EXTENDING THE IMPACT OF DFMA BEYOND PRODUCT DEVELOPMENT TO CAPITAL INVESTMENT PROJECTS

How tools and techniques used in product development can be leveraged to improve the return on investment and viability of capital projects

Dantar Oosterwal

Sr. VP & Partner, ARGO-EFESO | D.Oosterwal@ArgoConsulting.com

Title: Extending the Impact of DFMA beyond Product Development to Capital Investment Projects

Abstract:

This paper explores the transformative potential of applying Design for Manufacture and Assembly (DFMA) principles and Value Engineering (VE) beyond product development to capital investment projects. In today's challenging economic environment, the escalating cost of capital has made many capital projects non-viable, impacting their return rates. However, by leveraging the tools and techniques derived from DFMA and VE, organizations can not only achieve substantial cost savings, but in many cases resurrect killed projects through enhancing their viability.

Through a series of first-hand case studies and industry examples, we demonstrate how integrating DFMA and VE principles into the design and planning phases of capital projects can turn non-viable ventures into profitable endeavors. By altering the design through DFMA, supporting procurement through cost modeling, and optimizing resource utilization, organizations can identify cost-saving opportunities throughout the project lifecycle, allowing organizations to reduce the overall investment cost of a project as much as 30% to 40% drastically improving their return on investment.

Furthermore, the paper highlights the role of VE as a mechanism for cost reduction in projects that are past the Front-End Engineering Design (FEED) stage. By applying VE methodologies, organizations can identify and eliminate unnecessary costs, streamline project execution, and enhance project feasibility.

In conclusion, this paper underscores the critical role that DFMA and VE play in transforming the cost structure of capital projects, making them more resilient to economic uncertainties and ultimately enhancing their overall viability and return on investment as an extension of the DFMA techniques traditionally reserved for Product Development.

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

Author's Bio

Dantar Oosterwal is a renowned expert in Lean Product Development, with a distinguished career spanning over two decades. He has made significant contributions to the lean development community as well as driven the application of Design for Manufacture and Assembly (DFMA) and Value Engineering (VE) principles across various industries. Dantar holds a bachelor's degree in Mechanical Engineering from the University of Michigan and a master's degree in Business from the Massachusetts Institute of Technology (MIT).

Dantar's professional journey includes leadership roles at iconic companies such as Harley-Davidson and General Motors. At Harley-Davidson, he implemented groundbreaking lean product development methods, resulting in a five-fold increase in development throughput. Additionally, he established cost engineering and brought design-to-cost methodologies to the company, leading to substantial cost savings and enhanced efficiency. His tenure saw him institute DFMA and VE methodologies that further underscored his passion to optimize value and improve product quality.

In addition to his corporate accomplishments, Dantar is a published author. His books, "The Lean Machine: How Harley-Davidson Drove Top-Line Growth and Profitability with Revolutionary Lean Product Development" and "Visible Knowledge for Flawless Design," have been widely acclaimed for their insights into lean product development and practical applications in the manufacturing industry. His writings and thought leadership have influenced a broad spectrum of industries, including aerospace, automotive, energy, and telecommunications.

Currently, Dantar is a Senior Vice President and partner with ARGO-EFESO Consulting, where he leads the Idea to Value practice for the Americas. In this role, he continues to drive innovation and efficiency improvements for clients, leveraging his extensive experience and expertise in Lean Development, DFMA and VE principles.

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

Introduction:
Throughout my career, my experience in Design for Manufacturing and Assemble as well as value engineering and cost engineering have been focused on the design of products. My career has been one passionate about innovation and developing new products. Recently we have had a number of clients ask for support in improving their investment expenditures in capital projects. In working with our clients in the adoption of product development techniques to capital projects, I have come to realize that tools and techniques we have used in product development are applicable in a more extended aspect of engineering and design; in particular, the impact these tools and techniques can have on capital projects.

Overview of the Principles

Design for Manufacture and Assembly (DFMA) and **Value Engineering (VE)** are two key methodologies that have been instrumental in optimizing product development design and reducing costs across various industries. Both methodologies aim to improve efficiency, reduce waste, and enhance overall product quality, but they approach these goals from slightly different angles.

