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PREDICTING ENEMY FORCE CLOSURE WITH SIMULATION

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ABSTRACT

This paper presents a model and an analysis done to predict enemy force closure. The simulation replaces a pencil and ruler method that has been used by Department of Defense planners for over a century. More importantly, the model provides planners with the capability to assess previously "impossible to quantify," yet critical, factors: transportation network constraints, equipment reliability and maintainability, varying task times, nighttime operations, and the effects of air interdiction. War planning implications are discussed and notional results are presented.

1 INTRODUCTION

As a superpower, the United States must be proactive in planning for enemy operations around the globe. Our planners require accurate and reliable estimates of enemy capabilities to make force structure decisions, determine our appropriate force presence abroad, and acquire the necessary weapon systems to protect and defend the United States against all enemies.

The ability of our enemies to position forces and mount an attack—called enemy force closure—is critical to military planning. Our planners use assessments of enemy transportation and logistics capabilities, which ultimately provide expected warning timelines, as a foundation for determining peacetime regional force posture and developing war plans. To ensure the United States military is properly positioned to respond to aggression, we need an accurate estimate of enemy force closure capability.

2 SITUATION

Fortunately, enemy attack operations are relatively rare occurrences; but this fact makes it difficult to assess enemy movement capability. For example, Iraq does not often attack Kuwait, and thus we cannot assess Iraq's capability from historical movement data. An analytic method is needed to estimate enemy force closure capability in the absence of historical data.

2.1 Schedule Development

Over a century ago railroad planners used graph paper, pencil, and a ruler to plan train movements and develop schedules. While the pencil and ruler method has merit (particularly in its simplicity and transparence), it is not sufficient for estimating enemy force closure. These train schedules assume that every train will run on time, every time. This approach cannot adequately account for the queuing and variability inherent to the execution of an enemy force closure schedule. In addition, the time-consuming, labor-intensive process of creating schedules by hand is not conducive to application in a dynamic environment. The military planning environment, in particular, demands accurate estimates of both friendly and enemy movement schedules, as well as the ability to rapidly re-evaluate these schedules in response to unexpected contingencies.

2.2 The Military Planning Method

Interestingly, the graph paper method is the same method used by military planners to estimate enemy ground movement capability today! Figure 1 shows a notional Iraq-Kuwait scenario that typifies the complexity of force closure assessments currently accomplished with the pencil and paper method.

In this scenario, three Iraqi armored divisions and corps-level air defense assets (Corps HQ) are moved from typical garrison locations to tactical assembly areas (TAAs) in southern Iraq. Each division is composed of one air defense unit (ADA), two armored brigades (AR BDE), and one mechanized brigade (MECH BDE). The brigades are moved either by rail or on the roads using heavy equipment transporters (HETs) from starting locations to the Basrah region. In Figure 1, the rail system is shown in red and the major roads are shown in blue and green. Once in Basrah, the units must be off-loaded from either the rail or HETs and self-deploy to the TAAs.

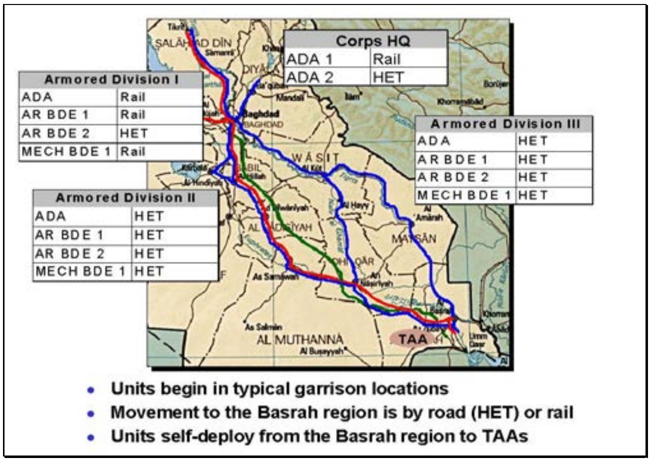

Figure 1: Unclassified Scenario

Military planners currently spend nearly three months developing schedules for scenarios like Figure 1. The process is extremely labor-intensive, yet fails to adequately quantify transportation bottlenecks, equipment reliability, and other known impediments to enemy force closure. In the end, planners are left with a point estimate of enemy capability based on a deterministic evaluation of a single, very specific set of assumptions. Consequently, planners prepare for a "worst case" attack in an attempt to mitigate potential risk. This ultimately results in regional force posture that may be unnecessarily high.

