Draft: Military Operations Research Response to COVID-19

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## Introduction

Military operations researchers have dozens of current Coronavirus Disease 2019 (COVID-19) projects supporting leaders up and down the chain of command. This paper describes 10 of them. They support decisions that mitigated risks to installation communities, formed Army health policies, shut down and reopened installations, and kept West Point cadets home for half of a semester. These decisions and more all happened in the last 16 months.

Traditionally, operations researchers work from rearward positions on long-term problems with clear deliverables and established progress schedules. Data analytics was just another tool in the box. Then one day, this new, microscopic enemy sprang from nowhere. It was resourceful. It moved quickly and unpredictably. Army leaders had to make next-day decisions that pitted life and death against mission readiness, and they had no intelligence on which to base those decisions.

What was to be learned about this enemy would come from billions of bytes of data buried in datasets; and the datasets themselves had not been clearly identified. And to complicate things, the enemy was already here. The tragic effects of the disease were all around us. Military operations researchers were no longer in the rear.

Luckily, those military operations researchers, speckled across installations around the world, were in positions and were willing to put their personal lives aside. Center for Army Analysis’s COVID-19 case projection model, for instance, grew out of a private hobby of two Majors. Before the pandemic first peaked, their hobby had become a useful model that quantified risk nationwide down to the county level. Its results are based on data only hours old. Another analyst, Dr. Ian Detwiller of the Engineer Reachback and Development Center was held to account for requesting a one-day leave on a weekend. For weeks, his team had been working around the clock to stay ahead of their analysis consumers that Dr. Detwiller’s boss, part in jest, questioned Dr. Detwiller’s leave. Dr. Detwiller then reminded his team that Saturday was his wedding day; the analysis behind his leave request concluded it would take longer than a day to mitigate his bride’s anger had he missed their wedding.

Data science, the field that most of the following projects leverage, is not new to the operations research. However, the COVID-19 pandemic has shed light on data science as a valuable and relevant capability in operations research. Operations researchers are not limited as they once were to long-turn analysis completed with little data and limited computing power. Today, data and statistical modelling tools are cheap (if not free) and widely accessible. A data scientist with a laptop and an internet connection can gather massive amounts of data, leverage the latest machine learning techniques, and access more computing power than ever before. Moreover, an operations researcher trained in data science can do all that and synthesize the analysis and its accompanying uncertainty into information relevant and useful for a decision maker.

The challenge is not over. In fact, it has hardly begun. The final outcome remains unknown. And the enemy will not be defeated by operations research alone. But the 10 projects described here may surprise you about what an operations researcher with a laptop and a broadband connection can do. Don’t feel bad if it does. The team members on these projects were surprised too.

## Center for Army Analysis

The Center for Army Analysis (CAA) developed a model to estimate future active COVID-19 cases and their resulting hospitalizations and fatalities nationwide at the U.S. county level and core-based-statistical-area level. CAA also conducted analysis on key Army installations for Army Senior Leaders. Until Summer 2020, CAA’s primary audience is the Secretary of the Army or Vice Chief of Staff, the Army G-3/5/7, Army Medical Command, and Army Material Command. Following Summer 2020, CAA’s primary customers were United States Indo-Pacific Command and U.S. Army Central.

CAA’s primary model, from which other smaller models were developed, is a SEIR (Susceptible, Exposed, Infectious, Removed) compartmental model. The SEIR model relies on static, deterministic parameters, except for the contact rate, . To estimate the basic reproduction rate ()—in turn, —CAA uses an XGBoost model with multiple routinely updated datasets, including nationwide mobility data, state policy data, COVID-19 testing data, and population demographics.

Scott Lynch, Center for Army Analysis; Dusty Turner, Center for Army Analysis; Maxine Drake, Center for Army Analysis; and the CAA COVID Modeling & Analysis Team

**Engineer Research and Development Center**

The Engineer Research and Development Center (ERDC) developed a Bayesian calibrated SEIR model in order to forecast COVID-19 spread. Their work supported Federal Emergency Management Agency, the Corps of Engineers, and local officials to help make decisions regarding where to set up alternative care sites. Alternative care sites were arenas and hotels these organizations converted into temporary hospitals. Their model was critical to senior decision makers in the Corps of Engineers.

