Validity and Utility of Wargaming

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MORS Wargaming Special Meeting
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Working Group 2

Stephen Downes-Martin (Working Group Chair)
Michael Anderson, Gil Cardona, Thomas Choinski, Rebecca Dougharty,
John Hanley, Frederick Hartman, John Lillard, Roger Meade,
Keith Morris, Peter Perla, Merle Robinson, Vincent Schmidt,
Gary Schnurrpusch, Bill Simpson, Eugene Visco, Timothy Wilkie

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Contents – Validity and Utility of Wargaming

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Executive Summary

Working Group Definitions used during Meeting – These are necessary but insufficient**:**

Validity	**Utility** (can be negative)
Sponsor's objectives are suitable for gaming and drive game design. Wargame is played according to the design. Forensics and reporting is honest and complete.	Wargame is accepted as valid by Sponsor. Stakeholders act on information from the wargame in a way that has an observable effect on national security. Participants gain value.

Key Takeaways

Examining benign gaming provides best practices and lessons learned. However, every phase of wargaming, from initial contact between game sponsor and wargaming organization, is vulnerable to malign deception. At best malign deception is driven by the good intentions of influencers believing they are right and that anything that might contradict them must be avoided. At worst it is driven by careerism, corruption and hostility to other military communities and services. Examining malign gaming provides additional wargaming principles dealing with conflict of interest, intellectual fraud, self-deception, political imperatives and outright careerism. Malign games actively exploit the environment of time crunch, career pressure, resource constraints and the beliefs and opinions of sponsors, stakeholders and players, while poorly designed and executed benign games are exploited by this environment.

External – Engage with the Sponsor and Stakeholders:

- Ensure the event is a wargame with the possibility that Blue can lose and the gamed concepts can be overcome by Red, do not call non-game events "wargames".
- Recruit, not invite, senior leaders to lead game cells to execute game as designed, do not permit these leaders to derail the game in-stride to fit their non-sponsor agendas.
- Playtest the game with sponsor participation or with sponsor's empowered action officers to ensure sponsor is paying proper attention to objectives and design.
- Immerse the players in the scenario and play. Include the sponsor and key stakeholders as Red players. Do not let the sponsor or key stakeholders play Blue or be Adjudicators.

Internal – Work within the Wargame Organization and its Chain of Command:

- Engage and use an empowered Independent Peer Review Board to examine objectives, assumptions, scenario and capabilities data, design, game play, adjudication, data collection and analysis.
- Minimize cognitive dissonance in the mind of the sponsor by ensuring wargame design and play is as consistent as possible with their preconceptions, while not allowing these preconceptions to drive objectives, design, game play, analysis or reporting.
- Conduct wargame forensics and reporting to provide actionable recommendations.
- Report ruthlessly and honestly, unencumbered by sponsor or stakeholder wishful thinking.

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Mission and Objectives

1. Produce a corpus for the wargaming community of theory and practice which identifies:

- characteristics of valid wargames that have utility for DoD decision makers, and
- barriers to the inclusion of these beneficial characteristics into wargames.

2. and, in addition, identifies:

- characteristics of malign wargames that deceive DoD decision makers, and
- mitigations of these malign characteristics from ill-intentioned wargames.

The hypothesis for this second pair of items is that the opposite of a "valid and useful wargame" is not an "invalid and not useful wargame", it is "a wargame that appears valid and deceives the decision maker into making poor decisions based on the game". Looking at valid and useful games gives us characteristics to seek and behaviors that interfere with those characteristics to avoid, i.e. best practices and lessons learned. By looking at wargames that are deliberately designed to be malign (deceptive) we may identify additional characteristics to explicitly avoid in wargame design that are not obvious from looking at a list of characteristics to seek.[1] Furthermore, in nearly all cases of scientific fraud, three risk factors have been identified as present:

1. the perpetrators "knew, or thought they knew, what the answer to the problem they were considering would turn out to be if they went to all the trouble of doing the work properly;
2. were under career pressure; and
3. were working in a field where individual experiments are not expected to be precisely reproducible."[2]

These risk factors are clearly present in both wargames and the decision making that the wargames inform, to claim otherwise is to deny human nature and the purpose of the various existing DoD auditor agencies and activities. Note however that the presence of risk factors indicates the need to deal with them, they do not prove malignity is present.

[1] "Wargaming to Deceive the Sponsor: Why and How?", Stephen Downes-Martin, Connections UK Wargaming Conference 2016, http://www.professionalwargaming.co.uk/WargamingToDeceivePaper.pdf (last accessed 11/19/2017).

[2] David Goodstein, On Fact and Fraud: Cautionary Tales from the Front Lines of Science, (Princeton, N.J.: Princeton Univ. Press, 2010). See also Michael Shermer, "When Scientists Sin," Scientific American 303, no. 1 (July 2010), p. 34.

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Process

We chose working group participants who were competent and experienced wargamers by their reputation and their biographies, and employed a disciplined normative approach[3].

1. Before the meeting

Group members were provided with materials to read before the meeting. These consisted of papers written specifically for the Working Group as well as previously published material:[4]

- "Characteristics of Games that Make a Difference", COL Matt Caffrey
- "Recent Wargames Executed by the USEUCOM", LTC Gil Cardona
- "Dramaturgy, Wargaming and Technological Innovation in the US Navy", Dr. Thomas Choinski
- "Wargaming to Deceive the Sponsor: Why and How", Dr. Stephen Downes-Martin
- "Characteristics of Games that Make a Difference", Dr. John Hanley
- "Playing War", Chapter 6 (Conclusions), Dr. John Lillard
- "Wargaming the Atlantic War", Draft 20170924, Dr. Paul Strong

Team members were requested to think about the following questions and bring their thoughts with them to the meeting:

- What does validity and utility mean when applied to wargames?
- What were the characteristics that led to success of past games "that made a difference"?
- What additional characteristics might be in play today and in the future?

2. During the meeting

The Working Group engaged in an open discussion addressing the question "What do validity and utility mean for wargames?" using their wargaming experience, the read-aheads, and their intelligence.

[3] We used a disciplined normative approach using Language Processing™, Silent Clustering and Formal Debate since as it has long been proven they give superior results than those obtained from ill-disciplined methods such as brainstorming or BOGSATS. See for example "The illusion of group productivity: A reduction of failures explanation", Barnard Nijstad, Wolfgang Stroebe & Hein Lodesijkx, *European Journal of Social Psychology*, 36, 31-48 (2006). For a general overview of how brainstorming has long been debunked see "Groupthink: The brainstorming myth", Jonah Lehrer, *The New Yorker*, January 20, 2012 online at http://www.newyorker.com/magazine/2012/01/30/groupthink (last accessed 11/18/2017) and references contain therein. For details on Language Processing and Silent Clustering see the "Language Processing Method" manual at https://goalqpc.com/?s=Language+Processing (last accessed 11/18/2017).

[4] A copy of these materials is included in this report.

The group then split into two parallel teams of eight people, each led by one of the Chairs of the working group as an additional team member.[5] Using Language ProcessingTM, Silent Clustering and Debate each team addressed the question "What are the characteristics of games that made or can make a difference to the DoD?" Team A (Benign Wargames) addressed the question from a positive sense, i.e. identifying characteristics of well-intentioned games to which decision makers' paid attention and doing so turned out well. Team B (Malign Wargames) addressed the question from a negative sense, i.e. characteristics of ill-intentioned games to which decision makers' paid attention and doing so turned out badly due to the game itself.

Each team then used Language ProcessingTM, Silent Clustering and Debate to address the following questions. Team A (Benign Wargames) addressed "what gets in the way of obtaining the characteristics of well-intentioned valid wargames to which DoD decision makers pay attention". Team B (Malign Wargames) addressed the question "how can we mitigate the characteristics of ill-intentioned games which deceive the decision maker to incorporate their invalid insights into their decision making?"

The two teams recombined, briefed and challenged each other on their work, identified immediate top-level takeaways and created the Working Group out-brief to the Meeting.

3. After the meeting

After a few days to several weeks, Group members wrote short papers on "what validity and utility means for wargames" following careful consideration of the products and discussions that took place during the working meeting. These papers are an integral part of the Working Group product and are included verbatim in this report.

4. Reporting

The read-ahead papers, product from the face to face working group meeting, and the follow-up short papers are all products of the working group and are included in this report to provide an integrated and complete record of the working group.

[5] We had sixteen slots plus two facilitators and had to turn away several qualified applicants. We were one short due to a last-minute injury. We restricted each team to eight people based on the observation over many years that in groups of more than eight people the additional people do not effectively contribute while adding to the time taken to execute the process. It is better to create parallel teams either addressing the same or complimentary questions.

Working Group Members

Team A (Benign Gaming)	Team B (Malign Gaming)
Michael Anderson	Rebecca Dougharty
Gil Cardona	Stephen Downes-Martin
Tom Choinski	Fred Hartman
John Hanley	John Lillard
Keith Morris	Roger Meade
Peter Perla	Merle Robinson
Vincent Schmidt	Gary Schnurrpusch
Bill Simpson	Gene Visco
Tim Wilkie	

First	Last	Organization	Email
Michael	Anderson	BAH	Anderson_Michael3@bah.com
Gil	Cardona	EUCOM	gilbert.m.cardona.mil@mail.mil
Tom	Choinski	NUWC	thomas.choinski@navy.mil
Rebecca	Dougherty	Lockheed Martin	rebecca.l.dougharty@lmco.com
Stephen	Downes-Martin	Naval War College	stephen.downesmartin@gmail.com
John	Hanley	Independent Consultant	jhanleyd71@aol.com
Frederick	Hartman	IDA	fhartman@ida.org
John	Lillard	Modern Technology Solutions	john.lillard@mtsi-va.com
Roger	Meade	BAH	meade_roger@bah.com
Roy	Morris	Air Force Wargaming Institute	roy.morris.3@us.af.mil
Peter	Perla	CNA	peterperla@aol.com
Merle	Robinson	National Security Decision Making Game	murno.robinson@gmail.com
Vincent	Schmidt	AFRL Wargaming Lead	vincent.schmidt@us.af.mil
Gary	Schnurrpusch	Independent Consultant	gary.schnurrpusch@gmail.com
Bill	Simpson	Information Solutions and Assessment	simpsonw@cna.org
Gene	Visco	Lockheed Martin Corp HQ	eugene.visco@lmco.com
Tim	Wilkie	NDU	timothy.wilkie@ndu.edu

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Characteristics of Benign and Malign Games

The group split into two parallel teams of eight people, each led by one of the Chairs of the working group as an additional team member.

First, each team addressed the question "What are the characteristics of games that made or can make a difference to the DoD?" Team A (Benign Wargames) addressed the question from a positive sense, i.e. identifying characteristics of well-intentioned games to which decision makers' paid attention and doing so turned out well. Team B (Malign Wargames) addressed the question from a negative sense, i.e. characteristics of ill-intentioned games to which decision makers' paid attention and doing so turned out badly due to the game itself.

Second, Team A (Benign Wargames) addressed "what gets in the way of obtaining the characteristics of well-intentioned valid wargames to which DoD decision makers pay attention", while Team B (Malign Wargames) addressed the question "how can we mitigate the characteristics of ill-intentioned games which deceive the decision maker to incorporate their invalid insights into their decision making?"

After proposing answers to the questions each Team used "silent clustering" to cluster the items into a 1st level, then discussed what those clusters meant and agreed titles for them. After that each Team again used "silent clustering" to group their 1st level clusters into a 2nd level, then debated the meaning of the 2nd level and agreed titles for those clusters. Note that some 1st level clusters are stand-alone, the teams chose not to cluster them into 2nd level clusters.

Team A: Benign Games

Characteristics of Benign Games

Question: What are the characteristics of games that made or can make a difference to the DoD?

Address the question from a normative active but positive sense, i.e. how would you generate well-intentioned games to which decision makers' paid attention and doing so turned out well.

Normative form of Characteristic	1st Level Clustering	2nd Level Clustering
Game's purpose and objectives are clearly stated.	*A1. The game objectives drive the game design.*	**Iterate purpose and objectives with sponsor to address actionable questions.**
Game design clearly answers a specific question.		
Game design clearly links desired learning objectives to game's product.		
Design team anticipates and helps shape sponsor question.	*A2. Use game facts and objectives to set expectations with the decision maker.*	
Explicitly express all SME counsel, citations and assumptions at each milestone and in the deliverable to maximize study integrity.		
Game design team sets achievable expectations with the decision maker.		
The game addresses a decision maker's major concern and provides innovative ways to address it.	*A3. The game addresses a decision maker's major concern and provides innovative ways to address it.*	
Properly specify the state of the world (scenario) using well founded data and information.	*A5. Setting is plausible and clearly explained*	**Create the game context to set the stage for play that addresses the questions.**
Base the wargame on a plausible scenario.		
Create and deliver a clear, concise and credible Road to War & Situation briefing.		
Consult relevant SMEs to inform the design and conduct of the game.	*A4. Consult relevant SMEs to inform the design and conduct of the game.*	
Scope the game to support the appropriate level of analysis of the problem.	*A6. Scope the game to support the appropriate level of analysis of the problem.*	

Normative form of Characteristic	1st Level Clustering	2nd Level Clustering
Design and rehearse the game with actual participants to ensure the objectives and the data collection plan are achievable.	*A7. Involve participants before the game.*	**Involve stakeholders and players to refine the design and execution process.**
Rehearse participants within their teams to ensure they understand the gamebook.		
Decision makers trust those involved in the game.	*A8. Involve stakeholders and sponsors throughout the timeline.*	
Produce the game report in time to fit the decision maker's decision cycle.		
Involve the sponsor from design through final report.		
Involve the right mix of people (including backgrounds necessary to fully address the question).	*A9. Recruit and utilize players for their expertise.*	
The players accurately reliably represent the tastes and beliefs of those in the roles that they represent; ideally the decision makers themselves.		
Players have the right level of experience and are in the appropriate role.		
Players are experts and are recognized as such by the decision maker.		
Use design to identify weak points and play test to break and then fix those weak points.	*A14. Failure is an option.*	**Tailor adjudication tools and methods to sponsor objectives and players.**
Do not guarantee victory to Blue.		
Base game adjudication on a written set of rules approved by the sponsor.	*A13. Generate appropriate adjudication rules and processes.*	
Rules and adjudication represent decisions at the appropriate level of fidelity.		
Deal with unintended negative lessons so that the participants do not take them away.	*A15. Participants take intended positive actionable lessons from the game.*	**Post-game interpretation and reporting leads to positive actionable results.**
The participants act on their findings from the game.		
Goals and results are concisely articulated.	*A16. Generate high quality after action reports.*	
Use language, terminology and format familiar to the sponsor to ease acceptance.		
Capture the knowledge generated by the game in a manner suitable for dissemination and disseminate it.		

Normative form of Characteristic	1st Level Clustering	2nd Level Clustering
Game raised controversial issues that caused the decision maker to revise his position.	*A12. Confront and challenge assumptions.*	**Participants confront and test assumptions through active participation.**
Identify and test specified and implied assumptions.		
Verify assumptions with appropriate SMEs prior to completion of game design		
Minimize resistance by the sponsor to unexpected results by keeping him informed about game outcomes.	*A11. Game play positively resonates with the audience*	
Game play is consistent with the preconceptions of the decision maker.		
Exploit the power of participatory narrative to create fertile opportunities for innovation by the players.	*A10. Game leverages active player participation to achieve the objective.*	
Participants interact to generate and capture knowledge during the game.		

Barriers to including benign characteristics

Question: What gets in the way of obtaining the characteristics of well-intentioned valid wargames to which DoD decision makers pay attention?

Barriers	1st Level Clustering of Barriers	Applied to 1st Level Clustering of Benign Characteristic
Mission creep occurs when stakeholders demand more from the wargame than it was designed to support.	Sponsor not properly engaged or supportive.	A1, A2, A8
Sponsor has a poorly framed the problem.		
Sponsor is preoccupied with the scenario and does not pay enough attention to the objectives, coupled with the failure of the design team to focus the sponsor on articulating the objectives.		
Game sponsor is not fully engaged throughout the wargame cycle.		
Military organizations and members are not wired to fail and thus resist games in which it is possible for Blue to fail.	Careerism by players.	A9, A14, A15
Blue not allowed to fail, the weak points of the concept or "the thing" being gamed is not researched by either the developer of "the thing" or the wargame designer.		
Wargame participation has no effect on future career path or position selection.		
Time constraints with day job reduces capacity for participants to engage before the actual game.	Wargames require more time ahead of the game than stakeholders are willing to give.	A7, A9
Required and desired SMEs are a high demand low volume resource.		
Player expertise is not always recruited or utilized, SME is often limited and in high demand.		
The setting may take multiple wargames to fully capture the context.	Game scenario insufficient to handle game objectives.	A5
The emerging geo-political situation is changing at too rapid a pace to understand.		
The scenario or setting is selected to support traditional service procurement.		

Barriers	1st Level Clustering of Proposed Mitigations	Applied to 1st Level Clustering of Benign Characteristic
Developers of the concept, equipment or COA being gamed rarely address their own assumptions, making it hard for game designers to identify and question them.	Assumptions not properly addressed.	A5, A13
It is hard to specify the capabilities and effects of new technologies being gamed with respect to other elements in the game. Owners of these technologies are sometime unwilling to commit to specific effects and outcomes		
Findings that were not the result of player interaction are included in the AAR as a player finding.	The DCAP and Reporting Plan is poor or lacks sponsor support.	A16
Report generation is not looked upon as exciting.		
Lessons learned and game outcomes are not captured or recalled accurately and are not included in the report.		
Full game report is rarely read, stakeholders preferring the analytically invalid hot wash briefing.		
Poor game design, materials and dynamics disengage the players.	Players are not properly managed.	A9, A10, A11, A12, A15
Game design or setting are unimaginative or perceived as ridiculous and so the game fails to engage players intellectually or emotionally		
Participants are selected based on expertise from the past rather than potential for future influence.		
Participants exclusively use what they know and do not leverage discoveries or direction of SMEs and analysts.		

Barriers	1st Level Clustering of Proposed Mitigations	Applied to 1st Level Clustering of Benign Characteristic
Inexperienced or less capable design teams do a poor job identifying key assumptions and building game dynamics to force players to confront them.	Game design is poor.	A5, A8, A12, A13, A14, A16
Concepts and capabilities are given or available to Blue without Red's knowledge.		
Drive for a "turn the crank" (models, simulations, games) process to provide an answer vice information and learning.		
Wargaming organizations use a single or limited set of predetermined adjudication techniques.		
Adjudication rules and processes and analysis for after action reports are not able to extract the full range of DOTMLPF recommendations.		

Team B: Malign Games

Characteristics of Malign Games

Question: What are the characteristics of games that made or can make a difference to the DoD?

Intent: Address the question from a normative active but negative sense, i.e. how would you generate ill-intentioned games to which decision makers' paid attention and doing so turned out (or will turn out) badly for them due to the game itself.

Normative form of Characteristic	1st Level Clustering	2nd Level Clustering
Build the game at an inappropriate level for the game's objectives (for example a tactical game to answer an operational level question).	*B1. Build in a mismatch between the game's focus and objectives*	**Construct the game to produce malign results.**
Mask biased outcome intentions by making the game's objectives too general.		
Design the game to omit critical elements from game play.	*B2. Manipulate time, space and scope to influence game's trajectory.*	
Deliberately make the game's clock rate, number of turns planned or time-period covered by the scenario inappropriate for the game's objectives.		
Utilize game boundaries to exclude or minimize significant competing alternatives (for example exclude cyber and EW from a missile targeting game).		
Use invalid or irrelevant assumptions in the game design.	*B3. Manipulate the game's assumptions to generate a malign result.*	
Narrow the scope of the game to a predetermined course by overly restricting the game's assumptions.		
Misrepresent assumptions or add unneeded assumptions to produce malign results.		
When interpreting sponsor's objectives add unnecessary topics and elements that diverts the players away from the real objectives and onto predetermined results.	*B4. Construct game teams in such a way that they obstruct the sponsor's objectives.*	**Staff and structure the game to encourage players to exert inappropriate influence on game play.**
Construct player teams using their known biases about the topics being gamed to push the game trajectory down a malign path		
Exploit or amplify the pressure on the game's sponsor by his or her community to prove the gamed concept is valuable.	*B5. Enable the game sponsors and players to exert inappropriate influence on game play.*	
Select for players or control people with a vested interest in a specific game output.		
Allow the game's sponsor to lead the Blue team.		

Normative form of Characteristic	1st Level Clustering	2nd Level Clustering
Design the adjudication process to avoid or give preference to preselected outcomes.	*B6. Influence game flow by manipulating control and adjudication.*	
Control team arranges for critical elements to be omitted from play by manipulating Red and Blue actions.		
Place the advocates of the concepts being gamed on the adjudication team.		
Exclude the target decision maker from the design process and game until the final briefing.	*B7. Design the game to disconnect decision makers, players and objectives.*	
Design the game to produce insights that are not actionable.		
Design the game to steer players away from the sponsor's objectives.		
Exaggerate and under-play capabilities to bias players' decisions.	*B8. Misrepresent the capabilities of entities within the game scenario.*	
Omit and adjust data dealing with fundamental physics.		
Use black box simulations during adjudication.		
Fail to properly immerse players into challenging game play so they disengage and therefore are distracted from noticing deceptive game processes.	*B9. Exploit sponsor and player lack of experience and engagement.*	
Excluding real SMEs in the systems and concepts being gamed from the adjudication team.		
Populate player cells with people who lack specific detailed expertise in the systems and concepts being gamed.		
Design the game and data to prevent transparency and auditability.	*B10. Drive game's trajectory by obscuring key elements of game data and process.*	**Manipulate data collection, production and reporting to deceive game participants.**
Introduce biased data or algorithms in a non-transparent manner.		
Introduce bias for certain "successes" in the adjudication process to minimize those elements.	*B11. Distort player perceptions by in-stride manipulation of data.*	
Emphasize non-core and irrelevant information by manipulating visual game components and feedback.		
Ensure uneven data collection to skew interpretation.	*B12. Design the collection and reporting of game information to deceive the analyst.*	
Omit critical topics when interpreting game objectives and when designing and implementing the game to slant game outcomes.		
Omit or shade elements of play from the narrative report that do not support the desired malign result.		

Normative form of Characteristic	1st Level Clustering	2nd Level Clustering
Limit access to and flow of critical information using classification barriers	*B13. Exploit and distort the information flow between players, analysts, decision makers and sponsors.*	
Create misunderstanding using language and cultural barriers (between services, communities within services, etc.)		

Mitigation of malign characteristics

Question: How can we mitigate these characteristics from ill-intentioned games that made or can make a difference to the DoD?

Intent: Address the question from an active normative sense, i.e. how would you protect games from deceptive practices? Apply the question to the 1st level clustering of the malign characteristics.

The team used the Characteristics of Malign Games to explore possible mitigations (i.e. barriers to including malign characteristics into wargames), and proposed twenty-nine, each of which addressed one or more deceptive practices. The proposed mitigations fell into seven broad areas listed below. Some of these mitigations will be resisted on the grounds that they are onerous, costly and time consuming, or that the characteristics of malign games are not a problem for the DoD. The first argument against implementation is addressed by the trade-off between the importance to national security of the game and the cost of ensuring the game is valid. The second argument assumes away human nature and the history of intellectual fraud when money, careers and stakes are high.

Proposed Mitigation	1st Level Clustering of Proposed Mitigations	Applied to 1st Level Clustering of Malign Characteristic
Test and document links from every element of game to sponsor's objectives.	Rigorously test the logic linking game design to sponsor objectives, using external peer review if necessary.	B1 – B3, B8
Test and document why time, space and scope support the sponsor's objectives.		
Document assumptions and obtain their impact on the game from the design, control and analysis team leads.		
Do a sensitivity analysis on questionable assumptions.		
Document capability assessment assumptions used for the game and the logic linking those assessments to the game's objectives.		

Use an external peer review board to examine game design.	Establish and use an independent empowered external peer review board.	B1—B3, B6—B8
Use an independent peer review board to examine, approve or reject assumptions.		
Use independent peer review board to examine the ability of the game design to properly address the sponsor's objectives for the game.		
Obtain and use independently derived data and document its level of validation, or if this is not possible submit the data to an independent review.	Establish Quality Assurance plan for data used in the game as part of the design and the DCAP.	B8, B11, B12
Establish transparency for all data used in the game.		
Submit data for external analysis by independent analyst team.		
Use an independent external archive with change log function.		
Document data collection points, types of data, and purpose of that data in the DCAP.		
Obtain unambiguous written guidance from sponsor on game objectives and level of war.	Engage the Sponsor and Stakeholders.	B1 – B8, B12, B13
Conduct a separate decision game for decision makers (i.e. an executive level shadow game after the game and based on the game flow of events).		
Ensure the sponsor's Red Team staff engages with the game design team.		
Incorporate the decision maker, sponsor or senior representative into Red player team.		
Identify and document all jargon, areas of cultural difference, and potential conflicts of interest between the communities and stakeholders involved in the game.		

Assign honest brokers from external organizations to each player team.	Use an independent monitoring team during the game.	B5, B6, B10 – B13
Use an independent experienced wargamer (team?) to aggressively monitor game staff and cells to provide quality assurance of performance.		
Use independent external analysts as monitors during the game.		
Use a supernumerary data collector with analysis expertise to monitor data handling and collection.		
Incorporate and recruit advisors from business and industry gaming, fraud investigators, and psychologists into the wargaming organization.	Expand DoD Wargaming Organizations perspectives and expertise by including SMEs from a wide variety of industries.	B1, B7
Provide outside industry perspectives to the wargame's government and technical teams.		
Actively construct player teams using invited mix of military and technical experts, do not use "pick up teams" or people imposed from outside. Review teams with sponsor.	Retake control of the construction, mix, and quality of Player Teams from the Sponsor.	B4, B5, B9
Allow game directors to re-allocate players between teams if they see an imbalance or potential conflict of interest.		
Identify stakeholders with conflict of interest or predispositions to a desired game output and take these into account when allocating players and when analyzing and reporting game outputs.		
Specify standards for players and enforce them. Do not accept pick-up teams or players imposed by Chain of Command. If this is not possible, document the lack of experience and its effects in the final game report.		
Run multi-stage games and rotate players between cells between stages.		

Summary Conclusions

Examining benign gaming provides best practices and lessons learned. However, every phase of wargaming, from initial contact between game sponsor and wargaming organization, is vulnerable to malign deception. At best malign deception is driven by the good intentions of influencers believing they are right and that anything that might contradict them must be avoided. At worst it is driven by careerism, corruption and hostility to other military communities and services. Examining malign gaming provides additional wargaming principles dealing with conflict of interest, intellectual fraud, self-deception, political imperatives and outright careerism. Malign games actively exploit the environment of time crunch, career pressure, resource constraints and the beliefs and opinions of sponsors, stakeholders and players, while poorly designed and executed benign games are exploited by this environment.

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- Ensure the event is a wargame with the possibility that Blue can lose and the gamed concepts can be overcome by Red, do not call non-game events "wargames".
- Recruit, not invite, senior leaders to lead game cells to execute game as designed, do not permit these leaders to derail the game in-stride to fit their non-sponsor agendas.
- Playtest the game with sponsor participation or with sponsor's empowered action officers to ensure sponsor is paying proper attention to objectives and design.
- Immerse the players in the scenario and play. Include the sponsor and key stakeholders as Red players. Do not let the sponsor or key stakeholders play Blue or be Adjudicators.

Internal – Work within the Wargame Organization and its Chain of Command:

- Engage and use an empowered Independent Peer Review Board to examine objectives, assumptions, scenario and capabilities data, design, game play, adjudication, data collection and analysis.
- Minimize cognitive dissonance in the mind of the sponsor by ensuring wargame design and play is as consistent as possible with their preconceptions, while not allowing these preconceptions to drive objectives, design, game play, analysis or reporting.
- Conduct wargame forensics and reporting to provide actionable recommendations.
- Report ruthlessly and honestly, unencumbered by sponsor or stakeholder wishful thinking.

Working Group Papers on Validity and Utility of Wargaming

In accordance with best practice for normative processes, after the meeting working group meeting members wrote short papers on "what validity and utility means for wargames". The papers run in length from an extraordinarily insightful single paragraph to several pages of valuable insights.[6]

[6] Authors retain full and sole rights to the content of their specific papers.

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Gil Cardona
"Thoughts on Wargaming Validity and Utility"

Validity is an imprecise measure of how well the wargame is designed to answer the central question and objectives. The measure of validity for Wargaming is imprecise because it is a much more complicated than a binary answer as to whether a wargame is valid or not. Most participants walk away from a wargame either feeling fed by their participation or wanting more. If the wargame sponsor, the key vote in terms of validity, leaves a wargame feeling fed and objectives met, then that wargame should be considered valid. Conversely, if the wargame is poorly designed or executed to where the central question and objectives are not met, then that wargame is not valid.

Wargame utility is simply a measure of how much work the results of the wargame generates upon post game analysis and "feel." Wargames must not be conducted to serve as a vehicle for justifying pre-game perceptions but rather as tools to identify shortfalls, risks and topics that require further study. Wargames are fantastic vehicles for challenging assumptions and after conducting a wargame participants "feel" as though their pre-game notions were challenged, then that is the mark of a useful wargame. Wargames cannot be treated as the culminating event for a particular problem set but rather another part of the cyclical process of plan improvement.

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Thomas Choinski
"Wargaming, Innovation and the Motivation to Take Action"

Working Group 2 (WG2) delineated the value delivered by current wargaming activities. Nevertheless, given the renewed interest in wargaming, growing research and its role in helping to navigate through today's complex emerging geo-political situations[7], WG2 would benefit by highlighting the value delivered from another vantage point. The accelerated adoption and diffusion of innovation in the Department of Defense (DoD) serves as this vantage point.[8]

Decision making assumed a privileged position during WG2's value-based discussions on wargaming, yet decision making does not fully address return on investment (ROI) concerns for all wargaming events. The motivation to take action serves a privileged position for wargames focused on innovation. Decisions without the motivation to take action remain dormant. The adoption and diffusion of innovation requires action. The human situational interaction fueled by wargames stimulates the motivation to take action that delivers a ROI.

Scholarly research indicates that the motivation to take action derives from four levels of human interaction engendered by wargaming, two levels external to the wargame and two levels internal to the wargame.[9] The first level of external human interaction occurs when stakeholders and game designers formulate the purpose of the game by defining the problem. Identification and delineation of the problem provides an initial return on investment. Two levels of internal human interaction lead to other returns on investment. The first level of internal human interaction occurs when participants prepare for the wargame. Wargames staged to advance innovation require participants to assimilate new technologies, as well as operational concepts to employ them. In addition, participants conceive novel concepts of operation throughout the conduct of the wargame within the second level of internal

[7] Kissinger, Henry. *World Order: Reflections on the Character of Nations and the Course of History*. Penguin Press, 2015.

[8] Choinski, Thomas. "Innovation Challenges: Past, Current and Future," *Military Innovation and the New Presidential Administration*, Naval War College, Newport, Rhode Island, 30 March 2017.

[9] Choinski, Thomas. *Dramaturgy, Wargaming and Technological Innovation in the United States Navy: Four Historical Case Studies*, Salve Regina University Dissertation, Newport, Rhode Island, March 24, 2017.

interaction. They also purge inferior courses of action while shaping technologies and distinguishing concepts for external action. The second level of external human interaction entails the selection and communication of alternative courses of action to work up within the "circle of research," i.e., prototyping, experimentation, etc. These external actions provide ROI by helping stakeholders navigate their way forward and through complex emerging geo-political situations. Human interaction characterized by the engagement between the four disparate communities that shape technology (science/engineering, acquisition, doctrine and warfighting end use) improves ROI. Wargames help stakeholders formulate problems; moreover, wargames chart plausible courses of action to act on.

Human interaction and the ensuing motivation to take action assume a privileged role when activities in the DoD conduct wargames focused on innovation. Participants and stakeholders must take action on the courses of action distilled from the wargame to achieve the return on investment for the accelerated adoption and diffusion of innovation.

Stephen Downes-Martin
"Validity and Utility of Wargames"

A. What does Validity and Utility mean when applied to wargames?

Validity means the wargame had the following characteristics:

- It had objectives that were suitable for gaming
- The game design was tailored to the objectives
- The game was executed according to the design
- Other characteristics (for example suitability and expertise of players, agendas not being imposed, adjudication based on reality and not wishful thinking) are part of the game design.

Utility means the wargame had the following three characteristics:

- It informed national security related decisions in a way that enhanced mission success, i.e. increased the probability of achieving the objectives of the decision at some combination of reduced cost, casualties and time
- It was accepted by the sponsor or other senior leaders as valid
- Senior leaders acted on the information from the wargame(s)

B. What were the characteristics that lead to success of past games "that made a difference"?

Not all of these are present at the same time:

- In general the absence of pathologies as listed in the literature
- Senior leaders were facing real death and destruction in the real world
- Senior leaders, real planners and decision makers played the game, and were allowed to lose
- Highest ranking officer played Red
- Game was repeated and refined multiple times, not a "one-off"
- Senior leaders played many games, and played in repeated games. They became skilled at playing and saw the link between the games and the real world.
- Senior leaders focused on results, not avoiding embarrassment (to themselves or their communities)
- Games focused on decision making process, not on specific decisions
- Games linked warfighters, science & engineering, doctrine and acquisition
- Games were not in a vacuum, they linked to analysis, conferences, other activities.

C. What additional characteristics might be in play today and in the future"?

- Computers are used and abused more, and there is an institutional bias by DoD against wargaming in favor of exotic and expensive technology that is encouraged by

contractors with financial interests involved. The flip side of that are lazy processes -- such as brainstorming -- being promoted as wargaming by contractors and accepted by DoD because they are fast and not intellectually hard.

- Psychology of gaming and decision making is better understood now but the results of the research are not being explicitly incorporated into wargame design to the same level of skill that similar (or analogous?) knowledge is used by video game designers. Wargaming needs to catch up.

D. What is a "Malign Wargame"?

A malign game is one that deceives the sponsor into thinking it is valid, into acting on the game's insights, but those insights lead to reducing mission effectiveness. This is not a game that is poorly designed and the sponsor is ignorant or unintelligence, this is a game that fools the intelligent, dedicated and experienced leader into making mistakes.

The hypothesis is that the opposite of a "valid and useful wargame" is not a "invalid and not useful wargame", it is "a wargame that appears valid and deceives the decision maker into making poor decisions based on the game". Looking at valid and useful games gives us characteristics to seek and behaviors that interfere with those characteristics to avoid. By looking at wargames that are deliberately designed to be malign and deceptive we may identify additional characteristics to explicitly avoid in wargame design that are not obvious from looking at a list of characteristics to seek.

