Chapter 2

The Two Modes of Operation of the Company – Operational and Entrepreneurial

The company moves to the rhythm of two basic modes of operation: the operational mode and the entrepreneurial mode [DEC 80]. Figure 2.1 shows the process of moving from research toward the industrial process unit C which is represented by a black square. This new process unit will be integrated into an existing facility where process units A and B are already functioning. This facility includes administrative services such as management, Human Resources (HR) department, purchasing department, shipping and receiving, and so on, support facilities, necessary for its operation such as the treatment plant for effluents, production of utilities, and maintenance.

The creation of the new plant C will induce changes in the host plant:

– technically: increased requirement of utilities, additional means of pollution control, storage, and shipping of the new product;

– economically: development of new overheads corresponding to the new requirements in manpower and maintenance;

– in terms of manpower: it will be necessary to hire new staff, train them, and possibly qualify the existing staff, who will be employed in plant C.

So, the plant and company face their highest level in the existing management when managing new businesses.

The aim of this chapter is to describe the two basic modes of the company: the operational and entrepreneurial functions.

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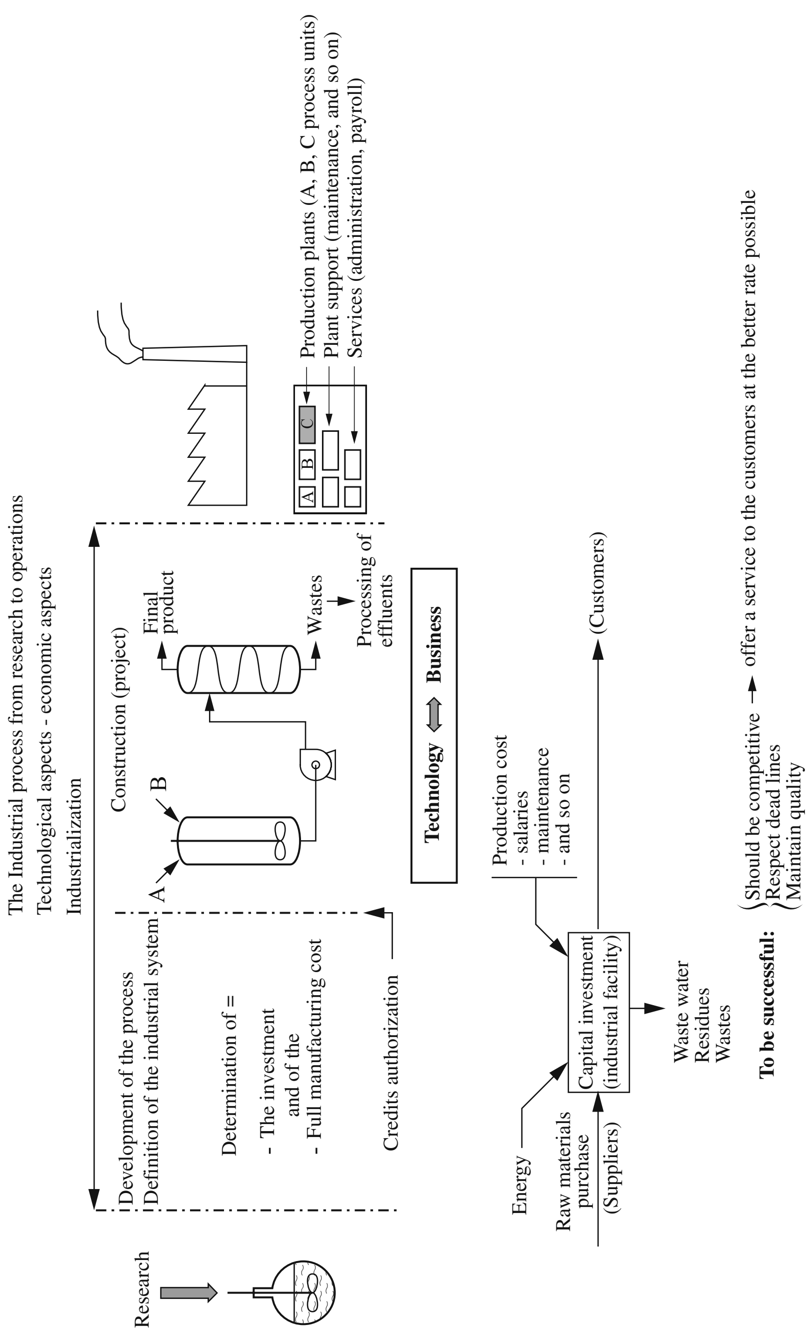


Figure 2.1. *The industrial process*

2.1. Operational mode

The operational mode or management of operations (research, production, administration, etc.) corresponds to the daily management, in order to *generate the profit* essential for the company to meet its current expenses, overheads of which are salaries of the employees, purchase of raw materials and supplies, expenses related to investment, maintenance, repayment of loans and debts, compensation of shareholders, and so on.

The operational mode consists of managing everything currently available in a prudent manner, one might say that it means to make the most of the industrial tools in place. The daily management that perhaps does not have the entrepreneurial glitz and adventure must generate profit and is the "nerve center" of any development.

The company usually monitors itself by using balanced scorecards and by measuring the deviations from the plan and standards.

There is no performance without measurement.

Analysis of sales by volume, price, and margin is the indicator most immediately accessible with the status of inventories and work in progress. It is the most immediate indicator of economic health (good or bad).

The manufacturing site has to measure its specific consumption of raw materials and utilities (steam, water, electricity, nitrogen), overheads, and scrap rate. This is the technical analysis of the operations.

The frequency rate of work accidents, claims, absenteeism, analysis of major dysfunction such as technological accidents and damage to the environment are indicators of its "mental" health. Nowadays, more and more attention is paid toward psycho-social problems; stress which is one of these problems is a phenomenon that is spreading more widely with some serious consequences on individuals and the company itself.

Do not take the term "daily management" as "day-to-day" because it is actually about measuring, evaluating the performance of the company over time, comparing with what was expected (objectives), drawing lessons from it and taking the appropriate corrective action.

2.1.1. *Management – company structure organization – organization chart*

2.1.1.1. *Management*

R.A. Thiétard [THI 99] defines management as "the act or art or the way of leading an organization, managing it, planning its development, and controlling it".

The author states that the word management probably has the same Latin origin as *ménagement*, the 16th Century French word, derived from *ménager* and which means set carefully and skillfully (Petit Robert dictionary, 1976).

Management applies to all areas of business operations. Its essential components are as follows, according to the same author:

– planning;

– organization;

– activation;

– control.

The company management lies within a world that is increasingly unpredictable, complex, and paradoxical. The management must adapt to take into account globalization, hyper-communication, and new requirements in terms of liabilities with respect to the environment and sustainable development. The company must be *agile* enough to meet these new challenges.

The world is no longer dependent on the Western culture resulting from the Europeanization of the world, as we have already mentioned in the chapter on the history of the company.

Globalization – “glocalization” to use a neologism – mixes cultures. The company has to consider this both in its home country and in countries where it operates.

This new situation is particularly palpable in the *headquarters* of multinationals where there can be executives of all origins, an Italian may be in charge of the Asian sector, an Asian of North America, and engineering entrusted to an American. Is there any wonder that English has become the language of business? These people need to know the company, understand its organization, goals, values, and skills. They must understand whom they work for and who is working for them.

Organization charts, job and function descriptions should be brought to the attention of all. The following section aims to explain this briefly.

2.1.1.2. *Corporate structure – functions*

For Pierre Conso and Farouk Hemici [CON 01], “the company is a particular form of organization. It is an organization whose aim is to produce and exchange”. “An organization is an association that proposes specific goals” (Petit Robert dictionary, 1996). The organization is undoubtedly the most visible part of management [THI 99].

Structuring an organization means:

– defining the tasks to be accomplished and the human and financial resources to achieve this;

– establishing the means of communication, coordination as well as the different functions and individuals within them;

– energizing the individuals; this is activation according to Thiétard.

2.1.1.3. *Functions*

A function is defined as a set of activities bringing together skills of the same type (production and finance). A century ago, Henri Fayol distinguished six functions: administration, technical, commercial, financial, security, and accounting functions.

One can classify the functions into three categories:

– operational functions (*online*);

– support functions (*on staff*);

– transverse functions.

The *operational functions* include:

– top management;

– purchasing;

– production;

– logistics (distribution)/*supply chain*;

– marketing/sales.

The *support functions* include:

– human resources;

– finance;

– administration with management control, information technology, accounting, agreements and legal department, and communication;

– audit;

– research and development.

The *transverse functions concern*:

– quality;

– health, safety, and the environment (HSE).

Each function contributes to the studies, projects, major decisions, implementation control, and so on. Under the same name the same function can have its nature, degree of freedom, style, mode of operation, responsibility, and connection to the top management vary greatly depending on the company.

Thus, industrial management can be either *online* (hierarchical), that is to say, in direct charge of the plants and take responsibility for production, or "*on staff*" (functional liability of staff) and have a "dotted line" connecting with the industrial "*online*" major divisions to share experiences, identify issues for industrial development, working methods and to ensure the general development of the execution of the domain.

The size of the company also has a considerable impact on the segmentation of the organization; in a small company, the same person can have multiple "duties". For example, a boss can act as both Chief Financial Officer (CFO) and Director of Human Resources (DHR).

2.1.1.3.1. Operational functions

Chief executive officer

The Chief Executive Officer (CEO) embodies the power; he has the power of decision-making. The function of the top management also has a legal status: they represent the company as a corporation. The Chief Executive Officer is the main contact for shareholders who elected him which ensures his legitimacy. He is also the boss of the company in the sense that he is the supervisor of all the employees.

On the basis of the size of the company, top management may include Vice-presidents (VP), who have decision-making power in their respective fields. The CEO, VPs and the bosses of large support functions (HR, CFO, etc.) constitute what is commonly referred to as the board of directors, the executive committee, the strategic committee, or the *corporate*.

CEO styles change depending on the individuals. A corporate culture: the result of years of "cohabitation" is difficult to change: it takes several years to curb it. The CEO can be very authoritarian and centralist or, on the contrary, may tend to decentralize or delegate.

Corporate size can vary in large proportions. If the CEO wants to control and measure everything, he will tend to surround himself with a powerful *corporate*, very often not well recognized by people online who do not perceive the added value. *Corporate* controls will be exercised by multiple reports, many meetings, and committees of all kinds. It may cause dilution of liabilities, lack of entrepreneurial spirit, a gap will separate those who know and those who do. A very small *corporate* tends to motivate the performers who feel "empowered" with a risk of lack of control and therefore slippage.

There is no quick fix. Everything depends on the people, the organization in place, and the corporate culture. We should also note that the management style can be very authoritarian and litigious in sectors which are in crisis or non-profitable and much more flexible in high growth sectors such as might be the case in the branches of high-growth countries.

The representation of the company

The CEO is the sole authority of the company. He has the signature authority in the corporation. He commits the company to third-parties when purchasing a company and signing major contracts. The CEO does not specifically seek the agreement of the Board before taking a major decision. He can justify it *a posteriori* to the Board who can sanction it.

