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TECHNICAL REPORT

RAND's Portfolio Analysis Tool (PAT)

Theory, Methods, and Reference Manual

Paul K. Davis • Paul Dreyer

Prepared for the Office of the Secretary of Defense

Approved for public release; distribution unlimited

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Summary

Challenges of Strategic Planning

Strategic planning often seeks to balance investments across numerous objectives. Defense planners, for example, have objectives relating to force capabilities for future traditional and irregular warfare and for operations other than war. The objectives apply separately for different geographical regions and time periods. Acquisition planners have objectives of providing future weapon-system capabilities in each of many mission areas—again for different operational circumstances and time periods. Trainers have objectives such as preparing troops to operate in diverse missions and circumstances. None of these planners have the luxury of a single objective to be maximized. Rather, they are confronted and sometimes confounded by multiple objectives, few, if any, of which can be ignored. Nonetheless, choices must be made, because resources are finite.

Consequently, strategic planning often involves investing in a mix of capabilities and activities to address a mix of objectives. It is therefore natural to use the terminology of portfolio planning. The “portfolio” itself may be characterized by the allocation across investment categories (e.g., Army, Navy, Air Force; tanks, ships, and planes) or by the corresponding allocation across objectives (e.g., traditional versus irregular warfare). In either case, the idea is to *balance* the portfolio. This does not mean spreading money evenly across categories, because not all objectives are equal and because attending adequately to one may require much less effort than doing so for another. Further, given a large baseline of investment such as is enjoyed by the Department of Defense (DoD) and the Department of Homeland Security (DHS), among others, some ways of spending a marginal billion dollars provide far more leverage than others. Spending (or cutting) that marginal billion in proportion to the baseline patterns of expenditure is often irrational. Early in 2009, Secretary of Defense Robert Gates made this point as he proposed a defense budget that will rebalance the portfolio by shifting relatively small resources on the margin toward capabilities for irregular warfare and stabilization, security, transition, and reconstruction.

Dealing with Uncertainty and Disagreement

Against this background, portfolio analysis should assist decisionmakers to frame their thinking about balance, to construct good multifaceted options for consideration, and to make

subsequent choices.¹ Such analysis must include solid data and accurate calculations, but it also includes subjective inputs and analysis under deep uncertainty. Further, it must deal with the reality of major disagreements among senior leaders, disagreements that we can partially capture under the rubric of strategic perspective. A strategic perspective corresponds analytically to a way of weighing various objectives and priorities and assessing options' adequacy in meeting them. Much of this is about managing strategic risk. The essence of strategic decision-making is often either choosing a perspective or crafting options that will be valuable across important perspectives. Analysis can help by making perspectives-related issues explicit and, in some cases, by suggesting nuanced alternatives that are seen as having cross-perspective value.

RAND's Portfolio Analysis Tool

RAND's Portfolio Analysis Tool (PAT) was designed to facilitate strategic portfolio analysis dealing with both uncertainty and differences of perspective. It reflects lessons learned with earlier tools and has evolved considerably as the result of various RAND studies since 2005.

Comparing Options by Various Measures and by Cost

PAT generates high-level summary depictions for discussing issues of balance. It uses a spreadsheet-based format with options shown in rows and various measures of option goodness in columns. Figure S.1 indicates the structure of PAT's *Summary* sheet schematically. On the left is a five-color scorecard;² toward the right are optional columns for specific numerical outputs of interest in a summary; and still farther to the right are column groups for different depictions of cost and for overall effectiveness across measures and cost-effectiveness. At the top left are various "control panels" that allow the user to change the way underlying calculations are made, as well as a number of other items. At the lower left is a color bar that relates the colors to underlying effectiveness scores in a range from 0 to 1.

