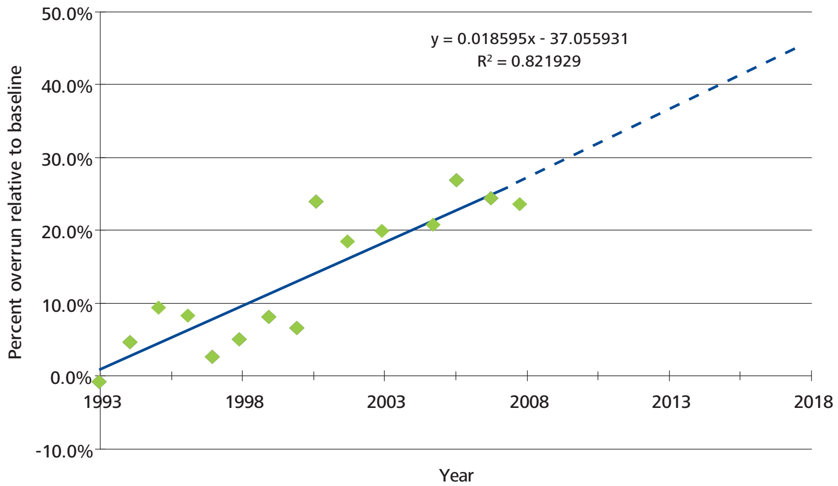
Improving engineering
Lessons from the field

In 2008, Deloitte released a study entitled *Can we afford our own future? Why A&D programs are late and over budget — and what can be done to fix the problem.* The study painted a very disappointing picture of the Aerospace & Defense (A&D) industry's ability to deliver programs in a timely and cost effective manner. In fact, if the trend of the past 15 years continues unabated, the analysis suggests that in the next ten years the average budget overrun will exceed 46%, as illustrated in Figure 1.

Figure 1: Unsustainable cost overrun rate



This trend places tremendous pressure on the engineering executive — and unfortunately, we do not see that pressure reducing any time in the near future. The causes of this condition are complex, multifaceted, and pose a significant risk to programs and to the individuals leading them. Against this backdrop, how can the engineering executive effectively deal with:

- Complex customer needs and continually evolving requirements
- Long development cycles that further exacerbate or enable the adjustment of requirements as technologies and threats evolve
- Utilization of immature technologies that are required to meet these advanced needs
- Introduction of "nontraditional" competitors not possessing similar overhead structures
- Multitiered engineering value chains driven by partnerships, joint ventures, and alliances
- Aging of key talent and the potential for intellectual capital to depart the organization
- Declining Research and Development (R&D) budgets

All of these challenges are compounded by an ever-increasing level of customer oversight. Clearly, the risk of failure is high and the industry is littered with case studies of development programs gone wrong. So how should the engineering executive respond? There is a multitude of potential actions that engineering executives can consider, ranging from product simplification strategies to engineering talent development. However, we believe that a key focus for engineering executives should be to improve the "business of engineering" by employing a systematic, data-driven approach to increase the efficiency and effectiveness of the engineering function. Essentially, engineering executives must learn to apply the same rigorous systems engineering approach used to innovate and develop products to improve engineering operational performance.

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Improving the "business of engineering" requires an integrated improvement effort evaluating processes, policies, organization, and infrastructure that supports the innovation life cycle and enables engineers to focus on the "science of engineering." Ultimately, to take a significant step forward in addressing program performance challenges, it is imperative that engineers are "freed" from nonvalue-added activities and provided the opportunity to focus on innovation, integration, and achieving performance and affordability targets.

To date, the A&D industry has demonstrated a more positive bias toward improving engineering operations over other industries — approximately 30% more likely to pursue improvement initiatives.[1] From our vantage point, improvements efforts have tended to focus on:

- Establishing and solidifying innovation life cycle methodologies and tools
- Pursuing new supporting engineering design and supporting operational technologies
- Pursuing engineering improvements and lean efforts

However, improvement efforts along these lines have achieved limited results. In fact, a recent study concluded that more than 50% of A&D engineering activity is nonvalue added — a figure confirmed by our own experience working with clients in this area.[2]

We have seen that innovation life cycle methodologies are at times inflexible and monolithic — and often possess a one-size-fits-all mentality. New information technologies are often implemented without a process emphasis — limiting the end user adoption and leveraging of the solution. In addition, lean process improvement efforts tend to be scattered, with no overarching strategy or system-level view.

