

Cartography and geovisualization - application in the crisis management and command and control systems

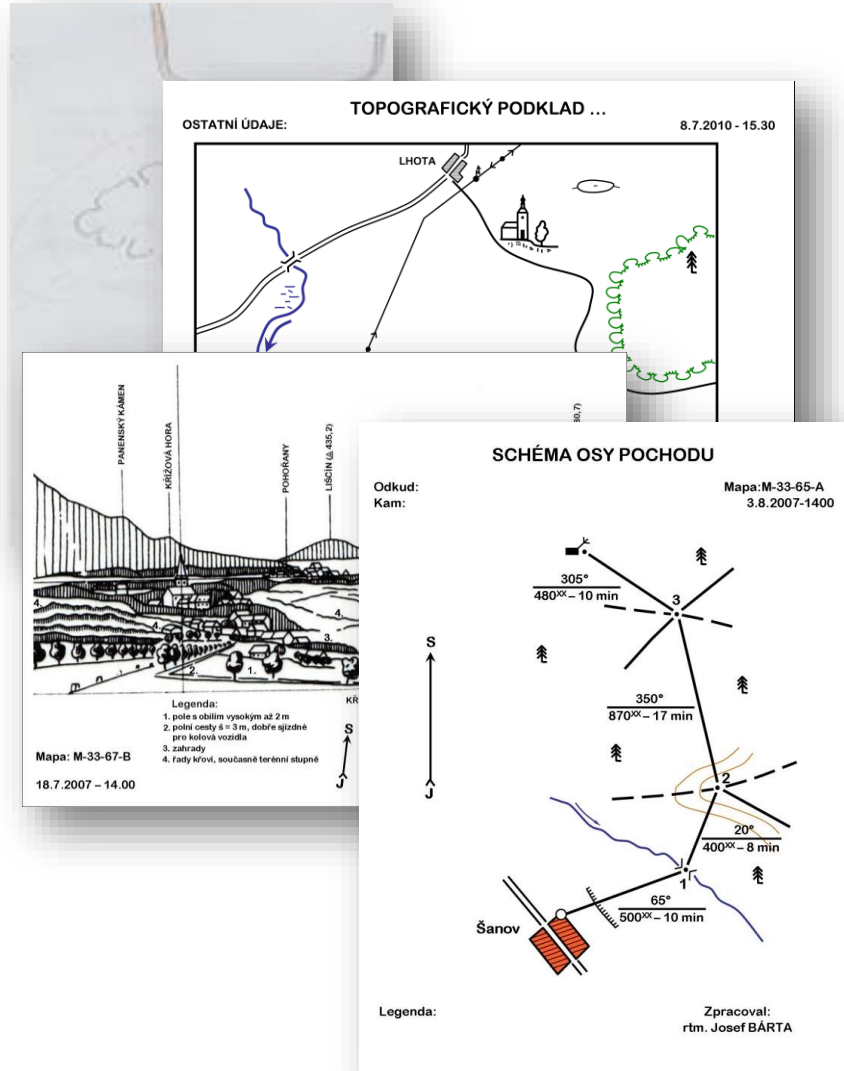
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1.

**DIGITAL GEOINFORMATION AND
CARTOGRAPHY**

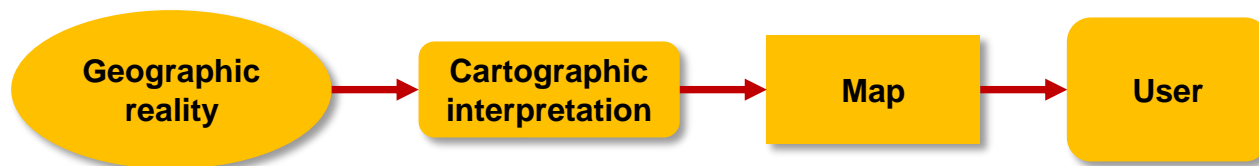
Cognitive mapping

- Reality – surrounding terrain:
 - Objects – key, remaining
 - Phenomena – visible, invisible
- **Transfer of information about reality**
 - Verbal description
 - Graphical – mental recording → mental map → formal mental map (sketch, scheme)
- **Perception of information about reality** – form **own imagination** about reality from transferred information – cognitive map – **where?, when?, what?**

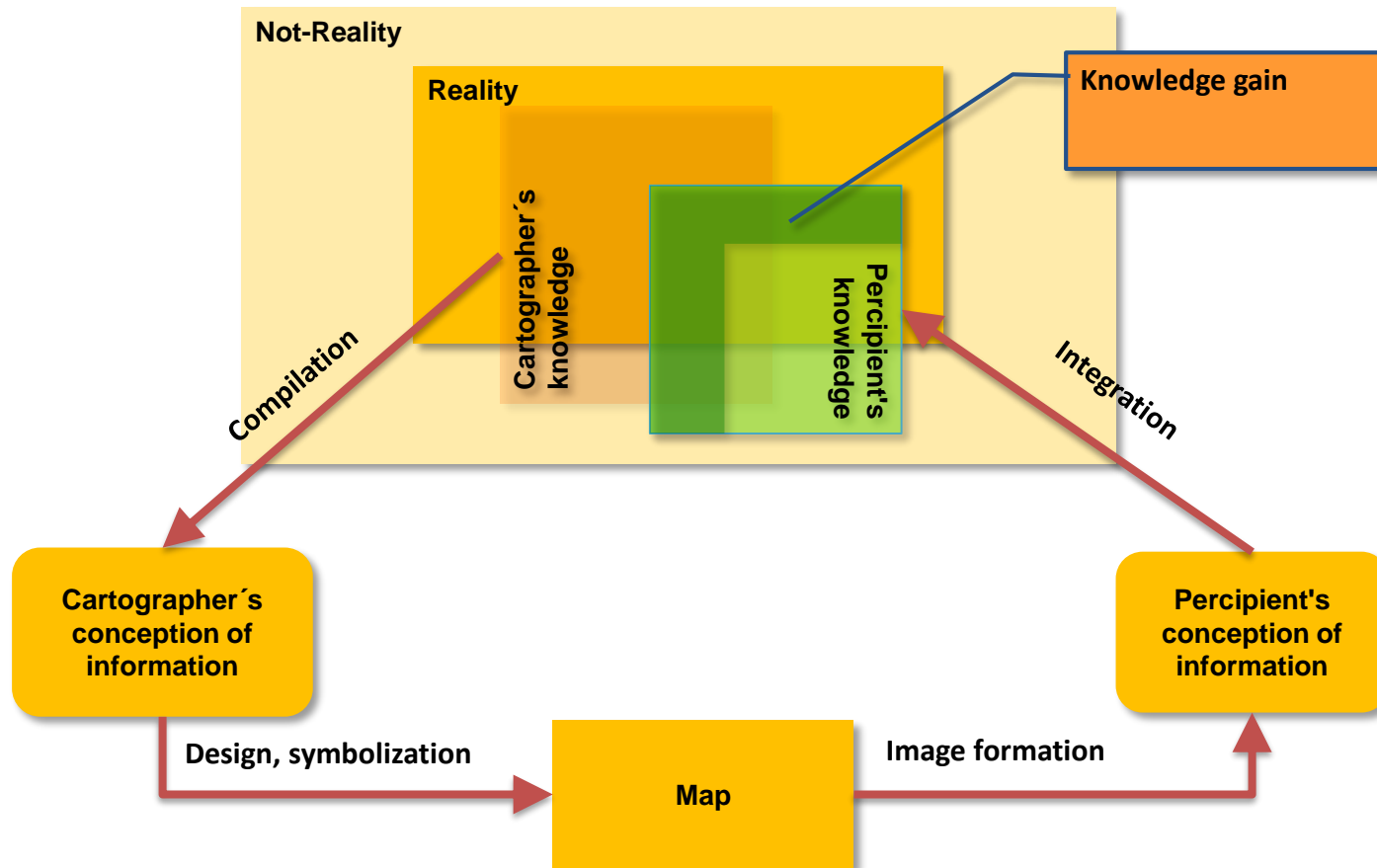


Formalization of reality description

- **Multi-user access** – necessity to formalise the reality description:
 - Where? – determination of position → geodetic (geographic) coordinate system (GCS), Projected coordinate system (PCS) – reference frame – grids
 - What? – map content - geographic objects and phenomena
 - System of symbols – cartographic representation
 - Selection of information
 - cartographic interpretation
- **User** – personal characteristics:
 - Knowledge
 - Experience
 - Physiological abilities
 - Psychological abilities (space perception, ability of abstraction...)
- **Map creation** – general scheme:

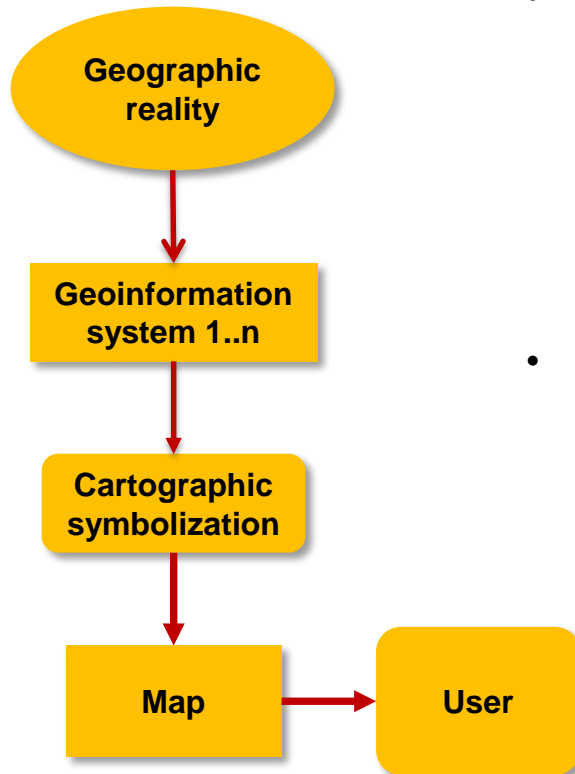


Cartographic communication

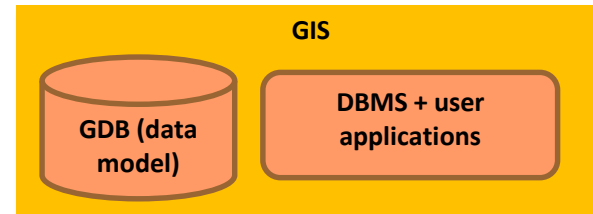


Source: MacEachren: How maps work, 2004

Geoinformation systems

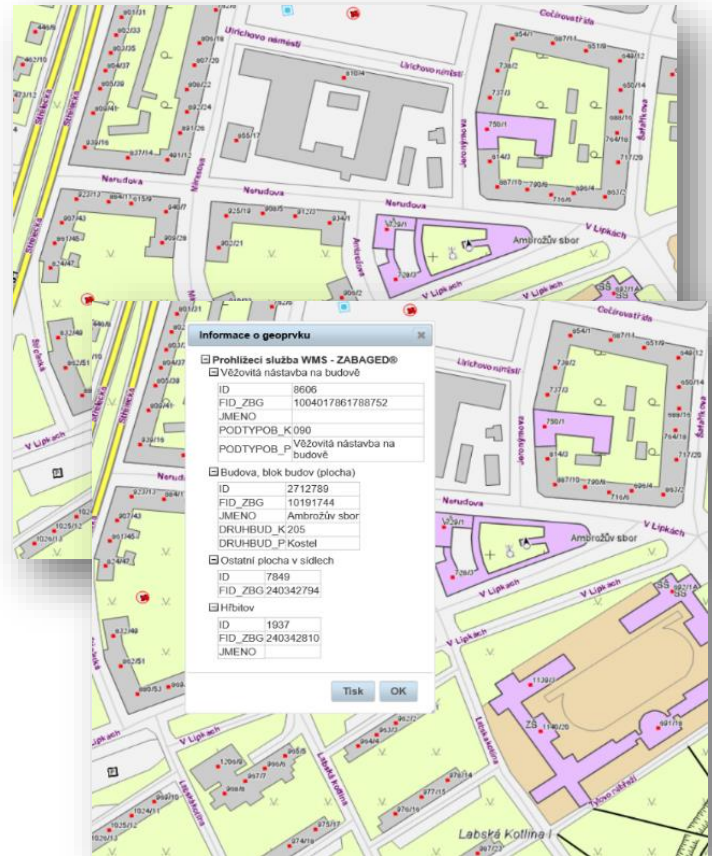


- Basic source for information about geographic reality – **geographic information systems** (geoinformation systems – **GIS**) consist of:
 - Hardware (HW)
 - Software (SW)
 - Data – data models
 - Users (people, systems)
- GIS **basic functions**:
 - Data collection
 - Data storage and management
 - Data analyses
 - Data presentation



