Measuring Portfolio Value for Government Programs and Initiatives

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Contents

1 Introduction 4
2 Government Business Cases 5
2.1 Government Capital Investments, Return on Investment, & Program Portfolios 5
2.2 Measuring Value in Business Cases & Portfolios 6
2.2.1 Finance Metrics – Discounted Cash Flow (DCF) Analysis and Net Present Value (NPV) 6
2.2.2 Challenges of Using NPV and other Finance Metrics for Government Acquisitions, Projects, and Portfolios 7
2.2.3 Portfolios - Why We Need a New Way to Measure Value in Government Acquisitions 8
3 A Roadmap for Measuring Portfolio Value 11
3.1 Identify Prioritized Initiatives 11
3.2 Determine Intended Outcomes and Shortfalls Solved 11
3.3 Initiative-Level Influence Diagrams 12
3.4 Engage & Collaborate with Portfolio Stakeholders 15
3.5 Align Program Schedules with Portfolio Initiatives 15
3.6 Portfolio-Level Influence Diagrams 15
3.6.1 Change Management and Policy Changes for Portfolio Integration 15
3.6.2 Introducing & Integrating New Processes and Capabilities 16
3.6.3 Bigger Picture Integration 16
3.7 Portfolio Schedule 16
3.8 Investment Sequence & Timelines & Using Decision Trees to Map Portfolio Decisions 17
4 Calculating Portfolio Value – Aggregate Cost & Benefits Estimates 17
4.1 Decision Tree Analysis 17
4.1.1 What Are Decision Trees? 17
4.1.2 How to Apply Decision Trees to Series of Investments 18
4.1.3 Additional Branches 19
4.1.4 Recalibrating Trees, Schedules, and Portfolio Value at Decision Points 22
4.1.5 Calculating Value 22
5 Capital Investment Portfolio Scorecard 26
5.1 What is a Scorecard? 26
5.2 How to Compare Portfolios 26
5.2.1 Scorecard Metrics and Ranking 27
5.2.2 Budget Allocations with Limited Capital 27

5.3 Updates and Rebalancing 27
5.4 Government Supply Chain Example 28
6 Conclusion 29

Abstract

Transformational government initiatives which require major capital investments or acquisitions are complex, difficult to measure, and challenging to articulate to decision-makers. Considering the complex dependencies and implementation risk of individual programs, risk-adjusted cost estimates for portfolios are often overstated. This paper examines how cost estimators and analysts measure portfolio value and generate stakeholder advocacy for major government initiatives, which require multiple acquisitions for implementation and agency policy changes to change behaviors and realize value.

1 Introduction

In many government agencies, large capital investments in information technology, infrastructure, and new technologies that offer new capabilities for multiple public stakeholders are designed not as stand-alone investments and acquisitions. Instead, they are part of a larger portfolio of programs that help government agencies achieve ambitious but distinct initiatives. Large agency initiatives often cannot be accomplished by a single stand-alone investment, and government agencies develop multiple programs and acquisitions, some sequential and some simultaneous, to achieve agency goals. Government budget offices struggle to decide in any given year in which capital portfolio they should invest as portfolios with multiple investments are complex, integrated, and valued separately. Further challenging government decision makers responsible for planning government goals and initiatives, limited annual capital budgets require agency budget offices to restrict capital spending to incremental program segments or phases to fit within budget constraints. The multiple program investments and segments add complexity to government capital investment portfolios and to the decisions that agencies must make in developing their annual spend plans. The success of critical and transformational government initiatives is dependent largely upon the ability of decision makers to choose the most strategic and valuable investment decisions each year within the constraints of an annual capital budget without adversely impacting future investments within a portfolio.

Managing programs and required initiatives within a portfolio is equally as challenging for agencies as managers must identify and address interdependencies, combined requirements, change management, and policy changes that are extraneous and difficult to coordinate and implement from different departments without a more strategic view and objective means of measurement and comparative valuation. With limited capital funds, agencies need to have the flexibility to adjust investment sequences, capabilities, and scope among interdependent programs required to achieve agency goals and capabilities. Without a better way to approach, measure, and adjust portfolios, agencies will make decisions without context and without understanding the impact of adjustments in investment decisions.

Many government agencies do not have a portfolio analysis solution to properly track, value, identify risk, and reassess portfolio investments at any given point in time. For transformational government initiatives which require multiple acquisitions for implementation, agency policy changes to change operational behaviors and ensure program adoption, and dynamic portfolio schedules to track the impact of interdependent programs, cost estimators and business case analysts need a process and objective system to measure portfolio value and generate stakeholder advocacy.

Despite the challenges to measure portfolio value and make strategic portfolio budgeting allocation decisions, cost estimators and business case analysts can develop comprehensive evaluation processes and objective strategies to dynamically measure portfolio value, identify investment challenges and portfolio shortfalls, and make more informed decisions to adjust stand-alone investment decisions and portfolios. These evaluation processes can help agencies meet strategic goals and achieve new initiatives on time and within cost.

To ensure agency decisionmakers and investment boards make prudent and strategic decisions for capital investments and their portfolios, governing bodies, analysts, and cost estimators can follow a defined portfolio analysis process to objectively evaluate mutually exclusive investments, minimize investment risk, and fund critical investment initiatives. By developing a portfolio scorecard, organizations can objectively decide between mutually exclusive investments along a time horizon using pre-defined finance metrics. In addition, cost estimators can use decision trees to identify and capture the right mix and sequence of capital investments, process changes, and agency policies that need to be implemented to realize value to the government. This approach prevents program compartmentalization, analyzing individual investments on a stand-alone basis instead of within a portfolio. Designing a portfolio implementation strategy with the flexibility to absorb individual program implementation challenges and government budget constraints is critical for the success of portfolio initiatives and to generate stakeholder advocacy. This paper will outline a methodology for portfolio measurement, design, and decision-making for government acquisitions.

2 Government Business Cases

2.1 Government Capital Investments, Return on Investment, & Program Portfolios

In many government agencies, large capital investments in information technology, infrastructure, new technologies, or new capabilities are designed not in stand-alone investments and acquisitions. Instead, they are part of a larger portfolio of programs that help government agencies achieve ambitious but distinct initiatives. The success of those initiatives is dependent largely upon the accuracy and success of the programs and portfolio design, measurement, cost estimation, cost/benefit analyses, interdependencies, dynamic scheduling, and account of risk.

In these government agencies, especially civilian agencies, capital investments are valued not only with attention to cost estimating and cost savings, but also with a cost-benefit analysis where program benefits to multiple stakeholders are quantified, monetized, and compared against the total program cost to establish a return on investment (ROI). These civilian agencies require a combined cost-benefit analysis using associated Finance metrics, like Net Present Value (NPV), payback, Internal Rate of Return (IRR), and Benefit/Cost (B/C) ratio, in order to justify the investment. Much like capital investments in the private sector, these government agencies devote special attention to the monetization of benefits, both the altruistic benefits to the public and the efficiency gains directly to the agency.

Stand-alone investments and acquisitions are tested against a value benchmark of NPV, IRR, and B/C to inform decision-makers when deciding whether or not or how much should be obligated to the investment. If a smaller amount would be obligated than requested, the program office must reduce program scope to fit within these bounds.

If stand-alone investments are insufficient to complete a full capability or achieve an agency initiative goal, the government must invest in either (1) multiple capital investments, programs, or acquisitions or (2) multiple segments or phases of a single investment. Often, the government, to both limit capital risk and to fit within a constrained annual capital budget, segments programs into smaller phases of a larger initiative. The agency does not lose sight of the larger goal, but it spreads out the investments into sequential or overlapping stand-alone investments to achieve a larger goal. This adds complexity and interdependencies between individual programs and challenges program managers and organization directors to both cross-functionally collaborate with their counterparts and measure the portfolio programs as an aggregate whole.

When measuring the portfolio value versus the value of each of the stand-alone segments and programs, agency directors and program managers must have a means of the following:

- Aggregating value and calculating portfolio cost and benefits
- Isolating risk from an individual program and then extrapolating that risk across a portfolio
- Escalating portfolio cost estimates to account for both
    - Cost growth due to schedule risk and interdependencies
    - Implementation challenges and cost growth for any one segment or stand-alone investment
- Reevaluating program return on investment at the portfolio level including
    - Discounts to benefits based on delays or scope changes of early investments
    - And benefits' upsides when realizing portfolio synergies of multiple investments and agency policy changes
    - Accurately identifying and adjusting portfolio value based on interdependencies
- Understanding and quantifying the impact of program funding decisions, including obligating more or less capital funds for an initiative or changing the timing of the investment life cycle

Government agencies are challenged not only by limited capital budgets, mutually exclusive capital projects, and multiple agency portfolio initiatives, but they need to better understand the impact of funding decisions at any given point in time on a single investment and the cascading effect on multiple dependent investments within a portfolio. Without a means of dynamically scoring and measuring a portfolio of programs, agency directors, boards, and program managers cannot make informed budgeting decisions or accurately account for the consequences of their decisions.

2.2 Measuring Value in Business Cases & Portfolios

2.2.1 Finance Metrics – Discounted Cash Flow (DCF) Analysis and Net Present Value (NPV)

In agencies conducting cost-benefit analyses, how is value quantified? Just like the build-up of an independent government cost estimate (IGCE), the agency calculates benefits value to the agency and stakeholders – (1) cost avoidance by implementing an infrastructure program that is more efficient than the legacy system it is replacing, (2) time savings provided by a new technology that enables users to do their jobs quicker, or (3) a new technology which provides quicker transportation and saves time for the general public and direct operating costs for service providers. All of these examples can be quantified and provide program value from which the analyst can offset investment costs.

Just like companies in the private sector, value incorporating both cost and benefits are measured according to popular Finance metrics, including NPV and IRR. A positive NPV or an IRR greater than the cost of capital means that, assuming unrestrained capital funding, the project provides value, and the agency should invest in that project.

When calculating value, both benefits and costs are discounted in order to represent present value (PV) of the investment. PV uses a specific discount rate, the long-term government bond rate in government agencies or the company or project cost of capital in the private sector to discount nominal or real dollar benefits and costs. PV discounts for inflation, incorporates the time value of money, and accounts for the opportunity cost of capital.