Design for Manufacture and Assembly (DFMA)

In its simplest form, DFMA can be described as a systematic approach aimed at simplifying product design for ease of manufacturing and assembly. (In the case of DFx, this list is extended to include, service, recycling, etc. where x represents any number of attributes important for the business and apply equally throughout this paper.) The principles of DFMA focus on reducing the complexity of products, minimizing the number of parts, and ensuring that components can be easily and cost-effectively manufactured and assembled. Key principles include:

- **Design Simplification**: Simplifying the design by reducing the number of parts and using modular components. This reduces the potential for assembly errors and the need for specialized assembly processes.
- **Standardization**: Using standard parts and materials to reduce costs associated with procurement and inventory management. Standardization also facilitates easier assembly and maintenance.
- **Ease of Assembly**: Designing components in a way that makes them easy to handle, orient, and assemble. This includes considering factors such as part symmetry, the use of snap-fits or other simple fastening methods and minimizing the need for specialized tools.
- **Process Optimization**: Ensuring that the design is compatible with existing manufacturing processes to avoid the need for new, expensive production techniques. This involves close collaboration between design engineers and manufacturing teams.

The implementation of DFMA leads to a reduction in production costs, shorter assembly times, improved product quality, and increased reliability. It is particularly valuable in industries where high production volumes and complex products are common, such as automotive, electronics, and consumer goods.

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

Value Engineering (VE)
In basic form, Value Engineering (VE) is a methodical approach to improving the value of a product or project by analyzing its functions and finding ways to achieve those functions at a lower cost without compromising quality or performance. VE should typically be applied during design and development of a product, but it can also be used in later stages of a project. Key principles of VE include:

- **Function Analysis**: Identifying and understanding the essential functions of a product or system. This involves breaking down the product into its components and understanding the purpose and contribution of each part.
- **Cost-Benefit Analysis**: Evaluating the cost and benefit of each function to identify opportunities for cost reduction. This may involve comparing different materials, manufacturing processes, and design alternatives.
- **Creative Problem Solving**: Encouraging innovative thinking and brainstorming to find alternative ways to achieve the required functions at a lower cost. This may include exploring new materials, technologies, or design concepts.
- **Team Collaboration**: Involving cross-functional teams, including designers, engineers, manufacturers, and procurement specialists, to ensure that all perspectives are considered in the value engineering process.

The goal of VE is to maximize the value of the product or project by achieving the optimal balance between function, cost, and quality. VE is widely used in automotive, white goods, construction, and consumer products industries to enhance project feasibility, reduce costs, and improve performance to maximize value.

Integration of DFMA and VE Principles
While DFMA focuses on simplifying design for manufacturing and assembly, VE takes a broader approach to cost reduction by analyzing and optimizing the value of each function. When integrated, these methodologies provide a powerful toolkit for enhancing product development and capital investment projects. By applying DFMA principles during a product's initial design and incorporating VE strategies throughout the project lifecycle, organizations can achieve substantial cost savings, improve efficiency, reduce time to market, and enhance the overall viability of their projects.

Typically, these techniques have been applied in high volume environments often driven by low margins and highly competitive markets. This paper explores the impact of extending these principles beyond traditional product development into the realm of capital investment projects, which may be low volume or one-off builds demonstrating how the integration of DFMA with VE can drastically transform cost structures and improve project returns in today's challenging economic environment.

The Significance of Capital Investment across Various Industries
Capital investment projects are crucial for the growth and development of business and impact certain industries particularly hard. The investments in these projects typically involve significant financial outlays to acquire, upgrade, or maintain physical assets such as buildings,

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

machinery, and infrastructure. The success and viability of these projects are critical for the long-term sustainability and competitiveness of companies within these industries and in turn reflect a significant percentage of the final product or service cost. The size of these investments in capital and subsequent anticipated returns can often derail a project due to being financially non-viable.

Oil and Gas Exploration and Production

The oil and gas industry is characterized by high capital investment requirements. Exploration and production projects often require extensive investments in drilling rigs, production facilities, and transportation infrastructure. According to the International Energy Agency (IEA), global capital expenditures in the oil and gas sector amounted to approximately $483 billion in 2022. Capital equipment costs alone can represent 10% to 30% of the total cost of producing oil and gas products. For example, in deepwater drilling projects, capital expenditures can exceed $100 million per well, underscoring the financial intensity of these operations.[i]

Aerospace and Defense

The aerospace and defense industry also demands substantial capital investments, particularly in research and development (R&D), manufacturing facilities, and specialized equipment. Capital expenses can account for 20% to 40% of the total cost of producing aerospace products. Boeing, for instance, invested $4.3 billion in capital expenditures in 2021, highlighting the significant financial commitments required to maintain and advance their manufacturing capabilities.[ii]

