MINE ACTION 2026
March 23-25 2026
Hotel Le Meridien Lav, Split

Methodological challenges in the approach to complex humanitarian demining

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Introduction

- Research team from **University of Split**, Croatia
- Teaching students at **Engineering Faculties**, and Navy cadets at **Military Maritime Studies**
- R&D projects and collaboration with **Coast Guard of the Republic of Croatia**, **Croatian Mine Action Centre** and **International Mine Action Community**

OBALNA STRAŽA REPUBLIKE HRVATSKE

hcr
HRVATSKI CENTAR ZA RAZMINIRANJE
CROATIAN MINE ACTION CENTRE

TIRAMISU
Toolbox Implementation for Removal of Anti-personnel Mines, Submunitions and Uxo

Sveučilište u Splitu
Fakultet građevinarstva, arhitekture i geodezije

SVEUČILIŠTE OBRANE I SIGURNOSTI DR. FRANJO TUĐMAN

War experience

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Croatia in 1991

Croatia today

Post-war experience

1991

Republic of Croatia

Population: **4.800.000**

1991-1995

The Croatian War of Independence

Death toll: **15.000**

2021

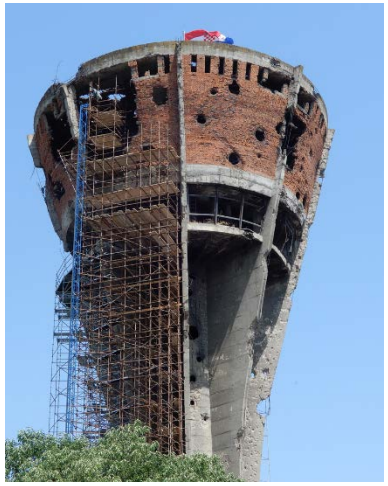
Republic of Croatia

Population: **3.800.000**

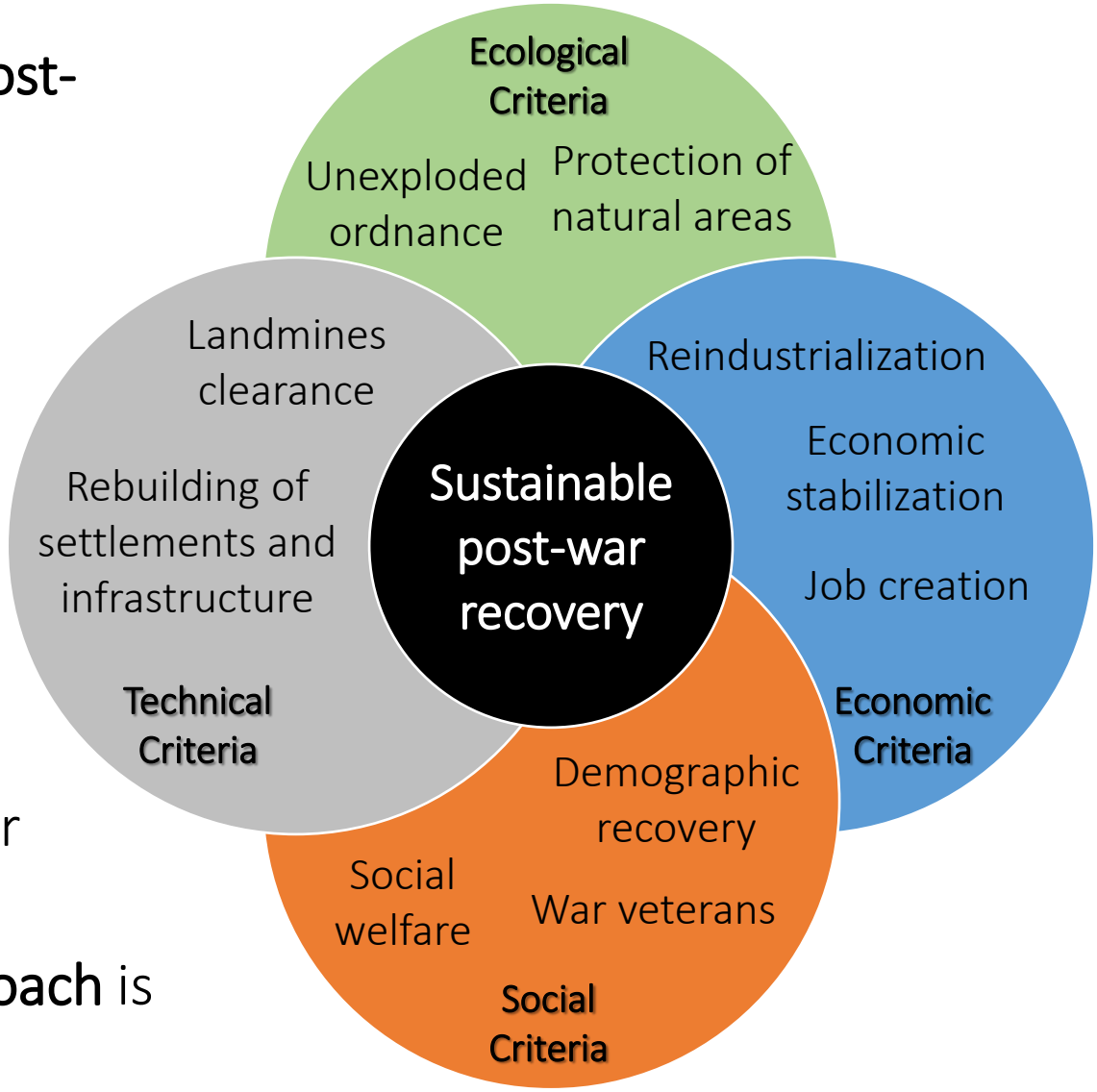
- Has Croatia **actually lost 1 million people** because of the war?
- Has **post-war recovery failed** in Croatia?

