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

Walter David[1], Prof. Francesco Giannino[2], Duncan Heathfield[3], Antony Hubervic[4], Dr. Athanasios Sfetsos[5]
[1] Ronin Institute, 07043 Montclair NJ, United States
[2] University of Naples, 80055 Portici, Italy
[3]World in a Box, 00100 Helsinki, Finland
[4]MASA Group, 75002 Paris, France
[5]National Centre for Scientific Research "Demokritos", 15310 Agia Paraskevi, Greece

Abstract — Climate change driven heat waves and wildfires are becoming more likely and severe. In the Mediterranean region, hotter summers are leading to more dangerous fires as in Portugal in 2017 and in Greece in 2018. In addition, incendiary kites and balloons are deployed as asymmetric warfare weapons with devastating effects on Israeli farms and forests.

The authors propose to exploit the dual-use and interoperability of civilian hazard predictive tools and military simulation systems in order to enhance the preparedness of military and civil protection and humanitarian aid agencies, and strengthen the resilience of responding organizations. Within this research, the TIGER wildfire simulation software has been adapted to a scenario with residential districts, refugee camps and critical infrastructures. TIGER has been linked to an EU-CIRCLE smoke dispersion model, and associated impacts to the electricity network and road network. The authors transferred the fire information to the AI-powered SWORD simulation for better damage computing. TIGER and SWORD simulation results feed a common operational picture where disaster managers and military commanders can train and evaluate the outcomes of their chosen decisions.

In conclusion, the paper highlights the potential of closing the gap between disaster simulation and dual-use military simulation capabilities in supporting preparedness and resilience of responding organisations by addressing a wildfire scenario where military and civil responders' tools and systems have been made interoperable by software design changes.

1 Introduction

Due to climate change, in particular, in the Mediterranean region, hotter summers are leading to more dangerous fires (e.g. Portugal, 2017 and Greece, 2018).

In addition, in the Middle East, incendiary kites and balloons are used as asymmetric warfare weapons targeting crops and forests. The real first responders in emergencies are the affected people and local communities but the response usually involves the national military and security services and, as an option of last resort, include foreign military assets [1] and requires civil-military coordination and effective training [2].

2 Purpose/Objective/Benefit

The authors propose to exploit the interoperability of dual-use (civilian) hazard predictive models and (military) constructive simulation systems to enhance analysis, preparedness, and training thus strengthening the resilience of responding organizations.

3 Approach

Within this research, the University of Naples' TIGER wildfire simulation software [3] for fire prevention and training of forest firefighters in Italy, has been adapted to a complex scenario where the countryside, per-urban city districts, refugees camps and increasingly interconnected [4] lifeline and critical infrastructures can be threatened and impacted by fire.

TIGER input data comprise the fuel map of the region, the digital elevation model, updated wind data (that can be transmitted from portable devices) and the ignition/burned area. TIGER combustion/convection/diffusion processes are described by the formula:

$$\frac{\partial T}{\partial t} = -\nabla \cdot (v(P,t)T) + \nabla \cdot (\chi(P)\nabla T) - h(T)(T - T_\infty) + f(t,T) \quad (1)$$

where:

T(P,t) is the temperature scalar field

$$\frac{\partial T}{\partial t} = -\nabla \cdot (v(P,t)T) + \nabla \cdot (\chi(P)\nabla T) - h(T)(T - T_\infty) + f(t,T)$$

v(P,t) is the wind vector field, function of space and time.

In the present work, TIGER has been linked to an EU-CIRCLE smoke model for dispersion and impacts to electricity networks and road traffic viability (e.g. for evacuation of the resident population from the affected area), on a GIS environment [5].

TIGER output data comprise results as time series mappable data and kml (lines and polygons), which can be displayed using Google Earth technology for visualisation. In addition, for the present research, the kml files have been converted in near-real time for an ESRI GIS environment and the TIGER model has been extended to provide as output (in asci grid format) also the maximum heat per unit area (kJ/m2) to be exported to the AI-powered MASA SWORD military constructive simulation system.

