2015-04-01

Analytical Tools for Affordability Analysis

Tate, David

Monterey, California. Naval Postgraduate School

http://hdl.handle.net/10945/53569

SYM-AM-15-093

PROCEEDINGS
OF THE
TWELFTH ANNUAL ACQUISITION RESEARCH SYMPOSIUM

THURSDAY SESSIONS
VOLUME II

Analytical Tools for Affordability Analysis

David Tate, Institute for Defense Analyses

Published April 30, 2015

The research presented in this report was supported by the Acquisition Research Program of the Graduate School of Business & Public Policy at the Naval Postgraduate School.

Analytical Tools for Affordability Analysis

David Tate—joined the research staff of the Cost Analysis and Research Division at the Institute for Defense Analyses in 2000. Since then, he has worked on a wide variety of resource analysis and quantitative modeling projects related to national security. These include an independent cost estimate of Future Combat Systems development costs, investigation of apparent inequities in Veterans' Disability Benefit adjudications, and modeling and optimization of resource-constrained acquisition portfolios. Dr. Tate holds bachelor's degrees in philosophy and mathematical sciences from the Johns Hopkins University, and MS and PhD degrees in operations research from Cornell University. [dtate@ida.org]

Abstract

Beginning with the Better Buying Power initiatives, the military components have been required to perform full life-cycle portfolio-level affordability analyses with respect to major defense acquisition programs at key milestones. Prior to this, there was no formal requirement to reconcile program acquisition baselines with resource forecasts beyond the five years of the Future Years Defense Program. This paper discusses the analytical challenges associated with Affordability Analysis and describes methods and tools that the Institute for Defense Analyses is developing to address these challenges.

Introduction

What Is Affordability?

> Affordability means conducting a program at a cost constrained by the maximum resources the Department can allocate for that capability. Many of our programs flunk this basic test from their inception.
>
> —Honorable Ashton B. Carter (2010), Under Secretary of Defense for Acquisition, Technology, and Logistics (USD[AT&L])

> Affordability policy is about establishing the dollar amount the Component is willing to spend on the desired capability in the context of all other fiscal demands over the long term.
>
> —Chad J. Ohlandt (2013)

Over the last two decades, the Department of Defense (DoD) has spent a historically unprecedented amount of money on acquisition programs that, in the end, did not deliver the warfighting capability they had been intended to provide. For example, the Army Acquisition Review commissioned by the Secretary of the Army and published in 2011 estimated that

> every year since 1996, the Army has spent more than $1B annually on programs that were ultimately cancelled. Since 2004, [35%–42%] per year of Army [Development, Testing, and Evaluation] funding has been lost to cancelled programs. (Decker & Wagner, 2011)

The Army is scarcely unique in this regard. All military components have seen significant program cancellations with little or nothing to show for the billions spent. In addition to cancellations, many other programs have been severely truncated or restructured, providing far less national security capability than had been envisioned.

While some programs have been canceled for technical reasons, or because the threat they were intended to counter went away, others have been canceled or curtailed simply because there was not enough money available to pay for everything. Affordability simply means having enough resources to be able to finish the programs you start.

What Is Affordability Analysis?

> At the Milestone A Review [the DoD Component will] present an affordability analysis and proposed affordability goals based on the resources that are projected to be available to the DoD Component in the portfolio(s) or mission area(s) associated with the program under consideration. The analysis will be supported by a quantitative assessment of all of the programs in the prospective program's portfolio or mission area that demonstrates the ability of the Component's estimated budgets to fund the new program over its planned life cycle.
>
> —DoD Instruction (DoDI) 5000.02, *Operation of the Defense Acquisition System* (USD[AT&L], 2015)