Recovery experience

- Usually, focus of **post-war recovery** is on **reconstruction**

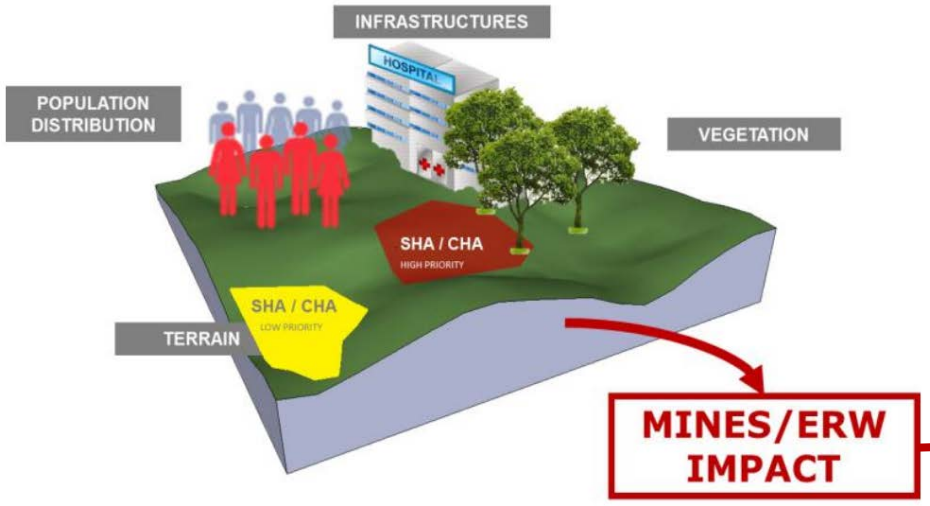


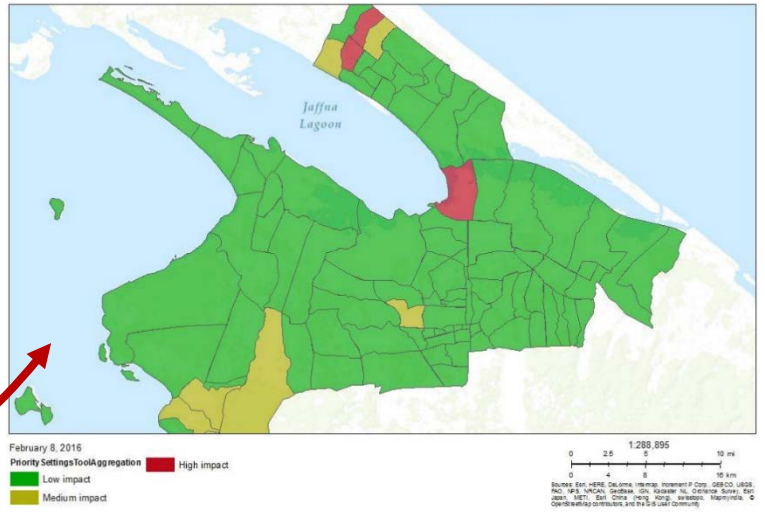
- But the **reality** is far **more challenging**!
- **Multi-criteria approach** is imperative!



Multi-criteria approach

- For instance, **landmines / unexploded ordnance clearance is a very expensive** activity, therefore a **transparent priority-setting procedure** must be established
- **It requires a multi-criteria analysis** to find out in which area the mines have the greatest impact in terms of safety, economic recovery, social welfare, etc.

