Multilayer Wargames: Lessons from Gaming Intermediate Force Capabilities

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ABSTRACT

Generally speaking, wargames are tools for exploring human decision-making in an environment with incomplete and imperfect information. They can provide important insights into the complexity of military operations or can be used to generate novel ideas. One of the limitations of wargames is that they tend to focus on a single temporal/spatial scale. For example, tactical games can represent minutes to hours of real time, and the area of several square kilometres, whereas strategic games can span months to years and be global in their nature. Usually, if an analyst desired to conduct analyses spanning multiple warfare levels, the only feasible approach would be to select the largest domain and the highest resolution to accommodate even the smallest scales involved. This could lead to oversimplification and aggregation, or to extensive cost due to very high game resolution. While designing a wargame series to support development of the NATO intermediate force capability concept, NATO SAS-151 study developed a prototype multi-layer wargame integrating tactical and strategic levels. We present some lessons learned from this approach, and we propose a more complex approach to integration of multiple wargame layers in order to simulate warfare across multiple scales. This approach avoids oversimplification and enables capturing the complexities of warfare without unduly increasing the cost of analysis.

1.0 INTRODUCTION

Wargames, in their very nature, are tools for exploring human decision-making with incomplete and imperfect information. [1] Most realistic military systems are too complex to be amenable to simple analyses, and often need to be represented through some type of simulation. Such simulation can be live (using real soldiers in physical environment), virtual (using simulated soldiers in a virtual environment), or some combination of these two. The wargames fall into the latter category. Peter Perla defined a wargame as: "A warfare model or simulation that does not involve the operations of actual forces, and in which the flow of events shapes and is shaped by decisions made by a human player or players." [2]

Consequently, wargames are played by real players operating in a simulated environment; this environment can be in a form of a computer model or a map on a table. [3] Each of these approaches has some strengths and limitations. Live exercises, while best capturing the human-decision-making, are costly; that often constrains the numbers of repetitions that can be done, or even the number options that can be evaluated. Simulations are cheap compared to live exercises, many of them represent physical realities very well, but they generally abstract the decision-making processes. [4]

Wargames cover the vast space between the two extremes. They can range from seminar wargames at one end to computer-assisted wargames that represent every single entity. [5] Depending on the type and fidelity they can be relatively cheap, but they can also cost tens of thousands of dollars. [6]

Wargames usually address a specific level of warfare (e.g., tactical, or operational). Games at different levels can differ by scope, level of detail, and spatial and temporal scales. [7] For example, at the tactical level the games would span hours to possibly days, and can cover from few square kilometres to few hundred square kilometres. They can have the resolution from single entity (soldier or platform) to various aggregated units. Capabilities can be represented with significant level of detail. The turns can range from minutes to hours, possibly days. On the other hand, strategic games usually span months to years, can cover from thousands of square kilometres to the entire globe, usually consider abstracted large formations with abstracted capabilities, and have turns that range from weeks to months. [8]

As noted by Appleget et al., wargames flow on a continuum from rigid kriegsspiel, to free kriegsspiel, through matrix games, on to seminar games. [9] Tactical games commonly employ a kriegsspiel approach (either rigid or free) whereas strategic games generally employ a matrix or seminar approach. [10] Exceptions to this division are possible; e.g., seminar games are traditionally used at all levels for analysis of complex problems and exploratory work when the rules and actions are difficult to foresee in advance. [11] Intuitively, using higher fidelity games with more constrained vignettes, while using more abstract approaches with broader and less defined problems makes sense. According to Appleget et al., different wargames have applicability to different problems, different aims, and different objectives. Furthermore, the most useful wargames are not kriegsspiel games or matrix/seminar games in of themselves, but rather hybrid wargames that employ different aspects of the wargames together. [9], [12]

