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META-ANALYSIS OF TOTAL FORCE COSTING METHOD LITERATURE

by

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META-ANALYSIS OF TOTAL FORCE COSTING METHOD LITERATURE

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Submitted in partial fulfillment of the
requirements for the degree of

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from the

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ABSTRACT

This report analyzes publicly available, current and historical Total Force Costing (TFC) methods, data sources, modeling assumptions, and strategies to determine if TFC similarities exist between the services. If similarities are found, is it possible to construct a best-practice TFC model that will satisfy multi-service budget estimating needs in a joint environment? Despite the blending of resources in a joint-warfighting environment, it is apparent that each service continues to use its own assumptions, cost groupings, and calculations to plan future spending. Cross-talk between service budget planners is a mandatory starting point for future TFC calculation research. This will allow the services to create similar cost groupings, coordinate assumptions, and more accurately estimate future total force spending.

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I. INTRODUCTION

A. OVERVIEW OF ANALYSIS

In society, it has become easiest to understand the impact of a decision if the impact can be expressed in terms of cost. Being able to monetize time, materials, manpower, and effort is a relevant and necessary skill for budget planners, especially regarding military spending. As budgets tighten and undergo greater scrutiny, total force costing methods are in higher demand. Sharing those methods across services appears to be a helpful way of ensuring calculations are developed appropriately to meet the needs of the joint warfighting military.

Since our military's inception, budgeting has been a necessary tool in shaping force infrastructure, manpower, and capabilities. As warfighting needs become more complex, the analysis required to determine budgeting needs has also grown. Pre-World War II, budgeting methods relied solely on the costs related with developing, building, and delivering a new weapon system. However, this method of analysis failed to account for manpower, repairs, and a myriad of other aspects of sustaining a next-generation military force.

In the early 1960s, economists and mathematicians began developing methods of parametric cost estimation. These formulas more accurately calculated the true costs of employing a military and its associated systems. Parametric cost estimation laid the foundation for total force costing, which was first presented to the Air Force in 1961. Since then, every United States military department has used total force costing methods in one form or another, and a large sample of their reports and methodologies are public record.

This report is intended to be a meta-analysis of total force costing methods that have been published into the public domain, cataloging datasets by military service and method of calculation to determine if the total force cost model can be replicated, recreated, or is similar to models found in other publications.

B. PROBLEM STATEMENT

Despite decades of total force costing development, there does not appear to be cross-talk between the departments when it comes to total force costing methods. Each service appears to be developing their total force costing methods in a vacuum. And while reports on total force costing can be found through various online and print outlets, there does not appear to be any analysis linking total force costing methods and their development. This report seeks to correct that deficiency and provide perspective on how these methods have developed over time.

C. RESEARCH QUESTIONS

For this report, the following questions will be analyzed. Further research and analysis as a result of this report may also enhance future budgeting analysis for all departments.

1. Are there any quantitative similarities between total force costing methods?
2. Is it possible to construct a total force costing method best practice?
3. If so, what would that method look like?

D. SUMMARY OF FINDINGS

Scholarly debates about the nature of total force costing have ensued since World War II. The calculation methods of total force costing have been largely refined by research firms such as the RAND Corporation and the Institute for Defense Analyses. However, the actual process of total force costing is performed by the various services in a vacuum with only the numerical results provided to the services and the public for use in future budget estimations. No specific method of calculation appears to exist between the services as each service inserts their own assumptions and relevancies into their costing calculations. Therefore, the services must cross-share information on calculations and assumptions to eliminate cost element disparity between services and increase the accuracy of overall total force cost calculations.

II. HISTORY AND BACKGROUND

The need to analyze military sustainment through a monetary lens has been a staple of government economics since its inception. Navy sailors are raised on anecdotal naval history stories outlining the Act to Provide a Naval Armament of 1794, which funded construction of the first six frigates of the United States Navy.¹ The bill outlined the design and manning requirements for their operation in meticulous detail. Included in the act were monetary appropriations and a very simple pay scale for the personnel serving aboard.² This early example established budgetary limits for the procurement of equipment and the human resource payments to the people operating it. As there is no indication of the systemic modeling inherent in present-day budget planning, at what point did the government realize it had grown so large it needed to re-evaluate its costing methods? To answer this question, it is necessary to review the collected works of David Novick, an economic analyst of the RAND Corporation and the “father of cost analysis.”³

Until his death in 1991, Novick spent over 40 years connected in one way or another to the RAND Corporation.⁴ Publishing 21 articles in his first 15 years, Novick quickly established himself as the frontrunner of economic thought within RAND. During his tenure, he inaugurated the Cost Analysis program and the Planning, Programming, and Budgeting System.⁵

In February 1950, Novick was assigned to a Cost Analysis department at RAND to determine the cost of a futuristic Air Force bomber. He quickly deduced there were many other cost factors involved in a new bomber, such as the cost to man the bomber with

¹ “Launching the New U.S. Navy,” National Archives, August 15, 2016, <https://www.archives.gov/education/lessons/new-us-navy/act-draft.html>.

² National Archives, “Launching the New U.S. Navy.”

³ Paul Hough, *Birth of a Profession: Four Decades of Military Cost Analysis*, P-7539 (Santa Monica, CA: RAND Corporation, 1989), <https://www.rand.org/pubs/papers/P7539.html>, 6.

⁴ “David Novick, 85, Federal Advisor, Consultant, Economist,” *The Morning Call*, November 06, 1991, http://articles.mcall.com/1991-11-06/news/2828364_1_santa-monica-economics-david-novick-associates.

⁵ Michael Beltramo, *David Novick: A Leader, An Innovator, A Character*, P-7824 (Santa Monica, CA: RAND Corporation, 1993), <https://www.rand.org/pubs/papers/P7824.html>.

personnel, manning to maintain the bomber, or the supplies and logistics necessary to repair the bomber.⁶ He created a cost element list and with that came a new school of thought, one of determining cost estimating relationships for given cost elements.⁷

However, determining the cost of, and relationship between, cost elements was daunting. Novick highlights the early school of thought toward military procurement as the cost to purchase hardware.⁸ He describes the formation of Weapon Systems Analysis beginning as early as 1948, when RAND mathematician Ed Paxson determined the ultimate common term for measuring spending is cost.⁹ However, Novick and other RAND researchers easily deduce there is more to military spending than just purchasing products.

Novick spent two years performing studies on Air Force spending, evolving his conceptual costing theories into what is today called Parametric Cost Estimating.¹⁰ However, in 1955, Novick's Parametric Cost Estimating methods required numerous man-hours on adding machines and resulted in approximately 30 linear feet of analysis reports arranged in rows and columns.¹¹ The next year, Novick published *Weapon System Cost Methodology*, which revolutionized the concepts of measuring economic resources, incremental expenditures, and differentiating between one-time cost versus recurring operating expenses.¹² It took RAND another four years to create a computer-based program that could perform parametric calculations with ease. In the meantime, Novick prepared and published six more articles on various costing and economic relevancies.

From 1956 to 1961, total force costing methods grew rapidly with changes in technology and conceptualization. In April 1961, Novick published *System and Total Force Cost Analysis*, abandoning the concept of "cost methodology" and accepting that

⁶ David Novick, *Beginning of Military Cost Analysis 1950–1961*, P-7425 (Santa Monica, CA: RAND Corporation, 1988), <https://www.rand.org/pubs/papers/P7425.html>, 3.

⁷ Novick, *Beginning of Military Cost Analysis 1950–1961*, 3.

⁸ Novick, *Beginning of Military Cost Analysis 1950–1961*, 2.

⁹ Novick, *Beginning of Military Cost Analysis 1950–1961*, 1.

¹⁰ Novick, *Beginning of Military Cost Analysis 1950–1961*, 3.

¹¹ Novick, *Beginning of Military Cost Analysis 1950–1961*, 8.