Semiconductor Manufacturing

Semiconductor manufacturing is one of the most capital-intensive industries, with fabrication plants (fabs) requiring investments that can exceed $10 billion each. Capital equipment costs typically represent 30% to 50% of the total cost of producing semiconductor chips. According to the Semiconductor Industry Association (SIA), global semiconductor capital expenditures reached $153 billion in 2021, driven by the need for advanced manufacturing technologies and capacity expansion.[iii]

Automotive Manufacturing

In the automotive industry, capital investments in production facilities, assembly lines, and robotic systems are essential. These investments can constitute 20% to 40% of the total cost of producing vehicles. For example, General Motors reported capital expenditures of $7 billion in 2021, reflecting ongoing investments in electric vehicle production and automation.[iv]

Mining and Metals

The mining and metals industry involves substantial capital investments in exploration, mine development, heavy machinery, and processing plants. Capital equipment costs can account for 20% to 40% of the total cost of producing minerals and metals. In surface mining, capital expenses typically range from 20% to 50% of total product cost, while in underground mining, they can range from 30% to 60%. These investments are critical for accessing and processing raw materials efficiently.[v]

Energy Generation and Utilities

The energy generation and utilities sector require significant capital investments in power plants, renewable energy facilities, transmission lines, and distribution networks. Capital equipment costs often represent 30% to 50% of the total cost of producing electricity and providing utility services. For instance, capital expenditures in the U.S. utility sector were approximately $140 billion in 2020, driven by investments in infrastructure upgrades and renewable energy projects.[vi]

Telecommunications

The telecommunications industry demands substantial capital expenditures to build and expand network infrastructure, including fiber-optic cables, cellular towers, and data centers. Capital equipment costs typically range from 10% to 30% of the total cost of providing telecommunications services. In 2021, major U.S. telecommunications companies collectively invested over $70 billion in capital expenditures, reflecting the ongoing need to enhance network capacity and coverage.[vii]

Chemical Manufacturing

The chemical manufacturing industry involves significant capital investments in production facilities, chemical processing equipment, and research laboratories. Capital equipment costs can account for 20% to 40% of the total cost of producing chemicals and specialty products. Companies in this sector continually invest in capacity expansion and process improvements to meet market demand and regulatory requirements.[viii]

Biotechnology and Pharmaceuticals

Biotechnology and pharmaceutical companies require substantial capital investments in research and development, clinical trials, and manufacturing facilities. Capital equipment costs may represent 30% to 50% of the total cost of developing and manufacturing drugs and biotech products. In 2021, the top 20 pharmaceutical companies spent a combined $91 billion on capital expenditures and R&D, underscoring the financial commitment to innovation and production capacity necessary in this industry.[ix]

Renewable Energy

The renewable energy industry, including solar, wind, and hydroelectric power, involves significant capital investments in developing and installing renewable energy systems. Capital equipment costs typically represent 30% to 50% of the total cost of renewable energy projects. Global investments in renewable energy reached $366 billion in 2021, driven by the need to transition to sustainable energy sources and reduce carbon emissions.[x]

The Impact of High Capital Expenses

High capital expenses can significantly influence the feasibility and profitability of projects within these industries. The substantial financial outlays required for capital equipment and infrastructure can pose significant challenges, particularly in an environment of rising capital costs. As we’ve seen interest rates rise in recent years this has served to compound the importance of reducing capital expenditures both at a company level in the amount available to spend as well as at a project level to achieve the returns necessary to make projects viable. The

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

ability to optimize these expenses through methodologies such as Design for Manufacture and Assembly (DFMA) and Value Engineering (VE) can make a critical difference in project viability, return on investment (ROI), and overall financial performance of a company.

Extending DFMA to Capital Investment Projects

The principles of Design for Manufacture and Assembly (DFMA) and Value Engineering (VE) have long been recognized for their effectiveness in reducing costs and improving efficiencies when effectively applied during the product development process. As the name implies, the focus has largely been on improvements to *Manufacturing* and *Assembly* methods by designing differently, generally this thinking is applied to high volume low margin products with highly repetitive manufacturing and assembly tasks or motions. Extending these principles to capital investment projects represents a strategic evolution that can yield significant benefits in terms of cost savings, project viability, and return on investment (ROI). In this case we are applying these same principles to very high cost, very low volume, or even one-off units.