> Affordability analysis is a DoD Component leadership responsibility that should involve the Component's programming, resource planning, requirements, intelligence, and acquisition communities. The Department has a long history of starting programs that proved to be unaffordable. The result of this practice has been costly program cancelations and dramatic reductions in inventory objectives. Thus, the purpose of Affordability Analysis is to avoid starting or continuing programs that cannot be produced and supported within reasonable expectations for future budgets.
>
> —DoDI 5000.02 (USD[AT&L], 2015, Enclosure 8)

Beginning with the Better Buying Power (BBP) memorandum and directive of 2010, and continuing through BBP 2.0, BBP 3.0, and the newly revised DoDI 5000.02, *Operation of the Defense Acquisition System,* the Office of the Secretary of Defense (OSD) has defined and implemented a series of new requirements for the military components to address affordability issues at the inception of new programs and at every subsequent milestone (DoD, n.d.)[1]. The required Affordability Analysis should be performed at the portfolio level, over a planning horizon of decades. The guidance is explicit: the responsibility for Affordability Analysis lies with the component leadership, not with the program. Only the component leadership has the necessary understanding of component priorities, risk tolerance, and resource forecasts to support the required analysis, and only the component leadership has the authority to stretch, truncate, or cancel some programs in order to make room for others.

What Tools Do Affordability Analysts Need?

Predictive Costing—"What If?"

The first fundamental requirement for Affordability Analysis is the ability to consider hypothetical alternative futures in which the current plans cannot be executed. Current law requires that planned acquisition costs must fit within forecast budgets through the five-year

[1] Better Buying Power (BBP) 1.0 was introduced in 2010 as part of the DoD's Efficiency Initiative. The stated objective was to deliver warfighting capabilities needed within the constraints of a declining defense budget by achieving better buying power for the warfighters and taxpayer.

Future Years Defense Program (FYDP), but not in the "outyears" after that. This leads to the phenomenon known as "the bow wave," in which the total planned costs of all acquisition programs exceed reasonable budget projections in the years immediately beyond the FYDP. Each new President's Budget imposes fiscal reality on one additional year, pushing the excess off into the future. The new Affordability Analysis requirement extends the constraints of the FYDP out to a 30-year planning horizon, eliminating the bow wave. The top line budget assumptions for each component are provided by OSD.

To meet this requirement, component programmers need to be able to understand how annual program costs would change under hypothetical alternative schedules. As we shall see below, this is not an easy task.

Consistency Checking

Another important requirement for Affordability Analysis is the ability to assess the consistency between various affordability submissions. The new guidance requires Affordability Analyses to support milestone decisions for specific programs. These generally provide considerable detail about the program in question, some detail about other programs in the same acquisition portfolio, and minimal detail about other portfolios. Decision-makers need to be able to recognize whether new Affordability Analyses are consistent with past submissions by other programs and portfolios. They need to be able to distinguish updated information (e.g., new cost estimates or quantity requirements) from inconsistent assumptions. They also need to be able to understand the implications of reconciling inconsistent submissions using the most authoritative available data for all programs.

Risk Modeling

Because all Affordability Analyses are uncertain, it is essential for decision-makers (both within the components and in the oversight community) to understand the potential implications of that uncertainty. One important tool in this regard is sensitivity analysis—the ability to see the overall consequences of changing specific assumptions or forecasts. For affordability, it will be important to understand sensitivity to cost estimating assumptions, sensitivity to budget forecasts, and sensitivity to future needs for not-yet-defined systems.

More generally, "affordability" is not a yes/no question. It makes much more sense to think of the probability that a given portfolio of programs can be acquired within a given budget, even though both program cost estimates and budget forecasts are subject to unknown errors. An ideal tool for Affordability Analysis will support probabilistic modeling of individual program outcomes, portfolio contents, and budget forecasts.

Visualization

Finally, it is important for any Affordability Analysis support tool to provide outputs that are informative and understandable. Numerical reporting is important, but data visualization can greatly enhance the utility of any analytical tool. In particular, dynamic visualizations that highlight the patterns of change that occur as budgets grow tighter (or portfolio contents grow) would be very useful. To support this requirement, it will be necessary for the tool to be able to perform its "What if?" computations in near-real time.

