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Citation for published version:
David, W, King-Okoye, M & Garmendia-Doval, B 2023, Artificial Intelligence support to the paradigm shift from reactive to anticipatory action in humanitarian responses. in J Mazal, A Fagiolini, P Vašík, A Bruzzone, S Pickl, V Neumann, P Stodola & S Lo Storto (eds), *Modelling and Simulation for Autonomous Systems: 9th International Conference, MESAS 2022.* Lecture Notes in Computer Science, vol. 13866, Springer, pp. 145-162. https://doi.org/10.1007/978-3-031-31268-7_9

Digital Object Identifier (DOI):
10.1007/978-3-031-31268-7_9

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Peer reviewed version

Published In:
Modelling and Simulation for Autonomous Systems

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Download date: 16. Aug. 2023

Artificial Intelligence Support to the Paradigm Shift from Reactive to Anticipatory Action in Humanitarian Responses

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Abstract. Climate change impact factors, drought, food insecurity, exacerbate existing vulnerabilities, with security implications as often they generate opportunities for insurgence and complicate peacebuilding efforts. Humanitarian anticipatory action is an innovative approach which systematically links early warnings to actions designed to provide protection ahead of a hazard. Leveraging authors' experience in stabilization, this article investigates the role that artificial intelligence (AI) and modelling & simulation (M&S) can play to support early actions. As a proof of concept, the Expert.ai Cogito hybrid natural language processing and machine learning platform and the AI supported MASA SYNERGY system have been tested, to collect open sources information and to simulate the use case of deployment of unmanned aerial vehicles (UAVs), or drones, in a region affected by violence and natural disasters. Different prepositioning of cargo drones and resources can be tested and compared. In fact, a network of cargo drones set up in the optimal locations, ready to be deployed, can make a difference in establishing action plans and relief aid delivery.

Scenario exercise and brainstorming have captured the value of AI and M&S to improve situational awareness and early actions prior to the onset of a shock. AI and M&S tools shows the ability to support decision making and anticipatory action by training crisis cells, verifying the impact of disaster, and testing contingency plans for significantly faster and more cost-effective responses, compared with the traditional reactive approach.

Keywords: Artificial Intelligence, Simulation, Anticipatory Action.

1 Background

Armed conflicts, energy crisis, climate change, drought, pandemic, hunger, displacement, never has the world seen such complex mega crises [1]. While we observe a trend for longer crises [2, 3], infectious diseases and epidemics add a further layer of complexity to humanitarian response [4, 5].

1.1 Climate and (in)security

Conflicts, economic shocks, and weather extremes are the main drivers affecting 193 million people by food insecurity [6]. Many factors and compounding drivers lead to armed conflicts but among the countries most vulnerable to climate change, many are involved in conflicts and less able to cope [4, 5, 7].

Environmental scholars and advisors consider climate change as a conflict multiplier [8] that exacerbates vulnerabilities, causes displacement and huge humanitarian needs with negative implications for security [9].

The climate-security link is obvious to international actors deployed [5], including authors and stakeholders of this research, in the Global South. Horn of Africa communities face the threat of starvation after four consecutive failed rainy seasons including the last, the driest in the last 70 years [10]. In Somalia, severe drought has already affected, as of July 2022, at least 7 million people, of whom 918,000 are internally displaced persons (IDPs) in search of water, food, and pasture [11]. Lack of water, food insecurity and poverty create opportunities for the al-Shabaab insurgence that controls the countryside where they collect taxes. They spread corruption even in government held areas where they act as a mafia. Climate change effects empower insurgence force generation as poverty pushes many to join [12-14], influence the ongoing conflict and complicate the efforts of the international community to build peace and develop institutions.

In North-Eastern Nigeria, the insurgency has displaced over 2.2 million people, devastated agriculture and cut off people from essential services [4, 5, 15, 16]. High temperatures, wildfires, drought, tropical storms, flooding, and diseases are leading to food insecurity [16-19]. Hundreds of thousands of IDPs live in congested, garrison towns protected by the Nigerian Army [15, 17-19]. Many aid workers have been abducted or killed [5, 17] and access is a major concern because often insurgence attacks or flooding cut off remote communities, urging humanitarian officers to use helicopters. Requirements have been identified for data sets and IT tools to improve information management, early warning, surveillance, and monitoring at the tactical level (camp-like local level) [5].

Military Contribution. According to NATO Standard AJP-3.26, the primary objective of humanitarian assistance is to alleviate human suffering during and after disasters and crises. NATO military forces may be deployed in support of civil authorities overseeing the emergency [20]. Stabilization activities as described in NATO AJP 3.28 [21], should be focused on mitigating the immediate sources of instability and should help establish the foundation for long-term stability. Such activities require supporting local and regional actors to reduce violence, ensure basic security and facilitate peaceful political deal-making.

