Supporting enhanced disaster management with interactive 3D and Mixed Reality Maps
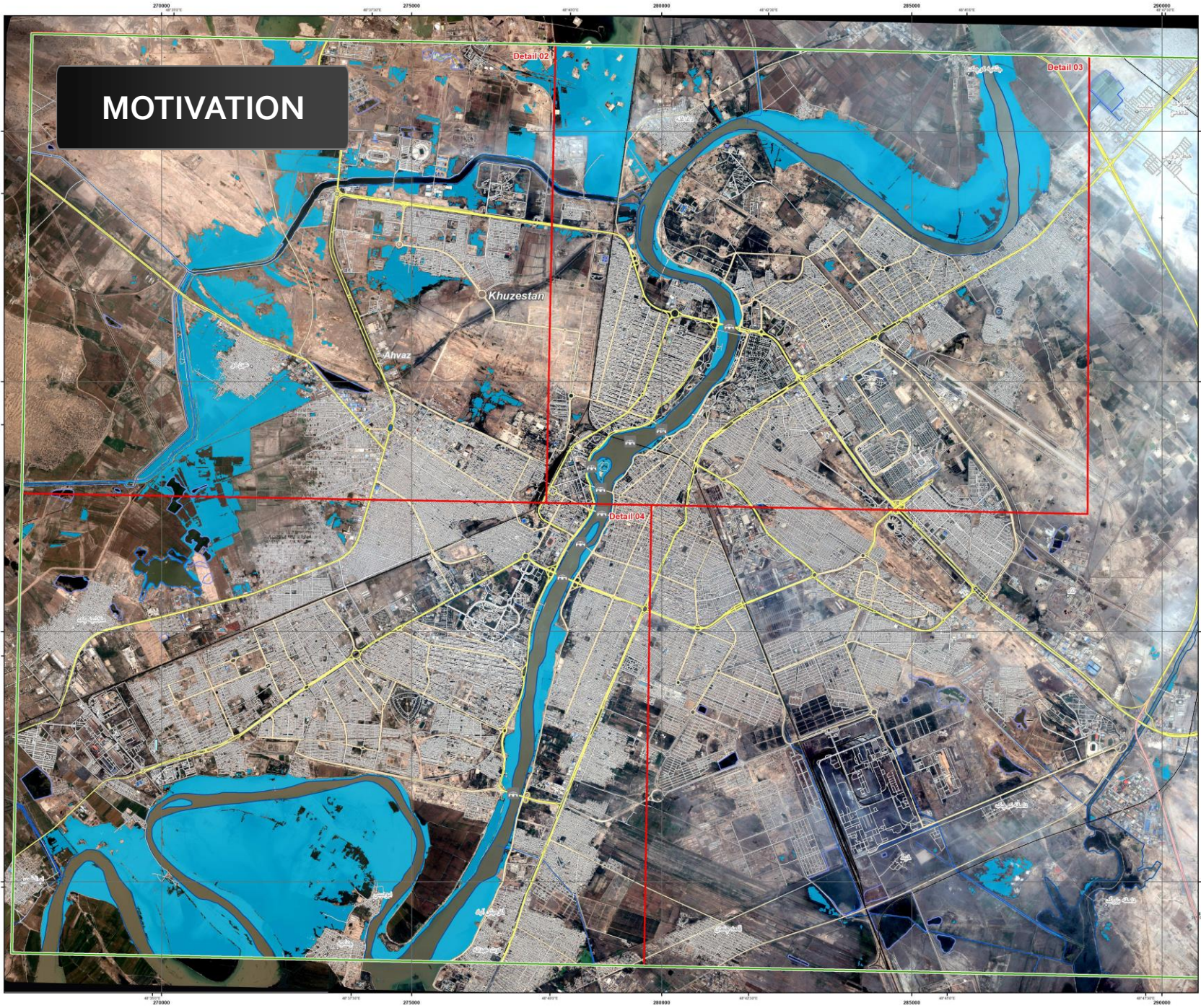
Master Thesis Defense

24.09.19

Kevin Patrick Helzel

Fig.1: COPERNICUS EMS
DELINEATION MAP
SOURCE: Copernicus
EMS, 2019

MOTIVATION

Research Objective

To test and investigate the benefits as well as the usability of 3D and Mixed Reality Maps facilitating crisis communication of disaster information and planning of disaster response during the process of disaster or emergency management.

Hypotheses

H1: Present cartographic products in the field of disaster management do not facilitate an effective management of disasters.

H2: Mixed Reality and 3D maps are useful tools for disaster visualizations and planning of response during disaster management activities.

Methodology: Research Design

Literature Review

User Requirement's Survey

Analysis of Status Quo

Choosing use case scenario(s)