Digital landscape model

- **Datasets stored in database** systems or personal databases
- **Vector or raster models** of landscape objects or phenomena
- Given **geodetic reference system** must be applied (longitude, latitude at least)
- Some **cartographic projection** can be applied
- Maximum **position precise** of geometry is required
- Maximum **precision of thematic properties** is required
- **„Unlimited“ objects** and their properties is possible to store and manage
- Linkage to **other sources** (databases, documents, images etc.) is possible to create
- Ready for **space analyses**
- If **visualized – default symbols** are usually used



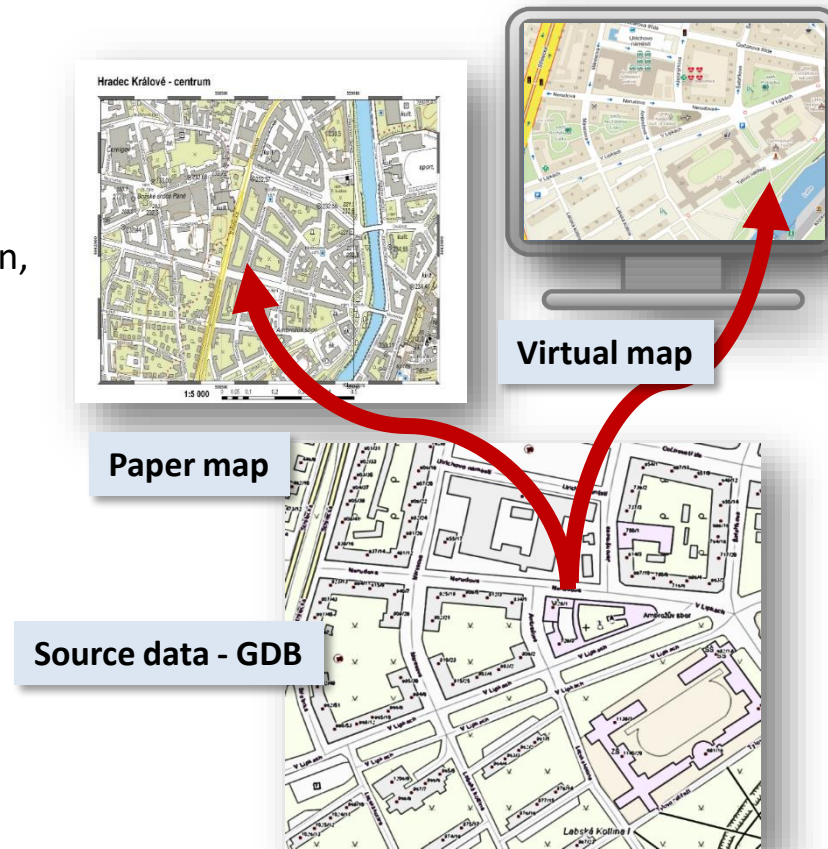
Digital cartographic model

- Preparation of **digital model for cartographic visualization:**

- Objects selection
- Geometry generalization
- Properties selection, generalization, and transformation into scales
- Cartographic harmonization

- **Cartographic visualization:**

- Symbols
- Colors
- Patterns
- Text
- ...
- Paper maps vs. electronic maps (virtual)



What is map

- A map is a **symbolized representation** of geographical reality, representing selected features or characteristics, resulting from the creative effort of its author's execution of choices, and is designed for use when spatial relationships are of primary relevance. (source <http://icaci.org/mission/>)
- Given **geodetic reference system** and given **map projection** must be applied
- **Features are displayed** in the map content according to one of the following **criteria**:
 - **qualitative**—the species are expressed (e.g. language map)
 - **quantitative**—the quantifiable properties (e.g. population density map) are displayed
 - **topological**—the features are represented by their ground nature (the way they relate to the Earth surface) by point, line and areal symbols (e.g. road map)
 - **developmental**—the changes in space and time are displayed (e.g. troop movement map)
 - **meaning**—or significance (the significance of a small settlement in the desert is higher than that of a similar settlement in a well-populated area)
 - **structural** —the feature as a unit together with its sub-components and interrelationships are represented (e.g. map of the age structure of the population)

What is map

Paper map

- Printed content on paper (fabric, plastic etc.)
- Stable (given) scale
- Grids (graticule, measured, reference)
- Light
- No electric power is necessary
- No dynamic objects
- No changeable content
- ...

Electronic (virtual) map

- Virtual visualization
- No stable scale – view scale vs. map content scale – minimum/maximum zoom is possible to determine
- Various sources – e.g. off-line personal database, on-line geodatabases, WMSs
- Adaptation of content visualization is relatively simple
- Multifunctionality
- Dynamic objects – on-line sources
- Different size of display (computer, mobile phone, navigation system etc.)
- HW is necessary
- Electric power is necessary

2.

CARTOGRAPHIC SYMBOLS

Map content

Every map contains four groups of map elements:

- ***Mathematical:***

- Geodetic reference system, projected coordinate system

- ***Physical-geographic:***

- Relief
- Hydrology
- Vegetation
- Surface cover (soils, stone...)

- ***Social economic:***

- Settlements
- Transport network
- Industry and farming, and cultural objects
- Borders

- ***Additional:***

- Legend
- Identification of editor
- Map description
- etc.

Mathematical elements

- Geodetic reference systems (position, elevation)
- Cartographic projection
- Reference grid

The image displays a GIS software interface with three panels on the left and two map visualizations on the right.

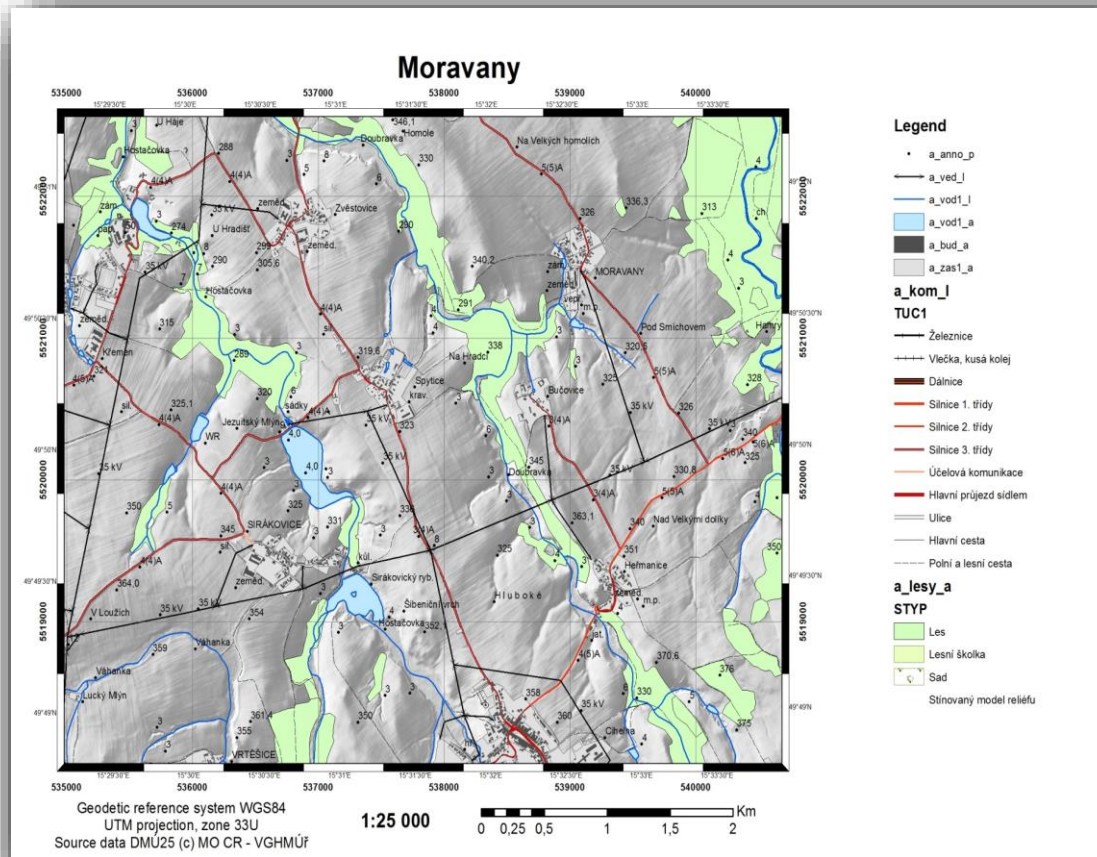
Data Frame Properties: Shows the current coordinate system as GCS_WGS_1984. A list of coordinate systems is visible below, including ITR, NSI, and WG.

Geographic Coordinate System: Shows the Name as GCS, Datum as D_W, Spheroid as WGS, and Angular Unit as Deg.

Projected Coordinate System: Shows the Name as GCS_Sp, Linear Unit as Meters per unit, and Geographic Coordinate System as GCS_Sp.

Map Visualizations: The first map shows a geographic coordinate system with latitude and longitude lines. The second map shows a projected coordinate system with a grid of lines and numerical values. The third map shows a reference grid with letters A-E and numbers 1-5.

Map compilation



Cartographic language

- **Cartographic symbols** - part of cartographic language
- **Transfer** cartographic information into **user brain**
- Source of **shapes** – **pictures** describing real object (association)
- Symbols have **sensual** and **cognitive** properties
- Symbols **can express** quality, quantity and intensity
- **Types of symbols:**
 - Point
 - Line
 - Area

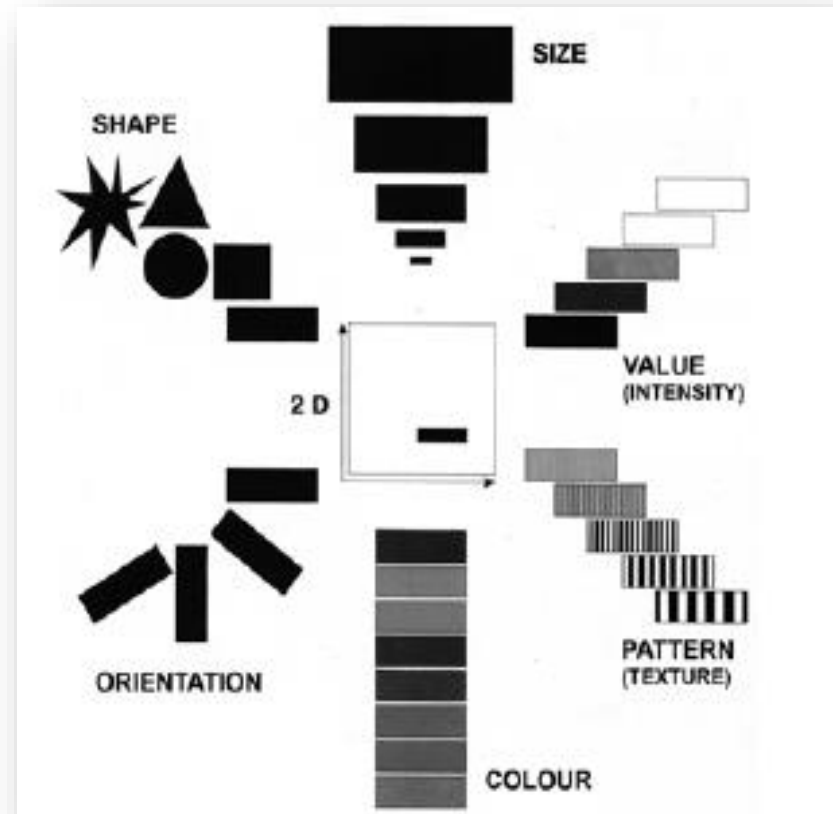
Symbols variables

- **Basic symbols variables (2D):**

- Shape → quality
- Size → quantity
- Value (intensity) → quantity
- Pattern (texture) → quality and quantity
- Color → quality
- Orientation → quality and quantity
- Placement (reference point, reference set of points)













- **Additional symbols variables:**
















- Structure
- Animation – time of displaying, duration, particular animation ordering, frequency...
- Sound – frequency, volume, rhythm
- Interaction
- Join to other objects

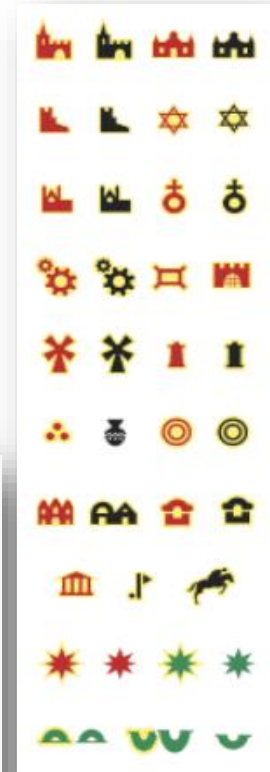


Point symbols

- No ground plan is possible to draw at given scale
- **Types of point symbols:**
 - geometrical
 - symbolical
 - picture
 - figural
 - alphabetical
 - numerical
- **Placement of symbol** is important

		kostel; kaple
		věžovitá stavba; těžní věž
		ústí šachty v provozu; mimo provoz
		tovární komín; pošta
		kříž, sloup; mohyla, pomník
		rozhledna; vysílač
		rozhledna s vysílačem, vysílač s rozhlednou