Definition and Importance of Capital Investment Projects

In this case, we will refer to capital investment projects as large-scale endeavors that involve significant financial resources to acquire, upgrade, or maintain physical assets such as buildings, machinery, and infrastructure. These projects are vital for the growth, sustainability, and competitive edge of various industries, including oil and gas, aerospace, automotive, mining, energy, telecommunications, and many more. The success of these projects is critical as they often determine the operational capacity, efficiency, and market position of the organizations involved.

Given the high stakes for the business and the significant outlay of resources, optimizing the cost structure and execution of capital investment projects in a timely manner is paramount. This is where the application of DFMA and VE principles can make a transformative difference.

Rationale for Applying DFMA Principles to Capital Projects

The rationale for applying DFMA principles to capital projects lies in the potential for substantial cost reductions, simplified project execution, reduced time to market, and enhanced project outcomes. The traditional focus of DFMA on product development—minimizing part count, standardizing components, and designing for ease of assembly—translates effectively into the context of capital projects. Here’s how DFMA principles can be adapted:

Design Simplification

Just as DFMA aims to simplify product designs to reduce manufacturing complexity, similar strategies can be employed in capital projects to simplify build and construction processes. By minimizing the number of unique components and using modular designs, projects can achieve faster construction times, reduced error rates, and lower labor costs.

Standardization

Standardizing materials and components within and across capital projects can lead to bulk purchasing discounts, reduced inventory costs, and streamlined maintenance processes. This approach not only simplifies the assembly and installation processes and lowers procurement cost, but also lowers maintenance cost long-term.

Ease of Assembly
Designing components and structures for ease of assembly ensures that less time and fewer resources are required during the construction phase. This includes considering factors such as part symmetry, the use of prefabricated modules, and minimizing the need for specialized tools or reducing skilled labor. For instance, prefabricated modular units can be assembled off-site and then transported to the project location, significantly reducing on-site construction time and costs. We often think of reducing time in repetitive tasks in high volume, but this thinking applies equally well when you consider the number of repetitive tasks associated with hangers for piping, for example.

Process Optimization
Ensuring that the project design is compatible with existing construction and manufacturing processes avoids the need for new, expensive techniques. Collaboration between design engineers and construction teams is essential to align design decisions with practical execution capabilities. This can involve using virtual simulations and digital twins to optimize the design before actual construction begins.

Potential Benefits: Cost Reduction, Improved ROI, and Project Viability
By integrating DFMA principles into capital investment projects, organizations can realize several significant benefits:

Substantial Cost Reductions
Applying DFMA coupled with VE can lead to cost reductions of 30% to 40% in capital investment projects. Simplified designs, standardized components, and optimized assembly processes contribute to lower material, labor, and overhead costs. We have found that this level of savings can make previously non-viable projects financially attractive.

Improved Return on Investment (ROI)
Cost savings directly enhance the ROI of capital projects. With lower upfront investment costs and faster time to market, the financial returns from the project become more attractive. This is particularly important in the current economic climate, where the cost of capital is rising, and investors are increasingly scrutinizing the resource outlay of large projects.

Enhanced Project Viability
Many capital projects are shelved or canceled due to high estimated costs and extended timelines. By adopting DFMA and VE principles, projects can be re-evaluated and potentially resurrected with a more favorable cost structure and streamlined execution plan. This enhances their viability and aligns them with strategic business objectives.

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

Improved Quality
Similar to what is seen in the case of high-volume products, the application of DFMA and VE improves the quality of the product. By standardizing work whether it is repetitive or one-off, and optimizing the design to make it easier for the worker can drastically reduce quality defects.

Reduced Time to Construct
In our traditional applications, one of the benefits we see on the product side is a reduction in the time to produce or assemble a product. This similarly carries over into the capital projects world with a reduced time to construct and greater predictability in project completion resulting in faster time to market or a project coming on-line.

Incorporating VE in Later Stages of Project Development

DFMA is particularly effective during the initial design phases, which we refer to as Design-to-Cost or Design-to-Value and we highly recommend adopting both DFMA and VE in this stage of a project. Nevertheless, Value Engineering (VE) can play a crucial role in later stages, especially post-FEED (Front-End Engineering Design) in capital projects. VE focuses on analyzing project functions and identifying opportunities to reduce costs without compromising quality or performance. With a completed FEED, there is plenty for a team to evaluate and scrutinize.

Post-FEED Stage Application
After the initial design is complete, VE teams can conduct a thorough review to identify and eliminate unnecessary costs. This may involve re-evaluating material choices, construction methods, and design features to find more cost-effective alternatives to maximize value.

