Risk and Reward in Investment Decisions

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Abstract

The U.S. Navy's investment decisions across the PESTONI pillars (personnel, equipment, supply, training, ordnance, networks, and infrastructure) are interconnected. These relationships also mean that incremental changes to resourcing a particular pillar may not have a simple, incremental effect on another. Most often, decrements or increases to budgets are spread evenly across the pillars out of a sense of fairness, without an appreciation of whether a different approach may result in less risk or outsized readiness gains. Understanding the interconnectedness of the PESTONI pillars may allow senior leadership to better assess trade-offs and make informed decisions about investment. This report reviews how complex systems have been approached and understood, and how risk/reward decisions are made in the science and engineering world. This analysis promotes a new, arguably feasible paradigm—backcasting, with a focus on resiliency in the context of wholeness—for thinking about resourcing decisions.

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Introduction

The U.S. Navy's investment decisions across the PESTONI pillars (personnel, equipment, supply, training, ordnance, networks, and infrastructure) are interconnected, such that they have downstream effects on one another. These relationships also mean that incremental changes to resourcing a particular pillar may not have an incremental effect, or, conversely, that funding one pillar may mean bills will come due on another. These relationships are not well appreciated at the systems level. Most often, decrements or increases to budgets are spread proportionally across the pillars out of a sense of fairness, without an appreciation of whether a different approach may result in less strategic risk or outsized readiness gains. Understanding the interconnectedness of the PESTONI pillars may allow senior leadership to better assess trade-offs and make informed decisions about investment.

Decision-making about weighing and balancing risks is complicated by the fact that the situation involves multi-issue processes: actions can have influence at multiple levels, and many actions are interconnected. Furthermore, decision-making often involves the participation of multiple parties, and each party might address the issues with a narrow focus. In addition, sequential, decoupled processing—due to decisions made on one issue affecting later matters—can limit options unless flexibility and redundancy have been built into the decision-making processes. Unfortunately, flexibility and redundancy sometimes come across as confusion and opacity.

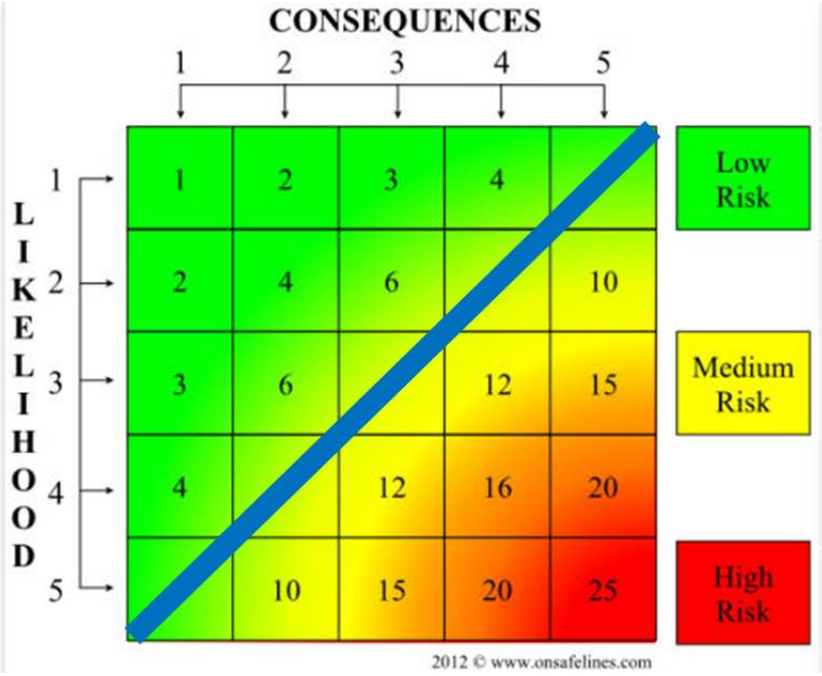
CNA examined the question of risk and reward in investment decisions by examining previous studies, science and engineering approaches, and the private sector to understand whether—and how—complex systems and perturbations to them can be understood and decisions made in a more transparent manner. Our goal was to develop a conceptual paradigm for senior decision makers to think about risk and reward in Navy investment decisions. In the process, we refocused the question from how to calculate and manage risk to how to ensure resiliency.