¹² David Novick, *Weapon System Cost Analysis*, P-0794 (Santa Monica, CA: RAND Corporation, 1956), <https://www.rand.org/pubs/papers/P0794.html>.

total force cost is an analysis of inputs and not a routine operation.¹³ The emphasized process found in this new document “emphasizes the basic importance of sensitivity analysis in realizing the full usefulness of cost estimates.”¹⁴ As Novick was the pioneer of total force costing, other members of the RAND Corporation began publishing costing related research over the course of the next few decades. Reports published by J. D. McCullough and H. G. Massey were pivotal in developing total force costing concepts from the 1960s to the 1990s.

With the abundance of data and assumptions needed to create a total force cost estimate, reports were either large and bulky or required complex computer programming in an age before personal computers were invented. Imagining the 1960s-style computer rooms with 16-inch magnetic tape drives spinning in the background and dot matrix printers buzzing reams of perforated paper printouts, J. D. McCullough’s *Cost Effectiveness* report served to teach budget estimators how to read total force cost estimates.¹⁵ McCullough is specific in that he is not attempting to make cost estimates. He even states he and other analysts doubt it is possible to establish a standard procedure for creating cost estimates.¹⁶ This is indicative of the state of development of total force costing in the mid-1960s.

In the 1970s, H. G. Massey published two significant reports developing total force costing. His first report, published in 1972, was written with Novick and outlined updates to cost methodology for policy decision-making.¹⁷ This resulted in his 1977 work, “Introduction to the USAF Total Force Cost Model.” This report further developed costing

¹³ David Novick, *System and Total Force Cost Analysis*, RM-2695-PR (Santa Monica, CA: RAND Corporation, 1961), vi. https://www.rand.org/pubs/research_memoranda/RM2695.html:

¹⁴ Novick, *System and Total Force Cost Analysis*, vi.

¹⁵ J. D. McCullough, *Cost-Effectiveness: Estimating Systems Costs*, P-3229 (Santa Monica, CA: RAND Corporation, 1965), <https://www.rand.org/pubs/papers/P3229.html>, 1.

¹⁶ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 1.

¹⁷ H. G. Massey, Novick, and Peterson, *Cost Measurement: Tools and Methodology for Cost Effectiveness Analysis*, P-4762 (Santa Monica, CA: RAND Corporation, 1972), <https://www.rand.org/pubs/papers/P4762.html>, 2.

methodology by creating a widely applicable force model.¹⁸ Massey's total force cost model innovated the practical application of force costing, resulting in a flexible, standardized assumption-based method of calculating and estimating Air Force operating costs.¹⁹

In the late 1980s and early 1990s, the nation fell into the grips of modern warfare. With Operations Desert Shield and Desert Storm, heavy reliance on reserve forces required an analysis of their operational readiness. Congress mandated a review of reserve forces in the early 1990s, resulting in numerous RAND Corporation reports highlighting how to calculate the appropriate mix of active to reserve components. These reports relied heavily on total force costing data and their comparison between active and reserve forces.

"Assessing the Structure and Mix of Future Active and Reserve Forces" was a series of reports produced by the RAND Corporation during this timeframe that required the use of every economic analyst the RAND Corporation had to offer. Assessing the Structure and Mix of Future Active and Reserve Forces: Assessment of Policies and Practices for Implementing the Total Force Policy,²⁰ Cost Estimation Methodology,²¹ and Final Report to the Secretary of Defense²² were all published in 1992, utilizing a significant portion of the economic brain-trust of the RAND Corporation. Those three reports utilized over 30 RAND analysts including H. G. Massey and Leslie Lewis.

In the late 1990s and early 21st century, a majority of the development of total force costing methodology came from the Institute for Defense Analyses. The most significant

¹⁸ H. G. Massey, *Introduction to the USAF Total Force Cost Model*, R-2098-AF (Santa Monica, CA: RAND Corporation, 1977), <https://www.rand.org/pubs/reports/R2098.html>, 9.

¹⁹ Massey, *Introduction to the USAF Total Force Cost Model*, 47.

²⁰ Leslie Lewis, Roll, and Mayer, *Assessing the Structure and Mix of Future Active and Reserve Forces: Assessment of Policies and Practices for Implementing the Total Force Policy*, MR-133-OSD (Santa Monica, CA: RAND Corporation, 1992), https://www.rand.org/pubs/monograph_reports/MR133.html.

²¹ Adele Palmer et al., *Assessing the Structure and Mix of Future Active and Reserve Forces: Cost Estimation Methodology*, MR-134-1-OSD (Santa Monica, CA: RAND Corporation, 1992), https://www.rand.org/pubs/monograph_reports/MR134-1.html.

²² Bernard Rostker et al., *Assessing the Structure and Mix of Future Active and Reserve Forces: Final Report to the Secretary of Defense*, MR-140-1-OSD (Santa Monica, CA: RAND Corporation, 1992), https://www.rand.org/pubs/monograph_reports/MR140-1.html.

report of this period came from Stanley Horowitz in 2015. Titled “Active-Reserve Force Cost Model,” the report served to compile the different services’ cost estimating procedures and group their cost elements into similar categories.²³ While it does not procedurally calculate the total force, it does serve to illuminate the significant improvement in budget estimation when the services share cost estimating procedures.²⁴

Throughout over a half-century, there have been as many methods as people trying to solve the problem of calculating the total force. Laying the foundation was David Novick, a RAND Corporation analyst who used a problem breakdown structure to determine groups for simplifying estimates. Since then, there have been numerous entities and researchers stating which assumptions and elements are significant and which are not. These variations have resulted in disparity between services in calculating costs. Only in the last three to five years has the scholarly thought of combining service costing in a joint environment emerged.

²³ Stanley Horowitz et al., *Active-Reserve Force Cost Model*, D-5057 (Alexandria, VA: Institute for Defense Analyses, 2015), https://www.ida.org/~media/Corporate/Files/Publications/IDA_Documents/CARD/D-5202.ashx: v.

²⁴ Horowitz et al., *Active-Reserve Force Cost Model*, 79.

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III. METHODOLOGY

A. DATA RESEARCH/GATHERING

The key starting point for data collection was the popular indexing website Google. The Google Scholar search engine (<http://scholar.google.com>) is estimated to reference approximately 100 million English-language documents, 27 million of which are freely available to the public.²⁵ The remaining almost 63 million documents are references to abstracts and require a form of payment on their host domain. The first search I performed on Google Scholar used the words “total force cost” without quotations as a litmus test for the sea of non-phrased responses to those three words. This search produced an unwieldy 2.2 million results. Adding quotations to the search term created an exact-match search phrase and reduced the results to a more manageable 104 documents, which served as the targeted pool of potential resources in this meta-analysis.

The top result of this revised search was David Novick’s “System and Total Force Cost Analysis” memorandum from 1961. As discussed earlier, David Novick was a foremost pioneer of total force costing. Therefore, the logically refining step was a Google.com search for Novick and the RAND Corporation. The top result linked to the RAND Corporation, providing a list of Novick’s 35 published works from 1951 to 1988 and one that was published posthumously in 2004. With Novick’s lauded contribution to this field of study, the entirety of his work is considered significant to this report.

The second Google search result was published by another RAND Corporation member. Michael Beltramo celebrated Novick’s contribution to financial analysis in his document David Novick: A leader, an innovator, a character.²⁶ Novick’s various obituary articles rounded out the rest of the first page of results. The Beltramo article and one obituary were retained for this report.

²⁵ Madian Khabisa and Giles, “The Number of Scholarly Documents on the Public Web,” *PLoS ONE* 9(5): e93949. (May 9, 2014), <https://doi.org/10.1371/journal.pone.0093949>.

²⁶ Beltramo, *David Novick: A Leader, An Innovator, A Character*.

