Facilitating the Usage of Value Management Processes by Charactering Capital Facility Projects

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Abstract

Defining value as a measure of how well the project value objectives are met, Value Management Process (VMP) is considered to be any management effort or process that can proactively pursue one or more project objectives (i.e., security/safety, cost effectiveness, schedule optimization, and risk containment). The collection of 44 VMPs has been established based on a rigorous effort conducted by Construction Industry Institute (CII). Because varying circumstances on each project determine the level of suitability, it is crucial to identify which VMP should be implemented on a particular project. The current VMP selection process is primarily based on human intuition. The main objective of this paper is to provide a systematic method to facilitate the usage of VMPs on a particular project. This paper identified and quantified the selection principles (i.e., targeted value objectives, timing of initiation, project characteristics, and relative impact). The data collected from industry practitioners and VMP experts characterized each VMP in terms of the magnitude of benefit. An automated selection tool by Visual Basic Application (VBA) on MS ExcelTM, was developed and proved its validity. As a pioneering study, this paper provides a comprehensive and structured knowledge on the subject of VMPs. From the industry's perspective, the automated selection tool, the premier of this study, contributes the facilitation of the VMP implementations in the construction industry thereby maximizing the potential benefits to a particular project.

Keywords : Capital Project, Value, Value Management, Value Management Process (VMP), Value Objective

1. Introduction

Many innovative management processes are being increasingly introduced into the capital projects. One example is the Construction Industry Institute (CII)'s Best Practices. Another example is the Independent Project Analysis' (IPA) Value Improving Practices (VIPs). (McCuish and Kaufman 2002, Ruthven and Stripling 2002).

These innovative processes or efforts cause among project stakeholders a great concern about which to select on a particular project. Furthermore, the selection process is dependent on a manual system or an individual's intuition.

This intuitive approach, fails to pinpoint the best management process that can effectively maximize the value of a project.

As a result, it has become a critical challenge to effectively select the most beneficial management processes for a particular capital project.

This paper introduces a systematic method to select one or more of the management processes. This systematic approach is advantageous because of the following reasons.

- Only a limited number of available management processes are practically implemented on a single project. (Lenzer 2001, McCuish and Kaufman 2002).
- There are numerous factors to be considered when examining the magnitude of benefit of each management process.
- A lean organization is a predominant pattern in the industry. As

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such, the identification of a limited number of qualified management processes is extremely significant.

This paper discloses the "black box" of the selection process and provides a new methodology for extracting the most suitable management processes for a particular project. The study methodology is primarily dependent on the effort of the Construction Industry Institute (CII) Project Team (PT) 184. The members of CII PT 184 consisted of 17 project practitioners. Their experienced knowledge represented building and industrial projects from both private and public organizations.

For the purpose of this study, any management effort or process that can proactively pursue articulated project value objectives (e.g., security/safety, cost efficiency, quality, schedule, environmental stewardship, and risk containment) are defined as Value Management Processes (VMP). Forty-four management processes are considered as the state-of-the-practice VMPs, based on the identification effort conducted by CII PT 184. It is assumed that each VMP is independently applicable to a construction project. The compilation of the available VMPs is presented in Table 1.

Table 1. List of 44 Value Management Processes

Value management Processes	
■ Activity-Based Costing	■ Peer Review
■ Chartering Project Teams	■ Planning for Startup
■ Choosing by Advantages	■ Post-Occupancy Evaluation
■ Classes of Facility Quality	■ Predictive Maintenance
■ Constructability	■ Pre-Project Planning
■ Construction Simulation	■ Process Simplification
■ Design Effectiveness	■ Project Delivery Methods
■ Design for Maintainability	■ Project Execution Plan
■ Design to Capacity	■ Quality Functional Deployment
■ Design to Cost	■ Risk-based Estimating
■ Energy Optimization	■ Risk Management
■ FAST Diagramming	■ Schedule Optimization
■ Function Analysis Concept Development	■ Six Sigma
	■ Sourcing Strategies
■ Individual Value Engineering	■ Successive Estimating
■ Knowledge Management/ Lessons Learned System	■ Sustainable Design & Construction
■ Lean Construction	■ Technology Gatekeeper
■ Life-cycle Costing	■ Technology Selection
■ Mechanical Reliability Modeling	■ Total Quality Management
■ Minimum Standards & Practices	■ VE Change Proposal
■ Modularization/ Mass Customization	■ Value Engineering
■ Owner Values & Expectations	■ Waste Minimization/ Pollution Prevention
■ Partnering	

2. Research Objectives

The primary research objective of this study is to provide a new VMP selection method for implementation on a particular capital facility project. To achieve this objective, VMP selection principles were identified that might affect the magnitude of benefit from each VMP. Based on these principles, a new selection method was proposed with a computerized application tool.

