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Project Selection in Large Engineering and Construction Programs

Key Points

- Project selection must flow from a strategy defined by strategic business objectives (SBOs) and their outcomes.
- Key performance indicators must cascade through strategy assessment into overall project portfolio assessment and ultimately into individual projects.
- Weak project selection results in lower-value capture.
- Project selection must simultaneously optimize multiple SBOs.
- Weak project evaluation methodologies that seek to reduce all benefits to a singular cost-related value, such as net present value (NPV), must be avoided.
- It is essential to understand potential sources of selection bias and carefully review objectives, metrics, constraints, and evaluation criteria to ensure such biases have been minimized.
- Many techniques exist for evaluation of potential project portfolios.
- Identifying and understanding the efficient frontier allows the best project portfolios to be identified.

Introduction

One of the most important steps in the implementation of a program management approach is the selection of the projects that will comprise the program. This selection process, done properly, is neither intuitively obvious nor simple. Done poorly, the program may achieve less than optimum results or be exposed to risks that may degrade its value over time. Project selection must flow from a strategy that in turn is defined by an organization's strategic business objective that supports the organization's strategic business outcomes. Key performance indicators (KPIs), which are established to assure strategic business objectives (and by extension strategic business outcomes) are met, must cascade through strategy assessment into overall project portfolio assessment and ultimately into individual projects.

Selection of Projects

The selection of the portfolio of projects that will comprise the program must:

- Optimize multiple strategic business objectives.
- Address sequencing required for optimization.
- Address interdependencies between projects.
- Reflect real-world resource constraints.
- Enhance program (and organizational) flexibility and resiliency.

Programs which experience weak project selection may have failed to:

- Maintain focus on strategic business objectives.
- Prevent biases from entering the process.
- Establish a sufficiently strong methodology for project portfolio evaluation, often only considering one primary SBO without attention to other such objectives.
- Appropriately cascade metrics to the assessment of project portfolio performance and ultimately individual project performance.
- Inadequately reflect uncertainty and risks in portfolio evaluation.

Weak project selection will result in lower-value capture and, to the extent to which project selection appears to be driven by biases or other non-objective factors, undermine organizational honesty and openness.

The basis for a project's selection must be constantly monitored, in addition to monitoring project performance under program management. This is an area that requires increased focus in the engineering and construction industry. Changes in market conditions, resource constraints, risk levels, or execution performance may drive a re-evaluation of the portfolio or the project after it is underway, which shows that redeployment of resources is in the best interest of achieving the program's strategic business objectives even when sunk costs and commitments are fully considered.

Termination of a previously selected project may be a simpler matter if it is performing below expectations (schedule delays, cost overruns), but when driven by a reduction in the benefits that will accrue or value derived, it is a much harder matter. Who wants to be the program manager who terminates a strong performing project (ahead of schedule, under budget)?

Best Performing Not Necessarily the Best Investment

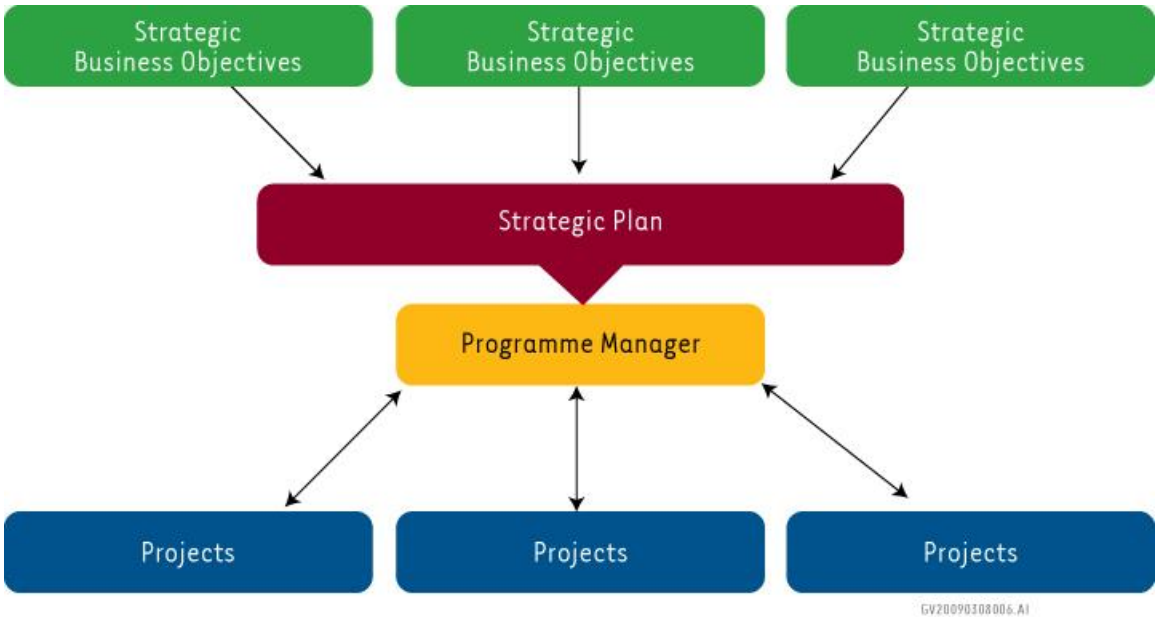
On one large mining program, several megaprojects were underway at the same time. Overall, the program was struggling to maintain budget and schedule, and market conditions had changed significantly since the program was originally conceived. One of the projects in the program was the expansion of railroad throughput and it was the best performing of all the megaprojects.