Identifying and Eliminating Unnecessary Costs
VE methodologies involve a systematic analysis of each component and process to ensure that it adds value to the project. Non-essential features or overly complex designs are streamlined or eliminated, resulting in significant cost savings.

Streamlining Project Execution
By optimizing the design and construction processes, VE helps to streamline project execution, reducing the time and resources required to complete the project. This not only lowers costs but also minimizes project risks and enhances the likelihood of on-time delivery.

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

Case Study 1: Demonstrating the Impact of combining DFMA and VE through VE-360™

Client Background and Challenge

Our client, a global leader in their industry, faced a critical challenge. They had developed an innovative processing technology that promised significant long-term benefits for their business. However, the capital expense required to transition to this new technology rendered the project non-viable. The amortization of the capital into the product cost made the approach prohibitive, threatening the viability of this strategic initiative. The project involved constructing an entirely new plant in a greenfield location and introducing new processing lines. Although early prototyping in brownfield facilities had shown promise, the capital investment required for the full-scale implementation made the project non-viable.

Project Scope and Initial Strategy

The client engaged us to help them reduce the capital costs to make the project viable. Given the project's scale, we decided to break the effort into functional areas, starting with the facility's piping. Piping was chosen for the pilot phase because it was past the FEED stage, with designs considered stable enough to provide a reliable basis for our approach. Although the client initially believed there was little opportunity for cost savings in the piping area, our experience suggested otherwise.

Application of VE-360™

We applied our VE-360™ approach, which integrates Value Engineering (VE), Design for Manufacture and Assembly (DFMA), and cost modeling tools. VE-360™ is a structured methodology we've developed over 20 years of helping customers and involves five steps across three stages: Define, Design, and Deploy. The entire effort across all steps took approximately 14 calendar weeks.

Stage 1: Define

Preparation Step: We began with comprehensive preparation, which involved gathering all relevant data and documentation about the piping system. This included design specifications, cost estimates, and operational requirements. We also identified key stakeholders and assembled a cross-functional team that included engineers, designers, procurement specialists, project managers, manufacturing experts, assembly teams, processing specialists, and suppliers.

Stage 2: Design

Ideation Workshop: Within the 14 weeks, we conducted a week-long ideation workshop. The team brainstormed potential cost-saving opportunities through a structured, facilitated process. Facilitating the team through various DFMA principles, we challenged existing assumptions and explored alternative designs and approaches. The focus was on simplifying designs, reducing material usage, and improving assembly efficiency.

The team generated a total of 388 ideas during the workshop. These ideas encompassed a wide range of potential improvements, from material substitutions to process optimizations.

Proposal Development: After the ideation workshop, we developed detailed proposals for the most promising ideas. Out of the 388 ideas generated, 140 proposals were crafted. These proposals included design modifications, alternative materials, and new assembly methods. Each proposal was rigorously analyzed for feasibility and potential cost savings.

Stage 3: Deploy

Consolidation: In this step, we consolidated the proposals into a cohesive plan. This involved integrating the selected ideas into the overall project design and ensuring that all changes were compatible with the existing project scope and requirements. Out of the 140 proposals, 102 were consolidated for further validation. This step also involved some detailed cost modeling to evaluate the financial impact of ideas.

Validation: Finally, we validated the proposed changes through sending the proposals to suppliers for actual quotations to validate our predictions. This step ensured that the proposed cost-saving measures would not compromise the project's technical or operational integrity and that the cost savings we anticipated could be achieved in reality. Of the 102 proposals validated, 37 were recommended for implementation. These included:

- **26 proposals** that drove direct cost savings.
- **7 proposals** with no quantifiable savings but recommended due to anticipation of enhancing the total cost of ownership.
- **4 proposals** that negatively impacted the cost but were recommended for their enhancements in areas such as safety.

Of the 26 savings proposals, 17 had a confidence level greater than 75% and could be implemented immediately. The combination of these 17 ideas generated a savings of 39% for the project in the piping area we evaluated.

Results and Impact

The VE-360™ approach is a proprietary approach developed by ARGO-EFESO consulting over 20 years of working with our clients which combines DFMA, VE, and cost modeling. In this case, the team’s efforts resulted in a remarkable 39% reduction in capital expenditure for the piping system. This significant cost saving was achieved by:

1. Simplifying the piping design to reduce material usage.
2. Standardizing components to streamline procurement and reduce inventory costs.
3. Optimizing the assembly process to minimize labor costs and time.