Risk factors for malign games do not mean the game is malign, just that these factors must be examined in case the game is malign. Unfortunately, malign games do not come with a label! Some risk factors are:

- Game sponsors or Players are under career pressure for results
- Game sponsors or Players think they already know the answer
- Game is a one-off, or hard to repeat
- The game sponsor or other stakeholders are on the adjudication team
- The game sponsor or other stakeholders are on the (only) analysis team

John Hanley
"Validity and Utility of Pseudo-Experimentation Using War Games and Combat/Campaign Simulation"

Pseudo-experimentation involves improving understanding and exploring innovations using a simulated "world", rather than the real world. As computers have become more powerful, Military Operations Research uncritically adopted computer simulation over gaming as the principal means for informing resource allocation and operational decisions in the belief that it was more valid and useful. Computer simulation even displaced much of the analytical effort involving observation and analysis of operations in the field, which provided the origins of Operations Research. This paper offers some cautions regarding the valid use of large combat/campaign simulations and perspectives on the power and limits of games to promote a new conversation on the subject.

Validity of the Simulation

Games such as baseball have key features of competition:

- teams,
- terrain (field features),
- choice (batting and fielding lineups, pitch choice, play choice, plays, swing or not, etc.),
- the information available when making a choice (outs, strikes/balls, private signs to the pitcher and batter, etc.),
- sequences of moves (strikes/balls, home and away, innings, etc.),
- strategy; the selection of courses of action (small ball/long ball),
- outcomes of each move describing the state of play (outs, runs, hits, errors, etc.), and
- overall pay off (win or lose).

Games also have rules that affect the play and umpires to oversee the rules. Some rules are firm and well understood, others are firm and not well understood, and some are conventions (e.g. stealing bases when leading by a large margin is frowned upon).

War – acts of force (increasingly gray) to compel one's enemy to do one's will – has the same key features as games. However, each feature is more varied and the rules are subject to change with fewer effective enforcement mechanisms.

In addressing the validity and utility of war games, the implicit questions are "for what purpose" and "compared to what?" Games used strictly for training presume that the questions and correct answers are known. They are used to rehearse actions and determine the extent to which the players know the answers to contingencies that have accepted solutions. More interesting is the use of war games to explore strategy, operations, tactics, and DOTMLPF-P for anticipated contingencies or to explore future alternatives to existing systems and practices.[10] Since one cannot experiment by conducting wars, war games and combat/campaign simulations provide means for conducting pseudo-experiments using a simulated "world".

Both computer and game simulations begin with a complex reality – the real world. Those observing this "world" use their perceptions and beliefs to create an abstract conceptual model of the competition that forms the basis for simulation. The first question regarding validity is the extent that the simulated "world" captures relevant features and accurately represents phenomena of the real world. Are the actors (including nature) who affect outcomes of the competition represented? Does the simulation capture terrain that will affect choices and outcomes? Are actors allowed the choices that they could make in the real world? Do the actors have the information that they would expect to have in the real world? Are the rules governing the outcomes of actions accurate? Etc.

Objectivity and rigor are attributes of validity. Objectivity is a result of intersubjectivity; i.e. all using their subjective perceptions in observing an object agree on its attributes. For example, observers could observe a coffee cup and agree upon its color, size, weight, etc. The validity of games is enhanced by have teams of subject matter experts involved in the design, play, adjudication, and findings from a game who can question aspects upon which they agree and disagree to arrive at more objective judgment. A way to check the objectivity of campaign and combat simulations is to have different teams model the same contingency, or have a team use different models. Should different teams model the phenomena the same way, their simulation satisfies the criteria for objectivity. Should they differ substantially, their simulated "world" is

[10] DOTMLPF-P is doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy.

not objective. Analytic teams using more than one model on the same problem have benefited from learning considerably more about the problem, and he models and modeling assumptions within them than they learned from one model.[11] Simpler models amenable to manual calculation, such as Salvo Equations, can be understood widely, whereas computer models involving thousands of variables require independent review to meet objectivity standards for validity. One must carefully question the validity of proprietary simulations.

Rigor requires using appropriate precision, not more precision. As Aristotle said, "A well schooled man is one who searches for that degree of precision in each kind of study which the nature of the subject at hand admits." Appropriate precision depends upon the nature of the *indeterminacy* involved in the phenomena being simulated.

Combat/campaign simulations using mathematical models are either deterministic or stochastic. Deterministic models typical of the exact sciences provide point solutions/predictions. Probability distributions provide the solution/prediction for models of phenomena involving the *statistical/stochastic indeterminacy* associated with random variables. Indeed, to save calculations and time many models are pseudo-deterministic in that they use expected values as a statistic to characterize otherwise random phenomena rather than Monte Carlo or Markov models that select values of random variables from the probability distribution the phenomenon or state of the "world" modeled during each run.

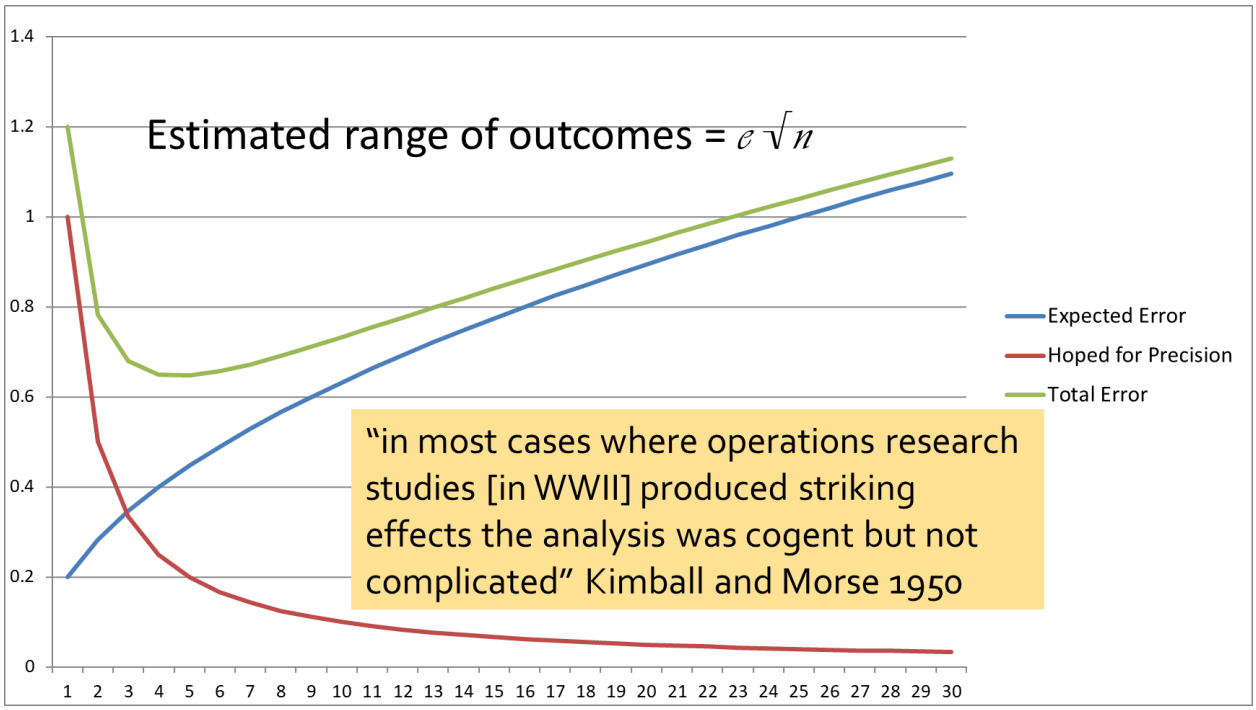
Frequently modelers add detail to make their models of the "world" more accurate. Rarely does one see an estimate of the variance or deviation of the possible results. An estimate of the deviation in outcomes of a quantitative model is the error of a typical variable times the square root of the number of variables. For example, an analyst using a computer simulation with 5000 random variables having an error of about 10 percent can be confident that the answer is accurate within a factor of about 7.[12] Figure 1 illustrates how adding variables actually adds to

[11] Hillestad, R., Owen, J., & Blumenthal, D. (1995). Experiments in Variable Resolution Combat Modeling. In J. Bracken, M. Kress, & R. Rosenthal (Eds.), Warfare Modeling (pp. 63-86). Danvers, Massachusetts: Military Operations Research Society.

[12] Koopman, B. O. (1970). "A Study of the Logical Basis of Combat Simulation," *Operations Research,* Vol 18, No 5, 880.

the deviation in possible outcomes when striving to increase the accuracy of the model and suggests that fewer variables provide the greatest accuracy, in addition to being easier to understand.

Figure 1: Accuracy of Combat/Campaign Models



Finding accurate data to use in combat models is challenging. Dean Emeritus Wayne Hughes (Captain, USN Retired) provides comparisons of data from structured exercises to combat data illustrating factors of 3, 5, 7 or more between the results.[13] And then factors such as the timing and rate of interactions, the speed with which an enemy can react, the effects of an enemy's readiness and training, etc. are largely unknowable.

Work on deterministic chaos and complexity over the past several decades has shown that human behavior is not random. It occurs in bursts and follows power laws. Power law distributions challenge typical statistical approaches in that one can calculate a mean, but the standard deviation is infinity. The law of large numbers does not apply. This further complicates estimating confidence factors for models using expected values.

[13] Hughes, (2012). Prediction: An address to the Military Application section of INFORMS,.

John von Neuman and Oskar Morgenstern developed a theory of games and economic behavior to deal explicitly with the *strategic indeterminacy* resulting from the choices of multiple actors. Unique solutions in Game Theory are rare. Most solution concepts provide sets of solutions. These sets involve equilibria for discrete choices and core sets for choices involving continuous variables. Statistical/stochastic indeterminacy may be embedded in the game, adding to complications for calculating solutions and representing predictions.

Table 1 summarizes these types of indeterminacy, specifications for calculation, Operations Research techniques, and solution characteristics. In general, as indeterminacy increases, detailed analysis is useful for eliminating infeasible solutions, but cannot provide a point prediction. Once infeasible solutions are eliminated, selection of a particular solution is a matter for the decision maker, not the analyst. Inaccuracies in any specifications – particularly those misrepresenting the nature of the indeterminacy inherent in the phenomena modeled – erode the rigor and validity of the model.

Table 1: Techniques for the Resolution of Indeterminacy

Nature of the Subject	Deterministic	Statistical Indeterminacy	Stochastic Indeterminacy	Strategic Indeterminacy
Features	1. State space clearly defined 2. Persistent data 3. Units of measure understood 4. Relationships determined 5. Initial state known	1. State space clearly defined 2. Persistent data 3. Units of measure understood 4. Probability distributions known	1. State space clearly defined 2. Persistent data 3. Units of measure understood 4. Relationships determined 5. State transition probabilities & rates known, and are Markovian	1.Conflicting interests 2.Players specified 3.Information conditions specified 4.Probability distributions for “moves of nature” specified 5.Player tastes and beliefs known 6.Players consistent and logical (rational)
Techniques	Mathematic Analysis and Programming	Monte Carlo, Regression, Analysis of Variance	Markov, Monte Carlo	Game Theory
Solution Characteristics	Unique solution	Unique distribution	Unique distribution	Nash Bargaining set (2 players) Core of solutions (>2)

Deterministic and statistical/stochastic models and Game Theory require well specified problems to formulate predictions and rarely admit learning and adaptation.[14] Deterministic and statistical/stochastic models embedded in a simulation require a rational means for incorporating human variables. War gaming and rehearsal of concept exercises have been used effectively to inform the representation of human decision in some computer-based campaign simulations.[15]

Warfare is in a class of phenomena involving "wicked problems" with large measures of *structural indeterminacy*. In wicked problems, the boundaries of the problem, the elements included within, and the relationships between those elements are poorly understood. Analyzing wicked problems first requires a theory of the phenomena under study. As Clausewitz wrote:

> *Theory will have fulfilled its main task when it is used to analyze the constituent elements of war, to distinguish precisely what at first sight seems fused, to explain in full the properties of the means employed and to show their probable effects, to define clearly the nature of the ends in view, and to illuminate all phases of warfare through critical inquiry.*[16]

Combat and campaign outcomes depend upon many, varied interactions with feedback and learning. Campaign analysis as taught by Wayne Hughes at the Naval Postgraduate School, Operational Design developed by John F. Schmitt and adopted in *Joint Operational Planning*, and scenario planning are techniques for articulating a theory to simulate "worlds" for pseudo-experimentation.[17]

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[14] Bayesian approaches are an exception, but are difficult to implement in large scale models.

[15] Appleget, J. and Cameron F. (March 2015). "Analytic Wargaming on the Rise", *Phalanx,* 28-32.

[16] Clausewitz, C. v., edited and translated by Howard, M. and Paret, P. (1976). *On War,* Princeton University Press, Princeton, New Jersey, 141.

[17] Kline, J, Hughes, W., and Otte D. (14 January 2011). *Campaign Analysis: An Introductory Review*, Published Online; Schmitt, J. F. (n.d.). A Systemic Concept for Operational Design. Retrieved November 11, 2017, from http://www.au.af.mil/au/awc/awcgate/usmc/mcwl_schmitt_op_design.pdf; JP 5-0, 2017. Joint *Operational Planning*, Joint Publication 5-0, Joint Staff; Schwartz P. (1991). *The Art of the Long View,* Doubleday, New York.

Whereas combat/campaign simulations reduce elements of a complex contingency to a set of cause and effect relationships, games synthesize interrelationships between participants and features of the contingency under study. Interaction of participants enhances the objectivity of games in ways rarely achieved through the interaction of teams of analysts.

Games provide a bridge for bringing together embedded deterministic, statistical, and stochastic phenomena for adjudicating outcomes of player's choices and expose aspects of structural indeterminacy not previously appreciated. Like other forms of inquiry and analysis involving large measures of indeterminacy that eliminate infeasible solutions, gaming historically has been useful in exposing infeasible, inadequate, unacceptable, or incomplete courses of action when faced with an intelligent adversary; in exposing factors that will govern successful strategies; in enriching an appreciation of logical adversary courses of action; and in exposing knowledge required for better planning and analysis.

Repeatability and Validity

Distinguishing between a game and a play of the game is important when discussing the validity and utility of game and combat/campaign simulations. The distinction is akin to discussing the game of baseball and the Yankee's /Astro's game on 18 October 2017.

Superficially, computer simulations appear to be more objective than games, and thus their results more valid. Different analysts can run a computer simulation with the same input and repeat the same output whereas multiple plays of a game will produce different outcomes. In games, different players will make different decisions, and even if the same players are in the lineup, they will learn from their previous play and make efforts to improve their performance. The fact that the game is not repeatable does not reflect on the validity of the game. Have any two baseball games ever been exactly repeated? No war has. Since wars and battles never repeat, can a computer simulation that always produces the same outcome be said to be a more objective, and thus valid, representation of competition and cooperation than a game?

Models involving non-linear dynamics, such as Lanchester equations, exhibit deterministic chaos where the most minute difference in inputs will produce wildly different outcomes over

time.[18] Though the model is deterministic, the outcomes are chaotic. Weather models are an example of how such models can provide only short range predictions. The solution space is an attractor. Statistics on attractors is an open area worthy of more research for understanding how frequently nearby the system will be in nearby states, given that they never repeat.

Whereas combat/campaign simulations reduce elements of a complex contingency to a set of cause and effect relationships, games synthesize interrelationships between participants and features of the contingency under study. Interaction of participants enhances the objectivity of games in ways rarely achieved through the interaction of teams of analysts.

The validity of a play of the game, or the calculation of a model, depends upon whether design/rules of the game were followed. A game where one of the teams "threw" the game by making mistakes to allow the other team to win invalidates the game. Similarly, participants in war games whose objectives differ from game objectives and are reflected in their play invalidate the play of a wargame. The validity of a calculation requires also requires that rules of mathematics and logic be followed correctly. One may have created a valid game or computer model "world" for pseudo-experimentation that is executed invalidly.

Though a game played only once follows one set of players' decisions and adjudications describing a course of action for each team, the participants in the game discuss, make and observe the wisdom of each decision at each move. Thus, while playing one course of action, they explicitly and implicitly consider many branches.

Historically games played only once have been very useful for highlighting factors that govern the outcome of a battle or campaign; even though one play of a game can no more predict a specific outcome any more than one play of a baseball game can predict the score and player injuries of a following game. As with computer-based combat/campaign simulations pseudo-experimentation, the validity of lessons taken from a game depends upon accurately characterizing the precision of the results.

[18] Dewar, J.A., Gilogy, J.J., and Juncosa, M.L. (1991). Non-Monoticity, *Chaos and Combat Models*, RAND R-3995-RC, Santa Monica, California.

Utility of Pseudo-Experimentation

Utility of Games

For centuries, militaries have found games useful for exploring and developing courses of action, developing concepts for future forces, and familiarizing officers and troops for warfare. More recently, the non-military use of gaming has grown.

Gaming has demonstrated predictive value. Early gaming at the Naval War College anticipated tactics and predicted the outcome of the Russo-Japanese war. Russian and German gaming in planning operations in World Wars I and II accurately identified opportunities and weaknesses realized in subsequent operations. German and Naval War College gaming between is legendary for anticipating the character of future campaigns, developing operational schemes, and promoting the development of technology and systems to conduct the campaigns. During the war in Vietnam, the U.S. Joint Staff's Strategic Analysis and Gaming agency anticipated the Tet offensive, though it did not affect how national command authorities pursued the war.[19] Many other examples exist.

Beginning in the 1980s, the Chief of Naval Operations' Strategic Studies Group used gaming as its primary technique for exploring shortfalls in existing war and contingency plans and developing alternative courses of action in the form of innovative strategic and operational concepts and tactics. Their work in 1981-1983 quickly changed war plans and informed the Maritime Strategy.[20] To explore future U.S.-Soviet relations after the fall of the Berlin Wall, in February 1990 the Group conducted a war game based on an Iraqi invasion of Kuwait and Saudi Arabia. Though the Red team had to work from first principles rather than follow previous scripts, the game accurately anticipated factors driving the Soviet response. It also highlighted operational issues involving strategic lift for U.S. and coalition forces, the Navy having too few precision weapons, and others that occurred as forces deployed for operations beginning in July

[19] Hanley, J.T., (1991). *On Wargaming: A Critique of Strategic Operational Wargaming,* Chapter 4, University Microfilms International Dissertation Information Service, Ann Arbor, Michigan.

[20] Hanley, J.T., (2014). Creating the 1980s Maritime Strategy and Implications for Today, *Naval War College Review*, Vol 67, No 2, 11-29.

1990. Having been reassigned to a battle group in the Persian Gulf, the SSG's intelligence officer sent back for the game books he had prepared, which had better intelligence than he was able to obtain in theater.

In the early 1990s, the Group exploited a "path gaming" technique employed by Mr. Andrew Marshall at the Office of Net Assessment in the Pentagon (along with Royal Dutch Shell scenario planning techniques) to anticipate the security environment 20 years into the future. While predating the general use of the term "cyber" and specific terrorist groups like Al Qaeda, this work accurately anticipated trends informing the development of naval capabilities. Given the mission of naval warfare innovation in 1995, the Group used gaming to develop operational concepts for future fleet architectures and weapons using emerging technologies that are just coming to fruition today. The Chiefs of Naval Operations always encouraged the Group to be innovative. The Group used a saying attributed to T.H. Huxley that: "Every new idea begins as heresy and ends as superstition." They found that time from heresy to common wisdom took about five years for operational concepts using existing forces and at least ten years when they proposed developing new force structures and weapons; e.g. unmanned vehicles, rail guns, etc. The Naval Postgraduate School has also used gaming to explore alternative fleet architectures.

Again turning to Clausewitz:

> *It is immensely important that no soldier, whatever his rank, should wait for war to expose him to those aspects of active service to amaze and confuse him when he first comes across them. If he has met them even once before, they will begin to be familiar to him.*[21]

The value of war gaming at the Naval War College and by the German Wehrmacht for preparing officers for World War II is part of the legend. Though the games did not anticipate tactical details such as kamikazes, torpedoes, and radar, and could not anticipate atomic weapons, they did present many features that prevented surprises during the course of campaigns.

[21] Clausewitz, C. v., edited and translated by Howard, M. and Paret, P. (1976). *On War,* Princeton, New Jersey, Princeton University Press, 122.

U.S. Joint doctrine calls for staffs to prepare alternative courses of action (COAs) for the adversary's most likely and most dangerous potential COAs, if time is available, along with a set of criteria for assessing those COAs.[22] Knowing what the adversary could do to achieve its objectives, and which is "most dangerous" is often difficult to discern before conducting games, as the adversary must consider difficult tradeoffs often not apparent without more careful analysis from its perspective. Schmitt and Kline have documented that commanders and their staffs rarely have the time (or interest) in gaming multiple adversary COAs in the preparation of any single contingency plan even when conducting deliberate planning, and in actual crises often have time only to rehearse their concepts mentally.[23] The authors' experience at a combatant command is that higher authority prescribes planning scenario, the commander provides the strategic concept and, and the staffs involved in planning for large contingencies have time to explore only a few variations of the many prescribed planning assumptions.

Rather than tasking staffs to come up with multiple COAs, Ross, Klein, et. al. recommend a Recognitional Planning Model (RPM) as a more natural and faster way to arrive at adequate, feasible, acceptable, distinguishable and complete courses of action.[24] The commander provides the initial COA for analysis, rather than the staff generating alternatives for the commander to consider. Alternative COAs, if needed, are derived in overcoming problems discovered when assessing the initial COA, rather than arbitrarily creating multiple COAs. The analysis shows that "the commander's knowledge, training, and experience generally help in correctly assessing a situation and developing and mentally war gaming a plausible COA, rather than taking time to deliberately and methodically contrast it with alternatives using a common set of abstract evaluation dimensions."[25] The RPM process also involves fewer steps and in

[22] Joint Publication 5-0, V-35.

[23] Schmitt, J., & Klein, G. (1999). A Recognitional Planning Model. *Proceedings to the Command and Control Research Symposium 1999*, Newport, RI: Naval War College. Deliberate planning is the planning in anticipation of a potential future contingency and distinguished from the Crisis Action Planning that occurs when actually facing a contingency.

[24] Joint Publication 5-0 calls for COAs with these "characteristics, V-28/29.

[25] Ross, K., Klein, G., Thunholm, P., Schmitt, J., & Baxter, H. (2004, July-August). The Recognition-Primed Decision Model. Military Review , 6.

evaluations has reduced planning times by 20-30 percent with no apparent loss in effectiveness of the resulting plan. The Chief of Naval Operations' Strategic Studies Group used the approach recommended by Schmitt and Kline in conducting a series of orientation, concept exploration, and concept evaluation games in their studies. Recent doctrinal publications have adopted some aspects of the RPM process.[26]

A key feature of both the doctrinal and RPM processes is the importance of who participates in the war gaming. Joint Publication 5-0 recognizes that gaming is most effective when the people making decisions participate in gaming. Wargaming provides a common understanding that allows them to determine the advantages and disadvantages of each COA and forms the basis for the commander's comparison and approval. Wargaming stimulates thought about the operation so the staff can obtain ideas and insights that otherwise might not have emerged.[27] If time is available, Where those involved in the planning and operations are not participants in the gaming, some means for efficiently transferring the experience derived by the gamers to the planners and commanders is required.

As in baseball, multiple plays of a game can produce some statistics. These can be valuable if the game is simple enough. However, the utility of multiple plays of a war game is to understand the strategic indeterminacy created by the interaction of players selecting different courses of action. Drawing from Game Theory, one useful way to represent multiple plays of a game is in the form of a game tree with each branch showing the choices that the players made and the consequences of those choices on each move. Playing the game many times provides an extensive game tree filling out many courses of action and amenable to analysis of strategies that dominate or result in equilibria (where no team could improve the consequences to itself).[28] Analysis of such trees can highlight equilibria where none of the actors can improve

[26] For example, see TRADOC Pamphlet 525-5-500 (January 2008). *The U.S. Army Commander's Appreciation and Campaign Design,* Version 1.0, 28, and the discussion of operational design in JP 5-0, Chapter IV.

[27] Joint Publication 5-0, V-32.

[28] The absence of equilibrium suggests opportunities for deception.

their outcome by selecting another course of action.[29] The objective is not play that repeats the same strategies by the players, but to develop a greater appreciation of strategies that the players may use. Cultural norms, doctrine, training, etc. will constrain choices the players make. Understanding this, and the consequences of violating such constraints, enhances the utility of gaming.

Gaming stimulates creativity through play in a safe environment and discovery of approaches that were unknown or unanticipated. A strength of gaming is that it promotes innovation, even in training exercises, by suggesting alternatives to existing DOTMLPF-P, tactics, operations, and strategy. War games provide a forum for the integration of ideas. The representation of the contingency on maps and through supporting information provides a concrete experience that allows players to know they are talking about the same situation. The communication allows the derivation of statements that are beyond logical dispute. Games provide military officers experiential learning about the military geography, their own and adversary organizations and weapon capabilities, and likely consequences of alternative courses of action in more tangible ways than reading and memorization could provide.

Studies on the value and power of play show that playing games enhances creativity, communication, and understanding complex behavior governed by social rules.[30] The studies and experience Duke and Guerts (Duke & Guerts, 2004) in conducting policy games for strategic management in a hospital, a rail corporation, the technical components industry, etc. support their assertion that gaming is a powerful method for simultaneously mastering complexity, enhancing communication, stimulating creativity, and contributing to consensus and a commitment to action.

Immersing the participants in the play of the game makes it more useful both to the players, and those observing the play of the game. The shared, concrete experience of a game facilitates consensus and the commitment to action. Having those responsible or influential in making

[29] Hanley, J.T. (2017). Planning for the Kamikazes: Toward a Theory and Practice of Repeated Operational Games, *Naval War College Review*, Vol 70, No 2, 29-48.

[30] Google TED talks on play for a series of talks on useful research.

decisions participate in a game provides a major advantage over analyses that must be reduced into a report and explained to decision makers. [31]

The Utility of Combat and Campaign Simulation

Several centuries ago, Newton and others transformed science with the new idea that rules based upon mathematical equations could be used to describe the natural world. This scientific approach emphasized breaking a system down to define its underlying parts, and then trying to analyze these parts in as much detail as possible.[32] Mathematical formulas predicting outcomes could then find out how the system behaved by running an experiment and watching what happened. This use of mathematics underlies the extensive advances in physics, many other sciences, and engineering over the intervening centuries. As the speed of computer calculations has increased exponentially over the past several decades, experiments run on computers have increased an understanding of the value and pitfalls of mathematically modeling systems in ever greater detail; and that simple, non-mathematical rules-based models can better simulate biological behavior.[33]

In the 18th century, the "enlightenment" fostered by science led to a "vogue of mathematics" in military planning. War gaming largely displaced this fad in the 19th century. Operations Research groups in World War II expanded the use of mathematics in developing models phenomena they observed and predicting the effects of alternative tactics, techniques, weapons, and operations.[34] Their mathematical models could be calculated by hand. They advanced topics such as search theory to the point of becoming operational decision aids. To deal with uncertainties inherent in their models, the U.S. Operations Research Group in World War II emphasized "hemibel thinking"; recognizing that improvement in the operations was

[31] See Richard D. Duke and Jac L.A. Guerts (2004). Policy games for strategic management, Amsterdam, Dutch University Press for an extensive discussion of these attributes and the supporting research.

[32] These parts are the state variables of the system that are necessary and sufficient to predict the future trajectory of a system.

[33] Wolfram, S. (2002). A New Kind of Science, Champaign, Illinois, Wolfram Media, Inc.

[34] Kimball, G.E. and Morse, P.M. (1951). Methods of Operations Research, Los Altos, California, Peninsula Publishing.

unlikely unless the theoretical result from their analysis was at least a factor of three better than that observed.[35]

Following World War II, simulation using both war games and computers became important to provide synthetic experience to prepare for conflicts using nuclear weapons and traditional warfare. Models and techniques developed by the Operations Research Group formed the foundations for establishing Operations Research as a discipline focused on mathematical modeling, mathematical programming (linear, non-linear, dynamic, etc.) and stochastic processes. As the Operations Research discipline advanced, so did the sophistication of the models used in combat/campaign simulations and to adjudicate outcomes in war games.

Secretary of Defense Robert McNamara's demand for cost benefit analysis and creation of the Systems Analysis Office in 1962 led to the use of Operations Research techniques for cost-benefit analysis before acquiring new platforms and weapons systems. In the late 1960s and early 1970s, military modelers concentrated on modeling combat and logistical processes as though they were physics problems. As computer speeds increased exponentially with Moore's Law, these models were aggregated into ever more complicated campaign simulations, losing sight of the Operation Research Group's cautions and methods for estimating confidence factors.

Combat and campaign simulations allowed analysts to compare alternatives quickly. They also met senior decision makers' desires to have a staff process where scenarios for analysis could be specified and analysis conducted on a cycle responsive to annual budget and program submissions to Congress. Unfortunately, these desires led to the search for universal answer machines allowing merely varying inputs into the same model "world" to provide outputs that would drive, and ideally in the minds of the DoD staffs, specify decisions. Turning war gaming into a staff process encumbered by centralized standards would greatly reduce any benefits that war gaming could provide.

[35] Kimball, G. E. and Morse P. M. (1951). Methods of Operations Research, tenth printing, Los Altos, CA, Peninsula Publishing, 38.

Competition between military services over scenarios, data, models that better supported their acquisition programs led to rapid expansion of the defense consulting industry in 1970s and 1980s, fostering significant commercial interest in modeling and simulation based upon the modeling paradigm that had been created earlier: creating a positive feedback for ever larger computer-based simulations. Secretary of Defense Donald Rumsfeld created an Analytic Agenda to provide more discipline to a process that was producing huge quantities of analysis, but affecting few acquisition or other resource allocation decisions. His successor Robert Gates found the system that had emerged unresponsive to the needs of ongoing wars. When Ms. Christina Fox became Director of the Cost Assessment and Program Evaluation Office in 2009, she began deemphasizing the use of large campaign simulations.

Though large campaign simulations have a poor performance record, more tailored models and calculations embedded in war games have been more useful. At the Naval War College in the 1980s, military officer umpires in war games became proficient in using individual models for their warfare area. Trained primarily on the job, they came to know the limits of the models for calculating platform interactions resulting from player decisions and applied their judgment to adjudicate outcomes for situations falling beyond the bounds of the model. In annual Global War Games, each military service employed its own models for adjudicating warfare in its domain.

The end of the Cold War led to a hiatus in classical naval combat. The models in the Enhanced Naval Wargaming System designed for fighting canonical battles involving traditional naval forces were inappropriate for adjudicating conflicts such as those in the Balkans, Iraq, and Somalia, or dealing with terrorism. As games at the Naval War College turned to these conflicts, the expertise required to use the models in the wargaming system dissipated within one cycle of military officer umpire assignments, about three years. With the prospect of classical naval combat, with some hybrid characteristics, returning, the Naval War College turned to addressing adjudication as part of each game's design and no has many officers assigned to adjudicate their warfare areas. This has the advantage of tailoring adjudication to each game, but forfeits capturing the latest theories of naval combat in formal models that are tested in fleet exercises and operations.

Primary strengths of combat models are in representing testable quantitative theories of combat and the deep learning that accrues to the analytical team as it goes through the process of making judgments in the formulation of the model, efforts to validate data, and contrasting model results to existing intuition regarding causes and effects.

Summary

In contrasting the validity and utility of war games and combat/campaign models for exploring courses of action for military operations and preparing forces and organizations, each has its strengths. Combat models are most useful when they involve physics, such as passive search where the object being sought is not reacting to the sensor and logistics not involving enemy interdiction. Should strategic indeterminacy resulting from adversary and/or ally action significantly affect the outcome, gaming is both more valid and useful.

The ludic – play – aspect of gaming involving military officers having current or future roles in making decisions regarding the subject under study also provides significant advantages over analysts' reports that the decision maker must interpret and weigh. Analysis reduces the abstraction of the "world" to distinguished causes and effects. Computational limits prevent using feedback in combat models. Games address the admittedly truncated "world" as whole. Feedback is natural. Communication in games between the participants is enhanced and by the concrete context. Communications between analysts and decision makers cannot replicate the experience of a game. Creativity in computer simulations is limited by the skills of the analytical team, where the interaction of memes in games creates new ideas and shorthands for communicating those ideas. Finding examples of extensive analytical efforts affecting major resource allocation decisions is rare, where history is replete with games creating a consensus and commitment to operational courses of action.

War games conducted by senior military staffs have been less successful in changing policies of the political leadership once they were committed to a course of action. The momentum of the military-industrial-congressional enterprise (MICE) slows implementation of innovations resulting from war games. However, U.S. Navy and German war gaming between the world

wars led to the development of alternative forces and operations, and given a chance can do so again.

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Frederick Hartman
"Validity and Utility of Wargames"

What does validity and utility of wargames mean when applied to wargames?

Determining the validity and utility of wargames is very different from the work MORS did in the early 1990's determining the methods for validating models, simulations and other analysis tools. Most evident in the difference is the wide differences in design, purpose, and intended use of wargames. Additionally, the psychological and human variances that are key in most wargames are not "repeatable" making a validation tenuous at best until final game products are determined. There has been a strong push by MORS for several decades to strive for better verification, validation, and accreditation (VV&A) of models and the certification of data. MORS developed specific definitions for each of these terms as they applied to models and simulations. The application of VV&A to models and their input data is fairly straightforward compared to assessing the validity of a wargame. Unlike the use of models and data supporting analysis, wargaming presents challenges when using "standard, defined terms" such as validity and utility which might mean different things in the context of different functional practitioners. Those terms may be discoverable only after completion of the game." Many large military operational analyses may employ some type of wargaming to establish scenarios, set force requirements, determine needs for logistics, or even require materiel acquisition and force structure tradeoffs, etc. In one such analysis a "business game" was employed to determine alternative acquisition and support alternatives. The ability to "validate" wargames is not as simple as for some other tools, especially when they are included as key decision inputs in large Defense studies and acquisition programs. However a good list of characteristics have been introduced in this report and are a good reference to plan for a "valid" wargame.

Wargaming as an analysis tool has a wide variety of uses that can radically impact game design and the desired outcomes. Sitting in with expert gamers during our Group 2 sessions was very educational and has prompted the conclusion that validity and utility of specific wargames is achievable only after the games are accomplished, although in a piecewise fashion each of

the game processes may be deemed valid for the final game and product(s) may be deemed "not valid" for its intended objective(s) and use.

The utility of wargames also provides a diverse set of considerations. For instance when the game objective is training, the process of walking through the wargaming might be more valuable in satisfying learning objectives than the resulting game products. Several of the senior plenary members warn that a certain significant number of the wargame may be more psychological in nature as opposed to quantitative. Such variation in wargames causes the outcomes to be more variable and not absolute in nature. The validity of a wargame may be keyed to the senior decision makers (sponsor?) perception of the credibility of the trusted players or direct participants that influence those very products.

What were the characteristics that led to the success of past games that "made a difference"?

One of the most important elements is communication at each major phase of the game to validate the emerging products with original game objectives. It is therefore important to include the involvement of senior decision makers (or trusted agents) at each significant phase to allow peer or independent review on a continuing basis during the wargame.

What additional characteristics might be in play today and in the future?

There will be changing requirements that will dictate each element of the game process, the characteristics, and perhaps even change the complete nature of gaming due to psychological or technical innovations, tools and understanding. The time spent by Team B on malign games is valuable at several levels. One should remain aware that a clever, experienced gamer with malign intent can introduce elements that move away from validity at any phase of the game. One must therefore remain constantly alert to check that the characteristics of a valid game are visible through the process and adhered to by the leader and sponsor.