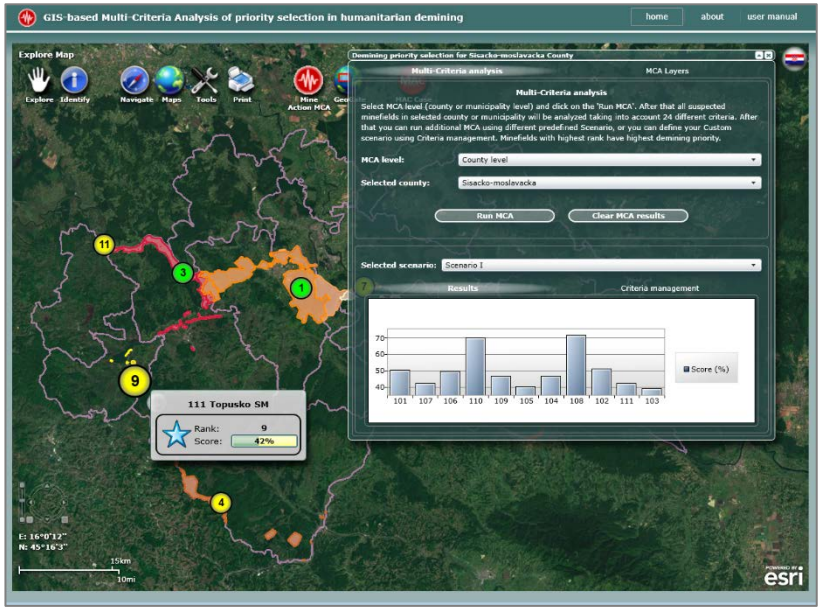


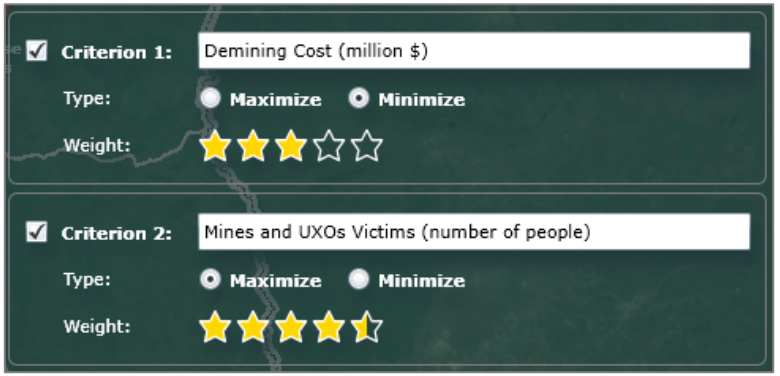


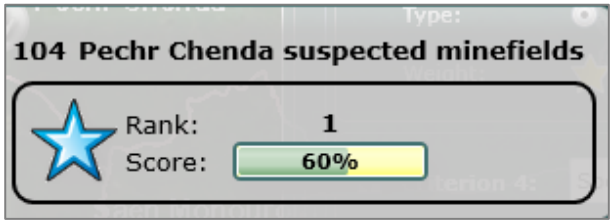
(source: Geneva International Centre for Humanitarian Demining)

Multi-criteria approach

- In projects with **Croatian Mine Action Centre** and, later, in the EU **FP7 TIRAMISU** project, a transparent and innovative **Multi-criteria analysis for Mine Action** has been developed
- Its main advantages are a **simplified multi-criteria tool** and **semi-automated criteria generation** from the GIS

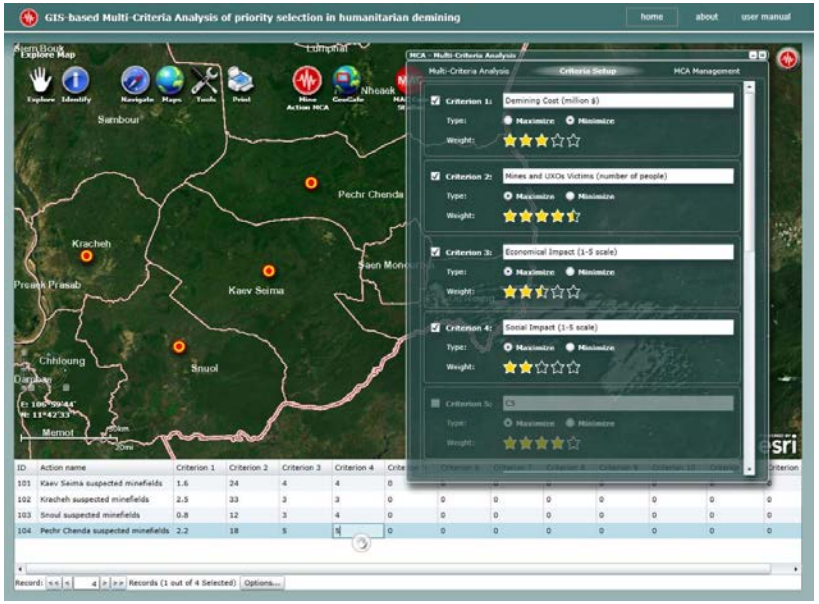






Multi-criteria approach

- In 2020, we presented a research paper "*GIS-based and simplified PROMETHEE approach in the management of the landmines and UXO clearance*"
- In 2022, this research won **Jean-Pierre Brans Award 2020** for application of PROMETHEE method



JEAN-PIERRE BRANS AWARD 2020 CERTIFICATE

THIS DOCUMENT CERTIFIES THAT

MARKO MLADINEO

NENAD MLADINEO AND NIKSA JAJAC

Won tied, the 1 000 Euros of the Jean-Pierre Brans Award 2020
Best paper presented at the PROMETHEE Days 2020

Title: "GIS-based and simplified PROMETHEE approach in the management of the landmines and UXO clearance"