During this research, four secondary objectives were also established. They include the following:

- Development of structured knowledge of fragmentary VMPs.
- Characterization of VMPs by timing
- Quantification of relative impact among VMPs
- Identification of project characteristics that trigger the implementation of one or more VMPs

3. Background

Value Management is defined as any management process or effort to meet a client's expectations in association with project value objectives. Value Management is often interchangeably referred to as Value Analysis and Value Engineering in the literature. Value Analysis focuses on analyzing a product or project to reduce its cost without affecting its function (Miles 1972). Thus, sometimes Value Analysis is interpreted as a cost-reduction effort. Value Engineering, on the other hand, has evolved into a creative and systematic approach. While Value Engineering is defined as an "organized and creative approach to optimize cost and performance of a facility" (Dell'Isola 1982, Zimmerman et al. 1982), one of the recent definitions of Value Management is a "systematic approach to maximize a client's value by continuously auditing throughout all project phases" [mb1](Kelly et al. 1993).

The various types of VMPs were based on widely accepted standard project management processes, derived from various resources including American Society of Civil Engineers (ASCE), Society of American Value Engineers (SAVE), American Association of Cost Engineers (AACE), and other agencies or institutes such as CII and IPA. The nominated VMPs have been carefully and rigorously screened with following screening criteria.

- VMPs are non-conventional but relatively new management processes. Accordingly, cost control, master scheduling, and safety management are excluded.
- VMPs are optional, rather than essential, project management

processes.

- VMPs are either successfully proven or demonstrable process.
- should follow a relatively well-documented process.
- VMPs are significantly beneficial for capital facility projects.

Since the VMPs are relatively new and innovative, it is necessary to define each VMP in a structured manner. Key elements, including purpose and objectives, output or deliverable, optimal timing of implementation, and sequence of process, have been formalized. An example of a formalized VMP, or VMP descriptive profile, is illustrated in Appendix I.

To document the VMP descriptive profiles, a rigorous literature review has been conducted. In addition, experiences of the project practitioners including CII PT 184 have been incorporated. Finally, the profiles were revised and refined numerous times. The descriptive profile of the identified 44 VMPs consists of nine elements as seen in Appendix I. For additional information, author recommends to refer to the CII's Value Management Toolkit (O'Connor, et al. 2003).

- "Purpose and Objectives" describes why the VMPs should be implemented.
- "Primary Benefits" details how the VMPs can benefit a project.
- "Key Output or Deliverable(s)" deals with the end product of the VMPs.
- "Circumstances for Leveraged Application," describes the specific situations in which the VMPs have the highest impact.
- "Optimal Timing of implementation," indicates the best initiation timing for the VMPs.
- "Lead Organization(s) for Implementation," suggests who should guide the effort of each VMP.
- "Other Participants" describes the critical participant.
- "References for More Information" explains where more information can be found.
- "Sequence of Steps in the Process" illustrates how the respective VMPs are implemented.

At the time of this writing, the VMP selection is completely dependent on a manual-based process. The project value objective is a fundamental component in the VMP selection process. To achieve a project success, it is crucial to establish project objectives at the initial stage of a project (CII 1989). For the purpose of this paper, these project objectives are limited to 12 Project Value Objectives (PVOs). These 12 PVOs include:

- "Security of Personnel and Facilities,"
- "Operations/Maintenance Safety and Health"
- "Construction Safety and Health"
- "Regulatory Compliance"
- "Capital Cost Efficiency"
- "Operating Cost Efficiency"
- "Maintenance Cost Efficiency"
- "Project/Service Quality"
- "Construction Quality
- "Schedule Optimization"
- "Environmental Stewardship"
- "Containment of Risk and Uncertainty"

As a result of the group consensus reached by CII PT 184, each relationship between VMPs and PVOs has been determined. Table 2 represents the number of VMPs in association with each PVO.

