

M&S to support wargaming for concept development: Multi-domain operations in urban environment use case

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ABSTRACT

Development of a concept for Multi Domain Operations in the Urban Environment (MDO in UE) required validation effort to ensure that identified capabilities and the concept principles are pertinent to the future operating environment. In 2023 there was an ACT wargaming event bringing unique mixture of qualitative and quantitative assessment while seeking for a synergy between manual wargame and Modelling and Simulation (M&S).

The MDO in UE concept is designed at the operational level; therefore, it requires inclusion of tactical activities in all five military domains while aggregating effects at operational level. The simulation framework was composed of a constructive simulation, an analytical tool harvesting M&S generated data, strategic dashboards using operational level metrics and a system dynamics model assessing the civil environment.

The paper commences with the Use Case description and M&S requirements. In later part, based on the design of M&S support to wargame and wargaming execution, the results of the validation event are portrayed. The last part describes lessons identified when looking for WG and M&S synergy in Concept Development arena.

1.0 INTRODUCTION

NATO Military Committee approved the Urbanization Capstone Concept - Joint Military Operations in an Urban Environment in 2019 and directed Allied Command for Transformation (ACT) and Allied Command for Operation to take forward a number of lines of effort, including the development of an Operating Concept for Multi Domain Operations in the Urban Environment (MDO in UE). Development of a concept requires validation effort as recommended by NATO Concept Development process [1]. The concept validation may benefit from a mixture of qualitative and quantitative techniques to reach required maturity and rigour. An experimental objective was to compose wargaming and Modelling and Simulation (M&S) support into a single real time event while identifying gaps and way ahead for the future ACT concept development activities. The role of wargaming and M&S within a concept development is described in NATO CD&E Handbook [1]. Use cases and best practices on composing wargame and M&S are known [2] [3] [4] [5] [6] [7] [8]; this use case is specifically aimed to CD&E domain, urban environment operational level activities and most importantly it demonstrates benefits and limitations of current simulation systems applied into the real-time wargame execution support.

2.0 MDO IN UE CONCEPT VALIDATION USE CASE

2.1 Concept

Essential to the validation was a) the identification of when the MDO in UE principals - Interconnectivity, Creativity, Unity, Understanding, Interaction, and Agility – were used, b) the ability to compare the differences between a Multi Domain Task Force approach and a traditional Joint Task Force approach in the UE and c) to evaluate validity of capability requirements defined in concept for future urban operational warfighting.

MDO in UE concept is articulated around six main principles:

- *Interconnectivity* - unites are using interoperable command, control, communication, computers, information/intelligence, surveillance, target acquisition and reconnaissance (C4ISTAR) system enabling continual synchronization of effects across all domains.
- *Creativity* - internal decision-making is enhanced through scalable AI- assisted C4ISTAR and battlespace management tools supporting human machine teaming driven by the Commander's direction for the level of machine input and automation to decision-making.
- *Unity* across all domains requires broad collaboration and negotiation at the operational level.
- *Agility* - increased C2 tempo, allowing C2 elements and units to better meet the challenges in a complex and dynamic operation in the UE, namely compression of the levels of warfare with tactical incidents having a strategic effect.
- *Understanding* - C4ISTAR elements delivers understanding of the adversary, the UE and local population supported by dynamic intelligence feeds, with rapid access to internal and external resources with reach back capacity to higher headquarters as required.
- *Interaction* - continuous interaction of MDO units at all levels of command with the UE, including the civilian population, urban infrastructure and urban information environment enables effective operation within the UE in comparison to those only with temporary effect.

Subject Matter Experts (SMEs) at HQ SACT identified 66 capabilities in the MDO in UE concept that would be required for the concept to work. These capabilities were refined down to 16 for the use in the MDO in UE concept validation and transformed into Capability Cards (CC). Each CC consisted of a title, a short description, the effects to be achieved and explanation how these effects can be portrayed in three dimensions of the operating environment -Physical, Virtual and Cognitive (PVC).

