APPLYING CMMI AND STRATEGY TO ATE DEVELOPMENT

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Abstract - This paper provides a viewpoint of the Capability Maturity Model Integration (CMMI[SM]) from the perspective of Automated Test Equipment (ATE) Development and Test Engineering.

ATE development is a specialized segment of product development and shares many of the same issues. Requirements for the test equipment are very dependent on continually evolving product characteristics. Even with the best planning, lead times for ATE development are typically eroded by late changes to product requirements and designs, and eventually the critical path leads right through test! Without a solid process foundation, chaos ensues.

The CMMI process models provide a framework for the integration of best practices in many disciplines. Portions of the Systems Engineering, Software Engineering, Integrated Product and Process Development and Supplier Sourcing models all offer important perspectives which affect ATE developers. This paper focuses on the CMMI processes and best practices which yield the greatest impact to test organizations and groups that provide ATE. The overall Test Strategy should help prioritize the process areas which deserve the most attention.

Mature ATE organizations use a Balanced Scorecard approach to provide alignment with corporate and program level goals. Metrics monitor their progress against their corporate goals. At the program level, they apply a risk-driven approach to selectively apply resources that achieve the highest ROI for test dollars. From this business-oriented vantage point, organizations are likely to see increased efficiencies that will decrease overall system development costs by streamlining the testing component of their budgets.

INTRODUCTION

Even before the introduction of the CMMI (or preceding models) organizations have been struggling with the concepts of "Process Improvement", so that they can meet both industry expectations and corporate goals. The resulting initiatives have been the "money pit" for many organizations. The ROI for those organizations that have made it up the maturity ladder is well published and provides motivation for others to follow in their footsteps.

In the last decade there has been a plethora of Maturity Models and Bodies of Knowledge that cover many different disciplines to include not only engineering topics, but medical, project management, quality assurance, and even interior design and social issues. In each case, there is a quest to provide an index to best practices that are the accumulated knowledge base for that area of interest. Since our knowledge continues to grow in all of these areas, the process of collecting, sorting, categorizing, building consensus and disseminating the information, is never ending. The resulting pool of information can be overwhelming and difficult to absorb from anyone's perspective. Test Engineers, including developers of ATE, are included.

THE WORLD OF "TEST"

Every group sees the world from their own unique perspective. Each has organizational-specific interfaces and influence from many different sources, both internal and external to the group

Forces on Test Systems

The responsibility of "Test" can be distributed into many different groups within an organization and often outside suppliers. Each of these groups may carry a portion of the overall responsibility for testing a product or system. In many organizations, a Test Group picks up the responsibility for Design Verification (DV) and/or Production Verification (PV). Regardless of the distribution of the responsibility, there are many forces that affect the development of a testing strategy and resulting Test Systems. Figure 1 highlights some of the many pressures that influence the strategy and approach to testing.

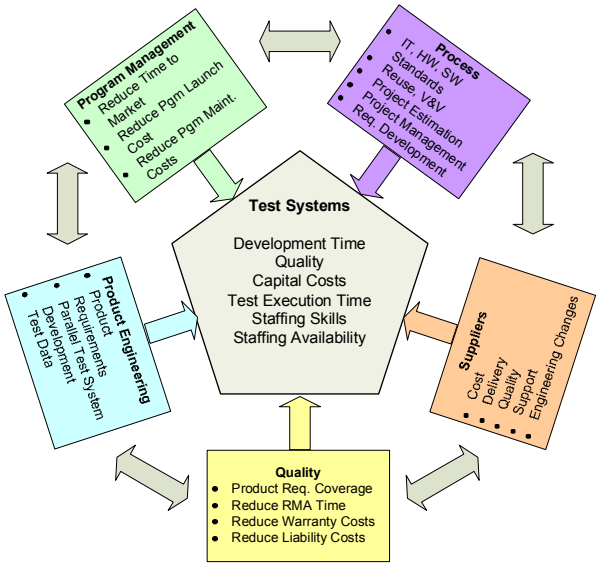

Figure 1. Forces on Test System Development

Although many of these same forces are common with development, the specific influence on testing can be unique and provide additional pain points. One of the most common issues comes from the inevitable changes to the product design as it progresses through a development lifecycle.

"We seem to be the last group to know that there has been a change…" – Automotive Test Group Manager.

These changes not only have a ripple affect into test cases and procedures, but may require design changes to long-lead items such as custom test fixtures.

Process models such as the CMMI address many of the common pain points which can be interpreted within the context and scope of a test organization.