The CEO reports on the results, justifies his actions, proposes a course of action, and defines the major objectives for the forthcoming years. He plays out his own future. A shareholder buys and sells the shares in the company following what he thinks to be his personal interest but, if the shareholder is *volatile*, the company is normally *stationary*.

The CEO represents the company to the media whose importance will be increasing. The company mostly considers him to be its president. In the role of spokesperson, the CEO appears in the press, appears on the radio and television. From this point of view, next to the obligation of results, the ethics of the company are becoming more important.

Finally, the Board can lobby at a government, political, union level, and so on.

Definition of the strategy

The Board is responsible for the corporate strategy, as we have defined it. It is important to define the broad guidelines and the main areas: amalgamations, assignments, partnerships, and major projects are a reflection from the general public and shareholders of such shares.

Management and outcomes

The Company has an obligation to produce the results, the shareholders have entrusted money and want to take dividends from it or profit from the increase in their capital. For this, the Board is in charge of the overall organization of the company, its structure and mode of operation. The budget has a specific importance: mandatory approval by the Board, it engages all stakeholders in the company. It is responsible for appointing executives to key positions.

The Board must, increasingly, define an ethic, thereby setting the values of the company: economic values, with performance targets (such as return on capital incurred); social morality toward individuals (respect for humanity, freedom from discrimination, compliance with laws, etc.), the environment (no major pollution, no catastrophic accident, a policy for product stewardship), and third-parties (business practice, attitudes toward developing countries, etc.).

One of the roles of certain support functions and the transverse processes is to ensure the consistency, compliance with procurement, and regulations that the company has to set up.

Purchasing – supply department

According to M. Darbelet [DAR 98], the procurement functions are to provide the company with the goods (raw materials, finished or semi-finished products) and services necessary for its operation at low costs, and within deadlines responding to the needs of the company. It therefore determines the profitability, quality, and price of the products sold, production, and delivery times. It belongs to the logistics/*supply chain* of the purchasing function whose role is to:

– evaluate, select suppliers, and supply;

– negotiate with suppliers;

– order;

– monitor and receive the order.

The modern approach is about establishing buyer-supplier-partnerships. The company then seeks to gain a competitive advantage by establishing strategic relationships with a limited number of suppliers, especially due to the fact that some so-called strategic raw materials are in the hands of a limited number of suppliers, or even countries. Globalization and the emergence of some countries led to a fierce competition that aggravated the depletion of natural resources.

Some raw materials such as copper may be at risk within 10 years, their prices soaring, reflecting the shortage, and speculation. It is not just oil/petroleum that will cause problems!

Manufacturing

The production system is the heart of the industrial company as its equipment and plants will release the finished goods, the basis of creation of its wealth.

The typology of means of production is extremely broad. Petroleum refining, the assembly of an Airbus, household appliances, pharmaceutical chemistry, crafts, and printing will make use of very different tools, methods, and organizations. In addition, as mentioned earlier, the company raises the question of whether to do it themselves or outsource (it now uses this term rather than contract out).

It also raises the question of where to produce? In a global economy, the question amounts to asking whether to produce abroad. The manufacturing process cannot be conceived without the procurement, distribution, and maintenance processes.

In the first approach, we can distinguish the *process industries from the manufacturing industries*. *Process* is often synonymous with continuous, because large process industries (oil/petroleum, heavy chemicals, cement industries) work in continuous flow. The manufacturing industry produces discrete, that is to say, unique products that can be extremely large in number and can be of various sizes (cars and bolts). Contractors make a unique project for a client; this is the case of engineering and construction. Their operational mode is based on project management.

The process industry talk about processes and they are studied by research and development (R&D) and industrialized by an engineering and design department or by engineering firms. It is the planning department that, in the case of manufacturing industry, defines the process (line) and equipment to implement. Managing the production system is managing people, workflows, and techniques. Scheduling, a real conductor, is responsible for managing all the phases of manufacturing, including those assigned to subcontractors, taking into account the constraints of the industrial tools, procurements, inventories of finished goods, and work in progress. The concept of flow, now managed by the ERP (see below), resulted in the concepts of production following the principle of “just in time” (JIT), discovered by the Toyota Company in the 1960s. This is a “pull system”, supported by the downstream, i.e. by customer demand. One does not produce for the sake of it, but only what is necessary to avoid creating stockpiles beyond the necessary. But there must be good estimates, at the risk of losing sales if there is a surge in demand.

The factory or the plant is inconceivable today without a quality program and HSE program. Compliance with procedures is most likely one of the essential features required in manufacturing. We cannot imagine a successful company without a performing manufacturing tool. Companies and countries that have ignored it have lived to regret it, for example, the United States, a country of “great American cars” invaded by Japanese cars.

Performance, besides the pure technical success includes “zero defects”, whether in quality, safety, environment, and waste.

Let us also recollect that the production system can sometimes require very large investments relative to turnover. Strategic investments, whose profitability will be effective (hopefully) after long years, can be a significant source of risk.

Logistics (*supply chain*)

Logistics, a relatively new term introduced recently into corporate vocabulary, now refers to all flows irrigating the company: financial flows, physical flows of raw materials and finished goods, as well as information flows. The flow of information relates to the domain of transportation, storage, import-export, IT, and so on.

Martin Christopher [CHR 92] is the developer of the *supply chain* concept, which states that: "*The goal is to link the market place, distribution network, manufacturing process, and procurement activity in such a way that the customers are serviced at higher level and yet at a lower total cost*". This is a very promising concept of a systematic vision of the company, its suppliers, and customers.

Sales, marketing

The commercial function is one of the key interfaces between the company and its environment. Usually, this function includes the trade itself, with its network of sellers (sales force in direct contact with the customers) and marketing. The latter is in charge of market research, and includes product managers, advertising. The sale in a larger sense includes a major number of operations:

– managing the sales force in market segments, countries;

– distribution of products;

– processing of orders and billing;

– logistics and sales administration;

– statistics, scorecards, planning, inventory management, procurement, and after sales service.

2.1.1.3.2. Support functions

Human resources department (HRD)

From a policy defined by the Board, the HR department must ensure that the company has the necessary human resources in terms of quality and quantity, and in time in order to ensure proper operation. Staff motivation is an essential component.

Management of personnel

Employment

The employee is related to the company by an employment contract which, apart from the status of the post, location, and mission, defines the salary. Salary may have, especially for executives, a variable part related to performance.

Career management and training

A career cannot be envisaged today without variation, the expatriation of which is an important variant. It equally cannot be considered without further training to upgrade the knowledge and adapt the employee to new assigments.

The definition of the job is a complex issue. It has a technical component, skills, and human components: leadership, accountability, initiative, and so on.

Social and legal obligations

Relationships with unions and the settlement of social conflicts are a major component for businesses of a certain size.

The HRD has a role of collective management of the employees and management of individuals. It must play a major role in all processes of corporate restructuring, i.e. *re-engineering*. New forms of organization require the necessary support to redefine the responsibilities and relationships between the individuals and cannot do without a HR worthy of the name.

Finance department

The finance department makes use of the data provided to it by accounting (see below). As a result, there is some confusion. Accounting in itself is pure and simple. The finance department is involved in the management of the company and, as such, it interprets the results and, sometimes, it gives the result for publicity in media!

The main goals of the finance department are:

– to control the capital of the company, the financing plan;

– to maintain financial equilibrium. It manages cash, which reflects the creditworthiness of the company. The company needs cash to meet its commitments: without cash, there is a stop in payment, that is to say, it can no longer pay its debts that have reached maturity;

– to seek means of funding.

In the case of major investments, the finance department shall make the calculations of profitability, research funding, and assess the risks of the investment. A new word has appeared, finance engineering, which includes fund raising, banking portage, *leasing*, and so on.

Currently, the CFO is very often found alongside the CEO in boards and presentations of results to the specialist press, which reflects his importance.

Administration

Management control

Management control has gained considerable importance in most companies. Its role is to collect information on regular dates, process it, and inform the CEO using balanced scorecards and indicators. The budget of the company is one of the main items of control. The budget is established for the calendar year based on hypotheses, like growth of the country, market trends, evolution of exchange rates. It is part of management control to attract the attention of the CEO on deviations with respect to the forecasts, to explain and sometimes propose solutions.

Information technology (IT)

IT is a major technological revolution of the 20th Century: no company can do without it. Software companies claim that the future belongs to those companies that will master this discipline. It is difficult to contradict it, as the management of the company depends on it.

IT manages all financial flows and human and material resources, to provide the current situation, analyze performances, and so on.

Computer technology has created new management methods. ERP (Enterprise Resource Planning) integrates accounting, business management, procurement management, and production not to mention e-commerce (e-business), which creates a new type of relationship between the company and its customers.

To paraphrase a famous saying, we can say that if the computer is a good servant, it is a bad master, as it serves the company and not the other way...

The role of the IT department is to choose and adapt the ways of processing information that its “customers” need, and to ensure its maintenance, in other words to adapt the systems based on the needs.

Accounting

Accounting aims to provide information for the company. It is divided into two categories:

– general accounting works across the company. It periodically updates the status of assets (balance sheet and income statement). It measures the financial flows in and out. In this context, it meets the legal requirements, which is the tax return;

– cost accounting focuses on the business, operating cycle, product costs, overheads of plants, and so on. It is an essential element in managing the business and all related matters in general.

Large groups are required to present a consolidated balance sheet, that is to say, to take into account their subsidiaries or holdings. The newspaper *Le Monde* on August 7, 2002 ran an article entitled "Accounting standards in the heart of stock exchange scandals". The collapse in world stock markets in the summer of 2002 is attributed to a lack of confidence of shareholders with respect to the companies after the collapse of Enron, Aol.com, and Vivendi Universal. It is the lack of visibility and difficulty of reading the results that are at the root of these problems, which involve billions of dollars.

An essential but difficult element is the evaluation of assets. Some large companies have bought other companies at increased rates, sometimes well above their *real value*. This is the famous *good will*, synonymous with overrating.

The crisis which began in 2009 after the collapse of Lehman Brothers in September 2008 shows the opacity of certain banking operations, their derived products where no one can find their way around, a system where the central profit of the capitalist system leads to excess; a strange paradox, as capitalism seems to be the only viable system since the advent of the Industrial Revolution.

Legal – intellectual property

The activities of the company that involve third-parties are the cause of a multitude of contracts to be drafted in accordance with the laws of the countries where they operate. This may include contracts for supplies, engineering contracts in the case of construction of physical assets, subcontracts, services (security, maintenance, etc.), and so on.

Joint-Venture (JV) has a particular character. Let us consider the example of a company that wants to practice in a new country, it chooses to partner with a local company that puts at the disposal of this company, its sales network, means of production, and so on.

Many Western companies have thus moved to settle in China, India, Japan, and other Asia-Pacific countries. These operations can sometimes be difficult if commercial success is not attained or if promises are not kept. In these cases, the *Joint-Venture* contracts are critical. It is not always easy for "Western" expatriates to live with it!

Intellectual property of the company is protected by filing patents and trademarks. *In the US, the* “Lawyer” *is a key player in the company, nothing can be done without his advice. This reflects an aspect of American lifestyle where the “Judicial quarrel” is pervasive. The American wants his* “*civil rights*” *to be the guarantee of his* “*liberty*” *as honored*.

