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Dual-use Models and Simulations for Emergency and Military Responders' Interoperability in a Wildfire Scenario



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Agenda

- Global threats: who, what is at risk ?
- Threats to Critical Infrastructures
- Purpose and Objective of the research
- Approach and methodology
- Wildfire study case and the TIGER model
- TIGER SWORD interoperability
- Results and discussion
- Lessons Learned and Future works
- Conclusions





Global Threats

- Increased temperatures, sea level rise, changes in precipitation threat resources and basic needs: Food Security, Water, Sanitation, Hygiene (WASH), Health, Shelter
- Hotter summers leading to more dangerous fires (Portugal 2017, Greece 2018)
- Incendiary kites and balloons as asymmetric warfare weapons
- Response includes national military/civil defence. Foreign military assets may be requested: need of **civil-military** coordination and common training
- **Identified gaps** in training, estimation, forecast, response planning in disaster management





Who, what is at risk of Climate Change ?









By 2030, there will be least **41 megacities,** mainly located on sea coast. (UN, 2014)



https://www.citymetric.com/skylines/three-million-people-move-cities-every-week-so-how-can-cities-plan-migrants-1546Rio's Rocinha shantytown: informal settlements like this are booming as developing countries urbanise. Image: Getty.



Climate Threats to Critical Infrastructures

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ΙΤΕΟ



| | Research | Space | Chemical | Transport | Financial Health | Food | Water | ICT | Nuclear | Energy |
|-----------------------|----------|-------|----------|-----------|---------------------|------|-------|-----|---------|--------|
| High winds | | | | | | | | | | |
| Extreme convection | | | | | | | | | | |
| Extreme precipitation | | | | | | | | | | |
| Ice storms | | | | | | | | | | |
| Hurricanes | | | | | | | | | | |
| Flood-inducing storms | | | | | | | | | | |
| Fire weather | | | | | | | | | | |
| Cold snaps | | | | | | | | | | |
| Heat waves | | | | | | | | | | |
| Drought | | | | | | | | | | |
| Climate change | | | | | | | | | | |

Low impact High impact

Faster degradation of performance Change in supply and demand profiles (e.g. higher energy demand in summer) Increased vulnerability of infrastructures to physical damages, impact on humans (e.g. heatwaves), changes in operational profiles. (Source: EU-CIRCLE)



Wildfire Scenario Study case



Example: Greece, July 2018 Affected areas in orange colour



https://www.ct100.ro/solidaritatea-grecilor/





http://emergency.copernicus.eu/mapping/system/files/components/EMSR300_02RAFINA_01DELINEATION_MAP_v2_100dpi.jpg



Wildfire in Hybrid/Asymmetric Warfare

Palestinian militants in Gaza are using some unusual weapons to attack Israel.

מזירה בוערת אחת לאח<mark>רת, ריח</mark>

המחדל גובר על ריח השריפות.

צילום: תאיר אלוש



Imagine a kite, which you build with your kids, but the rope is burning

https://www.bbc.com/news/av/world-middle-east-44743813/how-kites-and-balloons-became-militant-weapons



Wildfire impacts on Electricity & Roads







Impact to Electricity network from:

- direct fire crossing high voltage transmission lines,
- dense smoke over a certain concentration (> 500 μg/m3) causing flashovers in air gaps (EU-CIRCLE)

Smoke Impact to Roads traffic viability to affect logistics, movement, evacuation

62 dead in Portugal wildfires; many killed in cars

Burnt cars block the road between Castanheira de Pera and Figueiro dos Vinhos, central Portugal, 18 June 2017 https://www.mercurynews.com/2017/06/18/portugueseradio-says-25-people-killed-in-forest-fires/





Purpose and Objective of research

- To exploit **dual-use** and **achieve interoperability** of (civilian) hazard predictive models and (military) simulation systems
- To close the **gap** between civilian hazard models and military *constructive* simulations.
- To enhance **analysis**, **preparedness**, and **training** thus strengthening resilience of responding organizations





Approach & Method

How can Modelling & Simulation help?