While Kriegsspiel games are generally effective when comparing various capability options at the tactical level, due to their limited time scales and scope they preclude the analysis of strategic effects. Even large scale operational kriegsspiel games that typically take place against a strategic backdrop do not consider changes to the strategic environment in of itself. [8] In contrast, matrix and seminar games can represent the full range of political, military, economic, social, infrastructure, and information (PMESII) events. [10] Consequently, they can accommodate more complex strategic scenarios with multiple competing agendas. The price for this is that due to their abstraction and aggregation of forces they are generally unsuitable for gaming tactical level engagements, particularly at small scales where individual entities often need to be represented. [13]

In order to leverage the strengths of both matrix games and kriegsspiel, Christensen and Dobias proposed a hybrid approach. In this approach, a modified/shortened version of a matrix game is executed to assess the outcome of an initial tactical level kriegsspiel engagement game, The latter is in turn set within a strategic and operational context of the matrix game. [12] This approach will be discussed in greater detail below, as the simplest example of a multi-layered wargame. [14]

The need for an alternative approach to wargaming which would provide a means of assessing the strategic and operational implications of tactical actions was driven by the previous experience of one of the authors with experiments assessing mission effectiveness of non-lethal capabilities. More specifically, during the wargaming and live experimentation supported by NATO Systems Analysis and Studies research task group 094 (SAS-094) it was identified that there is often no direct link between tactical performance, and operational and strategic effectiveness. For example, a lethal force might have performed significantly better at accomplishing a specific task (such as stopping a vehicle), but this did not always translate to superior accomplishment of operational or strategic objectives. [15] Hence, as the analytical focus considers more cross-domain capabilities, especially below the threshold of a major armed conflict, it becomes obvious that a novel method enabling such analysis would be highly desirable: "Nevertheless, in a strategic situation … where tactical effects of various capability mixes can have dramatic strategic consequences both in terms of success and failure, neither …[war]game would work in isolation." [16]

This paper presents lessons learned from the SAS-151 [17] series of wargames designed in support of intermediate force capabilities (IFC)[1] concept development. [18] These wargames combined two distinct types of wargames in order to assess the strategic implications of tactical capabilities, particularly directed energy (DE) non-lethal capabilities. [12] It is organized as follows. The next section looks at the observations from two NATO Non-lethal Technology Exercises that led to the concept of multilayer wargames. In the subsequent section the idea of multilayer games is explored. Then the structure of the SAS-151 wargames, and their development are summarized, followed by the discussion of key lessons from these wargames. Finally, potential future research directions are recommended. The paper is largely based on previously published work, and the reader is invited to consult the original papers for additional details.

2.0   EXPERIMENTATION AND NON-LETHAL WEAPONS

SAS-151 had a strong foundation to build from, particularly based on the previous work of SAS-094, initiated in support of development of a NATO non-lethal capabilities concept, and two military utility assessments – NATO Non-lethal Technology Exercise-2015 Maritime (NNTEX-15M) [19] that took place 22 June - 3 July 2015 in Belgian territorial waters and NATO Non-lethal Technology Exercise-2016 Land (NNTEX-16L) [20] that took place 19-30 Sep 2016 at Belgium's Camp Elsenborn – conducted under the auspices of NATO's Defence Against Terrorism Programme of Work (DAT PoW).

SAS-094 study researched a particular future security environment and its anticipated implications for the development and use of non-lethal capabilities, developed and synthesized 15 case studies from past NATO and US operations, conducted two concept-focused tabletop wargames on mission impact of non-lethal capabilities (NLC), and provided the analytical support to NNTEX-15M and NNTEX-16L. [15] The two wargames preceded and paralleled NNTEX field exercises. One was a maritime game considering non-lethal capabilities employment in Visit-Board-Search-Seizure (VBSS) operations designed and conducted by the Naval Postgraduate School [21] paralleling NNTEX-15M which analysed non-lethal capabilities in VBSS and force protection (FP) tasks. The second game was a Concept Development Assessment Game (CDAG) [22] examining a case study scenario – Intervention in the Sahel – developed by SAS-094's Concept Analysis Working Group ahead of the NNTEX-16L which assessed non-lethal capabilities employment in perimeter security, vehicle control point operations, and dismounted patrolling. [15]

Both the wargames and the NNTEX events focused on the tactical assessment of the non-lethal capabilities' effectiveness in furthering mission objectives in order to determine costs and benefits associated with weapon selection and employment. [15] Mission success criteria considered factors such as numbers of deaths and serious injuries among the non-combatants (target vessel's crew, or civilians in land scenarios) and friendly forces. The analyses recorded actions, weapon selection, employment, expected outcomes, and player feedback. For the CDAG, because it did not employ multi-turn approach with a Red team[2], the analysis focused on compensating trade-offs when size, weight, and weapon carriage were considered with the objectives of minimizing potential civilian casualties.