Dr. Ian Dettwiller, Engineer Research & Development Center, and the ERDC COVID Modeling & Analysis Team

## G3/5/7 Operations, Plans, and Training, Resource Analysis and Integration Office

A team in the Resource Analysis and Integration Office (DAMO-ZR) developed a cluster based Poisson regression model to make week-long case projections to predict future deaths, developed a severity metric to classify recent history of the pandemic across the United States, and predicted future host spots by measuring the relative rate changes of various metrics. Their model provided situational awareness to MG Paul Calvert, Assistant Deputy Chief of Staff, G3/5/7, and his staff as they assessed risks posed by opening installations.

Dr. Anh Tong, Resource Analysis and Integration Office, and MAJ Larry Tobin, Resource Analysis and Integration Office

## Corps Headquarters, 1st Corps and 4th Infantry Division

The Fort Carson ORSA team provided a COVID policy assessment primarily to MG Matt McFarlane, 4th ID Division Commander and Fort Carson Commanding General, and his staff. The ORSA team provided assessments on friction points and policy compliance among the installation population as well as recommendations to improve the style and tone of command messaging. These assessments were based on social media comments, town hall comments, MWR program data, temperature check teams, and serious incident reports across the installation. The team also conducted contact tracing analysis, helped the Commander and his staff develop policies to mitigate the spread of COVID-19.

MAJ Mike Seminelli, Corps Headquarters, 1st Corps and 4th Infantry Division

## Army Public Health Center

Army Public Health Center (APHC) created the Army COVID-19 Model for Epidemics (ACME). They created ACME, an SIR-based model, to project impacts on hospital and intensive care unit bed requirements and estimate when the pandemic would exert maximum stress on resources. This informed medical planners responsible for allocating Army resources. ACME was later adapted to provide guidance to garrison and installation Commanders on when and how Force Health Protection Conditions (i.e., installation health policies) should be reduced or raised based on local epidemiological conditions.

As the pandemic progressed, they partnered with the Center for Army Analysis and a contracted company, Lawrence Livermore National Labs (LLNL), to improve their COVID-19 projection model. From this partnership, LLNL develop a comprehensive agent-based model to optimize non-pharmaceutical interventions, such as testing protocols and restriction of movement protocols, specifically for units deploying to Army Combat Training Centers.

Primary customers for APHC’s analysis included the Army's Office of the Surgeon General, Army combatant commands, and Army hospital commanders and staffs. Throughout their analysis APHC collaborated with LTC Isaac Faber, Futures Command Artificial Intelligence Task Force; LTC Nicholas Clark, US Military Academy at West Point, Department of Mathematical Sciences; and Dr. Stephanie Cinkovich, formerly APHC, now a contractor supporting Armed Forces Health Surveillance Division's Global Emerging Infections Surveillance branch; and Center for Army Analysis.

Dr. Jacob Ball, U.S. Army Public Health Center

## United States Military Academy at West Point

The United States Military Academy at West Point departments of Mathematics and Systems Engineering teamed together to support senior leaders’ decisions impacting the welfare of cadets, faculty, and families on post. The team rapidly prototyped and implemented an SEIR model and these results led the academy to keep the corps of cadet’s home for the duration of the semester following their spring break. Their modeling also helped develop their testing protocols to monitor and limit future outbreaks at the academy.

*COL Matthew Dabkowski PhD, COL Paul Evangelista PhD, LTC Nicholas Clark PhD, and Mr. Ian Kloo, United States Military Academy at West Point*

## Center for Naval Analysis

The Center for Naval Analysis’s (CNA) initial work focused on the health and safety of naval vessels across the world. Their team studied the risk of bringing in an infection from outside (e.g., maintenance workers, supply refit personnel, etc.) as well as the potential impact of an outbreak on a ship. The CNA simulated outbreaks on their ships to test various mitigation strategies as well as explore various vaccination protocols. The team was able to apply their lessons across all naval ships and also apply these lessons to Navy bootcamp, A-School, and correctional environments.

