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Mending the patchwork of requirements from multiple standards using participative goal modelling: a case in the food industry

Abstract: An increasing number of concurrent standards and regulations is being imposed on organizations operating in various domains. From healthcare to automotive to food, demands from national legislation, directives of each target market, and edicts from specific clients are creating a patchwork of requirements for compliance and audit. Managing these disconnected frameworks involves considerable overhead, duplications, and conflicts. But integrating and harmonizing these requirements needs the collaboration of varied stakeholders, with different trainings and backgrounds, capable of translating the impacts of the various norms in the different sectors of the organization. We propose a participative goal-oriented approach, consisting of four steps, to assist in this process. It brings together the requirements from the various regulations, the organizational goals, and measurement indicators. We describe its use in a company operating in the food industry, one of the most regulated in the world, where audits are very frequent, to integrate ISO 22000, IFS Food, and BRC Global Standards. Our findings show that an effective integration of the multiple regulations was possible, and that the resulting goal diagrams are an effective tool for communicating with various stakeholders, such as employees, clients, auditors, consultants and representatives of industry initiatives.

Keywords: Participative goal modelling; GRL; multi-standard integration; food safety standards; audits; regulatory compliance.

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1. Introduction

For the past 15 to 20 years, organizations have been forced to comply with an increasing number of concurrent standards and regulations. These address issues such as quality, security, safety, and impact domains as diverse as software, healthcare, automotive, telecoms, and finance, among others. The food industry is one of the most regulated in the world, with companies having to adopt multiple standards for quality and safety in their daily practice [39]. Each standard has its own structure of chapters and clauses, providing a diversity of requirements that must be implemented and continuously audited.

These demands on organizations originate from various sources: national legislation, directives of each target market, and mandates from specific clients, effectively leading to the adoption of a plethora of disconnected frameworks. Consequently, organizations are faced with the considerable overhead of maintaining multiple models, with some amount of overlap, potential conflicts, different levels of scope, focus, and detail, as well as different rules for audits.

This reality makes modelling of regulations a relevant research topic, with some work addressing goal-oriented approaches, such as [18–20, 43, 47]. Compliance with regulations is not new in requirements engineering, as revealed by [42] in their review of the past fifty years of addressing legal issues in this domain. A recent literature review presented by [25] also confirms the importance of compliance topics in goal-oriented RE research. However, despite their important contributions, the available studies (1) focus on formalizing goals and rules from legal texts, (2) do not address the integration of standards that exist in various sectors of the economy, (3) do not explain how to align organizational goals and requirements with multiple standards, and (4) do not report to cases of participative goal modelling in global supply chains. Moreover, we agree with [25] about the importance to "*see even more convergence and utilization of existing work […] making an effort to understand, adapt, extend and re-use what has been done [… and the] evaluation of existing methods, rather than the introduction of new ones*". We were faced with these gaps when dealing with the case of a company in the food industry. It needed its staff, with heterogeneous backgrounds, to collaborate in harmonizing guidelines for simultaneous compliance with the requirements of three

popular standards: ISO 22000, IFS Food, and BRC Global Standard. In this context, a modelling method and a language that is acceptable and comprehensible by all involved stakeholders is key [33, 55].

In the remainder of the paper, section 2 provides some common ground on standards, regulations, and audits in the food industry, to better illustrate the problem faced by the case company. Next, we introduce canonical action research as our method of inquiry. Section 4 describes the action research process, and it is followed, in section 5, by a discussion about relevance, rigor, validity, and generalizability. Finally, section 6 states the conclusions, limitations, and provides an outlook for future work.

2. The context of the food industry

International organizations, government authorities, retailers and associations of producers have introduced standards to improve food quality and safety [9, 23]. Currently, food legislation for quality and safety is complemented with several private regulatory systems [39]. Although not mandatory, most of food producers adopt these directives, since they are a *de facto* requirement to compete [23]. Information alone is not enough to ensure the trust of consumers in the food industry: "*Just doing what is legally obliged offers not enough ground to trust someone in a changing and complex situation*" [38]. Rather, it is necessary to supplement transparency with responsibility by all the process participants and interested parties in the food chain [34, 38].

