

FMEA

FAILURE MODE AND EFFECT ANALYSIS

FMEA – FAILURE MODE AND EFFECT ANALYSIS

- Also called: potential failure modes and effects analysis; failure modes, effects and criticality analysis (FMECA).
- **Failure modes and effects analysis (FMEA) is a step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service.**
- “**Failure modes**” means the ways, or modes, in which something might fail. Failures are any errors or defects, especially ones that affect the customer, and can be potential or actual.

FMEA – FAILURE MODE AND EFFECT ANALYSIS

- “Effects analysis” refers to studying the consequences of those failures.
- Failures are prioritized according to how serious their consequences are, how frequently they occur and how easily they can be detected.
- The purpose of the FMEA is to take actions to eliminate or reduce failures, starting with the highest-priority ones.

FMEA – FAILURE MODE AND EFFECT ANALYSIS

- Failure modes and effects analysis also documents current knowledge and actions about the risks of failures, for use in continuous improvement.
- FMEA is used during design to prevent failures. Later it's used for control, before and during ongoing operation of the process.

FMEA – FAILURE MODE AND EFFECT ANALYSIS

- Ideally, FMEA begins during the earliest conceptual stages of design and continues throughout the life of the product or service.
- Begun in the 1940s by the U.S. military, FMEA was further developed by the aerospace and automotive industries. Several industries maintain formal FMEA standards.

When to Use FMEA

- When a process, product or service is being designed or redesigned, after **quality function deployment**.
- When an existing process, product or service is being applied in a new way.
- Before developing control plans for a new or modified process.
- When improvement goals are planned for an existing process, product or service.
- When analyzing failures of an existing process, product or service.
- Periodically throughout the life of the process, product or service

FMEA Procedure

- **This is a general procedure. Specific details may vary with standards of your organization or industry.**
- Assemble a cross-functional team of people with diverse knowledge about the process, product or service and customer needs.
- Functions often included are: design, manufacturing, quality, testing, reliability, maintenance, purchasing (and suppliers), sales, marketing (and customers) and customer service.

FMEA Procedure

- Identify the scope of the FMEA.
- Is it for concept, system, design, process or service?
- What are the boundaries?
- How detailed should we be?
- Use flowcharts to identify the scope and to make sure every team member understands it in detail. (From here on, we'll use the word "scope" to mean the system, design, process or service that is the subject of your FMEA.)

FMEA Procedure

- Fill in the identifying information at the top of your FMEA form.. The remaining steps ask for information that will go into the columns of the form.
- Identify the functions of your scope. Ask, “What is the purpose of this system, design, process or service? What do our customers expect it to do?” Name it with a verb followed by a noun. Usually you will break the scope into separate subsystems, items, parts, assemblies or process steps and identify the function of each.

FMEA Procedure

- For each function, identify all the ways failure could happen. These are potential failure modes. If necessary, go back and rewrite the function with more detail to be sure the failure modes show a loss of that function.
- For each failure mode, identify all the consequences on the system, related systems, process, related processes, product, service, customer or regulations. These are potential effects of failure. Ask, “What does the customer experience because of this failure? What happens when this failure occurs?”

FMEA Procedure

- **Determine how serious each effect is. This is the severity rating, or S.** Severity is usually rated on a scale from 1 to 10, where 1 is insignificant and 10 is catastrophic (disastrous) . If a failure mode has more than one effect, write on the FMEA table only the highest severity rating for that failure mode.
- **For each failure mode, determine all the potential root causes.** Use tools classified as cause analysis tool, as well as the best knowledge and experience of the team. List all possible causes for each failure mode on the FMEA form.

FMEA Procedure

- For each cause, determine the occurrence rating, or O. This rating estimates the probability of failure occurring for that reason during the lifetime of your scope. Occurrence is usually rated on a scale from 1 to 10, where 1 is extremely unlikely and 10 is inevitable (Predictable) . On the FMEA table, list the occurrence rating for each cause.

FMEA Procedure

- For each cause, identify current process controls. These are tests, procedures or mechanisms that you now have in place to keep failures from reaching the customer.
- These controls might prevent the cause from happening, reduce the likelihood that it will happen or detect failure after the cause has already happened but before the customer is affected.

FMEA Procedure

- For each control, determine the detection rating, or D. This rating estimates how well the controls can detect either the cause or its failure mode after they have happened but before the customer is affected.
- Detection is usually rated on a scale from 1 to 10, where 1 means the control is absolutely certain to detect the problem and 10 means the control is certain not to detect the problem (or no control exists). On the FMEA table, list the detection rating for each cause.