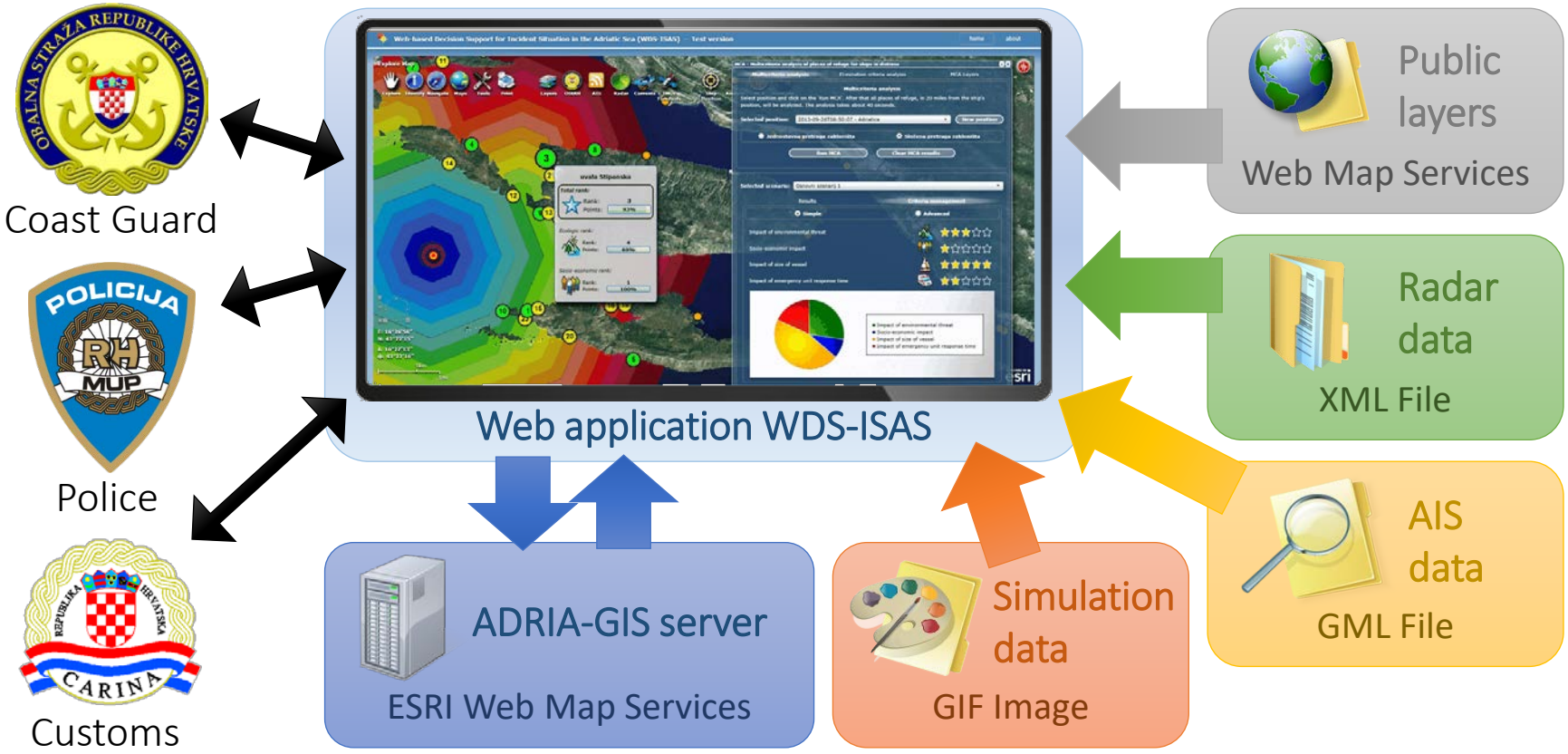
MAY 19, 2022

Jean-Philippe Waaub
President of the jury

Gabriela Fernandez Barberis
Jury Member

Multi-agency approach

- Pilot project **Web-based Decision Support for Incident Situation in the Adriatic Sea** (2012-2014) successfully applied **multi-agency approach** and **multiple data formats**



Multi-agency approach

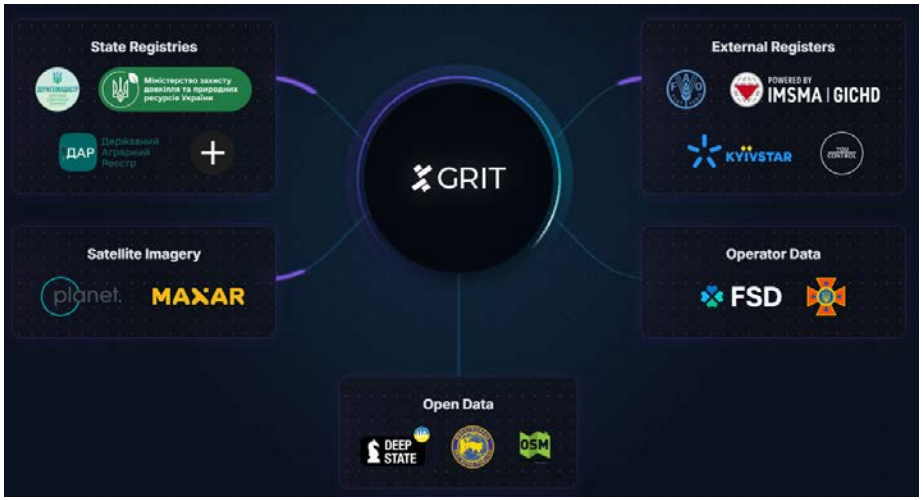
- In 2022, Team UNIST was selected as **Finalist of NATO Innovation Challenge** among more than 80 teams from all over the world
- We presented: **Recover-IS** – the innovative and pervasive information system for quick **response and resilience building in the post-war recovery operations**