John Lillard
"Thoughts on Malign Wargaming"

A good analogy to explain malign wargaming:

> *There are two ways to build a metal fitting. You can either machine it from a block of metal or cast it using a mold. Group A's work (benign) was like machining, while Group B's method was like building the mold for a casting. B's product is the negative of A's, but in the end both should result in the same shape of an object.*

"Malign wargames" occur when the game sponsors cannot or will not provide the resources and / or priority that the game needs. "Resources" in this case means the time and the experts to do the game design, the sponsor involvement in communicating the vision, the immersion of the players, and the time to post process result.

One of the biggest insights gained from the session was the concept of player immersion. If players are immersed in the game to the extent that they would be if it was a real situation, then their actions would correspond more accurately to the real thing. If they allow themselves (or are allowed) to be distracted during the course of the game by things like taskers from their offices, long periods between moves, and the perception that the game isn't a high priority for the sponsor, they won't perform properly.

The current DoD wargaming environment (especially inside the beltway) is one characterized by:

- compressed timelines
- limited budgets
- overtasking of staffs
- career progression pressures
- bias for quick answers or responses
- preconceived notions / opinions
- strong personalities

All of these contribute to malign games. They can only be overcome by strong commitment and leadership from the project sponsor – commitment to provide resources and priority, and leadership to set the example of immersion into the game and abiding by the results.

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Roger Meade
"Wargaming Validity and Utility"

Validity – A valid wargame includes a number of key elements. First and foremost, it must address the stated objectives outlined by the Sponsor. The process of developing game objectives should be guided by the game design team as they understand the capabilities and limitations of wargames. If the game does not adequately address the objectives it is unlikely that the results will be accepted by the stakeholders. Second, a valid game is built on valid assumptions. Assumptions are the foundation upon which the entire game is built. If the assumptions are invalid, the game will be invalid. This does not mean that the assumptions must be realistic, nor even plausible, they only need to be possible. One of the most valuable aspects of wargaming is the ability to examine improbable situations and consider issues from a fresh perspective.

The perception of validity of a wargame by stakeholders is critical – without it, the insights gleaned from the game will be wasted. A draft version of the workgroup out brief included a quote by Upton Sinclair that observed that "It is difficult to get a man to understand something, when his salary depends on his not understanding it". I was disappointed that this quote did not make it into the final draft as I think it perfectly captures the challenges facing game designers when trying to develop an intellectually honest game that meets the needs of the sponsor and stakeholders. It is a delicate balancing act, as I think it vital to win the support of the game sponsor, without pandering or allowing their institutional and cultural biases to influence the structure, and ultimately the trajectory, of the game.

Utility – It does not matter how valid a game is if the results are not useful to the sponsor and stakeholders. When assessing utility, we must begin by asking "useful for what purpose?" As with "validity" our starting point must be the game objectives. A valid game may prove useful in teaching players important lessons or may provide important insights. However, if the game results cannot satisfy the requirements of the sponsor then the game has failed to achieve its objective.

A second critical aspect of utility is whether the game results in some sort of concrete action. The "action" produced by the game can occur either during, or subsequent to, game execution. For example, a game designed to train or educate is producing action (i.e. training/education) and a game developed to examine a question can produce a concrete action with its output. Again, it is critical to accurately define what the sponsors expectations are and what they intend to do with the game.

Peter Perla
"Thoughts on Wargame Validity"

The Case for Validity

The ORSA community has a concept of validity based to a great extent on the principles of mathematics and physical science.

Mathematical validity stems from the (almost) universal acceptance of the basic definitions and axioms of the field and the rules for combining those to derive (prove) theorems that result from a logical progression of steps. The results of a mathematical derivation or calculation are valid to the extent the processes for creating them are valid. Hence, mathematical product validity stems irrevocably from process validity.

The physical sciences derive much of their epistemology from the same sources as mathematics because they often depend on mathematics in the determination of the truth of their conclusions. But it is sometimes the case that the physical sciences propose as true concepts that are beyond the reach of pure mathematics to calculate—at least at the time of the proposition. And, of course, physical science requires physical measurements rather than pure reason, introducing error and vagaries not present in pure mathematics and so introducing the application of statistical methods. Finally, physical sciences rely heavily on their accuracy at predicting the outcomes of physical events for the ultimate determination of their scientific validity. Thus, process validity, while important, may be trumped by product validity—usually in the negative sense, as when a valid process of reasoning and mathematical manipulation predict physical events which fail to occur in practice. Hence, unlike mathematics, physical science is frequently subject to revision and, indeed, revolution.

Then there is social science. This field may be characterized as applying scientific and mathematical philosophies and methods to the study of the vagaries of human behavior and performance. This application of largely formal techniques to mostly unruly subjects results in explicit concerns about the different flavors of validity. Indeed, social scientists concern themselves with several varieties of validity:

- Internal validity: the degree to which an instrument, such as a survey question, measures what it is intended to measure
- External validity: the ability of results of an experiment to be generalized beyond the immediate study,

and as described in a website targeted at sociologists: [36]

> True validity comes when both the instruments used and the results of experiments themselves are found to be accurate each time an experiment is conducted; as a result, all data that is found to be valid must be considered reliable, which means it must be capable of being repeated across multiple experiments.
>
> As an example, if a survey posits that a student's aptitude score is a valid predictor of a student's test scores in certain topics, the amount of research conducted into that relationship would determine whether or not the instrument of measurement (here, the aptitude as they relate to the test scores) are considered valid.
>
> THE TWO ASPECTS OF VALIDITY: INTERNAL AND EXTERNAL
>
> In order for an experiment to be considered valid, it must first be considered internally and externally valid. This means that an experiment's measuring tools must be able to be used repeatedly to generate the same results.

In other words, the methodology must be reliable. It must help us make accurate (or at least more accurate) predictions of future results when applied in similar circumstances.

What of wargaming?

Wargaming resides at the nexus of mathematical, physical, and social sciences, and overlays—for good measure—elements of visual, narrative, and performance art. This confluence of influences, ontologies and epistemologies creates a knotty dilemma of validities. One result is that wargame validity is a unique (at least I think it so) combination of objectivity and subjectivity.

The physical sciences (and especially mathematics) emphasize objectivity—impersonal application of established principals and strictly truthful and "accurate" observations leading to

[36] Because I am not a practitioner of social science nor often, I must admit, sympathetic to their ideas, I have taken the social-science description from https://www.thoughtco.com/validity-definition-3026737

reproducible conclusions. Yet there is hidden subjectivity even in physical science. That subjectivity manifests itself in the assumptions underlying the model (usually mathematical) the scientist constructs to represent the phenomenon, as well as in the means the scientist uses to define, collect and interpret physical data. This subjectivity tends to be swept under the rug when analysts present their results by emphasizing the mathematical rigor of the calculations themselves rather than the assumptions that lay behind them.

The social sciences wrestle with the subjective more intensely because of the nature of their, well, subjects. The social scientist strives to go beyond the idiosyncrasies of individuals to derive truths about people, or specific subpopulations, in general. Returning to our sociological touchstone quoted earlier[37]

> However, as University of California Davis psychology professor Barbara Sommers puts it in her "Introduction to Scientific Knowledge" demo course, the truth of these two aspects of [internal and external] validity may be hard to determine:
>
> *Different methods vary with regard to these two aspects of validity. Experiments, because they tend to be structured and controlled, are often high on internal validity. However, their strength with regard to structure and control, may result in low external validity. The results may be so limited as to prevent generalizing to other situations. In contrast, observational research may have high external validity (generalizability) because it has taken place in the real world. However, the presence of so many uncontrolled variables may lead to low internal validity in that we can't be sure which variables are affecting the observed behaviors.*
>
> When there is either low internal or low external validity, researchers often adjust the parameters of their observations, instruments, and experiments in order to achieve a more reliable analysis of sociological data.

These comments resonate with the wargaming experience. The subjectivity of wargaming permeates the entire process. But most especially it permeates the insights individuals take away from the game. For example, a wargame employing detailed, scientifically “accurate” models (as accurate as we can model such complex phenomena as those in actual warfare) and expert and experienced decision makers as players may have high internal validity in this sense.

[37] https://www.thoughtco.com/validity-definition-3026737

Yet, its external validity may be questioned exactly because of its reliance on unreal models and specific players. Relaxing the models and broadening the players may well reduce the internal validity of the wargame as a representation of a specific real situation, but may actually increase its external validity to tell us something true in a general sense about people making decisions during a conflict situation. In both cases, however, the actual participants in the wargame will take away from it the insights they personally derived from their experience in playing the game, synthetic though that experience may be. And to that extent they have little or no experience of a similar situation in the real world, that synthetic experience will have a greater effect on their personal insights and beliefs. Hence the danger of the often heard shibboleth, "We proved that in the wargame."

Some of the insights derived from participation in a wargame—or indeed from reports about the course and outcomes of a game—might well be predictions. Indeed, as Dr. Ed McGrady has argued persuasively on many occasions, games can get closer to predicting how people will act and react to circumstances far better than other techniques. There have, indeed, been studies (such as one highlighted by Major Tom Mouat of the U.K. Army[38]) that show this. The games work in this way not by asking people to predict how they would react, but by forcing them actually to react, even if that action is within the context of the simulacrum of reality that is the game. A wargame is, in effect, a conflict simulation run on the human brain rather than a computer.

So how can such a human-run simulation be judges as valid and reliable? If a scientific theory or model – whether in the physical or social sciences – is really only validated by its ability to predict the future (based on its ability to "predict the past"), how is an insight derived from a wargame validated? Let us dip for a third time in that sociological well:[39]

[38] http://www.umsl.edu/~sauterv/DSS/green.pdf as cited in http://www.professionalwargaming.co.uk/160604-EffectsBasedGames-Mouat-O.pdf

[39] https://www.thoughtco.com/validity-definition-3026737

THE RELATIONSHIP BETWEEN RELIABILITY AND VALIDITY

When it comes to providing accurate and useful data analysis, sociologists and scientists of all fields must maintain a level of validity and reliability in their research—all valid data is reliable, but reliability alone does not ensure the validity of an experiment.

For instance, if the number of people who receive speeding tickets in an area varies immensely from day to day, week to week, month to month, and year to year, it is unlikely to be a good predictor of anything—it isn't valid as a measurement of predictability. However, if the same number of tickets are received monthly or annually, researchers may be able to correlate some other data that fluctuates at the same rate.

Still, not all reliable data is valid. Say the researchers correlated the sale of coffee in the area to the number of speeding tickets issued—while the data may appear to support one another, the variables on an external level invalidate the measurement tool of the number of coffees sold as they relate to the number of speeding tickets received.

Can you see the connections? Let's assume that a series of repeated plays of a single wargame (or multiple games exploring similar topics)—note, repeated, not replicated, wargaming isn't a Monte Carlo process—using the same or different players produces dramatically different dynamics. That game is an unreliable predictor of the actual dynamics of a real-world event, but it still can provide useful, even valuable, insights into critical factors and uncertainties associated with such an event. On the other hand, suppose the same (or near enough) results show up repeatedly in games dealt NG with the same general topic (a conflict over the Baltic States, for example). Correlation does not imply causation; assessment of the underlying reasons for the similarities must relate those game artifacts to the existing real-world variables before the apparent reliability of the results can be translated into validity of insight.

When real people make real decisions in which they take uncertainty into account, not only do they consider the implications of the possible outcomes from their own perspective (such as the concept of utility) but also they define the range of uncertainty on the basis of their own evaluation of relative likelihood of outcomes. Sometimes those subjective probabilities coincide with what we might consider objective or frequentist ones, such as the coin flip or die roll. But in a sense that consensus occurs precisely because so many of us have agreed to consent to

that interpretation. But as my old friend Taleb argues, if a supposedly fair coin has come up heads a hundred straight times, I might be forgiven for doubting that it is, in fact, a fair coin!

So, when I experience a game outcome, no matter what its objective likelihood, it did in fact occur during the one-off experience of the game. Just as the German blitzkrieg of 1940 did in fact occur during the one-off experience of WWII. And just as I can derive an insight from the latter unique event (such as, the integration of tactical air power and armored and mechanized ground forces can create a powerful synergy that dislocates and defeats even larger but less integrated enemies), so too can I derive an insight from the unique events in a wargame.

Subjectively, I think my insight is valid if I believe it enough to act on it when I must. Objectively, others might later evaluate my insight on the basis of whether it successfully predicted the course of future events and my decision proved somehow correct.

Quantitative analysts—the proverbial ORSAs—who attack wargames for their lack of rigor and so lack of validity are arguing from the perspective of internal, or process, validity. If you cannot show the ***geometric logic*** connecting the cause and outcome of a game writ large (they stole the strawberries![40]) then the game cannot be valid. But in that case, no leap of creative insight that goes beyond the strict limits of standard logic would ever be valid. Yet, all real science depends on, indeed is driven by, precisely such creative leaps. What matters most in the real world is product, or external, validity; does the insight, regardless of how I got it, lead to behaviors or predictions that the real-world shows are correct or appropriate. It is here that wargaming finds its true value. Games do not predict—people do. And will. And the insights produced by the game will factor into those human predictions, for good or ill. It requires both the wargaming and analysis communities to understand this fact, and to improve our ability to design, run, and interpret wargames fairly and accurately if we are to avoid the ill and harvest the good.

[40] See *The Caine Mutiny* if you don't get the joke.

Merle S. Robinson
"Ensuring the Validity and Utility of Wargames"

Why the concern about validity and utility?

Wargaming's Value: The future success of wargaming in organizations depends upon our ability to demonstrate value to sponsors and stakeholders. It is imperative we build confidence in our products by demonstrating each product considers the fundamental aspects of each case. Because wargaming's value is greater than the sum of just its empirical parts, capturing only the concrete returns on investment (ROI) does our customers a disservice. Less tangible dividends also need to be noted where possible including:

- Those "eureka" moments where participants can articulate a new understanding of relationships/opportunities, and consequences for their actions.
- Professional networking value for participants.

As devotees of the art and science of wargaming wanting to demonstrate and share the tremendous insight the synthetic experience that well-made models can provide is part of our collective DNA. In the DoD world, this can directly correlate to savings both money and lives of our fellow citizens. So far, our lack of precise language, lack of guidelines for due diligence, and lack of documented examples showing impact has stood in the way of wider acceptance of wargaming approaches to provide insight into real world problems.

Good design needs "Profound Knowledge": In wargame design our *artisans* typically have a continuing challenge of how to apply our skills as both *architects* and *artists* to the product. This s embedded in our world because we are trying to theorize and simplify complex problems to identify their key attributes and what levers/vectors of change are important in key relationships or systems. As we strive to do this in development, aspects of almost every problem range from well understood to poorly understood. Ultimately success in this approach requires us to look at each part of our design using something close to W. Edward Deming's "System of Profound Knowledge". This requires:

- Appreciation of the system we want to use
- Knowledge of variation in the attributes/vectors of that system
- Understanding of the limits of what can be known of the situation

- Knowledge of how psychology impacts the situation both in and out of the game

Our goal: Our working group strove determine how to "ensure" customers get quality wargames that provide valid and usable (actionable) results. The underling concern was how to avoid fielding a wargame that could superficially appear to have validity and utility, but which failed in some fundamental way.

Our approach: Our approach was to determine how to best "ensure" the processes used in wargame creation appropriately covers all the elements of design. It is critical to point out that this approach was intended to provide insurance against numerous possible malign influences creating a critical failure in design (stakeholder bias, resource constraints, hidden agendas, et.al).

Terminology for improved understanding: One of our group insights was a recognition that we use the term "analysis" differently in various for parts of our development cycle. Upon reflection the group started using a forensic analogy to provide more precision.[41] But use of the forensic terminology such as the anatomy, autopsy, and use of forensics to ascertain relationships, insights, and lessons from each wargame seemed to help focus discussion.

Results: In essence, the improvements suggested by the working group centered on development of guidelines, checklists, and peer review. At this time, they address predominately the basic architectural approach to our craft rather that the full integration of architect and artist that makes the artisan. The focus is almost exclusively on the things easily measured and checked in the development, execution, and analysis of a wargame. Application of these process improvements represents a significant step forward in providing a minimum guarantee (insurance) to the customer of a better wargame from a journeyman level artisan. However, this is not a substitute for use of a master level artisan for the most complex problems.

[41] The first time I heard this approach used was by Bill Lademan (Director, Wargaming at USMC) at a Connections conference. I am uncertain if he would claim to be its originator.

Implications of Checklists and Peer Review: Integration of the working group suggestions into your design process will likely increase development time/cost by about 20% (in my view). This has a clear value by reducing the probability of producing a poor design not reflective of reality, executing ineffectively, and failing to produce useful analysis. Since these measures predominately focus on subjective review of objective elements (like determining appropriate scope), these resource costs can potentially be mitigated by using an acknowledged master to conduct the peer review.

Other Cautions: None of the elements addressed by our working group dealt with deeper core issues regarding development and design for the most complex wargames. Nor did we address details regarding appropriate depth of pre-game research, how to assess proper variability in results, how to maximize player education or role immersion, or how to maximize the value of analysis (among other things).

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Vincent Schmidt
"Scientific Perspective of Validity and Utility of Wargaming"

Validity and Utility is hard to quantify from a scientific ("bench scientist's") perspective. A scientific Concept Owner may define a Wargame Design based on their research and experimental studies, with the intent to gather information from wargaming the Concept – information that will further improve the quality and applicability of the research.

Whereas in many cases a game is designed to capture and examine the decision processes surrounding the employment of specific well-defined assets, technologies, and tactics, an additional level of complexity is introduced when some of these wargame pieces represent completely new technologies or processes being defined and developed by the scientists who are, or work for, the Concept Owners.

This complexity is partially captured and potentially mitigated by noting the objectives of the games being designed, recognizing that what it means to play a Concept will vary according to the specific game. Two examples come to mind:

1. Games designed specifically to playtest and evaluate the definition of a new scientific Concept, such as the Air Force Research Laboratory's Future Analytical Science and Technologies (FAST) games – When used for Concept evaluation, these games are small (~24 participants), focused wargames executed with narrowly-defined vignettes, with the intent of determining if the Concept has been defined in a way that is understandable and complete (in the sense that the information describing the Concept is sufficient to allow proper Red and Blue play and the adjudication can be applied correctly).

   In addition to ensuring the Concepts are well-defined, these games allow the consideration and revision of the Concept of Operations (CONOPS) and Concept of Employment (CONEMP) for the "new" scientific Concept, providing useful feedback to the Concept Owners. Such feedback might include comments about Concept capabilities and constraints, unusual or unanticipated approaches to employing the system, and

similar ideas.

A key benefit of testing the Concepts tested in these evaluative games is that they will have been playtested in a representative environment, and modified if necessary. This dramatically improves Concept validity (and utility), and de-risks the Concepts for higher-level game play.

2. Games designed to examine the decision processes under certain scenarios, when provided with specific offensive and defensive capabilities – These games are characteristic of large Title-10 wargames, and are not intended to provide "technical" feedback to the Concept Owners of scientific Concepts. In most of these wargames, Commanders (decision makers, sponsors, etc.) playing the games are provided with well-defined assets and are expected to strategize and deploy their assets to meet the mission or vignette objectives.

   In these games, a wide variety of assets is generally available for the use by the Red and Blue Commanders, who may pick and choose when and how to deploy them. Therefore, the Concept Owners must provide well-defined Concepts with very few (if any) configuration options. (I.e., instead of "this Concept can be flown on any selected aircraft platform," explicitly define "this Concept is installed on every F16," for the purpose of high-level games such as these.)

   Due to their complexity and size, these games are not expected to cater to the imagination of the Commanders by enabling them to tweak and configure the options available in the Concepts; their imagination and vision must be reserved for (1) understanding the well-defined assets available to them, and (2) employing them effectively in the wargame.

   The only feedback Concept Owners should expect is some explanation of if/when/how their Concept was played. In some cases, in-game logistics and events may even deny a

Commander the opportunity to use a Concept. The value a Concept Owner might get from have their Concept played in these games may be completely intangible, such as visibility and recognition (vs. technical or operational feedback).

Clearly, each type event could have considerably validity and utility, but the intent of the wargame and the audience for whom it is designed are necessarily the key indicators that determine the value of the game, both real and perceived. A game that is valuable to one audience cannot be expected to be valuable to another.

The challenge is to ensure that the Concept Owners (whether they are game players, advisors/subject-matter experts, or merely Concept providers) have appropriate expectations regarding the nature, content, quality, and sources of the information they obtain from participating in different types of wargames.

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Gary Schnurrpusch
"Thoughts on Wargame Validity and Utility"

What makes a wargame "valid?"

A dictionary definition of "validity" includes a simple "logically and factually sound; soundness and cogency." In my experience, dominated for years by Naval warfighting operations analysis and supporting Naval wargames, I suggest wargame "validity" means:

- A realistic representation of "actual" or "likely" operations, one that conforms to suitable operations principles, and in particular is "believable, plausible, and credible."
- Outcomes of players' actions and choices reliably reflect players' behavior and skills (why players must be carefully selected and assigned to wargames).
- Game elements of context and content reflect well-formed characterizations and representations and are predominantly factual; granulated carefully for the game level of play … otherwise varied and tailored only by game assumptions for content.

The "validity of a wargame" is based upon its factual, credible, or plausible foundation. That is, the elements of content and representations, such as units, combat systems, and operating principles must conform to substantiated real-world factors.

For example, in a tactical or mission game in the near-term, performance factors like weapon range, P_{hit}, P_{kill}, speed, and altitude, must reflect what weapons of the game's epoch really are. If the game is near-term, then those factors would be best based upon current test data, tactical doctrines, and real-world experience. In contrast, employment of those weapons is a matter of players' choices, such as salvo size, launch range, and attack axis.

In mid-term or far-term games, factors could be expected to evolve or new weapons may just be conceptual, then performance factors must at least conform to physics and plausible capability … even when game assumptions are "stretched" to examine "what if" scenarios. Sensitivity checks prompt variable performance factors. That is okay as long as those factors are advertised as only "what if" and less factual. The game remains credible.

In operational level games in which precise performance factors are more often subsumed or averaged into more macroscopic factors, but derived from only realistic and plausible bases, then more aggregated factors, such as force sizes and force mixes must be based upon actual fleet sizing. As games become mid-term or far-term, force sizes and mixes must be shown to

evolve from factual fleet size so as to retain plausibility in out-year force size. In contrast, force deployment, employment, locations, and maneuvering are players' choices. Again, the "validity of a wargame" is based upon its factual, credible, or plausible foundation.

What makes wargame "utility?"

A dictionary definition of "utility" includes a simple "useful, beneficial; measures preference; represents satisfaction." In my experience, dominated for years by Naval warfighting operations analysis and supporting Naval wargames, I suggest wargame "utility" means:

- The game as a forum has a methodological approach that is "useful" to sponsors AND players to evoke thorough and insightful products.
- The game is designed carefully to conform clearly to game objectives.
- Game lessons learned, observations, and more formal conclusions are "usable and "applicable" to inform decisions … whether the sponsors' post-game decisions precisely reflect game conclusions or not … at least they were well informed by game play so as to be able to say the game had impact.

Further, a useful game is not derailed from its objectives by hidden adversity, maligning intentions or mechanics, such as skewed databases, poorly prepared players, or hidden agenda. A useful game is moves the knowledge bases of the sponsor, game staff, and players tangibly closer to answering the posed questions that prompted the game in the first place. Moreover, game reconstruction and the game report, for examples, can show an audit trail that captures the actual play of the game, players' thought substance, how it all led to the documented game observations, and includes minority or dissenting content that was actually in the game play. The game was thorough. Game outputs were properly derived from game inputs and actions.

It is fair to say that the usefulness of a wargame will not likely be fully known or understood until substantial time after the game is concluded, analyzed, and reported. However, a hopeful early sign is that an engaged sponsor, the game staff, and players all come away from the game with a good sense that the game was well formed, well conducted, and was reasonably credible, whether the game results bore out all members' expectations or not. A baseball analogy may be that batters may not like the home umpire's strike zone, but if he was consistent throughout the game and for both teams, then the game was a good game.

It is also important to focus on the documentation and portrayal of the wargame. While sponsors want to have their decisions informed quickly; and game staff want to "go to school" on game conduct, success, or flaws in preparing for the next game; and players want to learn something from their participation, lasting payoff of a game is its longer term applicability. Documentation must be thorough, CLEARLY and COGENTLY reporting the set-up and reasons for the game, the details of the conduct of the game, the post-game analysis, and how it all led to the observations and more formal conclusions of the game. The game record must be "useful" to readers and researchers well down the road. If late follow-on readers cannot "know" the game with a high confidence of detail and understanding, then game utility is likely to be short-lived at best. A well understood, "useful" game can provide lasting lessons learned for later decision-making and perhaps can preclude playing another game to address largely the same questions … could be wasted effort which could be applied to new questions or the same questions with new, varied assumptions, conditions, or at least updating.

<u>Maligning wargames</u>

1. Form excessively general objective(s) that mask more specific, predisposed outcome intentions.
2. Skew game content to be played/addressed toward predisposed outcomes by limiting/omitting selected elements.
3. Select players with only narrow/off-target expertise and/or limited experience in game content areas.
4. Bias game assumptions, databases, and adjudication process/results toward preferred outcomes.
5. Edit game reports to omit observations that would be contrary to predisposed conclusions.

<u>Preventing maligned wargames</u>

1. Carefully formulate comprehensive objectives that rigorously capture all critical/pertinent content elements to play.
2. Ensure game staff/players have critical skills/expertise and particular experience (preferably firsthand) in game content areas; populate with senior SMEs.
3. Use independent a priori peer reviews/in-game monitoring of all game objectives, designs/game flow, adjudication processes, data collection, and analysis.
4. Keep game sponsors/decision-makers involved from design to out-briefing/reports.

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Bill Simpson
"Validity and Utility of Wargaming"

Wargame Validity

The validity of the wargame depends on:

1. Does the wargame have purposes and objectives relevant/appropriate to the issues being addressed?
2. How faithfully does the game addresses the stated wargame purposes and objectives?
3. How accurately the game report(s):
    a. Describes the nature of and conduct of the game.
    b. States that the game did or did not met the purpose and objectives and why.
    c. Reports those things originating from game development, design, execution.
    d. Clearly identifies opinions and conclusions about the game and not from the game play.
4. Does the Gaming Organization have full editorial control of and responsibility for the game reports?
5. That it has a collection plan that effectively captures and evaluates the information needed to satisfy the game purpose, objectives and reporting requirements. The Collection Plan should capture both the digits and discussions to record not only the moves and results of engagements, but the situations, decisions, and considerations behind the moves and engagements.

The collection plan should not be a rigid preordained process, but an integral part of game development tailored to support the purpose and objectives of the game.

The game designer should, from the beginning of game development, consider the questions below and address what is relevant to the game:

1. What information (numerical and non-numerical) is needed to satisfy the game purpose and objectives?
    a. When and how will this information be generated?
    b. How will this be captured?
    c. What analysis or assessment is needed?
    d. What are the reporting requirements?
    e. How can game design and execution accommodate and facilitate all of the above?
    f. How many people are you going to need to observe and record?
    g. What preparation will they need and what they should listen for and record?

2. What information should be captured and recorded?
    a. The players decisions: i.e. what was the situation, what did they consider and discuss, and why they made the resulting decision.
    b. The movements, actions, and engagements of the game forces and the results.
    c. Important group discussions, issues, and recommendations including the minority opinions.
    d. Did the game go well? Are there any lessons learned or recommendations for future games?
    e. Other information as required to satisfy the objectives.

The Capture Plan must be an integral part of the game plan and approved by the sponsor.

Wargame Utility

If the wargame is not valid, then the utility is as a case study of what not to do in a wargame. The game play and outputs must provide some things useful to the participants and stakeholders. It must make available to participants something to take away from the game, such as:

- Game Information packets to go with the trip reports.
- Lists of participants
- Briefings, etc.
- The Executive Summary

Often the Main or Final Game report can take months to issue. By then the enthusiasm and interest has faded and the utility has been lost. Issuing a series of increasingly detailed reports from the end of the game until the final report, will maintain the interest in and the utility of the game. The timing, number, format, and type of reports will vary with the desires and editorial policies of the gaming organization and the sponsor. As an example, six game report options were developed and used, as needed, by Wargaming Division Quantico. They were: None, the Executive Summary, the Quicklook, the Game Summary, the Final Game Report, and the Battlebook. The formats and timing of the reports must be approved by the sponsor and included as part of the game design.

1. No report maybe required when the conduct of the game and the observations of the sponsor satisfies the purpose and objectives. This is quite common in educational / training games where the professor or instructors observe and record what is needed. (A Memorandum for the Record for the game files or archives should be considered.)

2. The Executive Summary is a one-page report issued immediately after the game. The Executive Summary provides senior decision makers with a snapshot of the game and the immediate findings or issues. The summary had four sections: The game purpose and objectives, the things being gamed, immediate findings, and post-game plans. The capture plan and/or player outbriefs should be designed to provide the findings or issues in a timely fashion. Sometimes one person was designated, in advance, to collect the information, draft the report and have it approved and ready for release at the final plenary session or emailed immediately after the game.
3. The Quicklook is an abbreviated game report issued within 5 to 10 working days of the end of the game. It's format generally contained: Introduction, Bottom Line Up Front, Game Purpose, Objectives, Methodology, Scenarios, Initial Findings, and Contact Information.
4. The Game Summary is an update that can be used to fill a large time gap between reports. There is no set format, but it can be drawn from the other three report formats.
5. The Final Game Report is a complete report covering all aspects of the game. The final game report usually contains all the products of the game including any executive briefings and game analysis.
6. The Battlebook is a multi-media CD/DVD that is produced in about 2-6 months.

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Gene Visco
"Final Thoughts on Malevolence, Malfeasance and Misfeasance in Wargaming"

The list of deliberately malevolent actions, malfeasance, generated by the Working Group cannot be considered examples of Clausewitzian friction. Friction lies more in the misfeasance category. However, some of the malfeasant actions may be, by chance, misfeasance as well, hence Clausewitzian friction. In that vein, they can lead to *caveats* or assumptions that must be identified with the war games. The assumptions are important to convey to the war games' sponsors, along with the games' reports. The assumptions contribute to the sponsors understanding of the limitations and the values of the games. Assumptions are presently overlooked by war game designers and implementers, as they are overlooked in other analytic processes related to military operations analyses.

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Working Group Bios

First	Last	Organization	Email
Michael	Anderson	BAH	Anderson_Michael3@bah.com
Gil	Cardona	EUCOM	gilbert.m.cardona.mil@mail.mil
Tom	Choinski	NUWC	thomas.choinski@navy.mil
Rebecca	Dougherty	Lockheed Martin	rebecca.l.dougharty@lmco.com
Stephen	Downes-Martin	Naval War College	stephen.downesmartin@gmail.com
John	Hanley	Independent Consultant	jhanleyd71@aol.com
Frederick	Hartman	IDA	fhartman@ida.org
John	Lillard	Modern Technology Solutions	john.lillard@mtsi-va.com
Roger	Meade	BAH	meade_roger@bah.com
Roy	Morris	Air Force Wargaming Institute	roy.morris.3@us.af.mil
Peter	Perla	CNA	peterperla@aol.com
Merle	Robinson	National Security Decision Making Game	murno.robinson@gmail.com
Vincent	Schmidt	AFRL Wargaming Lead	vincent.schmidt@us.af.mil
Gary	Schnurrpusch	Independent Consultant	gary.schnurrpusch@gmail.com
Bill	Simpson	Information Solutions and Assessment	simpsonw@cna.org
Gene	Visco	Lockheed Martin Corp HQ	eugene.visco@lmco.com
Tim	Wilkie	NDU	timothy.wilkie@ndu.edu

Michael Anderson

Michael Anderson is a computer expert and wargame designer. He currents serves as a Booz Allen contractor supporting wargaming of OSD CAPE. Mr. Anderson served as the primary researcher for one SBIR contract - MeNTAT (computerized training for fifth generation fighter pilots) and the developer for two other SBIR projects - CyberWar XXI (extensible, multi-layered, near-future conflict analysis system) and Crisis XXI (COIN/counter-terrorism doctrine analysis system). He has designed a dozen published commercial board wargames, specializing in novel resolution systems and subject matter approaches.

Gil Cardona

I am a US Army Simulation Operations Officer currently serving as the Wargaming Branch Chief at US European Command, Stuttgart, Germany. In the past 16 months, I have coordinated and executed six wargames, all with the emphasis upon Operational Planning (OPLAN) development and refinement to synchronize activities and identify gaps/shortfalls in the plan. This past summer, we conducted a simultaneous Operational and Strategic wargame to synchronize an OPLAN at the Operational Level of War while executing a parallel Strategic game intended on de-escalating the conflict through political-military means. Previous to my service at US European Command, I worked at the US Army Special Operations Command where we developed the Silent Quest series of wargames. These wargames looked beyond the Future Years Defense Program (FYDP) to influence Command decisions with respect to Army Special Operations force structure, programmatics and technology investments.

Tom Choinski

Tom Choinski is the Deputy Director for Undersea Warfare at NUWC Headquarters. He previously served as the Head of the Emergent and Transformational Systems Division, Science Advisor to the CNO's Strategic Studies Group and other leadership positions at NUWC. He has over 38 years of experience in government and industry encompassing innovation, management, engineering, research and development. Tom has served as a subject matter expert for wargames, workshops and concept exploration events conducted by the OSD Office of Net Assessment, Naval Warfare Development Command, CNO's Strategic Studies Group, RAND and Naval War College. He developed courses in innovation strategies and has published/presented more than 60 papers on topics including innovation, unmanned systems, undersea warfare, digital signal processing, microwave design, ethics and autopoiesis expressed through art. The National Society of Professional Engineers selected him as one of the Top Ten Federal Engineers of the Year in 2008. He received a Meritorious Civilian Service Award for his contributions to the CNO's Strategic Studies Group. Tom defended his Ph.D. dissertation on *Dramaturgy, Wargaming and Technological Innovation in the U.S. Navy: Four Historical Case Studies* at Salve Regina University. He earned an MBA from RPI, an MSEE from the NYU Polytechnic School of Engineering, a BEE from Manhattan College and completed an MIT Seminar XXI fellowship in Foreign Politics, International Relations and the National Interest. Tom holds DAWIA level III certification in program management from the Naval Postgraduate School, as well as one in systems engineering. He received his professional engineering license from New York State.

Rebecca Dougharty

Wargaming, Enterprise Architecture, Operations Analysis, DoDAF, Interoperability, Programming, System Test Wargaming. Participated in MORS Wargaming Workshop 2015. Lead design and execution of TTX wargame with Naval Postgraduate School in 2013 Co-presented design, analysis process, and results of NPS Wargame at MORS Symposium 2014 with NPS Jeff Appleget. Observed SSA TTX hosted by Lockheed Martin (LM) at its Center for Innovation. Participated (Red Cell) in CSBA Space 20XX Wargame hosted by LM at its Center for Innovation. Have observed adjudication and pursued self-study. Attended MORS Wargaming online lectures. Attended Connections UK 2016. Have planned and will execute LM-Internal wargame Nov 2016.