FMEA Procedure

- (Optional for most industries) Is this failure mode associated with a critical characteristic? (Critical characteristics are measurements or indicators that reflect safety or compliance with government regulations and need special controls.)
- If so, a column labeled “Classification” receives a Y or N to show whether special controls are needed. Usually, critical characteristics have a severity of 9 or 10 and occurrence and detection ratings above 3.

FMEA Procedure

- Calculate the risk priority number, or RPN, which equals $S \times O \times D$.
- Also calculate Criticality by multiplying severity by occurrence, $S \times O$. These numbers provide guidance for ranking potential failures in the order they should be addressed.
- Identify recommended actions. These actions may be design or process changes to lower severity or occurrence. They may be additional controls to improve detection. Also note who is responsible for the actions and target completion dates.
- As actions are completed, note results and the date on the FMEA form. Also, note new S, O or D ratings and new RPNs.

FMEA Example

- A bank performed a process FMEA on their ATM system. Figure 1 shows part of it—the function “dispense cash” and a few of the failure modes for that function. The optional “Classification” column was not used. Only the headings are shown for the rightmost (action) columns.
- Notice that RPN and criticality prioritize causes differently. According to the RPN, “machine jams” and “heavy computer network traffic” are the first and second highest risks.
- One high value for severity or occurrence times a detection rating of 10 generates a high RPN. Criticality does not include the detection rating, so it rates highest the only cause with medium to high values for both severity and occurrence: “out of cash.” The team should use their experience and judgment to determine appropriate priorities for action.

1. Define FMEA. When should we use FMEA ?
2. Explain FMEA procedure.

MQT– COST OF QUALITY



Cost of Quality

- Cost of Quality is a measurement used for assessing the waste or loss from a defined process.
- These costs are significant and can be significantly reduced or avoided.
- Cost of quality measurement can track changes over time for a particular process, or be used as a benchmark for comparison of two or more different processes.

Cost of Quality

- Cost of Quality is usually measured in monetary terms, requiring all losses and waste to be converted to their liquidated cost equivalent, for example, staff hours lost or spent are converted to their dollar equivalent by multiplying the hourly rate for the staff by the hours spent.
- Cost of quality measurements can be used to identify the optimum for a process, that is, the best possible outcome from all operating modes, combinations and permutations of the current process.

Quality-related costs

- **Prevention costs**
 - activities to keep unacceptable products from being generated and to keep track of the process
- **Appraisal costs**
 - activities to maintain control of the system
- **Correction costs**
 - activities to correct conditions out of control, including errors

Prevention costs

- Quality planning and engineering
- New products review
- Product/process design
- Process control
- Burn-in
- Training
- Quality data acquisition and analysis

Appraisal costs

- Inspection and test of incoming material
- Product inspection and test
- Materials and services consumed
- Maintaining accuracy of test equipment

Correction costs

1. Internal Failure Costs:

- Scrap
- Rework
- Retest
- Failure analysis
- Downtime
- Yield losses
- Downgrading (off-specing)

Correction costs

2. External Failure Costs:

- Complaint adjustment
- Returned product/material
- Warranty charges
- Liability costs
- Indirect costs

Symptoms of no quality measurements in Organizations

- Slow rate of improvement
- Bureaucracy or complexity in processes that continues to worsen
- Changes in one area tend to have large, negative effects in one or more other areas
- Management gets personally involved in quality problems only during a major crisis
- Management is running out of ideas as to how to cut costs further
- All employees are not actively and personally involved in driving the organization's mission forward
- Many individuals and departments disagree on what the top priorities are for the organization
- Sub-processes and departments are operated in a manner that is detrimental to the organization's overall best interest

Symptoms of poorly implemented cost of quality

- Organizations that have a poorly-designed or poorly-implemented cost of quality measurement system often encounter the following symptoms:
- Data collection is watered down or superficially implemented, and the process quickly becomes a make-work exercise with little or no real benefit
- Efforts are directed at where it is easy to collect data or implement changes instead of focusing on cost of quality priorities such as largest cost category, most variation or largest business risk

Symptoms of poorly implemented cost of quality

- Input data are often incomplete and definitions are often unclear or not fully understood, resulting in varying interpretation and implementation over time, thus adding significant noise to the data, clouding interpretation attempts and hiding significant trends of extended periods of time.
- Management does not effectively use the data in an effective manner. Decisions are often made without realizing or considering cost of quality.

