A Predictive Decision Analysis Tool for Risk Informed, Capital Investment Planning within the Department of Veterans Affairs

Henry Carroll, Peter Digenan, Scharl du Toit, Nathan Jose, Brook Mitchell, and James Schreiner

Department of Systems Engineering
United States Military Academy
West Point, New York 10996

Corresponding author's Email: pdigenan323@gmail.com

Author Note: This paper was previously published and presented in the Donald R. Keith Memorial Capstone Conference at USMA in May of 2023. The authors would like to thank the Department of Systems Engineering at West Point and the Department of Veterans Affairs Office of Construction and Facility Management, specifically Mr. Ross Davidson and Mr. James Symanski. The views expressed in this work are those of the author and do not necessarily reflect the official policy or position of the United States Military Academy, Department of the Army, DoD, or U.S. Government.

Abstract: The Department of Veterans Affairs (VA) advances healthcare research and contributes to the Federal Response in the state of a national healthcare emergency while providing healthcare to veterans. The VA needs to maintain and improve accessible and safe healthcare infrastructure using risk-informed decision models. The VA relies on the Strategic Capital Investment Planning (SCIP) process to allocate resources but lacks predictive modeling. The Strategic Analysis and Risk Tool (START) creates a user-friendly interface to display environmental and veteran migration risk data, leveraging Power BI and Python. Our research presents a georeferenced risk assessment model that provides insights to regional and facility decision makers about these risks. This risk score helps SCIP decision makers allocate limited resources among VA facilities.

Keywords: Department of Veterans Affairs, Risk Assessment, Resource Allocation, Infrastructure Management

1. Introduction

1.1 Background

The VA Asset and Infrastructure Review (AIR) Commission, conducted in 2021, outlines the updated priorities of the VA (Department of Veteran's Affairs, 2021). These priorities include addressing risks inherent to veteran migration and environmental factors which could influence capital investment and divestment criteria. The SCIP is the current process model that the VA uses to make risk-informed decisions about resourcing projects. The SCIP does not adequately consider environmental threats and their impact on infrastructure. Additionally, it does not account for infrastructure capacity imbalances in relation to veteran migration. The Veterans Health Administration (VHA), the healthcare arm of the VA is the largest healthcare network in the United States (US) (Veteran's Health Administration, 2022). The VHA lacks a decision tool for making effective infrastructure investment and divestment decisions in the face of dynamic veteran migration patterns and environmental threats.

1.2 Literature Review

The VA is one of the largest departments in the federal government, consisting of 340,000 employees serving roughly 9 million veterans annually in its healthcare arm – the Veterans Health Administration (Ibid, 2022). The VA has three primary goals: empowering veterans to improve their well-being, enhancing and developing trusted partnerships, and managing and improving the well-being of veterans (United States Department of Veterans Affairs, 2020). Because the VA has a national client base, the organization constantly needs to make decisions accounting for population movements and the migration of veterans. Historically, there have been two "waves" of veteran migration, following World Wars I and II (Cowper, 2000). Similar trends are beginning to emerge following the Global War on Terror, and the VA is adjusting its infrastructure footprint to support this. Patterns of veteran migration show an increasing population density in the

DOI: https://doi.org/10.37266/ISER.2023v11i1-2.pp67-72

Southeastern United States, with corresponding decreases in the Ohio River Valley and Northern Regions of the United States (Amaral, 2018). In these modern

conditions, infrastructure adjustments also need to account for the environmental threats facing the Southeastern Region. The VA has emphasized this as a priority in capital allocation priorities. However, the VA lacks a data-driven methodology to guide these investment decisions. To support the data-driven methodology, the team analyzed two authoritative data sources. The US Census and the Federal Emergency Management Agency (FEMA) National Risk Index (NRI) provided valuable insight to support the development of the data driven methodology.