2.3 The Need

Obviously, the dynamics and complexity of this scenario cannot be captured via pencil and paper. Hundreds of tanks, armored personnel carriers, infantry fighting vehicles, and artillery pieces must be moved over several hundred kilometers on limited capacity rail and with scarce HET resources. A more robust, less labor-intensive method is needed to provide planners with a tool to assess this complex process. The tool should automate the planning process and allow planners to test alternatives in a minimal amount of time. It must also account for the inherent system variability and provide planners with a means for assessing the risk of potential contingencies. If this can be achieved, significant insight may be added to the planning process.

3 SIMULATION MODEL

The Air Force Studies and Analyses Agency (AFSAA) was tasked to address this need; military planners at the Defense Intelligence Agency (DIA), Checkmate (AF/XOOC), and 9th Air Force provided assistance. Two objectives were identified:

1. Develop a tool to rapidly produce enemy movement schedules
2. Determine the impact to enemy force closure of variability due to transportation bottlenecks, equipment reliability and maintainability, and air interdiction

To meet these objectives, AFSAA built a simulation model of the perceived enemy capabilities.

3.1 Development

Using the paper and pencil schedule as a baseline, the simulation model was developed in Arena® to mimic the static schedule. A screen-capture of the simulation animation is shown in Figure 2.

Figure 2: Simulation Animation

In addition to the animation, a front-end was included to facilitate experimentation with factors that are typically difficult to assess with absolute certainly. This allows planners to evaluate a range of potential values and assess the sensitivity to uncertainty in those factors. Moreover, the uncertainty inherent to some key factors often causes sharp disagreement among planners as to the appropriate input assumptions. The simulation front-end allowed planners to rapidly assess enemy movement capability based on multiple sets of input assumptions.

3.2 Verification

The complexity and dynamic nature of the problem required a significant amount of time devoted to model verification. Arena® TRACE reports and a rough animation were used to verify the model. The model took the same time to develop as a single iteration of the paper and pencil method. However, the pencil and paper method will take nearly three months to re-accomplish every time an input assumption is changed. In sharp contrast, the simulation can be used to change input assumptions and determine the impacts on the enemy movement in less than one minute.

3.3 Validation

Once the model was verified, a run was accomplished using the constant values that were assumed for the pencil and paper model. The validation results are shown in Figure 3. The green bars indicate the results of the pencil and paper method—the "benchmark"—and the blue bars represent the "constant input data" simulation results. In most cases, the simulation differs from the benchmark by only a few hours—differences deemed "insignificant" by the client.

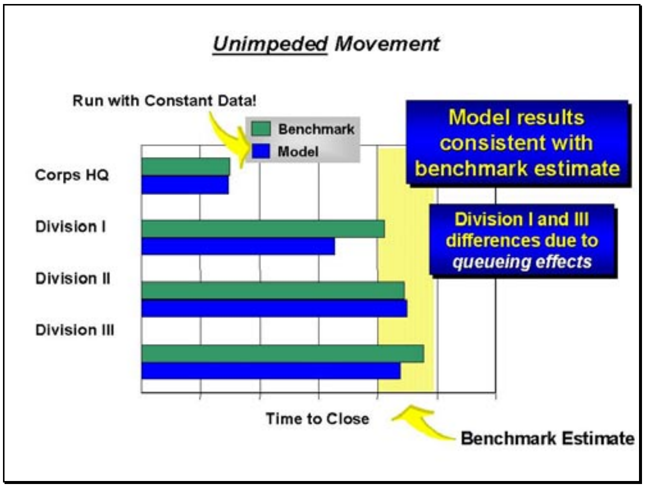

Figure 3: Model Validation

Where discrepancies existed, the clients highlighted deficiencies in their own pencil and paper method as the root cause. For example, the benchmark results for Division I represent an attempt to account for rail queuing and network constraints arbitrarily. In contrast, the specific network constraints (rail capacity per day) were explicitly included in the simulation model. The animation provided with the model was instrumental in displaying this rail constraint feature, and resulted in instant model credibility. Consequently, the client accepted the simulation results as more reliable than the benchmark.

4 ANALYSIS

Once the simulation was validated, we experimented with the model to assess the sensitivity of enemy force closure to the key impeding factors not previously captured with the pencil and paper method. An experiment was designed to assess transportation bottlenecks, equipment reliability and maintainability, and air interdiction effects.

4.1 Beyond Point Estimates

Typically, fifty replications of the model were sufficient to assess the impacts of these factors on enemy force closure. Interestingly, even this number of replications did not produce a normal distribution of results. The distribution was actually much more skewed as depicted in Figure 4.