Symptoms of poorly implemented cost of quality

- Cost of quality dollars expended shift around among the four categories on a revolving basis, with little or no reduction in the total cost of quality.
- For example, money is spent to increase assessment, which indicates a problem exists with internal or external failure costs. Assessment costs are stopped but preventive costs increase to reduce failure costs.

Symptoms of poorly implemented cost of quality

- The preventive actions are not comprehensive or consistently applied so internal and external failure costs reappear.
- The rising failure costs prompt another round of assessment costs, and the cycle is repeated.

Symptoms of poorly implemented cost of quality

- Collection of cost of quality data becomes more costly, burdensome and bureaucratic over time, making it slower to respond to significant changes.
- Statistical analysis of cost of quality data is not performed. Early recognition of trends are missed and random variations are mistaken for significant signals.
- The cost of quality system is isolated from other key performance indicator systems, missing the opportunity for more in-depth understanding of cause and effect relationships for the cost of quality results.

Things to Consider Before Implementing Cost of Quality

- Some of the issues management must discuss and agree on in advance of implementing a cost of quality program are as follows:
- Is the management team committed to making rapid changes for maximum efficiency within the organization's constraints (such as mission, laws and regulations, stakeholder satisfaction, etc.)?

Things to Consider Before Implementing Cost of Quality

- Are there “sacred cows”, legacy systems, departmental silos and empire building that are exempt from re-evaluation?
- Are hard costs more easily measured or more important than soft costs (such as morale, satisfaction, societal losses)?
- Are the current management measurement systems compatible with cost of quality? Can these systems be adapted to include cost of quality without duplication or conflict?

Things to Consider Before Implementing Cost of Quality

- Will stakeholders be receiving mixed messages and conflicting signals between cost of quality and the traditional management measurements?
- Will management commit to do something about cost of quality results on a timely basis?
- Can the organization obtain cost of quality software that suits its current and future needs for maximum value at minimum cost?

How To Use the Cost of Quality Tool:

- 1. Cost of quality data can be either collected on a sampling basis or on a continuous basis.
- 2. After confirming that the data is accurate and comprehensive or representative, and consistent with previous definitions and implementations, data is analyzed for trends and opportunities.

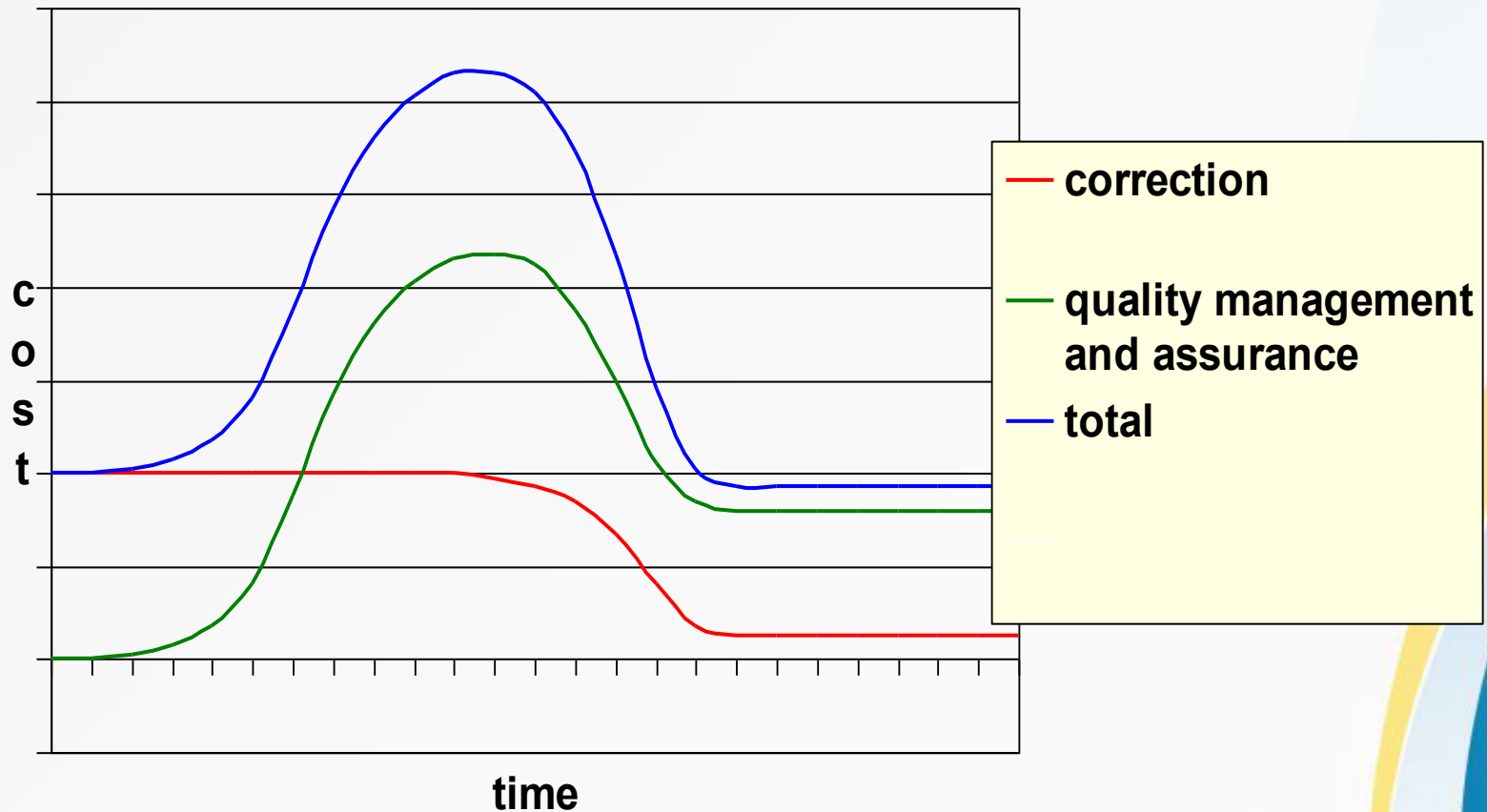
How To Use the Cost of Quality Tool:

- 3. Statistical analysis such as regression analysis, indexes, correlations, Pareto analysis, etc., is utilized to formulate conclusions about the present state and recommendations.
- 4. In some cases utilizing tools such as modeling can predict the optimum cost of quality and the process design or improvement necessary for achieving the optimum can be defined.

How To Use the Cost of Quality Tool:

- 5. A plan is then defined to modify the current process, phasing as appropriate, to move towards the optimum cost of quality.
- 6. Projects are analyzed for their impact on cost of quality, and projects or processes that show a high return on quality (Return on Quality = (Dollar Cost of Quality Savings/Dollar Cost of Implementation) x 100)
- 7. Improvements are measured and evaluated for effectiveness, and a continuous improvement cycle is implemented. Results are also communicated widely.

Cost of implementing quality management, accreditation and quality assurance



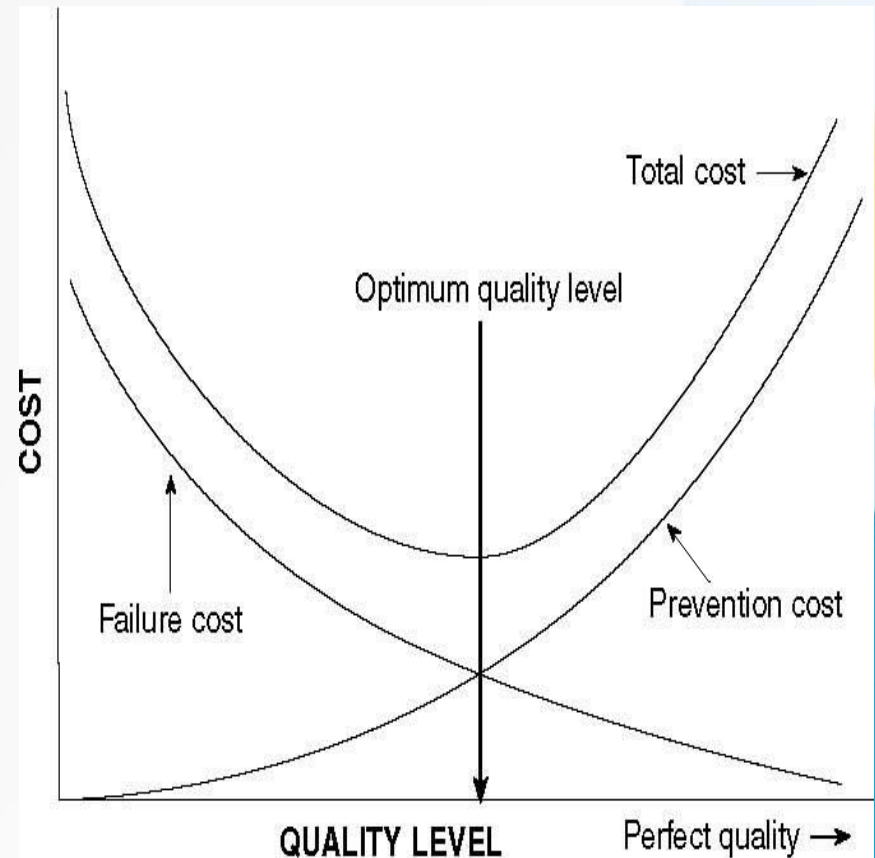
Cost of quality

The goal of any quality cost system is to reduce quality costs to the lowest practical level. This level is determined by the total of the costs of failure and the cost of appraisal and prevention.