The Office of Construction and Facilities Management (OCFM) is seeking to enhance the existing SCIP and corresponding multi-criteria decision tool as specified in the VA Handbook 0011 (Veteran's Health Administration, 2023) to provide enterprise decision makers with accurate and timely analysis of potential risks of imbalance in hospital supply and veteran demand, while at the same time accounting for infrastructure resilience given the increasingly complex and emergent qualities of market migration and environmental threats. The aim is to address risk left of the SCIP process, and improve capital investment decision quality across the VA.

2. Methodology

2.1 Systems Thinking Functional Analysis

Systems thinking helps to define the VA's infrastructure portfolio boundaries, inputs, outputs, process structure, and complex relationships of entities (Parnell et al, 2011). The Systems Decision Process (SDP) (Figure 1) is an iterative and value-based decision process consisting of four major phases: problem definition, solution design, decision making, and solution implementation (Ibid, 2011). This framework provides a mapping of the iterative process ultimately used to develop the START. This is important because the START or any process of this kind, did not exist for this problem prior to this.

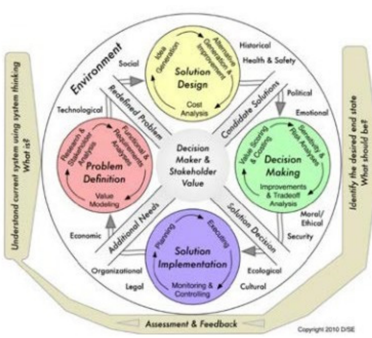

Figure 1: Systems Decision Process (Parnell, Driscoll, & Henderson, 2011, pp. 281-282)

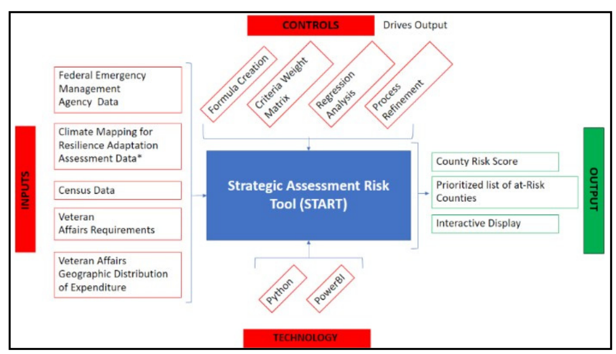

Figure 2: Initial Functional Decomposition – IDEF0

The initial functional decomposition of the system in Figure 2 illustrates the inputs, controls, technology, and outputs of the START. The inputs are the data sources that create the risk score. The data most heavily relied on is census data ranging from 2011 – 2021, FEMA risk score data, and VA infrastructure requirements. The controls were derived from a value weight hierarchy and an additive risk model. Python and Power BI, the technological enablers of the model, ultimately drive the final output. The output is an interactive user interface incorporating risk at the county level. The end users are VA Planners.

2.2 Lean Methodology and Process Improvement

The initial focus of the project was to optimize and create an efficient decision-making tool to drive infrastructure investment decisions for the VA. The tool concept included investment/divestment criteria, and environmental influences, relying strictly on GIS technology to create an interactive georeferenced model. After time spent at the Manhattan Harbor Health Care Center, and interacting with facility level stakeholders, and multiple iterations of the problem definition phase, the emphasis shifted towards the environmental factors and veteran demand that impact resource allocation. The START is intended to close the gap that existed between the VISN and SCIP Panel levels. Multiple stakeholder engagements with the

DOI: https://doi.org/10.37266/ISER.2023v11i1-2.pp67-72

Office of Construction and Facilities Management left the team focused on creating a risk assessment tool that provides a risk score for each VA healthcare facility based off veteran demand and environmental threats. The intent of this tool is to be used before the SCIP level to provide a more informed resource allocation assessment.

