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The contribution of knowledge bases to compliance assessment : a case study of industrial maintenance in the gas sector.

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Abstract : The question of compliance arises for companies interested in sustainability. In trying to meet the expectations of its various stakeholders, a company determines the scope of its responsibilities, outlines its internal regulations and identifies the evaluative framework. Whatever standard the company uses, the compliance assessment of its practices should operate simply and consistently. However, it is interesting to note that this exercise appears generally complex to implement for most companies. Various alternative solutions are developed. Nevertheless, an examination of these tools reveals that for the most part, they only provide a partial solution, which is poorly suited to the deployment of an effective compliance management system.

This paper therefore discusses the criteria for a knowledge base management tool, tailored to meet the various needs of businesses, which addresses the issue of compliance management from a more global angle. The context for the analysis is industrial maintenance in the gas sector. In this domain the issue of industrial safety compliance is particularly relevant, as it touches upon many sensitive issues (human, financial, infrastructure). Moreover, the nature and variety of the applicable requirements, and the characteristics of the population affected by the compliance assessment create a particularly suitable environment. The application of the analysis to this technical field makes it possible to verify general assumptions, which can be applied to less sensitive sectors.

We first highlight the regulatory context that applies to industrial maintenance in the gas sector. We then present some criteria for the proposed tool, which include; a method to identify the scope of applicable requirements, a way to evaluate regulatory compliance, and an investigation of other possible applications for the results obtained. Finally, we explore the potential uses for a knowledge database, as a complement to a compliance assessment tool.

Keywords : Compliance assessment, knowledge bases, industrial maintenance.

1. INTRODUCTION

In the business context, risk management, in particular regulatory compliance management has become a driver for the strategic performance of companies. Consequently, the market for compliance management tools is booming, particularly in the field of health, safety and environmental (HSE) risk management. Collaborative research in France between the Centre for Research on Risk and Crises (CRC) of MINES ParisTech and the private company PREVENTEO led to the development of an innovative software platform for managing risk, through the management of regulatory compliance. Originally oriented towards HSE issues, the long-term intention is to apply the platform to other domains. The tool has already been applied to the environmental domain. It proved possible to apply the original compliance management model directly, it was only necessary to update the knowledge base. This observation raised the question of whether there was potential to transfer the model to other domains.

This article illustrates the use of a template knowledge base processing model in a bench-test carried out in the domain of industrial maintenance in the gas sector. This field of study involves the management of several sensitive issues, such as strong technical constraints, and numerous diverse and complex regulations. This makes it the ideal scenario for testing the hypothesis that the original knowledge base model can be used to diagnose organisational compliance regardless of the regulatory corpus.

Section 2 sets out the principle issues of regulatory compliance management. Section 3 describes the knowledge base processing model and analyses its contribution to compliance management systems. Section 4 describes the experimental application of the model in a case study in the field of industrial safety in the gas sector.

2. REGULATORY COMPLIANCE MANAGEMENT

Any company pursuing a goal of sustainability must consider the question of compliance. The profit motive is meaningless unless it is accompanied by assessment of the risks the company is exposed to. Whether financial, legal, commercial, etc., the impact of these risks is ultimately economic and can put the future of the company into question. It is therefore essential for the long-term future of any company to identify the various risks that it is exposed, to clearly identify the scope of its responsibilities, and to meet these responsibilities.

2.1. The challenges of regulatory compliance

In the corporate world, the concept of regulatory compliance [1-2] does not usually translate into virtuous but naive attempts to respect the letter of the law; rather it involves an assessment of the risks of non-compliance. The consequences of non-compliance can be defined as the risk of prosecution, administrative, financial loss, and damage to business reputation. Moreover, these multiple responsibilities may be cumulative. Consequently, risk management systems are very much in demand.

For example, the findings of the investigation into the explosion of the Deepwater platform in the Gulf of Mexico on 20th April, 2010, which caused the largest oil spill in the history of the United States of America, highlights the responsibility of the operator (British Petroleum, BP) and some of its subcontractors, particularly Halliburton and Transocean. The report identifies as the “principal cause of the accident [...] the failure of the well casing cement”, which should have prevented oil and gas from rising [3]. Halliburton (the contractor responsible for this work) claimed in court that BP had not provided sufficiently accurate information to enable it to carry out the work properly. Nevertheless, the completed work was declared “compliant with BP’s rules”.