What Are the Analytical Challenges of Affordability Analysis?

Why is Affordability Analysis hard? Setting aside the political challenges of competing interests within a given military component, it might not be obvious that there are also substantive *technical* challenges in figuring out whether or not a set of proposed programs is affordable. In this section, we discuss three necessary enablers for effective

Affordability Analysis and the technical challenges associated with each. All three of these challenges arise directly from the nature of program cost estimates.

Any Affordability Analysis must begin with cost estimates for the various programs in the relevant portfolio. These estimates generally take the form of annual quantity and cost forecasts that reflect the program offices' planned (or proposed) development and fielding schedules. If the sum of these forecasts fits within the predicted available budget for the portfolio, then the portfolio would seem to be affordable. But what if it does not fit? And what about the possibility that the budget forecast or the cost estimate (or both) might turn out to have been overly optimistic? To address those concerns, we need to be able to predict the annual costs for production schedules other than the planned schedule—and that turns out to be rather tricky.

Estimating the Annual Costs of Hypothetical Schedules

The problem is easy to state: "The program says that the planned schedule of lot quantities would result in these estimates of annual lot costs. How much would each lot cost if we bought them according to this alternative schedule of procurement quantities instead?" The DoD has detailed records of cost and schedule for hundreds of acquisition programs, going back decades. Given that wealth of data, why is it hard to figure out how schedule affects cost? There are several important analytical obstacles.

Obstacle #1: Cause Versus Effect

Consider three procurement programs: A, B, and C. Program A is doing fine, but due to overall budget reductions, its production schedule is going to be stretched, which will increase unit costs. Program B has just announced significant cost growth—not caused by a schedule change—that has made its planned production schedule too expensive, given other priorities in the portfolio. Program C has been experiencing integration issues—its electronics are going to require a new design that uses a more expensive subcomponent, which will have to be retrofitted into existing units. This means both a cost increase (due to the new component) and a schedule slip (to accommodate the new design and the rework).

For all of these programs, unit cost went up and average production rate went down. Causally, though, we have three distinct cases:

- For Program A, schedule stretch caused cost growth.
- For Program B, cost growth caused schedule stretch.
- For Program C, technical issues caused both cost and schedule growth.

Although we are trying to understand only the first of those mechanisms, we cannot tell just by looking at historical numbers which case was in effect—or whether it was some mix of all of them—for a given program. We need a way to isolate the Program A effect from the others.

Obstacle #2: Not All Costs React the Same Way to Schedule Changes

Since 2006, Selected Acquisition Reports have broken out cost forecasts into subcategories: end-item recurring flyaway costs, non–end-item recurring flyaway costs, nonrecurring costs, and two categories of support costs. This is very helpful, because we do not expect all of those costs to react identically to a change in production schedule. End-item recurring costs should be most directly affected, while nonrecurring costs and non-spares support might not be affected at all. Any econometric model of how schedule affects cost should take advantage of these different cost categories and treat them separately when they are known.

Obstacle #3: Limited Relevant Data

Even if we have multiple historical cost estimates for Program A, those past estimates might not tell us anything about the relationship today between Program A's production schedule and lot costs. Since those past estimates were developed, Program A may have changed in any number of ways—new designs, revised cost estimates, requirements changes, technology insertions, planned product improvements, new contracts, new demands from the field, and so forth.

Unless we could somehow correct for all of the program changes other than schedule, those past forecasts do not tell us what the estimated cost would be today for that previous planned schedule. More generally, we seldom get to see multiple proposed schedules (and their associated costs) for the same exact program. Since we are trying to figure out how cost varies as schedule varies, this is a major limitation.