Choosing visualization software and technology

Developing (1): Maps

Developing (2): Interaction

Developing (3): User Interface

User Feedback: Expert Interviews

Final Model

Discussion and Outlook
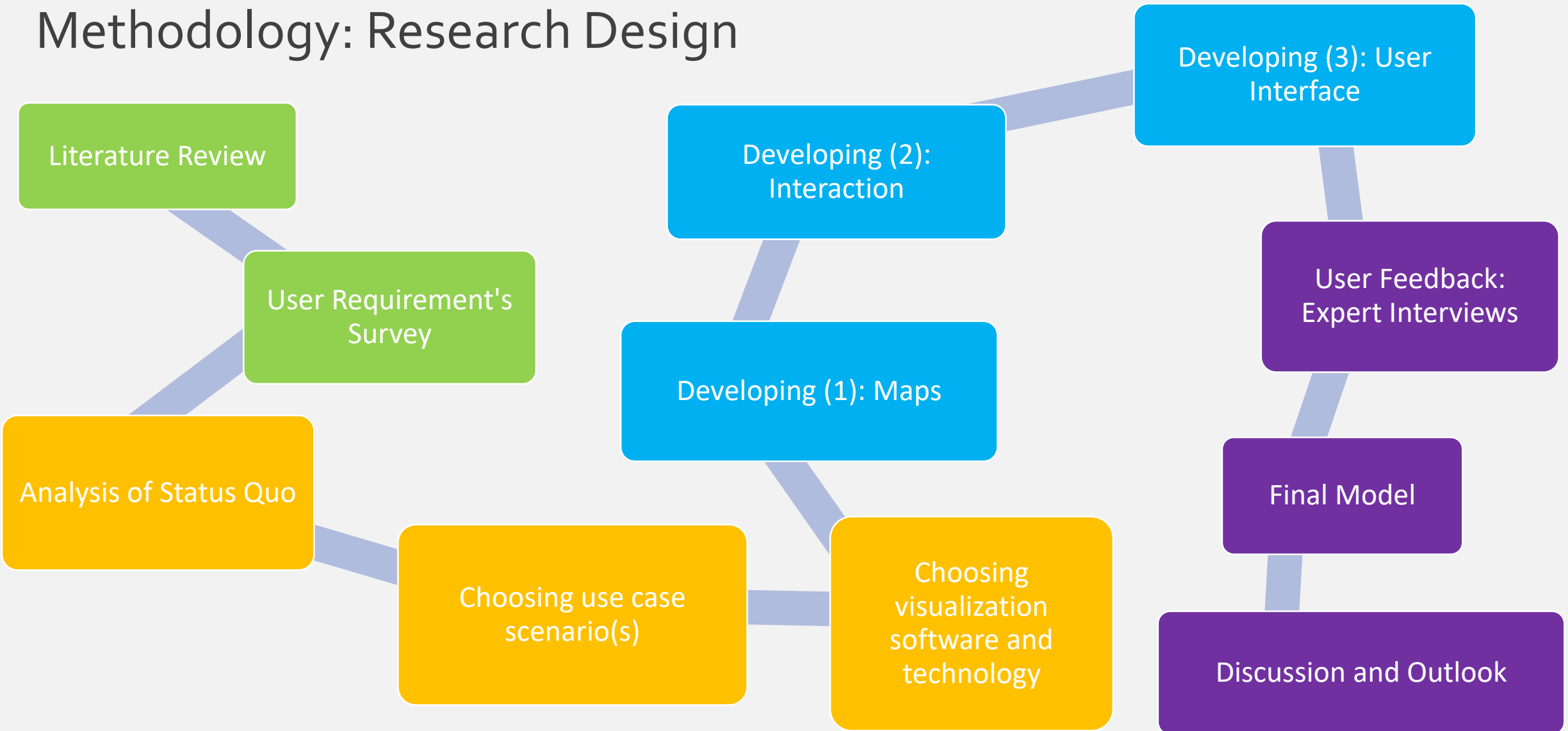
→ Research design based on a *mixed-methods approach* and *user-centred design principles*

Definitions I

→ Reality Technologies: Virtual Reality, Mixed Reality, Augmented Reality

Fig.2: DIFFERENTIATION BETWEEN REALITY TECHNOLOGIES
SOURCE: adapted from Valendu, 2018
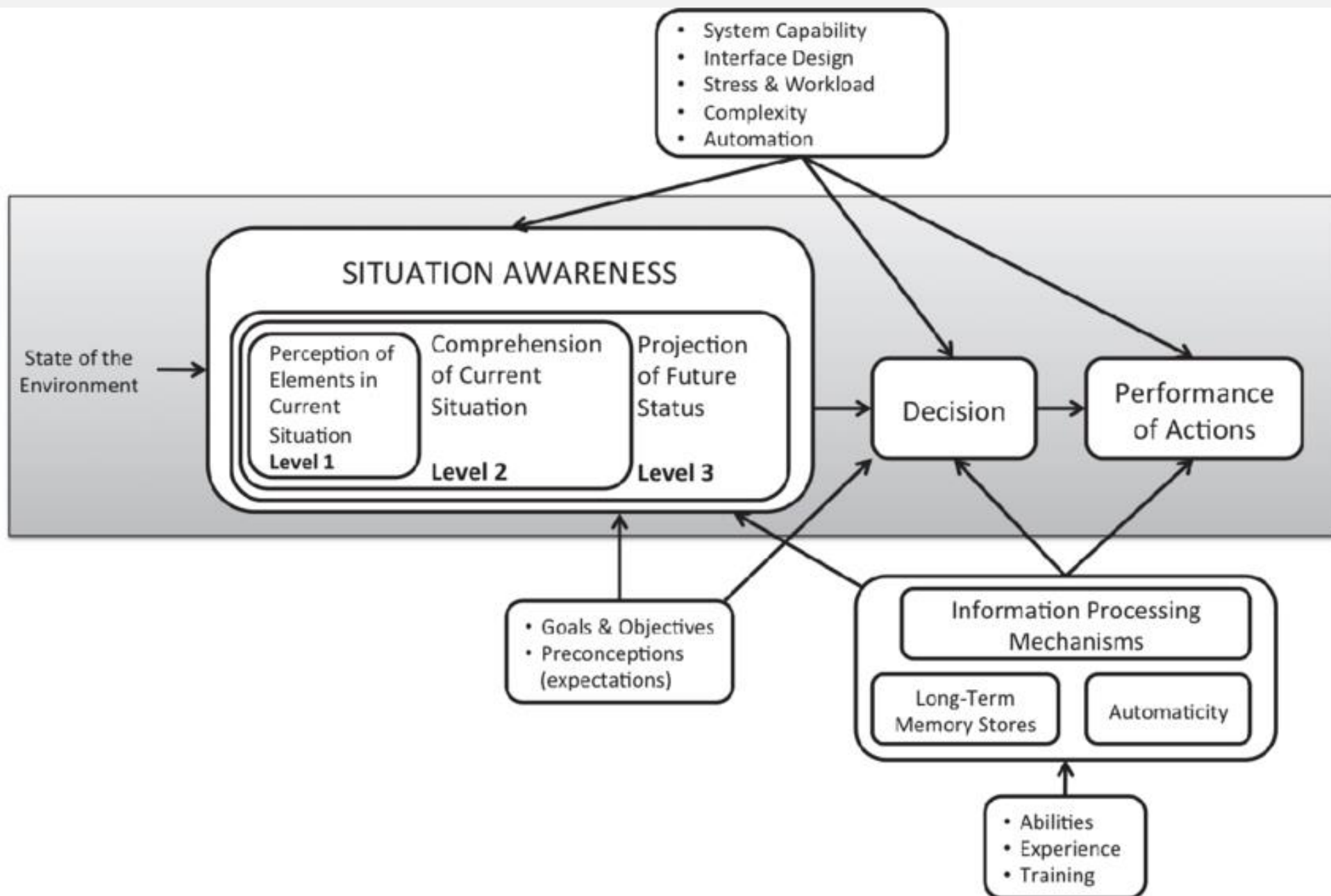
Fig.3: ENDSLEY'S SITUATIONAL AWARENESS MODEL
SOURCE: quoted from Oxstrand et al., 2013

RESULTS I: User Requirement's Survey

Pre-Survey: Emergency Management Questionnaire

conducted via SoSci Survey (online).

