



MAINTENANCE: BODY *of* KNOWLEDGE

*Issues, methods, techniques and
practices to be known by stakeholders
of the maintenance process*



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PREFACE

This booklet is the result of work by the European Federation of National Maintenance Societies (EFNMS), a non-profit organisation created in 1970. It brings together the National Maintenance Societies (NMS) of 24 European countries, with the aim of sharing experiences and collaborating to develop the maintenance profession and create a European maintenance culture. EFNMS carries out various activities to achieve these objectives, including leading six committees focused on key areas of maintenance: asset management, certification of personnel, training, health & safety & environment, maintenance indicators and assessment, and digitisation and new technologies. Additionally, every two years, in partnership with a selected NMS, EFNMS organizes the Euromaintenance conference, attracting experts and companies from around the world. Together, these activities aim to collect and develop maintenance knowledge to increase the visibility of this field and its professions, thus playing an essential role in the sustainable development of our industries and economies.

To further enhance its work, EFNMS has decided to create a Maintenance Body of Knowledge (BoK). The objective of the BoK is to define the landscape, scope, boundaries, and content of maintenance to foster a better understanding of this area and highlight its importance within organisations. The BoK is based on European maintenance standards, actively contributed to by EFNMS, particularly the terminology and standards that describe the maintenance process and its relationship with asset management.

The BoK is constructed upon these standards; it combines the maintenance actions and the knowledge necessary to carry them out (industrial issues, methods, techniques, practices, etc.). It serves as a catalog of maintenance knowledge, compiled from Euromaintenance conferences, the European standard on the qualification of maintenance personnel, various works of the EFNMS committees, and expert opinions. The texts were written by European experts and validated by the EFNMS Reading Committee. They provide short summaries of the subjects and include bibliographies that allow readers to access more detailed information. The links to the maintenance processes are indicated, enabling better identification of

the competences expected from technicians, engineers, maintenance managers, and asset managers.

This BoK is a collaborative document intended to be regularly supplemented, updated, and improved by any expert in a particular area who wishes to propose changes, under the supervision of the Reading Committee. The goal is to create a dynamic reference that clearly explains the content of maintenance and its relationship with other processes within companies or organisations, thus contributing to the development of maintenance for the benefit of European and global populations. Readers are invited to communicate their points of view, clarify descriptions, and correct or supplement subjects with the intention of developing the culture of maintenance.

ANTOINE DESPUJOLS

EFNMS - French Maintenance Society (AFIM)



INTRODUCTION

INTRODUCTION TO THE EFNMS MAINTENANCE BODY OF KNOWLEDGE

OBJECTIVE OF THE EFNMS MAINTENANCE BODY OF KNOWLEDGE

Maintenance is required wherever failure mechanisms or out-of-dimension events affect items and lead to failures and faults that could be avoided or repaired. Maintenance concerns various sectors, including industrial, building, and infrastructure. Even if the techniques used are different, the processes implemented are similar.

EFNMS aims to develop maintenance in all areas where it is performed and promote a common European maintenance culture. To achieve this, it is crucial to clearly define the maintenance landscape, in other words, the maintenance scope, boundaries, content, and interactions with other related areas. Maintenance involves technical, administrative, and managerial actions performed by technicians, engineers, supervisors, and asset managers. These individuals require precise knowledge and skills, in addition to their foundational knowledge and soft skills, to successfully implement the methods, techniques, good practices, and tools that are the basis of successful maintenance.

To gather these essential fundamentals, EFNMS develops a Maintenance Body of Knowledge (BoK), which is independent of company organisations and intended for all stakeholders involved in maintenance. While the responsibility for maintenance is often assigned to a specific entity within a company, other entities, such as operation and human resources, also participate in this generic process, and their personnel must possess the necessary knowledge and competences.

To describe the BoK, we must have in mind the other areas included in the 'maintenance landscape'. We then discuss the maintenance process in more detail, including the identification and structure of the required knowledge.

THE MAINTENANCE LANDSCAPE

All items (components, equipment, systems, installations), are subject to constraints and external stresses resulting from:

- their operation (start/stop, nominal operation, transients, etc.);
- their environment (humidity, pollution, vibrations, etc.);
- external events (overvoltage, failures of other items, operating or maintenance errors, etc.).