This example provides a good illustration of the challenges of managing regulatory compliance. It shows that it is not simply a question of determining the applicable rules and corporate responsibility at the judicial level, but also concerns the disastrous impact that non-compliance may have on the company’s image, both for the population at large and potential investors.

2.2. The ‘responsible’ company

The concept of responsibility is generally confined to one area of law. Consequently the meaning of responsibility [4] differs depending on the area of law concerned¹. However, the company (which has become an actor to be reckoned with in modern Western society) has many and various responsibilities (moral, legal, financial, etc.) raising complementary — and sometimes conflicting — issues.

¹ For example, in civil law the principle of responsibility involves a physical or moral entity who must answer for the damage they have caused to others by making reparation, either equivalent or in kind, through the payment of compensation. In criminal law, the acknowledgement of personal or legal responsibility requires the perpetrator to answer for the offense they have committed.

In practice, the scope of corporate responsibility is defined by the expectations of its various internal and external stakeholders². Each of these parties pursues different and sometimes divergent objectives, and it becomes a complex task for the company to fully meet these expectations, while at the same time respecting its primary strategic objective, namely economic sustainability.

The binding obligations³ of a company can be the result of the application of a constraint (this is particularly true of the 'regulations'⁴ issued by public authorities) or they can be voluntary (obligations based on a repository, standard, charter, or prepared by headquarters, which the company undertakes to respect). The compulsory nature of these rules is seen at a later stage in the implementation of a compliance management system; it becomes apparent when the company decides the priority of compliance actions. However, this diversity in the origin of obligations has an impact on compliance diagnosis. Depending on the source of the rule, many key elements vary in particular its form, its foundations, and its scope. This fact contributes significantly to an understanding of why the compliance assessment repositories⁵ of a large number of companies are incomplete and/or inconsistent.

It is therefore clear that the issue of compliance arises not only in legal terms, but also concerns stakeholder expectations. The company must manage its many and various obligations (all formulated differently), and the potential liabilities resulting from its responsibilities. In many companies the concept of corporate social responsibility⁶ (CSR) is finding increased acceptance; this is an illustration of an introspective process that leads companies to take responsibility for their actions. Adopting a system to ensure compliance can become a condition for continued sustainability, as well as a potential driver of performance⁷ [5]. Given the challenges of regulatory compliance management, it is essential for companies to adopt effective and efficient compliance management systems, and to establish assessment repositories that are comprehensive, homogeneous, clear, and legible, and that provide easily exploitable results.

An analysis of various business practices revealed the many challenges they face. This observation formed the basis for the development of a model to process the raw data found in regulatory knowledge bases, and made it possible to implement a highly-capable compliance management system suited to any type of organisation.

3. THE KNOWLEDGE BASE PROCESSING MODEL

In order to evaluate the knowledge base processing system, it is first necessary to describe the compliance management model adopted.

3.1. The compliance management model

Beginning in 2008, research carried out by the CRC led to the development of a model Compliance Management System (CMS). A parallel study [6] of 820 French OHS professionals [7] identified the emerging needs of French companies in terms of work methodology and/or tools to support regulatory compliance management. The initial CMS model [8] drew upon the results of this study. The model has been operationalized and tested using software developed by PREVENTEO and applied to the

² 'Stakeholder' indicates any individual or collective actor directly or indirectly affected by the life, interests, or policies of the company.

³ 'Binding obligations' describe the constraining nature of a rule with respect to an actor (here, the company). It is therefore an obligation to which the actor cannot subscribe without incurring liability.

⁴ As used here, the term 'regulation' encompasses the various applicable rules of law, whether of legal or regulatory origin.

⁵ The regulatory compliance assessment repository of an organisation is defined as the corpus summarizing all the rules applicable to that entity.

⁶ Corporate Social Responsibility (CSR) refers to the consistent efforts of a company to incorporate sustainable development goals into its overall strategy.

