INSTITUTE FOR DEFENSE ANALYSES

Exploratory Tactical Operational Simulations for Intermediate Force Capabilities (IFCs) and Non-lethal Weapons (NLWs)

(Presentation)

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About This Publication

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Executive Summary

Background

The Institute for Defense Analyses (IDA) was tasked by the Joint Intermediate Force Capabilities Office (JIFCO) to conduct an independent analysis of the potential opportunities and limitations of military operational simulations or exploratory tactical "wargames" to develop and test operational concepts and inform new system capabilities for intermediate force capabilities (IFCs) and non-lethal weapons (NLWs). In this study, IDA considered various types of analytical questions, differences between conventional weaponry, and inclusion of resulting human effects with IFCs/NLWs in wargames. This briefing contains a short primer on wargames, analysis of wargame designs most relevant for IFCs/NLWs, and several toolkits for representing human behaviors.

Findings

IDA found that there are a number of opportunities when utilizing wargames:

- Better understanding of how IFCs/NLWs apply to a tactical setting, specifically:
  - Comparing tactical utility of different IFC/NLW systems
  - Understanding utility of a diverse suite of IFC/NLW systems
  - Understanding how changes in system performance relate to tactical utility
- Exploring the synergy between lethal and non-lethal effects and associated perceptions with respect to various actors in a given scenario
- Exploring a wide range of IFC/NLW employment concepts and determining the sensitivity of the IFC/NLW or associated employment concepts

- Quantifying the tactical implications of current IFC/NLW policies, and possible changes to policy, for comparison to safety metrics
- Discovering *ad hoc* and deliberate countermeasures to IFCs/NLWs for a range of scenarios

However, the study also found a number of challenges:

- Designing wargames that account for the pairing of NLW and information operations (IO), especially given the complex interactions of Blue IO, Red IO, local culture, local and social media, and visual presentation of IFCs/NLWs
- Representing the effects from both lethal and non-lethal systems, in a comparable manner
- Translating the physiological and behavioral effects of IFCs/NLWs on individuals, to the reaction of crowds
- Demonstrating the broad range of conditions and missions in which IFCs/NLWs might be used in a game
- Extracting the complexities in the decisions and actions on the deterrence/conflict escalation ladder
- Accounting for the potential impact of other elements of doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF), beyond the materiel/system technology, that make a capability

Recommendations

When deciding to use wargames, we recommend the following be considered:

- Use an iterative approach with wargames to define IFC/NLW requirements and capabilities
  - Start with tactical level simulations, only later expand to the operational level
  - Gradually introduce complexity in wargames with IFCs/NLWs to systematically understand the nuances
- While challenging to incorporate in the simulation, give attention to the IO and IFC/NLW pairing
- Pay special consideration to the intricacies of the conflict escalation ladder and timing of IFC/NLW use
- Go beyond just the materiel/technology to explore the broader context of a capability, such as other DOTMLPF elements

Exploratory Tactical Operational Simulations for IFCs/NLWs:

Part of the Independent Research Assessment Project for JIFCO

Allyson Buytendyk, Alec Wahlman, Jennifer Bewley,
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14 February 2022

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IFCs – Intermediate Force Capabilities NLWs – Non-Lethal Weapons JIFCO – Joint Intermediate Capabilities Office

Outline

- Project Overview
- Wargames: A Primer
  - Uncovering Knowledge with Wargames
  - Components of Wargames
  - Spectrum of Wargame Designs
  - Game-Design Considerations
- Designing Wargames with IFCs/NLWs
  - Game Purpose
  - Level of Warfare
  - Type of Conflict
  - Game Scaling
  - Adjudication
  - Hierarchy of Design Considerations
- Toolkits for Game Design
  - Model Considerations
  - Multiagent Systems
  - Agent-Based Models (ABMs)
  - ABMs for IFCs/NLWs
- Findings and Recommendations
  - Key Opportunities
  - Key Challenges
  - Recommendations

Project Overview

- JIFCO requested that IDA assess:
  - Opportunities & limitations of military operational simulations or exploratory tactical “wargames” for intermediate force capabilities (IFCs) & non-lethal weapons (NLWs)
  - Utility of wargames to develop & test operational concepts with IFCs/NLWs
  - Potential of wargames to inform new system capabilities
- IDA considered:
  - Various levels & types of analyses
  - Differences between conventional weaponry & IFCs/NLWs
  - Inclusion of resulting IFCs/NLWs human effects in wargames

Wargames: A Primer

The slides in this section provide a brief introduction to wargames on the following topics:

- Uncovering knowledge with wargames
- Aspects of wargames
- Spectrum of wargame designs
- Game-design considerations

Uncovering Knowledge with Wargames

- Wargames are:
  - A type of simulation where events are shaped by decisions made by humans (players) & the resulting consequence of their actions.
  - A flexible tool that creates a model which,
    - generates information
    - Is related to different levels of war
    - applies to various types analyses
  - Used to explore the outcomes of different
    - situations
    - capabilities
    - approaches

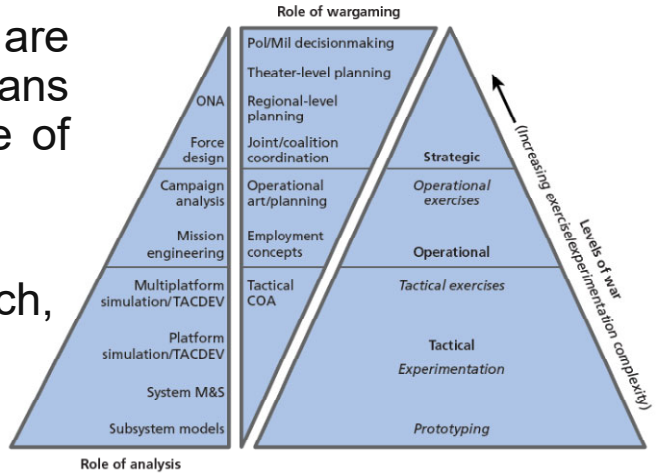


Figure from Wong 2019, reproduced from Navy Underwater Warfare Center (NUWC).

The closest Department of Defense (DoD) definition of wargames is based on evaluating courses of actions (COA):

Wargames are representations of conflict or competition in a synthetic environment, in which people make decisions and respond to the consequences of those decisions (Joint 2020).