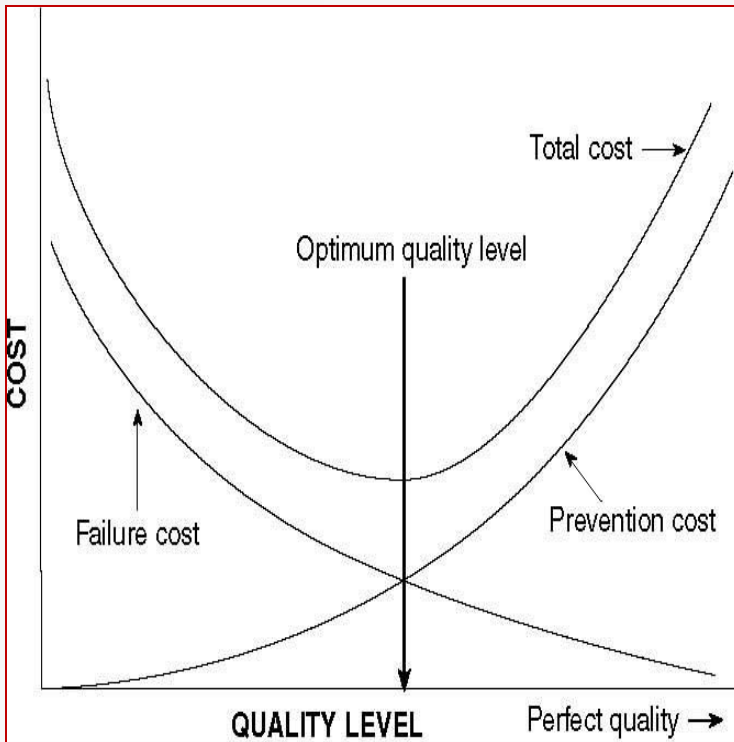
Juran and Gryna (1988) present these costs graphically. In the figure it can be seen that the cost of failure declines as conformance quality levels improve toward perfection, while the cost of appraisal plus prevention increases.

There is some optimum target quality level where the sum of prevention, appraisal, and failure costs is at a minimum.

Efforts to improve quality to better than the optimum level will result in increasing the total quality costs.



Cost of quality



- Juran acknowledged that in many cases the classical model of optimum quality costs is flawed.
- It is common to find that quality levels can be economically improved to literal perfection.
- For example, millions of stampings may be produced virtually error-free from a well-designed and built stamping die.
- The classical model created a mindset that resisted the idea that perfection was a possibility.
- No obstacle is as difficult to surmount as a mindset. The new model of optimum quality cost incorporates the possibility of zero defects.

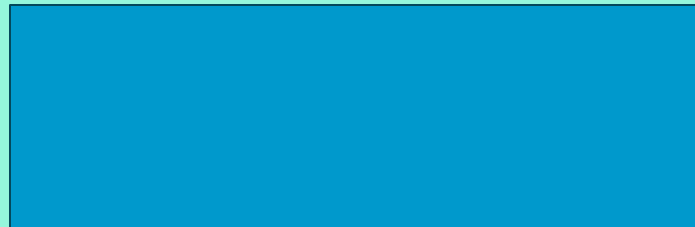
Lowering Quality cost

- Quality costs are lowered by identifying the root causes of quality problems and taking action to eliminate these causes.
- The tools and techniques useful in this endeavor are KAIZEN, reengineering, and other continuous improvement approaches and are commonly used.

Assignment – Cost of quality

- Q 1. What do you mean by cost of quality ? Explain the quality related costs.
- Q 2. What are the symptoms of no quality measurements in Organizations.
- Q 3. What are the symptoms of poorly implemented cost of quality.
- Q 4. What are the things to Consider before implementing Cost of Quality.
- Q 5. How can we lower the cost of quality ?
- Q 6. Explain the graph by Juran and Gryna for cost of quality.
- Q 7. How to use the cost of quality tool.

PERFORMANCE MEASURES



Performance Measures

- A system which guides the managers for implementing the strategies and comparing the actual with the goals and objectives is called performance measurement system.