These factors give rise to failure mechanisms (wear, fatigue, aging, etc.) or stresses (overpressures, heating, overloads, etc.) that can exceed the item's resistance capacities, causing them to malfunction. Over time, item degradation, akin to entropy in thermodynamics, increases. Without maintenance, all items degrade, albeit at varying rates, and active items eventually cease to operate. Maintenance is therefore crucial and applicable to all industrial sectors, including buildings and infrastructure. It encompasses technical, managerial, and administrative activities that prevent failures, restore items, and mitigate the consequences of their unavailability.

These activities are described in standards, particularly EN 17007, which provides a generic description of the maintenance process, from the management process to the realisation processes which are the reason for maintenance and the support processes which provide the necessary resources and activities for all other processes. This standard thus delimits maintenance and delineates its scope, boundaries, and content.

Importantly, maintenance does not exist in isolation. It plays a significant role in three other domains within its landscape (see Figure 1):

- **Management of physical assets.** As introduced in ISO 55000, this domain aims to translate strategic objectives of companies and organisations into decisions and actions. Integrated with other processes like design, acquisition, production, modernisation, sale/disposal/dismantling, maintenance helps optimise the value created. It participates in defining objectives and policies for efficient and profitable asset management. The relationship between maintenance and physical asset management is described in EN 16646 and EN 17485.
- **Risk management and dependability.** In these domains, maintenance is an essential preventive and protective control measure. By addressing item reliability, maintainability, and logistic support, maintenance helps prevent failures and reduce downtime, which can have serious consequences. The role of maintenance in dependability management is explained in IEC 60300-3-1.

- Sustainable development.** Maintenance acts as a crucial pillar of sustainable development. Designing items with maintenance in mind and ensuring their continuous upkeep throughout their life cycle extends their useful life. This approach reduces the need for raw materials and energy for reconstruction, benefiting both the economy and the environment. Maintenance activities create local employment opportunities, providing a social advantage. They include defensive tasks that serve as a shield against serious risks to the health and safety of people and the environment. They also include combative tasks that act as a spearhead to gain competitiveness by optimising availability and durability and reducing costs. All of these tasks are clearly part of a sustainable development process that positions maintenance as the profession of the future. Sustainable development is covered by ISO 26000.

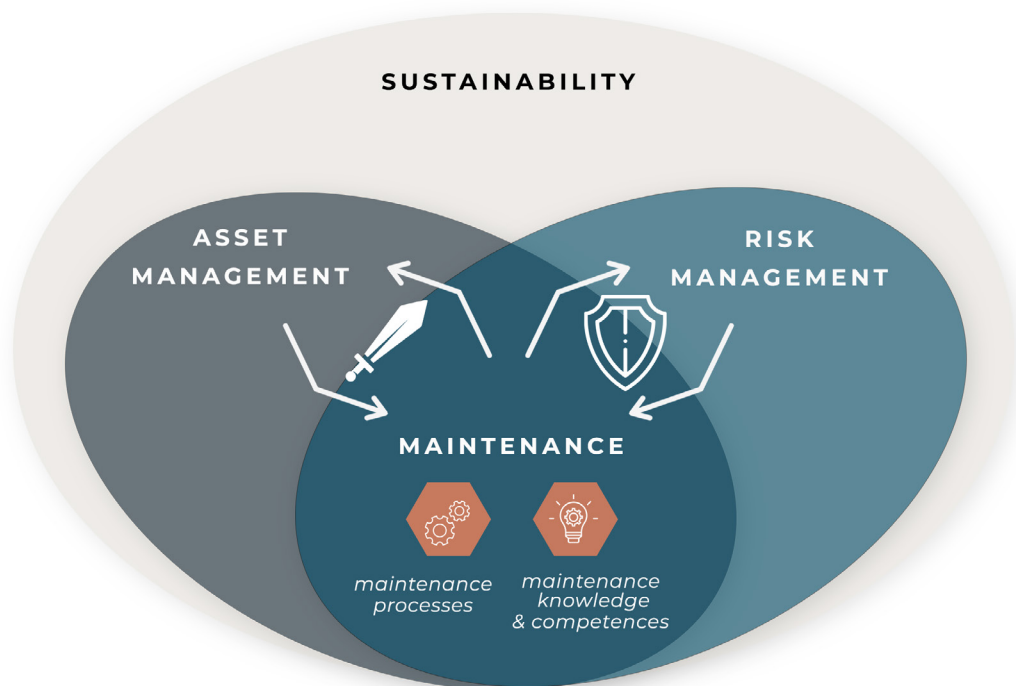


FIGURE 1: THE MAINTENANCE LANDSCAPE

Maintenance is considered a set of actions (processes), but it also encompasses the knowledge required to carry out those actions. Defining the scope and content of maintenance means not only determining the maintenance activities but also creating an inventory of the methods, techniques, practices, and other knowledge and competences that characterize maintenance professions and other jobs involved in maintenance. EFNMS has long been working on the competences of maintenance personnel, particularly through the European Certification Committee (ECC). Since