However, the broader definition commonly cited in the wargaming community is:

A wargame is a warfare model or simulation in which the flow of events shapes, and is shaped by, decisions made by a human player during the course of those events (Perla 1990).

The figure shows the relationships between the different levels of war and how wargaming could be used to inform various decision points. Wargames are an opportunity to explore the functional relationships between input variables (scenarios, capabilities, approaches, and information) and the combat outcomes.

Slide References:

Bartels, E. Innovative Education: Gaming-Learning at Play. Last accessed 2 Feb 2022. https://www.informs.org/ORMS-Today/Public-Articles/August-Volume-41-Number-4/INNOVATIVE-EDUCATION-Gaming-Learning-at-play

Joint Publication 5-0, Joint Planning, 01 Dec 2020 . https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp5_0.pdf

Perla, P. 1990. “The Art of Wargame.” Naval Institute Press: Annapolis.

Wong, Y. H., S. J. Bae, B. S. Bartels. 2019. *Next-Generation Wargaming for the U.S. Marine Corps: Recommended Courses of Action*. Santa Monica, CA: RAND Corporation. https://www.rand.org/pubs/research_reports/RR2227.html

Components of Wargames

- Wargames consist of four elements.

Element	Description	Examples
Actors	roles involved in the activity represented by the players who make decisions on the actions for the entity they represent	U.S. forces, peer nation adversary, rebel combatants, civilian population
Environment	geographic setting & scenario where game play occurs	real world or fictional region/terrain & strategic situation that frames the circumstances that led to conflict
Rules	constraints & processes that govern outcome of players' decisions	results of players interactions determined by data & established procedures
Models	representation of how actions affect actors and environment	real people/players using virtual systems where time is represented by players turns

- The game's purpose & objectives will dictate the formulation of these elements.

No single element creates a wargame, but collectively, the actors, environment, rules, and models create the structure and techniques to explore what works/what success looks like and what it does not.

There are various ways to represent the game elements.

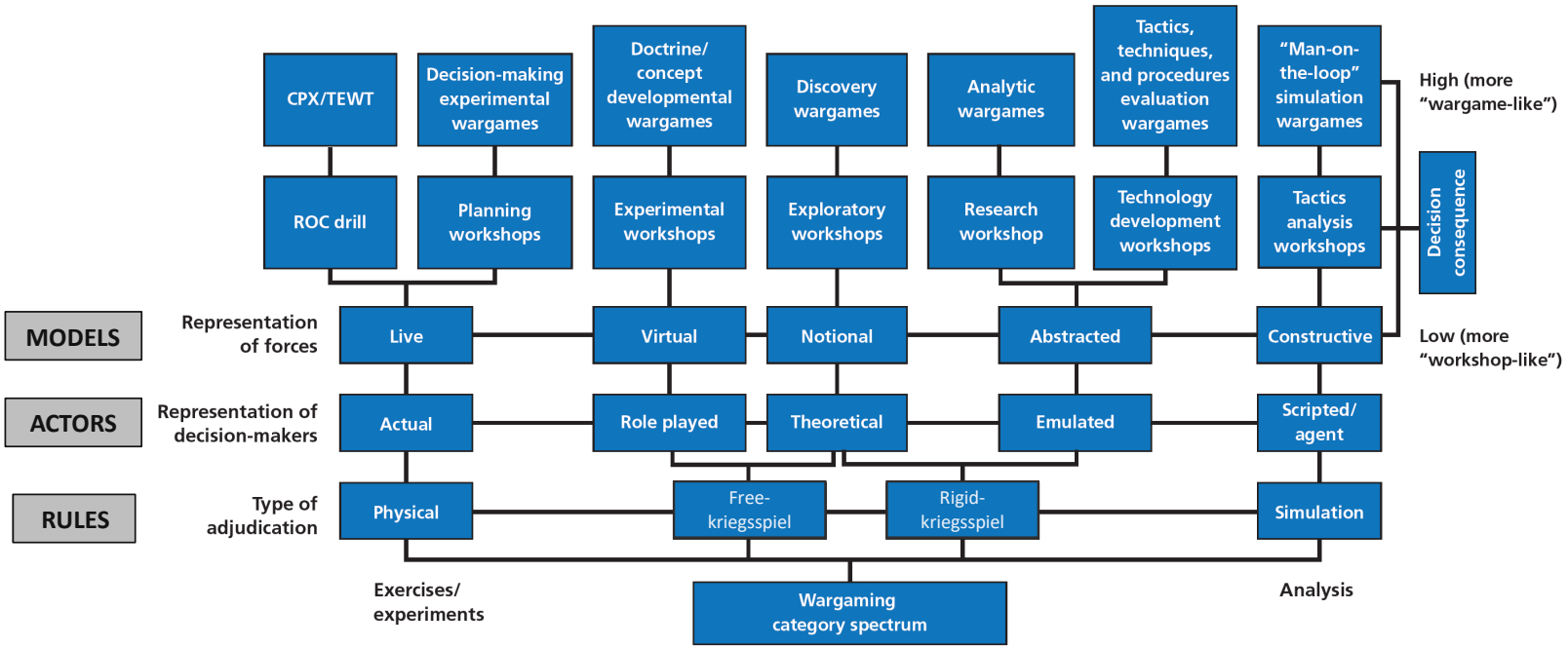
- Actors' roles could be detailed descriptions from research, general knowledge, or subject-matter expertise that the players draw from to make their decisions in the game.
- The environment could include maps, diagrams, and written descriptions of the immersive setting and scenario where the game takes place.
- The rules could be casual reminders about what players are allowed to do, strict procedures established before the game, or adjudication methods (more on Slide 8)
- The models could be a representation of a system, entity, or phenomenon in the game over the passage of time which could be simulated (e.g., 1 player turn = 2 hours) or occur live (e.g., real people using physical systems).

Slide References:

Ministry of Defense. *Wargaming Handbook*. The Development, Concepts and Doctrine Centre, Wiltshire: 2017. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/641040/doctrine_uk_wargaming_handbook.pdf

Wong, Y. H., S. J. Bae, B. S. Bartels. 2019. *Next-Generation Wargaming for the U.S. Marine Corps: Recommended Courses of Action.* Santa Monica, CA: RAND Corporation. https://www.rand.org/pubs/research_reports/RR2227.html

Spectrum of Wargame Designs



Adapted figure from Wong 2019, reproduced from Navy Underwater Warfare Center (NUWC).