Returning to Google Scholar, the 104 search results were further narrowed by publication year. Between 2000 and 2018, only 32 scholarly documents contained the phrase “total force cost.” Of those 32 results, 11 were published within this decade. 8 of the 11 were not significant to this report. The remaining three reports were published by the Institute for Defense Analyses (<http://www.ida.org>) and all three contained the following rote disclaimer:

This work was conducted by the Institute for Defense Analyses (IDA) under contract DASW01-04-C-0003, Project BE-7-3306, “Total Force Cost Methodology,” for the Office of the Under Secretary of Defense (Personnel and Readiness). The views, opinions, and findings should not be construed as representing the official position of either the Department of Defense or the sponsoring organization.²⁷

Since it appeared significant that a contract for services was opened to perform research on Total Force Cost Methodology, I performed a Google search for the contract number DASW01-04-C-0003. Google returned 3,020 results with that string of letters and numbers. The first page of results contained various articles with the same disclaimer referenced above, but with a different project code. For example, one document contained a project code of AA-6-3630, referencing a project title of “DoD Command and Control. Research Program (DoD CCRP) Support.”²⁸ Since the project code became significant, I searched Google.com for DASW01-04-C-0003 and BE-7-3306, returning 103 results. The top three search results matched the top three Google Scholar results from 2010 to 2018 and were retained for analysis in this report.

Google Scholar returned 21 documents published between 2000 and 2009. Eight of the documents contained the following disclaimer:

The DoD components shall rely on the most effective mix of the total force, cost and other factors considered, including active, reserve, civilian, host nation, and contract resources necessary to fulfill assigned peacetime and wartime missions.

²⁷ Horowitz, McGee, Roark, and Wahedi, *Active-Reserve Force Cost Model*, About This Publication.

²⁸ David Alberts et al., *C2 Approaches: Looking for the “Sweet Spot,”* NSD-5036 (Alexandria, VA: Institute for Defense Analyses, 2013), https://www.ida.org/~media/Corporate/Files/Publications/IDA_Documents/SFRD/ida-document-ns-d-5036.pdf, About This Publication.

All eight of the documents containing this disclaimer were published theses from the U.S. Army War College and directly quote Department of Defense instruction 3020.37 “Continuation of Essential DoD Contractor Services During Crises,” policy bullet 4.1.²⁹ While all eight documents appeared to fall within the spectrum of government acquisition, none of them appeared relevant to this report.

Of the original 104 Google Scholar results for the exact phrase “total force cost” search term, 72 documents were published before the 21st century, half of which were published by David Novick. With the majority of total force costing research taking place greater than 20 years ago, and mostly by one person, the need for a meta-analysis of literature on the subject is clear.

It should also be noted that one intended search pattern for this report was reference-hopping. I had originally planned to read a document and then use its cited references as a path to additional research. However, in my data collection, it appears that most documents relevant to this report were created in a vacuum, having no references at all. Most articles in this field appear to have been requested, contracted, or created through inception, further adding to the relevance of this meta-analysis.

Despite a lack of reference-hopping, document authors created search opportunities. Just as searching for “Novick RAND Corporation” (without quotation) resulted in his collected works, I searched the names of authors and the names of research institutes that produced relevant results from the “total force cost” exact-phrase search. For example, searching “Beltramo RAND Corporation” (without quotation) resulted in his collected works, of which one might be relevant to this report³⁰ but requires purchase to read.

Ultimately, I identified a pool of approximately 50–70 documents containing some relevant reference to the phrase “total force cost.” Additionally, searching the “total force

²⁹ Department of Defense, *Continuation of Essential DoD Contractor Services During Crises*, DoD Instruction 3020.37 (Washington, DC: Department of Defense, 1990), 2.

³⁰ Michael Beltramo, *Considering the Cost of DoD Personnel: A Look at Some Issues Requiring Further Analysis*, P-5166 (Santa Monica, CA: RAND Corporation, 1974), <https://www.rand.org/pubs/papers/P5166.html>.

cost” exact-phrase within NPS Theses produced only 12 results, none of which addressed methods of total force cost estimating. This is the crux of the justification for this report. Most references in my document pool appear to discuss the need to use total force costing, but most of them do not address how to use it, or where to formulate the calculations. After preliminary review of my data pool, I estimate only five to 10 references will be relevant to total force costing estimation formulation, and therefore relevant to this thesis.

B. CATEGORIZING REVIEWED RESEARCH METHODS

1. Novick’s System and Total Force Cost Analysis

David Novick’s “System and Total Force Cost Analysis” set the basic standard of total force costing methods. His report expands the essential direct costs to procure a system to include estimations for non-system activities.³¹ Novick focuses on methods for costing individual systems, total force structures, and performing sensitivity analyses to ensure a precise cost estimation, but his method is simple. He proposes the analyst break down cost elements into identifiable groups, determine costs for those groups, and then sum the totals.³² To put it simply: you eat the elephant one bite at a time. Lastly, Novick acknowledges that his report offers only one method of costing, providing that newer costing methods can and must be derived, developed, or produced from changes in technology and the evolution of system manufacturing over time.³³

It should be noted that Novick’s report does not calculate anything. It merely provides a method for calculating these costs that is as simple as it is complex. Individual system cost analysis requires a detailed breakdown of cost elements and organizing them into larger cost categories.³⁴ In his example, Novick attempts to simplify the entire process by grouping costs into subheadings that are “within and directly related to the system,”³⁵ a process that now includes research and development costs. Novick stated this was one of

³¹ Novick, *System and Total Force Cost Analysis*, v.

³² Novick, *System and Total Force Cost Analysis*, 13.

³³ Novick, *System and Total Force Cost Analysis*, vii.

³⁴ Novick, *System and Total Force Cost Analysis*, 15.

³⁵ Novick, *System and Total Force Cost Analysis*, 13.

the new additions to costing theories, as research and development is a significant part of the life-cycle of the system.³⁶ The analyst must categorize cost elements into three distinct and time-based groups: research and development, investment, and operation.³⁷ In addition to the three categorical costs, Novick states the analyst must have a generic understanding of applicable costs related to the industry in which the system will be used.³⁸ He writes:

The set should be as all-inclusive as possible so as to preclude the omission of significant cost elements... [and] the cost categories should be designed in a way that will facilitate determination of those cost elements of the system which have the greatest impact on total cost, and which are most sensitive to changes in hardware characteristics or variations in operational concept.³⁹

Novick requires the analyst to understand the system they are analyzing.⁴⁰ He asserts that in-depth knowledge of the system is an advantage, allowing the analyst to rely on professional insight and judgement while formulating relevant assumptions to the system.⁴¹ He acknowledges that some portions of the cost estimation will require assumptions. Novick states values that are bound by assumptions should be reported as value ranges instead of specific costs.⁴² His framework of cost analysis categories can be found as Figure 1.

The subsequent 40 pages of Novick's report defines the above categories and lists potential cost elements that would be contained therein. Novick restates the need for the analyst to clearly encapsulate each cost group and identify cost elements that are relevant that might not have been previously discussed.⁴³ This is a testament to the analysts need to truly understand the system they are costing. This understanding becomes even more relevant while performing sensitivity analyses.

³⁶ Novick, *System and Total Force Cost Analysis*, 15.

³⁷ Novick, *System and Total Force Cost Analysis*, 10.

³⁸ Novick, *System and Total Force Cost Analysis*, 15.

³⁹ Novick, *System and Total Force Cost Analysis*, 15.

⁴⁰ Novick, *System and Total Force Cost Analysis*, 13.

⁴¹ Novick, *System and Total Force Cost Analysis*, 17.

⁴² Novick, *System and Total Force Cost Analysis*, 15.

⁴³ Novick, *System and Total Force Cost Analysis*, 105.