1.2 Catching the black swan

Ukraine war impact effects. An increasingly uncertain world was already grappling with the COVID-19 pandemic and climate change but, due to the consequences of the war in Ukraine and economic sanctions, people globally are facing a cost-of-living crisis not seen in more than a generation, with escalating price shocks in food and energy [22]. Today, about 60 percent of the world's workforce is estimated to have lower incomes than before the pandemic. World Food Programme (WFP), the United Nations (UN) logistic agency estimates that severely food insecure persons doubled from 135 million pre-pandemic to 276 million over just two years; this number is likely to increase up to 323 million in 2022 [22, 23].

Black swan events. So-called black swan events (e.g., pandemic, Ukraine war, etc.) [24], are so rare that even the possibility that one of them might occur is unknown, have a catastrophic impact when they do occur but they are explained in hindsight, as if they were actually predictable [25]. For extremely rare events, Taleb argues that the standard tools of probability and prediction, such as the normal distribution, do not apply since they depend on large population and past sample sizes that are never available for rare events by definition [25, 26].

While black swans are hard to catch, it is estimated that half of today's crises are somewhat predictable and 20 per cent are highly predictable. Recently, the humanitarian community has actively pursued ways to get ahead of crises by helping people earlier, as soon as they see problems coming, exploring disruptive technologies, and taking early actions [27]. The intent is to move from the traditional approach, where they observe the disaster, decide the response, and then mobilize funds and resources, to an anticipatory approach, where they plan, in advance for the next crises, preparing response plans and funds, release money and mobilize the response as soon as they are needed [28].

Risk is global, resilience is local. Lessons identified from the pandemic, when airplanes where grounded, travels and international staff movements restricted, suggest the need for more dynamic risk assessment tools, investments in early warning and analytics and localization of leadership. In fact, while risk is global, resilience is local, and involves the engagement of the local community, calling for shifting the focus from managing risk to building resilience, and early action [29].

Initiatives include the WeRobotics sponsored Flying Labs, locally led robotics knowledge hubs networks across Africa, Asia, Latin America, focusing on local effective, sustainable solutions to strengthen local expertise in the use of drones, robotics, data, and AI for positive social change [30].

1.3 Methodology

This paper is informed by scholarly literature but, due to the rapidly evolving attitude to innovative technologies among humanitarian organizations, also by reports from UN working groups and missions.

In fact, the humanitarian community is exploring new approaches, cost-efficient project designs and programming and is open to explore the opportunities that innovative technologies can provide. Recently, big data analytics, AI, and machine learning (ML) have supported a better understanding of some events and have contributed to the response to COVID-19 pandemic [31, 32].

Aim. Leveraging authors' and partners' experience from deployment in the field, this article aims to present application concepts for promoting a discussion on the role of AI and modelling and simulation (M&S) to support humanitarian action. Due to their different organizational culture, learning approach, and skill sets, emergency and humanitarian organisations have not exploited the potential of computer simulation as the armed forces where computer assisted exercises (CAX) are routine in staff and headquarters training.

Objectives. The approach includes presenting and testing selected AI and M&S tools to explore their potential in tackling some of the tough operational challenges posed by climate change, conflict and displacement, and their nexus. Realistic scenarios of a humanitarian operating theatre have been created, discussed, and validated with the support of subject matter experts (SMEs) and decision-makers. In particular, in a real crisis scenario, the AI powered SINERGY simulation system has been tested to understand its potential in supporting decision making on the use of cargo drones and their optimal deployment in a dangerous region.

Scenario Exercise. A cargo drone simulation use case has been proposed. A Northeast Nigeria scenario has been generated to simulate a vaccines delivery contingency plan to support IDPs camps located in Borno state. As a proof of concept, two commercial tools have been tested. The Expert.ai Cogito tool, supported by natural language understanding (NLU) and machine learning (ML) technologies [4, 33] has been deployed in the humanitarian setting to produce open sources intelligence.

A scenario exercise has been conducted with the application of the MASA SYNERGY AI powered constructive simulation system to simulate efficient ways, including the deployment of Unmanned Aerial Vehicles (UAVs), commonly known as drones, to transport and deliver medical items to remote locations in a difficult access region, affected both by insurgence armed attacks and natural disasters.

Obviously, a network of cargo drones set up in the optimal locations, ready to be pre-deployed, ahead of a hazard, can make a huge difference in the times needed to establish action plans and start sending relief aid.

Humanitarian experts, academia, think tanks, non-governmental organizations, and the private sector have participated in an ad hoc session that authors have organized at the UN OCHA HNPW 2022 conference. Discussions have spotlighted the role that AI, M&S and robotics can play to support anticipation and mitigation of climate-induced hazards impact, and compounding drivers (e.g., armed conflict) of humanitarian needs across multiple regions including Somalia, Nigeria and Mozambique.

2 Anticipatory Action

Anticipatory action is an innovative approach linking systematically early warnings to actions designed to provide protection ahead of a hazard in response to a trigger (before the manifestation of humanitarian need), aiming to prevent and mitigate the shock impact of a foreseen hazard such as drought, floods, and cyclones, to reduce humanitarian needs and enhance resilience [34, 35].

