White Paper

IDEaS

Getting The Most Out of Design For Six Sigma

SIX SIGMA QUALTEC

IDEaS: GETTING THE MOST OUT OF DESIGN FOR SIX SIGMA

A White Paper from Six Sigma Qualtec

Companies that implement a Six Sigma program often find that a majority of defects are actually created during the design process. As a company's processes begin to exceed improve they typically hit a "wall" that requires a redesign of some or all of those processes. Known as Design For Six Sigma (DFSS), this approach provides a rigorous method for designing products and services, as well as the processes that produce them, to ensure from the outset that they produce Six Sigma-quality products and services, meet customer expectations, and increase profits over the life of the product or service.

DFSS Questions

To understand the potential of DFSS, consider you current design process and ask yourself these questions:

- ❑ How are customer requirements captured and quantified?
- ❑ How are specifications set?
- ❑ How are risks assessed and measured?
- ❑ What is the total cost to produce one item or complete one transaction?
- ❑ What is the financial benefit of this project?
- ❑ What is a realistic schedule (concept to implementation) for your design project?

If you have difficulty providing concrete answers, you are not alone. Most firms can't answer tough questions like these, even if they have already implemented Six Sigma and Lean. Design for Sigma was developed to answer precisely those questions and provide solutions for the design process that greatly improve the quality and reduce the cost of all subsequent activities to produce and deliver the product or service.

Overcoming Performance Barriers

By applying Six Sigma in the design and development stages, Design for Six Sigma overcomes the performance barriers built into conventional design processes. Targeted at eliminating opportunities for creating defects before they can create waste, DFSS should be an integral part of any company's Six Sigma strategy. We know, through years of successful application, that DFSS can enable your firm to achieve substantial, lasting financial gains. Moreover, by integrating the proven Six Sigma principles of DMAIC (Define, Measure, Analyze, Improve, Control) with design tools and Six Sigma Qualtec's unique IDEaS approach to the design process, you can not only achieve product designs that consistently meet customer requirements, target costs, target release dates, and process requirements, but also do it more effectively than with other approaches.

When to Adopt Design for Six Sigma

Six Sigma tools were initially deployed to improve existing processes. However, when new designs for products or services were introduced, Black Belts often found themselves deploying solutions to similar problems again and again. Yet the deployment of these solutions did not result in a Six Sigma level of performance. As a result, pioneering practitioners of Six Sigma realized that Six Sigma problem-solving techniques needed to be incorporated into the design process itself. They also realized that the designs of "new" products or services were constrained by the imagination and creativity of the designers. Design for Six Sigma proposed to greatly enlarge the pool of creative talent by focusing the design process on the customers' requirements, seeking input from all who would use the product or service.

Nevertheless, not all situations require DFSS. Companies also have the option of applying the DMAIC methodology of Six Sigma or of Lean methodology, a less statistically rigorous but powerful approach to quality, especially when used in conjunction with Six Sigma. Table 1 provides a comparison of the approaches of DMAIC, Lean, and Six Sigma, which can be used to help decide which approach best suits your situation. For example, it sometimes may not make good business sense to aspire to Six Sigma. Among other things, you should consider whether the return on investment (ROI) in Six Sigma justifies the capital expense. It may make more sense to simply fix defects after they occur.

DMAIC	LEAN	DFSS
Focuses on a project	Focuses on a process	Focuses on either a product or process
It is a problem solving methodology	It is a problem solving methodology	Provides measure and metrics
Provides solutions to a specific question	Provides solutions to a specific question	Identifies problem areas
Focuses on defect elimination	Focuses on waste elimination	Focuses on defect prevention
Focuses on a few key customer requirements	Focuses on the internal process	Considers trade-offs between all the customer requirements
Uses Six Sigma tools	Uses Lean tools	Uses Six Sigma tools
May cross functional boundaries	Usually does not cross functional boundaries	Crosses functional boundaries

Table 1: Consider which approach is right for your business situation.

Consider Using DFSS When:

- ❏ Creating a new process/product
- ❏ A process reaches "entitlement" – that is, when it is working as well as possible but is failing to meet client specification requirements
- ❏ Future customer requirements will exceed current process capability
- ❏ Redesign of the product/process will be faster or less expensive than DMAIC

Facing these situations, you should be able to profitably employ DFSS to design any product or process to satisfy both the external customer and internal business requirements at a six sigma level of performance.