- I. Research and development costs
 - A. System development
 - B. System test and evaluation
 - C. Other system costs
- II. Investment costs
 - A. Installations
 - B. Equipment
 - 1. Primary mission
 - 2. Specialized
 - 3. Other
 - C. Stocks
 - 1. Initial stock levels
 - 2. Equipment spares and spare parts (initial)
 - D. Initial training
 - E. Miscellaneous
 - 1. Initial transportation
 - 2. Initial travel
 - 3. Intermediate and support major command
- III. Operation costs
 - A. Equipment and installations replacement
 - 1. Primary mission equipment
 - 2. Specialized equipment
 - 3. Other equipment
 - 4. Installations
 - B. Maintenance
 - 1. Primary mission equipment
 - 2. Specialized equipment
 - 3. Other equipment
 - 4. Installations
 - C. Pay and Allowances
 - D. Training
 - E. Fuels, lubricants and propellants
 - 1. Primary mission equipment
 - 2. Other
 - F. Services and miscellaneous
 - 1. Transportation
 - 2. Travel
 - 3. Other (including maintenance of organizational equipment)
 - G. Intermediate and support major command operating cost (only exceptionally included in cost analysis of individual systems)

Figure 1. Cost Analysis Categories for Individual Systems⁴⁴

There are countless uncertainties in estimating future costs. As the word “estimation” inherently implies, cost estimations are based on assumptions. These

⁴⁴ Novick, *System and Total Force Cost Analysis*, 16.

incremental changes can and do have a large impact on the range of costs found in the analysis. However, the greater the understanding of the system, the more easily those incremental changes are discovered and evaluated.⁴⁵ This sensitivity analysis will provide “a range of system costs which is likely to be a more realistic guide than a single, most probable cost.”⁴⁶

The above discussion is important to total force costing models simply because total force costing is nothing more than the sum of system and non-system activities on a large scale.⁴⁷ The addition of new systems is merely an analysis of marginal cost, wherein the sum of the new system is added to the total force as a whole.⁴⁸ However, Novick’s principle of understanding is still relevant. “The analyst must draw from a much wider universe of information”⁴⁹ to apply incremental costing methods to the analysis of the total force. Total force costing is nothing more than eating a much larger elephant, still one bite at a time.

2. McCullough’s Cost Effectiveness: Estimating Systems Costs

Certainly, one of the most unique research projects to come from the RAND Corporation, J.D. McCullough’s report begins with his intention to *not* illustrate how to craft an estimate of system costs.⁵⁰ He states the intent of the report is to discuss features and general procedures for cost estimates at the user of cost estimates level.⁵¹ Essentially, he intends to present a general roadmap for using cost estimates.

This essay is more about the art of creating a system cost estimate as opposed to the approach. McCullough cites the relationship between total system cost and the probability of having an effective system at time of launch.⁵² This relationship makes

⁴⁵ Novick, *System and Total Force Cost Analysis*, 60.

⁴⁶ Novick, *System and Total Force Cost Analysis*, 105.

⁴⁷ Novick, *System and Total Force Cost Analysis*, 59.

⁴⁸ Novick, *System and Total Force Cost Analysis*, 59.

⁴⁹ Novick, *System and Total Force Cost Analysis*, 60.

⁵⁰ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 1.

⁵¹ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 1.

⁵² McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 5.

sense, but he highlights how the relationship is affected by budgeting decisions, wherein a fixed budget requires maximum system effectiveness and a specified effectiveness level requires analysis of the least amount of resources to reach that effectiveness.⁵³ He lists the most important features of a cost analysis as the following.⁵⁴

- End-product orientation
- Extended time horizon
- Incremental costing
- Life cycle costs
- Constant dollars as the measure of resources
- Statistical techniques

Throughout his definition of these six attributes, he relates how costs can impact that attribute of system procurement. He concurs with other authors that costs can be grouped into three categories, research and development, investment, and operations,⁵⁵ but he believes that the art of analyzing the costs associated with the six above listed features will help cost analysts become more precise in their estimations.⁵⁶

McCullough asserts there are no fixed procedures with which one may perform an accurate cost estimation.⁵⁷ However, he generalizes the steps as defining the problem, collecting data, deriving the estimate, presenting the estimate, and documenting the analysis.⁵⁸ Essentially, he is tackling cost analysis like a critical thought research project,

⁵³ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 6.

⁵⁴ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 6.

⁵⁵ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 11.

⁵⁶ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 12.

⁵⁷ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 15.

⁵⁸ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 15.

even going as far as saying the listed elements can be tackled in any order, perhaps even looping back on one another as the estimation process continues.⁵⁹

Lastly, McCullough concludes by challenging the user of cost estimates to review it through the lens he presented in his report. He believes evaluation of the study and the underlying data will generate questions on the validity of the estimate. The questions presented back to the analyst will, in turn, generate better cost estimates in the future.

3. Massey's Introduction to the USAF Total Force Cost Model

In H. G. Massey's "Introduction to the USAF Total Force Cost Model," Massey introduces a consistent means of projecting Air Force costs over the five-year future.⁶⁰ To accomplish this, he states an annual baseline is required to be performed.⁶¹ Using the previous 15 years of costing data, his model outputs anticipated costs over the five-year future, allowing for projections to reach out as far as the next 15 years ahead.⁶² It should also be noted that this study was performed and published by the RAND Corporation, just as Novick's study was also performed for the Air Force.

Massey's model is completely automated. In his words, "a computerized set of computational routines combined with a basic analytical framework" is employed to produce resource requirements for the future.⁶³ In this instance, "resources" equal budgeting dollars. Massey uses the USAF Force and Financial Plan (F&FP), essentially a budgeting resource document, as an annual update to his model.⁶⁴

The relevance of the F&FP impacts the inputs and outputs of Massey's model. Since the F&FP is in terms of Air Force appropriations, the model's outputs are in those same terms. For an outline of those appropriations, see Figure 2.

⁵⁹ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 15.

⁶⁰ Massey, *Introduction to the USAF Total Force Cost Model*, v.

⁶¹ Massey, *Introduction to the USAF Total Force Cost Model*, vi.

⁶² Massey, *Introduction to the USAF Total Force Cost Model*, v.

⁶³ Massey, *Introduction to the USAF Total Force Cost Model*, 11.

⁶⁴ Massey, *Introduction to the USAF Total Force Cost Model*, 11.

<u>Appropriations Included in TOA</u>	<u>Appropriation Excluded from TOA</u>
Aircraft Procurement	Airlift Service (IF)
Missile Procurement	
Other Procurement	<u>Non-add Cost Categories</u>
Military Construction	
Research and Development	Depot Maintenance
Operations and Maintenance (AF)	Medical Additive
Military Personnel	Miscellaneous Support (BOS)
AFR Personnel	PCS Travel
AFR Operations	
AFR Other	
ANG Personnel	
ANG Operations	
ANG Other	

Figure 2. Force Model Appropriations and Non-Add Cost Categories⁶⁵

Massey's model was strictly computational. As such, punch cards were used to generate data within the FORCE model computer. A pair of programs labeled SORT and CREATE would generate base data, and other data cards representing future force changes would generate the alternative, future results.⁶⁶ "The principal requirement is that the base case be comparable in the five-year program period to a current F&FP" since the future projections model relies heavily on current Air Force resources.⁶⁷

The base data was expected to be updated with the President's Budget or the Program Objective Memorandum,⁶⁸ as both were key planning documents for future operations. The base case was also constructed with relevant anticipated changes for the future of the Air Force at the time of planning.⁶⁹ By doing so, the FORCE model would concern itself with relevant alternatives that differ from the base case.⁷⁰ A graphical representation of how the FORCE model works is provided as Figure 3.

⁶⁵ Massey, *Introduction to the USAF Total Force Cost Model*, 13.

⁶⁶ Massey, *Introduction to the USAF Total Force Cost Model*, 16.

⁶⁷ Massey, *Introduction to the USAF Total Force Cost Model*, 16.

⁶⁸ Massey, *Introduction to the USAF Total Force Cost Model*, 16.

⁶⁹ Massey, *Introduction to the USAF Total Force Cost Model*, 17.

⁷⁰ Massey, *Introduction to the USAF Total Force Cost Model*, 17.