Table 2. VMPs by Project Value Objectives

Project Value Objectives	# VMPs with Benefit
Security of Personnel or Facilities	14
Operations/ Maintenance Safety or health	15
Construction Safety & Health	14
Regulatory Compliance	17
Capital Cost Efficiency	35
Operating Cost Efficiency	29
Maintenance Cost Efficiency	28
Product or Service Quality	23
Construction Quality	18
Schedule Optimization	24
Environmental Stewardship	16
Containment of Risk or Uncertainty	37

As represented in Table 2, the frequently iterated PVOs are "Capital Cost Efficiency" (35) and "Containment of Risk and Uncertainty" (37). These results indicate that capital costs and risk containment are the primary concern in implementing most of the VMPs.

In addition to PVOs, the timing of implementation affects the maximum benefit of VMPs Many experts maintain that earlier effort is important in magnifying the benefit (Gibson et al. 1995) because the magnitude of benefit varies according to the initial timing of implementation of VMPs. Five major project milestones are used in determining the magnitude of benefit by timing of VMP implementation as follows:

- "Feasibility/planning phase".
- "Detail design phase"
- "Procurement phase"
- "Construction phase"
- "Operation/maintenance phase"

Finally, the optimum selection of VMPs depends on the leveraged project circumstances. In this paper, project characteristics are defined as project circumstances in need of implementing one or more VMPs. Project characteristics for each VMP have been identified based on a trial-and-error approach in association with a rigorous literature review and experienced knowledge of experts.

As a result of identifying the project factors, 149 project characteristics have been finalized and classified into 12 categories. These categories include "owner characteristics (4 items)," "project objectives/performance (18 items)," "budget/cost/economics (8 items)," "contracts/organization (16 items)," "site conditions/existing facility (13 items)," "facility scope and characteristics (18 items)," "technologies/manufacturing process (17 items)," "project design (19 items)," "facility operations/maintenance (17 items)," "materials/equipment/procurement/supply chain (5 items)," "site labor (4 items)," and "procedures and communications (10 items)."

4. Selection Principles

The schematic diagram of Figure 1 illustrates the interrelationship among VMP selection principles.

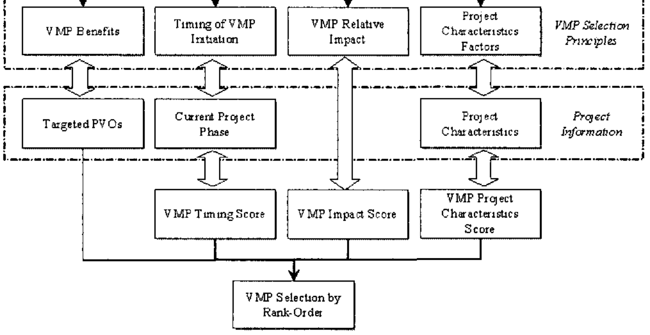


Figure 1. VMP selection principles

The first selection principle is PVO(s). The primary PVO(s) of a given project effectively eliminate any irrelevant VMPs from the pool. The second principle, the timing of VMP initiation, plays an important role in determining the maximum magnitude of benefit. Thirdly, the relative impact among VMPs is also included in the proposed selection process. According to a recent study, the level of enhancement in terms of project performance varies with different types of VMPs (Lee 2001). In addition, it is a common belief that each VMP has a different magnitude of impact on a project. Therefore, the relative impact of each VMP should be considered to be a significant factor in the selection process. The final selection principle is the project characteristics. How a project is characterized makes a big difference in the magnitude of benefit for a particular VMP.

To effectively apply these principles to the VMP selection process, scoring metric systems have been developed for timing, relative impact, and project characteristics. The "timing" metric system represents the maximum benefit that can be obtained at the current project phase, such as planning, design, procurement, construction, and operation/maintenance. This scoring system has been developed by comparing VMPs in terms of relative benefit at each project phase.