Obstacle #4: Rate Effects and Learning Curves

The cost of producing one unit of a product depends on the production rate. For one thing, at lower production rates, the indirect costs (overhead) of the producer and the fixed costs of production get amortized over fewer units, so that each unit bears a higher proportion of those costs. In addition, there can be logistical issues related to supply chains and staffing that make it inefficient to produce at low rates. We will discuss the mechanisms of rate effects below; for the moment it suffices to note that they exist. As a result, the cost of a unit depends on how many other units you make in the same year.

In addition, even at constant production rates, unit costs are generally not constant over the production life of a program. In particular, most procurement programs exhibit *learning curves*, in which the marginal cost of successive units decreases as a function of cumulative production. As a result, the cost of a given unit depends not only on how many other units you make in that year, but which units (cumulative) they are. In the standard model, the cost of the nth unit produced is predicted to be $T_1 n^{\beta}$, where T_1 is a notional first unit cost and β is a parameter that describes how quickly unit costs decline with cumulative production (Lee, 1997). This formulation is often expressed in terms of the learning "slope," $S = 2^{\beta}$, where unit cost decreases by a factor of S every time cumulative production doubles.

Shifting units of planned production from one year to another thus changes both the production rates in those years and the portion of the learning curve that falls in those years, resulting in nonlinear changes in annual costs.

Mechanisms and Models for Schedule Effects

There are several competing theories about how and why unit costs change when schedules change. These theories are not necessarily mutually exclusive, which makes it even trickier to figure out how to combine them into a coherent model.

Fixed Costs and Sticky Costs

As noted above, most of the indirect costs and some of the direct costs of producing a weapon system are incurred per unit time, rather than per unit produced. For example, the costs associated with running the program office do not depend much on the current production rate, or on how many units have been produced so far. Similarly, the indirect costs associated with contractor overhead are only a little bit sensitive to production rates. What's more, overhead rates tend to be "sticky"—they don't generally adjust instantaneously to changes in work level. A useful model of how cost depends on schedule should be able to distinguish rate-insensitive costs from rate-sensitive costs, and estimate how sticky the fixed costs are.

Learning and Forgetting

It is not uncommon for unit production costs to follow a standard learning curve for most of the life of a program, but then start to climb upward again toward the end of the program. To account for this, C. Lanier Benkard (2000) suggested that producers improve in efficiency by gaining “experience” making units (learning), but that this experience depreciates at a constant rate (forgetting). Thus, early in production (when cumulative quantity is doubling frequently), or at high production rates (when more experience is being gained per unit time), learning behavior dominates. Late in the production run, or at low production rates, the gains from learning are visibly offset by forgetting.

We investigated this model, and found that it fits many historical programs quite well. It can also be improved by combining it with a fixed cost model, so that indirect and rate-insensitive costs are modeled separately, while rate-sensitive costs are modeled by a combination of learning and forgetting.

Regulatory Lag

Finally, William Rogerson (1994) has proposed that the interaction between unit cost reduction and production rate can be understood by looking at the incentives inherent in how procurement contracts are awarded. In general, a new fixed-price procurement contract is awarded for each annual lot, with a negotiated unit price based on the contractor’s demonstrated historical costs. A contractor who invests in management or tooling changes that reduce production costs will only realize extra profits from that investment until a new price is negotiated—typically two or three years later.

At high production rates, contractors have more incentive to invest in reducing production costs, because they will realize extra profits on many units during the two- to three-year “regulatory lag” period before the price is renegotiated downward to reflect the lower production costs. As a result, more potential cost-reducing investments will be cost-effective for them, given the need to make back the initial investment costs through higher profits.

Conversely, at lower production rates, contractors have less incentive to reduce costs, as well as fewer available cost-reduction alternatives that would provide the necessary return on investment. If this theory is correct, we should expect to see less learning at low production rates, and more learning at higher production rates. This is very different from the standard learning model, which assumes that the learning curve slope is an intrinsic characteristic of the system being produced and does not vary with rate.

