Chapter 3

Preparation

3 Preparation

3.1 Overview

Electrical Test is a critical operation in HGA manufacturing process, it is one of non value-added (NVA) operations which should not be a part of ideal manufacturing process. Figure 3.1 demonstrates hour per unit, an indicator of productivity, of each operation in HGA process (Taos product). Electrical Test consumes 15% of total HPU of 0.175. Basically, 15% of product operating cost could be saved by eliminating Electrical Test.

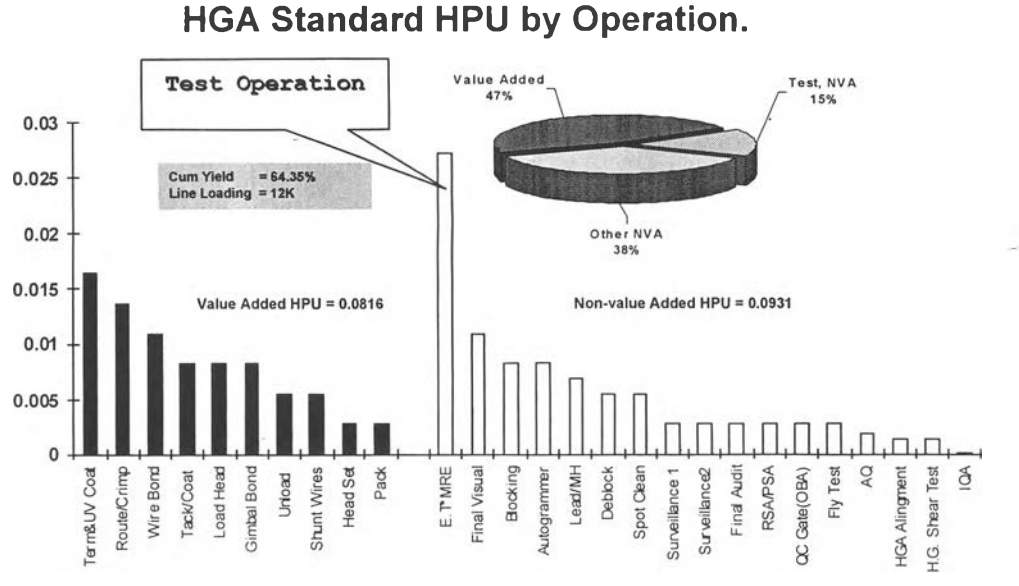

Figure 3.1 Standard Hour per Unit (HPU) of each operation in HGA Process.

Though test operation is considered as an NVA operation, necessity of the operation is still remained. What is the value of test operation? It does not only provide sorting good parts and bad parts, but also it provides test data. The value of it depends on how good the data is managed and utilized. Upstream process requires feedback data for process improvement. Design engineer requires coherent data for product improvement and new product development. Manufacturing site requires data for analytical troubleshooting and in-process improvement. Figure 3.2 shows global key process flow of hard disk drive manufacturing and its data collection.

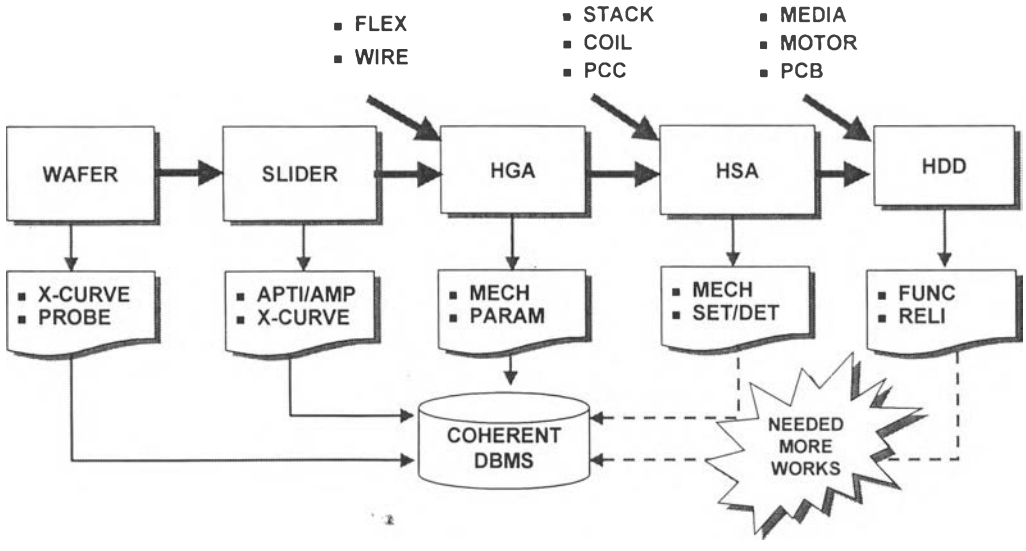

Figure 3.2 Global Process Flow of Hard Disk Drive Manufacturing.

Dynamic test at HGA is the only place that can provide parametric performance of upstream manufacturing. Data collection of the process up to HGA including wafer fabrication and slider machining are well established but the disconnection exists between HGA and HSA up to HDD due to some technical reasons. Current possibility of data utilization is from HGA down to wafer fabrication only.

With the value of test and customer-focused alignment, a matrix organization approach incorporate with cross functional works seem to be the right approach. An optimization of functional and product organization is required, based on its capability and corporate objectives. Manager of the organization should be the person who know the strengths and weaknesses of the organization. A good manager with a clear vision ought to know how the organization should operate, since the organization capability and corporate objectives are perceived.