Global and local data. The occurrence and impact of some shocks can be predicted with increasing confidence, by combining different analytical approaches [34] supporting decision-makers to take early action, in the humanitarian, development, and peacebuilding sectors and their interlinkages (known in the humanitarian sector as the *HDP Triple Nexus*).

Analysis is 'data hungry', meaning large amounts of data are needed to forecast hazards, understand vulnerabilities and risk, and calculate potential impacts. Global datasets are created in data centers, such as the recently established OCHA Centre for Humanitarian Data [1], but often lack the resolution needed to take actions at the tactical and local levels.

Local data are key in disaster response and disaster risk reduction. In fact, in the time of crisis, closer to the centre of the crisis, the more information you need, in more detail and in real-time, in particular for tactical level information required by ground response teams [36]. Local data are also critical for building community ownership and improving resilience.

Early actions. Working on data and predictive analytics to support evidence-based decision-making during the time window between the forecast, prediction or warning and the hazard onset (extreme event) facilitates the implementation of mitigating measures. For example, before drought impacts on livelihoods and lives, cash can be provided and water points can be built to prevent competition among pastoralists for scarce water resources [29].

Early actions fill the gap between traditional disaster risk reduction, aiming to reduce vulnerability to hazards over the long-term, and humanitarian response, which provides relief after the occurrence of an event. Early actions can be pre-identified to proactively mitigate the projected humanitarian impact (*forecast-based actions*) to protect people before a disaster strikes. These actions could include refreshing staff training, works to strengthen houses and shelters, distribution of cash, and deployment of resources [35]. Still, to be effective, early actions require the meaningful engagement and the cooperation with the at-risk communities [37].

2.1 Robotics supporting Humanitarian Action

Unmanned Aerial Vehicles (UAVs), commonly known as drones, have the potential to play a crucial role in early action, enabling real time capture and processing of local data, and performing emergency logistics tasks [38]. The UN OCHA Unmanned Aerial Vehicles (UAVs) in Humanitarian Response Policy Paper 3 registered the increasing use of drones, in six categories [39] identified by the Swiss Foundation for Mine Action Report Drones in Humanitarian Action [40]:

- mapping,
- delivery of essential products to remote or hard-to-reach locations;
- search and rescue,
- support for damage assessment,
- increased situational awareness,
- monitoring changes (urban and camp growth, agricultural use, construction of roads or infrastructure).

As previously mentioned, local data are key in disaster response and disaster risk reduction and UAVs can provide the resolution and the timing required to take appropriate actions at the tactical and local levels. In fact, the improved performance in visual analytics enables the production of aerial drone imagery [39], more detailed compared with available satellite imagery. The generalization of deep learning methods, significantly improve drone visual recognition and image analysis, letting UAVs further capture their operating environment and perform more complex missions while reducing required manning [39].

Drones are rapidly becoming cheaper and affordable to humanitarian agencies and even small non-governmental organizations. Authors believe that the convergence of AI and robotics technologies has the potential to facilitate the adoption of drones and, increasing autonomy simplifies their operation in the context of humanitarian early actions.

2.2 Medical and Security Threats Analysis

In an increasingly connected and digital world, affected communities become a valuable source of relevant information [41]. Authors and SMEs have explored the use of an evolved medical intelligence platform (MIP) supported by the Expert.ai Cogito engine [4], able to processes, in addition to scientific literature, national and local press, tweets and other social media data [42-45] available on the surface, deep and dark web [42, 46, 47].

In fact, the Cogito hybrid cross-lingual cognitive engine combines deep semantic natural language understanding (NLU) and machine learning (ML), exploits (un)structured real world text data, resolves text ambiguity, captures contextualized meanings of texts *the way people do*, producing knowledge, insight and actionable intelligence, saving the analyst time-consuming manual work [4].

Key indicators are generated for data clustering, to discover even weak signals, for outbreaks early detection and data driven decision-making, both for prevention actions aiming to anticipate events (ex-ante analysis) and to analyze historical situations to mitigate future events by using past experiences (ex- post analysis) [4].

I the present research, the Cogito engine has been tested beyond the digital detection of diseases [48, 49], for the evaluation of risks to humanitarian workers in a region affected by armed groups' insurgence and violence.

2.3 AI supported simulation

With the aim to bridge the capacity gap between humanitarian and military simulation and show case to UN decision-makers, authors have selected, for a proof of concept, MASA SYNERGY constructive simulation system.

The reason for this choice is twofold: the system is powered by the same AI engine of SWORD, used for military staff training, concept development and experimentation, and it provides the ability to model disasters and human behavior, groups, and doctrines in the context of crisis. Such features show SYNERGY as very promising for training crisis cells and teams, but also for analyzing disasters' impacts and loss on population and infrastructures, for studying the introduction of new equipment, and for testing contingency plans.

Scenario Representation. In SYNERGY the information is represented in different layers (see Fig.1). Entities represent and perform the work of units, teams, groups, or assets (e.g., firefighters, police patrols, a crowd, a helicopter, etc.) but the simulation is performed at a lower level, where the equipment are modelled from those really used by those units when calculating speed movement or capabilities [50].