Desirable characteristics of performance measures

- It should be based on critical success factors of the company.
- It should combine the past, present and future actions of the company mainly to have smooth transition from past to future.
- It should be a result of tradeoff of the needs of the organization' stakeholders viz. shareholders, employees partners, suppliers etc.
- Fixation of targets for the measures should be based on the fact and reality.

Effective performance Measures

An effective performance measurement system should have following features:

- Alignment of the initiative taken at middle and bottom levels with the strategies of the organization, which leads to goal congruence.
- Identification of opportunities and problems from time to time.
- Deciding of priorities and accordingly allocation of resources.
- Adjustment of measures based on the semi dynamic nature of strategy and process.

Performance Measures

Performance measures should aim at the long-term and should be forward-thinking initiative designed to fundamentally change the way corporations do business.

It is not a post-mortem of what happened but a step towards how we do better in the future.

Why measure performance?

Objectives for ; for-profit organizations:

- Measure changes to stakeholders wealth; put in simple terms, the value of a firm.
- Reward an employee for contributing to increase in firm value

The value concept (Results control)

- The performance measurement concept indicates that employees can increase the value of the firm by
 - Increasing the size of a firm's future cash flows,
 - By accelerating the receipt of those cash flows, or
 - By making them more certain or less risky.

If you are a CEO or CFO, how would you increase the cash flows?

Measure the right things

- An ideal performance management system is one that energizes the people in an organization to focus effort on
- Improving things that really matter –
 - One that gives people the information and freedom that they need to realize
 - Their potential within their own roles and that aligns their contribution with the success of the enterprise.

Then, why do performance measures fail?

- Root cause: complexity - details, details, details
- Staff who collect data get frustrated.
- Follow: "What has to be done" (WHTBD).

Measure What Matters

- Easy to say but difficult to do.
- Find out what is valued both by customers and stakeholders
- Examples:
- **process:** new product development,
measure: time to market.
- **process:** customer service,
measure: customer retention.
- **process:** treasury management,
measure: cost of service vs. value created.

Keep it simple

- Performance Measures must be
 - simple to operate
 - simple to understand
 - simple to action
- Ex: If a sales person spends too much time on call reporting, they have less time for making calls.

Performance Measurement in Organizations

Most organization measure performance using accounting measures – Net profits, gross margin, ROA (Return on Assets), ROE (Return on Equity), etc.

Why do organizations choose accounting data as measures of performance?

- Accounting profits and returns can be measured on a timely basis relatively precisely and objectively.
- Because they are timely, precise, and objective, employees would react positively.
- The short term measures keep employees on check.

Why accounting measures of performance are not adequate?

- Accounting measures are lagged indicators.
- Dependent on the choice of measurement method.

Accounting can create management myopia

- Accounting is short term earnings or returns.
- Why focusing on the short term is inappropriate?
- Why would this short-term focus affect long-term relationships?

Performance Measurements for the new era

- In the global, technology-driven, decentralized environment, measuring Financial performance, while important, is not adequate. Even if less than precise, other measures of performance are required.
- These measures should be capable of measuring multiple attributes of an organization.

What we need ?

We need a balanced set of
Performance Measures –
We need both lead and lag indicators

Lead indicators as value drivers

- Many non-financial indicators can serve as lead indicators in certain settings.
- Common examples are:
 - Market share, backlog (book-to-bill ratio), new product introductions, new product development lead times, product quality, customer satisfaction, employee morale, personnel development, inventory turnover, bad debt ratio, or safety

Lag Indicators

- In contrast to lead indicators, lag indicators are measures that point to earlier plans and their execution.
- Financial performances are lag indicators.
- Many times, financial performances are too late to affect future products and services.
- Therefore, we need multiple measures that include both financial and non-financial measures.

Comprehensive Performance Measures must address:

1. Financial performance
2. Customer satisfaction
3. Internal business process developments and
4. Allow an organization to learn and grow.