4 Parts

- Demography, Profession and Experience
- Current problems and biggest challenges
- Disaster maps, information and technology
- Future vision (potential of Augmented Reality)

→ 40 completed questionnaires (☐)
→ 30 filled out 95% of all questions
→ N = 30

SURVEY POPULATION

Map types

→ used during operations for mission planning and/or post-analysis purposes

6%

28%

34%

25%

6%
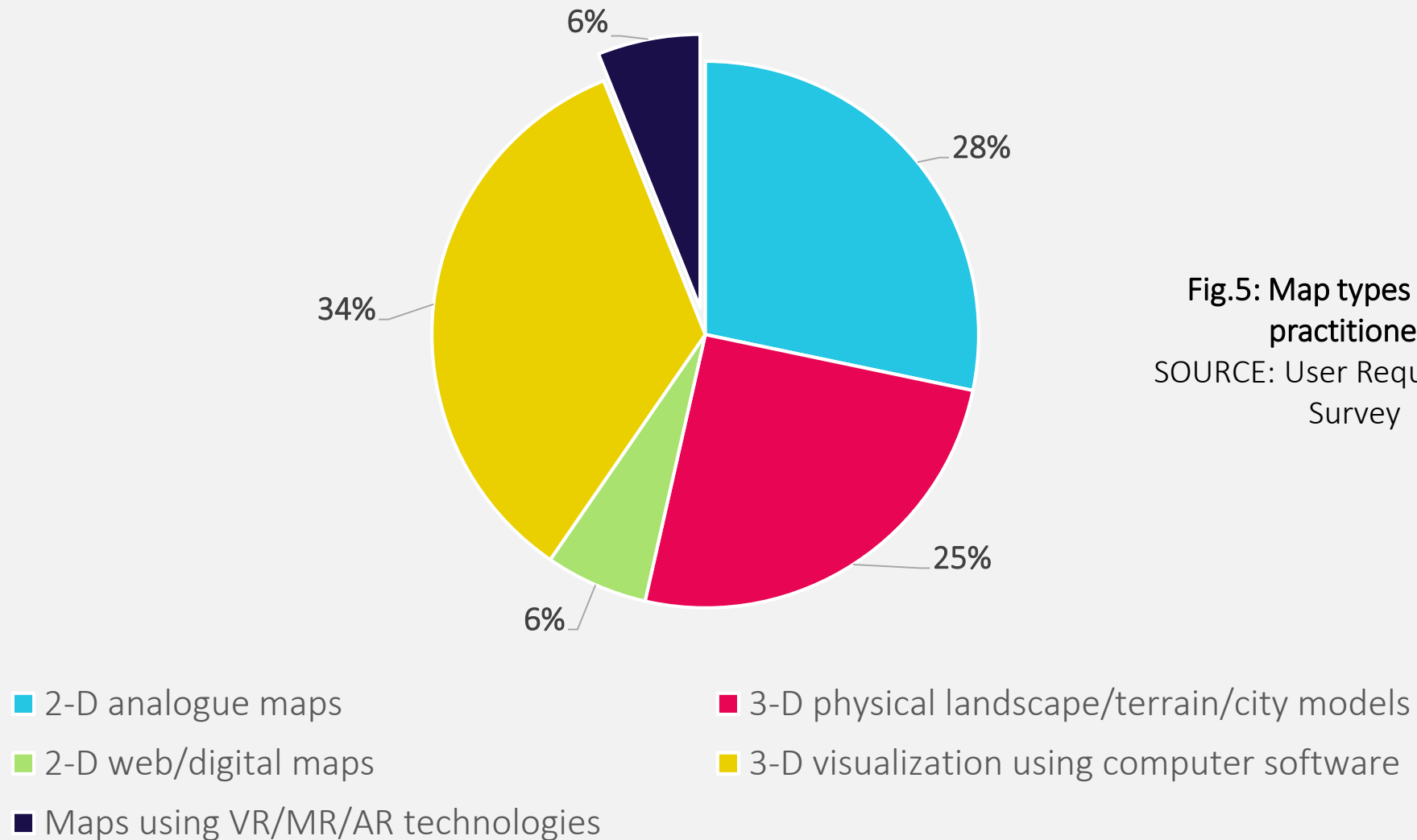
Fig.5: Map types used by practitioners
SOURCE: User Requirement's Survey

- ■ 2-D analogue maps
- ■ 2-D web/digital maps
- ■ Maps using VR/MR/AR technologies
- ■ 3-D physical landscape/terrain/city models
- ■ 3-D visualization using computer software

