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MEMORANDUM

From: Undersea Constellation Wargaming Team, NPS
To: Wargaming Course Instructor, NPS

Subj: UNDERSEA CONSTELLATION WARGAME EXECUTIVE SUMMARY

1. Purpose.

a. The Undersea Constellation Wargame (UCWG) examines how an undersea communications network can enhance America's undersea operational effectiveness in a wartime scenario.

b. The game reveals that UC increased operational effectiveness when paired with complementary technologies: Long range torpedoes (LRTs), switchblades, and TERN UAVs. U.S. forces gained accurate situational awareness of red force structure and location more quickly when it had UC available. In addition, the force exchange ratio (FER) for blue water naval assets increased from 1:1 to 2:1. However, some of that success is predicated on the ability for undersea volumetric nodes to pinpoint an enemy unit's location, classify him, and communicate the information real-time to a submarine.

c. In addition, the game also reveals that without air dominance, the undersea dominance strategic doctrine has a critical vulnerability from air-based anti-submarine warfare (ASW) assets such as helicopters and maritime patrol aircraft (MPAs). This critical vulnerability must be addressed in order to allow UC to realize its full potential.

2. Background.

a. The Undersea Constellation attempts to address a critical capability gap within the current submarine force: the inability for a submarine to actively communicate real time information at depth. As a result, naval operational commanders have poor command and control over their submarine assets because submarines have no ability to share in-situ information with the command staff or other naval assets in the region. In addition, military radar technology has advanced to the point that submarines are at high risk against near-peer adversaries when operating at periscope depth (PD) to communicate with other assets or visually identify targets.

b. The Undersea Constellation, paired with LDUUVs, switchblade UAVs, and long range torpedoes, attempts to addresses this capability gap by allowing submarines to communicate at depth, visually identify enemy combatants outside their military radar ranges, and engage enemy forces from outside their weapons range.

3. Analysis Objectives.

a. The UCWG seeks to examine how an undersea communications network paired with long-range weaponry can enhance submarine effectiveness. To accomplish this goal, the team created a small-scale conflict that would stress the operational capability of submarines in an anti-access, area denial environment. Red forces employed a robust mix of submarines, ASW helicopters, and surface ships.

b. Because a large part of undersea warfare focuses on stealth, the UCWG is a closed game where players conduct two games simultaneously. On one side of the board, players have the Undersea Constellation available to them. On the other, they must accomplish the objectives with a force mixture that mimics current capabilities. A white cell adjudicates interactions between units and reveals the results according to probability tables and operational postures.

c. Quantitative essential elements of analysis included the force exchange ratio for surfaced and submerged assets, how quickly each team could detect and classify the other's units, and how well each team destroyed the enemy. In addition, the team recorded notes on engagements and player feedback for future qualitative analysis about the Undersea Constellation.

d. Since this is the second iteration of the game, the secondary objectives are to decrease the time it takes to adjudicate moves, add realism to the way units interact, simplify the game objectives and gameplay to streamline team decision making, and allow for player innovation. The secondary goals help accomplish the primary goal of providing a thorough, accurate analysis of how Undersea Constellation can enhance America's undersea dominance and identify any critical vulnerabilities by allowing more data to be collected and more closely modeling a wartime naval operation.

4. Analysis methods.

a. The UCWG team collected in-situ data as the game progressed. The templates for collecting data are included in

Enclosure 1. Once data was collected, the team conducted both qualitative analysis of player tactics and quantitative analysis of unit effectiveness. The qualitative analysis is conducted by critically scrutinizing player decisions and conducting post-game discussion to discover why each team decided to employ their assets in the game and whether they had accurate situational awareness of the enemy's capabilities and plans. In addition, the UCWG team scrutinizes how each unit was killed to determine qualitatively determine which units and tactics were most effective at destroying enemy combatants.

b. In the quantitative analysis, a one-way analysis of variance (ANOVA) in JMP to determine if the presence of UC was significant in the following metrics: Total red classifications over time, total red losses over time, total blue losses over time, and effective long range torpedo shots. In addition, the team analyzed for the difference in force exchange ratio between naval combatants. This metric is selected for two reasons: First, because surface ships and submarines are significantly more expensive than UAVs and ASW helicopters. Secondly, each team knows that they can reinforce UAVs and helicopters, so they take higher risks with these units and are more willing to accept losses.

5. Results.

a. Quantitative Analysis.

(1) The wargaming team determined that blue was far more effective at engaging enemy submarines and surface ships when it had UC available. On the UC side of the game, the blue forces used nodes, TERN UAVs, and switchblades to scout for enemy combatants and used long range torpedoes to destroy them much sooner than on the non-UC side. The red team attempted to counter by staying within a safety zone covered by its rocket propelled torpedoes (ASROCS); however, this strategy was ineffective because red forces never closed blue forces within weapons range. On the UC side, the red team believed it was forced to retreat its forces to the shoreline to prevent them from being destroyed, while on the non-UC side they still believed that they had an ability to trade forces at an equal rate.

