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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 176, *Quality management and quality assurance*, Subcommittee SC 3, *Supporting technologies*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The quality of products and services delivered by an organization is achieved through the processes and procedures that constitute a quality management system (QMS). The function of a QMS is, in broad terms, to enable and ensure that the resulting products and services meet the desired objectives.

Quality tools are an integral element of a QMS. This document seeks to familiarize users with a range of quality tools that potentially have useful applications in a QMS as described by ISO 9001, and to assist in the selection of quality tools appropriate to the task at hand.

In this document, the term “quality tool” is synonymous with “quality techniques”. The range of tools that could be cited is vast. Therefore, the focus of this document is on tools that have seen successful application in a wide range of activities in diverse sectors, and to draw attention to some that can be relatively less known to some users. Statistical techniques are addressed in a separate standard, ISO 10017.

This document provides a brief description of each of the selected tools to assist the user in determining whether the tool has beneficial application in a particular context. The document also provides instruction on how the tool can be used.

Quality management — Guidance for quality tools and their application

1 Scope

This document gives guidance on the selection and application of tools that can be used in a quality management system to:

a) characterize a process or a variable;

b) facilitate problem solving;

c) highlight areas for improvement;

d) improve effectiveness.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9000, *Quality management systems — Fundamentals and vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9000 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
quality tool
quality technique
method or procedure to perform an operation to achieve a quality objective

4 Quality tools

4.1 General

The quality tools described in this document have been arranged in approximate alignment with the sequence of the quality system requirements of ISO 9001. This structure is intended to help the user and does not imply priority. A listing of the tools in relation to the Plan-Do-Check-Act (PDCA) approach is provided in Annex A.

Annex B gives examples of how quality tools are used together as storyboards.

Annex C provides an overview of quality tools to guide their appropriate application.

4.2 Review

Each frequently used quality tool is reviewed, as applicable, including:

— a short explanation of the tool and its use within a quality system;

— how the quality tool is normally used;

— reasons to use the quality tool and guidance on its effective use.

Less frequently used tools which can be of interest are listed at the end of each clause as “Other relevant tools”.

NOTE References to the bibliography are shown by figures square brackets (e.g [27].)

5 Strategy

5.1 SWOT analysis

Strengths, weaknesses, opportunities and threats (SWOT) analysis[30-33] is a tool designed to help develop strong business strategy by consideration of key strengths, weaknesses, opportunities and threats faced when implementing the intended strategy.

SWOT is used:

— to review the impact of external and internal factors;

— to prioritize action;

— to help identify strategic options, i.e. the risks and problems to solve;

— to determine the positive points that need to be maintained, the opportunities that should be considered, and the internal and external issues that present challenges;

— to identify areas and actions to eliminate weakness.

SWOT analysis is used to:

— explore new solutions to problems;

— identify barriers that will limit achieving objectives;

— decide on the direction that will be most effective;

— reveal possibilities and limitations for change;

— prioritize actions.

Benefits and points to note for SWOT are given in Table 5.1.

Table 5.1 — Benefits and points to note for SWOT

Benefits	Points to note
Focuses on actions that are most beneficial to achieve strategic objectives and sustainability.	— Should be reviewed frequently enough to recognize and react to changes.
Responds to new influences such as technology, legislation, market demand, etc.	— Output should be used as a basis of future actions.
External review includes interested parties such as competitors, customers, etc.	— Should recognize any limitations in data quality to avoid misrepresentation.
SWOT analysis benefits from the diversity of perspectives. Management alone will not have visibility of all interested parties’ perspectives.	— Should be carried out by the leadership team with external inputs as appropriate (not a single person).

5.2 PESTLE analysis

Political, economic, social, technological, legal and environmental (PESTLE) analysis is a tool used by an organization to determine and track the environment in which it operates. It is often used in strategic planning, sometimes with SWOT (see 5.1) and Porter's five or six forces (see 5.3).

PESTLE analysis is used:

— when developing, reviewing and updating an organization's strategic business plan;

— as a precursor to determining an organization's strategies, and risks and opportunities;

— to capture relevant external issues that impact on the organization's strategy.

Benefits and points to note for PESTLE are given in Table 5.2.

Table 5.2 — Benefits and points to note for PESTLE

Benefits	Points to note
Uses a structured approach.	— Users may wish to adjust the names of some of the PESTLE factors and/or add other factors that are particularly relevant to its context.
Helps organizations to address factors they might not otherwise consider.	— Users should update the PESTLE information periodically to reflect incidents such as pandemic, epidemic, military situations, etc.

5.3 Porter's five or six forces

Harvard Professor Michael Porter developed a strategic analysis tool[29] and also a method to understand the competing forces that organizations face.

There were originally five competing forces but a sixth was added, as follows:

1. threat of new entrants;
2. rivalry among existing firms;
3. bargaining power of buyers;
4. threat of substitute product or services;
5. bargaining power of suppliers;
6. complementors.

Porter says: "the collective strength of these forces determines the ultimate profit potential in the industry where profit potential is measured in terms of long run return on invested capital". [30]

The organization should consider the need to obtain the resources, technologies and infrastructure to support the strategic analysis activities. The importance of some competing forces can restrict opportunities to take action or experience improvements.

Porter's five or six forces model is used for analysing context to support developing strategic objectives. Benefits and points to note for Porter's five or six forces are given in Table 5.3.

Table 5.3 — Benefits and points to note for Porter's five or six forces

Benefits	Points to note
The six competing forces can provide both risk and opportunity considerations. Often provides a fresh approach to strategy.	— Actions should be determined based on data gathered from reliable sources. — Can be used to assess the attractiveness of the industry or sector.

5.4 Vision and mission statements

5.4.1 Vision

A vision is the aspiration of what an organization would like to become as expressed by top management. It describes in words, or sometimes visually, how the organization wants to be perceived by the world. It can also communicate the message to the people working within it and those wanting to join it.

A vision statement should be underpinned by agreement by top management on the following three key elements:

a) the strategic goal of satisfying customers and other interested parties, e.g. what are the planned products, now and in the future and how they will be delivered;

b) the unique market it wants to secure;

c) the future horizon, e.g. the future state or end point.

5.4.2 Mission

A mission is the reason for the organization's being or existence as expressed by top management, what the organization does, the core competence and what it is known for. This is sometimes called a "purpose".

A mission statement:

a) gives unanimity of purpose to the organization;

b) provides a basis to derive goals and objectives;

c) provides an answer to the question: "Does this activity contribute to the organization's purpose?".

Vision and mission are used to communicate effectively at the highest level with customers, employees and other interested parties. Benefits and points to note for vision and mission statements are given in Table 5.4.

Table 5.4 — Benefits and points to note for vision and mission statements

Benefits	Points to note
Provides common goals to guide all planning and direction activities. Frames the values, beliefs, principles and governance disciplines and behaviours. Provides a basis for distilling a complex strategy to a "plan-on-a-page".	— Should be simple and easy to communicate.

5.5 Other relevant tools

Other relevant resources include the following:

— context of the organization (COTO) diagram/matrix/log;

— ISO/PAS 24644-1

— committee of sponsoring organizations framework (COSO) shown in Figure 1.

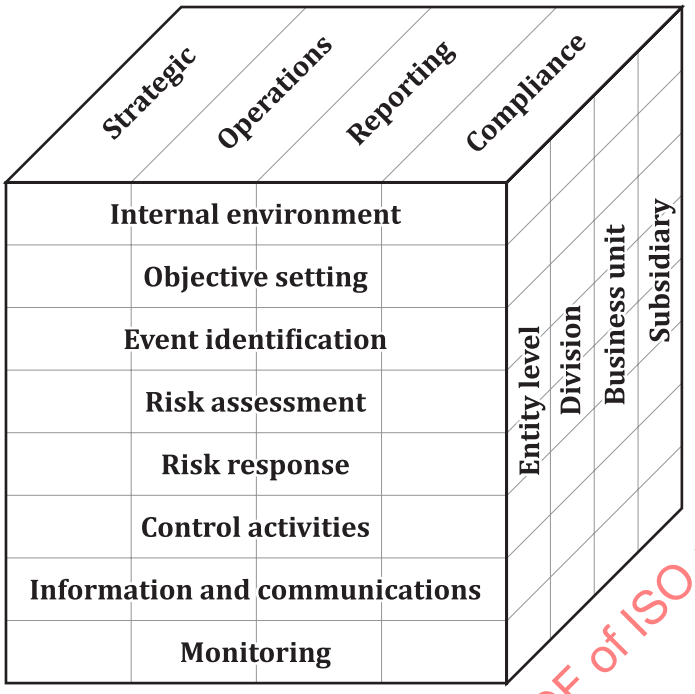


Figure 1 — COSO

6 Process approach and planning

6.1 SIPOC/COPIS (useful for identifying processes)

SIPOC (supplier, input, process, output, customer) is a process mapping tool that is useful in the high-level identification of the main elements of any process. COPIS is the process in reverse and is useful for identifying "customer-facing processes". It may be used to obtain high-level information about any process, and to identify inputs and outputs between suppliers, process owners and customers. It is a tool used for understanding the bounds of a process and the linked processes, related controls and how effectiveness is managed.

SIPOC is used for:

— mapping an existing or a new process;

— providing basic information regarding a process in a simple and short format;

— defining the scope of an improvement activity or project.

Benefits and points to note for SIPOC and COPIS are given in Table 6.1.

Table 6.1 — Benefits and points to note for SIPOC/COPIS

Benefits	Points to note
Simple to use and understand. Delivers results quickly. Provides an overview of the whole process from the beginning to the end on one page.	— Avoid going into too much detail (four to five key steps of the process should be identified). — Should be completed by a team, so there is a common agreement on the start and the end of the process being analysed. — Suppliers and customers can be internal. — SIPOC can be hierarchical.

6.2 Turtle diagram

A turtle diagram is a tool for visualizing the components or characteristics of a process. It provides the opportunity to examine a process more closely for better understanding, more effective execution and identification of areas for improvement. The diagram (see Figure 2) looks like a turtle, with the process components as the body, legs, head, and tail.

A turtle diagram is used:

— to describe the basic elements of a process for communication and understanding;

— to develop more detailed procedures and process flow diagrams (flow charts);

— to help auditors to understand and effectively assess processes.

Benefits and points to note for turtle diagrams are given in Table 6.2.

Table 6.2 — Benefits and points to note for turtle diagrams

Benefits	Points to note
Uses visual and standardized methods which are easy to understand. Provides a complete view of the most important elements of a process on a single page. Aligns process performance to higher level business strategy and objective(s).	— The turtle diagram does not necessarily document all of the information necessary to fully describe a process, but provides a good starting point.

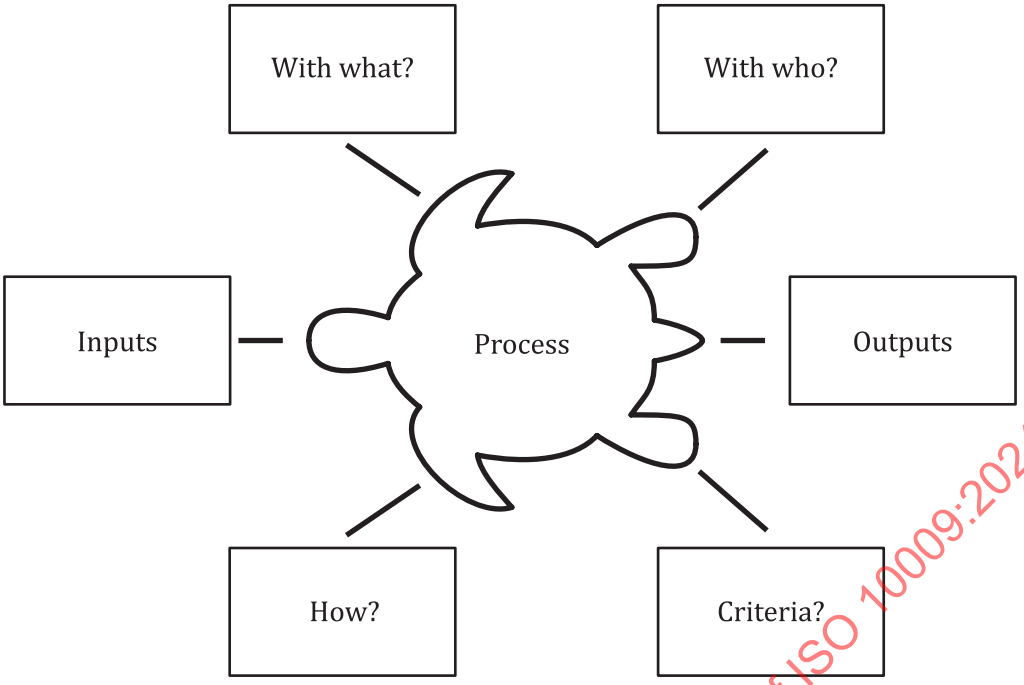


Figure 2 — Turtle diagram

6.3 Control plan

A control plan provides a structured approach to determining the controls applied to a process. Each process is listed in sequential order, typically aided by the use of a process flow diagram. Product and process criteria to be controlled are identified at each stage including special characteristics, typically using a process failure modes and effects analysis (FMEA) as an input. Controls are identified with methods of measurement, frequency, method of recording results and the reaction plan to be invoked in the event that the product or process criteria do not conform with requirements.