CMMI

The CMM Integration project team was formed to deal with the issues associated with using multiple CMMs. Their mission was to combine three source models: (1) Capability Maturity Model for software (SW-CMM), (2) Electronic Industries Alliance Interim Standard (EIA/IS) 731, and (3) Integrated Product Development Capability Maturity Model (IPD-CMM) into a single framework. The team took on the task with the intent to create a common framework that would support the integration of other discipline-specific CMMI models. At this time, there are four bodies of knowledge that provide amplification of process areas most relevant to that perspective. These include:

- Systems engineering
- Software engineering
- Integrated Product and Process Development
- Supplier sourcing

Although there are several other discipline-specific CMMI models in development, the perspective of Test Engineering is currently missing from the list. To address this void, several attempts have been made to propose and/or develop both a Testing Body of Knowledge [8] and a Testing Maturity Model [3,4]. The SW-TMM[SM] developed by the Illinois Institute of Technology is intend to be a complement to the SEI's SW-CMM and address issues important to test managers, test specialists, and software quality assurance staff. This model follows a framework similar to the SW-CMM by defining five levels of testing maturity:

1. Initial
2. Phase Definition
3. Integration
4. Management and Measurement
5. Optimization and Defect Prevention and Quality Control

It allows an organization to assess their maturity against a framework of recommended practices focus on testing. Although the model is oriented toward software, it is rather easy to extrapolate the ideas into a systems engineering context.

Best Practices for ATE Development

Although test groups may exist within an organization that has been assessed at a CMMI maturity Level 3 or better, many of these groups seem to remain in the shadows and avoid the process spot light.

"Our company is a Level 3 organization, but it really has not affected the test group" – Test Team Leader.

In some groups there is a general perception that the "CMMI stuff" is really more for the product development groups and will not provide a direct benefit to the ATE developers. In many of these organizations, there is actually more software and hardware developed by the test group than any other area. This is particularly true for mission-critical systems for mil-aero and medical applications.

Clearly the development of test equipment and systems should be treated with at least the rigor that is applied to the Unit Under Test (UUT). Now take into account that testing always ends up on the critical path, consistently wagged by changes in the UUT, is typically under staffed and under funded, and most people will likely conclude that it needs extra attention to be successful.

Although each of the process areas in the CMMI can be applied to ATE development, some are more critical under these conditions. Working with companies ranging in size from very small to Fortune 100, and in many different industries, there emerges a very common set of issues. By applying process improvements in these specific areas, many organizations could take a quantum leap in their effectiveness. These critical areas include:

- Requirements Development and Management
- Configuration Management
- Change Control

Requirements Development & Management

Requirements Management is a CMMI Level 2 process area and *Requirements Development* is associated with Level 3. Both are critical.

SG 1 "Manage Requirements" includes these five specific practices:

SP 1.1 Obtain an Understanding of Requirements
SP 1.2 Obtain Commitment to Requirements
SP 1.3 Manage Requirements Changes
SP 1.4 Maintain Bidirectional Traceability of Requirements
SP 1.5 Identify Inconsistencies between Project Work and Requirements

At Level 3, Requirements Development is divided into three specific goals:

SG 1 Develop Customer Requirements
SG 2 Develop Product Requirements
SG 3 Analyze and Validate Requirements

As with any type of development, solid requirements are the foundation of not only the development processes, but also the verification activities. This is best illustrated with the V-Model (Figure 2) typically associated with software development.

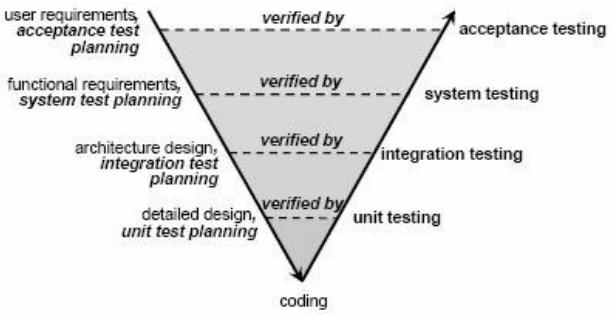

Figure 2. V-Model

Without a solid foundation of test system requirements that are traced to Product Specifications, Design Descriptions, and Test Plans, all other process areas are potentially compromised. In addition to these inputs which are directly related to the UUT characteristics, ATE systems typically provide automated test sequences (see Figure 3). These sequences embody the Test Protocols by providing specific measurement points and pass/fail indicators according to the test plans for that UUT. Although these sequences are an important part of the ATE system, they should be maintained as a separate collection of requirements. This approach facilitates maintenance of these requirements, since they are most likely to change over time. Feedback from DV and PV testing on initial production runs will hone the sequence requirements by adjusting thresholds, timing and other measurement points.

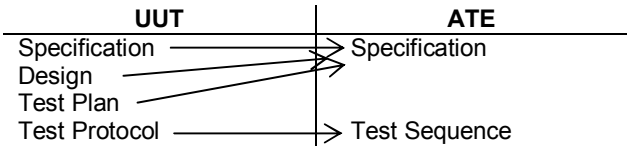

Figure 3. Inputs to ATE Specifications

Configuration Management

Within the context of ATE development, there are two main factors that drive the need for strong Configuration Management (CM) practices. The first is the obvious need to control the configuration of the test system(s). A harsh example is provided by a major defense company that lost a contract with lifetime value of over a billion dollars, due to poor CM practices on a test bench. Without managed configurations and proper controls on setup parameters, all testing activities are futile and may lead to an endless loop of test and re-test.

The second factor is the connection between the evolving UUT and the test requirements. This is particularly an issue during incremental DV testing, since both sides must work hard to stay in sync. Just watch the fun when the Independent Test Organization (ITO) proudly reports a major finding after a costly test cycle, just to be informed by the software lead "..of course it failed, I have not released that feature in this build".

Within the CMMI framework, Configuration Management is a fundamental Level 2 process area. It is represented by three specific goals:

SG 1 Establish Baselines
SG 2 Track and Control Changes
SG 3 Establish Integrity

Change Control

Effective requirements and configuration management are highly dependent on a well defined and executed change control process. People responsible for testing activities must be integral to the change control process within an organization. This includes test personnel within a development group, test organizations and outside suppliers which have a testing responsibility. Establishing a Change Control Board (CCB) with appropriate representation from these groups can be a major step in the right direction. The CCB review and approves baseline changes. It provides a critical synchronization point for a program that will eliminate many potential costly miscues. Although sometimes it seem like these groups can grow to stadium-size attendance, clear lines of authority and good meeting management skills can make these reviews efficient and effective.

Test Strategy

Regulations, company policies and industry expectations may form the boundaries of the testing requirements, but there is still a lot of room to determine the best strategy from a business perspective.

Many companies develop their test approach incrementally, based on feedback from field failures. Although this type of feedback is very important to process improvement, it may lead to a costly approach focused on the past. It is the equivalent of the pages and pages of fine print in many contracts. Each clause was added over time to address a problem that ended up in a legal battle. In both cases, prevention would be the best cure.

A Test Strategy is more than just a Test Plan for any single program. It must rise above the specific program needs to address topics such as capital improvements, outsourcing, metrics, process compliance and most importantly business goals.

CONNECTION TO BUSINESS STRATEGY

Major organizations that have struggled up the test maturity ladder, have corrected many of the issues discussed so far in this article and have met their quality objectives, but are still struggling to meet their business objectives. In many cases, there is a failure to directly tie the testing strategy to the organizational business needs, goals and initiatives.

Top organizations around the globe are successfully using approaches like "Balanced Scorecard" to develop and align their organizational strategies and goals. The Balanced Scorecard provides a perspective that is consistent with a metrics-driven approach to business decision making. Mature organizations are beginning to discover that "Test" should not be buried 37 layers deep under the product group, quality and/or production, but rather deserves attention at a business level.

"We recently lost a major program by $10M, and I know that my test budget was a significant portion of our costs. I must find ways to improve to meet our business objectives." – Aerospace Test Manager

Balanced Scorecard Approach

John C. Maxwell in his book, "The 17 Indisputable Laws of Teamwork", includes The Law of the Scoreboard. It states, "The team can make adjustments when it knows where it stands". His point is the scoreboard is essential to:

- Understanding,
- Evaluating,
- Decision making,
- Adjusting and
- Winning.

The Balanced Scorecard approach was developed in the early 1990's to address a measurement problem. It was recognized that financial measures could not capture the value-creating activities from an organization's intangible assets like skills, competencies, information, technologies, innovation, customer loyalty and others. From this beginning, the concept has evolved into a proven methodology for developing and implementing a "Strategy-Focused Organization" [2].

With success stories from a wide variety of organizations including banking, gas and oil, health care, automotive and government agencies, it clearly has a proven track record. The focus on measures that are lead indicators and directly monitor the organizational objectives is one of the foundational strengths of this approach. A testament to this strength is the story of Mobil's first quarter results after adopting a Balanced Scorecard approach. As the story goes, the company's revenues fell far short of their goals for the period. In the past, poor financial performance had led to people being fired. Walking into a meeting to review the first quarter results, people were trembling in fear. What they heard was both surprising and refreshing.

> *From what I can see, we had a good quarter even though the financial results were disappointing. The poor results were caused by unusually warm weather that depressed sales of natural gas and home heating oil. As you know this is also the first quarter we are operating with the Balanced Scorecard, so I can see performance across a broader set of indicators. Market shares in our key customer segments were up. Refinery operating expenses were down. And the results from our employee-satisfaction survey were high. In all the areas we could control, we moved the needle in the right direction. We actually had a pretty good quarter. Keep up the good work.*[2]

An organization's test strategy can be refined by selecting measures that provide objective evidence and a quantified ROI on initiatives and improvements.