CPX – Command post-exercise ROC – Rehearsal of concepts TEWT – Tactical exercise without troops

This figure shows the spectrum of wargame designs by types of activities and possible representation of elements. While the list is not exhaustive, it does illustrate a good variety of game types and common practices.

Debate exists among game designers whether certain activities (e.g., seminar or workshop) where players do not make clear decisions should or should not be included. We chose to present a broad spectrum of wargaming approaches that could be used to explore the testing, tactics, and operational concepts of IFCs/NLWs rather than focus on generating a set of criteria to exclude activities or events.

Models can be both physical representations as well as computer-assisted or computerized:

- Live – real people as actors using real systems.
- Virtual – real people as actors using simulated systems.
- Notional & Abstracted – real people as actors using simulated systems of varying degree (e.g., block diagram model, general description).
- Constructive – simulated actors using simulated systems that can further be divided into entity-level (modeling individual platforms) and aggregated (modeling groups of platforms).

Slide References:

Ministry of Defense. 2017. *Wargaming Handbook*. The Development, Concepts and Doctrine Centre: Wiltshire. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/641040/doctrine_uk_wargaming_handbook.pdf

Wong, Y. H., S. J. Bae, B. S. Bartels. 2019. *Next-Generation Wargaming for the U.S. Marine Corps: Recommended Courses of Action.* Santa Monica, CA: RAND Corporation. https://www.rand.org/pubs/research_reports/RR2227.html

Game-Design Considerations

- Determining the analytical purpose and objectives are the first tasks when designing a wargame.
- Specific purposes could include:
  - Capability development & analysis
  - Concept development
  - Operational decisions and plans
  - Policy development
  - Science & technology (S&T) development
  - Senior leader engagement & strategic discussion
  - Training and education
- Objectives are the open-ended research questions that a sponsor wants to better understand.
- Purpose & objectives will strongly influence the game type.

The game purpose provides clarity and familiarizes the players with the intended outcomes of the games; that is, whether the goal of the game is to create knowledge or convey knowledge.

Slide References:

Ministry of Defense. 2017. *Wargaming Handbook*. The Development, Concepts and Doctrine Centre: Wiltshire. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/641040/doctrine_uk_wargaming_handbook.pdf

Wong, Y. H., S. J. Bae, B. S. Bartels. 2019. *Next-Generation Wargaming for the U.S. Marine Corps: Recommended Courses of Action.* Santa Monica, CA: RAND Corporation. https://www.rand.org/pubs/research_reports/RR2227.html

Game-Design Considerations (cont'd)

- Adjudication is the process that decides the outcomes of player actions & advances the game based on the rules.
- Methods include:
  - Rigid – Set of rules that all players understand. Outcomes rely on pre-determined rules/models (look-up tables, software tools, etc.).
  - Free – Outcomes are based on expertise of adjudicators.
  - Semi-rigid – Outcomes are based on pre-determined rules or models, but adjudicator can override/adjust outcomes based on experience or consensus.
- Adjudication supports the analysis; therefore, specific methods are better suited for certain game types.

Depending on the actors' roles, adjudication could be open (where all players understand how the outcomes are determined) or closed (not transparent to all players).

Common adjudication method by game type:

- Rigid kriegsspiel – structured, rule-based (math- or physics-based) adjudication
- Free kriegsspiel – structured, but more freedom than rigid kriegsspiel; calculations may assist in the adjudication process
- Matrix – typically free form (expert panel, collective consensus, adjudicator rules) with an adjudicated argument/counter-argument process
- Seminar – structured discussion

Slide References:

Australian Defense Force. Background for the Basic and Advanced Analytic Wargaming Courses from the Naval Postgraduate School in Canberra, 17 February to 6 March 2020: Adjudication. Last accessed 2 February 2022. http://opanalytics.ca/aus/adjudication.html

Lee, A. 2020. *An Exploration of Wargame Methodologies: Manual Adjudication, Data Collection and Analysis*. Defence Research and Development Canada.