Instead of focusing on a task, entire process would be focused by product manager who performs cross-functional work. In test engineering, each focused-group would be responsible for entire test-related work process and perform cross-functional work within the organization. A proper structure to suit key functions of the organization and to align with direct customers has to be determined to align with corporate objectives.

Schonberger (1996) suggested 16 principles of customer-focused, employee-driven, and data-based performance that firms can assess and make improvement against. The key principles will be adopted and refined to suit with improvement of organization level.

Though the principles are applied to company, business unit, or product line not to a function, or department, Test Engineering, as a multi-function organization should be able to adopt basic principles for QSFV, which stands for Quality, Speed, Flexibility, and Value as a main view.

Schonberger also addressed that next-decade management must take a step toward management by principles. Test Engineering Organizational Restructuring was moving toward that path to create a strong organization providing support for future requirements and to align with corporate objectives.

Inventory turnover is not a direct measure of a support organization, but the organization performance can make impacts to the operational metrics. Organizational principles will be concentrated while putting a focus on Quality, Speed, Flexibility, and Value (QSFV); and maintain the importance of cost contribution due to the organization performance. The key points of organizational restructuring are listed below:

- Knowing who are the customers
- Knowing what is the core product and value
- Knowing the constraints that impact organization internally and externally
- Aligning organization's value to the needs of customers
- Measuring and actions

Test engineering is not ready to extreme Product Line Management (PLM) where everyone is lined up to a corporate product including manufacturing technical support resources, unless the organization adequately has an equal capability level of support resources to spread over every product line. [It does not mean PLM is not the right approach but the organization has to be well prepared and be able to build up technical and managerial capability to its resources.] It is not dealing with one quarter or two, it takes years or probably decades in some types of business to be there. The capability of resources in the organization has to be managed and balanced against business requirements, which there is no one magic solution to suit all organizations and all environments.

3.2 Restructuring Road-map

Management by principles would be applied throughout the restructuring of test engineering organization as the following road-map:

- Organization and its development will be understood, as well as an assessment of engineer's focus allocation, and understanding the concerns of current structure.
- Organizational restructuring exercises are discussed, based on organization statistics and its projection, incorporated with technology roadmap of the industry. The following exercises are performed:
    - Employee is involved in addressing organization difficulties and expected improvement due to restructuring.
    - Organizational functions are reshuffled and regrouped to create center of excellence.
    - Framework is established to provide a big picture of the organization.
    - Workflow is established for key activities to be a cross-functional work guideline and to be a process map for future improvement activities.
    - Product and customers of the organization are defined to formulate vision, mission, and objective goals.
- Key processes within organization are analyzed to eliminate unnecessary tasks and shorten the processes.
- Organization measures are defined based on 5 key aspects: cost, quality, speed, flexibility, and customer satisfaction.
- Mission and objective goals are formulated based on new customer-focused structure against corporate objectives.

The road-map could be simply drawn into a flowchart as shown in figure 3.3.

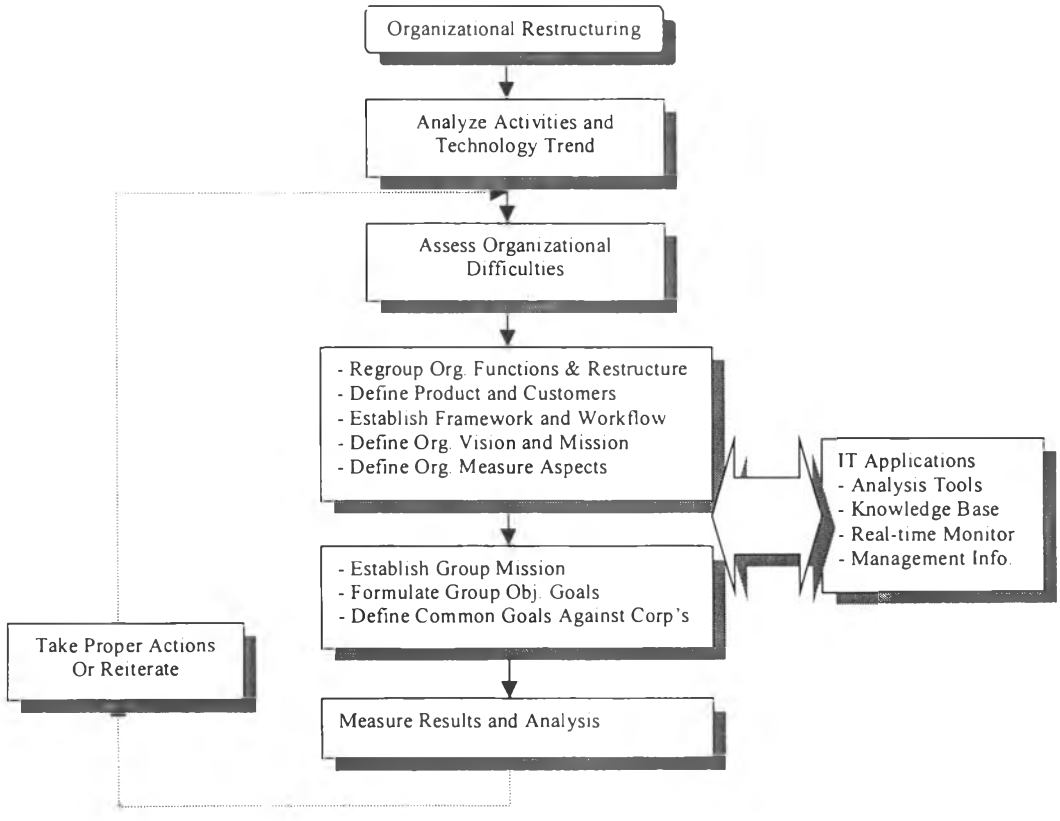

Figure 3.3 Restructuring Flowchart

- IT applications are exploited to support the restructuring and leverage organization capability as the following:
  - Systematic analysis tool
  - Knowledge base and computer-based training
  - Real-time monitoring tool
  - Technical management information
- Results from the restructuring are discussed for further continuous improvement.