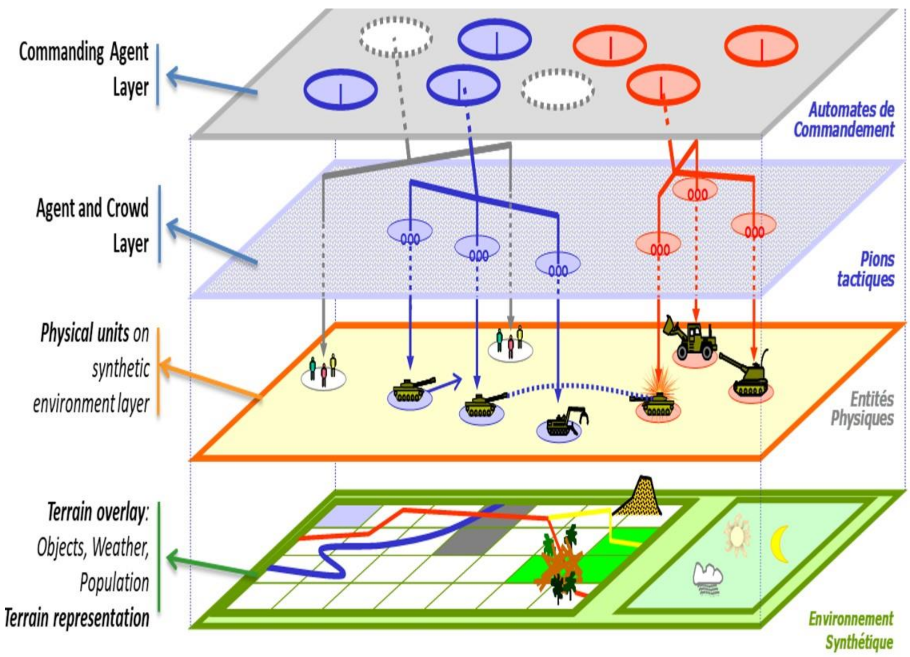

Fig. 1. Information layers in a SYNERGY scenario.

2.4 SYNERGY Decisional Process

At each simulation tick, for each entity, its perception is updated, i.e., the knowledge that each entity has of the situation depending on its location, its sensors, the terrain, the weather. Consequently, for each entity, the system computes its next action, depending on default behavior and current mission. The actions are implemented, and the scenario updated (reference needed).

The decisional process [50] comprises four steps (see Fig. 3). During the *Perception* phase, simulation agents perceive their own situation, build their knowledge of terrain, of other agents, and of their own physical capabilities. During the *Decision* phase, each agent makes decisions based on its own knowledge and its mission. In this phase the actions to be performed are selected. During the *Implementation,* the effects of the actions are computed. Finally, during the *Scenario update*, the effects are applied to the scenario representation.

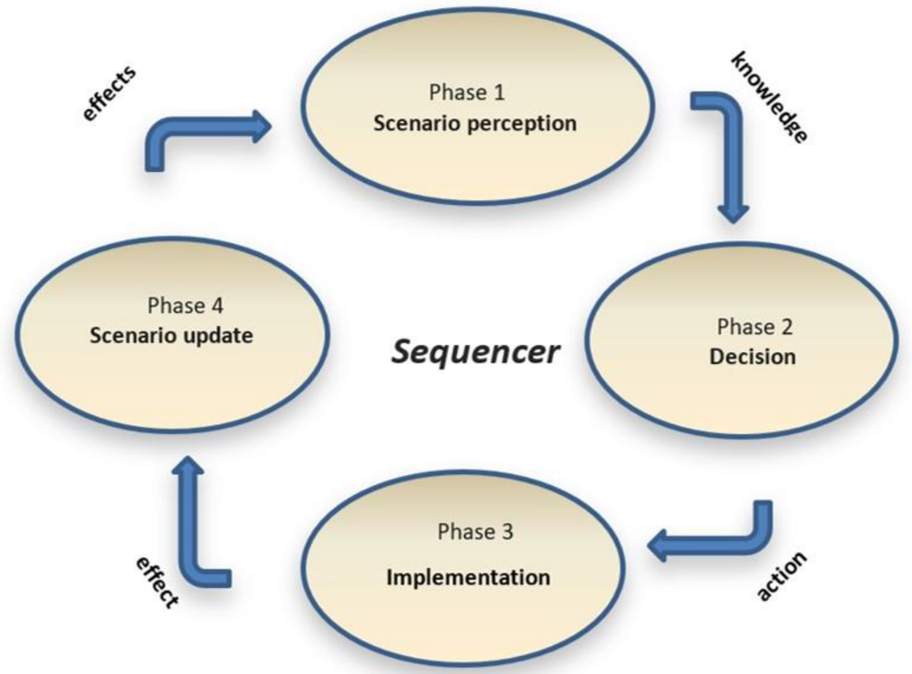

Fig. 2. SYNERGY simulation decisional process workflow.