It is possible to formulate an econometric model based on Rogerson’s (1994) framework, assuming a profit-maximizing contractor with a notional pool of cost-reducing investment options. We can also combine this model with a fixed-cost model, as we did with the learning-and-forgetting model. In theory, we could add forgetting to this model as well, but there are serious limits to how many model parameters can be estimated from the available data.

Estimating the Impact on Schedules of Hypothetical Budgets

In order to understand the impact of portfolio budgets on cost and schedule, it is not enough to be able to predict the annual costs associated with a given sequence of lot quantities. We also need to be able to predict how each program’s production schedule might adjust to accommodate a budget that is too tight for each program to execute its current individual plan.

In a prior research effort (Weber et al., 2003), we used optimization to find minimum-cost feasible schedules within a given budget, subject to constraints on minimum and maximum production rates and latest permitted delivery date. This approach is unsatisfactory for several reasons. First, the nonlinear mixed-integer optimization problem is quite difficult, requiring industrial-grade optimization tools and considerable time. Second, the optimized schedules are generally implausible—they rely on the portfolio manager's ability to make trades among future years in a manner that is often politically impossible. They also tend to oscillate between minimum and maximum rates for a given program unless additional constraints or penalties are imposed. Finally, they give a very misleading view of the consequences of a change in forecast budget, since the bulk of the cost difference between the current planned schedule and the revised schedule is due to optimization of the current plan, not due to the change in budget.

For the current effort, we have chosen to use a greedy constructive heuristic to model the potential impact of a budget change on production plans within a portfolio. The heuristic attempts to maintain the same proportionate cumulative funding by program as in the plan, but is constrained by both the budget and the minimum (and maximum) feasible production rates of the various programs. The combination of fixed costs and minimum sustaining production rates implies that it may not be possible to match the planned relative funding levels very closely. This is especially true if some programs are near their minimum sustaining rates in the original plan. Those programs cannot be stretched further, so that the cost burden of stretching to fit under the budget will be borne disproportionately by the other programs. Optionally, the heuristic can also incorporate user-specified program priorities.

At present, the heuristic simply reports infeasibility if there is insufficient budget to produce each program at its minimum sustaining rate. Future versions may suggest quantity reductions where needed, based on user-provided priorities among programs and minimum useful quantities to field.

Affordability Risk Analysis

All of the analytical challenges discussed thus far make the implicit assumption that the estimated costs for each program in the portfolio are accurate. History teaches that this is not generally true; weapon system acquisition is notorious for cost growth. Without getting into the thorny question of what causes cost growth, we can nevertheless ask what implications cost growth has for Affordability Analysis.

If we knew both program costs and future budgets with certainty, affordability would be a yes/no question. Budget uncertainty can be handled to some extent through sensitivity analysis—how much do costs change as a function of future budget levels, and at what point does the portfolio become infeasible unless we reduce quantities or cancel programs? There is also a time dependency—one bottleneck year of low budget can render a set of programs infeasible, even if the overall funding level over the planning horizon is generally high.

Cost uncertainty is even trickier, because we need to know not only how the costs might change, but *why* they might change. Is the problem higher labor rates than expected? Higher fixed costs? Less learning? Faster forgetting? Some combination of all of those? The answers to those questions will affect how much further cost growth will be incurred when we realign production schedules to fit under the budget.

Because of the complexity of how cost depends on various econometric parameters and on schedule, there is little prospect of an analytical model of affordability risk. Even if we were confident that we knew the probability distributions for future budgets and for procurement cost growth in each program, that is not enough information to allow us to derive the conditional distribution of resulting costs when all programs are modified to fit within a given budget. If we also want to be able to model uncertainty due to new programs arriving into the portfolio, the problem is even worse.

Monte Carlo methods seem like the most promising approach here. If we can characterize the cost risk in terms of probability distributions on the parameters of our econometric model, we can then simulate the future repeatedly to estimate the probability of affordability, the expected unit cost, the probability of a Nunn-McCurdy breach, the expected time to deliver the Nth unit, and other measures of interest. We can do this for a fixed budget, or we can allow the budget to vary randomly at the same time, including making room for future programs. The trick, of course, is deriving plausible probability models for the econometric parameters and budgets, based on historical data.