- Better prediction and preparation uniformed Information gathering processes and sharing of standardized data.
- **Resources optimization** in action decision after testing solutions.

Wildfire study case

- University of Naples' **TIGER wildfire simulation** tested in a scenario with city districts, refugees camps and interconnected critical infrastructures.
- Linkage to EU CIRCLE smoke model for dispersion and impacts to electricity networks and road viability.
- **TIGER model extended** by World in a Box, to transfer data to MASA SWORD simulation.





TIGER Wildfire Model





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TIGER Processes

Combustion model computes **fuel consumption/**heat production in a cell. **Convection/diffusion** model balancing temperature with neighboring cells.



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convective term

in plane diffusive term heat flux due to vertical convection

heat source due to combustion

MATLAB simulations to calibrate Wind Influence on Convection processes.

Wind intensity/direction (also in *real-time* from portable devices) modelled by WASP Engineering.



TIGER 3D (Forest Fire Area Simulator)











TIGER Wildfire visualization



time series data and kml (polygons) for Google Earth visualisation

Kml files converted in *near-real time* for ESRI web map visualisation



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SWORD Constructive Simulation

- AI-powered (military) constructive simulation.
- Internal damage model can use external data for accurate calculating disaster material damage/human loss.
- Output in Military Scenario Definition Language (MSDL) feeding web map and C2 system Common Operational Picture (COP).
- MSDL standard enables creation of scenarios for sharing and reuse between simulation systems, and C2 systems.



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TIGER - SWORD interoperability



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Main view 💲

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No rainfall

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TIGER - SWORD interoperability

TIGER computed area in SWORD and impact on simulated units.



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SWORD simulation engine has the ability to use external data for **better computing** of material damage and human loss.

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TIGER visualization on GIS web map



TIGER and SWORD simulation outcomes feed a web map or a Command and Control (C2) system Common Operational Picture (COP) for optimal decision-making.



TIGER - SWORD - GIS







Results' Discussion

- Interoperability TIGER wildfire simulator SWORD constructive simulator GIS and web map.
- Other High Level Architecture (HLA) federated simulations (e.g. JCATS) can be stimulated by TIGER using MSDL standard and ad-hoc interfaces.
- Contribution to development of:
 - Disaster simulation architecture
 - HLA Disaster Federated Object Model (FOM) for wildfire.





Lessons Learned

Interoperable simulations are the key. Simulations provide disaster managers, humanitarian actors and commanders with:

better situational awareness

(hazard propagation + info on people in need, critical infrastructures)

- interaction with simulated deployed assets performing chosen Courses of action (COA) and logistics supply
- analysis of COA outcomes and re-plan









Challenges

- Analysis of chosen decisions vs expected outcomes & procedures/SOPs.
- HLA Federation Object Model (FOM) for disasters (for information exchange among simulations).
- A **Disaster Module** for an HLA simulation federation.
- Finalization of a **disaster simulation architecture**.







- Common Operational Picture (COP) overlay of hazard prediction

 simulated damage real-time update
 (drones sensors' data, webcams, citizens' tweets, satellite imagery, crowdsourced information)
 - Contribute to alert people to danger, e.g. sending text messages and emergency broadcasts.



Conclusions

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- **Complementary tools** for simulating disasters, infrastructures and their interconnections, responding organisations' assets.
- Filling the gap between civilian and military simulations.
- Functions: crisis and disaster management, humanitarian action, resilience of responding organisations, hybrid/asymmetric warfare.
- Support analysis, training and exercises (damages, loss and decisions, estimation of preparedness level, evaluation of mission concept, simulation of assets deployment and supply).





Take Away

- An example of dual-use technology interoperability.
- **Potential of military simulation** capabilities in supporting preparedness and resilience of organisations.
- Tools and systems interoperability achieved by software design changes and use of standards.
- Improved analysis, decision-making, preparedness training in disasters and hybrid/asymmetric warfare.





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Questions & Answers