The risk vs. reward construct

The academic definition of risk—echoed in military publications—involves both probability and consequence [1]. That is, it is a combination of the likelihood of something undesired occurring and how much it would matter. Reward is the other side of the coin: the potential gain from taking an action.

Often, options for risk assessment and strategies are displayed as risk matrices. A risk matrix is a table that has several categories of probability, likelihood, or frequency along one dimension. Along the other dimension are several categories of severity, impact, or consequences. The matrix provides a means to visualize and compare risks by associating a level of risk or urgency with each row-column pair.

Figure 1. Risk matrix



Source: www.risk-assessments.org

The matrix format gives the impression that values from the likelihood and consequences categories can be multiplied to compute and compare options, which generally is not the case. First off, the variables are not quantifiable values in most cases, so the input and output usually require subjective interpretation; often, the values represent unstated assumptions. In addition, it is unclear what

"multiplication" means; in many contexts, the computations involve mixing large and small numbers together. Indeed, for most realistic military contexts, the relevant cases usually involve high-probability/low-consequence and low-probability/high-consequence options (the blue diagonal line in Figure 1). As a result, the matrices do not provide much assistance for developing an analytic framework to help decision makers select strategies.

Risk often is associated with uncertainty in financial markets and investments, and economics concepts offer several ways to deal with it [2, 3]:

- Tolerate. The risk really isn't overwhelming or a game changer. Being aware of the risk factors can cue timely actions to reduce any further negative effects.

- Transfer. These strategies are tied to the hedging actions of insurance and diversification. The applicability of these approaches hinges on the ability to identify common currencies across long-term and short-term considerations.

- Treat. Mitigation efforts address either the probability or the consequences of undesired circumstances. They involve some sort of treatment: changing the environment, developing robust responses, and/or planning for resilient responses. The efforts often involve setting up protection measures and implementing controls (e.g., training and inspections), sometimes with other consequences (e.g., the potential of water damage from sprinkler systems set up to control fires).

- Terminate. The risk is assessed as intolerable, and an alternative concept of operations is required.

These concepts can be implemented in familiar ways, and one can find parallels in military applications:

- Buying insurance (for spreading the risk by having multiple participants subsidize the loss of one, or compensation after the fact) has counterparts in reconstitution and resiliency. For example, maintaining a well-structured personnel pipeline provides flexibility that enables the Navy to employ and sustain emerging platforms and systems.

- Diversifying and balancing investment portfolios (averaging the risk) has counterparts in jointness concepts and the employment of multimission platforms. For example, Aegis cruisers can contribute to joint air defense for CSGs, BMD, and strike with TLAMs.

- Hedging (rainy-day funds, deductibles) has counterparts in war reserves, as well as strategic efforts to deter conflict in the first place. For example, theater security cooperation (TSC) efforts to promote access may pay off in future contingencies.

So clearly, it is conceptually possible to use economic responses to risk in a military construct. The problem, however, is that making business trade-off decisions regarding risk (and its counterpoint, reward) requires a common unit of currency—dollars. Yet decision-making in the military often involves trade-offs at various levels: strategic, operational, and tactical. A historical example has been trying to determine the value of forward deployments. For example: What is the payback of another port visit or coalition exercise? How do you compare investment to improve a sensor's detection accuracy (which will have tactical benefits) with investment to engage in or bolster TSC (which may have strategic benefits)? Quantitative assessments of such issues have been fraught with unsubstantiated assumptions and unclear data.

Risk and reward in terms of readiness

Several recent studies examining risk and reward for the Navy have used *readiness* as the common currency to examine trade-offs.

- A recent Institute for National Strategic Studies (INSS) report [4] states that traditional unit-level readiness metrics are useful as part of a larger readiness management construct, but they do not provide enough information to proactively manage strategically. That requires an understanding of the entire process of creating ready forces and spotting problems deep in the pipelines.

- A recent CNA report [5] states that predicting readiness and predicting operational effectiveness are different endeavors with different goals. To connect them requires a layered package of supporting processes and resources: primary resources fed by secondary processes (which in turn are fed by secondary resources, and so on). Again, a full understanding requires the collection, archiving, and analysis of a large amount of empirical data describing operational effectiveness and operator proficiency.