Quality Evaluation

→ "How satisfied are you with the general quality and the quality of information you receive from your maps?"
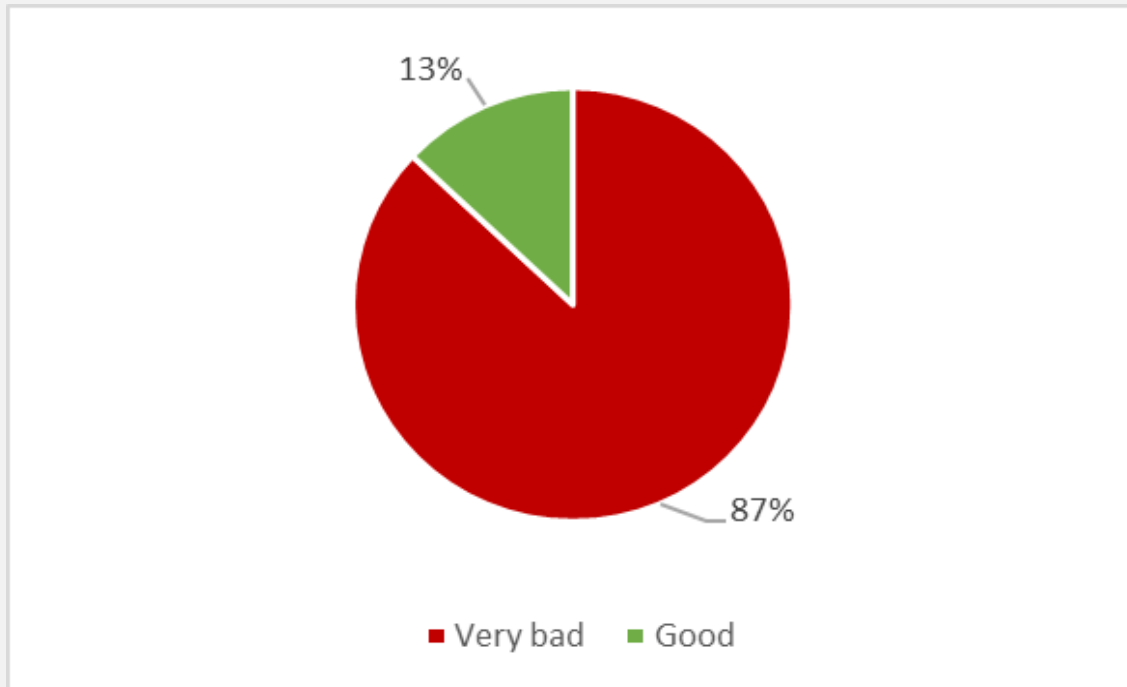
Fig.6: General map quality
SOURCE: User Requirement's Survey
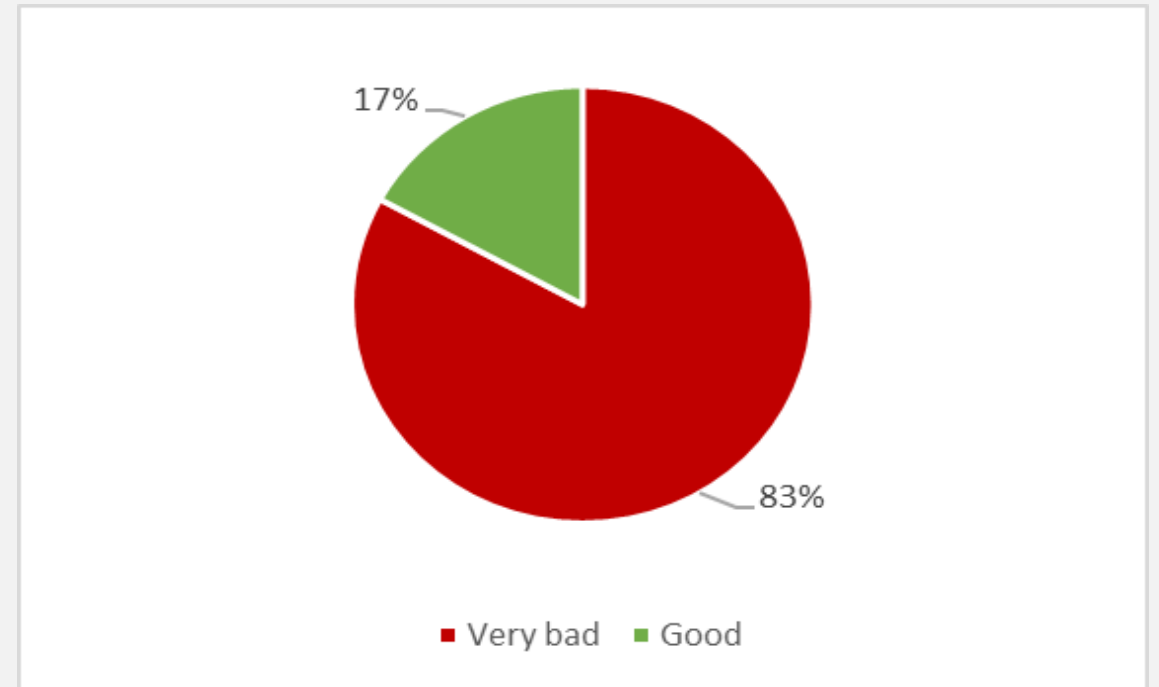
Fig.7: Information quality of maps
SOURCE: User Requirement's Survey

Problem Areas and Challenges

- Facing of *unexpected situations* in *unexpected environments*

- Missing *human* and *financial resources*

- Slow *process of digitalization*

- *Clean communication* without any information loss

- *Lack of acceptance* of EM and disaster protection in politics, society and administration

