CYCLE TIME IMPROVEMENT

GUIDEBOOK

A PARTNERING FOR TOTAL QUALITY DOCUMENT

SEMATECH

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"Success in competitive markets increasingly demands ever-shorter product and service introduction cycles and more rapid response to customers. Indeed, fast response itself is often a major quality attribute. Reduction in cycle times and rapid response to customers can occur when work processes are designed to meet both quality and response goals. Accordingly, response time improvement should be included as a major focus within all quality improvement processes of work units. This requires that all designs, objectives, and work unit activities include measurement of cycle time and responsiveness. Major improvements in response time may require work processes and paths to be simplified and shortened. Response time improvements often 'drive' simultaneous improvements in quality and productivity. Hence, it is highly beneficial to consider response time, quality, and productivity objectives together."

1992 Award Criteria, Malcolm Baldrige National Quality Award™ [1]

1. Fourth award criterion, *Fast Response*, page 3.

ACKNOWLEDGMENTS

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KEY DEFINITIONS

Time to Market

A business process that begins when resources are assigned to assess product feasibility and ends with customer payment for the first production unit.

Cycle Time

The time to complete a continuous repetitive work process from start to completion.

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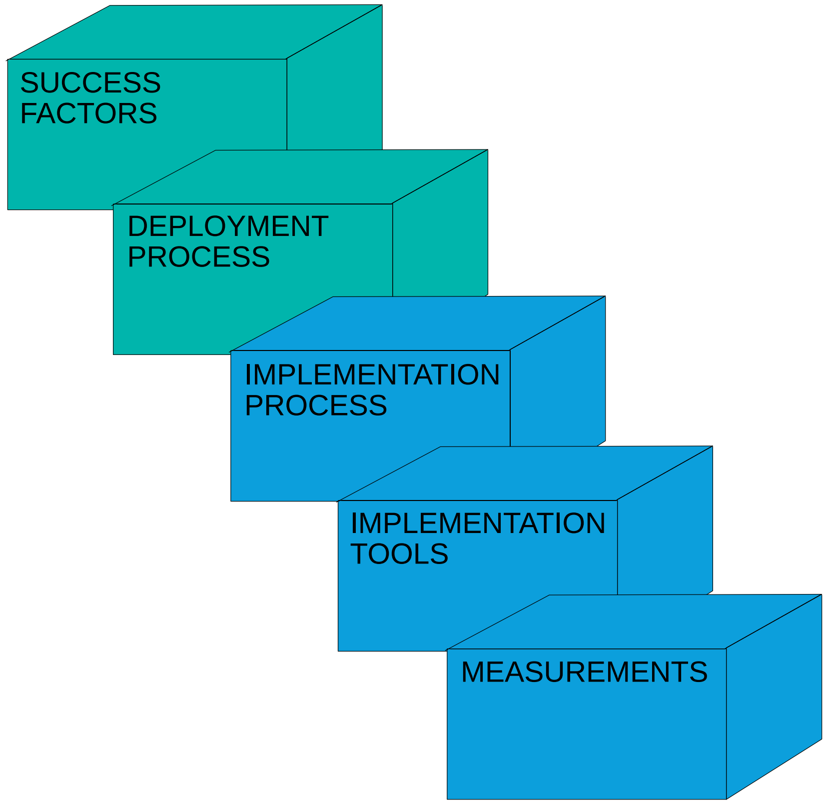
BACKGROUND

This guidebook provides an introduction to Cycle-Time Improvement (CTI) and its five major components. These components are:



This guidebook is for senior management who already have the resolve to reduce cycle time. It provides an overview of the steps and tools involved in cutting time to market and cycle times by half or more. The guidebook identifies:

- The steps to make it happen
- The roles people play
- Improvement techniques and tools
- How to make a time-based mindset part of the organization's culture

Did You Know

- You can estimate the dollar value of a one-month delay or acceleration of projects? This allows you to make better trade-offs between schedule, costs, expenses, performance, and other competing projects.
- The extent to which cycle-time improvements can affect the company's bottom line? Here is a subset of published examples of improvement ranges.[2]

Total cycle time	30 to 70%
Return on assets	20 to 105%
Revenues	5 to 20%
Inventories	20 to 50%
Invisible inventories	20 to 60%
Delivery lead times	30 to 70%
Time to market	20 to 70%

- That quality actually improves when cycle time is shortened?
- That project overload is one of the major causes for long time to market?
- That design-automation tools are not the first-order answer to faster cycle times?
- SEMATECH's Partnering for Total Quality and Total Quality Management (TQM) are consistent with the stepped-up cycle-time techniques and tools of this guidebook?
- The symptoms that prevail when quantum time-to-market or cycle-time improvements can be made?

Cycle-time improvement will also significantly aid in improving product quality.

2. Philip R. Thomas, *Competitiveness Through Total Cycle Time - An Overview for CEOs,* New York: McGraw-Hill, 1990, pp 44 and 45.

Indicators That Cycle Times and Time to Market Can Be Significantly Improved

- Projects get staffed slowly or weakly after being approved.
- Schedule slips on most projects.
- Engineers split their time among multiple projects.
- Priorities shift constantly.
- People frequently say "I haven't had a chance to get to it yet."
- Processing queues occur in such areas as Drafting, Model Shop, or the Testing Lab.
- There are many dormant projects.
- There is a reliance on expediting to get things done.
- There is a high incidence of engineering changes after product introduction.
- Manufacturing inventories are high.
- Supplier relationships are at an arm's length.
- Specifications change constantly.
- Trade-offs between time and expense are usually made in favor of lower expense.
- Few processes are documented.
- Manufacturing Engineering and Engineering are not working together early in the program.
- Management concentrates attention on a project near its completion rather than its early stages.

Is CTI for You?

- Is your organization's financial success clearly linked to the time it takes you to complete certain business cycles or to meet certain response times?
- Do you have a reason to be concerned about present and future cycle times of your competitors?
- Have any of your products been late to market, giving your competitors the edge? Have you suffered a negative impact on market share or financial health due to this?
- Does the CEO / President within your organization support CTI? Will the CEO / President be visibly committed to the pursuit of CTI?

If your answer to any of these questions is *yes*, then your organization clearly stands to benefit from an active CTI program.

CTI and Total Quality

Cycle time is one of several competitiveness factors that TQM aims to improve. Fast cycle time can improve *customer satisfaction* and the *internal operations* of a company. These competitiveness factors include:

Customer Satisfaction	**Internal Operations**
■ Cost of ownership	■ Development expense
■ On-time delivery	■ Product cost
■ Product features	■ Employee morale
	■ Time-to-market

The internal operations factors are not seen directly by the customer, but they do play an important role in achieving customer satisfaction along with other business goals.

Fortunately, you do not have to choose between improving cycle time and other competitiveness factors, you need only to decide on how much to emphasize each. It is a myth that improving cycle time lowers product or service quality. Faster cycle time and improved quality *can be* mutually reinforcing. A faster cycle time with a learning feedback loop for *quality*, as well as *cycle time*, will result in a faster rate of product or service quality improvement. Higher quality will, in turn, usually improve cycle time because of less rework.

Cycle-time improvement is one aspect of Total Quality Management; faster cycle time and improved quality are mutually reinforcing.

The cycle-time improvement success factors presented in this guidebook are consistent with *Partnering for Total Quality* (PFTQ). PFTQ addresses several cycle time reduction tools. Just-in-time manufacturing and simultaneous engineering, for example, can yield cycle-time improvements for selected cycles and sub-cycles.[3] The success factors in this guidebook, however, emphasize CTI, and can achieve 50% or greater improvements company-wide, including within the Predevelopment and Design / Development cycles.

The content of this guidebook is applicable to and recommended for use by your company whether or not you are currently involved in a PFTQ or TQM effort. If your company has considerable experience in these areas, you are likely to achieve a successful CTI deployment and implementation more quickly. This is true because CTI deployment involves a change in company culture similar to Total Quality (TQ) and you will have a platform to build on. But even if your company has no prior TQ experience, you should get started on the CTI path. Cycle-Time Improvement and TQ are totally compatible, and there is no reason why they cannot be introduced in parallel.

3. United States General Accounting Office Report to the Honorable Donald Ritter, House of Representatives, GAO / NSLAD-91-190, May 1991, *Management Practices, U.S. Companies Improve Performance Through Quality Efforts:* Washington.
This survey of approximately 20 top Malcolm Baldridge Award applicants concludes that the average cycle-time improvement per year was 6%.

INTRODUCTION

World class companies are finding that a concentrated effort to reduce cycle time is one way to do the following:

- Enhance their competitive positions
- Increase profitability
- Achieve these results in a short period of time with minimal investment

The purpose of this guidebook is for you to develop a broad perspective of the processes and tools used for CTI.

Major cycle-time improvement is not achieved by working faster, but through improved processes and the application of proven techniques and tools.

Results that you can expect from applying the CTI success factors, process templates, and tools are the following:

- An improvement in your important cycle times by *50% or greater* within one or two improvement cycles
- An overall improvement in product quality

Purpose

It is the purpose of this guidebook to answer the following and other questions that you, as an executive, may ask concerning CTI.

What is my role?

What resources are required?

When is experienced help advised?

How much training is required and in what areas?

Is my company ready to take on CTI efforts?

Is CTI compatible with Total Quality Management?

What CTI tools are available and which should I use?

It is essential that you acquire a detailed understanding of the elements of CTI (not necessarily the implementation details) that must go on in an improvement effort in order to effectively support such an effort. This document satisfies both the conceptual understanding and the actions you must take to support your company's CTI efforts.

Also, this guidebook can serve as an overview reference for anyone involved in CTI. It describes processes and tools and provides information sources that can be used by middle management, implementation-team leaders and teams before and during their involvement in CTI.

Scope

This guidebook covers five major components as shown on the guidebook overview on page 9. These are:

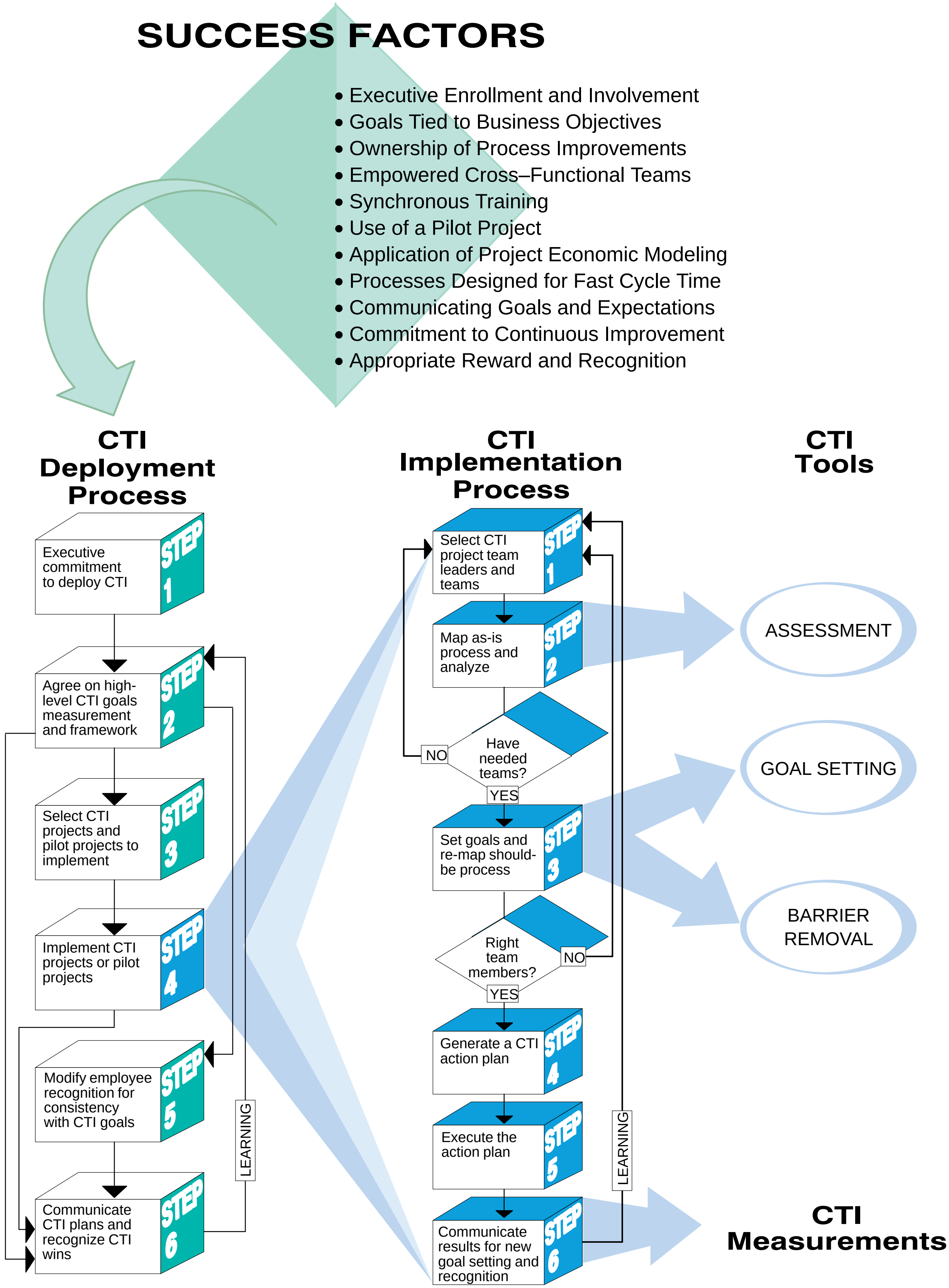
1. The success factors for CTI deployment (i.e., launch and institutionalization)
2. The deployment process for which management is responsible
3. An overview of the step-by-step implementation process for which a CTI team is responsible
4. An overview of CTI implementation tools
5. An overview of CTI measurements

This presentation of CTI's tools and techniques assumes essentially no added capital or human resources to your company.

The detailed information required for implementation is found in materials referred to in this guidebook, in workshops, and in courses that are conducted by SEMATECH and other providers.

This guidebook addresses CTI from your current performance state, the *As-Is* performance, to the new state of performance, or *Should-Be* level of performance, without the need to add capital or human resources to any organization.

Guidebook Overview



Cycles Addressed

This guidebook targets four cycles and their subcycles (illustrated on page 11).