Both approaches seem impractically complex, but they highlight an analytical spectrum of sorts: INSS focuses on managing readiness, CNA on implementing it operationally; INSS more on measures of performance (which historically have been more measureable), CNA on measures of effectiveness (which historically have been more difficult to calculate). Both require a bottom-up approach involving massive amounts of data that may or may not be available. Perhaps more important, though, making decisions about trade-offs in this way requires intuition—and predictability about the relationship between resources and readiness. But it is unlikely that this relationship is knowable or static.

Another approach: wholeness, resiliency, and backcasting

Because of the challenges with the risk, reward, and readiness approach, we propose an alternative that uses *wholeness* as a common currency, *resiliency* as a goal to be achieved, and *backcasting* as a way to explore how investment decisions can achieve it.

Wholeness

To address the challenge about lack of a common currency, we propose *wholeness*. As far as we can determine, there is no formal definition of wholeness, but we can infer its characteristics from statements and writings of the Navy's senior leaders [6-8]. Wholeness is reflected in the availability of platforms, sensors, and systems, as well as their operational utility—now and in the future. Achieving wholeness involves mitigating gaps and show-stoppers, balancing across programs, and accepting that "good-enough" is good enough.

As noted before, a bottom-up readiness decision construct is data-intensive and not effectively defined. Instead, we suggest decision-makers take a top-down approach—one that assumes that existing investment decisions are reasonably good ones, and that efforts may simply need to be made to make modifications to not only improve the current situation, but also to sustain it.[1] Wholeness, then, is the effort to make sure the existing investment landscape is *complete*.

Resiliency

Resiliency, in the engineering sense, is the concept by which you start with the degree of wholeness of the existing fleet and manage perturbations from it. In the academic literature [9, 10], resiliency has several characteristics:

- It is the ability to absorb external, unplanned-for stresses
- It facilitates quick recovery from anything untoward, as long as one is prepared to deal with the consequences

[1] Admittedly, this argument fails when considering disruptive technologies—for example, are CSGs passé? Will cyberwarfare bizarrely change the character of conflict? But that is a subject for a future study and more a concern for RDT&E and the systems commands than the operating forces.

- It incorporates adaptive responses to managing complications along the way
- And it involves foresight to anticipate potential problems.

A system is resilient if it robust, yet flexible enough to adjust its functioning prior to, during, and after events (that is, changes, disturbances, and opportunities), thereby sustaining required operations under both foreseen and unforeseen conditions. Resiliency is a paradigm for management that focuses on coping with complexity to achieve success. However, effective management must also take into account the possibility of problems resulting from potential events and changing circumstances. A program must be nimble enough—or *resilient*—to adapt to a range of potential events. In some cases, events can be anticipated and planned for. In others, people must be able to respond quickly and take timely action to avoid fallout from unexpected events.

So how do wholeness and resiliency fit together? Is it possible that they provide a synergistic framework to think about resourcing decisions?

- As the underlying environment shifts, beyond our control, the feature of absorbing stresses sustains a good-enough path from here to there. It offers viability rather than optimization, which is fraught with complex factors and changing assumptions.
- There is more than one way to do things. If one path becomes obstructed, a resilient foundation, sustained by keeping options open, allows a prompt alternative as a way around any seeming show-stoppers.
- Ultimately, continual management is paramount—not merely making an investment and letting it ride. Maintaining balance may mean shifting closest attention to the spinning plate soonest to falter.

Backcasting

Thus, the wholeness/resiliency construct for decision making is based on a problem statement of outcomes-to-investment, rather than one of investment-to-outcomes. Fortunately, there is a recognized analytic approach to examining the outcomes-to-investment path: backcasting [11]. The development of the backcasting paradigm sprung from the realization that the predictive record of most forecasting approaches has been poor [12]. Previous approaches suffered from an inherent lack of knowledge about underlying dynamics, and an inability to account for the prospects for innovation and surprise.