What It Takes to Succeed

Because DFSS integrates business and technical processes, a high-performance cross-functional team is critical for its success. The design process should include not only design engineers but also a cross-functional design team. Participants should come from all functions in the organization that contribute to successful process design and launch (e.g., sales, marketing, design, operations, purchasing, and finance.) The input of each function is essential to the final product or process.

Failing to use a genuinely cross-functional team entails serious risks. For example, a product that is developed without any legal input may infringe on a competitor's patent. A service designed and deployed without input from human resources may be developed without consideration for ongoing training needs. A process developed without the contribution of subject matter experts (SMEs) may simply automate a function that cannot meet customer requirements. A process developed without IT involvement may take too long to deploy due to complexity of the IT solution.

More positively, efficient designs created by fully cross-functional teams enable a faster start-up time, easier introduction to market, and lower and more predictable investment requirements. Why? Because such designs will consistently meet customer requirements, target costs, target release dates, and cycle-time requirements. As figure 1 shows, ratios of improvement go up dramatically the earlier in the process that defects, waste, and costs are eliminated.

When a design is released, over 70% of the product cost is captured.

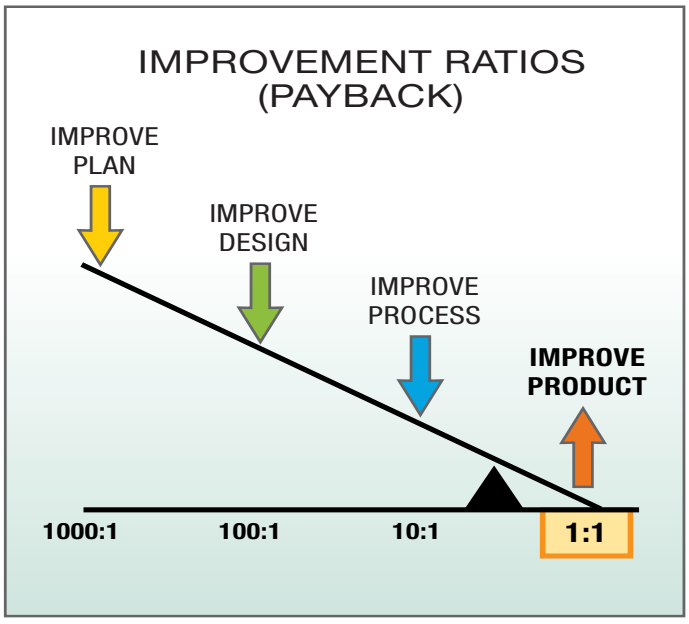

Figure 1: The earlier a problem can be identified and prevented/fixed the higher return on the investment.

In addition to possessing the requisite competencies in their areas of expertise, participants in a DFSS project must also possess competencies in business and technical processes. Business processes include tollgate reviews, risk management, project management, product cost analysis, allocation of capital and resources, program prioritization, and strategic planning. Technical processes include design reviews, risk analysis and abatement, and piloting and prototyping. DFSS also requires expertise in DMAIC and design tools. For example, during any design process, there are likely to be individual DMAIC projects that will be identified for Black Belt attention. Most importantly, achieving the ultimate goal of designing a product or process to satisfy requirements at a superior level of performance for both the external customer as well as the internal business requires a proven methodology that enables you to successfully integrate all of these competencies or acquiring them where they are lacking.

Harnessing the Power of IDEaS™

Unlike Six Sigma proper, with its widely used DMAIC methodology, Design for Six Sigma has no standard methodology. Rather it is a set of shared principles and tools with the ultimate aim of designing quality and customer requirements into products and services at the outset. As a result, there are numerous possible approaches to achieving DFSS. Based on years of experience, Six Sigma Qualtec has developed a four-phase process known as IDEaS™ (Initiate, Design, Execute and Sustain) that is designed to help organizations achieve DFSS rapidly, cost-effectively, and with better results than might otherwise be attainable.

The Four Phases of IDEaS

Initiate the project: A cross-functional team is formed, the customers are identified, their needs are quantified, and the output specification limits are defined. In Six Sigma terms, the Initiate phase determines the Y's. In layman terms, the Y's refer to the Process outputs. The aim of this phase is to establish a project charter that defines both external and internal stakeholder requirements. Put simply, you are answering two questions: (1) who are my customers and (2) what do they want? However, arriving at the answers may not be so simple – over 70% of failed projects result from an incomplete or an incorrect step taken in the Initiate phase.