Shape			
Size			
Structure			
Fill			
Orientation			



Line symbols

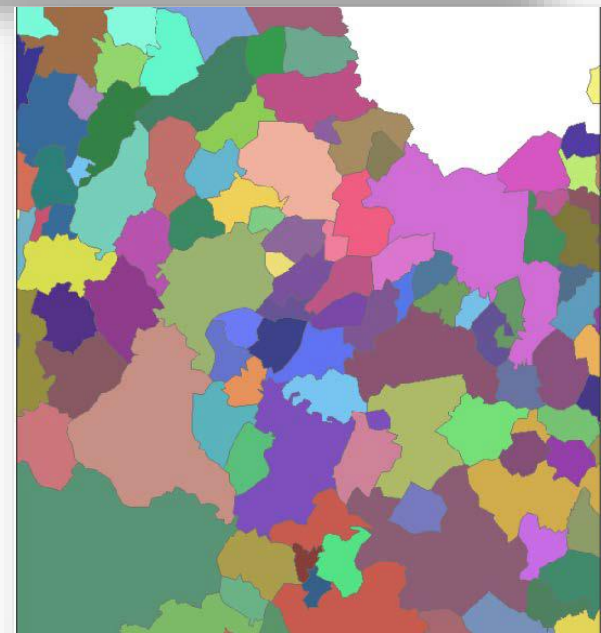
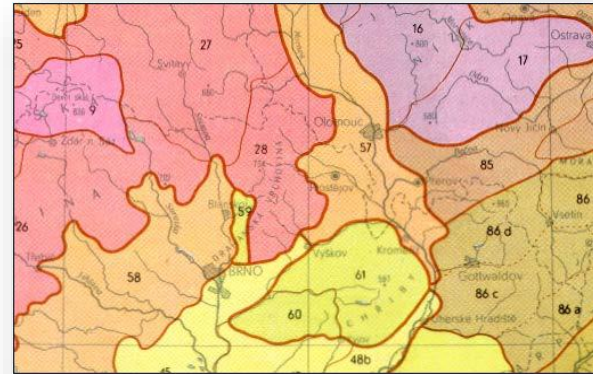
- **Length of symbol** answers length of object – it is possible to measure it
- **Position** – set of points defined generalized object position
- **Quality and quantity** are expressed:
 - Line structure
 - Thickness
 - Colour
 - Additional



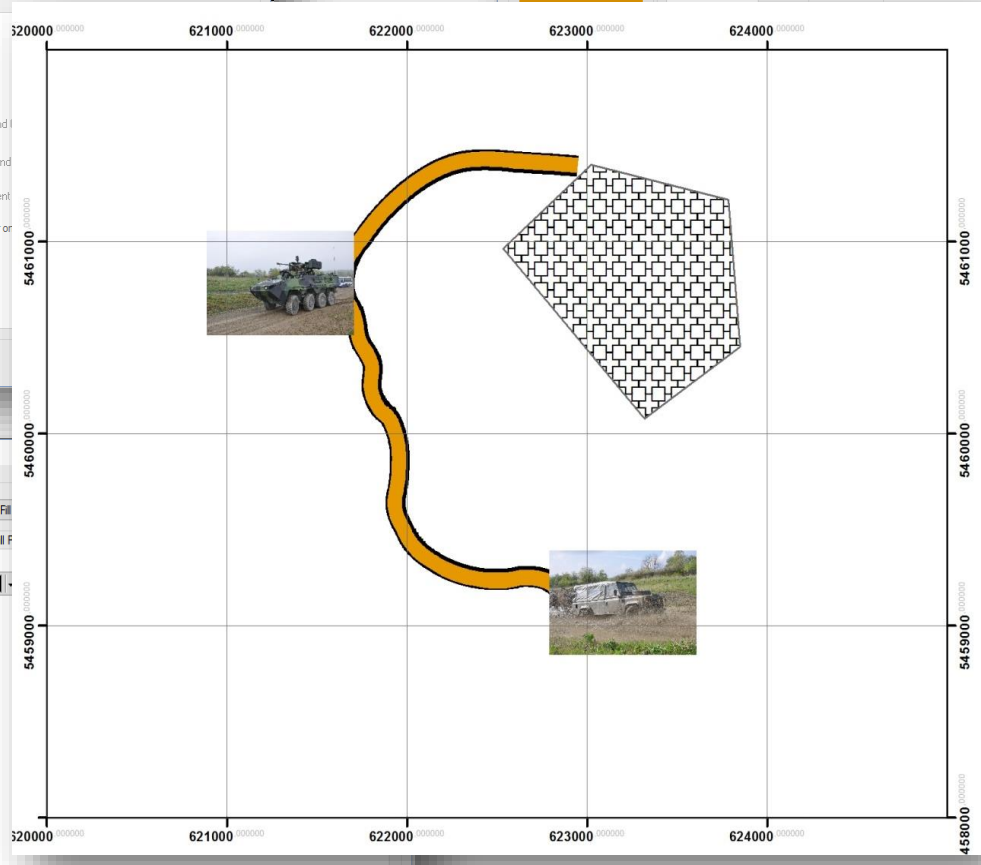
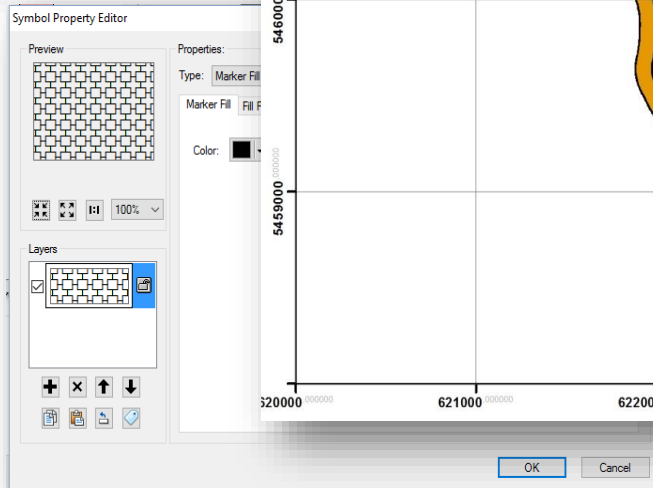
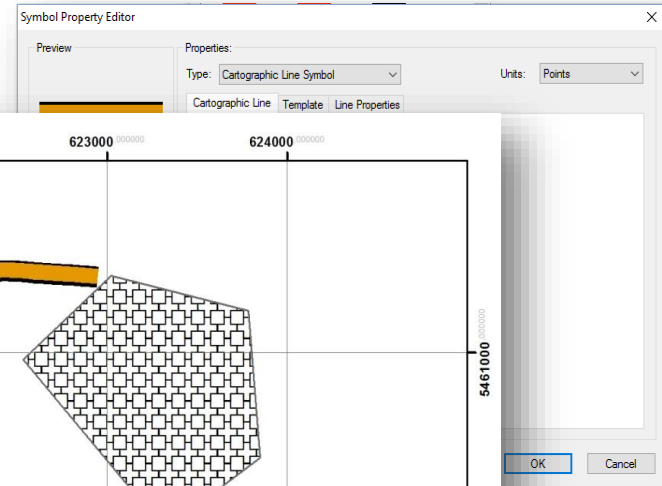
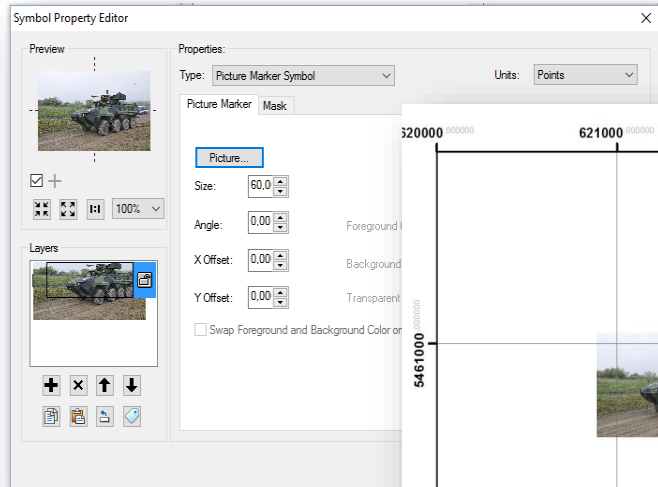
	dálnice s číslem
	rychlostní silnice s číslem
	mezinárodní silnice s číslem
	silnice I. třídy s číslem
	silnice II. třídy s číslem
	silnice III. třídy, hlavní ulice
	ostatní průjezdné silnice a ulice; parkoviště
	jednosměrná ulice; zákazy vjezdu
	silnice se zákazem vjezdu motorových vozidel
	zpevněná cesta; polní či lesní cesta
	pěšina; průsek
	víceproudé úseky silnic

Areal symbols

- **Area of object** is possible express – it is possible to measure it
- **Quality and quantity** visualization:
 - Colour
 - Texture
 - Pictures or symbol regular sampling
 - Elevation – hypsography, shading
- Frequently used for **thematic maps**



ArcGIS Symbol editor

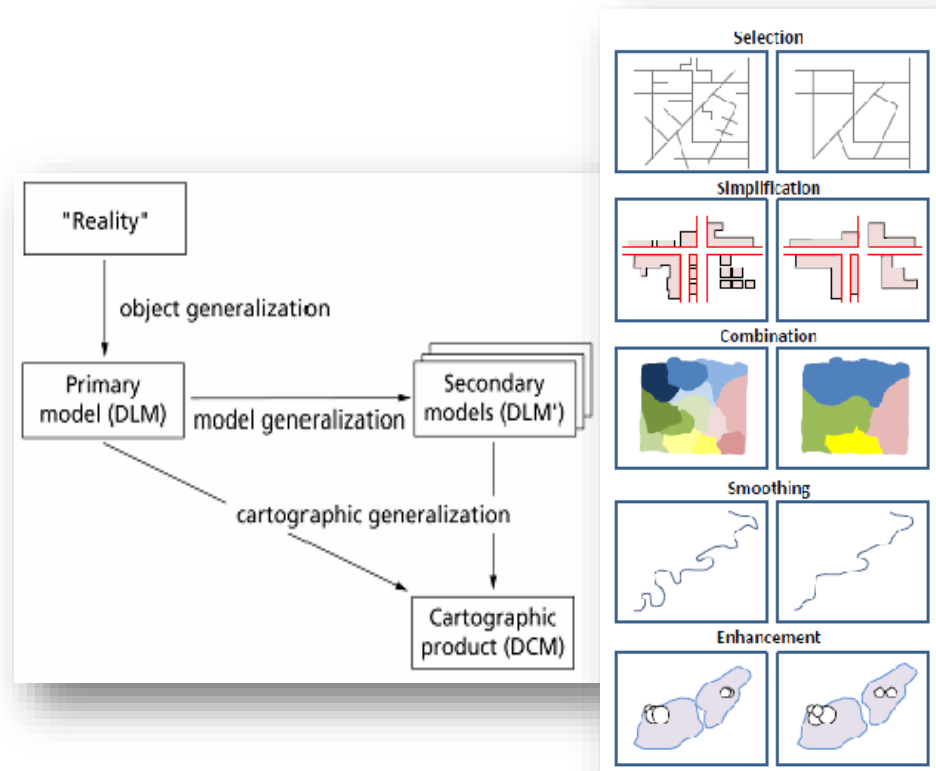


3.