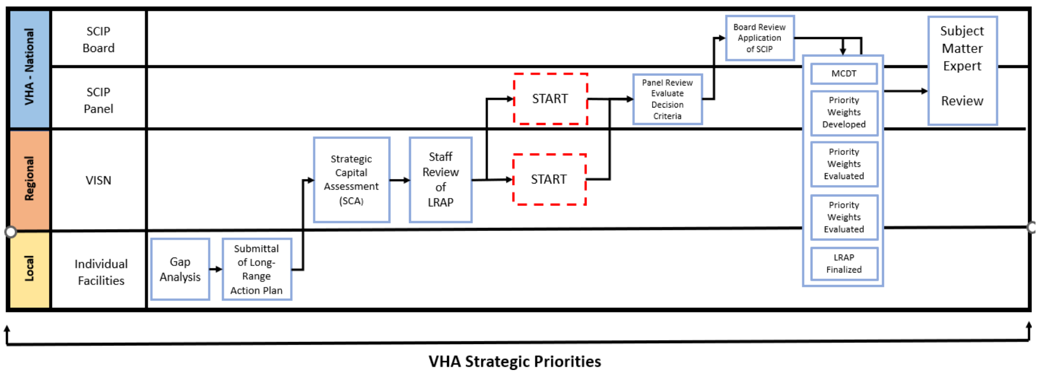

Figure 3: Capital Investment Process with 'To Be' Swim Lane Model with START Improvement

2.3 Decision Model and Risk Score

The value model created addressed the two primary risks of population supply and demand imbalance, and environmental threat to infrastructure in Figure 3. The team examined both risks at the county level and aggregated them to facility areas of responsibility as determined under VA guidelines. Stakeholder analysis determined that these are the two most challenging risks faced from an infrastructure capital allocation standpoint.

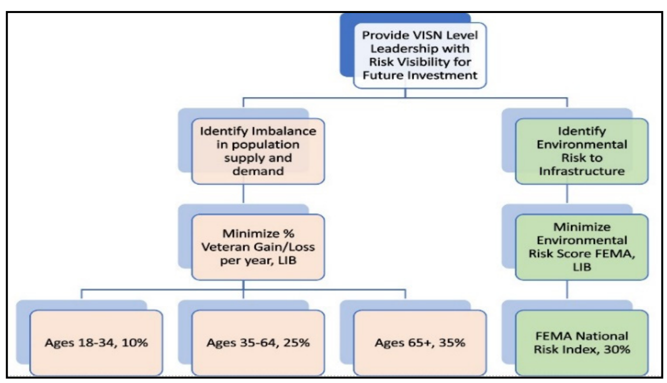

Figure 4: Value Model to assess Risk to a County or VA Facility Area of Responsibility

The proposed decision tool relies on a weighted score that is developed using the criteria highlighted the value hierarchy in Figure 4. Each demographic group within the population corresponds to its respective weight in Equation 1, while environmental threats receive a weight of 0.3, also reflected in Equation 1. The demographic breakdowns correspond to US Census Data age brackets for Veteran Population and are dynamic in nature. Stakeholder analysis affirmed the grouping of specific brackets to these three age groups. The team obtained value criteria weights through stakeholder engagement and reflect VA decision priorities.

The team created a veteran population regression analysis using the rate of change of the veteran population in each county over a 10-year period (2011- 2021), and then extended to make predictions at the 10-year and 25-year mark. The environmental threat regression analysis analyzed the rate of change over three years of environmental threat data from 2020 – 2022 at the county level. This is the only available environmental threat data. The regression created from 2020 – 2022 extends to the 10-year and 25-year mark. The 10-year risk score will provide VA with a timely risk analysis of current migration and environmental threats, while the 25-year risk score will provide the VA with veteran migration and environmental threat

DOI: https://doi.org/10.37266/ISER.2023v11i1-2.pp67-72

insights into strategic decisions on where to establish new VHA infrastructure to serve the dynamic veteran population.