APASS—The Acquisition Portfolio Affordability Support System

We are currently developing a software environment for Affordability Analysis for our sponsors in the Office of the Secretary of Defense for Acquisition, Technology and Logistics (OSD[AT&L]) Acquisition Resources & Analysis, which we call the Acquisition Portfolio Affordability Support System, or APASS. The purpose of APASS is to provide an environment for evaluating and tracking the affordability of portfolios over time. APASS features are focused on five specific areas of support: tracking, forecasting, risk analysis, reporting, and visualization.

Tracking

APASS will provide both a “living” operational view and a historical record of portfolio affordability and cost and schedule data. This combination will support both current decision-making and assessment of historical trends and changes.

Affordability analyses are generally performed on behalf of individual programs for use at milestone reviews. These analyses generally feature detailed cost and schedule information for the program under review, aggregated cost and schedule information for other programs in that portfolio, and at best top-line summary data for other portfolios. APASS will allow managers to remember the information submitted at prior reviews, compare that information against the new information, and identify any inconsistencies or changes. In particular, APASS will support comparison of data sources with slightly different portfolio definitions. APASS will also be able to compare new submissions against routine DoD-wide data submissions, such as the annual Selected Acquisition Reports (SARs) or President’s Budget justification exhibits.

APASS will also allow analysts to merge multiple submissions into user-defined data sets. Authoritative data from multiple sources could thus be combined to create a “single integrated affordability picture” across all programs and portfolios. This would let managers maintain a living representation of the current best forecast of the acquisition future, with which they could explore the implications on that future of alternative budgets, new programs, or cost growth.

Forecasting

The primary analytical function of APASS is to predict the annual quantities and costs for all programs in a portfolio, conditioned on a portfolio budget other than the current planned budget. This function relies heavily on both the econometric modeling and the schedule adjustment heuristic described above.

Figure 1 shows an APASS screenshot of a notional current production plan for a set of portfolios. FYDP years are shown in darker hues; outyears are lighter shades of the same color. If we drill down into a single portfolio, we can see the individual program plans and the projected portfolio budget (Figure 2). The combined plans exceed the projected budget, so we invoke the “fit to budget” heuristic to extrapolate how the portfolio might adapt to the lower budget. The result is shown in Figure 3. In this example, the total procurement cost for the portfolio increases significantly. The percent increase in unit cost is not shared evenly across programs; those programs that finish quickly or that are already near their minimum production rates will not be as strongly affected as those that have more flexibility to stretch.