- Predevelopment
- Design / Development
- Order to Delivery
- Customer Service

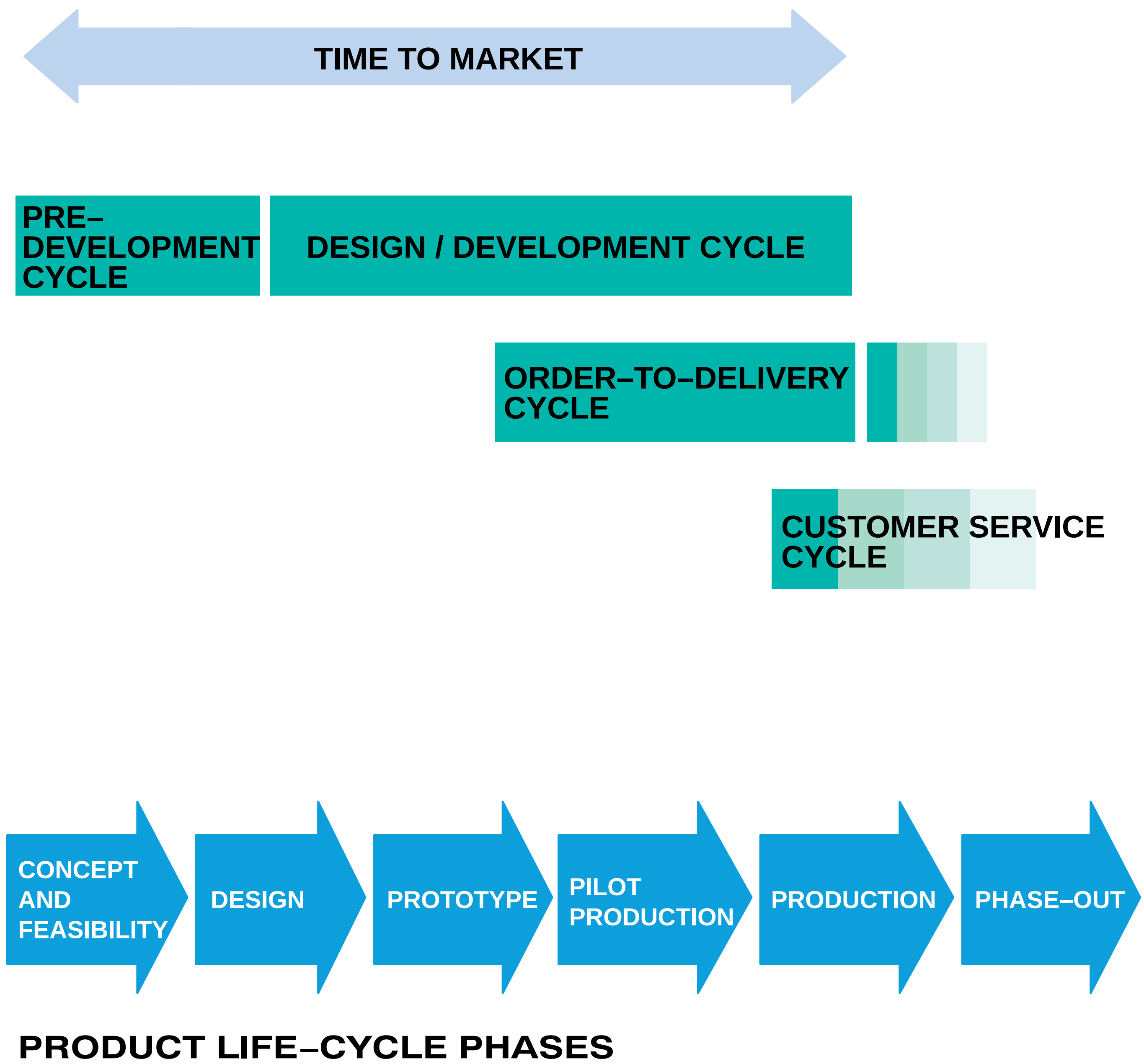
The first two are often combined and referred to as *time to market*. Based on the needs that several U.S. semiconductor equipment manufacturers have expressed, this guidebook places more emphasis on the equipment Design / Development cycle. However, the concepts and tools for this cycle apply equally well, in general, to most cycles and to non-equipment companies.

For some companies, starting the Predevelopment cycle earlier may have considerable leverage.

For some companies, starting the Predevelopment cycle earlier may have considerable leverage. For example, using the Project Economic Modeling trade-off tool, you can place an economic value on time lost before the Predevelopment cycle. This information could then be used to justify assigning ownership for initiating the Predevelopment cycle sooner. See the example of Rules of Thumb computed by applying the Project Economic Modeling Tool on page 12.

This guidebook does not address the cycle *before* the Predevelopment cycle (which begins with the emergence of customer demand for a new product or feature and ends when Predevelopment begins) because of the subjective and dynamic nature of its beginning time and the associated measurement difficulties. To help manage the time before Predevelopment as well as your time-to-market window, contact SEMATECH's Strategic Integration organization for information that is applicable to your segment of the industry.

Cycles Addressed Overlaid on the Product Life Cycle



Rules of Thumb Example
Project Economic Modeling

The following are examples of trade-off decision Rules of Thumb derived from the simple but powerful tool Project Economic Modeling.

These Rules of Thumb were based on an illustrative product development project with the following characteristics:

- Estimated sales of $100M over a six-year product life
- $5.5M in engineering expenses
- Average product gross margin of 37%
- Average profit margin of 10% before tax

Development Problems	Rules of Thumb
■ Cost of delay in product introduction	$470K per month delay
■ Development expense overrun	$55K per % expense overrun
■ Unit sales reduction due to performance problems	$160K per % unit sales reduction
■ Overrun on product cost target	$104K per % cost overrun

This tool is described in more detail on page 67 in the Tools Section of this guidebook and in the reference cited below. [4] These thumb-rules reflect the lost pretax profit over the product's lifetime due to the development problems listed.

4. Preston G. Smith and Donald G. Reinersten, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991, Chapter 2.

Use these success factors to create a management framework for CTI launch and institutional-ization.

SUCCESS FACTORS—SUMMARY

For successful CTI deployment, you must create an organizational framework based on proven key principles and approaches (success factors). The 11 success factors shown below are the ones recommended in this guidebook. Used with the tools and processes outlined in this guidebook, they can yield dramatic initial and sustained CTI results. The first six are for launch; the next five are for institutionalization.

For *launching* a successful CTI effort, the management framework should include these factors:

- **Executive enrollment and involvement**
  As the executive of the company, you must be enrolled, committed and involved to lead the changes to a company-wide, time-based mindset.

- **Goals tied to business objectives**
  Establish a quantitative link between CTI goals and your company's business objectives for return on assets, profit, market share, etc.

- **Ownership of process improvements**
  Establish clear ownership of the process to be improved, improvement goals, and their measurements.

- **Empowered cross-functional teams**
  Establish and empower cross-functional working teams for effective decision making related to the CTI implementation process.

- **Synchronous training**
  Make CTI-related training available to all parties who need these skills as the skills are needed.

- **Use of a pilot project**
  Launch an active CTI program through a small pilot project. This will demonstrate success quickly and gather valuable experience without mobilizing the entire organization.

For ***institutionalization*** **of a fast cycle time culture, the following should be added to the management framework.**

- **Application of Project Economic Modeling**

  Use this powerful tool to establish Rules of Thumb for making such decisions as project prioritization and trade-offs between product schedule, cost, development expense, and features.

- **Processes designed for fast cycle time**

  Use cycle time needs as the driver for designing or redesigning your various business processes.

- **Communicating goals and expectations**

  Communicate your CTI goals, expectations, successes, and plan for recognition of everyone involved.

- **Commitment to continuous improvement**

  Use a continuous process-improvement methodology to map the current process, set CTI goals, and remove barriers to fast cycle time.

- **Appropriate reward and recognition**

  Recognize employees, teams and managers for their CTI accomplishments.

These success factors are discussed in greater detail on pages 35 through 49.

DEPLOYMENT PROCESS

The process is presented as a guide and should be tailored to fit your particular organization size, stage in CTI deployment, stage in TQ deployment, and type of products.

The CTI deployment-process flow chart shown on page 17 is based on the success factors just described, and suggests the following:

- An action sequence for successful CTI launch and culture change
- Who is responsible for each action or step
- What tools or skills are required for each step

The deployment process starts when you, as senior management, resolve to focus on CTI to improve your company's competitiveness. It is complete when CTI is part of your company culture or when CTI is in its second or third generation and is every employee's concern.

This process is presented as a guide and should be tailored to fit your particular organization size, stage in CTI deployment, stage in TQ deployment, and type of products.

Organizational culture transformation is usually set in motion by a high-level assessment to set a strategy for action. Although such an assessment has not been made part of the deployment process presented in this guidebook, it is important that all senior management have a clear understanding of the company's readiness to move into CTI activities. This includes understanding the following:

Cycle-time improvement is part of the company culture when CTI is in its 2nd and 3rd "generation" and is every employee's concern.

- How the financial success of the company is linked to cycle and lead times
- What the priority of CTI should be relative to other improvement activities
- Which cycle or cycles (business processes) need to be addressed
- How committed you are to improving competitiveness through CTI

Some companies benefit from the experience and objectivity of an outside resource to do such an assessment. The resources required for an outside assessment vary considerably, depending on your organization's size, complexity, and TQ sophistication. The low end of the range may require only a one-person week for making an assessment relative to improving a specific process. Resource requirements could be significantly longer if the assessment includes mapping and analyzing organizational relationships and complex business processes.

Deployment Process

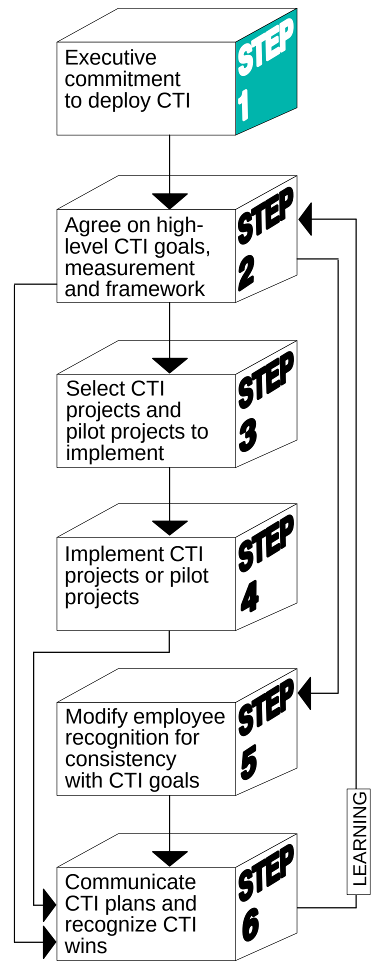
Step	Activity	Who is Responsible	CTI Tools
STEP 1	Executive commitment to deploy CTI	Executive Management	1. SEMATECH CTI Guidebook 2. CTI Awareness Seminars/Presentations
STEP 2	Agree on high-level CTI goals measurement and framework	Executive Management	1. Project Economic Modeling 2. Strategic Business Goals 3. Customer Satisfaction Survey
STEP 3	Select CTI projects and pilot projects to implement	Executive Management or CTI Steering Committee	1. Project Economic Modeling 2. Pilot Project Selection Criteria
STEP 4	Implement CTI projects or pilot projects	See CTI Implementation Process	See CTI Implementation Tools
STEP 5	Modify employee recognition for consistency with CTI goals	Executive Management/ Human Resources	
STEP 6	Communicate CTI plans and recognize CTI wins	All levels of management	Employee Meetings and other communication forms

LEARNING

Step 1: Commit to CTI

The deployment process starts with a commitment by the CEO / president to embark on CTI efforts. This critical step is for the executive staff, in turn, to commit to launching a company-wide CTI effort.

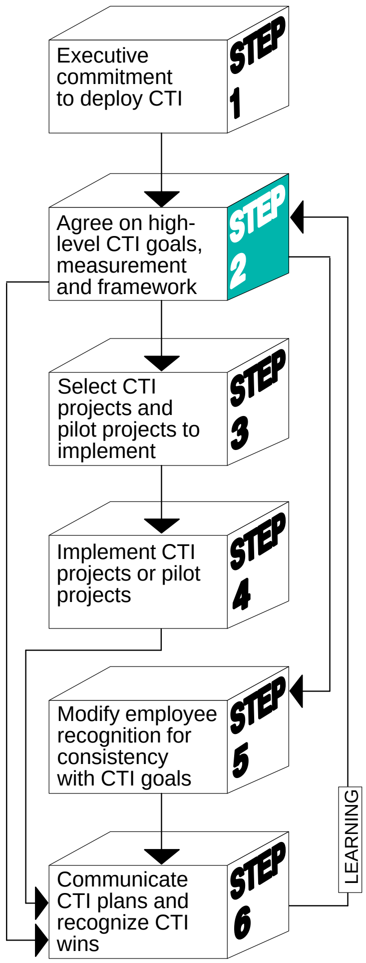
Ideally, every executive staff member should be enrolled, but the launch of CTI could proceed even if one or two members are not. However, except for the customer service cycle, it is important that engineering and manufacturing management are committed to the CTI effort.



Besides reviewing this guidebook, taking CTI awareness courses or engaging the help of experts could facilitate full enrollment.   For some companies this is the most difficult and time consuming step. Since it involves the values of individuals and of the organization, however, it cannot be rushed. ***Successful completion of Step 1 is critical and cannot be skipped.***

The output of Step 1 is to form a CTI steering committee in which one of the vice presidents / directors assumes the role of the chairperson. One or more of the vice presidents / directors becomes a key process owner and a CTI team sponsor. The teams that perform the actual work of CTI are cross-functional. Teams are explained in more detail under the Implementation Section.

Many successful companies have demonstrated management commitment to the CTI process by having senior management actually work on one of the initial pilot projects. This commitment also helps management gain a detailed understanding of what is involved in cycle-time improvements, which becomes critically important later, when management must allocate scarce resources among competing continuous improvement efforts.



Step 2: Agree on High Level CTI Goals and Framework

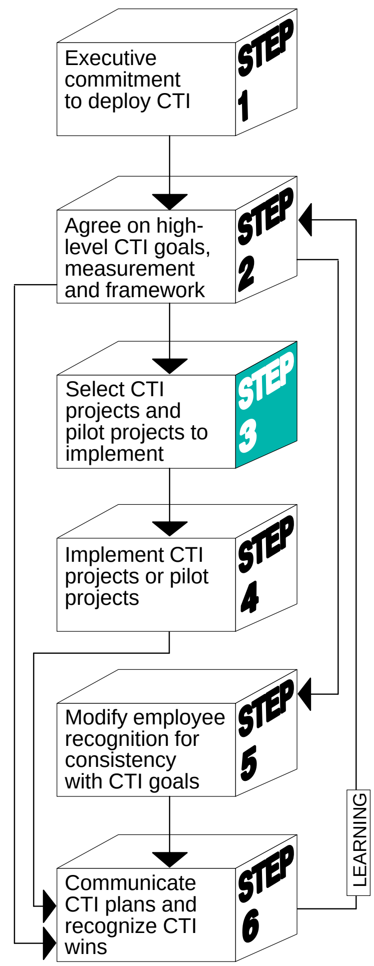
In this step, senior management establishes the top-level CTI goals and framework. For example, this agreement includes:

- The relative emphasis that will be placed on each of the four cycle times targeted in this guidebook
- The CTI *stretch* goals, including their learning rates to be communicated to the process and sub-process owners
- The cycle time measurements consistent with goals, measurement owner and user, and reporting frequency and method (See page 61 for more information on measurements)
- The projected improvement in the various key business measurements if the stretch goals are achieved
- The process owners
- A deployment process that will work for your company
- The key changes that are required in the employee performance measurement and recognition system to achieve the desired CTI goals
- A communication plan, which outlines the target audiences, desired messages, media, communication strategies, and communication feedback loops to ensure that messages are being sent and understood

A key tool used for making cycle time related business trade-offs is the Project Economic Modeling described on page 82.

Step 3: Select Pilot or Other CTI Projects to Implement

If there is minimal CTI implementation experience in the organization, starting with a pilot project is highly recommended. A pilot project can quickly demonstrate success and can be a case study to convince others in the organization of CTI's value. Additionally, your company benefits by using the results of such a pilot activity as part of the roll-out of more extensive, possibly company-wide, CTI activities.

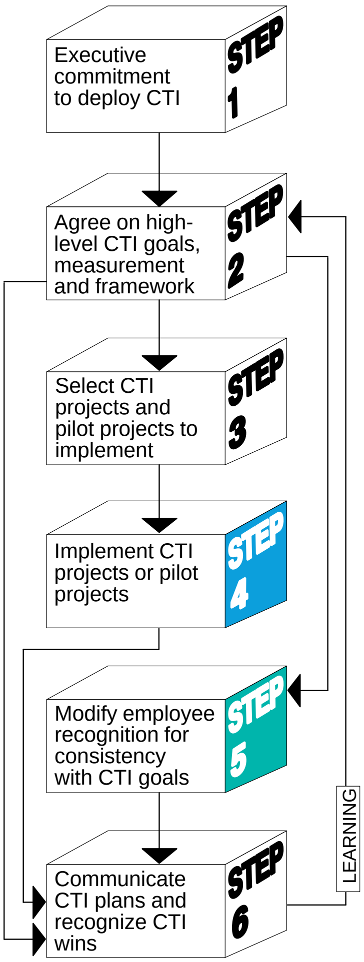


The pilot project selection is critical. It is important that the project not take more than a few months. It may be even shorter if it is the order-to-delivery or the customer service cycle. It must be representative, and it must be successful. See the pilot project selection check list on page 23.

A pilot project may not be the best way to start CTI when, for example, your management culture will not support an empowered team, your company's support infrastructure is too weak, or your company is so small that the pilot is the company's major project. Likewise, the urgency to proceed with CTI for business reasons may be so great that you may elect to bypass the pilot.

Even if the pilot is skipped, following Steps 5 and 6 before starting one or more CTI projects will improve the probability of success.

Step 4: Implement CTI



Step 4 is a detailed implementation process described more fully in the next section. It is similar to the typical continuous improvement process, which includes these elements:

- Assessment
- Goal setting
- Barrier removal

The first time through a CTI cycle would usually be implementation of the pilot project.