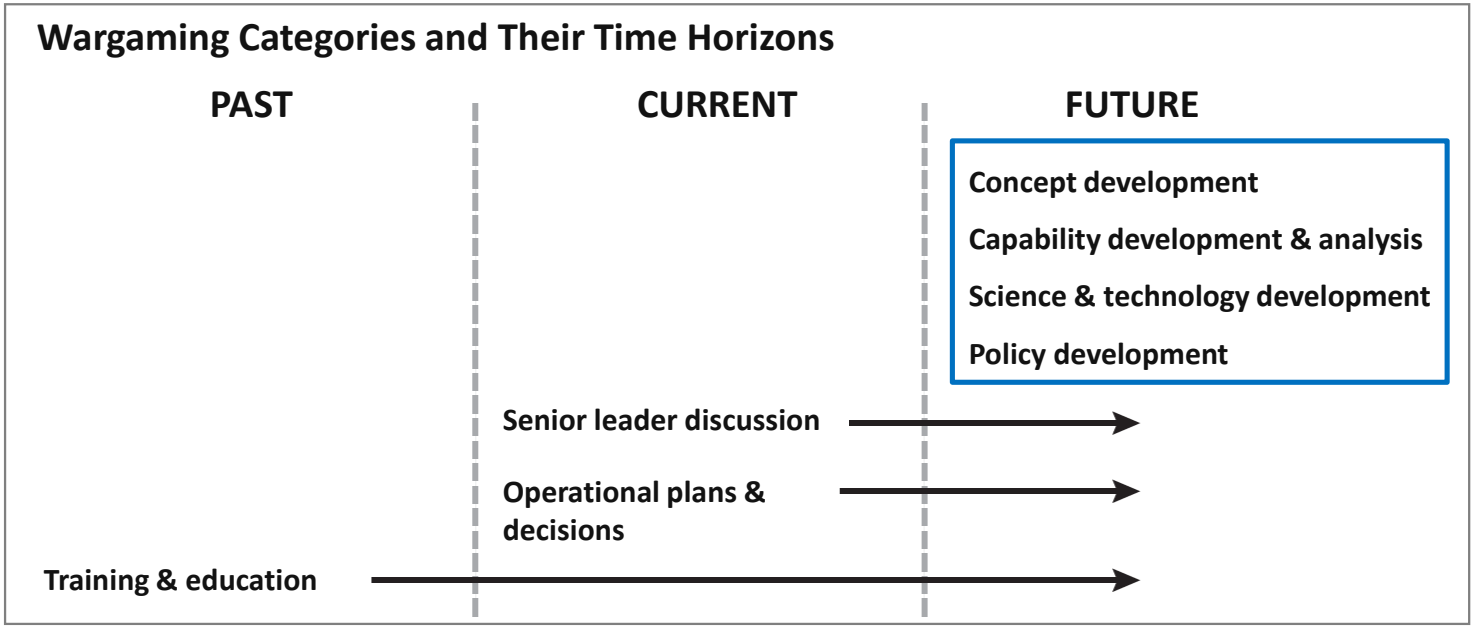
Designing Wargames with IFCs/NLWs

The slides in this section cover design aspects of wargames most relevant to IFCs/NLWs :

- Game purpose
- Level of warfare
- Type of conflict
- Scaling
- Adjudication
- Hierarchy of wargame considerations

Game Purpose

- Future-oriented wargames are most relevant to IFCs to explore areas where little to no data exists.



Adapted figure from Wong 2019.

Exploratory or discovery wargames typically have the following purpose:

- Concept development
- Capability development and analysis
- Science & technology (S&T) development
- Policy development

The next several slides address each of these game purposes for IFCs/NLWs with notional research questions (i.e., game objectives) to help illustrate the focus for a specific game type.

Slide Reference:

Wong, Y. H., S. J. Bae, B. S. Bartels. 2019. *Next-Generation Wargaming for the U.S. Marine Corps: Recommended Courses of Action.* Santa Monica, CA: RAND Corporation. https://www.rand.org/pubs/research_reports/RR2227.html

Game Purpose: *Capability & Concept Development*

Possible game objectives:

- How will the IFC/NLW be used in a specific concept (e.g. concepts of operation or employment, functional concepts)?
- What is the relative tactical utility, and potential synergy, between different IFCs/NLWs systems?
  - Combinations that yield the most overall capability?
  - Systems that stand out for their relative tactical utility?
- How can lethal and IFCs/NLWs be used in combination?
  - How do changes in mission or conditions affect this?
- What type of countermeasures could be used against IFCs/NLWs?
- What impact do various rules of engagement (ROE) have on utility of IFCs/NLWs?
  - Interplay between Blue ROE for lethal vs NLWs?

This slide and the next address both capability and concept development, as those two topics are often intertwined. A given capability will be the product of many various characteristics of a force, such as the equipment possessed, a unit's organization, and the employment concept for that equipment. Thus, a given effort could easily include the development of both capabilities and concepts.

Game Purpose: *Capability & Concept Development (cont'd)*

Possible game objectives:

- Implications of IFCs/NLWs for unit organization?
- How important is the "when" of IFC & NLW use?
  - Does it matter if Blue IFC use is immediate upon Blue forces arriving?
- How important is the pairing of IFC/NLW use & information operations?
  - Will NLW be perceived by a population as less threatening absent supporting Blue messaging?
  - What combinations of Blue messaging & IFC/NLW use are most/least effective in minimizing hostile reactions from the population?
  - Can Red messages offset any benefits from using IFCs/NLWs?
  - Impact of media, social media, and local culture?

U.S. forces face cultural challenges in operations abroad where countries have different customs and social practices from the United States. One example of a messaging challenge for U.S. forces comes from the early days of Operation Iraqi Freedom. There was a rumor on the streets of Iraq that the wrap-around sunglasses, used by many U.S. military personnel, gave them the ability to see through the clothes of Iraqi women. Per one Iraqi, "With those glasses, he can definitely see through women's clothes" (Tiernay, 2003). That rumor generated significant hostility towards U.S. forces, accelerating the timeline for shift in perception from liberator to occupier.

Other questions that could pertain to information operations:

- What role does the visual/acoustic presentation of NLW play?
- Importance of messaging reaction speed?
- How is the Blue rules of engagement reflected in the messaging campaign?

Slide Reference:

Tierney, J. "G.I.'s Have X-Ray Vision. Of Course." *The New York Times.* August 7, 2003. Last accessed 2 February 2022. https://www.cnn.com/2003/WORLD/meast/08/07/nyt.tierney/index.html

Game Purpose: *Science & Technology Development*

Possible game objectives:

- For a given system, how do various performance levels impact operations?
- For a given system, how do changes to various features compare in their tactical utility?
- How does a given system characteristic fit with various environmental conditions?
- How do a system's logistical requirements fit within the overall Blue logistics system?

Example wargame results:

- System X has little tactical value unless its range is at least 300 m
- For System X, +30% range is more useful than +30% effectiveness
- System X is expected to operate poorly in dense urban & dusty/desert environments
- System X, if issued to an infantry company, would triple unit fuel demand

This slide describes the types of research questions that could be explored for S&T development using wargames (left). On the right, notional outcomes or conclusions from the wargame specific to the system under analysis in the game are listed.

Game Purpose: *Policy Development*

Possible game objectives:

- How does existing policy shape the tactical utility of IFC/NLW systems or concepts?
  - What are the current policies, with respect to the technical characteristics of systems, and the rules of engagement?
  - What are the implications of any policy changes?
- What are the implications of the future policies?
  - What is the trade space between safety and tactical utility?

Policies or requirements could provide benefits or hinderances in different tactical scenarios. This slide includes some examples of game objectives that would generate information to inform policy recommendations. Another possibility is to run two games: one with and then one without those constraints and then compare the game outcomes to assess the tactical impact.