The success of the pilot phase demonstrated the potential of our approach and provided a strong foundation for applying the VE-360™ approach more broadly to other areas of the project. By systematically addressing each functional area, these savings across the entire plant construction and processing lines, ultimately make the project financially viable.

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

Conclusion

This case study illustrates the transformative power of integrating DFMA and VE principles through our VE-360™ approach. By breaking down the project into manageable functional areas and applying a structured methodology, we achieved substantial cost savings, turning a previously non-viable project into a profitable and sustainable venture. The collaborative efforts of a cross-functional team, over a span of 14 weeks, ensured that all aspects of the project were meticulously analyzed and optimized. This success underscores the importance of innovative approaches in managing capital investment projects, particularly in industries facing escalating costs and economic uncertainties.

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

Case Study 2: Unlocking 'Stuck Projects' with VE-360™

Client Background and Challenge

Our client, a large global Engineering, Procurement, and Construction (EPC) company, was grappling with a series of 'stuck projects.' These projects, typically around $5 billion in scope, had progressed through the Front-End Engineering Design (FEED) stage but were subsequently put on hold by their customers due to financial viability concerns. Although the company routinely conducted Value Engineering (VE) as part of their development process, these efforts had not yielded the necessary savings to move the projects forward.

An individual within the company was exposed to our VE-360™ approach and believed that the integration of VE, DFMA, and cost modeling could provide the breakthrough they needed. However, the organization as a whole was skeptical. To demonstrate the potential of our method, we agreed to conduct a three-day mini workshop focusing on a very small portion of one 'stuck' project, taking it through to the proposal development step for evaluation of the VE-360™ process.

Project Scope and Initial Strategy

The selected project was an infrastructure initiative for a mine extension that had been put on hold due to capital cost concerns. This project had already undergone two separate VE efforts at the EPC's customer request, with limited success. Given the skepticism within the organization, the project manager candidly expressed doubt about achieving even a 2% savings.

We decided to conduct a three-day mini workshop involving a small cross-functional team. This team included representatives from engineering, procurement, and cost modeling, ensuring a comprehensive perspective. Our goal was to demonstrate the potential of our VE-360™ approach, even within the limited scope of a three-day workshop.

Application of VE-360™

The VE-360™ approach we employed integrates Value Engineering (VE), Design for Manufacture and Assembly (DFMA), and cost modeling tools. Despite the short timeframe and minimal scope, we followed our structured methodology through the initial stages: Define and Design in a very abbreviated fashion.

Stage 1: Define

Preparation Step: Extensive preparation preceded the workshop. We gathered all relevant project data, including design specifications, cost estimates, and operational requirements. We also ensured that the small cross-functional team was prepared to engage in the process.

Stage 2: Design

Ideation Workshop: The three-day workshop began with an ideation session. Despite the short duration, the team was able to generate nearly 150 new ideas, a significant number given the project's previous VE efforts. Using DFMA principles, the team challenged existing assumptions, explored alternative designs, and considered new materials and methods. The focus was on simplifying designs, reducing material usage, and improving assembly efficiency.

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

Proposal Development: Following the ideation session, we developed high-level proposals for the most promising ideas. The proposals included design modifications, alternative materials, and new assembly methods. The potential cost savings and technical impacts were assessed for each of the proposals within the limited scope of the mini workshop.

Results and Impact

The VE-360™ effort, which integrates VE, DFMA, and cost modeling, resulted in significant breakthroughs. Despite the initial skepticism and the short timeframe, the workshop yielded nearly 15% in potential capital reduction for the small area the team focused on. This result far exceeded the project manager's expectations and highlighted the effectiveness of this approach.

Moreover, the process generated a concept for an entirely new approach to the project. This new concept had the potential to restructure the project operations significantly, with an estimated savings potential of nearly 40%. This transformative idea illustrated the profound impact that integrated VE-360™ methodologies could have on large-scale capital projects.

Conclusion

This case study demonstrates the power of the VE-360™ approach in unlocking the potential of 'stuck projects.' By integrating VE, DFMA, and cost modeling, we were able to achieve substantial cost savings in a short timeframe, even for a project that had already undergone multiple VE efforts. The results underscore the importance of innovative, cross-functional approaches in addressing the financial viability of large-scale capital projects. The success of this mini workshop not only validated our methodology but also provided a compelling case for broader application across the client's portfolio of projects.

