Chapter 6

Integrating the CMMI and Six Sigma: Strategies

If one accepts the value proposition that synergistic implementation of multiple standards and initiatives accelerates the improvement journey and renders it more effective, then the next question is how to go about it. There is not a “one size fits all” solution to this question. However, several common approaches and considerations can be leveraged.

In this chapter, we build on Chapter 4’s research and Chapter 5’s case studies and highlight possible sequencing scenarios, followed by frequently observed strategic approaches to the joint implementation of the CMMI and Six Sigma. Then we proceed with a discussion of integrated deployment tactics. The Motorola case is revisited here, with a field report on Six Sigma deployment, specifically focusing on integrated training.

6.1 Sequencing Scenarios

One way for an organization to begin reasoning about a joint implementation is to consider its starting point in terms of CMMI and Six Sigma deployment and performance. Figure 6–1 shows several possible paths, with different possible starting points.

- Path 1 (solid): Implement the CMMI to high maturity, and then implement Six Sigma. In this approach, the CMMI is likely to be the organizational
governance model, with Six Sigma methods used in an isolated fashion to help with the implementation of specific process areas and practices. After high maturity is achieved, Six Sigma is formally adopted as the means for continuing process improvement.

- Path 2 (dash): Institutionalize Six Sigma fully and then the CMMI. In this approach, Six Sigma is likely to be the governance model, with the CMMI (and other standards) being selected to close problematic gaps in process infrastructure.

- Path 3 (dot): Jointly implement and institutionalize Six Sigma and the CMMI from the beginning. In this approach, the two initiatives may alternate as the governance model or the tactical engine. For instance, Six Sigma may lead the organization to deploy particular CMMI process areas, and it may dictate a lean process infrastructure. The CMMI may lead the organization to quickly identify critical process factors as well as opportunities against which to apply the Six Sigma frameworks.

- Path 4 (dash-dot): Implement the CMMI to level 3, then establish Six Sigma and proceed with a joint implementation. In this scenario, the organization first establishes its defined processes and then uses Six Sigma in its quest for high maturity.

The question that arises by examining joint deployment from this perspective is whether there is strategic advantage in implementing the CMMI first
and then Six Sigma, or vice versa, or implementing them in tandem. In truth, the choice about which path to pursue depends on the organization’s circumstances when it decides to pursue synergistic, rather than parallel/-independent implementation of the initiatives. In some cases, a sequential path is dictated by current reality. For instance, a CMMI adoption may be well under way when the enterprise levies the adoption of Six Sigma on the organization. Or an enterprise may have institutionalized Six Sigma and be well into the process of extending it into engineering when the non-software-oriented Black Belts realize that there is no established software process infrastructure or measurement system (as there is in manufacturing). Presuming they have awareness of domain-specific models and standards, they then face the equivalent of a “build or buy” decision: invent software process infrastructure from scratch or tailor what the community has codified.

Thoughtful, joint implementation throughout the entire improvement journey (path 3) is likely to be the most efficient path, but only if the engineering process group and the organization are ready for that approach. In some contexts, due to politics, previous organizational training, and many other factors, implementing one and then the other may be more ideal. Either way, it comes back to the matters of choice, conscious strategic decision making, and thoughtful designs.

Happenstance and timing issues notwithstanding, an organization can be successful with any of the paths.

### 6.2 Joint Implementation Strategies

From the published information available and our research, we have abstracted the following strategies for using these initiatives together. This is not an exhaustive list, but rather reflective of patterns we have observed, overlaid with what our experience tells us works well. These strategies, which range from coordinated to fully integrated implementations, are not mutually exclusive. In fact, in some organizations, all of them have been leveraged. These strategies do not presume that the CMMI precedes Six Sigma adoption or vice versa.

Chapter 7 continues the discussion by describing dimensions of design connectivity between the CMMI and Six Sigma that can (and should) be leveraged to execute these strategies. Understanding these relationships enables the successful execution of the chosen strategies.
Strategy 1: Implement CMMI-based processes (or, more simply put, CMMI process areas) as Six Sigma projects.
This strategy establishes the objective(s) of the Six Sigma project team as implementing a process area or a group of process areas. The team is responsible for defining the problem or opportunity that would be addressed by the new process(es) and for using data and analytical methods to inform the design, redesign, and performance improvement and thereby achieve the organizational mission and model compliance. Depending on whether the process area implementation involves updating existing processes or defining new processes, DMAIC, DFSS, or Lean might be appropriate.

Process Implementation via Design for Lean Six Sigma
As described in this chapter, there are different strategies for jointly implementing the CMMI and Six Sigma—including such choices as implementing an internal process standard comprising all models of interest and implementing process areas as Six Sigma projects. Either way, an oft-observed phenomenon in CMMI adoption is that the organizational collection of processes gets larger before it gets smaller. This has been shown pictorially in a presentation about the joint use of the CMMI and

Figure 6-2: Relative amount of process with maturity level (Reprinted with permission [Beardsley 05]).
Six Sigma, with specific attention to planning an approach that seeks a direct path to the optimal amount of process [Beardsley 05].

Such a planned approach calls for a systemic architecture and design of the organization’s processes. In the Beardsley presentation, Design for Lean Six Sigma is implied as a technique to use in this quest.

The advantages of having an architecture and a process design extend beyond CMMI implementation—to the world of multimodel process improvement. When multiple models and standards are implemented, especially in different timeframes, one might imagine an ongoing version of Figure 6–2—a profile with periodic peaks and valleys as each new model or standard is implemented and then optimized. A robust architecture should minimize (if not prevent) such peaks and valleys and maximize the amount of time an organization spends with just the right amount of process.

Strategy 2: Apply Six Sigma to improve process performance and serve as the tactical engine to achieve high capability and/or high maturity.

There is natural synergy between the high-maturity process areas and the tenets of Six Sigma’s DMAIC framework. As such, the tactics of Six Sigma can be used to directly enrich the defined processes that correspond to the high-maturity process areas.

In one aspect of this strategy, Six Sigma steps can enrich the process design, in conjunction with the specific practices of the high-maturity process areas. For instance, the processes to which Quantitative Project Management (QPM) and Causal Analysis and Resolution (CAR) map would obviously reflect the specific practices of both process areas. They could also reflect the steps and tools of DMAIC and/or Lean.

In another aspect of this strategy, the DMAIC steps and toolkit can be used to actually achieve high performance, via Six Sigma projects and high-maturity process execution. Similarly, the steps and tools of DMAIC and Lean support the implementation and execution of the generic practices associated with high capability—those that mature a process to be quantitatively managed and then optimized.

Specific design connections between DMAIC and groupings of process areas will be further discussed in Chapter 7 and in the example on product quality improvement in Section 9.1.

Strategy 3: Apply Six Sigma, specifically DFSS, as a tactical contributor to achieve highly capable engineering processes.
A variation on the previous strategy is to use Six Sigma as a tactical engine underlying the Engineering process areas, alongside architecture and engineering technologies such as ATAM. In this instance, tenets of DFSS would be used to enrich the engineering process. This could be coupled with the usage of DMAIC and the generic practices to institutionalize, optimize, and achieve high capability in those processes.

**Strategy 4: Apply Six Sigma to improve or optimize an organization’s improvement strategy and processes.**

Six Sigma can be used in making decisions about the adoption of improvement initiatives and in the management and overhead associated with adoption. Possible ways to apply Six Sigma in this manner include the following:

1. Appraisal process streamlining and cost reduction
2. Identification of highest-priority organizational problems, which informs decisions about improvement project selection and portfolio management
3. Optimization of the CMMI and overall improvement program execution

DMAIC and Lean seem particularly well suited to these approaches. If a process redesign is warranted, DFSS might be leveraged. Combining with the previous strategies, an organization might use the Define, Measure, and Analyze steps of DMAIC to define an improvement project portfolio that serves the organization’s mission. Using the CMMI for guidance and possibly as governance for specific improvements, the organization could then employ DMAIC, Lean, or DFSS for each respective improvement effort and propel itself toward control and optimization one project at a time. A focus on mission and performance ultimately results in compliance to the model.

**Strategy 5: Institutionalize Six Sigma project results, and culture, via the CMMI’s institutionalization practices.**

While the Six Sigma deployment approach (sponsorship, training, belt certification, and so forth) ensures that it is pervasively used in an organization, it does not have formal, codified mechanisms to leverage and disseminate the learnings of individual projects. Many Six Sigma organizations rely on their informal networks of Belts, internal community of practice conferences, and sometimes intranet-based data-sharing systems.

In CMMI organizations, however, the generic practices and such things as the organization’s asset library provide ready-made institutionalization mechanisms for Six Sigma project results [Bergey et al. 04; Anderl- finger et al. 06; Kirwan et al. 06]. Usage of these mechanisms typically becomes a de facto strategy for those pursuing joint implementation of the CMMI and Six Sigma. It enables an organization to maximize the value of every Six Sigma project.
Strategy 6: Develop an internal process standard that maps to or integrates the CMMI, Six Sigma, and all other improvement initiatives of choice. This standard defines the process by which every project is to be executed, across its entire lifecycle. While the previous approaches are tactical, very oriented toward the use of Six Sigma projects and very oriented toward supporting a CMMI deployment, this strategy is longer term and more visionary. It embodies the idea that an organization should take control of its destiny and manage its initiatives rather than be managed by them. In this strategy, the focus is on embedding Six Sigma alongside other initiatives in the organizational business and engineering processes. It builds Six Sigma thinking into the fabric of the organization, supporting culture change and, in a way, becoming the ultimate enabler of Six Sigma. It also builds every other initiative of choice into the organizational DNA.

Many people describe this idea in different ways. It has been called, among other things, integrated process architecture, interoperable process architecture, and internal integrated standard process. Lockheed Martin IS&S labels its approach the Program Process Standard [Penn and Siviy 03]. Regardless of the label, the idea remains the same: The organization establishes a set of standard processes that incorporate all the features of the initiatives of choice. This idea assumes that the process is adaptable with time (i.e., capable of iterative refinement) and instrumented and robust to the realities of the organization (e.g., the types of work done and the degree of organizational acquisition). This approach can be executed at any maturity level, with any maturity level as the end goal. When possible, it’s best to start while at low maturity.

In addition to Lockheed Martin IS&S, whose mapped Program Process Standard has been presented at a high level at conferences, Northrop Grumman Mission Systems (formerly TRW), Wipro, Tata Consultancy Services, JPMorgan Chase, EDS, and others have also presented their enterprise strategies, showing how they jointly leveraged the CMMI, Six Sigma, and other initiatives. (See References and Additional Resources near the end of this book for pointers to some of these presentations.)

### 6.3 Considerations for Staged and Continuous CMMI Representations

When considering the joint use of the staged representation of the CMMI with Six Sigma, the most frequently asked question relates to whether and how Six Sigma can be applied at lower maturity levels. The answer is
that yes, Six Sigma can be applied at lower maturity. Two of the previously

described sequencing scenarios call for Six Sigma to be used at lower ma-

turity, and all of the strategies allow for this. The use of Six Sigma at lower ma-

turity is different than at higher maturity and, in fact, contributes to an

accelerated attainment of high maturity.

As depicted in Figure 6–3, Six Sigma philosophy, frameworks, and toolkits
can all be leveraged at lower maturity. Even its measures can be used, al-
though they may not reflect organizational performance (yet). If Six Sigma
project portfolio management and methods are being employed, there is rea-
sonable assurance that local improvements provide added value for the or-
ganization and are not just isolated exercises that will not contribute to the
greater good. As such, there is a likelihood that these efforts will accelerate
the CMMI solution—a key aspect of the value proposition for joint model
implementation—because people will gain experience with the effective use
of measurement and analysis to gain control of a situation and possibly opti-
mize a process, albeit a local one. CMMI-compliant processes may be piloted

\[\text{Figure 6–3: CMMI staged representation and Six Sigma}\]
and refined as part of individual project efforts. As an organization climbs the maturity ladder, the use of Six Sigma can continue, but now applied across organizational processes.

In the continuous representation, Six Sigma may be used to drive the design and/or improvement of any process area that has been selected for implementation, much as it may be used in the staged representation.

An additional usage of Six Sigma for the continuous representation relates to the selection and sequencing of process area implementation. An organization could use Six Sigma thinking to establish its highest-priority issues and the requisite process areas that need to be implemented to solve them [Vickroy 03]. It might also blend in a strategic prioritization of processes. For instance, an organization might choose to develop its capability in process areas that are tightly coupled with Six Sigma skills and methods—those that would enable it to effectively baseline and characterize process performance and issues, such as MA, QPM, and CAR. Figure 6–4 shows a possible scenario that could result when Six Sigma is used to prioritize issues and decide the order of implementation of the CMMI process areas. Alternatively, if new product introduction or market growth were a priority for the organization, it might choose to select the Engineering process areas as first priority. This is also indicated in Figure 6–4, by a dashed line.
6.4 Considerations for Joint Deployment

Fundamentally, CMMI deployment focuses on establishing and improving process infrastructure. In contrast, Six Sigma involves a portfolio of improvement solutions across many domains. Both require management sponsorship and trained change agents. However, the sponsorship and resources are often at different levels of the organization or different parts of the enterprise. When the two initiatives intersect, such as what is currently happening in many organizations, significant gaps emerge. Traditional Six Sigma practitioners often do not have the software, systems, or IT experience that enables them to see how to apply their toolkit in that domain. And they often do not have sufficient awareness or understanding of the CMMI and other domain best practices to build in their adoption as a critical part of the Six Sigma project portfolio. Similarly, CMMI implementers often don’t have the depth of analytical or cross-discipline experiences to extrapolate from traditional Six Sigma examples into their own domain and bridge gaps in communications and applications.

To address this, we recommend attention to three fundamental elements of joint deployment:

1. Shared organizational roles, particularly the primary change agents of each initiative
2. Training that is designed to bridge gaps
3. Synchronization of improvement project portfolios

Of the three, the first requires the least amount of explanation. It suggests that engineering process improvement experts should also hold expertise in Six Sigma and vice versa. If expertise in both topics is not held by the same people, the respective experts should work in the same group or otherwise have a seamless partnership. Either way, the objective is for the CMMI people and the Six Sigma people to have a shared sense of organizational mission and goals as well as a shared sense of responsibility to establish an improvement program that achieves its objectives.

One way to bridge gaps between different roles is to conduct cross-training—minimally at the awareness-building level and, for some, at the proficiency-building level.
• Manufacturing Six Sigma Black Belts who are trained in basic software development principles and in the CMMI will more easily recognize the “software factory” and the advantages of leveraging standards and models when establishing process infrastructure.

• CMMI implementers with Six Sigma training will more easily recognize how to achieve quantitatively managed processes and statistically managed subprocesses.

Such cross-training may require adaptations of existing training curricula. Numerous organizations have begun specializing or supplementing their Six Sigma curricula with domain-specific training. This allows the presentation and practice of domain-specific case studies, thereby alleviating the need for trainees to make the leap from the use of analytical tools in manufacturing to their respective disciplines. It also allows the inclusion of awareness sessions about domain-specific topics. This might include special analysis considerations, such as non-normal distributions, and it might include an introduction to improvement technologies, such as the CMMI or software measurement best practices, or to architecture practices (the latter being particularly well suited in a DFSS curriculum). Conversely, CMMI training might include an awareness session about relationships between the CMMI and Six Sigma.

Shared roles and cross-training enable synchronized project portfolios. One risk of not synchronizing is competition for resources, particularly funding. In the worst situation, CMMI-oriented projects get shortchanged, and Six Sigma projects are launched on the false presumption that instrumented software processes stand ready for Six Sigma improvement—a mutually disabling situation. One way to bootstrap synchronization is to create a project identification and definition process that is more efficient due to the presence of both the CMMI and Six Sigma. This approach might include the following features.

• The use of Six Sigma methods to transform fuzzy problem statements into quantitative improvement objectives against which specific improvement projects (including those serving CMMI goals) can be launched. An example of this type of project is included in Section 9.2.

• The recognition of the need for enabling projects that establish processes and measures required for subsequent Six Sigma efforts and the incorporation of the CMMI and other domain model implementation as a critical driver of an enabling project portfolio. The enabling projects might be
executed via the aforementioned strategy to implement CMMI process areas as formal Six Sigma projects.

Specific approaches for project portfolio identification and alignment with mission are discussed in Chapter 8, as part of the general case of multimodel process improvement.

6.4.1 Motorola Retrospective: Integrated Training Curriculum

At Motorola, the fourth week of the traditional Six Sigma DMAIC Black Belt program involved choosing one of four different discipline-specific training options: Software, Hardware, Transaction, or Manufacturing (refer back to Table 5–2). This approach enabled cross-discipline classes during the first three weeks of the DMAIC training and helped to both bridge the communication gap on the methods and enable some degree of cross-training between disciplines.

Within the Design for Six Sigma Black Belt program, a similar type of cross-discipline training took place with the approach of training product development teams in a single class. Table 6–1 shows the initial customized DFSS curriculum, which included a number of SEI technologies and training in the CMMI as well as software-specific topics. During the actual training, at times the class broke out to side rooms to cover discipline-specific topics for that point in the Design for Six Sigma methodology.

6.4.2 Motorola Retrospective: Roles and Responsibilities

Table 6–2 depicts software engineering and management functional roles and job categories mapped to the recommended software DFSS curriculum, as well as recommended supplementary training in software practices. The champion training brought senior management up to speed on the concepts taught to the DFSS Black Belts so that the champions could help create demand for the use of the DFSS toolkit. The gatekeeper training brought senior and middle management up to speed on the DFSS product team scoring process and additional probing questions to ask during the MGates management reviews.

Examples of supplementary software specialty training are shown in Figure 6–5, targeted to specific job categories. This supplementary training spanned the CMMI as well as the SEI’s architecture and product line practice technologies, depending on the role.
### Table 6–1: Motorola DFSS Curriculum Tailored for Software

<table>
<thead>
<tr>
<th>Week 1 Topics</th>
<th>Week 2 Topics</th>
<th>Week 3 Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFSS Overview</td>
<td>Critical parameter management</td>
<td>Linear and multiple regression</td>
</tr>
<tr>
<td>CDOV Process</td>
<td>DFMEA</td>
<td>RSM</td>
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<tr>
<td>DFSS tools and project management</td>
<td>Basic Stats (statistics package)</td>
<td>Monte Carlo</td>
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<tr>
<td>Voice of the customer/KJ analysis</td>
<td>Hypothesis testing</td>
<td>Robust design</td>
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<td>QFD</td>
<td>Confidence intervals</td>
<td>Tolerance optimization</td>
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<td>First Principle Modeling (Monte Carlo)</td>
<td>ANOVA</td>
<td>CPM</td>
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<tr>
<td>Pugh</td>
<td>MSA</td>
<td>Architecture and design-based software reliability modeling</td>
</tr>
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<td>DFSS Scorecards</td>
<td>SPC</td>
<td>Software reliability growth testing and modeling</td>
</tr>
<tr>
<td>Six Sigma and CMMI synergies</td>
<td>Design and Process</td>
<td>Motorola Lab’s TRAMS (Test Planning using fuzzy logic)</td>
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<tr>
<td>Parametric SW project forecasting</td>
<td>Statistical capability analysis</td>
<td>Taguchi Noise Testing</td>
</tr>
<tr>
<td>Requirements management processes</td>
<td>Design of Experiments (DOE)</td>
<td>Small memory management</td>
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<tr>
<td>Developing SW operational profiles</td>
<td>Full factorial designs</td>
<td>Throughput and timing analysis</td>
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<td>SW Quality Attribute Workshops</td>
<td>Fractional factorial designs</td>
<td>Orthogonal Defect Classification</td>
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<td>Attribute-Driven SW Architecture</td>
<td>Modeling</td>
<td>Advanced SW inspection</td>
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<td>Active Reviews for Intermediate Designs</td>
<td>Advanced DOE</td>
<td>Human error analysis</td>
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<td>SW Architecture</td>
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<td>Cleanroom Software Engineering</td>
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<tr>
<td>Tradeoff Analysis</td>
<td></td>
<td>Agile/Extreme Programming</td>
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<tr>
<td>Method (ATAM)</td>
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<td>SEI Personal and Team Software Process and relationships to DFSS</td>
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<tr>
<td>Cost/Benefit Analysis of Architecture Decisions</td>
<td></td>
<td>Usability engineering</td>
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<tr>
<td>Software Product Line Planning and Execution</td>
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</table>
Table 6–2: Motorola Role-Specific Training Plan