The two NNTEX military utility assessments provided opportunities to take lessons and insights from the wargaming to the field. In both, the first week included hands-on training, tabletop exercises examining baseline techniques, tactics and procedures (TTPs), as well as TTPs adapted to account for available NLC capabilities, and a walkthrough to discuss scenarios and permissible engagements versus the opposing force and simulated targets. For NNTEX-15M, the second week was at-sea on the Belgian Frigate LEOPOLD I

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[1] According to the proposed NATO definition, intermediate force capabilities encompass all active means to employ force below lethal intent. This includes non-lethal weapons (legacy and directed energy), information operations, cyber, electronic warfare, but also stability policing and special operations forces.[18]

[2] CDAG normally uses Blue Team and a challenge board (playing a limited Red Team role). The players are expected to develop an operational plan in response to game scenario. This plan is then challenged by the board and adjusted as appropriate. Normally only one cycle is played, so there is a limited consideration of actual opposing force counteractions. [22]

(F930), with rotation of the four Boarding Teams (Belgian Navy, Belgian Special Forces, German Sea Battalion, and Royal Dutch Marines) conducting VBSS on the target ship, the Belgian Patrol Boat CASTOR (P901)[3]. NNTEX-16L's five national contingents (from Austria, Belgium, Netherlands, United Kingdom, and United States) conducted vehicle control point and perimeter security operations. The military utility assessments generated quantitative data on engagements with comparisons of action-reaction-counteractions sequences and precise measurements of ranges, effects, and outcomes. They also afforded opportunities to gain warfighter feedback. The quantitative and qualitative results (reported in the SAS-094 Final Report [15] highlighted NLC's ability to promote compliance/warn/deter, facilitate engagement, facilitate manoeuvre, defeat threats directly, enhance protection, and reduce civilian casualties and collateral damage. [23]

For both the wargames and the NNTEX events all the measures focused on tactical performance, and the operational and strategic implications were considered only indirectly. It was assumed implicitly that one of the objectives was to minimize the civilian and friendly casualties, but there was no in-depth assessment of possible implications if civilian casualties occurred. In fact, the game and the experimental design made such assessment impossible. [15]

As alluded to in the introduction, the assessment of the mission effectiveness of non-lethal capabilities made it apparent that superior tactical performance is not always translated to better operational and strategic effectiveness, especially when comparing distinct classes of capabilities. For example, one can consider a simple tactical task of stopping an incoming vehicle at a checkpoint. In the vignettes assessed during NNTEX 16L, that was the actual BLUE force task. [24] The incoming vehicle could have been a distracted driver, distressed parent looking for medical aid, or a suicide bomber. Now let us consider that BLUE force has several distinct capabilities to achieve this objective: lethal force, e.g., a heavy machine gun or 40mm high explosive round; warning device such as flash bang grenade, or optical [[25]] or acoustic [[26]] warning device; or finally a mechanical [[27]] or directed energy [[28]] vehicle stopping device. The examples here do not necessarily correspond to the actual capabilities used during the NNTEX, they are selected to somewhat exaggerate the differences. The tactical task is to "stop the vehicle". The natural measure of performance, outside of the operational context, is the likelihood that the vehicle stops, and how quickly it stops. The use of lethal force will accomplish this task with (almost) 100% success rate, and the effect can be almost instantaneous. In contrast, the warning devices depend on the cognitive response from the driver. If the driver complies, vehicle will stop, otherwise it can continue almost indefinitely. Hence, unlike the lethal force, the warning devices are likely to have limited effects on distracted or determined individuals. [[24]] The performance of the vehicle stopping devices will be somewhere in between these extremes.