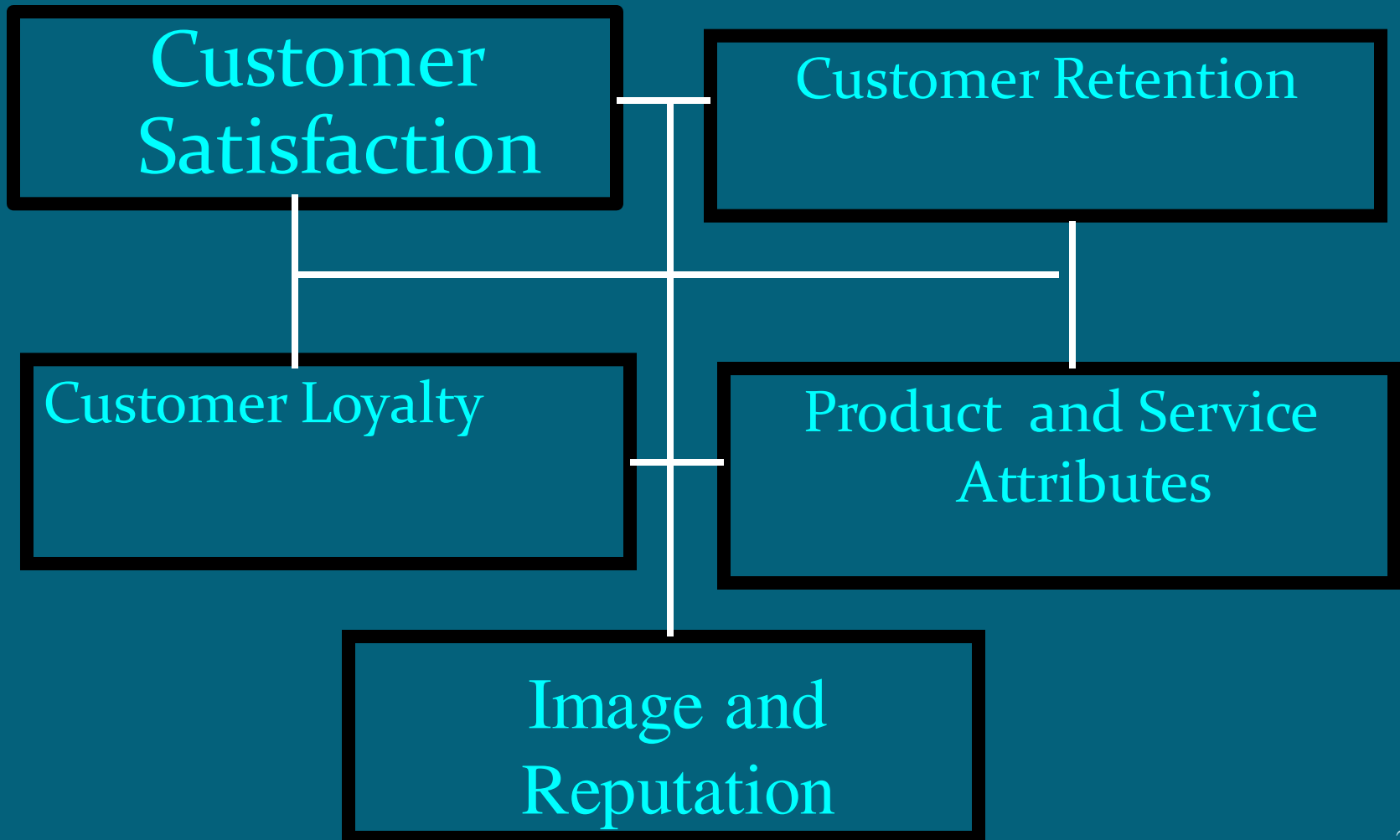
Financial Performance can be measured by

- ROA (Return On Assests),
- ROE (Returns On Equity),
- EPS (Earnings Per Share)etc.
- These measure are essential to summarize the economic consequences of strategy.

Customer-related measures

- Managers must identify the customer and market segments in which the business desires to compete.
- Develop measures to track the business unit's ability to create satisfied and loyal customers.