2.2 M&S Requirements

In general, in support of concept development and validation M&S provides modelling and visualization services to support design execution and assessment of a wargame (WG) that validates the MDO in UE concept. A System of Simulation Systems (SSS) needs to replicate expected behaviour of CCs. The SSS needs to be tailored to visualize entities' operational status and potential operational effects in the PVC dimensions that can be brought from actions in five Operational Domains (5OD). Synthetic environment generated by the SSS needs to replicate a littoral highly populated city with infrastructure features that are foreseen in the horizon of the next twenty years. Wargaming execution platform needs to be synchronized with the SSS bringing a synergy for the real time wargame execution. The scenario and urban data needs to be built up into the SSS facilitating support to the wargame execution, data capture and analysis plan.

3.0 M&S SUPPORT TO MDO IN UE WARGAME AND CONCEPT VALIDATION

Two weeks of wargaming and M&S activities in JFC Naples were synchronized to deliver qualitative and quantitative data for the concept validation. In the first week, during the rehearsal period, the SSS was mostly used as a visualization tool to understand operational effects generated by CCs. It was proven vital for the second week of WG execution period described in Figure 1-1. Planning phase for one turn in the WG started in the afternoon with a vignette brief setting up the current situation in the Joint Area of Operation (JOA). The SSS was used mostly as an Information Management System (IMS) supporting separately the planning process of three Joint Operations Planning Groups (JOPG)s. IMS provided Common Operational Picture (COP) to JOPG as the single entry point to all ORBATS, Scenario, Road to Crisis, terrain and urban specific data. Planners developed their Operational Design, Synchronization Matrix and selected limited number of CCs essential to reach the mission end-state. M&S Team with Planners translated planning products into series of actions for the SSS. Over the night, the simulation run was executed and in the morning after the Red, Blue and Green briefings M&S Team and facilitator described the main findings from the SSS run to stimulate following free play in the pace of Action, Reaction and Counter Action. D+3 was selected period of a single simulation run because of time constraints (night shifts) and computational demand related to the complexity of operations in the urban environment. After the back briefs within JOPG, JOPG leads (Blue Team Leaders) were part of a Combined Hot Wash (CHW) led by the Senior Mentor. The CHW started with simulation driven comparison of three plans created by JOPGs and the Senior Mentor put stress on the differences and commonalities within plans. Analysts assured qualitative assessment questioning the Planners during the WG run. The SSS automatically collected all data for quantitative analysis for latter validation of the concept through operational level metrics. There were four plus one methodologically similar runs driven by four plus one training vignettes varying from a peace keeping operation up to force on force activities within urban environment. Namely:

- Training Vignette from D+1 to D+52 to Understand, Shape & Enter.
- Vignette 1 from D+53 to D+58 to Defend, Consolidate & Clear.
- Vignette 2 from D+59 to D+89 to Defend, Consolidate & Clear.
- Vignette 3 from D+90 to D+119 to Attack, Consolidate & Clear.
- Vignette 4 from D+120 to D+180 to Stabilise & Transition.