The resulting equation below gives a general form for the risk score calculation discussed above. This additive value score replicates a 'risk value', or Risk Priority Number (RPN) which scales from 0 to 100 – with a score of 100 being high risk, and a score of 0 being low risk. While traditional RPNs account for subjective assessment of likelihood, severity, and detectability of a risk, the data in this additive decision model reflects these attributes and could, in time be augmented with a more subjective assessment of risk.

$$RPN = .1(vet18to34) + .25(vet35to64) + .35(vet65plus) + .3(environmental) \quad (1)$$

3. Findings

3.1 Sensitivity Analysis

A key component of the model is the adjustable global weights. Adjustable global weights provides the clients at the VA with a dynamic user interface that can be changed to meet the current needs of the VA. While this dynamic feature was requested by the VA, it poses potential threats to model validity, thus requiring a robust sensitivity analysis performed on the model. Increasing each global weight by 50%, comparing the resulting county RPN to original county RPN to create a sensitivity analysis range shown below in Figure 5. The RPN for Clay, Georgia (data point 11) is extremely sensitive to change in the 35-64 veteran population as well environmental threat. The RPN for Stephens, Georgia (data point 106) is extremely sensitive to change in the 65+ veteran population.

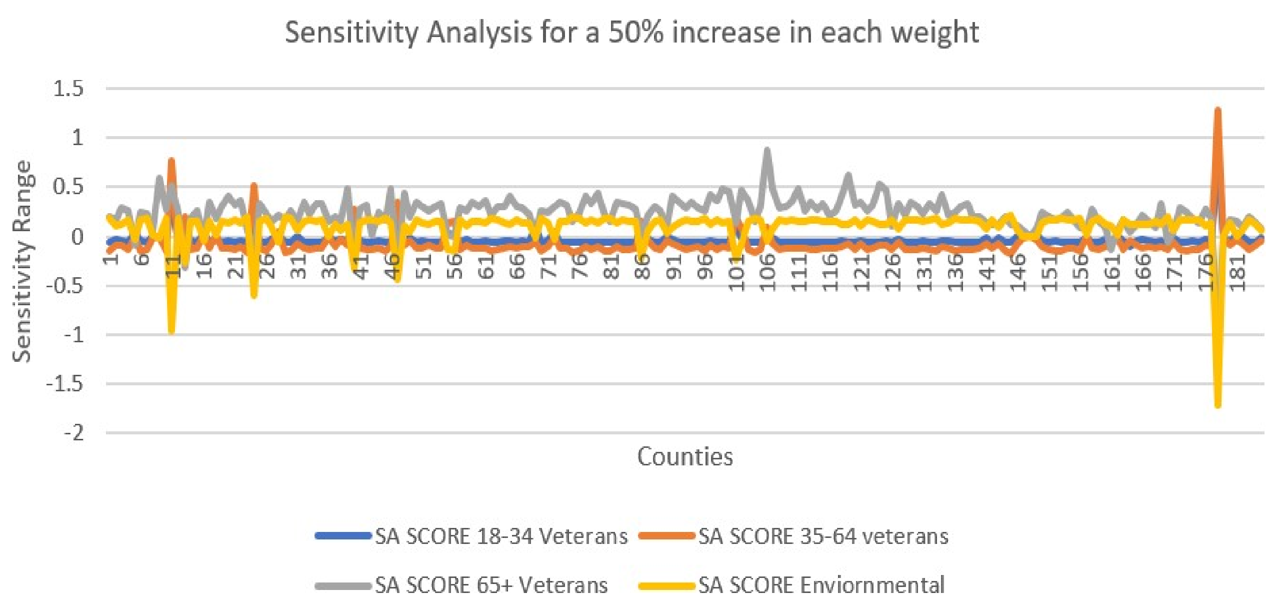

Figure 5: County Sensitivity Analysis to Risk

3.2 User Interface

In order to develop a tool that is usable for the VA, the team developed prototype models using Microsoft's Power BI and Python. In designing the user interface, the objective was to depict the risk priority numbers associated with environmental threats and veteran migration. Through stakeholder analysis and the initial problem statement, the primary element of the interface is the geo-referenced display. Within the display, the risk scores for three states are built on a spectrum of low risk to high risk and mapped accordingly. Table 1 identifies the dynamic qualities of each model through the functional layers.