Stephen Downes-Martin

Dr. Stephen Downes-Martin is a Research Fellow at the US Naval War College researching wargaming (theory and practice), confrontation analysis, systems thinking, decision analysis, deception and assessments methods applied to problems at the strategic, operational and tactical levels of warfare. At the War College he worked on wargame design, adjudication and analysis teams for a range of games at the operational and strategic level. A research focus is on how to manipulate wargaming and adjudication methods to deceive decision makers, how decision makers misuse such methods to deceive themselves, how to detect such attempts and protect decision makers from them. He received two Superior Civilian Service Awards for his contributions to I Marine Expeditionary Force (Forward) in Helmand Afghanistan and for his research accomplishments while a Research Professor at the Naval War College.
(https://sites.google.com/site/stephendownesmartin/)

John Hanley

Dr. Hanley's experience in operations research began developing tactics and techniques as nuclear submarine officer. Following active duty, he continued to design, conduct, and analyze submarine exercises in the Navy reserve. As a Principal Analyst and Vice President at Sonalysts, Inc, he wrote fleet exercise analysis guides and the Navy Tactical Development and Evaluation Master Plan, and designed, conducted, and analyzed fleet exercises in all fleets, using the data to support modeling, simulation, and gaming. He conducted campaign analyses for the Chief of Naval Operations Strategic Studies Group and assisted the Naval War College in the development of their Enhanced Naval Wargaming System. As Program and Deputy Director of the CNO SSG, he played a major role in the design, conduct, and analysis of SSG wargames; the main technique for exploring and evaluating their concepts. He also was an active participant in the Naval War College Global War Games in the 1980s. While pursuing his degree in operations research, he discovered that no techniques were better suited to the development of strategy and operational schemes than war games. His dissertation "On Wargaming: A Critique of Strategic Operational Gaming" addressed this proposition, and provided analysis and critique of the Global War Games. He went on to serve as Special Assistant to USCINCPAC; Assistant Director for Risk Management at OSD's Office of Force Transformation; Deputy Director of the Joint Advance Warfighting Program at the Institute for Defense Analyses; Deputy Director for Acquisition Concepts in OSD Acquisition, Technology and Logistics; developed long-term comprehensive strategies in OSD's Strategy Office; and served as Deputy Director for Strategy Management in the Office of the Director of National Intelligence. He currently is an independent consultant. He received A.B. and M.S. degrees in Engineering Science from Dartmouth College, and his Ph.D. from Yale University in Operations Research and Management Science.

Frederick Hartman

Fred Hartman has an extensive background in models, simulations and training applications with Defense related management and analysis positions in both industry and government. He has specialized in problem solving with use of modeling and simulations, assessing training systems and technical applications for over 35 years. Fred graduated from the U. S. Military Academy with a BS in Engineering and served as a Field Artillery Officer and Army Aviator in Viet Nam. After receiving an MS in Operations Research from the Naval Postgraduate School, Fred completed several Army analytic assignments prior to leaving active duty for an industry career. Fred joined CACI, Inc. in 1981 and over the next ten years progressively grew from Department Manager to Executive Vice President by building an analysis and software development group consisting of professionals in operations research, software engineering, logistics engineering, financial analysis, and software development. In 1992 Fred became Chief Operating Officer, was co-founder and on the Board of Directors for Applied Solutions International, Inc, a technology start-up company with consulting services for Defense industries and international trade. Consulting and analysis at ASI included work for the United Nations Development Programme, Army Research Labs, and the Small Business Innovation Research Program (SBIR). Fred joined IDA in 1996 as a modeling and simulation advisor to the DUSD (Readiness) and served from 2000 to 2003 as Technical Director, Joint Simulation System and Manager, Enterprise Division of the Defense Modeling and Simulation Office. In 2003 Fred joined the Office of the USD (Personnel and Readiness) as Director, Training Transformation Joint Assessment and Enabling Capability and as Deputy Director, Readiness and Training Policy and Programs returning to IDA in 2007. Mr. Hartman continues to support the Department of Defense with strategic planning and training acquisition projects. In addition to leadership positions in modeling and simulation volunteer organizations Fred has served as a member of the Army Science Board, led a study panel for the National Academy of Sciences, Board on Army Science and Technology, and is a past President and Fellow of the Military Operations Research Society.

John Lillard

John is an Operations Analyst and naval historian who has over 30 years of experience in systems analysis, requirements development, modeling and simulation, and wargame development. After leaving active service is the US Navy in 1995, he worked in the Joint Strike Fighter program office as the survivability requirements analyst. From there he moved to Whitney, Bradley & Brown Inc. (WBB), where he spent 16 years as a manager for requirements development and eventually the Director of Modeling and Simulation. He filled the same role for 2 years at Newport News Shipbuilding, and is presently the director of the Integrated Mission and Operations Analysis business unit at Modern Technology Solutions Inc. (MTSI). He received his MS in Operations Research from Naval Postgraduate School is 1987, and his PhD in History from George Mason University in 2013. While at WBB, he designed small and large-scale war games to develop requirements for the next generation aircraft carrier (CVNX), and for airborne surveillance systems. His dissertation, Playing War: Wargaming and US Navy Preparations for World War II, was published as a book by Potomac Press in 2016.

Roger C. Meade

I am the wargaming lead at U.S. Pacific Command; in that capacity I oversee the development and delivery of wargames to the USPACOM Staff, subordinate components and partner nations from around the Asia-Pacific. For the past three years I have been a Senior Military Analyst at Booz Allen Hamilton, where I have been under contract to the Pacific Command's wargame re-vitalization effort. I have designed and constructed wargames for both the Army and Navy here in Hawaii, as well as the Joint Inter-Agency Task Force West. I am the manager of the command's wargame repository and their principle advisor on wargaming in the Pacific Rim. I led a team that conducted a study of wargaming within the command that serves as the basis for USPACOM's current wargame alignment efforts. In addition to extensive experience in wargaming and military analysis, I currently hold credentials as an Assistant Professor at the Joint Forces Staff College, where I was a member of the faculty from 2007-2010 and routinely conducted/facilitated wargames.

Roy Morris

Architect for the Air Guardian wargame series, tasked by the AU/CC, to create and execute a series of wargames exploring a hypersonic aircraft concept in less than five weeks. Wargame Director for three wargames: Joint Planning Exercise (JPEX), Joint Air Exercise (JAEX) and the Joint Wargame (JWAR), all supporting the Air Command and Staff College. These three wargames involve approximately 510 players, 30 faculty members and 5 game controllers each. Responsible for all phases of these wargames from wargame preparation through execution, to include all required game materials, reference materials, order of battle data as well as individual database for specific scenarios. Game Director for Tandem Challenge, the largest wargame ever created by AFWI. This wargame was developed, from a blank sheet of paper, from concept through execution and involved 850 Air War College and Air Command and Staff College students, 50 faculty members and 125 game controllers. Subject Matter Expert on the operational art of war, to include participation in several Title X wargames. RFI Chief for five different Unified Engagement and Futures wargames. Also filled key game positions during all AFWI-hosted events. Participated in hundreds of wargames over the past 22 years.

Peter Perla

Peter P. Perla has been involved with wargaming, both hobby and professional, for over fifty years. After earning a PhD in probability and statistics from Carnegie-Mellon University he joined the Center for Naval Analyses (CNA) in 1977 as a naval operations research analyst. Over his forty-plus year career at CNA he has directed major projects, served as Special Assistant for Command and Control, led a research team for Interactive Research Products, and received the award for Outstanding Analyst of the Year in the Advanced Technology and Systems Analysis division in 2012. Dr. Perla continues to serve CNA currently as part-time Principal Research Scientist. In 1990, the U.S. Naval Institute published the first edition of his book, The Art of Wargaming. This book became a fundamental international reference on the subject (including a Japanese-language edition), and a standard text at U.S. military schools. It was republished by the History of Wargaming Project in 2011. Dr. Perla is regarded as one of the nation's leading experts on wargaming and its use in research, learning and innovation. He has spoken at international conferences on wargaming and analysis, including presenting keynote addresses at Connections professional wargaming conferences in the United States, the United Kingdom, and the Netherlands. He has published articles and columns in both the professional and hobby wargaming press, and has designed or developed half a dozen games in the commercial boardgame industry. His writing has received a Hugh Nott award from the Naval War College Review and a John K. Walker, Jr. award from the Military Operations Research Society (MORS). Dr. Perla is one of the instructors for the Wargaming Certificate course sponsored by MORS, beginning in 2016. In 2017, he received the first award for Lifetime Achievement in Wargaming by the Connections Wargaming conference and was congratulated on that achievement by the CNO.

Merle Robinson

Merle S. Robinson [Wargame designer, Lean Six Sigma Black Belt; DoD civilian analyst (retired)] has over 40 years' experience in hobby wargaming including lead operator of eight regional wargaming conventions. Extensive involvement in conflict simulation gaming, Euro-style gaming. historical/fantasy miniatures and roleplaying. Currently lead Wargame Designer for the National Security Decision Making Game (NSDMG). Operating since 1990, NSDMG is a non-profit educational group running events on historical/contemporary periods at wargame conventions and universities. NSDMG wargames are Political, Military, Economic, Social, Infrastructure, Information (PMESII) style rooted in the US Naval War College tradition. for over 1500-2700 participants annually. NSDMG annually offers 18-30 wargames and 16-30 seminars/lectures on historical, military and political topics.

Vincent Schmidt

I am the Air Force Research Laboratory's (AFRL) wargaming lead for the 711 Human Performance Wing, one of a handful of AFRL Technical Directorate leads involved in recommending the direction and participation of AFRL in upcoming wargames. One of my roles includes effectively advertising to my colleagues the importance and value of wargaming.

Gary Schnurrpusch

Gary is a retired Navy Surface Warfare Captain, an extensively experienced ORSA in uniform and in the private sector. His wargaming experience dates to the 1970s-1980s on active duty when he contributed to several Navy wargames as a player, analyst, and designer, including annual POM Games, the annual Global War Game series, and the Tactical Command Readiness Program (TCRP) games, largely at NAVWARCOL for OPNAV and OSD PA&E. More recently in OSD CAPE Simulation Analysis Center, he supported SAC's wargaming team, such as: Navy combat adjudicator in "Tightrope Endeavor" ... an ASUW game to contrast submarine anti-ship capabilities versus air-to-surface attack capabilities; as the Red Cell Controller in "Threadbare Ultimatum" ... a political-military game; provided Red, Blue, and Green Naval warfare threats, capabilities, strategies and context for game play in a series of Europe wargames. The vast majority of his ORSA experience has been directly applied to multi-mission Naval warfare analysis, that is, modeling, measuring, and explaining operations and outcomes by using numerous ORSA tools including modeling and simulation, probability and statistics, spreadsheet and tabletop ORSA calculations. That experience involves the same skillsets as in game adjudications and same methodologies used for game designs, evaluations, and assessments.

Bill Simpson

Served at Wargaming Division, Quantico from Dec 1994 until Oct 2015 as a Wargaming Specialist where my activities included: (a) Designing, planning, executing, assessing and reporting war games, workshops, and seminars; (b) Training incoming personnel in wargaming history, design, procedures; (c) Representing the Division to other agency and service wargaming organizations; (d) Providing technical and Subject Matter Expert (SME) support to external war games, experiments, exercises, workshops, and related events. Adjudication experience includes being Umpire at most Navy Global War Games both old and new from 1995 to 2011 and Senior Ground Umpire at the 2011 Global War Game by invitation. I have designed and executed all levels of war games at Quantico and have considerable experience incorporating adjudication into the game design and conducting adjudication during the games. Hired by the Center for Naval Analysis as a Senior Wargaming Specialist in January 2017. Editor of the “A Compendium of Wargaming Terms” posted at the MORS and Naval War College Wargaming Sites.

Eugene Visco

I bring over six decades of military operations analysis as a US Government, US Army and a defense contractor employee to wargaming. I am currently a member of the corporate headquarters staff (Enterprise Operations, Mission Development team) of Lockheed Martin where my responsibilities include operations analysis and wargaming for the corporation. My most recent hands-on wargaming experience is as a member of the game planning team, where I worked on the development of the first-ever (for Lockheed Martin) cyber wargame conducted at the Center for Innovation (aka The Lighthouse, Suffolk, VA), conducted last fall (an in-house game). During the game, I was a member of the White Team, helping adjudicate as needed. Following the game, I assisted in the preparation of an unclassified quick-response report and a second more deliberate classified report. In earlier years, at the Army's original think tanks (JHU ORO and RAC, 1956-66) I was involved in the application pf quick gaming, an approach of highly aggregate games to provide rapid contributions to decision making. In 1963 I developed Schnellspiel for use in NATO's Central Army Group to provide a more objective umpire for FTXs and CTXs.

Timothy Wilkie

Tim Wilkie is a Research Fellow at the gaming center of National Defense University (NDU), the Center for Applied Strategic Learning (CASL). Previously he worked as a Foreign Service Officer for the Department of State, serving in Colombia and Chile. He is a graduate of the University of Chicago (AB) and The Fletcher School of Law and Diplomacy (MALD), where he wrote his thesis on the application of decision-making theories to free-form gaming. As part of CASL's ongoing efforts to engage with the broader gaming community, he has served as the co-chair of the annual Connections interdisciplinary wargaming conference since 2012. He is currently teaching an elective at NDU on Strategic Gaming.

Read Aheads for the Working Group Participants

The following documents were selected as read-aheads for the working group participants for their description of wargames that demonstrate utility. Some of them were written specifically for the Working Group while others have been published. They constitute an integral part of the Working Group product and so are reproduced here to provide the readers of this report with a complete record of the Working Group.[42]

"Characteristics of Games that Make a Difference"	COL Matt Caffrey
"Recent Wargames Executed by USEUCOM"	LTC Gil Cardona
"Dramaturgy, Wargaming and Technological Innovation in the US Navy"	Dr. Thomas Choinski
"Wargaming to Deceive the Sponsor: Why and How"	Dr. Stephen Downes-Martin
"Characteristics of Games that Make a Difference"	Dr. John Hanley
"Playing War", Chapter 6 (Conclusions)	Dr. John Lillard
"Wargaming the Atlantic War"	Dr. Paul Strong

[42] The originals are in PDF form, some extracted from other documents, so the page formatting and numbering from this point forward does not follow that of the rest of this report. Permission has been obtained from the authors (and for previously published work the publishers) to include these documents in this report.

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Wargames seem to provide two main classes of benefits and a third lesser class;

- Developing strategists
- Developing strategies
- Communicating in a way that implications are grasped

Both apparent correlation and common sense indicates that like other skills developing and implementing strategies in wargames increases the speed and effectiveness of strategists.

Wargames that identify and help avoid problems

- Ensure the highest ranking individual present is NOT the Lead Blue
- Out of character Red play

Wargames that produce "untrue" results with high seeming credibility

First, not all untrue results are bad. Based on wargame outcomes the Chinese changed their plan to intervene in Korea and the US Army changed their plans for the invasion of Iraq. Out of character Red play seems to be the defect that has produced the greatest problems. Both the Japanese at Midway and the French in 1940 under reacted to "Red" because inaccurate Red play understated the threat. Though it seems to get the most attention I've found few cases of "bad date" causing misleading results. Even the best case, the overstatement of anti-tank gun effectiveness before by US Army in wargames before North Africa also included inaccurate Red play. The cause that perhaps attracts the least attention is the scenario. All too often truly untenable start conditions are provided, then wargames diligently move these situations forward. Early Missile submarines did not know exactly where they were, so their missiles could not create great accuracy even if their direction and distance was precise.

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Three Recent Wargames Executed by the US European Command Wargaming Branch

Joint Reception, Staging, Onward Movement & Integration (JRSOI) Wargame

Game Description: This wargame addressed the challenges of a contested JRSOI process in the European theater. The scenario covered significant force flows into European aerial ports of debarkation (APOD), sea ports of debarkation (SPOD) and onward towards intermediate staging bases (ISB). The events of the wargame took place in the near term and focused upon setting the theater, with an active red component. The red component actively sought to disrupt JRSOI activities to delay and degrade blue forces as they entered the theater and moved onwards to the ISBs. The event provided analytical results to support JRSOI planning, experiential learning for the participants and a means to prioritize resources towards theater development to support JRSOI requirements.

Game Objectives / Study Questions: 1) Refine JRSOI plans and planning factors for major force flows into the European theater. 2) Identify critical JRSOI network nodes, flows and activities for moving major forces. 3) Identify potential red actions to delay & degrade forces during the JRSOI process. 4) Identify and assess mitigation strategies for red actions and likely residual effects on JRSOI timelines and combat effectiveness. 5) Identify shortfalls in current planning and coordination between Combatant Commands and other agencies regards to JRSOI in the European theater.

Key Take-Aways: Identified chokes points in the logistical network; identified some critical nodes (single points of failure); identified areas and locations that require contracting support; identified locations of competition amongst friendly forces for scarce resources; identified requirements and locations for theater investment for POD improvement.

Wargame Effectiveness (How the Game Made a Difference): Overall the game was effective but to what extent depends on the perspective and role/organization from which the participant works. The game brought together multiple agencies involved the in JRSOI process for Europe and provided a shared understanding of the totality of the problem. Previously, most participants understood their particular role in the process but not necessarily how their portion related to all the other moving pieces.

The game did identify multiple ‘unknown-unknowns,’ but those participants most familiar with the problem set were less impressed with the game as it only reinforced their understanding of the problem and did not provide for additional discovery.

Simultaneous OPLAN Wargame

Game Description: This wargame addressed the challenges of executing two operational plans (OPLAN) in one geographic Combatant Command along with the simultaneous conduct of an OPLAN supporting a neighboring Combatant Command. Expected outputs included the sufficiency of cross-Combatant Command coordination procedures, sufficiency of planned forces to respond to requirements as detailed in the OPLAN as well as the broader lessons for contested force flow, and Joint Reception, Staging, Onward Movement & Integration into the theater.

Game Objectives / Study Questions: 1) Assess the availability/readiness of forces to execute the simultaneous OPLANs in theater one and support the OPLAN in theater two. 2) Assess the capacity to conduct JRSOI for two OPLANs in theater one simultaneously. 3) Assess the capacity of the proposed forces to execute their assigned missions. 4) Assess cross-Combatant Command and interagency coordination issues in execution of operations spanning the theater.

Key Take-Aways: Identified key strategic nodes that impact JRSOI success; refining and rehearsing cross-Combatant Command coordination for planning and execution is key; resources challenges for forces and supplies was persistent (but cross-Combatant Command coordination must remain paramount); strategic messaging across Combatant Commands must remain coordinated and consistent; significance of US allies and their contributions.

Wargame Effectiveness (How the Game Made a Difference): This game provided the first opportunity for planners of multiple Combatant Command to discuss and integrate their OPLANs as much of their previous work was done on single OPLANs independent of one another. The impact of this game resulted significant follow-on work for planners regarding risk management resulting from force availably and subsequent risk to mission.

USEUCOM Problem Set Wargame

Game Description: This wargame was a coordinated and synchronized strategic (political-military) and operational level wargame for OPLAN synchronization. There was a facilitated strategic political-military seminar style game and a simultaneous and linked, turn-based, adjudicated operational level wargame with an active red component. This wargame provided USEUCOM feedback on how global actions impact regional actions in a conventional fight and conversely, how the conventional fight in the region impacts global actions against US interests across the DIMEFIL.

Game Objectives / Study Questions: 1) Synchronize supporting plans from components and other Combatant Commands to the OPLAN. 2) Determine the feasibility and acceptability of the OPLAN in conjunction with supporting plans from the components and other Combatant Commands. 3) Identify capability and capacity shortfalls in the OPLAN and supporting plans. 4) Assess and refine the political-military and operational effectiveness of global options as outlined in the OPLAN. 5) Identify areas for future plan refinement.

Wargame Effectiveness (How the Game Made a Difference): This game concluded in late July 2017. Final report with insights is not yet completed.

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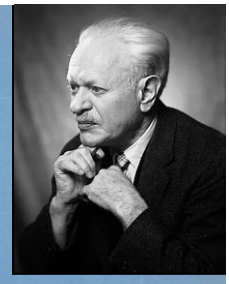
Disclaimer: The information in this presentation does not represent an official position of the U.S. Government, DoD, the Department of the Navy or NUWC

Military Operations Research Society
Community of Practice



Dramaturgy, Wargaming and Technological Innovation in the United State Navy: Four Historical Case Studies

19 June 2017

Dr. Thomas Choinski

Salve Regina University
Dissertation

Cold War Innovation

Reference:
Choinski, Thomas. "Innovation Strategies for Undersea Sensing," Leading Edge Magazine, Volume 7, Number 2, October 2009, pp. 42-51.

Today's Innovation Challenge

Reference:
Choinski, Thomas. "Innovation Strategies for Undersea Sensing," Leading Edge Magazine, Volume 7, Number 2, October 2009, pp. 42-51.

3

Short Term Advantage with Rapid Diffusion

- **First-Mover Gains Hypothesis**: First movers should experience relative gains in power proportional to the length of their monopoly over the MMI and *its relevance in international politics*. The length of the first-mover advantage will be inversely proportional to the diffusion rate of the innovation.
- **Late-Mover Gains Hypothesis**: Late adopters will face lower barriers to adoption due to more available information about the innovation, giving them a *relative power edge over first and early movers* once adoption occurs

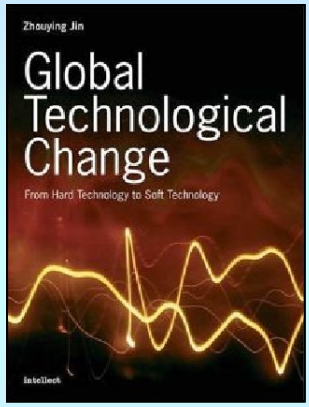
MMI – Major military innovation

Reference:
Michael Horowitz, *The Diffusion of Military Power.* Princeton University Press, 2010..

4

China's Emphasis on Soft Technology

Developing countries are obviously trailing in their R&D capability and technological prowess. The main barriers to their becoming technologically competitive, however, are failures in technology transfer and low efficiency in absorbing advanced technologies, which, in turn, result mainly from the incompleteness of their innovational environments and from their backwardness in developing soft technology. This is particularly true for China where the main tasks are still technology introduction, digestion and re-innovation. *Therefore, technology transfer is the key for success in the coming two decades.*



Reference:
- Zhouying Jin, *Global Technological Change: From Hard Technology to Soft Technology*, Intellect, United Kingdom, January 2005, p 237.

5

Historical Examples of Dramatic Geo-Political Situational Change

- **Spanish American War**
- **Japan's rise to power**
- **U.S. Soviet competition**
- **Fall of the Berlin Wall**

Today's 4+1 environment exemplifies dramatic geo-political change

6

Wargaming: Interaction to See Through the Ambiguity

"The problems of national and global security and welfare are interlinked... A strong correlation exists between the importance of these problems and the complex interaction of technological, socioeconomic, cultural, and physical environmental circumstances....To engage in the research above requires a multi-disciplinary team. Such a team should include those with training and experience in operations research, history, statistics, social psychology, computer science, and political science."

Dr. John T. Hanley Jr.
Yale University Dissertation

Definitions

The world – the object (system) about which a person is concerned

A state of the world – a description of the world, leaving no relevant aspect undefined

The true state – the state that does in fact obtain, i.e. the true description of the world

Statistical Indeterminacy: in this situation the initial state is a random variable, we do not know the true state of the world at any given time, but we do know its statistics

Stochastic Indeterminacy: We could know the state of the world at a given time, but the transition from this state to any number of other possible states is probabilistic.

Strategic Indeterminacy: The decision maker takes action that affects the outcome of the process.

Structural Indeterminacy: This indeterminacy covers all that we do not know about the structure of the data describing the systems, e.g., kinematics of the process, acts of nature, available response time, and the perceptions, beliefs and values of the decision makers. Structural indeterminacy puts art into quantitative analysis.

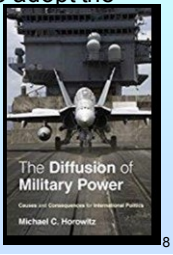
Wargaming addresses the strategic and structural indeterminacy in a way that simulation and modeling cannot

Reference:
Hanley, Jr., John T. *On Wargaming: A Critique of Strategic Operational Gaming*. New Haven, CT: Yale University, 1991, 8-19.

7

Long Term Advantage with Complex Diffusion

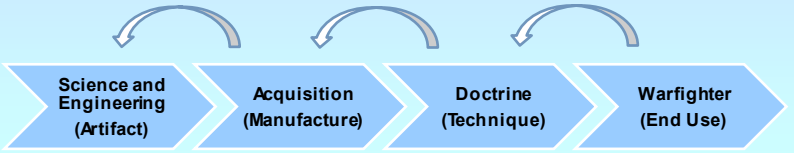
- **Military Interaction Hypothesis**: In general, states that experience an MMI will have more frequent, varied, and intense military interactions with a broader range of states than those that have not experienced an MMI.
- **Financial Intensity Hypothesis**: The greater the financial intensity required to implement the innovation, the slower the spread of the innovation at the system level and the lower the probability that a state will attempt to adopt the innovation.
- **Organizational Capital Hypothesis**: The greater the organizational capital required to implement the innovation, the slower the spread of the innovation at the system level, and the lower the probability that a state will attempt to adopt the innovation.



Reference:
Michael Horowitz, *The Diffusion of Military Power*. Princeton University Press, 2010..

8

Case 1 Variant: Stable Geo-Political Situation
Chain Linked Model of Innovation



The players in Navy communities can drive and shape technological innovation

"They (organizations) know that innovation is not "just" science or technology, but value. They know that it is not something that takes place within the organization, but a change outside."
Peter Drucker

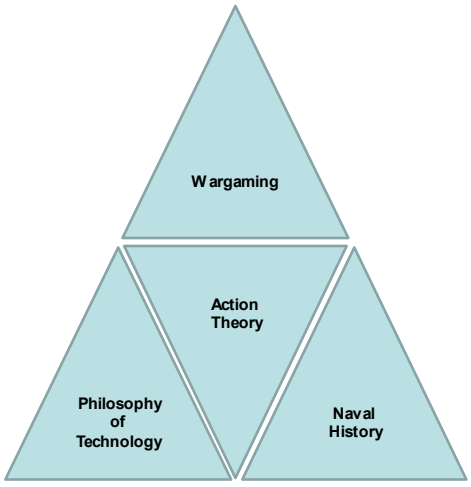
9

Research Question

Does historical evidence exist within the wargames conducted during the interwar years to corroborate that dramaturgical action serves as a motivational force for the diffusion of technological innovation in the U.S. Navy?

10

Why the Humanities?



- Ambiguity of problem
- Interdisciplinary nature
- Breadth of findings
- Advancement to scholarly research

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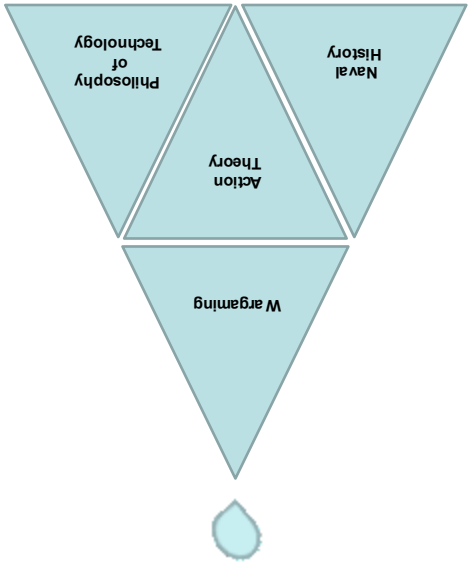
What's the Contribution



- Lens for Technology
- Dramturgical Situation
- Levels of Interaction
- Technological Aliasing
- Analysis of four wargames from the onset of the interwar years
- Persistence of interaction over time, through space and for an audience

12

Findings

- ***The modified Klein definition of technology provides a valuable analytical lens***
- ***Historical evidence corroborates a dramaturgical situation in each wargame***
- ***Wargame agreements entailed focus on doctrine and end use:***
  - ***Estimating the situation and dissemination of orders***
  - ***Dramaturgy***
  - ***Effectiveness of the submarine platform in the battlegroup***
- ***Wargame differences included:***
  - ***The situation: act, scene, agent, agency and purpose***
  - ***Maneuver detail***
  - ***Results***
- ***Human motivation for action occurred at four levels: external geo-political influence, orders disseminated based on the estimate of the situation, conduct of the wargame and external influence from wargames***
- ***A meta-narrative emerges around the situational interaction that include:***
  - ***An emerging estimate of the geo-political situation***
  - ***Officers carrying their wargaming experiences into war***
- ***Dramaturgical action serves as a motivational force for the diffusion of technological innovation; however, technological innovation is a complex process including many other human interactions***
- ***Wargaming reveals the potential for technological aliasing in the navy***

13

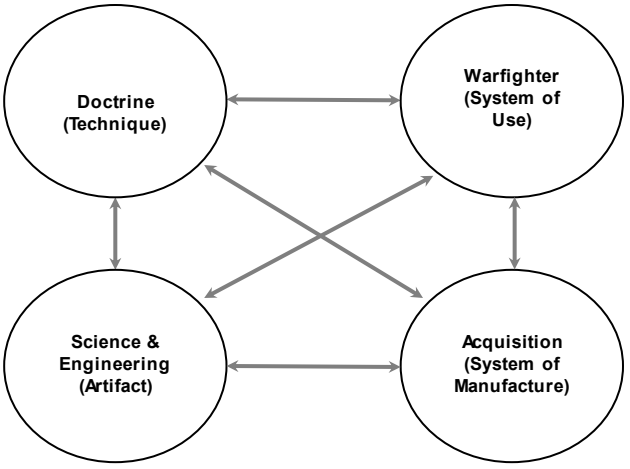
Definition of Technology

Four Causes	Stephen Kline	Navy
Materialis	Artifact	Science & Engineering
Formalis	Socio Economic System of Manufacture	Acquisition
Efficiens	Technique	Doctrine
Finalis	Socio Economic System of Use	Warfighter End Use

References:
Choinski, Thomas. "Macro Perspectives on Wargame Culture and Innovation." Connections 2016 Wargaming Conference. Maxwell Air Force Base, Montgomery, AL., August 11, 2016.
Kline, Stephen J. "What Is Technology?" *Philosophy of Technology: The Technological Condition, An Anthology*. Malden, MA: Blackwell, 2003. 210-12.

14

Nonlinear Model for Innovation



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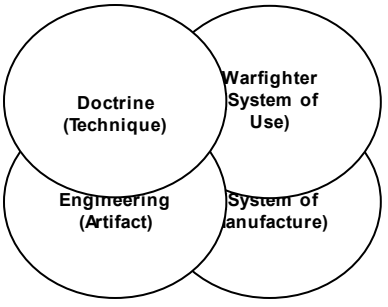
Innovation Derived from Situational Interaction



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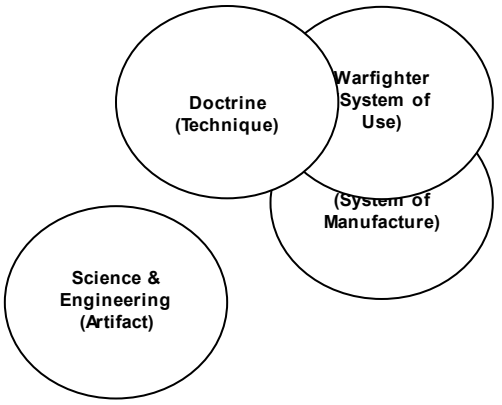
Technological Aliasing



17

Contemporary History of the U.S. Navy

- Onset of the interwar years selected for case studies:
  - Innovations perceived from submarine technology
  - Emergence of debate on unrestricted submarine warfare
  - Restrictions emerging from the Washington Treaty of 1922
  - Desire to revitalize the Naval War College and the Navy
- Tactical submarine wargames available from NWC archives
  - Class of 1919: Tactical Problem IX (Tac. 49), Blue vs. Red
  - Class of 1922: Tactical Problem IV (Tac. 85), Blue vs. Orange
  - Class of 1923: Tactical Problem III (Tac. 93), Blue vs. Red
  - Class of 1924: Tactical Problem III (Tac. 96), Blue vs. Orange
- Unclassified data available for analysis

18

Philosophical Underpinnings of Dramaturgical Action

- Jean Luc Nancy: The Staging of Co-existence
  - Re-invention of the staging of co-existence toward communion
  - Truth is revealed by giving a place to non-truth
- Hannah Arendt: *The Vita Activa*
  - Establishes relationships
  - Forces open limitations
  - Cuts across boundaries
  - Creates the condition for remembrance
- Jürgen Habermas: Action Theory
  - Teleological, normative, communicative and dramaturgical
- Erving Goffman: Dramaturgical Action
  - Presentation of self
- Kenneth Burke: Dramaturgical Interaction
  - Significance of meaning
  - Emphasis on the situation: act, scene, agent, agency and purpose

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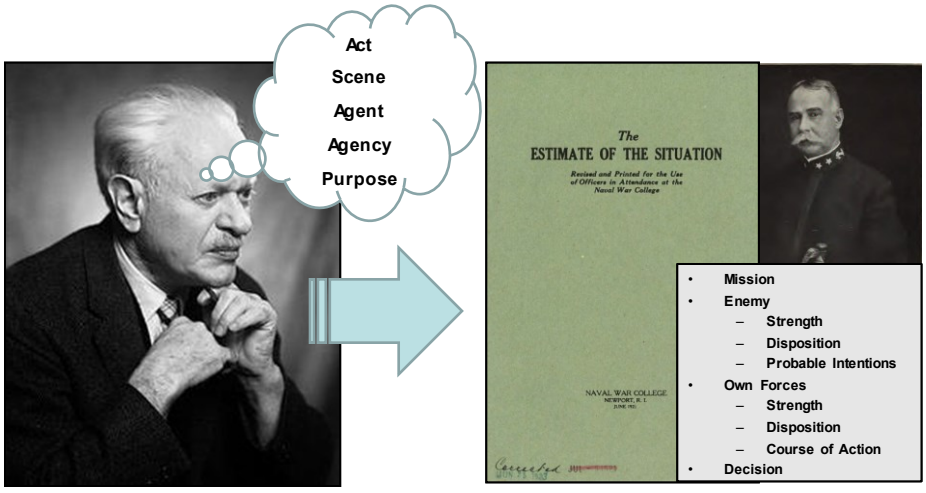
Dramaturgical Connection to Wargames



The dramatic situation sets the stage for interaction!