⁷ The advantages of developing a corporate legal culture can be negated in cases where the regulatory compliance management system is mismanaged. It then becomes no more than a source of incomprehensible rules and bureaucratic requirements [3].

domains of environmental law and OHS. It describes the organization of various variables within processes and sub-processes. The three principle processes are, (i) regulatory monitoring, (ii) the compliance assessment and (iii) the management of action plans. The process of managing the company's compliance practices according to the applicable rule⁸ can be schematised as follows:

Table 1. Compliance management system steps.

1	Definition of the scope of the applicable regulation	An actor, whose rules must be respected, develops a rule that impacts the company's actions ⁹ .
2	Regulatory monitoring	The company must be able to identify this rule, together with possible updates, modifications or its deletion.
3	Definition of the applicable regulatory repository	Once identified, the rule must be integrated and recorded in the management system of the corpus applicable to the business.
4	Regulatory compliance assessment	The correct application of the standard by the various levels of the business in question must then be evaluated.
5	Planning of corrective actions	Following the compliance assessment, any business practice inconsistent with the applicable rule must be the subject of a compliance action forming part of an overall action plan for establishing regulatory compliance.
6	Management review	Finally, the implementation and effectiveness of the planned corrective actions must be analysed.
NB: Tools that assist in completing these stages can vary. Nevertheless, compliance with all of these phases, in the order described, must be achieved.		

An analysis of the practices of various companies [4] of variable sizes and in different lines of business revealed that the implementation of this phased compliance management process often proved to be incomplete and difficult. It was frequently the case that the compliance management system had not been fully thought through and/or correctly and completely formalized. Some simple questions can detect this deficiency, for example: Who carries out monitoring? How is it done? What monitoring information is collected and who receives it? Who assesses compliance? What is the schedule? Who receives reports? Who is responsible for monitoring compliance at field installations? One of the main difficulties proved to be an incorrect or incomplete identification of the applicable rules¹⁰. A second difficulty was the identification of a single repository (a corpus of data that brings together all applicable regulations) that could be easily accessed by the various categories of actors (assessors, interviewees, sponsors, local, middle or senior management, etc.) involved in the compliance assessment process. Finally, few companies had at their disposal a formalized compliance assessment system¹¹, from which a compliance action plan could be generated. These elements highlight the importance of the repository in the implementation of an efficient CMS. In fact, each process draws upon it. Monitoring activities provide its input; in turn, it supplies the compliance assessment with source material and the action plan identifies the consequences of any differences observed between the repository and business practices. This observation motivated the development of a template repository model.

⁸ This applies whatever the origin of the standard that applies to the company and therefore whether its application is compulsory or voluntary.

⁹ This will vary according to the company's activities, categories of staff, type of work carried out, equipment and products used, etc. Based on these parameters, specific regulations must be observed.

¹⁰ This can be attributed to various causes: poorly defined rules, difficulty in accessing the sources of rules, lack of resources dedicated to monitoring, inability to analyse rules, etc.

¹¹ It is very often the case that the company has no 'integrated' system of compliance assessment, i.e. a system where the various tools for carrying out an assessment and preparing action plans interact, and complement each other. Instead, the company must manage multiple, complex tools, that are sometimes contradictory or redundant.

3.2. Processing the knowledge base

At the heart of the compliance assessment repository lies rules, legal obligations, regulations and internal procedures, etc. The form and scope of these rules vary depending on the nature of the text and its source. This, as we have already seen, is the source of many difficulties for business, both in the context of regulatory monitoring and in the development of their repository.

The template repository model aimed to be exhaustive, uniform, and accessible. First, the raw data that constitutes the provisions of a regulatory text was methodically processed, in order to build a relevant knowledge base. Then, the model structured the content of the knowledge base into a compliance assessment repository. Figure 1 is a schematic of the model.