Communication

The company must make its products known (advertising, brochures, leaflets, booklets, etc.), give off an image that attracts the shareholder, and thereby facilitating the hiring of senior executives and especially young graduates. This is called external communication.

Internal communication is intended to inform all employees of main events, the *success stories* to create a *sense of belonging* and pride, an easy role to play when things are going well, but difficult when things go wrong.

Audit and expertise

The Board can attach an audit function which is responsible for checking the application of procedures in place (including accounting procedures), the quality of information issued, contract enforcement, the integrity of assets, and so on.

Internal audit is generally composed of a multidisciplinary team of bright young graduates led by the seniors: it enables the newly hired young people to quickly understand the business from each and every angle.

The *external audit* is performed by qualified persons outside the company, including accountants and auditors, who have a legal role. The Board can also be attached with experts, industrial management is an example of this.

The purchase of assets and companies requires a particular audit. It is necessary to know the value of what one is buying and what can be taken from it, and assess the risks and opportunities over time. It is about the comprehensive diagnosis of the property to be bought, in terms of human potential, technologies, markets, products, and organization. The term *due diligence* refers to such essential but difficult activities! Multidisciplinary teams must get an idea what one plans to purchase over a very short time!

Research and development (R&D), innovation

R&D covers different concepts according to the company. It can be basic research that is about data acquisition which can be used in the future. It can be about applications if one tries to find the applications for existing products or to meet the needs of customers with existing products. Large groups often focus their resources on impressive R&D centers, a real showcase of the company. To survive, the company must innovate; that is to say, find new products or new applications for existing products. In chemistry, a purer product can satisfy new markets: electronics, for example, required the provision of ultra-pure products.

Research is also at the intersection of marketing, production, and sometimes purchases and sales. Research is now conducted in a project mode, that is to say, the effort is targeted and the result is measured. The improvement of existing processes can lead to significant gains.

One way to measure the effectiveness of the research is to see its contribution margin to turnover (sales) and profit. The research may represent 1% of sales for traditional companies and 12–15% for high technology companies (such as pharmaceuticals) and almost 100% for some small size start-ups.

It is not just the research that provides ideas. Ideas come from the market and manufacturing as well. Continuity in research is a delicate problem: should one continue or abandon? Breakthrough analysis shows that technological *breakthroughs* take years of effort.

This is nothing new since Edison: "*Invention is 99% perspiration, 1% inspiration*".

2.1.1.3.3. Transverse processes

Organizations become increasingly more matrix, as they become more and more global and more and more complex. The search for dedication of individuals leads to structures called "flat", that is to say, with a limited number of hierarchical levels. The decrease in the number of "managers" leads to a lack of control which is replaced with the establishment of transverse procedures of "governance". Let us cite areas concerning quality and HSE.

Hierarchical power – influence – expertise

Strictly speaking, the "Corporate", whose role is governance, derives its legitimacy from its proficiency. The interfaces are sources of conflict: these conflicts are inevitable and must be managed.

2.1.1.4. *The organization*

The division of labor is necessitated by the physical limitations of individuals – one person cannot do everything! – and the need for different skills – one person cannot be competent in everything!

The organization chart displays the organization of the company by establishing graphical hierarchical relationships and functional entities within it. We are going to describe the three basic organization charts in the following.

2.1.1.4.1. Organization by function

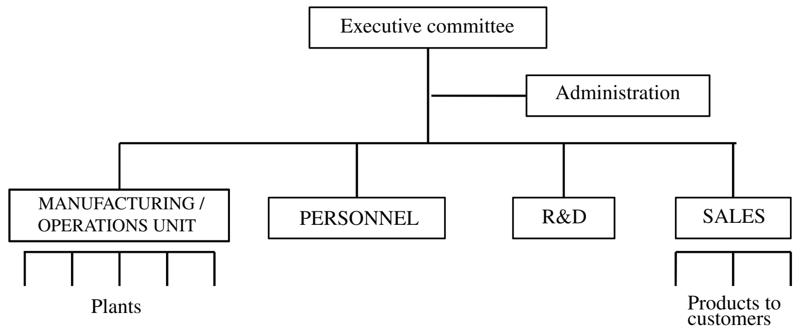


Figure 2.2. *Organization chart of organization by function*

Organization by function is an old type of organization which is directly inspired by “Fayolism”. The same skills are grouped under the same management, whether it concerns production or sales.

2.1.1.4.2. Organization by operation

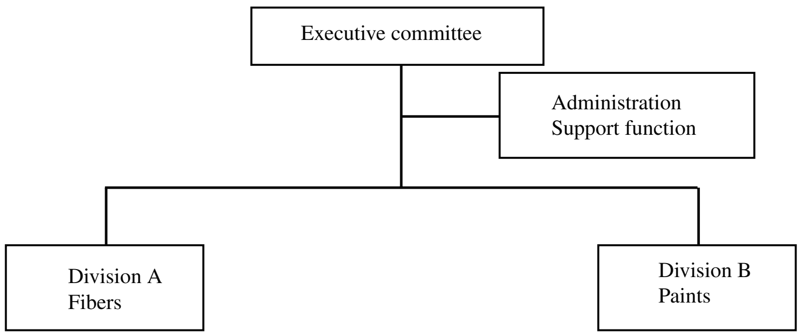


Figure 2.3. *Organization chart of the organization by operations*

Organization by operation is market oriented. Each division is a practically independent company, managing its own plants, sales, marketing, and sometimes its research. Divisions pool the functions of Board (HR, legal, etc.). Engineering and research, among others, are pooled to achieve the critical mass of expertise and experiment equipment.

NOTE.– Divisions are commonly named SBUs (Strategic Business Units).

The "internal agreements" are passed between the divisions and corporate functions, neither without difficulty nor without much debate and lamentation (everything is too expensive! The competence of players is criticized).

This type of organization was established for the first time in the United States by DuPont de Nemours in 1921 [NDI 01]. It was, for this company, a managerial revolution that would allow the company to return to profit! Quotes from the book by Pap Ndiaye:

– "the industrial departments were from then focused on products rather than functions";

– "the department of paint and varnish, for example, was henceforth free to choose the marketing strategy that suited it";

– "departmental decentralization was an unexpected consequence, the continued existence of the cultures specific to each department".

There would be at DuPont the culture of the mechanics (explosives), the culture of the chemists (dyes), and the culture of the chemical engineers (ammonia technology of high pressures).

2.1.1.4.3. Matrix organization

Matrix organization has emerged because of the importance that the concepts of product-market and globalization have taken. A product can have many applications and can be used in different markets. Thus, a biopolymer can be used in formulations for cosmetics, drilling muds, paints, and food ingredients: it will be marketed by different divisions and trade-offs are often necessary.

The function of the *product manager* is a relatively new concept; the person concerned has a transversal, cross-divisional, cross-market role to promote his product, he intervenes in manufacturing, research, and marketing.

The organization chart shown in Figure 2.4 illustrates a multinational case to gain a foothold in Asia. Largely staffed divisions A and B in the home country are undeveloped in Asia. They are therefore grouped under the same management; this "local" director has two bosses in the home country who will lead a global policy, and he will report to the "Asia" CEO who could be Asian.

The *industrial manager* will have many people to interact with! The plant manager will receive many visitors who want to see the process units at the origin of the product they are dealing with.

The matrix operation is far from that recommended by Henri Fayol: knowing that each individual has only one boss! Let us add to this the culture shocks and we will measure the difficulty to create cohesion in the business once it acquires a certain size. It is the role of governance to ensure the cohesion of the company by sharing common values with its players.

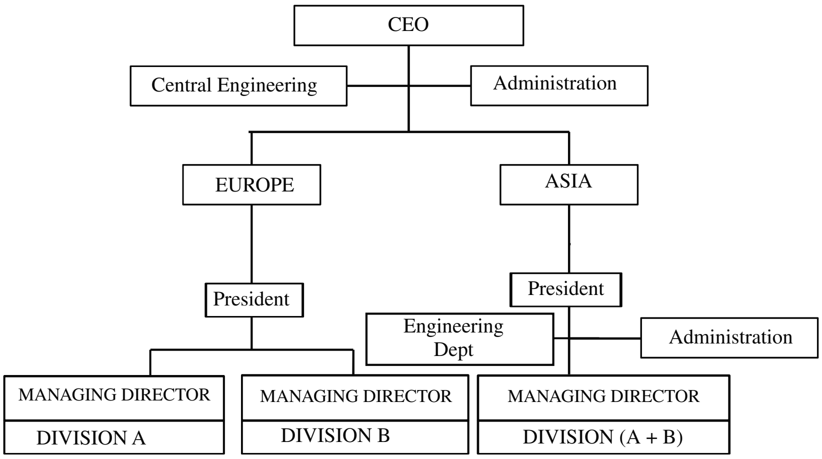


Figure 2.4. *Organization chart of matrix organization*

2.1.2. *Corporate governance*

The concept of governance is relatively new and results from the inclusion of the concept of sustainable development in the management of the company, thereby trying to be transparent and "democratic". The term "democratic" implies that decisions will be made after consultation with the majority and for the general good.

Governance can thus be defined as a set of *best practices*, or procedures that will allow the *governance* of the company with a set of *ethics*, hence conforming to a set of affixed *values*. Governing includes both setting targets and *measuring* the differences between planned and actual ones.

In the following section, we will focus on two major tools of governance related to *quality* and *HSE* (health, safety, and the environment).

2.1.2.1. *Quality*

The concept of quality is as old as the world. The saying "a satisfied customer is a customer who returns" has probably been around since the beginning of time. Quality implies two components: customer satisfaction, the end user, and avoiding wastage during manufacturing. Both are related: the quality of the finished product requires control of the industrial process that involves both machines and operators. What happened at the Hawthorne plant is significant.

A little bit of history - the Hawthorne plant (Chicago)

The plant belonged to the *Western Electric Company*, a subsidiary of *Bell Telephone Laboratories*, and largely produced telephone equipment. It was a flagship and experimentational plant. In the quality department, created in 1924, Shewart invented the first control card.

Samples were taken at regular intervals along the production lines; their characteristics were analyzed statistically to alert the managers and workers about the possible slide of the manufacturing process. This was the beginning of *statistical process control* (SPC).

SPC would be of great importance during World War II, in weapon production. Its success continued uninterrupted in the years that followed and was the basis of the modern Six Sigma approach.

It was in the Hawthorne plant that Juran, Edwards, and Elton Mayo, one of the founders of work sociology worked. They can be regarded as the fathers of modern quality control and SCP (see Box 2.1).

We will return in Chapter 10, devoted to “Japanese methods”, to quality approaches in the land of the rising sun, methods that Deming and Juran largely contributed to putting in place. We will discuss Deming in more detail.

To make it simpler in the following, we will not use standard notations, but we will just define a few terms. The purpose of this chapter is not in fact to make the reader, an expert in quality but, hopefully, to interest him in it, and to awaken in him a concept of considerable importance.