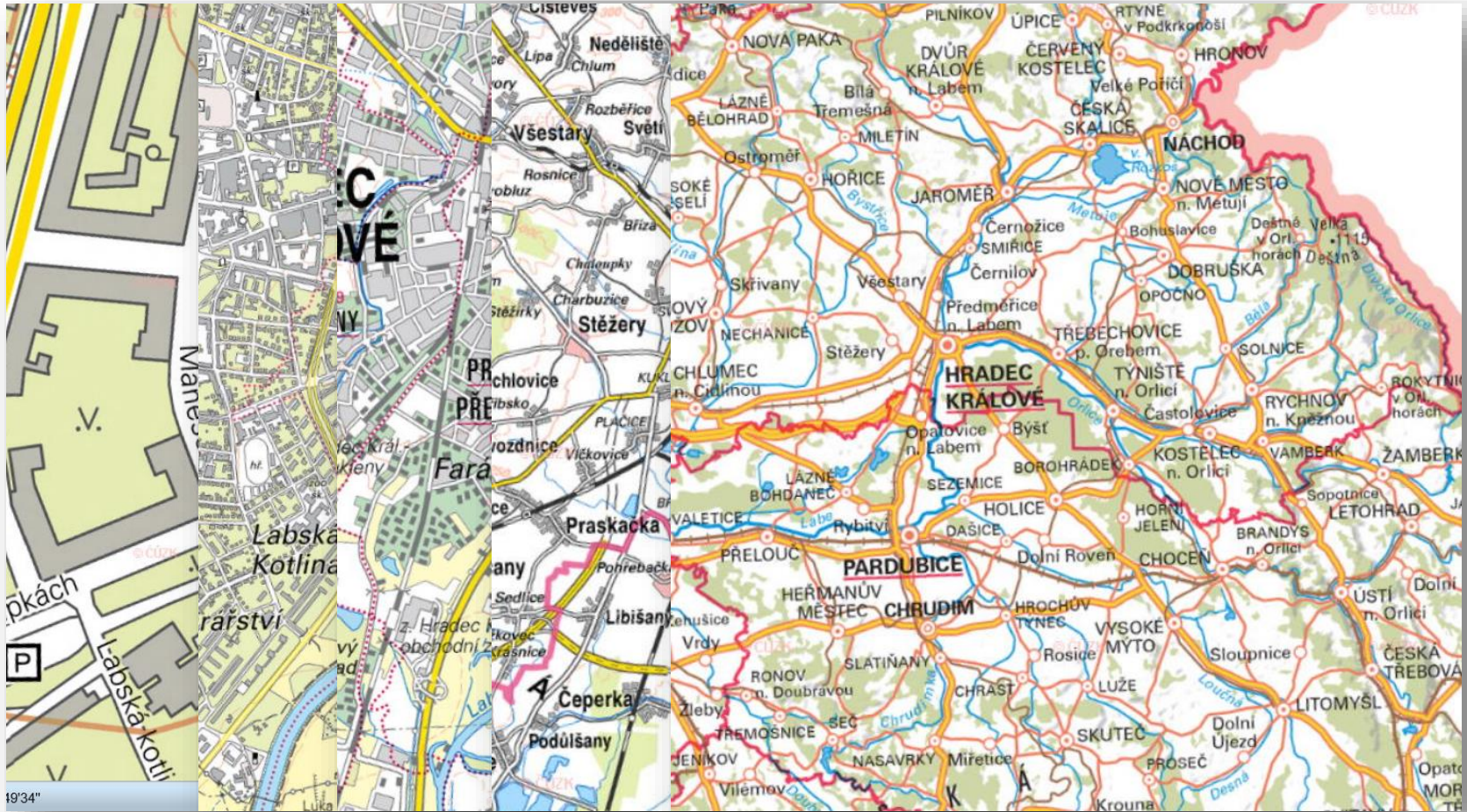
CARTOGRAPHIC GENERALIZATION

Fundamentals of cartographic generalization

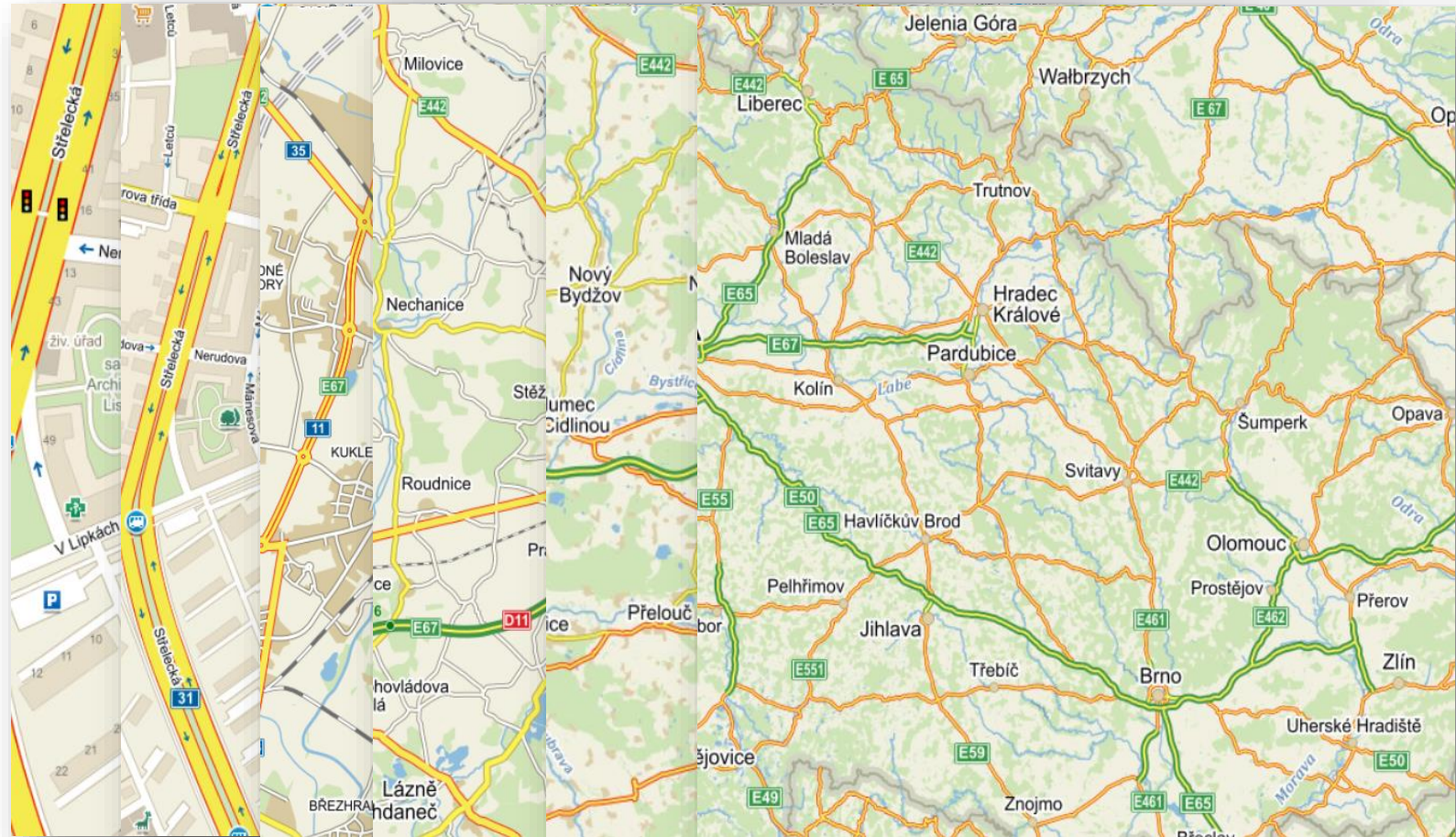
- No all objects of reality can be visualized – **reduction of content** – cartographic generalization
- **Methods:**
 - **Selection** – the most important objects stand out
 - **Simplification** – geometry, thematical properties
 - **Combination**
 - **Smoothing**
 - **Enhancement**
 - Cartographic **harmonisation**
- Generalization paper maps vs. electronic maps (WMS, satellite navigation)



Paper maps generalization - examples

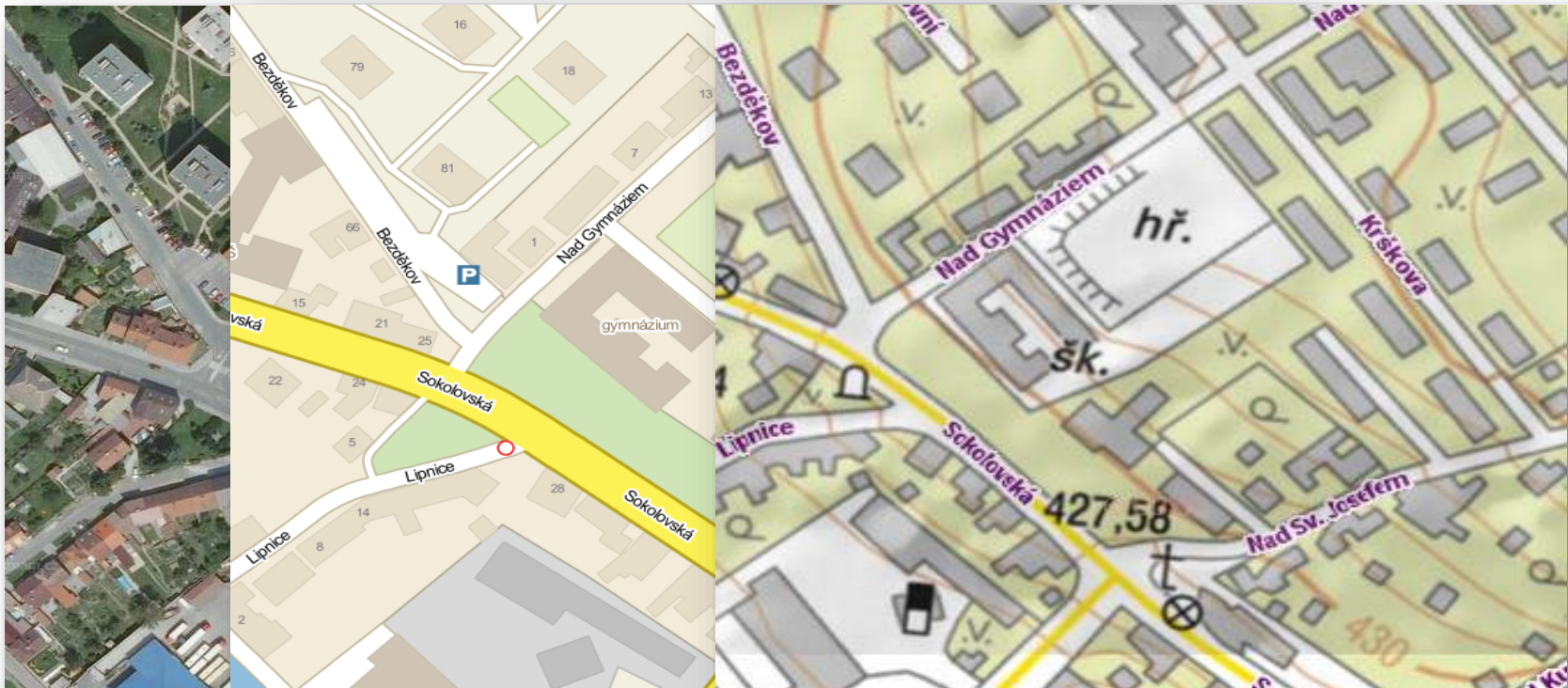


Electronic maps generalization - examples



Conflicts solution – paper vs. electronic maps differences

Velké Meziříčí, Nad Gymnáziem, 2013



WMS -Orthofoto

WMS - Mapy.cz

Paper map - ZM 10K

4.

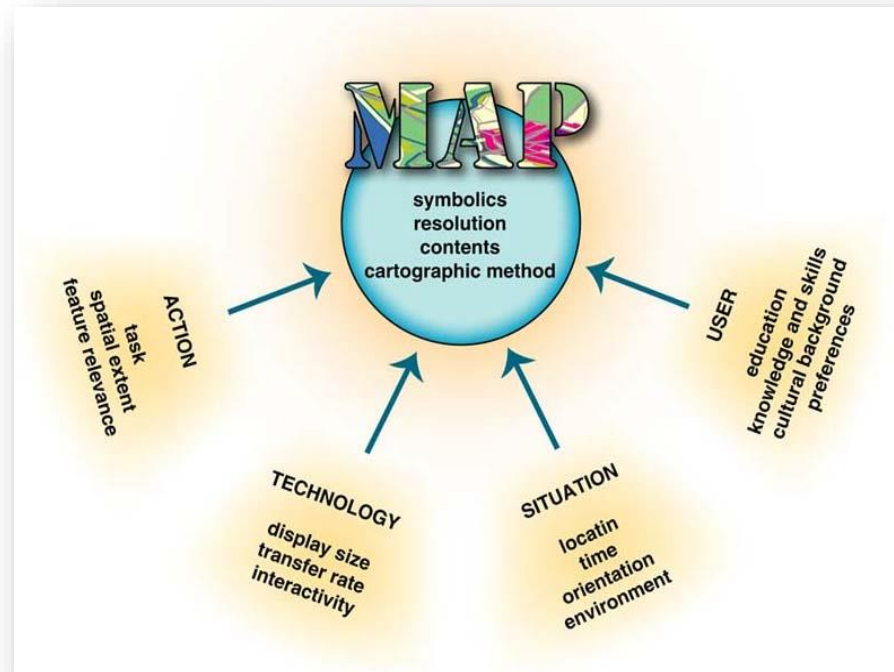
ADAPTIVE CARTOGRAPHY

Adaptive visualization

- Originally in information technology - „context-aware computing“ (Weiser, Dey and Abowd, Schilit)
- 2000s: Introduction to cartography (e.g. T. Reichenbacher)