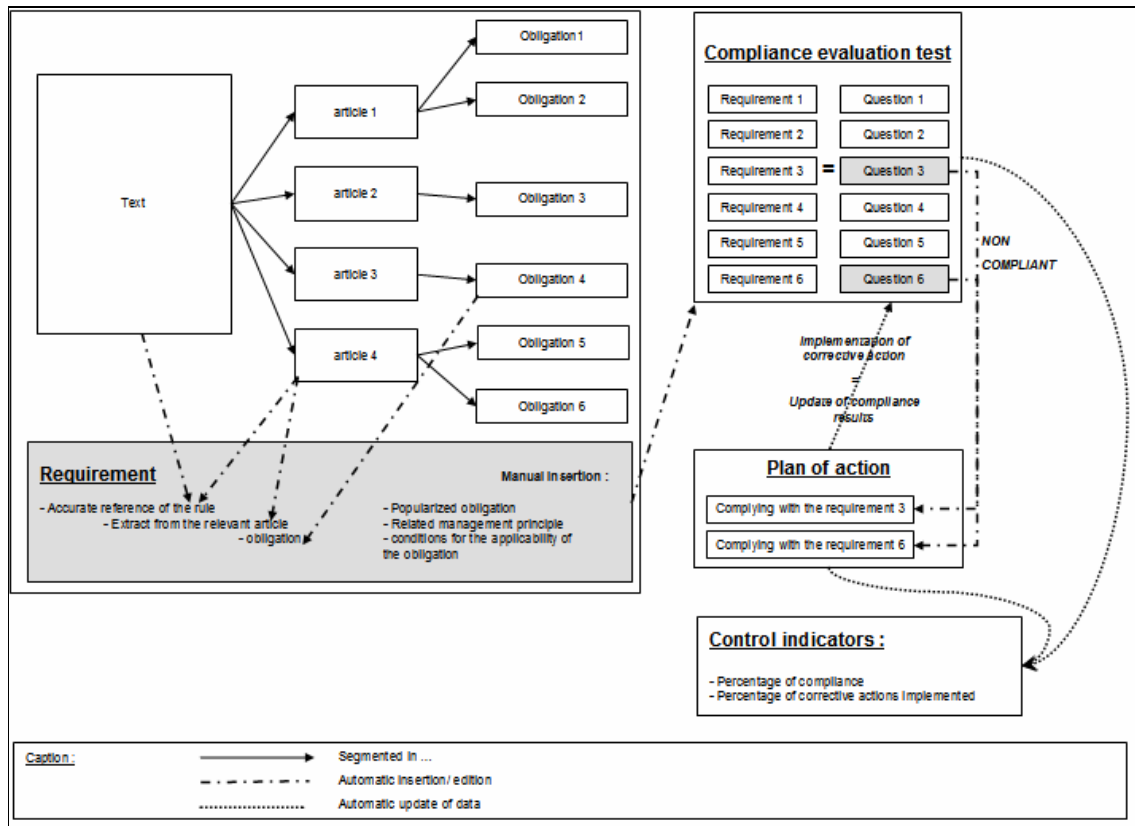


Figure 1. Knowledge base processing model

Figure 1 explain what is the text, in whatever form, is split into several parts, usually taking the form of articles. Within an article, certain provisions will give rise to obligations that affect the company. The knowledge base is created by associating the raw data that comprises the article (and therefore the obligation) with a 'requirement' (relevant to compliance management) that arises from the obligation. In other words, each obligation gives rise to a regulatory requirement, against which compliance must be evaluated.

Obligations become a knowledge base through the following elements:

- The accuracy of the obligation (if necessary expressed in simpler terms, but faithful to the original text).
- The link between an obligation and its origin: exploitable regulatory references are created by the association of an obligation with an extract from the originating article, supplemented by the exact article title and text. In fact, the completeness of the reference (in the context of a

compliance assessment) makes it possible to clearly identify the source of a requirement and understand its scope.

- Identification of the management principles associated with the obligation (e.g. compliance with the obligation can be linked to the organisation's document management processes).
- The specificity of the conditions under which the obligation applies: like a regulatory text, each obligation may or may not be applicable, depending on whether one or more variable conditions are met. Applicability conditions define the scope of the obligation.