1993, the ECC has developed and implemented a European certification for maintenance managers and maintenance technicians. The European Training Committee (ETC) has also played a significant role, contributing to the European standard EN 15628 on the qualification of maintenance personnel and participating in the European Euromaint project under the Leonardo program dedicated to education and vocational training.

In terms of knowledge, it's important to mention the International Euromaintenance Conference, established by EFMNS in 1974. This conference serves as the main European and international event for presenting and discussing maintenance knowledge. The development of the BoK is part of these activities and helps gather and structure this knowledge.

THE MAINTENANCE PROCESS

As emphasized earlier, the need to perform actions is the origin of the knowledge and skills required by those involved in maintenance (Figure 2). To identify the necessary knowledge, we must start with the actions to be performed. EN 17007, which describes maintenance processes, forms the basis of this work and allows knowledge to be structured according to its use. This makes knowledge more concrete and directly links knowledge to its implementation.

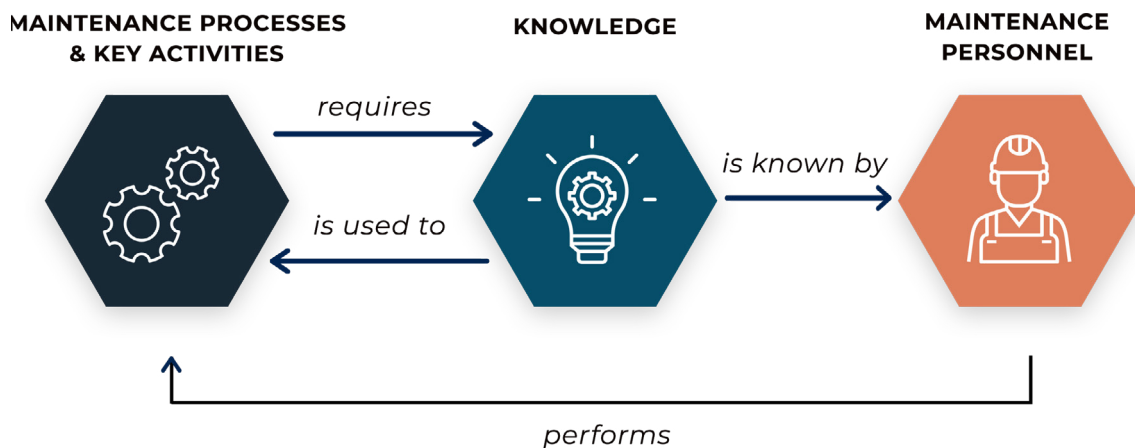


FIGURE 2: RELATIONSHIPS BETWEEN MAINTENANCE PROCESSES, KNOWLEDGE, AND PERSONNEL

EN17007 categorises maintenance processes into three types (Figure 3):

1. A management process establishes policy and strategy, defines the organisation, assigns responsibilities, negotiates budgets, manages actions, analyses data, and leads a continuous improvement process.
2. Realisation processes are the reason for the overall process and produce the expected results. They include preventive and corrective maintenance; these share a common process of preparation, scheduling, and performing tasks on items. Beyond preventive and corrective maintenance, a third maintenance process is intended to improve the intrinsic reliability and maintainability of items.
3. Support processes are necessary for both the realisation process and the management process and include:
 - Risk management for personal health and safety and the environment when performing maintenance tasks.
 - Provision of resources necessary for maintenance (e.g., spare parts, tools, information systems, documentation, infrastructures, internal staff, external services).
 - Budget forecasts and monitoring, analyses, and actions to consider maintenance in the design and modification of items.
 - Management of historical data.
 - Process optimisation as part of continuous improvement.