The owner took a comprehensive look at their program considering the changed market conditions. It was determined that the expanded rail capacity would no longer be required. With a large sunk investment (about 50 percent of the project total), however, the owner completed the project since it was their "best performing project."

The several hundred million more dollars in expenditures provided no incremental value to the program or the strategic business outcome the owner was trying to achieve.

Optimize Multiple Strategic Business Objectives

A key attribute of project selection in major engineering and construction programs is the need to simultaneously optimize multiple strategic business objectives.



This need is driven by an "outcome focus of programs" versus the more typical "outputs focus of individual projects." Successful optimization will rest on:

- Clear definition of strategic business objectives.
- Smart key performance indicators for each objective:
    - Specific
    - Measurable
    - Achievable
    - Realistic
    - Targeted
- Well-defined constraints facing the program and individual projects.
- Delineated interdependencies between projects, including any precedence requirements.
- Clarity around attendant risks and uncertainties at the program and project levels.
- Appropriate weighting of benefits and constraints that comprise the project portfolio's evaluation criteria by the executives most focused on strategic business objective achievement.

Evaluation criteria and constraints may include:

- Financial
    - Life cycle return on investment
    - Return on assets employed
    - Net present value (NPV) of cash flows
    - Payback period
    - Total capital expenditures
    - Product/project gross margins

- Market
    - Market share
    - Market growth and duration
    - Period of profitable production
    - Product flexibility
    - Customer impacts

- Strategic
    - Flexibility
    - Resiliency
    - Contribution to overall portfolio performance
    - Enablement of SBO achievement
    - Enablement of other portfolio projects
    - Critical resource utilization

- Sustainability or Triple Bottom Line focused criteria
    - Economic
    - Social
        - Community impacts
        - Capacity building
        - New industry/business creation
        - Stakeholder support
        - Workforce impacts
        - Social justice
    - Environmental, Health & Safety
        - Airborne emissions
        - Water consumption
        - Discharge water quality
        - Environmental degradation
        - Worker health and safety
        - Public health and safety
        - Carbon footprint
        - Energy consumption
- Risk
    - Economic or market uncertainties
    - Other event risks
    - Financing uncertainties
    - Cost uncertainties
    - Schedule uncertainties
    - Labor risks
    - Stakeholder risks
    - Sovereign and legislative risks

- Political risks
- Technology risks
- Intellectual property risks
- Business model risks
- Project execution risks

Weak project evaluation methodologies that seek to reduce all benefits to a singular cost-related value, such as NPV, must be avoided in recognition that:

- Uncertainty in estimates is compounded.
- Structured multi-variate risk analysis would produce a better assessment of risk.
- Benefits of later phase projects are not fully appreciated.
- Changes in risk profile over time are not recognized.