As already mentioned, during the *Decision* phase (see Fig. 3), a decision is made for each entity, by considering the behaviour models, the physical data of each entity and the current scenario information (e.g., terrain, weather, entity's knowledge perception).

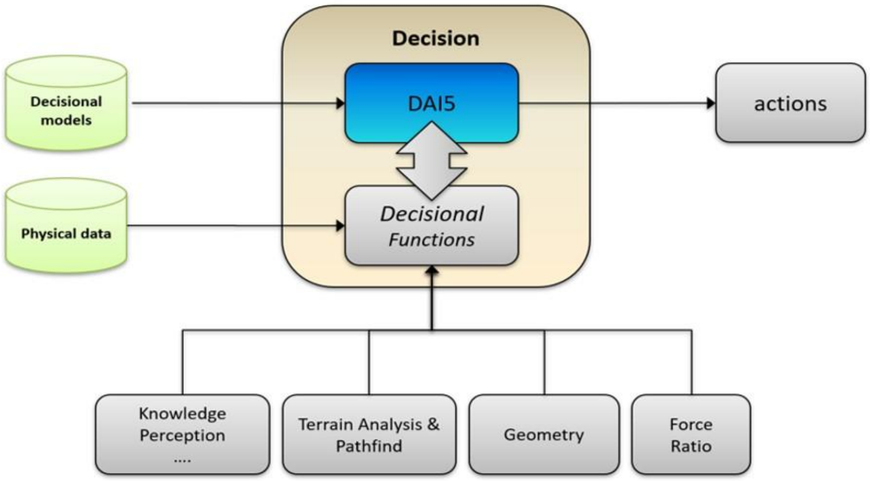

Fig. 3. The decision algorithm in SYNERGY.

The DirectAI brain. The MASA DirectAI engine is the core of the SYNERGY simulation system. It is configured and used to integrate decisional processes in simulation agents. Such agents are created to perform several different tasks, but they must choose their actions in dynamic and unpredictable environments and their tasks may conflict the allocation of resources (e.g., if the situation requires to extinguish a fire and to transport injured people at the same time) [50].

The DirectAI brain implements an action selection policy, based on drives and representations. Its architecture comprises two layers; a decision layer propagates decisional information to an action layer that performs the most appropriate action according to the current situation. A graph of nodes represents the brain, with nodes able to receive activity from other nodes or from external drives; they can consult representations to modulate their output activity. The graph's leaves correspond to action nodes and the most activated actions compete for the control of the agent's actuators [50].

Direct AI Paradigm: A two-level language. The complexity of defining the behavior depends on the level of abstraction of the atomic actions. For example, the driving a car behavior is easier to implement when split in atomic actions such as go straight, turn left, turn right. Therefore, it is possible to reduce the complexity by providing more abstract atomic actions (atomic behaviors) (see Fig. 4).

Because in a brain information can flow freely, a powerful paradigm is used for selecting actions, such as the *Free-Flow Hierarchy* (FFH), to create atomic behaviors while an easy to read (and implement) paradigm, such as the *Finite State Machine* - FSM – like), is used to create complex behaviors, using the activation of atomic behaviors as atomic actions [50].

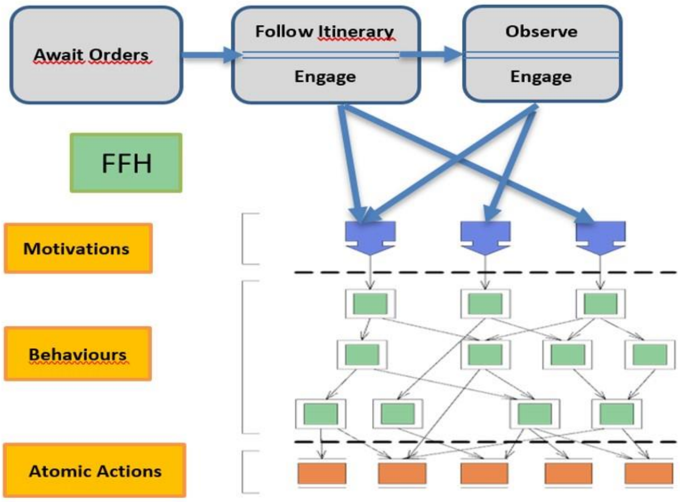

Fig. 4. SYNERGY DirectAI Paradigm: A two-level language.

3 Scenario Exercise and Outcomes

Cargo drone simulation and prepositioning. One of the most interesting use cases of robotics in the context of humanitarian action is represented by the deployment of UAVs, both for mapping and monitoring following rapid-onset emergencies like hurricanes and earthquakes, and for transporting light but time-critical loads. In fact, UAVs do not require extensive infrastructure such as runaways and can be pre-positioned in disaster-prone regions as a complementary tool when the use of land vehicles like 4x4s, motorbikes, and airplanes is restricted, slow, or too expensive for fast deliver [54], among other items, of:

- critical medical supply when roads are impassable,
- samples from field clinics to testing labs,
- health supply for unpredictable needs, such as anti-venom.