Drilling Down

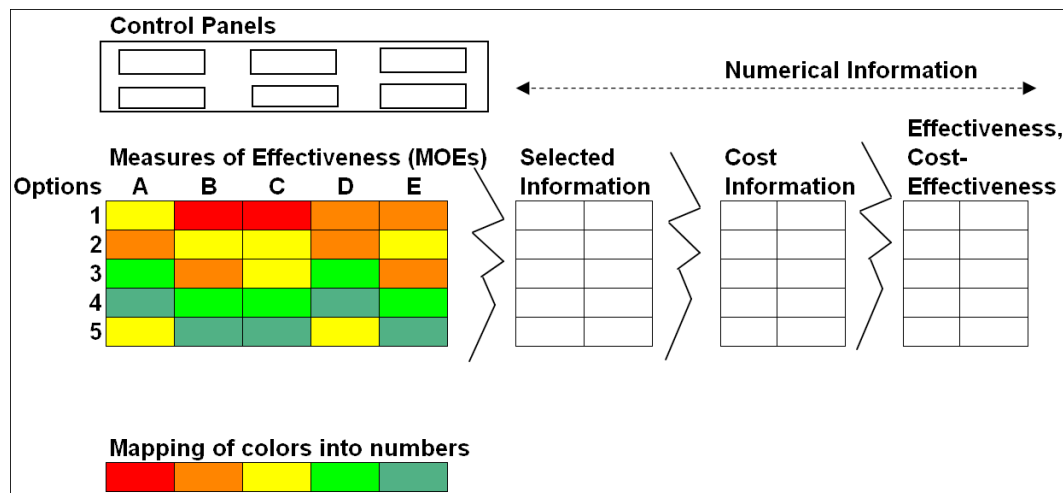
PAT makes it possible to drill down (zoom) to understand the basis of high-level characterizations and to put a spotlight on troublesome problems. The mechanism for what we call the drilldown function is shown schematically in Figure S.2, which indicates that the results shown for the Measure 2 column come from a lower-level (Level 2) calculation that considers two subordinate measures, M2.1 and M2.2. Similarly, the results shown for M2.2 come from an underlying calculation that considers Level 3 measures. A user looking at the *Summary* sheet can click on a column to bring up the Level 2 scorecard or go deeper to see the Level 3 scorecard of interest if such detail is provided.

Such drilldown can be part of interactive high-level presentations if a decisionmaker challenges a particular assessment out of interest or to test the depth of staff work. Alternatively, it

¹ The primary concepts are described elsewhere (Davis, 2002a; Davis, Kulick, and Egner, 2005; and Davis, Shaver, and Beck, 2008). The latter applies RAND's Portfolio Analysis Tool (PAT) to acquisition issues. Another publication (Davis, Johnson, Long, and Gompert, 2008) uses PAT in an assessment of alternative global strategies. Applications are ongoing with the U.S. Air Force and DHS.

² Red, orange, yellow, light green, and green denote very poor, poor, marginal, good, and very good, respectively. The underlying numerical scores may also be shown, but they are usually distracting and misleadingly suggestive of precision.

Figure S.1
Schematic View of PAT Summary Sheet



can simply be part of staff work ensuring that analysis is clear, well grounded, comprehensible, and accompanied by an audit trail. That is, undertaking a project with the expectation of using PAT can help structure the work along the way.

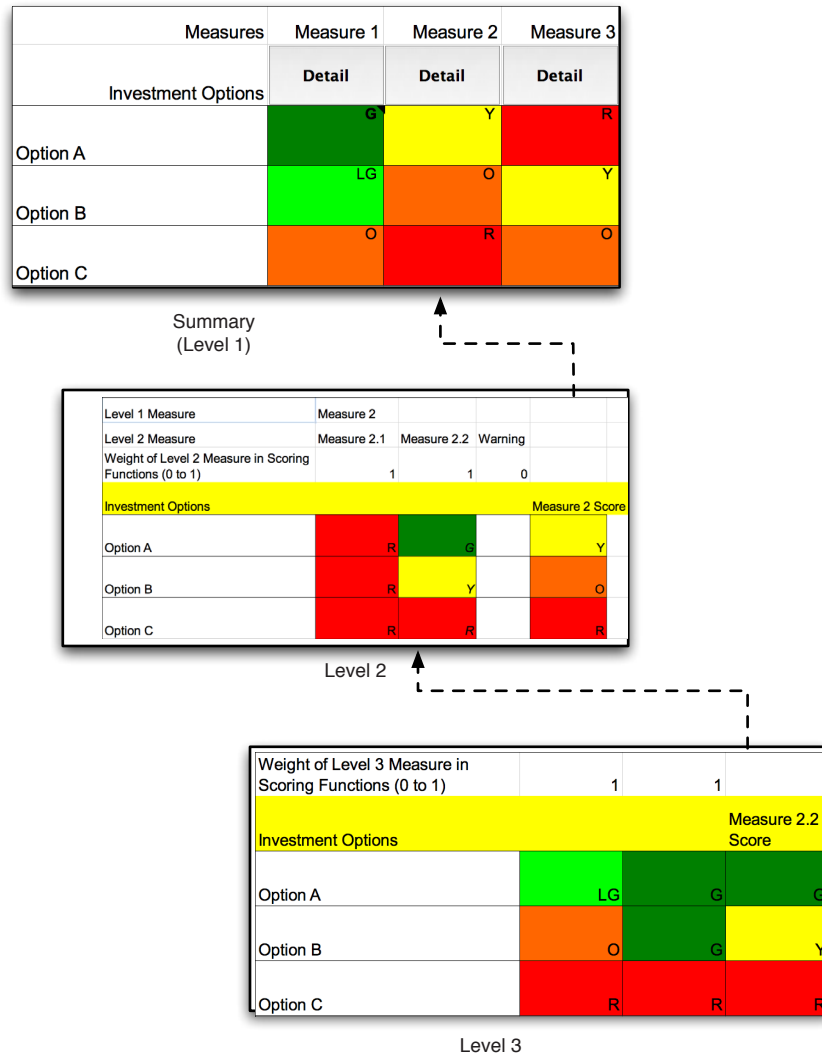
Alternative Combining Rules (Aggregation Rules)