Adding operational and strategic considerations and thus adding context to the task itself will reveal additional complexity. What are the implications of tactical success or failure? For example, what if the vehicle was driven by a distressed parent seeking help and the Blue force killed that person? What if the vehicle was a suicide bomber and it hit the checkpoint? Depending on this additional context, such as the legal requirement to minimize civilian casualties [[29]], the operational effectiveness would be different. As is noted above, for this simple scenario the operational and strategic implications can be inferred leveraging findings from a variety of case studies of past operations. However, what if the vignette becomes more complex and such direct inference of these implications is not possible? What if there are additional concurrent and competing tasks, and additional threats?

Asking these additional questions, it became apparent that in order to analyse the performance of non-lethal capabilities and to compare it with the lethal weapons, the broader operational context and constraints must be considered. However, traditional wargaming and experimentation approaches are not best suited to these types of questions because of potentially vastly different scales of the tactical actions on one hand, and the operational and strategic outcomes on the other hand. [[12]]

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[3] On the days when Boarding Teams were not at-sea, the Belgian Special Forces Group arranged additional target of opportunity boardings of Belgian Navy vessels and commercial ships and a day of breaching operations.

Integration of various wargames into a single mega-game, while often desirable, for example to capture effects across multiple domains, is not trivial. [[30]] Horizontal integration (across different domains) of wargames can be generally straightforward if different wargames use the same or comparable temporal and spatial scales. However, the story is far more complex for the vertical integration (i.e., integrating tactical, operational, and strategic levels across often vastly different temporal and spatial scales). [[14]] This type of integration requires designed wargames as linked, nested layers, rather than like a series of interacting parallel events (which would be the case for horizontal integration). For example, in horizontal integration the question could be "what is the impact of an air attack on enemy supply lines on the land operations depending on the supplies?" However, if the vertical integration the question would be more along the lines of "What is the implication of the air attack outcomes on the planning of land operations several weeks into the future?"

In spite of complication, the vertical integration of wargames can be highly desirable. One example, already discussed, is gaming the operational/strategic implications of tactical actions. The other example is the analysis of specific tactical actions within operational wargames, and assessing the possible range of options and their impact on the outcomes of the operational game. It needs to be highlighted here that the operational game is distinctly different from a tactical game. While the tactical games ask: "are we doing things right?", the operational games ask: "are we doing the right things?" [5] Hence the integration does not consist in simply collecting the information from one or multiple tactical games to create the operational picture, but in adjudication of the impact of tactical actions (executed well or poorly) on the operational (or strategic) situation. An example of the operational game with tactical deep dives would be for example gaming demining of a particular area or suppression of adversary's air defence within a context of a major amphibious operation. The tactical games would not look at "why do we need to do it?", only on "how do we do it/can we do it with the allocated forces?". Since the force allocation would depend on other developments at the operational level, it might not be possible to pre-analyse the tactical vignettes ahead of the operational game and the integration would be necessary. [14]

3.0   SAS-151: WARGAMING INTERMEDIATE FORCE CAPABILITIES

The NATO SAS-151 activity was initially chartered to conduct a Stakeholder Event on Intermediate Force Capabilities (IFC) defined as active means (such as non-lethal directed energy, cyber, electronic warfare, information operations, and other effectors) beyond presence but below lethal thresholds. [31]

The IFC, because they are designed with strategic imperative of minimizing civilian casualties and collateral damage in mind, are a prime example of capabilities for which the tactical performance alone provides only a limited, or even skewed, picture of their military value. Furthermore, some of these capabilities (cyber, information operations) may have a direct strategic effect that would be lost if only tactical vignettes are considered. [32] Therefore, it became imperative to design a wargame that would integrate strategic and tactical actions in one game. With this in mind, and leveraging a maritime force protection wargame designed to analyse force protection requirements for a ship in a port or in confined navigation channels, [33] and incorporating it within a strategic matrix game [9], Christensen and Dobias designed and implemented a first example of a vertically integrated wargame. [12]