In total, value for many civil agency capital investments accounts for both program benefits and costs. Both benefits and costs are discounted and risk-adjusted to calculate a project NPV to inform the agency whether or not the investment has economic value. While project value calculated via discounted cost and benefits accounts for investment risks, the program upside opportunities, integration with other capital investments, and portfolio impact are not captured.

2.2.2 Challenges of Using NPV and other Finance Metrics for Government Acquisitions, Projects, and Portfolios

When evaluating major capital investments or acquisitions, agencies pay special attention to risk. Not only are agencies concerned about the risks associated with implementation, but when conducting investment analysis, risks of cost overruns and unrealized benefits take precedence. Management champion any valuation method that allows them to mitigate these risks, and government agencies develop processes to ensure accuracy and to minimize surprises.

Both cost estimates and quantified benefits are risk-adjusted and discounted to account for downside program risk. Analysts risk-adjust cost estimates to account for uncertainty factors which might drive project costs up. While risk ranges for cost WBS elements represent the uncertainty of both cost increases and decreases, the risk-adjusted cost almost always exceeds that of a point estimate. Similarly, analysts calculate risk-adjusted benefits to account for factors that may prohibit all potential benefits from being realized. As a result, mostly downside risk is captured for both benefits and costs.

To apply risk in business cases, the government agencies apply risk range conditions when calculating valuation metrics. To better inform decision-makers about the financial impact of project risk, instead of just calculating a point estimate, analysts risk-adjust benefits and costs using Monte Carlo Simulations. After running risk, the government applies the most conservative Monte Carlo risk ranges, the 80th percentile of costs and the 20th percentile of benefits. By applying these conservative values, the government assures a high probability of not exceeding the 80th percentile cost estimate and a low probability of achieving fewer benefits than what was quantified at the 20th percentile.

Since it is difficult to measure uncertainty when quantifying costs and benefits, government civilian agencies endorse this conservative risk-adjustment approach to reassure government decision-makers that the business case will deliver the value that it proposes. It essentially takes a pessimistic view versus the base case valuation of the capital investment and lowers the bar of performance in the rare event where a business case will realize a higher cost as well as lower benefits. Despite this approach, public sector business cases sometimes still breach baselines and have cost overruns, but this is partly attributable to the complexity and scope of major federal government acquisitions and the proprietary nature of the business cases.

When measuring value of program portfolios, analysts cannot simply aggregate the risk-adjusted costs and benefits of each stand-alone investment of which the portfolio is comprised. Instead, the portfolio must be examined and valued based on a sequence and likelihood of investment success, and analysts must apply probability, risk, and the impact of different sequences of investments on overall portfolio value. This can be best accomplished by introducing decision trees into the portfolio valuation methodology. If a portfolio requires five acquisitions to complete a government initiative and the second investment is completed out of sequence, program capabilities and value of investments three and four may be delayed due to a dependency on the delayed second investment. These types of adjustments must be considered when evaluating government portfolios.

In addition to downside risk adjustments to programs and portfolios, current valuation practices often discount or disregard potential upside risk, risk where under certain conditions, benefits might exceed the initial point estimate. In a portfolio of programs, upside risk might be overlooked all together. Specific upside value for which traditional NPV and ROI analyses do not consider for program portfolios include the following:

1) Traditional analyses can overlook upside risk where one investment might inform another allowing program managers to adjust requirements and cost allocations and realize additional value. This reinforces why program portfolios and their costs and benefits are not static. Over a period of months, portfolio value can change significantly.
2) Traditional portfolio analyses do not consider major changes in portfolio programs. In situations where initial investments determine subsequent investments would not be successful or would be obsolete, managers may opt to eliminate individual investments all together, reducing the total portfolio cost estimate and portfolio capabilities.

Although these risks are not captured in traditional government cost-benefit analyses, the application of decision trees allows managers to explore these upside opportunities.

2.2.3 Portfolios - Why We Need a New Way to Measure Value in Government Acquisitions

For both public and private sector capital investments, finance professionals measure value by estimating project cost and revenue (or cash flow), applying risk, and discounting the investments by the cost of capital. This is the best capital budgeting methodology for stand-alone projects. However, most government capital investments and acquisitions are not stand-alone investments. For each investment decision, there are subsequent investments that contain interdependencies with the initial investment, or which impact the same strategic portfolio. As a result, changes to the scope, implementation, or schedule of the initial investment will have a cascading effect to on future investment segments and on other dependent stand-alone investments. With government initiatives comprised of multiple investments and program segments, investment success is not restricted to the development and deployment success of an individual investment. Instead, government agency decision-makers must account for the aggregated value of portfolios and the ever-changing dynamic of individual investments that make up that portfolio.

2.2.3.1 Undervaluing Investments

When government agencies estimate the value of an investment, they assume that programs will realize the benefits that were estimated during investment analysis. The degree to which these benefits are realized is tempered by risk factors and measured by running Monte Carlo simulations on the costs and benefits. Assuming all project benefits are realized, and the program is a success, did the agency account for all of the program benefits and impacts?

Are there additional benefits that the program might enable if successful? Is this specific acquisition a "platform investment" for subsequent acquisitions and capital investments? Would these follow-on investments be achievable without the first investment's deployment success? If incremental future value is dependent upon a specific government capital investment or acquisition to enable value from follow-on investments or a series of investments, discounted cash flow (DCF) analysis and project NPV alone do not capture that value. Essentially, the agency would be leaving value on the table by not accounting for the incremental value of enabling follow-on investments.

In addition, when considering between mutually exclusive investments, where with limited capital resources, the agency must decide between two investments because it cannot afford both, not accounting for this incremental enabling value might artificially discount or impair the total value of an acquisition. Without accounting for this additional subsequent value, agencies might mistakenly fund a less valuable investment.

2.2.3.2 Value to the Portfolio

While some government acquisitions might enable value for subsequent investments, almost all acquisitions have a portfolio impact. By simply calculating present value benefits and costs, agencies do not account for the portfolio impact of a single investment or a series of investments. Using DCF analysis and NPV, analysts can accurately measure value of a stand-alone investment. However, this approach does not accurately account for upside opportunity or the aggregate impact on portfolio value.

Related programs within a portfolio often have interdependencies. Software interfaces between programs must be developed within a specific timeframe, or deployment could be delayed and benefits unrealized. If one program is dependent upon the success of another prior to deployment, a reduction in scope of the initial investment could result in additional costs for subsequent investments. Even investment sequence can determine portfolio value and upside. Investments out of sequence can impair the upside value of a portfolio and delay an agency's strategic objectives.

2.2.3.3 Challenges to Managing Separate Programs in a Portfolio and the Impact of Portfolio Budget Decisions

How government acquisitions are managed, defined, and integrated drives investment value and can complicate aggregating programs into larger portfolios. In many government agencies, a program manager is assigned to a specific investment and, perhaps, to the follow-up segments of that initial investment. Individual program managers may or may not remain in charge of an acquisition leadership through its definition, scope development, investment analysis, and implementation, and the lack of continuity adds risk to implementation success and continued integration with dependent concurrent and subsequent investments in the same portfolio.

In addition to potential changes in immediate business case leadership, programs within the same portfolio are sometimes led from different organizations within a government agency. In the example of a government supply chain transformation initiative, explored later in this paper, a logistics and supply chain portfolio might have a maintenance acquisition led from within the technical operations organization. The logistics ERP acquisition might be led out of a separate logistics group or sponsored by the logistics organization and led from a completely separate program management organization (PMO). At the same time, technical refreshes of a configuration management system, upon which both the maintenance and logistics systems are dependent, could be led from a different department in the PMO. If these three different organizations, program managers, and department heads do not plan the development and deployment of the initiative and individual programs at a portfolio level, the agency risks inefficient implementation, redundant capabilities and rework, and significant delays to achieving agency goals and stakeholder benefits. Budget offices deciding to which programs they will allocate annual funding need to account for the individual program dependencies within portfolios and their timelines to prevent disrupting program deployment at a portfolio level.

Another primary restriction on program implementation and portfolio execution derives from funding constraints and annual budgets. If budgeting offices restrict capital spending based on government funding allocations and cannot fund each initiative to its full capacity, agency organizations must segment or phase individual investments, acquisitions, and capital projects based on smaller-scope capabilities. Managing portfolios of not only separate programs in different organizations, but programs with multiple segments, complicates portfolio analysis, capital budgeting decisions, and budget allocations. Furthermore, programs developed at a segment level may lose both (1) the original intended capabilities of the fully funded program and (2) the time-phased integration with other dependent programs within the same portfolio. If new segments are not planned with sufficient context and deployment requirements to match sister programs within the same portfolio, individual segments could be approved without achieving their intended capabilities.

Budgeting offices must be conscious of the fact that a budget delay for a specific program segment or phase could have a cascading effect on an entire portfolio, and subsequent programs dependent on that initial segment could be further delayed in a non-linear fashion as a result. Without an objective means of tracking and mapping program portfolios for decision-makers and objectively scoring separate investments and portfolios, budget managers may not realize the impact of their funding decisions until it is too late to change course and make up for lost time.

3 A Roadmap for Measuring Portfolio Value

3.1 Identify Prioritized Initiatives

The first step in developing a program portfolio is defining its scope. What are the strategic initiatives of the organization and overall mission or capability that the government agency wants to achieve? Once the organization identifies what it wants to accomplish and the end-state capabilities it wishes to achieve, the agency can develop a pathway and the individual steps it takes to get there. This strategic process follows a top-down approach from a capability-centric organization. For sustainment of existing capabilities and infrastructure initiatives devised as a means of avoiding legacy obsolescence, agencies can still take this top-down approach of identifying the end-state or goal first. If an organization does not know where it is going, it cannot devise a prudent business plan to achieve those ill-defined goals.

Ultimately, the agency will compare the current state and insufficiency of legacy systems and capabilities with an overall goal or initiative. Once the goal is defined, the agency can go one step further, just as it does for individual investments, acquisitions, and capital investments. It should list the requirements and characteristics of that end state, so those deciding on the required investments, acquisitions, policies, procedures, and change management required to achieve that state understand how to assemble the contents of the capital investment portfolio and the dependencies between the stand-alone investments.