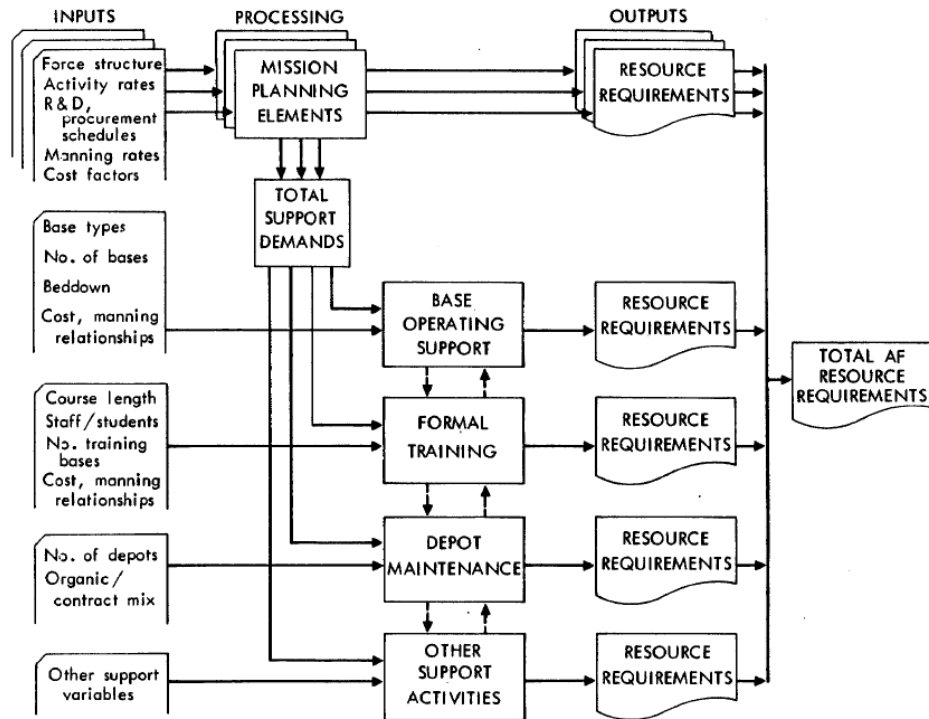


Figure 3. Structure of FORCE Model Computations⁷¹

4. Department of Defense's Total Force Policy Report to the Congress

This report advises Congress on the total defense force structure for fiscal years 1990 and 1991 in the wake of the political evolution of the changing strategic environment in Eastern Europe and the Middle East.⁷² This article focuses on force shaping and not total force costing methods.

5. Lewis' Assessing the Structure and Mix of Future Active and Reserve Forces

This article serves to analyze the implementation of the "base force" model of military resource allocation in the wake of worldwide changes.⁷³ Both this and the DoD

⁷¹ Massey, *Introduction to the USAF Total Force Cost Model*, 14.

⁷² Department of Defense, *Total Force Policy Report to the Congress* (Washington, DC: Department of Defense, 1990), <http://www.dtic.mil/dtic/tr/fulltext/u2/a235382.pdf>, 57.

⁷³ Lewis, Roll, and Mayer, *Assessing the Structure and Mix of Future Active and Reserve Forces*, xi.

article discussed above report on the same world issues while analyzing the militaries and their organization.

6. Wilson's Considerations in a Comprehensive Total Force Cost Estimate

In 1992, James Wilson (as the project leader for Waynard Devers, Thomas Frazier, Matthew Goldberg, Stanley Horowitz, and John Kane) published a report on "Considerations in a Comprehensive Total Force Cost Estimate" for the Office of the Assistant Secretary of Defense, Force Management and Personnel. As this report was generated at the Department of Defense (DoD) level, it focuses on the varying structure, size, and mix of active and reserve forces.⁷⁴ The intent of the report was to define and apply a framework that would estimate impacts of force structure changes, define costs affected by force structure decisions, and alleviate cost assumptions within alternative force configurations.⁷⁵

To this end, the framework described within starts at the defense strategy level, splitting into force structure and non-force related programs. Both of those groupings affect force infrastructure, and all three incur costs to sustain. This is the Total Force Cost Framework concluded in the report.⁷⁶ It is assumed these are computational models relying on current and relevant data even though it is not explicitly stated in the report.

Any costs of day-to-day operations in direct support of the DoD's primary defense mission are considered "direct unit costs."⁷⁷ These are the force structure inputs in the framework. The secondary effects of reserve procurement, training, and deployment support are considered "direct support costs" and are analyzed on a program-by-program basis.⁷⁸ These are the non-force related programs in the framework. The infrastructure

⁷⁴ James Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, P-2613 (Alexandria, VA: Institute for Defense Analyses, 1992), <http://www.dtic.mil/dtic/tr/fulltext/u2/a257839.pdf>, 1.

⁷⁵ Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 1.

⁷⁶ Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 3.

⁷⁷ Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 5.

⁷⁸ Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 5.

inputs to the framework are analyzed as changes in force size are projected.⁷⁹ The final variable in Wilson’s model is the one-time cost required to implement change decisions.⁸⁰

As with Novick, Wilson divides each cost grouping into cost elements. For example, direct unit costs are divided into manpower, operating, and equipment subheadings, each with their own lists of relevant costs.⁸¹ However, cost estimating the U.S. military is a grand scope requiring overgeneralization. The report defines cost elements and categories and then highlights differences in assumptions and their effects on the overall bottom line, and it appears the actual intent of the report was to distinguish between costs for active-duty personnel and the reserve force,⁸² searching for cost savings between the two. For example, the report concludes that “lower training levels permit the use of a high fraction of part-time personnel and thereby have much lower operating costs in peacetime.”⁸³

Essentially, Wilson recommends cost-estimating be revised to match the patterns described in their report.⁸⁴ This is a critical recommendation, as the unwritten subtext is input data is not standardized. “Standardization of the elements of unit operating costs will help make comparisons of active and reserve units more equitable and comparable.”⁸⁵ Since the DoD must make budgeting decisions based on data, it would be beneficial if that data were standardized across the military branches.

7. Dahlman’s Cost of a Military Person-Year

The conversion of military support duties to civilian personnel is not a new concept. However, much analysis is required to ensure cost effectiveness and savings supports the transition. This is the purpose of Carl Dahlman’s report on the cost of a military person-

⁷⁹ Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 5.

⁸⁰ Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 5.

⁸¹ Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 8.

⁸² Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 68.

⁸³ Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 68.

⁸⁴ Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 70.

⁸⁵ Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 70.

year.⁸⁶ Using what he calls the “DoD mandated calculus,” he observes that the military pay system is as complex as it is archaic.⁸⁷ Dahlman’s report lists the results of the DoD mandated calculus in Table 2.1 with a bulletized list of service expenditures such as basic pay or family housing and their aggregated and averaged total expenditure for 2005.⁸⁸ Their source of data for Table 2.1 comes from the Office of the Secretary of Defense, Office of Program Analysis and Evaluation (PA&E)⁸⁹ and illustrates the calculations are performed in a vacuum. Reports published by PA&E contain the results of the calculus for services to use in budget planning but do not show how they are calculated.

Dahlman explains the calculus results as cumbersome.⁹⁰ Showing the complexity involved in performing a monetary manpower assessment illustrates how challenging a formal assessment of military costing is. As such, the DoD condensed the calculations into a paygrade-specific set of costing factors called the Standard Military Composite Rate.⁹¹ Within those rates are the Regular Military Compensation rates (RMCs) which include base pay, housing allowance, subsistence, and the federal tax advantage found within allowances.⁹² These rates are the standard by which the DoD calculates the cost of a military person-year. The simplified version of RMC is included as Figure 4.

There is, however, a large disparity between the DoD mandated calculus results found within the elements of cash and non-cash compensation and the simplified RMCs.⁹³ Dahlman calculated these differences between one-fourth and one-third of the total cost calculation.⁹⁴ Furthermore, he acknowledges there is a wide array of assumptions used in

⁸⁶ Carl Dahlman, *The Cost of a Military Person-Year: A Method for Computing Savings from Force Reductions*, MG-598-OSD (Santa Monica, CA: RAND Corporation, 2007), <https://www.rand.org/pubs/monographs/MG598.html>, 1.

⁸⁷ Dahlman, *The Cost of a Military Person-Year*, 5.

⁸⁸ Dahlman, *The Cost of a Military Person-Year*, 7–9.

⁸⁹ Dahlman, *The Cost of a Military Person-Year*, 9.

⁹⁰ Dahlman, *The Cost of a Military Person-Year*, 13.

⁹¹ Dahlman, *The Cost of a Military Person-Year*, 13.

⁹² Dahlman, *The Cost of a Military Person-Year*, 13.

⁹³ Dahlman, *The Cost of a Military Person-Year*, 16.

⁹⁴ Dahlman, *The Cost of a Military Person-Year*, 16.

the calculation of these figures and the figures he uses to calculate the disparity.⁹⁵ However, since there is no other way to tackle data this large, he introduces several refinements to produce more meaningful calculations.⁹⁶ The subsequent 25 pages of Dahlman's report determine the value of military retirement benefits.