(2) The blue team was frustrated by the inability to deal with ASW capable helicopters, which were the red units that were most effective at killing blue submarines. The UCWG did not include MPAs because the team believed it would not be able to evaluate the UC concept with extensive air units in the game.

Nevertheless, blue team's frustration with air-based ASW illustrates the need to obtain air superiority to employ an extensive undersea strategy, even with Undersea Constellation. Employing submarines in an area of operations that is being sanitized by air-based ASW combatants puts U.S. submarines at high risk.

(3) Throughout playtesting and the live game, the wargaming team noticed that players with Navy backgrounds tended to be more much more cautious than those with Army backgrounds. This reflects an interesting difference in doctrine between the two services: the Army, having conducted combat operations for most of the last decade, is more willing to be aggressive and accept losses than the Navy. On the other hand, the Navy has functioned as a deterrent force and is much more risk adverse. This difference was especially highlighted in the employment of units that can reinforce such as TERN UAVs and ASW Helicopters. A more aggressive strategy employed by red forces to get units inside of blue's long-range sensors might have had better success. This result highlights the importance of conducting wargames with players from a broad spectrum of warfare backgrounds to encourage teams to consider multiple different tactics.

(4) The blue team did not try to employ any innovative solutions, while the red team did. For example, after blue lost forces it never requested additional forces from the carrier strike group. On the other hand, red forces considered two innovative tactics: They wanted to kamikaze their helicopters into the LCS, and they commandeered a cargo ship to try to scout for blue forces.

6. Quantitative Analysis.

a. A one way ANOVA is conducted to determine if the presence of UC affects total red classifications over time, total red losses over time, total blue losses over time, and effective long range torpedo shots. The statistical results of these analysis are displayed in Enclosure 2. At an $\alpha=0.05$, the presence of UC was significant in all of the mentioned metrics except blue losses over time. Graphs of total classifications and kills over time are displayed in Figure 1 below, while total effective long range torpedo shots and losses over time are displayed in Figure 2.

b. One can clearly see how the presence of UC allows blue forces to classify and attrite red forces sooner, which enhances situational awareness and operational effectiveness. Finally,

the force exchange ratio of submarines and surface combatants increased from 1:1 to 2:1, indicating that blue forces were more effective at destroying red forces with one less submarine allocated to the battle.

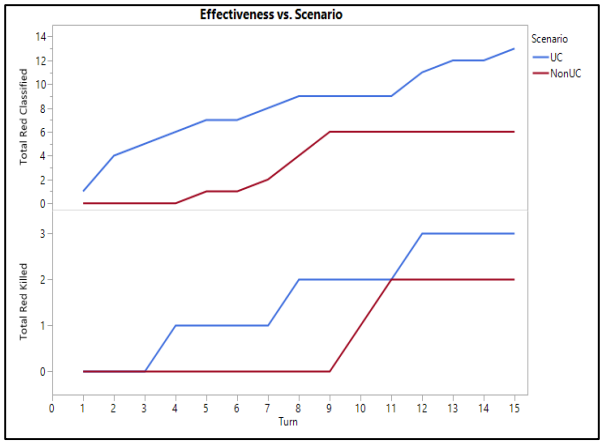


**Figure 1**: Overall effectiveness over time. Blue has better situational awareness and kills more red units earlier with UC.

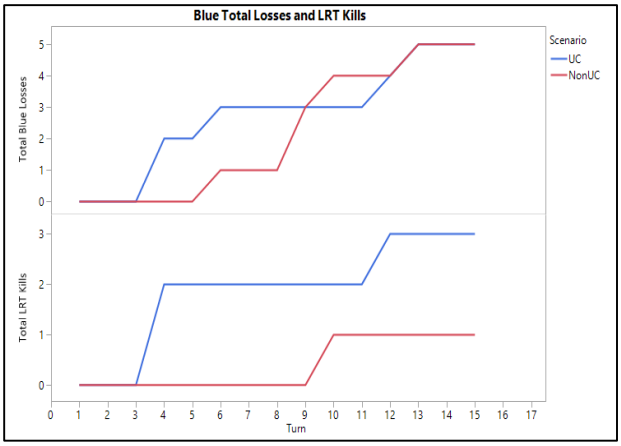


**Figure 2**: Blue losses and effective LRT shots over time. While UC increases effective LRC shots, it does not have a significant impact on total blue losses.