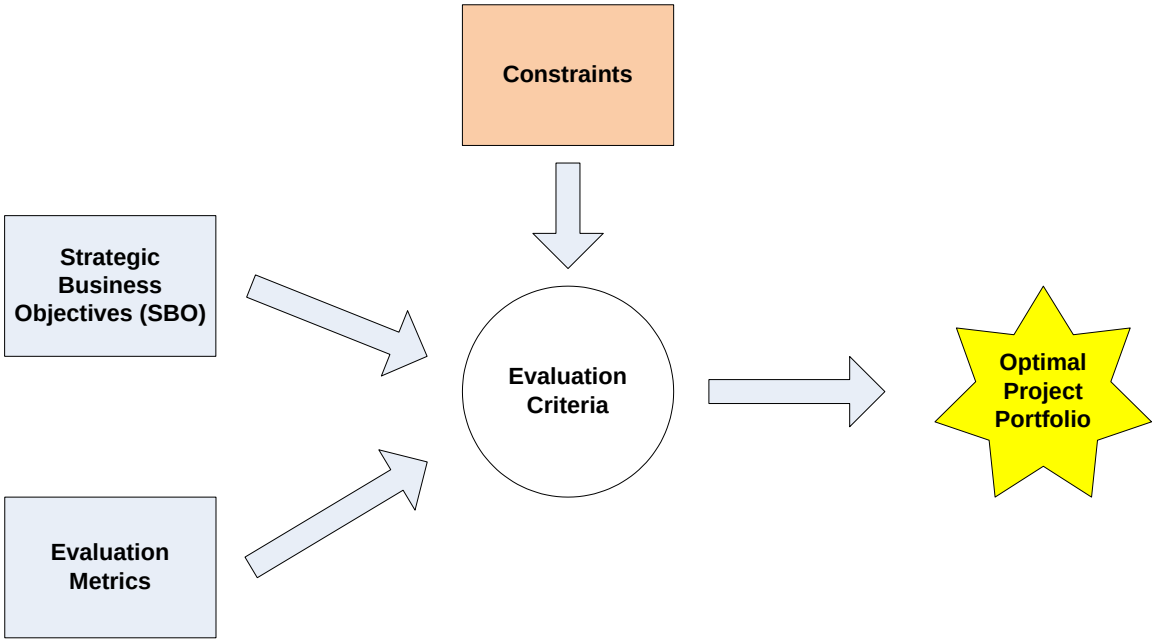
Meet the Objectives – All the Objectives

On one giga program, the owner faced a broad array of stakeholders with often competing objectives. He attempted to satisfy these needs by developing a broad, compelling vision that would serve to satisfy all stakeholder groups in one grand sweep. He failed, however, to ensure that this grand vision met his other strategic business objectives with respect to cost and schedule. The immediate effect of this grand vision was to raise the bar for each and every stakeholder's expectations. The owner continued to try to cajole every stakeholder through a series of further concessions until cost and schedule forecasts could no longer be ignored. By then it was too late.

Strategic Program Management is built on defining a set of true, strategic business objectives and then developing a strategy to achieve each and every strategic business objective. Strategic Program Management is built on the word "and" when it comes to meeting these objectives. Strategic Program Management is not about placing primacy on one of the strategic objectives. To be successful, giga programs require careful attention and selection of the over-arching strategic business objectives. These objectives cannot be a set of wishes and wants, but rather must be those things required for program success.

Avoiding Bias in Project Selection

Objective assessment rests on well-defined objectives, constraints, and evaluation metrics that can be mapped to well-defined evaluation criteria.



Avoiding Bias in Project Selection

It is essential that the owner's team and the program manager understand potential sources of selection bias and carefully review objectives, metrics, constraints, and evaluation criteria to ensure such biases have been minimized and ideally eliminated. The use of unconscious shortcuts to make complex decisions has been well documented and may lead to systematic errors in the project portfolio selection process.

The following table lists some of the biases more commonly observed in programs with weak project selection.