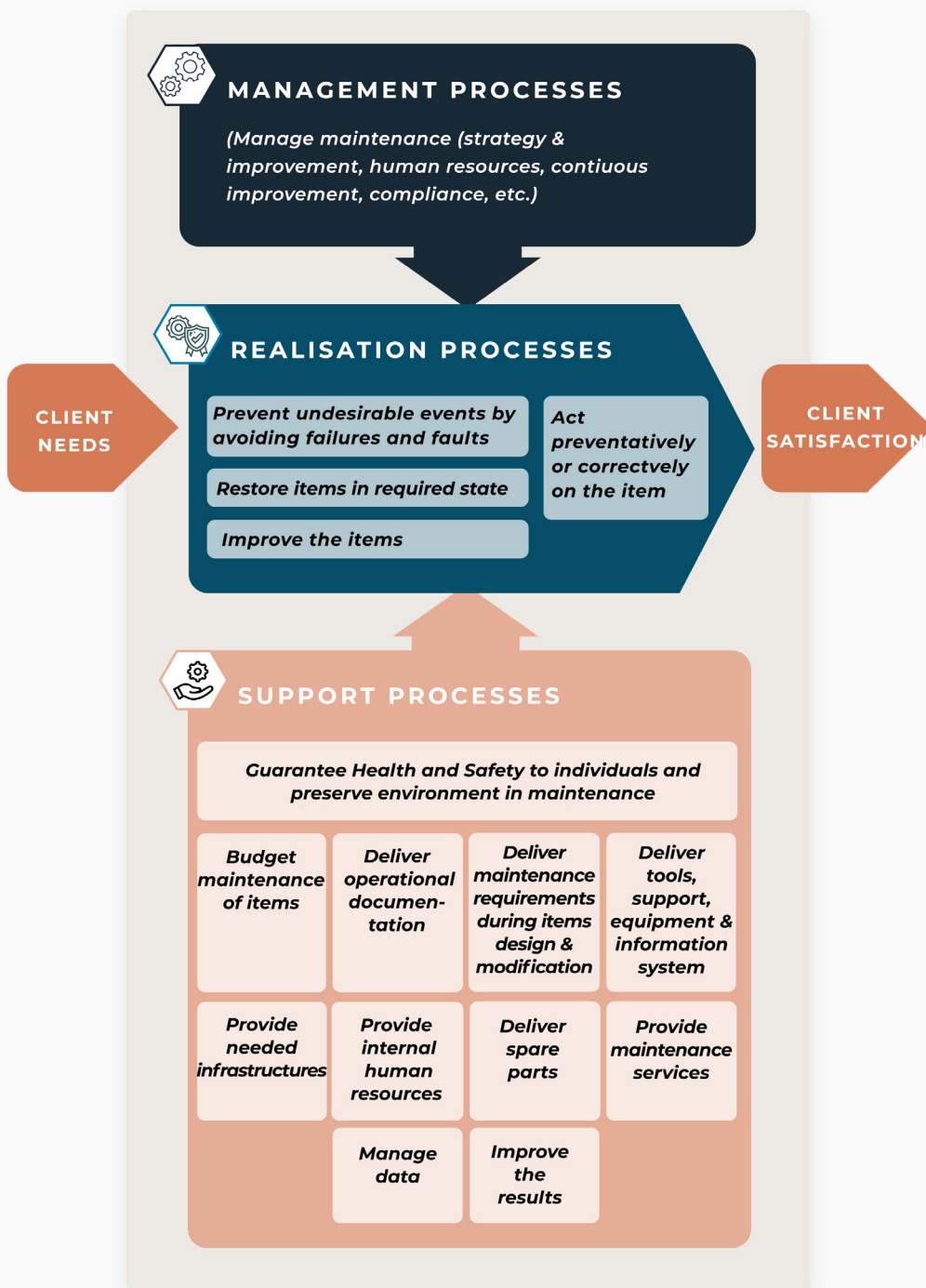
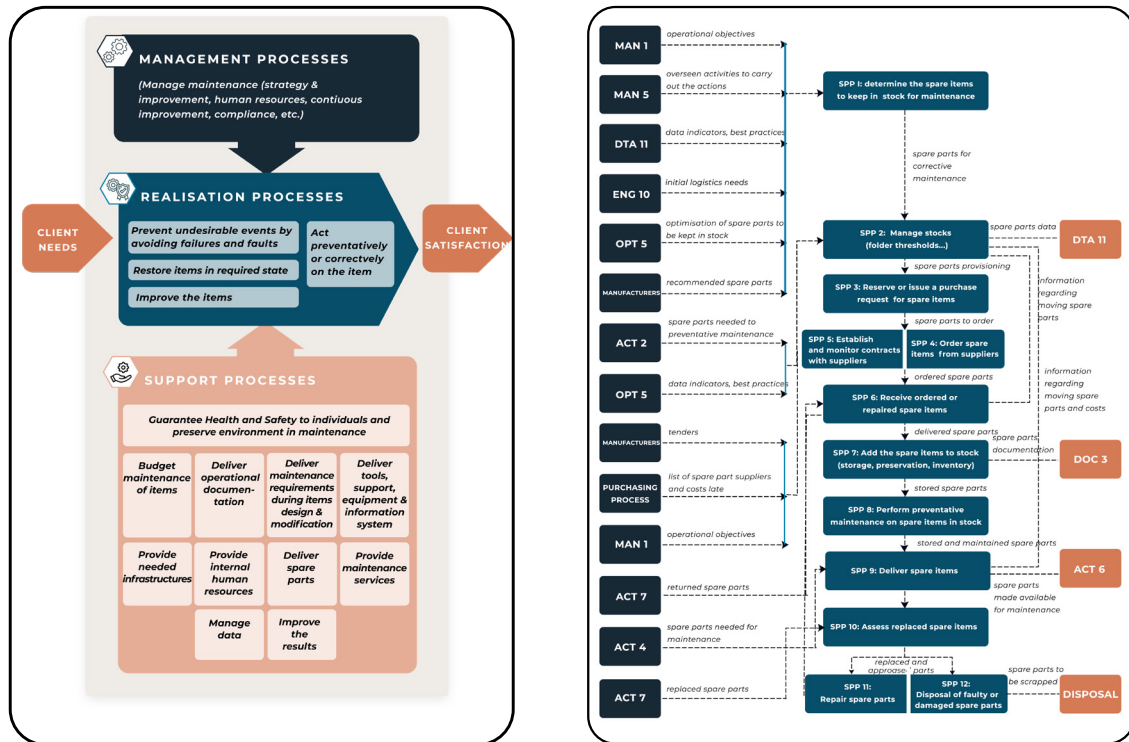