3.3 Test Engineering Organization Development

To understand the current organization, entire engineering structure and development history of Test Engineering organizational structure needs to be explained.

3.3.1 Operational Organization Structure

Teparuk Operation consists of 6 major divisions (see figure 3.4), Manufacturing is supported by other 5 divisions including Human Resources,

Administration,Engineering, Quality, and Materials. Engineering is formed up from 4 major departments, including 1) Industrial Engineering handles facilities for production, 2) Capacity Planning handles production line layout and tools/equipment required in the process, 3) Process Engineering handles assembly and test process structured as product specific, 4) Test Engineering handles test capacity support and maintenance as well as engineering data collection system.

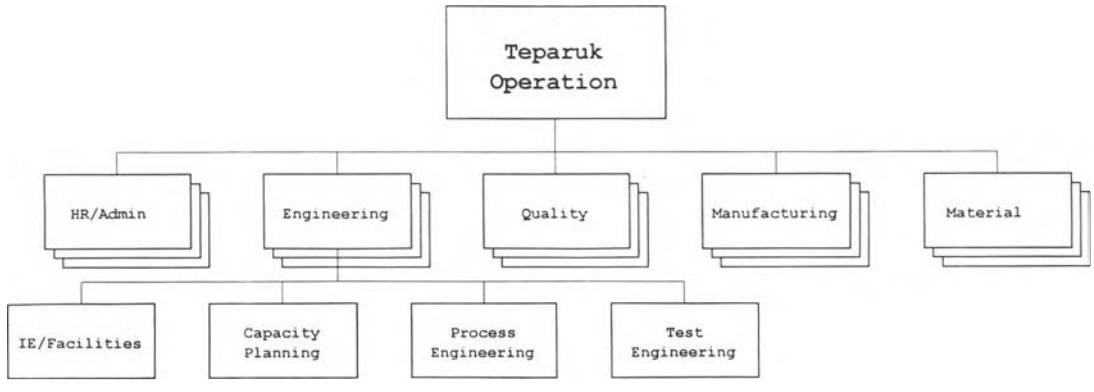

Figure 3.4 Teparuk Operational Structure

3.3.2 Engineering Organizational Structure

The alignment will be concentrated in Process Engineering and Test Engineering including its development over time, as shown in figure 3.5.

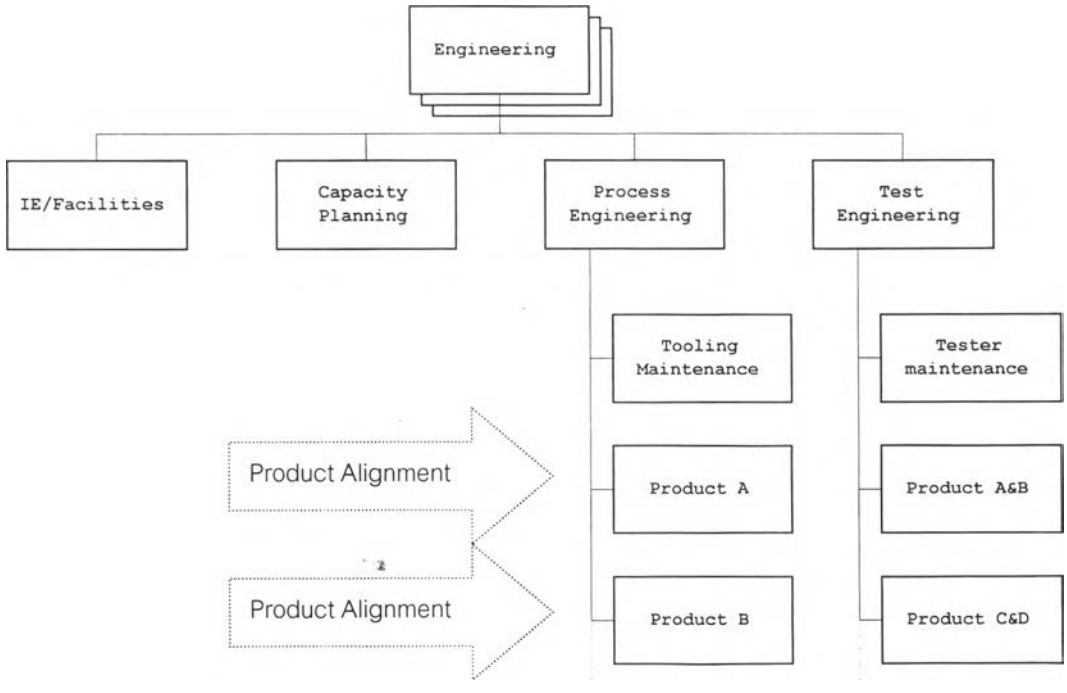

Figure 3.5 Teparuk Engineering Organizational Structure and Test Engineering Structure at Early Stage (1990)

Figure 3.5 shows structure of Teparuk Engineering which Test Engineering aligns to Process Engineering structure as product specific by Product Test Engineering. This alignment creates a comprehensive Test Engineering interface to external organizations at that time. Stages of Test Engineering development will be described as 4 stages, early stage, middle stage, current stage, and future stage as proposed in this paper.