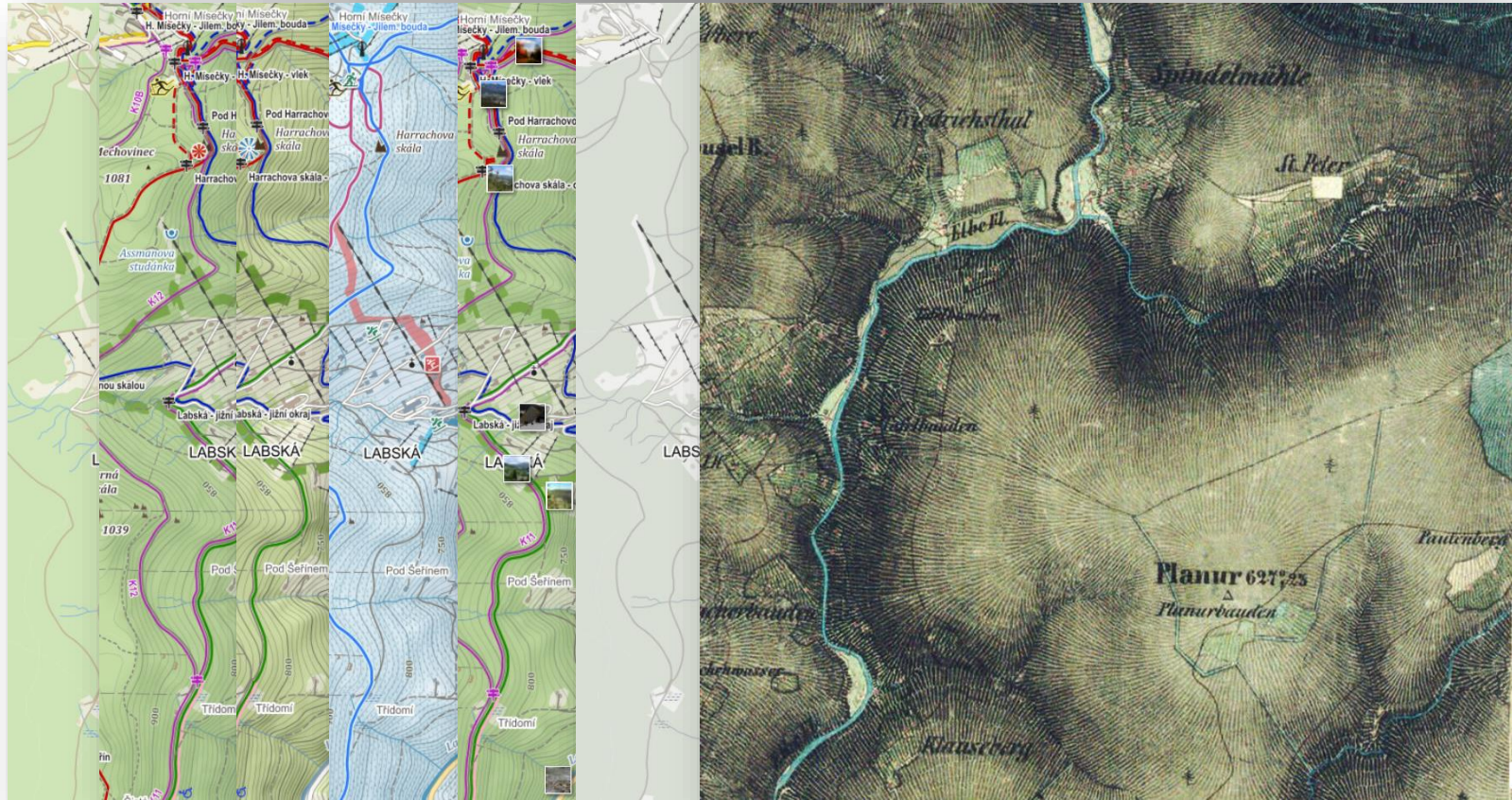
Basic principles:

- Method of representation of displayed objects and/or phenomena is selected (and/or modified) according to **context**
- **Context** = sum of all information that can be used to describe circumstances under which the visualization is used



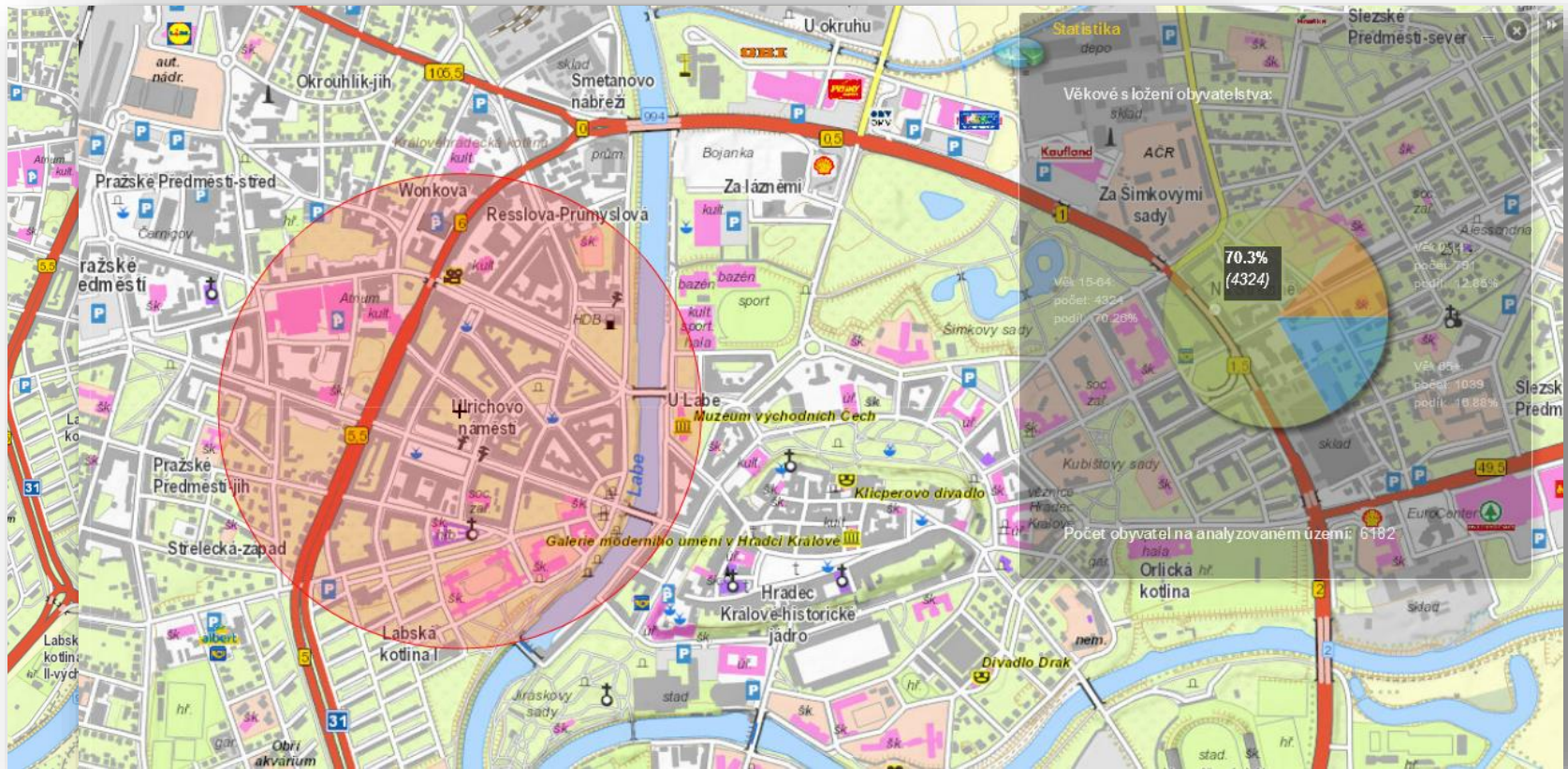
Adaptive visualization examples

(<https://mapy.cz/>)



Adaptive visualization examples

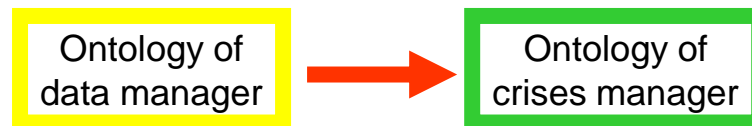
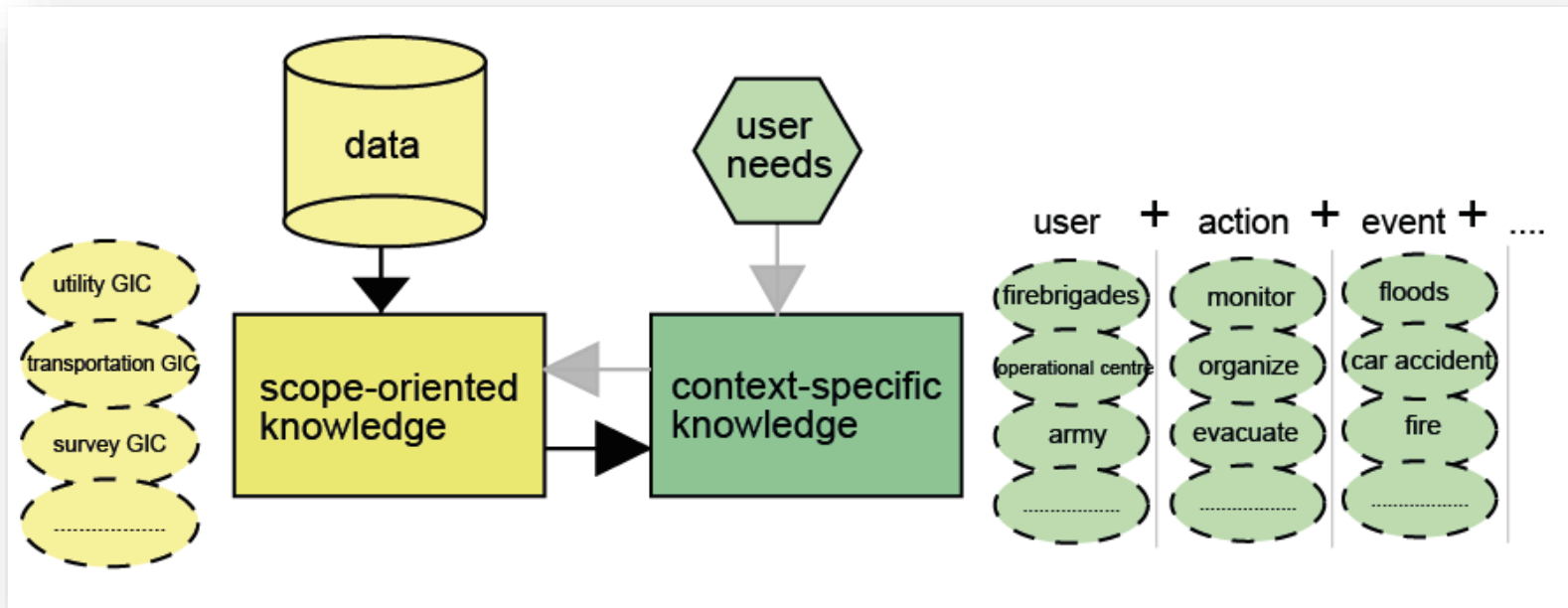
(<http://gis.izscr.cz/map2/>)