Level of Warfare

- Most IFC/NLW wargames will be at the tactical level
  - Tactical tools, used by tactical units
- Some IFC/NLW wargames could be at the operational level
  - Blue mission would be a key variable
  - Missions for which the civilian population is central are more likely to have NLWs playing an operational-level role
    - E.g., humanitarian assistance/disaster relief, counter-insurgency
  - Missions focused on conventional conflict probably less applicable
- Operational-level effects that IFC/NLW could provide:
  - Mitigating impact on relations with population when Blue uses force
  - Use of NLW during combat to lessen reconstruction burden post-conflict

Note: "Operational level" considered equivalent to "theater campaign"

Type of Conflict

- Tactical-level wargames with IFC/NLW could be designed to fit with a broad range of conflict types.
  - Civil disturbance – Interaction with civilians central, no military opponent
  - Gray zone conflict – Low-signature opponent intermixed with population
  - Conventional combat operations – Combat operations central, IFC/NLW in a supporting role
- Non-lethal and lethal means – not always an either/or
  - Historical example – Hue, Vietnam (1968): Extensive use of CS gas by U.S. forces with lethal means*
- Key variables shaping the type of conflict:
  - Signature of the various hostile actors (e.g., wearing uniforms or camouflaged as civilian population)
  - Blue mission – (e.g., peace keeping, fight rebel forces)
  - Combat capabilities of Red

* Enemy forces were largely regular infantry from the North Vietnamese Army, not Viet Cong insurgents (see backup slide)

Throughout U.S. history non-lethal means have been used to deescalate opposing forces, regardless of explicit military doctrine at the time. Ortho-chlorobenzalmalononitrile was made the standard riot control agent by the Army in 1959. The term "CS" is derived from the two scientists, B.B. Carson and R.W. Sloughton, who first prepared it in 1928. For details on battle for Hue, see Chapter 6 in Wahlman (2015).

Slide Reference:

Wahlman, A. 2015. *Storming the City: U.S. Military Performance in Urban Warfare from World War II to Vietnam.* University of North Texas Press: Denton.

Game Scaling

A wargame's scale will be shaped by the wargame objectives – three elements of scale, include:

- Human Scale
  - Individuals or small groups – evaluating individual IFCs/NLWs and tactics
  - Crowds – secondary effects of mass human reactions
  - Cities & subsets of the population – HADR missions, information operations
  - National population – counter-insurgency campaign
- Time – game and turn length
  - Seconds or minutes – for exploring short-term effects and tactics
  - Hours or days – persistent effects, logistics of IFCs/NLWs
  - Weeks or months – campaign strategies, tolerance of the population over time
- Distance/Geography
  - Single street or city block – evaluating individual IFCs/NLWs & tactics
  - A city – HADR mission, logistics of IFCs/NLW
  - Region or nation – counter-insurgency campaign, information operations

HADR – humanitarian assistance and disaster relief

Adjudication

Adjudication for IFC/NLW vs. Lethal Weapon Wargames

- Methods for adjudication will be the same.
  - When using subject-matter experts (SMEs) for adjudication, the SME for determining physical effects of the IFC/NLW may not be the same person as the SME judging the human reactions.
- IFC/NLW system will require more information to convey the larger range of possible effects (e.g., levels/types of injury) compared to lethal weapons in games where the human scale is represented by individuals or small groups.

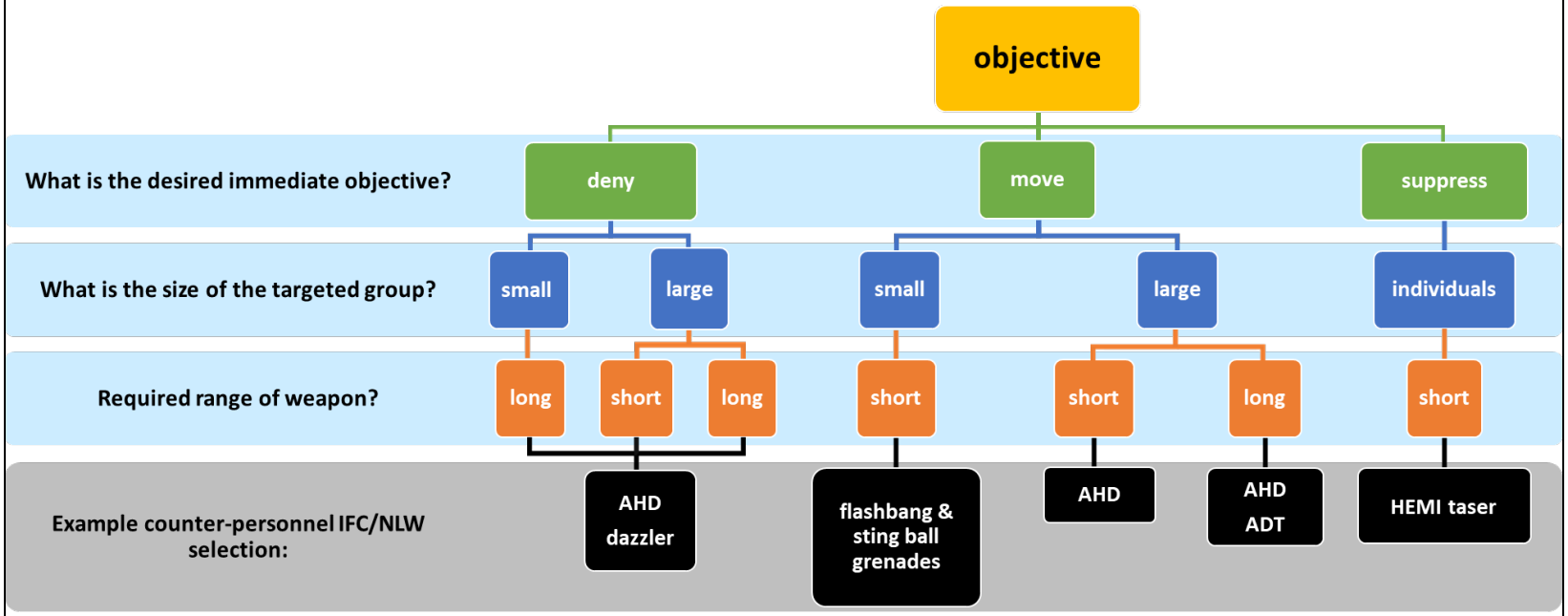
Risk of significant injury is one way to represent the range effects that could be used to adjudicate the outcome from an IFC/NLW when used in a wargame. For example, in a consensus/matrix-game that uses a semi-rigid adjudication, agreed-upon probabilities are assigned to each possible outcome where players role dice to determine the result in the game.

