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TECHNICAL REPORT

A Portfolio-Analysis Tool for Missile Defense (PAT–MD)

Methodology and User's Manual

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Prepared for the Missile Defense Agency

NATIONAL DEFENSE RESEARCH INSTITUTE

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Summary

RAND's Portfolio-Analysis Tool for Missile Defense (PAT-MD) was built to support high-level discussion and decisionmaking in the Missile Defense Agency (MDA) by providing summary portfolio-style characterizations of alternative investment options. These characterizations may involve projected capabilities in different missions, such as defense of the homeland from long-range missile attacks; the balance of emphasis across missions; the managing of risks; and economic considerations such as relative cost-effectiveness. The portfolio-style depiction attempts to provide a holistic, top-level view across all of these considerations and is intended to facilitate discussion of program tradeoffs and adjustments. Equally important, PAT-MD and a companion tool, RAND's Capabilities Analysis Model for Missile Defense (CAMMD), make it possible to "zoom" to higher levels of detail in order to understand the basis of high-level characterizations and how they would change if assumptions or priorities were changed.

Characterizing Investment Options with PAT-MD

PAT-MD is a tool that can accommodate many different choices made by the user. For example, a typical measure of ballistic-missile defense system (BMDS) capability is the fraction of an attack that would be intercepted. With PAT-MD, this can be generated separately for cases with different numbers of attackers and different countermeasure capabilities. Such capabilities can also be characterized separately for the missions of homeland defense (HD), defense of friends and allies (DOFA), and defense of deployed forces (DODF). And, of course, a given investment option generates capabilities over time, so potential capability can be assessed at different nominal slices of time, such as 5, 10, or 15 years into the future.

In characterizing risk, a typical application of PAT-MD may distinguish between strategic and technical/programmatic risks. An investment program might mitigate the former by assuring strategic adaptiveness—i.e., the ability to adapt to changes of mission emphasis, the emergence of new threats, the pace at which particular threats emerge, or positive opportunities. Technical and programmatic risks may be mitigated, for example, by competing approaches, competing contractors, and special risk-reduction investments.

PAT-MD can highlight a variety of budget considerations, including an investment option's cost in the next fiscal year, over the future years defense program (FYDP), or over 20 years. The costs might be expressed in nominal dollars, constant dollars, or present-value terms.

A classic issue in portfolio-style thinking is *balance*. Will a given investment program provide an appropriate balance of capabilities across missions, one consistent with strategic

priorities? Does the program balance the need to achieve effectiveness with the desire to reduce technical and programmatic risks? This issue is particularly troublesome for MDA because the capabilities needed for effective defense are especially demanding.

Finally, an important element of portfolio-style summary assessments is the providing of measures of relative cost-effectiveness. Analysts may use PAT-MD for marginal or chunky marginal analysis and may even use a composite measure of an option's effectiveness that considers the various missions and classes of risk. However, the philosophy underlying PAT-MD is that decisionmakers can best reason about the various issues of balance by seeing information presented simultaneously in various categories (e.g., implications of an investment option for mid-term and longer-term capability for homeland defense, defense of forces abroad and allies, and various types of risk). Rolling such information up into a measure of composite effectiveness and relative cost-effectiveness should be done, if at all, only as part of summarizing and tidying up once issues are well understood.

Consistent with this philosophy, PAT-MD can support a limited exploratory analysis of how robust composite-effectiveness and cost-effectiveness comparisons turn out to be. In practice, this is important, because, unless care is taken, such comparisons can be unduly sensitive to deeply buried mathematical assumptions.

Understanding the Origins of High-Level Assessments

Although it is difficult to quarrel with the need for high-level summary assessments across multiple considerations, such summaries necessarily are the result of many assumptions, some of which are subtle or even insidious. A core feature of PAT-MD is its ability to zoom to higher levels of detail as necessary to understand and second-guess summary judgments. A user observing a top-level scorecard may, for example, ask why an option is characterized as bad in providing capability for homeland defense. PAT-MD can zoom to a level of detail that shows the factors and assumptions that led to that characterization, allowing the user to change many of those interactively, as in "Oh, that 'requirement' wasn't intended to be quite so rigid. What happens if it is relaxed slightly?"

Sometimes, a second or third level of zoom is necessary—even in discussions with high-level decisionmakers—to achieve an adequately deep understanding of the issues. The information needed typically is different in character from that in a portfolio-style display. In particular, it must reflect broad, parametric capabilities analysis such as is provided by the capabilities-analysis tool, CAMMD. Because PAT-MD and CAMMD have been designed to work together, it is easy to zoom from one to the other, either in real time or by providing the relevant CAMMD displays as backups in a briefing.

Underlying Methodology

Tools for decision support provide summary information abstracted from more-detailed considerations. The methods used to abstract the information can materially affect results and impressions about those results, again sometimes in subtle or even insidious ways. It is therefore important for analysts to choose and tune the methods appropriately, and for decisionmakers receiving related analyses to ask related questions. PAT-MD provides five alternative

methods which correspond mathematically to alternative aggregation functions. Which method is appropriate depends on the analysis and context. In some cases, simple linear weighted sums, which are used extensively in utility-based decision-analysis methods, are adequate. In other cases, nonlinear methods are needed to enforce the concept that a system with several critical components will fail if *any* of its critical components fail, a situation that arises frequently in capabilities-based planning. Thus, doing even better than required on one component does not substitute for doing poorly on another, critical component. This has important implications for resource allocation. PAT-MD provides several ways to reflect such system effects. Significantly, PAT-MD also provides a straightforward way to test sensitivity to goals and thresholds in order to ensure that results are not unduly sensitive to arbitrary assumptions.