Grade	Annual Pay Rate
Enlisted Personnel	
E-1	\$34,785
E-2	\$36,498
E-3	\$38,879
E-4	\$46,044
E-5	\$55,713
E-6	\$67,628
E-7	\$78,116
E-8	\$88,733
E-9	\$104,933
Officers	
O-1	\$62,982
O-2	\$78,991
O-3	\$100,883
O-4	\$126,746
O-5	\$145,941
O-6	\$175,928
O-7	\$180,720
O-8	\$199,215
O-9	\$215,758
O-10	\$215,043

Figure 4. DoD Comptroller's Standard Military Composite Rates⁹⁷

As the original intent of the report was to determine the appropriate math behind civilianization of military support, Dahlman asserts this calculation is nearly impossible

⁹⁵ Dahlman, *The Cost of a Military Person-Year*, 30.

⁹⁶ Dahlman, *The Cost of a Military Person-Year*, 31.

⁹⁷ Dahlman, *The Cost of a Military Person-Year*, 15.

due to the wide array of jobs in the military.⁹⁸ He offers a wide variety of methods to reduce the variance of the calculation but does not waver from his goal of reducing overall military spending. This is a well-considered application of manpower costing, a key element of total force cost methodology.

8. Cox's Improving Cost Estimates in the Force Mix Allocation Process for the Active and Reserve Components

Gerald Cox of the Center for Naval Analyses offered a report in 2013 highlighting the cost differentials between active and reserve components. He highlighted recent attempts to standardize approaches to estimating relative costs between the two components while lamenting the differences between cost estimates considering which modeling approach is employed.⁹⁹ While the report does not attempt to calculate or define the method by which to calculate total force cost, it is relevant to this study due to the comparison and contrast of different costing methods.

Between the mid-1990s and 2010, astoundingly few articles were published regarding methods of total force cost estimating. Cox acknowledges this fact, stating the most recent influx of analysis has been since 2008, when the “boots on ground” (BoG) concept was presented.¹⁰⁰ The BoG approach was first introduced by Jennifer Buck in her article “The Cost of Reserves” published in *The New Guard and Reserves*.¹⁰¹ According to Cox, the BoG article led a small surge of articles attempting to standardize relative active and reserve component costs across the services.¹⁰²

In 2010, Cox attempted to modify the BoG model, hoping to better allocate costs of the reserve component at the same time as other branches of service attempted to do the

⁹⁸ Dahlman, *The Cost of a Military Person-Year*, 75.

⁹⁹ Gerald Cox, *Improving Cost Estimates in the Force Mix Allocation Process for the Active and Reserve Components*, DRM-2012-U-003418-Final (Arlington, VA: Center for Naval Analyses, 2013), https://www.cna.org/CNA_files/PDF/DRM-2012-U-003418-Final.pdf, 1.

¹⁰⁰ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 2.

¹⁰¹ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 2.

¹⁰² Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 2.

same.¹⁰³ He aggregated complaints that active and reserve component costs were calculated in too narrow of scope and applied in too broad of scope.¹⁰⁴ Therefore, he wrote this article attempting to reconcile the differences between modeling methods, stating it can be applied broadly across all service components.¹⁰⁵

In Cox's analysis, he acknowledges cost estimating as only one component of policymaking, and that non-cost-related considerations are also critical in determining the appropriate mixture of active and reserve forces.¹⁰⁶ He states the "simplest and most straightforward approach to estimating the costs of active and reserve elements applies when both forces are viewed as only part of a strategic reserve."¹⁰⁷ He asserts that when both active and reserve components are not involved in kinetic operations, they can both be perceived as strategic reserve elements, grouping their costs into more relatable terms.¹⁰⁸

Costing a strategic reserve force can be traditional or proportional. The traditional approach compares expenditures for each component at total end strength.¹⁰⁹ Cox states this method is overgeneralized, with disagreements as to which more specific elements to consider. However, he does agree with other researchers in that the cost of forces accounts for a very large percentage of the military's budget.¹¹⁰ The proportional approach shows the difference between costs of active duty forces and the costs of the reserve component, obviously highlighting the comparative advantage of the reserve force.

At this point, Cox's analysis focuses on a purely operational reserve component. Although he does not state this, the term the Navy uses for reserve members on permanent active duty is called Full-Time Support (FTS). Cox's calculation of differences between

¹⁰³ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 2.

¹⁰⁴ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 3.

¹⁰⁵ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 5.

¹⁰⁶ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 9.

¹⁰⁷ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 15.

¹⁰⁸ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 15.

¹⁰⁹ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 16.

¹¹⁰ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 16.

active and FTS is compared over four models, an individual members approach, the BoG approach, the Air Force's Total Force Enterprise Analytic Framework model, and the IDA model.¹¹¹ Incidentally, the IDA model discussed in Cox's article is also known as the Horowitz model briefly discussed and dismissed earlier in my report. Each of these methods has its place in total force cost methodology, but his summaries of each, found in Figure 5, are the reason Cox's article was considered appropriate for analysis.

In the end, Cox accurately states that each of these models produces different results when calculating costs related to understanding the difference between active and reserve forces. New costing models that have developed over the years leading to this report have developed new approaches to costing active and reserve components,¹¹² but as stated before, there are no new methods for costing. He merely recommends the need to improve joint costing models across all services.¹¹³

¹¹¹ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 33.

¹¹² Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 61.

¹¹³ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 35.

Type	Name	Application	Model complexity	Level of aggregation	Limitations	What data can be used?	Examples of use
Strategic	Traditional simple method	Comparison of costs: RC dwell and AC non-deployed	Simple	Highly aggregated, component level	Does not account for any costs associated with deployments (phased or full-surge deployments). Obscures variation in relative costs between capabilities, units. Using incomplete or inappropriate cost elements will bias estimates.	Any costs associated with maintenance of a nondeployed force (accrual, recurring short-term, or nonrecurring)	Occasionally used in theoretical discussions of component costs. Because estimates are made at a high level of aggregation, they are not of practical use in determining AC/RC force mix.
Strategic	Cost of Guard and Reserve approach	Comparison of costs: RC unit (e.g., BCT) in dwell vs. nondeployed AC unit	Complex: assumes detailed analysis of cost elements	Unit level	Does not account for costs associated with deployments (phased or full-surge deployments). Using incomplete or inappropriate cost elements will bias estimates.	Same as above	Widely used and effective in comparing the costs of AC and RC when used in strategic reserve
Operational	Cost of individual members	Comparison of costs per deployment: RC individual vs. AC individual	Simple	Individual	Does not account for strategic value of RC, for cost of larger rotational base required when RC supports sustained operations, or for variation across units in O&M and equipment costs	Any costs associated with maintenance of units in dwell and on deployment. May be accrual, recurring short-term, or nonrecurring.	Notable as an early attempt to capture costs of using RC in operations. Superseded by Boots-on-Ground model.
Operational	Boots-on-Ground (BoG) model	Comparison of costs of RC rotation base vs. AC rotation base	Simple to complex: readiness & capacity can be represented	Rotation base (no. of units needed to sustain one unit BoG)	Does not account for strategic value of RC	Same as directly above	Widely used and effective in comparing the costs of AC and RC when used on a purely operational footing. Army, OSD, and NECC all use variations of this model.
Operational	Air Force's Total Force Enterprise Analytic Framework	Comparison of costs of different levels of AC/RC blending at various deploy-to-dwell ratios	Very complex	Force package: a grouping of manpower/ equipment that provides a specific war-time capability	Does not account for strategic value of RC. Model considers various deploy-to-dwell ratios when RC is used operationally but does not account for strategic contribution of RC. Because of its complexity, model requires significant manpower to maintain.	Same as directly above	Principal force-shaping tool used by the Air Force
Joint Strategic and Operational	IDA model: Horowitz (2012)	Determining trade-space of budget, no. of deployable units, size of force, and proportion of AC in force	Complex	Rotation base (no. of units needed to sustain one unit BoG)	By necessity, model's trade-space output is complex, and users face a significant learning curve to understand full implications of model's findings.	Same as directly above	Being developed for OSD CAPE

Figure 5. A Summary of Characteristics of Cost Models¹¹⁴

9. Horowitz's Active-Reserve Force Cost Model

This report serves to update research provided by the Institute for Defense Analyses in determining the appropriate mix of active to reserve forces. Stanley Horowitz was the project leader for this report as he was for the 2012 report on Analyzing the Costs of

¹¹⁴ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 34.