Design the process, validate the design, and develop an implementation plan: During the Design phase, the focus is on identifying the X's – the downstream inputs that will produce the desired outputs. It also looks at the transfer function of Y=f(X) to determine which of the X's make the greatest contribution to producing the desired Y. By clarifying the targets and acceptable tolerances for the desired output and then transferring them to the targets and tolerances of controllable inputs, this stage can provide a window onto the cost implications of maintaining various tolerances, their importance to the customer, and the acceptable trade-offs that can be made. In this phase, the design team translates the customer's requirements into a prototype that demonstrates the product or process capabilities and that performs within the customer's specifications. The working environment is prepared for start-up and the production process capability is validated.

Execute the project: The Execute phase initiates implementation of the production process, demonstrates its short-term capability, and identifies short-term risk. During the Execute phase, the focus is on short-term capability. The actual process begins during this phase and this phase culminates when the process performs within the specification limits and the customer need is satisfied.

Sustain the process: During the Sustain phase, your aim is to maintain long-term capability and control, to document actual vs. expected results, to implement continuous improvement as needed, and to close the project. The Sustain phase focuses on long-term capability. In this phase the process should continue to operate within the specification limits, and internal and external customers remain satisfied

Key Tools

Like Six Sigma, DFSS employs a powerful array of tools, which, used within the IDEaS™ framework, produce powerful results. Among the most prominent of these tools are:

Tollgate Reviews – These cross-functional business reviews of a DFSS project are conducted at the end of each phase of the IDEaS™ process. The key topics of review include customer requirements, project risks, financial objectives, and schedule/timeline. Using the information provided at the tollgate review, each stakeholder decides whether the current phase merits a Pass, a Conditional Pass, a Do Not Pass, or a Kill Project vote. If the decision is Pass, then the project is allowed to continue to the next phase. If the decision is Conditional Pass, then the conditions need to be met to the stakeholders' satisfaction to permit continuation of the project into the next phase. If the decision is Do Not Pass, then the tollgate review is rescheduled and the cross-functional design team has an opportunity to redo the current phase of the project. If the decision is Kill Project, then the project is discontinued. It is important to note that tollgate reviews are business reviews, not technical reviews, and their cross-functional character as well as the review process itself improves the probability of success for a project.

Quality Function Deployment (QFD) – Quality Function Deployment, also known as "House of Quality," is a key tool used throughout the DFSS process. A living document that is first created during the Initiate phase and continually updated, QFD enables you to capture Voice of the Customer (VOC) information and transform it into tangible customer requirements. It can be used at many levels – or "houses" – to transform customer requirements down to the actionable process level. It captures and ranks customer requirements and helps turn them into measurable design objectives and assigns targets and limits for those objectives. It can also be used to assess competitive advantages and weaknesses.

Above all, QFD focuses teams on the most important customer requirements by following a carefully structured, ten-step process:

1. Capture customer requirements.
2. Rank customer requirements to indicate their relative importance.
3. Translate customer requirements into quantitative or measurable values.
4. Correlate customer wants to design requirements.
5. Calculate priorities by summing the products of the importance of each customer requirement and its correlation with the technical requirement and by calculating the relative importance of each technical requirement.
6. Analyze the competitive environment including your competitive strengths and weaknesses.
7. Assess the design requirements against the competition.
8. Identify correlations between design requirements such as positive correlations in which improvement in meeting one requirement improves a second requirement, negative correlations in which one improvement degrades the ability to meet a second requirement, and neutral correlations in which improving one requirement has no effect on the second requirement.
9. Identify potential design challenges/constraints such as government regulations, corporate policies, technology limits, and budget and correlate them against each design requirement.
10. Add customer target values and specification limits to each requirement.

Together, these steps allow you to build a “House of Quality” (depicted in Figure 2) by filling out each element of the house. Once the house is filled out you may find that you have some blank rows, which indicates that you are probably not addressing one of the customer’s requirements. Blank columns indicate that you probably have a non-value added design requirement. You may also discover sales points, such as advantages over the competition or opportunities or imperatives for creating such advantages.

The first QFD house can then be used to build subsequent houses that would identify more detailed design requirements. In each additional house, the requirements section of the previous house becomes the customer want section of the new house. The goal in each case and in any QFD activity is to focus on the most important requirements and set targets against which you can measure.