Slide Reference:

Australian Defense Force. Background for the Basic and Advanced Analytic Wargaming Courses from the Naval Postgraduate School in Canberra, 17 February to 6 March 2020: Adjudication. Last accessed 2 February 2022. http://opanalytics.ca/aus/adjudication.html

Hierarchy of Design Considerations

These three tiers could help guide the selection of the most relevant IFC/NLWs within a given scenario both when designing a game & during the event.



IDA 19

ADT – active denial technology AHD – acoustic hailing device HEMI - human electro-muscular incapacitation

This tree conveys a hierarchy of useful quantitative, tactical considerations that can guide IFC/NLW choice within wargame scenarios. The foremost consideration is the desired objective of IFC/NLW deployment. Does one desire to deny access? Disperse or move a crowd? Suppress an individual through incapacitation? The second consideration is the size of the aggressing group. Small groups (< 20 people) will entail potentially different IFC/NLW choices than large groups (> 20 people), while scattered individuals require yet different IFC/NLW considerations. The required range of IFC/NLW efficacy is the factor to consider. Is short range (< 10 m) required? Long range (> 50 m)? These three tiers of factors thus allow for convergence toward the optimal IFC/NLW(s) of relevance within a given context.

Slide Reference:

Leimbach, W. B. 2019. "DoD Non-Lethal Weapons Program Brief 2019 NDIA Armaments System Forum." Joint Non-Lethal Weapons Directorate.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/641040/doctrine_uk_wargaming_handbook.pdf

Toolkits for Game Design

The slides in this section provide a brief introduction to wargames on the following topics:

- Model considerations
- Multiagent systems
- Agent-based models (ABMs)
- ABMs for IFCs/NLWs

Model Considerations

- A model represents a system, entity/player, phenomenon, or process in the wargame.
  - simplifying dynamic interactions between entities & events
- Detailed computer-based models can aid game play.
  - more complex simulations require greater time & resources

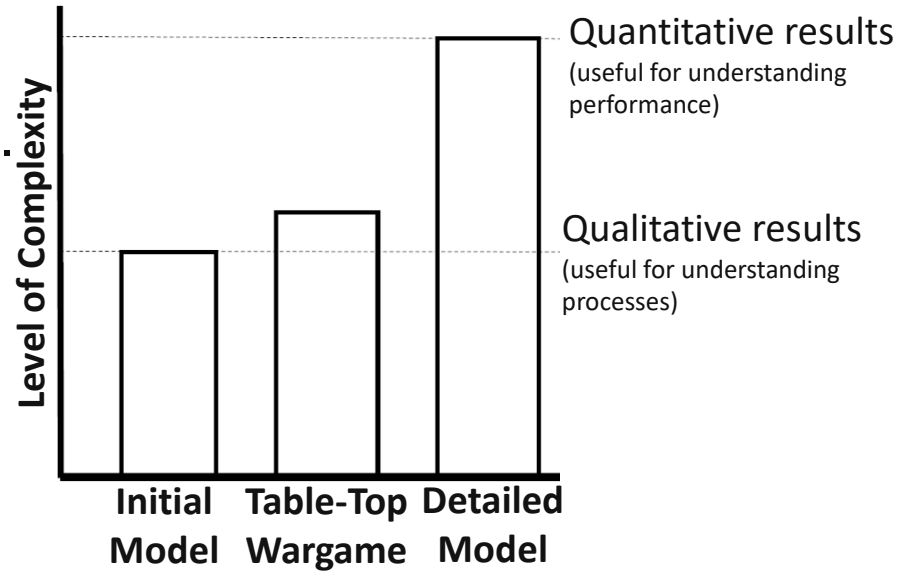


Figure adapted from Mittal 2017.

Initial models may be abstract representations to provide theoretical or qualitative insights about a process whereas later detailed models add realism to produce quantitative data that better elucidates the decision space.

Computer-based models can also aid in the validation of wargame results and produce quantitative metrics especially when the game outcomes are qualitative. For instance, the results captured in a table top wargame could be used as inputs for a more detailed computer simulation to generate a quantitative metric.

Slide References:

Ministry of Defense. 2017. *Wargaming Handbook*. The Development, Concepts and Doctrine Centre: Wiltshire. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/641040/doctrine_uk_wargaming_handbook.pdf

Mittal, V., J. B. Denarest, K. S. Gilliam, R. L. Page. 201). *Models of Models: The Symbiotic Relationship between Models and Wargames.* West Point Research Papers. 107, 215-223. https://digitalcommons.usmalibrary.org/usma_research_papers/107

Multiagent Systems

- A multiagent system (MAS) may be particularly applicable for modeling NLWs
- MAS may be considered a subfield of distributed artificial intelligence
- MAS is characterized by autonomous, intelligent agents with (Mahmoud 2020):
  1. Reactivity – ability to react to changes in its environment
  2. Proactiveness – goal-directed behavior and the ability to dynamically change its behavior to meet those goals
  3. Social ability – ability to interact with other agents, including negotiating and cooperating
- MAS examples:
  - Robot swarms
  - Power distribution systems
  - Agent-based models
  - Several types of commercial software systems

Slide Reference:

Mahmoud, M. S. 2020. *Multiagent Systems: Introduction and Coordination Control*. Taylor & Francis Group.

Agent-Based Models

- Agent-based model (ABM)
  - Developed by Thomas Schelling to explain racial sorting in neighborhoods (Schelling, 1969)
  - Allow for heterogeneous agents
  - Emergent behavior comes from individual agents seeking goals (such as segregated neighborhoods)
- Apparent trend from named models developed by defense agencies in the 2000s to single-use cases
- ABM applications have been used to model several urban-related topics:
  - Crowd panic/stampede
  - Criminality, gangs, police deployment
  - Civilians in urban combat

Slide Reference:

Schelling, T. 1969. “Models of Segregation.” *The American Economic Review*, Vol. 59, No. 2, Papers and Proceedings of the Eighty-first Annual Meeting of the American Economic Association, pp. 488–493.