The objective of a control plan is to provide concise and useable information to users and minimize process and product variation.

Control plans are used:

— within manufacturing and service industries;

— where there are processes where the conformity of the resultant output cannot be verified through inspection and testing and defects would only become apparent at a later time;

— where needed for process approval on the pre-launch and production phase, with linkage and information from the design risk analysis (as necessary);

— where process/product monitoring is required to determine process capability or to assess conformity to requirements.

Benefits and points to note for control plans are given in Table 6.3.

Table 6.3 — Benefits and points to note for control plans

Benefits	Points to note
Provides a clear and structured approach to product and process control. Assists in effective auditing. Helps drive conformity in processes which cannot be verified through inspection.	— Product and process characteristics should be unambiguously defined. — Process flows, FMEA and control plans should be reviewed and updated when nonconformities occur. — The control plan does not replace work instructions which provide greater detail of the manufacturing process.

6.4 Flow diagram/swim lane diagram/cross-functional flow chart

Flow charts provide a quick, visual way to show how a series of activities, tasks or processes are sequenced. [3,34,35] Swim lane diagrams (see Figure 3) add the responsibilities for activities shown on a simple flow chart.

ISO 5807:1985, 3.3 defines a flow chart as a "graphical representation of the definition, analysis, or method of solution of a problem in which symbols are used to represent operations, data, flow, equipment, etc."

In practice, they comprise symbols, text and connecting lines.

They are used:

— as a starting point in documenting activities;

— to communicate how activities are carried out;

— to identify inefficiencies and allow for analysis and improvement.

Benefits and points to note for flow charts, swim lane diagrams and cross-functional flow are given in Table 6.4.

Table 6.4 — Benefits and points to note for flow charts/swim lane diagrams/cross-functional flow

Benefits	Points to note
Visual Can be quick to develop (depends on the complexity of the activities under consideration). Easy for non-experts to interpret. Assists in the automation and or digitalization of processes.	— The direction of flow is mainly left to right, and top to bottom. — Arrows indicating the flow should be used whenever increased clarity will result. — Considers the position of the reader. — Tries to anticipate the reader's problems in understanding the chart. — Swim lane diagrams (see Figure 3) are a type of flow chart which use lines (or other methods, such as shaded rectangles) to separate activities done by different departments or persons. The name comes from their appearance which looks like the lanes in a swimming pool used for competition. — Not to be confused with block diagrams which use only one shape (a block or rectangle). — Not to be confused with process charting (e.g. Graham Process Charting) which uses different symbols.

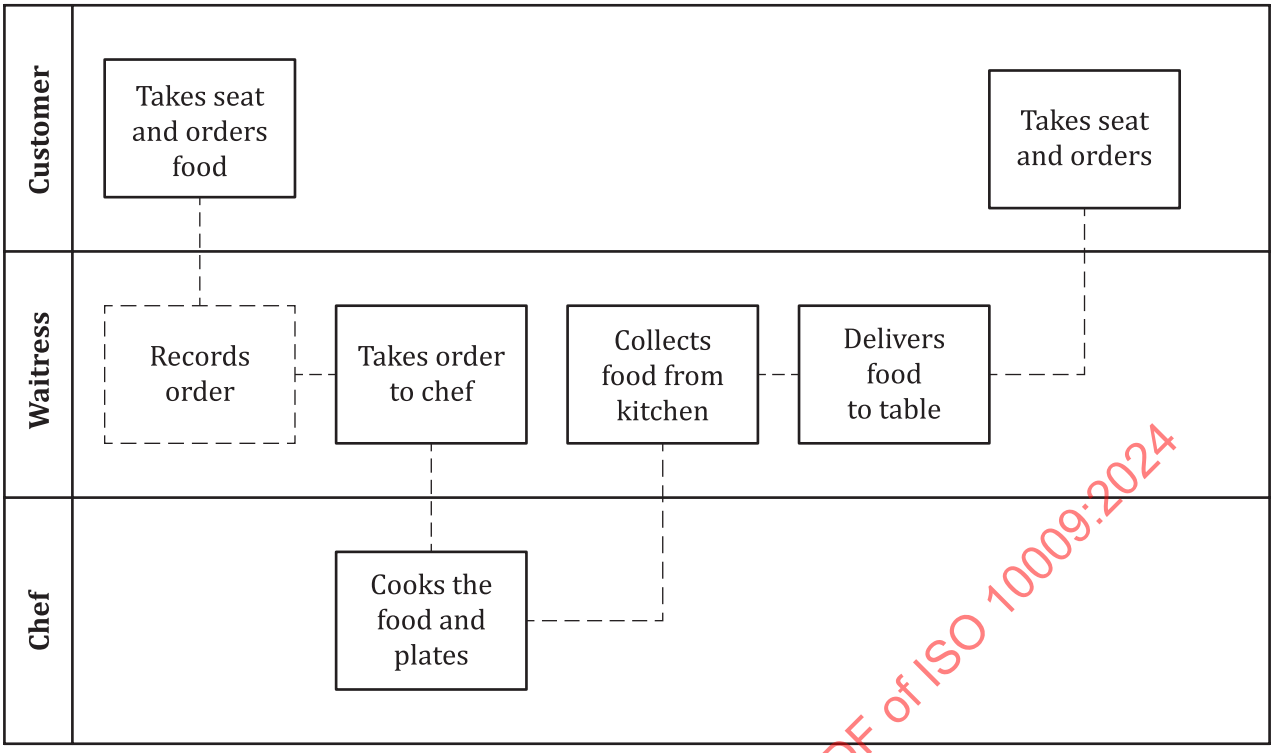


Figure 3 — Swim lane diagram

6.5 Authority matrix/RACI/RASCI

The term "authority matrix" covers a range of uses for a basic matrix that has persons (or functions) on one axis and responsibilities on the other.

When used for financial compliance, it is usually referred to as a "delegated authority matrix".

It shows the level of engagement or decision-making authority in an organization. RAC(S)I [meaning responsible, accountable, consulted, (supporting) and informed] can be used for identifying and communicating changes as necessary.

RACI/RASCI is used to clearly show responsibilities:

— responsible: the person(s) doing the work in the process;

— accountable: the member of management assigned to the process;

— consulted: other interested parties with potential input to the process or affected by outputs;

— supporting: interested parties with inputs only (e.g. IT department / engineering / laboratory);

— informed: parties who are kept informed but not directly involved.

Benefits and points to note for authority matrix/RACI/matrix diagram are given in Table 6.5.

Table 6.5 — Benefits and points to note for authority matrix/RACI/matrix diagram

Benefits	Points to note
Focuses on effective collaboration and decision-making by removing ambiguity. Uses a graphical format. Shows relationships between persons (or functions) in, or across, processes. Supports team-building. Can be used to map current-state to future-state for authorities, etc.	— Should be linked to job descriptions and updated as necessary

6.6 Other relevant tools

Other relevant resources include the following:

— the IDEF0 Functional Modelling method, which was designed to model the decisions, actions and activities of an organization or system;[3][36]

— quality plans (see ISO 10005);

— advanced process and quality plan (APQP);[19,20]

— success path method (SPM).[38,39]

7 Risk and opportunity

7.1 SWIFT

The Structured What If Technique (SWIFT) is a flexible, high-level risk identification technique that may be used on a standalone basis, or as part of a staged approach to make more efficient the use of bottom-up methods such as FMEA (see 7.3).

SWIFT is used in risk assessment where a series of brainstorming prompts are used for each step of the process or component of the system being assessed. Each prompt helps to consider different types of hazards that can be present in the system.

EXAMPLE A HAZOP analysis is an example of a SWIFT.

Benefits and points to note for SWIFT are given in Table 7.1.

Table 7.1 — Benefits and points to note for SWIFT

Benefits	Points to note
Structured. SWIFT can overcome the self-censorship that occurs in the brainstorming in an unstructured group, allowing members of the group to think the unthinkable.	— The process or system should be mapped out using no more than 10 steps or components (or use a P+ID).
Simplicity. It does not go into the same level of detail as FMEA (see 7.3) does on the process steps to be risk assessed.	— SWIFT may be used by itself, or as part of a staged approach.

7.2 Risk register/risk assessment

A risk register is used to identify, prioritize, record and monitor the actions to be taken on the identified risks. A risk register is displayed in tabular format describing each risk, its nature or type, the probability of occurrence, its impact on the organization, the risk owner, mitigation measure(s), contingency action(s) and the residual risk after mitigation.

Inputs to the risk register may come from sources such as SWOT (see 5.1), PESTLE (see 5.2) or FMEA (see 7.3). Outputs may inform improvements, objectives, human resources development, etc.

Benefits and points to note for risk register/risk assessment are given in Table 7.2.

Table 7.2 — Benefits and points to note for risk register/risk assessment

Benefits	Points to note
Displays information on current risks in a single document which is easy to navigate and understand.	— It should to be regularly monitored and kept up to date.
Defining risks can also present opportunities for the organization.	— The use of risk priority numbers (RPN) to evaluate risks may be used as a tool to prioritize risk impact. Sometimes a cost is associated with risks and linked to insurances, contingencies or liabilities. — It is often structured by categories such as financial/human resources/regulatory / customer, etc.

7.3 Failure mode and effects analysis (FMEA)

FMEA[18,21,22] is a risk-based methodology for ensuring that potential problems are identified, analysed and prioritized during product or process development, and during subsequent production or service delivery and product life cycle.

Variants of the tool can be seen in:

— design (DFMEA);

— manufacturing process (PFMEA);

— design review based on failure mode (DRBFM);

— tooling;

— software;

— service design;

— service delivery;

— monitoring systems.

Benefits and points to note for FMEA are given in Table 7.3.

Table 7.3 — Benefits and points to note for FMEA

Benefits	Points to note
Enables early identification and mitigation of problems. Reduces risk of late design or process changes. Reduces risk of field failures and warranty costs. Reduces risk of problems during production or service delivery. Focuses on actions which address the most significant risks with a priority on occurrence reduction, and where possible elimination of high severity failure modes (the severity of a failure mode cannot be reduced but it can be possible to design it out).	— FMEA is a team-based activity. — FMEA is a living document and should be updated when there are unexpected issues. — There should be no incentive to score low to avoid high RPNs (risk priority numbers)/ action priority and any need for action. — The scoring criteria should use a scale where there are clear criteria for each point on the scale. — The methodology considers only single failure modes and is not suitable for compound failure modes. — Preparation is vital. Documented process flows or system schematics should be available or created at the start of the process. — Sufficient time and resources should be allocated to the team. — Facilitator competence in FMEA and team selection are critical to effectiveness. — The team should represent all functions involved (and can include the customer).