4 Results and discussion

The authors successfully tested the transfer of information about the fire propagation and the combustion from the hazard and impact chain simulation to SWORD that has the ability to use external data for better computing of the material damage and human loss. SWORD output in Military Scenario Definition Language (MSDL) standard [6] can feed a web map or a command and control (C2) system common operational picture (COP) and provide the updated situational awareness to support analysis and optimal decision-making.

In addition, the use of MSDL standard enables the creation of scenarios that can be shared and reused between simulation systems, and command and control (C2) systems.

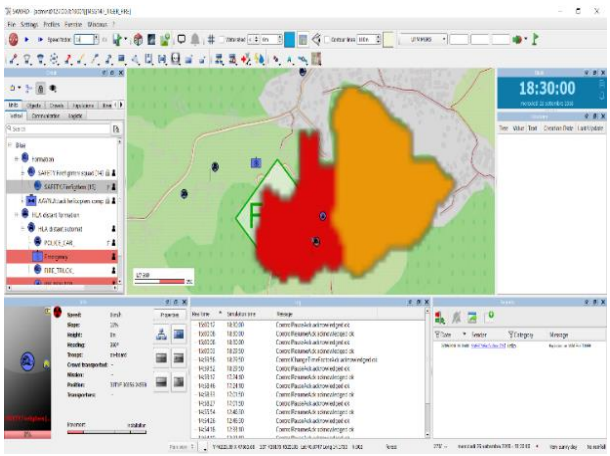

Fig. 1. TIGER wildfire computed area in SWORD and wildfire impact on simulated units.

5 Lessons Learned and Future Works

The tested simulation environment can provide disaster managers, humanitarian actors and military commanders with the ability to visualise on a decision support system and interact with simulated deployed units performing their chosen courses of action and analyse their outcomes.

As proposal for future works, the COP with overlay of hazard prediction and simulated damage can be updated in real-time with satellite imagery, crowdsourced information, data from drones and webcams, tweets, and finally contribute to alert people to danger, for example sending text messages and emergency broadcasts, thus helping in reducing the number of lost lives.

6 Conclusions

An example of dual-use technology interoperability in a hazard case study has been provided by the authors. This paper highlights the potential of the dual-use military simulation capabilities in supporting preparedness and resilience of responding organisations by addressing as proof of concept, a wildfire scenario where military and civil responders' tools and systems have been made interoperable by software design changes.

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Author/Speaker Biographies

Walter David, M.Sc. Eng. is a senior engineer, geospatial and M&S expert, Ronin Institute researcher, Lieutenant Colonel, Chief of Analysis & LL Section at NATO M&S Centre of Excellence. He has been member of many international workgroups. His research interests include M&S support to disaster management, decision-making, preparedness and resilience. **Prof. Francesco Giannino,** University of Naples Federico II/Department of Agricultural Sciences, has a M.Sc. in mathematics and a PhD in applied ecology. He is a researcher of numerical analysis; his interests include vegetation modelling, C-cycle modelling, fire modelling, software tools and theoretical aspects, landscape analysis and DSS. **Duncan Heathfield** has been designing and building spatial simulation software systems since 1994 interacting with scientific clients to develop software and systems. He is software and systems developer for wind energy applications since 1998 and runs a small software company with a team of developers since 2003. **Antony Hubervic** is senior engineer at MASA Group. He worked at DGA procurement agency as scientist and project manager and participated in the development of several simulation products in leading defence companies. He is involved in customer support and responsible for Interoperability projects. He participates in NATO M&S Working Groups. **Dr. Athanasios Sfetsos**, B.Sc. in Physics from University of Patras and Ph.D. Electrical Engineering from Imperial College, is a Senior Researcher at INRASTES-NCSR Demokritos and collaborator with the Greek Centre for Security Studies. His research interests are related to the impacts of climate change and critical infrastructure protection.