3.2 Determine Intended Outcomes and Shortfalls Solved

Looking backward from the intended capability or initiative end-state, portfolio managers and agency decision-makers list and compare both the intended outcomes and the current shortfalls preventing the agency from achieving those outcomes today. What does the intended initiative accomplish? Who are the beneficiaries of these capabilities and how will they be impacted? What characteristics does this system or major initiative provide? How complex is the implementation or adoption of this capability compared to the current means of operations today?

Managers might observe that current operations are constrained by the systems and capabilities of their software and hardware infrastructure. Therefore, the processes they adopted, which are constrained by technology, must also change in order for implementation of the new capability to be successful. Very quickly, agency decision boards and management will begin to realize the full scope of an initiative or agency goal, the process changes that must accompany the investments, and the required investment in human capital and change management to ensure success. Much like private industry, major changes require planning, multiple investments, and infrastructure development in advance of implementation to fully achieve intended goals. Capital budget allocation restrictions can damper progress in achieving goals, and the right allocation of limited resources at the right time is critical to achieve tangible capabilities and progress. This allocation and the critical considerations of system design, comprehensive changes, and end-state capability are the crux of portfolio analysis.

Examining the agency shortfall at a strategic level allows decision makers to better understand how far from a goal an organization currently is. Just like shortfalls developed for individual investments to define need, requirements, and end-state capabilities, portfolio shortfalls provide the same strategic awareness needed to plan, budget, and organize an investment portfolio. Like individual investments, agencies should not expect initiative capabilities to completely solve shortfalls; instead, decision boards must decide between capability trade-offs and decide what portion of shortfalls can be solved and what capabilities the agency (1) must have, (2) requires eventually to achieve other agency goals, and (3) those which are nice to have but not required for success. The trade-offs decision makers identify now will be utilized as decision criteria and portfolio ranking characteristics in an annual "budgeting-decision scorecard".

Now that managers have (1) established agency initiative and capabilities scope, (2) compared initiatives versus the current-state capabilities, and (3) examined shortfalls and some of the required steps to solve those shortfalls, management teams will need to focus on a means of getting there.

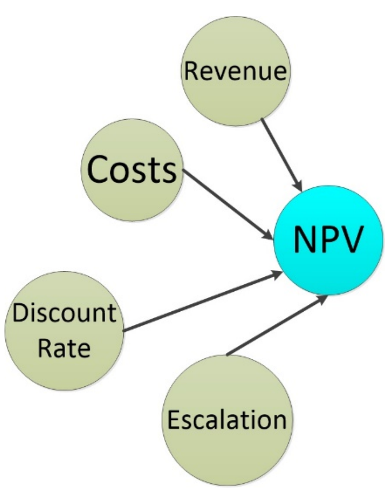
3.3 Initiative-Level Influence Diagrams

As an efficient means of understanding end-state requirements, drivers, and component parts used in capital investments for private industry (especially in the Energy and Technology industries), senior management and investment appraisal organizations utilize influence diagrams to map out the steps required to achieve an end-state. Financial managers use influence diagrams to identify the drivers of value. Engineers use influence diagrams to determine design requirements and components. Strategic decision-makers use influence diagrams to assemble investment portfolios, making sure not to neglect or omit any required dependencies to achieve an end goal.

Government agencies must decide what changes must take place in each organization to achieve defined end-state goals. Agencies deciding on the contents, design requirements, change management, policy, and processes required to achieve portfolio initiatives can efficiently use influence diagrams as a first means of defining a portfolio. And, just like the top-down initiative development defined in section 3.1 to identify prioritized portfolio initiatives, influence diagrams start at the end-state capability and work backward one step at a time.

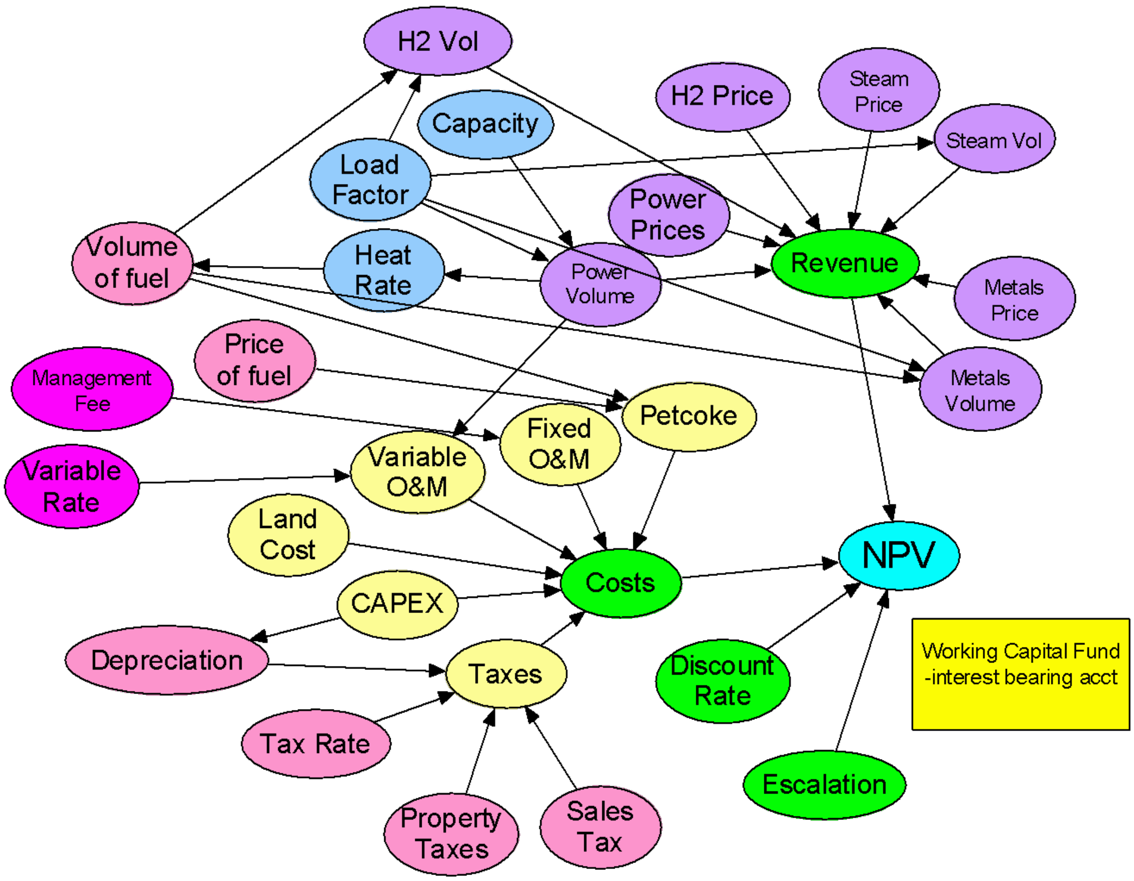
Before defining the use of influence diagrams in portfolio analysis, it is critical to define how influence diagrams are used to identify and break down, step-by-step investment value for individual capital investments, potentially the same kind of investments included in a portfolio.

Figure 1: First Step of Influence Diagram



In the Energy Industry in business case economics, influence diagrams are developed to trace back investment value to each value input through a visual flow diagram. To develop an influence diagram in the Energy Industry, an investment starts with total investment value or project NPV as shown in Figure 1. Then, NPV is broken down into revenue, costs, discount rate, and escalation. For government business cases, business cases substitute benefits for revenue. As each component of the diagram is broken down further, the individual driver of value becomes more detailed or specific. Influence diagrams are best constructed as a brainstorming exercise with all team members contributing, so stakeholders are heard, and value drivers identified (See Figure 2 – Influence Diagram).

Figure 2: Influence Diagram – Energy Example

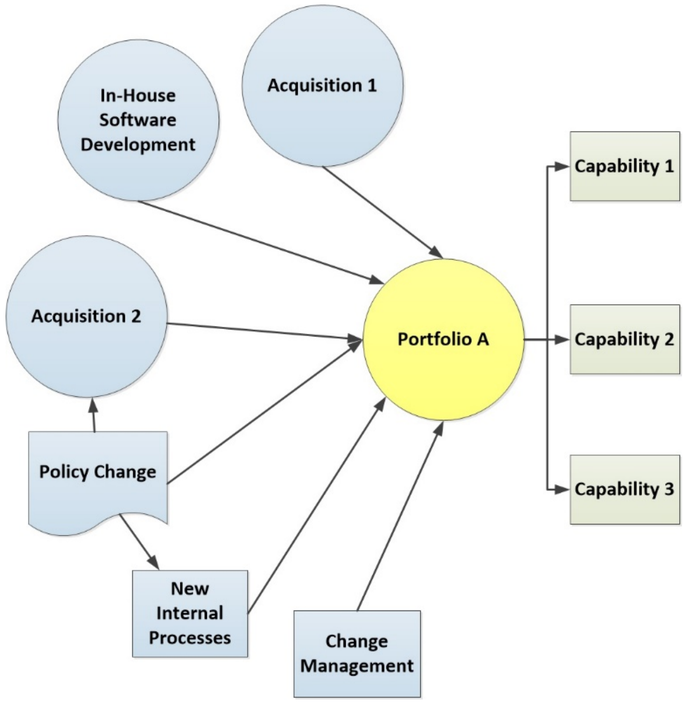


Each layer in the influence diagram, starting from the end state goal is represented on the same level by a common color. Once all major inputs to the first layer are defined, the analyst draws another layer of factors influencing each component of the first level of inputs. Each of the inputs, characteristics, or requirements is broken down layer after layer until primary assumptions or inputs is attained. To better distinguish each layer of inputs, individual levels are color-coded the same color. Influence diagrams are both a planning and design tool to make sure decision makers, analysts, and business case evaluators can identify and account for primary value drivers.