Although the A&D industry possesses unique technical and operational challenges compared to other industries, industry leaders must not allow themselves to excuse continued poor performance or assume that these fundamental challenges are insurmountable. Success will require fundamental operational, organizational, and technological changes, and we believe engineering executives should lead the way.

Organizations that have had success in this area simultaneously focus on improving engineering effectiveness and efficiency. In short, effectiveness is a function of focusing on the right things and efficiency is a function of doing things right. We believe pursuing a systems engineering perspective toward improving the "business of engineering" is critical to achieving transformational impacts versus incremental change.

1 Aberdeen Group, *Optimizing Lean Product Development for A&D Manufacturers*. (January 2009); The Lean Product Development Benchmark Report. (May 2007)

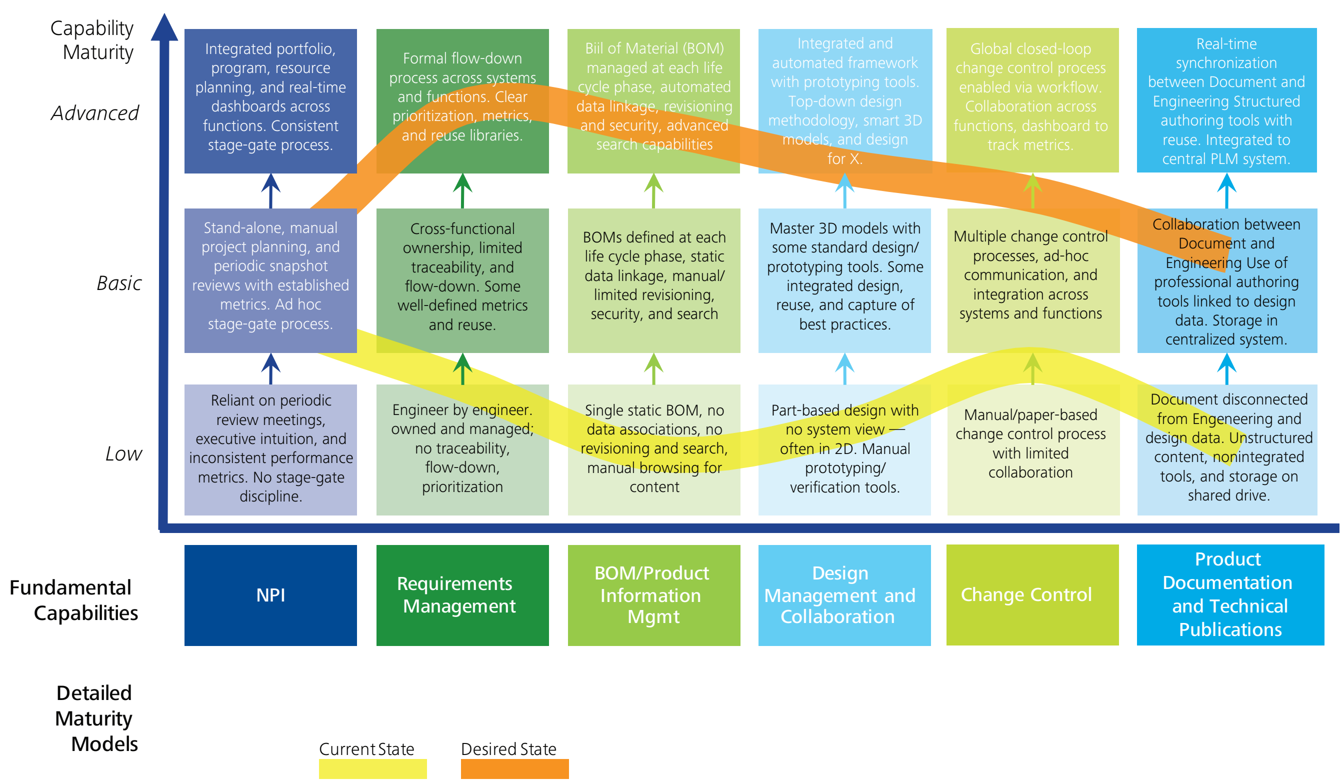
2 Aberdeen Group, *Optimizing Lean Product Development for A&D Manufacturers*. (January 2009)

