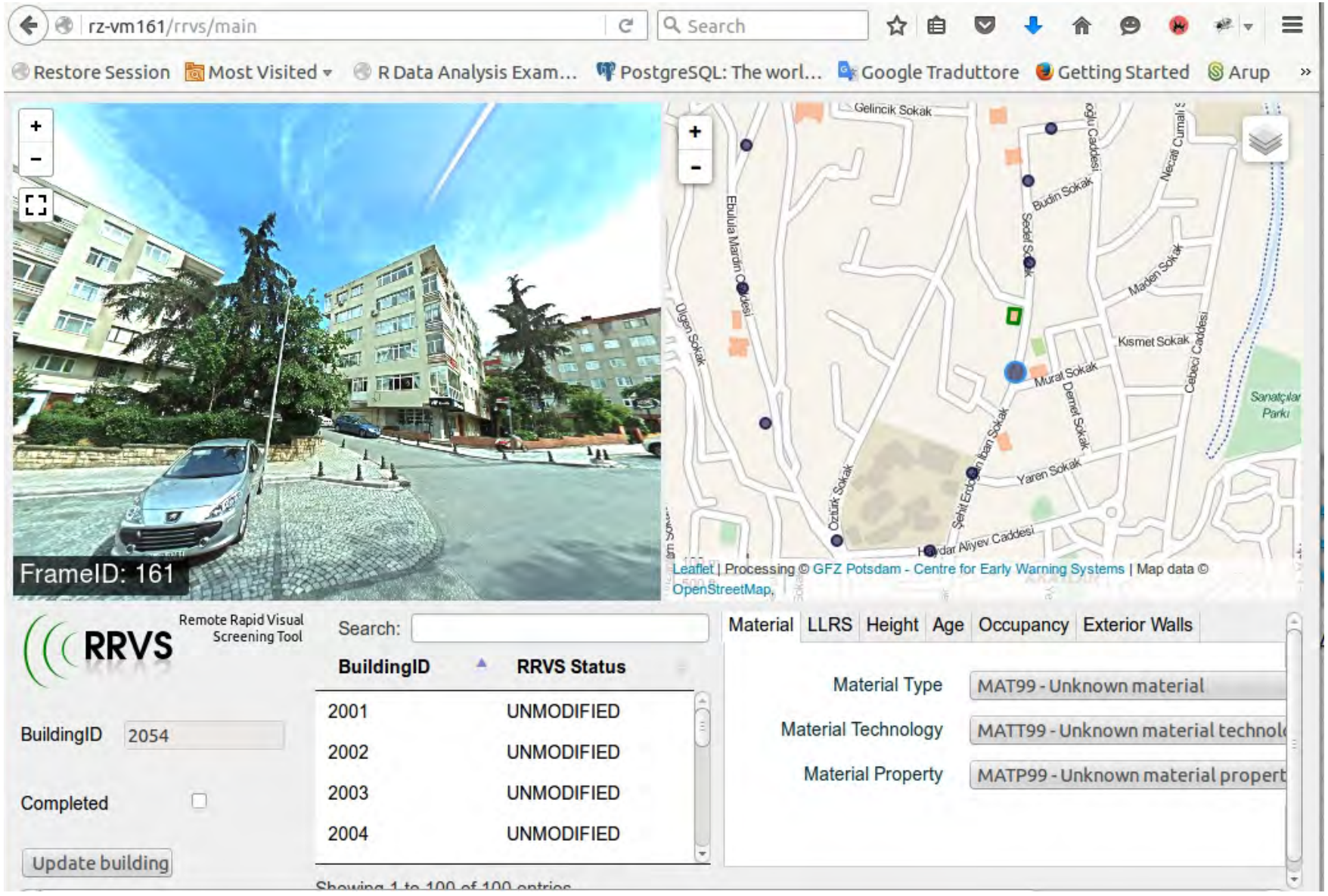
Use case: exposure / vulnerability assessment