The "relative impact" metric system represents the magnitude of impact that can be fully achieved in implementing the respective VMPs. These scores have been developed by pair-wise comparison among 44 VMPs. The "project characteristics" metric system reveals the relationship between each VMP and its corresponding project characteristics.

The primary methodology used in developing these metric scoring systems was iterative internal workshops conducted by CII PT 184. It was not simple, however, to develop the "project characteristics" metric system because both the number of VMPs and the number of the project characteristics were enormously large. As a result, the Delphi technique was introduced to establish the project characteristics metric system. This technique is a useful tool to employ a pooled intelligence (Emory, et al. 1991). At first, the VMP experts who were knowledgeable in one or more VMPs were identified. To facilitate the data collection process, the relatively significant project characteristics were selected instead of listing all 149 factors. Then, the data collection tool, or VMP ballot, was developed to collect the relative importance of each project characteristic within the respective VMPs. For each VMP, the fivepoint likert scale (0: no importance, 1: low importance, 3: moderate importance, 5: high importance) was used. The final weights of the project characteristics were determined by averaging the scores given by each expert respondent. The total number in the expert respondents group was 51. One interesting finding from the data analysis is the identification of the top project characteristics that drive the need for VMP implementation. The top ranked project characteristics are effectively determined by analyzing the data collected. They include the following:

- Project objectives, functional requirements, and/or priorities are unclear or have not agreed upon.
- Reducing facility life cycle cost is an important objective.
- Owner lacks in-house resources for project development and execution.
- The project is very complex.
- Owner objectives/expectations are often in conflict.

The author recommends to refer to the CII's Value Management Toolkit for more detailed information.

5. Selection Tool Development

In Figure 2, the overview of the VMP selection logic is illustrated. The selection methodology is aimed at ranking the VMPs in terms of the magnitude of benefit by combining four selection principles.

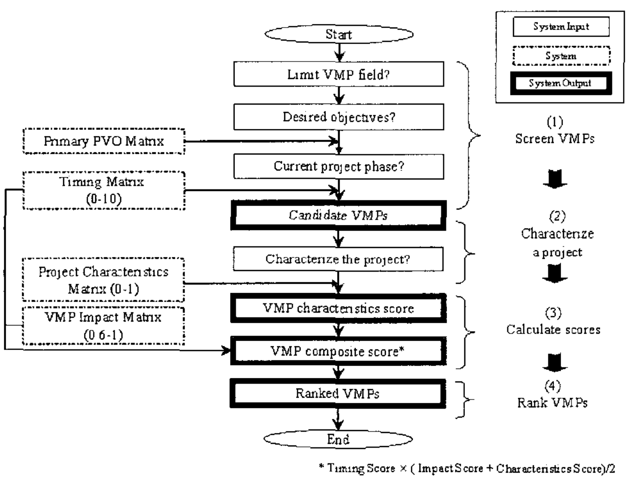


Figure 2. VMP Selection Tool Logic Flowchart

The proposed selection method involves four VMP matrixes (e.g., PVO matrix, timing matrix, relative impact matrix, and project characteristics matrix) as described in the previous sections. These matrixes are all combined into the composite score to rank the suitability of VMPs for a project except for the PVO matrix. The PVO matrix is used in filtering high-potential VMPs. Once the candidate VMPs are established by using the PVO matrix or ruling out the irrelevant VMPs, the current project phase is required to be input into the selection system. The timing matrix at this time is used to derive the timing scores of the candidate VMPs. It is also required that the system users single-out the current project phase from five options (e.g., feasibility/planning, detailed design, procurement, construction, and operations/maintenance). The third matrix of the project characteristics functions to score the VMPs using the project characteristics metric system. This matrix enables the selection of the relevant project characteristics linked to the candidate VMPs. If the list of the project characteristics is completed in the system, the users requires to evaluate each characteristic factor with an option of either agreement or disagreement. The candidate VMPs are scored by summing up the weights of the project characteristics based on the user's characterization of a given project. The final relative impact matrix functions to score the candidate VMPs in terms of the relative magnitude of impact.