7.4 Traffic light/heat map

The colours red, amber and green are used to illustrate whether a situation or risk is satisfactory/ unsatisfactory or high/low or positive/negative. This is often on a severity versus frequency matrix called a "heat map". This is sometimes referred to as RAG (red, amber, green).

It is used in situations such as:

— reports referencing key performance indicators (KPIs);

— risk analysis/registers;

— warning signs;

— dial gauges;

— safety signals;

— andon.[89][90]

Benefits and points to note for traffic light/heat maps are given in Table 7.4.

Table 7.4 — Benefits and points to note for traffic light/heat maps

Benefits	Points to note
Simple to use	— Care should be used with heat maps which are symmetrical as actual severity consequences can bias the outcome.
Easy to understand	— The colours are used to attract attention, but an indicator can change colour with a small change in data.
Supported by programs such as Microsoft Excel (conditional formatting).	— Will not be effective if a person is colour-blind.
[a] Excel is the trademark of a product supplied by Microsoft. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.	

7.5 Other relevant tools

Other relevant resources include the following:

— success path method (SPM);[38,39]

— failure mode, effects, and criticality analysis (FMECA);

— FMEA for monitoring and system response (FMEA-MSR).

8 Objectives and objective management

8.1 Kaizen

Kaizen means continual improvement by setting targets higher than the current level. When applied to the workplace, Kaizen means continual improvement for all human resources: managers and workers alike. Kaizen is a systematic and long-term action aimed at accumulating improvements and savings by achieving performance improvement through changes or small incremental improvements in the processes.

Kaizen may be used for any improvement project.

Benefits and points to note for Kaizen are given in Table 8.1.

Table 8.1 — Benefits and points to note for Kaizen

Benefits	Points to note
Standardization Waste elimination Cost reduction Performance improvement - See Do Check Act (SDCA)	— Kaizen should be an ongoing process and should not be practised on an ad hoc basis as its philosophy is based on continual improvement.
— First step is to standardize or follow the procedure if in place.	— Changes may come from any employee anytime and are not required to happen slowly.
— Then Do, Check and Act and repeat.	— Following the SDCA cycle, an initial 15 % improvement is possible.

8.2 Hoshin Kanri (also known as the “X-matrix”)

Translated from Japanese as “compass management”, Hoshin Kanri is a seven-step process to assist organizations to chart a course and realize their strategic objectives.

Hoshin Kanri sets out to operationalize organization strategy. It achieves this by breaking out the strategic plan into a structured set of achievable objectives. KPIs are used to ensure the organization is moving towards the delivery of its strategic vision.

Benefits and points to note for Hoshin Kanri are given in Table 8.2. See Figure 4 for an example of an X-matrix.

Table 8.2 — Benefits and points to note for Hoshin Kanri

Benefits	Points to note
Takes conceptual and aspirational objectives and turns them into a set of deliverables. Can focus the management team on strategically important KPIs. It is a powerful tool for communication, visibility and alignment in the deployment of objectives. It is a top-down approach, ensuring every member of staff is fully engaged in the plan. Allows objectives which are not met to be refined and carried into the next cycle. Engages management in forward thinking strategies (e.g. next three to five years rather than next quarter).	— It is vital that all members of top management are fully committed. — Hoshin Kanri can become a rigid framework that discourages deviation. This can lead to: — stifling innovation; — focusing on the wrong things; — loss of agility and ability to quickly change; — reduction in the ability to adapt to customer/market conditions. — The employees should be presented with tangible benefits that make it worthwhile for them to buy into and deliver the organization's vision. — Customers are a key component of the vision. KPIs should be aligned to (and match) customer requirements.

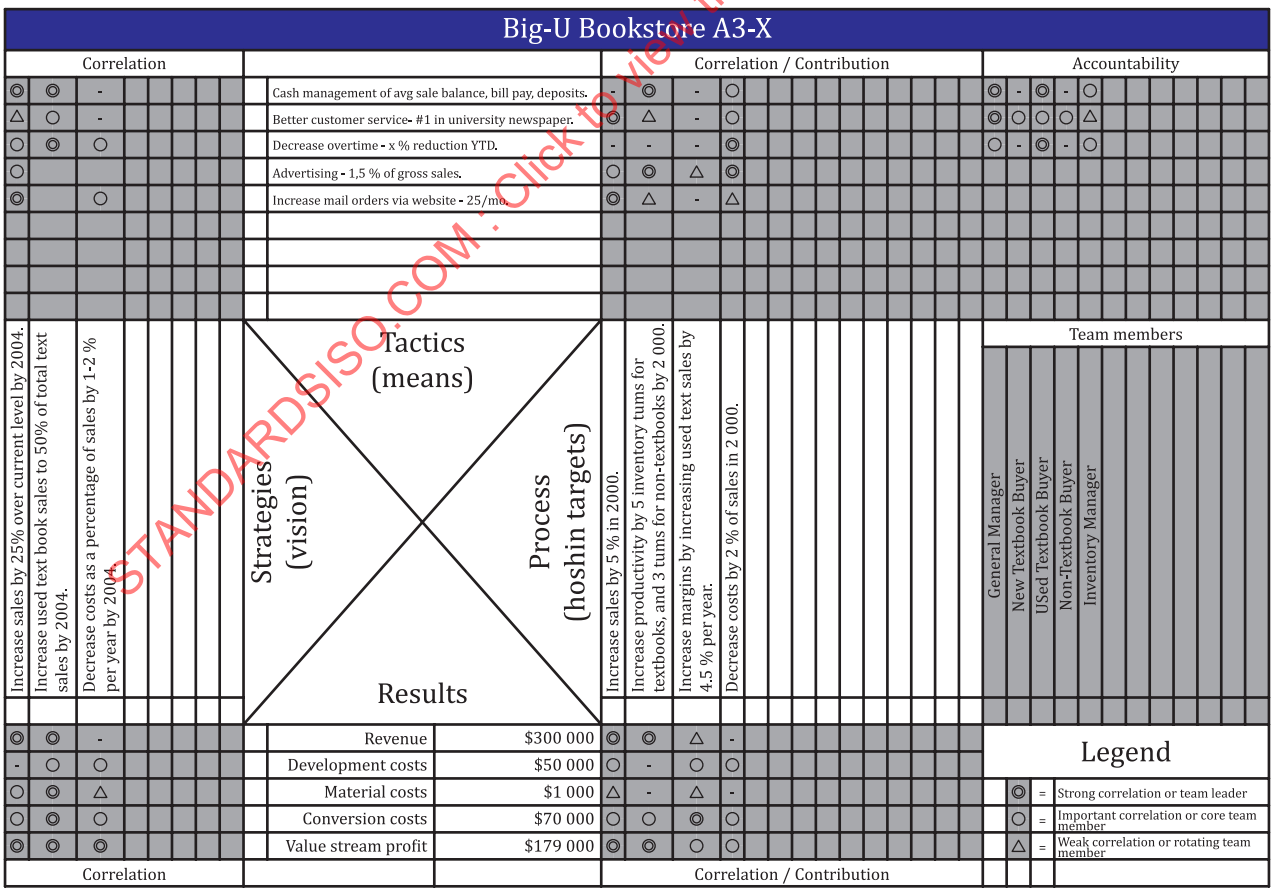


Figure 4 — X-Matrix

8.3 Management by objectives (MBO)

Setting objectives and achieving them is the goal of MBO.[40] SMART (specific, measurable, attainable, relevant and time-bound) is the acronym for the five key attributes of successful objectives.

MBO is a formal approach to realizing the strategy and can be an important part of any successful management system. Objectives can be linked with elements of performance of processes and, ultimately, the performance of the organization.

Once objectives are determined, SMART can be applied. Alignment with the strategy and KPIs is important and should be cascaded throughout the organization so that any individual is aware of how they can contribute to the relevant objectives.

MBO is also used with a balanced scorecard (BSC).[42,43]

Benefits and points to note for MBO are given in Table 8.3.

Table 8.3 — Benefits and points to note for MBO

Benefits	Points to note
Direct relationship with business results and success. Improves empowerment and self-worth when linked to positive feedback. Minimizes information overload. Energizes an organization.	— Objectives are not KPIs although appropriate KPIs provide an additional measurement. — Objectives are not "at any cost", they should be achieved within the normal operating environment of the organization and to their normal code of ethics, etc. — Plans which exist should be updated to align with the objectives.

8.4 Other relevant tools

Other relevant resources include the balanced scorecard (BSC).[41,42]

9 Customer focus/perception

9.1 Quality function deployment (QFD)

Quality function deployment (QFD)[11,43] is a method to ensure customer or interested party satisfaction and value with new and existing products by designing, from different levels and different perspectives, the requirements that are most important to the customer or interested party. These requirements are well understood through the use of quantitative and non-quantitative tools and methods to improve confidence of the design and development phases. In addition to satisfaction with the product, QFD improves the process by which new products are developed.

Benefits and points to note for QFD are given in Table 9.1. See an example of QFD in Figure 5.

Table 9.1 — Benefits and points to note for QFD

Benefits	Points to note
Improves customer satisfaction with products at time of launch. Improves cross-functional communication. Promotes systematic and traceable design decisions and efficient use of resources. Reduces rework. Reduces time-to-market and lowers the life cycle cost. Improves the reputation of the organization among its customers or interested parties.	— Requires time and significant resources. — The voice of the customer (VOC) should be kept in mind. — Also known as the "house of quality" because of the shape of the diagram usually associated with this tool.

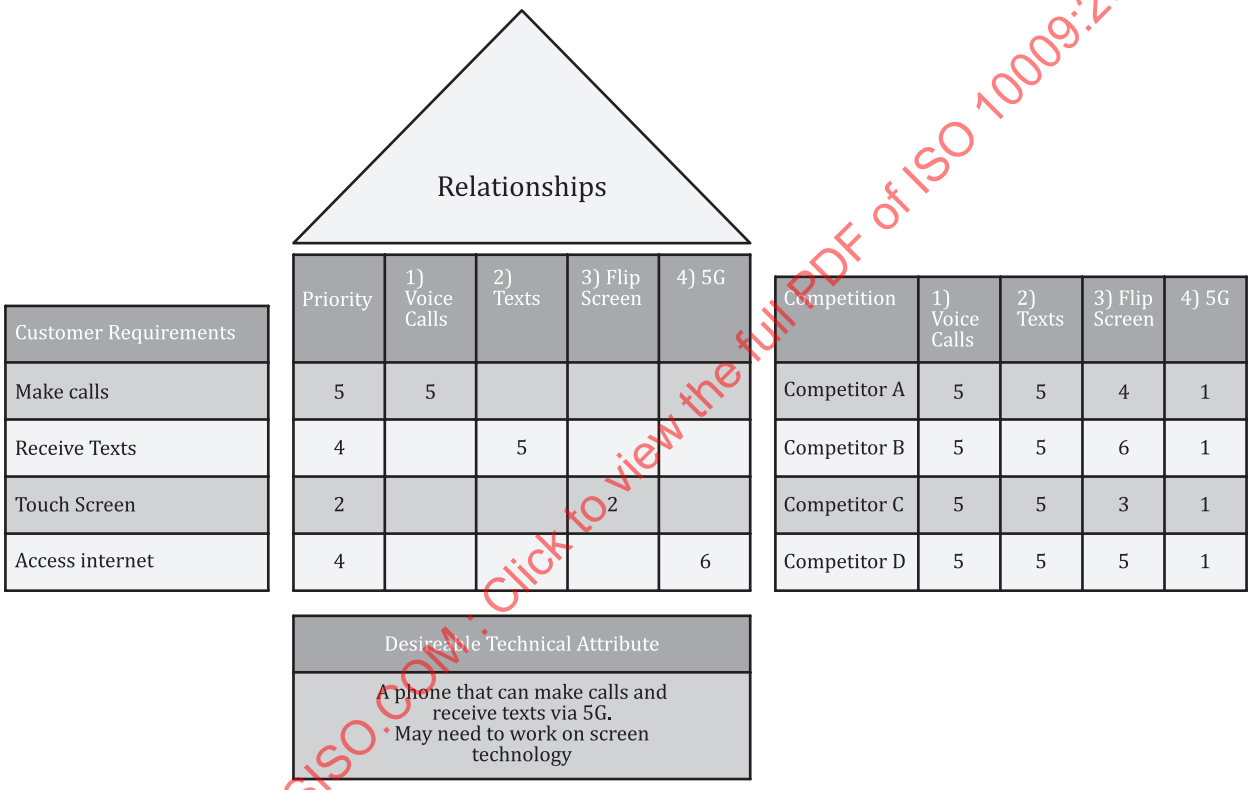


Figure 5 — Quality function deployment

9.2 Net promoter score (NPS)

NPS is a customer loyalty and satisfaction measurement taken by asking customers how likely they are to recommend an organization's product or service to others. Customers select a number from 0 (extremely unlikely to recommend) to 10 (extremely likely to recommend). Customers who give scores of 6 or less are considered "detractors", scores of 7 or 8 are considered "passives", and a score of 9 or 10 are considered "promoters". The NPS is simply the percentage of promoters minus the percentage of detractors.