Heuristic Biases Affecting Project Selection	
Motivation bias	**Motivation bias –** can affect estimates and forecasts whenever those doing the estimating believe that the judgments expressed may affect them personally. For example, managers may have an incentive to overstate productivity forecasts to reduce the risk that capital dollars allocated to their business units will be reduced. More subtle biases also affect estimates provided by managers. The influence can depend on the individual.
Status Quo bias	**Status quo bias** – the inclination of decision-makers to like things to stay relatively the same. This bias explains why ineffective management procedures often are not changed and why outdated technology is not replaced.
Perception bias	**Perception bias –** a broad term used to describe different situations in which inaccuracies are perceived. It is a type of cognitive bias that occurs when assumptions are subconsciously formed or conclusions drawn based on beliefs, expectations, or emotions.
Risk aversion	**Risk aversion –** a preference for a sure outcome over a gamble with higher or equal expected value.
Optimism bias	**Optimism bias –** the tendency to be overly optimistic about the outcome of planned actions. This manifests itself in project planning and forecasting. Project managers often overestimate the probability of successful project completion and underestimate the probability of negative events. The optimism bias is also related to wishful thinking.
Comfort zone bias	**Comfort zone bias –** refers to a category of powerful cognitive biases with the common characteristic that their effect is to promote behavior that is comfortable rather than reasoned.

Wishful thinking	**Wishful thinking** – the formation of beliefs and decision-making according to what might be pleasing to imagine instead of by appealing to evidence or applying rationality. For example, making estimates based on positive results desired instead of what is possible to achieve. Wishful thinking is related to the optimism bias.
Group think	**Group think –** a psychological phenomenon that occurs within a group of people in which the desire for harmony or conformity in the group results in an irrational or dysfunctional decision-making outcome. Cohesiveness, or the desire for cohesiveness, in a group may produce a tendency among its members to agree at all costs. This causes the group to minimize conflict and reach a consensus decision without critical evaluation.
Uncertainty bias	**Uncertainty bias** – failure to adequately consider the uncertainty inherent in drivers and outcomes. Uncertainty can range from predictable futures (the most comfortable) through alternate futures (A or B will happen) to a broad range of futures (multiple scenarios to be considered) to true uncertainty or ambiguity (such as one may see in technology adoption rates).
Judgmental bias	**Judgmental bias –** refers to systematic patterns of deviation from the norm and/or rationality in judgment. Actual bias is subjective and deals with the state of mind, while apparent bias is objective and deals with the conduct and the surrounding circumstances.
Sunk cost bias	**Sunk cost bias** – the tendency to make a choice considering the cost that has already been incurred and cannot be recovered (sunk cost). Sunk costs affect the decisions due to the loss-aversion effect. Sunk costs may cause cost overruns and may also lead to investment in a project that now has no value.
Confirmation bias	**Confirmation bias –** the tendency to seek out and attribute weight to pieces of evidence that support the hypothesis and ignore evidence which disproves it. It manifests itself in the tendency to interpret ambiguous evidence as supportive of one's own hypothesis.

Contradictory evidence avoidance	**Contradictory evidence avoidance –** Ignoring facts that do not fit with your belief set or existing hypothesis. Often when your deepest convictions are challenged by contradictory evidence, your beliefs get stronger.
Biased argument framing	**Biased argument framing –** occurs when people react differently to something depending on whether it is presented as positive or negative. In other words, a decision is influenced by how the information is presented rather than what is being said.
Anchoring	**Anchoring –** a cognitive bias whereby an individual's decisions are influenced by a particular reference point or anchor. Both numeric and non-numeric anchoring can occur. In numeric anchoring, once the value of the anchor is set, subsequent arguments or estimates made by an individual may change from what they would have otherwise been without the anchor.
Illusion of control	**Illusion of control** – the tendency of decision-makers to believe they can control or influence outcomes over which they have no influence. They plan under the assumption that they can control most processes, which in reality they cannot.
Planning fallacy	**Planning fallacy** – a phenomenon in which predictions about how much time will be needed to complete a future task display an optimism bias and underestimate the time needed. This phenomenon sometimes occurs regardless of the individual's knowledge that past tasks of a similar nature have taken longer to complete than generally planned.
Semmelweis reflex	**Semmelweis reflex** – the tendency to reject new evidence that contradicts an established paradigm.
Bounded awareness	**Bounded awareness –** is a serious problem. Rather than make use of all information necessary to make an informed decision, people attend to only the limited set of data that is most directly in front of them and fail to seek out other data that are clearly needed. People, especially when overly focused, fail to recognize and detect changes to what should be obvious visual, auditory, and other sensory data and routinely overlook information that can be crucial for decision making.