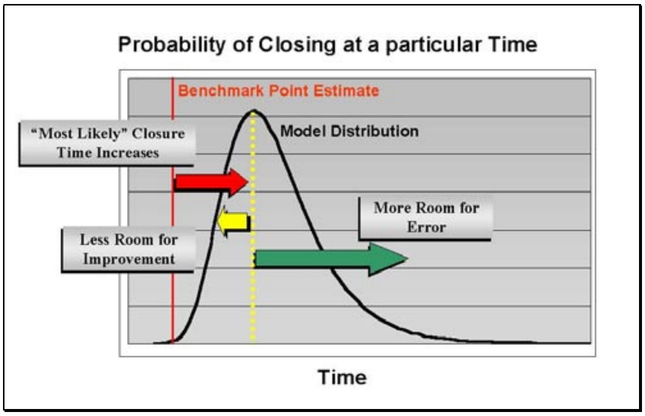

Figure 4: Distribution of Results

This makes intuitive sense as a graphical depiction of Murphy's Law – "What can go wrong will." Assuming that everything will go right all of the time is a gross assumption and leads to extremely optimistic conclusions.

Since the output data was not normally distributed, ExpertFit® was used to determine the appropriate distribution to use for the analysis. The ease of use and extremely detailed information provided by ExpertFit® significantly sped up the output analyses and provided critical insight that would have been missed if we had assumed the output was normally distributed.

4.2 Results

A comparative analysis of the results is displayed in Figure 5. These results clearly demonstrate the importance of accounting for previously "impossible to quantify" impeding factors.

In the baseline case, minimal adjustments were made to the constant data used for validation with the benchmark—for example, task times to upload equipment to transportation assets were changed from constants to relatively narrow triangular distributions. Even with these minor changes, the impact to enemy force closure estimates is significant. It is clear that the benchmark estimate was indeed "worst case", and that the probability of occurrence for this worst case is quite low. A conservative, low-risk estimate of force closure is significantly longer than the benchmark.

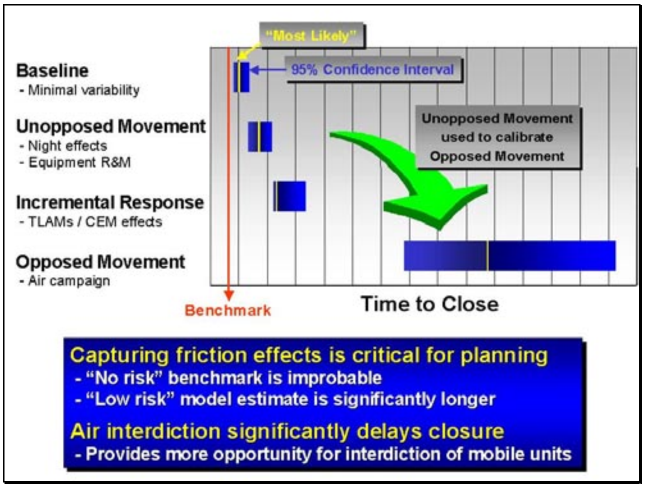

Figure 5: Comparative Results

Finally, the results from this analysis were used to calibrate enemy force movements in a campaign-level simulation. Once calibrated to the low-risk estimate of enemy force closure, the campaign model was used to assess the effects of air interdiction on enemy force closure. This extension enabled planners to assess a wide range of potential air interdiction campaigns. Figure 5 shows the comparative results of both a minimal effort (Incremental Response) and a full air interdiction campaign (Opposed Movement). Even the incremental response--which employs a limited number of Tomahawk Land Attack Missiles (TLAMs) and Combined Effects Munitions (CEM) to impede enemy mobility--delays enemy force closure significantly. As expected, the opposed movement case results in a dramatic delay to the enemy timeline, which provides the corresponding benefit of additional time for friendly forces to attack mobile enemy units.

5 CONCLUSIONS

Clearly, both logistical "friction" factors and air interdiction will have significant impacts on enemy force closure capability; the ability to assess these impacts is critical to effective planning. This effort convinced military planners that simulation is an efficient and effective means for accomplishing this task. Consequently, the simulation model developed for this effort is replacing the pencil and ruler method that is over a century old.

By enabling planners to quantify known enemy transportation and equipment problems, as well as the effects of air interdiction, the simulation model provides a significantly improved method of assessing of enemy force closure. This method will help planners evaluate potential risk to U.S. interests abroad, and appropriately structure our regional force postures.

ACKNOWLEDGMENTS

A team of experts accomplished this simulation project. AFSAA developed the model and performed the analyses. DIA provided functional area expertise, assumptions, and data. Checkmate molded the simulation-provided insights into a compelling message that inspired decision-makers to take action.

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