2.1.2.1.1. Quality: basic concept

The maxim: “quality is customer satisfaction” summarizes the purpose of this concept. There are many definitions of quality, among them: “Quality is saying what you do, doing what you say”, is the one which implies that the company has implemented procedures after analyzing all its processes. We will return to the concept of the process in Chapter 13 devoted to “Change Management”.

To simplify, at this stage, let us say that a process is an identified activity, like placing an order, launching a product, analyzing a finished product, and so on. A process can be described by a procedure or a set of procedures that are *written* documents.

William E. Deming (1900–1993), a statistician, was one of the greatest figures of modern quality control. He integrated quality in the management system of the company as summarized in his famous "14 points". This was the beginning of TQM: *Total Quality Management*. Deming was regarded as a demigod in Japan. The Japanese have founded the Deming Prize for quality.

Joseph M. Juran (1904–2008), an electrical engineer, published the "Bible" on quality management in 1951. This book was reprinted several times. It covered all the aspects of quality and that was applied for a wide variety of companies. He was invited to Japan in 1954 and he predicted in 1966 that Japan would become a champion of quality in the following 20 years.

Armand V. Feigenbaum (born in 1920), a statistician, published *Total Quality Control* in 1951. The success of this book is undeniable. We owe to him the concept of the hidden plant, i.e. the proportion of plant source of off-spec products.

Peter F. Drucker (1909–2005), a prolific author, was a consultant at very large companies and had worked for the Wall Street Journal from 1975 to 1995. He was one of the big-shots of international management.

Philip B. Crosby (1926–2001) invented the "zero defect" concept. He established the principles of cost of quality and non-quality.

Box 2.1. *The great masters of modern quality control in the US*

Let us consider placing an order for some goods: Who expresses the need for it? Who selects the suppliers? Who approves the final choice? Who receives the goods? Who authorizes the payment?

Quality is also about providing the customer with a tangible or intangible product (result of research, software), a service (bank loan, rental car, etc.), *at the price he is willing to pay*.

To use an old image, quality is not selling a Rolls Royce at the price of compact car nor vice versa: selling a compact car with the quality of a Rolls Royce. The customer has acquired the concept of quality/price ratio. The goal of the value analysis is to optimize this ratio. *Quality is customer satisfaction at the right price*.

2.1.2.1.2. Quality assurance (QA)

The term quality assurance can be misinterpreted; it lies with the company to implement a number of steps to ensure the customer is *assured* that the company with whom he is related is doing “quality” work. It is about creating a sense of *confidence* among the customers.

The customer who visits a supplier and finds a good reception, good organization, and proper settings will trust it from the beginning.

2.1.2.1.3. Total quality management (TQM)

The modern concept of quality includes *all* processes of the company. Today, one tends to prefer the term *process* to function; “Process” has a connotation of added value and a broader sense that “function” does not have.

There is talk about *quality control*, QA (*quality assurance*). TQM (*total quality management*) is the term most widely used today. We *manage* quality and we *manage* using quality.

Quality, is doing it right from the beginning, faster, better, and more efficiently than the competition. Quality has become an economic weapon, and it must provide a competitive advantage. The modern company must satisfy its partners and “*stakeholders*”, that is to say, all those who have a stake in the company:

– customers, in the classical sense. Without them, there is no business;

– employees: they are the engine of the company. Without them, nothing happens;

– shareholders: they placed their money and thus their confidence in the company;

– suppliers: they are increasingly partners who contribute to certain processes of the company such as design, maintenance, and distribution;

– society in the broadest sense: the country, governments, communities, and certain NGOs.

We must not forget to mention the people who are close to dangerous plants.

The image of the company depends on what its *stakeholders* think of it: *profit no longer justifies everything*.

2.1.2.1.4. Establishment of a quality management system (QMS)

The quality management system (QMS) comprises all procedures from the top of the hierarchical pyramid to the base and allows everyone to know what to do and how to do it. The individual knows what to expect from the upstream and knows what to give to the downstream of the organization.

The company that decides to have a quality approach will select a *system of reference* and implement it by making the most use of external consultants or training part of its staff in order to create an infrastructure of experts who are guarantors of the QMS.

The success of such an undertaking, whose establishment can last over 2 or 3 years, requires the commitment of management. This is the *sine qua non* condition, without which the fight is already lost. That is why the Board may decide that the quality manager must report to them.

A set of procedures will constitute the "quality manual" of the company. If the system of reference chosen is ISO 9000 (see below), the quality manual will be configured as described below.

2.1.2.1.5. Documentary structure of the quality management manual

Authority giving the final agreement	**Document structure**	**Document's field of implementation**	**Availability of documents**
Management Executive team	Level 1 Management manual	Handbook of quality management	Clients
Quality department	Level 2 Process	General organizational procedures	Customers (documents consulted on the spot)
Head of department	Level 3	Implementation handbook Process description	Documents Absolutely confidential "Operators only"
Quality department and related services	Level 4 recording – filing		

Table 2.1. *Documentary structure of the quality manual*

The documentary system has a pyramidal structure. The top level generates the documents of the level that is directly beneath it. This manual can be the manual of a company, a plant, a division, or a business unit. The principle of *subsidiarity* is necessary; which implies that an activity is executed by the appropriate level that is "*as low as possible*".

Let us provide an example: a foreman must have the organizational chart of his process unit and the list of his staff up to date. It can vary several times a year after hiring, transfers, and departures. He must be at level 3. Otherwise, in the spirit of quality, one must modify the materials at a rate that is unacceptable as it is unnecessary.

Quality systems have led companies to loss by overabundant procedures. Nobody knows where they stand, everybody is confused!

The company that embarked on the "quality journey" seeks an *accreditation*, that is to say, a certification about the fact that the procedures in its QMS are actually followed in the field. It will be for outside agencies, generally independent, to issue this certification after a number of audits.

2.1.2.1.6. Quality and accreditation organisms

In France, many quality-promoting organizations have emerged in the 1950s. The French Association for Standardization (AFNOR), founded in 1926, focused on quality in the 1970s. AFNOR represent France in the *International Organization for Standardization* (ISO) established in 1947 for the development of standardization to facilitate exchanges between countries. The *European Foundation for Quality Management* (EFQM) was founded in 1988. ISO TC 176 is the ISO committee responsible for the standardization of quality systems.

The idea behind the ISO standards is that all companies have a single reference manual and that the resulting quality system is audited by a duly accredited third-party. The company is thus certified and can boast about a quality system that works.

Accreditation is one of the bases of QA. NATO was at the origin of accreditation in the field of the weapons industry.

2.1.2.1.7. ISO standards

The ISO published the first version of the 9000 series of standards for quality management in 1987; these standards were revised in 1994 and 2000: we talk about ISO 9000, version 2000. This revision of standards was primarily made to inject continuous progress and make management tools to take into account the study of processes and leadership.

The ISO 9000 (version 2000) standards include environmental management, but not safety. We talk about the integrated management of quality.

Briefly, there are four ISO 9000 (version 2000) standards:

– ISO 9000: fundamentals and vocabulary;

– ISO 9004: advice for improving performance;

– ISO 9001 requirements;

– ISO 19011: audit quality and environment.

Certification is the equivalent of an academic degree. The ISO reference manual corresponds to knowledge, tests to be passed by the company. The examiner is an independent accreditation organisation which, in France, may be the AFAQ (French Association for Quality Assurance), the first certification agency established in 1988.

Being certified is an important element to creating quality assurance among customers. It is an essential goal. For the company, if the assurance works well, then everything works well. The certification process itself is preceded by an internal self-assessment, blank audits to detect abnormalities that must be corrected before the final test.

2.1.2.1.8. Other reference systems, price, quality

There are a multitude of reference manuals. Industrialized countries, organizations, corporations, and associations develop culturally appropriate reference manuals based on their requirements. The automotive industry has a specific reference manual, QS 9000, the weapons industry has its own QA system. Renault developed the reference manual EAQF 94 to evaluate suppliers and plants and AQTE (autoévaluation, qualité totale de l'*entreprise* – self evaluation, total quality of the company), to analyze all business activities. The reference manuals can be considered as a set of rules of conduct.

The pursuit of excellence, quality awards: quality awards are excellence awards! These include:

– in Japan, the Deming Prize established in 1951;

– in the United States, the Malcolm Baldrige Award established in 1987;

– in Europe, the European award for quality created in 1992 by the EFQM (European Foundation of Quality Management).

2.1.2.2. *SMS and risk management*

2.1.2.2.1. Safety control

The total quality management (TQM) approach of the company includes increasing the management of health, safety of people, goods and products, the environment, and generally all the risks inherent in the company. A company is subject to many risks of all sizes. By definition it is a risky undertaking. Its creation, which requires a down payment, is made in the hope of future gains. *The entrepreneur is one who is willing to take risks*.

The majority of people yearn for the security that can be defined as "*a situation where one has nothing to fear*, *the peace of mind that they get from it*". Few people on Earth can enjoy this enviable state throughout their lives. Human activity has risks: as man is moving, working, enterprising, and playing sports, he will be subjected to risks that will be due to him or he will suffer because of others or the environment in which he is located.

The French, in their history, have never lived so long. However, they are increasingly conscious of living in a risky society which is based on science and technology (*Science & Technology based Society*). This society is made fragile and complicated by the interconnection of networks created by new technologies: telecommunications, transport energy, financial system, medical system, and so on. Asbestos, GMOs (genetically modified organisms), new drugs, cell phones, nuclear energy, and new technologies in general, are new sources of concern; they add to the concerns due to unemployment, insecurity, and the degradation of the environment.

This legitimately raises a number of questions: can modern society control it, manage those risks, or at least reduce them to an acceptable level as globalization, rapid technological changes, terrorism, increasing global population, and the energy crisis looming on the horizon, are all sources of imbalance and instability? The dramatic events of September 11, 2001 in New York and Washington DC have heightened the concept of *vulnerability* because of their size and the fact that they were not foreseeable.

2.1.2.2.2. Hazard, risk, accident, acceptability of risk, and product risk

In everyday language, one often confuses *hazard* and *risk*. These two concepts are the foundations of safety, so it is necessary to understand them [LAU 03].

Hazard

This is an integral property of a product; it is a situation, a condition, a practice that carries in itself the potential to create/cause damage to people, property, and the environment. Sulfuric acid is a *hazardous* product, which causes very serious burns.

Knowledge of hazards is essential to control the risks that are caused by them. Most industries often have to face the same hazards as practically all industries use chemicals, electrical energy, or set parts in motion. Some industries, however, have specific hazards: the case of the hazard of radioactivity in the nuclear industry.

Risk assessment involves a large number of sciences and technologies: medicine, chemistry, physics, mathematics, metallurgy, mechanics, fluid flow, computer science, environmental science, geopolitics, statutory law, and so on.

Risk

This is the probability of occurrence of harm from exposure to a hazard. It is a dreaded event. Risk is the component of two parameters, *probability* (or frequency) and *consequence*:

$$\text{Risk} = \text{consequence} \times \text{probability}$$

Probability is expressed in number of occurrences per unit of time. We often take a whole year. Thus, a probability of 10^{-2} means that the risk might occur once in every 100 years. The greater the probability and the greater the consequence, the greater the risk will be. If there is a risk, there must have been an exposure to the hazard and there must have been a contact.

Let us consider several examples. Sulfuric acid will be a source of *risk* if one approaches it, and it can spread. Anyone carrying a phial of concentrated acid takes risks if he climbs up or down a staircase where he can fall (exposure).

On a very steep mountain, snow is a hazard for the mountaineer. He is taking risks when climbing the mountain (contact). The change in weather conditions, a shift from a beautiful sunny day to dense fog will increase the probability of the risk to the climber. He will be exposed to greater risk if his skills are not sufficient to overcome the obstacle or if he is on his own alone and is not roped to an experienced guide.

Accident

This is defined as an undesirable event resulting in damage to people, property, and the environment; it is a loss. An accident can have immediate or delayed consequences. An explosion can lead to sudden death. Pollution of a river or a lake in small doses can take months or sometimes years to show the harmful effects. It is accidents that one wants to eliminate.

Let us show some examples based on significant accidents:

– "Plus jamais ça, ni ici, ni ailleurs (never again, not here nor elsewhere)" is the name of the group of persons created in Toulouse after the explosion of a warehouse of ammonium nitrate at the AZF plant, on September 21, 2001: the explosion caused the death of 30 people, caused considerable damage to the surrounding residents, and destroyed the plant. This "chemical" accident occurred after other accidents such as Bhopal in India in December 1984, the biggest industrial disaster of all time which resulted in the deaths of around 5,000 people; one will never know the exact number of victims as thousands of people are still living near the plant in extremely precarious conditions;

– March 24 1999, a fire in the 11.8 km long Mont-Blanc tunnel killed 39 victims; it took 56 hours for the firefighters to extinguish the fire. Counsel for the families of the victims said that "the disaster was destined to happen ... Everything was going well in the best tunnel of the world";

– July 25 2000, a Concorde aircraft crashed into a hotel a few minutes after takeoff killing 113 people: a piece of metal on the runway was probably the cause of this tragedy;

– November 15 2003, in Saint-Nazaire (France), the fall of a single gateway on the *Queen Mary 2*, the largest cruise ship ever built, a technological marvel, caused the death of 15 people a few weeks before the maiden voyage;

– in France the 2003 heat wave caused excess mortality estimated at 14,000 people, mostly elderly people: France, normally organized, administered, equipped, was caught off guard;

– in France the roads killed "more" than 4,264 people in 2009 (12 per day on average) and injured 83,911 (230 a day on average) among which about 4,000 with severe consequences.

The acceptability of risk

The French react very differently to the announcement of accidents. They accept the massacre of dozens of highway victims over a long weekend, but there will be much more criticism regarding accidents caused by industrial activity. Residents near a factory are at risk but its workers are much more at risk and there are inconveniences to those near the factory as opposed to those who are far away. One can talk about the accepted risk. *Zero risk does not exist! The risk arises from the existence of hazard*!

The nature of the risks

Each of us meet lots of risks in our day-to-day life. To make an exegesis of risks in a company, would require a full development.

One will only deal with a few elements:

– the employee is a source of major risk. He can cause misoperations unintentionally through negligence or incompetence, or through ill will;

– industrial hazards are through fire, fire accident, destruction of equipment, and serious injury to people and the environment. Statistics of insurance companies show that 70% of SMEs that have had a serious incident (e.g. fire accident) stopped working after a few years. Long and repeated strikes could cause the shutting down of a factory;

– technological risks can be the hacking of know-how, the marketing of products that have bad side-effects in the long run (medicines and plant protection chemicals);

– financial risks are related to exchange rates, payment issues, major investments that do not provide the desired result etc.

The five major risk factors are grouped together and shown in Table 2.2.

Risk	Examples
Natural	Lightning, earthquake, landslides, volcanic eruptions, floods, fires, cyclones, tidal (tsunami), storms, avalanches, and drought.
Economic (Company)	Inadequate management, lack of long-term vision, competition, regulations, loss of experts, information hacking, heavy investment, labor disputes, patents, exchange rates, customer insolvency, product safety, litigation, failure of suppliers, risks related to innovation (new products), organizational changes, risks associated with acquisitions (buy-out, setting up abroad etc.), risks associated with production and distribution, malice, terror, IT, purchasing.
Professional	Occupational sickness/illness (physiological problems: physiological changes (silicosis), functional alterations (loss of sleep), psychological issues: stress, loss of sociability etc.), and occupational accidents.
Transport, travel	Transport of dangerous goods; Transport of people (represents half of all deaths in the industry)
Technology	Product risks: burns, poisoning; Explosions: gas, powders (flour, wheat, sawdust, divided metal, organic products, etc.); Biological hazards including viruses; Nuclear risks: radiological hazard, contamination by radioactive material; Fire hazards; Spills risk: air contamination, soil, surface water, groundwater pollution; Structure risk: collapse (Roissy Terminal 2E in May 2004); System failure: power failure, computer failure, failure of communication (e.g. heat wave in France in 2003).

Table 2.2. *Major categories of risk*

Product stewardship

Product stewardship implies the consideration of the impact of a product on the environment from its manufacture, use and possible recovery (from cradle to grave). This concept must be taken into account in the process of product design, lifecycle assessment (LCA), and its implementation.

Risk management

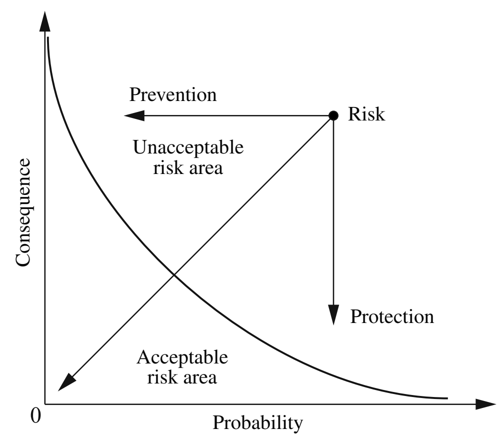
Managing risk is about playing on its probability of occurrence and/or the magnitude of its consequences to bring it to an acceptable value. The decrease in the probability is *prevention*; it tries to act on the source (prevention is better than cure, goes the popular saying).

Preventing fire in an industrial building can require the removal of flammables, moving away from the sources of ignition (open flames, internal combustion engines) and banning smoking. Our mountaineer climbs down if the weather is not good. The decrease of the *consequences* is *protection*. The above discussed building will be equipped with fire extinguishers, sprinkler systems, emergency exits, smoke control, and so on. Our climber will leave with a helmet, ice axe, blanket, and means of communication.

The "*iso-risk*" *curve* is the curve which marks the boundary with the two theoretically distinct zones: the area where the risk is acceptable and where it is not (Figure 2.5).

Very serious	Acceptable risk	Unacceptable risk	Unacceptable risk	Unacceptable risk
Average	Acceptable risk	Unacceptable risk	Unacceptable risk	Unacceptable risk
Not serious	Acceptable risk	Acceptable risk	Unacceptable risk	Unacceptable risk
Minor	Acceptable risk	Acceptable risk	Acceptable risk	Acceptable risk
Consequence / *Probability*	*Very low*	*Low*	*Average*	*Very strong*

a)



b)

Figure 2.5. *a) Acceptability grid of risk versus consequence and probability; b) iso-risk curve: prevention and protection*

Risks vary greatly according to the time period or country. To give just a few examples, Japan suffers on an average of one earthquake per day of highly variable amplitude. The Japanese live with it. Its buildings are usually designed to withstand earthquakes. Precautions to be taken are made subjects to be taught in school and with appropriate exercises. Foreigners can find on the bedside table of their hotel rooms instructions to be followed in English and a pocket-size flashlight.

Let us not forget financial risks: "*Managing a company is managing risks*", some managers argue to the point where "*Risk Management*" has become a major feature of large corporations. The man on the street is confused by the sums involved in the "business", that compromised companies like Enron, a company based on energy and whose bankruptcy hit Wall Street. Vivendi made headlines in French newspapers for months. The man on the street and, *a fortiori*, the shareholder, are surprised that the audit firms and the auditors have not raised any questions from time to time to update the existence of questionable practices!

In order to control the risks of a system, basic knowledge about the hazards is required. Which company would dare to establish itself in Japan without taking into account seismic hazard?

As an illustration, let us consider the case of domestic gas causing casualties and widespread destruction of residential buildings. The risk assessment specific to domestic gas requires knowledge of the conditions for the explosion and should calculate the effects of the explosion. One will talk about explosive and flammability limit, minimum ignition energy, deflagration, detonation, the speed of the flame spread or shock wave, and overpressure. It is therefore an expert work. It is understood that the control of risks through hazard identification is a *job for specialists*.

2.1.2.2.3. The identification and management of risks[1]

NOTE.– The reader may profitably consult articles on *Risk Management Treaty* (*Treaty SE*) in *Techniques de l'Ingénieur*.

Figure 2.6 shows the *flowchart* for the general method of assessment and risk management of a given system. The system can be an organization, a service company, an industrial company, a plant, a storage facility, and so on.

The system studied "immerses" itself in a statutory socio-economic environment, which has its own cultural characteristics and hazards. The same process unit of production built similar to Marseille or in mainland China will certainly be subjected to external risks that are very different.

1 General methodology [DAL 10, LAU 03].

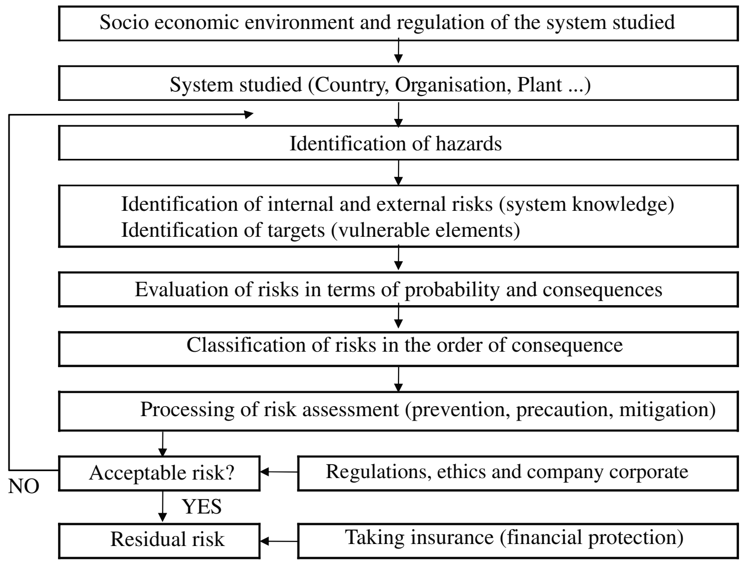


Figure 2.6. *Flow chart of identification and risk management*

The various stages of this process consist of:

– hazard identification;

– risk identification;

– identification of targets for each component. The system is broken down into basic components, each of which will be the subject of study. For example, storage of liquefied gas (propane, butane) alone deserves special consideration. This is an evident source of risk; a gas leak can cause an explosion. The storage facility destroyed in a fire accident in a nearby plant in turn becomes a major risk. Liquefied gas is a source of hazard, storage can be a target. The hazard is even greater as the storage is close to houses (obvious target) or communication lines;

– quantification of risk in terms of probability and severity;

– risk classification in order of importance. In the safety review of an existing plant, we will at first treat the most significant risks;

– reduction of risk to an acceptable level.

The level of acceptability, we have seen, is difficult to determine. Figure 2.5, consequence-probability-acceptability grid of a feared event, is a selection guide. If the feared event is “estimated” to be in a box of acceptable risk, one evaluates the residual risk which, we remember, is never nil. In the case where the risk is deemed unacceptable, the process is repeated. The residual risk can be covered by an insurance policy; this is the case of fire protection.

Systems analysis and risk assessment tools

Systems analysis

There are about 60 systems analysis methods for controlling potential risks. Some are simple, others are more complex and all require practice and practical experience in the area studied for those who use them.

As mentioned earlier, risk identification is done on each system component. The methods mostly used are the PAR, HAZOP, FMEA, and the methods based on trees (Table 2.3).

Methods	**Qualitative**	**Semi-quantitative**	**Quantitative**
Inductive	PAR, FMEA, HAZOP, MOSAR, *What-if*, HACCP	FMEA, HAZOP	Hazan, fault tree, event tree
Deductive	Fault tree		REX

Table 2.3. *Classification of risk analysis methods (Indicative only)*

We distinguish between deductive and inductive methods. The former is from a real or perceived event to determine the causes of it. The second is from a probable failure and seeks to determine the consequences.

List of methods (indicative only):

PAR: preliminary risk assessment

FMEA: failure modes and effect analysis

FMECA: failure mode, effects and criticality analysis

FTA: fault tree analysis

ETA: events tree analysis

HAZOP: hazard & operability studies

HAZAN: hazard analysis

HACCP: hazard analysis, critical control points

MOSAR: organized and systematic method of risk analysis (France)

REX: feedback

As an illustration, Figure 2.7 shows an agitated chemical reactor, maintained at a desired temperature by a loop consisting of a pump and a heat exchanger supplied with cooling water. This reactor can be part of a process unit of production of an active ingredient of pharmacy encompassing other reactors, distillation columns, various devices for separation and purification. This facility will serve to fuel our thinking in what follows.

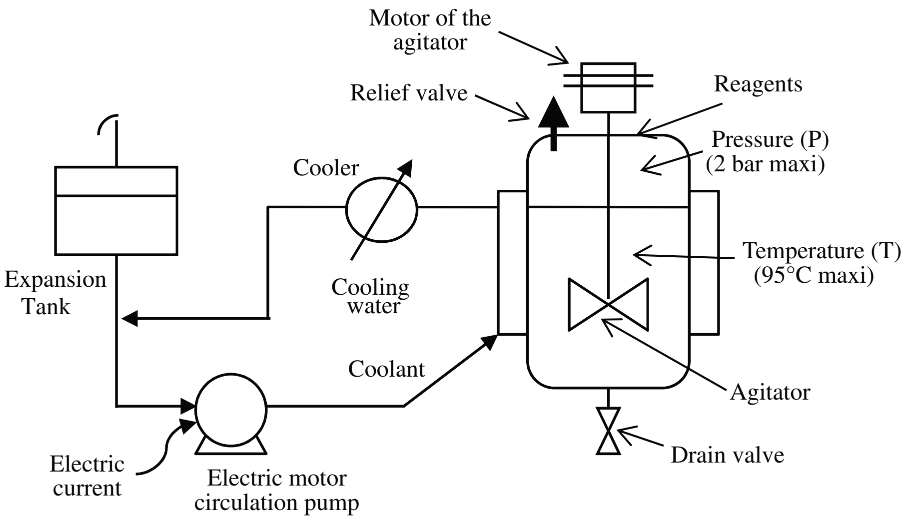


Figure 2.7. *Case study: batch reactor site of an exothermic reaction*

Preliminary risk assessment (PRA)

This method is widely used before using more sophisticated methods. It is essential at the time of the preliminary studies of a project. Various hazardous elements of the project are identified and potential risks are assessed. This chapter does not go into detail, but the feared events and their potential consequences are listed. We are only concerned about the possibility of reducing the risk.

EXAMPLE 1.– A plant under study uses a liquefied gas (propane, butane), usually stored in a refrigerated vessel. The risk will be acceptable or not acceptable based on the distance of houses and heat sources. In this case, the PRA will be decisive in choosing the site.

EXAMPLE 2.– The temperature of the reactor shown in Figure 2.7 is normally 90°C, it must not exceed 95°C, beyond which there is a risk in excess pressure due to the decomposition of the reaction mixture. It is a risk but we know that we will control it; the means to implement it are known and their costs are usually acceptable. The project can be continued.

HAZOP method

The HAZOP method (*Hazard & Operability Studies*) was developed by ICI (Imperial Chemical Industry) in the 1970s. It aims to ensure that the system keeps its integrity throughout the course of its operations and, in particular, during the transitional phases (startup, shutdown, and maintenance).

Its implementation by a multidisciplinary team must be made on process flow diagrams and plans. It is well suited to process industries. It aims to identify the possible deviations from normal operating parameters by seeking the causes of it and determining the consequences of it, therefore, the possible risks incurred. To do this, we use keywords (words or guides) such as "more than", "less than", or "no" that are applied to temperature, pressure, flow, and so on. The temperature of the reactor mentioned above must be maintained at a maximum of 95°C. It may exceed this value (deviation) if there is no longer agitation, if there is an excess of reagents, and if the cooling system no longer works.

The agri-food industry uses the HACCP (hazard analysis, critical control points) approach designed to identify the critical factors of manufacturing processes.

Tree methods

The so-called "tree" methods are a tree-like graphical representation of successive intermediate elements whose chain will lead to the feared event. If the feared event requires the conjunction of two intermediate events, gate is an AND gate (see Figure 2.8).

Let us take two examples as proposed in Figure 2.8.

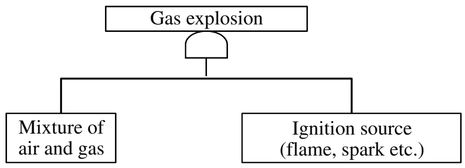
EXAMPLE 1.– The explosion of a mixture of gas and air will require a source of ignition of a specific energy level. If the feared event may occur or if two or more intermediate events occur independently: the gate is an OR gate.

EXAMPLE 2.– The loss of circulation of the loop in Figure 2.7 may be due to mechanical failure of the pump OR to the lack of coolant.

Fault trees

This deductive method is either from an event that actually happened or from a feared event. Selected *a priori*, the event constitutes the head of the tree or the top event. It works from the top down.

Example 1: gas explosion



Example 2: absence of coolant circulation in the case presented in Figure 2.7

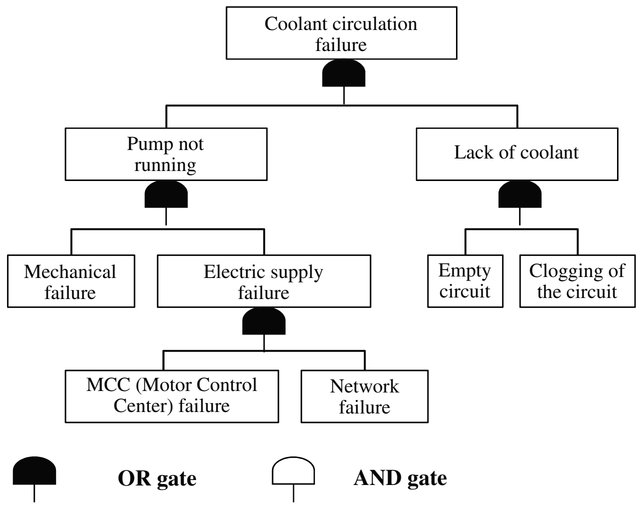


Figure 2.8. *Examples of construction of fault tree*

This method is extremely useful for the analysis of real accidents, and is a key element of feedback. It allows enriching the knowledge about the system, by identifying weaknesses in order to take adequate actions to ensure the probability of the occurrence of the same type of accident is greatly reduced.

Event trees (consequence trees)

This is an inductive method. On the basis of breakdowns or possible failures, the method will try to analyze the behavior of the system. The starting point is an initiating event.

Let us use again the example shown in Figure 2.7. There raises the question: what happens if there is a power failure? Obviously, the electric pump will stop and by consequence the coolant will no longer circulate, the reactor temperature may rise if the feed of reagent is not stopped immediately.

Failure mode and effects analysis (and criticality) (FMEA/FMECA) methods

These methods are extremely common in the manufacturing industry. It involves identifying the effects on the system of each failure mode of each component (FMEA). The FMECA studies the criticality of the consequences in more detail. Example: What will happen with a bicycle if the brake cable of the rear wheel breaks down?

Previous methods may be used separately but, in most cases, in complementarity, allows the system to analyze in detail all its components, to identify its risks and to assess the consequences of it. The ultimate goal is, of course, to manage risks, reduce them to acceptable levels, and deal with the residual risk. The so-called tactical risk management will be applied to both the organizations as well as to its supply chain, and to networks (transport, electrical, etc.), industrial tools, consumer products, and so on, throughout their lifecycle. The basic principles that have already been mentioned consist of prevention, protection, and mitigation, which consist of mitigating and minimizing the damages caused by accidents.

2.1.2.2.4. Safety

Safety design

No inventor, architect, designer or process engineer wants their product or project to be the cause of accidents. And yet ...

General principles

At present, any design uses the *value analysis* (*VA*) and *functional analysis* (*FA*) methods invented in the United States during World War II. The FPS (functional specifications), established by the client destined for the general contractor, must absolutely specify the constraints generated by risk analysis (see Chapter 9, “Project Management Techniques: Engineering”).

Barriers (protective features)

This concept was originated in the nuclear industry, whose main risk is the spread of radioactive materials. The idea is to protect the people and environment by confining hazardous materials. The reactors used in France are of PWR-type (pressurized water reactors), which implement three barriers:

– the fuel is kept in a zirconium shaft;

– the reactor itself is enclosed in a casing;

– the last barrier is a concrete vault lined by a metal wall that covers the reactor and primary circuit.

This type of defense is illustrated in Figure 2.9.

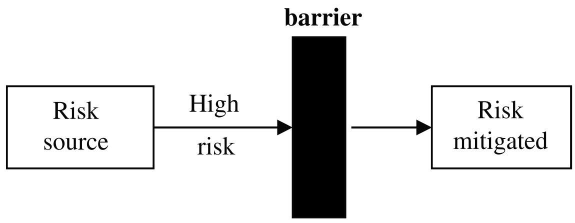


Figure 2.9. *Principle of establishing a barrier*

In depth defense enhances the safety of industrial systems by increasing their resistance to "attacks" of any kind and especially the ones originated by human or technical misoperations. Technical barriers can be:

– *static*: a firewall slows down the spread of the fire; a hazardous reactor can be installed in a blockhouse closed on three sides and the fourth open onto an earth dam (the possible "shrapnel" caused by an explosion can be stopped), storages of hazardous materials can be buried, submerged in water, and so on;

– *dynamic*: sensors, measuring instruments contribute to make the system safe. Example in Figure 2.7: an abnormal rise in temperature will cut the supply of the reagents. Another barrier would be as a last resort to empty the reactor contents into a blow down vessel containing a neutralizing agent;

– *organizational* (or administrative or procedural): trained operators must comply with instructions, written procedures that require them to take action in the case of the drift of the system. These administrative procedures are inexpensive; they reflect the fact that operators are entrusted.

Technical barriers, especially dynamic, evidently complicate the system of which they may form an integral part and be themselves a source of hazards if they are not maintained in good working condition. A highly "instrumented" system can be very difficult to start. The "redundancy" of various safety features and alarms can cause untimely shutdowns that disturb the operators.

Construction safety (realization of the project)

Any construction uses codes, standards, and must abide to regulations. Risks can be minimized by the use of specifications more stringent than what is normally necessary or required:

– increasing pressure design (as a result it will be necessary to perform the tests at a higher pressure!);

– choosing more sophisticated materials that are totally corrosion resistant to fluids in use: stainless steel 316 instead of steel 304;

– total X-ray of the weldings;

– eliminating flanges and gaskets (the cooling circuit of Figure 2.7 can be completely welded ... but in order to dismantle it, it is necessary to cut it ...);

– choice of intrinsically safer pieces of equipment: the circuit pump may be of the hermetic or magnetic drive type: therefore, one need not worry about the leakage of the mechanical seal (although the pump may be more expensive!).

Safety at the end of lifecycle

No company producing goods today can ignore the fate of its product at the end of its lifecycle. At present, car manufacturers must consider the recovery of vehicle components and the fate of their component products (paint, plastics, heavy metals). The French are increasingly concerned about the pollution of groundwater by herbicides, fungicides, and insecticides that helped to lift their agriculture to the forefront globally. “Farming” must meet certain distances of groundwater, to limit the prescribed doses, and so on.

Protection, mitigation

Protection against the hazards, which aims to reduce their consequences, can take many forms:

– equipment that can be subjected to explosions will be equipped with relief valves, relief traps, and vents connected to ducts that lead explosive products toward a place where circulation is prohibited (in Blaye, France the explosion of wheat silos had 11 victims);

– control rooms will be designed to withstand the pressure wave caused by a possible explosion;

– sensors, controllers (of pressure, temperature, flow) that continuously monitor the system are all watchdogs designed to keep the system within operating limits where the risk is under control!

– water curtains can reduce the spread of toxic clouds;

– fire protection is an integral part of any facility as well as personal safety equipment: helmets, goggles, gloves, safety shoes, proper clothing, and self contained breathing apparatus save many lives. Let us just look at our firefighters fighting against forest fires.

Mitigation is intended to mitigate the damage of accidents when they occur: in general, reducing all that is a source of energy such as temperature, pressure, quantities used, speed, and to ensure that flow of solids, liquids, gases in case of spill are oriented in a direction where their impact is minimal.

The plant layout plays an important role: emergency exits, fire escapes, easy access during emergency (ambulances, fire trucks) enable to reduce the consequences of disasters. At first, it is necessary to save human lives and protect the property as much as possible.

As discussed, the Seveso Directive requires the establishment of an "internal operation plan" (IOP): this is implemented under the authority of the person in charge of the site. From potential accident scenarios, one defines the means and actions to be implemented to address the residual risks such as fire, explosion, and spill of harmful products.

When the consequences of an accident go beyond the local management capabilities, administration can implement a special intervention plan (SIP). This plan will take over the management of relief operations. These plans must be exercised to be effective! These exercises often reveal shortcomings that are the least unexpected; sirens not working, emergency electricity generators that do not start, lack of procedures, misunderstanding of staff, who confuse reality and exercise and do not go to the shelter designed for ultimate personal protection points fixed in advance …

Communication with neighbors is essential when the accident has consequences that go beyond the limits of the plant. Neighbors must be informed and told about it, trained in the case of a severe accident. They must know beforehand what has to be done; do they have to shut themselves away in their homes and stay by the phone or evacuate through determined routes? The interruption of rail and automobile traffic, proximity of schools, hospitals, nursing homes create much additional difficulty. The more and more aggressive intervention of the media may create additional difficulties.

2.1.2.3. *Cost and time management – concept of accounting*

2.1.2.3.1. Investment management

This theme is addressed in Chapter 9.

2.1.2.3.2. Profitability criteria

Basis for manufacturing cost evaluation – Full Manufacturing Cost (FMC)

NOTE.– The concepts developed below were those in force in the Rhone-Poulenc. The names may vary depending on the policy of the companies. But, the basic concepts that every engineer should know are the same.

The FMC is the sum of the proportional costs (PC) or variable costs, and non-proportional costs (NPC) or fixed costs:

$$FMC = PC + NPC$$

The PC vary with the tonnage unlike the NPC that are fixed.

Proportional costs (PC)

The PC include the cost of raw materials (RM) and utilities (UT) and are expressed in \$/kg. The cost of raw materials and utilities is obtained from their purchase price or price per unit and the specific unit consumption:

$$Costs\ RM/kg = Price\ per\ kg \times Specific\ unit\ consumption\ (SUC)$$

SUC is expressed in kg/kg and is higher than the stoichiometry because the reaction yield is never 100%. SUC may be:

– the budget values;

– The actual unit consumption; this one can be smaller than budget in the case of process improvement or greater in the case of process deterioration.

The PC depends on the price of chemicals and raw materials consumption. The chemist in charge of research must calculate the PC from the beginning of the study. The cost of certain strategic raw materials may depend on negotiations with the supplier. This can be a major variable of a project that will only succeed if there is an agreement with the supplier.

The *proportional costs* are mainly independent of the percentage of load of the process unit. In fact, there may be improvement or degradation of performance according to the load (percentage of the minimal capacity).

Generally, the cost of utilities (in \$/kg) decreases if the rate increases because the energy losses are practically constant.

Non-proportional costs (NPC)

Non-proportional costs of the product (NPC) include:

– direct NPCs that represent the labor costs (LC) of manufacturing (direct and supervisory), maintenance, and laboratory work:

$$Manpower\ direct\ in\ \$/kg = \frac{hours \times cost\ per\ hour}{tonnage\ produced}$$

The maintenance costs include the cost of labor, spare parts, and the cost of contractors.

Laboratory costs are inclusive of costs of routine tests (control of operations) and analysis done on request (Figure 2.1).

NPCs are direct costs that new process unit created at the plant who hosted it:

– indirect NPC or SPC (specific plant charges) Plant overheads (OVHD).

A process unit which will be located in an existing plant will benefit from its infrastructure:

– administration: general management, personnel department, accounting, and so on;

– support functions: fire department, security department, first aid center, utility production, waste water treatment, shipping and receiving, and so on.

Proportional Cost (PC)	**SPC**	**Raw material cost in $/kg**	**Poduction cost in $/kg**
Raw material 1	3.0 kg/kg	0.30	0.90
Other raw materials			0.20
Total raw materials			1.10
Utilities (electricity)	10 kW/kg	0.06	0.60
Other PC			0.10
Total utilities + PC			0.70
Total PC			**1.80**

NPC and depreciation	**NPC in k$/year**	**Product cost in $/kg**
Labor:	3,600	0.24
Maintenance: 1.4 M$/year	1,400	0.09
Other costs = fixed costs + taxes + plant OVHD	6,000	0.40
Total NPC (excluding depreciation)	11,000	**0.73**
Depreciation of 8 years: 70 M€/8	8,750	0.58

Analysis of the full manufacturing cost	**€/kg**	**FMC %**
PC	1.80	57.9
NPC	0.73	23.5
Depreciation	0.58	18.6
Product cost	**3.11**	100

Table 2.4. *Example of product manufacturing cost highlighting proportional cost*

SPC is some thing like the *property tax* paid by the product to the plant.

SPC is *broken down* on products using keys defined with the accounting service. For example, the costs of administration can be broken down proportionally into the number of operators on each process unit.

The NPC will vary greatly depending on the size of the process unit, the percentage of the plant load, i.e. the percentage at which the plant is run in terms of percentage of the industrial capacity, the size and organization of the host site. Unlike the PC, NPCs are not easily accessible; they will depend on the plant organization and efficiency.

Cost analysis

Let us consider a process unit with the following characteristics:

– capacity: 15,000 tons/year;

– investment: 70 M$;

– maintenance costs: 1.4 M$/year (2% of investment);

– staffing (number of operators): 60.

Indicators of the analytical income statement (AIS)

The AIS includes several profitability indicators: contribution margin, gross margin (GM), operating income (OI), earning before tax (EBT), net income (NI), and so on, as shown in Figure 2.10.

Contribution or contribution margin is calculated by subtracting the PC from net sales (NS). This is the most easily accessible profitability criterion. If the contribution is small, the case is hopeless; one must reconsider the chemical process (raw materials, performance) or the purchasing policy.

The contribution shows whether one is a good chemist and/or a good buyer: this is a vital indicator.

A low contribution margin leaves no hope of profitability; it is the result of a bad choice or difficult access to essential raw material(s) or a sale price that cannot be increased.

This is the case of “*commodities*”; customers can easily find substitutes.

The value of the *minimum contribution* for the activity to be profitable depends on the sector of the chemical industry. As an example the following economic sectors should have a certain contribution margin if one can expect a profit:

– fine chemicals: contribution > 40%;

– agro-chemicals: contribution > 60%;

– pharmacy (the high contribution needed for the pharmaceutical sector is due to the high cost of research, high cost of manufacturing and huge investments costs of production facilities): contribution > 80%.

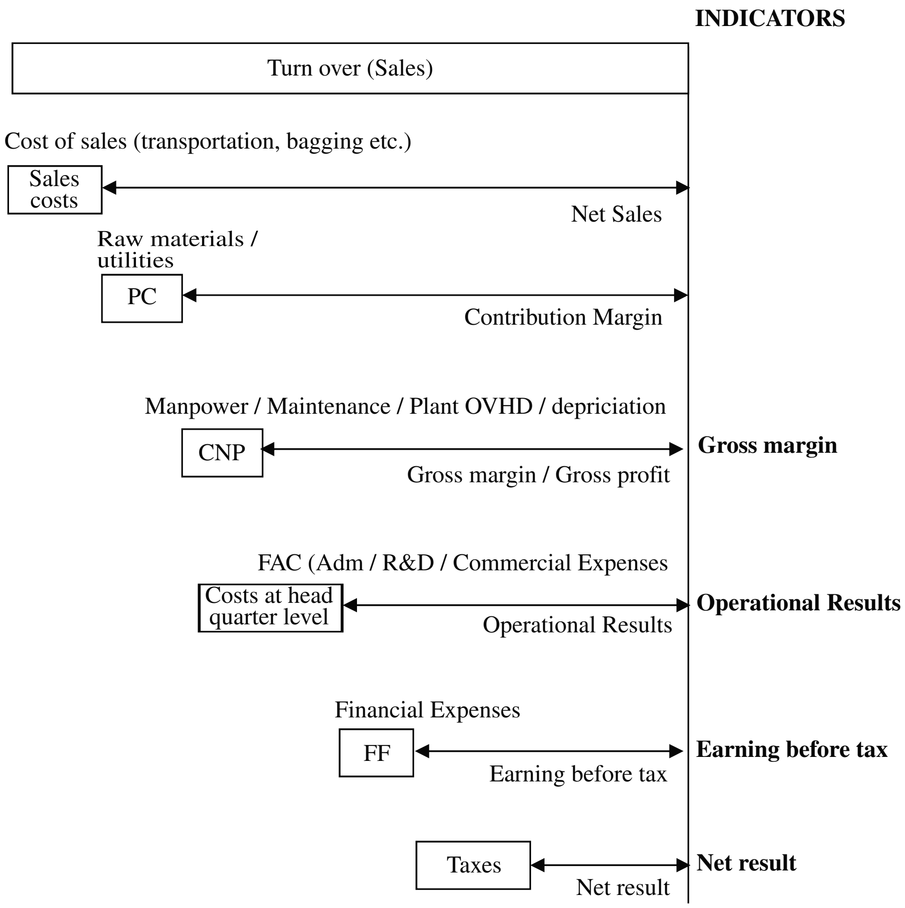


Figure 2.10. *Analytical income statement or profitability indicators*

We define the "*break even point*" of the process unit as the intersection between the product contribution (contribution margin) to the fixed costs of the process unit (NPC): it is expressed in tonnages. This concept is illustrated in Figure 2.11.