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Class of 1919

Tactical Problem IX (Tac. 49, Mod. 1)

Situation	Blue	Red
Act	Defend against Red	Attack Blue
Scene	Coast off Provincetown	Attack from Halifax
Agent	Class of 1919	Class of 1919
Agency	8 AA, 6AB, 15 VS, 10 UF, 3 BS and 3 BC	4 BB, 8 AA, 42 VS and 5 BS
Purpose	Employ submarines	Defend against submarines

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Class of 1922

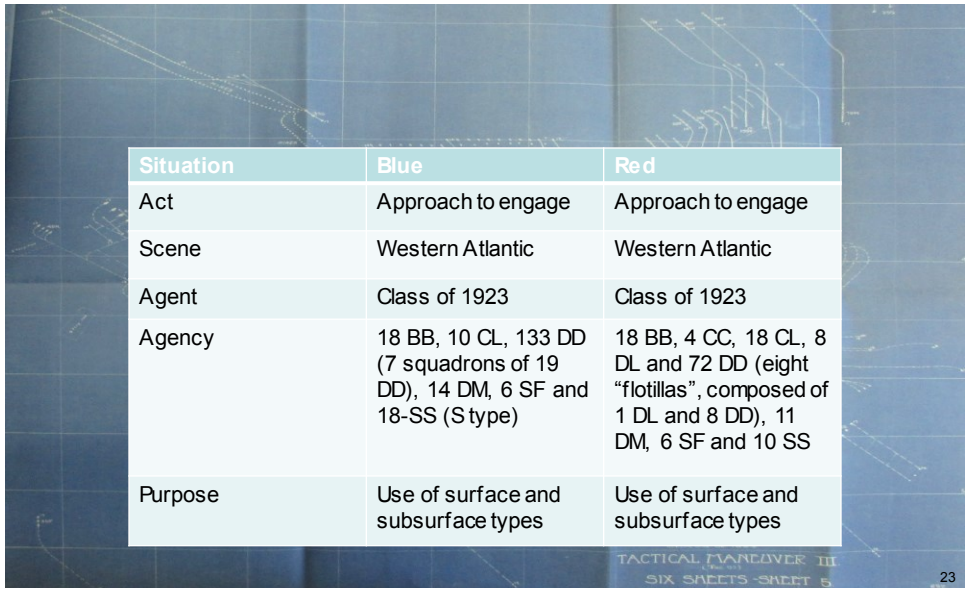
Tactical Problem IV (Tac. 85)

Situation	Blue	Orange
Act	Sea control in western Pacific	Sea control between Orange and western Asiatic
Scene	Need to transit to increase forces in Pacific	Unified forces in the Pacific
Agent	Class of 1922	Class of 1922
Agency	16 BB, 6 CC, 10 CL, 57 DD, 6 SF and 6 SS	16 BB, 6 CC, 10 CL, 57 DD, 6 SF and 6 SS
Purpose	Fleet organization for battle without train	Fleet organization for battle without train

22

Class of 1923

Tactical Maneuver III (Tac. 93)



Situation	Blue	Red
Act	Approach to engage	Approach to engage
Scene	Western Atlantic	Western Atlantic
Agent	Class of 1923	Class of 1923
Agency	18 BB, 10 CL, 133 DD (7 squadrons of 19 DD), 14 DM, 6 SF and 18-SS (S type)	18 BB, 4 CC, 18 CL, 8 DL and 72 DD (eight "flotillas", composed of 1 DL and 8 DD), 11 DM, 6 SF and 10 SS
Purpose	Use of surface and subsurface types	Use of surface and subsurface types

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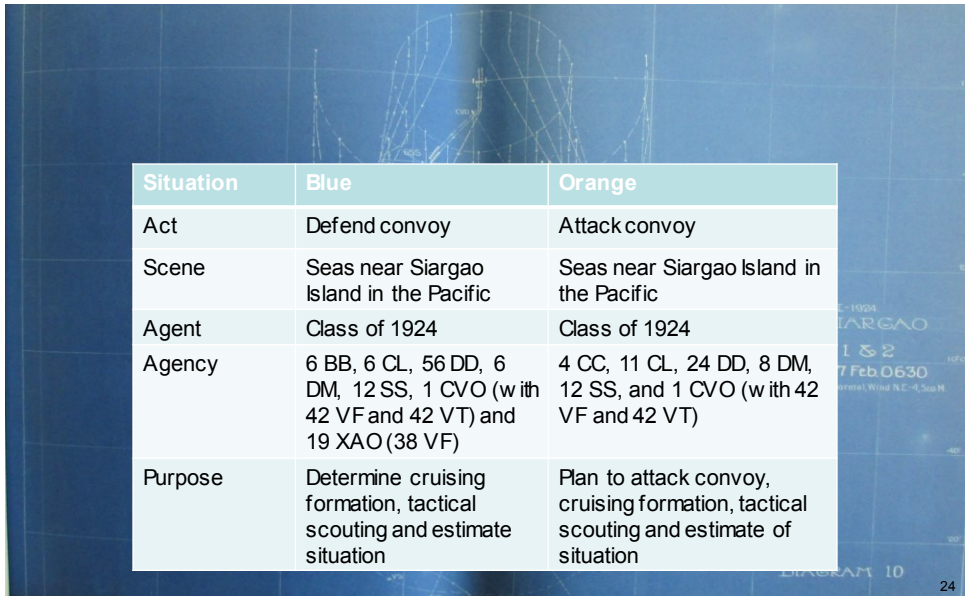
Class of 1924.

Tactical Problem III (Tac. 96).



Situation	Blue	Orange
Act	Defend convoy	Attack convoy
Scene	Seas near Siargao Island in the Pacific	Seas near Siargao Island in the Pacific
Agent	Class of 1924	Class of 1924
Agency	6 BB, 6 CL, 56 DD, 6 DM, 12 SS, 1 CVO (with 42 VF and 42 VT) and 19 XAO (38 VF)	4 CC, 11 CL, 24 DD, 8 DM, 12 SS, and 1 CVO (with 42 VF and 42 VT)
Purpose	Determine cruising formation, tactical scouting and estimate situation	Plan to attack convoy, cruising formation, tactical scouting and estimate of situation

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Comparative Agreements

Category		Graduating Class			
		1921	1922	1923	1924
Technology	End Use	Estimate of situation and disseminate orders	Estimate of situation and disseminate orders	Estimate of situation and disseminate orders	Estimate of situation and disseminate orders
	Doctrine	Need doctrine for submarine platforms	Doctrine available	Fleet formations added	Doctrine emerging and studies in international law
Dramaturgical Interaction		Micro and macro with 4 levels	Micro and macro with 4 levels	Micro and macro with 4 levels	Micro and macro with 4 levels
Aliasing		Doctrine/end use	Doctrine/end use	Doctrine/end use	Doctrine/end use
Diffusion		Graduation address, theses, lectures, officers (see Appendix 8)	Graduation address, theses, lectures, officers (see Appendix 8)	Graduation address, theses, lectures, officers (see Appendix 8)	Graduation address, theses, lectures, officers (see Appendix 8)

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Comparative Differences

Category		Graduating Class			
		1921	1922	1923	1924
Leadership	Leader	Sims	Sims	Williams	Williams
	Messaging	Importance of Naval War College	Call officers to engage the public	Estimate of situation and dissemination of orders skills	Innovation for the future navy
External Geo-political influence		Unrestricted warfare and end of WWI	Emerging concerns for rise of Japan in the Pacific	Armament Limitations Conference concerns for force reduction/ limitation, submarine warfare and Pacific basing	Washington Treaty, Department of Navy Support and ratio of 5-5-3-1.7, capital ship limitations, ban on submarine raiding of commercial shipping
Technology	Science/ Eng.	Existing	Existing	Existing and inclusion of fleet submarines	Existing and airplane payloads across platforms
	Acquisition	NA	NA	NA	NA
Situation	Act	Attack on basing	Battle at sea	Battle at sea	Attack on convoy
	Scene	U.S. eastern coast	Pacific ocean	Atlantic Ocean	Philippines
	Agent	Blue vs. Red	Blue vs. Orange	Blue vs. Red	Blue vs. Orange
	Agency	Asymmetric submarine force	Symmetrical forces	Asymmetric submarine force	Asymmetric raiding force
	Purpose	Homeland defense	At-sea engagement	At-sea engagement	Logistics escort

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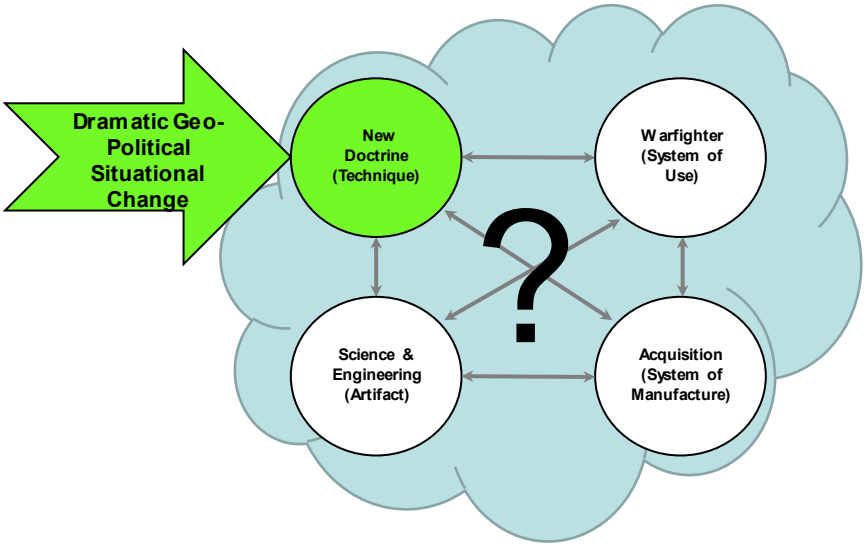
External Dramatic Situational Change



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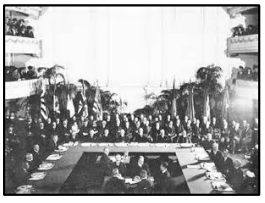
Four Levels of Situational Interaction Drive Diffusion

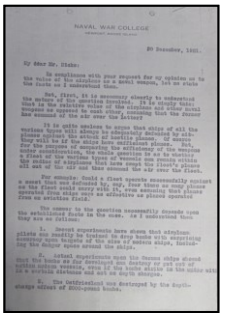
Washington Naval Disarmament Conference



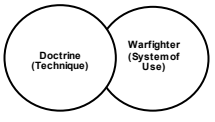
Maneuver Detail

Engagement with the Enemy

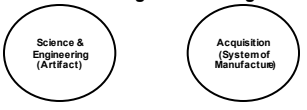
External Influence



Wargaming emphasized the interaction between doctrine and warfighting end use



Technological Aliasing



References:
Naval War College. *The Formulation of I. Orders, II. Doctrine and III. Dissemination of Information (revised and reprinted for the officers of the Naval War College)*. June 1921. Naval War College Archives, Newport RI.
Naval War College Museum photo archive, Photo Record Group 1-5-2, "NWC War Gaming: 1890s-1935", Naval War College Museum, Newport, RI.
Sims, RDML William S. Letter to Honorable Frederick C. Hicks on the Value of Aircraft and Submarines, 30 December 1921. Reprinted from the Manuscript Division of the Library of Congress.

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Level I Interaction: Infusion of the External Geo-Political Situation

- The Battle of Jutland
- Unrestricted submarine warfare during WWI
  - CAPT Rose and U-53's trip to Newport, RI
- CAPT Hart's appropriation of German subs after WWI
- RADM Sims' reinvigoration of the Naval War College
- CAPT Hinds "Orange Situation Lecture" after tour as acting governor of Guam
- Washington Naval Conference, Nov. 1921 – Feb. 1922
- Arms Limitations Treaty, Feb. 26, 1922
- Treaty ratification, Aug. 17, 1923

Reference:
Sims, Rear Admiral William S. Address by Rear Admiral Wm. S. Sims, U.S.N, President, U.S. Naval War College to the Graduating Class of 1921, 19 November, 1921, Naval War College Archives, Newport, RI.

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Level II Interaction: Internal Diffusion of Innovative Ideas

- Formulation of Maneuver Details
- "Estimate of the Situation," June 1921
- "The Formulation of Orders, Doctrine and Dissemination of Information," June 1921
- Progression of students to Naval War College staff
- CAPT Laning's thesis
- CAPT Tompkins "Submarine Signaling" lecture
- Integration of airplanes with other platforms

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Level III Interaction: Technological Aliasing in the Wargame

- The 12 SSs were submerged well in rear of the convoy with their batteries run down.
- The turn of the convoy brought it on a converging course with the 12 Orange submarines…having been submerged for three hours… the storage batteries of the subs were now almost exhausted… the anti-submarine DDs would run for a few minutes and then stop to use listening devices.. Some of them heard Orange subs, hoisted the submarine warning… ships left and headed away from the threat… depth barrage that drove them to a deep submergence and because the noises over them prevented their accurate use of listening devices… 12 torpedoes in all were discharged… none of the torpedoes hit.
- The Blue destroyers used listening devices and covered the area that Orange subs might be in…the only subs the Blue ships passed over were Blue subs… a depth barrage was laid... Blue subs went to a considerable depth, slowed down and escaped without injury.
- While ordinarily submarines should not waste torpedoes in attacking light cruisers, that doctrine probably should not be followed by submarines protecting a convoy since as against convoy ships light cruisers are almost as valuable as battle cruisers.
- Train ships need guns for air defense even more than they need them for surface ships.
- Blue Commander sent an order to the submarines to come to the surface at a given time and seek a position between the convoy and the Orange CCs. All of Blue's surface ships having been warned of this movement and ordered not to attack subs coming to the surface at that time until they had been recognized as enemy subs, all Blue subs came up safely.

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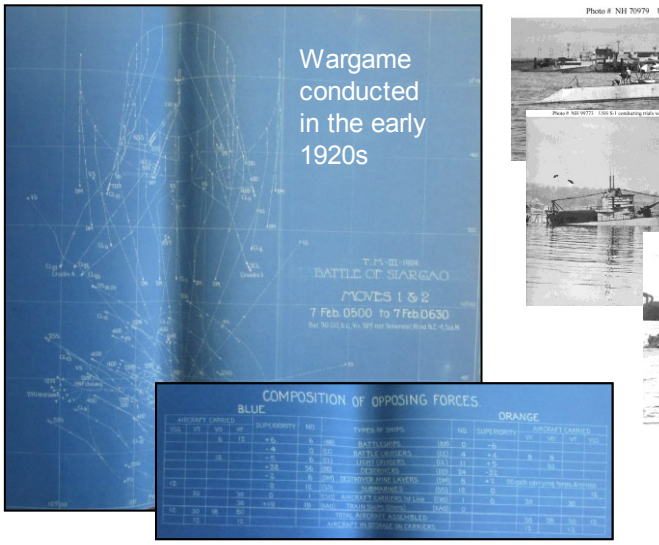
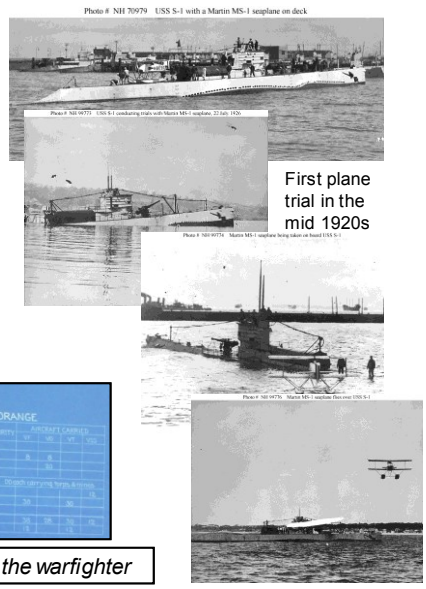
Example: Tactical Problem III Prototype





First plane trial in the mid 1920s

Wargaming, prototyping, acquisition, doctrine and the warfighter

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Level IV Interaction: Diffusion to External Communities

- RADM Sims' letter to Congressman Hicks on submarines, December 30. 1921
- Naval War College Fleet Conferences
- CAPT Laning's engagement with the Bureau of Aeronautics leading to a recommendation to the General Board for a mix of aircraft platforms
- Harvard professor's observation that wargaming not only teaches officers how to fight, but determines the U.S. line for naval policy, naval building and naval operations.
- CAPT Laning's conversation with Congressman Butler clarifying the disarmament vs. arms limitations treaty
- CAPT Reeves' increased sortie rate on the USS Langley
- Progression of naval officers

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Flag Officers with the Potential to Carry Wargame Experiences into War

First Name	Last Name	Class	War College Rank	1941 Rank	Courses & Quals*	1941 Status
H. R.	Stark	1923	CDR	ADM	16	Chief of Naval Operations
W. B.	Woodson	1923	CDR	ADM	16, 29	Judge Advocate General of the Navy
R.	Whitman	1923	CDR	ADM		Public Works Officer, 3rd Naval District, Civil Engineer Corps.
T.C.	Hart	1923	CAPT	ADM	1, 16, 19	Commander in Chief, Asiatic Fleet
L. C.	Rowcliff	1919	CAPT	RDML	16	Commander, Cruisers, Scouting Force and Cruiser Division 5
J. K.	Taussig	1919	CAPT	RDML	16	Commandant 5th Navy District and N.O.B, Norfolk
C. W.	Nimitz	1923	CDR	RDML	1, 16, 18	Chief of Bureau of Navigation
A. B.	Cook	1922	CDR	RDML	2, 16	Commander, Aircraft, Scouting Force
L. C.	Noyes	1923	CDR	RDML	2, 16	Director of Communications for the Chief of Naval Operations
F. J.	Horne	1923	CAPT	RDML	3, 5-a b, 16, 18, 19	Navy Yard, Mare Island
S. A.	Taffinder	1923	CDR	RDML	16	Chief of Staff and Aide to the Commander of the Battle Force
A. L.	Bristol	1923	CDR	RDML	2, 16	Commander Patrol Wing 2
M. H.	Simons	1924 (S)	CAPT	RDML	15, 16, 18	Commander Norfolk Navy Yard, Portsmouth, VA
W. N.	Vernou	1924 (S)	CAPT	RDML	16	Commander Battleship Division Two, Battle Force
J. W.	Wilcox	1924 (S)	CDR	RDML	5-a, 16	Commander Special Service Squadron (President, Board of Inspection and Survey (ord.))
R.	Willson	1924 (S)	CDR	RDML	16	Commander Battleship Division One
W. C.	Fite	1924 (S)	CDR	RDML	16	Supply Corps./Pay Director
T.	Withers	1924 (S)	CDR	RDML	1, 16, 18	Inspector Ordinance in Charge of Naval Torpedo Station Newport
A.	Sharp	1924 (S)	CDR	RDML	16, 18	Office of the Chief of Naval Operations

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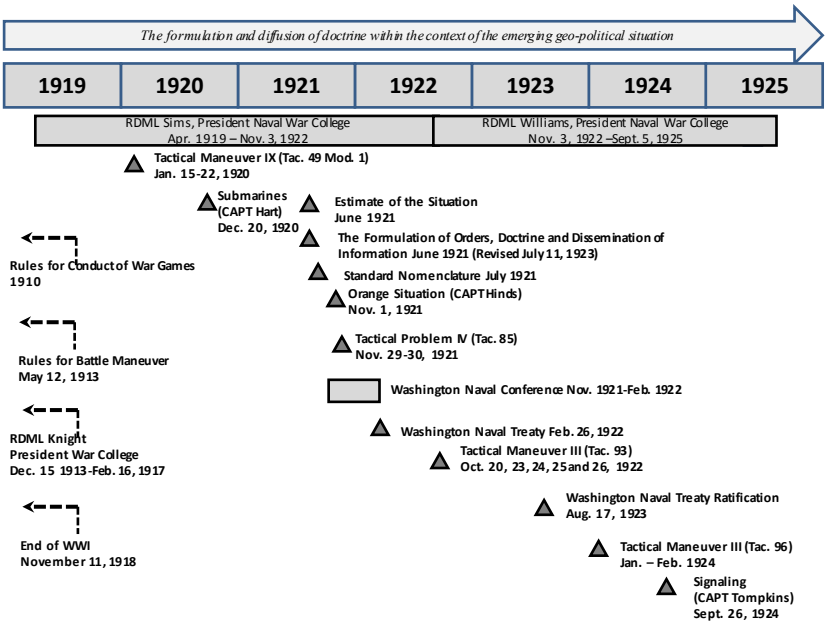
Emerging Meta Narrative



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Research Question

Does historical evidence exist within the wargames conducted during the interwar years to corroborate that dramaturgical action serves as a motivational force for the diffusion of technological innovation in the U.S. Navy?

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Findings

- *The modified Klein definition of technology provides a valuable analytical lens*
- *Historical evidence corroborates a dramaturgical situation in each wargame*
- *Wargame agreements entailed focus on doctrine and end use:*
  - *Estimating the situation and dissemination of orders*
  - *Dramaturgy*
  - *Effectiveness of the submarine platform in the battlegroup*
- *Wargame differences included:*
  - *The situation: act, scene, agent, agency and purpose*
  - *Maneuver detail*
  - *Results*
- *Human motivation for action occurred at four levels: external geo-political influence, orders disseminated based on the estimate of the situation, conduct of the wargame and external influence from wargames*
- *A meta-narrative emerges around the situational interaction that include:*
  - *An emerging estimate of the geo-political situation*
  - *Officers carrying their wargaming experiences into war*
- *Dramaturgical action serves as a motivational force for the diffusion of technological innovation; however, technological innovation is a complex process including many other human interactions*
- *Wargaming reveals the potential for technological aliasing in the navy*

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Wargaming to Deceive the Sponsor
Why and How?

Connections UK 2016 Conference
King's College, London
September 2016

Speaker's Notes

Stephen Downes-Martin, PhD
Research Fellow, US Naval War College
401-935-4808
stephen.downesmartin@gmail.com
https://sites.google.com/site/stephendownesmartin/

The opinions and errors contained in this document are those of the author alone.

The author thanks Peter Perla for his invaluable critique of the ideas presented.

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Why Study Deceptive Wargames?

One important use of wargaming is to inform high stakes defense decisions concerning acquisition of equipment or implementation of concepts. In any situation where the stakes are high there will be motive for engaging in deception if the decision makers have a career interest in the value of the program or concept being wargamed, or belong to a community with such an interest, or simply believe in the value of the program or concept independent of the results of inquiry. Vulnerability to deception is introduced if the barriers to engaging in deception and the likelihood and penalties for being caught are low. Stakeholders with influence and motive to deceive include the sponsor, the organization producing the wargame and players (including their respective chains of command).[1]

We desire general principles of good wargame design and execution that provide the best possible information support within the limits of wargaming to the decision process. One way of improving a process and ensuring its quality is to examine what happens when the process runs poorly or fails. However, lessons learned from examining failed or poor wargames and identifying the wargame pathologies is insufficient – the opposite of a well-designed game is not simply a poorly designed one.

Understanding the mechanisms behind the deliberate corruption and manipulation of the wargame process in the form of "deceive the sponsor" as a baseline for malignancy, will help us build processes explicitly designed to detect deception (inadvertent and deliberate) and defend against it, and will identify additional wargame design, development and execution principles that do not surface from simply examining "best practices" or "lessons learned".

These speaker's notes to the conference presentation discuss the psychology involved in how one can deliberately and with malice aforethought design and execute a wargame to deceive the decision makers who use wargaming to inform their decision making. The two primary methods explored will be the manipulation of the sponsor and the sponsor's chain of

[1] Downes-Martin, Stephen, "Your Boss, Players and Sponsors: The Three Witches of Wargaming", Naval War College Review 2014, Vol 67, No. 1, pp 31 – 40

command (for example the Sponsor's action officers) outside the game, and the manipulation of game players during the game in order to deceive the Sponsor.[2]

Critical Caveats

Wargaming in this paper refers to serious national security related wargaming done by or for organizations such as the US DoD (or equivalent for other Nations) addressing novel future related problems dealing with the acquisition or modification of equipment or the implementation of concepts at the operational or strategic level. It does not deal with hobby gaming, tactical gaming of well understood scenarios, training or education. It might be the case that the arguments in these notes apply to such cases, but these notes do not make or discuss that claim. Furthermore, the discussion does not distinguish between the roles within an organization that provides wargaming (wargame director, designer, developer, analyst, etc.), since who does what within the wargaming organization is not important to this discussion.[3]

The discussion does not address the "hidden scenario" approach in which one benignly deceives the players as to the nature of the scenario in order to "hide the benefits of hindsight or the pitfalls of prejudice" gained from previous experience with real world or wargamed events.[4] Also the discussion does not address players deceiving their protagonists in the game to explore operational or strategic deception.

This discussion is strictly focused on games that deceive the sponsor for bureaucratic and programmatic reasons.

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[2] Manipulating the Sponsor outside the game starts with the first approach by the sponsor to the organization responsible for providing the wargame, and continues through the game to the delivery of the final report by the wargaming organization.

[3] For an excellent review of the roles within an organization that provides national security related wargames for the US DoD see the "War Gamers' Handbook: A Guide for Professional War Gamers", Edited By Dr. Shawn Burns, War Gaming Department of the Naval War College, https://www.usnwc.edu/getattachment/Research---Gaming/War-Gaming/WGD-HB---Complete-2.pdf.aspx.

[4] For a discussion on "Hidden Scenarios" see page 87 of "Innovations in Wargaming Vol 1 Developments in Professional and Hobby Wargames" 2012 by John Curry. For a hidden scenario wargame see "Home Front 86" by Timothy McCoy Price, 1986 (provided by Major Tom Mouat). For an example of a hidden scenario in the Organizational Behavior Classroom see the "Carter Racing" case study "Facts, Figures, and Organizational Decisions: Carter Racing and Quantitative Analysis in the Organizational Behavior Classroom", Jack Britain & Sim Sitkin, Journal of Management Education, 1989, Vol 14, #1.

The Deception Target

Most of us have experienced sponsors seeking to have their ideas "validated" by a wargame, and watching some organizations provide precisely a game that appears to do that. But that is easy, the sponsor or organization has set out to suspend disbelief in their own ideas. It is more useful to examine how to design and execute a game which successfully persuades a skeptical sponsor to believe in and act on the deception. Our goal is to understand that process and the factors involved in order to create wargames that are resistant to inadvertent and deliberate deception even when the deceiver is skilled enough to hide the existence of the deception.[5]

One use of wargaming is to inform the decision process concerning acquisition of equipment and implementation of concepts. The time, financial and opportunity costs are high as are the consequences of getting these decisions wrong in terms of blood and treasure. For high stakes decisions the decision makers are therefore and obviously senior military officers and civilian officials, and herein lies an opportunity for the malign deceiver. Research shows that older and more experienced people tend to be vastly overconfident about their ability to control events that involve chance.[6] Their successes in past situations, many of which involved elements of chance, lead them to underestimate the role of luck and to overestimate their ability to handle contingent situations.[7] This is especially true in competitive situations, where competence at bluffing is critical to success but can mask actual incompetence thanks to luck.[8] We have decision makers facing high stakes decisions who as a group tend to be over confident in their abilities. Not only can this be exploited to deceive them, but they are open to falling

[5] This is analogous to microbiologists studying disease, simply following a regimen of healthy living only goes so far.

[6] Most people tend to interpret "most people tend to" as meaning "everyone else but not me." This is especially true of senior, experienced, and successful people, precisely because they have been successful in the past.

[7] Ellen J. Langer, "The Illusion of Control," *Journal of Personality and Social Psychology* 32, no. 2 (August 1975), pp. 311–28.

[8] Dominic D. P. Johnson, Richard W. Wrangham, and Stephen Peter Rosen, "Is Military Incompetence Adaptive? An Empirical Test with Risk-Taking Behaviour in Modern Warfare," *Evolution and Human Behavior* 23 (2002), pp. 245–64. See also Eliot Cohen and John Gooch, "Military Misfortunes: The Anatomy of Failure in War" (New York: Free Press, 1990), and Malcolm Gladwell, "Cocksure: Banks, Battles, and the Psychology of Overconfidence," *New Yorker*, 27 July 2009.

into the trap of deceiving themselves or others in the decision process about which alternative best satisfies the stated selection criteria. Understanding what they are over confident about gives the deceiver and edge by exploiting what have been identified as the three risk factors for intellectual fraud. In nearly all cases of scientific fraud, three risk factors have been identified as present:

1. the perpetrators "knew, or thought they knew, what the answer to the problem they were considering would turn out to be if they went to all the trouble of doing the work properly;
2. were under career pressure;
3. and were working in a field where individual experiments are not expected to be precisely reproducible."[9]

In wargames, the first factor is likely present for senior, more experienced people – precisely the people engaged in the decision process – given the results of the psychology research just presented, that older and more experienced people tend to be unaware of their lack of skills in novel situations and to be overconfident. The second factor is often present; the third factor is clearly characteristic of warfare and wargaming. The three risk factors for (perhaps unintended) intellectual fraud must be considered likely to be present when wargaming novel and important operational and strategic problems. The presence of these three risk factors imply that at least self-deception must be considered to be likely present among senior officers and senior civilians in the decision process informed by the wargame, and in some cases a predisposition to engage in intellectually dubious decision making will likely be present.

[9] David Goodstein, On Fact and Fraud: Cautionary Tales from the Front Lines of Science, (Princeton, N.J.: Princeton Univ. Press, 2010). (Goodstein is vice provost of the California Institute of Technology.) See also Michael Shermer, "When Scientists Sin," Scientific American 303, no. 1 (July 2010), p. 34.

Deception Exploits

Exploiting Stress

Some decision making targets are easier to deceive than others. Studies in deception indicate that three broad levels of stress in the target are of interest to the deceiver. Relaxed targets with no immediate decision required have no disadvantage to giving way to their own predispositions. They are extremely hard to deceive – i.e. shift them away from their predispositions – during whatever pre decisional analysis they are engaging in. At the other end of the spectrum are highly stressed targets that have become rigid. They are required to make a decision and without enough time to analyze information, they tend to actively search for and prefer information that supports predispositions and avoid discrepant information. They may make poor decisions, but they are hard to deceive into making decisions the deceiver would prefer they make if those are different from the ones the target is predisposed to make. In the middle of the stress spectrum are targets that are referred to in the literature as "vigilant". Research into deception has shown the counter-intuitive result that it is vigilant targets that are easiest to deceive. They are under tension because a decision is required but have enough time to deal with information, so it becomes possible to change beliefs by inserting deceptive information.[10]

The deception planner must identify who in the sponsor and decision chain are relaxed or rigid and identify their predispositions and underlying biases and beliefs to determine if they support the deceiver's goals. If they do not then an attempt must be made during pre-game negotiations and design to increase the stress on relaxed targets (perhaps by deliberately expanding the scope of the game or the number of game objectives, or by introducing rigid/stressed colleagues to the relaxed ones) and reduce the stress on rigid/stressed targets (perhaps by introducing delays in the wargame schedule to provide the target more time and thus reduce stress during the pre-game negotiations and design process). These approaches are

[10] Donald Daniel and Katherine Herbig, "Propositions on Military Deception" in *Strategic Military Deception*, Donald Daniel and Katherine Herbig (Eds), Pergamon Press 1981.

very much easier if very senior leaders in the sponsor and stakeholders' chains of command have delegated decisions about the game's objectives and schedule to action officers, who being more junior are more available.

If the goal is to manipulate the perceptions of the sponsor through deceiving the players, then the game design should consider manipulating the stress of the players. If the deceiver believes the players have strong pre-conceived beliefs about the concepts or equipment being gamed and those beliefs are other than what the deceiver desires, then the game design must balance the stress on the players to engender a vigilant state of mind. Deceptive material can then more likely be introduced into their game behavior. On the other hand, if the players' beliefs agree with what the deceiver desires then the game design should overstress the players to drive rigid perception behavior and lock them into their preconceived beliefs. Players who "check out" of the game can be ignored. Indeed, the more who do so the more the diligent players will be stressed.

Exploiting Erroneous Beliefs and Perceptions

Another incision point into the psychology of deception targets is provided by research into the nature of beliefs. Amplifying the overconfidence problem is the effect demonstrated by research that "beliefs can survive potent logical or empirical challenges. They can survive and even be bolstered by evidence that most uncommitted observers would agree logically demands some weakening of such beliefs. They can even survive the total destruction of their original evidential bases."[11] Asking someone to generate an explanation of why something is true often will strengthen belief in that "something" even after contradictory evidence is provided.[12] In addition, corrections to erroneous evidence may actually strengthen

[11] Lee Ross and Craig Anderson, "Shortcomings in the Attribution Process: On the Origins and Maintenance of Erroneous Social Assessments," in *Judgment under Uncertainty: Heuristics and Biases*, Daniel Kahneman, Paul Slovic, and Amos Tversky (Eds), Cambridge Univ. Press, 1982, pp. 129–52

[12] Martin F. Davies, "Belief Persistence after Evidential Discrediting: The Impact of Generated versus Provided Explanations on the Likelihood of Discredited Outcomes," *Journal of Experimental Social Psychology* 33, no. 6 (November 1997), pp. 561–78.

misperceptions under some circumstances.[13] This is especially useful when the wargame designer couples this to player stress to influence the sponsor by deceiving the players. The Central Intelligence Agency analyst community suggests five reasons for the persistence of (even discredited) beliefs;[14]

- "We tend to perceive what we expect to perceive."
- "Mind-sets tend to be quick to form but resistant to change."
- "New information is assimilated to existing images."
- "Initial exposure to blurred or ambiguous stimuli interferes with accurate perceptions even after more and better information becomes available."
- "Surplus information results in reduced accuracy of conclusion and an over-confidence in that conclusion."

The implications of these established results are startling when applied to deception. It is reasonable to expect information to be blurred or ambiguous in the initial phases of any operation. Any system that rapidly provides information – something most decision makers desire – will have the distinct potential of not only interfering with accurate perceptions, but also of reducing the use made of better information in the future (thus locking in the initially formed inaccurate perceptions) while at the same time increasing the confidence in the inaccurate perceptions. We face the real possibility of our deception targets rapidly acting with confidence on an institutionally accepted but erroneous picture of the world. Since we can expect initial information to be blurred or ambiguous, the deceiver should explicitly deal with this to manipulate the target's future perceptions.

The sponsor is the ultimate deception target, but if the sponsor believes in the quality of the game then deceiving the players into making game decisions preferred by the game designer is a possible mechanism for manipulating the post-game decision process of the sponsor. Note that strategic or operational level games dealing with novel future situations require an

[13] Brendan Nyhan and Jason Reifler, "When Corrections Fail: The Persistence of Political Misperceptions," *Political Behavior* 32, no. 2 (June 2010), pp. 303–30.

[14] Richards Heuer, Jr., "Perception: Why Can't We See What Is There to Be Seen?," chap. 2 in *Psychology of Intelligence Analysis*, 1999 www.cia.gov/. See also Robert Jervis, "Understanding Beliefs", *Political Psychology* 27 (Fall 2006).

inductive game design in which the adjudicators are not only players but in fact are dominant players.[15] Since players may have motives for playing to deceive the sponsor (not just the opponent players) then the same is true of the adjudicators. Furthermore, this motive is amplified into a vulnerability if the adjudicators are provided by the organization producing the wargame via a deceptive design. One possible way to manipulate the decision behavior of the players without the sponsor noticing is to ensure players requests for information is answered with large amounts of detailed information whenever they ask for it starting from the very beginning of the game. People tend to home in on their comfort level (tactics) even during an operational level game, tend to seek confirmatory information, and tend to seek more information than they need to make a decision, so answering all requests for information from the beginning of a game will tend to assist the players in locking onto their initial perception.[14] Careful construction of the initial scenario will increase the probability that the initial scenario is ambiguous (which reflects reality) in a way desirable to the deceptive game designer. Answering requests for information will be perceived by the sponsor as an innocent and reasonable way to run the game.