The implementation of the model in software made it possible, from the identified requirements, to automate both the association of compliance management criteria with obligations, and to generate the compliance assessment questionnaire. The accuracy and optimal structuring of the assessment questionnaire is left to the company (which can then specify in detail what it sees as being associated with a regulatory requirement). As a result, an assessment of compliance with various types of texts can be carried out on the basis of assessment questionnaires, all structured identically. At the same time, the source of the document (legal, normative, internal, etc.) is retained and remains easy to identify. Finally, each of the assessed requirements is associated with an action plan. The action plan receives input automatically as the company's assessment of compliance with the repository progresses. Each time a non-compliance issue is identified it is automatically translated into a corrective action. Therefore, both the compliance assessment repository and the associated action plan can simultaneously be created from the knowledge base.

The original CMS, operationalized and tested in the domain of OSH, was founded on this model. An extended version incorporated environmental regulations. In both cases, the challenges involved were identical: legislative and regulatory texts applicable at a national or local level, similar company requirements for repository management, etc. Therefore, in order to validate the generalization to any type of repository it was necessary to test the model in a different and more complex context.

The issue of compliance has particular resonance in the domain of Industrial Safety (IS). This sector has to manage many sensitive issues, such as human resources, finance and infrastructure [9]. Furthermore, the nature of the applicable requirements (operating procedures, design rules, etc.), the variety of their sources (regulatory, normative, internal procedures) and the groups involved in the compliance assessment creates a particularly suitable field for analysis. The application of a compliance management tool to this highly technical domain makes it possible to verify general hypotheses that can then be applied to other, less sensitive sectors.

4. THE CASE STUDY

First, we examine the regulations that apply to industrial maintenance in the gas sector and how they are understood by the company in question (Section 4.1). Then, we describe the experiment carried out to bench-test the proof-of-concept compliance assessment tool (Section 4.2). Finally, we analyse the results of the experiment (Section 4.3).

4.1. Industrial safety regulatory management

The variety of sources of applicable regulations is the main difficulty identified in IS compliance management. The IS repository consists primarily of laws and regulations arising from national and local legislation. For the most part, these texts provide general principles, leaving it to the operator¹² to translate them into technical modalities. To achieve this, the operator draws up internal memoranda¹³.

¹² Here 'operator' means the gas distribution network manager.

¹³ Internal memoranda are organized as follows: 1. Memoranda for national distribution, which comprise: general principles applicable to all parts of the organization; technical memoranda governing the use and maintenance of equipment and tools; guides describing specific operating procedures for equipment maintenance. 2. Memoranda for local distribution: these relate to regional strategies.

Internal procedures are therefore prepared on the basis of both legal regulations, and technical standards¹⁴.

This active participation of the operator in defining the relevant rules underlies two problems:

- Do internal memoranda reflect as well as they should, the regulatory and legal general principles?
- Are these principles correctly and completely transcribed into non-redundant technical requirements?

Compliance verification creates many other problems for the company. The multiplicity of sources increases the risk that applicable regulations are only partially identified. Consequently, regulatory monitoring becomes unreliable, both in relation to the correct updating of texts, and in monitoring relevant texts. In addition, as the rules to be applied vary in form and are often highly technical, they can be difficult for managers or operations staff to understand. Finally, the company is highly decentralized and has to manage a wide variety of compliance assessment methods, which vary according to local practice. It is almost impossible to compare or synthesise the results of assessments, and when it is possible, the information produced is unreliable¹⁵. It does not seem sensible to base strategic decisions on these uncertainties.

These issues relate to the three phases of the compliance management process mentioned earlier. They provide a good illustration of the main difficulties of managing regulatory compliance and highlight the attendant issues¹⁶. This provides a suitable background to verify the potential generalization of the proposed tool. Therefore, a bench-test was designed to demonstrate a proof-of-concept, self-assessment compliance tool.