A single meaning measure was used to combine the three VMP scores, i.e., timing score, relative impact score, and project characteristics score. This composite score is computed using the following equation:

VMP Composite Score = Timing Score X (Impact Score + Project Characteristics Score)/2

Using the equation above, the candidate VMPs are effectively quantified in terms of the applicability for the subject project in a range from 0 and 10. The average of the Impact Score and the Project Characteristics Score, which is multiplied by the Timing Score, represents how powerful a VMP is for the subject project and plays a role in modifying the maximum VMP timing benefit from implementation on the particular project

A computerized application tool was designed to effectively facilitate the VMP selection using computer software programs: Microsoft ExcelTM and Visual Basic Application (VBA). The Tool was developed based on nine graphical user-interface screens in the Excel Worksheets. They include the following:

- Introduction
- Project Information
- VMP Screening

- Desired Benefits
- VMP Exclusion
- VMP Confirmation
- Project Characteristics
- VMP Recommendation
- VMP Drivers

The introduction screen of this program is illustrated in Figure 3. Each screen above is interlinked via the VBA program for ExcelTM. A brief instruction is shown in the "Introduction" screen. The second "Project Information" screen requires users to input the project information (e.g., project name, project number, project location, owner company, evaluator(s) name, and evaluation date). The third screen, "VMP Screening," enables users to choose an option to limit the candidate set of VMPs. The purpose of VMP screening is to limit the number of VMPs by filtering only high-impact VMPs. The screening process can be achieved by either using the PVO matrix or eliminating specific VMPs.

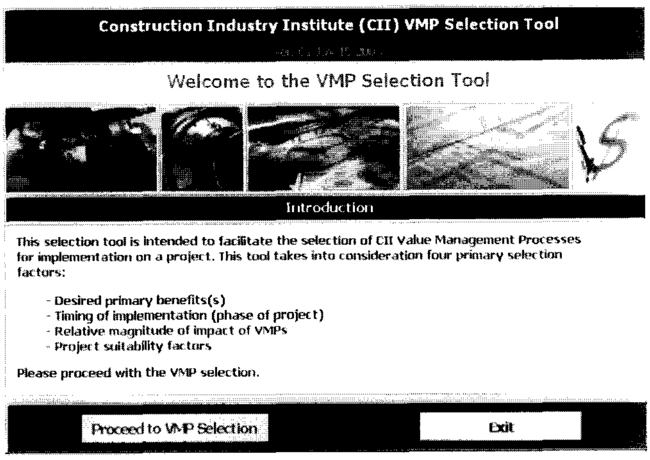
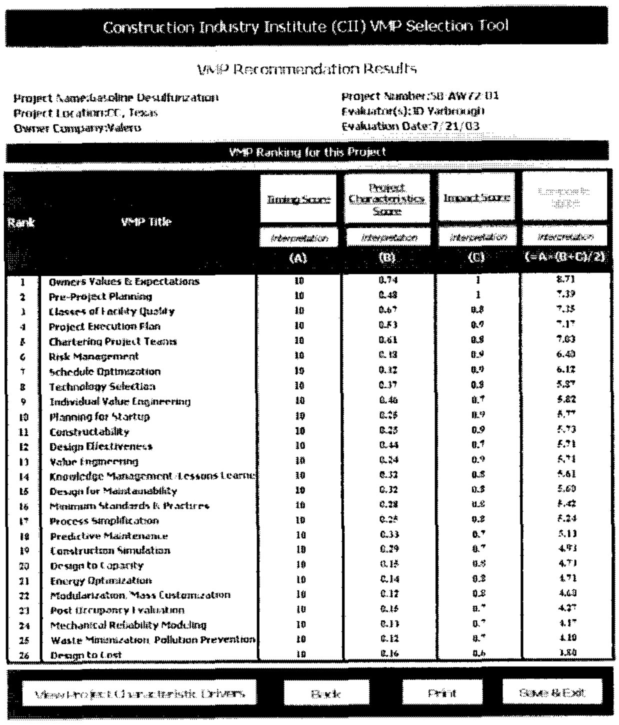


Figure 3. VMP Selection Tool Introduction Screen

Under the "VMP Screening," there are two optional screens. One optional screen is the "Desired Benefit" that contains the listing of 12 project value objectives with option buttons attached to the respective value objectives so that the candidate VMPs can be elicited based on the users' input. The second optional screen is the "VMP Exclusion" that enables the users to eliminate any VMPs listed on the screen by activating the corresponding VMP option buttons. The "VMP Confirmation" screen helps the users to reassure the candidate VMPs and enables them to finalize the set of VMPs to be considered in the selection process. The "Project Characteristics" screen enables the users to characterize the project by answering each project characteristic statement that is generated based on the project characteristics matrix. The resulting screen of "VMP Recommendation" shows the rank-order of the candidate VMPs by composite score as pictured in Figure 4.