Reasoning by analogy	**Reasoning by analogy –** a cognitive process where one uses a comparison between two things to understand or solve a problem. It involves identifying the underlying relationships and mapping them from one domain to another. Reasoning by analogy is a type of inductive argument, which means it can be valid or invalid depending on the strength of the similarity and the relevance of the differences.

Removing biases from the project selection processes requires a conscious set of actions that begin with the recognition that potential biases because of the individual's prior experiences and behavioral make-up will exist and that a motivated and conscious effort by the entire review team is required to remove such biases from the process.

Project Portfolio Evaluation Methodology

Many techniques exist for evaluation of potential project portfolios that will optimally meet an organization's Strategic Business Objectives. We have already discussed the importance of metrics and unbiased evaluation criteria and constraints.

Numerous techniques exist for solving multi-objective project portfolio problems. However, proper application is dependent on accurately evaluating benefits and constraints. So called "rate and weight" methodologies lend themselves to the bias concerns discussed above and should be avoided. Weighting and rating is the simplest and most commonly used form of concept selection. Easy to understand and apply but demands reliable information to be truly effective. Commonly used method for assessing the relative merits of a range of options. This approach can be good at indicating the front runners, but numerical methods like this can be dangerous, as they tend to imply only one 'right' answer. It should always be remembered that both the weightings and the ratings are subjective and arbitrary, and thus although a quantitative answer is gained, it too is subjective. This approach is also extremely sensitive to small changes, and it can be easy to "cook the books," reflecting bias. Thus, it needs to be used with caution.

Project proponent claimed assumptions pertaining to costs, schedule and benefits need to be carefully reviewed and challenged as part of the project selection process, with one or more capital allocation methodologies utilized. These capital allocation methodologies include:

- Ranking of potential projects by cost benefit ratios
    - Independent projects with singular budget constraint
- Linear programming

    - Multiple constraints especially when extensive project options being considered.
- Integer programming using “branch and bound” methods.
    - Most accurate when project options are narrowed.
        - There are 2^n potential project portfolios, where n is the number of projects that are either funded or not funded.

Linear programming, also called linear optimization, is a method to achieve the best outcome (such as maximum profit or lowest cost) in a mathematical model whose requirements are represented by linear relationships. Linear programming is a special case of mathematical programming, also known as mathematical optimization.

The **branch and bound method** can be used to solve problems containing a few integer-valued variables. If the number of variables is large, or if the linear programming solution to the problem is not optimal, then do not use the branch and bound method, because the number of iterations required to solve such a problem may be too large.

The standard capital allocation model is derived from work done by Markowitz on Portfolio Theory and may be written as:

$$\text{Maximizing } \sum_{i=1}^{N} b_i x_i$$

Where b_i is the benefit associated with the i^{th} project; and x is either zero or one depending on if the project is included in the portfolio or not.

The above capital allocation model is constrained in such a way that the total cost of all projects in the portfolio does not exceed some maximum capital cost such that:

$$\sum_{i=1}^{N} c_i x_i \quad \leq C$$

Given that a total budget constraint is typically not as hard as the above formula would suggest, it may be convenient to understand the sensitivity of the portfolio optimization to the maximum capital cost level.

This simple capital allocation model can be extended to address:

- Multiple benefits (associated with multiple evaluation criteria, appropriately weighted).
- Benefits spread over time (net present value).
- Costs spread over time (net present value).