In portfolio analysis, agencies can use influence diagrams to identify the major components of a portfolio end-state. Those major components include the following:

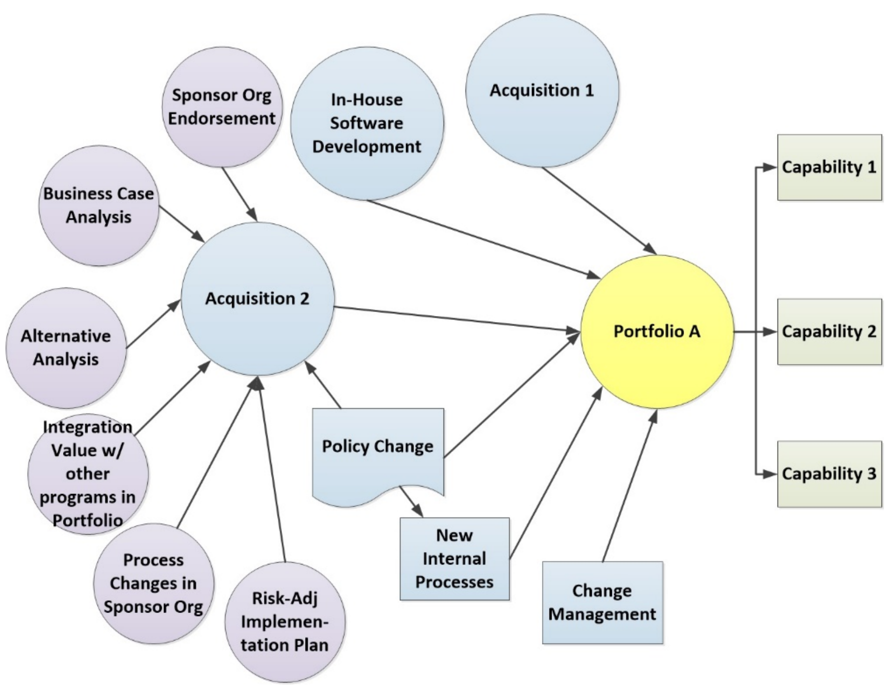
- Major in-house developed capital investments
- Acquisitions or third-party capital investments
- Policy Decisions required to achieve capabilities or initiatives
- Change management for the workforce to adopt new processes and procedures to ensure portfolio success
- System integration and interfaces required to communicate legacy systems and processes with newly adopted ones

Figure 3: Influence Diagram – Portfolio Analysis – 1st Level



The blue first level components in the Figure 3 diagram depict the major decisions and contents of a portfolio and how an influence diagram helps decision makers develop a comprehensive view of value drivers and investments that must be tracked to achieve agency initiatives. In this diagram, the portfolio first level consists of multiple program acquisitions, agency in-house software development, new processes to enable the full capability of the consumer-off-the-shelf (COTS) acquisitions, policy changes to facilitate the processes and enforce compliance with new COTS practices, and change management incentives to ensure adoption of a new business model for the portfolio capabilities. Some of the level-one components influence each other as well, and these interdependent relationships start the foundation of a portfolio, which, together, enable end-state capabilities and agency initiatives.

Figure 4: Influence Diagram – Portfolio Analysis – 2nd Level



Analysts and budget organizations will develop second level components while conducting portfolio management to determine the major contributing factors for success of individual acquisitions, policies, processes, internal development, and management strategies that make up the contents of the portfolio. Looking at one of the portfolio acquisitions, the major influence components could include (1) getting advocacy or endorsement from the sponsor organization, (2) the development of a full business case cost-benefit analysis, (3) a compelling and completed down-selection to a preferred alternative in the alternative analysis, (4) integration value with other dependent programs, organizations, and legacy systems to effectively roll out the acquisition and realize integrated value, (5) process changes within the sponsor organization to realize value of the COTS acquisition and to adopt the most streamlined efficient steps to execute new capabilities, and (6) the development of an implementation plan that accounts for program and portfolio risks. The budget organization or decision board would then develop similar second level influence diagram components for each of the first level programs, processes, and policies in the portfolio.

3.4 Engage & Collaborate with Portfolio Stakeholders

During the development of influence diagrams, portfolio managers and analysts should identify all agency stakeholders required to achieve the end-state system. Acquisitions might originate from different organizations. Policy decisions and change management efforts have to be coordinated within their respective departments, and these changes must be adopted in coordination with the program implementations to enable value. Without advocacy, program portfolios can encounter resistance, timeline setbacks, and roadblocks to adoption. As later defined by portfolio decision trees, a single program or policy roadblock can seriously inhibit portfolio value. By identifying stakeholders and critical agency decisions during portfolio design, stakeholders can become part of the solution, not just an informed party during program development.

3.5 Align Program Schedules with Portfolio Initiatives

In the same context of multiple stakeholders, capital investments, policy decisions, and coordinated adoption efforts, program and agency initiative schedules must be developed at the portfolio level. To enable the value of each subsequent investment in a portfolio, the timelines of interdependent programs and policies must be aligned, and any schedule slip in one program would have a cascading effect across the entire portfolio.

When one or more programs in a portfolio falls behind schedule, budgeting offices with annually constrained capital funds must track portfolio schedule timelines and portfolio impacts to decide in which programs and portfolios to invest. Then, they can reallocate funds to other programs which may more effectively use the capital.

Dependent relationships between programs, policies, and initiatives should be clearly articulated in influence diagrams, so analysts can develop investment sequences against a timeline and measure the impacts of alternative investment options.

3.6 Portfolio-Level Influence Diagrams

At the portfolio level, influence diagrams help management better understand all of the investments, activities, initiatives, policies, and processes that need to be implemented in concert with one another to enable an end-state capability. By developing a time-phased influence diagram to the third or fourth level from the end-state, managers can determine which activities have co-dependencies, which need to be developed in parallel, and which activities should be delayed after the initial investment.

3.6.1 Change Management and Policy Changes for Portfolio Integration

Capital investments and acquisitions alone do not assure implementation success of government initiatives and capabilities. In order to generate stakeholder buy-in, user product adoption, and process changes to enable the full value of an initiative, agencies must consider what parallel activities are required to ensure success. Those other activities to be considered in program portfolios include policy changes since some existing policies may have been written to the legacy system constraints. New systems from an acquired COTS product may have more capabilities, and constrained policies should be revised. To ensure adoption from users, agencies need to plan for change management initiatives, where current and future users can understand how a new system will improve their processes, save time, and increase and improve their responsibilities. In the Supply Chain use case in this paper, the impact of change management policies will play a major role in portfolio success. Activities such as including demos for users in the field, instituting a proof of concept and gathering feedback from users, and documenting the current system processes and using Value Stream Analysis to identify new processes and which legacy steps can be eliminated can facilitate the adoption of initiatives and prevent delay. By mapping out all of these activities and processes in a portfolio level influence diagram, program offices and portfolio management can better understand a complete list of required activities and plan accordingly.

3.6.2 Introducing & Integrating New Processes and Capabilities

When implementing new systems and redesigning legacy capabilities, often agencies have to implement new processes to realize the full value of acquisitions and capability upgrades. Management must consider process changes that best match the new tools and not carry over inefficient legacy processes just because that is what they do now, retaining the same processes is easier, or users may be hesitant to adopt a new way of doing business. Capturing in influence diagrams required process changes for each phase of a portfolio will allow portfolio managers to better time-phase investments and understand the complexities of program portfolios.

3.6.3 Bigger Picture Integration

From a program management perspective, complex agency capital investments with multiple dependencies or those which require significant changes to existing processes often take longer to implement than planned. Many factors are outside of the program manager’s control, and cost analysts must risk adjust acquisitions and capital programs to account for many “unknown-unknown” risks. Project portfolios add more complexity with dependencies between programs, processes, databases, shared software. A delay in one program can delay the capability of another, so timing between investments is critical for portfolio management. If the portfolio budgeting office believes a dependent investment will be delayed, it might choose to fund another portfolio more in the short-term, allowing for dependent investments to “catch up” with one another.

3.7 Portfolio Schedule

These dependent investments and coordination between dependent programs within a portfolio make portfolio scheduling even more critical. While individual stand-alone investments have detailed implementation schedules to which program managers plan, portfolio managers and analysts must develop a portfolio-level schedule with portfolio dependencies – each required program, process change, policy, and change management consideration. To better plan for budget allocations for each portfolio and to meet their annual capital dollar (Facilities & Equipment) needs, agencies have to develop dynamic and integrated portfolio-level schedules that change as investment timelines adjust in investment analysis and in implementation. Over time, budget needs for each portfolio will change each year, and portfolio managers and budget offices can adjust capital fund allocations depending on a need-based timeline. In the case of constrained capital, where not all portfolios will be funded, a portfolio timeline might indicate a significant change in economic value compared to the portfolio baseline at conception.

3.8 Investment Sequence & Timelines & Using Decision Trees to Map Portfolio Decisions

In addition to a dynamic and integrated portfolio-level schedule, portfolio managers and each of the program managers whose programs are within the portfolio should draw out a detailed list of sequential investments, segments, and dependent policies and process changes. After planning out the investments along a timeline, portfolio managers can create a "decision tree" that indicates a primary "best value" sequence and alternative next-best sequences. To quantify the value of these sequences or "branches," cost analysts can add value and probability. Section 4 will define how to draw decision trees and quantify portfolio value.

4 Calculating Portfolio Value – Aggregate Cost & Benefits Estimates

To best approach portfolio analysis, analysts need to first establish a methodology for estimating capital project value as defined in Section 2 of this paper. Capital investments, acquisitions, and infrastructure programs all require up-front capital funding, have a total program cost, and can attribute a total dollar program benefit. For government investments, benefits are measured as incremental value from the investment which benefit the agency, users, the public, and other stakeholders. For instance, for a major Federal Aviation Administration (FAA) investment which by the user of modern radar technology allows air traffic control to reduce aircraft separation, while retaining current safety standards, the benefits might be an increased number of aircraft landing per hour at major airports, resulting in monetizable benefits for the FAA (reduced manual air traffic radio communication per flight), airlines (reduced number of aircraft delays and an increase in number of flights during high-revenue flight times), and the flying public (reduction in time spent in flight, measured as passenger value of time). In private industry, capital investment benefits would equate to incremental revenue. A company would value the additional revenue it could earn from a capital project and weigh that against the incremental cost.