As can be seen from the process description on page 27, there is an important learning feedback loop from Step 6 back to Step 1. Steps 2 and 3 need to be revisited during the company's strategic planning cycle to select new CTI projects, revise the goals, and to improve the management framework around CTI activities.

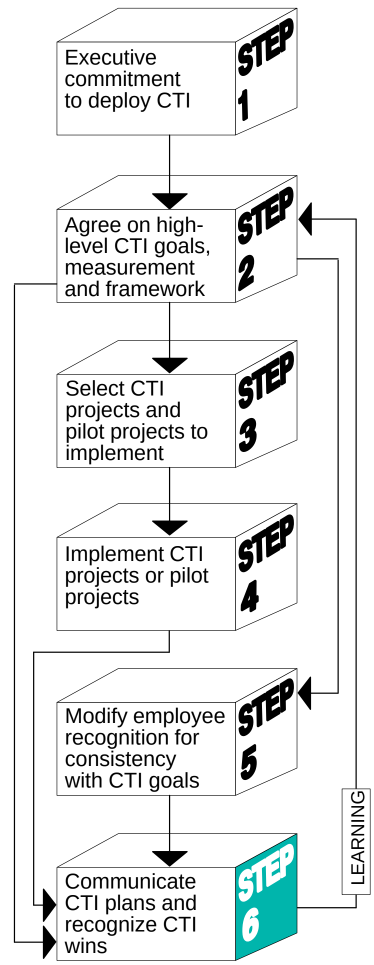
Step 5: Modify Employee Recognition for Consistency with CTI Goals

Start this step as soon as possible after completing Step 2 so that it does not become a gating step in the deployment process. This step is vital for aligning the employee performance evaluation and recognition system with the company CTI goals. Decisions need to be made around CTI-based performance plans and evaluation; individual and group awards; gain sharing; and other forms of recognition.

Step 6: Communicate CTI Plans and Recognize CTI Wins

Communicate to the entire organization information about your company's cycle-time improvement framework and plans, such as:

- Priority
- Goals
- Plans
- Pilot project successes
- Management enrollment
- Employee recognition tied to CTI
- Benefits to the business



It is best to use a variety of media in your communication plan to ensure it permeates all levels of your organization. It is important that the organization as a whole understands the senior management commitment, as indicated by executive enrollment and involvement.

This roll-out step could begin as you start TQ efforts, or could be done separately if TQ efforts are already in progress.

The first time through, Step 6 is the CTI roll-out step and should be carried out by the top executive (usually the CEO) as well as all other levels of management. After the roll-out, Step 6 is the ongoing communication about the company's CTI accomplishments, recognition, plans, or new goals. It is vital that this interactive communication take place with all levels of management and relevant functions throughout your company.

The deployment of the communication message should be in accordance with the communication plan developed earlier. Management should periodically check various feedback loops to ensure that the correct messages are being communicated.

Pilot Project Selection Check List

The following are the ideal criteria for a pilot project that may be adjusted to fit your company's situation.[5] You will most likely not be able to pick a project that meets all the criteria. When a criterion is violated, however, it is important to recognize this and apply appropriate corrective measures. For example, if your company has only a few products, you will not be able to comply with the second criterion, so it will be more important to appoint a highly-seasoned team leader in whom top management will have confidence.

- Select a project that is important to your company, so that it is not likely to be canceled or delayed for lack of interest or priority.
- Do not select a project that is crucial to the survival of your company. Management will have difficulty letting the pilot project team run itself if this is a *bet the company* situation.
- The project should not be technically trivial. Critics should not be able to conclude later that the project was fast only because it was so simple. By contrast, avoid projects that require basic invention for obvious reasons.
- Make sure that the project is consistent with the accelerated management approach to be used; that is, it should be consistent with a dedicated, cross-functional team.
- Choose a project that is typical, encompassing the cost, timeliness, and political issues the business generally faces. This choice is made so the lessons learned can be as applicable as possible to future projects, and the results obtained can be measured relative to past projects.
- Make sure there is a clear, believable, market-driven sense of urgency to the project.
- Pick a project that is of short duration, because you want to experience and apply the benefits of this experiment as soon as possible.
- Select a project that has not started yet, because there is a great deal of schedule leverage in the very early decisions, such as team staffing and task parallelism.
- Choose a project that can be started soon, so that the enthusiasm for change developed during the diagnostic phase can be converted into actual change in the pilot project.
- Finally, select a project for which you already have the basic resources; there will be no time to hire people or build new facilities.

Select your pilot project for maximum success.

5. These criteria are reproduced with the permission of Preston Smith, New Product Dynamics, 240 N. Main St, West Hartford, CT 06107.

IMPLEMENTATION PROCESS

In this guidebook, implementation process means the actual process of executing CTI, usually by a cross-functional team.

In this guidebook, *implementation process* means the actual process of executing CTI, usually by a cross-functional team. The process goal is to shorten the time it takes to perform a series of activities by using cycle time assessment and barrier-removal tools.[6]

The goal of the CTI implementation process includes both:

- Continuous incremental improvements
- Breakthrough improvements

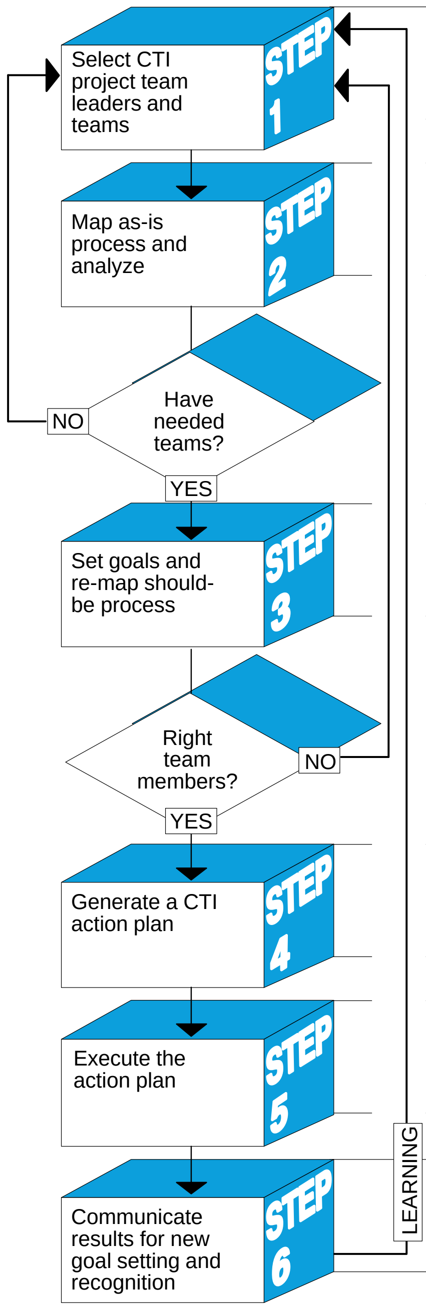
The CTI implementation process flow chart is shown on page 27. This process moves directly into the selection of teams and process mapping for the cycle to be improved. Other implementation processes start with extensive organization mapping to help with the selection of the cross-functional team members and to identify fast cycle time barriers rooted in the organization structure. With careful process mapping, these barriers will become apparent, since each activity will have a person or an organization assigned to it. Thus, this implementation process does not incorporate organization mapping as a separate activity.

6. The implementation process should not be confused with the product life cycle or development processes. The product life cycle process traditionally describes the various phases of a product starting with a product idea and ending with the product's obsolescence. The development process refers to the early phases in the product life cycle process up to volume manufacturing. The product life cycle process has typically provided a structure for risk and financial management through check pointing completion of a set of tasks for the various product phases. Since the construction of the product life cycle processes could have a beneficial or adverse effect on cycle time, it should be carefully constructed with fast cycle time considerations. Guidance for how to construct the development process portion of a product life cycle process is a module in SEMATECH's course, named *Faster New Product Development*. For a brief description of an example product life cycle process, refer to SEMATECH's *Guidelines For Equipment Reliability*, May 1992, Technology Transfer number 92031012A-GEN.

Performing cycle time assessments, goal setting, and barrier removal requires specialized skills. These skills are best developed and best honed through a combination of training and experience. This training for the cross-functional implementation team or teams should be provided in the form of synchronized workshops or courses. When using consultants, ensure that the CTI knowledge is transferred to the organization so that the early teams can spread the knowledge throughout the entire organization.

Each step of the CTI implementation is outlined starting on page 30.

Implementation Process



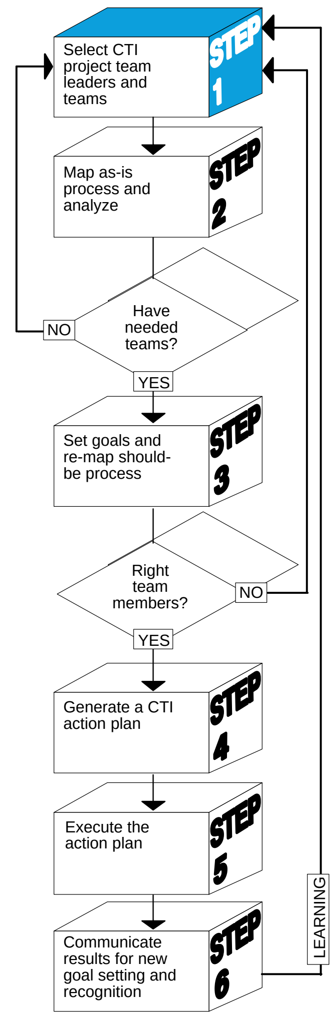
Activity	Who is Responsible	CTI Tools
Step 1: Select CTI project team leaders and teams	Process owner	Team selection criteria in this guide
Step 2: Map as-is process and analyze	CTI project team	Process mapping and analysis tool in this guide
Step 3: Set goals and re-map should-be process	CTI project team	Goal setting and barrier removal tools in this guide
Step 4: Generate a CTI action plan	CTI project team	
Step 5: Execute the action plan	CTI project team	See text
Step 6: Communicate results for new goal setting and recognition	CTI project team leader	Measurements

Step 1: Select CTI Project Team Leaders and Teams

The objective of this step is to achieve the following:

- Select a team leader
- Assemble the team
- Define the project scope
- Identify constraints

Depending on the size of the project or cycle, there may be a hierarchy of project leaders. Key characteristics and experience to look for in the CTI leader include:



- Recognized subject expertise in the process to be improved
- Team facilitation experience
- Ability to drive a cross-functional CTI team with diverse responsibilities
- Experience or training in the CTI implementation process and tools
- Ability and desire to teach other project teams and their leaders in the process and tools for CTI

The team should be composed of individuals who represent the departments responsible for the process. The team may contain individuals from multiple levels in the organization.

A facilitator is usually also part of the team if the team leader is not an experienced facilitator.

In addition to selecting a CTI team and team leader, the scope of the process is established, and any key constraints are clearly laid out.

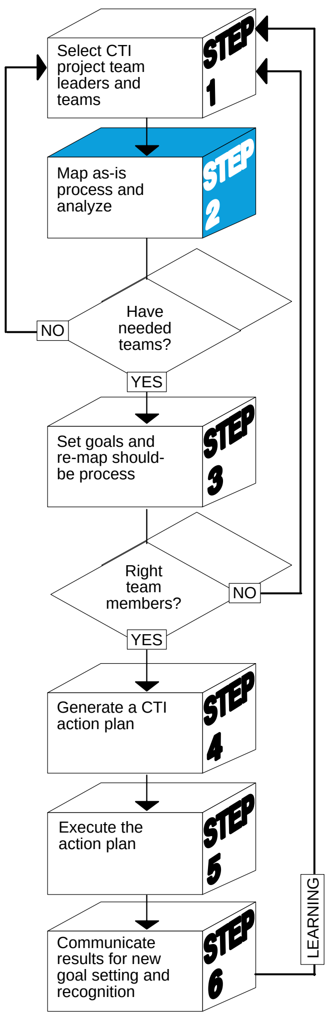
The scope refers to the boundaries of the process to be improved; and the beginning and end steps. This includes the beginning steps of all the processes that feed into the overall process to be improved.

Typically, constraints refer to the time constraints to get through Step 4, such as:

- Completion requirements of a CTI action plan
- Time allotted to the team members to work on the CTI project

Step 2: Map and Analyze the As-Is (Baseline) Process

In this step, you strive to gain a more detailed understanding of the process and subprocesses, and their behaviors. Start by documenting various characteristics of the process, such as its objectives, customers, suppliers, and key known problems.



A cross-functional team then proceeds to develop an *As-Is* process map that graphically depicts the interaction of key process elements, such as the flow of activities, tasks, delays, and queues. This mapping task may take from 3 to 15 workdays. The actual time spent on developing the map depends upon many variables. These variables include:

- The complexity of the process
- Experience of the team with improvement tools
- Stability of the process
- Solid blocks of time dedicated to the mapping effort
- Learning capabilities of the team to function as an effective group

At this point, the team also begins to identify and document potential barriers to reduced cycle times.

To understand a process thoroughly, a map of how activities and subprocesses are interconnected needs to be created. Mapping such a relationship is difficult and may require outside assistance, such as course / workshop training or hands-on support by someone experienced with such programs. Sufficient detail for each activity should be recorded as:

- What each activity is
- How the activities are interconnected

- Time it takes to complete each activity
- Input required and output expected
- Input supplier and output customer
- Activity owner
- Owner's functional organization
- Geographically where such activities are performed

Another sub-task of this step is the analysis of the mapped current process. The analysis provides a deeper understanding of the process's problems and opportunity areas. A value analysis and identification of process patterns that suggest improvement opportunities is performed. In value analysis, the activity is usually classified into the following categories:

- Value added
- Queuing
- Transport
- Delay
- Inventory
- Decision

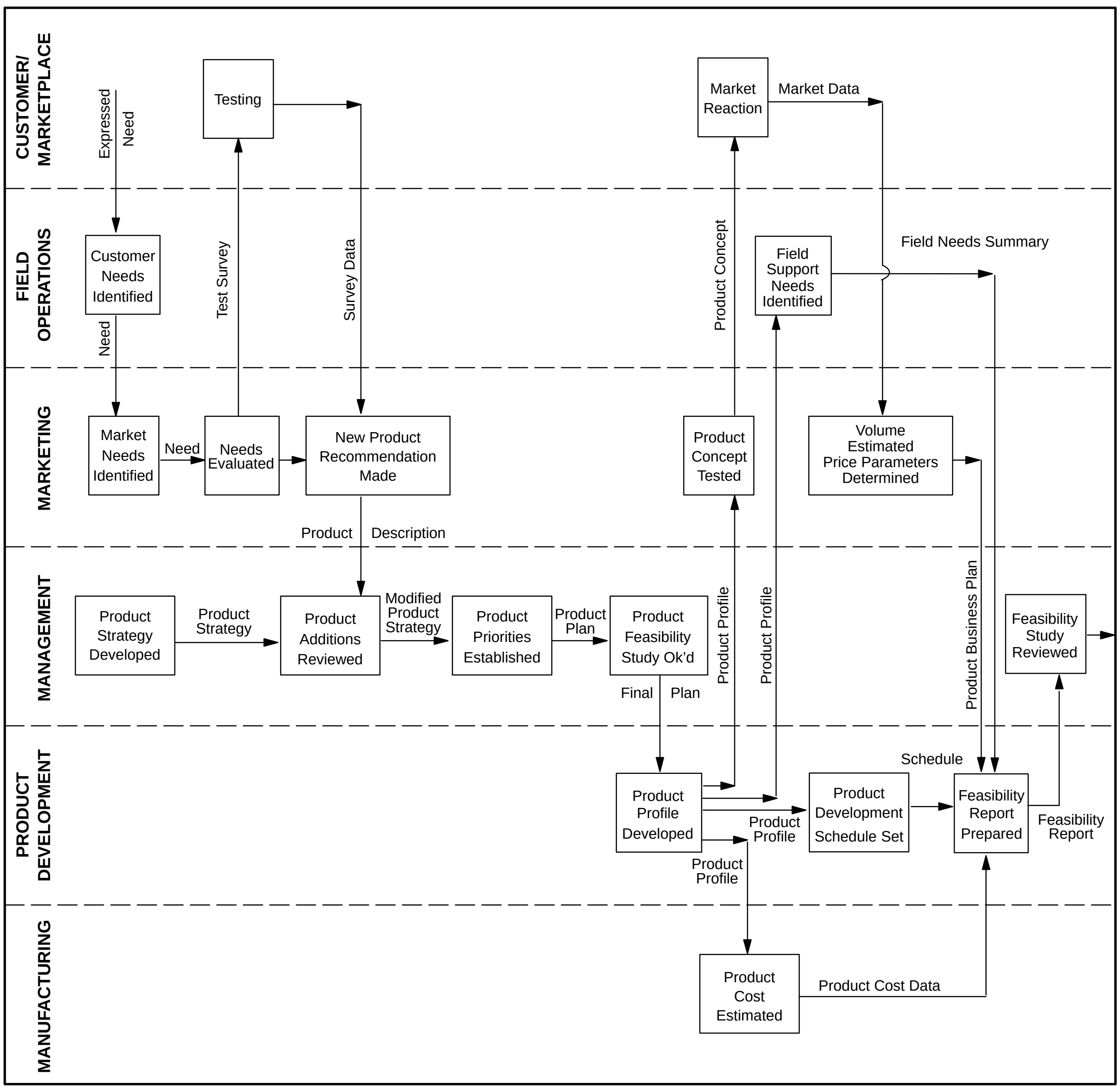
This information is then used as a base for these activities:

- Establishing organizational interfaces to ensure representation by all key organizations on the CTI team
- Collecting data used for projecting new CTI goals (The data includes the value-added steps and the distribution of time required for their execution)
- Understanding the activity sequence that gates the cycle time (critical cycle time path)
- Highlighting activities that are cycle-time barriers to be removed
- Establishing a cycle time measurement base for managing improvement and understanding the level of success for the ensuing CTI activities

During the mapping process, you may find that the process involves organizations not represented by the team. The leader should then loop back to Step 1 to add the necessary members to the CTI team before proceeding to the next critical steps of mapping out the *Should-Be* process.

Shown below is an example of a cross-functional *As-Is* process map for the Predevelopment process. The map is at a relatively high level of activity and may require more detail (mapping of subprocesses) for an actual CTI project. The various parameters for the activities are usually recorded on separate documents, including the time for the activities in the critical path to establish the total cycle time.

PRODUCT PREDEVELOPMENT - PROCESS
(A Cross-Functional Process As–Is Map)[7]



7. Reprinted with permission from the Rummler-Bracke Group.

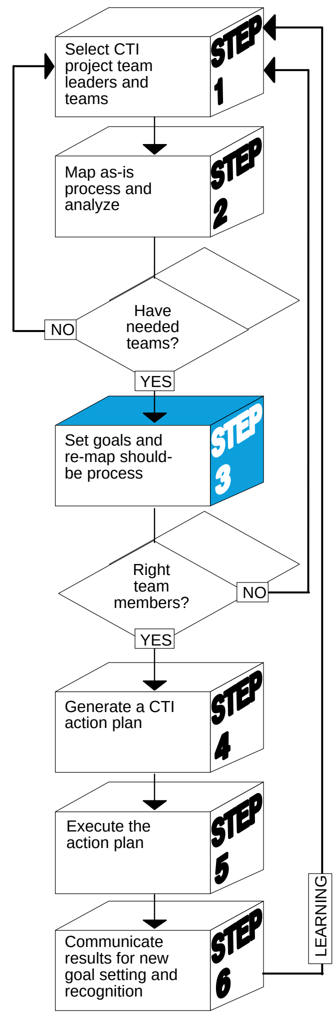
Step 3: Set Process Goals and Re-map the Should-Be Process with Cycle Time Barriers Removed

Creating the *Should-Be* process is the most skill-intensive step. The team involved must collectively be skilled in the subject matter of the process. Along with Step 2, Step 3 requires selecting appropriate tools and obtaining training. Synchronous workshops and / or courses are recommended.

In developing the *Should-Be* process map, the team executes these sub-tasks:

- Select goal-setting tool(s) from ones discussed on page 53
- Identify barriers
- Select barrier-removal tools from ones listed in the tools table on page 59
- Set the process and sub-process goals
- Propose improved processes
- Analyze potential economic impact
- Identify interface requirements

The goal-setting and barrier-removal tools are described in a later section.



The development of the *Should-Be* process map is often iterative and a second iteration is required to incorporate:

- The effects of organizational changes
- Best of alternative processes considering economic trade-offs
- Solutions to resolve the impact on other processes or resources

For the Predevelopment and Design / Development cycles, mapping has its limitations. It is useful mainly for the more predictable subcycles, for example, printed circuit-board design, prototyping, and documentation. These and numerous other predictable subcycles may cover as many as 80% or more of all the engineering activities that are repeated from one product generation to the next.

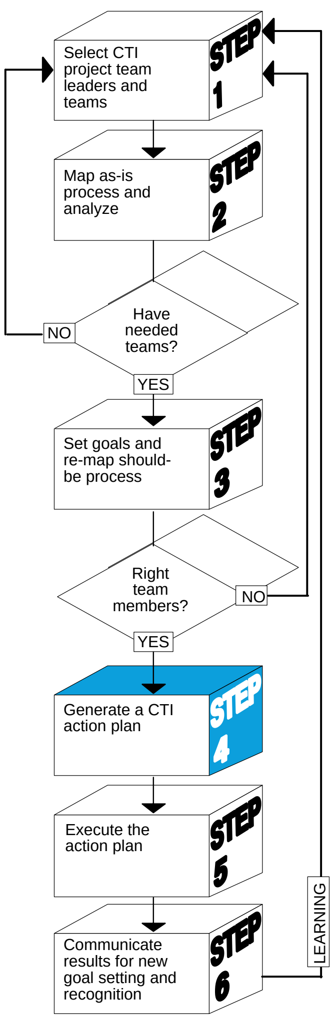
For the component of the process that is less predictable because of invention required, the *Should-Be* and faster cycle time must be achieved by using the applicable barrier-removal tools listed in this guidebook.

When selecting CTI implementation tools there is no one *right* set of tools. Selection is based on these factors:

- The cycle being improved
- The tools that are already working for your company

The recommended techniques and tools are discussed in the next section and are summarized on the tools table on page 59.

Step 4: Generate a CTI Action Plan



The output of the prior step is used to generate an action plan for execution. This action plan often involves changes to business processes, organization realignment, job responsibilities, and other significant issues.

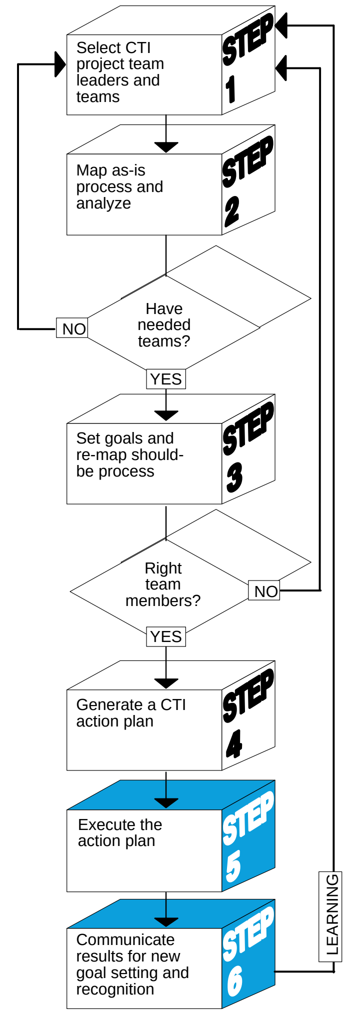
The action plan should include several elements, such as:

- The proposed process changes with new time-based activity attributes
- A plan of time-based measurements, such as what activities will be measured; who the provider and the receiver are; how frequently each activity is measured; and what the measurement units are
- Key training that must occur to ensure success for the *Should-Be* process
- A list of migration issues and strategies to address those issues

Before implementing any changes, the mentoring executive of the team should submit the action plan to the CTI steering committee for approval. Also, the team should present its proposed solution and action plan to all groups who will be affected by the *Should-Be* process and its improved cycle time.

Step 5: Execute the Action Plan

In this step, the action plan is executed.



Step 6: Communicate Results for Setting New Goals and Recognition

For short projects of less than a few months, this step would most likely be a one-time activity upon completion of the CTI project. The project team leader documents the results of the CTI project for lessons learned. These lessons can be applied to other project implementation processes and for feedback to the steering committee for continuous improvement of the CTI deployment process and for purposes of reward and recognition.

For longer projects, communication feedback to the steering committee and other fast cycle-time teams could take place after significant check points in the CTI project. For example, the team leader could report on the action plan, prior to execution, to show such accomplishments as:

- What barriers were identified and proposed for removal
- The proposed new response or cycle times
- Lessons learned to date about any aspect of the CTI implementation process

SUCCESS FACTORS – DESCRIPTIONS AND TIPS

Success Factor 1
Executive Enrollment and Involvement

For a company-wide CTI effort to become successful, it must have the full enrollment and involvement of the executives, starting at the very top. Intellectual buy-in that CTI is a good thing is insufficient. It requires executives to practice what they preach through personal involvement in the decision and communications meetings that are part of the deployment process. The executives must know how CTI will help the business; be active promoters and explainers of CTI; and provide support and encouragement for those making CTI advances. At the outset, senior management must be clear about the benefits of CTI for their business and the implications for them as its leaders. Then the same enrollment process must flow down to lower levels of management. All successful organization-wide CTI efforts have this factor in common. Executive Enrollment and Involvement achieves the following:

- Demonstrates to the entire organization that the executive management considers CTI a priority effort
- Sets the stage for cross-functional problem solving and trade-off decision making at the executive level that are key ingredients for CTI at all levels of the organization
- Sets the stage for cohesive leadership in defining the rest of the framework, the remaining success factors, for successful CTI launch and culture change

Tips

- Having stated that this success factor is fundamental to CTI, not all is lost when only a few company leaders enroll and are involved. You can still demonstrate wins that will be significant for the business. These wins could be held up as examples for other organizations, managers and teams to follow. Eventually, the increasing number of wins could lead to buy–in by all levels of management and a company-wide, time-based mindset.

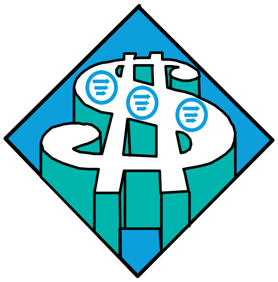
- In situations where buy-in is not pervasive, top management responsible for the organization leading CTI of a particular process must have buy-in. This buy-in could be at a division level or at the project level.

Sources

John P. Kotter, *A Force for Change*, New York: Free Press, 1990.

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991, Chapter 14.

Success Factor 2
Goals Tied to Business Objectives



Because CTI can easily be misinterpreted as a quick fix – a “hurry up” exercise or in conflict with improved quality – it is important for all employees to know how CTI will help the organization meet its business objectives. Thus, it is important for management to clarify how CTI goals, along with goals for other competitiveness factors, are linked to the firm’s success in business terms (profit, market share, and ROI) and to develop a statement for explaining this connection.

Shown below are published examples of improvement ranges.[8] No new investment in capital or human resources was assumed for this example. No specific elapsed time is given for this improvement. The elapsed time obviously depends on the cycle being improved, but would range from about six months to several years where long development cycles are involved.

Total cycle time	30 to 70%
Time to market	20 to 70%
Delivery lead times	30 to 70%
Revenues	5 to 20%
Return on assets	20 to 105%
Inventories	20 to 50%
Invisible inventories	20 to 60%
Blue-collar productivity	5 to 25%
White-collar productivity	20 to 105%
Depreciation	10 to 30%
Scrap	20 to 80%

8. Philip R. Thomas, *Competitiveness Through Total Cycle Time – An Overview for CEO’s*, New York: McGraw–Hill, 1990, pp 44 and 45.

Goals tied to business objectives will produce several benefits:

- Help employees at all levels to understand the value of CTI, improving their buy-in to the improvement effort
- Help to focus CTI efforts on processes that are projected to provide the desired business results
- Provide a touchstone for assuring that the CTI program stays on track

Tips

- CTI goals must be balanced with other business objectives so that CTI improvements do not come at the expense of other objectives
- The tool, Project Economic Modeling, is recommended for calculating how cycle time affects many of the financial indicators mentioned above.

Sources

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991, Chapter 2.

George Stalk, Jr., “The Strategic Value of Time,” *Time–Based Competition*, Joseph E. Blackburn, Editor, Business One Irwin, 1991, pp. 67–101.

Success Factor 3
Ownership of Process Improvements

Ownership of process improvements refers to ownership of business processes and subprocesses, their CTI goals and measurements.

Ownership of process improvements involves understanding the current CTI capability and taking responsibility for their improvement. Establishing ownership and maintaining ownership is one of the most critical aspects of successful CTI.

Tips

- Promote ownership of CTI process, stretch goals, and measurement by:
  - Providing a solid framework for CTI success (success factors)
  - Training in the various CTI methodologies and tools
- Allow for goal adjustments (usually more aggressive) as a result of CTI teams having had a chance to study the processes to be improved

Because of the cross–functional nature of most major processes to be improved, the overall process owner will often be at an executive management level while the subprocess owners will be CTI team leaders, either management or non-management (see success factor SF4, Empowered Cross Functional Teams for more about CTI teams)

Source

George Stalk, Jr. and Thomas M. Hout, *Competing Against Time*, New York: Free Press, 1990, pp. 189–195.

Success Factor 4
Empowered Cross-Functional Teams

One feature that makes CTI difficult in conventional organizations is that many cycles involve different functions in the organization. This success factor is the preferred means of linking activities seamlessly across traditional **f**unctional boundaries.

One of the principles of CTI is that much of a cycle's time is often decision-making time, and decisions can be made faster if the decision loops are short. For teams to be effective, they need to be empowered. Allow CTI-related decisions to be made by the teams that have the information, eliminating the waiting time for approvals.

An empowered team does not have to be focused on explaining problems. Rather, an empowered team will spur creative CTI solutions for timely and optimal cross-functional trade-offs.[9]

For example, a CTI team trained in the application of trade-off Rules of Thumb generated by using project economic modeling can make quick trade-off decisions around product cost, performance, development resources, and cycle time. Without empowerment, these decisions are usually made by a higher management level without the benefit of data.

Empowering cross-functional teams:

- Provides a working group capable of making cross-functional process improvement trade-offs more accurately and quickly

9. Ed Oakley and Doug Krug, *Enlightened Leadership*, no place: Stonetree Publishing, 1992.

- Better identifies and resolves organizational barriers that lengthen cycles
- Improves morale by providing more meaningful work, and work that is under one's own control

Tips

- Ensure successful team empowerment by including other success factors as part of the CTI framework, especially synchronous training and reward and recognition.
- Clearly establish the team leader and team member roles.

Sources

Peter Block, *The Empowered Manager: Positive Political Skills at Work*, San Francisco: Jossey-Bass Publishers, 1987.

Kim B. Clark and Takahiro Fujimoto, *Product Development Performance*, Boston: Harvard Business School Press, 1991, Chapter 8. (Although this pertains directly to the Design / Development cycle, it illustrates the principles well for all cycles.)

Robert E. Kelley, "In Praise of Followers," *Harvard Business Review*, vol. 66, no. 6, 1988, pp. 142–48.

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991, Chapters 7 and 8.

Success Factor 5
Synchronous Training

Many of these factors of success and implementation tools require training. This required training is typically intensive and timely for the few people who are directly involved. Training should ideally be conducted just before it will first be needed, not in a broad program in anticipation of possible need. When training is immediately applied to a task, it is likely to reinforce the newly acquired skills. Such synchronous training also sends a clear message from management that the employee will be supported in the CTI effort. Synchronous training also accomplishes the following:

- Accelerates a CTI program by providing training in advance of need rather than reacting to a demonstrated need for training
- Displays management's firm commitment to providing the needed framework for CTI

Tips

- Training can be in the form of courses, workshops or hands-on learning.
- Check with SEMATECH for workshop and course availability.

Source

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991, Chapter 15.

Success Factor 6
Use of a Pilot Project

Using a pilot or small project to launch CTI will demonstrate success quickly without having to mobilize the entire organization, especially when the company size is greater than 200 to 300 employees. The pilot CTI project can be used as a case study to inspire a larger segment of the company. It is suggested that the results of such a pilot activity then be used to support the roll-out of more extensive, possibly company-wide, CTI efforts.

Using a pilot project:

- Provides an early success on which further improvement can be built
- Is relatively low in cost and risk
- Employs the principle that behavior can be changed more readily than attitudes

Tips

- Remember that the purpose of the pilot is to demonstrate a successful management approach that can be emulated. Emphasize the management process rather than the fruits of the immediate project. However, the pilot project must be provided with the resources required to succeed.
- Consider hiring a consultant to help with certain aspects of the pilot project (depending on your organization's level of experience or training relative to cross-functional teams and the CTI process and tools).
- For pilot project selection criteria, refer to page 23.

Sources

Robert H. Shaffer, *The Breakthrough Strategy,* New York: Ballinger, 1988.

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time,* New York: Van Nostrand Reinhold, 1991, Chapter 15.

Success Factor 7
Application of Project Economic Modeling

If time is tied to the firm's business objectives, then saving time has an economic value that can be calculated. Doing so sensitizes everyone in the organization to how timeliness supports business success. It encourages people to appropriately balance time with cost, rather than pursuing time at any cost or vice versa. By providing clear Rules of Thumb for the value of time associated with a given project or product, time-related trade-offs against product cost, development expense, and features can be made faster, more precisely, and by people closer to the issue. This tool can also be used to evaluate several projects for prioritization when a development organization is overloaded. Application of this important CTI tool:

- Crystallizes the notion that time has business value
- Results in better time / money trade-off decisions
- Speeds up decision making by moving decision making to a lower level

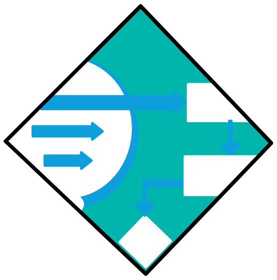
Tips

- Calculations are done by designated analysts and the information is used by everyone in the organization who can influence cycle time.
- An understanding of market dynamics is required for calculating the economic value of time. (The market dynamics are a product's sales volume and profit as a function of product cost, development expense, performance, and introduction time.)

Source

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991, Chapter 2. (Applies directly to the Design / Development cycle but can be adapted to other cycles.)

Success Factor 8
Processes Designed for Fast Cycle Time



Without a cycle time focus, business processes are often designed with an objective such as low process cost; simple hand-off between the various organizations; ease of management reviews; and reducing defects at the various stages of the process as the primary driver. With a goal of large cycle-time improvements, however, business processes should be designed with cycle time as the primary driver. This principle is difficult to apply, because by their very nature, most business processes cut across functional lines. Using cycle time as the primary process design driver will only happen with the simultaneous application of the earlier success factors: Ownership of Process Improvement and Empowered Cross-functional Teams.

The above principle needs to be applied to subprocesses as well to attain the stretch CTI goals. Everyone in the company must view their work as part of a larger process and understand how their actions interact with other parts of the overall process.

Fortunately, besides achieving fast cycle times, using cycle time as the primary driver will accomplish the following:

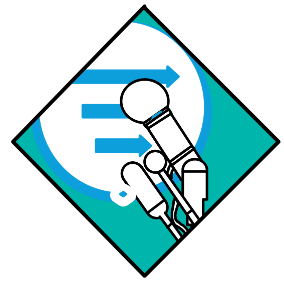
- Speed up the learning cycle for improving product quality (reducing defects) in the process output with a learning feedback loop
- Improve the process cost, (i.e., the development expenses for the Design / Development cycle) (This trend continues until the point of diminishing returns on resources applied to cycle-time improvement is reached)

Sources

Eliyahu M. Goldratt and Jeff Cox, *The Goal*, New York: North River Press, 1986.

Edward J. Hay, *The Just-In-Time Breakthrough*, New York: John Wiley & Sons, 1988, Chapter 4.

Success Factor 9
Communicating Goals and Expectations



To truly become a cycle time based company, all employees will eventually have to embrace this new mode of operation. Communicate your CTI goals and their relative priority company-wide. Most likely, CTI is being introduced into an existing environment where the focus has been on product cost, human-resource cost, product performance, or other parameters. Causing employees to emphasize new CTI parameters requires active communication by all levels of management. Communicating goals and expectations achieves two things:

- Keeps employees informed and aligned with the organization's CTI goals
- Provides expectations for employee performance

Tips

- As soon as the executive management is fully committed and enrolled to begin CTI activities, communicate the following essentials to those involved in the pilot project, and later, to all employees, perhaps quarterly in the early phase of the effort:
  - The reasons for the change
  - What CTI is and is not
  - What the CTI goals are
  - How they are linked to the business objectives
  - What is expected from each employee in terms of role and performance
  - How the human resource system has been aligned with the new goals
- Even though the message may be broadcast strongly, some naysayers will not commit to the new culture. However, as proponents develop, the program will gain momentum, and skeptics will either join or leave.

Sources

Benjamin B. Tregoe, et al., *Vision in Action,* New York: Simon & Schuster, 1989, Chapter 6.

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time,* New York: Van Nostrand Reinhold, 1991, Chapter 14.

Success Factor 10
Commitment to Continuous Improvement

A fast cycle time culture is built in steps which cumulatively develop a competitive advantage that distinguishes a company from its weaker competitors. A commitment to continuous improvement is a decision by the executive management to make continuous improvements in these areas:

- The cycle time of any given process
- The management framework
- The skills of the cross-functional implementation teams
- The number of processes being addressed

This requires establishing clear processes and multiple communication feedback paths for lessons learned.

Tips

- Business processes, sometimes very sacred ones, can be major cycle time barriers and should be included in the list of processes to be improved.

Sources

Geary A. Rummler, *Improving Performance: How to Manage the White Space on the Organization Chart*, San Francisco: Jossey-Bass, 1990.

Robert H. Shaffer, *The Breakthrough Strategy*, New York: Ballinger, 1988.

Success Factor 11
Appropriate Reward and Recognition

If CTI is to become a part of the firm's normal operations, then the reward systems (performance planning and evaluation, pay incentives and other recognition) will have to be redesigned accordingly. Reward systems and recognition will:

- Give employees a feeling that the effort they put into a CTI project benefits employees as well as the company
- Build momentum and support for a CTI program as recognition occurs

Tips

The following are examples of the "what" and "how" you may wish to change in your current reward and recognition for a CTI emphasis:

- Traditional performance planning and review
  - "Expectations" are set between subordinate and supervisor at the beginning of a period as part of a merit system.
  - The employee and supervisor discuss expectations and negotiate measurable performance objectives, including cycle time, defined with appropriate measurement techniques and deadlines, as well as the costs and required resources to achieve the action plan milestones.
  - Weights are also negotiated for each area of expectations with cycle-time improvement being a major category in order to reach an overall evaluation of performance.
- Pay is based on a plan with merit pay categories by performance level achieved and relative position in the market place.
- Incentive/bonus pay in addition to the normal merit system
  - Group or individual target objectives can be established similar to the first category.
  - Cycle-time improvement can be a total or partial aspect of this reward system, depending on the company goals and the focus needed on CTI relative to other efforts.

- Management determines the plan formula for payout that is normally based upon profit or contribution to it from the lowest levels to the highest. The formula for payout is not negotiated with participants.
- Incidental / spontaneous monetary awards built into budgets at various levels of management.
  - Normally done at budget time with lots of discretion given the budget manager.
  - Broad Rules of Thumb are worked out between budget managers and the next level of management.
  - Awards are given at times when accomplishment warrants recognition.

Awards can get out-of-hand if all levels of supervision involved don't learn how to administer the program.

- Non-monetary rewards
  - Such as the team having lunch with the president or a photo of a successful CTI team in the company annual report or newspaper.
  - Celebrations can be enjoyed at any time one is warranted and budgeted by management.
  - Plaques, a letter from upper-level managers, paper weights, dinners for employee and guest, and other forms of appreciation.

Care must be given to recognizing *all* those who contribute to an accomplishment to insure ill-will is not created.

Sources

John Boddie, *Crunch Mode*, Englewood: Prentice-Hall, 1987, pp. 117–120.

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time,* New York: Van Nostrand Reinhold, 1991, pp.128–130.

IMPLEMENTATION TOOLS

This section provides a perspective on the classification of the many CTI implementation tools and can help you select the appropriate tool. With few exceptions, the tools described require training in the form of workshops or courses.

The CTI implementation tools are grouped into the following categories:

- Assessment
- Goal setting
- Barrier removal

With few exceptions, the tools described require training in the form of workshops or courses.

These tools are listed in the table on page 59. Each tool is shown with information about its applicability to the four cycle types addressed in this guidebook. Descriptions of these tools may be found on pages 64 through 116 in the Tool Summary section.

Many of the tools are described in the context of hardware development and manufacturing. Their application, however, should not be limited to these areas. They have been successfully used in a variety of areas, such as software development, order processing, and customer service.

In this section, we provide a summary description of each of the tool categories.

Assessment Tool

The assessment tool is used for detailed mapping and analysis of a given cycle or subcycle to understand the critical cycle time path activities and to set the overall process and subcycle improvement goals. Information collected to understand this critical path usually includes:

- The activity itself (such as a value-added operation, transport, inspection, test, delays, or storage)
- How long each activity takes
- How activities are linked with each other
- The organizations responsible for such activities
- The distance between activities, when transport time is significant

CTI assessment is the process of mapping activities and analyzing them for understanding and shortening the critical path.

This assessment is referred to as *time-based process mapping, time-based activity mapping*, or, simply, *process mapping*. More information about the Time-based Process Mapping and Analysis Tool, which is applicable to all major cycles and subcycles, can be found on page 64.

Goal-Setting Tools — Repetitive Processes

Your goals must be sufficiently aggressive.

The two key tools recommended for setting stretch goals are

- Rules of Thumb
- Benchmarking or *Best-of-Class*

Data indicates two categories for Rules of Thumb that are useful when implementing CTI in areas that have had no CTI effort to date. These categories are:

- Reduction from current cycle time
- Multiples of value-added activities

The following cycle-time improvements have proven typical for companies who have not yet initiated a CTI effort[10] These figures should provide a sanity check on the projected cycle times for the *Should-Be* process that is developed by the process improvement teams.

REDUCTIONS FROM CURRENT CYCLE TIMES

Manufacturing	30%–90%
Administrative	40%–50%
Predevelopment and Design / Development (single loop)	30%–80%

These figures are a useful guide when setting stretch goals for teams that are not experienced with CTI.

The second rule of thumb is based on a multiple of the time it takes to perform value-added activities within the process.

10. Premiere Integration Enterprises, 317 Lookout View Court, Golden CO 80401

Multiples of Value-Added Activities	
Manufacturing	2–3 Times
Administrative	5–10 Times
Predevelopment and Design / Development (single loop)	2–2.5 Times

For example, if the current manufacturing cycle time is 12 weeks and the process is mapped and analyzed to have 12 days of value added time, the improved cycle should be 24 to 36 days or roughly 5 to 7 weeks for a possible improvement of 50%.

Use benchmarking with caution – it may not lead you to set sufficiently aggressive goals.

In an ideal environment, the time to execute a cycle would be equal to the sum of the value-added activities within that cycle. However, even in a perfectly-designed process, external delays may creep in when the process is implemented across functional boundaries.

Benchmarking or Best-of-Class comparisons are useful in three areas:

- Internal benchmarking, which compares intracompany data regarding cycle times and cost
- Competitive benchmarking, which compares company data with industry leaders
- External benchmarking, which compares a company's data with leaders in other industries who have achieved world–class status for a particular process

As you apply Best-of-Class principles to set goals for your project, keep in mind some of the general criticisms of Best-of-Class concepts, namely:

- It is often difficult to compare exactly your target process to another in terms of process objectives, organizational differences, and differences in the number and types of variables.

- Such data is often current or historical, so it may limit breakthrough thinking if this is your only set of goal-setting criteria.To avoid these common Best-of-Class issues, attempt to improve even on the Best-of-Class data you receive.

Goal setting for the Predevelopment and Design/ Development cycles is one of the most difficult aspects of CTI.

Both the Rules of Thumb and Best-of-Class comparisons should be used as guidelines. Specific results at your company will vary depending upon your specific environment.

Historical best case can also be used as a guideline, provided the process is repetitive and historical cycle time data is available. Often, the best-case cycle time represents movement through an undocumented shortcut process. Such best-case cycle times are good indicators of how much a process can be improved and could be used to augment the prior two tools.

How are goals for the Predevelopment and Design/Development cycles set for which the exact detailed process cannot be mapped?

The Predevelopment and Design / Development cycles present some unique challenges. Previously discussed goal-setting tools can be applied to the more predictable subcycles, such as drafting and testing. There are less-predictable activities in these cycles, however, for which setting a goal is more difficult. Invention, new technology searches, and software debugging are examples of activities for which the aforementioned tools may not be applicable.

Setting CTI improvement goals for these unpredictable activities is mainly the process of estimating how much the unpredictable activities are subject to barrier-removal techniques and tools (for example, risk concentration, incremental innovation and product structure opportunities). Thus, projecting the time savings using the various barrier-removal techniques becomes part of the goal-setting process.

The total cycle time for the full process is, of course, the sum of the cycle times for the predictable and less-predictable subprocesses.

Setting aggressive goals, especially for the Predevelopment and Design / Development cycles is one of the most difficult aspects of CTI and is best done with the help of someone experienced in this activity.

Barrier-Removal Tools

A CTI barrier is any event, practice, situation, or environment that extends process cycle time. Obvious barriers include:

- Unnecessary, extensive approval processes
- Numerous non-value-added steps
- Project overload

Removing barriers to cycle-time improvement is performed with tools that can be used either in selected combinations, or as standalone.

Examples of some less obvious barriers are:

- Design practices early in the cycle that waste time later in the Design / Development or order-to-delivery cycle
- Unmanaged risk
- Ineffective organizational interfaces
- Suboptimal facility layout
- Poorly designed and executed trade-offs between cycle time and resources

Barrier–removal tools include specific cycle-dependent techniques and more universal problem-solving tools. They are grouped together because, in each case, they help to break down the barriers to faster cycle times. Exact effectiveness of these barrier-removal tools is difficult to pinpoint because of the large number of surrounding variables and because they are often used in combination. There are a number of claims.

For example, breakthroughs in CTI are claimed by all of the following tools or techniques:

- Value-added analysis (AΔT™)[11] in combination with problem-solving tools for the administrative cycles
- Engineering resource management for the Design / Development cycle[12]

11 AΔT is a trademark of Digital Equipment Corp.
12 Ron Kmetovicz, *New Product Development: Design and Analysis*, New York, Wiley-Interscience,1992.

- A series of design and development techniques, including overlapping activities and partnering for the Design / Development cycle[13]
- Quality function deployment (QFD) for the Design / Development cycle[14]
- Just-in-time (JIT) manufacturing[15]

Since many of these approaches have common features such as cross-functional teams, partnering, and activity overlapping, their improvements are not cumulative. There should be no doubt, however, that using a selected combination of these and other tools can result in breakthroughs in CTI for all of the cycles addressed in this guidebook.

Based on the area of greatest leverage for the semiconductor equipment industry, many of the barrier-removal tools in this guidebook are focused on the Design / Development cycle. A significant number of tools are from a recent publication on developing products faster.[16] Other publications describing barrier removal tools are cited in the bibliography.

13. Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991.
14. Bob King, *Better Designs in Half the Time*, 3rd edition, GOAL / QPC, 1989.
15. Edward J. Hay *The Just-in-Time Breakthrough: Implementing the New Manufacturing Basics*, New York: John Wiley & Sons, 1988.
16. Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991.

Implementation Tools Table

	TOOL NAME (PRINCIPLE, APPROACH, OR TOOL)	APPLICABLE TO CYCLE OF: Predevelopment	Design/ Development	Order to Delivery	Customer Service	COMMENTS	PG #
	ASSESSMENT						
A1	Process Mapping and Value Analysis	X	X	X	X	SEMATECH Workshop – Day 1 of 2 Days	64
	GOAL SETTING						
G1	Rules of Thumb	X	X	X	X	SEMATECH Workshop – Day 2 of 2 Days	67
G2	Cycle–Time Benchmarking	X	X	X	X		70
	BARRIER REMOVAL						
B1	General Problem Solving Tools Applied To CTI	X	X	X	X	SEMATECH Workshop – Day 2 of 2 Days	72
B2	Partnering – Supplier	X	X	X	X	Also See PfTQ Volumes 2 and 4	74
B3	Partnering – Customer	X	X	X	X	Also See PfTQ Volumes 2 and 4	76
B4	Sacred Barrier Removal Team	X	X	X	X		78
B5	Computer Aided Tools (CAE, EDI, Etc.)	X	X	X	X		80
B6	Project Economic Modeling	X	X	X	X		82
B7	Opportunity for Overlapping	X	X	X	X		84
B8	Project Prioritization	X	X	X	X		86
B9	Development Process for Fast Cycle–Times	X	X				89
B10	Jointly Written Product Specifications	X	X	X	X		92
B11	Incremental Innovation	X	X	X	X		93
B12	Product Structure Opportunities	X	X	X	X	SEMATECH 3 Day Course	94
B13	Engineering Resource Management	X	X				96
B14	Design Reviews		X				99
B15	Simultaneous Engineering		X	X			101
B16	Risk Resolution Plan		X				103
B17	Risk Concentration		X				105
B18	Design for Manufacturability and Testability			X			106
B19	Fast Prototyping		X				108
B20	Modeling and Simulation	X	X	X		Check with SEMATECH for Courses	110
B21	JIT Manufacturing			X			112
B22	Quality Function Deployment (QFD)	X	X	X		Not a First Order CTI Tool	114

MEASUREMENTS

A key aspect of CTI measurement is in clearly linking it with your company's business goals.

Examples of time-based measurements are shown on page 62. The full importance of time measurements is realized only when the links with other measurements are understood. (See success factor SF2 on page 37, CTI Goals Tied to Business Objectives, for their interrelationship.) Time-based measurements of an *As-Is* process, in combination with measurements of CTI results against goals, can be used for the following:

- Progress and success indicators
- Benchmarking within or outside the company
- Establishing appropriate CTI recognition
- Communicating success case studies throughout the company
- Setting and communicating future CTI goals
- Marketing to increase sales
- Correlating cycle times to business goals

It is important that you break down long lead time processes into detailed activities to obtain sufficient information for your CTI efforts.

Cycle Time Measurement Examples

Measurements should be in the smallest unit of time possible to facilitate breakthrough thinking.

Predevelopment

- Predevelopment cycle time
- Subcycle times

Design and Development

- Design / Development cycle time (often referred to as time to market)
- Design cycle time (hardware and software)
- Drafting cycle time
- Printed circuit board physical design cycle time
- Tooling design cycle time
- Unit test cycle time
- Prototyping cycle time
- Integration test cycle time
- Alpha test cycle time
- Beta test cycle time
- Other subcycle times

Order-to-Delivery

- Order-to-delivery cycle time
- Order entry time
- Order processing time
- Materials procurement time
- Manufacturing cycle time
- Percentage of on-time delivery to customer request date
- Other subcycle times

Customer Service

- Customer response time
- Fault occurrence to return to service cycle time
- Fault to root cause removal cycle time
- Other subcycle times

TOOL SUMMARIES

CONTENTS

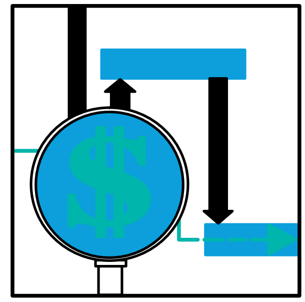
Page

Assessment Tools

Goal-Setting Tools

Barrier Removal Tools

A1: Time-Based Process Mapping and Value Analysis



This tool can be used for three purposes in the reduction of cycle times. The first is the analysis of long cycle time activities on the *As-Is* process map. By comparing the relative activity durations, the team can identify those activities that should be allotted the most time, those activities that are likely candidates for CTI, and those activities that can be eliminated.

Secondly, this tool provides the project team with a method to estimate the execution time of the *Should-Be* process. The team can then compare this estimate to the cycle time stretch goals established at the start of the improvement effort.

The third purpose of this tool is to analyze the value of each activity in relation to its contribution to the total process. Non-value-added activities that contribute significantly to the overall cycle time are candidates for elimination. Conversely, long lead time value-added activities indicate the need for streamlining and the possible application of statistical monitoring.

The mechanics of applying the tool are simple:

- Graphically depict activities as boxes in a flow chart (or process map) and then estimate the time required to perform each activity.
- Classify each activity as value-added or non-value-added. This classification is typically based on the *external* customer's perception of what constitutes worthwhile effort performed on behalf of the customer.
- Identify which activities in the process map must be performed before other activities.
- Calculate the cumulative process cycle time of the activities that are dependent on the execution of other activities. According to this definition of cumulative lead time, parallel activities and optional activities would specifically be

excluded from the estimate of cycle time for the *Should-Be* process.

- Verify the execution times and dependencies for each activity with people involved in those areas of the process.

Target Users

- Cycle time analysts

Prerequisites

- Familiarity with process maps in the context of cycle time reduction is essential to a high-quality output of this process
- Experience with critical path flow charting or process mapping is helpful but not essential

Benefits

- The graphic nature of the tool provides an effective means for a team to quantify the impact of eliminating, consolidating, or streamlining activities.
- The pictorial representation of sequentially-dependent activities provides a constant reminder to the team of the importance of re-engineering sequential activities into parallel activities when possible.
- The consideration of an activity's value injects the all-important *voice of the customer* into the cycle time reduction analysis. This point of view helps the project team make improvement decisions that are based on external customer requirements versus those based on purely internally-focused adjustments to activity sequence and content.

Ease of Use

Because of the graphic nature of the map and the few rules that govern the process, the process is fairly simple to learn and apply.

Comments

There are several caveats regarding the use of this tool.

- *Don't allow the map to get too complex.*

  The complexity of the map tends to be inversely proportional to its usefulness. As the complexity level rises, the relationships among activities often becomes variable, and it sometimes becomes difficult to identify the true critical path with any degree of accuracy.

- *Watch for variable activity execution times.*

  Often, the execution time of an activity will vary considerably. The team can do little to minimize this variability. Rather than try to portray an average activity time, identify a range for that activity (the lower limit would represent the best case, the upper limit would represent the worst case).

- *Be on the alert for partial dependencies.*

  Often, an activity does not have to be 100% complete before the next activity in the sequence can be started. This situation can lead to inaccuracies in the total cycle time estimate. If, for example, a second activity can be started when the first activity is only 60% complete, then the calculated time of the total process would be overstated unless you factor in the parallel work during the remaining 40% of the first activity.

- *Consider different time estimates for conditional branches.*

  Within a process, branches may exist for different situations or transactions. For example, in an order-to-delivery cycle, a decision box would separate process flows for custom orders and ship-from-stock orders. Ship-from-stock orders require less time than assembling a custom order. It would, therefore, be inaccurate to quote a single time estimate for the order-to-delivery cycle. When activity times are materially different after a conditional branch in the process, the team should consider developing a critical path estimate for each key situation that stems from a conditional branch.

Source

Thomas J. Devane, *Process Reengineering: A Starter Toolkit,* 317 Lookout View Court, Golden, CO, 80401, 1990.

G1: Rules of Thumb

Often teams that have no previous experience with cycle time reduction have a difficult time setting goals for reducing process cycle times. These Rules of Thumb are intended to provide new cycle time reduction teams with a set of rules to establish realistic cycle time reduction goals. These Rules of Thumb were derived from historical data in the semiconductor industry.

There are two categories of Rules of Thumb for setting cycle time reduction goals:

- Reduction from current cycle time
- Multiples of value added activities

Because of the different nature of processes, the target range for CTI will vary for different types of processes. Different target ranges for manufacturing, administrative, and Predevelopment and Design / Development processes are shown below.

For companies who have not yet initiated a CTI effort, the first set of Rules of Thumb, reduction from the current cycle time, are:

Manufacturing	30%–90%
Administrative	40%–50%
Predevelopment and Design / Development (single loop)	30%–80%

These figures should provide a useful guide for setting stretch goals for teams that are not experienced with CTI.

The second set of improvement Rules of Thumb, multiples of value-added activities are:

Manufacturing	2–3 Times
Administrative	5–10 Times
Predevelopment and Design / Development (single loop)	2–2.5 Times

In an ideal environment, the time to execute a cycle would be equal to the sum of the value-added activities within the cycle. However, even in a perfectly designed process, external delays may inevitably creep in when the process is implemented across functional boundaries.

These figures should provide a cross check for the projected cycle times for the *Should-Be* process developed by the process improvement teams.

Target Users

- Cycle time analysts will use the rules to develop cycle time reduction targets.
- Steering Committee members will use the rules to evaluate reduction targets established by the team.

Prerequisites

- An understanding of the concept of “value-added activities” is helpful, but not necessary.

Benefits

- Provides a simple set of rules to use as estimating Rules of Thumb
- Can be used by teams with little or no cycle time reduction experience

Ease of Use

The rule sets are very easy to use, even for a novice.

Comments

The rule sets are meant to serve as general Rules of Thumb only. Results will vary based on individual company environments, but the rules provide a check for team-developed goals.

Sources

Thomas J. Devane, *Process Reengineering: A Starter Toolkit*, 317 Lookout View Court, Golden, CO, 80401, 1990.

SEMATECH's *Time-Based Process Assessment and Barrier Removal Workshop*.

G2: Cycle-Time Benchmarking

Benchmarking studies help the team evaluate process improvement opportunities based on data collected on similar processes at other locations.

- When data is compared within the company, such as among divisions or departments, the study is referred to as an *internal benchmarking* study.
- When data is compared to other companies within a similar industry, such a study is called a *competitive benchmarking.*
- When data is compared to other companies or organizations in another industry, the study is referred to as *external benchmarking.*

Target Users

- Top Management
- Cycle time Analysts
- Steering Committee

Prerequisites

Some member of the team should have previous Best-of-Class experience.

Benefits

- Provides a useful starting point for process improvement
- Provides a relative ranking for a company's position in the national and world marketplaces
- Provides input to the prioritization process for improvement projects to be selected first

Ease of Use

The tool is moderately easy to use, but can require some judgment calls at key junctures, which could affect the outcome of the overall analysis and improvement structure.

Comments

While Best-of-Class studies can provide a useful starting point for many cycle time reduction projects, the team should take the following items into consideration:

- *No two processes are exactly the same.*

  Though the team may do an excellent job of drawing process boundaries, individual process and activity variations will tend to exist between companies within the same industry or even between divisions within the same company.

- *Competitive benchmarking data may not be reliable.*

  Because the source of the data is a competitor within one's own industry, the data should be considered to be suspect until verified.

- *Best-of-Class data is either* current *or* historical.

  Strive to improve, even on world-class practices.

Source

Thomas J. Devane, *Process Reengineering: A Starter Toolkit,* 317 Lookout View Court, Golden, CO, 80401, 1990.

B1: General Problem-Solving Tools Applied to CTI

These tools are used for developing a complete picture of all the possible causes of a problem and to reach agreement on the basic one(s). There are numerous tools in this category. For CTI, typical problem-solving tools include:

- Brainstorming
- Cause and Effect Diagrams
- Force Field Analysis
- Nominal Group Technique
- Pareto Chart
- Histogram
- Affinity Diagram
- Interrelationship Digraph
- Prioritization Matrices
- Analytical Matrices

Target Users

- CTI teams

Prerequisites

- Basic knowledge and training in the tools

Benefits

- Improving cycle time, especially in the order-to-delivery and customer-service cycles
- Cross-functional team building

Ease of Use

These tools are simple to use. With a good description or guideline, minimal training is required.

Comments

In the spirit of continuous improvement, the team members may wish to educate themselves with new tools to expand their problem-solving capabilities.

Sources

The Memory Jogger, A Pocket Guide of Tools For Continuous Improvement, Goal / QPC, 13 Branch Street, Methuen, MA 01844, 1988.

Michael Brassard, *The Memory Jogger Plus*, Goal / QPC, 13 Branch Street, Methuen, MA 01844, 1989.

Thomas Devane, *Process Reengineering: A Starter Toolkit*, 317 Lookout View Court, Golden, CO, 80401. 1990.

SEMATECH, "A Total Quality Tool Kit," *Partnering for Total Quality*, Volume 6, #90060279B-GEN, Austin, TX: SEMATECH, 1990

B2: Partnering—Supplier

If a cycle under consideration depends on a supplier, then there are several kinds of supplier-related opportunities to shorten the cycle. These include:

- Using a supplier’s industry experience to set CTI goals
- Using a supplier’s technical expertise to assess feasibility and risk and to reduce your need to innovate
- Getting the supplier’s ideas on eliminating unneeded steps
- Sharing joint concerns so that they can be managed together
- Eliminating the learning-time delay that occurs when information is transferred at the last minute

Target Users

- CTI teams
- Purchasing and quality people
- Design engineers
- Process engineers

Prerequisites

- Knowledge of the cycle involved

Benefits

- Shorter cycle times
- More reliable cycle times (fewer surprises)
- Higher probability of right-first-time solutions

Ease of Use

Conceptually easy, but in American industry it is contrary to long-standing practices of supplier relations as an arms-length transaction.

Comments

Effective supplier partnering means changing the conventional practice of arm’s-length relationships and three-bid, lowest-price procurement. Not only do conventional relationships preclude the trust needed for partnering, but they also make it difficult to get involved early with suppliers for advice, which is a key for using suppliers to cut cycle time.

Sources

SEMATECH, “A Partnering Overview”, *Partnering for Total Quality,* Volumes 2 , #90060276B-GEN, Austin, TX: SEMATECH, 1990

SEMATECH, “A Partnering Guidebook”, *Partnering for Total Quality,* Volumes 4 , #90060277B-GEN, Austin, TX: SEMATECH, 1990

B3: Partnering—Customer

This tool involves customer partnering in several ways to improve cycle times:

- Jointly written product and interface specifications
- Early testing of product features or prototypes at the customer site for customer feedback
- Improved understanding of the product application environment by the product developer

Target Users

- Top management
- Everyone in the cycle who is involved in satisfying customers

Prerequisites

- Customer relations training before contact with the customer

Benefits

- Encourages CTI by getting quick customer feedback and, thus, rapid refinement of the product or service
- Improves time to market by providing only the services or features that the customer values
- Manages customer expectations by educating the customer as to what is possible on the supplier end

Ease of Use

Conceptually easy, but in American industry it is contrary to long-standing perceptions of customer relations as an arms-length transaction.

Comments

Of course, customer partnering, when properly executed, can significantly improve other competitiveness factors besides cycle time, product quality, and cost.

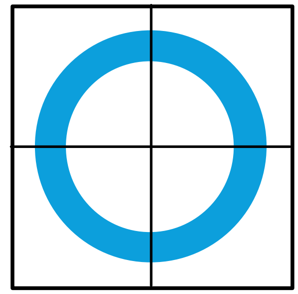
Relationships with customers are fairly obvious for those who normally contact customers—such as sales, marketing, or service people—but such relationships are just as vital, though more obscure, to recognize for those in the background, such as designers or machinists.

Sources

SEMATECH, “A Partnering Overview”, *Partnering for Total Quality*, Volumes 2 , #90060276B-GEN, Austin, TX: SEMATECH, 1990

SEMATECH, “A Partnering Guidebook”, *Partnering for Total Quality*, Volumes 4 , #90060277B-GEN, Austin, TX: SEMATECH, 1990

B4: Sacred Barrier Removal Team



A sacred barrier removal team is a committee or team, consisting of executive management who have the authority and / or the influence to remove significant and high-level barriers to improving cycle time. This team meets regularly (approximately every four to six weeks) to review identified high level CTI barriers and ensures progress toward removing them.

The approach is to

- Get with the people who have identified barriers and understand what needs to be changed (Individuals identifying barriers are usually members of a team focused on improving the cycle time of a critical process with high-leverage impact.)
- Evaluate the value and prioritize
- Put together a plan for removing the barrier(s)

The plan for removing the barriers could take the form of

- Naming the committee member who owns the barrier
- Identifying who must approve a particular barrier's elimination
- Naming the individual(s) who have the authority to execute the barrier removal
- Providing a column for tracking remarks

Target Users

- Cycle-time improvement barrier-removal teams

Prerequisites

- None

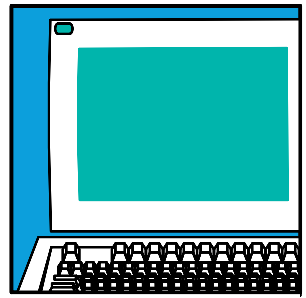
Benefits

- Removes cultural and sacred business process barriers to cycle-time improvement

Ease of Use

Straightforward, but requires cross-functional executive buy-in

B5: Computer-Aided Tools



Computer-aided tools, such as computer-aided design (CAD) — both mechanical and electrical, computer-aided manufacturing (CAM), and electronic data interchange (EDI), have become standard engineering tools in some companies and unfulfilled dreams in others. These tools influence development time in several ways. There is often considerable start-up and learning time. For systems like CAD, an original drawing is often no faster than if done manually, but revisions are much quicker.

Target Users

- Potentially applicable by almost any group, although product developers have taken the lead

Prerequisites

- Hardware and software training

Benefits

- Can save great amounts of time on certain tasks, particularly on repetitive or error-prone ones
- In some cases, like solids modeling, can lead to completely new and faster ways of doing business if the management process can be changed to accommodate them

Ease of Use

Selection and application of tools is usually complex because of the availability of a multitude of hardware platforms often bundled with software with different capabilities and characteristics. It is further complicated for those organizations that have to fit new tools around existing tools, networks and data bases. Thus, depending on the organization's computer-aided tools history, degree of networking, and need for bridging to existing data bases, ease of use can vary from straightforward to difficult, requiring months to years for evaluations, system integration, installation, and application training.

Comments

In many cases, the time that the tool can save is small in comparison with the queue time involved before the tool is employed, so process improvements should come before these tools.

Sources

John Krouse, et al., "CAD / CAM Planning 1991: Breaking Down the Barriers to Integration," *Machine Design,* July 25, 1991, pp. CC1–CC39.

John Krouse, et al., "CAD / CAM Planning 1990: Gaining the Competitive Edge, " *Machine Design,* July 26, 1990, pp. CC1–CC20.

Steven C. Wheelwright and Kim B. Clark, *Revolutionizing Product Development*, New York: Free Press, 1992, pp. 243–254.

B6: Project Economic Modeling

If cycle time is important, its monetary value can and should be calculated. This allows all of those making trade-off decisions about the product—from the president to the shipping clerk—to balance time properly with other variables such as product cost and performance. The process is to model the project life-cycle economics and then construct variations of the model to represent lateness, high cost, and other considerations. From this, simple Rules of Thumb for making trade-off decisions can be calculated.

Target Users

- Creators of models, such as finance, engineering, manufacturing, and marketing personnel
- Everyone who influences the product's schedule

Prerequisites

- For model builders, an understanding of how product problems, such as lateness and cost overruns influence finances
- For model users, familiarity with the model itself

Benefits

- Produces higher quality decisions than those based on just guessing or emphasizing one goal (like timeliness) at the expense of all others
- Trade-off decisions are made faster because there are Rules of Thumb commonly accepted by all levels in the organization
- Because the rules are clear, such decisions can be made at a lower level, further speeding decision making

Ease of Use

Relatively simple to model, but it may take some effort to discover the relationship between lateness and costs. The modeling results are easy to apply.

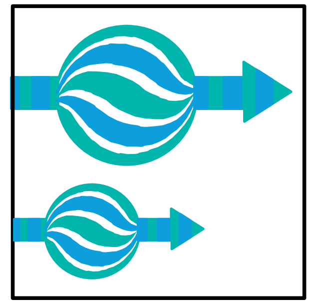
Comments

Cross-functional teams actually force overlapping. For example, by having a manufacturing engineer on a development team from the outset, that engineer will have to find ways to overlap tasks in order to be more productive.

Source

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time,* New York: Van Nostrand Reinhold, 1991, Chapter 2.

B7: Opportunity for Overlapping



Overlapping two tasks is one of the fundamental conceptual means of shortening cycles, but it is not so easy to do in practice. One problem is that overlapping relies on using partial information from the predecessor (incomplete) task, but partial information is dangerous to use without a strong team and communication structure in which to handle it. Thus, successful overlapping depends on cross-functional teams. (See Success Factor 4, Empowering Cross-Functional Teams.) Overlapping opportunities tend to be specific to an organization. They provide a competitive edge, but require effort to discover.

Target Users

- Everyone involved in a cycle

Prerequisites

- A strong understanding of the cycle concerned
- An empowered cross–functional team
- General Problem-Solving and Brainstorming skills (Tool B1)

Benefits

- Provides a relatively secure competitive capability
- Exploits the strength of the team
- By its nature, fosters a mentality in which the sequential nature of tasks is challenged

Ease of Use

Relatively difficult in that it requires a shift from serial thinking to parallel thinking in the organization

Comments

Cross-functional teams actually force overlapping. For example, by having a manufacturing engineer on a development team from the outset, that engineer will have to find ways to overlap tasks in order to be more productive.

Source

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991, Chapter 9.

B8: Project Prioritization

All too often, development projects stretch out in time simply because they are understaffed. To a first approximation, if a company is carrying twice as many projects as it can staff effectively, each project will, on average, take twice as long to complete. A firm that listens to its customers may be tempted to undertake more development work than it can digest.

Thus, it is essential to know the firm's development capacity and to manage the start-up and prioritization of new projects with great discipline if development cycle time is to be minimized. Because the benefits of short cycle times are driven by the economic value of the time saved, Project Economic Modeling (Tool B6) is the foundation of this activity.

Two types of information form the basis of the resource-allocation process. One is an understanding of the resources that are actually available for new projects, after allowing for the needs of routine product maintenance, vacations, training, and non-project meetings. Many companies find that they do not have the resources that they thought they had. The other type of input is a product-line strategy that is the basis for apportioning effort among breakthrough projects, new platforms, derivatives, and line extensions so that planning can balance the needs of today with those of tomorrow.

Resource allocation for rapid product development is done quite differently than the normal planning process. Rather than lining up the resources and seeing how many projects they will cover, you pick the highest priority project and see how heavily it can be loaded so that it completes as soon as possible (Application of Tool

B13, Engineering Resource Management). Then you fence off those resources, choose the second project, and plan it similarly. When the resources run out, the remaining projects must wait until resources are free again.

Target Users

- Product line and strategic planners
- Top management

Prerequisites

- Systems for assessing development capacity
- Project Economic Modeling (Tool B6)

Benefits

- Shortens development cycles if the current process is overloaded
- Does not increase costs or reduce the number of new products introduced per year
- Avoids investing in projects which the organization does not have the resources to complete
- Keeps everyone in the company working toward the same objectives

Ease of Use

Although simple in concept, controlling the project load is very difficult in practice. It takes a great deal of management discipline to not start a project until it can be staffed adequately.

Comments

This is a senior management issue, not a development team issue. Priorities should be communicated throughout your organization and remain stable. Managing the development load is a powerful opportunity because the benefit can be large and is essentially free.

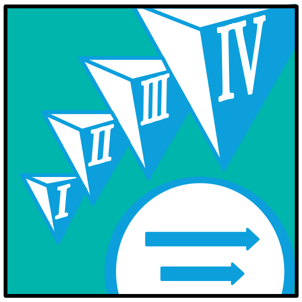
Sources

Ronald Eugene Kmetovicz, *New Product Development: Design and Analysis,* New York: John Wiley & Sons, 1992, pp. 134–42.

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time,* New York: Van Nostrand Reinhold, 1991, Chapter 11.

Steven C. Wheelwright and Kim B. Clark, *Revolutionizing Product Development,* New York: Free Press, 1992, Chapter 4.

B9: Development Process for Fast Cycle Times



Traditionally, most firms have a development process or product life-cycle process intended to both form a common understanding of their process and to provide a uniform baseline for assigning responsibility, managing risk, and tracking progress. Although such processes have apparent management benefits, they also create several problems for rapid development projects:

- They tend to be sized for large projects, overburdening smaller ones.
- They impose artificial constraints that discourage the creative use of task overlapping.
- They seldom have a time scale that allows rapid management response to slippage.
- They tend to let accountability shift from the people to the system.

A four-checkpoint development process with technical design reviews during the execution phase is recommended:

Checkpoint I. Early in the cycle, senior management should approve project feasibility start-up in order to strictly control the natural proliferation of projects that dilute resources and slow every project.

Checkpoint II. Later, after the development team has further narrowed the number of projects based on feasibility study completion, a project planning phase is approved.

Checkpoint III. Next, when detailed project planning is complete with verification of resource and skill availability, the execution phase is approved.

Checkpoint IV. The last checkpoint releases the new product to manufacturing for volume production.

Target Users

- Executive and project managers of Predevelopment and Design / Development cycles

Prerequisites

- Familiarity with the tool Engineering Resource Management, B13

Benefits

- Provides a methodology for narrowing the number of development projects to be pursued while managing financial risk
- Provides a methodology for allocating resources consistent with technical risk
- Provides a means of tracking schedule progress on a time scale commensurate with rapid development
- Clarifies task accountability
- Results in a CTI-based development process, usually unique to a company, that cannot be copied effectively by competitors

Ease of Use

Changing to the recommended development process may be difficult because of

- Your company's existing "sacred" processes
- A high level of interdependence with other business processes
- Its crossfunctional nature at the highest management level

Comments

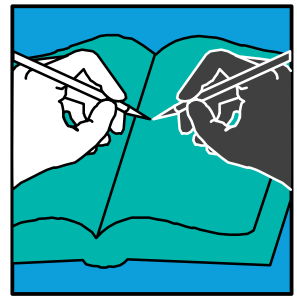
The process adopted must be supported by the company's business objectives, organizational structure, management style, and reward systems.

Sources

Ronald Eugene Kmetovicz, *New Product Development: Design and Analysis*, New York: John Wiley & Sons, 1992, Chapters 4–6.

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991, Chapters 10 and 11.

B10: Jointly-Written Product Specifications



All too often, product specifications are written either by marketing or engineering in relative isolation. In order to obtain a workable balance between technical complexity and usability by marketing, much time is wasted in the review and approval process. This tool offers an improved process in which the parties involved, including customers or customer surrogates, jointly create the specification.

Target Users

- Development teams (Predevelopment or Design / Development cycles)

Prerequisites

- Meeting facilitation
- A strong vision for the product to be specified

Benefits

- Speeds specification creation greatly and makes approval almost automatic
- Provides a specification in which development time is well balanced with the market need
- Fosters buy–in by the key parties who will be responsible for developing the product, thus avoiding delays later on

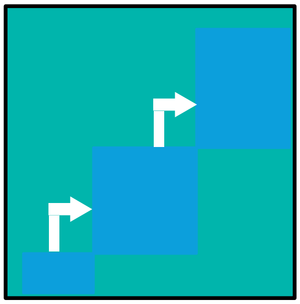
Ease of Use

Moderate, depending on the strength of the facilitator and the degree of teamwork among the participants

Source

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991, Chapter 5.

B11: Incremental Innovation



Successful, competitive, innovative, fast companies develop new products in several small steps, selling products at each step to get rapid customer feedback. This tool teaches you how to think incrementally but innovate quickly in response to customer desires.

Target Users

- Product planners and developers (Predevelopment and Design / Development cycles)

Prerequisites

- An understanding of the market benefit associated with incremental, but early introduction of new product features

Benefits

- Achieves customer-desired features faster because of more timely and frequent customer feedback
- Reduces the risk and resources required at each stage of development
- Makes product planning more responsive, more accurate, and less dependent on long-range forecasts

Ease of Use

Moderate, often requiring some effort to find an incremental strategy that allows for future enhancements.

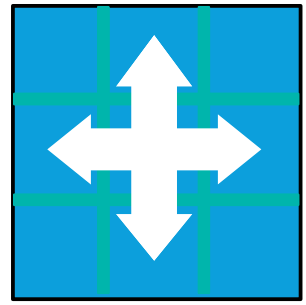
Comments

Often, this tool can be used in conjunction with Tool B12, Product Structure Opportunities.

Source

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991, Chapter 4.

B12: Product Structure Opportunities



Products can often be developed faster when they can be divided into modules and worked relatively independently by separate teams. This is particularly true when a development team for the complete product would require more than ten people. However, this division necessitates planning the product's structure so that it can be divided. This tool covers how to architecturally plan the modules and the interfaces between them.

Target Users

- Product planners and developers (Predevelopment and Design / Development cycles)

Prerequisites

- An understanding of the basic technical structure of the product

Benefits

- Can speed up development greatly
- Lends itself to easier upgradability, adaptability, and Incremental Innovation (Tool B11)

Ease of Use

Conceptually straightforward, but requires people with a high level of subject matter skills to do the technical architectural planning.

Comments

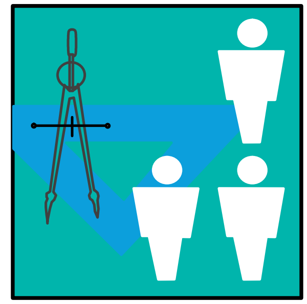
Product structure options carry costs as well as benefits. For example, product cost can rise as it is divided into modules.

A related and important design practice that can speed time to market is the careful minimization of component and subassembly part numbers. There are examples of companies producing the same product with one thousand versus ten thousand components. The number of components is a key resource and schedule driver.

Source

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991, Chapter 6.

B13: Engineering Resource Management



The challenge in new product development is to move from concept to revenue fast enough to meet internal, competitive, market, and customer demands. Resource management provides the foundation on which to improve cycle time through the optimal application of limited engineering resources. This tool combines sub-tools and techniques that are used to model, measure, and manage the resources applied to the new product development process.

Managers and team members work together as they use the tool to create effective models of the new product-development effort. This approach to resource management is new to most organizations. The new techniques show how to make planning distributed, fun, and fast—the characteristics that are needed to make it effective.

The model is converted into database format. Once resident in the computer, the data is carefully analyzed. The KMET Chart, resource histograms, to-do lists for each resource, and other items are used to measure the quality of the model. Through model analysis, the application of resource-to-task improves. As cycle time is better understood—the critical path is identified and the resource means by which it can be shortened becomes known.

With accurate models in place, tracking group performance over time becomes friendly and easy as resource and task adjustments are inserted to maintain team effectiveness on a concurrent, cross-functional basis. No longer is it necessary to second-guess where resource problems reside and what should be done about them. Data about the execution phase are presented by the tools to provide early warning and detection. Timely identification of problems leads to their effective correction.

Target Users

- Project managers, team leaders, and managers of other functional groups which contribute to the realization of the new product during the Predevelopment and Design / Development cycle

Prerequisites

- Project Economic Modeling
- Application requires training in the concept and commercial availability of a computer program to model the development activity network

Benefits

- Improved cycle-time of the Development and Design / Development cycles
- Provides visualization techniques to illustrate how management can optimally apply resources to projects and tasks to meet time objectives
- Real-time tracking, measurement, and adjustment of the execution phase to get the job done on time through effective management of resources
- The data serves to effectively justify optimal project resource requirements and obtain full management support

Ease of Use

Straightforward, but requires training

Comments

First-time application of the tools frequently requires on-site professional assistance. Additionally, two training sessions (approximately 12 to 16 hours) are required to create and utilize the resource driven database.

Source

Ronald Eugene Kmetovicz, *New Product Development: Design and Analysis,* New York: John Wiley & Sons, 1992, Chapters 3–6.

B14: Design Reviews

Design reviews are the standard means of assessing progress of a development project, so reviews are clearly of interest for managing and reducing cycle time. However, reviews themselves consume time in scheduling, in preparation, in execution, and in response to the action items generated. They can also appear to relieve the development team of its responsibility for the project and its schedule, thus undercutting employee empowerment. Consequently, the review process must be designed carefully so that it aligns with cycle time objectives.

Target Users

- Upper management
- Development teams (Design / Development cycle only)

Prerequisites

- A development process (Tool B9) that provides a basis for review

Benefits

- Helps to minimize technical risk and improve design quality which in turn will improve cycle time.

Ease of Use

Can vary greatly, but an easy procedure is more likely to be used

Comments

Formal reviews conserve management time. Informal methods are faster and less disruptive to the development team.

Phase-end reviews are most common because they divide the project into clearly defined modules and, perhaps, also into funding decision points. However, they also create artificial time barriers that tend to slow the project.

The preferred approach is periodic reviews, independent of phases, which keep the review off the Critical Path (Tool A1). It is important to keep technical design reviews separate from management reviews of progress. This is easier to implement in small, technical, entrepreneur-led companies.