The final screen, "VMP Drivers," shows the justification of the rank-order by listing the high-scored project characteristics of the recommended VMPs. This screen is helpful to predict the vulnerability of the project in the context of project value improvement.



Rank	VMP Title	Timing Score (Interpretation) (A)	Project Characteristics Score (Interpretation) (B)	Impact Score (Interpretation) (C)	Composite Score (Interpretation) (=A×(B+C)/2)
1	Owners Values & Expectations	10	0.74	1	8.71
2	Pre-Project Planning	10	0.48	1	7.39
3	Classes of Facility Quality	10	0.67	0.8	7.35
4	Project Execution Plan	10	0.53	0.9	7.17
5	Chartering Project Teams	10	0.61	0.8	7.03
6	Risk Management	10	0.18	0.9	6.40
7	Schedule Optimization	10	0.32	0.9	6.12
8	Technology Selection	10	0.37	0.8	5.87
9	Individual Value Engineering	10	0.46	0.7	5.82
10	Planning for Startup	10	0.26	0.9	5.77
11	Constructability	10	0.25	0.9	5.73
12	Design Effectiveness	10	0.44	0.7	5.71
13	Value Engineering	10	0.24	0.9	5.71
14	Knowledge Management /Lessons Learne	10	0.32	0.8	5.61
15	Design for Maintainability	10	0.32	0.8	5.60
16	Minimum Standards & Practices	10	0.28	0.8	5.42
17	Process Simplification	10	0.25	0.8	5.24
18	Predictive Maintenance	10	0.33	0.7	5.13
19	Construction Simulation	10	0.29	0.7	4.93
20	Design to Capacity	10	0.15	0.8	4.73
21	Energy Optimization	10	0.14	0.8	4.71
22	Modularization, Mass Customization	10	0.12	0.8	4.63
23	Post Occupancy Evaluation	10	0.16	0.7	4.37
24	Mechanical Reliability Modeling	10	0.13	0.7	4.17
25	Waste Minimization, Pollution Prevention	10	0.12	0.7	4.10
26	Design to Cost	10	0.16	0.6	3.80

Figure 4. VMP Selection Tool Results Screen

6. VST Validation

The VMP Selection Tool (VST) was tested through application on the real projects. At the time of this writing, five volunteered project were participated in the validation test. The VST validation was accomplished by comparing the manual-based-outcome with the Tool-based outcome. The results of VST validation test are provided in Table 3.

The author developed two quantitative validation indicators to further effectively analyze the test results:

- Match Rate: The proportion of the top ten VMPs from the manual-based method ranked among the top ten VMPs recommended by the Tool

- Consistency Rate: The proportion of the matched VMPs (between the manual-based and the Tool-based methods) within four-step rank change by the Tool.

As shown in Table 3, the averages of both the Match Rate (76%) and the Consistency Rate (77%) turned out to be fairly high. Although the number of volunteered projects is limited, the resulting values of the two indicators quite support the validity of the Tool. A sensitivity analysis was conducted to determine whether an optimum Composite Score algorithm exists. From the analysis, no dominant or preferred coefficients resulted in maximizing both Match Rate and Consistency Rate. As such, it is recommended that the proposed Composite Score algorithm be verified in a future study by expanding the validation test projects.