For capital projects, civilian government agencies conduct cost-benefit analyses, calculating and monetizing both cost and benefits. This quantification can be extended to portfolios, but due to the interrelationships, dependencies, risks, funding, and sequential investments in portfolios, portfolio value is more complex than simply calculating individual project values and adding them for the whole portfolio. In addition to the complexities between multiple investments in a single portfolio, portfolio requirements for policy decisions, change management, and new process changes needed to achieve end-state capabilities can also impact monetized portfolio value. These additional portfolio components can add an either positive or negative factor to the value of an aggregated portfolio of investments.

One way to capture the complex and intricate interrelationships and sequence of investments and policies is to use decision tree analysis at a portfolio level to quantify value. Decision trees allow for dynamic changes to assumptions and investments over time to impact portfolio value and help analysts and management make informed portfolio decisions.

4.1 Decision Tree Analysis

4.1.1 What Are Decision Trees?

Decision trees are a means of mapping potential investment decisions and uncertain outcomes by:

1) Determining multiple investment decision paths to achieve (or not achieve) a program or portfolio capability with the top "branch" assigned as the most efficient and value-added path to achieve an end state
2) And applying probabilities and monetized value (cost and benefits) of each decision point, which when aggregated (multiplied through the entire probability series or "branch") sum to 100%.

Throughout this section, this paper will provide examples of decision trees and their application in both individual program business cases and in program portfolios.

Over the last two decades, decision tree analysis (DTA) has been used in private industry to measure probability-weighted investment value, especially when applied to a series of sequential and dependent investments, like exploring an oil field and drilling a series of wells. Successfully discovering oil reserves in the first well provides "option value" for the drilling company to continue drilling subsequent wells with a high probability of successful yields. The decision to drill subsequent wells is largely dependent on the outcome of the first one.

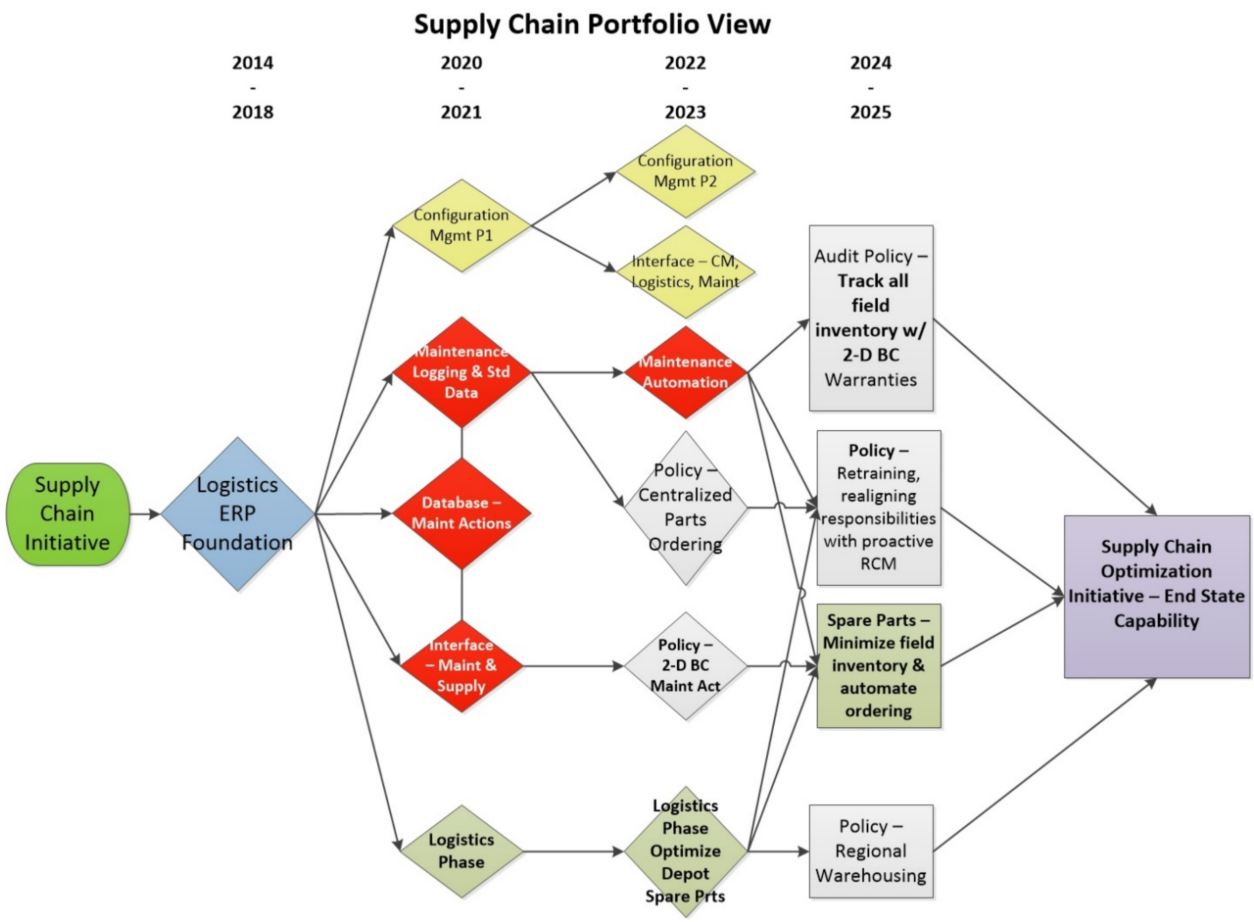
For government agency portfolios, decision trees allow managers to map out on a timeline each sequential, parallel, and dependent investment, policy, and major change and then apply the natural sequence of those investments to different probability-weighted outcomes. In a capital environment of limited F&E funds for which an agency might spend each year, the portfolio program sequence and likelihood of success is constrained, and the "branch" highlighting the affordable sequence of investments might deviate from the optimum sequence.

4.1.2 How to Apply Decision Trees to Series of Investments

In the first step of developing a portfolio-level decision tree, the analyst must map out along a timeline the preferred or optimum path of sequential and parallel capital investments, policies, process changes, and internal operational changes. For a starting point, the portfolio team can either choose the point at which a board or group of stakeholders defined an initiative, or they can identify the first major proposal or investment which initiated the portfolio.

In Figure 5's Government Supply Chain example, the initiative is listed first, and the approximate date of that initiative is correlated along a timeline along the x-axis. Then, a foundational enterprise resource planning tool capital investment is the next major step in the portfolio as the foundational investment for change. In this example, the logistics ERP investment enables the agency to invest in subsequent dependent investments and strategic policy changes and initiatives, including (1) an investment in an updated configuration management tool (in yellow), (2) an investment in a maintenance logging system, maintenance action recording database, and interface between maintenance and supply (in red), and (3) an incremental phase of the logistics ERP system (in green). All three of those major components, some of which have multiple sub-components, occur in parallel, and it is optional as to whether or not the agency will constrain capital and choose whether or not to invest in all three parallel activities. However, this is the optimum path for achieving the portfolio initiative end-state capability in the most efficient manner possible – lowest cost and highest benefit. The branches extend in parallel to another layer of investments and policies along this optimum path with policies indicated in a gray color to distinguish between policy decisions which are not capital-intensive and colored investments, which require major capital commitments from the agency along the defined fiscal year.

Figure 5: Supply Chain Portfolio Decision Tree – Primary Path or "Branch"



It is easy to see that this portfolio decision tree is much more complex than a decision tree path for an individual investment or segmented investment. One branch of an individual program decision tree would list a list of sequential decisions. In Figure 5's portfolio example, multiple sequential and parallel decisions are made at the same time, and many variations of that optimum course could be chosen, resulting in significantly different portfolio value. Figure 5 represents one potential path for the portfolio. If there are budget constraints, and the given preferred path is unaffordable, or if the agency chooses to prioritize a different program portfolio and defers some of the investments in this supply chain portfolio, the portfolio team would have to draw a different decision tree scenario and recalculate its value.

4.1.3 Additional Branches

When building out a decision tree for a program portfolio, the portfolio stakeholders must collaborate and determine optional high-probability investment scenarios for which the government agency might choose to invest. These decisions have to be made in context of a limited annual capital budget, obligation commitments which the agency has made for future years, and risk-adjusted allocations for unforeseen capital needs which might take precedence over discretionary spending. Using these constraints and considerations, the portfolio team can arrive at least two to three additional funding scenarios for each of the portfolio member investments, policies, initiatives, and procedures. Portfolio stakeholders would also have awareness about the advocacy within their own organizations and could determine if a policy change might be met with resistance, and, as a result, the policy might be postponed, and the subsequent portfolio investments delayed. Each potential option for a group of investment decisions should have an associated probability, and cost estimators and analysts can calculate the incremental cost and benefit of each subsequent portfolio-weighted decision. Figure 6 provides an expanded picture of the Supply Chain Portfolio with three major portfolio decision scenarios. All three of the scenarios add to 100%. Analysts could choose additional scenarios, but at some point, complexity simply adds confusion and discourages adoption of portfolio analysis.