4.2. Bench-testing the proof-of-concept tool

The tool was bench-tested in a French gas distribution company. The company designs, operates and maintains gas distribution networks and is organized into two main areas. The first is dedicated to gas management, and the second to common service activities. Industrial safety compliance management issues are mainly concentrated in the first area. The gas distribution service covers the whole of France, and administration is generally decentralized at the regional level. The bench-test was focussed on a particular aspect of gas management: maintenance of network valves at a regional level. This limited domain was chosen as it implements the majority of the IS regulations that apply to the company. Valve maintenance involves network design rules, operations, the maintenance of technical equipment (measuring tools, checking for leaks, etc.), and an assessment of the competency of field operators. It therefore offers a representative illustration of the problems encountered by the company in the domain of SI compliance management.

The bench-test was prepared in collaboration with personnel responsible for monitoring the regulatory compliance of the company at national and regional levels. The proof-of-concept tool was presented to a representative sample of managers and operators in charge of network valve maintenance in the pilot region¹⁷. As some of the regulatory requirements related to IS were applicable at a national level, general managers were also asked to participate. This represented a population of about twenty people. Testing was carried out between July and November, 2011. The first phase consisted of defining the scope and content of the proof-of-concept tool. This was done between July and early September. The

¹⁴ Rules defined by standards are generally not legally binding. However, their application may be made mandatory by the provisions of law or even internally.

¹⁵ An operational check on the application of the rules is carried out through national internal audits performed on geographic samples every two to three years, based on a specific issue and external local audits. Most of these assessments are paper-based or use standard office software.

¹⁶ The case study assumes that the compliance management tool is capable of distinguishing the different regulatory sources (legal, normative and internal) in order to be able to prioritize compliance actions identified during the assessment as a function of the likely associated responsibility. It must also make it possible to identify the links that exist between a statutory provision stating a general principle and its transcription into an internal technical memorandum.

¹⁷ This included local management responsible for managing network operations agencies, maintenance agents, research departments, and operational IS matters at regional level.

second phase (mid-September to mid-November) was to prepare the on-site bench-test. During this phase the tool was fine-tuned, the compliance assessment method was defined, and interviewee populations were identified. The final on-site bench-test, which took place during one week in late November, involved interviews with the personnel previously identified. Following the interviews, the results were analysed in collaboration with the pilot company.

The proof-of-concept tool was created from a list of texts applicable to industrial maintenance in the gas sector submitted by the pilot company¹⁸. The tool was developed as follows:

- Eleven texts were identified as relevant to the scope of the bench-test, from a list provided by the company.
- Each of these texts was integrated into the tool and each identified obligation was associated with its regulatory source(s) (legal, normative, internal to the company).
- Each text was classified by regulatory theme (see Figure 2).
- Each text was translated into regulatory requirements and into a questionnaire to assess compliance with regulatory requirements. Processing the texts identified approximately 550 applicable requirements, distributed across 12 compliance assessment questionnaires.

Category	Theme	Questionnaire
National policy	General provisions	Design and architecture of the fuel gas pipeline distribution network
Design and architecture of installations	Networks: general	General principles for network design

Figure 2. Example of Industrial Safety theme classification.

An example will help to demonstrate the process. The following is an extract from an internal maintenance memorandum. "Gas detectors must be checked by comparison with standard gases on the appropriate scales (refer to specific appliance guides and maintenance manuals).

The Appendix contains details of the nature of these gases as a function of appliance measuring scales, and verification methods. The use of the verification (or calibration) bench, and equipment used to check the correct operation of gas detectors must be authorised (MDGP guidelines)."

This extract contains two separate requirements:

- Check gas detectors by comparison with standard gases using the appropriate scales.
- Ensure that the use of the verification (or calibration) bench, and equipment used to check the correct operation of gas detectors has been authorised.

The bench-test aimed to verify the transferability of the methodology for processing knowledge bases. Various other sub-goals therefore had to be validated with interviewees and corporate compliance managers. These included not only the relevance, quality and readability of the knowledge base, but also the proposed methods for assessing compliance (self-assessment or audit by an IS expert). The outcome of this second action was to correctly identify the end-users of the tool¹⁹.

The test consisted of submitting the proof-of-concept tool (compliance assessment questionnaires) to the relevant actors. After outlining the issues, the actors were interviewed in the presence of personnel responsible for monitoring the company's regulatory compliance. The interviews were based on compliance assessment questionnaires integrated into the software platform. Participants in the

¹⁸ The knowledge base processing model was initially tested in the disciplines of environmental law and OHS (the domains of competence of the research team). IS regulations did not form part of their area of expertise. Although this initially appears problematic, it in fact makes it possible to verify that it is the text treatment methodology that gives meaning to the data. It also confirms that the compliance assessment repository that is developed is relevant and does not simply contain the knowledge of the person responsible for the processing.

¹⁹ In the OHS and environmental context the software is used by local and middle managers who arrange operator interviews and edit, update and disseminate the action plan arising from the assessment. Senior management, for its part, has access to the resulting relevant indicators and the outcomes of compliance management monitoring.

assessment were asked to critique the tool, both in terms of its form, content, and the assessment methodology. In this way, the relevance and wording of questions could be analysed in light of the regulatory provisions of the source texts. Each participant was asked to comment on each of the answers they provided during the assessments, and for any further comments at the end of the interview.

4.3. Results

Bench-testing of the tool provided confirmation of the initial hypothesis of the portability of the knowledge base processing model. The quality and relevance of the compliance assessment repository was validated. The repository was complete, readable and user-friendly²⁰. Through a series of simple questions each applicable regulatory obligation could be assessed through the identification of its source (legal, normative, or internal). The results of the assessment fed automatically into an action plan, where compliance measures were planned, prioritized, and commented upon, according to the company's objectives. Reports summarizing the compliance percentages obtained were automatically generated. Finally, relevant indicators [10-11-12] provided decision-making support by making it possible to monitor the progress of the assessment at different levels in the company, their compliance percentage, the rate of implementation of corrective actions, etc.

Through this process, all levels of the company were able to document their specific regulatory compliance, based on a common and easily understandable methodology. This made it possible to automatically and rapidly consolidate all compliance assessments conducted over an extended geographical area, involving personnel employed in different trades and falling under different regulatory scopes. With these foundations, constructive benchmarking could be achieved.

Furthermore, the bench-test revealed unexpected results concerning the problem of multiple rule sources (normative, regulatory and internal). While the methodology ensured a complete, consistent and non-redundant transcript of legal provisions into internal memos, these memos have sometimes proved difficult to understand by those responsible for implementing them. Some internal rules have proved confusing, ambiguous, and out of step with the vocabulary used in the field. These findings led to a revision of internal memos with the dual purpose of clarifying and tailoring them to operational realities.

Finally, the integration of regulatory data from the gas sector into the software broadened the potential uses for the database. The development of new compliance assessment repositories led to the creation of a library of databases related to maintenance processes in the gas industry. Extracts from this database could be used to supplement the existing compliance management tool.

5. CONCLUSIONS

The difficulties encountered by companies in managing their regulatory compliance are largely due to uncertainties and confusion in their compliance assessment repository. The model presented here may provide a solution to this problem, using a novel way to process regulatory obligations. The bench-test carried out in the gas sector has, firstly, validated the transferability of the method to any type of regulatory context, and secondly, identified other potential uses for the knowledge bases obtained.

The processing of regulatory data made it possible to develop a library of knowledge bases, which provide multiple opportunities, not only for the production of compliance assessment repositories, but also many other diagnostic compliance tools. During the course of the bench-test, a large number of the obligations processed were considered to be technical requirements. The operational nature of these requirements makes it possible to envisage complementary uses for the repository. A first

²⁰ The bench-test led to the exclusion of operators as potential end-users of the proposed tool. Compliance assessment at this level does not provide real added-value to a general analysis of corporate compliance. However, their operational expertise provided interesting feedback, particularly with respect to language disparities between internal memos and practice in the field. Tools derived from the knowledge bases (operations manuals, checklists for assessing knowledge, etc.) would make it possible to assess the competency of these operators.

alternative use may be in the form of operations' guides: the extraction of this data could provide an effective tool for the preparation of operating or emergency procedures to be followed in crisis situations. The second could take the form of knowledge assessment checklists, i.e. the ability to evaluate task execution conditions that provide the optimal level of safety in operational conditions. This knowledge could be formalized through training modules or periodic assessments of staff skills.

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