In fact, one of the recurrent issues in a disaster is the delivery where resources are needed to mitigate the situation, but main supply routes could be affected and the movement in general could be almost impossible. Even, cargo drones able to carry heavy loads for meaningful distances are becoming available. WFP is to test a Remotely Piloted Aircraft System (RPAS) which could transport almost 2 tonnes of humanitarian aid over significant distances [53].

Scenario Exercise. A cargo drone simulation use case has been proposed and SINERGY has been applied to develop a proof of concept: using simulation to support decisions on where best to deploy different resources, in this case drones.

Hypothesis. A hypothesis has been considered for the test. Given a real crisis scenario, AI powered SINERGY simulation has the potential to support decision making on the use of cargo drones and their optimal deployment locations.

Simulation Scenario. A Northeast Nigeria scenario has been created to simulate a COVID-19 vaccines delivery contingency plan for IDPs camps located in Borno state (see Fig. 5). The initial data for the simulation scenario generation have included:

- hospitals,
- IDPs camps,
- population,
- roads,
- logistic units to distribute food items, water, fuel, etc.

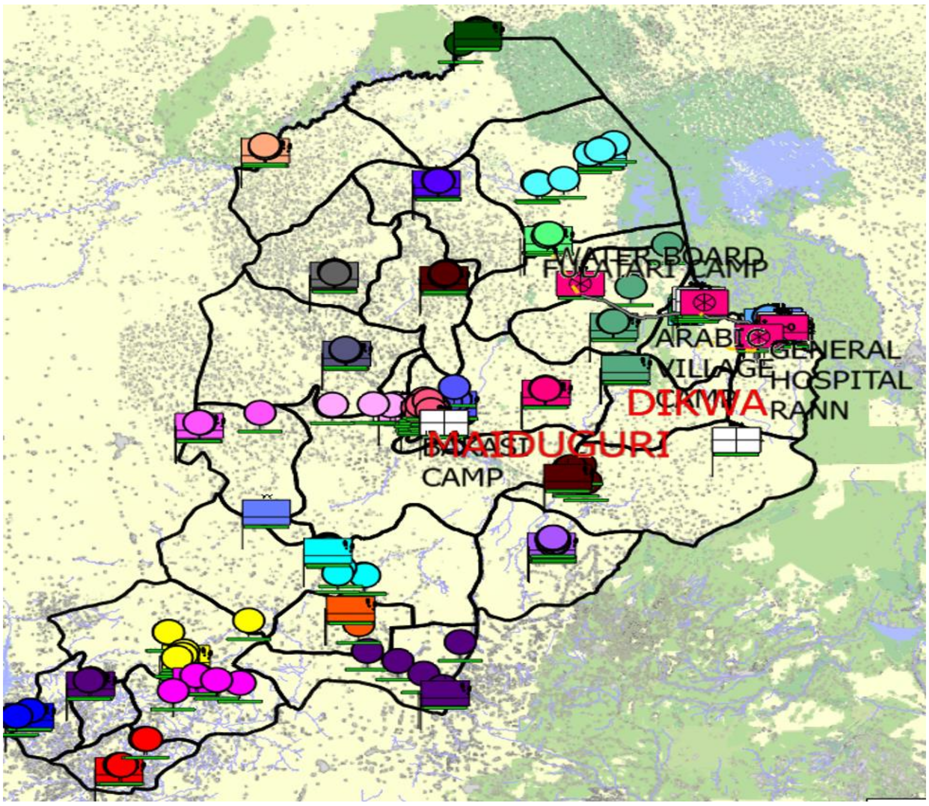

Fig. 5. SYNERGY Borno scenario.

IDPs camps data retrieved from official sources have been supplemented with data of informal camps-like settings that have been discovered after the deployment of the Cogito intelligence analysis tool, thus updating the SYNERGY scenario [4]. In addition, Cogito has been configured to identify critical situations in real time (e.g., insurgence activity, alarms affecting the area, i.e., armed attacks, blocked roads or landslides).

The simulation has been run to analyze the logistics associated with camps: food, water, shelter, plus security issues. Both trucks convoys and drones have been modelled. It has been simulated the deployment of 6 drones at the central hospital (Rann General Hospital) and 6 drones at Gajiram.

Initially, truck transportation has been simulated. Vaccines arrive to Rann General Hospital, a central regional hub from where they are delivered to different remote IDPs camps sites by standard trucks. Several itineraries have been investigated. Multiple simulation instances have been run, each one with its own course of action.

Finally, the use of standard trucks has been compared with that of cargo drones. Drones have been deployed in two locations, at the central hospital hub and at another site, centrally located with respect to most of the delivery sites. In the second use case, trucks have been only used to transport the vaccines from the central hospital to the drones' site.

Boundary conditions. It is assumed that drones can transport much less weight than trucks (one fourth) so it was necessary to perform several drone trips compared with just one trip required by trucks. Each drone can carry maximum 1 ton of weight and maximum 1 m3 of volume, 1,000 vaccines a payload - 1 ton each. The defined speed has been set at 220 km/h. To compare with the trucks, they can drive a maximum of 60 km/h but they can carry a maximum of 12 ton and a maximum of 14.1 m3.