Table 3. Validation test results

Test No.	Project Type	Participant Type	No. of Pooled VMPs	Match Rate(%)	Consistency Rate(%)
1	Industrial/Large	E/P	20	70	86
2	Industrial/Large	Owner	15	80	63
3	Industrial/Med	A/E	11	90	78
4	Industrial/Med	E/P/C	14	90	78
5	Building/Med	Owner	29	50	80
Average of all five tests				76	77

7. Conclusions

The construction industry environment has become "mega-challenging" because of both internal and external factors. Internally, construction projects are more integrated and complicated. From the external perspective, the business climate is highly competitive and involves numerous project stakeholders within a single project. To surmount these difficulties, the Value Management Processes (VMPs) are introduced and proven effective in the construction industry. Overwhelmed by the number of these VMPs, the conventional selection process has been only dependent on hit-and-miss approach thereby resulting in the failure to select the best-fit VMPs for a particular project. This paper proposes an unprecedented selection methodlogy for the purpose of systematically pointing out the most suitable VMPs for individual capital facility projects. This newly developed selection method is based on the identification and quantification of the selection principles (e.g., Project Value Objectives (PVO), timing of initiation, relative impact, and project characteristics).

Furthermore, a computerized application tool has been developed to facilitate this selection process. The preliminary pilot tests of this tool effectively rank-ordered the selected 44 VMPs. Additionally, the present study identified 149 leveraged project characteristics that can trigger one or more VMPs. Based on the knowledgeable expert input, the significant project characteristics in need of VMPs were also identified.

As a pioneering research, this paper contributes to a growing area of research not only by providing comprehensive and structured knowledge of VMPs, but also by developing a selection tool to pinpoint the most beneficial VMPs. From the industry perspective, the results of this study, especially the computerized selection tool, facilitate the implementation of the VMPs.

However, an in-depth tool validation should be conducted by expanding the number of projects and modifying the proposed composite score algorithm. Although the project characteristics are identified and quantified in this study, a more rigorous investigation can be made by expanding the respondent VMP expert pool. Further research can also pursue the synergetic effect on VMPs by determining the benefit of combining VMPs, because the magnitude of benefit can vary according to the collaboration of two or more VMPs.

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Appendix I. Example of VMP Descriptive Profile

VM Process:	Function Analysis Concept Development ("FAC-D")

Purpose & Objectives:

- To efficiently and quickly "rough-out" an agreed-upon conceptual design for the facility and resolve all significant design and budget issues through an intense 2-week workshop involving all key stakeholders and design personnel
- A scaled-down 3 to 5 day version (called a "charette") is another option for smaller, less complicated projects

Primary Benefit(s):

- Buy-in of conceptual design by customer authority and facility users
- Early documentation and resolution or tasking of all significant design and budget issues/conflicts
- Early Value Engineering analysis where appropriate, thereby enhancing capital cost value and operating cost value
- Partnering-like team-building effects, including alignment of all key stakeholders on approval of the conceptual design
- Project review at 35% design complete that has few surprises and is more easily accomplished
- Reduced need for subsequent redesign, change orders, etc.; may experience some acceleration in the overall design phase
- Identification of key contacts needed for the detailed design phase

Key Output or Deliverable(s):

- "Best value" agreed-upon conceptual design for facility that is within budget
- Clear understanding of remaining issues needing attention/resolution

Circumstances for Leveraged Application:

- For projects with multiple unaligned customers or customers with conflicts
- For the most challenging projects, which may be technically complex or unique
- For projects with tight budgets and TIC over $5 Million
- For foreign projects involving diverse stakeholders

Optimal Timing of Implementation:

- Two-week workshop should be scheduled to begin two to three months after the start of conceptual design; This will allow adequate time for site survey, customer interviews, and development of first conceptual design for critique/feedback during the workshop

Lead Organization(s) for Implementing:

- Owner project management
- Planning/design contractor
- Independent experienced facilitator that leads the process and helps ensure quality of output

Other Participants:

- Authoritative, knowledgeable facility customer representatives committed to the process
- Adequate senior experienced design specialists (e.g., mechanical, electrical, architectural, etc.)
- Experienced qualified cost estimator equipped with all needed data resources

References for More Information:

Value Engineering specialists from the Naval Facilities Engineering Command
Pena, William, Parshall, Steven, and Kelly, Kevin, Problem Seeking: An Architectural Programming Primer, AIA Press, Washington, 1987

Appendix I. Example of VMP Descriptive Profile(Continued)

VM Process:	Function Analysis Concept Development ("FAC-D")

Sequence of Steps in Process: