





RAYTHEON— NEW CHALLENGES, NEW SOLUTIONS, AND DOCUMENTED RESULTS

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Born from a multi-billion dollar debt and a driving commitment to customer success, Raytheon Six Sigma™ (R6σ™) has generated over \$2 billion in financial benefits resulting from over 3,000 projects. The culture change is now part of the fabric of Raytheon, with over 21,000 specialists, 1,200 experts, and 50 master experts guiding 76,000 employees to customer success. Raytheon Six Sigma™ is now an integral part of the business strategy and is successful because it focuses on achieving success for customers while delivering results for the company. Guarding against complacency, Raytheon leadership ensures that R6σ™ continues to evolve with the changing needs of the business. This paper highlights how R6σ™ was used to forge a culture of customer focus and productivity improvement that led to higher levels of financial stability and customer success.

Raytheon's initial focus for Raytheon Six Sigma™ (R6σ™) was to address debt—the company's *Burning Platform*. Early on, leadership took ownership of R6σ™ by creating an initiative that was unique to Raytheon. This early work created *ownership* for this business strategy and led to investment in R6σ™ infrastructure and learning throughout the organizations. Soon after R6σ™ Experts started working projects in the business, teams were delivering results that reduced debt and changed the corporate culture. Raytheon leaders were delighted with these initial success stories and internalized how R6σ™ could be used to tackle their next set of business challenges and achieve the goals of the organization.

As use of R6σ™ in the organization became widespread and goals were achieved, a higher level of performance became the expectation. As the bar was raised for

business leaders, R6σ™ needed to raise the bar as well. As a result, businesses increased focus on working R6σ™ projects *with the customer for the customer* as well as embedding use of it in product development. The case studies provided later illustrate two examples of projects in these areas.

The fact that the R6σ™ initiative continues to evolve, and has prospered with a change in Executive Leadership, indicates it is not the *program* of the day at Raytheon. It continues to be the business strategy of choice.

THE JOURNEY BEGINS

During the 1990s, Raytheon acquired the defense businesses of E-Systems, Hughes Texas Instruments, and others. While adding to the business base, these acquisitions had driven Raytheon's debt to \$9 billion by early 1999. It was a business imperative to reduce the debt costs as well as to improve cash flow.

Raytheon initiated Raytheon Six Sigma™ in late 1998. It leveraged the best approaches from *legacy* companies with the vision for Raytheon. Raytheon Six Sigma™ was developed by benchmarking other companies and leveraging best practices internally. An internal team, supported by a consortium of external experts, worked to explore approaches and to define a strategy unique to Raytheon. Dan Burnham, who had just become the new CEO, guided the team and planned to bring the company together by embedding Raytheon Six Sigma™ into the fabric of the organization. His Vision was to:

- Make customer success a strategic focus for the company.
- Increase productivity.
- Transform the culture.
- Grow the business.

Figure 1 shows the integrated business strategy that emerged and brings together the following key areas:

- **Customer Focus:** Customer satisfaction is the top priority. Understand each customer's culture and needs. Focus on activities that add value to their products and eliminate those which do not. Build lasting relationships and anticipate customer needs to achieve a competitive edge. Be the supplier of choice.
- **Tools:** Identify the constraints and high leverage opportunities through the Business Diagnostic process. Combine the statistical process analysis techniques of traditional Six Sigma with the *Lean* manufacturing approach to eliminate waste and non-value added activity. Provide the right analytical tools for each situation.

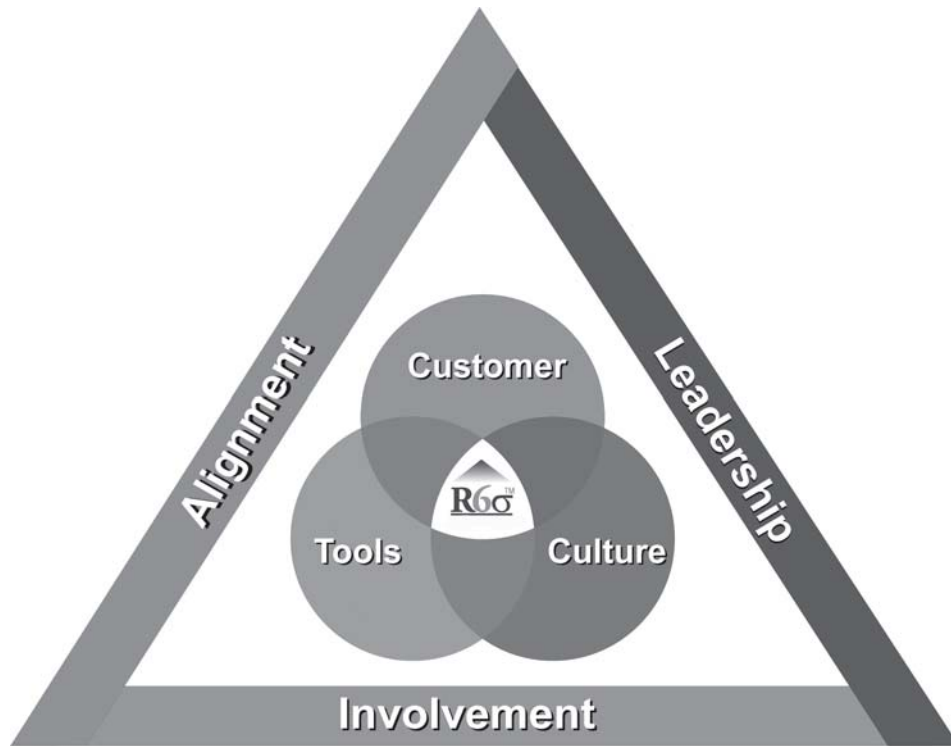


FIGURE 1.

RAYTHEON'S SIX SIGMA (R6σ™): AN INTEGRATED BUSINESS STRATEGY

- **Culture:** Transform the corporate culture to embrace a process improvement/measurement focus, teamwork and empowerment. Shift from valuing functional behavior to adopting a business/customer focus.

The following important elements were also incorporated into the R6σ™ deployment strategy:

- **Alignment:** Ensure company leadership understood and are committed to the R6σ™ strategy before deploying techniques to the workforce.
- **Involvement:** Get all company employees informed and motivated. Make R6σ™ a way of life that touches everyone.
- **Leadership:** Demand leadership involvement and accountability at every level to make R6σ™ the focus of their operations.

Many companies have used Six Sigma, Total Quality Management, Quality Circles, or similar approaches with varied results. Experience gained from these initiatives highlighted the need for R6σ™ to require leadership and workforce involvement, commitment and ownership. Five days of Leadership Education for 1,200 of Raytheon's

leaders stimulated discussion and debate as to why they needed this initiative, what they needed to do as sponsors in their businesses, and how they would behave and act differently.

The results from this significant investment were measured in each leader's actions and the results achieved. They dedicated resources to deployment in their organization, invested in additional training for their mid-level managers (over 7,000 mid-level leaders attended 2.5 days of training), selected their best people to become R6σ™ Experts, and sponsored projects in their organizations. Project work was initiated in each business and cash was generated to reduce the debt. Support for the business came from corporate resources that were allocated to develop and deliver training for Experts, implement corporate-wide Communications programs, and create and implement an R6σ™ Human Resources toolkit.

STRUCTURED FOR SUCCESS

Determined to create the environment for success, Raytheon leadership ensured that every level of the company was engaged in R6σ™ development and deployment. Deployment started with corporate leadership *walking the talk*, with full support throughout the organization.

IMPLEMENTATION ROLES

- **Raytheon Corporate Leadership Team:** Sets the vision, approves planning, removes barriers and tracks progress.
- **Businesses:** Business leaders work daily with their Master Experts to integrate R6σ™ into their operations and business strategy process. Approaches are tailored to each business' needs and situations.
- **Raytheon Six Sigma™ Council:** Chaired by the Vice President of R6σ™ and comprised of Master Experts from each business and corporate functional office; the Council ensures corporate consistency, coordinates plans, schedules and resources, communicates the vision, expectations and experiences, and builds/sustains momentum.

Successful deployment also required individuals with the knowledge, skills, and behaviors essential to being a successful change agent. Business leaders selected their best candidates and dedicated them to R6σ™ in roles that accomplished the goals of the business and in assignments that would offer opportunities for growth. The roles include:

- **Master Expert:** Full time highly experienced and trained leaders who integrate R6σ™ planning, training, mentoring, and highly complex projects within their organizations. Directs reports to business and functional leaders.



- **Experts:** Full time individuals trained to lead complex projects and train/mentor others in R6σ™ activities.
- **Specialists:** Individuals trained in basic R6σ™ concepts and productivity improvement skills to transform their work areas.

KNOWLEDGE AND SKILLS

A framework for deployment was needed to ground the Leadership, Experts, and Specialists in a set of principles, a definition, and a process. In every training session these basic tenets of R6σ™ were presented and then applied by each new project team. Experienced Master Experts or Experts were assigned to coach all Expert-led and Specialist-led projects to reinforce learning and ensure successful completion of their projects. Project work focused on meeting the corporate goals and business operating plans while focusing on making a difference for customers.

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THE PRINCIPLES

Each project team used the guiding principles listed below:

1. Specify Value in the Eyes of the Customer (Work on projects that will deliver outcomes desired by the Customer.)
2. Identify Value Stream and Eliminate Waste/Variation (Ensure teams understand the current reality, have identified the undesired outcomes and effects, know the root cause, and create solutions that are within the boundaries established by leadership.)
3. Make Value Flow at the Pull of the Customer (Deliver what the customer wants, when the customer wants it.)
4. Involve, Align, and Empower Employees (Ensure all employees have the knowledge and skills to be involved and know where they can add value/make a contribution.)

5. Continuously Improve Knowledge in the Pursuit of Perfection (Ensure teams are continuously striving to take the next step and never stop striving for perfection.)

DEFINITION

Leadership created and communicated the definition of Raytheon Six Sigma™ throughout Raytheon: *Raytheon Six Sigma™ is a knowledge based process that we will use to transform our culture in order to maximize customer value and grow our business.*

The definition captures the essence of the strategy: Deliver customer value (satisfaction), transform the culture, and grow the business. The *knowledge-based process* refers to Raytheon's unique six step process—visualize, commit, prioritize, characterize, improve, and achieve—to identify and accomplish productivity improvements to make customer satisfaction and business growth a reality.

THE R6σ™ SIX-STEP PROCESS

The six-step process is iterative (arrows go both ways) and is graphically in Figure 2.

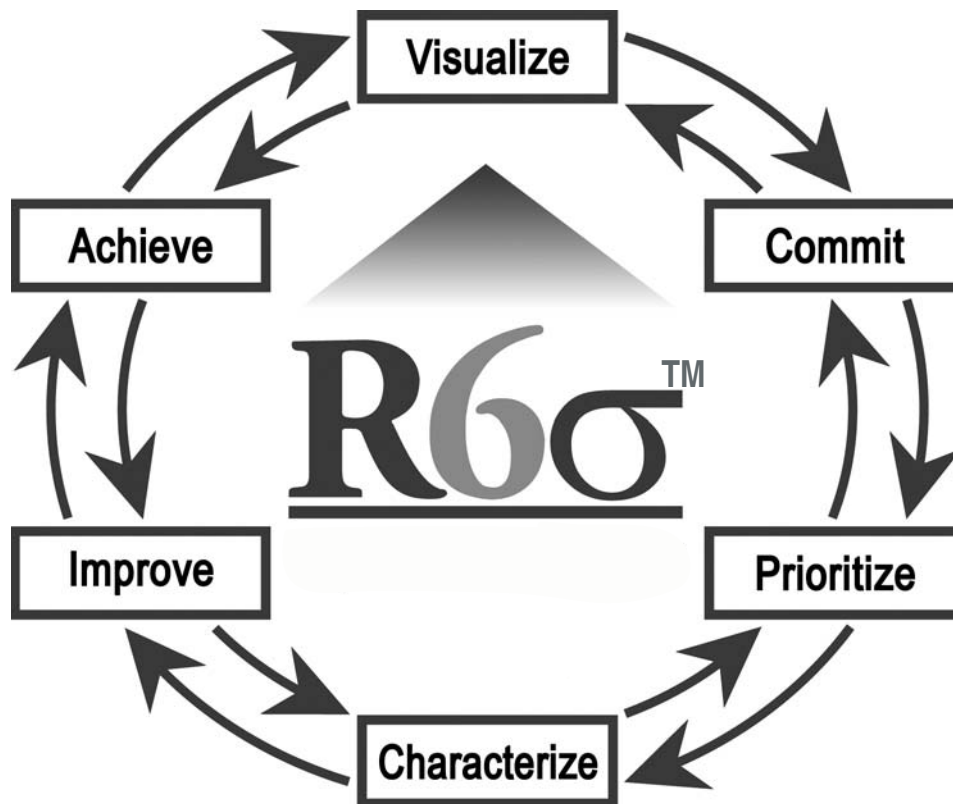


FIGURE 2. RAYTHEON SIX SIGMA™ (R6σ™) SIX-STEP PROCESS



This process starts with the creation of a clear vision of the future with a clear and pressing need for change. The vision focuses the project team on the goal and business need.

Next, the Commit Step is required. The Commit Step ensures the project has the necessary support from business leaders. This step is a go/no-go point in the process, and project teams do not progress to prioritize until they have a committed sponsor and team aligned with the vision. The process is iterative and some teams will be asked to return to previous steps.

“Throughout the journey, leadership ensured that all project teams understood the important linkage between customer success and financial results.”

After Commit, the next step in the process is Prioritize. Using facts and data, project teams will discover improvement opportunities and understand organization readiness for change. At this time, resources needed to work the project are identified and initial return on investment (ROI) estimates are completed. Teams will use this analysis to prioritize the highest leverage projects necessary to achieve goals. Those projects offering the highest returns will be scoped and resources are assigned to work project(s) that will make the most difference to the customer and business. Teams will typically revisit *Commit* with the project sponsor to ensure they remain aligned with the business needs and goals.

Next, the process teams characterize and define their understanding of the current state performance: identify opportunities, develop potential solutions, conduct tradeoffs, and create a plan for improvement. The results are reviewed prior to implementation of the improvements. The Improve Step in the process completes the detailed design and implementation of improvements and control systems necessary to sustain the change. For example, this step delivers new operating instructions, training, capital equipment and facility changes, process changes, and most importantly, value for the customer.

The Achieve Step in the process delivers the sustainable, measurable results to build momentum for continuous improvement. The project team leader(s) ensure all team members are recognized and celebrates success. Project results are publicized to share lessons learned and to motivate others to join the R6 σ TM Journey.

SUCCESS FOR OUR CUSTOMERS: SUCCESS FOR THE BUSINESS

Throughout the journey, leadership ensured that all project teams understood the important linkage between customer success and financial results. Raytheon business leaders ensured in their communications that they did not lose sight of the Raytheon mission to ensure customer success through delivering products that meet end user needs. Leaders also focused project teams on the business need to deliver financial returns. These teams needed bottom line results to:

- Develop new products.
- Conduct essential independent research and development.
- Create customer solutions.
- Bid on new opportunities.

By the end of 2002, debt was successfully reduced from \$9 billion to \$7.4 billion. Four years into R6σ™ Raytheon had exceeded the initial goals for the program, and the infrastructure was in place to take R6σ to another level. This infrastructure continues to strengthen monthly with completion of projects, Expert and Specialist training classes, and Master Expert selection. R6σ™ infrastructure, as characterized by the number of resources available to work projects, now includes 30 percent of Raytheon employees. Financial benefits to the corporation are estimated at approximately \$1 million per full time Expert per year.

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THE NEXT LEVEL

As R6σ™ success stories started to pour out of the company, identifying ways to make customers successful using R6σ™ has become the standard for Raytheon to manage its business. Leadership enthusiastically celebrated past project work that delivered greatly reduced operating costs and debt; increased customer satisfaction; and created a dynamic company culture that embraced change, empowerment, and



process improvement. The results achieved reset business leader expectations and R6 σ TM resources were refocused on growth and creation of new products. Changing business needs were again reflected in Annual Operating Plans, Goals, and in the continued evolution of R6 σ TM.

To meet these changing business needs and expectations, R6 σ TM training was also changed to feature discovery learning, debate, and case studies. New classes were also opened to all Raytheon employees and designed to deliver training in context with project work requirements. The new classes cover in-depth, analytical knowledge based tools, and robust design methods and techniques for teams supporting Product Development Design for Six Sigma (DFSS), Integrated Supply Chain, Business Operations (Information Technology, Finance, Human Resources, etc.), Program Management, and Marketing. This context-specific training provides more employees with the opportunity to add depth to their R6 σ TM knowledge and skills.

“Sharing lessons learned and best practices is encouraged at periodic Expert forums and celebrations where project teams brief project work, hear guest speakers, and network with other project teams.”

PROJECTS DELIVER RESULTS

Project teams deliver the desired outcomes for customers as well as the corporation and use of knowledge sharing to accelerate application of R6 σ TM has become a part of the culture. Sharing lessons learned and best practices is encouraged at periodic expert forums and celebrations where project teams brief project work, hear guest speakers, and network with other project teams. The R6 σ TM Project Library now includes a database of over 3,000 projects and is searched on a regular basis by teams interested in jump-starting their project work by learning from others. Project teams also learn through participation in Communities of Practice, benchmarking, and regular communication with other teams working similar projects.

The case studies described below are incorporated in the knowledge base and are used to illustrate examples of successful projects. These projects are two of the 3,000-plus projects that have delivered business results since 1998. The teams who worked these projects were all trained to apply the R6 σ TM principles, process, and tools to support completion of their project work.

CASE STUDIES

The cases are short descriptions of the project work completed on the Global Hawk program and Design for Six Sigma in the Raytheon Missile Systems organization.

GLOBAL HAWK

The Challenge

Theater Commanders conducting Operation Enduring Freedom needed the real time intelligence that was available from the new Global Hawk system. The Air Force needed completion of Engineering and Manufacturing Development for the Global Hawk Integrated Sensor Suite 6 months early—7 months shorter than the 13-month development time.

Background

Global Hawk is a high altitude, unmanned, aerial vehicle system designed to provide real time intelligence to theater commanders. Raytheon produces the integrated sensor suite and ground stations as a subcontractor to Northrop Grumman. Technology demonstrations were ongoing when the September 11 tragedy accelerated the need for an operational system. The goal was to turn a technology demonstrator into a deployable system that supported the troops and saved lives.

A full-time R6 σ TM Expert was recruited to lead the project team. Team members were assigned actions to gather data and used interviews and a Quality Performance Indicator¹ (QPI) tool as the assessment methodology that set the baseline for understanding the current situation. This first step allowed everyone on the team to baseline current state and measure progress toward the goal. Next, the data were analyzed to identify the constraints, establish priorities, and create solutions that would achieve the project goals. From the analysis came the following prioritized solutions:

- Define clear roles, responsibilities, and accountabilities.
- Establish lines of communication with the customer.
- Create program run rules.
- Develop the risk management plan and tracking metrics.
- Post *radar* chart² used to measure communication improvements.
- Move to a contributory team culture.

The team also used Critical Chain Project Management³ techniques to accelerate the schedule. Subject matter experts, in conjunction with the Customer and Program Team, used reverse planning to develop workflow plans, identify unrealistic task completion

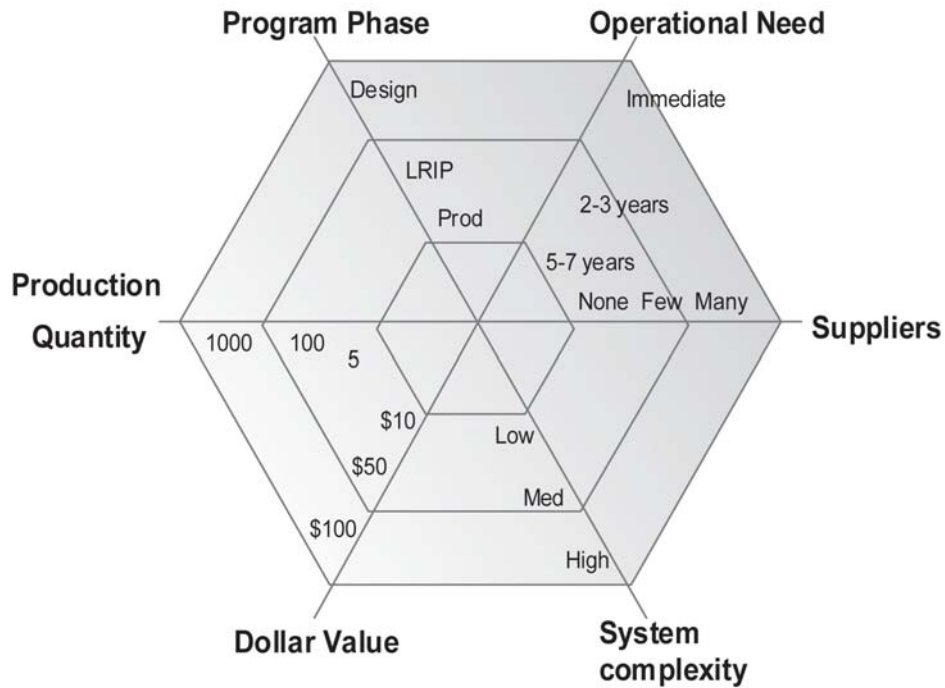


FIGURE 3. EXAMPLE OF A RADAR CHART

expectations, address opportunities to improve information flow, and identify resource constraints. Run rules were established to optimize the use of the critical resources and inch-stone charts were used to monitor progress. Sensitivity to the existing culture dictated use of workshops that addressed the staff mindset and focused them on the goal. When everyone agreed that the teams were committed and ready, changes were implemented such as daily stand-up meetings used to identify any barriers and assign actions.

Results

Delivery was completed 6 months ahead of schedule. The customer achieved the outcomes needed when this mission critical asset was delivered to the Theater Commanders. Additionally, production costs were reduced and customer satisfaction and focus was improved. The Raytheon team was able to capture follow-on business, increase profits, and improve cash flow. The team's focus on changing the culture, keeping the customer involved, and sensitivity to resistance to change was essential to delivering a system in half the scheduled time.

DESIGN FOR SIX SIGMA

The Challenge

Raytheon business needs have evolved since initiating R6σ™ in 1999 and project teams needed to evolve as well. As project results were achieved, the importance of

DFSS⁴ became evident. More robust design processes were the long-term solution to increase customer satisfaction and further improve Raytheon financial performance.

Raytheon Missile Systems has been implementing DFSS and provides the following insights and challenges to others interested in DFSS deployment.

Background

Raytheon's application of Six Sigma tools during development can be traced to the AIM-9X Sidewinder Missile Engineering and Development program. In 1995, through the application of Cost as an Independent Variable (CAIV), a reduction of \$1.2 billion in AIM-9X Life Cycle Costs was achieved. Particular emphasis was placed on the cost of the Raytheon-supplied Integrated Detector Assembly (IDA) using Design of Experiments⁵ (DOE) and other variability reduction techniques. By 1998, success on this program and others resulted in the Navy recognizing Raytheon's CAIV process as an industry best practice.

***"IPDS is the systems engineering methodology
by which Raytheon manages, develops,
and produces products."***

The joint Air Force/Navy AMRAAM missile Phase III program, started in 1998, also implemented CAIV. Through the application of Quality Function Deployment⁶ (QFD) and Design for Manufacture and Assembly⁷ (DFMA) workshops (and other efforts) a reduction of 20 percent in Average Unit Production Cost (AUPC) of the missile was achieved. Phase III incorporated Electronic Counter-Counter Measures (ECCM), an upgraded seeker, and longer range capabilities into AMRAAM. Over 25 QFD/DFMA workshops were conducted with Air Force customer participation. Involving the supply chain, key supplier workshops with circuit card manufacturers Kuchera and Group Technologies resulted in 15 percent reductions in circuit card count and electronics cost.

Building on this Success

As a result of these and other early successes, Raytheon is now integrating a suite of Six Sigma tools into a structured methodology and incorporating them within the Integrated Product Development System (IPDS). IPDS is the systems engineering methodology by which Raytheon manages, develops, and produces products. It fosters use of a consistent process across all Raytheon programs. IPDS is divided into stages along the life cycle of the business. DFSS focuses on the early stages of the life cycle—business capture, requirements and architecture, product development, and system integration.



DFSS delivers the most return if implemented at the front end of a program and is consistently applied throughout the system life cycle. One of the new development programs that will be piloting Raytheon's DFSS methodology is the Army's Non-Line of Sight Launch System (NLOS-LS) Precision Attack Missile (PAM). The NLOS-LS PAM, a low-cost direct attack missile with variable-thrust propulsion, has a range of 40 to 60 kilometers and will be developed by Raytheon. Aerojet, the variable-thrust propulsion supplier, will be a key participant in DFSS, as will Army customer representatives.

Implementation of DFSS

While Raytheon's application of Six Sigma tools to the development process is not new, the structured methodology being integrated into their IPDS will allow the toolset to be consistently deployed across the corporation. A DFSS practitioner course has been deployed to teach engineers and program managers the tools and techniques to establish it as the way that Raytheon does its business. Customer benefits from DFSS include improved affordability, higher quality, and continued performance excellence.

Raytheon will create high performance, affordable products through the application of Six Sigma tools during the development phase.

FACTORS FOR SUCCESS

Raytheon's implementation experience continues to grow and the following factors provide the summary to date of the key factors that contributed to Raytheon's success. This list continues to grow and be refined as Experts and Specialists refine their skills.

Key Success Factors

1. Focus on customer success and allocation of ample resources.
2. Set goals and vision to challenge the organization.
3. Leadership commitment: leaders must be knowledgeable, informed, and involved.
4. Involve everybody, not just an elite few. Ensure active participation of *legacy* talent. Ensure customer and supplier involvement.
5. Use empowerment, intensive communication, education, and training.
6. Identify and work on the constraints.
7. Apply the right tools at the right time.
8. Consider the culture and organization readiness for change—address the barriers and change the culture first.

9. Evolve the approach to meet the changing needs of the business. Never stop learning and working toward perfection. Complacency will result in a temporary plateau before the inevitable slide downhill.
10. Measure and reward results. Celebrating success will lead to more success.

SUMMARY OF RAYTHEON'S APPROACH

Raytheon Six Sigma™ continues to evolve as the needs of projects and Raytheon change, but the focus on customer success as the central mission to R6σ™ has never wavered. The journey has been successful at Raytheon because R6σ™ balances achieving success for customers as well as delivering financial benefits to the corporation. Bill Swanson, who became Raytheon's chief executive officer in July 2003, is now guiding it. Swanson is currently leading Raytheon Six Sigma™ by shaping the strategy and applying his in-depth knowledge and experience with the defense industry to evolve R6σ™ to meet future challenges for customers and in product development. As Raytheon changes to meet new customer needs and competitive pressures, R6σ™ has the leadership, the vision, and the agility to change with it.

R6σ™ is a trademark of Raytheon Company.



ENDNOTES

1. Quality Performance Indicator (QPI) is a consistent, predictive indicator of the risk of achieving a project's quality product. The QPI uses project specific criteria and weightings established at program start-up. It is closely aligned with the integrated product development system, and assessment of the Program is conducted monthly and reviewed at key milestones. The QPI measures contract compliance, customer satisfaction/expectations, deliverable product performance, and program plan implementation, results of quality evaluations, rework, and product/mission assurance involvement.
2. Radar charts are assessment tools used to evaluate and prioritize using multiple criteria and are useful to show the gaps between current organization performance and the vision. This example may be useful to assess project priorities in a program office. Get multiple perspectives on each project measured using each axis on the radar chart. Connect the ratings and evaluate priorities. Results from this example could be used to best allocate scarce acquisition management resources across multiple programs.
3. *Critical Chain Project Management and Buffer Management* is a proven *whole system* approach to project management that does not rely on managing a project based on a series of supposedly *safe* task estimates. A project schedule can now be designed to protect the project due date by taking *safety* that was spread among the tasks and concentrating it where it does the most good—as buffers at the end of the critical path and where others paths feed that critical path. Implementations of *Critical Chain Project and Buffer Management* typically result in project schedules that can be 15 to 25 percent shorter than traditional schedules but with considerably more reliability of the promised final project due date with less chaos and rescheduling.
4. Design for Six Sigma (DFSS)—This strategy for product development uses a wide range of tools and methodology to provide project management, executives, and engineers the data, risk measures, and design deliverables for each gate in the integrated product development process. The focus is to develop products that are highly valued by customers. DFSS identifies and focuses on critical parameters in the design to ensure delivery of a product that delivers the desired customer outcomes and is compatible with the company manufacturing capabilities and processes.
5. Design of Experiments—A systematic and efficient way to simultaneously investigate causes of variation in a process. Statistical analysis techniques are used to identify those factors and their interactions that best control the output of a process. The goal is to find the optimal factor settings from among many potential factors to achieve the output goal (e.g., improve performance characteristics, reduce cost,

reduce cycle time, reduce variation, increase yield, increase sales, and increase the impact of communication). Both expected output value and variation in the output could be modeled using this technique. Through the analysis of many factors, this technique prioritizes the few factors that make the most impact to the end goal. This technique has been successfully applied in engineering, manufacturing, and business operations situations.

6. Quality Function Deployment—This is a method for translating a customer's wants and needs into company requirements for deployment throughout all aspects of the business including product development, engineering, manufacturing, and marketing. It is used to determine which aspects of the product or service are most important to the customer and ensures critical performance parameters are addressed. It provides users with a systematic and structured process for translating the Voice of the Customer (VOC) into appropriate requirements and actions.
7. Design for Manufacturing and Assembly—This process focuses on cycle time reduction at the manufacturing stages, and improving producibility and maintainability. The approach develops a *teaming* philosophy between Design Engineering and Manufacturing Engineering when a product is being designed. The cross-fertilization that occurs between the functions of design and manufacturing results in tremendous benefit in improved producibility, improved yields, and cost reduction. In more mature teaming environments, assemblers and operators on the manufacturing floor (even suppliers) participate in these design/manufacturing teams. Therefore, the key to success is to set a goal that the team can agree upon, focusing on simplicity that meets the design requirements.



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