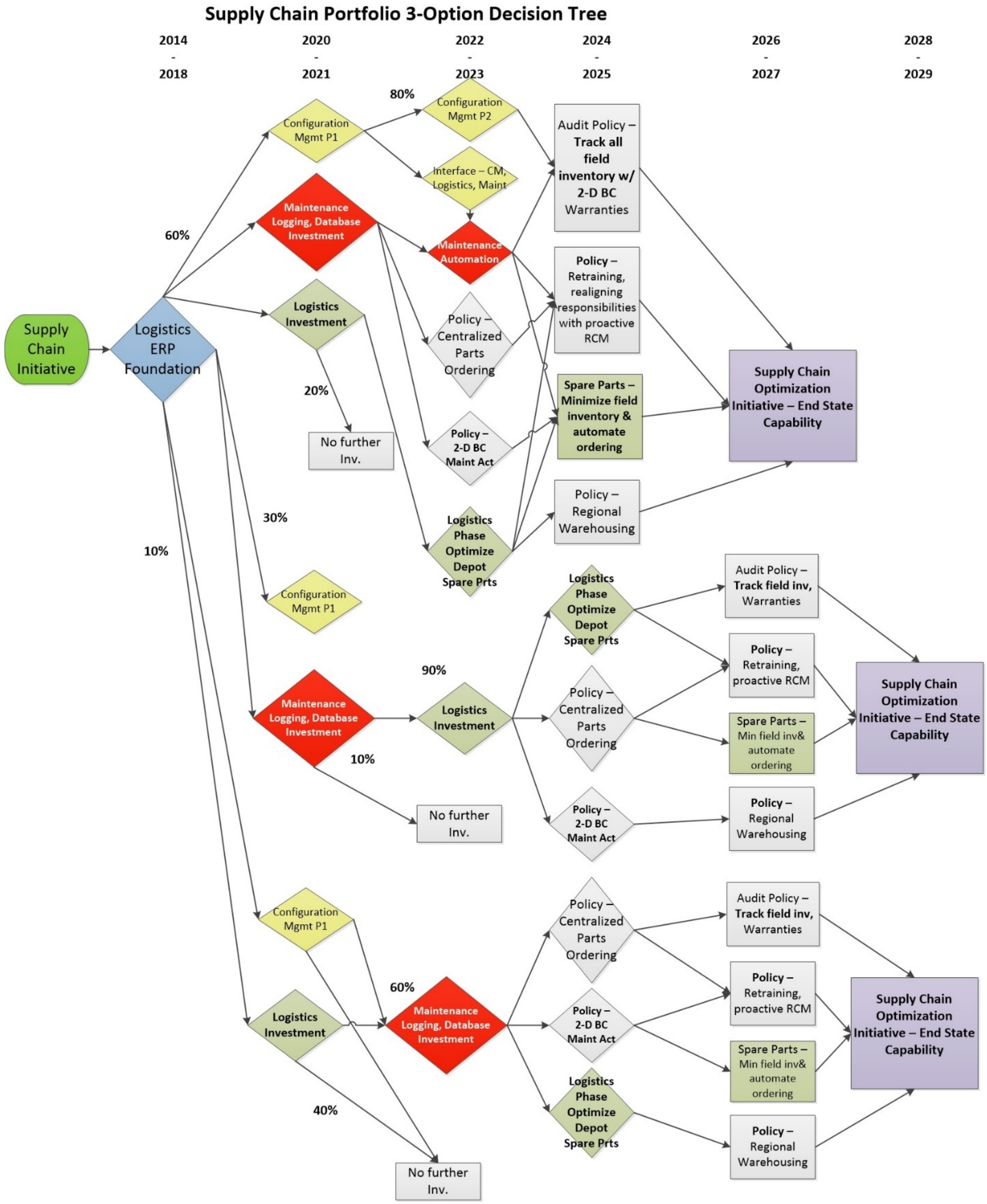
The first major “portfolio branch” in Figure 6 replicates the entire diagram of Figure 5. This first branch includes all the major decisions of the portfolio and the optimum investment path for achieving the portfolio capability or end-state. Considering potential funding constraints, other agency portfolio priorities, the probability of stakeholder advocacy for these investment decisions, and any number of unlisted individual program risks, stakeholders might arrive at a probability of executing the initial investment step in the 2020 and 2021 fiscal years for the optimum portfolio branch of 60%. This is a subjective measure of likelihood and can be adjusted as stakeholders, the portfolio team, and budget office learn more, but it is needed for capital budget planning purposes.

The second major “portfolio branch” in Figure 6 excludes the follow-on logistics investment in the 2020 – 2021 fiscal years as that investment shifts to the 2022 – 2023 timeframe. Since all three major investments in configuration management, maintenance, and logistics must happen prior to the next tier of investment decisions, in this scenario, the entire portfolio would shift outward. Full capability would not be achieved until 2028 – 2029, a loss of two years. Upon seeing this potential consequence, agency leadership who would want to achieve the portfolio end-state sooner might reprioritize the investment portfolio to incorporate the logistics investment in the 2020 – 2021 timeframe to avoid a slip. In the diagram, the portfolio team attributed a 30% probability of this scenario.

The third major “portfolio branch” in Figure 6 includes the second logistics investment and the configuration management investment in 2020 – 2021, but it postpones investment in the maintenance investment due to some measured agency risk. The portfolio team only attributed a 10% probability to this scenario, and the consequence is similar to the second scenario, shifting out the end-state capability by two years.

For the next set of decisions, for simplicity’s sake, Figure 6 only includes probabilities associated with choosing or not choosing to fund the previously delayed investment. And, the assumption is that if the agency chooses not to fund the delayed single investment a second time, it would conclude the portfolio at that point and not achieve full end-state capability. For cost estimators, overall cost of this “no further investment” branch endpoint would be significantly less than the full portfolio investment, and the benefit value would also significantly decrease as well.

Figure 6: Supply Chain Portfolio 3-Option Decision Tree



4.1.4 Recalibrating Trees, Schedules, and Portfolio Value at Decision Points

Figure 6 is a snapshot in time. Each decision tree can be modified or redrawn as an individual investment decision is approved, delayed, or encounters challenges and requires schedule adjustments. Each change to individual investments will have a cascading impact on the entire portfolio, impacting other dependent program schedules and potentially modifying the subsequent sequence of investments within the portfolio. At the prospect of any new strategic information or direction, the portfolio team has to re-plan the portfolio, the decision tree scenarios, and the potential dependent outcomes and recalculate portfolio value.

Using decision trees is one methodology for calculating any possible scenario for portfolio value. For government budgeting purposes, however, agencies may choose to plan budgets around one potential scenario or decision tree branch. They may choose to plan toward the optimum funding path for a portfolio, which would result in the highest value and earliest schedule to achieve the initiative. Given a constrained budget, the agency may choose a more conservative decision tree branch, which would be easier to achieve and may free up annual capital for other portfolios, especially if those other portfolios have a higher value proposition or are strategically more important to the agency. Choosing one specific investment scenario to which the agency budgeting office can commit fiscal year capital dollars is critical for planning purposes. However, the agency has to be flexible to rebalance portfolio allocations in the event that a primary scenario cannot be achieved and after new, updated decision trees have been developed. Budget offices can best execute portfolio planning if they can reallocate funding and reassess funding profiles at least once a year. If one portfolio slips too far, and value erodes, the agency may choose to forward fund another portfolio instead.

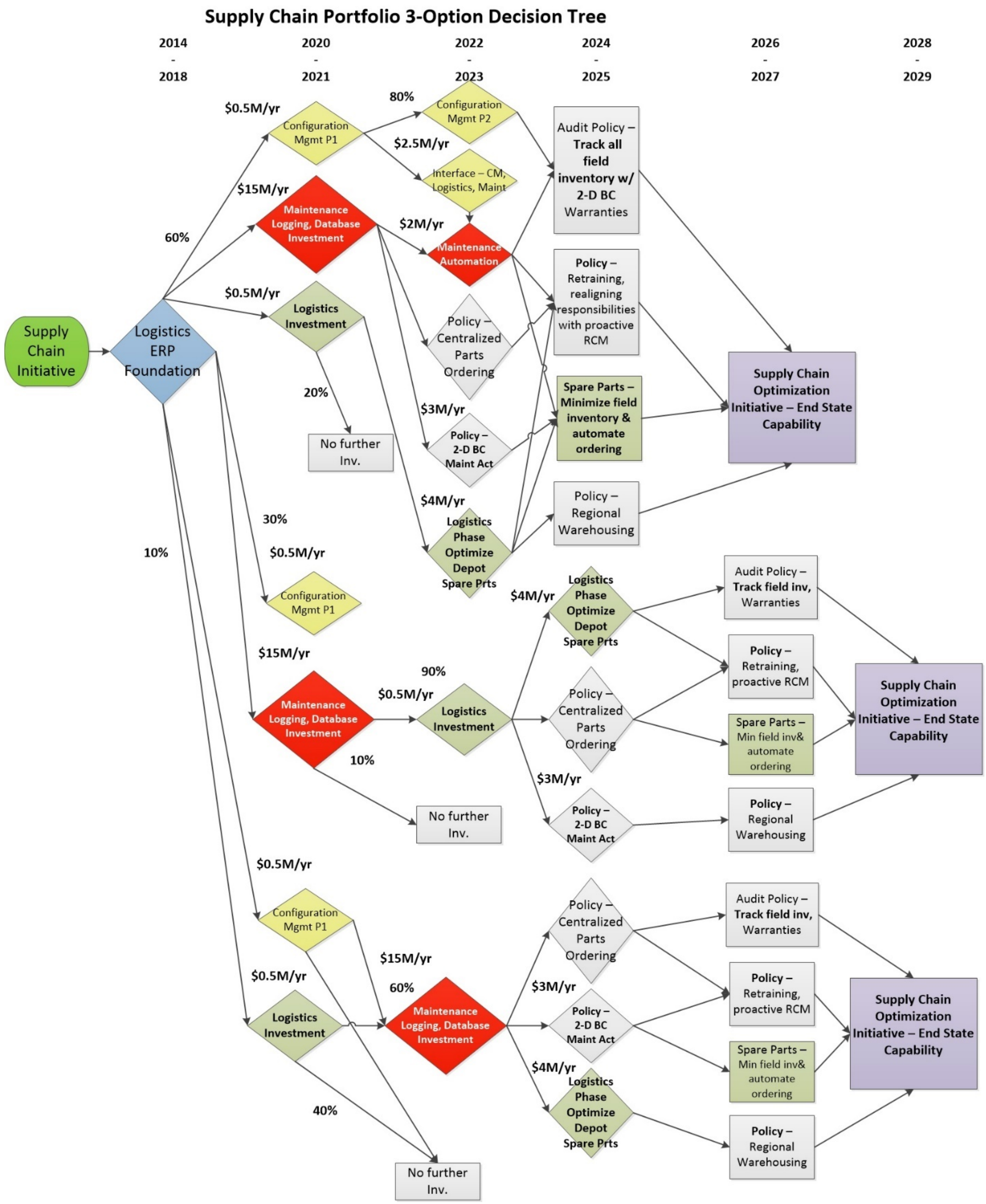
4.1.5 Calculating Value

To calculate portfolio value using decision tree analysis (DTA), cost analysts must quantify both (1) the cost of each investment in the portfolio, risk-adjusted, and discounted based on the time phasing of each investment and (2) the benefit or value of each investment for the stakeholders, also risk-adjusted and discounted by inflation and the cost of capital. Essentially, decision tree analysis allows analysts and management to assign objective value to each program portfolio from which the agency can rank portfolios and determine funding allocations. This is especially important when capital budgets are constrained and full-funding cannot be allocated to each portfolio and business case. Again, for budgeting purposes, agencies may choose to fund the most likely portfolio path, so they can obligate funds accordingly.