Customer-based measures

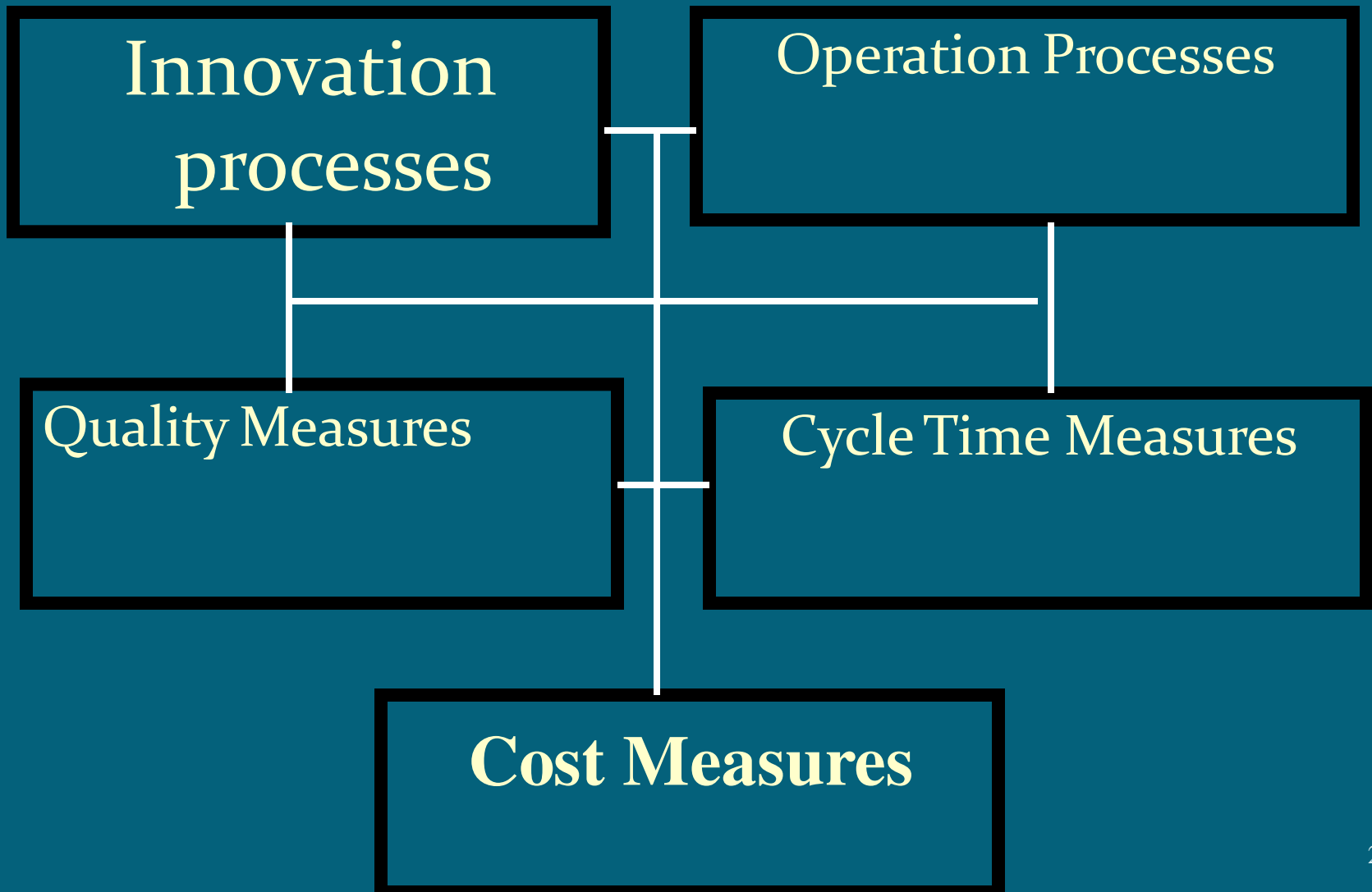


Internal Business Process Measures

Identify the critical internal processes for which the organization must excel in implementing its strategy.

IBP dimension enable the business unit to deliver the value propositions that will attract and retain customers in targeted market segments, and satisfy shareholder expectations regarding financial returns.

Internal Business Process Measures



Learning and Growth measures

- Learning and growth identifies the infrastructure an organization must build to create long-term growth and improvement.
- Growth comes from: people, systems and organizational procedures.

A performance concept that combines everything that we discuss so far is

Six Sigma

The Six Sigma

- Is “a business process that enables companies to increase profits dramatically by streamlining operations, improving quality, and eliminating defects or mistakes in everything a company does.”
- The objective is change the process so that defects are never produced in the first place.

The objectives of Six Sigma

- To 'satisfy the customer' by changing internal performance and processes.
- To enable better performance by better design
- To improve the 'quality' of supplies and other operational processes.
- Manage the costs

Six Sigma points out

- You don't know what you don't know You can't do what you don't know
- You don't know until you measure
- You don't measure what you don't value.
- You don't value what you don't measure.

Difference between TQM and Six Sigma

- **TQM** focuses on improvement in individual operations with unrelated processes; takes many years before all operations within a given process are improved.
- **Six Sigma** focuses on making improvements in all operations within a process, producing results more rapidly and effectively.

Assignment

- Q 1. What are desirable characteristics of performance measures ?
- Q 2. What features should an effective performance measurement system have ?
- Q 3. Explain lead indicators and lag indicators of performance measures.