Alternative Active/Reserve Force Mixes noted earlier. At its heart, this report offers one key statement.

Despite a majority of shared concepts, the coverage provided by the tools for each Service differs significantly. Both the Army and Marine Corps tools address units of all kinds, both combat and support. The Air Force tool addresses flying units only, including those using unmanned aerial systems. The Navy tool addresses only units belonging to the Navy Expeditionary Combat Command (NECC), responsible for expeditionary forces other than ships and aviation such as construction battalions and demolition teams. This is because we were able to draw on NECC modeling not available for most of the Navy.¹¹⁵

Horowitz's report amalgamates costing methods across all services. Despite using these costing methods to formulate blending possibilities between active and reserve components, the report holds the additional benefit of summarizing costing methods across all services that have been used within the last 5 years.¹¹⁶ Unfortunately, the report must have been delivered with software or an excel spreadsheet that has since been separated. Horowitz describes the operation of the program and how to manipulate it,¹¹⁷ but I was unable to find the software on the Internet with any search terms.

Another valuable resource provided by this report is the location of base data relevant to making total force costing decisions. Each chapter of the report outlines base data for a particular service (e.g., Army, Navy). The opening of each chapter outlines the base data used in the costing software and from where it was derived. A compilation of each data source table is included as Figure 6.

¹¹⁵ Horowitz et al., *Active-Reserve Force Cost Model*, iv.

¹¹⁶ Horowitz et al., *Active-Reserve Force Cost Model*, 1.

¹¹⁷ Horowitz et al., *Active-Reserve Force Cost Model*, 16.

Primary Army Data Sources	
Category	Source
Personnel	OSD
Equipment Operations and Maintenance	Army Cost & Economics
Procurement	Army Cost & Economics
Indirect	FYDP
Deployment	IDA COST Army Cost & Economics
Primary Marine Corps Data Sources	
Category	Source
Personnel	OSD
Equipment Operations and Maintenance	Total Force Structure Management System (TFSMS) Navy Visibility and Management of Operating and Support Costs (VAMOSC) Army Cost & Economics
Procurement	Marine Corps Program Analysis & Evaluation (PA&E)
Indirect	FYDP
Deployment	IDA COST Marine Forces Command (MARFORCOM)
Primary Air Force Data Sources	
Category	Source
Personnel	OSD
Equipment Operations and Maintenance	AFI 65-503 AFI 11-2
Equipment Replacement	AFEMS
Indirect	AFI 65-503 FYDP
Deployment	IDA COST AFI 65-503 Air Force Total Ownership Cost (AFTOC)
Primary Navy Data Sources	
Category	Source
Personnel	OSD
Equipment Operations and Maintenance	NECC Capability Costing Model Navy VAMOSC
Procurement	Not Available
Indirect	FYDP
Deployment	IDA COST

Figure 6. Primary Data Sources from the Active-Reserve Force Cost Model¹¹⁸

The primary issue with the above list is the myriad of costing models and the unknown source of their derivation. The software to which Horowitz refers in his report

¹¹⁸ Adapted from Horowitz et al., *Active-Reserve Force Cost Model*, 15, 31, 48, and 67, respectively.

also contains an unknown quantity of sub-calculations required to adjust cost mixtures between service active and reserve components.¹¹⁹ Lastly, the model presented only focuses on the cost differences between active and reserve forces and not the effectiveness differences between the two.¹²⁰

10. Research Categories

Given the summaries above, the best methodology to catalog these reports are to separate them into total force cost structures, total force cost analyses, total force cost applications, and articles that do not pertain to total force cost.

Total force cost structures are those articles that conceive methods of calculating total force cost. The following articles are relevant to this category.

- Novick's System and Total Force Cost Analysis
- McCullough's Cost Effectiveness: Estimating Systems Costs

Total force cost analyses articles use total force costing data to derive solutions and attempt to refine their solutions for more accurate results. The following articles are relevant to this category.

- Wilson's Considerations in a Comprehensive Total Force Cost Estimate
- Cox's Improving Cost Estimates in the Force Mix Allocation Process for the Active and Reserve Components

Total force cost application articles are those using total force costing data without explaining how they derived their data. These articles largely express answers without posing suggestions to improve methodology. The following articles are relevant to this category.

- Massey's Introduction to the USAF Total Force Cost Model

¹¹⁹ Horowitz et al., *Active-Reserve Force Cost Model*, 79.

¹²⁰ Horowitz et al., *Active-Reserve Force Cost Model*, 80.

- Dahlman's Cost of a Military Person-Year
- Horowitz's Active-Reserve Force Cost Model

Articles that did not pertain to my research but may support additional research outside this lens are as follows.

- Department of Defense's Total Force Policy Report to the Congress
- Lewis' Assessing the Structure and Mix of Future Active and Reserve Forces
- Horowitz's Analyzing the Costs of Alternative Active/Reserve Force Mixes

C. MODELING ASSUMPTIONS

As with any method of calculation, assumptions must be present to shape the prediction environment. Each of the reports analyzed in this chapter contained their own assumptions, but very few were relevant to this study. The two articles that developed total force costing methods in the mid-1960s are the only ones to begin with no assumptions. Two articles offered analysis of total force costing methods and considerations on how to improve those analyses. These articles provided revised assumptions to make total force costing more accurate. The three articles offering application of costing methods offer assumptions. However, their assumptions focus on details necessary to prove their assertions.

The virtue of David Novick's models are that there are no assumptions. He leaves the assumption-making to the individual performing the work.¹²¹ The models he presents explain how to critically scrutinize a problem and then analyze the individual components.¹²² The method by which anyone can analyze a large problem, not just total force costing, begins with the disassembly of the question one wishes to answer and then

¹²¹ Novick, *System and Total Force Cost Analysis*, 1

¹²² Novick, *System and Total Force Cost Analysis*, 16

chooses which elements to include in the process. However, anyone choosing to perform this task must input their own assumptions as to what is relevant and what is not. The analyst breaks down the issue into components and then arbitrarily decides which components are pertinent for inclusion.

McCullough's models are similar to Novick's, and rightly so as both worked for the RAND Corporation at the same time. The virtue of McCullough's analysis is that he attempts to make the concept of total force costing more accessible to the average reader. His model requires understanding of comparatives and uncertainties.¹²³ He has determined that for one to use a costing model that projects into the future, one must understand that the accuracy of those costs will become less accurate the further into the future the costs project.¹²⁴ The one key assumption of his model is that the base case is accurate.¹²⁵ The existing resources in use are the base, and any future projections are modeled from the base. Therefore, if the base is inaccurate, then the future-based additional resources, capability, effectiveness, or expenditures will be miscalculated.

Wilson's considerations on a total force cost estimate bring many assumptions to the calculation. As it deals largely with active versus reserve components, it must assume length of time of a reservist on active duty,¹²⁶ likeness of equipment and manning,¹²⁷ and many other calculation corrections. However, he also asserts that standardization of these assumptions across all services will assist with total force costing methodology in the future.¹²⁸

Another source of force costing between active and reserve components came from Cox. His methods focus largely on lifetime costs of the total force to include retirement and assumes that only 17% of active members and 24% of reserve forces reach

¹²³ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 2.

¹²⁴ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 3.

¹²⁵ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 9.

¹²⁶ Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 10.

¹²⁷ Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 15.

¹²⁸ Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 70.

retirement.¹²⁹ A majority of his study seeks to determine whether the military retirement system can support this ratio. Another assumption is the cost of active versus reserve in deployment and non-deployment status.¹³⁰ However, these assumptions do little for the modeling of total force costing calculations other than to set the framework for his study. Ultimately, Cox recommends an analysis of capabilities of the reserve component. He believes an accurate study of their costs could eliminate capability-related studies to employ the reserve component more efficiently.¹³¹ This assumes, however, that the reserve component can sustain these changes.

Assumptions from those studies employing total force costing values largely focused on which values were important to the study and which were not. As each study aimed to answer a particular question, the assumptions derived within their respective reports were not focused on standardization. Massey's, Dahlman's, and Horowitz's reports utilize force costing data to make future assumptions while assuming the costing inputs to their calculations are correct.

As any assumption inserted into total force cost modeling relies heavily on what an individual believes is relevant, a wider lens must be employed to understand how these assumptions can apply to all services at the same time. Of course, assuming nothing and calculating everything will provide more accurate results than those with assumptions (note I wrote "more accurate," as any future-based value will be impossible to calculate with precision). However, those calculations would be large and cumbersome, which is why assumptions are made in the first place. But, as we have already seen, the assumptions that are used in total force costing are tailored to the intent of the analysis.

¹²⁹ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 22.

¹³⁰ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 25.

¹³¹ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 62.

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IV. ANALYSIS

A. MODEL CHANGES OVER TIME

It is my assessment that there has been very little change in total force costing models over the last 50 years. The illusion of change is present in the quantity of available research utilizing total force costing data available to the public. Except for the models presented by Novick and McCullough, all publicly available total force costing articles discovered for this report have contained two general components: base data and future projections. The assumptions contained within the base data and future projections appear to be the changing factors between analyses.

Casting a wide net, the articles presented by Novick and McCullough over 50 years ago present the foundation of critical thought experiments toward total force costing. Their models break down the vastness into edible components and ask the analyst to calculate smaller pieces to aggregate into a full research model. While the components vary slightly between the two economists, the concept remains the same.

The quantity of uncertainty held within these costing models is the stumbling block. Both Novick and McCullough assert that uncertainties bring difficulty to calculating a future-projection cost estimate.¹³²¹³³ McCullough calls cost estimating an art,¹³⁴ while also stating “there is considerable doubt among cost analysts as to whether it is possible to set out beforehand in cookbook fashion a set of procedures that, if followed, would result in a good analysis or estimate.”¹³⁵

The issue with contemporary cost estimating is that the base data is largely produced in a vacuum. From the reports accumulated online, the ones published within the past 10 years have started with base data provided in reports by either the services or the

¹³² Novick, *System and Total Force Cost Analysis*, 17.

¹³³ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 2.

¹³⁴ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 2.

¹³⁵ McCullough, *Cost-Effectiveness: Estimating Systems Costs*, 1.

Department of Defense¹³⁶.¹³⁷¹³⁸ The services and the DoD appear to perform their base calculations behind the veil, reporting costs to the public in general terms instead of fixed amounts, likely for showing transparency in government spending. Analysts, in turn, use these reported values to estimate total force costing or project the value of changes to service compliments or equipment.

Therein lies the long-term change to total force costing methods. The assumptions used to calculate service or equipment changes are the key differences between modeling techniques. As any one analyst conforms the costing assumptions to their needs, they make recommendations about how to change the force costing process.¹³⁹ However,^[HS((2] it is up to the services and the DoD to determine whether they choose to implement these recommendations. As previously noted, the services and the DoD perform their calculations outside the public eye, making it impossible to tell if they are incorporating these recommendations as they are developed.

B. MODEL SIMILARITIES

The similarities across all articles found in this report are base data and future projections. Across the services, costs are aggregated and reported in similar values such as manpower,¹⁴⁰ equipment,¹⁴¹ and indirect costs.¹⁴² Assumptions are largely similar as well. As each service determines their own method for compiling current costs, analysts can formulate methods for predicting future costs and estimating total force costs.

¹³⁶ Cox, *Improving Cost Estimates in the Force Mix Allocation Process*, 17.

¹³⁷ Horowitz et al., *Active-Reserve Force Cost Model*, 4.

¹³⁸ Lewis, Roll, and Mayer, *Assessing the Structure and Mix of Future Active and Reserve Forces*, 15.

¹³⁹ Dahlman, *The Cost of a Military Person-Year*, 58; Massey, *Introduction to the USAF Total Force Cost Model*, 41; Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 70.

¹⁴⁰ Wilson et al., *Considerations in a Comprehensive Total Force Cost Estimate*, 4.

¹⁴¹ Massey, *Introduction to the USAF Total Force Cost Model*, 23.

¹⁴² Horowitz et al., *Active-Reserve Force Cost Model*, v.

C. FINDINGS

Total force costing requires breaking down large spending into cost elements. These elements can be grouped into cost categories and reported by the various services. Without knowing the calculation algorithms currently employed by the various services, it is nearly impossible to tell how accurate category values are. Furthermore, most spending reported by the services is rounded and generalized. The services must cross-share information on calculations and assumptions to eliminate cost element disparity between services and increasing the accuracy of overall total force cost calculations.

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V. RECOMMENDATIONS

A. TOTAL FORCE COST MODELING BEST PRACTICES

As the process of calculating costs is bound to a point in time, it is possible to determine true and accurate values at that point in time. The first element of modeling best practice would be cross-talk between service economists to determine similar cost categories across all services. I recommend using Horowitz's Summary of Cost Elements¹⁴³ as a relevant starting point. The next best practice of total force costing is for the services to break down costs elements within each category, using additional cross-talk to find similar or comparable cost groupings. Finally, cost elements must be calculated for their individual values and then have their values aggregated to determine the cost of the total force.

B. RECOMMENDED USE OF THE BEST PRACTICE

The intent of these best practice for total force costing is to create similar cost groupings between the services to support accurate calculating of cost elements. Eventually, as the forces blend for joint warfighting, cost redundancies will be noted and eliminated while calculating costs across the total force.

C. POTENTIAL IMPLICATIONS FOR BUDGET PROJECTIONS

The potential implications on budget projections from my research could have lasting impacts on multi-force budget planning. The sharing of cost elements across services can result in spending efficiencies as the joint warfighters are blended for 21st century combat. As costing methods are developed, the sharing of formulas, assumptions, and values will target redundant spending and save taxpayer dollars.

¹⁴³ Horowitz et al., *Active-Reserve Force Cost Model*, v.

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VI. CONCLUSION

A. SUMMARY

Total force costing has been largely ignored for decades. Instead, the elements of total force costing are produced in vacuums and the results are used to perform cost-savings analysis. Cost elements that have been calculated from total force costing methods are being used to support budgeting decisions, but the method of calculating base values has faded into the background of individual service economists. These economists calculate spending on cost elements and report them to the public, but do not divulge how the values were determined. This forces budget analysts to assume the base values of military spending are accurate.

I have been unable to determine if there are quantitative similarities between total force costing methods among the services. However, I was able to determine there are similar groupings of cost elements that are used for future-cost analysis. In constructing a total force costing best practice, the appropriate method for calculating costs would be to break them down into constituent elements and then calculate the cost of each element, aggregating them into a total cost. However, as the services blend together in a joint warfighting capacity, these costs can also blend between services. Therefore, the constant sharing of cost calculation formulas between services is required to ensure accurate costing of the total force.

B. LIMITATIONS

This report is limited by the availability of published reports. As the intent of the report was to evaluate publicly available research, this was a known limitation from the beginning. Other limitations include the lack of available research on the mathematical formulas used by the services to produce cost values that have been reported to the public. Furthermore, the widespread sources of military spending values, such as the FYDP, OSD, and IDA Cost reports make cumbersome the collecting of base data.

This research is also limited to reports explicitly self-identified as relating to total force costing. As the intent of this report was to determine the calculation process related

to total force costing calculations, other studies relating to specific categories of government spending such as human resources or research and development were excluded. Further research that widens or narrows the scope of relevant spending can be analyzed through a similar lens and may be warranted by the results of this study.

C. FUTURE RESEARCH

This thesis is fully intended for additional research in this field. As noted previously, very little study is being performed on the method of calculating the costs of the total force, giving way to research on cost efficiencies after costing elements have been calculated. With the blending of services in support of joint warfighting efforts, costing methods must evolve with the future of service spending.

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