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Computational Experimentation to Simplify and Optimize a Large-Scale Simulation of Resourcing Marine Corps Readiness

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NPS NRP Executive Summary

Computational Experimentation to Simplify and Optimize a Large-Scale Simulation of Resourcing Marine Corps Readiness

Report Date: 10/31/2019 Project Number (IREF ID): NPS-19-M249-A

Naval Postgraduate School, Graduate School of Operational and Information Sciences (GSOIS)

NAVAL RESEARCH PROGRAM

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

COMPUTATIONAL EXPERIMENTATION TO SIMPLIFY AND OPTIMIZE A LARGE-SCALE SIMULATION OF RESOURCING MARINE CORPS READINESS

Executive Summary Type: Final Report
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EXECUTIVE SUMMARY

Project Summary

Marine Corps senior leaders need to allocate service resources to deliver ready units to combatant commanders when required. The goal of this research was to use computational experimentation to provide model-based evidence to Marine Corps decision makers as they seek policies and investments to achieve force readiness objectives in future years. The Marine Corps' Readiness and Availability Tool (RAT) is a model that provides insight into operational readiness. This research developed an updated version of RAT that facilitates massive experimentation. This new design of experiments (DOE) capability was used to efficiently explore the dynamic interactions of RAT. Analysis of 1,200 simulated readiness timelines shows that in developing a force-wide readiness strategy for the Marine Corps, it is critically important to consider the interactions between force structure, deployment demand, and force-generation-timeline decisions rather than to focus on any single aspect of readiness planning. This executive summary is based on Doherty (2019), which contains the details of this research.

Keywords: *Future Years Defense Plan, FYDP, data farming, design of experiments, DOE, large-scale simulation, operational readiness, Readiness and Availability Tool, RAT, Special Purpose Marine Air Ground Task Force, SPMAGTF*

Background

The interactions between resources and readiness are complex, involving thousands of decisions and intermediate outcomes. To help understand the potential impacts of policy decisions on readiness, the Marine Corps' deputy commandant for programs and resources is building a suite of models of operating force elements that propagates the effects of resourcing and policies in the Future Years Defense Plan (FYDP) to quantify the readiness of force elements in each year of the FYDP. The objective of this research was to use data farming techniques to improve upon the Marine Corps' ability to provide model-based evidence to Marine Corps leadership on the potential impacts of policies and investments in achieving force readiness.

Data farming is the use of computers and designed experiments to build and analyze computational models. Recent advances in our ability to explore high-dimensional computational models include greater computational speed, new DOE (Cioppa and Lucas 2007), and data visualization.

The Marine Corp's RAT was selected as the readiness tool to data farm. RAT simulates a process in which both force elements and demand nodes cyclically move through a scheduled steady-state rotation of deployment, dwell, and pre-deployment training. The steady-state rotation can be disrupted by contingency operations that pull force elements in order to fill pop-up needs. RAT utilizes discrete categorical input variables to facilitate the modeling of different force structures, deployment requirements, force-generation timelines, and contingency mission scenarios.

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Findings and Conclusions

This research developed a DOE-enabled update of RAT and used this new capability to efficiently explore the operational readiness impacts resultant from Marine Corps decisions regarding force structure and force employment. A total of 1,200 readiness timelines were simulated with a goal of stressing the Marine Corps' readiness system in order to find breaking points in its capacity to meet demand. We used basic summary statistics and metamodels to explore the simulation response surface of RAT for factor significance, key decision thresholds, and variable interactions. Some key findings from this analysis are:

- The number of infantry battalions is the dominant factor in determining average home-station readiness. The primary threshold to consider is whether the utilization is less than or greater than 23 battalions.

- Factor interactions are significant in each of the four metamodels developed for this research. Specifically, the percentage of non-ready units deployed three-way interactions provide insightful thresholds that could be translated into Marine Corps policy decisions.

- At the Marine Corps' current force structure of 24 infantry battalions and deployment-demand equal or greater than seven steady state deployments, RAT displays a risk factor of 11% in deploying non-ready units even if resourcing is provided to ready units in less than nine months. By increasing the force structure to 26, the risk can be reduced to 4.4% and a resourcing requirement of less than 11 months.

- If the Marine Corps were to reduce its Special Purpose Marine Air Ground Task Force (SPMAGTF) deployments to only one, the risk of deploying non-ready units could be reduced to less than 1% at its current force structure. However, if the Marine Corps were to also reduce its force structure to less than 23 battalions, then this risk would increase to 9.8% with a requirement to ready units of less than 11 months.

- A potential error exists within RAT's business rules for sourcing contingency operations, which has been identified to the sponsor.

Recommendations for Further Research

The Marines can leverage several findings from this research toward improving their ability to estimate operational readiness in the future. These include making more of their modeling tools stochastic and data farmable.

References

Doherty, K. J. (2019). *Data farming the Marine Corps' Readiness and Availability Tool* (Master's thesis). Naval Postgraduate School, Monterey, CA. Retrieved from https://calhoun.nps.edu/handle/10945/62851

Cioppa, T. M., & Lucas, T. W. (2007). Efficient nearly orthogonal and space-filling Latin hypercubes. *Technometrics, 49*(1), 45–55.

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Acronyms

design of experiments	DOE
Future Years Defense Plan	FYDP
Readiness and Availability Tool	RAT
Special Purpose Marine Air Ground Task Force	SPMAGTF