There are popular standards in the food safety context, some of them recognized by the Global Food Safety Initiative (GFSI), for example [50]: ISO 22000; International Food Standard (IFS); Safe Quality Food (SQF); and British Retail Consortium Food Global Standard (BRC). ISO 22000 for food safety combines the key components of interactive communication, system management, prerequisite programs, and the principles of Hazard Analysis Critical Control Point (HACCP). SQF is an Australian initiative that combines a quality management system such as ISO 9001 and HACCP. BRC was created in 1998 for UK retailers and manufacturers, while German, French, and Italian counterparts developed IFS. A comprehensive presentation of the history of private food regulations and a summary presentation of the most popular is offered by [39], stating

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that a majority of the standards also refer to public law that must be complied with. Therefore, the organizational regulatory space in this industry is a complex combination of voluntary (e.g., food safety standards) and enforced (e.g., laws) regulations that organizations implement with the participation of all their stakeholders [5].

There are frequent audits in the food industry with distinct criteria for requirements satisfaction. Some with the purpose of verifying compliance to standards, but there are also approaches to diagnose core control and assurance activities of the organization that include: information system; design of prevention measures; monitoring systems; and operation of control strategies [35]. Moreover, the audits may be internal or external, based on standard checklists or on approaches more specific to each organization [1]. Some authors, for example [1], suggest risk-based auditing, that contrasts with standardized checklists because it focuses on target risk-areas of the organization. Authors such as [54] argue that the effectiveness of food quality models depends on factors that are specific to each company: (1) the complexity of the food chain (e.g., number of elements in the network; degree of dependence between chain members); (2) the complexity of the organization (e.g., number of products; managerial characteristics); (3) the complexity of the production (e.g., batch/continuous); and (4) the complexity of product assortment which depends on the variety of product lines and product composition.

Although popular in auditing and multi-standard regulatory compliance in food industries, checklists are not sufficient [1]. For example, IFS includes six main chapters and hundreds of more specific requirements to guide the organization [27]. The BRC global standard includes quality principles in its structure (e.g., management commitment and continuous improvement) among others, more specific for the food industry, such as the HACCP and product control [8]. An integrated food safety management system requires the modelling of each standard, establishing links between their structural components [32], and intertwining the requirements with organizational practice.

According to [20], it is possible to compare high-level goals of distinct regulations to understand their potential convergences and/or divergences. The descriptive models that we have found in the literature are important to identify the system components and their relations, but do not

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provide guidance for creating links between the structures of multiple standards, nor for establishing goals and assessment indicators with the intervention of modelling participants.

Some authors have provided models aimed at a strategic perspective [6, 48]. The strategic business model ontology (SBMO), proposed by [48], is based on the i* modelling framework [60] and includes two interrelated layers: strategic and operational. In [6], the authors propose a model-based performance management framework for the entire lifecycle of strategic initiatives. The framework includes the business intelligence model (BIM) for the strategic layer and the conceptual integration model (CIM) for the implementation view. Both contributions, presented by [6, 48], address the challenge of modelling dynamics over time, according to the evolution of company strategy. However, the above-mentioned studies do not address organizational values (e.g., customer focus, transparency, consumer safety) in their practical examples, even if both proposals seem to have the potential to be adopted to account for high-level principles of the organization. For example, the BIM model in [6] could be used for modelling the evaluation of quality principles, and [48] could be used for the decomposition of high-level principles (soft goals) into more detailed standards, goals, and rules.

There is an increasing interest in schema integration and ontology matching to the coordination and integration of data and conceptual models [51, 52]. The methodology presented by [44] uses Unified Modelling Language (UML) to model safety standards. Their main purpose is to verify compliance, establishing a relationship between the concepts of a given standard and the application domain [44]. However, existing approaches focus on automated matching, and we could not find in the literature a solution that could be adopted in participative goal modelling of multiple regulations, accessible to organizational stakeholder with different background educations.