Application of Balanced Scorecard to Test Strategy

The first requirement to aligning a test strategy with a Balanced Scorecard approach is to actually have a strategy! This may seem obvious, but in many organizations there is no holistic test strategy that provides cohesion between all of the various functional groups that have their hands in testing. Yes, there may be various policies, plans and procedures, but they lack a bird's eye view that can spot gaps and overlaps in the approaches.

"I spend $30k on bench testing, $400k on DV/PV testing, $400k on Mfg testing, and an unknown amount on warranty and field service testing. Each group has its own test platform and agenda" – Product Manager, Automotive Supplier

The test strategy is not just about the process of testing, it is about alignment with the corporate goals. It should not be developed in isolation and then bolted on to the business strategy, but rather derived from the business requirements. Answer the question, "What are the major issues faced in the business and how does Test play a part in those issues?" By prioritizing the answers and then focusing the resources on initiatives with measurable results, an organization will start the process of alignment.

Selecting the appropriate measures is really not about finding areas that can be measured, but more about asking the right questions. Don't be constrained by current measurement points or

distracted by items which can be easily measured. Strive to eliminate the assumptions and provide quantification.

In one example, a primarily software-based service company found that the high cost of unit testing was contributing to the loss of business based on price. The company had been using a tiered test strategy that was intended to lower cost by using less costly techniques on the majority of the code and reserving the more "expensive" techniques for critical items. By challenging some assumptions, they found that the supposedly less costly black-box unit testing was just as expensive as white-box testing in the way it was being performed. Further analysis showed that the number of defects uncovered per dollar spent was the highest with formal inspections (previously perceived as the most expensive type of testing). By adjusting their test approach based on this information, the organization was able to reduce costs and still meet quality expectations and regulatory requirements of its clients.

Measurement and Analysis

The purpose of the Measurement and Analysis (MA) process area in the CMMI is to create quantifiable results for all aspects of the engineering, management and business areas [9]. The results are the basis for many of the other process areas including Project Planning, Project Monitoring and Control, and Quantitative Project Management (ML 3). All of these areas are extremely important to managing the risks and forces impacting ATE development. Although the focus of the MA area is at the project-level, the results certainly prove useful in addressing organizational goals with a Balance Scorecard approach. This area includes the following practices:

SG 1 Align Measurement and Analysis Activities
- SP 1.1 Establish Measurement Objectives
- SP 1.2 Specify Measures
- SP 1.3 Specify Data Collection and Storage Procedures
- SP 1.4 Specify Analysis Procedures

SG 2 Provide Measurement Results
- SP 2.1 Collect Measurement Data
- SP 2.2 Analyze Measurement Data
- SP 2.3 Store Data and Results

SUMMARY AND CONCLUSIONS

Focusing on the unique perspectives of "test" provides insights that may be lost in the details of the other disciplines. It is not a breakthrough in technology or the invention of new testing techniques that will make the difference for most organizations, instead it will be "seeing the forest through the trees" that will provide the needed insights for improvements.

Alignment of the testing perspective with the business strategy and goals will provide the best value for an organization as they make investments and improvements. Measure the score along the way to determine the effectiveness of the strategy and feed the results directly or indirectly into a Balance Scorecard approach to making good business decisions.

REFERENCES

[1] Robert S. Kaplin, David P. Norton, "Alignment", Harvard Business School Press, 2006.

[2] Robert S. Kaplin, David P. Norton, "The Strategy-Focused Organization", Harvard Business School Press, 2001.

[3] Burnstein, Ilene, Taratip Suwannasart, and C.R. Carlson. "Developing a Testing Maturity Model: Part I." CrossTalk Aug. 1996.

[4] Burnstein, Ilene, Taratip Suwannasart, and C.R. Carlson. "Developing a Testing Maturity Model: Part II." CrossTalk Sept. 1996.

[5] CMMI Product Team. "Capability Maturity Model[R] Integration (CMMI[SM]), Version 1.1, Carnegie Mellon, Software Engineering Institute, March 2002

[6] Thomas C. Staab, "Using SW-TMM to Improve the Testing Process, CrossTalk Nov. 2002

[7] John C. Maxwell, "The 17 Indisputable Laws of Teamwork"

[8] Janne Harkonen, "Testing Body of Knowledge", Thesis for Master of Science in Technology, University of Oulu, July 2004.

[9] Wyatt Meek, "Achieving CMMI Levels 2 and 3 with LabVIEW, www.viengineering.com

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