Results' discussion. Two courses of actions (COA) have been compared: only trucks versus six drones in Ngazai plus six drones at the General Hospital Rann. Vaccines are either distributed all to the hospital or some to the hospital, some to Ngazai. From there they can be delivered to different locations (Kala/Balge, Maiduguri, Monguno and Ngala).

- **Trucks**: trucks can deliver everything with just one trip to each camp site; vaccines arrive soon to the hospital but then it takes a long time to reach the remote camps locations.
- **Drones:** several trips are needed to complete the delivery. It takes some time for vaccines to arrive to Ngazai but once they are there the use of the drones makes the distribution of the 120,000 vaccines quite fast, completing the delivery 1:30 hours earlier in a 6:00 hours scenario.

The following graph compares the results of both COAs (see Fig. 6):

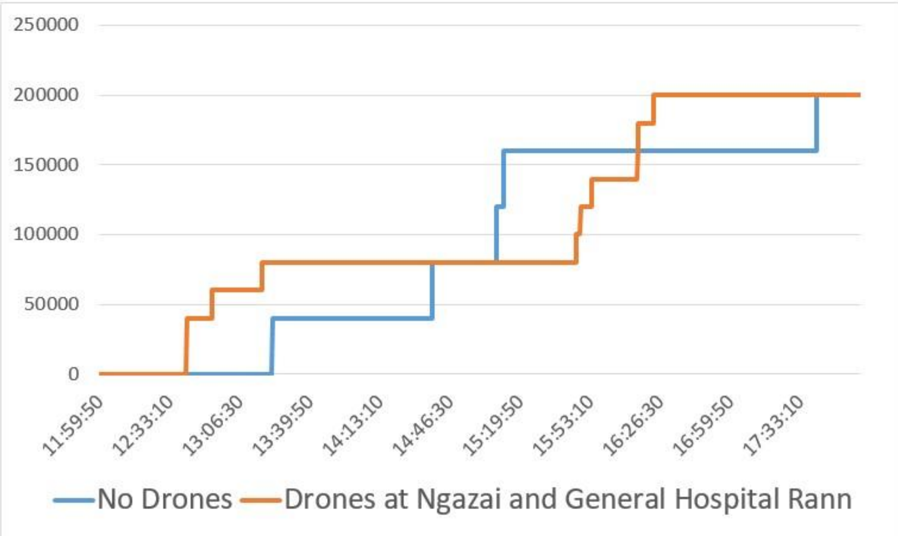

Fig. 6. Drones vs Trucks vaccines delivery in Borno.

Simulation findings. Performed tests highlight a 25% reduction in delivery time in case of transportation by drones compared with the delivery performed using only trucks. This is a very specific example. It is important to emphasize that a real scenario, in our case Northeast Nigeria, has been recreated in SINERGY; the simulation can be used to support the decision on the feasibility of the drones' deployment and on the optimal location for their deployment, depending on the final destinations of transportation and the available locations.

A Monte Carlo tool allows to compare several simulations of the same exercise considering, at each iteration, the outcomes due to different probabilities. However, in our case the Monte Carlo did not add much information because there was not so much difference between the different runs. Tested 10 times but got a very similar result each time.

On the other hand, Monte Carlo has the potential to add value when in the exercise scenario comprises terrorist attacks, random breakages, road problems or other negative events, when the probability of delivering everything with just one trip of each truck is almost impossible due to the unstable conditions on the roads. That can be simulated with probabilities of the convoys being destroyed or at least damaged, compared with the small probability of a drone being destroyed. In such instance, the Monte Carlo tool will be able to provide a general picture of the expected outcome when using trucks driving safer but longer routes, drones, and different drones' deployments.

It is possible to use SYNERGY to create scores to compare the different outcomes, considering not simply the time to complete all the deliveries but also to highlight the fact that the destruction of a truck is an event definitely more traumatic than the destruction of a drone as in the first case we have most probably human casualties.

Anticipatory action and drones simulation. SYNERGY has proved the ability to simulate cargo drones, their movement and load capacity. Different prepositioning of drones and resources that may be needed in that scenario can be tested and compared using the MASA Analysis Tool so that the best use and location for the drones can be planned, making the cargo drones ready to be used when the actual shock/event occurs.

In fact, a network of cargo drones set up in the best locations ready to be used when needed in emergency situations can make a huge difference in the times needed to establish action plans and start sending relief aid.

In addition, it has to be highlighted, the potential to reduce the need to allocate military escorts for the protection of medical supplies convoys.

In this research, Cogito has been deployed and used by humanitarian SMEs in the field, for evaluating its capabilities to improve situational awareness. Cogito and SYNERGY interoperability could evolve by implementing an automatic transfer of MIP real time intelligence with key elements and locations (JSON files) rapidly transferred to SYNERGY to modify the exercise scenario [4].