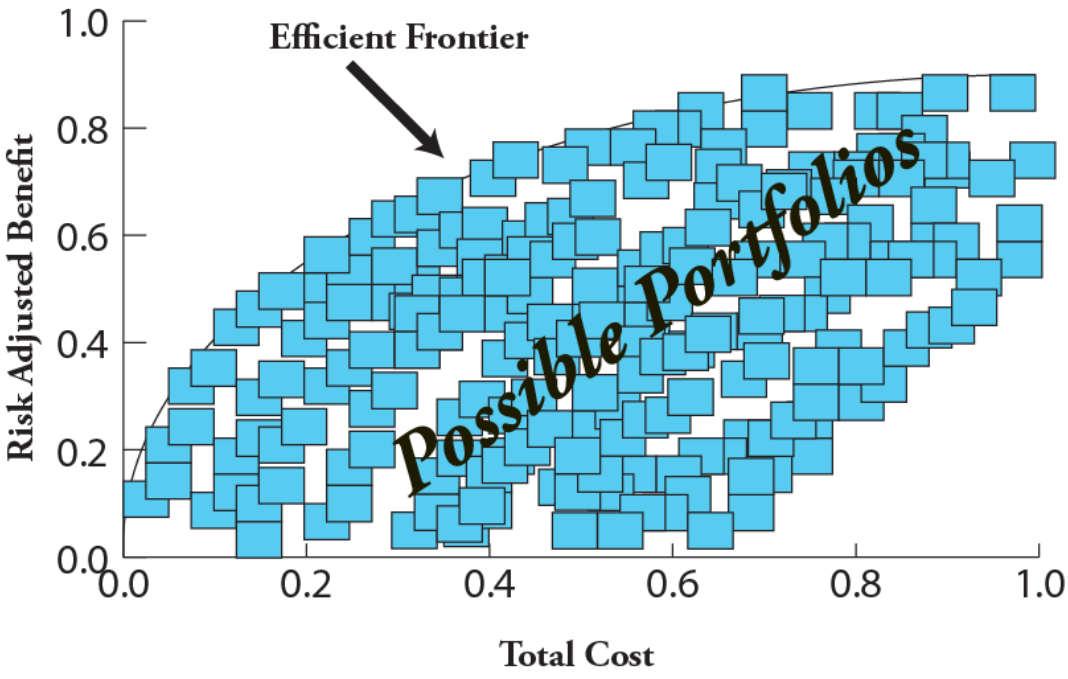
- Future costs associated with implementation of a project (maintenance and operating costs, consumables).
- Costs associated with not doing a project.
- Mutually exclusive projects or project alternatives.
- Project precedence.
- Partial project benefit interdependency.
- Cost, schedule other benefit synergies.
- Multi-period cost constraints.
- Sensitivity to delay.

The “Efficient Frontier”

Solving the capital allocation model does not result in a singular solution but rather an extensive solution set that may be considered by looking at:

- Risk adjusted benefits versus total costs (project portfolio management)
- Portfolio returns at various risk levels (portfolio theory)

These potential portfolio solutions may be plotted to create a view of the "efficient frontier."



Identifying and understanding the efficient frontier allows one to identify the best project portfolios at a given budget level and to assess the lost benefits or added costs associated with other than optimal portfolio selection.

As cost constraints are relaxed, additional or larger projects typically provide lower incremental returns. This is reflected in the flattening observed in the efficient frontier and closely mirrors Pareto's 80/20 rule, where 80 percent of all value available from all projects may be achieved from doing just 20 percent of the projects. This provides the program manager with a convenient tool for management prioritization and the development of critical controls for the program.

Characteristics of Successful Project Portfolios

Successful project portfolios:

- Assure projects are aligned with an organization's strategic direction.
- Are based on a sound portfolio decision process.
- Comprise projects that are resilient to the effects of uncertainties embedded in the project selection process.
- Recognize the shift in constraints as one moves from a project to program context.

Constraints Shift Under Program Management	
Project	**Program**
Scope	Alignment with strategic business objectives
Schedule	Required resources
Cost	Benefits

Successful project portfolios address key questions related to:

- Resources required for program implementation.
- Critical resource limitations that the program will face.
- Prioritization of objectives.
- Identification of critical controls.
- Projects critical to individual SBO achievement.
- Consideration of uncertainty and risk.
- Project interdependencies.
- Key portfolio risk areas.

Successful project portfolios recognize the critical aspect of the project selection process is represented by the quality of the decisions made.

Conclusion

Objective-driven, bias-free project portfolio analysis and selection provide the owner and program manager with another tool to:

- Build organizational alignment.
- Understand program sensitivities to changes in acceptable risk levels and profile.
- Understand the influence of budget and other constraints on benefit maximization.
- Identify project priorities, sequencing, and effects of interdependencies and synergies.
- Establish an appropriate set of critical controls.

For Further Reading – Executive Insights

The Importance of Strategic Business Objectives
Trust
Know What You Are Trying to Accomplish – The Primacy of the Scope Baseline

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Bob Prieto was elected to the National Academy of Construction in 2011. He is a senior executive who is effective in shaping and executing business strategy and a recognized leader within the infrastructure, engineering, and construction industries.