Exploiting Cheaters

One of the five categories of player identified and discussed by Salen & Zimmerman is the Cheater, the player who pretends to buy in to the game but violates the operational rules of the game in secret motivated by an intense desire to win.[16] The cheater seeks a deep understanding of the game's rules and then ways to break them secretly to further their goal of winning the game. Closely related to the Cheater is the Dedicated player, also with an intense desire to win who seeks to understand the rules in order to best use those rules, without breaking them, to win. Both of these types of players are valuable to the game designer. The latter may find loopholes in the rules that assist game designers to refine the game and improve future games. The game designer should build into the game design mechanisms for

[15] Downes-Martin, Stephen, "Adjudication: The Diabolus in Machina of Wargaming", Naval War College Review 2013, Vol 66, No. 3, pp 67 – 80

[16] Katie Salen and Eric Zimmerman, "Rules of Play: Game Deign Fundamentals", MIT Press 2004, see chapter 21.

spotting and controlling cheating behavior, simply assuming cheating does not occur in wargames – even by otherwise honest people – is naive. However, the cheater may be exploited by the game designer to deceive the sponsor. By selectively relaxing the monitoring function, or better by simply monitoring for cheating but not stopping it, and by setting up the game mechanisms and scenario to make it hard to win without cheating using methods desired by the deceiver (for example the subject categories discussed above), the game designer can create a game in which winning occurs because of mechanisms that are hidden from the sponsor (and other players). One real world example of cheating during a wargame seen by the author involved two officers from the same community but playing on opposite sides. The officers' community had an interest in the game outcome going in a certain direction. During the game we found the two officers passing information between themselves via the infamous "sneaker net" in order to influence their cell commanders.

Avoid Leaving Fingerprints

It is a wise deception planner who plans ahead to divert blame for the deception should it be discovered. Detecting the existence of such a plan is an important part of inoculating against deception. The deception planners passive defense against detection is the rotation frequency of the sponsor's position and the deception planner. However, if the deception is suspected by the sponsor while the deceiver is in position then the design notes for the game and records of the game execution can provide a distraction defense. These documents must be carefully written so that a reading of them in the absence of suspicion should not indicate deception is planned or occurred; but should deception be suspected they should provide evidence of the stress on the players and ambiguity in the game rules. This will motivate the sponsor to interpret the results as caused by over-enthusiasm by some players and stress on others and not realise these were planned.

What is to be Done?

Six categories of techniques are proposed which, if insisted on being used by the wargame sponsor, will reduce the likelihood that deception vulnerabilities are exploited by dishonest stakeholders to inappropriately influence the decision that the game is intended to inform. These design techniques are in addition to those normally used for good wargaming practice. However, some of them are onerous and may not be practical for every game. They should all be considered however if only to generate other solutions and identify caveats on game analysis. The game sponsor must decide early in the pre-game process how important is the game and what level of protection from deception the game deserves, always remembering that the more important a game the higher the motives for deception.

Game Peer Review Board

1. The primary defense against deceptive gaming and in support of quality gaming is the game peer review board. Assuming the game is important, it should be routine that the game design document, the development document, the execution report and the game analysis report be reviewed by a peer review board. The board contains experts from the organization that produced the wargame and its associated documents and critically it includes outside wargaming experts who are not part of the sponsor's organization. Care must be taken to avoid the boards from sister organizations giving each other a free pass on dubious game design, execution or analysis. The primary focus of the game review board is on the pre-game and post-game processes. They are responsible for approving or disapproving game design, and for auditing past game analysis.

Player Stress

2. Getting good performance from game players requires them to be neither over nor under stressed.[17] However, when they are in a state of vigilance they are vulnerable to deception during the game, and so performance is correlated with vulnerability to deception. The peer review board is the primary tool for ensuring that the stress level designed into the game to enhance performance is not used to engage in malign practices.

Sponsor Vigilance

3. Engage the senior Sponsor regularly and watch for any mismatch between what the Sponsor says and what the sponsor's Action Officers say. Educate the Sponsor and the Action Officers on the dangers of inadvertent deception creeping in due to stress, inappropriate expansion of game objectives, and hidden agendas.[1] Set up the game design explicitly to inoculate against deception and inform the sponsor.

Punish Cheating

4. The game must include a monitoring activity, with someone in charge of it, designed to spot game rule breaking (for example meeting in the head with an opposing and trading information), and must stop the rule breakers (and perhaps penalize them) while collecting information about the breakage. How important it is to have this function will depend on the game objectives and design. The review board has a say in whether the monitoring activity of the game design is sufficient.

Match Game Information Flow to Level of Gamed War

5. Be alert for attempts to introduce items into the game that are not justified by the stated game objectives (these could be introduced to warp the game results) and block their introduction.[1]

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[17] Downes-Martin, Stephen, "Stress, Paranioia and Cheating: The Three Furies of Innovative Wargaming", Connections US Wargaming Conference, National Defense University Washington DC, Jul 2015

6. Be alert for information flows that do not match the level of war being gamed, for example tactical information in an operational level game, and modify these flows to match the game objectives. Although often appropriate, providing tactical information in response to requests for information in an operational game is one way of introducing deception into the game results.

7. Be alert for senior leaders in the chain of command of any stakeholder (including senior players) attempting to change the game flow of information, especially just before game launch or during game execution, and block these attempts.[1]

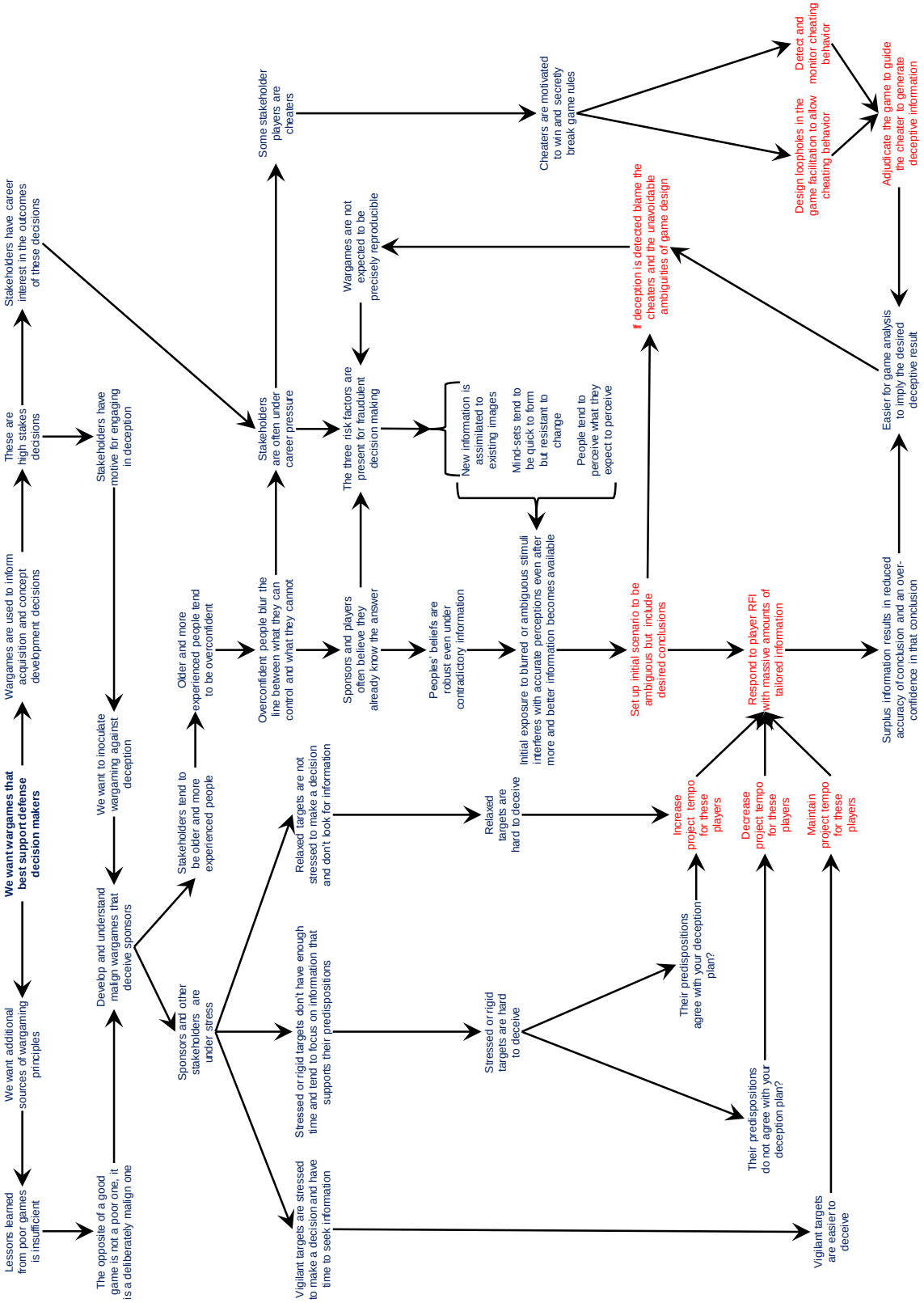
Watch for Ambiguous Game Rules or Process

8. Identify rule and process ambiguities and ensure they are consciously chosen to open up the decision space for the players and adjudicators to support the game objectives, and if they are not then remove them. Monitor for cheaters and inappropriate moves by the adjudicators and design procedures for dealing with them during the game. This may be done by a combination of adjudicator injects or decisions, removal of specific people (no matter how senior) from the game, and removing the options for cheating.

Rotate Player Roles

9. Rotate players between roles – red to blue and vice versa if possible, or between roles or between responsibilities within each cell otherwise. Not only will this provide players with a richer game play experience, it will also ensure that perceptions created in the initial stage of the game do not get locked in, they get broken and new information arriving is given its proper attention by recent arrivals into the role or responsibility being played.

Argument Structure Diagram



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A Positive Difference

1. A serious, appropriate research issue/learning objective to inform needed decisions, expressed in clear game objectives; supported by an analysis plan.
2. Clear identification of the players who have the greatest effects on the outcome, and conditions beyond the control of players, or not addressed in the game.
3. Experienced role players. Ideally the actual people who must arrive at a consensus and commit to action. If not, agents of those decision makers who have deep credibility with those who will make the decisions.[1]
4. A scenario that provides the "critical information" that affects decision makers' choice of courses of action, and that the decision makers would reasonably have based upon their sources.[2]
5. A game structure that:
    a. Includes the requisite number of sides,
    b. provides control and stimulation, with appropriate data collection,
    c. has the number and duration of moves appropriate to the research question and the constraints of duration of the game,[3]
    "The length of the move in every case should be determined by the time that would elapse before the conduct of one side would be so modified that by that of the other that a truthful representation of warfare would make it necessary for the troop-leaders to know what has transpired before making further indications."[4]
    d. has adjudication matched to the subject matter (quantitative where appropriate and qualitative where appropriate), which may require much pre-game analysis for quick reference,
    e. pays close attention to who would likely know what, and when,
    f. provides some measure of verisimilitude between game mechanisms and organizational decision making and communication,
    g. prepares the participants to adopt their roles in the game by informing them of the objectives, scenario, and game structure (including their role, "command" and communication provisions, etc),
    h. keeps players fully in their role during the game, encourages creative moves, and then has sufficient time at the end to discuss what they learned from the game and how they think the game could be improved.
    i. includes post-game analysis that addresses the research issue/learning objective and determines what appropriately should be learned from the game.

[1] The experience of those organizing and running the game is less important if they abide by the above characteristics and have a commitment to scientific methods.
[2] Commanders Critical Information Requirements specify the type of information deemed critical. These include Priority Intelligence Requirements.
[3] This characteristic is often one of the most demanding for achieving game objectives.
[4] Livermore.

Potential for Unintended Consequences or Contributing to Poor Decisions

The literature on poor versus better decision making is rich. Examples include Simon (1976), Janis (1989), Janis and Mann (1977), and many more. Simon addresses how actual human behavior falls short of the normatively rational. One can usefully argue that gaming goes a long way to address Simon's:

- Shortfalls in knowledge and anticipation of consequences,
- Imagination required to anticipate consequences and attach value to them, and
- Choice among "all possible alternative behaviors."

Gaming also addresses criteria suggested by Janis and Mann. It:

- Makes decision making more conscious
- Encourages thoroughly canvassing a wide range of solutions
- Surveys objectives to be fulfilled and values implicated by a choice
- Considers costs and risks of negative consequences, as well as positive consequences, that could flow from each alternative,
- Provides new information and expert judgment to inform choice,
- Makes detailed provision for implementing the chose course of action.

By doing so, it relaxes individual cognitive constraints by taking advantage of a broader set of knowledge and judgments of people experienced with various aspects of the issues at hand.

However, affiliative constraints derived from the need for acceptability, consensus, and social support constrains good decision making. When people come to a game with acceptable choices or outcomes predetermined, games will be less useful. Similarly, a desire for prestige or other self-serving motives leads to ego-centric constraints on good decisions. Finding games that have illustrated unwise policies and strategies, but have not been able to persuade top leaders is not difficult.

The bottom line is that abuse or misuse of gaming is mainly a consequence of the decision makers, and much less frequently a product of game design.

Excerpt from *Playing War: Wargaming and US Navy Preparations for World War II*
By John M. Lillard, PhD
Potomac Books, an Imprint of the University of Nebraska Press, (2016)
Chapter 6: Conclusion

The Interwar Period ended with the U.S. Navy on the precipice of war, a war that naval leaders attempted to predict and practice for 22 years in Fleet Problems and wargames. However, to say that the Navy *practiced* the Pacific War is not to say that they predicted it with complete accuracy nor were totally prepared for it when it came, as the Admiral Nimitz's statement quoted at the beginning of this book would seem to imply. Taken at face value, the Nimitz quote is an over-simplification or at least a distractor. Behind the words though, is a claim that the trained officers the War College fed into war planning positions played a significant role in transforming the U.S. Navy from its post WWI physical state and mindset to one that was much better prepared to fight a real war with Japan. This book explored the question of what roles the Interwar period wargames at the War College played in that transformation and to what extent any military organization could transform itself, even with untested principles or unproven technology.

This question is really one of agency and the instruments of agency. Historical agency is the ability of an entity to influence the development of the events of history. By that definition, the question becomes whether the Naval War College was a historical agent of preparation, transformation, and innovation in the same way that Kuehn argued for the General Board, and whether the wargames were instruments of that agency in the same way that Felker and Nofi argued for the Fleet Problems. The answer is contained in the War College wargame records of the Interwar Period. These show that, far from being irrelevant rituals, the wargames were definitive instruments of agency. Not only that, but the records reflect that the wargames were an *effective* instrument, at least within the limits of their stated objective. Through lectures, readings, and especially wargames, the War College taught decision-making, and not decisions. The decisions and results were important derivatives of the War College experience, as they gave the student-officers an adaptable process to follow and confidence in their decision-making abilities.

While he was conducting the research that led to his biography of Raymond Spruance, Thomas Buell came to some of his own conclusions that touched on the subject of Interwar Period transformation. He stated that on a *strategic* level, the wargames only partially prepared naval officers intellectually and psychologically for the war before they had to fight it. His "partial" qualification rested on the fact that none of the classes ever played the Battle of the Atlantic on the game board, which is true enough. The RED games in the greater part of the Interwar Phase and even the BLACK-SILVER games of the final years were still fleet-on-fleet actions and not the war of attrition between escorted convoys and U-Boat wolf packs that the Battle of the Atlantic turned out to be. Buell's assertion was that the major changes in the Navy brought on by the wargames were on a *tactical* level.[1]

The evidence reviewed in this book supports a different view, that the games did facilitate naval transformation across not only tactics but strategy and technology as well.

That transformation was far from complete in December 1941, and the list of unpleasant surprises for the U.S. Navy in that war went far beyond kamikaze attacks, but the ability to repeatedly practice procedures and experiment with innovations in a low cost, flexible venue gave the wargames a central role in that transformation.

Basil Liddell Hart defined strategy as "the art of distributing military means to fulfill the ends of policy."[2] Roscoe MacFall condensed that definition into "the concentration of purpose." By either one of these definitions, the Navy certainly did change strategically and the games had a definite influence on this change. The conclusions and recommendations of the 1933 Van Auken report, reinforced by the experiences of the scores of students who played the games he documented and then moved on to OP-12, was a deciding factor in the shift from the Mahanian "thruster" strategy to the more realistic "cautionary" strategy. One of the most striking reflections of this departure from the Early Phase Mahanian doctrine occurred in the first months of the Pacific War. When the Pacific Fleet reinforced and reconstituted itself shortly after the Pearl Harbor attack, a Battle Force expedition to relieve MacArthur's army in the Philippines—the bedrock rationale for the "thruster" strategy—was never seriously contemplated.[3] The island territories of Guam and Wake were similarly written off. Surviving, gaining battle experience, and building up for a prolonged war of attrition and a step-by-step advance comprised the Navy's early Pacific strategy.

The wargames also added to a growing recognition that a Pacific war would necessarily involve other nations besides ORANGE and BLUE. Wargame critiques from the Middle Phase frequently stressed the necessity and challenges of establishing forward logistics bases. While it is true that the bulk of naval fighting forces in the Pacific Theater were American, their recognition that they needed to push logistics support forward and their ability to use bases in Australia, New Zealand, Vanuatu and French Polynesia greatly relieved logistical difficulties during the Solomons and New Guinea campaigns.

Tactically, the Navy departed dramatically from the battleship Battle Lines that figured so prominently in Early and Middle Phase wargames. For the first six months of the war, Task Forces built around aircraft carriers and cruisers made small forays against Japanese bases in the Mandate islands, but the intact or slightly damaged battleships—not only slow but also voracious consumers of fuel in a fleet that was critically short of fleet tankers—stayed close to home.[4] Later, in 1942, when Nimitz arrayed his forces to face what he knew was a numerically superior opponent at Midway, he had the option of bringing seven battleships west to augment his two carrier task forces. Nimitz made a conscious decision to leave his battle line on the sidelines, though he had over twice as many battleships available as he had carriers at his disposal. His official rationale was "the undesirability of diverting to [the battle line] screen any units which could add to our long-range striking power against the enemy carriers."[5] In other words, Nimitz viewed the battleships more as a defensive liability than a contribution to the "striking power" of his force. His intent was to engage the Japanese fleet with his carriers alone. Certainly, Nimitz did not come to this decision overnight or even in the immediate aftermath of Pearl Harbor. The War College wargames and Fleet Problems had been illustrating the vulnerabilities of a Battle Force built around battleships for years. Increasing awareness of the potential of aviation is evident from as far back as the Class of 1923 in statements

from Harris Laning and others, and had ceased being a point of contention by the middle of the Late Phase. Nimitz' decision, made only seven months into the war, stands at odds with the popular canard that all senior Navy leadership at the time of Pearl Harbor remained myopically focused on battleships.

On the other hand, the wargame process appears, in retrospect, to have been a very poor venue to experiment with and develop submarine tactics. The causes for this failure are closely related to systemic problems in the submarine force that did not make themselves apparent until the start of hostilities. An excellent source for the complete history of the submarine service in WWII is Clay Blair's *Silent Victory*, but in summary, the deficiencies covered the full spectrum from strategy to tactics, and especially technology. Strategically, submarines were still something of an unknown quantity in Interwar Period navies. Only Germany had any significant experience in a submarine campaign, and Great Britain was still making attempts as late as 1930 to ban submarines altogether. The London Naval Treaty, which required submarines to abide by prize rules, outlawed unrestricted submarine warfare against commercial shipping. In the Interwar Period, the U.S. and other navies experimented with "submarine cruisers" equipped with large caliber guns and spotting aircraft (such as the French *Surcouf* and British *M2* and *X1*) and in a minelaying role (such as USS *Argonaut*), reflecting the conflicting views of how they should be employed. U.S. Navy submarine tactics reflected this strategic confusion. Since the War College emphasized combatant actions, especially fleet or at least task force engagements, submarines found themselves assigned to screening duties on the periphery of surface ship formations. Submarine tactics emphasized caution, avoiding detection, and submerged sonar approaches to targets.

U.S submarines were most deficient in the technical sense. Shortcomings in habitability, seakeeping and engine reliability were well known during the Interwar Period, but crippling deficiencies in torpedoes did not reveal themselves until after the start of hostilities. Due to small budgets and service infighting, U.S. Navy torpedoes were inadequately tested, but the small sample of test results was sufficient to convince Navy leadership that their torpedoes would work as advertised under operational conditions. These assumptions were reflected in Maneuver Rules and in War College wargames. Out of favor politically, chronically underfunded, and lagging far behind aviation and expeditionary warfare in terms of emphasis, the U.S. submarine force had to catch up and practice under combat conditions. This process took years, at the price of scores of unsuccessful patrols and avoidable losses. Once overcautious commanders were replaced with more aggressive officers, proper tactics were developed, and most of all, torpedo deficiencies were diagnosed and corrected, the submarine force rapidly evolved into a major factor in the eventual defeat of Japan.

The tactics that were most often exercised in the wargames were surface tactics, and the applicability of the lessons learned in those game to real combat, when it came, is questionable. Students moved from rigid linear formations to more flexible circular approach formations in the Early Phase, and then relaxed the need to remain in precise geometric formations during the Late Phase. The Solomons campaign of 1942-43 encompassed the greatest number of surface engagements fought during the war, but two things that the wargame designers did not foresee (and that Admiral Nimitz did not

mention in his speeches); the Japanese capabilities in night combat and the superiority of their Long Lance torpedoes drove the outcomes of those individual battles.

The wargames also provided a venue for students to experiment with some of the new or proposed technological developments of the Interwar Period. Rigid airships carrying aircraft, gas attacks against land and sea targets, and cruisers with flight decks were all tested, and their mixed performance reflected in game results undoubtedly played some part in the Navy's decisions not to continue with them. On the other hand, developments such as floating dry docks, aircraft carriers converted from merchant ships, converting older combatants for fire support roles, and recommendations for design changes to submarines and for anti-submarine warfare sloops were continued on from ideas to design, construction and deployment.

The game was a constant presence in the Interwar Period, but it was not a solid, tangible entity that the War College could box, label and place on a shelf like an Avalon Hill board game. Neither did it resemble the hardware, software and documentation of the Naval Electronic Warfare Simulator. The physical components of the wargames were simply a series of rooms, a stack of manuals, and some basic measuring and drawing equipment. Neither was the game an oracle or a crystal ball that provided a view into the future. The literal beating heart of the games was that of the people who worked in and around them. These included farsighted War College Presidents like William Sims, William Pratt, and Harris Laning who created and sustained an environment that encouraged and nurtured the initiative of faculty members like Raymond Spruance, Kelly Turner, and John Greenslade. These men in turn constantly updated maneuver problem scenarios, encouraged innovation, challenged their students to explore original solutions, and documented their lessons learned and passed them down from year to year.

One factor that contributed to making the games as useful as they were was that the staff and faculty of the College always considered them as primarily educational tools. There is no evidence in the statements of problems, post-game critiques, or player memoirs that suggests there were any scripts, agendas, or specific programs being showcased, as is often the case today. Students played on both sides, and played their best games regardless of their assigned role. These were not pro forma games, and there is no primary source evidence that results were ever been varnished or "spun" to favor BLUE. One might point to John Hattendorf's anecdote about Captain Ernest King's preference for a northern approach route for his BLUE fleet during OP IV-33 as opposed to the staff's recommendation for a southern route, but the wargame critique shows this to be an attempt to move away from a strategy already proved to be unworkable to one not yet attempted.

Another cause of wargame influence was their sheer ubiquity. Compared to what it would become after World War II, the officer community of the Interwar Period was small, and the War College was a common tour of duty for officers on their way to senior ranks. Officers attended the school, cycled back out to the fleet, and then returned for additional assignments as instructors. Almost all the officers listed on the Registry as staff and faculty were previously students, and six out of the eight Interwar Period War College presidents were former instructors or staff members. Student-officers also played the wargames in a real-world environment with generally current orders of battle as

opposed to notional or fictitious scenarios set years into the future. The upshot of this was a continual communication between the fleet and the school. This allowed graduates to more readily compare what they experienced in real world operations with what they saw on the game floor. With this rotational system in place, the game was continuously updated and refreshed. Wargaming was a widely shared experience among the senior officer corps, and War College methods and lessons became pervasive throughout the Navy. Vice Admiral Olaf Hustvedt '41 was specific in his postwar assessment of the relevance of his War College training. In an interview with the U.S. Naval Institute Oral History program, Hustvedt recalled:

> A couple of years later I was in the Pacific when the attack on the Marshall Islands took place, and when we attacked Truk… [T]hat brought Admiral Ike Giffen and me together for the first time since we had been neighbors at the War College, and…after the immediate fracas around Truk was over…I had time to send a little PVT, private message to Admiral Giffen on his flagship. I said something to the effect, "How are you, Ike? It's great to meet up again on the old campus," because we were actually operating around Truk which we had done on the game board at the War College a year or two before![6]

Hustvedt is referring to OP II-41, the BLUE defense of Truk against an attacking ORANGE force. Anecdotal evidence suggests that during the war, Navy planners painted a map of the Pacific area of responsibility (AOR) on the expansive concrete lanai floor of the Pearl Harbor Submarine Base Bachelor Officer's Quarters—adjacent to Admiral Nimitz' Pacific Fleet Headquarters—and used it for wargames while Marines guarded the building entrances. While this story is anecdotal, it is not implausible. Most of Nimitz' senior staff were War College graduates.

Finally, the War College environment also fostered a quantitative approach to measuring the results of naval tests and experiments, an approach that other venues such as the Fleet Problems could not replicate. The games were a comparatively data-rich source, due to successive iterations of similar games. The actual numbers of games conducted during the Interwar Period is open to question. The records are not complete, and some games such as demonstrations and quick decision problems do not belong in the same category as the major trans-pacific problems. But the true number of games is much less important than the fact that for the 22 years of the period the College conducted four to six two-sided games annually, which provided a significant data set by any measure.[7] In fact, these two wargame attributes—that they were ubiquitous and quantitative—provide an argument that the most significant part of the Nimitz quote was not his reference to the surprises, but his use of the phrase "so many people and in so many different ways." Virtually the entire U.S. Navy officer corps had been preparing to fight the Japanese in the Pacific for the whole Interwar Period in one venue or another, and most of the senior leadership of the Navy had done so at the Naval War College.

In the final analysis, the story of U.S. Navy preparation for World War II is not about the Fleet Problems, the wargames collectively or any single game. Individual

games were "simply vehicles for the transportation of ideas from the abstract to the concrete."[8] The story is more about how the maneuver problems were continuously repeated—differing in detail but constant in theme—and the number of students exposed to them. The interwar Navy was a tight, professional community and the War College games were a shared experience of virtually all naval leaders. The very similar situations were played every year with different students, many of whom came back to the school as instructors, bringing with them a balance of theoretical and practical knowledge. The games were not innovations in themselves or even particularly innovative. Instead, they were a common playing field, a shared experience, a flexible constant, and a proving ground. The games were transformative because the staff and faculty that administered them recognized their educational role and remained adaptable to changing conditions. The student of 1923 would have recognized the mechanics of the games of 1936—maybe not the scenario or the ships, but certainly the game experience. Like Sims's and Laning's football metaphor, the players changed but the game did not.

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[1] Thomas Buell, "Admiral Raymond A. Spruance and the Naval War College: Part I – Preparing for World War II," Naval War College Review Vol. XXIII No. 23, March 1971 32 and "Part II – From Student to Warrior," Vol. XXIII No. 8, April 1971, 33, 45

[2] Basil Liddell Hart, *Strategy* 2nd revised edition, (London: Faber, 1967), 321

[3] Five battleships were sunk at Pearl Harbor, but three (*Tennessee*, *Maryland* and *Pennsylvania*) were less damaged and able to sortie two weeks after the attack. They were joined within two months by *Colorado*, *New Mexico*, *Idaho* and *Mississippi* and grouped into Battleship Division (BATDIV) 1 under VADM William Pye. While the Carrier Task Forces and their cruiser escorts absorbed the brunt of the naval war through 1942 and into 1943, the prewar battleships did not enter a combat zone until after each had completed a comprehensive overhaul.

[4] James D. Hornfischer, *Neptune's Inferno*: The U.S. Navy at Guadalcanal, (New York: Bantam Books, 2011) 22, 383

[5] Gordon W. Prange, Donald M. Goldstein and Katherine V. Dillon, *Miracle at Midway* (New York: Penguin Books, 1983), 59

[6] Olaf M. Hustvedt, *The Reminiscences of Vice Admiral Olaf M. Hustvedt, U.S. Navy (ret.)*, (Annapolis, MD: U.S. Naval Institute, 1975), 186

[7] This figure does not include demonstration games, re-enactment games, or Quick Decision exercises.

[8] U.S. Naval War College, "Operations Problem IV-1928-SR (Trans-Pacific problem)," Folder 1382-VI, Box 41, RG 4 Publications, 1915-1977, NHC, 7 of Section (i) Conclusions and Lessons Learned, 3. The critique does not record the author's name, but it is most probably Captain John W. Greenslade.

Wargaming the Atlantic War:

Captain Gilbert Roberts and the Wrens of the Western Approaches Tactical Unit

by Paul Edward Strong

The staff at the Western Approaches Tactical Unit - 22 January 1945.
Note the chalk marks, indicating key moves in the wargame, on the tactical floor
(Admiralty Official Collection IWM)

Abstract

The Western Approaches Tactical Unit (WATU) was a Royal Navy analysis team founded in early 1942. Their remit was to study the conduct of convoy operations, to understand how the U-boats operated and to formulate tactics to counter this evolving threat. The unit was made up of experienced naval officers and a number of talented young women from the WRNS. Using conceptual/analytical wargames, WATU developed a range of tactics during the war and disseminated these to over 5,000 Allied officers through a series of lectures and tactical games. Many of these appeared in the Atlantic Convoy Instructions and were used with considerable success by Allied naval forces during the decisive engagements of the Atlantic War. The essay outlines the origins and purpose of the organisation, how the team functioned, the individuals that conducted the wargames, and the series of evolving challenges that it was intended to overcome – focusing on the series of Anti-Submarine Warfare training and analysis wargames conducted by the unit between 1942 and 1943. The article concludes with an overview of some of the numerous lessons that modern defence analysts could draw from the work of the unit and highlights its utility as an exemplar of the use of wargaming as a tool for modern defence analysis.

"The only thing that ever really frightened me during the war was the U-boat peril."

Winston Churchill

The Western Approaches Tactical Unit was a dedicated training and analysis team created in January 1942 and tasked to improve the development and dissemination of new tactics to Royal Navy and Allied vessels escorting convoys across the Atlantic. Using innovative analytical methods, WATU developed a range of tactics during the war and disseminated these to over 5,000 officers through a series of lectures and tactical wargames. Many of these appeared in the Atlantic Convoy Instructions and were used with considerable success by the Royal Navy, the Royal Canadian Navy, the United States Navy and other Allied naval forces during the decisive engagements of the Atlantic War.

Keeping supplies flowing across the Atlantic to the UK (and transporting a proportion onwards to Russia) was vital to Allied strategy during the Second World War[1]. Reminiscing after the war ended, Churchill noted "never for one moment could we forget that everything happening elsewhere, at sea or in the air, depended ultimately on (the) outcome (of the Atlantic War)"[2]. During the inter-war period, the Royal Navy had been confident that they could deal with almost any conceivable scenario involving a submarine threat. The tactics and technologies developed in the First World War (particularly convoy and the sonar technology known as ASDIC) were still deemed to have utility[3], the German U-boat fleet was relatively small, and the few ocean-capable boats that the Kriegsmarine possessed were assumed to have to transit the Dover Strait or the North Sea to reach Britain's shipping lanes. However, the Fall of France in 1940 transformed the strategic situation, giving the Germans access to bases on the French Atlantic coast. As the war unfolded, increased production increased the number of operational boats and eight U-boat flotillas were eventually deployed to French bases - Brest (1st and 9th), Lorient (2nd and 10th), Saint Nazaire (7th and 6th), La Rochelle (3rd) and Bordeaux (12th)[4]. Understandably, the British increased the number of convoy escorts to protect their shipping.

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[1] This essay is an expanded version of the short article that appeared in Issue 16 of the Women in War Group newsletter. The inspiration for this article came from Mark Williams, *Captain Gilbert Roberts RN and the Anti-U-boat School*, Cassell (1979) - the subject was first suggested by Edward Butcher of the Royal Navy's Maritime Warfare Centre and kindly supported by Jenny Wraight, the Admiralty Librarian at the Royal Navy's Navy Historical Branch. For detail on the impact on UK trade of the U-boat campaign, see *The Battle of the Atlantic – 1939 – 1945, The 50th Anniversary International Naval Conference* (edited by Stephen Howarth and Derek Law), Greenhill (1994), Philip Pugh, Chapter 1, 'Military need and Civil Necessity' and Thomas Adams, Chapter 8, 'The Control of British Merchant Shipping'.

[2] Winston Churchill, *The Second World War*, Vol 5, (1951) P.6

[3] Atlantic War Conference (1994), H. P. Willmott, Chapter 9 – 'The Organisations: The Admiralty and the Western Approaches', P180, Willmott notes that there was no attempt to analyse the lessons of the WWI ASW effort in the interwar period due to the expectation that the threat had been adequately countered. This delayed the re-introduction of convoys. William Glover - Chapter 10 – 'Manning and Training in the Allied Navies', P 189, notes that only 11 of 1,029 lieutenants and 16 of 972 lieutenant commanders specialised in ASW in 1935

[4] Atlantic War Conference (1994), Willmott in Chapter 9 points out that any analytical scenario that suggested that France would have been rapidly overwhelmed would not have been deemed plausible in the interwar period

In a series of pre-war wargames, Befehlshaber der Unterseeboote (Commander of U-Boats) Karl Dönitz and his planners had tested the potential for evading the Royal Navy's ASDIC and hydrophone capabilities by attacking on the surface in a series of wargames and exercises. In the early years, radar was rudimentary and the few sets available were limited to shore facilities and the largest warships so the escorts would have to depend on spotting potential attackers with the naked eye. In addition, the Ubootwaffe's analysts confirmed Dönitz's assumption during the Great War that a coordinated attack by several U-boats would be more effective than a single submarine taking on the entire escort group[5]. This was the origin of the dreaded wolf-pack, a term derived from Dönitz describing his captains as using *rudeltaktik* (wolf-pack tactics) to overwhelm a convoy's protection. Using these tactics, the available U-boats deployed in patrol lines across the Atlantic and then converged on a suitable target once it was spotted. Sometimes convoys were also spotted by a Focke-Wulf 200 (Condor) observation aircraft or identified from intelligence/signals analysis by the highly efficient B-Dienst (Beobachtungsdienst - observation service).