NPS is used as a proxy for gauging the customer's overall satisfaction with an organization's product or service and the customer's loyalty to the brand.

NPS may be used to:

— investigate consumers' willingness to buy;

— evaluate the degree of customer loyalty/brand cognition/brand favourite;

— measure customer experience;

— identify the causes of defect/complaints;

— predict business growth/sustained profitability;

— prioritize improvement efforts that will be most impactful;

— evaluate the organization's value;

— create internal benchmarks.

Benefits and points to note for NPS are given in Table 9.2.

Table 9.2 — Benefits and points to note for NPS

Benefits	Points to note
Simplicity. The surveys can use just one question but typically require two or three questions.	— The sampling plan, relevance and sample size should be as large as possible.
Ease of use. The surveys may be conducted by phone, email or web, whichever generates the best response rates and the most useful data.	— Follow up questions should be added if wishing to discover why the score (particularly if less than 6) is being given.
Quick follow-up. Customer feedback is shared very quickly after it is received.	— It is one of many types of customer satisfaction measures.
A growing body of experience. Thousands of organizations in many different industries have begun to measure their NPS.	
Adaptability. No high-priced vendors or "black box" statisticians are required.	

9.3 Kano model

The objective of the Kano model is to improve customer satisfaction by understanding, qualifying and quantifying the drivers of satisfaction. The model aids the identification of certain qualities that should be in place to ensure customer satisfaction. It also proposes that, over time, product perception will evolve and what was previously a "delighter" can become an "expected" quality. Understanding these nuances allows product and service designers to future proof against possible market complacency while also keeping the customer requirement front and centre. For a new product or service, it helps gain insights into the attributes which are perceived to be important for the customer.

The Kano model utilizes customer preference information to:

— help with the development of new products;

— help gain a competitive advantage;

— include "must have" design features;

— help define customer delights;

— discover unknown needs;

— future proof design;

— identify design risks and sources of waste.

— identify proportional and double-edged features

— eliminate indifferent features.

Benefits and points to note for the Kano model are given in Table 9.3. See an example of the Kano Model in Figure 6.

Table 9.3 — Benefits and points to note for the Kano model

Benefits	Points to note
Simple to use	— The relevant customers should be surveyed.
Focuses on product features not just customer requirements.	— The objective is to discover the minimum level of product attributes a customer expects and build from there.
Quickly identifies known and unknown qualities.	— Positive outcomes are achieved when the defined product qualities are those which the customer was not aware of needing in the first place (excite quality).

Figure 6 — Kano Model

9.4 Pugh matrix / Decision matrix

The Pugh matrix (or decision matrix) is used to compare a number of alternatives and find the best solution by testing against key criteria. The Pugh matrix uses scoring to help evaluate the best approach.

Having established the key criteria that are desired in the design, each is given a weighting score with the higher number for the more important criteria. The tool can be used by an individual but is best used by a team. It is normally used at the initial stages of design development to guide on the options that are best suited to fulfil the design brief.

The Pugh matrix is used:

— to evaluate alternative design approaches;

— to select vendors;

— to select applicants when hiring staff.

Benefits and points to note for the Pugh matrix are given in Table 9.4.

Table 9.4 — Benefits and points to note for the Pugh matrix

Benefits	Points to note
It is a structured method allowing easy comparison. It is most effectively used in a team-based approach. It allows an optimal solution to be developed which is a hybrid of other alternatives. It is a quick method which can be used repetitively if other alternatives are developed later.	— The score awarded for each category should be well assessed and, if possible, justified.

9.5 Other relevant tools

Other relevant resources include the following:

— lost business analysis;

— mystery shopper;

— customer surveys;[45]

— potential gain in the customer value (PGCV) index;

— focus groups;[44]

— customer relationship management (CRM);

— ISO 10004;[6];

— checklists;[37]

— TRIZ.[46]

10 Process performance

10.1 Theory of constraints (ToC)

The theory of constraints[47] is a methodology for identifying the most important limiting factor (i.e. constraint) in achieving an objective. It involves the following five steps:

1. identify the constraint;
2. determine how to address the constraint;
3. maintain focus on the constraint;
4. implement correction;
5. return to step 1.

The theory of constraints can be used on key processes to discover their limitations and formulate solutions to achieve the objective. Benefits and points to note for ToC are given in Table 10.1.

Table 10.1 — Benefits and points to note for ToC

Benefits	Points to note
Increased effectiveness of resources (the primary goal of ToC for most organizations). Focused improvement Improved flow/capacity Reduced lead times (see JIT, 11.2) Reduced inventory	— It can be most effective when combined with other methods such as lean thinking.

10.2 Value stream management (VSM)

VSM[48] is a method of understanding a process in terms of value adding activities (as against non-value adding activities such as waiting to process, movement around the facility, set-up time, rework, sorting, etc.). It may be linked to right first time, JIT (see 11.2), Kanban (see 11.1) and ToC (see 10.1).

A "value stream" is the sequence of activities that an organization carries out in order to deliver a specific product or service. A value stream map is a visualization of both material and information flows (see Figure 7).

The current state of the value stream is mapped according to the gathered data in order to subsequently design a future state with less waste and a reduced lead time. Benefits and points to note for VSM are given in Table 10.2.

Table 10.2 — Benefits and points to note for VSM

Benefits	Points to note
It is a visual tool, with pictures and symbols which makes it a simple tool to understand and develop a process for.	— VSM is not a process map and does not show all of the possible paths that a process can take.
Can help to design new manufacturing or service processes.	— VSM is supported by process flow charts to determine the value adding and non-value adding activities.
Can help to eliminate waste and delays. Can help with problem solving.	— VSM requires cycle times to be measured for all activities.

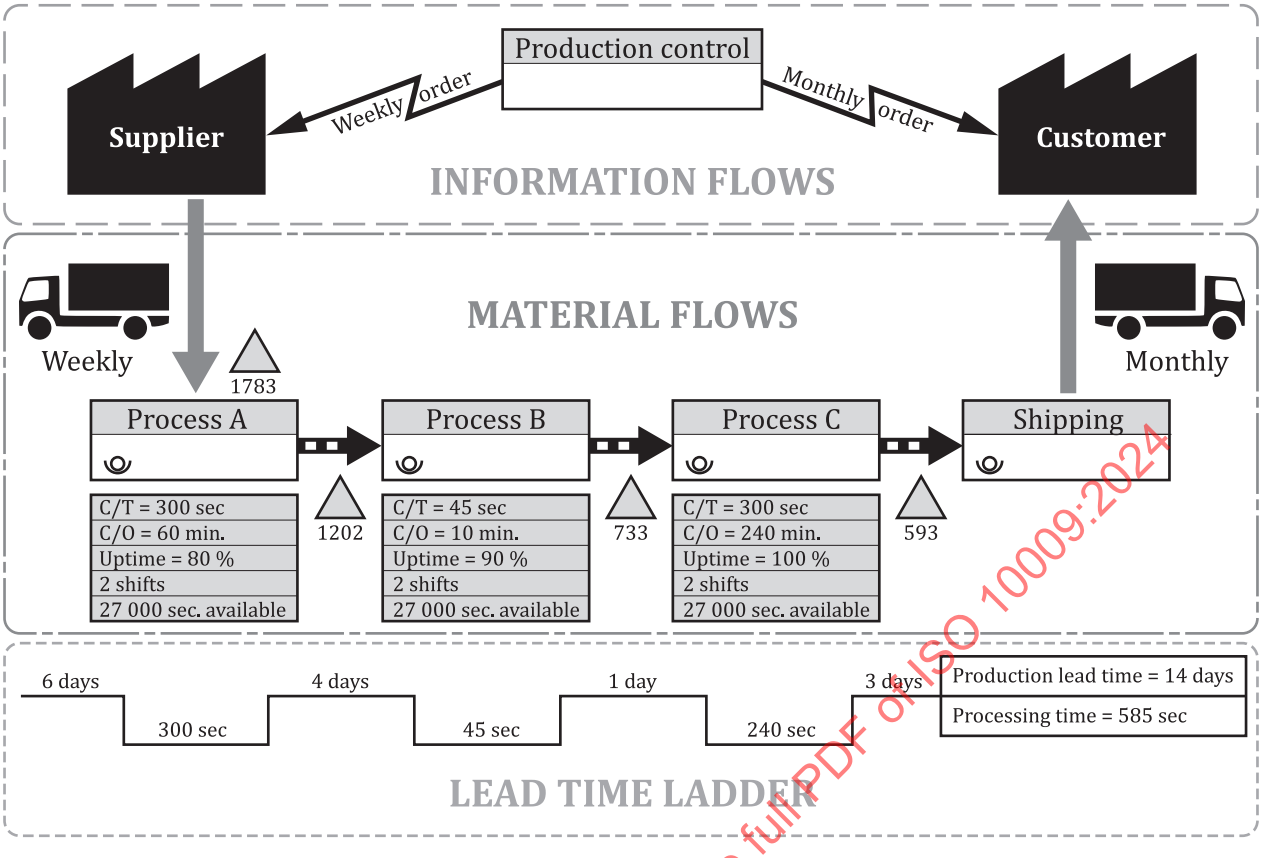


Figure 7 — Value stream map

10.3 Process wastes/muda

The aim is to identify waste in the organization's processes, and to minimize or eliminate the following eight wastes (in Japanese: "muda"):

1. transportation;
2. inventory;
3. motion;
4. waiting;
5. overproduction;
6. over-processing;
7. defects;
8. skills.

Benefits and points to note for process wastes/muda are given in Table 10.3.

Table 10.3 — Benefits and points to note for process wastes/muda

Benefits	Points to note
Improves process performance: reduced cycle time, lead time, on-time delivery, waste etc.	— Requires "hands-on" data collection. — Uses cross-functional teams to make sure that value-added aspects are not eliminated. — Part of the Toyota Production System. Used in conjunction with 5S (see 10.6) and Kaizen (see 8.1).

10.4 Work breakdown structure (WBS)

WBS[50] is typically used in project management or product/service development to decompose the high-level deliverables into smaller elements through two or more hierarchical layers.

Benefits and points to note for WBS are given in Table 10.4.

Table 10.4 — Benefits and points to note for WBS

Benefits	Points to note
Enables detailed project planning and resource allocation. Identifies any missing work elements and establishes boundaries.	— All necessary tasks should be identified to achieve the deliverables. — Tasks are broken down to a level where they can be delivered within one review cycle or by one discipline. — Focuses on planning outcomes rather than actions.

10.5 Spaghetti diagram

A spaghetti diagram is a visual lean tool to show the journey of a product or person in the workplace with the aim of rearranging the work to reduce crossovers and reduce the distance of travel (see Figure 8).

A spaghetti diagram is used in:

— evaluating flows as part of lean;

— designing work places;

— reducing accidents.

Benefits and points to note for spaghetti diagrams are given in Table 10.5.