Information Needs and Requests

Real-time information

Pictures and videos from the scene

Fast update cycle

Damage extent and propagation

Live data about objects

Drones and satellite imagery

Complete and reliable
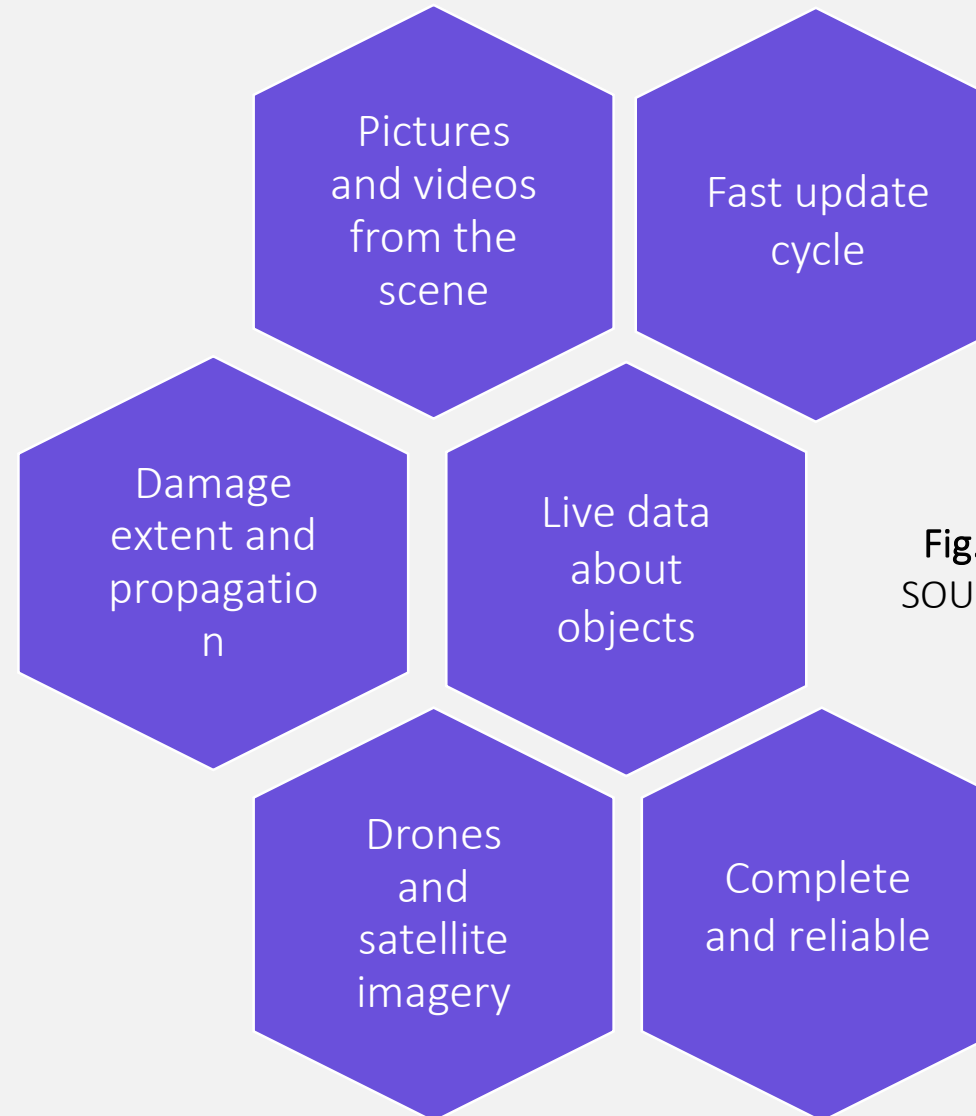
Fig.9: Real-time information needs
SOURCE: User Requirement's Survey

RESULTS II: Use-Case Modelling

Own visualization approach

- **Tabletop-MR application for Android platform**
- Designed for the management and planning of disaster relief activities
- Easily adaptable to other emergency/crisis situation

Software Development

- Developed inside Unity IDE
- Integration of Mapbox Maps SDK
- Integration of WRLD 3D SDK (indoor maps)
- Several AR packages
- <u>End product</u>: Unity Android application package

Fig.10: DiMAN disaster management application

EMSR501: ISTANBUL (TUR)

Event Time (GMT+3:00): 2019-08-12 08:43
Event Type: Earthquake (Ground shaking)

//Activation Status: Open
Last Update: 2019-08-14 22:04

⚡ Destroyed
⚡ Damaged
⚡ Possibly damaged

🔥 On Fire
🟩 Safe Zones
✚ Hospitals

Select Basemap...
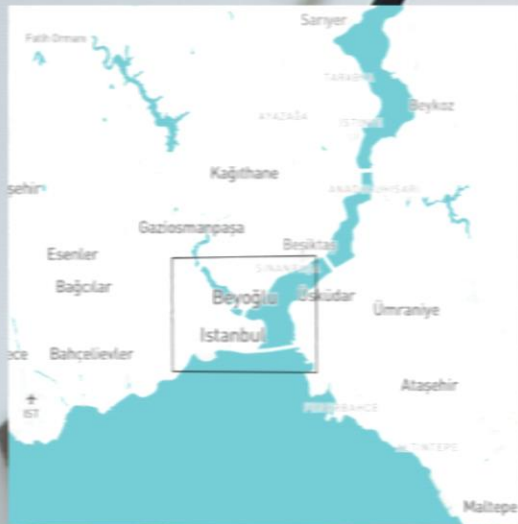
Tabletop-MR-Scene 1: Istanbul (Turkey)

EMSR372: Fire in Castelo Branco

Event Time (GMT+1): 2019-07-20 22:00
Event Type: Fire (Forest Fire)

//Activation Status: Open
Last Update: 2019-07-25 17:05

Area of Interest

Built-Up (Residential)

Rivers & Streams

Burnt Area

Active Flames

Coniferous Forest

Basemap...