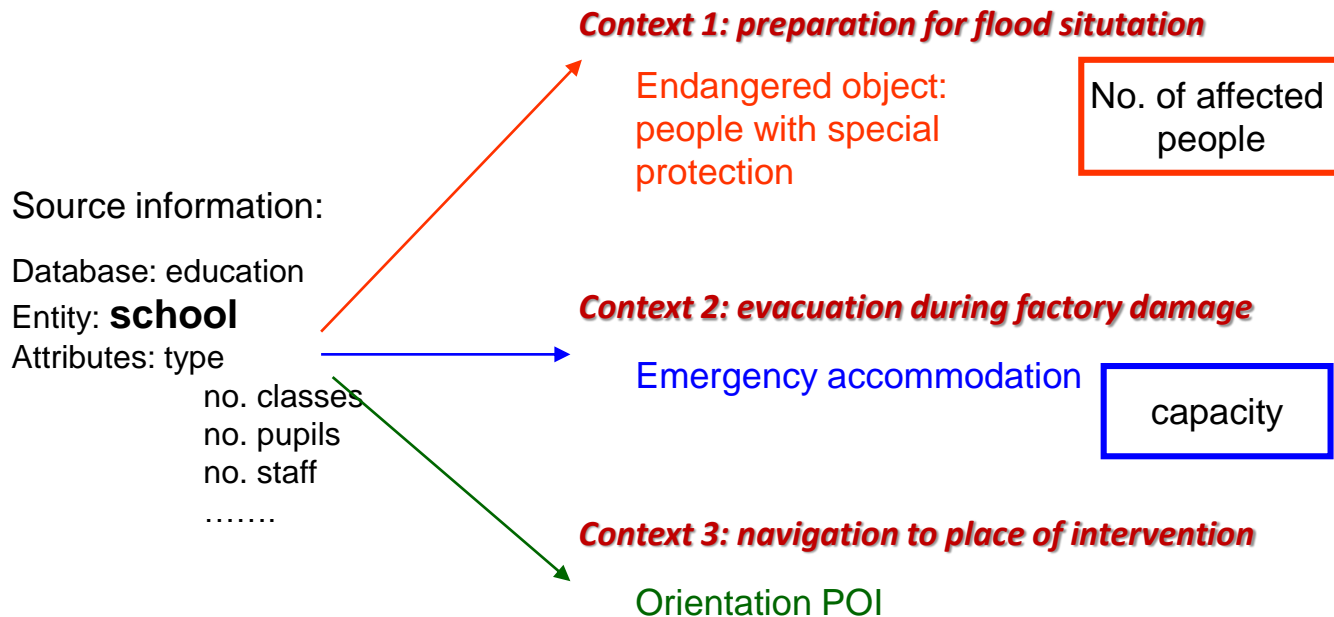
4.a

CONCEPTUAL BACKGROUND IN C2S

Map as decision making tool



Example: one object – more roles

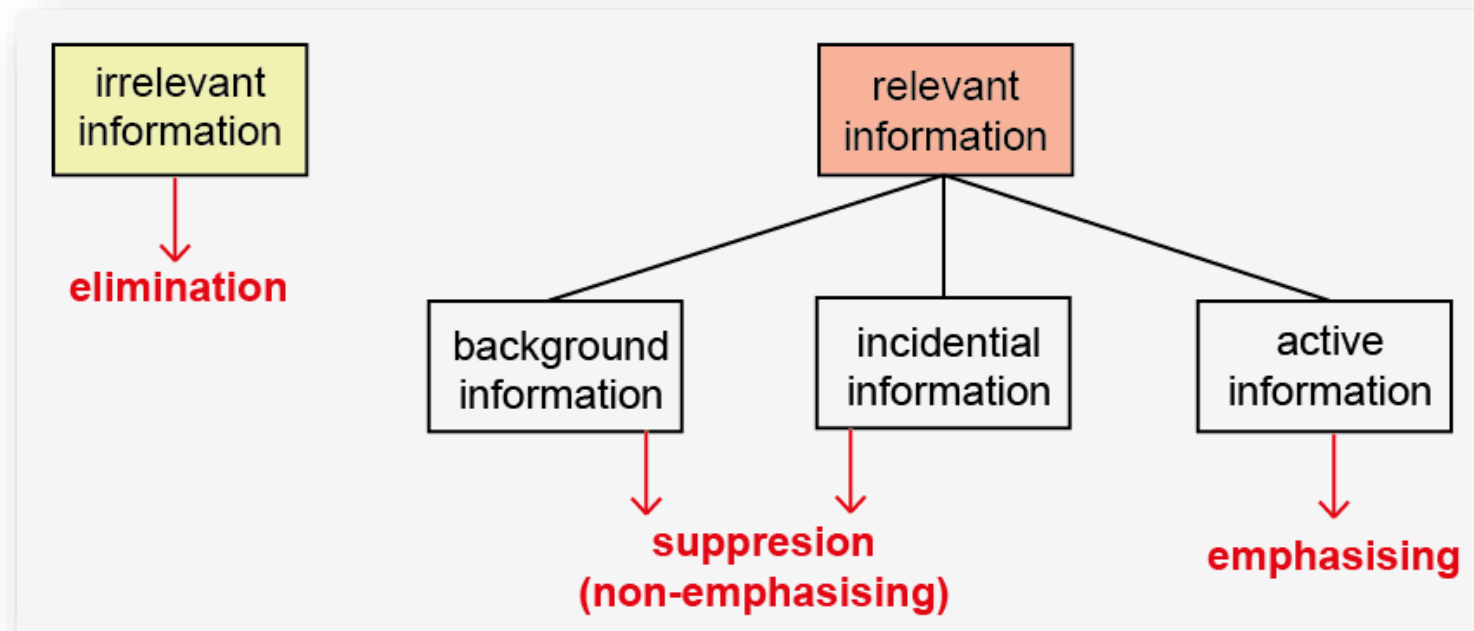


Cartography adaptation

- ***Data content***
 - Question of relevancy – What information is necessary for decision?
- ***Symbology***
 - Symbol must reflect the role of spatial phenomena in decision making process
- ***Generalization***
 - Amount of information on map

Relevancy of geoinformation – cartography aspects

Is spatial object/phenomena relevant for the application?



Symbol adaptation

- ***Intensity of emphasising*** (symbol size, colouring) depends on the degree of relevancy
- more important → more highlighted

- SPATIAL IMPORTANCE
- SEMANTICAL IMPORTANCE
- TEMPORAL DYNAMICS

Spatial importance

houses **vs.** expected flood extent

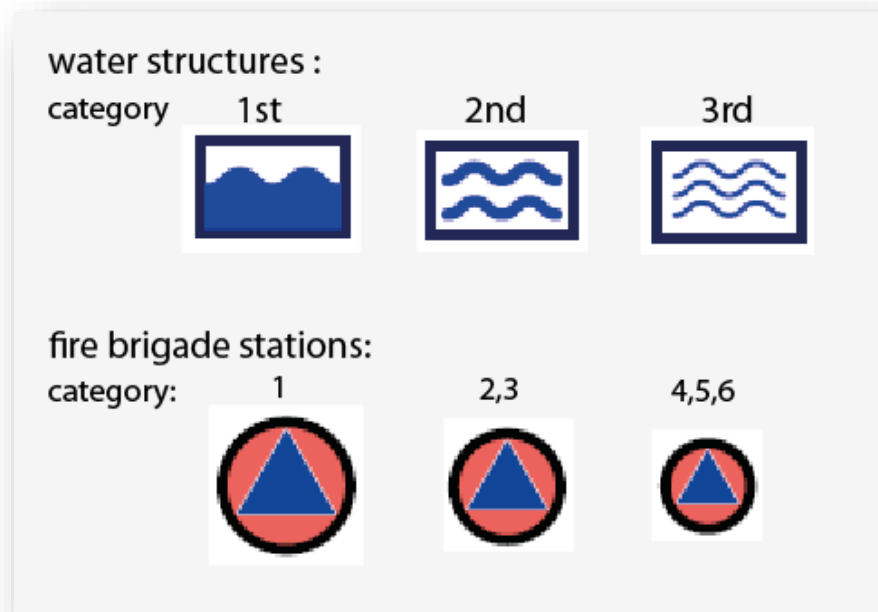


moving vehicle **vs.** critical infrastructure (CI)



Semantical importance

Categorization relevant to application



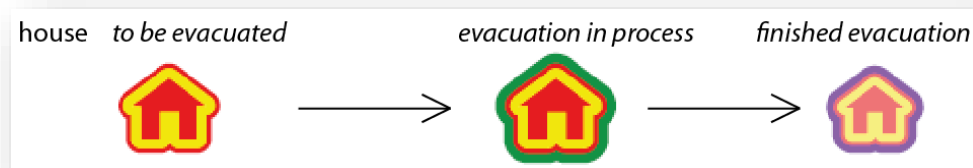
Temporal dynamics

⇒ STATUS OF OBJECT

Disaster dynamics - change of the object status due to disaster








Task dynamics - change of the object status due to progress in task

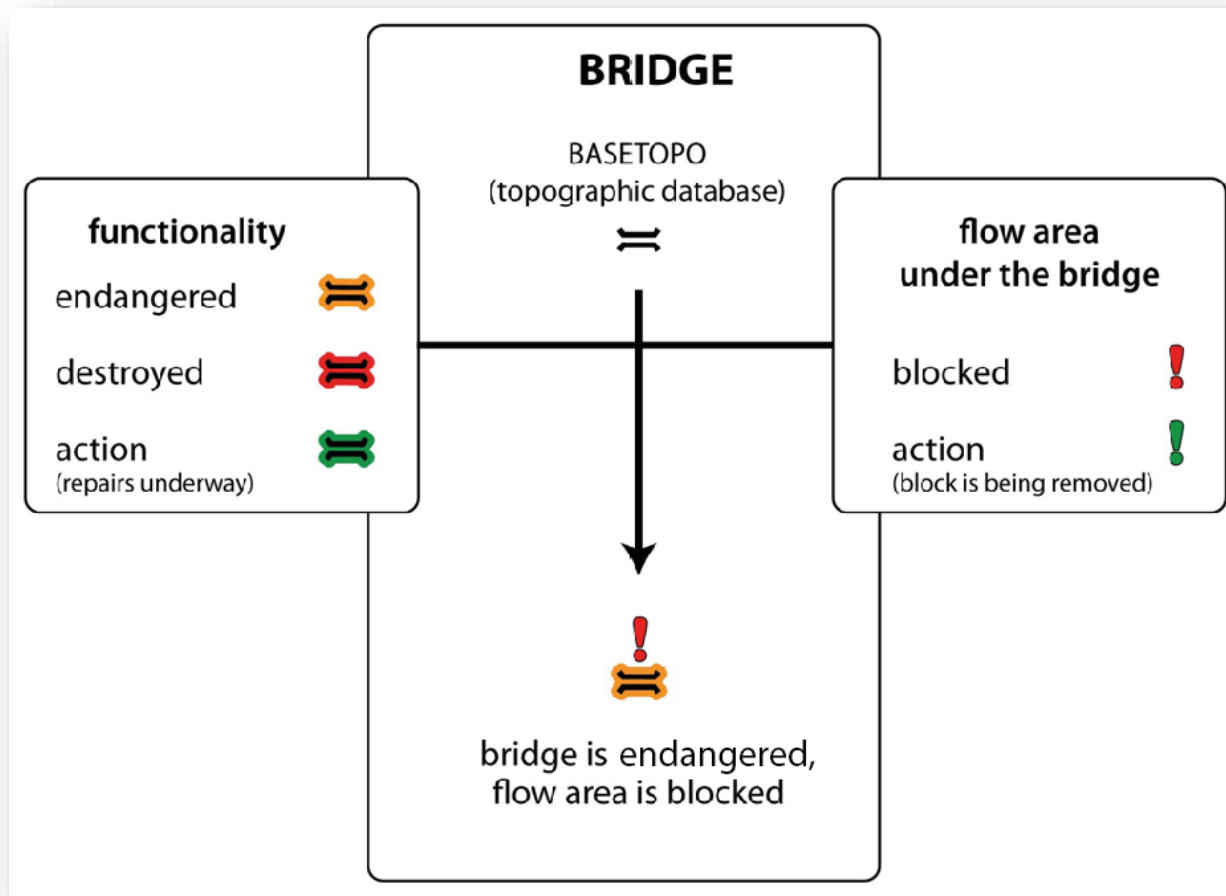


Temporal dynamics of object

- Main colour schema

- functional 
- endangered 
- destroyed 
- in action 
- repaired 

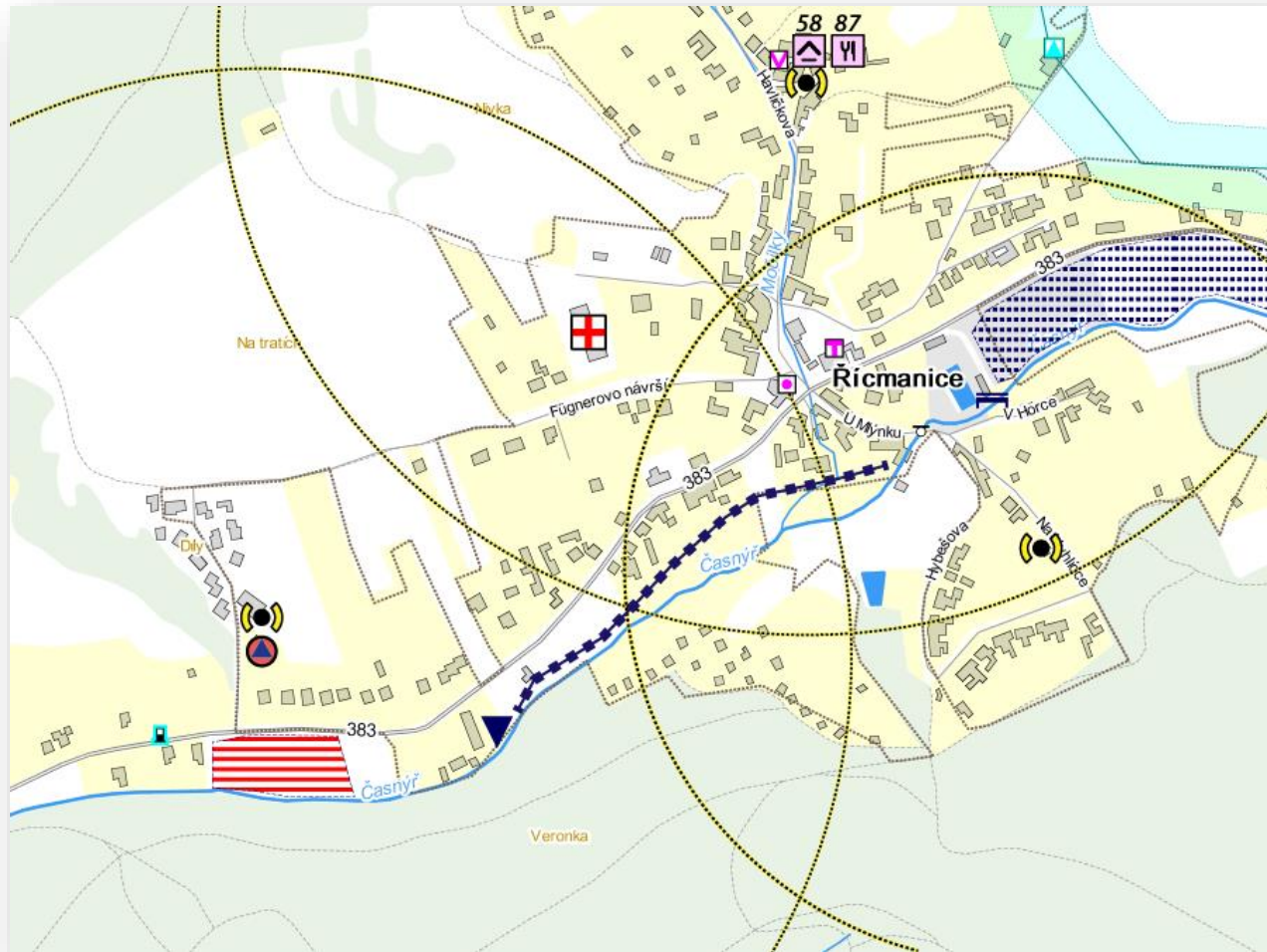
Example: BRIDGE – symbol syntax



Example: COLOUR SCHEMA APPLIED ON ROAD SYMBOLS

		ENDANGERED	DESTROYED	ACTION (REPAIRS ARE UNDERWAY)	REPAIRED
HIGHWAY					
ROAD, 1st class					
ROAD, 2nd and 3th class					
ROAD, other					
RAILWAY					
TRAM, TRACK ...					
TUNNEL					