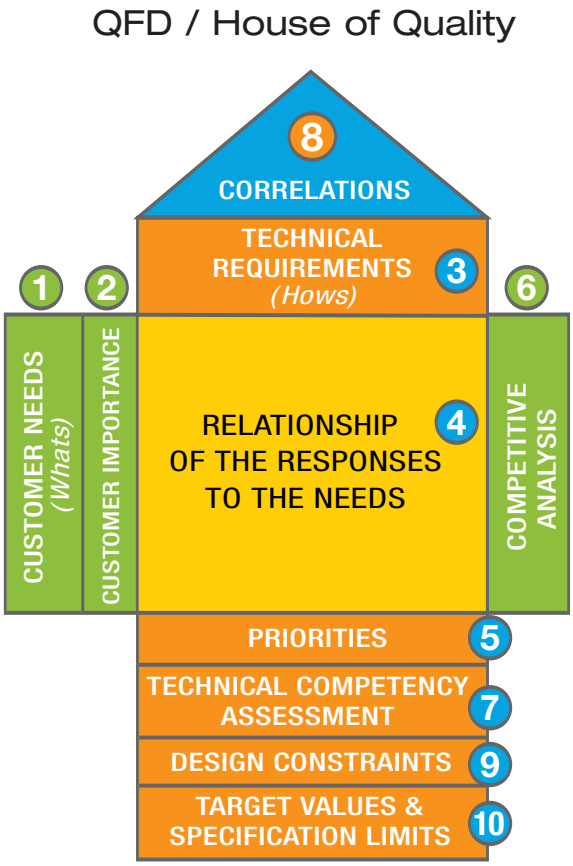

Figure 2: The QFD process keeps DFSS focused on most important customer requirements.

Product Scorecard: The product scorecard, as depicted in Figure 3, tracks the four main elements of a six sigma project: performance, process, part/items/suppliers, and software. It is a living document that can be used for project management, for communication, and for prioritization. It can also be creatively adapted for many other uses as well.

Using the product scorecard requires commitment throughout the organization to collect data and analyze it. Data is collected for each element and put into a corresponding scorecard. The data is then summarized and placed in the Product Scorecard.

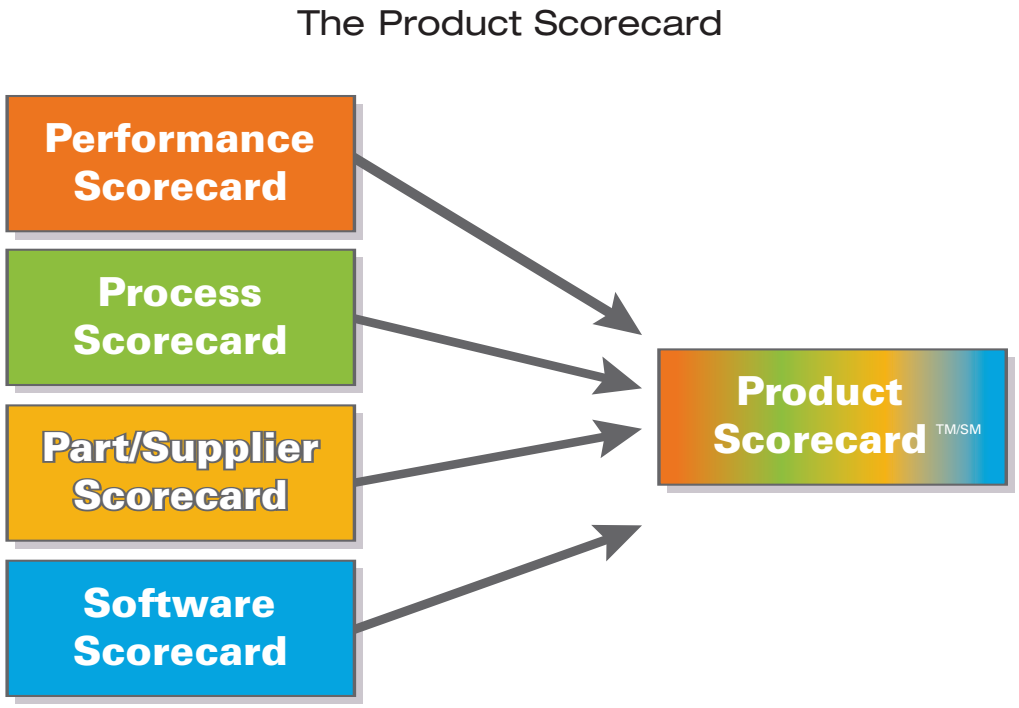

Figure 3: Systematically compile and analyze data in a DFSS project focused on a product.