In Figure 7 incremental value of each portfolio element is added to the decision tree timeline. Individual investments, policies, and processes have both cost and benefits, and incremental net benefits are captured by each investment in the portfolio. The analyst or portfolio team also assigns a probability at each decision point that assesses whether or not the investment will be approved at that point in time. The next set of branches follows the “yes” approved and “no” not approved decisions. Multiplying the value of each decision by its “yes” probability allows the analyst to calculate a probability-weighted aggregate portfolio value. Set against a decision timeline, analysts can discount this incremental value by the cost of capital. For the FAA, the real discount rate for benefits to the agency and outside stakeholders is seven percent. By discounting BY$ incremental costs and benefits by year and discounting by this cost of capital, the analysts can calculate portfolio net present value (NPV).

Figure 8 shows how to calculate the weighted average value of the portfolio using decision tree analysis and shows the application of a seven percent discount rate to calculate portfolio NPV.

Figure 7: Supply Chain Portfolio 3-Option Decision Tree with Incremental Values



In Figure 8, for the Supply Chain portfolio example, each of the three major decision branches is quantified by multiplying the portfolio decision point or investment probability by its incremental net value along a time series. In this example, we assume the first set of investment decisions happens in 2021, and cost savings and benefits are realized in 2022. For the second set of decisions, which occur between 2022-2023, the incremental value is realized annually, starting in 2024. For the first major branch set, the probability that configuration management, maintenance logging, and logistics will be approved and successfully enter implementation in 2020-2021 is 60%, so each of the incremental value of each of those investments is multiplied by 60%.

Alternatively, in Portfolio Branch 2, where only configuration management and maintenance logging are approved together, the probability of realizing the incremental value is 30%. Finally, in Portfolio Branch 3, where the maintenance logging investment decision is delayed, the probability of occurrence is only 10%.

For the next tier of investments on each of the major portfolio branches, the analyst will multiply the initial percentage times the probability of continuing through to the end-state, and this new probability is multiplied times the incremental value of the follow-on investments and policy changes. For example, in Portfolio Branch 1, configuration management phase 2 and maintenance automation are multiplied times a 48% probability (60% X 80%). After all the values of the branches are calculated, the present value sum of each branch becomes the portfolio's net present value (NPV).

Figure 8: Probability-Weighted Decision Tree Value and NPV

Decision Tree - 3 Parts - Supply Chain - ICEAA 2019										
Portfolio Branch 1	- Optimum -	FY2026/2027		3	4	5	6	7	15	
			NPV Factor	*0.76289521*	*0.71298618*	*0.66634222*	*0.62274974*	*0.5820091*	*0.3387346*	
Probability		**$M per year**		**2022**	**2023**	**2024**	**2025**	**2026**	**2034**	**Total**
60%	$0.5M/yr	$0.5	CMA P1	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	
60%	$15.0M/yr	$15.0	AMMS P1	$ 9.00	$ 9.00	$ 9.00	$ 9.00	$ 9.00	$ 9.00	
60%	$0.5M/yr	$0.5	LCSS P3	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	
48%	$2.5M/yr	$2.5	CMA P2	$ -	$ -	$ 1.20	$ 1.20	$ 1.20	$ 1.20	
48%	$2.0M/yr	$2.0	AMMS P2	$ -	$ -	$ 0.96	$ 0.96	$ 0.96	$ 0.96	
48%			Policy - Centralized Parts Ordering	$ -	$ -	$ -	$ -	$ -	$ -	
48%	$3.0M/yr	$3.0	Policy - 2-D Bar Coding	$ -	$ -	$ 1.44	$ 1.44	$ 1.44	$ 1.44	
48%	$4.0M/yr	$4.0	LCSS Phase 4	$ -	$ -	$ 1.92	$ 1.92	$ 1.92	$ 1.92	
	Total		Total	$ 9.60	$ 9.60	$ 15.12	$ 15.12	$ 15.12	$ 15.12	$ 185.52
	NPV		NPV	$ 7.32	$ 6.84	$ 10.08	$ 9.42	$ 8.80	$ 5.12	$ 95.01
Portfolio Branch 2	FY2028/2029									
Probability		**$M per year**		2022	2023	2024	2025	2026	2034	Total
30%	$0.5M/yr	$0.5	CMA P1	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 1.95
30%	$15.0M/yr	$15.0	AMMS P1	$ 4.50	$ 4.50	$ 4.50	$ 4.50	$ 4.50	$ 4.50	$ 58.50
27%	$0.5M/yr	$0.5	LCSS P3	$ -	$ -	$ 0.14	$ 0.14	$ 0.14	$ 0.14	$ 1.49
27%	$2.5M/yr	$2.5	CMA P2	$ -	$ -	$ -	$ -	$ 0.68	$ 0.68	$ 6.08
27%	$2.0M/yr	$2.0	AMMS P2	$ -	$ -	$ -	$ -	$ 0.54	$ 0.54	$ 4.86
27%			Policy - Centralized Parts Ordering	$ -	$ -	$ -	$ -	$ -	$ -	$ -
27%	$3.0M/yr	$3.0	Policy - 2-D Bar Coding	$ -	$ -	$ -	$ -	$ 0.81	$ 0.81	$ 7.29
27%	$4.0M/yr	$4.0	LCSS Phase 4	$ -	$ -	$ -	$ -	$ 1.08	$ 1.08	$ 9.72
	Total		Total	$ 4.65	$ 4.65	$ 4.79	$ 4.79	$ 7.89	$ 7.89	$ 89.88
	NPV		NPV	$ 3.55	$ 3.32	$ 3.19	$ 2.98	$ 4.59	$ 2.67	$ 45.04
Portfolio Branch 3	FY 2028/2029									
				2022	2023	2024	2025	2026	2034	Total
Probability		**$M per year**								$ -
10%	$0.5M/yr	$0.5	CMA P1	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.65
6%	$15.0M/yr	$15.0	AMMS P1	$ 0.90	$ 0.90	$ 0.90	$ 0.90	$ 0.90	$ 0.90	$ 11.70
10%	$0.5M/yr	$0.5	LCSS P3	$ -	$ -	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.55
6%	$2.5M/yr	$2.5	CMA P2	$ -	$ -	$ -	$ -	$ 0.15	$ 0.15	$ 1.35
6%	$2.0M/yr	$2.0	AMMS P2	$ -	$ -	$ -	$ -	$ 0.12	$ 0.12	$ 1.08
6%			Policy - Centralized Parts Ordering	$ -	$ -	$ -	$ -	$ -	$ -	$ -
6%	$3.0M/yr	$3.0	Policy - 2-D Bar Coding	$ -	$ -	$ -	$ -	$ 0.18	$ 0.18	$ 1.62
6%	$4.0M/yr	$4.0	LCSS Phase 4	$ -	$ -	$ -	$ -	$ 0.24	$ 0.24	$ 2.16
	Total		Total	$ 0.95	$ 0.95	$ 1.00	$ 1.00	$ 1.69	$ 1.69	$ 19.11
	NPV		NPV	$ 0.72	$ 0.68	$ 0.67	$ 0.62	$ 0.98	$ 0.57	$ 9.55
Total Risk-Adjusted Portfolio Decision Tree				2022	2023	2024	2025	2026	2034	Total
Probability		**$M per year**								$ -
100%	$0.5M/yr	$0.5	CMA P1	$ 0.50	$ 0.50	$ 0.50	$ 0.50	$ 0.50	$ 0.50	$ 6.50
96%	$15.0M/yr	$15.0	AMMS P1	$ 14.40	$ 14.40	$ 14.40	$ 14.40	$ 14.40	$ 14.40	$ 187.20
97%	$0.5M/yr	$0.5	LCSS P3	$ 0.30	$ 0.30	$ 0.49	$ 0.49	$ 0.49	$ 0.49	$ 5.94
81%	$2.5M/yr	$2.5	CMA P2	$ -	$ -	$ 1.20	$ 1.20	$ 2.03	$ 2.03	$ 20.63
81%	$2.0M/yr	$2.0	AMMS P2	$ -	$ -	$ 0.96	$ 0.96	$ 1.62	$ 1.62	$ 16.50
81%			Policy - Centralized Parts Ordering	$ -	$ -	$ -	$ -	$ -	$ -	$ -
81%	$3.0M/yr	$3.0	Policy - 2-D Bar Coding	$ -	$ -	$ 1.44	$ 1.44	$ 2.43	$ 2.43	$ 24.75
81%	$4.0M/yr	$4.0	LCSS Phase 4	$ -	$ -	$ 1.92	$ 1.92	$ 3.24	$ 3.24	$ 33.00
	Total		Total	$ 15.20	$ 15.20	$ 20.91	$ 20.91	$ 24.70	$ 24.70	$ 294.51
	NPV		NPV	$ 11.60	$ 10.84	$ 13.93	$ 13.02	$ 14.38	$ 8.37	$ 149.60

Figure 9 summarizes the portfolio decision tree into each major branch and by value metric. Adding the present value of each branch generates the NPV of the total portfolio.