Sao Joao do Peso

Serta

Vila de Rei
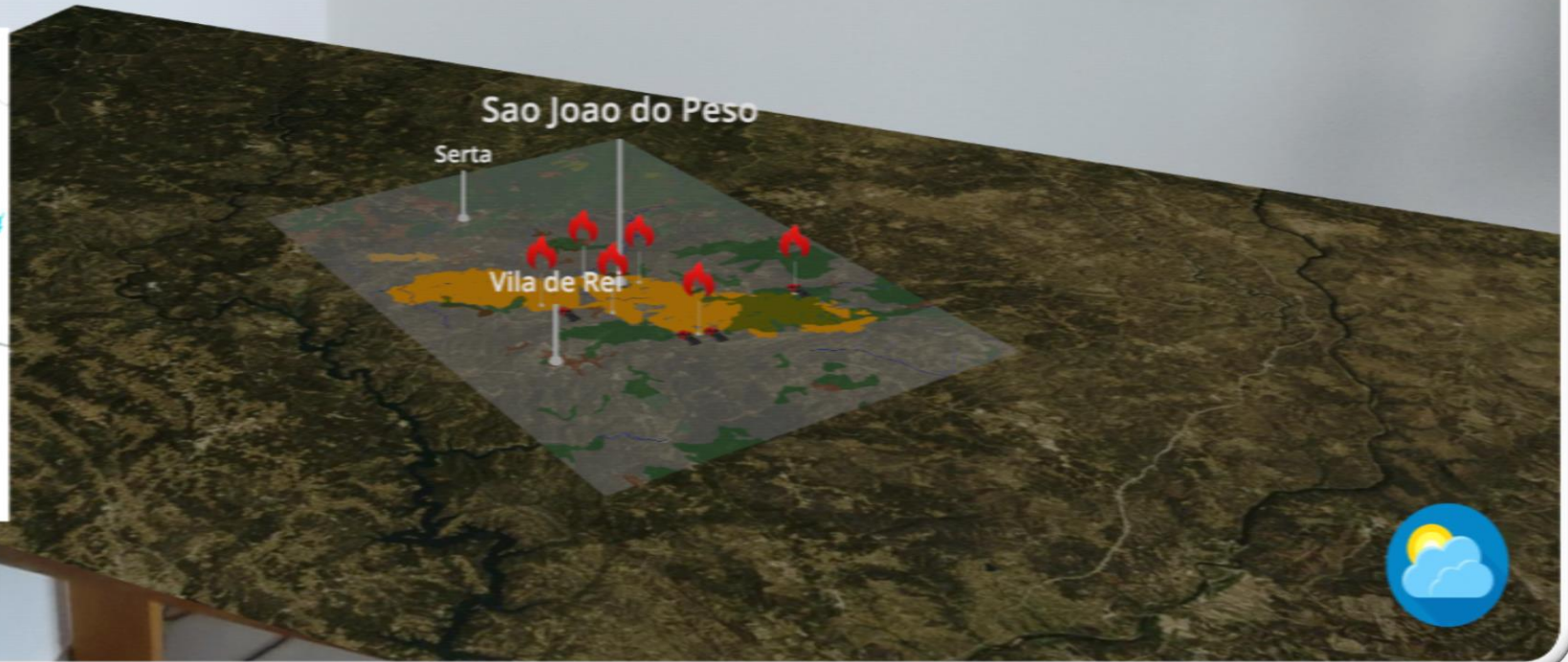
Portugal

Tabletop-MR-Scene 2: Castelo Branco (Portugal)

Prototype feature 1

⭐ Changing of satellite layer/basemap
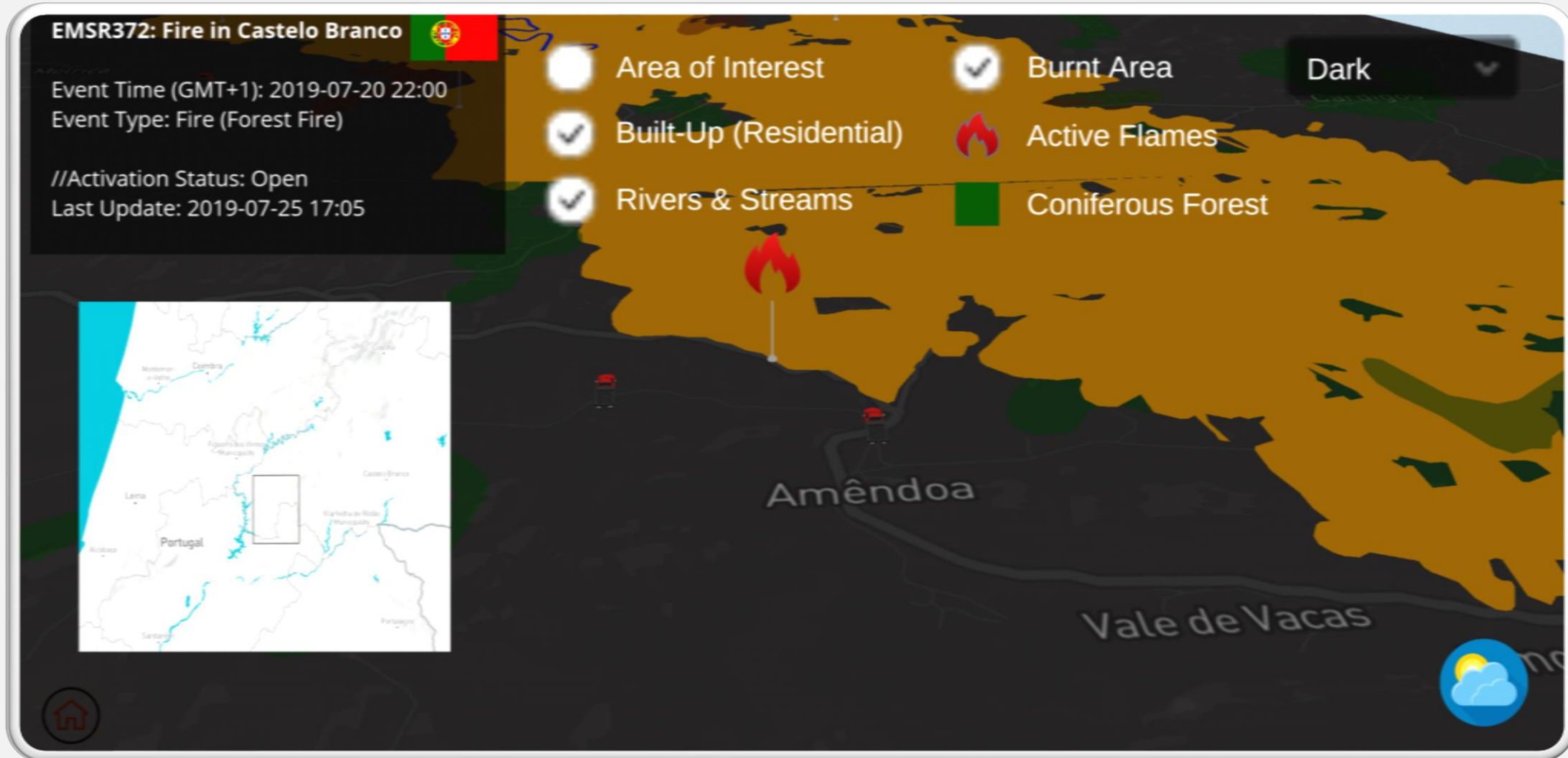
Prototype feature 2