High-level assessments depend on more detailed assessments, but how do they depend on them? When information is sent upward, as in Figure S.2, mathematical rules must be specified for doing so. Should lower-level assessments simply be averaged? Should linear weighted sums be used? What if the problem itself is not “linear”? Options for systems or strategies may have zero effectiveness in the real world if *any* of various critical components fail. A better weapon buys nothing if it cannot be delivered to the target. A stabilization strategy may fail if *any* of its political, military, or economic components is severely lacking—despite the quality of the other components. The natural measures in PAT analysis often include some that are individually critical and some that are important but perhaps substitutable. Recognizing such complexity, we designed PAT to accommodate a wide range of combining rules. Some are built in and can be chosen from a menu; others may be analyst-defined.

Alternative Perspectives

As discussed above, the concept of strategic perspective is important in framing issues and evaluating options. In our work with PAT, a strategic perspective translates into a coherent set of assumptions about the way objectives are weighed and assessments of capability for those objectives calculated and combined in aggregating from lower levels. One perspective, for example, might emphasize relatively near-term capabilities and activities along with currently relevant test scenarios, whereas another might emphasize longer-term matters and do so using test scenarios with intelligent adversaries responding to projected U.S. capabilities and vulnerabilities. Ultimately, perspectives differ in the value placed on various objectives, judgments about how much is enough, and the related matter of managing strategic risk. The user can also define “extended perspectives” that make distinctions based on, e.g., how the effectiveness of an option for a particular measure or submeasure is estimated.

Figure S.2
Drilling Down for Explanation



Multiresolution Data Entry and Modeling

A common problem in strategic decision support is that data—whether empirical and objective, the result of organizationally approved model calculations, or the result of the structured judgment of experts—can be overwhelming. Data can be the enemy of agile analysis intended for sharp, reductionist, high-level thinking. PAT is designed to enable data to be entered at alternative levels of resolution. Top-down thinking may begin with rather aggregated assessments, which may be quite sufficient for some purposes. Subsequently, more detailed assessments can be adopted, in which case, the aggregated-level results stem from those details. Alternatively, a bottom-up approach can be taken initially, but more aggregated inputs can be used for quickly addressing “What if . . .?” questions. In practice, greater detail is only some-

times justified and can even be misleading. A particular option's technological risk, for example, may best be judged at a high level, because that risk is the result of a myriad of problematic issues, not all of which are even identified.

Illustrative Outputs

An Illustrative PAT Summary Sheet

Figure S.3 shows an illustrative *Summary* sheet in which portions that may ordinarily be separated horizontally are juxtaposed. The left side of the sheet shows that options are being assessed by their effectiveness in two scenarios, A and B, and by something called "Other Measures," which might in a defense-planning context relate to something like shaping the international environment. The costs shown are total costs for a 20-year period. The effectiveness column shows an "overall" effectiveness across measures. Relative cost-effectiveness compares the cost-effectiveness ratio of an option with that of the most cost-effective option (except for treating the baseline as 0). We see that Option 2 is by far the most cost-effective (right column) but is still not satisfactory, as indicated by the yellow and red cells of the scorecard. To do well, however (Option 5), is quite costly.

As noted above, the values asserted for the aggregation of overall effectiveness depend not only on the assessments for each individual measure, but also on how those assessments are combined. Assumptions can be changed readily in either sensitivity analyses or more comprehensive exploratory analyses in which all key variables are varied simultaneously to explore what has been variously called the scenario space, outcome space, or possibility space. If such wide-ranging exploration has been accomplished first (whether crudely or in detail), the scenarios used to assess the options can be carefully defined analytically to stress the options in all of the ways regarded as important; i.e., they may constitute an approximate "spanning set." Current-day official planning scenarios do not typically have this virtue, but they could have it in the future. The number of test scenarios, of course, may be much larger than the number of scenarios in the illustrative examples in this report—at least at the working level, before simplifications are introduced for communicating efficiently to leadership.

Cost-Effectiveness Landscapes as a Function of Perspective

Displays such as Figure S.3 include a great deal of information. The scorecard information is especially important because decisionmakers need to understand how the options fare by different criteria (e.g., in the two scenarios). Balancing across such measures is fundamentally in the province of decisionmakers, and they are ill-served if they are presented only with super-aggregated information such as a nonintuitive single metric pretentiously called "effectiveness." So also, the drilldown feature is, in our view, essential.