An additional benefit from the application of SYNERGY is the ability to process actual data, if available, imported from external specialised predictive and expert tools including forest fire [51], flooding or gas contamination [4, 52]. Recently, authors have linked SYNERGY with the Spatio-Temporal Epidemic Modeller (STEM) [4, 52] to provide a realistic simulation of the virus spread, while in case of lack of actual data, past data can be used, e.g., the flood can be simulated from a previous event.

3.1 Ethical considerations

Discussions have identified critical areas related to improving targeted approaches for diverse populations. These include ethnic minorities, under researched and under represented groups. In fact, there is a requirement to support people from deprived backgrounds and also increase, through research, the visibility of these crises across different nations.

The use of AI for humanitarian anticipatory action has demonstrated ground-breaking potential towards early warning, analytics, and faster response to natural disasters. One example of this is evidenced in Mozambique following the cyclone in 2019 when AI-supported disaster mapping was implemented as a successful humanitarian emergency response [55, 56].

However, despite the powerful role that AI plays towards humanitarian response, ethical considerations are critical to guide implementation and processes. in relation to the use of AI including artificial intelligent drones. This is due to the potential risks involved, including algorithmic bias and privacy concerns.

Algorithmic bias. With regard to algorithmic bias, it is of great concern that AI systems do not adequately reflect differing ethnicities and abilities, which can lead to lack of data representativeness and in turn lack of impartiality [57-59]. This is particularly important for decision making and triage regarding humanitarian aid in identifying the specific needs of individuals.

For example, for persons in need of assistive equipment or those with learning disabilities. Without representative data sets, AI will be faced with shortcomings in meeting these needs, which promotes discrimination and further perpetuate existing inequalities.

Data privacy and data protection. To protect vulnerable populations, the use of AI for humanitarian anticipatory action calls for data governance and data protection. Although there are legislations that guide the use of and sharing of data, there are existing loopholes that can cause potential harm to vulnerable populations.

In emergency situations, both governments and humanitarian organisations may use their 'political power' to access and process personal data without individuals' consent [60, 61]. This also has implications for individuals who may not wish to give consent but are coerced to do so to access humanitarian aid, such as food, clothing and shelter.

In summary, AI plays a significant role in humanitarian anticipatory action. Measures to protect data, enhance data privacy and reduce algorithmic bias are fundamental and the humanitarian community to safeguard vulnerable populations in emergency response, must systematically take them into account. These aspects are just as important as the technical ones, and require careful consideration however, such complex topics would require further research, beyond the scope of this paper.

4 Conclusions

In an increasingly uncertain world, armed conflicts, energy crisis, drought, pandemic, hunger, displacement, never we have seen such complex crises. Climate change impacts factors are likely to exacerbate existing vulnerabilities and reduce people's livelihood options, with negative implications for peace and stabilization efforts.

The humanitarian community is looking for new approaches, cost-efficient project designs and programming. The intent to shift from the traditional reaction to crises to new anticipatory action approaches requires a digital transformation, creative solutions, exploitation of data and predictive analytics.

M&S systems have been used by the military since decades, with lower costs compared to *live* exercises and more realism than tabletop exercises, to train commanders and staff, while humanitarian organizations traditionally rely on games and tabletop exercises for staff training.

Authors have provided the humanitarian community with a proof of concept of an use case of possible AI and M&S application in the context of anticipatory action in a demanding operating environment. An exercise scenario has been generated to simulate cargo drones' pre-deployment and operation in Borno, where both armed insurgence and frequent natural disasters affect population and restrict movement; drone and truck transportation have been compared.

The Expert.ai NLU and ML hybrid Cogito has been applied for updating the initial simulation scenario data and detecting actionable intelligence useful to enhance both situational awareness and to update the simulation scenario. The AI supported simulation MASA SYNERGY has proved very promising to simulate cargo drones prepositioning, in disaster-prone regions to replace vehicles where terrain conditions or violence restrict road movements.

Seminar workshop and discussions have highlighted the awareness, in the humanitarian community, that deciding and acting prior to the onset of a predictable shock, will improve resource allocation, efficiency and (cost-)effectiveness of responses and operations, compared with the traditional reactive approach.

Tests and demo have captured the relevance and highlighted the consensus that AI and simulation enable humanitarian actors to efficiently prepare emergency management scenarios, rehearse procedures, and validate emergency plans, finally supporting faster decisions, real time monitoring and situational awareness.

Ethical considerations, algorithmic bias, data privacy and protection aspects are as important as the technical ones and require careful consideration to guide implementation and processes, in relation to the use of AI.

In summary, in the context of anticipatory action, SYNERGY can be used to simulate events with the aim of establishing action plans ready to be used in face of the occurrence of such events. MASA Analysis Tool allows the execution of different simulations and the comparison of those simulations using measurements and graphs. In preparedness, SYNERGY contributes to prevent and mitigate risks by improving the quality of crisis cell training within a reality - training – reality cycle, by testing contingency plans and simulating the impact of disaster on people, the environment, and infrastructures; during the response, it minimizes risks and supports decision-making process.

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