Figure 1. Army Procurement Portfolios

Figure 2. Portfolio With Budget

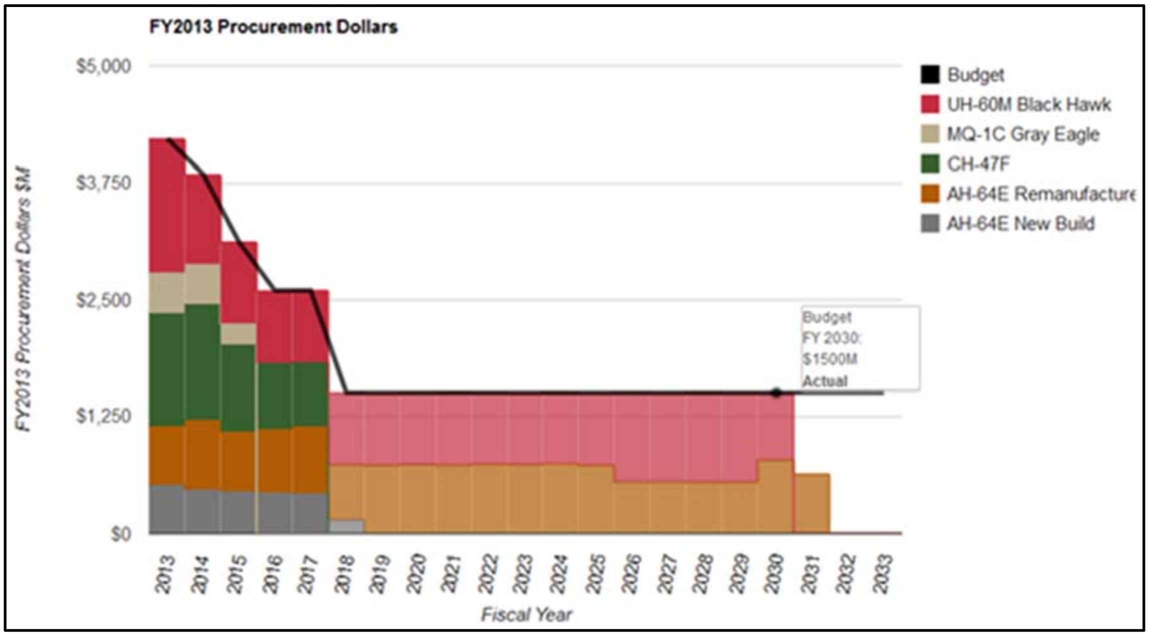

Figure 3. Portfolio Adjusted to Fit Within Budget

This is the fundamental analytical tool in APASS; all other analyses rely on this ability to extrapolate costs and schedules in response to different levels of available funding. The cost forecasts produced by the econometric models and extrapolation heuristic are not “budget quality” cost estimates, but they provide credible extrapolations of the type and magnitude of cost and schedule impact that would be implied by alternative scenarios.

Risk Analysis

The initial implementation of APASS will focus on sensitivity analysis, particularly with respect to changes in budget or portfolio contents. It is particularly important for decision-makers to understand how program costs and delivery schedules might change under various budget scenarios, or in the event that a new high-priority program is added to a portfolio. It will also be possible to use APASS to assess the sensitivity of all programs to cost growth in a particular program.

Future versions of APASS will include Monte Carlo modeling capabilities, to simulate the potential consequences of multiple simultaneous sources of uncertainty. The output from these simulations would include probability distributions on unit cost and delivery timelines for individual programs, as well as correlations among programs within a portfolio.

Reporting

The analytical capabilities of APASS will only be useful if they are able to provide users with the information they need to support acquisition decisions and oversight. To that end, APASS will include both standard and customizable reporting of both cost and schedule baselines and derived affordability data.

Because APASS incorporates data from multiple sources, including speculative analyses, its reporting requirements will be somewhat more varied than those of typical acquisition data repositories. In particular, APASS will need to be able to merge conflicting data sources to produce “best guess” forecasts that draw individual program forecasts (and their corresponding econometric parametrizations) from separate sources, using the current most authoritative source for each. This merged forecast will typically differ from each of its source submissions in some ways. It will therefore be particularly important for APASS to produce reports that highlight the differences between forecasts of the same program(s) from different sources. These comparison reports will also be useful for describing the unit cost and schedule impacts of various possible future portfolio-level budgets, as extrapolated by the schedule adjustment heuristic.

Visualization

As a complement to numerical reporting, APASS will also provide graphical visualizations of various baseline data and comparisons. To begin with, APASS will be able to produce the various graphical formats for presenting Affordability Analysis information that are recommended in the *Defense Acquisition Guidebook*, as revised in June 2013. APASS will also provide the ability to view animations of the sensitivity of a given portfolio to program cost growth, changes in budget level, or introduction of additional programs. Coupled animations, showing both the overall "sand chart" of program spending over time and an aligned display of the absolute or relative change from the baseline by program, will allow analysts to grasp the implications of alternative scenarios much more quickly than when using individual graphics or numerical displays.