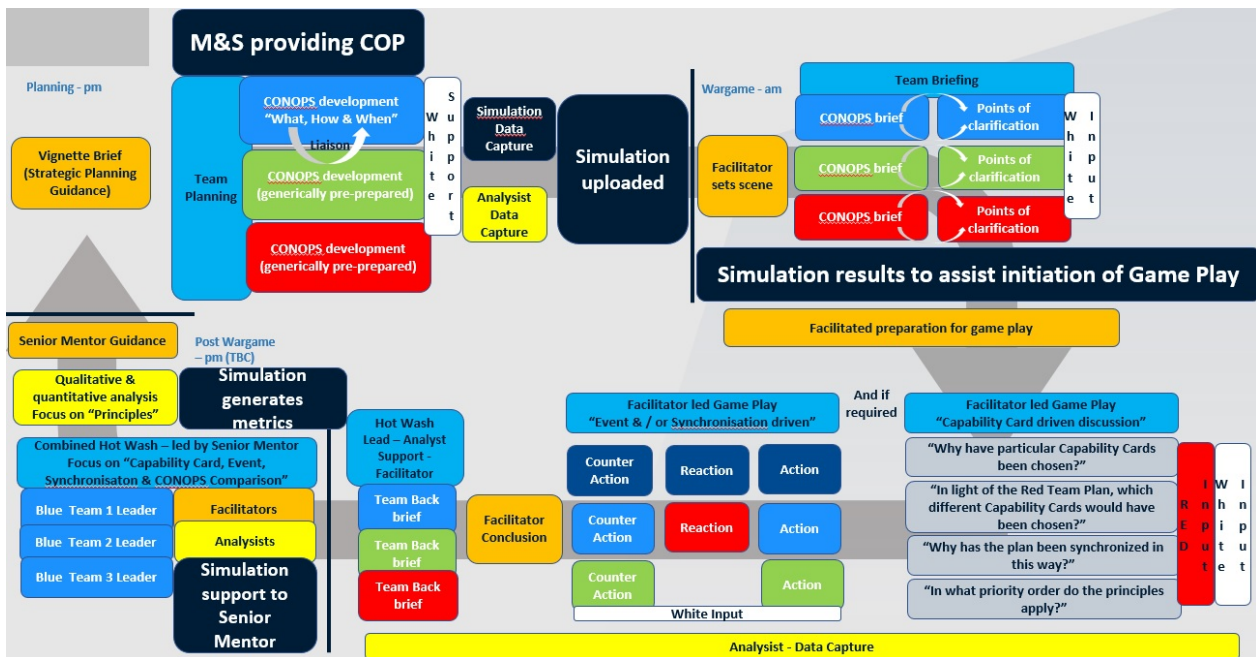


Figure 1-1: M&S support to MDO in UE wargame and the concept validation.

The SSS was composed of VR Forces constructive simulation [9], HIVE analytical tool [10] harvesting M&S generated data, strategic dashboards using operational level metrics and Resilience Models [11] built upon the system dynamics paradigm to assess the civil environment. Figure 1-2 describes the architecture of M&S solution. VR Forces working as IMS and adjudication tool was set up based on Scenario, Vignette, ORBATs, terrain and urban data. For each vignette, the main inputs were proposed Blue/Red/Green COAs. Resilience model supported planning of Green CoA and provided expected values of indicators forming operational level metrics to support the validation of the concept. These metrics were then visualized through HIVE generated strategic dashboards.