DOI: https://doi.org/10.37266/ISER.2023v11i1-2.pp67-72

Table 1: User Interface Comparison

	Power BI	Python
Purpose	Provide executive decision makers with a scalable tool for timely risk analysis through geo-referenced visuals.	Provide VA OCFM planners with a platform to display detailed heatmaps and risk data.
Functional Layers	1. County-Level Risk Priority Numbers 2. Filter Feature for Dynamic View 3. Infrastructure Locations	1. County-Level Risk Priority Numbers 2. Overlayed Infrastructure Locations 3. Ability to Integrate Multiple Layers
Data	- Federal Emergency Management Agency: National Risk Index - U.S. Census Data (2011 – 2021)	
System Usability Score (SUS)	64	57.5

Figure 6 displays the main page of the Power BI prototype interface. The purpose of this page is to allow the user to filter the information and data shown by selecting the desired county within Veteran Integrated Services Network (VISN) 7, which includes Alabama, Georgia, and South Carolina. With a county selected, the map zooms in to that location and provides the user with the respective RPNs. Figure 6 displays a visual of this action. Using the checkboxes on the left-hand side of the interface, users have the ability to focus in and filter specific counties, with their corresponding risk scores and relevant information used to aggregate that score.

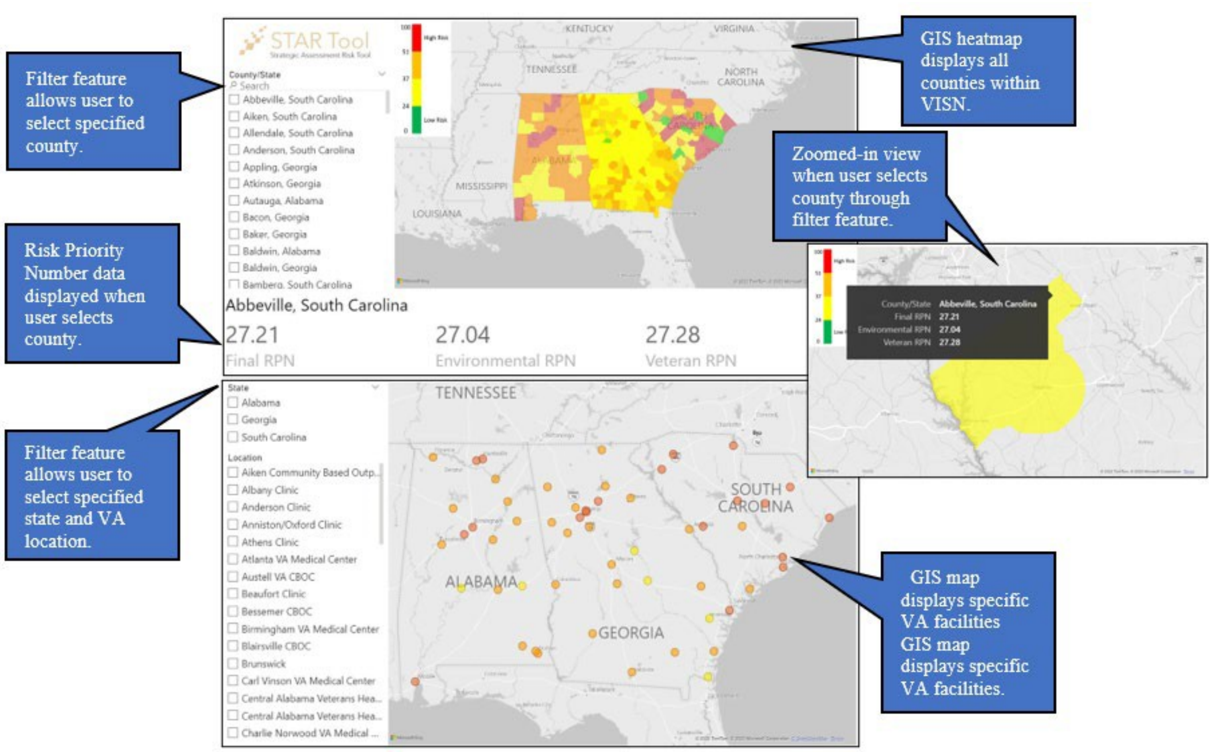

Figure 6: Example of Power BI User Interface VA Locations Page

Senior leadership at the Office of Construction and Facility Management (OCFM) suggested a map visual displaying all the VA locations in VISN 7. Figure 6 displays a visual of these locations on a map. The user can select the state and then the specific VA locations within it. The purpose of this page is to serve as a visual orientation of current infrastructure to aid in identifying opportunities for investment and divestment. Not shown, but in a complementary manner the Python interface can toggle on and off multiple "layers" of the map and can be customized to planner preferences. It maintains hover function in which users can simply click on a location and view its respective information. The interface is highly customizable and can take on a virtually infinite number of layers, allowing users to tailor the model to specific needs.

Our team met with high level VA stakeholders and their teams to demonstrate START. The team conducted an initial validation of the model with the client to test the tool; further statistical approaches will be used once a validation data set can be gathered from VA planners.

4. Conclusions and Future Work