This systems engineering approach should be based on an overall framework that includes understanding engineering capability and performance, utilization of a rich set of analytical tools, application of effective practices, and an integrated view of processes, organizational structure, policies, and technology solutions. We believe this framework can provide engineering executives with the flexibility to address known issues in specific process areas, such as requirements management, or it can be used to address general performance issues across the engineering function. This basic engineering improvement approach is Assess, Reconfigure, Implement, and Sustain. (Note: most companies believe they have a systems engineering approach, but upon investigation, we have found that most only apply limited systems engineering fundamentals to their development programs.)

Engineering efficiency and effectiveness improvement begins with a clear definition of performance improvement objectives, such as increased capacity, reduced development time, and lower engineering costs, etc. These objectives should be used to guide the assessment efforts and ultimately should provide the basis for a business case for investments. Once clear improvement objectives are set, engineering executives should employ a variety of analytical tools to evaluate the health of the engineering function, as well as to understand the root causes of performance problems. Some of the common tools employed are product development capability maturity models that cover all aspects of engineering operations, as well as value stream analysis tools that help assess process complexity, organizational handoffs, and information flow of core engineering processes. The maturity models (see Figure 2) are typically attribute-driven and can provide an objective method for assessing current capabilities, as well as understanding what capabilities are required to achieve the next level of performance. Organizations should not seek to be world-class in all areas of engineering capability, just in the ones that are most critical to achieving the defined improvement objectives.

Figure 2: Product development practices capability maturity model

Deloitte's Product Development maturity models were used to assess the fundamental capabilities of the New Product Introduction (NPI) processes at client. The goal is not to be "best in-class" across the board but to target improvements in areas of critical need.



Insight to maturity levels can be gained from interviews with program executives, engineering leaders, functional experts, and project teams. Additional insight can be gained through a variety of analytical tools, such as value stream analysis, churn analysis, engineering labor curves, and project portfolio analysis. These analytics and others can provide a fact basis for identifying root causes and making improvement decisions.

After completing a rigorous set of assessment activities, an engineering executive team can expect to see a comprehensive picture of the current state of the engineering organization, tools, and processes while highlighting the focus areas for improvement. For example, a deep analytical analysis of the engineering processes (see Figure 3 and associated side bar) can identify the complexity root causes of performance changes to be addressed through focused improvements. It is critical that engineering executives focus on the root causes of performance challenges (e.g., lack of rigorous requirements management) and not the symptoms (e.g., cost or schedule overrun). Although these efforts are essential to building the fact base, care must be taken to avoid analysis paralysis. As a general rule, assessments of complex engineering organizations can be completed in 8–10 weeks and should be clearly linked to subsequent design efforts.

The root causes identified through the assessment process are specifically addressed during the redesign or "reconfigure" stage of an improvement effort. Engineering leadership should target the highest-value improvement areas and prioritize them for detail design and solution