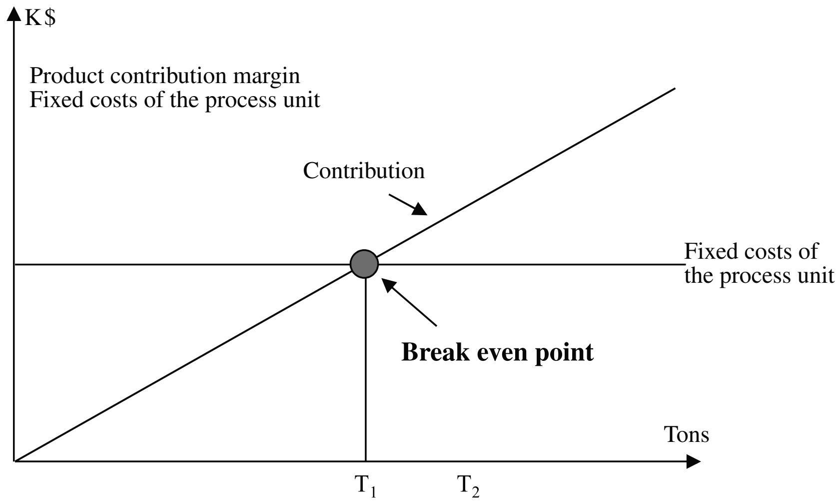


Figure 2.11. *Illustration of the concept of break even point*

Under tonnage T_1, the product contribution does not cover the fixed operating costs of the process unit. It is necessary to reach T_2 to begin to cover the over-heads, research, depreciation, and financial expenses, so as to start making money.

Gross margin (*or gross profit*)

This is obtained by subtracting the NPC from contribution and depends on the size of the process unit: a competitor who has a process unit several times larger can have an economical advantage, provided that his process unit is running at full capacity.

It also depends on the operating conditions:

– number of operators;

– maintainance cost (a process performing well on a chemical basis may be penalized if it uses high pressure, exotic materials).

The process unit can be penalized by a poorly managed, non-performing plant, with high indirect costs.

The gross margin shows if it is a good performing manufacturing plant.

Let us consider the previous example and calculate the cost and gross margin based on the plant running at a certain percentage: a percentage of the nominal capacity, and let us consider the case of the plant running at 50% of nominal capacity. The results are summarized in the following table.

	Product cost in $/kg	CM and GM (%)
Selling price of the product = $6.00/kg		
FMC at plant nominal capacity PC = 1.80 and NPC = 1. 31	3.11	
Product cost at 50% of the plant nominal capacity PC = 1.80 and NPC = 1.31 × 2	4.42	
CM = [(6.00–1.80)/6.00] × 100		70
GM with a nominal capacity = [(6.00–3.11)/6.00] × 100		*48*
GM to 50% of the nominal capacity = [(6.00–4.42)/6.00] × 100		*26*

Table 2.5. *Example of calculating the gross margin of a process unit based on the load*

NOTE.– The contribution margin (CM) is independent of load rate.

The gross margin (CM) is halved from 48% to 26% when the operation rate is reduced by half: the impact is almost considerable.

In the case of a new process unit, there is a question about its rated capacity (tons/day), whereas for an existing process unit, one can only consider the plant load of operation.

The first concern, building very big (with a risk of under-utilization) leads to big overloads and significant depreciation: investment must be reimbursed! In contrast, building very small can lead to a lack of sales. A competitor who has a larger workshop will have lower NPC provided the plant is saturated, thus better margins and a more aggressive trade policy.

In this type of dilemma, the answer can be sought from among these four options:

– be the first on the market (move fast);

– make use of modular facilities hoping that they can be at least partially for other productions. This can be realistic for the fine chemical sector including pharmacy where conventional batch reactors for instance are extensively used;

– outsource entirely certain steps of the process in order to decrease initial investment and therefore decrease the risk;

– use multipurpose workshops (<1,000 tons/year).

– this is an option valid for capacities in the order of magnitude of 1000 Tons per year.

Other indicators

OM	Operating margin = operating profit + amortization
EBITDA	*Earning before interest taxes, depreciation and amortization*
OM/EBITDA	"Money that is available"
CE	Cost of capital employed = Net fixed assets + (working capital)

Table 2.6. *Profitability indicators*

Other criteria of profitability

Pay back (simplistic)	= [Amount of the investment (k$) / Gain (k$ / year)] = years NOTE.– The gain can be from contribution (performance gain) or from operating margin
Capital intensity	= Total investment/sales turnover
IRR	= Internal rate of return
RCE	= Return on capital employed = operating margin/CE

Table 2.7. *Other criteria of profitability*

The downward spiral of fixed costs

Let us assume that in the plant schematized in Figure 2.1, process unit C is stopped. The activity considers that the product from C is no longer profitable.

Fixed costs *absorbed* by C must be allocated to other products (they are usually not absorbed at the corporate level). This is particularly the case of SPC (specific plant charges). Therefore the cost of process units A and B increases, then their margins decrease. The activity responsible for the product from B may lead to the closing of process unit B ...

The absorption of fixed costs is a key concept in industrial life!

2.2. Entrepreneurial mode, project management – the operational/entrepreneurial conflict

Entrepreneurial mode is to change the existing *by managing a project portfolio* from the strategic plan so that the company can evolve [DEC 80].

It is a condition *sine qua non* for its survival; it is about influencing the running of the company to give it new direction.

Current management techniques give the name *project to any set of operations related to a change*. The company has to monitor its projects, especially the physical investment projects that must be followed in terms of cost, schedule, quality, and profitability. These concepts are developed in Chapter 13, "The management of change".

Project management involves all functions of all areas of business operations. Its essential components are listed in Figure 2.12.

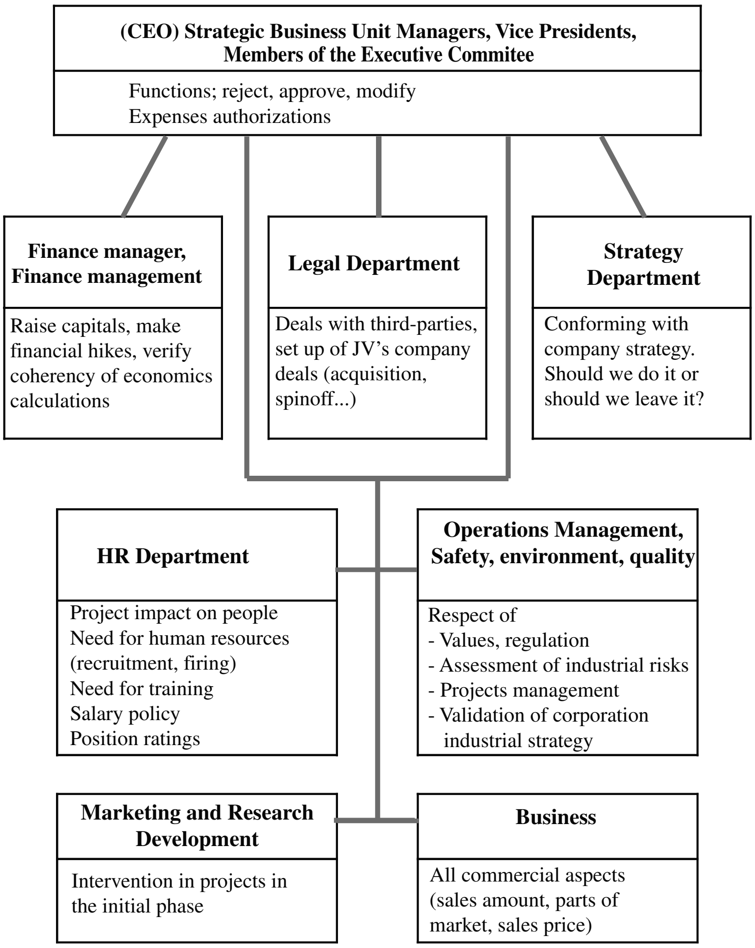


Figure 2.12. *The project and the major business functions*

A company cannot allocate large human resources to an activity whose future is uncertain. This applies to preliminary projects or studies covered in Chapter 6, "The industrialization process: preliminary projects".

It will, therefore, *draw* existing resources to form a temporary team or project group which will conduct the study as far as possible until it is decided either to continue or to stop.

The project team is often composed of members from the *corporate* and members "taken" from business activities (Figure 2.13).

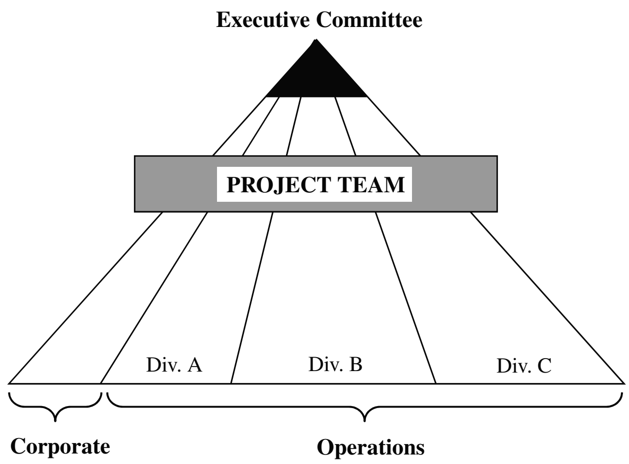


Figure 2.13. *Positioning the project team in the corporation*

This organization is, actually, a source of potential conflict, as a result of:

– dilution of responsibilities, an "online" person in charge of a specific duty is managed by a temporary boss different from the real one for activities not regarded as essential most of the time;

– the workload imposed on people who in addition to their daily work have to spend "hours" on an additional tasks.

Conflicts still exist. The problem is to solve them!

This "*respiration*" of the operational and entrepreneurial company is one of its major features. It has impacts on its employees. Some will find there a pleasant distraction on a daily basis at the risk of abandoning the existing with sometimes unfortunate consequences.

Some will refuse to the extent where they can turn away from the assignment entrusted to them.

Industrial life is no easier than other parts of life.

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