⭐ Different scales/map sizes possible (Zoom In/Out)
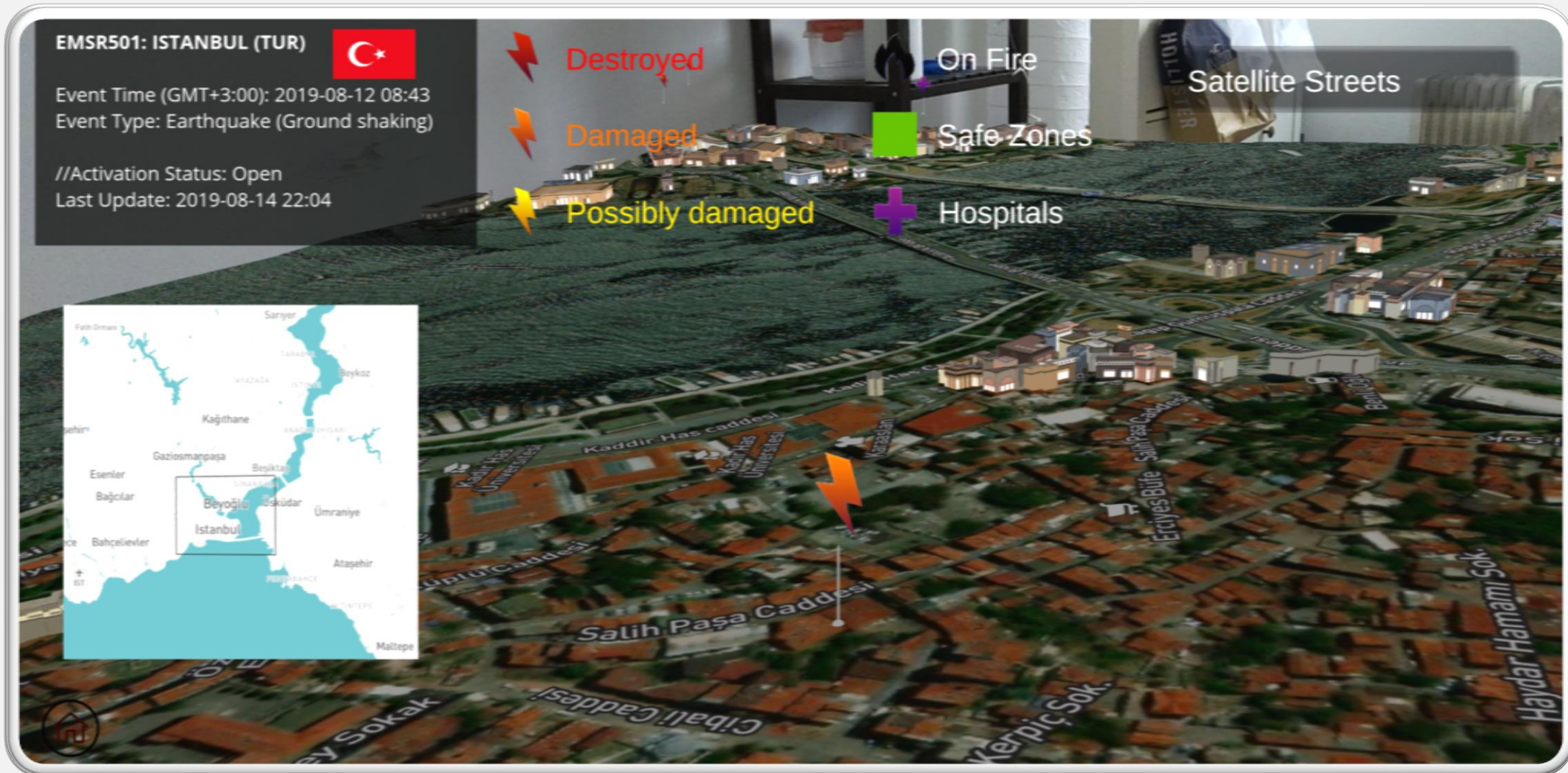
Prototype feature 3

★ Pictures/Videos from the scene can be integrated and displayed on touch

Prototype feature 4

⭐ Layers can be set active or inactive

Prototype feature 5

★ Real-time data implementation possible

➤ GPS positions of vehicles/first responders (at the moment only working in Unity)

➤ Current wind/weather prognosis & forecast (at the moment only via webservice)
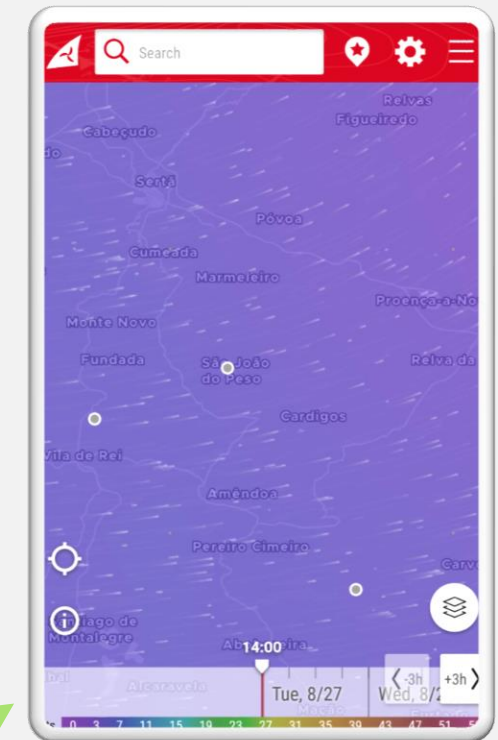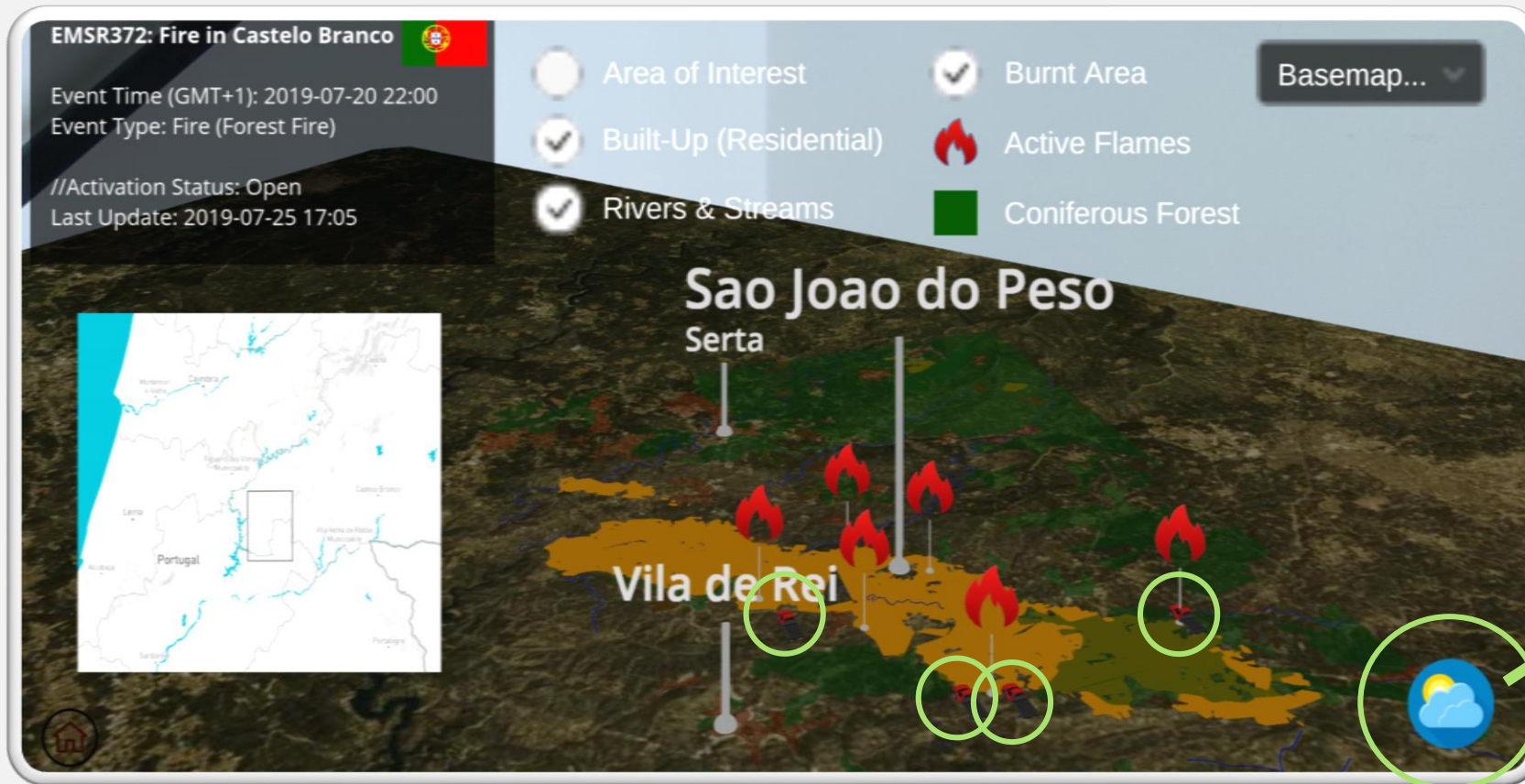
Prototype feature 6