Languages to support goal oriented enterprise modelling include, for example the User Requirement Notation (URN) [31] and its sub-notation goal-oriented requirements language (GRL). The latter can be used to describe intentions, goals and non-functional requirements of different stakeholders of a system [2]. A GRL goal graph includes elements interconnected by various kinds of links (e.g., contribution, correlation, dependency). GRL elements can be in the form of *goals*, *soft-goals* (which differ from the former due to the lack of a clear quantification), *tasks* (to operationalize

goals and soft-goals), *beliefs* that represent design rationales, and *resources* that must be available to the other elements [2]. In GRL, systems and their stakeholders are represented as *actors*, with a potential interest for modelling the requirements of compliance to regulations.

There are recent contributions for modelling regulations, for example [20], who adopted LEGAL-URN to model multiple legal statements. Another example is the work of [28], who proposed the Nòmos framework for modelling law-compliant software requirements. The work presented by [47] used i* to model the ISO 15504 standard, concluding that goal oriented approaches can be used to assess and measure compliance with the standards.

However, these studies do not address the case of participative goal modelling, and few authors have provided empirical evidence on the use of their models for auditing purposes. Moreover, we did not find any studies that aimed at developing models that end-users can integrate seamlessly with their existing performance evaluation and process improvement tasks that constitute their daily routine.

The literature confirms that modelling regulations is a priority for food industry [50], it is a complex endeavour [38] that must consider the specific context of each company [54] and must ensure requirements transparency and auditability [35]. The difficulties in managing multiple regulations with several – in some cases overlapping – requirements [1, 32, 40] requires new approaches to model food regulations and improve regulatory compliance. We were inspired by the work of [20] to start with a comparison of high-level goals of food regulations and integrate a strategic perspective of company policies in their goal models. Moreover, previous work on goal-oriented approaches confirms its potential in regulatory contexts [4, 28, 33]. We also agree with [45] that "*since much of the overhead and disturbance associated with multiple frameworks arises because of multiple appraisals in a narrow window of time, method integration must be considered as well as model integration*". Therefore, our challenge is to design an approach that can, simultaneously:

(1) Enable the participation of company and supply chain stakeholders with different backgrounds (e.g. quality, IT, finance, job floor, operations) using an understandable common language;

(2) Provide guidance for creating links between the structures of multiple, concurrently adopted food safety standards and for establishing goals and assessment indicators;

(3) Take organizational values (e.g. customer focus, transparency, consumer safety) into account when handling the multiple regulations;

(4) Minimize overhead and consolidate methods, to generate evidences suitable for frequent audits using disparate frameworks.

3. Research approach

Our goals were to assist the company in dealing with the challenges of complying with concurrent, disparate, standards and regulations and, simultaneously, expand scientific knowledge on the topic, namely by way of the devised procedures. This fits perfectly with the dual aims of action research, as defined in [26]. Further, according to [7], action research is "*(…) one of the few research approaches that we can legitimately employ to study the effects of specific alterations in systems development methodologies in human organizations.*"

For our work, we have selected one of the most used and well documented forms of action research, which is the canonical action research [11, 58], represented in figure 1.