Rather than employing a bottom-up methodology to predict from scratch what can be achieved, backcasting begins with an explicit statement of the desired goal, with the premise that Navy programmatics has self-organized over time, and that the

current system is close to equilibrium. Decision makers then describe potential undesirable situations ("What if?"), lay out how they might arise, and develop options to reduce the likelihood or limit and deal with consequences. The key questions to deal with problems are: How did we get there? How might we have avoided the situation? How can we live with the result?

Backcasting involves working backwards from the desired situations to determine the responses required for successful implementation of the scenarios. It requires knowledge of what alternative (desirable) futures are available, what their characteristics are, and how to set the conditions.

So, why is backcasting a promising approach? First, it is more feasible to implement, because one doesn't need to know "everything" to get started from scratch. Backcasting breaks the problem into small sets of cause-and-effect chains, whereas forecasting requires understanding multiple repeated interactions among the elements, and involves mapping to a large set of potential outcomes, most of which are uninteresting. Second, backcasting is compatible with the principles of wholeness and resiliency: By focusing on the desired end state as a starting point, it supports the identification of show-stoppers, and can hint at alterative paths to reach the end state. Short of finding roadblocks, backcasting can help identify which (of the many interconnected) contributors to success are out of whack, and thus help foster *balance* across the programs. And in the process of achieving balance, it can suggest where "good-enough" is really good enough.

Compellingly, the backcasting approach is not at odds with the previous readiness work cited earlier: the INSS report ultimately recommends that decision-makers watch and wait until things start fraying, and then respond appropriately to mitigate them; the CNA report identifies the importance of operational considerations.

If you insist on an answer

This paper promotes a different, more feasible approach—backcasting, with a focus on resiliency, in the context of wholeness—as a paradigm for thinking about resourcing decisions. However, in the process of coming to this recommendation, we also collected, collated, and characterized many other pertinent reports on Navy readiness PESTONI factors.

- A pertinent question is whether there even are any data to support a rigorous assessment of the trade-offs to support investment decisions. Indeed, there is a substantial set of relevant analyses, many of them cited in the reports from

INSS [4] and CNA [5]: There are, for example, data showing that greater total end strength leads to improved fit and fill, and thus to increased personnel readiness.[2] However, the data pertain only to small changes.

- An example of interconnectedness across pillars comes from data showing that an increase in operational tempo provides more time for training and improves training readiness, but leads to more depot maintenance and lower maintenance readiness. The result is intuitive: the more something is used, the more likely it is to break.

- A related example of interconnectedness is that a decrease in crew size leads to an increase in depot maintenance costs and in C3/C4 CASREPs. That is, a reduction in personnel has an adverse effect on maintenance readiness, perhaps because the available crew members are stretched too thin to devote the necessary attention to maintenance procedures. Again, the data pertain only to small changes.

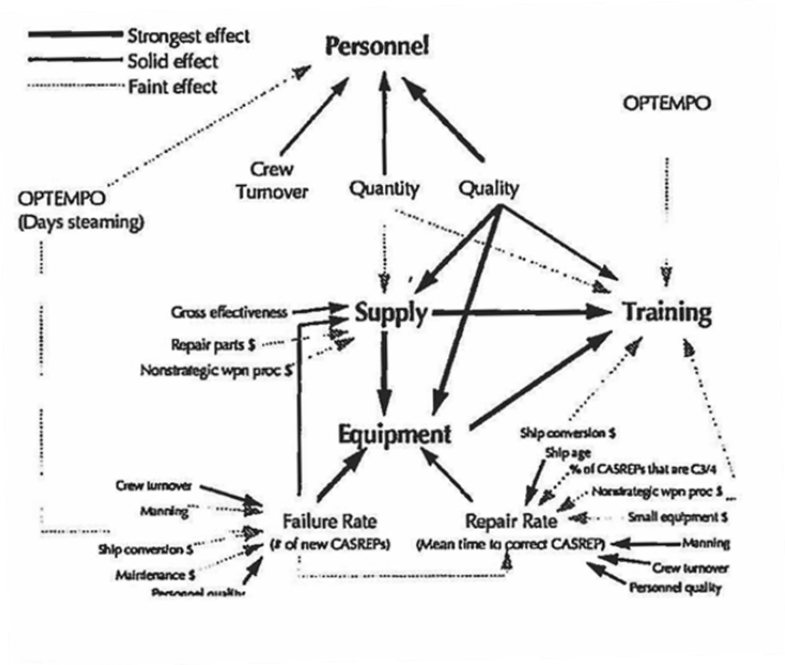
- An example of intricacies in extrapolation of data beyond the set examined involves maintenance funding: Small amounts of underfunding have been shown to have a negligible effect on a platform's service life, but persistent underfunding can reduce service life by 25 percent.