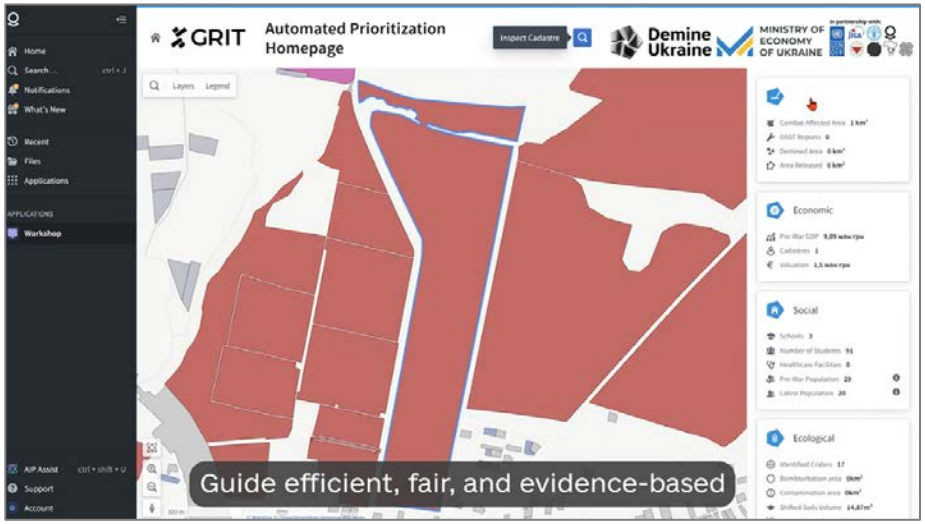
Current situation

- The **ongoing conflicts** in the world, **estimated at more than 60**, are generating suspected hazardous areas (SHAs)
- The conflict in **Ukraine** is representing a special problem due to a size of the front line that is resulting with enormous SHAs: **more than 139.000 square kilometers of territory**, at the moment

Current situation

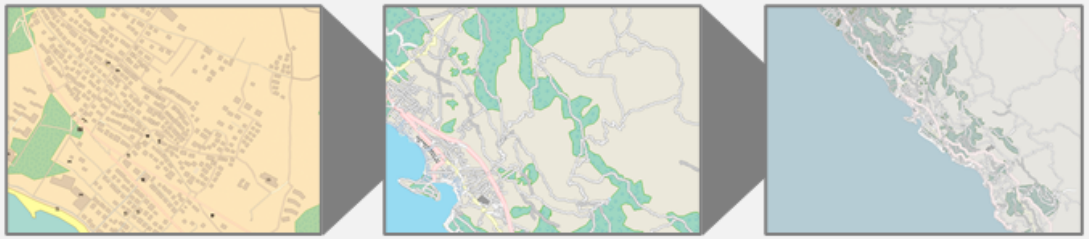
- Ukraine is using its **GRIT** (***Ground rehabilitation through innovation & technology***) system for priority setting in mine action
- It is unknown, **what kind of methodology they use** for priority setting and **how they generalize the data**, since they have demonstrated usage only on cadastral parcels





Advanced DSS

- The goal of our research is to unify the complex characteristics of the problem into one efficient transparent **information system for recovery management**
- It represents an **advanced DSS** (Decision Support System) that must support a multi-level approach, with at least 3 levels:



Operative level
(*City / Municipality*)

Operative criteria/indicators:

- Mine suspected areas
- UXOs areas
- Residential buildings
- Terrain characteristics
- Roads
- Critical infrastructure, etc.

Tactical level
(*Region / County*)

Tactical criteria/indicators:

- Mine suspected areas
- UXOs areas
- Settlements
- Landcover and agriculture
- Industrial areas
- Electric / Water supply, etc.

Strategic level
(*Country / State*)

Strategic criteria/indicators:

- Mine suspected areas
- UXOs areas
- Population density
- Ecologically valuable areas
- Economically valuable areas
- UXO victims distribution, etc.

Advanced DSS

- **Homogeneous zones approach** is an excellent approach to generalize the data, i.e. to **unify large number of mine-suspected areas** that have some common characteristics (density of landmines, vegetation, economic importance, etc)
- An **example of homogenous zones** creation: areas defined by specific urban characteristics, by main roads, and by terrain characteristics, result with 15 different homogenous zones

Advanced DSS

- Homogenous zones and criteria used on **different hierarchical levels** want to cover following details and answer following questions:
  - **Strategic level** – Country/State level, on which all important data and indicators are aggregated and evaluated to make strategic decisions: **What? Where?**
  - **Tactical level** – Region/County level, on which all important data and indicators of a single region are aggregated and evaluated to make tactical decisions: **Who? What? Where?**
  - **Operative level** – City/Municipality level, on which all important data and indicators of a single municipality are evaluated to make operative decisions: **Who? What? Where? When? How?**