★ 3D Indoor Map Implementation via WRLD 3D Platform
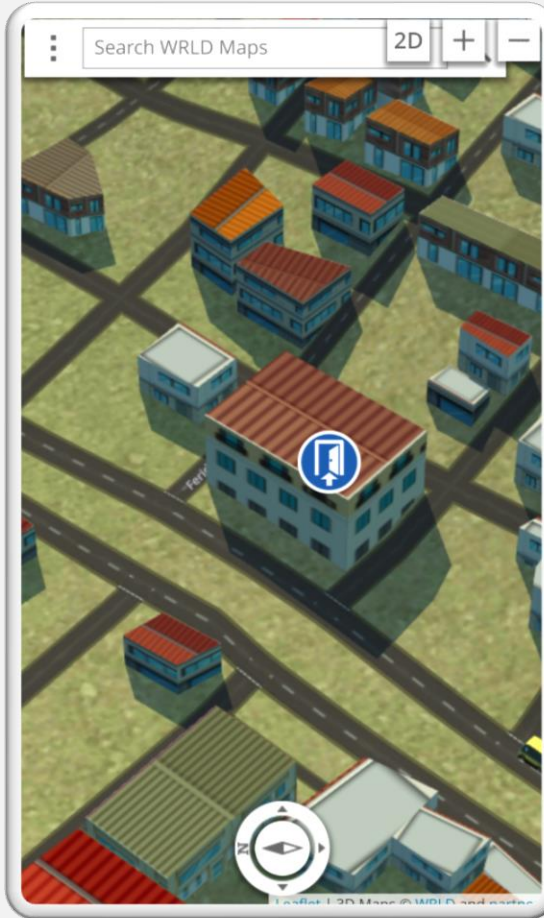
RESULTS III: Expert Interviews

Fig.12: Fire department control room
SOURCE: Own photograph

Core statements

BBK

- ➢ Used map types: *2D static digital maps*
- ➢ DiMAN *evaluation positive*, assumed benefits on all management levels
- ➢ Tabletop-MR approach declared as *science fiction* (not yet deployable at the BBK)

FWM

- ➢ Used map types mostly *analogue* and *on paper*
- ➢ Biggest problem area of used maps: *topicality*
- ➢ DiMAN *evaluation positive*, two main application areas were defined: for the *education of firefighters* and in *crisis rooms*

THW

- ➢ Used map types: *mixed (incl. 3D)*
- ➢ Biggest problem area of used maps: *homogeneity*
- ➢ DiMAN *evaluation positive*, 3D perception of space enhances perception and situational awareness

CONCLUSION

Main Results

❖ Disaster Management is a *complex*, *interdisciplinary* and *multi-actor* **process**

❖ Slow **innovation lifecycle** in EM

❖ Very **negative assessment** of *used maps* and *displayed information* by practitioners

❖ Clear *demand* of more **real-time data integration** into maps

❖ **Benefits/Potential** of cartographic 3D/MR visualizations were *indicated* in the survey and *confirmed* by experts from the field

❖ Developed **Tabletop-MR application** considered useful in *crisis rooms* and for *EM situation training* of practitioners

❖ **Limitations** exist in the form of *model sensitivity* to environmental influences, *data availability* and *hardware dependency*

❖ **Future research** should be pointed at *specific disaster types*

References

- Copernicus EMS (Cartographer). (2019). [EMSR352] Ahvaz detail: Grading Product, version 2, release 1, RTP Map #01. URL: https://emergency.copernicus.eu/mapping/list-of-components/EMSR352
- Onslow County NY (2019). Emergency Management. URL: https://www.onslowcountync.gov/581/Emergency-Management
- Oxstrand, Johanna & Ohara, John & Blanc, Katya & Whaley, April & Joe, Jeffrey & Medema, Heather. (2013). Development of an Initial Model of Human- Automation Collaboration – Results From a Needs Analysis.
- Valendu (2018). What is the difference between virtual reality, augmented reality and mixed reality? URL: https://medium.com/@valendu/what-is-the-difference-between-virtual-reality-augmented-reality-and-mixed-reality-67dfec904c64

ThankYou!

Kevin Helzel

+49 160 7709727

kevin.helzel@tum.de

TECHNISCHE UNIVERSITÄT MÜNCHEN