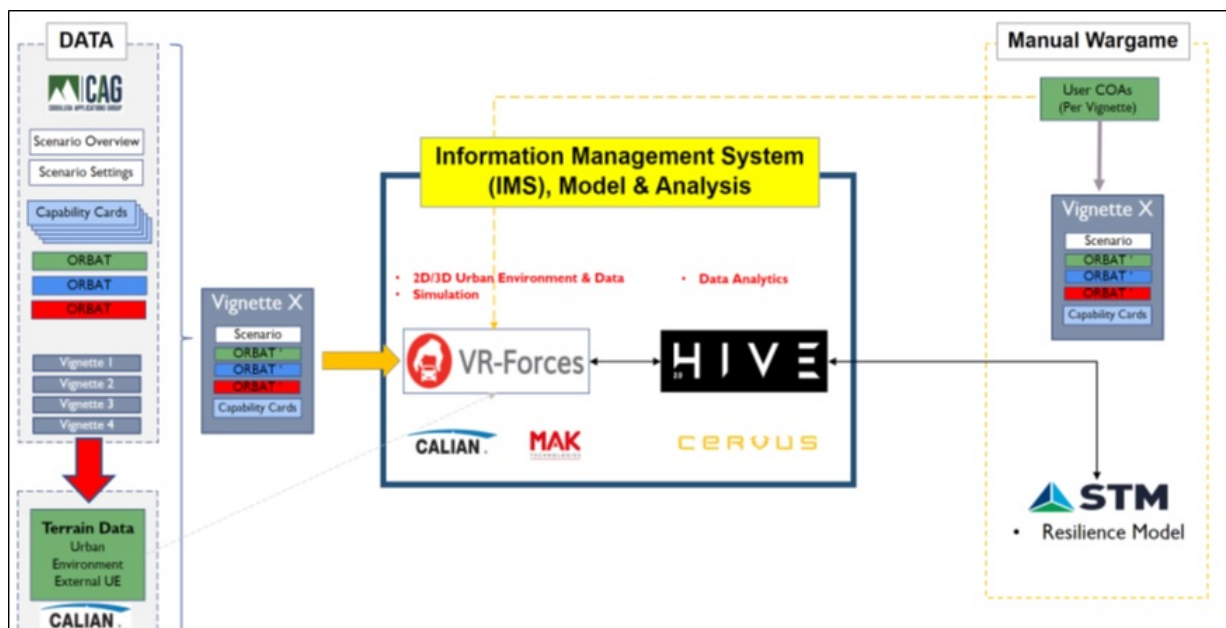


Figure 1-2: M&S architecture for the MDO in UE wargame and the concept validation.

4.0 SIMULATION BASED RESULTS FROM WG EVENT SUPPORTING THE CONCEPT VALIDATION

During the WG execution simulation data was recorded in the SSS and HIVE analytical platform aggregated it into operational level metrics and the concept principles metrics. Operational metrics, like Combat Effectiveness of Blue, Red, Green were used mostly during the WG execution to stimulate the wargaming free play. The concept principles metrics were used to support the validation phase.

4.1 Design of Experiment

Independent variables were: # of WG team, Synchronization Metric, Operations Design, Selected set of Capability Cards. Dependent variables were the concept principles metrics: Agility, Creativity, Interaction, Interconnectivity, Understanding and Unity. Controlled variables were: Terrain, Scenario and Weather.

4.2 Methodology of the experiment

To be able to identify if Planners were applying the concept principles and up to what extent, the Baseline CoA for each of vignette was created. The Baseline CoAs were created prior the WG execution, disregarding any of the concept principles. The Baseline COAs were planned as Joint not MDO operation. All Baseline CoAs were translated into the SSS actions and executed prior the WG event. Comparison between Baseline CoA and MDO in UE concept driven planned COA brings required evidence towards the concept validation. In Table 1-1 and Table 1-2 a score is a delta between values of the concept metrics in Baseline CoA and MDO in UE concept driven and planned COA.

An example of the Agility concept metric and its relation to the SSS generated indicators followed (It is composed of three indicators that are weighted equally):

- *Inter-domain communications*: Count of unique instances of radio transmissions between entities within different domains (e.g. Land -> Maritime, Space -> Cyber), divided by total possible unique transmission combinations.
- *Combat effectiveness change while moving*: Cumulative Delta of Combat Effectiveness for Blue + Green forces during periods when changes in latitude, longitude and altitude are changing. Measured as a % change from starting Combat Effectiveness.
- *Delta of applicable resilience properties* (availability of central government services, energy in production, hospital treatment availability, current communication availability, current transportation availability). Deltas are taken as a cumulative % change from the start time of the simulation to end of simulation.

4.3 Results

Table 1-1: Comparison between executed Baseline CoA and WG planned CoA by three planning teams for each vignette.

		Delta to Baseline in Scores per principle and per Vignette				
	Principle/Vignette [score]	Training	Vignette1	Vignette2	Vignette3	Vignette4
WG#1	Agility	0	0	0	0	0
	Creativity	-29	1	4	2	0
	Interaction	0	0	-2	3	0
	Interconnectivity	-16.5	-24.5	5.3	6.2	0
	Understanding	-25	0	0	0	0
	Unity	-29	1	4	2	0
WG#2	Agility	0	0	4	0	0
	Creativity	-9	3	7	6	0
	Interaction	0	7	3	2	0
	Interconnectivity	0.5	-24.9	9	8.2	0
	Understanding	0	0	0	0	0
	Unity	-20	3	7	6	0
WG#3	Agility	0	0	0	0	0
	Creativity	-9	8	2	0	0
	Interaction	0	7	-2	2	0
	Interconnectivity	0.5	-5.9	7.3	4.2	0
	Understanding	0	0	0	0	0
	Unity	-20	8	2	0	0