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

Challenges and Considerations

While the integration of Design for Manufacture and Assembly (DFMA) and Value Engineering (VE) into capital investment projects offers significant benefits, it is not without challenges. These challenges can hinder the adoption and effective implementation of these methodologies. Understanding these barriers and developing strategies to overcome them is crucial for organizations seeking to optimize their capital projects.

Potential Barriers to Adopting DFMA in Capital Projects

Organizational Resistance to Change

- **Cultural Resistance**: Many organizations have established processes and practices that can be resistant to change. Employees and stakeholders may be accustomed to traditional methods and wary of adopting new approaches. This resistance can stem from a lack of understanding of DFMA and VE principles or fear of potential disruptions to current workflows.
- **Management Buy-In**: Gaining support from senior management is critical for the successful implementation of DFMA and VE. Without buy-in from top leadership, it can be challenging to allocate the necessary resources and prioritize these methodologies within the organization.

Integration with Existing Project Management Practices

- **Compatibility Issues**: Integrating DFMA and VE into existing project management frameworks can be complex. Traditional project management practices may not align seamlessly with the iterative and collaborative nature of DFMA and VE. This can lead to initial confusion, inefficiencies, and resistance from project teams.
- **Training and Skill Gaps**: Implementing DFMA and VE requires specific knowledge and skills. Many project teams may lack the training and expertise needed to apply these methodologies effectively. Bridging this skill gap is essential to ensure successful adoption.

Resource Constraints

- **Time and Budget Constraints**: Applying DFMA and VE methodologies requires an upfront investment of time and resources. Many organizations underestimate the time in terms of human capital necessary to apply DFMA and VE. Project teams must allocate sufficient time for design iterations, value analysis, and collaborative efforts. In projects with tight schedules and budgets, finding the necessary resources can be challenging.
- **Availability of Tools and Technology**: Utilizing advanced tools and technologies, such as cost modeling software and virtual simulations, is crucial for the effective application of DFMA and VE. However, not all organizations may have access to these tools, limiting their ability to fully leverage these methodologies.

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

Solutions and Strategies for Overcoming Challenges

Training and Education

- **Comprehensive Training Programs**: Developing and implementing comprehensive training programs is essential to equip project teams with the knowledge and skills needed to lead DFMA and VE efforts. These programs should cover the principles, tools, and techniques of both methodologies, as well as practical applications, case studies, and facilitation practice.
- **Continuous Learning and Development**: Encouraging a culture of continuous learning and development ensures that project teams stay updated with the latest advancements in DFMA and VE. This can involve workshops, seminars, and online courses, as well as opportunities for hands-on experience.

Cross-Functional Team Collaboration

- **Interdisciplinary Teams**: Forming interdisciplinary teams that include members from design, engineering, procurement, construction, and project management ensures that diverse perspectives are considered. Collaborative efforts foster innovation and enable the effective application of DFMA and VE principles.
- **Effective Communication Channels**: Establishing effective communication channels facilitates the exchange of ideas and information among team members. Regular meetings, progress updates, and collaborative platforms ensure that everyone is aligned and working towards common goals.

Incremental Implementation Approach

- **Pilot Projects**: Implementing DFMA and VE methodologies in pilot projects allows organizations to test and refine their approaches on a smaller scale before rolling them out across larger projects. This helps identify potential issues and develop best practices.
- **Phased Implementation**: Adopting a phased implementation approach enables organizations to gradually integrate DFMA and VE into their project management processes. Starting with specific project phases or components and gradually expanding the scope ensures a smoother transition and minimizes disruption.

Leveraging Advanced Tools and Technology

- **Cost Modeling and Simulation Tools**: Utilizing advanced cost modeling and simulation tools allows project teams to evaluate design alternatives, predict costs, and optimize project plans. These tools provide valuable insights and support data-driven decision-making.
- **Digital Twins and Virtual Prototyping**: Implementing digital twins and virtual prototyping technologies enables teams to create accurate digital representations of physical assets. This facilitates virtual testing, scenario analysis, and optimization, reducing the risk of errors and enhancing project outcomes. This is particularly pertinent for large capital projects where traditional prototyping is impractical.

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

Securing Management Buy-In

- **Presenting a Compelling Business Case**: Demonstrating the potential benefits and ROI of DFMA and VE through case studies, success stories, and data-driven analysis can help secure buy-in from senior management. Highlighting the long-term cost savings, efficiency gains, and competitive advantages emphasizes the value of these methodologies.
- **Aligning with Strategic Goals**: Ensuring that DFMA and VE initiatives align with the organization's strategic goals and objectives reinforces their importance. By positioning these methodologies as integral to achieving business success, organizations can foster greater support and commitment from leadership.