In February of 2023, VA planners were able to get hands-on experience with the multi-criteria decision tool. This provided the team an opportunity to refine the START based off client feedback. As the healthcare industry evolves, having the ability to map and rate infrastructure with assessed priorities is integral to improving the efficiency of capital allocation. The team originally presented two independent prototypes for mapping risk. The team first used Power BI to demonstrate the ease of mapping and prioritizing risk, while the latter used Python, a highly customizable tool with a higher learning curve. During and after the demonstration, the team administered a system usability score (SUS) survey (Table 1) to the VA planners to determine the effectiveness of each model. This led to the conclusion that Power BI would represent the high-level executive decision interface with a complementary Python layered model for detailed planning. Both have critical strengths regarding their ability to overlay and visualize data inputs. Furthermore, VA Planners, the ultimate end users, expressed both enthusiasm and approval for both.

The future work will examine the most proactive ways to incorporate layers into Python for planner preferences while leveraging the initially developed code. Additionally, the 18 factors that make up the FEMA NRI can be disaggregated so that individual VA facilities and VISNs can assess climate risks specific to their regions. The framework for this tool is scalable for a variety of needs, not limited to those of healthcare infrastructure planning.

5. References

Amaral, E. F. L., Pollard, M. S., Mendelsohn, J., & Cefalu, M. (2018). Current and Future Demographics of the Veteran Population, 2014–2024. Population Review, 57(1). https://doi.org/10.1353/prv.2018.0002

Cowper, D. C., Longino, C. F., Kubal, J. D., Manheim, L. M., Dienstfrey, S. J., & Palmer, J. M. (2000). The Retirement Migration of U.S. Veterans, 1960, 1970, 1980, and 1990. Journal of Applied Gerontology, 19(2), 123–137. https://doi.org/10.1177/073346480001900201

Department of Veterans Affairs. (2021). *Strategic Capital Investment Planning Process*.Washington, DC. https://www.va.gov/vapubs/viewPublication.asp?Pub_ID=574&FType=2

National Risk Index | FEMA.gov. (2023). Hazards.fema.gov. https://hazards.fema.gov/nri/

Parnell, G. S., Driscoll, P. J., & Henderson, D. L. (2011). Decision making in systems engineering and management. Wiley.

Veterans' Health Administration. (2013). VA.gov | Veterans Affairs. Va.gov. https://www.va.gov/health/aboutvha.asp United States Department of Veterans Affairs. (2020). VA Functional Organization Manual (2020-4) [PDF]. Retrieved from https://www.va.gov/VA-Functional-Organization-Manual-2020-4.pdf

U.S. Department of Veterans Affairs. (2021). VA-Report-2-AIR-Commision-Volume-1. [Unpublished Manuscript].

U.S. Department of Veterans Affairs. (2022, May 27). About the Department - U.S. Department of Veterans Affairs. Department.va.gov. https://department.va.gov/about/

DOI: https://doi.org/10.37266/ISER.2023v11i1-2.pp67-72