Use case: post-disaster rapid damage mapping

Ref: FEMA-154

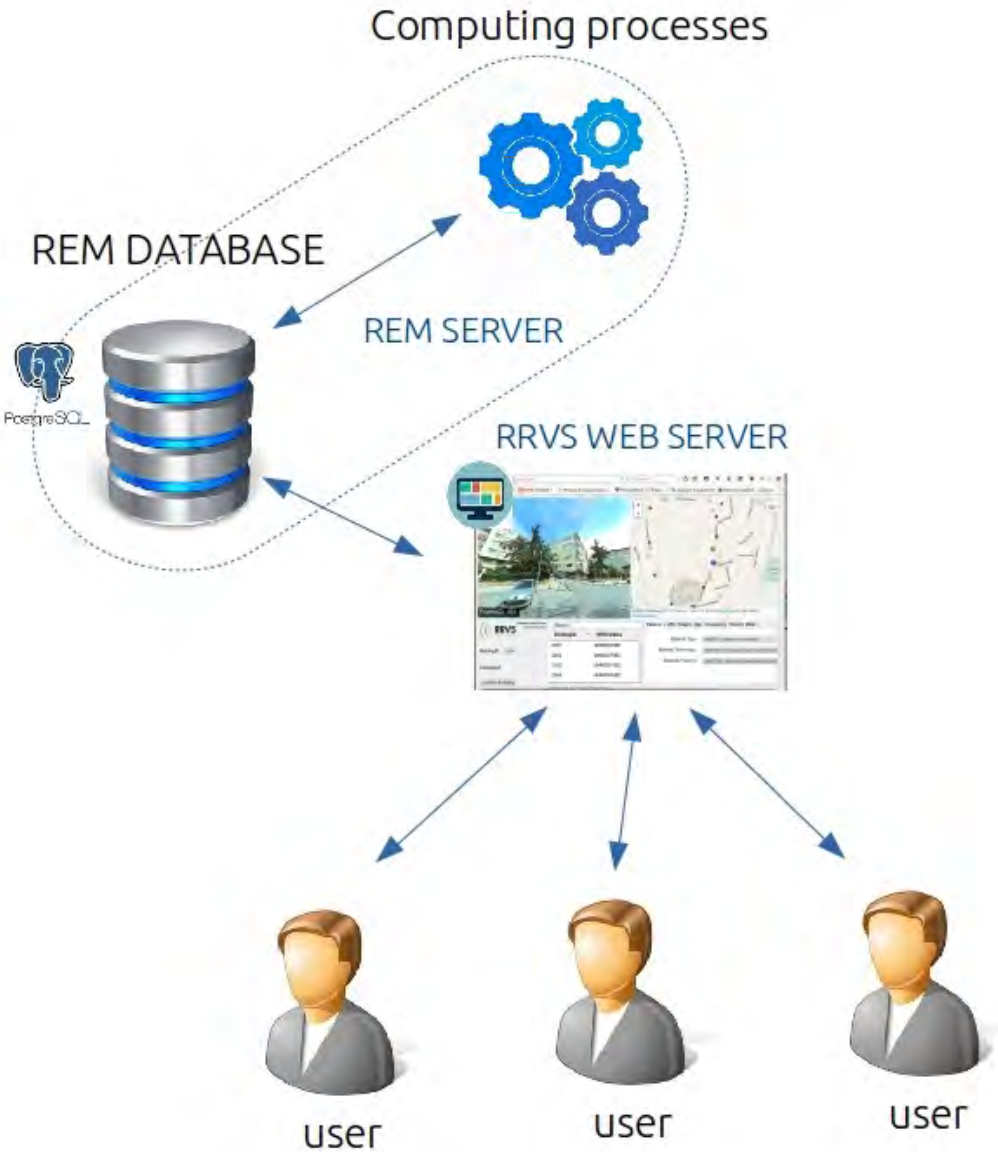
Ref: ATC-20

# RRVS Remote Rapid Visual Survey



# RRVS Remote Rapid Visual Survey

- Multiple, concurrent users
- Multiple tasks (set of sampled buildings)
- Pre-event and post-event surveys
- **Next**: automatic, incremental exposure analysis



# 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