Sources

Preston G. Smith And Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991, pp. 184–86.

Steven C. Wheelwright and Kim B. Clark, *Revolutionizing Product Development*, New York: Free Press, 1992, pp. 149–58.

B15: Simultaneous Engineering

This is an amplification of the *Partnering for Total Quality* tool (Volume 6, pages 86–87) to capture the time-saving benefits.

Simultaneous Engineering is characterized by:

- Early involvement of manufacturing process engineers so that easy-to-manufacture initial designs reduce the need for redesign
- Early involvement of manufacturing leads to their buy-in to the design to eliminate start-up time when the design is released to manufacturing
- Improved scheduling of long lead-time parts for faster prototyping and pilot production

Target Users

- Design / Development teams (Design / Development cycle only).

Prerequisites

- Cross-functional Team Skills (Success Factor SF4) are essential. Teams are strongly advised.

Benefits

- Time saving realized through less redesign, reduction of downstream manufacturing problems, and reduced waiting on long lead-time parts
- Organizational inertia reduced through better manufacturing ownership of the design and earlier learning about the design (faster manufacturing transition)
- Product cost and quality usually improve simultaneously as side benefits

Ease of Use

Difficult. Design engineers may perceive that their creativity is being infringed on, and manufacturing engineers may feel that the design engineers do not listen to them.

Comments

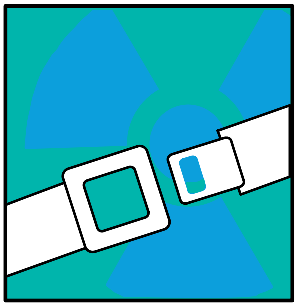
To the extent that suppliers manufacture critical parts, all of the above applies to them too. See Tool B2, Partnering—Supplier.

Sources

"Creating Teamwork in Engineering," *Machine Design*, March 26, 1992, pp. 99–106.

"Organizing for Concurrent Engineering," *Machine Design*, July 23, 1992, pp. CC2–CC10.

Preston G. Smith And Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991, Chapter 13.



B16: Risk Resolution Plan

Products can be late to market because no one took the time to identify the risks—technical and market—and make plans to resolve them. Then, time-consuming surprises occur late in the development cycle or, in the case of market risk, after the product is launched. This tool includes identifying the risks and planning means of resolving them, including testing, model making, analysis, and backup development activities.

Target Users

- The development team, particularly product engineering, manufacturing, and marketing

Prerequisites

- A solid understanding of the associated product technologies, manufacturing processes, and market

Benefits

- Shortens the Design / Development cycle and lessens the uncertainty in this cycle
- Balances technical and market risk so that one is not over-managed to the detriment of the other
- Improves product quality

Ease of Use

Easy

Comments

This is an area in which a great amount of technical and market experience is valuable. Outside experts can help the development team by reviewing these plans.

Source

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991, Chapter 12.

B17: Risk Concentration

The risk in a development project grows quickly with the number of areas having significant risk, either technical or market. This tool covers techniques for managing risk by concentrating it in a few areas where it can be assigned to the best people and monitored closely by management.

Target Users

- The development team (product development cycle)

Prerequisites

- A Risk Resolution Plan (see Tool B16)

Benefits

- Shorter, more predictable development cycle

Ease of Use

Straightforward, but requires careful risk analysis early in the design phase

Comments

Related to tools B11, Incremental Innovation, and B16, Risk Resolution Plan

Source

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time*, New York: Van Nostrand Reinhold, 1991, Chapter 12.

B18: Design for Manufacturability and Testability

These tools focus on designing a product so that it can be manufactured readily on specified machinery and in a way that enables all of its functions to be tested. A related methodology is design for serviceability. A portion of design for manufacturability deals with process capability studies, in which the plant assesses and publishes the capabilities of its manufacturing equipment so that product designers can design to those capabilities.

Design for testability refers primarily to tests for assembly-level debug, system integration, and final system test to ensure correct design and performance to specifications. It is not meant to be a test for finding manufacturing defects, which is a non-value-added step to be minimized through JIT principles and continuous process improvement.

Target Users

- Design and manufacturing engineers (Design / Development cycle)

Prerequisites

- Specific training in these techniques

Benefits

- Improves the Design / Development cycle by reducing eleventh–hour surprises in which tolerances cannot be held, yields are low, or the product cannot be tested
- As a side benefit, tends to reduce product cost and improve product quality

Ease of Use

Straightforward, with the proper training

Comments

This is a subset of Tool B15, Simultaneous Engineering.

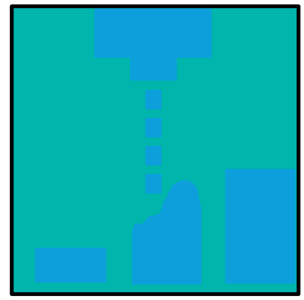
Sources

Jill J. Hallenbeck, Nick Kanopoulos and James R. Cybrynski, "The Test Engineer's Assistant: A Design Environment for Testable and Diagnosable Systems," *IEEE Transactions on Industrial Electronics,* Nat 1989, pp. 278–85.

Preston G. Smith and Donald G. Reinertsen, *Developing Products in Half the Time,* New York: Van Nostrand Reinhold, 1991, Chapter 13.

Steven C. Wheelwright and Kim B. Clark, *Revolutionizing Product Development,* New York: Free Press, 1992, pp. 234–43.

B19: Fast Prototyping



This heading refers to two completely different tools. One allows three-dimensional models to be made very quickly from a computer-design database. Various processes are used, including a laser in conjunction with a photocurable liquid polymer (stereolithography), fine streams of wax or thermoplastic deposited by computer control, and selective laser sintering. The other tool is a means of generating software quickly by starting with a very crude program and upgrading it in response to how it performs.

Target Users

- Product developers, hardware and software, respectively (Design / Development cycle)

Prerequisites

- Hardware: Requires a physical modeling tool, expensive equipment, and a sophisticated CAD system to provide the data
- Software: Requires experience to avoid architectural dead ends

Benefits

- For hardware, faster resolution of subjective form issues that require consensus
- For software, the tool is particularly helpful in reaching rapid consensus on subjective user-interface issues

Ease of Use

Conceptually simple, but there can be obstacles in practice that can be inferred from the prerequisites

Comments

For the physical model tool, there are services available to do the modeling, so it is wise to use them before deciding to invest in a machine that may have limited effect on cycle time.

Use of the software tool must be balanced with the advantages of a structured, top-down approach. Normally, rapid prototyping is advantageous for designing screen images and reports, whereas a more formal approach is safer and faster for the kernel.

Sources

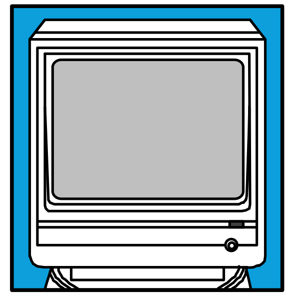
William W. Agrest, *New Paradigms for Software Development*, IEEE Computer Society, Part III, 1986 (software).

Steven Ashley, "Rapid Prototyping Systems," *Mechanical Engineering,* April, 1991, pp. 34-43 (hardware).

Paul Dvorak, "Other Routes to Rapid Prototypes," *Machine Design*, June 25, 1992, pp. 38–43 (hardware).

Sharon Hekmatpour and Darrel Ince, *Software Prototyping, Formal Methods and VDM,* PLACE: Addison Wesley, 1988 (software).

B20: Modeling and Simulation



Modeling, simulation, testing, and analysis are standard engineering techniques for complex product development in computer systems, VLSI circuits, aerospace, and electro-mechanical systems.

Use of physically based models of semiconductor process equipment is making progress to study the non-linear and time domain response of the system dynamics. So far, these models have been primarily used in stepper designs to predict the performance of the equipment and integration of new modules into the existing systems. Physically-based system models can also be used to test the operating software prior to implementation on the real hardware. Similar to the VLSI chip emulation, test vectors representing the equipment operating conditions such as process loads / variability, and event timing can be presented to the dynamic model to study performance and conflicts.

Using this methodology, computational accuracies, repeatability, timing and other response related hardware / software problems can be uncovered in a very short time by observing the critical system nodes in real-time.

The infinite number of user-end variations on the equipment makes design optimization extremely challenging. The methodology proposed by Pirbhai and Hatley for hardware / software co-design and test methodology is highly recommended for complex systems.[17]

Continuous design improvement methodology based on object-oriented design process management detailed in the Xerox PRIDE

17. Derek J. Hatley and Imtiaz A. Pirbhai, *Strategies for Real Time System Specification,* Dorset House, 1991.

system is recommended to capture total design learning from the equipment life cycle.[18]

Check with SEMATECH for course availability.

Target Users

- Development engineers (Design / Development cycle)

Prerequisites

- Knowledge of how real-time systems operate

Benefits

- Faster time-to-market is achieved through:
  - Early understanding of conflicts between hardware and software partitioning and trade-offs
  - Early understanding of non–linear interactions between equipment, process, technology and operating environment
  - Seamless integration of new modules and sub-systems into existing platforms
  - Need for hardware test time and instrumentation of breadboards can be avoided during the early stages of the development process
- By proper use of stress levels and multiplicity of environments in the test vectors, design quality can also be improved substantially

Ease of Use

Training and special hardware / software are required

Comments

The overall design quality depends on the degree of validation and robustness of the physical model employed to baseline the design.

18. *Xerox PRIDE System for Paper Handler Design Management,* Xerox Park Internal Reports, Palo Alto, CA, 1988.

B21: Just-in-time (JIT) Manufacturing

JIT is a production approach designed to improve product quality and manufacturing cycle time. This is accomplished through work cells that add value to the product based on a *pull* system. The pull system is a system where the demand is dictated by the work cell or customer further downstream in the production process. The lot sizes are usually small and inventory of unfinished goods is thus kept to a minimum. Because of low inventory, quality issues surface and get resolved quickly. The JIT production approach is usually applied from assembly or parts suppliers all the way to the shipping dock.

Target Users

- Manufacturing management and personnel, but the JIT concept can be adapted to other processes that have the characteristics of a manufacturing process

Prerequisites

- Management commitment
- Employee empowerment in area of problem identification and correction
- Tighter relationship with materials suppliers
- Training for managers and employees in the JIT manufacturing approach

Benefits

- Improved cycle time and customer lead time
- Improved product quality, or reductions in the cost of failure (scrap, rework, and warranties)
- Reduced unfinished-goods inventory
- Reduced factory space
- Increased direct and indirect labor productivity

Ease of Use

The concept is straightforward, but training is recommended for Manufacturing Engineering, Purchasing, Materials, Production Planning, Production, and Test. Usually, suppliers also would need to be trained.

Comments

Training is readily available from training organizations and consulting companies.

Sources

K. A. Wantuck, *Just in Time for America,* no place: The Forum, Ltd, 1989.

Edward J. Hay, *The Just-In-Time Breakthrough: Implementing the New Manufacturing Basics*, New York: John Wiley & Sons, 1988.

B22: Quality Function Deployment (QFD)

QFD acts to link more closely the various functions and departments in a company that are responsible for developing a new product, and it helps to tie the customer into the process more clearly. This is done by constructing a chain of matrices that first connect customer needs to engineering characteristics, then to parts characteristics, and finally to manufacturing operations and even specific production parameters. The development team builds the matrices, which help to illuminate the key linkages and critical parameters in the product, as well as to improve teamwork and communication within the team.

Target Users

- Product development teams, whether or not involved in CTI

Prerequisites

- QFD training is needed and is available commercially

Benefits

- Provides a strong focus on the customer, known as the *voice of the customer* in QFD parlance
- Links departments and functions, improving communication
- Reduces design rework, potentially (the CTI benefit)
- Clarifies key parameters and linkages in a design

Ease of Use

Fairly difficult to learn and to adapt to the needs of the organization. Plan on two to three years to become proficient. The difficulty often encountered is trying to make the first matrix too complex or to get it just right. Then the team gets bogged down or gives up, never getting to the latter matrices needed to manufacture the product.

Comments

Although QFD is an important element in applying world-class manufacturing principles to new product development, it is not so clear how QFD relates to the CTI aspect of developing products. QFD can produce a product that satisfies customer needs more exactly—which to some extent may reduce the amount of over-design—and it should improve the manufacturability of the product. Any of these improvements will reduce the likelihood of redesign. Less redesign, in turn, should improve cycle time.

Offsetting these advantages are the significant time demands of a useful QFD analysis. These time demands occur at the front end of the cycle, when the project is likely to be lightly staffed and awaiting the completion of some preliminary analyses, like QFD, before they actually enter development. To save time, the project will need extra people while the QFD analysis is being done, and design work should not await completion of the QFD matrices.

Few companies in the U.S. have reported time savings in their development cycles by using QFD, and the academic research so far has not shown a correlation between QFD and shorter cycles. Those who have used QFD generally report two types of improvement, a better feeling for customer needs and improved development teamwork. Both of these tend to accelerate the thousands of design trade-off decisions that must be made on a new product, but the effects so far do not seem to be measurable.

QFD should be viewed as just one of many development tools. It is not a first order CTI tool. For example, QFD will not help in providing the team with authority; understanding project economics; structuring the product for rapid execution and avoiding overly complex products; controlling project overload; or managing risk or progress.

Sources

John R. Hauser and Don Causing, "The House of Quality," *Harvard Business Review*, May-June 1988, pp. 63–73.

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GLOSSARY

Administrative cycle	Business processes such as order processing or customer service that are predictable
As-Is cycle time	The current cycle time. (Sometimes referred to as the baseline cycle time.)
Benchmarking	A continuous, systematic process for evaluating the products, services, and work processes of organizations that are recognized as representing best practices for the purpose of organizational improvement.[19]
Could-Be cycle time	The best cycle time that can be achieved through process and other improvements without additional capital or human resource investments
Critical path	The path in a process that determines cycle time
CTI	Cycle-time improvement
CTI barrier	Any event, practice, situation, or environment that extends process cycle time
CTI deployment	Cycle-time improvement launch and culture change within a company. (Cycle time is part of the company culture when cycle-time improvement is in its 2nd or 3rd "generation" and is every employee's concern.)

19. Michael J. Spendolini, *The Benchmarking Book*, Amacom, 1992.

CTI implementation	The actual process, usually carried out by a cross-functional team, to shorten the time it takes to perform a series of activities or eliminating steps using cycle time assessment goal-setting and barrier-removal tools
Customer Service cycle	A business process that begins with a fault occurrence and ends when the fault has been corrected via root-cause removal actions
Cycle time	The time to complete a continuous repetitive work process from start to completion
Development process	The development process refers to the early phases in the product life cycle process up through to volume manufacturing.
Design / Development cycle	A business process that begins with the successful completion of predevelopment and ends with the collection of first production unit receivable
Gain sharing	A reward system that distributes a firm's profit among its employees in a systematic manner
JIT	Just-in-Time. (A management tool for improving manufacturing cycle time, reducing inventory, and improving product quality.)
Order-to-Delivery cycle	A business process that begins with customer order for a specific product and ends with total payment for this product. (Request for quotation to order entry was purposely not included, but for some companies, it is also a candidate for CTI.)

PfTQ	Partnering for Total Quality. (A SEMATECH Total Quality Management approach based on the Malcolm Baldrige National Quality Award principles.)
Predevelopment cycle	A business process that begins when resources are assigned to assess product feasibility; (i.e., project manager and investigation team are assigned) and ends when marketing and development plans are concluded, approved and development is fully funded
Process	A set of parallel and sequential activities to create a work product
Product life cycle process	The various phases of a product starting with a product idea and ending with the product's obsolescence. (Typically provides a structure for risk and financial management through check-point completion of a set of tasks for the various product phases.)
Roll-out (in CTI context)	A management communication to all the members of an organization that cycle-time improvement is one of the key competitiveness factors; that there are special goals set; and that there are process owners and improvement teams
Should-Be cycle time	World class cycle time, often requiring additional capital and human resources

Stretch Goals	Cycle-time improvement goals that are more than incremental. (They are usually improvements in the order of 30 to several hundred percent.)
Time-to-market	The combined time of the Predevelopment and Design / Development-cycles. (A business process that begins when resources are assigned to assess product feasibility and ends with customer payment for the first production unit.)
TQM	Total Quality Management