ABMs for IFCs/NLWs

- Potential applications of ABMs for IFCs/NLWs:
  - Modeling localized crowd reactions to IFC/NLW use
  - Exploring larger, emergent behavior in the area
  - Addition of crowd panic behavior to explore injuries and fatalities from individual efforts to evade IFCs/NLWs
  - Exploring differing rates of injuries or deaths in heterogenous crowds, such as those who may be disproportionately affected (such as children or the elderly – Wong, 2006)
- Potential applications of ABM with agents representing individual people:
  - Could explore the behavioral effects of IFCs/NLWs
  - Could see emergent crowd behaviors
  - Potential to add in interactions with U.S. forces or adversaries as additional agents

Slide Reference:

Wong, Y. H. 2006. “Ignoring the Innocent: Non-combatants in Urban Operations and in Military Models and Simulations.” RAND Graduate School dissertation. Santa Monica, CA: RAND Corporation.

ABMs for IFCs/NLWs (cont'd)

- Potential limitations of applying ABMs to IFCs/NLWs:
  - No data on behavior effects for newer systems, though video could be examined for behavior effects from CS & existing IFCs/ NLWs
  - No way to validate model assumptions of agent behaviors and emergent crowd behavior until there is repeated real-world use of newer IFCs/NLWs
  - Potentially difficult to include complex behaviors such as voluntary and involuntary human shields in urban confrontations
  - Extremely difficult to incorporate political context and other factors shown to be important in the exploratory tabletop simulation
- Despite limitations, parameterization of different potential behaviors and distribution of behaviors might suggest operational effects of newer IFCs/NLWs

Slide References:

Badjonski, M., M. Ivanovic, Z. Budimac. 1999. “Agent Oriented Programming Language *LASS.”* In *Object-Oriented Technology and Computing Systems Re-engineering*, edited by H. Zedan and A. Cau. Horwood Publishing, pp. 111-121.

Fonoberov, V. A., M. Fonoberova, I. M. Se, J. Mezic. 2011. *MetaModel Analysis for Agent-Based Models: Scales, Uncertainty, Data Analysis*. Santa Barbara, CA: Center for Control, Dynamical Systems and Computation, University of California.

Macal, C. M., M. J. North. 2009. “Agent-Based Modeling and Simulation.” *Proceedings of the 2009 Winter Simulation Conference*. Edited by M.D. Rossetti, R. R. Hill, B. Johansson, A. Dunkin, and R. G. Ingalls.

Findings & Recommendations

The slides in this section provide a brief introduction to wargames on the following topics:

- Key opportunities
- Key challenges
- Recommendations

Key Opportunities

- Better understanding of how IFCs/NLWs may apply to a tactical setting, specifically:
  - Comparing tactical utility of different IFC/NLW systems
  - Understanding utility of a diverse suite of IFC/NLW systems
  - How changes in system performance relate to tactical utility
- Exploring the synergy between lethal & non-lethal effects and associated perceptions with respect to various actors for given scenarios
- Exploring a wide range of IFC/NLW employment concepts and determining the sensitivity of the IFC/NLW or associated employment concepts
- Quantifying the tactical implications of current IFC/NLW policies, & possible changes to policy, for comparison to safety metrics
- Discovering *ad hoc* and deliberate countermeasures in IFCs/NLWs for a range of scenarios.

Key Challenges

- Designing wargames that account for the pairing of NLW & information operations (IO)
  - Given the complex interactions of Blue IO, Red IO, local culture, local & social media, and visual presentation of IFC/NLW
- Representing the effects from both lethal & non-lethal systems, in a comparable manner
- Translating the physiological & behavioral effects of IFCs/NLWs on individuals to the reaction of crowds
- Demonstrating the broad range of conditions & missions in which IFCs/NLWs might be used in a game
  - Including circumstances beyond the designed concepts of employment & technical specifications
- Extracting the complexities in the decisions & actions on the deterrence/conflict escalation ladder
- Accounting for the potential impact of other elements of DOTMLPF, beyond the materiel/system technology, that make a capability

DOTMLPF - doctrine, organization, training, materiel, leadership and education, personnel, & facilities

Given the nature of non-lethal technology, evaluating the DOTMLPF may need to include integrated capabilities with the Department of State, the intelligence community, and other U.S. partners.

Recommendations

- Use an iterative approach with wargames to define IFC/NLW requirements and capabilities
  - Start with tactical-level wargames, only later expand to the operational level
  - Gradually introduce complexity in wargames with IFCs/NLWs to systematically understand the nuances (e.g., keep objectives focused, limit # of systems)
- While challenging to incorporate in a simulation, give attention to the IO & IFC/NLW pairing
- Pay special consideration to the intricacies of the conflict escalation ladder and timing of IFC/NLW use
- Go beyond just the materiel/technology to explore the broader context of a capability, such as other DOTMLPF elements

IO – information operations

DOTMLPF – doctrine, organization, training, materiel, leadership and education, personnel, & facilities

Backups

The following slides include additional information we uncovered during the study that may be useful.

Thoughts on Other Game Purposes with IFCs/NLWs:

Senior Leader Engagement

- Some events can include senior leaders as players
  - Rather than being recipients of heavily summarized results after the fact
- Event structured to replicate the perspective and challenges of those leaders
- Event would then present those leaders with changing circumstances and difficult decisions
- Examples of IFC/NLW-related objectives:
  - Tactical and operational implications of IFC/NLW rules of engagement
  - S&T investments over time & NLW options for future commanders

Operational Decisions & Plans

- Events allowing the players, who are planning or conducting a real-world operation, to explore various choices
- Essentially a planning aid to better understand implications

Training & Education

- Giving the players experience with a particular environment
- Practice employing the resources likely to be available, while dealing with a range of conditions, and a reactive enemy
- Giving the freedom to fail while exploring a wide range of possible options
- Making a real-world problem no longer seem new

Historical Example of Combat Operations Involving NLWs

- Battle for Hue, Vietnam (1968) was held in an urban area
- Large communist force attacks Hue (~7500) mostly North Vietnamese Army light infantry
- Communists take most of the city on first day, then U.S./S Vietnamese forces conduct slow, bloody 3-week counterattack to recapture the city
- USMC forces used a great deal & variety of CS gas in combination with lethal forces.
  - Including, hand-thrown grenades, launchers, mortar rounds, & aircraft spray tanks
  - More launchers & CS hand grenades were shipped into the city during the battle
  - Common tactic, CS used to flush defenders out from a building, Marines shot at those exiting
- First U.S. use of CS in Vietnam was 3 years earlier (1965), proved very useful versus opponents intermixed with civilians, use increased over time
  - 1964 U.S. Army field manual* on urban operations encouraged use of gas

* FM 31-50, *Combat in Fortified and Built-Up Areas,* 1964, p. 36. At that time, the U.S. was not party to any treaty that restricted the use of lethal or non-lethal chemical agents in combat. FM 27-10, *The Law of Land Warfare*, 1956, pp. 18-19.