The integrated wargame was demonstrated during the 2020 NATO International Concept Development & Experimentation (ICDE) Conference, followed by keynote presentations at the 2021 NATO Computer Aided Analysis, Exercise, Experimentation (CA2X2) Forum and 2021 ICDE Conference. As a result of these engagements, the study group's mandate was expanded in response to NATO Military Committee tasking via the 2021 NATO CD&E Programme of Work to

> *Support the development of a NATO Intermediate Force Capabilities Concept, agreed across communities of interest, which stimulates further development, acquisition, and effective employment of IFC to meet NATO and member Nations' requirements.* [34]

The new NATO IFC concept addressed the following military problem:

Adversaries are undertaking acts of aggression that deliberately stay below the lethal force threshold or that ensure a lethal response from NATO would incur costs – undesired escalation, risks of collateral damage including civilian casualties (CIVCAS), negative narratives, and other adverse strategic or political outcomes – to the Alliance. [35]

To drive insights and develop the draft IFC Concept, SAS-151 and ACT expanded the initial two wargames into a series of six wargames and Concept Development Workshops: [17]

- **Maritime Test Game:** This game integrated a tactical kriegsspiel and strategic matrix game; examined a NATO Task Force facing pier-side, waterside, and small uncrewed aircraft threats in a port; and directly compared the Baseline Case (with traditional – predominantly lethal – capabilities) versus IFC also being available to complement and facilitate lethal capabilities, an approach used in all subsequent wargames.

- **Maritime Research Wargame:** This game built on lessons from the Test Game, leveraged expertise from several NATO-accredited Centres of Excellence (true for all later games as well), addressed hybrid threats such as use of proxy or paramilitary forces employing a variety of small vessels and uncrewed aerial systems, in a confined waters scenario, and was subsequently played in condensed form in the 2020 ICDE Conference.

- **Land Wargame/IFC Concept Development Workshop:** As a precursor to and as part of the first workshop, this game examined NATO land forces supporting a Partner Nation confronted by near-peer backed proxy threats in an urban environment, addressing tactical through strategic actions and outcomes.

- **IFC Concept Development Workshop:** A separate workshop agreed to a statement of the Military Problem as defined above, and working definitions for the terms Intermediate Force (Force below lethal intent to temporarily impair, disrupt, delay, or neutralize targets across all domains) and Intermediate Force Capabilities (Active means below lethal intent that temporarily impair, disrupt, delay, or neutralize targets across all domains and all phases of competition and conflict).

- **Information Operations and Countering Disinformation Games:** These two games made use of a novel audience-based approach to implementing, assessing, and adjudicating competing information campaigns, and they were vital in shaping the capstone Joint Wargame.

- **Joint Wargame/IFC Concept Development Workshop:** The culminating wargame conducted in conjunction with the final workshop examined a contested Non-combatant Evacuation Operation (NEO) with a peer adversary acting not only through proxies but also directly. This wargame and workshop also provided final insights and inputs incorporated into the draft IFC Concept that is now in staffing.

Most of the wargames followed a similar format. The vignettes were set within the context of a strategic narrative that defined each player's strategic and operational objectives. The tactical vignette was resolved using a semi-rigid kriegsspiel approach. It used capability cards with estimated probabilities of success to assist adjudication, but the players were free to develop their own actions. There were between three and five different player teams in each game (Blue, representing NATO, Red representing a regional adversary, and Green, Yellow, and Orange representing state or non-state entities variously aligned with either Red or Blue). In each turn a player stated their actions; at this point the other teams were able to propose counteractions if they so chose. The event was then adjudicated, and the next player would present their action. This was followed by a strategic wargame that played out the strategic consequences of the outcomes, as well as of individual players' actions in the tactical wargame. Initially, the strategic game followed a matrix game approach", but this later shifted in favour of a Diplomatic-Military-Information-Economic (DIME) approach where each player stated their actions in each line and what they wanted to achieve strategically. Once each player stated their actions, a small team would adjudicate the turn. [17]