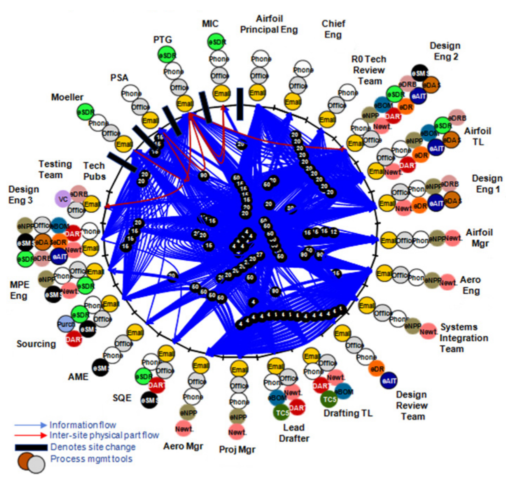


Figure 3. Example of the Deloitte Value Stream analysis of an As-Is Design/ Engineering Change process. Deloitte has a proprietary tool used to identify the complexity in engineering processes by visually depicting all of the activities incurred on a real-life project. All activities (including meetings, conversations, e-mails, system transactions, etc.) are depicted to demonstrate where breakdowns in communication and process are impeding the successful execution of work and causing significant back and forth communication to gain clarity.

How can you see complexity?
Many companies employ standard process mapping tools, such as functional swim lanes analysis, to gain an understanding of process flow. These methods are effective at identifying major process steps and dependencies, but often times focus on the "ideal" versus the actual way work is performed. Consequently, visibility into true process complexity is masked. To overcome this limitation, we developed a proprietary value stream mapping tool to model how work is actually completed that depicts the organizational information flow and process complexity associated with a given process, as well as the value and nonvalue-added work conducted in the process. The result is a picture of process complexity that shows handoffs, cycle time, and effort enabling the identification of areas where lean work simplification techniques can be applied. We apply this capability through a selective sampling of actual business events, such as a product introduction cycle. We typically select several systems, subsystems, or components that represent all aspects of the development process. The root cause insights gained from this value stream analysis provides the basis for redesign and improvement. Recommended changes can be modeled in the value stream mapping tool to generate "to-be" process views.

How to read the Value Stream diagrams:

1. Around the outside of the circle, we list all of the resources and/or functional areas that play a role in the process
2. The small colored circles depict the various systems used by that resource or functional areas to complete its work. These include legacy software, local databases, and enterprise solutions
3. Each line depicts a singular transaction (e.g., conversation, meeting, or information flow) that is conducted as part of the work execution process

What does it all mean?
Readers of the value stream maps need to look no further than the areas where there are extensive back and forth communications/transactions between resources and functional areas. Where this occurs, there are process and communication breakdowns that, if resolved, will significantly reduce the process complexity and improve the flow of information and decision making in the process. The process maps in functional swim lanes do not capture all of this back and forth communication and rework that occurs within the process. From our perspective, you can't fix what you can't see — hence, the power of highlighting detailed process complexity.

development. Reconfiguration efforts require strong subject matter expertise involvement and cross-functional teams (including resources outside of engineering) to architect process, organizational, and technology solutions. Integration across the improvement initiative can be facilitated through a formal design review process that involves multiple stakeholders from various business functions — a process not unlike a product development stage-gate process. The critical factor in design is to consider solutions from a multidimensional perspective and have a broad span of control. For example, deployment of a new Product Lifecycle Management tool to address information gaps should consider implications to functional areas like manufacturing, to other legacy systems, training, talent development, and process modifications. All too often, organizations deploy multiple continuous improvement teams who focus on specific issues, but don't have a cross-functional and engineering-wide span of control. As a result, these teams often create point solutions that simply do not generate strategic impact.

The next step in the engineering transformation process is to define a multiphase deployment road map that clearly articulates implementation activities across all functional processes and organizations affected, resources required, and the timing and associated interdependencies. Engineering executives should actively communicate and manage progress against this plan.

Successful execution requires active and sustained leadership, commitment of resources on a full-time basis, and disciplined project management skills.