Context map sample - WMS



4.b

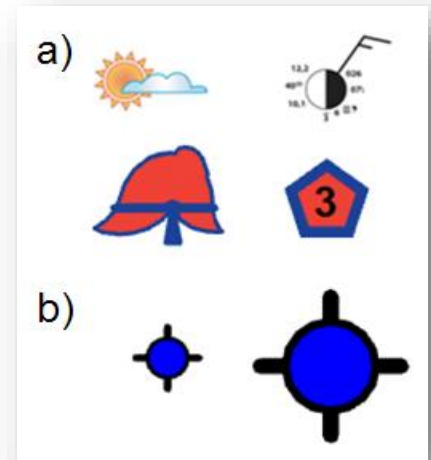
CONTEXT IN CRISES MANAGEMENT – CONCEPTUAL FRAMEWORK

Context

- set of factors that influence ***legibility and usability*** of the map
- What factors influence it the most?
 - ***WHO*** (identity context),
 - ***HOW*** (function context),
 - ***WHAT- WHEN-WHERE*** (emergency context)

Identity context

- *“Who will use the map? Who is responsible for what?”*
- Influence:
 - Visualization method
 - a) different educational background,
 - b) different eyesight - size
 - Authorization rights
 - (which data are administered by the user)
- *User groups: e.g. POLICE, FIRE RES.SERVICE, WATERCOURSE MANAGER, FLOOD AUTHORITY OF THE MUNICIPALITY...*



Functional context

- *“How the map will be used? What is the function of the map in the decision making process?”*
- Functions:
 - **INFO** - to know “what is where”
 - **CONTROL** - to update status of spatial objects (e.g. bridge is destroyed, road is closed)
 - **ORGANIZE** - to create new object (e.g. place where intervention is necessary, place of ice blockage)
- Influence GUI

Emergency core context

- ***What?*** – EVENT + ACTIVITY
- ***When?*** – *STAGE*
- ***(Where?)*** – *OPERATIONAL RANGE*

- refers to the issue of data content
- Influence cartography model

Activity + Event

- **WHAT?**
- *What activity within which event should be supported with the map? What needs to be done?*
- GENERAL (in colour) vs. EVENT-SPECIFIC ACTIVITY

<i>events:</i>	FLOOD	TRANSPORT	FOREST FIRE	RADIATION ACCIDENT
<i>activities:</i>	ORGANIZATION RESCUE PREDICTION TECHN. SUPPORT	ORGANIZATION PERIMETER MONITOR	ORGANIZATION PERIMETER	ORGANIZATION PERIMETER RESCUE

- Influences
 - what information will be on map
 - amount of information presented on map is minimised to level of task being solved

Example: ACTIVITIES within EVENT Flood and Transport

FLOOD

- *PREDICTION AND PROGRESS* - development and expected progress of the flood
- *TECHNICAL SUPPORT* – technical support in inundation area – support of Flood Security Activities
- *RESCUE* – evacuation of the citizens
- *ORGANIZATION* – organization of power and means
- *PUBLIC INFORMATION* – information for public about flood development, evacuation etc.

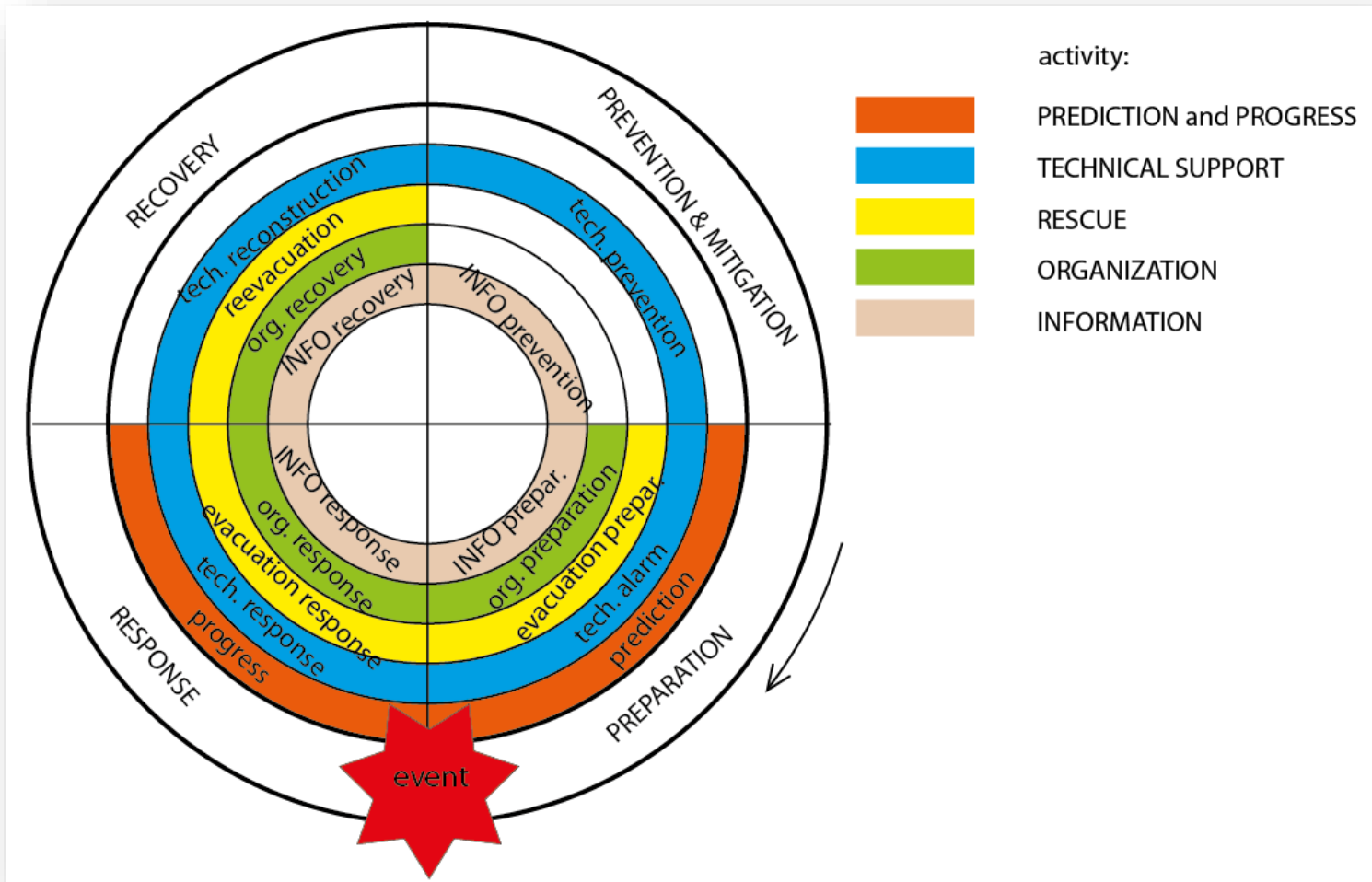
TRANSPORT

- *MONITOR* – monitoring of the vehicle with dangerous substance
- *PERIMETR* – organization in the place of the incident
- *ORGANIZATION* – organization of power and means

Stage

- **WHEN?**
- *In what phase of the emergency event the activity is realised?*
 - **prevention** (e.g. out of the flood)
 - **preparation** (e.g. shortly before the flood/before the potential vehicle accident)
 - **response** (e.g. during the flood, just after the vehicle accident)
 - **recovery** (after the flood)