3.3.3 Test Engineering at Early Stage (1990)

The organization divided into 2 sections as shown earlier in figure 3.5.

Product Test Engineering: acts as the organizational interface and performs cross-functional works within Test Engineering as the following functions:

- Product interface with others
- Support test capacity
- Product test yield analysis
- Test related changes management
- Support test standards for tester calibration
- Perform tester acceptance test

Tester Support: executes tester-related support, which is more front-line oriented activity as described in the following functions:

- Perform tester setup and calibration
- Perform tester conversion from one product to another
- Support 24 hours tester control and troubleshooting
- Perform tester preventive maintenance
- Perform tester upgrade both hardware and software
- Support tester's local area network (LAN)
- Support test data collection database system

Test engineers at the early stage were very capable with their technical experience and skill against the technology, quantity of activities, and complexity of the activities. The low variety of the product and its relatively high product capability did not create too much complexity to the activities.

3.3.4 Test Engineering at Middle Stage (1992-1995)

Since the numbers of activities increased as products variety and requirement in production flexibility increased, the organization has been split into 4 sections as shown in Figure 3.6. **Test Standards** has been split from **Product Test Engineering**, as well **as Test Database and Network** has been split from **Tester Maintenance.**

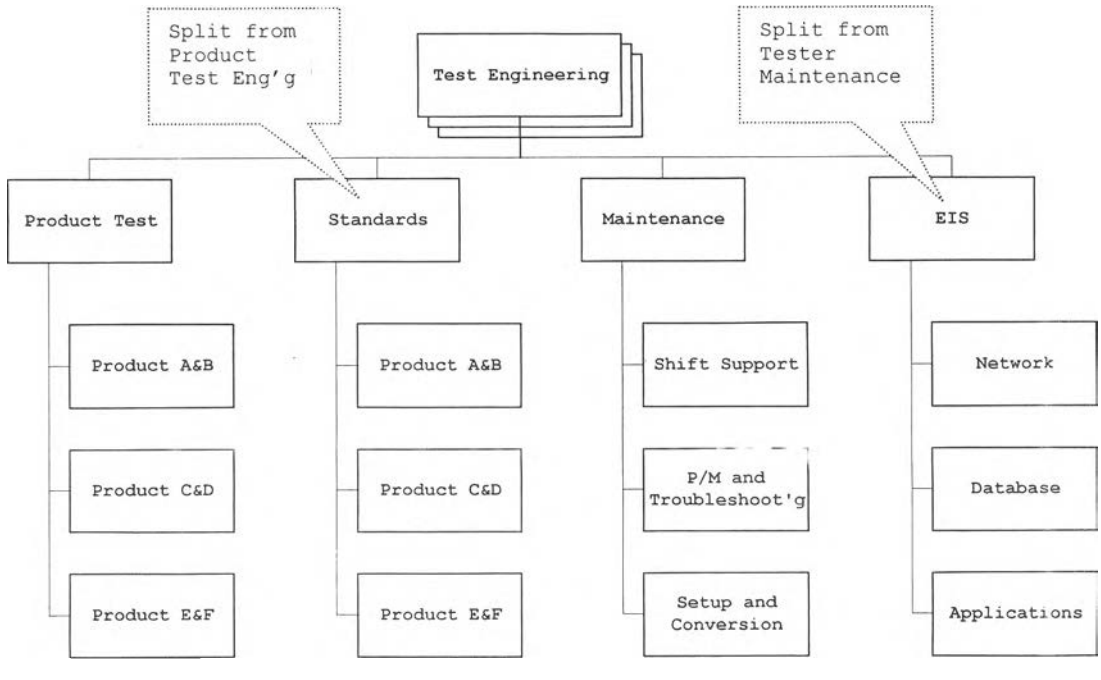

Figure 3.6 Test Engineering at Middle Stage (1992-1995)

This formed up a more functional oriented type of organization, but still the interface channel was at Product Test Engineering

3.3.5 Test Engineering at Present (1995-1997)

A significant tester requirement was foreseen as the expansion in HGA manufacturing and test requirements were significant. According to figure 4.1, during 1990-92 tester requirement increased by the rate of 20 testers annually, but during 1993-94 it increased by the rate of 70 testers with 150% acceleration beyond that. Tester Build section has been established to handle tester assembly activities supporting future requirement and to gain 20% saving in tester cost at that time.

HGA tester is a state of the art in-house design system; it deployed complicated technologies into its 890 kg weighted system. This activity has drawn skillful personnel within the organization to form up this additional group and to master advanced tools and equipment.