The Product Scorecard integrates data from four individual scorecards:

The Performance Scorecard is a list of the important product performance parameters from the customers' perspectives that were identified in the QFD. It is used to continually assess the current design against the known requirements. The scorecard can tell you what you know and what you don't know about a product's performance at any stage in the IDEaS™ process. It can also help prioritize design activities and, as a side benefit, it identifies the test and measurement system requirements.

The Process Scorecard is essentially a list of all the internal processes used to build a major sub-assembly or a finished product. Given that "Part + Process = Product," the intent of the Process Scorecard is to:

- ❏ Identify the needed process steps as an integrated part of the design process
- ❏ Determine the internal capability of the needed process
- ❏ Prioritize process improvement efforts
- ❏ Identify capital equipment and new process development costs

The Part Scorecard is essentially a product parts list. The intent of the part scorecard is to:

- ❏ Identify parts and suppliers early in the IDEaS™ process
- ❏ Use techniques to decrease the item count and reduce the number of suppliers
- ❏ Identify problem parts/suppliers early in the IDEaS™ process
- ❏ Prioritize the use of team resources

The Software Scorecard is a list of all of the internal processes used to build a software product or the software piece of a product. The intent of the Software Scorecard is to predict software reliability in the field. It can provide pointers into the automation processes, suggesting areas for improvements that will result in shorter development time and lower costs. It also supports Software Engineering Institute (SEI) Capability Maturity Model (CMM) level 3 and 4 requirements. The ultimate goal is to be able to predict the delivered software quality based on defect rates demonstrated during the build process.

The Pugh Concept Selection Matrix assists in choosing the best concept out of a number of possibilities for satisfying a given set of customer requirements. It was developed by Stuart Pugh, a Scotsman, to help engineers break the habit of relying on a few favorite techniques and instead look at new concepts more objectively. The Pugh Concept Selection Matrix can be used at several points in a design project. The process for building a Pugh Concept Selection Matrix is the same, regardless of the level of analysis at which you list new concepts. First, select a standard – a best-in-class competitor or a baseline set of measurements – to which all of the alternatives can be compared. Second, list selection criteria including customer requirements, design requirements, process functions, or physical resources. You may also want to include other business factors, such as cost and safety. Finally, compare each concept with the standard along each dimension of the selection criteria.

Additional Tools Include:

- **Voice of the Customer (VOC**), a five-step process that involves defining the purpose for VOC exploration, identifying customers and customer voices, segmenting customers, and finally rating customer requirements.
- **Multi-Generation Planning**, a tool for identifying current, intermediate, and desired states for a product or process over time and linking it to the strategic and operating plan and plans for next-generation products and processes.
- **Benchmarking**, the measuring of products and services and practices against the toughest standards in order to improve quality, reduce costs, increase volume, expand into new markets, increase market share, identify new business partners, identify non-value added process steps, and gain external perspective.
- P**roject Risk Assessment**, a simplified version of FMEA to identify and classify risk in terms of probability and impact in order to reduce the project cost, reduce the schedule impact, prioritize activities, allocate resources accurately, increase customer confidence, and improve the probability of project success.
- **Project Financial Analysis**, designed to encourage thinking in terms of business rather than technical solutions.
- **Process Capability**, to help determine whether components of an existing process or the entire process should be improved or redesigned.
- **Process Mapping**, to design the process flow in order to predict process cycle times and predict process defect levels.
- **Design of Experiments**, undertaken to collect, analyze, and interpret a wealth of historical data for information useful in problem solving and process improvement.
- **Stat Tolerancing**, to set tolerances on X's to ensure that a specific Y output remains within the customer specification.

  Used within the powerful IDEaS framework, these tools helps ensure product and process designs that consistently meet customer and manufacturability requirements, target costs and release dates.

Conclusion: When to Start

As you have read when Design for Six Sigma is implemented properly it elevates your company's productivity and avoids costly mistakes. The IDEaS™ methodology ensures companies avoid expensive design errors before they are created. The key question is remains: is your firm ready to embrace this approach? Though management teams realize the advantage of cost avoidance they are driven towards cost saving activities. Experience demonstrates the best time to launch your DFSS program is 6 – 18 months into your Six Sigma / Lean initiative. At this point management teams are experiencing large returns on their process improvement investment are typically prepared to reinvest a portion of the savings to launch a cost avoidance program. This timing is ideal because cross functional design team members have awareness of the Six Sigma results and are eager to experience the same gains in their productivity. Data collection processes are being established throughout the company that can feed the DFSS program. So don't try to everything at once. Start your process improvement initiative but lay the ground work early for DFSS so your company can reap the reward with the greatest possible return on investment.

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