At this early stage in the war, attacks on the sparsely defended convoys were made at night and the U-boats attempted to coordinate their attacks so that the escorts would be overwhelmed. If spotted, the U-boat would accelerate and crash-dive - turning off their diesel engines when they submerged and relying on their batteries to make a series of silent turns so that their course and position were as unpredictable as possible. The hunting vessel's ASDIC operator sent out a series of sonar pings (the effective range was about 1,300 yards), attempting to use the distinctive reflected counter-ping to identify the target's approximate range and bearing. An 'instantaneous echo' indicating that the U-boat was directly ahead of the escort – thus presenting an opportunity to drop a pattern of potentially lethal depth charges. In the early years of the war, these would be rolled off the back of the escort with additional depth charges being fired from spigot mortars. These would then detonate at a pre-set depth some distance behind the vessel. Later variants had more powerful explosives and the stern-deployed pattern was supplemented by improved devices to increase the size and effectiveness of the spread. Depth charges do not have to directly hit a submarine; in addition to improved explosive propagation underwater, sub-surface explosions create pockets of air that implode and cause structural stresses, damaging the target or rupturing their hull. Veteran U-boat captains often listened for the splashes created by depth charges entering the water and would 'go deep' or order a quick burst of speed and drastically change their bearing, knowing that the sound of the escort's engines during the final approach and the pattern of detonations that followed would temporarily blind the escort's ASDIC system[6].

[5] Richard Doherty, *Churchill's greatest Fear: The Battle of the Atlantic, 3rd September 1939 to 7th May 1945*, Pen & Sword (2015), P.20

[6] The Germans discovered that diving deeper would often put them beneath a thermal layer that would reduce the effectiveness of ASDIC. See also Peter Gretton, *Convoy Commander*, Corgi (1971), P.189, Gretton notes, after he had a chance to inspect U-boat command's records after the war, that the Germans use their hydrophones with great skill; both to monitor Allied escorts and to listen for distant convoys

Depth Charge detonating at the stern of HMS Starling (Wikimedia Commons)

As the numbers of U-boats increased, Dönitz eventually managed to gather large wolf-packs of up to forty submarines but he was rarely able to create decisive concentrations where they were most needed. The problem was that creating a wolf-pack required coordination and that created communications that the British could intercept and interpret. The British initially had considerable difficulty in breaking the more complex Kriegsmarine cyphers but, after getting access to U-110's codebooks and her Enigma machine in May 1941, the situation was transformed[7]. From this point onwards, U-boat communications were methodically collected by Y-Service's network of listening stations and then decrypted at Bletchley Park. This enabled Western Approaches Command to order convoys to evade the U-boat screen or concentrate escorts where they were most needed. The Kriegsmarine changed their codes more often than the Oberkommando des Heeres (army command) or the Luftwaffe so the code-breakers were often forced to work long hours to re-establish the flow of decrypted material. This process was hugely assisted by the flows of reports between the U-boats and the constant updates demanded by their HQ in Occupied France. The flow of communications also enabled high-frequency direction finding (HF/DF or Huff-Duff) which enabled the rough positions of U-boats to be triangulated, a process that got far easier once HF/DF sets were deployed on escorts. This information hugely assisted in the interception of surfaced U-boats by escorts or aircraft and was another method used by Western Approaches Command to re-route convoys so that they could evade the patrol lines[8].

The first 'happy time' for the U-boats ended once Royal Navy and Royal Canadian Navy vessels could cover the entire trans-Atlantic route and once sufficient air power was finally diverted to hunting U-boats lurking in coastal waters. The veteran U-boat

[7] Marc Milner, *The Battle of the Atlantic*, Tempus (2005), pp 61-62

[8] Atlantic War Conference (1994), Jurgen Rohwer, Chapter 22 – 'The Wireless War' and Paul Kennedy, *Engineers of Victory: The Problem Solvers Who Turned the Tide in the Second World War*, Allen Lane (2013), Chapter 1

commanders inevitably shifted to picking off stragglers and concentrating their activities on the Mid-Atlantic Air Gap, where the convoys were out of range of Allied aircraft - a region known for poor weather and described by many escort captains as 'The Gap' or 'The Black Pit'. The obvious solution was to deploy carriers to cover this region but these were a scarce resource and the larger fleet carriers proved to be too juicy a target to risk in a convoy so numerous smaller and cheaper Merchant Aircraft Carriers, and subsequently escort carriers, were commissioned and these eventually did sterling service against the U-boats[9]. A typical convoy escort group would shepherd their charges in a strict rectangular formation, with the escorts deployed in a ring around the convoy conducting ASDIC/Radar sweeps. In the early years of the war there were very few escorts and some of these more suited to dealing with surface raiders - Convoy HX-84 initially set sail with only HMS Jervis Bay for company[10]! The escorts would be deployed to cover the most likely direction of threat, either identified by HF/DF or the escort group commander's intuition.

For example, in December 1941, HG-76 protected by Escort Group 36, commanded by Captain Frederick 'Johnny' Walker, set off for the UK. The convoy consisted of thirty-two merchant ships protected by seventeen escorts - including an escort carrier (HMS Audacity). Dönitz ordered ten U-boats to converge on the convoy. Even with the high proportion of escorts and Walker's impressively pro-active approach to convoy protection, the U-boats still managed to sink two merchant ships, an escort and Audacity. Five U-boats were lost during the attack, a testament to the effectiveness of airpower and Walker's aggressive tactics. Some of the escorts were equipped with early radar sets and the effectiveness of these primitive systems was undoubtedly increased by the relatively calm sea-state during the engagement. At this stage in the war, radar operators often found it difficult to pick out a U-boat's conning tower from the noise created by an uneven sea state[11].

Early 1942 saw an unexpected setback in the duel between the U-boats and the convoy escorts. The Japanese attack on Pearl Harbour had brought the United States into the war but most of her best ships were transferred to the Pacific and the US Navy in the Atlantic proved surprisingly ill-prepared for combat against Dönitz's veteran U-boat commanders. Part of the problem was that the renowned series of US Navy wargames conducted in the 1930s had tended to focus on a future surface conflict against either Japan or the United Kingdom. The situation was exacerbated by the lack of escorts available for Atlantic duties, the failure to impose a blackout on the East coast, and the USN's *1941 Escort of Convoy Instructions* prioritising actively 'hunting' U-boats over the dull business of protecting convoys. The situation wasn't improved by Admiral Ernest King's notorious reluctance to listen to any advice offered by the Royal Navy[12].

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[9] The Fleet Carriers were used in the Mediterranean convoys where the threat from the Luftwaffe and Regia Aeronautica made combat air patrols essential

[10] See https://en.wikipedia.org/wiki/List_of_Allied_convoy_codes_during_World_War_II for a comprehensive list of 300 convoy codes – each defining the start point or destination of the convoy

[11] Atlantic War Conference (1994), Jan Heitman, Chapter 27 – 'The Front Line: Convoy HG76 – The Offense' and A.B. Sainsbury, Chapter 28 – 'The Front Line: Convoy HG76 – The Defence'

[12] Milner (2005), pp.75, 85-86, 93 and William Glover, Chapter 10 – 'Manning and Training in the Allied Navies', P.204, King insisted on trying to maintain personal control and it is possible that his notorious anglophobia was merely a way disguising his desire to retain control of the USN's overall operations. It is notable that US submarines were the one part of the USN that proved ill prepared for

The result was a second ‘happy time’ for the U-boats and a dramatic rise in sinkings off the US coast, particularly of the oil tankers that were critical to Allied survival. For several weeks, the U-boats appeared to have the decisive advantage in the Western Atlantic and food, sailors, and war supplies were being lost at a terrifying rate.

In January 1942, Captain Gilbert Roberts, a veteran officer unable to serve at sea due to a tuberculosis infection, was summoned to the Admiralty and directed to the office of the Second Sea Lord, Sir Charles Little. The First Sea Lord's adviser on Anti-Submarine Warfare (ASW), Admiral Sir Cecil Usborne, was also present as the Prime Minister’s representative. Winston Churchill wanted to know if the navy had the capability to defeat the U-boats and, if not, what needed to be improved. Usborne had discussed the situation with Admiral Sir Percy Noble at Western Approaches Command in Liverpool, and the solution they had identified was a tactical unit that could develop and review new ASW tactics and emerging technologies and then develop a course to train officers about to deploy on escort duty. The new unit’s activities would supplement the existing hands-on ‘working-up’ course, run at Tobermory by Commodore Gilbert Stephenson[13], and serve as a test-bed for tactics being developed for the regularly updated *Western Approaches Convoy Instructions* (after September 1942, these became the joint RN/RCN/USN *Atlantic Convoy Instructions)*[14].

Roberts was tasked to train a small team of analysts, to be called the Western Approaches Tactical Unit (WATU), and identify tactics that could be used to turn the tide of the battle in the Atlantic[15]. His selection was based upon his role in the Fleet Exercises in 1935 and his period at the Royal Navy’s Tactical School in Portsmouth between 1935 and 1937, where he had been an enthusiastic proponent of wargaming as a useful tool for both training and analysis – though it is notable that his suggestion that the school use a wargame to model the potential threat from commerce raiding was studiously ignored[16]. The seriousness of the appointment was made even clearer after a brief face-to-face meeting with the Prime Minister who growled "find out what is happening in the Atlantic, find ways of getting the convoys through, and sink the U-boats!”

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war in 1941 and it took over a year for them to reach peak efficiency against the relatively mediocre Japanese escort flotillas. For a US perspective see Clay Blair, *Hitler's U-boat War: The Hunters, 1939-42* v.1 (Vol 1) & *Hitler's U-boat War: The Hunted 1942-45 (Volume 2): The Hunted, 1942-45* Vol 2, Cassell & Co, (2000). There were a series of wargames dealing with ASW issues in the 1920s but only one of these dealt with the Atlantic (Tac 93 in 1923 examined a mixed engagement against the RN with submarines on both sides). See Dr. Thomas Choinski (forthcoming paper on Dramaturgy, ‘Wargaming and Technological Innovation in the United State Navy: Four Historical Case Studies’.

[13] Richard Baker, *Terror of Tobermory: Vice Admiral Sir Gilbert Stephenson*, Birlinn (2006). Stephenson was an eccentric genius who made a huge contribution to the effectiveness of the Escort Groups. See also Atlantic War Conference, Chapter 10, P.198

[14] Milner (2005), pp.125-6, Finally solving the problem of Allied escorts not understanding each other’s ASW signals – such as a RN *Pineapple* or a USN *Zombie Crack*

[15] ‘Interim Progress Report by Naval Advisor to First Sea Lord on U-boat Warfare,’ Vice Admiral C.V. Usborne, 20 January 1942, ADM 205/21, ‘Minutes of the 32nd Meeting held in the Upper War Rook, Admiralty House, at 1130 on 7 April 1942, to Consider Trade Protection Measures,’ DTD, 7 April 1942, ADM 199/2082, and, Vice Admiral C.V. Usborne, Naval Advisor to 1st Sea Lord on U-boat Warfare, 14 April 1942, ADM 205/22A, See also Atlantic War Conference, Glover, Chapter 10, pp. 202-3

[16] Williams (1979), pp.70-72

On arrival in Liverpool, Roberts was surprised to find that interest had already waned. Admiral Sir Percy Noble, then commanding Western Approaches Command at Derby House, had assured Usborne of his support for WATU in their initial meeting, but was far too busy to do more than dismiss Roberts to the uppermost floor of the Exchange Flags Building, part of the complex that included Derby House, after a short discussion marred by confusion over Roberts' experience at the Tactical School and his suitability for the role[17].

Roberts' first concern was to find out what was happening to the convoys so he pored over the after-action reports looking for clues to the U-boat's tactics. He questioned naval officers visiting Western Approaches Command and it became clear that almost the only tactic that was being followed was to dash to the assumed location of the attacking U-boat and conduct an ASDIC sweep in the hope of finding the enemy, or forcing them to abandon their attack and 'go deep'. One of the most interesting discussions was with Commander Frederic 'Johnny' Walker, one of the few officers that had developed tactics to counter the U-boats at night - on the signal "*Buttercup"*, the escorts under his command would turn outwards and fire a spread of star-shells in the hope of locating any surfaced U-boats lurking around the convoy[18]. Another successful officer, Commander Clarence Howard-Johnson, stated that he generally ordered his escorts to widen their search after an attack, radiating outwards and zigzagging to maximise their coverage. Roberts was intrigued and decided to investigate why these tactics worked.

The WATU facility was primitive, with tactical tables, a tactical floor divided into squares, basic ship models, and a small lecture theatre, but Roberts quickly got to work. A basic set of wargame rules were developed and a set of processes were designed to represent real-time decision cycles, tactical doctrine, and communications issues. Then the room was re-arranged so that players representing escort commanders could only see the gameplay through a restrictive canvas screen (see photograph on page 8) to represent the limited information that they would have in a real battle while the adjudication team moved the model ships according to the orders submitted by the players and their unseen adversaries. Orders were simplified to facilitate gameplay; each chit outlining the vessel's course, speed, radar track, ASDIC profile, and the commander's intent - each turn represented two minutes of time. The U-boat track was drawn on the tactical floor in brown chalk line so it would be invisible to players looking through their assign canvas slit but allow the umpires and 'movers' to still follow its progress.

Roberts was assigned a small staff to assist him. Chief Yeoman Raynor was the first to arrive from the Tactical School at Portsmouth, then the young women assigned to the unit from the Women's Royal Naval Service appeared. The four Wren officers, Elizabeth Drake, Jane Howes, Jean Laidlaw and Nan Wailes, were described as 'real gems' by Roberts, all brimming with enthusiasm and delighted to be doing serious work. In addition, four WRNS ratings also arrived, two were only seventeen. One of the

[17] Sir Percy assumed that Roberts was a surface gunnery specialist as many of the wargames he ran at the Tactical Focused were focused on gunnery (he was G on the staff)

[18] Doherty (2015) suggests that Walker's tactic may even have silhouetted Audacity and made her an obvious target

younger ratings, Janet Okell got lost in the building trying to find WATU during a blackout and was in tears by the time she was introduced to Roberts by her burly Royal Marine rescuer; an inauspicious beginning for one of the most talented analysts of the war. The Wrens had to be trained in ASW techniques and technology before they could be useful but the team proved quick learners and soon mastered the skills they needed to run the analytical and training wargames that were to become the WATU's contribution to the war effort.

WATU Wren Officer explaining the situation to an Escort Commander (Photo IWM Collection)

Armed with the information he gained from his interviews of returning escort commanders, Roberts set about finding out how U-boats made their attacks and what approaches they used to evade the escorts. Roberts quickly identified a key flaw in the existing approaches – very few escort commanders considered the U-boat commanders' point of view. As a result, they often depended on luck and not calculation when choosing where to start an ASDIC search-pattern. Realising that the key to understanding the enemy was seeing the problem from their perspective, Roberts studied the reports on U-boat attacks on convoy HG-76 to evaluate how best to approach a convoy during a night attack. As the team analysed the descriptions of the attacks on the convoy and wargamed alternative approaches, it soon became obvious that the optimum approach for the U-boat was not to attack from outside the defensive perimeter but to move stealthily between the lines of supply ships on the surface, selecting their target at leisure and then using their intended victims as cover[19]!

Roberts called RN Submarine Command hoping to consult an old friend but the phone was answered by Admiral Sir Max Horton, a WWI veteran and the Flag Officer at RN Submarine command. Horton patiently listened to Roberts' theory and confirmed that

[19] A tactic favoured and promulgated by Otto Kretschmer, commander of U-99

it was the approach that he himself would use, particularly as the maximum range of the standard German torpedo was 5,400 yards (the average firing distance would thus be far less) which would require the U-boat to launch from well within the escort screen. Delighted by Sir Max's confirmation, Roberts set up a new series of wargames to explore options for countering the approach the team had identified.

It was getting late but Raynor, Laidlaw and Okell stayed behind to test the concept on a convoy escorted by six vessels. A range of U-boat attack options were tested and it was clear that the best approach for a U-boat was from astern of the convoy. The obvious conclusion from their analysis was that Walker and Howard-Johnson had both intuitively come upon a tactic that worked best against any additional U-boats trying to join the battle and not against the original attacker. As Roberts re-examined Laidlaw's detailed plots from each game and her meticulous record of the discussions, he realised that a U-boat that evaded an escort would probably dive and come up again astern of the convoy. The team agreed that he was onto something and volunteered to continue wargaming.

The tactic they found most effective was a coordinated pre-determined movement activated by a simple one-word signal involving most of the escorts falling back after the initial attack then trawling up to the convoy with an ASDIC sweep in line astern, thus catching the U-boat as it switched off its engines and allowed the convoy to pass overhead. The key to the tactic was that the escorts had time to manoeuvre as the convoy slowly steamed over the hidden U-boat’s position. The theory was that the U-boat commander would assume that the escorts were conducting a general sweep or searching within the convoy and would thus be caught by the targeted sweep converging on the rear of the convoy. As dawn rose, the exhausted team were sent home and Roberts arranged a demonstration.

A sceptical Sir Percy Noble arrived with his staff (including Howard-Johnson) the next day and watched as the team worked through a series of demonstration attacks on illustrative convoy based upon HG-76. The team started with a run through of the original narrative, showing how the U-boats were evading the standard ASW tactics. Roberts then described the logic behind their assumptions about the approach being used by the U-boats and demonstrated the counter-move; one that Wren Officer Laidlaw had mischievously named *Raspberry*.

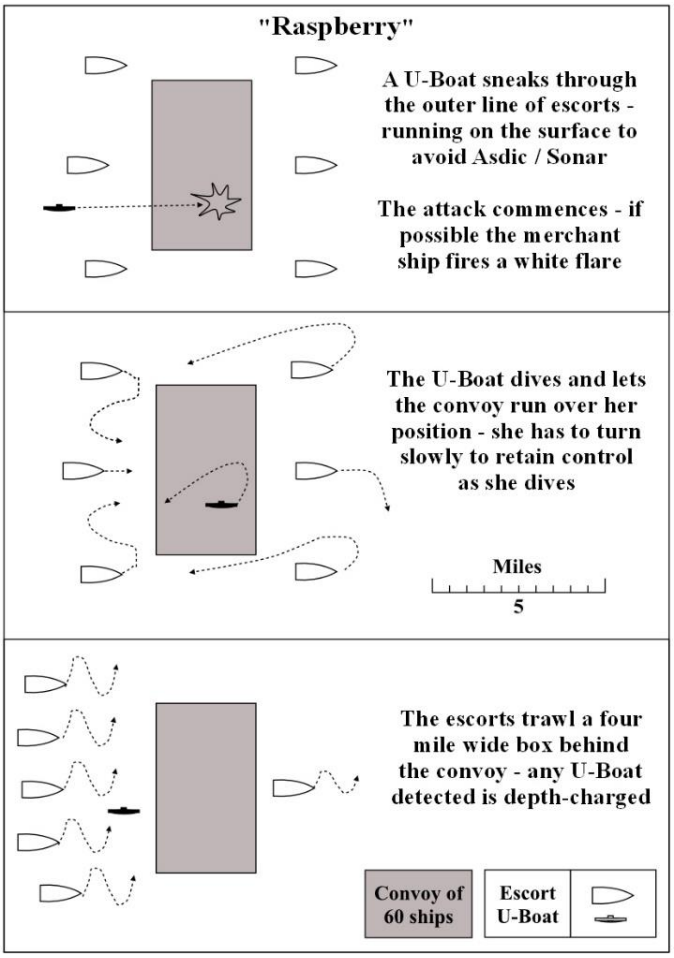

Figure 1: Illustrative Schematic of a Raspberry in Progress

Sir Percy Noble's demeanour changed dramatically as the demonstration unfolded. Unlike every other approach, the solution WATU had identified was based upon the U-boat commander's most logical course of action and not just a reaction to a stricken merchant vessel. The new tactic was immediately sent up to the Admiralty and Roberts was promoted on the spot. From now on the WATU would be regular visitors to the Operations Room, and Sir Percy ordered that all escort officers should attend the ASW course that the team were designing. Interestingly, after the demonstration, Roberts was sent to London to review interrogation transcripts from captured U-boat personnel, and these confirmed many of the assumptions made in the first series of wargames.

The first course included both junior officers and veteran escort commanders. Roberts wanted the participants to use the wargames to share their ideas and experiences, and deliberately using mixed groups of officers proved a very effective way of ensuring that the wargames were more than just rote demonstrations of doctrine. The training wargames appear to have been designed to highlight the issues and problems that escort commanders would face during an engagement with the results based upon detailed tables listing the projected capabilities of Axis and Allied weapon systems. Roberts debriefed the assembled officers on the results of each game and these were a key part of the process. The analytical wargames were more open-ended with multiple iterations of the same scenario and more extensive discussions on potential German tactics and technology. Out of the 5,000 officers, drawn from a wide range of Allied nations, who

attended the school, none had the slightest problem with being instructed by young Wrens - particularly as they proved extremely skilled at guiding their students through the more complex manoeuvres without hurting their feelings[20]. During the battle to defend convoy ONS 122, the senior escort officer noted that 'it was a pleasure to see (and hear) the Norwegians go into action, *Raspberry* went like clockwork and whenever, during the night, the cry of "Tally-ho" was heard on the scram, I only had to check the bearings' to know where a U-boat was being hunted[21].

Each of the courses looked at ASW and surface attacks on a convoy and the students were encouraged to take part in the analytical wargames that evaluated potential new tactics. *Raspberry* was soon followed by *Strawberry*, *Gooseberry* and *Pineapple* and as the escorts went over to the offensive, the tactical priority increasingly shifted from defence to hunting and killing U-boats. WATU also ran courses for escort groups deploying to other theatres and ran training wargames looking at potential engagements with surface raiders – one, codenamed *Umbrella*, explored options for drawing off the raiders and another explored potential approaches for conducting swarm attacks on surface vessels[22]. The PQ convoys transiting to North Russia faced unique challenges and the potential threat from both air and surface vessels was added to the wargames offered to these officers. Wargames looking at improving collaboration between surface vessels and escorts were particularly important, as aircraft - even before the introduction of rockets, Leigh Lights, improved depth charges and acoustic torpedoes – tended to force any U-boats trailing a convoy to submerge and abandon their pursuit. Forcing U-boats on the patrol lines to dive was an effective way of reducing their ability to spot a convoy.

Roberts continued as Director of WATU throughout 1942 but was also appointed as Assistant Chief of Staff Intelligence at Western Approaches Command to ensure that he had access to the intelligence data he needed to continuously update the course. One piece of intelligence that began to intrigue him was a set of reports of U-boats being spotted ahead and to the side of the convoy's course. This was clearly a 'sighting' submarine, reporting on the convoy's position and acting as a marker for other U-boats. If forced to dive, the U-boat usually sent a standard signal after two hours. Roberts noted that this could be used to warn the convoy that a wolf-pack was converging on their position. Alternatively, the escort group could then opt to attack the U-boat while the rest of the convoy changed course or even try to sink the U-boat before it signalled. The latter was clearly the more rewarding challenge and the team set about wargaming the various options. It soon became apparent that a U-boat had the option to 'go deep' immediately if he thought he was at risk (and attempt to reacquire the convoy later) or they could opt to dash off a brief signal. Roberts was sure that most U-boat captains would prefer to send a detailed signal so assumed that their default tactic was to evade

[20] Williams (1979) pp.101-102 and Nicholas Monsarrat, *The Cruel Sea*, (1951) pp.278-280
[21] Milner (2005) P.128
[22] 'Operation "Umbrella": Description of Raider Exercise,' C-in-C, WA, 3081/0770/65, M.014064/42, 25 October 1942, ADM 1/11931, 'Raider Exercise,' Admiral Percy Noble, Commander-in-Chief, Western Approaches, WA.3081/0770/65, 25 October 1942, ADM 1/11931, 'Operation "Umbrella" (for use by day),' Commander Gilbert H. Roberts, [WATU], Enclosure to, 'Raider Exercise,' Admiral Percy Noble, Commander-in-Chief, Western Approaches, WA.3081/0770/65, 25 October 1942, ADM 1/11931

to the rear of the convoy to avoid any escorts and then calmly report on any changes in convoy's course or dispositions. The discussions during the team's next series of analytical wargames confirmed the evidence drawn from signals intelligence that the U-boat's best option was to conserve its batteries and conduct a low-speed turn to its new position before sending the vital signal. The U-boat would thus have to be sunk by stealth if the escort wanted to destroy them before they signalled.

The solution the WATU games suggested was to allow the 'sighting' submarine to dive unmolested once it spotted an escort getting too close, but not to pursue immediately so that the U-boat wasn't alerted. As soon as the assigned escort was between the convoy and the submarine, the Allied vessel would suddenly increase speed and dash to U-boat's assumed position, using the convoy's combined propeller noise as cover, and then turn on their ASDIC once they were almost on top of the U-boat's predicted position. This process was named the *Beta Search*.

WATU Wren organising a set of convoy markers for a wargame (Photo IWM Collection)

In November 1942, Sir Max Horton was promoted to Commander in Chief Western Approaches and after hearing Roberts' brief on the work being conducted at WATU, volunteered to play a U-boat commander during his first visit to the unit. Roberts decided to ask the admiral to test the new tactic and the now eighteen-year-old Janet Okell was assigned the role of escort group commander. This apparently controversial selection was probably based on Okell having repeatedly demonstrated an instinctive grasp of U-boat tactics, a conclusion supported by the sequence of pictures of WATU at work (taken later in the war) where she is shown sitting at the adjudication table playing the U-boat commander.

Sir Max made five attempts to evade the escorts and each time Okell ruthlessly closed in and sank his U-boat. Horton was a skilled submariner but there was no way that he could confirm precisely when he had been spotted, taking away one of his major advantages over the convoy escorts. Each time he dived to avoid a patrolling escort and attempted to carefully manoeuvre into position to send a signal, his first clue that Okell had found him was the adjudication team telling him that he had been 'pinged' by

ASDIC and was being depth charged. After the third defeat, he even insisted on checking what the escort player could see of his U-boat's track through the grill before returning to his tactical table to write new orders[23]. When the notoriously ruthless and blunt Admiral Horton discovered that his opponent had been a young Wren rating, he was apparently horrified but, unlike many senior officers (then and today), he was far more interested in results than in his ego and *Beta Search* was included in the next set of Fleet Orders. HMS Vidette was the first ship to try out the tactic and bagged a U-boat with its first pattern of depth charges. Once again, the Royal Navy had shown that they could seize the initiative from their stealthier opponents.

Wargame in progress (1944) with a Wren Officer indicating a torpedo strike, Roberts directing the game and Janet Okell glancing over her shoulder to peer at the camera (Photo: IWM Collection)

As the U-boat commanders developed new tactics, WATU's enthusiastic and dedicated operational analysis team quickly identified each new approach and developed effective counters; the Germans often losing numerous U-boats before any weaknesses of the new tactic became apparent to Dönitz and his rapidly decreasing cadre of veteran commanders. The team also examined tactics developed by operational escort commanders and disseminated these to the escort groups once their tactical effectiveness was established. An example is the *Observant* tactic developed by HMS Spey, which WATU tested and deemed effective, but made improvements after their devious U-boat players discovered a gap in the pattern that a skilled submariner could exploit[24]. *Pineapple* was developed from a suggestion from a Canadian officer on how the Germans might shift their tactics if *Raspberry* was observed by a second U-boat

[23] W.S. Chalmers, Max Horton and the Western Approaches, Hodder and Stoughton, 1958, P.168
[24] 'OS 33,' Operations Secretariat Records, n.d., ADM 237/144, Minute, C.D. Howard-Johnston, SOAS, 20 October 1942, ADM 237/144

beyond the range of the initial sweep. *Pineapple* also assumed that U-boat commanders were not uniformly aggressive. The first objective of the new tactic was to force the sighted U-boat to dive by racing towards the enemy position, then conduct a more deliberate sweep of the optimum attack vectors to catch the ones that didn't go deep[25].

Roberts was fully aware of the proven skills of his adversary, and WATU did not wait for German tactics to evolve before adapting. Roberts used his access to intelligence data to compile a detailed history of known U-boat tactics and used the WATU wargames to evaluate possible adaptations of old tactics or to explore the capabilities of emerging technological breakthroughs. In addition, each course was attended by at least one Coastal Command officer to ensure that air/sea co-operation was properly represented and that any opportunities for joint operations were fully explored[26]. In the early years, U-boats could dive and avoid aircraft but as tactics, airborne radar systems, and weapons improved, Allied planes started to turn the tide against the U-boats[27]. WATU graduates were regularly popping by to share their experiences and these often proved invaluable. Peter Gretton, one of the most successful escort commanders of the war, was one of these regular visitors to the Unit[28].

Dönitz started to believe that the increased number of escorts, including Canadian and US vessels, was increasing the risk to his U-boat commanders. The obvious solution was to increase the size of the wolf-packs so that the escorts would be completely overwhelmed. Wolf-packs made every ASW tactic more difficult to operate, as the first U-boats to arrive would observe their target and signal any changes in the disposition of escorts to the rest of the converging pack. Once enough were in position, the whole group would begin to look for weak points in the convoy's screen. As the escorts homed in on the first U-boat detected by ASDIC, radar or observers, the rest would move in through any gaps and hunt the exposed merchant vessels at their leisure. Faced by a cascade of reports of U-boats, the escorts would be reduced to dashing from one crisis to another while the experienced German captains picked their targets and then left the less skilled U-boats to suffer the consequences. Unsurprisingly, WATU had predicted the increased impact of larger wolf-packs and, amongst their solutions, had proposed that air power (B-24s with extra fuel tanks or convoy escort carriers) could be used to hunt any surfaced U-boats awaiting updates on the convoy and gathering in her wake.

The WATU team also developed and tested pre-determined tactics for a range of situations – for example suggesting using an outer and inner ring of escorts for major wolf-pack attacks – with the outer screen dealing with the detection of incoming U-boats and the inner screen protecting the heart of the convoy from the veteran commanders that preferred to use the pursuit of their comrades as cover. This was the genesis of the Support Group tactics that were to dominate the second half of the Atlantic War. In all, five Royal Navy Support (Escort) Groups were created (the US

[25] Commander Douglas Prentice (RCN) named the tactic *Major Hoople* but WATU re-named it *Pineapple* after making several improvements

[26] Gretton (1971) P.177, Gretton highlights the master of a Merchant Aircraft Carrier having taken the course before being assigned to his B7 Escort Group

[27] Milner (2005), pp.113-114, Milner notes that, in early 1942, few submarines were sunk by aircraft but, by 1943, they were inflicting the lion's share of the kills. Atlantic War Conference (1994), Chapter 9 - Willmott notes that the improvements in coordination led to a 90% contact rate

[28] Gretton (1971) pp.107-8, Gretton eventually married Judith Duvivier, one of the WATU Wrens

Navy created similar hunter-killer groups), often deploying with a dedicated escort carrier. These were despatched to assist convoys under imminent threat of attack – both to strengthen the escort and enable more offensive tactics against any U-boats converging on the convoy – the most famous of these units was 'Johnny' Walker's Support (Escort) Group 2. It is important to note that the concept was reliant on access to accurate intelligence to direct the Support Group to where they would have the most effect[29].

Sir Max Horton worked closely with the WATU analysts and he was so delighted with the display Roberts and his team put on when King George VI visited WATU that he volunteered to take the course himself. The Admiral stayed for the whole week, attending the lectures and taking part in the wargames. This commitment might seem unusual for an operational commander fighting a major campaign, but Horton was keen to learn how WATU developed new tactics and understood the importance of being seen to embrace new approaches. When a petty bureaucrat in Whitehall unwisely threatened to remove Roberts' clearance to read classified material linked to WATU's work, because he was merely a retired acting-captain, Horton hunted down the offending individual and 'pinned back their ears'[30].

WATU's facility was eventually duplicated at Maydown in February 1943, at HMS Shrike, with a focus on air-sea collaboration – eventually becoming the Combined Anti-Submarine Training Centre. Similar facilities were created to support the main Allied navies. The Canadians sent numerous officers to take the WATU course but also developed their own training capability at Halifax, Nova Scotia in May 1942, under the control of the formidable Commander (later Admiral) J. C. Hibbard. Like Roberts, Hibbard identified coordination as the key to success and created a Night Escort Attack Teacher rig to enhance training[31]. Sadly, the USN's senior leadership were less keen on direct collaboration but did create both the Submarine Chaser Training Centre (commanded by the energetic and innovative Captain Eugene McDaniel[32]) and the Atlantic Fleet ASW Unit in Boston (later the Anti-Submarine Warfare Operations Group) in March 1942. In the latter unit, Admiral Wilder D. Baker and his colleagues developed new ASW tactics for the US Navy and fulfilled many of the functions of the Royal Navy's operational research team, making a major contribution to US air-sea coordination. Baker's team were later absorbed into Admiral King's integrated 10th Fleet Command in May 1943 after the Atlantic Convoy Conference[33]. Eventually, the insights of all these teams were combined with WATU's in the *Joint Atlantic Convoy Instructions*.

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[29] Gretton (1974), P.174, notes that the operations in Spring 1943 were guided by 'intelligent anticipation' after the flow of traffic from Bletchley Park dried up

[30] Williams (1979), P.117

[31] William Glover - Chapter 10 – 'Manning and Training in the Allied Navies', pp.203-4, see also Correlli Barnett, *Engage the Enemy More Closely: The Royal Navy in the Second World War*, Hodder and Stoughton, (1991)

[32] Thomas Cutler, *The U.S. Navy Reserve*, US Naval Institute (2015), Chapter 8. McDaniel included numerous women on his analytical staff but wargames were not prioritised in the curriculum

[33] Blair (2000) on 'Exploiting British ASW Capability', Charles Shrader, *History of Operations Research in the United States Army*, Vol. I: 1942-62 (2006), pp.21-23 and Atlantic War Conference (1994), Philip Lundberg, Chapter19 – 'Allied Cooperation'. Operational Research papers were regularly exchanged after 1942

At the Casablanca Conference in January 1943, Roosevelt and Churchill re-affirmed the necessity to target the U-boats and keep the convoys flowing[34]. The Allied leaders were keen to maintain momentum and to turn the tide in the West. The Allies were already conducting operations from Kharkov to Tunisia and the campaigns of summer 1943 would see the Soviet Army destroying the Wehrmacht's main panzer reserve at Kursk and the US/UK amphibious operations in Sicily and Southern Italy. By 1943, new tactics and technologies, including centimetric radar and the Hedgehog mortar (a device that projected a pattern of bomblets ahead of the escort each capable of damaging a U-boat if they made a direct hit – thus enabling ASDIC contact to be maintained), being used by Allied escorts meant that the U-boats had to develop even more cautious tactics as they attempted to evade the wide array of ASW assets (air and sea) that were being deployed against them with ever increasing efficiency. Dönitz and his captains tried numerous desperate tactics, but casualties continued to mount. Even when wolf-packs succeeded in making an attack, they tended to suffer heavy casualties.

In spring 1943, Patrick Blackett, Director of the Royal Navy's Operational Research department, submitted a series of reports based upon detailed analysis on the convoy battles of 1939 to 1942. Blackett supported Roberts' argument for larger convoys with stronger screens and for increased air cover on the Mid Atlantic Air Gap[35]. From this point onwards, the constant flow of intelligence reports, operational research (OR) reports and wargames gave Western Approaches Command a priceless advantage over the U-boats. The evolving convoy battles in spring 1943 show how far the tactics and technology involved in the anti-U-boat campaign had developed and highlights the role of WATU in the integration of these elements into the decisive instrument Churchill had demanded in 1942.