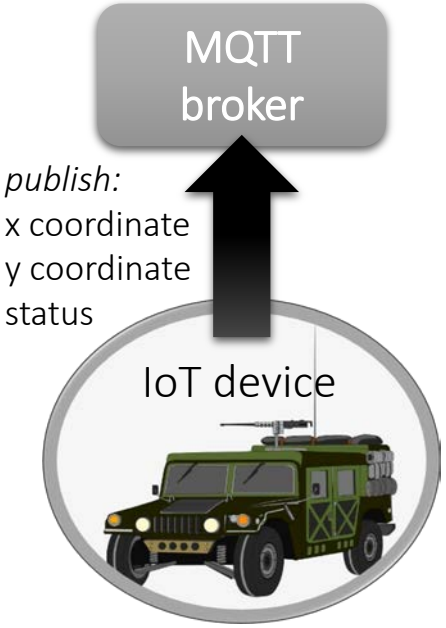
Advanced DSS

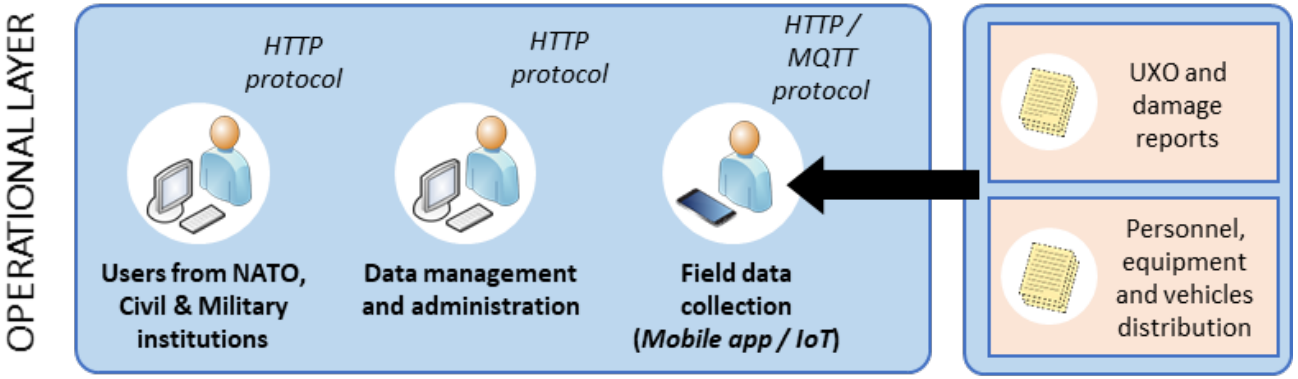
- Based on the **experience in humanitarian demining** in Croatia, the multi-level and multi-stakeholder **advanced DSS** is proposed for quick response and resilience building in the post-conflict mine action and post-war rebuild and recovery
- The idea is to combine all important **spatial data and real-time data** with powerful tools for multi-criteria analysis and GIS-based big data analytics, thus enabling **successful mine action management** together with **rebuild and recovery operations**
- To achieve these ambitious aims, the proposed DSS consists of **4 different layers** (*operational, data, cognitive, managerial*)

Advanced DSS

- <u>Operational layer</u> provides all important **data and apps for the end-users** from host nation's civil and military institutions and NATO

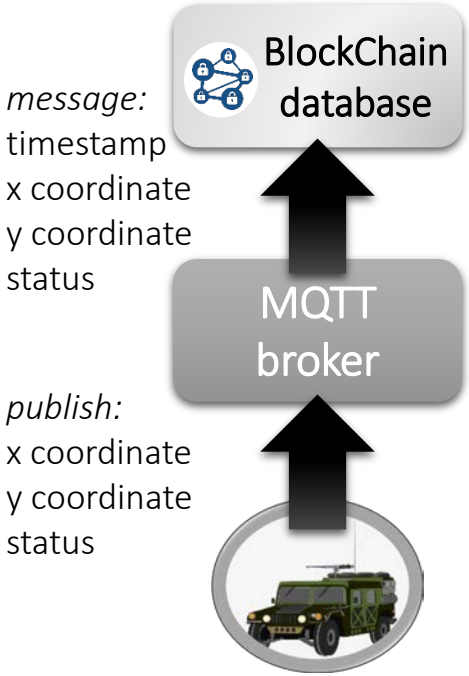
- Beside Mobile apps that can be used for field data collection, an **automated data collection through Internet of Things (IoT) via MQTT protocol** is considered