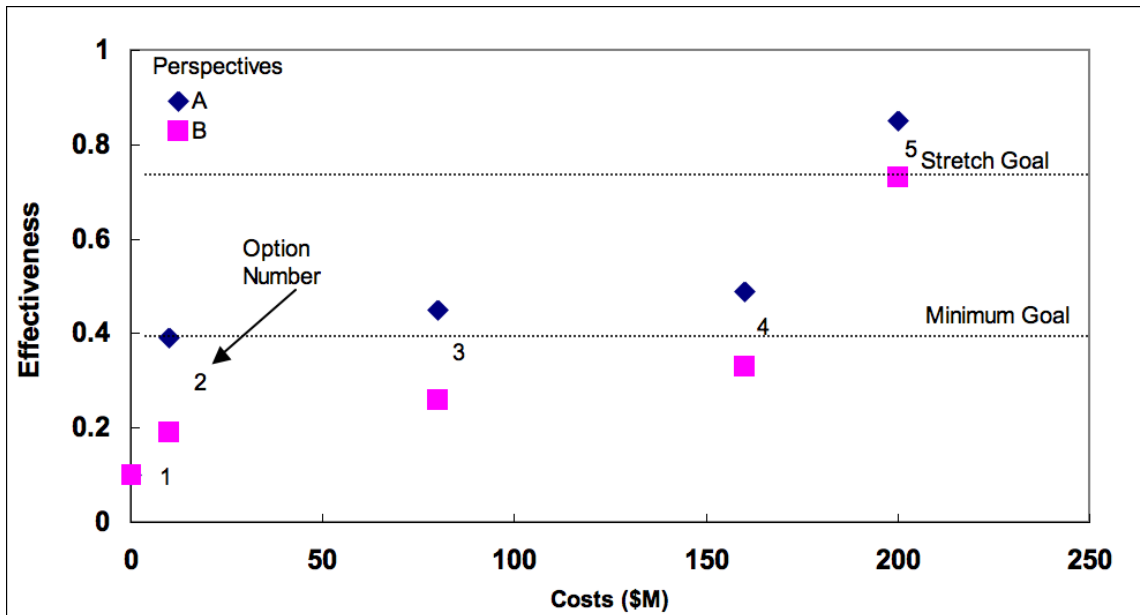
This said, *after* decisionmakers have oriented themselves adequately and discovered or asserted their preferences and the alternative strategic perspectives they wish to take seriously, it can be quite useful to generate visuals that exploit the simpler metric of overall effectiveness. This can be useful for communication and identifying marginal changes to improve cost-effectiveness. Figure S.4 illustrates this with what we call a "cost-effectiveness landscape." It plots the overall effectiveness and cost of each option and does so for each of two strategic perspectives (A and B). If enough well-chosen options have been considered, such a chart can communicate important information on what is gained as a function of expenditure. The results for

Figure S.3
Illustrative Composite Summary Sheet

Measures	Effect. in Scenario A	Effect. in Scenario B	Other Measures	Total Cost: 2010-2030 (\$000s)	Effectiveness	Relative Cost Effectiveness
	Detail	Detail	Detail			
Investment Options	1	1	1			
Baseline (Option 1)				0	0.1	0
Option 2				10	0.37	1
Option 3				80	0.48	0.16
Option 4				160	0.51	0.09
Option 5				200	0.85	0.12

Perspective A (upper, dark-blue diamonds) indicate that Option 2 is significantly better than Option 1 for little cost and that incremental improvements occur with expenditures (Options 3 and 4). Another big improvement occurs with the much more expensive Option 5. In contrast, in Perspective B, the options short of Option 5 have much less value. Perhaps Perspective B is based on more stressful missions and more conservative assumptions. Upon looking at such charts, one might choose to talk in terms of minimum and “stretch” goals, shown by the horizontal lines. The latter would be feasible only if a larger budget were forthcoming.

Figure S.4
Cost-Effectiveness Landscapes for Two Perspectives



Risk Management

Risk management is very important in strategic decisionmaking, so we note that PAT can depict various types of risk in a number of ways, e.g., with explicit top-level measures, with lower-level measures relating to more stressful versions of a test case, by showing consequences of more and less conservative combining rules, or with warning flags (as shown for Option 5 in Figure S.3).

Well-conceived work with PAT should convey a good sense of what is being assumed—a traditional objective in analysis. The goal in decision support, however, should be even higher. It is one thing to summarize for the decisionmaker the assumptions and risks associated with an option. The decisionmaker is better served, however, if he or she is presented also with options that mitigate or hedge against risks—even risks that seem unimportant under prevailing best-estimate reasoning. Wise decisionmaking is not about optimization for a set of assumptions; it is about finding strategies that are not only “likely” to be acceptably effective under nominal assumptions, but also flexible, adaptive, and robust.