When convoy SC-118 was attacked in January 1943, the deputy convoy commander (the commander was unwell) had not attended the WATU course and the deployment of the escorts left the rear of the convoy to just one Free French corvette, FFL Lobelia. Luckily her commander, Pierre de Morsier, was a graduate and fought a brilliant rear-guard action, engaging U-boat after U-boat and expending all 180 of his depth charges defending the beleaguered convoy. Roberts always spent extra time with his foreign students and many of his star pupils were from the navies of the other Allied powers[36]. Horton used the detailed analysis of the attacks on SC-118 to support his plan to create Support Groups that could be directed to reinforce a close escort screen and take the battle to the wolf-packs.

In March 1943, HX-229 and SC-122, with thirteen escorts protecting over ninety merchant ships, found themselves fighting one of the largest combined wolf-packs of the war. Raubgraf (Robber Baron) made the first sighting and two more packs (Stürmer and Dränger) closed in as the two convoys entered the Mid Atlantic Air Gap. The

[34] 'The Significance of the Casablanca Decisions, January 1943' by Alan F. Wilt, *The Journal of Military History*, Vol. 55, No. 4 (Oct 1991), pp. 517-529

[35] Milner (2005), P.147 and Altantic War Conference (1994), Paul Sutcliffe, Chapter 23 – 'Operational Research in the Battle of the Atlantic' and Peter Padfield, *War Beneath the Sea*, Thistle (2013), Padfield noting the story about Blackett suggesting that Coastal Command paint their aircraft white to make spotting them more difficult (P.321), a story also included in Gretton (1974), P.165

[36] For a more detailed description of the action, see Williams (1979) and Pierre de Morsier, *Les Corvettes de la France Libre*, France-Empire (1972)

engagement lasted several days and saw numerous attacks by the three wolf-packs. HX-229's formation had been broken up by bad weather and saw the surprise introduction of the latest Garman Flächenabsuchender Torpedos (FaT) – a weapon that followed a weaving pattern ('pattern running') after launch to increase their chances of a hit on a convoy. The escorts raced from crisis to crisis but the U-boats kept finding gaps in the screen, some even approaching in daylight to maximise their chances of hitting a merchant vessel. Without aircraft to protect the perimeter, there were simply too few escorts to keep the U-boats at bay. SC-122 was initially only attacked by U-338, commanded by a skilled and audacious young commander called Oberleutnant Manfred Kinzel, but others soon joined the melee and the screen was soon scattered as they desperately tried to force their tormentors to dive. The arrival of the latest long-range ASW aircraft on the periphery of the Black Pit finally forced the U-boats to break off their pursuit. During the battle, twenty-two ships were sunk for the loss of one U-boat. Dönitz was delighted, describing the action as 'the greatest convoy battle of all time'. Horton knew that the policy of keeping one third of the escorts back to complete their training had been an unpopular decision but he was confident that the tide was about to turn. 'The real trouble has been basic – too few (escorts), all hard worked with no time for training… The Air, of course, is a tremendous factor – it is only recently that the many promises that have been made show signs of fulfilment so far as shore-based aircraft are concerned, after three and a half years of war… All these things are coming to a head just now and although the last week has been one of the blackest on the sea, so far as this job is concerned, I am really hopeful.'[37]

In late April 1943, convoy ONS-5 set off from the UK and headed for North America. Peter Gretton's B7 Escort Group were protecting forty-two merchant ships. Two wolf-packs, totalling fifty-eight U-boats, were already strung out across the Atlantic awaiting a suitable target. U-boat Command's B-Dienst had already identified SC-127 but decided that ONS-5 was a better target. A RAF Liberator gave the first clue that the convoy was in danger when it sank U-710 but few realised that they would soon be forced to fight for seven days against a force of over forty U-boats. Gretton had rehearsed the route on a tactical table with all of his air and escort commanders and updated WATU on his experiences during the successful transit of HX-231[38]. After that action, Gretton was keen to ensure he had a dedicated escort tanker attached to the convoy due to HMS Duncan's fuel-hungry engines (a common problem with fast escorts), and had re-trained his men in close gunnery for night-fighting. He had also reminded the Admiralty that most of his casualties on HX-231 had been stragglers who drifted (deliberately or due to battle-damage) beyond the escort screen. The new convoy was a slow one and they had air cover until the Greenland ice pack. HF/DF located a U-boat but no contact was made and Gretton readied the convoy for a wolf-pack attack. Fourteen U-boats converged on the first night and Gretton concentrated his screen on the port beam. The weather worsened and HMS Tay reported the first U-boat. Radar soon showed three other U-boats closing in and the escorts raced to engage them

[37] John Keegan, *The Price of Admiralty, War at Sea from Man of War to Submarine*, Hutchinson, (1988), pp. 244-266
[38] Peter Gretton, *Crisis Convoy: The Story of HX231*, Davies (1974)

and forced them to dive. The pitching and rolling made depth charging difficult and no kills were made.

On the next night, Tay was sent to discourage U-boats from shadowing the convoy but one got between the columns and launched a full spread, hitting one merchant ship before making its escape. As the formation recovered, the weather continued to batter the convoy but the U-boats were in no mind to give up, particularly as the weather served to protect them from any attempt at air interdiction. They shadowed the convoy for another 24 hours, with individual captains making attack runs, but the wolf-pack was unable to coordinate their attacks. Gretton was finally forced to withdraw his own ship from the convoy due to a damaged boiler and lack of fuel. As soon as he departed, the U-boats converged again, this time they were reinforced by an additional wolf-pack that had missed SC-128 and was re-directed to intercept ONS-5. The combined pack numbered more than thirty U-boats and with the weather gradually improving, they surprised the escorts. With the screen soon overwhelmed, the wolf-pack managed to get amongst the columns and sink eleven merchant ships as the escorts desperately tried to re-establish their formation. The U-boats' triumph would be short-lived. As fog shrouded the convoy, the tables were turned and the U-boats found themselves being hunted by the escorts. All twenty-four attacks in the final phase of the battle were driven off and four U-boats were sunk and three more heavily damaged by Mid Ocean Escort Force B7 and Escort Group 1, supported by a small number of Canadian flying boats. By the time the convoy reached her destination, thirteen merchant ships had been lost but seven submarines had been accounted for, a very poor result for the U-boats after seven days fighting in near optimum conditions (the fog being the only stage of the battle where the escorts had the advantage). Tay reported the result to Gretton and the Admiralty, 'all ships showed dash and initiative. No ship required to be told what to do and signals were distinguished by their brevity and wit'. No higher compliment can be paid to the WATU course than the efficiency shown by her graduates in this battle[39].

Gretton's B7 command was then assigned to protect SC-130 in mid-May. The older ships produced huge columns of smoke and the Senior Escort Officer, Captain J. Forsythe, was concerned that every U-boat in the North Atlantic would see them as soon as they reached the inevitable patrol line. After avoiding a large iceberg in heavy fog, the convoy headed East. Gretton's team were confident, having survived two harrowing convoys, and they were eager to apply the principles developed at WATU. The convoy also had a rescue ship, which would both free up the escorts and assist with HF/DF. Unsurprisingly, they soon picked up a signal and the hunt was on. Gretton forced the first set of U-boats to go deep and the convoy shifted course, thus avoiding the initial ambush. RAF/Allied Liberators were despatched to hunt the pursuing U-boats and the escorts readied for the next wave to come in. Two more U-boats were chased off and Gretton's hedgehog damaged U-381. Gretton then directed the attacks of another vessel (using Walker's creeping attack method to guide the other escort[40])

[39] Gretton (1971), pp. 139-150

[40] The creeping attack used two ships; one escort to remain stationary and keep in contact, and guide a second vessel onto the target. The second escort approached slowly, in order not to warn the U-boat of its approach, and released its depth charges on a signal from the first. The method required practice and took time and numerous depth charges, but was extremely effective. Walker's two commands, 36 Escort Group and 2nd Support Group, were arguably the most successful U-boat hunters of the war

against three separate U-boats. His colleague, clearly feeling a little harassed during the chase, ruefully signalled to Gretton 'as Mae West said, one at a time, gentlemen, please'. With up to thirty submarines circling, the escorts were kept busy. Gretton directed escorts against the closer targets and aircraft against the converging U-boats, holding off the wolf-pack until 1st Escort Group arrived. With indications of another wolf-pack showing up on HF/DF, the convoy changed course and avoided a second ambush. In the end, only one U-boat attempted to engage the convoy and they were soon forced to dive. Several more turns bought the convoy back on course and more RAF/Allied Liberators joined the battle, sinking U-258. The battle had been a perfect demonstration of close coordination between Western Approaches Command, the Escort Groups and Coastal Command. Three U-boats were sunk, one was damaged and no merchant vessels were lost. Dönitz himself gave Gretton and his colleagues the ultimate compliment in his memoirs: 'the convoy escorts worked in exemplary harmony with the specially trained support groups. To which must be added the continuous air cover provided by the carrier-borne (diverted from HX-239) and the very long-range (VLR) shore-based aircraft, most of them Liberators equipped with the new radar'.[41]

Once Dönitz realised that the balance between merchant sinkings and U-boat losses had invalidated his strategy, he withdrew the majority of his boats from the most contested waters. Herbert Werner, then on U-230, lists the signals pouring in from stricken U-boats during this period and it is easy to understand why fewer and fewer U-boats were prepared to close with a convoy[42]. WATU took advantage of this lull in activity on the Western Approaches to develop tactics for other operational areas and to evaluate some of the tactics and technologies being developed by their adversaries. The team also tested new ways to improve air to sea cooperation; using wargames both to develop new approaches and to demonstrate them to students and to any senior officers visiting the facility. When Horton secured the Azores as a base for Allied Liberators, Roberts and the team mapped out a range of options for re-deploying some convoy escorts to increase the number of Support Groups hunting in the regions where the remaining U-boats were concentrated. These reinforcements were now equipped with an impressive array of ASW technologies and supported by Allied Liberators equipped with the latest ASW equipment including improved airborne radar sets (undetectable by the German Metox radar detection device), and almost all were veterans of the WATU tactics course[43]. In desperation, Dönitz ordered his U-boat commanders to stay on the surface and shoot down any aircraft that attempted to engage them. Casualties on both sides increased significantly, with twelve aircraft being lost for every submarine sent to the bottom, but the Allies had numbers on their side and the Germans were forced to abandon the campaign.

Dönitz refused to give up and turned to his scientists to resolve the situation. Snorkels were increasingly fitted to submarines that were being deployed to regions where the Allies had aircraft patrolling for submarines on the surface. Analysis had shown, after

[41] Gretton (1971), pp. 151-164
[42] Herbert Werner, *Iron Coffins: A U-boat Commander's War 1939 – 1945*, Cassell, (1969), Part 2, Above us Hell
[43] Milner (2005), Milner notes that the RCN were the last to get centimetric Radar sets and suffered accordingly in 1942

several false assumptions, that the Allies had developed a credible airborne radar system and Dönitz was desperate to stop the relentless increase in losses. Another solution was to turn the surface hunter into the hunted and this required a complete change in tactical emphasis, and the development of a weapon capable of targeting an escort as it closed in for the kill. HMS Londonderry, sailing via the Azores, was the first vessel to experience the new weapon. Her commander, John Dalison, sighted a U-boat just off the Azores (he was painting a picture at the time). The target didn't dive immediately and Dalison assumed the U-boat hadn't spotted him though he saw the periscope being raised even higher than usual as if to attract his attention. Seconds from making his attack run, Londonderry's stern exploded and the vessel was lucky to make it back to port intact.

Dalison was sent to be de-briefed by Roberts and described the failed attack in detail to his bemused mentor. Roberts headed for Horton's office and they agreed that the only plausible solution was some kind of passive acoustic homing torpedo. One solution was to accelerate the deployment of Foxer, a noise-maker that could be towed behind a vessel being targeted by an acoustic homing torpedo. The problem with Foxer was that it also blinded many of the detectors that an escort needed to hunt submarines – it was clear to Roberts that a noise-maker was a useful defensive device for merchant vessels but not for escorts trying to find and kill a U-boat. There had also been hints of an acoustic device in the Oslo Report passed to MI6 in 1939 and R.V. Jones Scientific Intelligence team had already highlighted the dangers such a weapon might pose[44]. Concerned that the Germans might utilise the new weapon in a wolf-pack attack on a major convoy, Roberts circulated a warning to all escort commanders to look out for the strange behaviour noticed by Dalison.

The G7es (T5) Zaunkönig (Wren), soon to be known to the Royal Navy as the GNAT (German Navy Acoustic Torpedo), was issued to twenty-three U-boats in August 1943 and these boats took up position in the Bay of Biscay and the Mid Atlantic Air Gap and awaited suitable targets, the operation was code-named Leuthen. Two convoys were at sea, ONS-18, a slow convoy of twenty-seven ships bound for Canada and the USA, and ON-202, containing another forty-two heading in a similar direction. Horton ordered the two convoys to converge as the Royal Navy's Operational Analysis team had shown that larger convoys were easier to defend than splitting up into smaller convoys – unless the U-boats attacked in very large numbers. B-3 Escort Group, C-2 Escort group and 9th Escort Group were tasked to protect the converging convoys. Confused orders (exacerbated by fake orders sent by U-boat Command) and poor weather delayed the link-up and the T5 equipped wolf-packs started to converge on their target.

A Liberator sank one of the U-boats closing in on the convoy and Horton and his team prepared for what they assumed would be a decisive demonstration of the latest ASW tactics and capabilities. Deploying the tactics developed at WATU, the escorts started hunting the wolf-pack as they infiltrated the convoy. Once spotted, each of the U-boats followed their orders and calmly dived, firing a T5 from their stern tube. HMS Lagan was the first to be hit. HMS Escapade tried to support her but suffered an onboard accident (her hedgehog system exploded). Both vessels were forced to detach from the

[44] R. V. Jones, *Most Secret War: British Scientific Intelligence 1939–1945*, Hamish Hamilton, (1978)

convoy. HMCS St Croix was the next escort to be struck and HMS Polyanthus quickly followed. The officers and Wrens in the Operations Room at Western Approaches Command listened in growing horror as the reports of escorts being hit flooded in. Undeterred by the chaos, Captain Tooley-Hawkins on HMS Orchis, a popular officer who was engaged to one of the WATU Wrens, took an enormous risk in slowing down to lower clambering nets in the hope of rescuing as many men as possible but noticed that the three U-boats around him were doing nothing to exploit his precarious situation. Fog might have obscured his position but this clearly wasn't stopping them from launching a spread of torpedoes as he could see all three of them watching him 'as bold as brass'[45]. As soon as Tooley-Hawkins had picked as many men as he could, he raced back to the convoy and signalled Liverpool and asked them to pass on what he'd seen to Roberts and his team.

Roberts, reading the reports pouring into Western Approaches Command, quickly realised that this was the new weapon that he and Horton had discussed a few months earlier. He headed up to the WATU tactical floor and summoned the analysis team. The initial reports were reviewed and then wargamed and two key points emerged from their deliberations. The U-boats only engaged when the escort was committed to the attack, having fired star-shell or moved towards the U-boat, and they clearly couldn't engage a vessel that was stationery. Tooley-Hawkins' intriguing experience suggested that the wolf-pack only had acoustic torpedoes so that a tactic that successfully negated the GNAT would also enable the escorts to break up the wolf-pack and force them to disperse. The problem was working out how an acoustic torpedo worked. Luckily, the Allies had their own version, the US Mark 24 mine, known as FIDO. This device was a passive homing torpedo designed to be dropped from ASW aircraft. The Anti-Submarine Experimental Establishment at Fairlie (a forerunner of Dstl) confirmed that a speed of 20 knots would evade an acoustic torpedo but most of the escorts were far slower and ASDIC would be next to useless if the escorts exceeded their normal cruising speed. Roberts soon realised that the solution would have to be based on the way the GNAT homed in on its target. Reducing speed was also considered but this would have clearly been unacceptable to the escort commanders.

After a night of heavy fog, the wolf-pack closed in again. HMS Keppel opened the new phase of the battle by ramming a U-boat and a Coastal Command Liberator sank U-270. HMS Itchen, HMCS Morden and HMS Orchis engaged a U-boat which had got inside the convoy and pursued her into the open sea. Morden managed to avoid one torpedo but Itchen was blown apart, almost taking Orchis with her[46]. Sadly, many of the sailors rescued earlier in the battle were on HMS Itchen, increasing the total losses to over four hundred. Even though both the escort and U-boat crews were exhausted, the next engagement was clearly the decisive phase of the battle. WATU had continued

[45] Williams (1979), P.129

[46] The sources for the engagement are confusing. Tooley-Hawkins testimony is not corroborated elsewhere but this is unsurprising given the complexity of cross-referencing the reports of nineteen Allied warships in a battle lasting several days. See Williams (1979) for Tooley-Hawkin's version, CONVOY ONS 18 / ON 202 REPORTS, National Archives and Records Administration, Washington, http://www.warsailors.com/convoys/on202report.html for Horton's report and http://ww2today.com/23rd-september-1943-another-tragic-night-for-convoys-ons-202-and-18 for the testimony of a Canadian witness who survived both the loss of both St Croix and Itchen

their wargames throughout the battle and Roberts phoned Horton and asked if he could come up to the tactical floor to review their proposed solution. Confident that Roberts and his team could at least explain how the U-boats were operating, Horton headed up to WATU to see what they had discovered.

The team had been frantically trying out options for countering the GNAT as the battle unfolded, their efforts focused by the fact that many of the officers were known to the team. The break-through came when they looked at the effectiveness of the GNAT's hydrophone array and realised that 60 degrees was the optimum angle as a wider array wouldn't be able to focus effectively and a narrower array wouldn't successfully acquire targets that weren't exactly where the U-boat captain predicted. The solution was to turn back 150 degrees after engaging the target and increase to full speed for a mile before turning back to run parallel to the U-boat's course for another mile. The acoustic torpedo would follow its initial course and then fail to detect its intended target; leaving the escort free to close in on the U-boat and commence an attack run. Horton had hoped for a way to evade the U-boats but this was far better – the new tactic might even turn the tide of the current battle.

The *Step Aside* tactic was immediately sent to the escorts[47]. Tooley-Hawkins, wounded when Itchen blew up, was one of the first to acknowledge receipt of the new orders and the WATU team breathed a sigh of relief. The escorts and U-boats continued their battle for the next 36 hours but no more escorts were sunk and the remaining U-boats were forced to 'go deep' to avoid destruction[48]. The new tactic had proved its worth and remained on the list of NATO ASW tactics for dealing with acoustic weapons until relatively recently. The Germans claimed a victory, suggesting that twelve escorts and nine merchant ships were sunk, and a further two ships damaged[49]. The reality was that three escorts were lost and six merchantmen. U-boat Command ordered two more attacks based on their 'success' but *Operation Rossbach*, versus SC-143, lost seven U-boats (three to escorts using *Step-Aside*) and sank only one warship and one merchantman. Operation Schlieffen, attacking ONS-20 and ON-206, was even less successful, losing six U-boats and sinking only one merchant ship.

By the end of the war the WATU had eight male naval officers (including a Norwegian and an Indian) and thirty-six female Wren officers and ratings. Amongst the many officers who passed the course were HRH Prince Philip of Greece and the author of The Cruel Sea, Nicholas Monsarrat. The novel includes a memorable description of Captain Roberts and it is thought that Robert's summing up of the campaign, given at the end of each course is the source for the book's title; "it is the war of the little ships and the lonely aircraft, long, patient and unpublicised, our two great enemies - the U-boats and the Cruel Sea". The novel also includes a lovely scene where Ericson is caught out during a wargame and is rescued by a "young, thoughtful and intelligent" Wren

[47] See Doherty (2015), P.223 for an excellent diagram of the tactic

[48] OEG report No. 51, Antisubmarine Warfare in World War Two, Charles M. Sternhell and Alan M. Thorndike, Operations Evaluation Group, Office of the Chief of Naval Operations, Navy Department, Washington, D.C., 1946 - http://www.ibiblio.org/hyperwar/USN/rep/ASW-51/

[49] Gunter Hessler, Alfred Hosschatt and Jurgen Rohwer, *The U-boat War in the Atlantic*, HMSO (1989), Paras 376-9, the U-boats dived straight after firing and this restricted their monitoring of success to hydrophones

officer "not more than "twenty years old"[50]. Intriguingly, Monsarrat's colourful description of Roberts is backed up by a Canadian officer, A. F. C. Layard, who described the WATU director, a few days after the battle against Wolf-pack Leuthen as a 'very good lecturer, very theatrical and, of course, would like you to know that he was 75% responsible for the recent defeat of the U-boats in the North Atlantic. He's probably right and is certainly thought of very highly here'.[51]

When Roberts accepted his award as Commander of the British Empire at the end of 1943, he took a Wren Officer and Rating with him to Buckingham Palace, intentionally sharing the honour with the team of remarkable young women that helped the Western Approaches Tactical Unit win the Battle of the Atlantic. In 1944, Roberts was tasked with planning the highly effective ASW operation that supported *Operation Overlord*. Eventually, Tooley-Hawkings took over WATU and the team concentrated their efforts, in the final months of the war, against Japan. When Roberts visited U-boat Headquarters in Flensburg after the war, he met Admiral Dönitz and they exchanged salutes. Roberts inspected the tactical notes and deployment maps for the period after January 1942 and was delighted to see that they matched many of the WATU assumptions. The only thing that bemused him was the way all the U-boat survivors stared at him as if they feared him. The mystery was solved when he was shown a photograph from a magazine interview hung up in the Operations Room. "This is your enemy, Captain Roberts, Director of Anti U-boat Tactics"[52].

The role of the WATU is a strange omission from the popular historiography of World War Two. Perhaps understandably, the commanders, the aces, and the technical advances tend to take centre stage and the organisational improvements are often relegated to footnotes or technical volumes[53]. Much of the problem is that the ASW Tactical Unit continued their work into the Cold War, re-focusing their attention on the threat from Russia's formidable submarine force, a task that required the unit's activities to remain classified. Roberts himself retired at the war's end and most of the team retired to civil life or were poached by other units. Few memoirs mention the WATU, Roberts own recollections in Mark Williams' book perhaps being the only coherent record. Ironically, the brief scene in Nicholas Monsarrat's 1951 novel, *The Cruel Sea*, remains the only public memorial to their work.

[50] Monsarrat (1951), pp. 374-377, Ericson specifically notes the course was 'tough'

[51] A. F. C. Layard, *Commanding Canadians: The Second World War Diaries of A. F. C. Layard*, UBC (2006), pp.33-35 Layard notes that one of his first wargames included the new 'glide bomb' – showing WATU's continuing interest in developing tactics against emerging threats. Roberts himself confirmed to Thames Television that his lecturing technique was developed with the assistance of the actor, Tommy Handley (IWM Recording 2766).

[52] Mark Williams (1979), P.144

[53] Milner (2005), Doherty (2015) and Gordon Williamson, *U-boats vs Destroyer Escorts: The Battle of the Atlantic*, Osprey (2007) are honourable exceptions

Captain Gilbert Roberts preparing a scenario for the next wargame in the WATU office (Photos: IWM Collection)

The Western Approaches Tactical Unit is a classic exemplar of defence analysis – almost perfectly demonstrating how a dedicated research team should function[54]. The WATU team were able to combine training courses with analysis work, test and disseminate new ideas, actively encourage the development of combined operations, develop new tactics to get the most out of new technologies, and identify and counter enemy technical and tactical innovations in real time. This iterative cycle of activities, centred on the wargames on the tactical floor, were used to create an experiential learning environment[55], where tactical decisions could be made without casualties and the officers taught to 'read the battle' and optimise their tactics instead of following simplistic doctrinal processes that their enemy would exploit. Commander (later Vice Admiral) Sir Peter Gretton later noted that the course 'improved everyone' who attended and ordered all duty officers and escort commanders under his command to take part in the WATU wargames. Gretton also highlighted in his memoirs that the wargame 'made a number of very stupid officers really THINK, sometimes for the first time in their lives'.[56] Fortunately, this conceptual perspective was not shared by their German opponents, who tended to focus on short-term issues, highlighted the achievements of aces instead of improving teamwork, and neglected both analysis and tactical training (their initial training was reasonable, but refresher courses were rare)[57].

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[54] *Guide for Understanding and Implementing Defense Experimentation* (GUIDEx), Subcommittee on Non-Atomic Military Research and Development (NAMRAD), The Technical Cooperation Program (TTCP), Joint Systems Analysis (JSA) Group, Methods and Approaches for Warfighting Experimentation Action Group 12 (AG-12) (TTCP JSA AG-12), Version 1.1, February 2006. See also 'Cycle of Research' in the UK Ministry of Defence Wargaming Handbook (forthcoming)

[55] See Gretton (1974), P.146, and also Gene Hughson on creating a 'learning culture' https://genehughson.wordpress.com/2016/12/09/learning-organizations-when-wrens-take-down-wolf-packs/#comments

[56] Gretton (1971), P.107, see also Monsarrat (1951), pp. 374-376, Ericson pondering the challenge of mastering the new ASW tactics

[57] Atlantic War Conference (1994), Graham Rhys-Jones, 'The German System: A Staff Perspective', P.141 and Atlantic War Conference, Chapter 11 - Erich Topp (an ex U-boat commander), 'Manning

The importance of training vessels in Escort Group tactics was clear to commanders of the time. As noted above, after the defeat of the wolf-pack hunting HX-239, Dönitz remarked on the convoy escorts working in 'exemplary harmony with the specially trained support groups' and the impact of 'continuous air cover' and Hessler admitted that the convoy battles of Spring 1943 had 'shown beyond doubt that the offensive power of the U-boat was incapable of dealing with the defence'[58]. Horton agreed with his opponent's analysis, attributing the success of the Allies to 'hard work, hard training and determination on the part of all officers and men of the surface forces and air units involved'. Gretton noted in his analysis of HX-231 that 'training was well catered for by a tactical school run by Captain G. H. Roberts in Liverpool, where captains of ships and other officers were able to attend week-long courses and study convoy defence problems'. Gretton also commended the close collaboration with Coastal Command facilitated by Sir John Sleesor in early 1943 and the combined training courses run at WATU and Maydown – an effort that increased the ratio of VLR aircraft kills from 9% of U-boat sightings to 30%[59].

The WATU case study also demonstrates how intelligence information and Red Teaming can be combined in a wargame. Roberts' access to detailed intelligence information, Enigma decrypts and operational information enabled him to make the training wargames as realistic as possible and to conduct analytical games while the battle was in progress. Throughout the campaign, Roberts seized every opportunity to review tactics developed by veteran officers and to access notes taken from the interrogation of U-boat commanders. When technical issues arose, Roberts consulted with subject matter experts and utilised their insights to gain a deeper understanding of emerging capabilities. The combination of operational experience, operational research, access to intelligence and immersive processes enabled the WATU wargames to provide an adaptive template for combining the numerous technological advantages developed during the war into a battle-winning formula[60].

The WATU approach encouraged conceptual thinking. Roberts set an example by making the most of the talents of his remarkable team. Jean Laidlaw's statistical tables and meticulous records of each wargame enabled Roberts and his team to coherently adjudicate each encounter and then thoroughly debrief the players after the wargames were complete. In the analytical games, her detailed plots enabled the team to identify patterns of enemy behaviour and explore opportunities to develop new approaches. These notes also facilitated the verification of WATU's approach once the U-boat archives were made available to Roberts and his team. Laidlaw was also noted as one of the Wrens who had a talent for gaining the respect and confidence of officers much more senior than herself (she may be the model for Ericson's gentle saviour in *The*

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and Training the U-boat Fleet', plus Gordon Williamson, *U-boat Tactics in WWII*, Osprey 2010 and Gretton (1974) is particularly scathing about the German failure to properly train their excellent submariners in tactics, pp.170-1, Haslop (2013) describes initial U-boat exercises but nothing resembling the conceptual work done at WATU and no evidence of refresher courses (P.262)

[58] Hessler (1989), Para 332

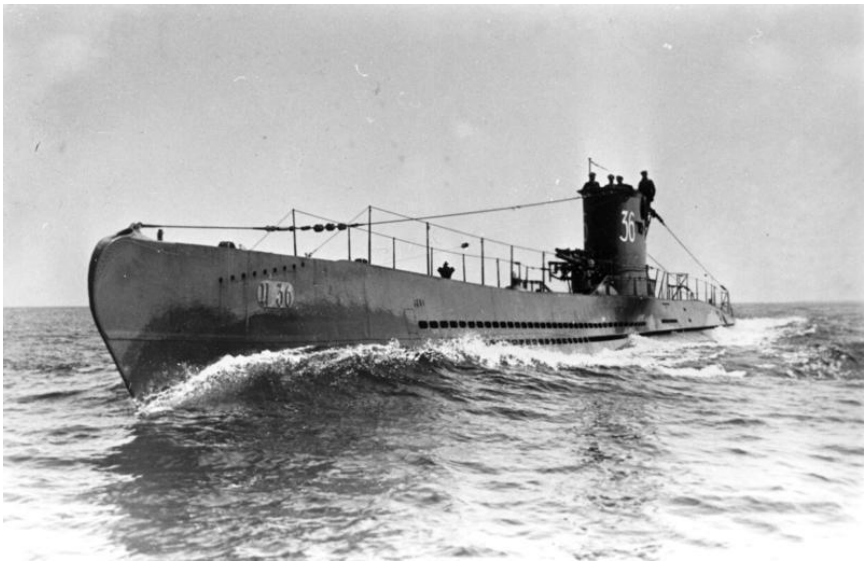
[59] Gretton (1974), P.155, P.169 and P.171

[60] S.W. Roskill, *The War at Sea: Volume II*, pp.380-1, amongst numerous useful tables and diagrams covering the campaign, Roskill includes a breakdown of the major convoy engagements between Mid-April and the end of May 1943 - showing the convoy numbers, the routes, the escorts assigned, the vessels lost, and the U-boats sunk

Cruel Sea). Barnard Rayner's organisational skills ensured that the signals and turn processes ran smoothly and 'the game' itself resembled the form and timings of the real thing. In the adversarial role, Janet Okell provided crucial insights into enemy thinking, helping Roberts to reveal the vital Red perspective that made the wargames so successful. The team also welcomed expert opinion from almost every Allied nation, consulting with experienced officers like Sir Max Horton, William Tooley-Hawkins, Pierre de Morsier, Peter Gretton and Frederic John Walker. The defeat of the Wolf-pack Leuthen would have been impossible without the officers involved knowing the kind of intelligence that the WATU team needed to develop a counter to the GNAT.

The support of senior officers was vital to WATU's success and it is notable that both Sir Percy Noble and Sir Max Horton observed wargames in progress, the latter even taking part in both 'The Game' and the course itself. Successful senior commanders in World War Two didn't hide behind their rank, they sought out the best minds at their disposal and actively encouraged the development of new tactics and technologies that could be used to counter one of the most formidable military machines in history. As Sir Max Horton noted in 1945, Roberts 'and his School of Tactics have played a far-reaching and significant part in the Battle of the Atlantic'[61].

While many factors contributed to victory over the U-boats, the team at WATU enabled the Royal Navy to gain a better understanding of the threat they were facing, facilitated the development of counters to German tactics and technology, revealed weaknesses in their adversary's approach to the campaign, and disseminated what we would now call 'best practice' to every Allied commander (both air and maritime) involved in the battle[62]. By enabling every facet of the Allies' evolving ASW capability to be combined and then disseminated, the WATU wargames were one of the decisive components in the Allied victory over the U-boats.

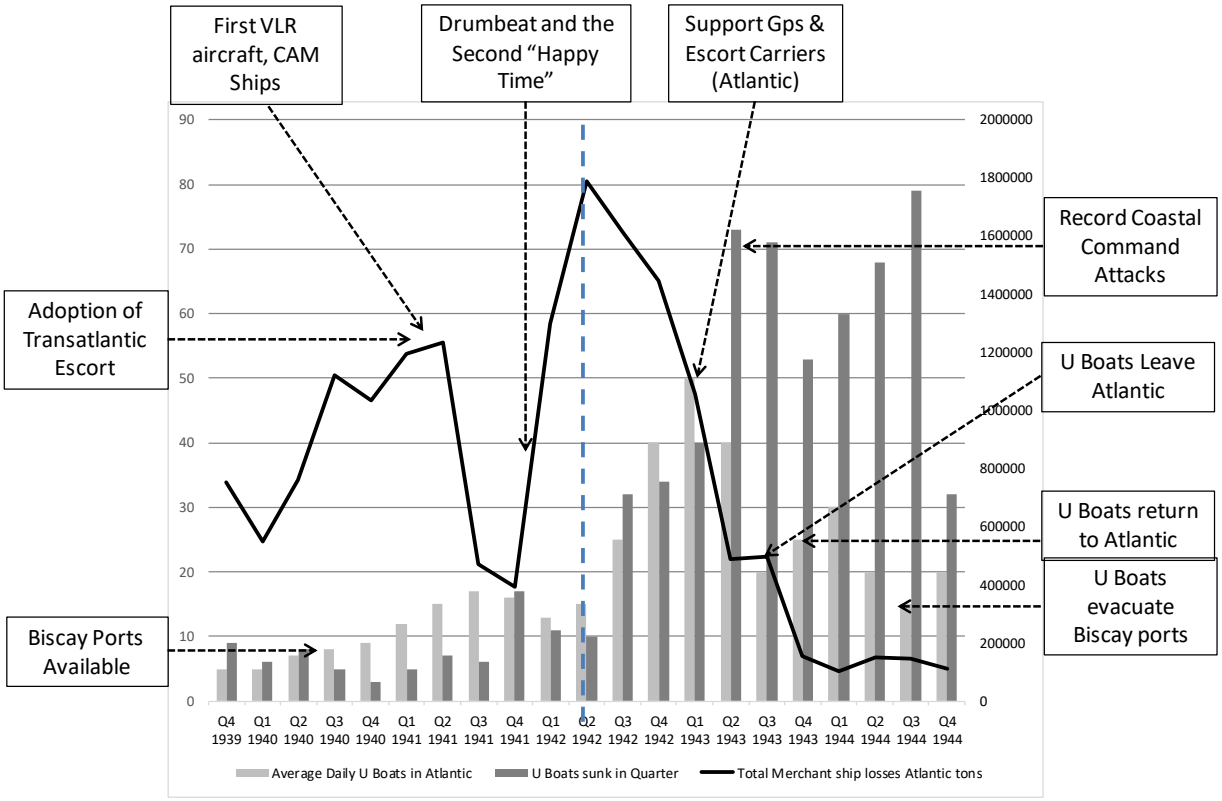


U-36 (Photo: Bundesarchiv)

[61] Williams (1979), P.148

[62] Atlantic War Conference (1994), Chapter 12 - James Goldrick, 'Work-Up', pp.227-228 and Alan Scarth, 'Liverpool as HQ and Base', P.246

A wargame in progress, showing the core team processing a turn in 1945 - Jean Laidlaw is on the left checking her notes, Bernard Raynor and Gilbert Roberts are discussing signals in the centre. The Wren at the noticeboard appears to be Janet Okell. (Photo: IWM Collection)



Graph highlighting the approximate timing of the introduction of key ASW events and technologies, including WATU (blue dashed line), and their relationship to the numbers of merchant ships and U-boats lost in the Atlantic during the campaign (Figure: Nicholas Bell)