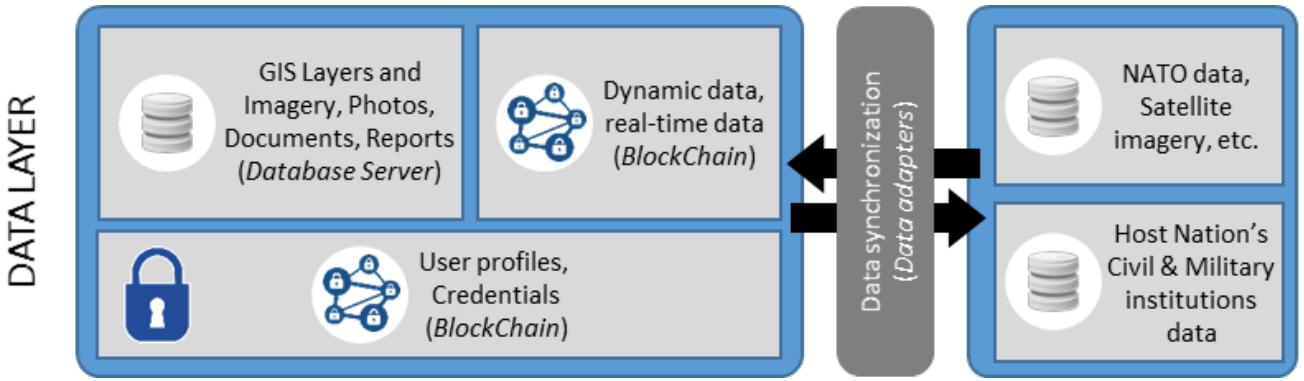




Advanced DSS

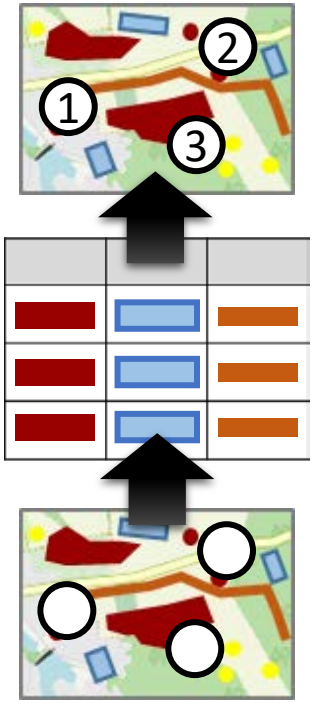
- Data layer should be based on **spatial database**, i.e. GIS server database
- Data adapters can be used for **data synchronization with other stakeholders**
- **BlockChain technology** is proposed for **dynamic and real-time data**, but it cannot be used for GIS imagery (Gigabytes of data!)

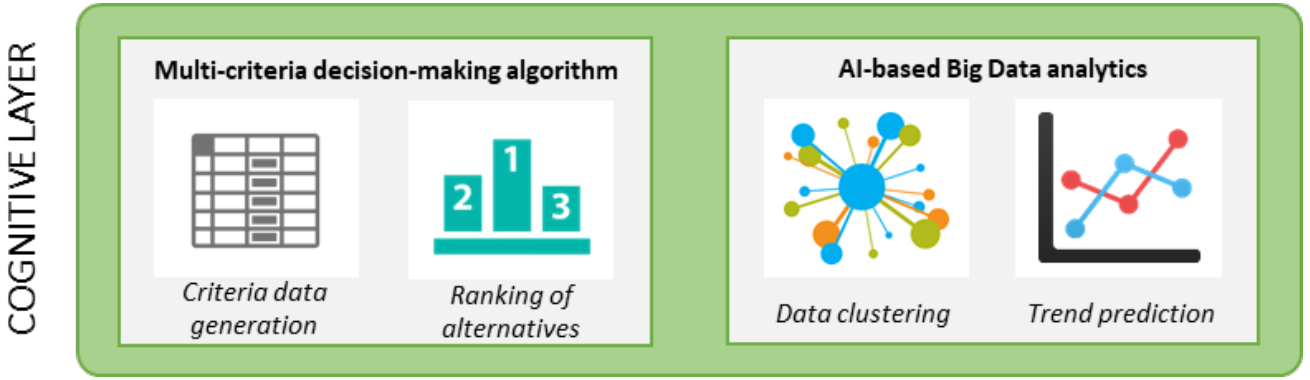




Advanced DSS

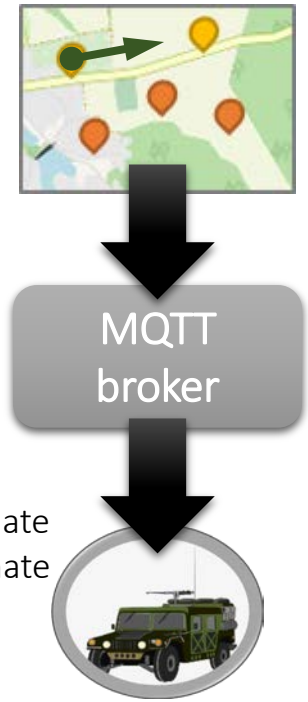
- <u>Cognitive layer</u> uses **AI-based Big Data analytics** for data clustering and trend prediction
- Other aspect is **Multi-criteria analysis** with data visualization, so it can be used by **different stakeholders with non-expert knowledge**
- Semi-automated approach is used, which creates **decision-making matrix** by generating the **criteria evaluations from the GIS** data