Example: ACTIVITIES in different STAGES of FLOOD

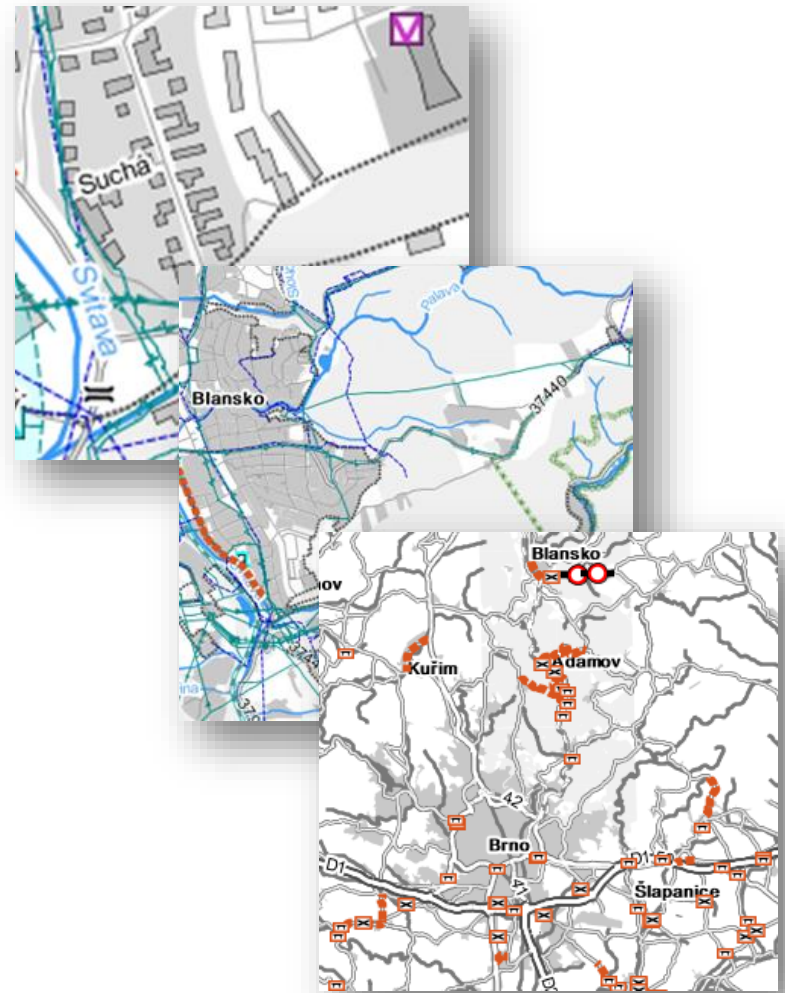


OPERATIONAL RANGE

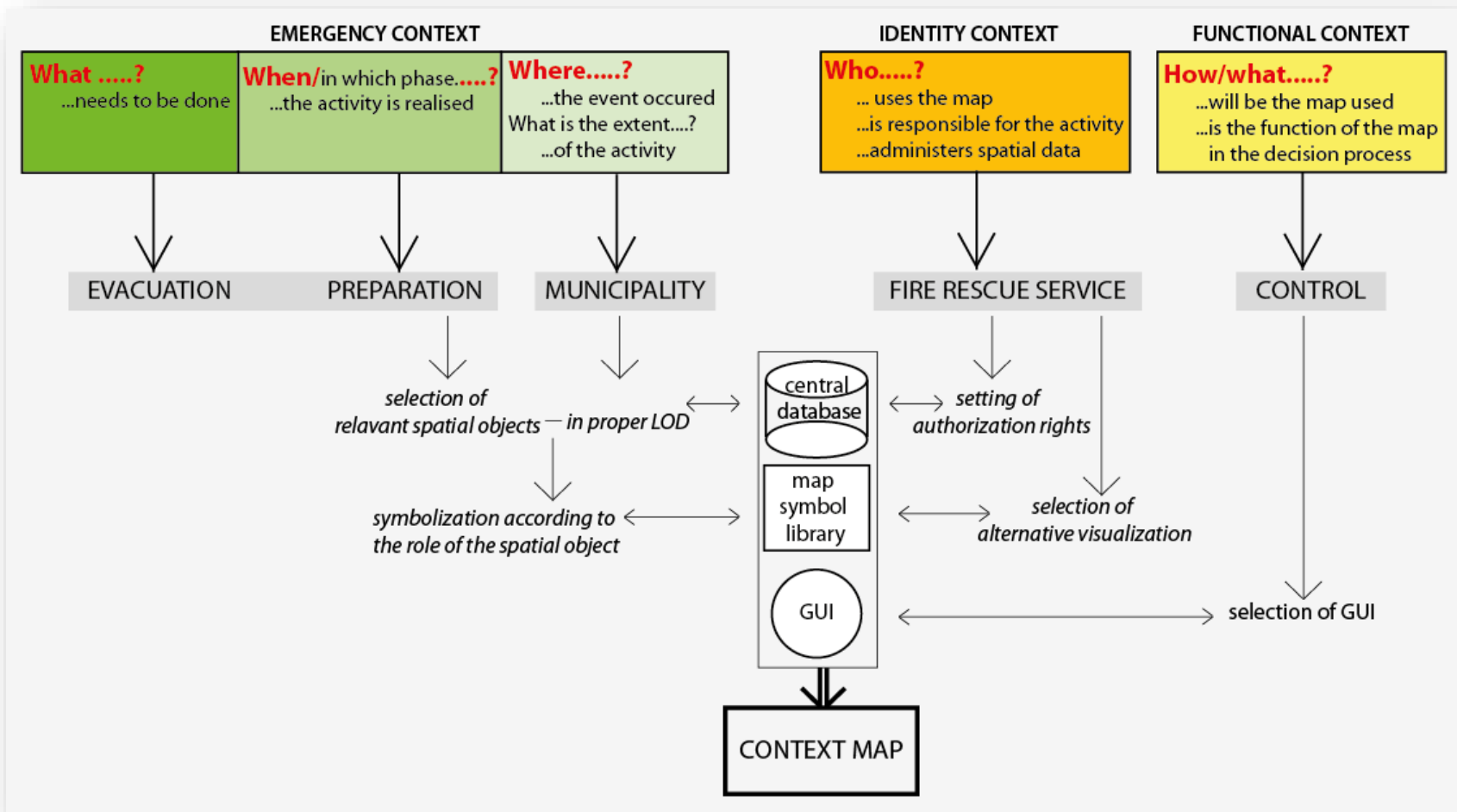
- **WHERE?**
- *Where the event takes place? What is the event extent? What is the activity extent?*
- Influences:
 - Amount of information portrayed on the map
 - According to the Level Of Detail – method of generalization
 - According to the Character of the Region (URBAN, SUBURBAN, RURAL) – lower importance of certain spatial objects in „information-dense“ regions, higher in „information-diluted“ regions

Operational range - definition

1. DETAIL – 0-5K
 2. LOCAL – 5K-10K
 3. MUNICIPALITY – 10K-50K
 4. DISTRICT – 50K-200K
 5. REGION/CATCHMENT – 200k-1M
- LOD's 3, 4 and 5 is defined to capture appropriate administrative/natural unit on screen

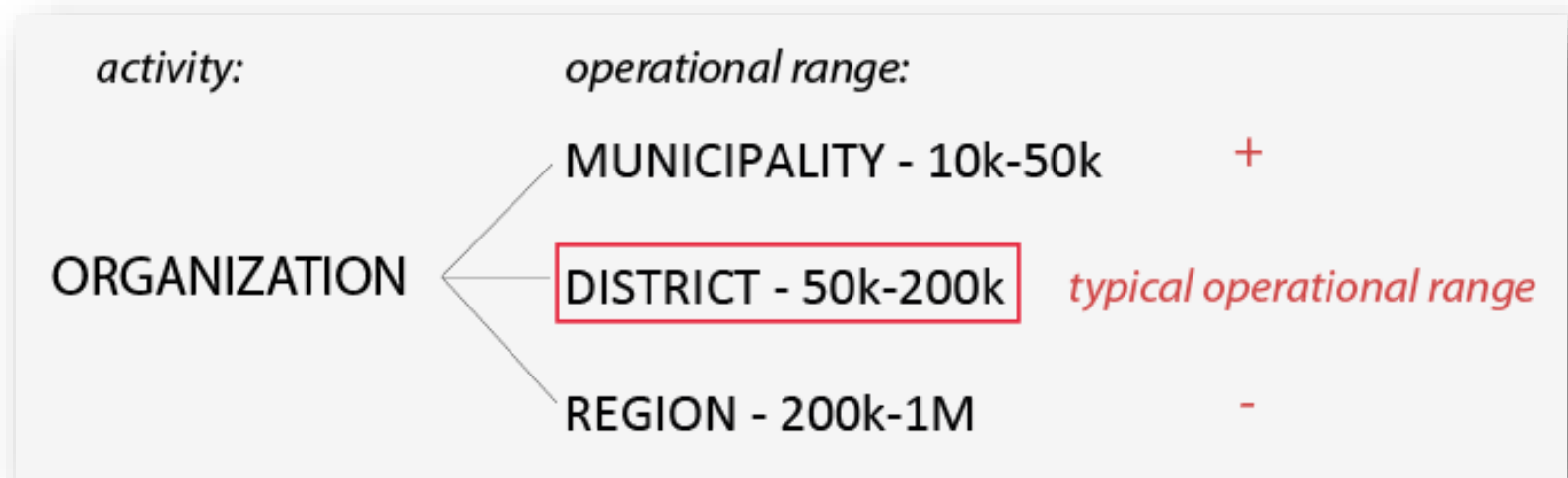


Context composition – conceptual framework



Cartography model

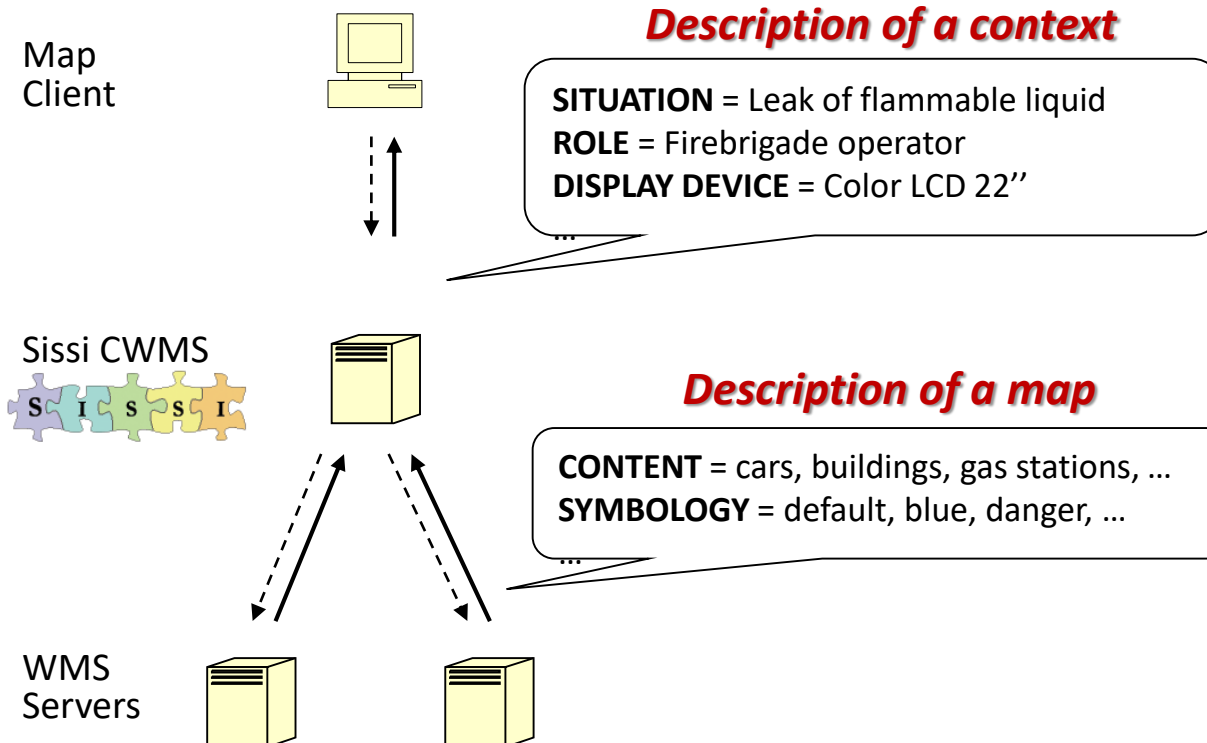
- **Cartography model** is defined for each **emergency core** context and the operational range in which the activity is typically done + one lower and higher LOD




Data content

- ***Background data:***
 1. **BaseTopo** - Topographic Data and Other Background Data (Fundamental Base of Geographic Data 1:10K, Orthofoto, Cadastral Maps, Digital Elevation Model, Admin. Boundaries)
- ***Thematic data:***
 2. **Universal Crises** – (Critical Infrastructure, Technical Infrastructure, Social Infrastructure, Environment)
 3. **Specific Crises** – (Flood - Flood Zone Mapping, Flood Management Plan, Flood Modelling, Transport - Sensor data)

Implementation of CWMS

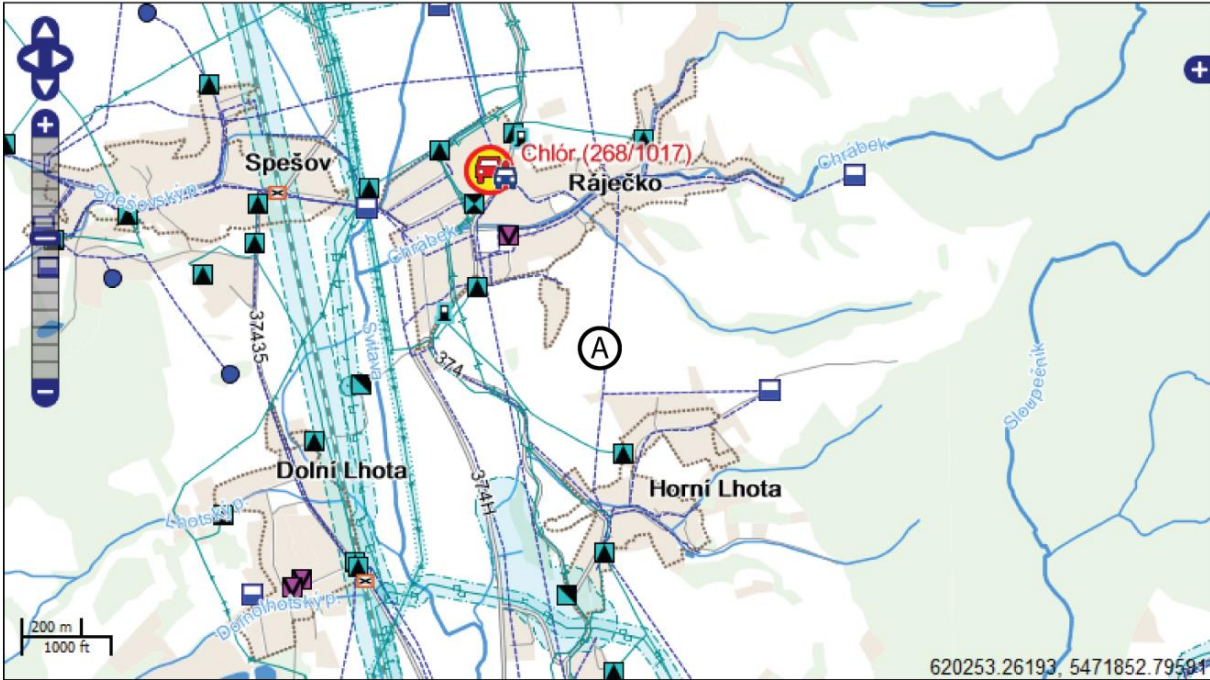



Contextual map in CWMS client

S I S S I Kontextová mapová služba  Klient: Jan Palas
Server: Jiří Kozel, Radim Štampach







Situace: monitor **(E)** Verze: barevný podklad

Legenda: zobrazit **(D)** SRS: EPSG:32633 Měřítko: 1:19 762






(C) 


(B) Vozidlo


- testovací vozidlo
-  zásahové vozidlo
-  sledované vozidlo
-  sledované vozidlo v KI techno
-  sledované vozidlo v KI socio
-  sledované vozidlo v KI enviro
-  havarované sledované vozidlo

Dopravní informace

kritický úsek

-  podjezd
-  přejezd
-  most

 dopravní uzavírka

 úsek dopravních nehod