Main consideration towards the concept validation:

- Vignette #4 Peace Support operations (stabilisation & reconstruction) seemed not to create an environment where the MDO principles could be observed more than in the Baseline for any of WG groups.
- We got negative values (decrease) in Training, Vignette#1 and then we got for Vignette#2-3 only positive values. We believe that this indicates learning effects as participants better understood the principles and their implementation in MDO in UE planning. Another, plausible, but less likely explanation is that these specific vignettes did not create enough stimuli to use the concept principles.
- From this point, we based following points mostly on results of Vignette#2 and Vignette#3, which we assess as the high tide of MDO understanding.

Table 1-2: Summarized scores from Vignette #2 and #3 per each WG team.

	<i>Sum score from WG#1, #2, #3 from Vignette 2 and3</i>			
<i>Principle/WG# [score]</i>	<i>WG#1</i>	<i>WG#2</i>	<i>WG#3</i>	<i>Sum</i>
Agility	0	4	0	4
Creativity	6	13	2	21
Interaction	1	5	0	6
Interconnectivity	11.5	17.2	11.5	40.2
Understanding	0	0	0	0
Unity	6	13	2	21

Main consideration towards the concept validation:

- For Agility and Understanding, we have not observed any significant changes from baseline through all Vignettes and WG teams. Therefore, Understanding and Agility, in this order, seems to be the least relevant/applicable from all principles to MDO in UE. Agility is giving very light signal on its relevancy to MDO in UE.
- As for Interconnectivity, Creativity, Unity and Interaction, we have observed increase in their use and the order describes their relevancy to MDO in UE. Interaction is giving only very light signal on its relevancy to MDO in UE.

5.0 CONCLUSION

The SSS composed of a constructive simulation, an analytical tool harvesting M&S generated data, strategic dashboards using operational level metrics and a system dynamics model assessing civil environment enables to support the overall wargaming lifecycle:

- In WG design – modelling effects of Capability Cards and their visualization for planners.
- In WG Rehearsal – understanding of Capability Cards operational effects through simulation visualization and strategic dashboards.
- In WG execution during the planning period of each vignette- the SSS served as Information Management System proving a Common Operational Picture.
- In WG execution providing support to adjudication:
 - producing analytical dashboards as D+3 situation for the facilitator of each planning team
 - producing analytical dashboards to compare three proposed plans as D+3 for the Senior Mentor
- In WG analysis generating quantitative data for the concept validation: to compare Baseline plan (Joint Force Task) and proposed plans with selected Capability Cards set (MDO Force Task) through lenses of six principles’ metrics.

Key conclusions:

- A single WG and M&S support solution does not fit to MDO driven requirements.
- A simulation shall not distract players from planning activities; it needs to create immersive conditions and mostly to provide quantitative data for a concept validation event.
- M&S personnel needs to be well prepared to interact with players and to translate simulation results into the operations language.
- Conceptual modelling of effects in five operational domain is of the key importance before implemented in a simulation system.
- A simulation shall be used in the WG rehearsal to demonstrate expected effects of actions decided by planers.
- There is a need to develop a best practice on metrics used in a simulation while supporting a concept development in five operational domains.
- Concept owner, analyst, experiment designer and modelling and simulation SMEs need to synchronize their effort from the very beginning of a concept design.
- WG facilitator needs to work closely with M&S team to deliver unified message based on the M&S results.

Main constraints:

- Speed of the translation of plans into the simulation was the bottleneck. Higher level of automation in the whole WG lifecycle is fundamental.
- WG documents production management system needs to be considered to implement in the future to speed up the process and assure the reuse of already created outputs for the future validation event.
- Nature of stochastic simulation involved requires repetition of simulation runs of Baseline and MDO driven CoAs to increase the level of confidence interval.
- Correlation analysis between the MDO in UE principles has not been executed.

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