The organization came to what is shown in figure 3.7 with the following functions for **Tester Build:**

- Assemble HGA tester to support rapid requirement
- Develop robotics for tester throughput enhancement
- Perform advanced board repair at component-level
- Perform advanced board calibration
- Develop technical training aids

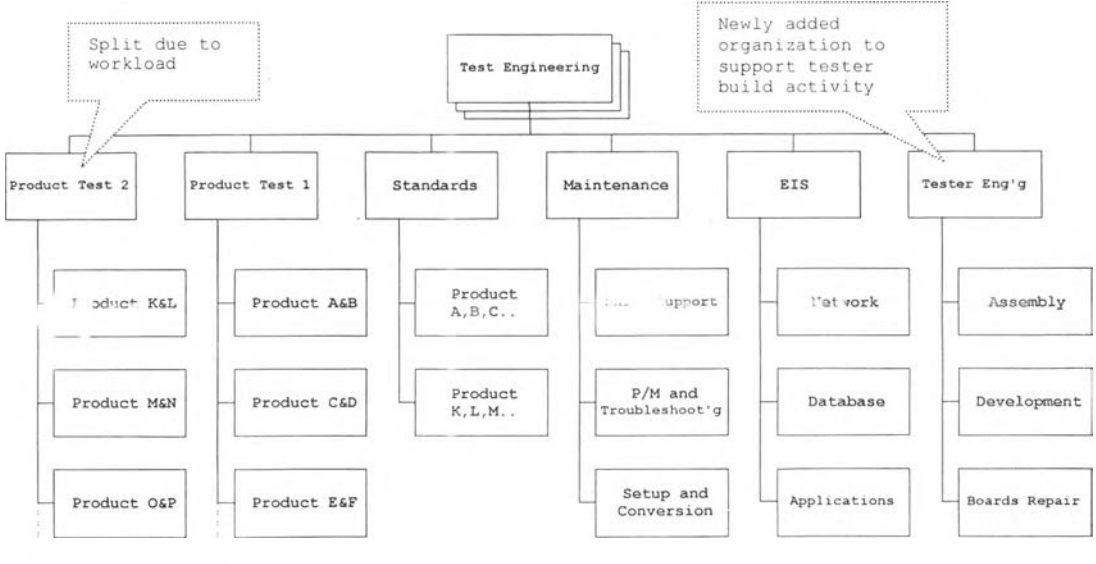

Figure 3.7 Current Test Engineering Structure (1995-1997)

Brief key functions for each section within Test Engineering are shown in figure 3.8. The major responsible persons in day-to-day activities are Product Test engineers. A proper balancing of engineer's focus was being sought.

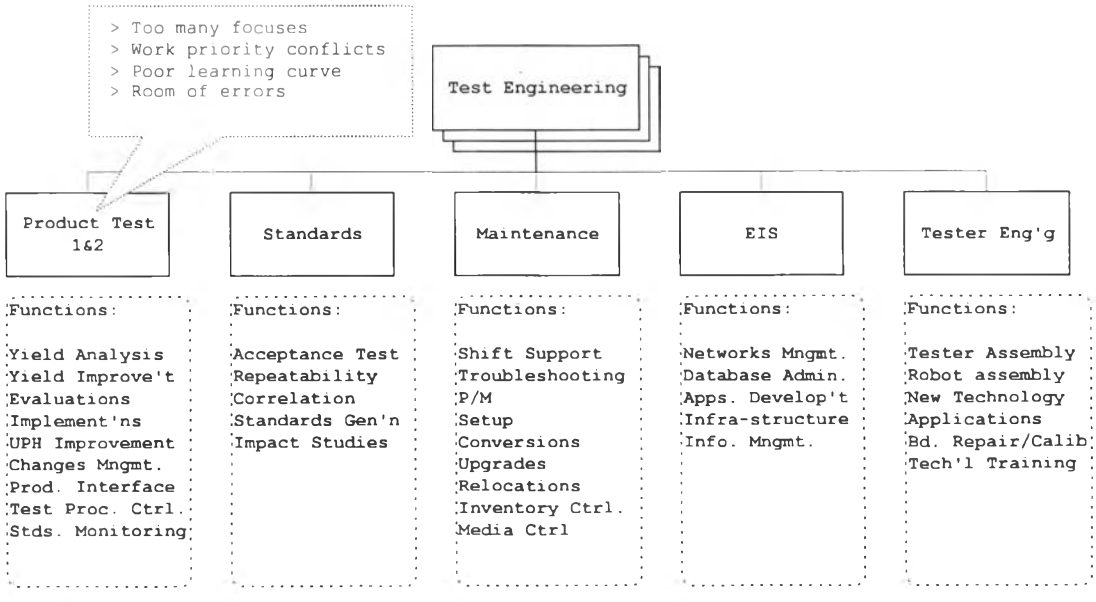

Figure 3.8 Current Test Engineering Functions (1995-1997)

Once all activities involved with advanced techniques for tester build and advanced board repairs are stabilized, several steady functions seem to be grouped improperly, while dynamic increasing of work focus are on one particular group which is **Product Test Engineering.**

Time-spent analysis is one of the tools that used for developing a Pareto of work focus allocation. This provided a picture of how engineers spend time on multiple focus.