FIGURE 3: THE MAINTENANCE PROCESS (FROM EN17007)

EN 17007 breaks down all these processes into actions by indicating their inputs and outputs. The outputs of one action become the inputs for other actions, establishing links between the various processes and providing a complete model of the maintenance process (Figure 4). Overall, the standard identifies over a hundred actions; these serve as a foundation for determining the necessary or useful knowledge to carry them out.



**LEVEL 1:
MAINTENANCE
PROCESSES**



**LEVEL 2:
ACTIONS OF A
MAINTENANCE
PROCESS**

PROCESS DESCRIPTION

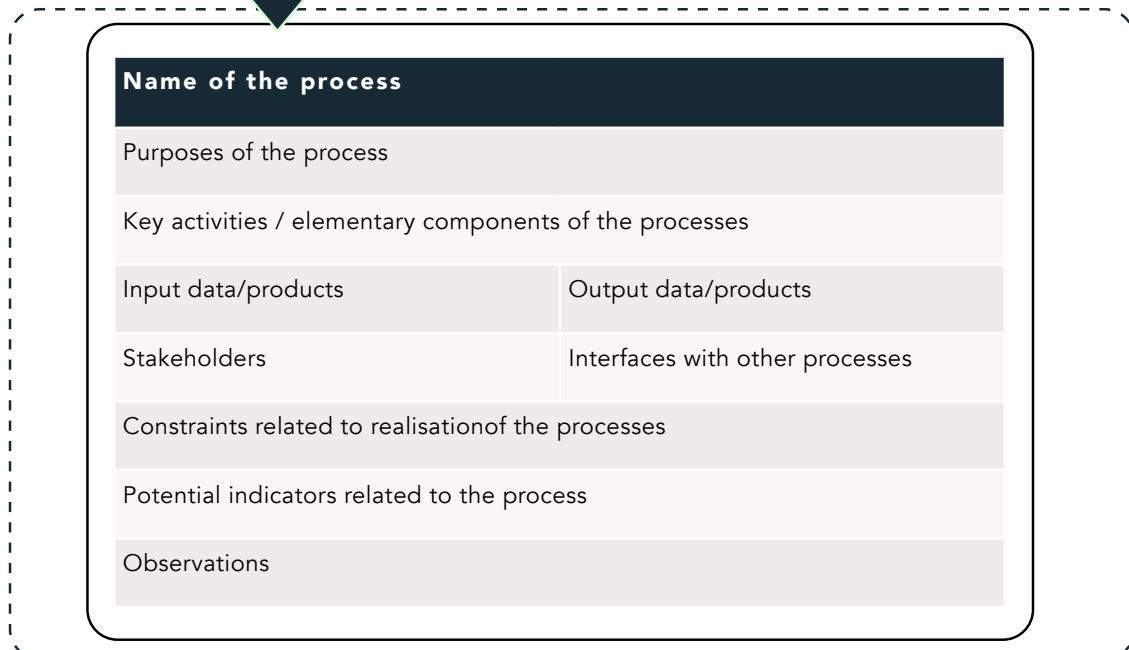


FIGURE 4: MAINTENANCE PROCESS MODEL

CONTENT OF THE EFNMS MAINTENANCE BOK

Personnel involved in maintenance activities must possess the knowledge, competences, and abilities described in the European standard EN 15628. Knowledge is a body of facts, principles, theories, and practices resulting from the assimilation of information through learning. Competences encompass the intellectual and practical aptitudes to utilise this knowledge, as well as personal dispositions suited for social behaviour.

The different types of knowledge and competences required to carry out actions, particularly to contribute effectively to maintenance activities, include:

- Learning to know (basic knowledge) refers to knowledge that is not specific to maintenance but essential for personnel to carry out their activities (communication, writing, mathematics, physics, chemistry, etc.).
- Learning to do (know-how) encompasses maintenance methods, techniques, practices, including maintenance engineering.
- Learning to be and to live together includes human relations, goodwill, teamwork, respect for rules, integration, curiosity, initiative, etc.


The BoK primarily focuses on 'learning to do' (know-how), although other knowledge and competences are also essential and should be carefully evaluated when seeking qualified personnel. The know-how presented in the BoK is derived from maintenance subjects commonly presented at conferences and seminars, available in published books or magazines, or taught in universities. The list has been enriched by experts who have added subjects, as well content from EN 15628. These subjects encompass the methods, techniques, and practices used in various maintenance processes.

Over 75 subjects are listed and briefly defined. They are linked to the maintenance processes (level 1) and activities (level 2) described in EN 17007. The results are presented in Table 1. To provide a more detailed description, EFNMS launched a call for experts to write short didactic texts that are easily understandable by non-specialists. While the subjects are broad and could be the titles of conference sessions, university lectures, book chapters, or even complete books, the aim of the BoK booklet is to provide a general and introductory description of maintenance. Therefore, the text for each subject is limited to 2-3 pages, and a bibliography containing reference standards, books, and conference papers is included for readers who seek more knowledge. The booklet covers the following areas:

- Industrial issues (life cycle management, maintenance & sustainability, education and training in maintenance, assessment of occupational risks in maintenance, etc.);
- Methods or techniques (total productive maintenance, fault diagnosis, root cause analysis, failure reporting, analysis, and corrective action systems, remaining service life assessment, benchmarking, etc.);
- Areas of knowledge and practices (negotiation techniques and industrial relations, fundamentals of project management and control, preparation & scheduling of work, budget control, good practices in health and security, etc.).

These subjects constitute a set of useful or necessary knowledge for maintenance and help understand its scope and content. They are grouped into chapters corresponding to maintenance functions, by which we mean the roles and responsibilities assigned to entities within organisations (Figure 5):

- Maintenance management associated with a broader vision of maintenance within physical asset management.
- Execution of maintenance.
- Control of occupational and environmental risks (health, safety, and environment function).
- Maintenance engineering, including methods, techniques, and practices.
- Maintenance support, covering the provision of necessary resources.



To successfully carry out the various technical, administrative, and managerial maintenance activities, stakeholders, and especially maintenance technicians, engineers, managers, and asset managers, must have specific competences that include understanding of industrial issues and knowledge of methods, techniques and practices.

The Maintenance Body of Knowledge (BoK) is a catalogue of this knowledge associated with maintenance activities to define the skills required from stakeholders. This knowledge is presented in the form of 75 subjects, shortly described and linked to bibliographies allowing the reader to deepen them.

The BoK is a collaborative document intended to be regularly supplemented, updated and improved to constitute a living reference which clearly explains the content of maintenance and its relations with other processes. It thus contributes to the development of a common maintenance culture for the benefit of companies and organisations.