The last three games (the information operations games and the joint wargame) were embedded within the same strategic narrative that was in turn developed through this series of wargames. The information operation games followed were played differently from the regular vignettes. This reflected the uniqueness of the information environment. The players played out a simplified strategic game, but there was a group of independent players with various assigned roles that played out the international audience. This groups only interacted with the game itself through the information provided by the main players to the information environment (whether real or fake), but they could also create their own information content that influenced the game. The final game was then played out in the strategic and information environment that resulted from the information operations wargames. [17]

4.0   WHAT WAS LEARNED FROM THE SAS-151 SERIES OF WARGAMES?

There was a significant progression in understanding the vertical integration, as well as modelling IFCs. The incremental use of integrated wargames to develop the IFC concept enabled both the improvements in the technical implementation of wargames and the expanding of the IFC set and their employment. While the initial wargames leveraged the original naval force protection tabletop game, that approach proved to be too limiting and too cumbersome for an exploratory game intended to develop an operational concept for a new technology. From that perspective, it was necessary to allow a greater freedom of action for the players. However, at the same time it was necessary to ensure that the IFC representation was realistic and did not overestimate the effectiveness. [17] This led to the recommendation to study the feasibility of incorporating modelling and simulation within this multi-layered construct to enable greater fidelity of IFC representation. [36] In the absence of the available modelling and simulation capabilities, the use of capability cards can fill the gap, providing the cards contain sufficient information about range, probability of success, collateral damage, etc.

The strategic game component of the study underwent significant progression as well. The initial matrix game approach [12] proved to be somewhat inefficient in the absence of subject matter experts with diplomatic, economic, and information backgrounds. During the initial games the players tended to default to military or relatively simple information operation solutions to problems ("we will announce …"). These actions included very little consideration for required resources, time requirements, etc. Replacing the simple matrix game approach with a DIME framework forced players to consider these additional dimensions; providing them with the action cards outlining possible actions, their prerequisites and their possible consequences made the games more efficient, and, in fact, expanded the range of possible actions employed by players to achieve their strategic objectives. [17] Furthermore, some IFC are by their very nature strategic (e.g., stability policing), hence they needed to be incorporated directly at the strategic level. The use of action cards provided a means to do that. The use of DIME framework and the cards also simplified the adjudication and made it possible to run more turns of the strategic game. The follow-on exploratory team that attempted to combine a strategic wargame with a computer-assisted operation wargame also concluded that: "It is recommended to use the DIME framework and to provide examples of actions to the participants to facilitate and speed up the planning process." [37]

Overall, the SAS-151 series proved the feasibility and value of the vertical integration across tactical and strategic levels. The key observation from the SAS-151 wargame series, and later confirmed by a follow-on study looking at the feasibility of vertical integration of wargaming with constructive simulations [37] was the need to ensure that each of the vignettes is well defined and of a limited scope, and that the wargame rules need to be simple enough to enable tracking of linkages across levels.

> *Design a series of limited vignettes that would enable testing all the desired capabilities, and yet will be simple enough individually to enable effective execution. ... If there is a need to represent larger scale operations, either they should be built up as a combination of independent small vignettes brought in together via a tabletop kriegsspiel, or alternatively, the game needs to be organized as an operational HQ. However, the latter approach would require a larger number of*

players than would normally be available. Hence a set of limited vignettes combined through an operational kriegsspiel would be preferable. [37]

Three items proved to be critical to the successful integration of the games. [17]

- Clear definition of strategic and tactical objectives for the game. These objectives must be limited, tied to the scenario (vignette) and be restated to the player just prior to the wargame and during adjudication. Vague or generic objectives will lead to very broad statements that may have limited value for the analysed scenario.

- It was imperative that the adjudicators reminded the players of the overall scenario and objectives; during the tactical game in order to ensure that the tactical vignette is played out in the appropriate strategic context.

- The adjudication team needs to have a sufficient breadth of expertise to maintain credibility and to incorporate the strategic context into the adjudication process.