External Support

- **Enlisting External Expertise and Support**: In working with our clients, we often find that the external support and expertise we offer is crucial either in getting this process initiated or in partnering with them to provide the coaching, training, and facilitation services they need to enable the application of DFMA and VE across their capital projects.

Long-Term Benefits and Organizational Transformation

Sustainable Competitive Advantage

- **Innovation and Differentiation**: Embracing DFMA and VE fosters a culture of innovation and continuous improvement. Organizations that successfully integrate these methodologies can differentiate themselves in the market, offering superior products and services at competitive costs.
- **Operational Excellence**: Achieving operational excellence through optimized design and efficient project execution enhances an organization's reputation and reliability. This can lead to increased customer satisfaction, repeat business, and long-term success.

Resilience to Economic Uncertainties

- **Cost Management and Flexibility**: Effective application of DFMA and VE enables organizations to manage costs more effectively and respond flexibly to changing economic conditions. This resilience is particularly valuable in times of economic uncertainty, where controlling expenses and optimizing resources are critical.
- **Enhanced Project Viability**: By reducing capital expenses and improving ROI, organizations can undertake more projects, even in challenging economic environments. This enhances a company's ability to invest and ensures that companies can continue to grow and innovate.

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

Organizational Learning and Development

- **Knowledge Sharing and Best Practices**: Implementing DFMA and VE promotes knowledge sharing and the development of best practices within the organization. Documenting successful projects and lessons learned creates a repository of valuable insights that can be leveraged in future projects.
- **Employee Engagement and Empowerment**: Engaging employees in DFMA and VE initiatives fosters a sense of ownership and empowerment. Employees who actively contribute to cost-saving and efficiency improvement efforts are more likely to be motivated and committed to the organization's success.

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

Conclusion

The application of Design for Manufacture and Assembly (DFMA) integrated with Value Engineering (VE) principles beyond product development into the realm of capital investment projects represents a transformative approach that holds significant potential for cost savings, enhanced project viability, and improved return on investment. In an era marked by rising capital costs and economic uncertainties, these methodologies offer a strategic advantage that can turn previously non-viable projects into profitable ventures.

Summary of Key Points

Broadening the Scope of DFMA and VE: The principles of DFMA, traditionally applied to optimize product designs, have been successfully extended to capital projects, leading to substantial cost reductions and more efficient project execution. Similarly, VE has proven effective in later stages of project development, particularly post-FEED, by identifying and eliminating unnecessary costs.

Industry Impact: Capital investment projects are critical to the growth and sustainability of various industries, including oil and gas, aerospace, automotive, mining, energy, and telecommunications. These projects often involve significant financial resources and optimizing their cost structure is essential for ensuring their feasibility and success.

Practical Benefits: By applying DFMA and VE principles to capital projects, organizations can achieve cost savings up to 30% or 40%, improve ROI, and enhance project viability. The methodologies help in simplifying designs, standardizing components, and optimizing assembly processes, thereby shortening time and reducing material, labor, and overhead costs.

Addressing Challenges: While the adoption of DFMA and VE in capital projects offers numerous benefits, it is not without challenges. Organizational resistance to change, integration with existing project management practices, resource constraints, and the need for specialized skills are some of the barriers that must be overcome. Effective strategies, such as comprehensive training programs, cross-functional team collaboration, incremental implementation approaches, and leveraging external resources can help mitigate these challenges and facilitate successful adoption.

Future Directions: The future of DFMA and VE in capital projects is promising, with opportunities for further evolution and innovation. Advanced digital technologies, sustainable design practices, and enhanced collaboration are some of the areas that hold potential for driving further advancements. Ongoing education and training, along with documenting and sharing best practices and success stories, will be crucial for sustaining the momentum and maximizing the benefits of these methodologies as organization begin to adopt them.

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

The extension of DFMA and VE principles to capital investment projects marks a significant evolution in project management and execution. By embracing these methodologies, organizations can unlock new levels of efficiency, cost savings, and project viability, making them more resilient to economic uncertainties and better positioned for long-term success. The journey of integrating DFMA and VE into capital projects requires continuous learning, innovation, and adaptation. As organizations navigate this journey, they will not only enhance their project outcomes but also contribute to the broader goals of sustainability, efficiency, and economic resilience.

Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148

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Dantar Oosterwal
D.Oosterwal@ArgoConsulting.com
312 292-6148