These examples indicate that, overall, it seems that subject matter experts' (SMEs) intuition about what drives readiness is generally valid. However, the available data are not sufficient to show thoroughly how strong the trends are, or how the pillars relate to one another. Nor do they provide any indication of whether further investments would have diminishing returns (in order to guide trade-off decisions when allocating scarce resources). The data are piecemeal, sparse, and potentially out of date. Thus, many quantitative input parameters for a predictive analysis would have large uncertainty error bars.

In our research, however, we did find one comprehensive report (from the "hollow force" years) [13] suggesting that *personnel quality* likely may be the key resource factor that supports wholeness (Figure 2). Personnel quality reinforces resiliency by providing preparedness (in the form of innovative and adaptive service members) to respond to surprises, and by maintaining options to foster recovery (since it affects most everything).

[2] *End strength* is the maximum number of personnel each of the military services is authorized. *Fill* compares total personnel with authorizations, without regard for skill or seniority. *Fit* accounts for how well sailors' skills and experience levels match those required by their assigned billets.

Figure 2. Personnel quality



Source: Matthew Robinson, James Jondrow, Laura Junor, and Jessica Oi, *Avoiding a Hollow Force: An Examination of Navy Readiness.* CNA Research Memorandum 95-238, April 1996.

But personnel quality is not about buying billets. It's about careful *management* of the force. The CNA report uses proxies for motivation, aptitude, discipline, and experience.[3] (Based on more recent issues, I'd add another metric about the relationship of destructive behaviors and morale/personnel quality.) And management may involve other PESTONI pillars. This, then, leads us back to backcasting, which can be used for both investment and management decisions—by starting with the Navy you want (or situations you would like to avoid), and identifying where you must build resiliency to ensure (or avoid) that outcome.

[3] Proxy for motivation: percentage of crew with a high school degree. For aptitude: high scores on the Armed Forces Qualification Test. For discipline: few crew demotions. For experience: average length of service and low frequency of rapid advancement (signaling difficulties in filling more senior positions).

Summary

Risk and risk-management are well-studied concepts in the social sciences. However, the application of the principles to military issues is fraught with complications, a key one being the lack of a "common currency" for making trade-offs. Some analyses implicitly have used readiness as the common currency, but there are feasibility problems when trying to use the approach. Furthermore, many forecasting approaches have limitations regarding the assessment of feasibility and desirability rather than likelihood.

So instead, we have proposed an alternative that uses *wholeness* as a common currency, *resiliency* as a goal to be achieved, and *backcasting* as a way to explore how investment decisions can achieve wholeness. The resulting management approach based on resiliency emphasizes keeping options open, expecting unexpected complications, viewing events regionally rather than locally, and emphasizing heterogeneity. The proposed approach has one key assumption—namely, that the current situation is close to a stable steady-state. We consider this a reasonable premise for this approach, in that Navy programmatics has self-organized over time so that the current system is reasonably close to equilibrium.

This preliminary analysis generates some optimism that backcasting could be a useful tool to guide resourcing decisions. To build further confidence in this idea, it will be necessary first to validate that wholeness is, indeed, the overarching metric, and then to define it more precisely. One way to do this would be to interview senior Navy leaders, and infer from intuitive insights based on their extensive operational experience the more concrete, tangible features of the concept. Perhaps wholeness is a reimagining of the readiness vs. modernization conversation. Maybe to be useful, we need a stronger understanding of how quickly certain capabilities atrophy and how long it takes to regenerate them.

Further analysis might focus on temporal, dynamic issues: How long can you wait? Together with the generally valid intuition we've gained from previous readiness analyses, this might provide the necessary fodder for SMEs to explore the impact of various decisions about investment. Then, perhaps a wargame or facilitated seminar could serve as a proof of concept that this is a feasible and productive approach to implement in the future for assessing programmatic trade-offs.

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