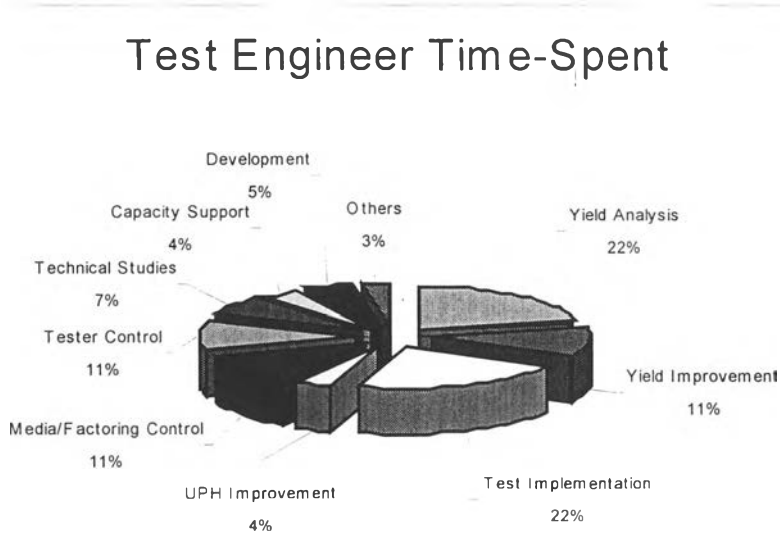

Figure 3.9 Test Engineer Time-Spent Analysis Prior to Restructuring

According to Figure 3.9, **Test Engineers** spent half of their work-hours on **yield analysis** and **implementations** while tester control related focus became minor which is definitely not a right ratio for test engineer. Tester control related activities should be their primary tasks. Broad focus of engineer responsibility tends to allocate engineer's focus to day-to-day issue driven by operation priority, such as: yield analysis, new implementation, and other short notice changes. The analysis suggested that the organization has to split Product Test Engineer's functions into multiple focused-groups to avoid priority conflicts. Some work responsibilities need to be allocated to other group and some tasks need to be handled by IT tools. Those are considered in the restructuring process which will be discussed later on.

The time-spent analysis also indicated that engineers spent much more time in the office than on the shop floor, dealing with data analysis instead of keep the contact with front-line technicians and test operators. This practice is different than what test engineer did in the past several years where major time-spent was on the shop floor to see firsthand issues and correct them in timely basis. Besides, operators and technicians had technical contact with test engineering in exchanging know-how and technical concerns, which are very important for a dynamic labor intensive, mass volume manufacturing. [Note: Teparuk facility was producing half a million

high-precision recording head assemblies a day with more than 13,000 employee and 100% electrical test is needed.]

Figure 3.10 shows time-spent ratio, on the shop floor vs. out the shop floor, of test engineers at different stages and how it needed to be in the future.

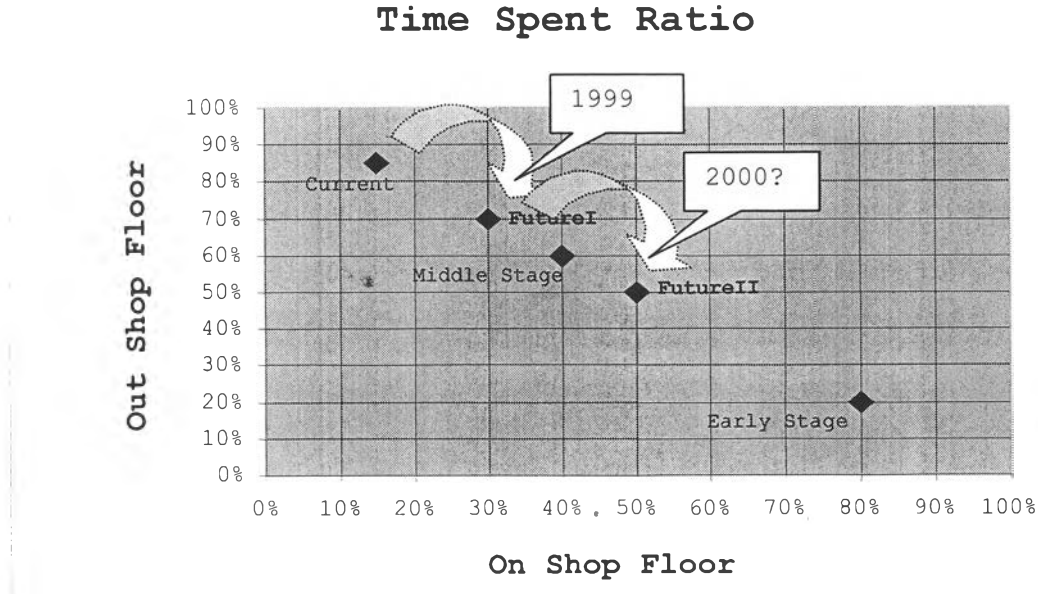

Figure 3.10 Time Spent Ratio of Test Engineers at Different Stages

It is not an easy task to make a radical change in culture and to allocate the workloads without management support. The restructuring is considered one of the management supports to make it happens by refocusing the resources.

There are several issues and concerns to the current structure which can be listed below

- **Too Many Focus;** product interfaces, yield analysis, implementations, down to tester control on the shop floor
- **Test Engineers Spend Less Time on Tester Control;** which is core product and value of the organization
- **Improper Functions Grouping;** e.g. Capacity support activities are in different focused-groups, which are in both Maintenance and Tester Engineering.

- **Broad Focus:** caused errors in execution and caused incompetence in technical area while technology trend and complexity of the problem keep growing.

Connection between engineers and frontline people has been broken down due to deviated focal activities. The consequences are in communication breakdown between engineer and production floor, while technical knowledge of frontline people could not be developed to accommodate the technology changes.

Figure 3.11 describes the proposed organization that will solve current issues and cover several aspects of customer focused and cross-functional work for product engineering managers.

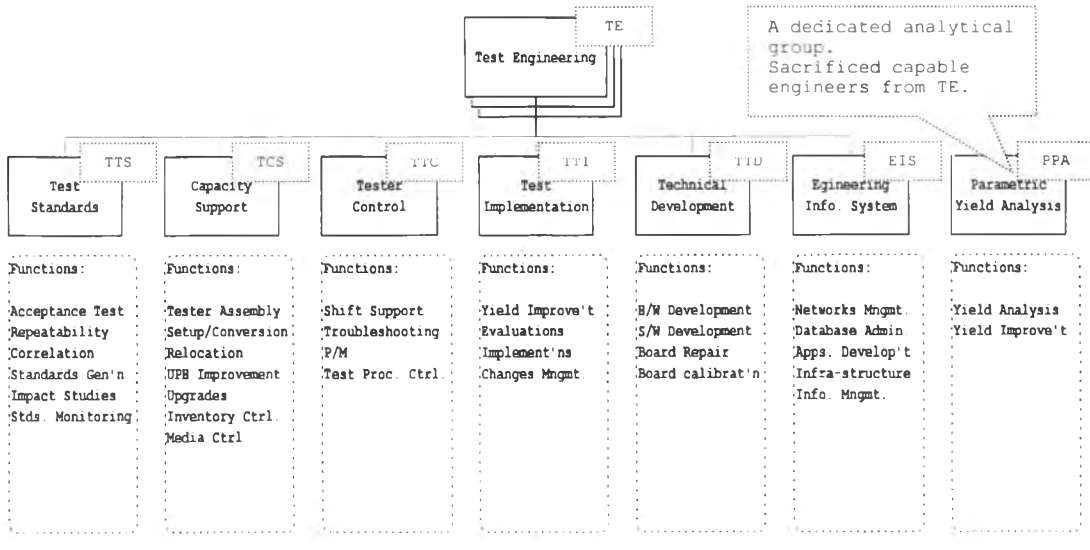

Figure 3.11 Proposed Structure with Regrouped Functions

The structure is similar to functional organization, but each focused-group owns entire process, not a task, of its key process cross functions. For example, TTC handles entire process of tester release, while other focused-groups understand their role for cross-functional work in the process. Centers of excellence can be accelerated while process ownership is created. Cross-functional work as a matrix organization is allowed for product engineering managers.

3.3.6 Three forms of Test Engineering Structure

There are 7 major functional areas, which can be divided into focused-group to create centers of excellence according to common technical skills development and customer-focused alignment. Future organization

development paradigm could be drawn as figure 3.12, three forms of organizational structure as requirement changes.

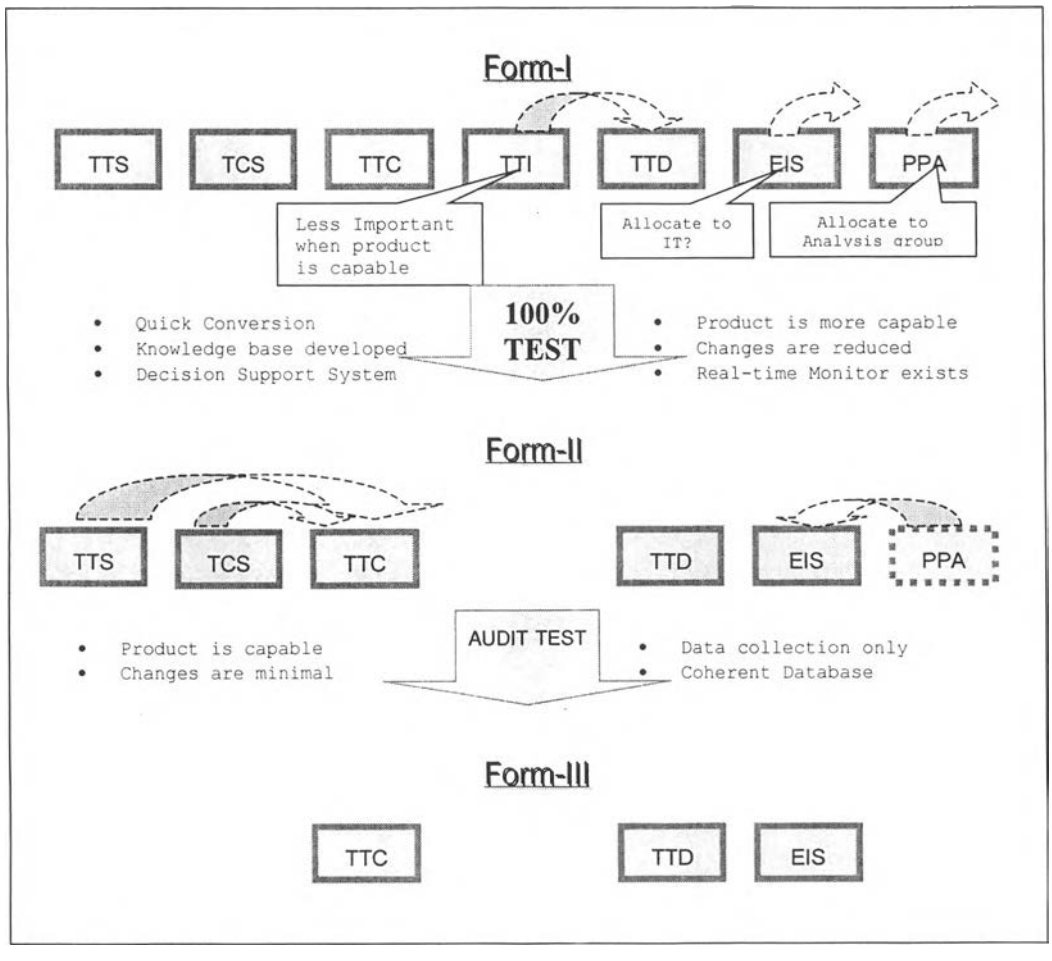

Figure 3.12 Three Forms of Test Engineering Organizational Structure

Test Standards (TTS):
It is required as long as test requirement exists. Standards generation, impact study, and standards monitoring exercises have to be separated and align with Corporate Standards Engineering. Repeatability and correlation exercises for tester acceptance test can be shorted-cut by deploying advanced electronic device incorporated with software application.