Dr. Bradley Dickey, Center for Naval Analysis

## Naval Operations Assessments Division (OPNAV N81) and Naval Health and Research Center (NHRC)

Naval Operations Assessments Division (OPNAV N81) and Naval Health and Research Center (NHRC) leveraged the Defense Threat Reduction Agency’s COVID projection model to estimate resource requirements to treat COVID patience at DOD Hospitals. Their model estimated usage of hospital ward beds, intensive care unit beds, and daily ventilator and PPE consumption at each military treatment facility. Their standard model provided usage estimates for two scenarios: “Relaxed Social Distancing” and “Improved Detection.” Along with the model, the team created a Shiny App [FOR WHOM?] that allowed a user to adjust parameters to run unique scenarios and visualize the impact at DoD hospitals. Furthermore, the team generated over 70 COVID-related products for various customers across the Navy.

CDR Kevin McMullen, Naval Operations Assessments Division

## Navy and Marine Corps Public Health Center

The Navy and Marine Corps Public Health Center, in collaboration with the Health Analysis Department of the Preventive Medicine department and EpiData Center, created a variety of models for Navy medical leadership to improve force health protection. Several of their models include: probability models to assess the likelihood of an infection-free cohort or transmission of infections; mathematically derived models to determine the crew inoculation percentage required to achieve the desired average COVID-19 reproduction number; non-linear dynamic models to determine the number of COVID-19 cases remaining in a population based on different testing strategies and crew sizes; and, stochastic models to determine the percent chance of an infected person exiting restriction of movement undetected.

Current models inform a wide range of decision to include delivery of care, hospital capacity and resourcing, disease spread and mitigation, disease tracking, and risk management. Early models helped inform questions we faced related to hospital capacity and resourcing, such as identifying high-risk populations and projected utilization for resources like emergency rooms, intensive care unit beds, and ventilators. Other models informed readiness and travel decisions by developing an interactive map of daily case counts by state and county. More recently they’ve analyzed spread and mitigation strategies to minimize risk; these projects look at restriction of movement, timing of testing, and vaccinations. Lastly, their work has also encompassed how COVID-19 has affected delivery of care, specifically mental health care.

Mr. Jonathan Koch, Health Analysis Department, Navy and Marine Corps Public Health Center, and Dr. Paul Rockswald, Navy and Marine Corps Public Health Center

## US Air Force Academy

Multiple departments from the U.S. Air Force Academy (USAFA) collaborated to form two models. The first, used early in the pandemic, was an agent-based Monte Carlo simulation of the day-in-the-life of a cadet to evaluate the effect of various “risky interactions” (academic classes, sports practices, meals, aviation programs, military training, etc.). The second was a stochastic SEIR model that permits evaluation of policy options, including surveillance testing. Since June 2020, they have used almost exclusively their stochastic SEIR model for 1) evaluating case dynamics and projected trajectories and 2) establishing policies on weekly surveillance levels, restriction-of-movement postures, etc. Different from a typical SEIR model, USAF’s stochastic SEIR model runs over a social network graph of the academy population. The USAFA team adapted their stochastic SEIR model from work by the Computational Biology Group at the University of Washington, whose GitHub page is <https://github.com/ryansmcgee/seirsplus>. The USAFA team briefed its approach to all levels of Air Force leadership, the DOD COVID Task Force, and the prior Deputy Secretary of Defense who received regular updates. Their work directly influenced decisions within USAF on the size the of the cadet population, mixing of in-person & remote teaching, relative risk of various return to campus options (e.g., 1-cohort vs 2-cohort returns), and much more.

COL Douglas Wickert, Aeranautics Department, U.S. Air Force Academy, and the USAFA Modeling & Analysis Team

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