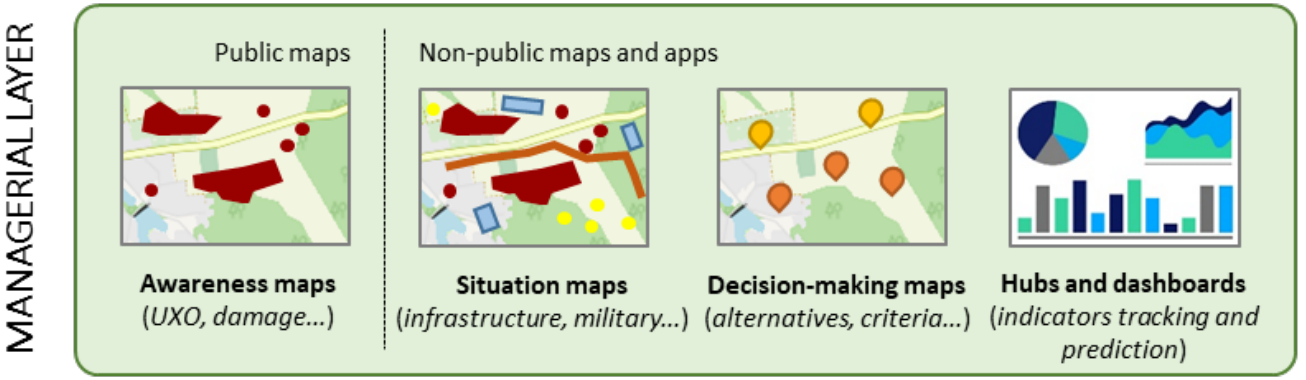




Advanced DSS

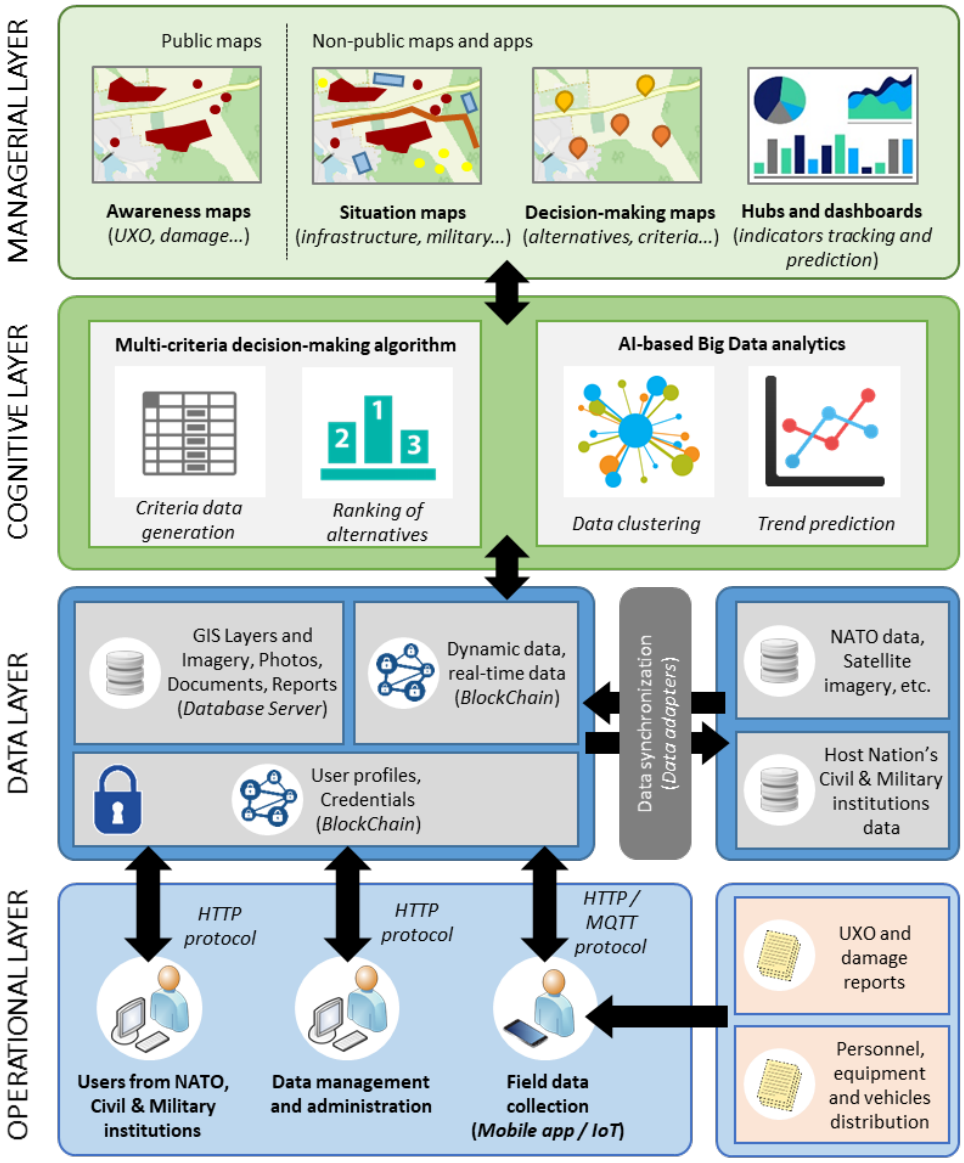
- <u>Managerial layer</u> **is** the top of the system with maps and apps for managerial purposes
- There are **public maps**, and **non-public situation maps** that are combined with **decision-making maps** and **hubs** in order to secure transparent **strategic planning**
- Almost **automated execution of some operations** is possible with MQTT protocol





Advanced DSS

- **Advanced DSS** provides **information and decision-making support** in the **planning**, **realization and control** of **the recovery**, through priority setting and mine action
- In order to enable **the rebuild operations**, especially related to critical infrastructure
- It is a **sustainable post-war recovery!**



Conclusion

- The only thing worse than the war itself, are the **consequences of war**!
- The landmines and UXOs contamination is one of the main obstacles to economic recovery and other types of progress in post-war recovery
- This research investigates a new approach to priority setting in complex humanitarian demining: **the multi-level and multi-stakeholder decision support system**
- The proposed **advanced DSS** is based on a combination of advanced GIS tools and **semi-automated multi-criteria analysis** in order to enable efficient and effective mine action management