Table 10.5 — Benefits and points to note for spaghetti diagrams

Benefits	Points to note
Simple visual tool Inefficient workplaces are readily identified Can be used in any workplace	

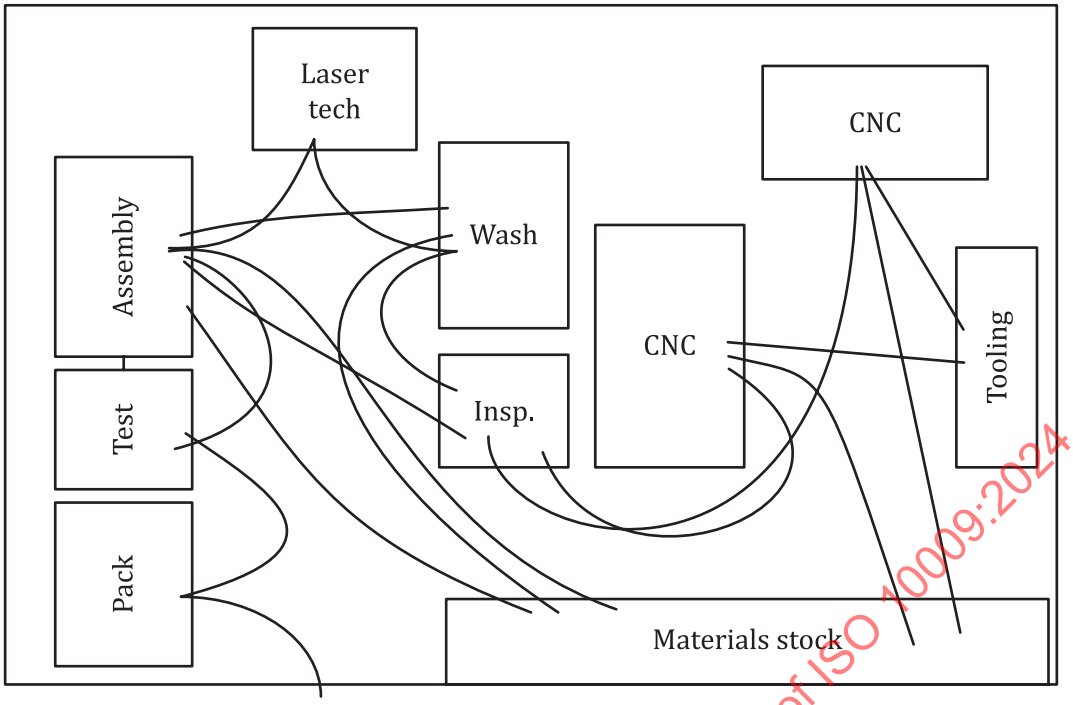


Figure 8 — Spaghetti diagram

10.6 5S

The 5S quality tool[49,51] is derived from five Japanese terms beginning with the English letter "S" used to create a workplace suited for visual control and lean production. An additional "S" for "safety" is often added. The aim is to have a workplace that is clean, uncluttered, safe and well organized to help reduce waste and optimize productivity. It is designed to help build a quality work environment, both physically and mentally.

The pillars of 5S are simple to learn and important to implement, as follows:

— Seiri (organization): to separate necessary tools, parts, and instructions from unnecessary materials and to remove the unnecessary ones.

— Seiton (orderliness): to neatly arrange and identify parts and tools to ensure availability/ accessibility when needed.

— Seiso (cleanliness): to conduct a clean-up campaign.

— Seiketsu (standardized clean-up): to conduct seiri, seiton and seiso daily to maintain a workplace in perfect condition.

— Shitsuke (sustain): To form the habit of always following the first four Ss (seiri, seiton, seiso and seiketsu).

The 5S philosophy applies in any work area suited for visual control and lean production. The 5S condition of a work area is critical to employees and is the basis of customers' first impressions.

The 5S methodology is applied to all kinds of work environments.

Benefits and points to note for 5S are given in Table 10.6.

Table 10.6 — Benefits and points to note for 5S

Benefits	Points to note
Improves safety, by reducing work accidents.	— It is essential to implement using a rigorous and disciplined methodology.
Increases equipment availability and better asset utilization.	— Depends on the ability of personnel to respond to process change.
Lowers defect rates.	— The fifth S, "shitsuke", essentially calls for performing the first four Ss on an ongoing basis.
Reduces costs through removing waste in the work place.	— It requires effort and perseverance to maintain.
Increases production agility and flexibility.	— Can be implemented gradually and only one pillar at a time. After having successfully implemented one pillar, the next one is started until all of them have been completed.
Improves employee morale and gives an enhanced image to interested parties.	— Tendency to see it as a minor tool focused on order and cleanliness, given its simplicity.
Suitable for use in any environment (even at home).	— Reinforced by audits and scoring.

10.7 Overall equipment effectiveness (OEE)

OEE[51] is a metric that considers three parameters (availability, performance and quality) to assess the effectiveness of an equipment or process, and supports the identification of opportunities to reduce downtime and cycle time, and improve quality.

OEE is used to support the identification of potential causes and losses that affect downtime, speed and quality such as:

— unplanned stops;

— planned stops;

— slow cycles;

— production rejects;

— start-up rejects.

Benefits and points to note for OEE are given in Table 10.7.

Table 10.7 — Benefits and points to note for OEE

Benefits	Points to note
Supports improvement	— OEE should be avoided as an organization-wide estimate.
Provides a better focus on where improvement can be made (availability, performance and quality).	— The data used in the calculation should be gathered over a representative period.
OEE is a key indicator of total productive maintenance (TPM).	— Can also be an indicator for effective energy management.
Can be used as benchmark, by increasing visibility of equipment or process performance.	— OEE is a single KPI that does not show the influence of individual parameters: availability, performance or quality.

10.8 Production levelling (Heijunka)

This is a methodology used to reduce unevenness in a continual production process and, therefore, minimize overload and spare capacity. Heijunka[53] in Japanese means “production smoothing or levelling”.

The aim is to produce in alignment with the customer demand. This reduces inventories (of raw materials and finished goods) which reduces the vulnerability of fluctuating demand. It is applicable to continual production process and is enabled by Kanban (see 11.1).

Benefits and points to note for production levelling are given in Table 10.8.

Table 10.8 — Benefits and points to note for production levelling/heijunka

Benefits	Points to note
Cost reduction (optimized inventory, line balancing, improved OEE, less disruption etc.)	— The success of production levelling depends on the ability of the line to adapt to producing a mix of products on customer demand (Kanban)
Reduces waste in the supply chain.	— Ergonomics should be considered in the production of levelling implementation.

10.9 Other relevant tools

Other relevant resources include the following:

— single-minute exchange of die (SMED);

— total productive maintenance;

— Kraljic model;[54]

— materials requirements planning (MRP);[55]

— enterprise resource planning (ERP);[56]

— Agile/SCRUM;[57]

— robotic process automation (RPA);[58]

— Reliability – Availability – Maintainability.

11 Inventory management/preservation

11.1 Kanban

Kanban (meaning "signal" in Japanese) is a system for preventing over-supply or over-production. It is a signal sent upstream from the point of consumption to indicate that re-supply is required. This may be used throughout a supply chain.

Kanban can be linked to visual production control and production levelling (see 10.8).

Benefits and points to note for Kanban are given in Table 11.1.

Table 11.1 — Benefits and points to note for Kanban

Benefits	Points to note
Easy to use. Prioritizes supply. Reduces inventory and work in progress (WIP).	— The amount to be supplied with each Kanban cycle is determined by the rate of use. — Often results in the use of a buffer warehouse close to the point of consumption. — Should be managed over time to ensure the system remains correctly balanced. — Kanban requires defect-free inputs.

11.2 Just-in-time (JIT)

JIT means delivering only what is strictly needed, when required. The aim is to meet customer demand with less waste and keep inventory to a minimum.

Elements of JIT can include:

— eliminating waste (see 10.3);

— 5S (see 10.6);

— set-up time reduction;

— levelled/mixed production (see 10.3);

— Kanban (see 11.1);

— Jidoka (autonomation).

Benefits and points to note for JIT are given in Table 11.2.

Table 11.2 — Benefits and points to note for JIT

Benefits	Points to note
Reduces waste. Improves quality and on-time delivery. Reduces cost.	— The supply chain should be stable.

11.3 Other relevant tools

Other relevant resources include the following:

— first-in first-out (FIFO) and last in first out (LIFO);

— cycle counts;[59]

— inventory turns.[60]

12 Detection and prevention

12.1 Error proofing/poka-yoke

Error proofing (in Japanese: “poka-yoke”) is when an incorrect application is stopped through physical or electronic controls.

Error proofing is used in the design of product or process (including tools and fixtures) to prevent the occurrence of a failure mode. It is used where safety or function is very important and incorrect positioning can impact the function or use.

Benefits and points to note for error proofing are given in Table 12.1.

Table 12.1 — Benefits and points to note for error proofing/poka-yoke

Benefits	Points to note
Stops misuse. Avoids incorrect assembly. Provides visual warning when misuse is expected.	— Will impact the design of a component, product or fixture.

12.2 Visual aid

A visual aid is a pictorial aid that can be used as a reference to assist in the standardization of operations, judging the quality of product and in problem solving.

Visual aids can be used, for example, to:

— classify defects;

— display location of defects;

— define acceptance criteria;

— grade ability (e.g. eyesight tests);

— grade natural products.

Benefits and points to note for visual aids are given in Table 12.2.

Table 12.2 — Benefits and points to note for visual aids

Benefits	Points to note
Simple to use No language used (suitable for foreign workers or low-skilled workers). Easier to explain an issue visually than by text.	— The visual material sometimes has to be reviewed periodically. — Minimum lighting levels sometimes have to be specified.

12.3 Cost of quality (COQ)

COQ[61-63,65] is the aggregate of the cost of internal and external failures (cost of poor quality - COPQ), and the cost associated with appraisal and prevention. This forms the basis for determining actions to address relevant issues. The objective is to reduce COQ by eliminating or minimising the causes of poor quality.

COQ is useful for systematic improvement of processes, products and services.

Benefits and points to note for COQ are given in Table 12.3.

Table 12.3 — Benefits and points to note for COQ

Benefits	Points to note
Focuses on cost (which is necessary information for management decisions). Considers cost in a holistic manner. Helps reduce costs to the organization and improves competitiveness. Applies to services as well as products.	— COQ is a basis for investment in prevention and appraisal which usually offsets the cost of failure and corrective action.

12.4 Other relevant tools

Other relevant resources include the following:

— checklists[37];

— ISO 10014.

13 Process control tools

13.1 General

A spectrum of statistical techniques is addressed in ISO 10017. Some simple graphical tools not specifically addressed in ISO 10017 are noted in 13.2 to 13.9.

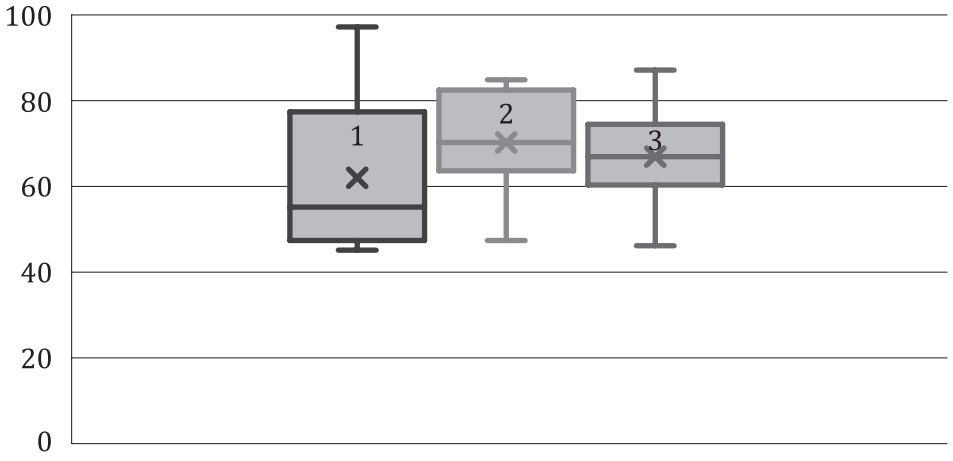
13.2 Box plot

Box plots (or box and whisker plots) visually show the range of numerical data, and they display five values: the minimum value, the first quartile, the median, the third quartile and the maximum value. They are used to show the differences between samples taken (possibly over time or by competing suppliers). Box plots help to display the range, the approximate average and outliers. See Figure 9.

Benefits and points to note for box plots are given in Table 13.1.

Table 13.1 — Benefits and points to note for box plots

Benefits	Points to note
Easy to use and interpret. Simple mathematics. Many computer applications can handle the arithmetic and presentation. Particularly useful for comparing distributions across groups.	— Proper interpretation requires sufficient data.



Key

1 maths

2 english

3 art

NOTE The values in the y-axis represent the per cent.

Figure 9 — Box plot

13.3 Pie chart

A pie chart (or diagram) is a simple visual tool used to show the relative proportions of a population as segments such as:

— sales (e.g. by region or product);

— costs;

— customer satisfaction scores;

— categories of complaints;

— type of defect;

— type of customers.

Benefits and points to note for box plots are given in Table 13.2. See Figure 10 for an example of a pie chart.

Table 13.2 — Benefits and points to note for pie diagrams

Benefits	Points to note
Easy to use for presenting and interpreting data.	— Works most effectively with few categories or segments. — The area of the pie chart (diameter) may be used to represent the total number in a sample.

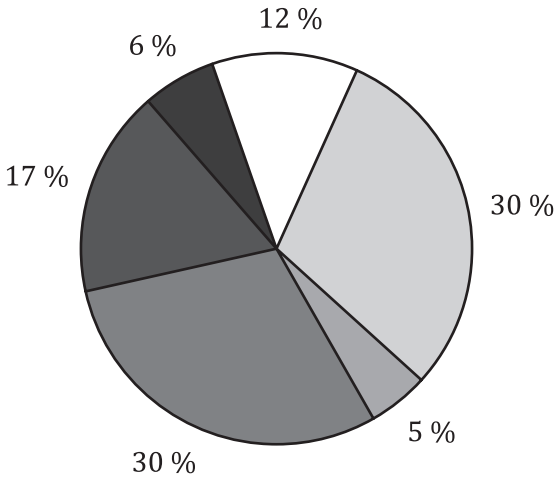


Figure 10 — Pie chart

13.4 Radar chart/spider diagram

The radar chart, also known as the “spider diagram” is a chart used to display several attributes as vectors on a polar grid.

They are most effectively used for displaying the performance of each attribute. The chart may be used to compare the properties of a single or multiple variables. The radar chart can benefit from the use of colours. See Figure 11 for an example.

Radar charts may be used when:

— tracking or reporting performance or progress;

— measuring overall performance using several variables.

Benefits and points to note for radar charts/spider diagrams are given in Table 13.3.

Table 13.3 — Benefits and points to note for radar charts/spider diagrams

Benefits	Points to note
Easy to use for presenting and interpreting data. Involves simple mathematics. Visually aesthetic and compact in presentation.	— It is good practice to keep radar charts simple and limit the number of variables used.

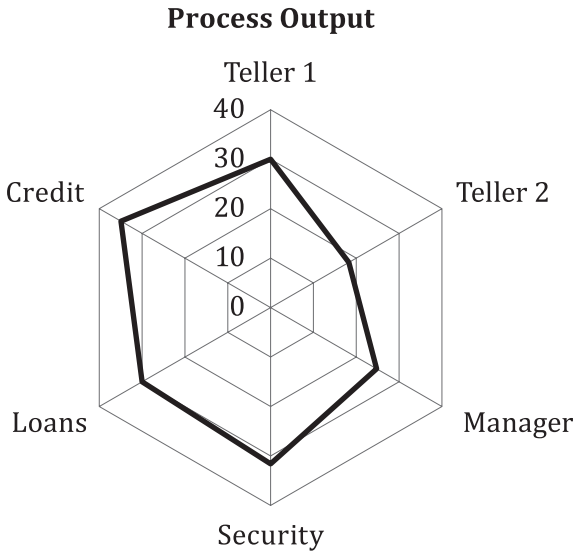


Figure 11 — Radar chart/spider diagram

13.5 Pre-control

Pre-control is a statistical technique[65] that seeks to prevent the production of units whose dimensions lie outside specifications.

A sample of five consecutive units from production should lie within the central half (50 %) of the range between upper and lower specifications.

When that condition is met, production can proceed with periodic sampling inspection of two units. The inspection results determine whether production can continue as is or if it is necessary to adjust the process.

Pre-control aims to maintain product quality through a sampling inspection procedure that governs whether production can continue or if process intervention is required.

Pre-control is used as a low-cost alternative to statistical process control (SPC) or where SPC is not viable. The technique lends itself more to the production of products than services. It is also used for monitoring machining processes which can be prone to drift because of tool-wear.

Benefits and points to note for pre-control are given in Table 13.4.

Table 13.4 — Benefits and points to note for pre-control

Benefits	Points to note
Requires minimal training. Simple methodology that allows the use of "go/no-go" gauges.	— Pre-control offers limited insight into the process and is not advocated as a tool for improvement. It can be useful in operations where defect levels of "1 % – 3 %" are permissible [91]

13.6 Critical to quality (CTQ) trees

CTQ trees can be used at the inception phase of a project to focus development on areas that really matter, or to drive an improvement initiative in existing products or services.

CTQ trees are used to:

a) define each critical need that the service or product is expected to satisfy;

b) define the quality drivers for each need that is expected to be in place for the customer to receive high quality;

c) determine the performance criteria needed to satisfy the quality drivers;

d) start a new tree for each need.

Benefits and points to note for CTQ trees are given in Table 13.5. An example of a CTQ tree is shown in Figure 12.

Table 13.5 — Benefits and points to note for critical to quality trees

Benefits	Points to note
Easy to use for presenting and interpreting data.	— None

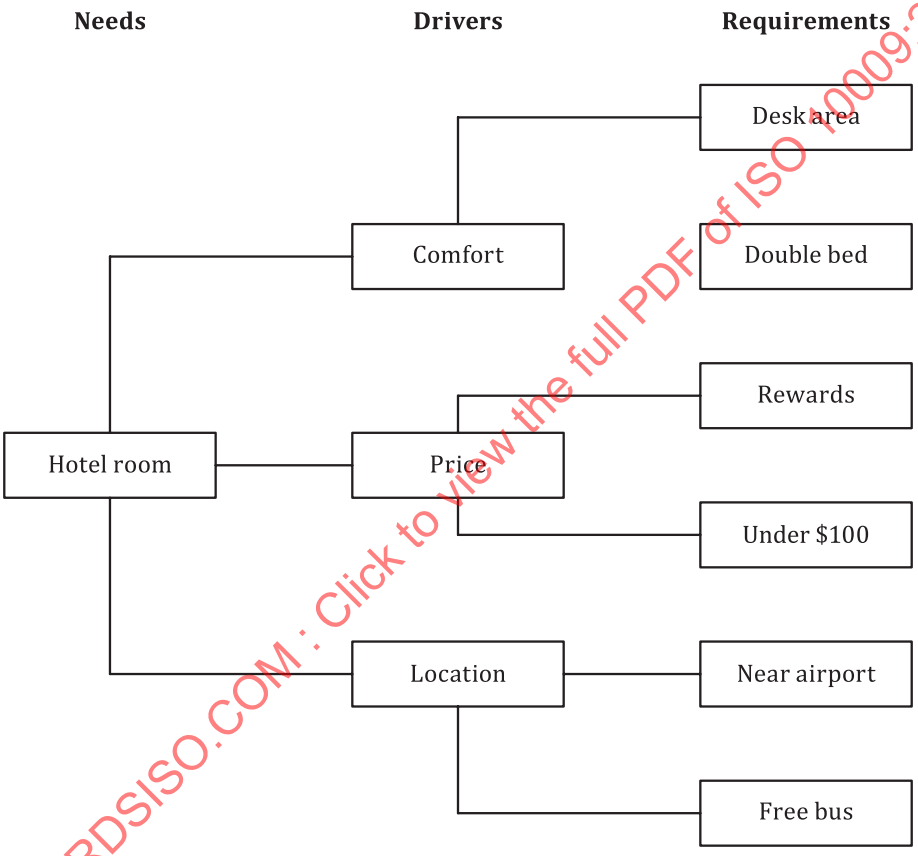


Figure 12 — Critical to quality tree

13.7 Pareto chart

The Pareto chart is used to display the causes that have the greatest influence on the outcome. The Pareto principle, also called the “80:20 rule”, states that the majority (80 %) of outcomes are produced by a few (20 %) causes.

A Pareto chart is used for analyses of data pertaining to, for example:

— costs;

— causes of complaints;

— defects;

— resources;

— risks;

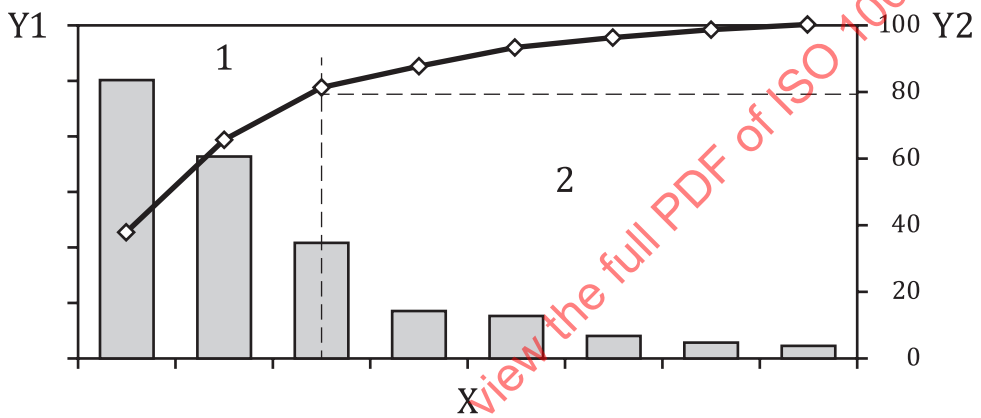
— sources of waste;

— market segments.

Benefits and points to note for Pareto charts are given in Table 13.6. An example of a Pareto chart is shown in Figure 13.

Table 13.6 — Benefits and points to note for Pareto charts

Benefits	Points to note
Easy to use, present and interpret data. Simple mathematics Focus on actions which deliver maximum results (the "vital few").	— None



Key

X	categories
Y1	measure of interest
Y2	cumulative frequency (%)
1	vital few
2	useful many
	category
	cumulative frequency

Figure 13 — Pareto chart

13.8 Gage repeatability and reproducibility (GR&R)

GR&R assesses the capability of a measurement system and is used to estimate how much variability can be attributed to various aspects of the measurement process, such as equipment and persons.[2,23] Typically, repeatability is related to equipment variation and reproducibility to appraiser variation.

GR&R can help to achieve a more consistent measurement process.

Benefits and points to note for GR&R are given in Table 13.7.

Table 13.7 — Benefits and points to note for GR&R

Benefits	Points to note
Identifies the capability of the entire measurement system. Separates the proportion of variability in measurement contributed by the appraiser, equipment and part variability. Can be used to validate the effectiveness of training. Can identify where differences of technique influence the result (e.g. parallax, lighting, instrument deployment).	— The instruments should be suitable for the measurement being undertaken. — The instruments should have a valid calibration. — The measurements should be undertaken in the environment in which they would normally be used (e.g. laboratory, production line). — It is important to understand the system in detail prior to commencement such as is there any "in part variation" (e.g. ovality, equipment or part hysteresis) and design the study accordingly. — Alternative methodologies using statistical tools such as Cohen's kappa exist for attribute gauges/gages.

13.9 Other relevant tools

Other relevant resources include the following:

— analytic hierarchy process (AHP);[66]

— ISO 5725-2.