<table>
<thead>
<tr>
<th>Functional Roles</th>
<th>Job Categories</th>
<th>DFSS Training for Software Engineering</th>
<th>Primary Responsibility in DFSS Deployment for Software Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management and leadership</td>
<td>Senior resource managers</td>
<td>Attend champion training</td>
<td>Serve as gatekeepers in DFSS gate reviews for software engineering</td>
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<td></td>
<td>Senior software managers</td>
<td>(1 day for each of the DFSS Weeks 1–3 for software engineering)</td>
<td>Use software scorecard measures and explanations</td>
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<td></td>
<td>Senior test managers</td>
<td>Gatekeeper training</td>
<td>Require DFSS training for software engineering within organization</td>
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<td></td>
<td>Gate review team members</td>
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<td>Ensure sufficient SW Green, Black, and Master Black Belts exist</td>
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<td>Operations managers</td>
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<td></td>
<td>Software directors</td>
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<td></td>
<td>Senior software architects</td>
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<td>Feature team leaders</td>
<td>Test team managers and leaders</td>
<td>Attend 3 weeks of DFSS training for software engineering</td>
<td>Ensure the timely use of DFSS tasks, tools, and deliverables for software engineering</td>
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<td>and working-level architects</td>
<td>Feature team leaders</td>
<td>Attend software specialty training as required</td>
<td>Present data at DFSS gate reviews for software engineering</td>
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<td></td>
<td>First-line software supervisors</td>
<td></td>
<td>Identify team members for follow-on in-depth training</td>
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<td></td>
<td>Senior technical experts, architects</td>
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<td></td>
</tr>
<tr>
<td>Specialists</td>
<td>Designers</td>
<td>Attend 3 weeks of DFSS training for software engineering when selected</td>
<td>Perform tasks in a timely fashion</td>
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<td></td>
<td>Programmers</td>
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<td></td>
<td>Testers</td>
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6.5 Summary

The joint implementation of the CMMI and Six Sigma should be considered from a strategic viewpoint, with attention to sequence, to their relationship when simultaneous deployment begins, and to several deployment execution factors.

Due to history and legacy, organizations’ sequencing of the two initiatives varies. When they reach the point in their timeline to deploy both initiatives simultaneously, several frequently successful strategic approaches may be employed. These approaches, which range in their extent of coordination versus integration, are not mutually exclusive and do not presume that the CMMI precedes Six Sigma or vice versa.

- Implement CMMI process areas as Six Sigma (DMAIC, DFSS, and/or Lean) projects.
- Apply Six Sigma (DMAIC and Lean) as the tactical engine for high capability and high maturity.
- Apply design for Six Sigma as a tactical contributor to achieve highly capable engineering processes.

**Figure 6–5:** Motorola software specialty training to supplement the DFSS curriculum for software engineering
Apply Six Sigma to improve or optimize an organization’s improvement strategy and processes.

Institutionalize Six Sigma (including Lean) project results and culture via CMMI’s institutionalization practices.

Integrate the CMMI, Six Sigma, and all other improvement initiatives of choice to provide a standard for the execution of every project throughout its lifecycle.

From the viewpoint of CMMI representation, Six Sigma can be used at all levels of maturity (staged representation) and can be used to guide the priority of process area implementation (continuous representation).

Deployment execution should also be managed in an integrated fashion, which might include the following fundamental shared activities: shared organizational roles, training designed to bridge gaps, and synchronization of improvement project portfolios.