Additional information on CS gas: “Since WWI [World War I] the most widely used irritant has been CN (tear gas). Recently, however, it has been replaced in many instances with CS whose action is more rapid and whose effects are more severe.”

“Sometimes CS is referred to as Super Tear Gas. Its effects onset is 0-10 seconds, depending on concentration. The duration of the symptoms takes about 10-15 [seconds] in clear air to tend. Produces choking sensation in throat and upper respiratory tract leading to violent coughing; difficulty in breather (which tends to induce panic), immediate lachrimation and involuntary eye closure; dizziness, running nose and extreme burning irritation of sweaty skin; high concentrations induce nausea; CS is replacing CN as the standard agent for controlling riots; it is approximately 10 times as effective as CN.” (Lacrimation = tear formation, crying.) (Westbrook, 1971)

Riot Control Agent, CS. First used by U.S. civilian law enforcement in 1968 during the riots in Washington D.C. While an effective riot control agent, which incapacitates on average from 5 to 10 minutes, decontamination and cross-contamination is a considerable problem in urban environments [13:19,82,337]. (Bunker, 1997)

Slide References:

Bunker, Robert J., ed., 1997. *Nonlethal Weapons: Terms and References*, United States Air Force Institute for National Security Studies Occasional Paper 15, USAF Academy, Colorado, pp. 25-27.

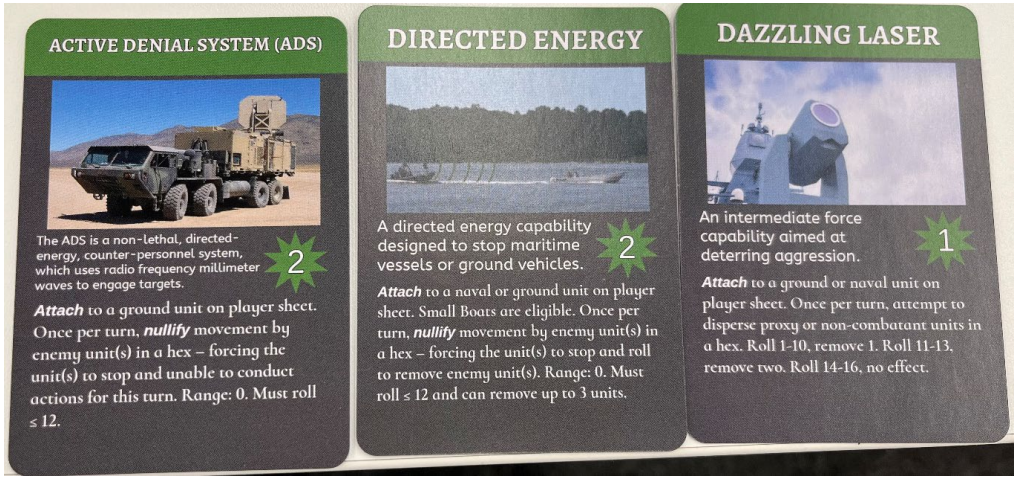
Wahlman, A. 2015. *Storming the City: U.S. Military Performance in Urban Warfare from World War II to Vietnam.* University of North Texas Press: Denton.

Westbrook, E. E., and L. W. Williams, 1971. *A Brief Survey of Nonlethal Weapons*, Columbus, Ohio, pp. 9, and A-1 to A-2.

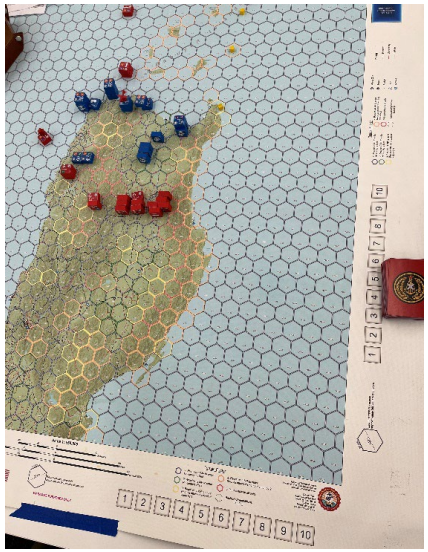
Table Top Wargame with IFCs/NLWs

Littoral Commander: Indo-Pacific is a tactical-level table top wargame that includes IFCs/NLWs as part of the joint capabilities available to Marine Corp units.

IFCs/NLWs Cards



Game Map



Slide References:

Bae, S. Littoral Commander: Indo-Pacific. https://dietzfoundation.org/product/littoral-commander-the-indo-pacific/

A presentation of the game at the Krulak Center: https://www.youtube.com/watch?v=-CNlT8OPHgo

Murphy, J. 2021. “Former Marine Invents War Game to Cultivate Tactical Thinking in the Corps.” *Audacy*. December 6, 2021. Last accessed 02 Feb 2022. https://www.audacy.com/connectingvets/news/wargame-aims-to-help-marine-corps-develop-tactical-thinkers

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14. ABSTRACT

IDA was tasked by the Joint Intermediate Force Capabilities Office (JIFCO) to conduct an independent analysis of the potential opportunities and limitations of military operational simulations or exploratory tactical "wargames" to develop and test operational concepts and inform new system capabilities for intermediate force capabilities (IFCs) and non-lethal weapons (NLWs). IDA considered various types of analytical questions, differences between conventionally weaponry and inclusion of resulting human effects with IFCs/NLWs in wargames in the study. This briefing contains a short primer on wargames, analysis of wargame designs most relevant for IFCs/NLWs, and several toolkits for representing human behaviors.

15. SUBJECT TERMS

exploratory simulations; intermediate force capabilities; Non-lethal weapons; wargaming

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