14 Corrective action/problem analysis

14.1 Root cause analysis (RCA)

RCA[70] refers to various methodologies to understand the cause(s) of a problem with a view to understanding why it occurred in order to prevent its recurrence in the same or other processes. RCA methodologies also seek to understand why the controls (if any) failed to recognize or escalate the problem, and whether the problem is a systemic or random occurrence.

The focus of RCA is on addressing the fundamental causes of problems rather than dealing with the symptoms or on correction of the immediate problem. Benefits and points to note for RCA are given in Table 14.1.

Table 14.1 — Benefits and points to note for RCA

Benefits	Points to note
When root causes are addressed, problems are less likely to recur. RCA therefore has financial benefits.	— A clearly defined problem statement is essential. — In addition to personnel with appropriate expertise, it can be useful to include personnel without experience in the problem area, as they can challenge embedded ways of thinking.

14.2 Decision tree

Decision tree is a model for exploring alternatives and their possible consequences. It is used to arrive at a decision or solution to a problem through a series of defined steps.

The decision tree tool offers a standard process for handling unplanned occurrences. It can also be used in dispute resolution. See an example of a decision tree in Figure 14.

Benefits and points to note for decision trees are given in Table 14.2.

Table 14.2 — Benefits and points to note for decision trees

Benefits	Points to note
Application of a decision tree allows personnel without a high level of knowledge of the situation, process or analytical tools to make the most appropriate decision under specific scenarios.	— The more frequently encountered events should be prioritized.

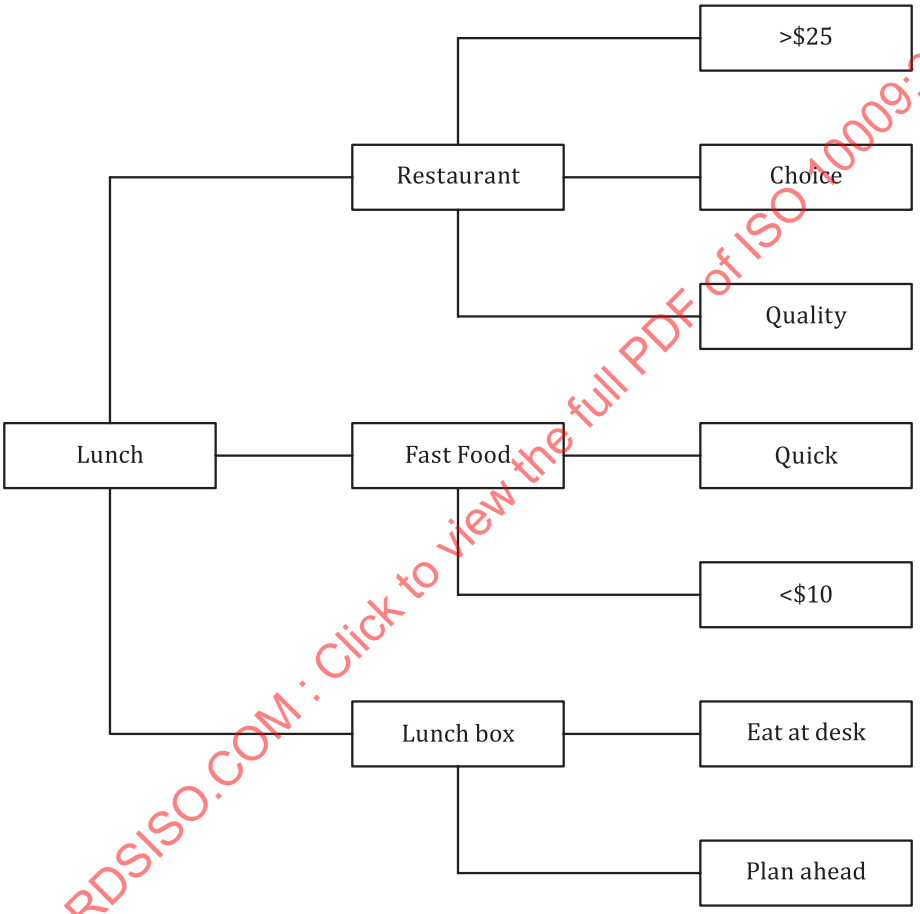


Figure 14 — Decision tree

14.3 Fault tree analysis (FTA)

An FTA is a tool to investigate failures or malfunctions of a process or system. An FTA graphic is constructed by placing the potential or actual undesired event at the top of the tree and the linked dependent components and systems (or events) in a hierarchy beneath. This is visually depicted using standard symbols to display types of dependencies – these in turn can identify vulnerabilities and their locations.

The components and systems can include human elements, software, etc. that are interlinked and together contribute to the totality of the system. See an example of a fault tree in Figure 15.

Benefits and points to note for FTA are given in Table 14.3.

Table 14.3 — Benefits and points to note for FTA

Benefits	Points to note
Displays system relationships and components for a better understanding of a system. Enables estimation of overall system reliability. Reveals dependencies, vulnerabilities and risks.	— The architecture of the system (its elements and their relationships) must be known. — Reliability metrics of each event (component, or sub-system should be known to arrive at the overall reliability metric for the system).

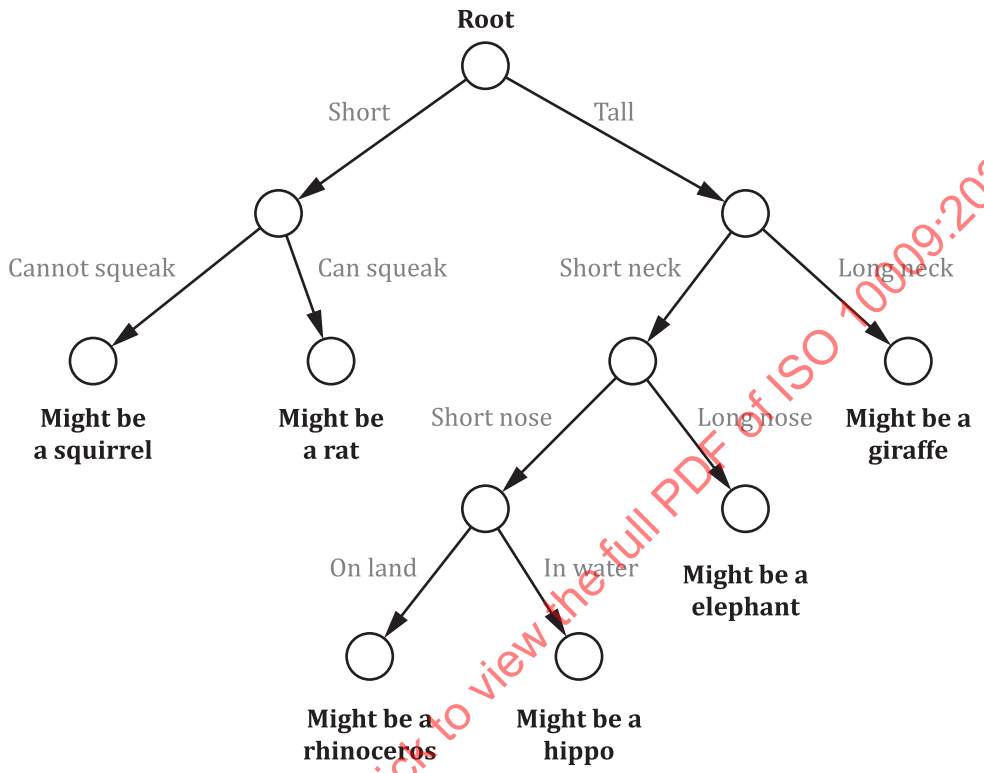


Figure 15 — Fault tree

14.4 Five whys analysis

The five whys analysis is a systematic, structured approach of identifying actual and potential cause(s) of a problem by repeatedly asking "why?" until a root cause is reached. It is possible that at each stage there can be more than one answer to the question "why?", and multiple actual and potential causal pathways can emerge which should be tested with facts, data and evidence to determine which ones are most likely to cause the problem.

The five whys analysis is typically used:

— in root cause analysis;

— where additional potential causes of a problem should be explored.

Benefits and points to note for five whys analysis are given in Table 14.4. The five whys analysis is illustrated in Figure 16.

Table 14.4 — Benefits and points to note for five whys analysis

Benefits	Points to note
Simple to use. Readily facilitates a comprehensive analysis to support decision-making.	— The number of times "why?" is asked can vary. — Five whys analysis should be conducted in parallel to address both causes of occurrence and non-detection.

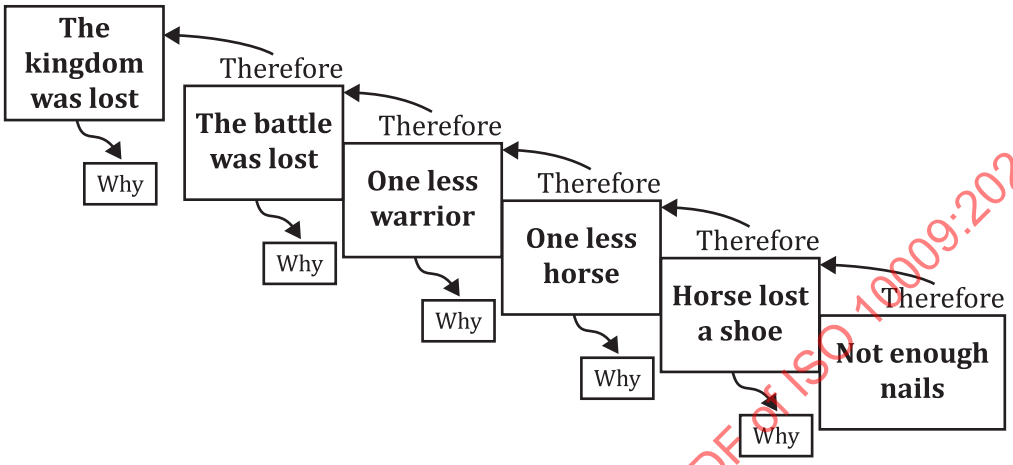


Figure 16 — Five Whys

14.5 Fishbone/Ishikawa diagrams

A fishbone diagram is a way of depicting causes of a situation or event under study. An Ishikawa process cause and effect diagram depicts the causes occurring at each step in the process. See Figure 17 for an example.

Fishbone / Ishikawa diagrams have application in problem analysis and process improvement.

Benefits and points to note for fishbone analysis are given in Table 14.5.

Table 14.5 — Benefits and points to note for fishbone analysis

Benefits	Points to note
Fishbone analysis is a visual tool and is easy to understand and communicate.	— The diagram can have as many branches as are necessary for the analysis.

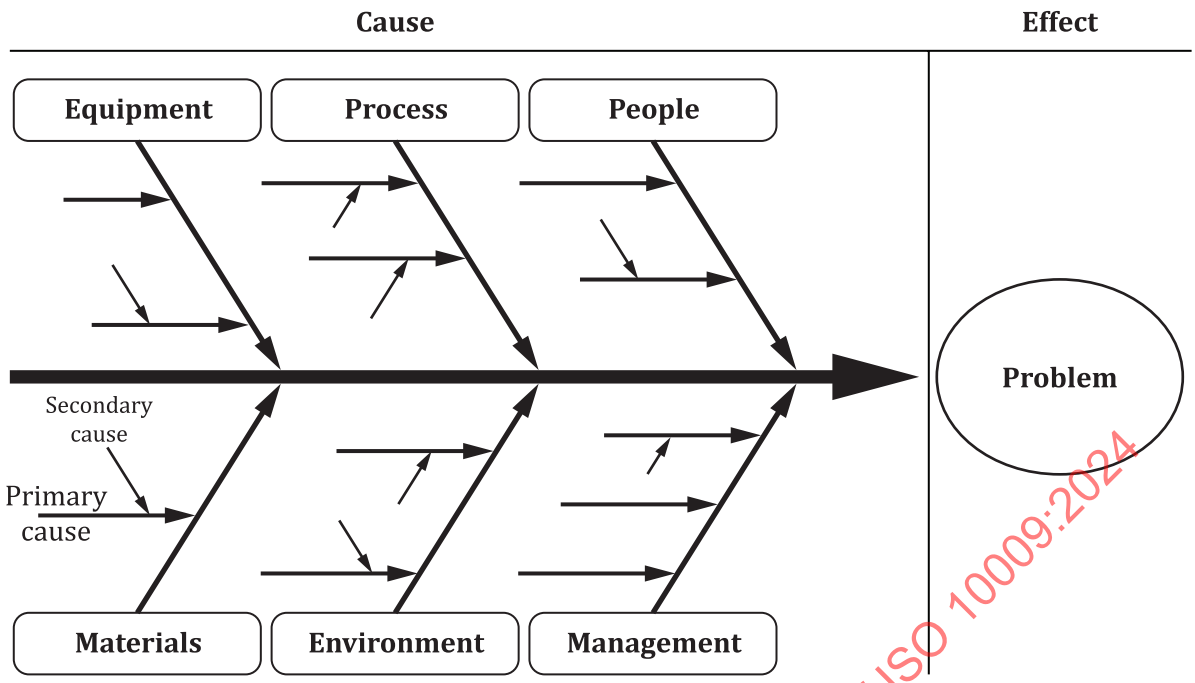


Figure 17 — Fishbone diagram

14.6 Is/is not analysis

Is/is not analysis can help to define the problem statement and supports the first step in problem solving and scope.