Summary and Conclusions

Program life-cycle affordability is a cornerstone of DoD acquisition planning. Ultimately, the goal of Affordability Analysis is to supply decision-makers with the best available information and analysis about defense acquisition programs so that they can

- allocate defense resources efficiently and effectively, both within and across programs;
- consider the full range of cost and schedule alternatives;
- understand and manage acquisition risk at the program, portfolio, and Service level; and
- avoid the time and money wasted by starting programs that cannot be completed.

Affordability is the measure that allows decision-makers to allocate appropriate resources to their future operational requirements. Affordability is not a "yes or no" attribute; it is the degree to which uncertain future resources can be expected to permit execution of current and future programs. This degree is best characterized in terms of probabilities and sensitivity to deviations from current plans.

The Better Buying Power (BBP) memoranda and the newly-revised DoDI 5000.02, *Operation of the Defense Acquisition System,* from the OSD have defined and implemented new requirements for the military components to address affordability issues at the inception of new programs and at every subsequent milestone. This Affordability Analysis is to be performed at the portfolio level, over a planning horizon of decades. The responsibility is given to component leadership.

In order to plan their acquisition strategies, the components need to be able to assess affordability over a wide range of future scenarios without needing to return to the program offices or the component cost estimators for new cost estimates every time a different portfolio plan is considered. At the same time, OSD oversight organizations need to be able to reconcile current affordability analyses with past analyses, assess the sensitivity of current forecasts to potential disruptions, and characterize the level of risk inherent in current plans, in order to fulfill their oversight responsibilities with respect to acquisition.

APASS is being implemented as a tool to support both Affordability Analysis as required by current DoD regulations and OSD oversight of affordability planning across the military components. To these ends, APASS will combine econometric modeling of procurement costs as a function of schedule, extrapolation of the effects of alternative budgets on portfolios of programs, and fusion of data from multiple divergent sources. APASS will also provide the reporting and visualizations services necessary to make these analytical capabilities practically useful on a day-to-day basis.

References

Benkard, C. L. (2000). Learning and forgetting: The dynamics of aircraft production. *American Economic Review, 90*(4), 1034–1054.

Carter, A. B. (2010). *Better Buying Power: Guidance for obtaining greater efficiency and productivity in defense spending* [Memorandum for acquisition professionals]. Washington, DC: Office of the Under Secretary of Defense.

Decker, G. F., & Wagner, L. C., Jr. (2011). Army strong: Equipped, trained and ready: *Final report of the 2010 Army Acquisition Review*. Retrieved from http://usarmy.vo.llnwd.net/e2/c/downloads/213465.pdf

Defense Acquisition University. (2013). *Defense acquisition guidebook.* Retrieved from https://acc.dau.mil/docs/dag_pdf/dag_complete.pdf

DoD. (n.d.). Better Buying Power. Retrieved from http://bbp.dau.mil/background.html

Lee, D. (1997). *The cost analyst's companion*. Tysons Corner, VA: Logistics Management Institute.

Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics. (2015). *Operation of the Defense Acquisition System* (Department of Defense Instruction [DoDI] 5000.02). Washington, DC: Author.

Ohlandt, C. J. (2013). Dispelling the myths of DoD's affordability policy. *Defense AT&L, 42*(5).

Rogerson, W. P. (1994). Economic incentives and the defense procurement process. *Journal of Economic Perspectives, 8*(4), 65–90.

Weber, C. A., Balut, S. J., Cloos, J. J., Frazier, T. P., Hiller, J. R., Hunter, D. E., . . . Tran, D. (2003). *Acquisition Portfolio Schedule Costing/Optimization Model: A tool for analyzing the RDT&E and production schedules of DoD ACAT I systems* (IDA Document D 2835). Alexandria, VA: Institute for Defense Analyses.

ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF BUSINESS & PUBLIC POLICY
NAVAL POSTGRADUATE SCHOOL
555 DYER ROAD, INGERSOLL HALL
MONTEREY, CA 93943

www.acquisitionresearch.net