The best analysis and reconfiguration efforts are immaterial if the organization cannot successfully implement and sustain the solutions. Successful execution requires active and sustained leadership, commitment of resources on a full-time basis, and disciplined project management skills. Throughout the design and implementation effort, the existing cultural norms of the organization should be challenged in an effort to adopt a more rigorous systems engineering approach that will deliver efficiency and effectiveness. Overcoming these cultural challenges will require significant communication, training, and executive leadership. Additionally, the engineering efficiency and effectiveness improvement road map should serve as the "true North" for the organization — forcing integration of activities, understanding of resource tradeoffs, and setting a common objective and target for the engineering function. Executives can help build and sustain improvement by celebrating small and large victories, while rigorously measuring progress over time. Our experience indicates that complex engineering organizations that employ these methods to improve the business of engineering can achieve 20–30% productivity (cost reduction or capacity increase) improvements, dramatic improvements to development schedule adherence, and 50–75% reduction in churn from requirement and engineering changes.

Absent fundamental changes in complex system development, the trends toward cost overruns and program performance problems will likely escalate. Engineering executives sit at the apex of this challenge in the A&D industry and, as stated previously, are under a wide array of pressures. A focus on improving the business of engineering can help relieve many of these pressures, while the capabilities to reverse the trends around cost and schedule performance are established. The answer to the question "Can we afford our own future?" is straightforward — yes, if we fundamentally improve the operating models and capabilities employed in the past.

Case Study #1: "Avoiding Cancellation"

An A&D firm was experiencing significant pressure to reduce costs and improve engineering efficiency in the development and launch of a new platform as it faced potential cancellation. Program and engineering management had inherited a number of overly complex and labor intensive processes from legacy platform programs resulting in:

- Work fragmentation and lack of engineering resources that drove significant engineering changes
- Poorly defined engineering workflow and handoffs to manufacturing creating unplanned work/rework
- Product variability, caused by multiple configurations, was a key driver of engineering and manufacturing labor costs

To address these challenges, the firm executed a comprehensive cost analysis and value stream evaluation of eight core engineering, planning, and supplier management processes to reveal process complexity and cost drivers:

- Nearly 50% of contract administration labor was directly related to the management of change
- A substantial portion of supplier interface costs were driven by technical requirements, engineering change, and schedule volatility

To rapidly reduce costs and improve engineering throughput/efficiency, the firm redesigned the key value streams and improved organizational alignment with engineering tasks:

- Redesigned processes to accelerate the transition from a development to a sustaining business model to provide the opportunity to release significant levels of nonrecurring engineering resources
- Implemented concurrent release to directly reduce the change volume attributed to rework
- Aligned resources within an integrated product team to facilitate collaboration to achieve an actionable and integrated design solution

Pursuing a systems engineering perspective of the challenges, coupled with a rigorous assessment of process, policy, and organization drivers —– the firm was able to achieve the following results:

- Instituted a value stream-based organization to increase communication and accountability
- Reduced engineering changes by 50%
- Decreased cycle time to approve a schedule change by 95% — to less than three days
- Reduced number of people required to make a schedule change decision by 70%
- Reduced labor costs of greater than $10M, with an expected reduction of greater than $50M over the life of the program

Case Study #2: "Charting a New Direction"

An A&D firm faced with declining market share and profitability was struggling with:

- Long development cycles
- Product launch and quality problems
- Significant operational complexity
- Lack of visibility to true costs by product line
- Increased difficulty in responding to customer inquiries

To combat these challenges, the firm developed a system-wide view of all activities and their associated costs to establish a baseline understanding of previously unknown profitability and cost drivers. This baseline enabled the evaluation of product line and derivative profitability and an understanding of the implications of complexity on cost.

As this system-wide view was completed, a deeper dive into engineering processes was executed to identify redundancies, nonvalue-added activities and provide a characterization of the most significant cost drivers. This was coupled with a detailed diagnostic to identify root causes of ineffectiveness and inefficiency leading to opportunities for improvement in design processes, functional integration, organization structure, and personnel capabilities.

This top-down, comprehensive assessment resulted in a road map for improvement that included the implementation of portfolio management concepts and the rationalization of products, redesigned engineering processes, improved reuse techniques, and new organizational roles and responsibilities. As a result of this, the firm achieved the following:

- Reduced product development process timeline of greater than 40%
- Reduced product development cost of greater than 30%
- Improved engineering capacity by over 25%
- Reduced warranty costs by over 40%

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