The other observations pertain to the representation of IFC in wargames and simulations. The IFC can be used in a dual role, to manage escalation or to enhance lethality. [35] This might not be obvious to the players. Therefore, it is important "to recapitulate the concept and to highlight in which role the IFCs are to be used. This is especially important because not all IFCs are suitable for both roles." [37]

The IFC delivery mechanism matters. As the exploratory team's work showed, this is especially important in simulations where an IFC could be modelled by adjusting another capability to deliver non-lethal effect. For instance, using an existing assault rifle to implement a non-lethal kinetic energy weapon needs to be able to distinguish between killing and temporarily disabling a target. However, the opposing force may be confused, or unable to distinguish between lethal and non-lethal effectors until it is too late. Hence the IFCs need to be clearly identified as such. Furthermore, it was recommended to:

> *Conduct a series of studies across a broad range of IFCs and a broad range of vignettes in order to gain further insights into the effectiveness of various capabilities and various delivery mechanisms at different stages of the competition/conflict continuum.* [37]

A series of military utility experiments, assessing IFC employments in a variety of vignettes would strengthen the credibility of the IFC representation, and would provide validation of the expected effects that could be then incorporated into wargames and simulations.

5.0   SUMMARY AND FUTURE RESEARCH DIRECTIONS

Using wargames and experiments to assess capabilities that are designed to have effects across domains and across different levels of warfare requires the ability to integrate the gaming, modelling and simulation, and experiments vertically, across levels. Another possible application of such integration is assessment of plans at higher level with real-time deep dives into tactical problems that may affect the outcomes. The IFC are a prime example of a capability requiring simultaneous assessment across levels. [12] Not only would strictly tactical assessment of these capabilities miss an important dimension of their effectiveness; in some cases, such assessment may be impossible. Furthermore, some of the IFC are in their very nature strategic (stability policing, strategic communications, information operations, in some instances cyber, or the use of special operational forces), and consequently their impact needs to be considered at the strategic level. The author's earlier theoretical work leveraging a renormalization group to design a multilayered wargaming framework [14], and the wargaming done during SAS-151 [17] and follow-on exploratory team [37] suggested that such integration should be possible.

In response to the request to support IFC concept development, NATO research task group SAS-151 designed and implemented a series of wargames integrating tactical kriegsspiel type wargames within broader strategic games. Overall, this work demonstrated that such integration is possible. The use of tabletop wargames provided the study team with the ability to use a wide range of unforeseen actions and thus enable better exploration of the problem set for the IFC concept, as well as various ways of IFC employment. [17]

Key wargame design observations that can be made from the SAS-151 [17] study as well as from the follow-on proof-of-concept study [37] are:

- It is possible to design and implement vertically integrated wargames. The two studies concluded that it was imperative for the game success to have a clear definition of objectives at each level, that the adjudication maintained the linkage between the levels, and, most importantly, that the individual games were simple enough for the players to focus on the scenario and not on fighting the rules. In other words, the game design and rules must be simple enough to allow participants and adjudicators to track the linkages between the strategic scenario and the vignettes.

- For the IFC, such integration is a necessity. However, while for the concept development games the abstraction and freedom of action provided by tabletop games is acceptable and perhaps even advantageous, for the options analysis for acquisition, and for the analysis of doctrine either more restricted games or simulation solutions are desirable.

- If more complex problems are to be represented, the complexity should be reflected by the overall integration, while the individual wargames (and their corresponding vignettes) should remain relatively simple and well defined. Integrating four simple games is more likely to succeed than integrating two complex games.

Future research, some of it already ongoing under the auspices of NATO bi-panel research task group SAS-MSG-180 [38], includes:

- Development of IFC representation in modelling and simulation (including computer-assisted wargames) and in tabletop wargames;

- Further development of the vertical integration approaches, including adding multiple layers and a greater variety of vignettes, and especially development of the mechanisms for real-time deep dives within higher-level scenarios;

- Further development of the theoretical basis for the integrated wargaming; and

- Practical development of different types of integrated wargames and computer models that could be used for doctrine development, analysis of strategic and operational plans, and options analysis for tactical capabilities.

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