Figure 9: Probability-Weighted Portfolio Summary & Metrics

Decision Tree Branch	Probability 1st Tier	Probability 2nd Tier	Potential Savings & Incremental Benefits ($M)	Probabiity-Adjusted Savings ($M)	NPV ($M PV)
Portfolio Branch 1 - Optimum Schedule & Funding of All Programs	60%	48%	$ 334.50	$ 185.52	$ 95.01
Portfolio Branch 2 - Delay of Investing in Logistics, Impact to Schedule & Probability of Not Investing in Full Supply Chain	30%	27%	$ 310.50	$ 89.88	$ 45.04
Portfolio Branch 3 - Delay of Investing in Maintenance and Logging, Impact to Schedule & Probability of Not Investing in Full Supply Chain	10%	6%	$ 310.50	$ 19.11	$ 9.55
Total Portfolio Benefit	**100%**		**$ 334.50**	**$ 294.51**	**$ 149.60**

5 Capital Investment Portfolio Scorecard

Once the agency calculates incremental probability-weighted portfolio value for each capital portfolio for which it is considering funding, the portfolio management team needs a method and tool to rank portfolios, metrics to evaluate and compare portfolios, and a dynamic means for updating comparative values. Agencies may not be able to make funding allocations between portfolios completely objective, but they can alleviate some subjectivity and run funding scenario analyses to see the potential impact of funding constraints on portfolio performance. One objective methodology for ranking and comparing portfolios and for running funding scenario portfolio impact analysis is to use a portfolio scorecard.

5.1 What is a Scorecard?

A scorecard is a simplified and dynamic tool used to review, rank, and evaluate programs or portfolios. For portfolio analysis, a scorecard can contain critical technical and financial data used to evaluate portfolios of programs, identify funding needs, and prioritize the funding allocations of a limited budget. Government agency budget offices can assemble and populate portfolio metrics quarterly or monthly depending on funding allocation needs, and during annual budgeting cycles where program offices submit annual capital budget requests two fiscal years in advance, budget offices can utilize portfolio scorecards for initial budget allocations. A portfolio scorecard is both a budgeting tool for capital budget allocations and a dynamic collection of portfolio data that can change and re-rank portfolio priorities as soon as investment decisions and policy changes (portfolio components) are approved.

5.2 How to Compare Portfolios

Unlike programs, portfolios have multiple components with interdependencies, policy change requirements, user adoption requirements, and dependencies on external program execution. Portfolios are complex and dynamic, and in section 4, we determined how to calculate portfolio value and establish decision trees to estimate probability and value. Decision trees change frequently, impacting portfolio value, but these value metrics can be collected in aggregate and in its sub-components in a concise scorecard. Agency senior management, budget offices, capital program evaluating committees, and budget teams should collaborate to determine which attributes are critical for collection and to compare between portfolios. These main metrics will be the means of ranking or prioritizing capital funding allocations to portfolios when capital portfolio needs exceed those of annual government capital allocations.

5.2.1 Scorecard Metrics and Ranking

To compare portfolios, prioritize them, and set funding allocations, the primary metrics for government finance for capital investments are two-fold:

(1) The strategic objective for each portfolio can be ranked independently by stakeholders, and this value can supersede economic value. There are some portfolios, no matter how economically valuable they may or may not be, best align with agency objectives and will receive funding prioritization no matter what.
(2) The main objective scorecard metrics are associated with value (NPV, IRR, B/C ratio), cost estimation, incremental benefits, and annual cost requirements.

Including these major components allows decision-makers a means of ranking portfolios and their underlying investments and to reassess their initial preconceptions of value.

5.2.2 Budget Allocations with Limited Capital

Government agencies are usually allocated limited capital budgets, a specific dollar allocation for a specific year to spend on capital projects. By aligning capital projects within capital portfolios with common objectives and strategic end-state capabilities, agency budgeting offices and senior management can best assess to which strategic objectives they should allocate more money in any given year. Not only should aggregate portfolio value and other economic metrics be included in a portfolio scorecard for evaluation of budget allocations, but annual portfolio funding requirements should be well-defined. In some cases, funding a high-priority or economically valuable portfolio in the next fiscal year might be a low commitment; the portfolio may not have high capital needs in that given year. In other years, this high-priority portfolio may require much of the capital budget for that fiscal year. The main objective of a scorecard is to inform decision-makers with objective information from which they can decide how to fund programs and portfolios and the implications of those decisions.

5.3 Updates and Rebalancing

By feeding objective data to scorecards from multiple quantification sources, including portfolio decision trees, program/acquisition cost estimates, cost/benefit analyses, and annual budget requests, portfolio managers and budget offices can update scorecards and their funding allocations multiple times a year. If an investment decision is not favorable or is delayed, it will likely impact the schedule and funding requirements for an entire program portfolio. With this new information, government agency boards and budget offices can decide to reallocate some of this portfolio’s funding for the impacted fiscal years to another portfolio, which has more tangible needs in the near term. This rebalancing of portfolio capital funding is a sort of “trade-off,” which can become more prevalent for agency capital teams when they have a dynamic and frequently updated decision tool, like a program portfolio scorecard. As long as program offices, stakeholders, cost estimators, and analysts regularly update decision trees, program dashboards, cost models, and schedules, portfolio-level metrics can provide regularly updated data for management and for rebalancing.

5.4 Government Supply Chain Example

For the government supply chain portfolio example introduced in section 4, this section introduces a sample government scorecard with metrics applicable for a 10-year funding cycle. It can be expanded to include the underlying investments, but in this example, we chose to keep the scorecard simple and straight-forward from an objective economic metric perspective. Government agencies might elect to add additional factors, depending on their strategic prioritization.

For instance, the FAA might add a safety component that values safety as a primary factor of ranking portfolios over all others. The first portfolio ranked highest might be the most safety-critical portfolio. After the first one, economic factors might prioritize the remaining equally-safety-critical subsequent portfolios, which are more discretionary for capital spending budgets.

In Figure 10, the portfolio scorecard includes a annual maximum budget allocation and lists the top 8 program portfolios, which will take the majority if not all of the capital program funding for each of the 10 fiscal years. The agency can expand the scorecard beyond a top number to fully allocate the capital budget for each year.

Figure 10: Agency Portfolio Scorecard

	Agency Portfolio Scorecard															
	Maximum Annual Budget		$1,000	Total Annual Allocation			$740	$1,000	$1,000	$1,000	$1,000	$990	$925	$935	$910	$1,000
Priority Rank	Portfolio	Components	Total Cost (PV$ M)	Incremental Benefits	NPV	B/C Ratio	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
1	Supply Chain		$500	$800	$300	1.6	$40	$100	$80	$60	$100	$60	$20	$20	$20	$0
2	Navigation		$700	$1,000	$300	1.4	$30	$120	$80	$100	$80	$110	$75	$75	$10	$20
3	Automation		$1,200	$1,500	$300	1.3	$80	$100	$70	$50	$200	$120	$130	$160	$90	$200
4	Surveillance		$1,600	$1,900	$300	1.2	$150	$200	$200	$200	$100	$100	$100	$150	$150	$250
5	Communication		$1,000	$1,200	$200	1.2	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100
6	Information Technology		$1,000	$1,080	$80	1.1	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100
7	Technical Operations		$1,500	$1,600	$100	1.1	$80	$200	$120	$120	$180	$200	$200	$80	$150	$170
8	Safety		$2,000	$1,500	($500)	0.8	$160	$80	$250	$270	$140	$200	$200	$250	$290	$160

In the example, eight portfolios are ranked by financial metrics, NPV and B/C ratio. Annual funding requirements for each portfolio are listed for each year and are modified to fit maximum funding allocation constraints depending on how far down they are on the prioritization list. Portfolios should start with an unconstrained allocation and then modify annual requirements if they exceed the maximum capital funding allocation. For example, if the Technical Operations Portfolio required $200M in 2023, the agency may choose to only allocate that portfolio $180M in 2023 and then increase the funding allocation in 2024 to make the program whole in the following year when funding constraints were not breeched. Program offices need to assess the impact of not being fully funded. For instance, a one-year delay might increase program costs by a 10% in total due to longer fixed cost allocations.

Some agencies without an objective measurement of portfolio analysis and prioritization instead decide to allocate capital funding lower than actual need for each of the capital programs. This often results in programs reducing scope, segmenting programs, and stretching out end-state objective goals over many additional years to stay within further funding allocation constraints. Scorecards, instead, require agencies to pick winners and losers and fully funding programs and portfolios, which are needed in an earlier timeframe to meet government strategic goals. Using decision trees and scorecards, agencies can run multiple funding scenarios and see the impact of lower funding on strategic goals and portfolio timelines. This "what-if" analysis allows decision-makers to make tough choices and prioritize investments.

6 Conclusion

For government agencies, where large capital investment portfolios have multiple interdependencies and where government-constrained capital budgets require tough choices between competing capital investments, management, budget offices, and decision boards require a process and a series of tools to objectively compare strategic portfolios, measure the impacts of their investment decisions, and confidently make challenging funding decisions. Where delays in schedules, changes to legacy systems and processes, and unforeseen implementation challenges impact capital programs and program management offices, portfolio managers can implement dynamic portfolio decision tools to capture and project potential impacts and adjust funding profiles to facilitate a prudent reallocation of capital resources.

Using influence diagrams, program managers, portfolio boards, cost estimators, financial analysts, and multiple stakeholders can design comprehensive portfolios, starting with a strategic capability goal or end-state. They can break down that end-state design to all of its component parts, including investments, acquisitions, policies and procedures, change management, and stakeholder advocacy to ensure a pathway for portfolio success.

Adding a decision timeline, management and analysts can develop complex portfolio decision trees, just as they might for individual investments, adding probability weighted values to each branch of the decision tree and adjusting these percentages and values at each decision point to dynamically readjust value calculations. If all participants in a portfolio consistently update the decision tree data, budget offices can continue to update value calculations multiple times per year.

Finally, to review all agency portfolios and make difficult funding decisions between portfolios and capital programs, budget offices and portfolio management can design an agency scorecard to help decision-makers choose optimum funding profiles and annual allocations of constrained capital budgets to make sure high-priority portfolios are funded when they need the dollars, and other portfolios are funded in the years in between.

Following a process using influence diagrams, decision trees, and scorecards, government agencies no longer need to be vulnerable to programmatic uncertainties, government capital funding constraints, and isolated investment decisions. Instead, agencies can act confidently and decisively to fund critical initiatives at the right times and ensure their success.