## 7. Recommendations.

a. The Navy should pursue the acquisition of the Undersea Constellation, but this must be paired with complimentary technology to realize its full potential. In particular, volumetric nodes must have the ability to communicate the precise location of enemy forces real-time so that the submarine commanding officer can target and destroy the unit. In addition, long range torpedo and switchblade UAVs are critical capabilities that enhance the kinetic ability of U.S. submarines in conjunction with the Undersea Constellation.

b. The Navy must address how it will defeat air-based ASW in an anti-access, area denial (A2AD) environment for its undersea dominance strategy to be fully effective. This problem does not only extend to ASW helicopters, but MPAs conducting wide-area search as well. The Navy must assume that enemy forces will build capabilities that it believes will counter developing U.S. technology and force projection abroad.

Undersea Constellation
Wargame Team
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ENCLOSURE 1: UNDERSEA CONSTELLATION DCMP TEMPLATES

| Blue UC Side DCMP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Turn | Red units detected | Red units classified | Red units are engaged | Red units killed | Blue Losses | LRT Shots utilized | LRT Shots effective | Notes |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |
| 12 | | | | | | | | |
| 13 | | | | | | | | |

Figure 1: DCMP example. This list was also provided for Red forces as well.

Below is the list of questions provided to players in the post-game survey. The UC team used this survey in its qualitative analysis of play.

1. What elements of the UC wargame did you find most helpful in evaluating the UC concept?
2. What elements of the UC wargame would you change to better evaluate the UC concept?
3. Blue: Did you believe that UC gave you an advantage? How so?
   Red: Did you believe that UC put you at a disadvantage?
4. Did unit behavior (aside from the helo engagement) and the pace of the game match your expectations of how they would behave in a live naval operation? If not, please explain.
5. Were the written instructions easy to understand?
6. Were the written instructions comprehensive enough to understand and play the game? If not, please provide what additional information you would have liked.
7. Did the in-briefs adequately explain the game? If not, please provide what additional information we would need to explain.
8. Please provide any additional/miscellaneous comments.

ENCLOSURE 2: STATISTICAL RESULTS

## Least Squares Fit

### Total Red Classified

#### Summary of Fit

| | |
|---|---|
| RSquare | 0.955335 |
| RSquare Adj | 0.90748 |
| Root Mean Square Error | 1.17108 |
| Mean of Response | 5.733333 |
| Observations (or Sum Wgts) | 30 |

#### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 15 | 410.66667 | 27.3778 | 19.9630 |
| Error | 14 | 19.20000 | 1.3714 | Prob > F |
| C. Total | 29 | 429.86667 | | <.0001* |

#### Effect Tests

| Source | Nparm | DF | Sum of Squares | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Turn | 14 | 14 | 237.86667 | 12.3889 | <.0001* |
| Scenario | 1 | 1 | 172.80000 | 126.0000 | <.0001* |

### Response Total Red Killed

#### Summary of Fit

| | |
|---|---|
| RSquare | 0.920737 |
| RSquare Adj | 0.835813 |
| Root Mean Square Error | 0.452506 |
| Mean of Response | 1.166667 |
| Observations (or Sum Wgts) | 30 |

#### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 15 | 33.300000 | 2.22000 | 10.8419 |
| Error | 14 | 2.866667 | 0.20476 | Prob > F |
| C. Total | 29 | 36.166667 | | <.0001* |

#### Effect Tests

| Source | Nparm | DF | Sum of Squares | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Turn | 14 | 14 | 27.666667 | 9.6512 | <.0001* |
| Scenario | 1 | 1 | 5.633333 | 27.5116 | 0.0001* |

## Least Squares Fit

### Response Total Blue Losses

#### Summary of Fit

| | |
|---|---|
| RSquare | 0.915929 |
| RSquare Adj | 0.825853 |
| Root Mean Square Error | 0.795822 |
| Mean of Response | 2.466667 |
| Observations (or Sum Wgts) | 30 |

#### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 15 | 96.60000 | 6.44000 | 10.1684 |
| Error | 14 | 8.86667 | 0.63333 | Prob > F |
| C. Total | 29 | 105.46667 | | <.0001* |

#### Effect Tests

| Source | Nparm | DF | Sum of Squares | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Turn | 14 | 14 | 94.466667 | 10.6541 | <.0001* |
| Scenario | 1 | 1 | 2.133333 | 3.3684 | 0.0878 |

### Response Total LRT Effective

#### Summary of Fit

| | |
|---|---|
| RSquare | 0.862782 |
| RSquare Adj | 0.715763 |
| Root Mean Square Error | 0.589592 |
| Mean of Response | 1.133333 |
| Observations (or Sum Wgts) | 30 |

#### Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 15 | 30.600000 | 2.04000 | 5.8685 |
| Error | 14 | 4.866667 | 0.34762 | Prob > F |
| C. Total | 29 | 35.466667 | | 0.0010* |

#### Effect Tests

| Source | Nparm | DF | Sum of Squares | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Turn | 14 | 14 | 14.466667 | 2.9726 | 0.0252* |
| Scenario | 1 | 1 | 16.133333 | 46.4110 | <.0001* |