Test Capacity Support (TCS):
This plays important role in supporting flexible manufacturing. Setup/conversion exercise is typically consuming 310 hrs per tester, including machine idle time between tasks, rework after acceptance failure, hours of extra tester assigned for setup/conversion. The changeover lead-time is currently managed with minimal impact to manufacturing by obtaining extra tester for

advance conversion. Total of 55 systems ($4.12M) is reserved while 30 systems ($2.25M) will be actually needed if acceptance test yield is 100%. A greater impact can be determined, only 5 systems ($0.38M) will be required if changeover lead-time can be reduced to 24 hrs, with the requirement of 30 conversions per week. Capital investment due to number of testers reserved for conversion is a function of Tester requirement per week and total lead-time per tester.

Conversion exercise will be significantly reduced, to virtual zero, if product is capable and 100% test is not required.

Tester Control (TTC):
It is always required to support 24 hrs manufacturing, leverage tool development is highly required to leverage tester control capability toward speed of reaction and quality aspect. It became a critical activity since product capability shifted from over 3-sigma process down to 2-sigma process (Cpk = 1 down to Cpk < 0.7). It will be less critical once product capability is developed as well as incapable test is eliminated. Statistical metrics need to be determined to reflect quality and speed of reaction.

Test Implementation (TTI):
It will become less important when product is capable as a result in less change to manufacturing process. The group functions could be allocated to other focused-group later if less change is demonstrated. Alternatively, value can be added to this focused-group by utilizing the growing technical knowledge to develop more comprehensive test for rigid disk drive manufacturing.

Technical Development (TTD):
As long as tester is required and test technology is moving forward, tester related technical development is required to enhance tester capability. Test system needed to be more robust to noise/vibration and be more intelligent to assist front line people catching tester related problem before it causes significant impact to test quality. Outsourcing for joint development and hardware replication is needed to maintain group size.

Engineering Information System (EIS):
This function is not supposed to be under test engineering responsibility, it started with a minor responsibility to support small local area network (LAN) for test systems. Once responsibility was rapidly increased as well as resource capability is developed, it provides significant advantages in engineering support, both flexibility and priority aspect. It is virtually impossible to gain priority support from Corporate IT

Department while Finance, Materials, and Administration support are their priorities, unless a dedicated group is sacrificed from IT department to closely work with engineering, understand both manufacturing process and engineering requirement. Outsourcing for application development is another alternative to increase its support capability.

Parametric Performance Analysis (PPA):
This function needs to be performed by skillful personnel who are knowledgeable in test technology and manufacturing process. It is highly required for current situation where a prompt analysis is necessary for day to day managing fluctuation of product performance due to external and internal variables. Group function could be allocated and combined with failure analysis group. It will be less critical once product is more capable and test process is more robust.

3.3.7 Organization transformation

Current situation does not allow a transformation to Form-II or Form-III, as explained in figure 3.12, yet. Major functions under organization responsibility are critical and required dedicated focus to carry out tasks. An attempt to create centers of excellence of each major function was chosen toward customer-focused alignment as shown in figure 3.13.

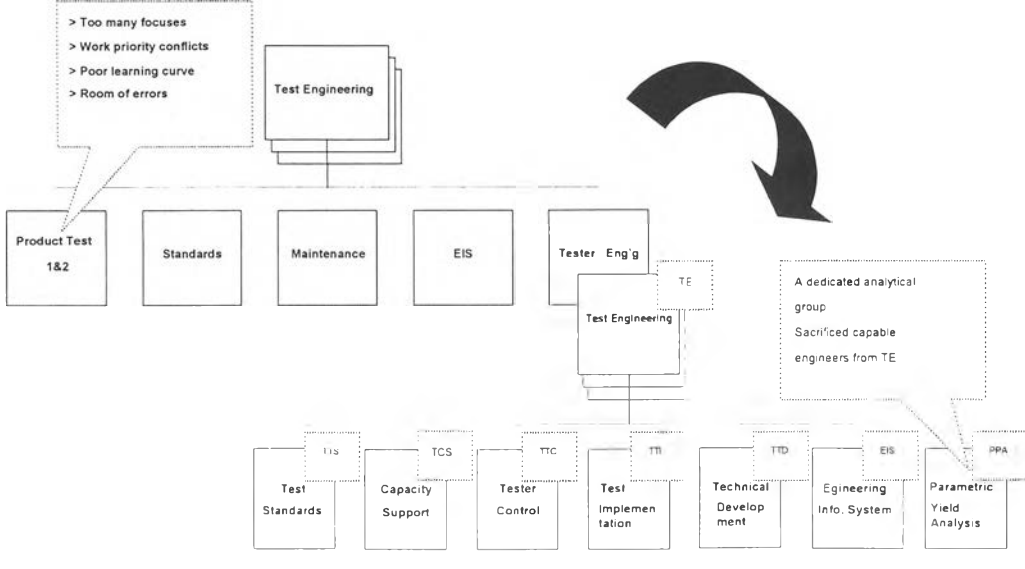

Figure 3.13 Organization Transformation to Form-I

Process ownership has to be built in to focused-group. Roles of each focused-group in the process have to be

visualized. Organizational metrics need to be developed to measure baseline for benchmarking. Job rotation should be allowed to developed multi-skill resources for future requirement.