Benefits and points to note for is/is not analysis are given in Table 14.6.

Table 14.6 — Benefits and points to note for is/is not analysis

Benefits	Points to note
Easy to use and understand Is/is not analysis helps to better understand and define the problem. What is not wrong is as important as what is wrong. Reduces time wasted though poor problem statements. Helps narrow down the problem area(s).	— The process flow chart, flow diagrams, swim lanes or procedures (see 6.4) can help to structure the process. — The affinity diagram (see 15.2), relationship diagram or mind maps can be helpful to identify scope.

14.7 Other relevant tools

Other relevant resources include the following:

— the solution effect;[67]

— Lewin's force field analysis;[69]

— 8D and A3 charts;[70]

— relationship diagram–entity relationship diagrams;

— mind mapping.[71]

15 Improvement

15.1 Benchmarking

Benchmarking[72] is the process of comparing processes, products, and/or services, within an organization against the performance of other businesses or business units. The aim of benchmarking is to identify risks and opportunities and to support improvement. [15,78]

Types of benchmarking include:

a) performance benchmarking, which involves quantitative measures;

b) benchmarking practices, which involves qualitative information;

c) strategic benchmarking, which involves reviewing future direction.

Benchmarking data and information may be readily available from a number of sources. Benefits and points to note for benchmarking are given in Table 15.1.

Table 15.1 — Benefits and points to note for benchmarking

Benefits	Points to note
Tangible performance improvements in a relatively short time period.	— The choice of the benchmarking topic and its design should be carefully considered or else the exercise may be unsatisfactory.

15.2 Affinity diagram

The affinity diagram is a technique that enables large numbers of ideas to be classified into groups for review and analysis towards a specific objective. Benefits and points to note for affinity diagrams are given in Table 15.2.

Table 15.2 — Benefits and points to note for affinity diagrams

Benefits	Points to note
It is a simple and visual tool that helps to arrive at an action plan.	— The results depend on the quality of the ideas from participants. — It helps to organize ideas but does not prioritize.

15.3 Quality circles / QC circles

Quality circles[16,73] are quality improvement study groups composed of a number of frontline workers (typically 10 or fewer) and their supervisor. The aim is to improve the stability of the process, solve problems and improve capability through the participation of the members of a group directly involved in the activity being studied.

Benefits and points to note for quality circles are given in Table 15.3.

Table 15.3 — Benefits and points to note for quality circles

Benefits	Points to note
Promotes teamwork, ability and motivation. Promotes cross-communication between managers and the workforce. Improved productivity and quality through small improvements Creates a pleasant, vibrant and satisfying workplace. Provides an opportunity to train staff on basic quality tools and foster leadership.	— It is possible that not all members of the company will want to engage.

15.4 Brainstorming

Brainstorming[71,74,76] is a technique for generating and gathering ideas that may be used towards a specific objective through consideration of opportunities, risks or approaches.

The applications of brainstorming can include:

— resolving an issue;

— providing insights to a problem;

— identifying potential/new products, markets, etc.;

— identifying potential root causes for nonconformities.

Benefits and points to note for brainstorming are given in Table 15.4.

Table 15.4 — Benefits and points to note for brainstorming

Benefits	Points to note
Promotes engagement between participants. Allows diversity of ideas to be expressed and considered. Can yield creative ideas towards an objective.	— Too many participants in a group can result in lack of engagement. — Advise participants before the session on the rules of engagement, such as no initial critique of ideas presented. — It can be useful to appoint a trained facilitator.

15.5 Six Thinking Hats

This technique involves an activity in which the roles of participants are identified by six colour-coded perspectives (thinking hats[75]) that people can assume to guide a discussion and to ensure that different perspectives are represented to formulate a solution.

The six perspectives are (1) fact-focused thinking, (2) positive critique, (3) creativity and alternatives, (4) feelings, emotions and intuition, (5) negative critique, and (6) management of the thinking process (facilitator). Benefits and points to note for the Six Thinking Hats technique are given in Table 15.5.

Table 15.5 — Benefits and points to note for Six Thinking Hats

Benefits	Points to note
The hats provide a pathway to recognize and break through persistent habits in the thinking of participants. It yields a better awareness and understanding of different perspectives and rationale on a specific subject.	— It helps to have diverse personalities and ways of thinking across the group. — Peoples' ideas should be respected and recorded effectively to promote continued participation.

15.6 Other relevant tools

Other relevant resources include the following:

— Plan-Do-Check-Act (PDCA);[79]

— capability maturity model (CMM);[80]

— suggestion schemes;[81]

— PICK chart;

— Crawford slip method/use of self-adhesive notes and also SCRUM techniques, see Reference [82];

— BCG (Boston Consulting Group) Matrix;

— Waterfall chart, see Reference [84].

16 Families of management tools

16.1 Six Sigma programme

Six Sigma[12, 84-88] is a statistical concept based on process capability, such that the process spread is well contained within specifications. Given this condition, the resulting defect level will be near zero even with shifts in the process average.

Six Sigma is also an organizational programme to achieve business improvement goals, and to even serve as a vehicle for business transformation. The Six Sigma programme is supported by a management framework designed to facilitate the achievement of stated objectives. The programme typically employs a project management methodology (DMAIC: define, measure, analyse, improve, control) and calls for investment in training in relevant statistical (and other) techniques.

Six Sigma programmes have yielded quantum improvements in quality and productivity, and the expertise gained in training and application is found to yield continuing benefits.

Six Sigma methodology can be adapted to the business needs in, for example:

— problem solving;

— quality or performance improvement;

— cycle time reduction;

— cost reduction;

— aligning the organization's focus and resources to achieve strategic business goals.

Benefits and points to note for the Six Sigma are given in Table 16.1.

Table 16.1 — Benefits and points to note for Six Sigma

Benefits	Points to note
Can yield quantum improvements in quality and performance of processes, products and services. The cost of implementing Six Sigma is typically offset by significant reduction in cost and/or increases in productivity and profitability. Can improve customer satisfaction and increase market share. Applicable to all sectors: manufacturing, software and service.	— Six Sigma programme requires executive commitment and engagement at the highest level. — The programme typically requires financial investment in training in: — management framework for implementation; — statistical tools and other quality techniques. — It is a disciplined approach with clearly defined targets and measures of success.

16.2 Total quality management (TQM)

TQM[17] requires top management commitment and engagement of all personnel to enable continual improvement and customer satisfaction. It is an organization-wide engagement activity ranging from QC circles (see 15.3) and Kaizen (see 8.1) to strategic improvement and innovation processes.

TQM involves a wide spectrum of aspects such as:

— vision and mission;

— cost of quality (see 12.3);

— voice of customer (see 9.2, 9.3);

— voice of process.

Benefits and points to note for TQM are given in Table 16.2.

Table 16.2 — Benefits and points to note for TQM

Benefits	Points to note
Improved customer focus and satisfaction. Improved employees' contribution	— It requires organization-wide adoption.

16.3 Other relevant tools

Other relevant resources include the following:

— Toyota Production System (TPS);[89]

— Dynamic work design (DWD).[90]

Annex A
(informative)

Overview of Plan-Do-Check-Act techniques

Tables A.1 to A.3 give an overview of the Plan-Do-Check-Act (PDCA) techniques for strategy and business planning, process improvement and continual improvement, respectively.

Table A.1 — Overview of the quality tools related to strategy and business planning in the context of PDCA

Plan	Do	Check	Act
5.1 SWOT 5.2 PESTLE 5.3 Porter's five or six forces 15.1 Benchmarking 15.2 Affinity Diagrams 15.4 Brainstorming 15.6 BCG Matrix	5.4 Vision and mission 7.4 Heat maps 8.3 Management by objectives 9.3 Kano model 9.5 Mystery shopper	7.1 SWIFT 8.4 Balanced scorecard 8.3 Management by objectives 9.2 Net promoter score 10.1 Theory of constraints 12.3 Cost of quality 13.1 to 14.6 Tools 14.2 Decision tree 14.7 Solution effect 15.4 Brainstorming 15.5 Six Thinking Hats	14.7 Lewin's force field analysis 6.5 RACI 16.3 Dynamic Work Design 7.2 Risk register 8.4 Balanced scorecard 9.5 Potential gain in customer value 12.2 Visual aids 5.2 PESTLE 5.3 Porter's five or six forces 5.1 SWOT 15.1 Benchmarking 14.7 Solution effect 13.3 Radar Chart

Table A.2 — An overview of the quality tools related to process improvement in the context of PDCA

Plan	Do	Check	Act
15.4 Brainstorming 15.1 Benchmarking 15.6 BCG Matrix 15.2 Affinity diagrams 9.2 Net promoter score 8.3 Management by objectives 10.7 OEE 12.2 Visual aids 14.6 Is/Is not analysis 13.9 Analytical hierarchy process (AHP)	6.1 SIPOC 6.2 Turtle diagrams 7.2 Risk register 9.1 House of quality 9.3 Kano model 14.5 Ishikawa diagrams 14.4 Five whys analysis 10.3 Process wastes	10.1 Theory of constraints 16.1 Six Sigma 12.3 Cost of quality 13.1 to 13.6 Tools 14.2 Decision tree 14.7 Solution effect 15.4 Brainstorming 15.5 Six Thinking Hats 8.3 Management by objectives 10.3 Process wastes 10.4 Work breakdown structure 10.9 Robotic process automation	7.2 Risk register 14.7 Lewin's force field analysis 10.8 Production levelling 8.4 Balanced scorecard 8.3 Management by objectives 9.1 House of quality 9.5 Potential gain in customer value 12.2 Visual aids

Table A.3 — An overview of the quality tools related to continual improvement in the context of PDCA

Plan	Do	Check	Act
8.1 Kaizen	10.2 Value stream mapping	16.1 Six Sigma	14.7 Lewin's force field analysis
16.2 Total quality management	6.1 SIPOC	10.1 Theory of constraints	10.8 Production levelling
16.1 Six Sigma	6.2 Turtle diagrams	12.3 Cost of quality	14.7 Solution effect
15.4 Brainstorming	7.3 FMEA	13.1 to 13.7 Tools	9.1 House of quality
14.6 Is/Is not analysis	11.3 Cycle counts	14.2 Decision tree	13.3 Radar Chart
14.2 Decision tree	11.3 Inventory Turns	14.7 Solution effect	8.4 Balanced scorecard
15.2 Affinity diagrams	12.3 Cost of quality	15.4 Brainstorming	8.3 Management by objectives
13.9 Analytical hierarchy process (AHP)	16.1 Six Sigma	15.5 Six Thinking Hats	9.5 Potential gain in customer value
12.2 Visual aids	14.5 Fishbone diagrams	10.3 Process wastes	12.2 Visual aids
	14.4 Five whys analysis	11.1 Kanban	
	10.3 Process wastes	10.4 Work breakdown structure	