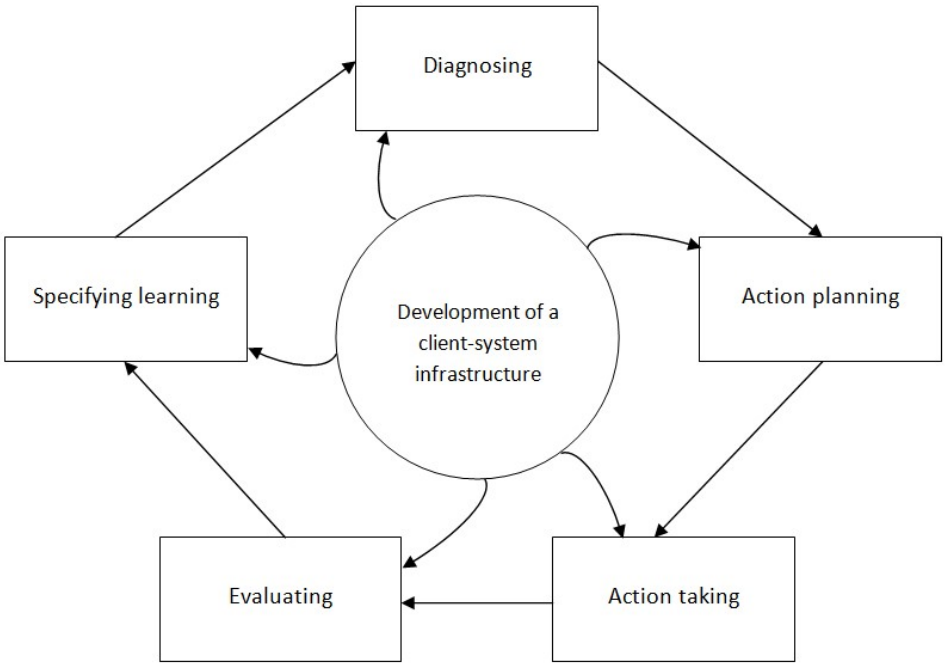

Fig. 1. The cyclical process of action research (adapted from [58])

Canonical action research involves a cyclic combination of five phases, namely [58]:

- *Diagnosing*, identifying, or defining the problematic situation, as a shared task by the researcher and practitioner. The actors holistically interpret the phenomenon and formulate working theories to be used in the subsequent phases of the cycle;
- *Action planning*, specifying possible courses of action to improve the problematic situation;
- *Action taking*, referring to the implementation of the course of action, causing change to occur and trying to create improvements to the situation;
- *Evaluating*, assessing the consequences of the actions, involving a critical analysis of the results;
- *Specifying learning*, identifying the findings, documenting and defining the outcomes that will add to the body of knowledge. Although appearing last, this phase is a permanent activity.

Equally important is the specification of the client-system infrastructure, which sets the context for the research, stipulating boundaries, responsibilities, sanctions, and collaborations, among other considerations stated in [58].

To ensure rigor and validity, we followed the five principles specifically formulated by [11] for canonical action research: *(1) Principle of the researcher-client agreement; (2) Principle of the cyclical process model; (3) Principle of theory; (4) Principle of change through action; and (5) Principle of learning through reflection*.

4. Applying canonical action research

The following sections describe how canonical action research (CAR) was applied to address the case of food company. We start with a brief description of the client setting and then move on to the various steps of CAR.

4.1. Context of the case organization

The history of the company where we intervened dates back to the 1930's, when its founder, owner of a grocery and bakery, decided to start a table olives business. Later on, besides the olives that were preserved in a natural way, some varieties started to be transformed under the oxidation process – a very advanced method at that time. The range was also extended to other products, such as pickles, lupin beans, hot sauce and mustard condiment, in a permanent inter-relation with the market, which demanded high quality products. This central idea of the market leading production quickly distinguished the company as national leader in the above-mentioned products, but also a key international player in food transformation.

Nowadays, the industrial plant is over 30.000 m^2 and, at a global scale, it is positioned as one of the top industrial units of the sector, employing hundreds of people. The company exports to all continents and is present in all the distribution channels (e.g. retail, fast-food chains) of the domestic market. The adopted quality standards include ISO 22000, IFS, and BRC. The multiple certifications are central to the company strategy, that plans to expand its business and started to install a new industrial unit.

But this reality is not without challenges. The quality manager explained that each sector of the company had a different perspective about the requirements involved in their regulatory space

and a sometimes-contradictory interpretation of similar requirements and evidences to support the audits. As she put it: "w*e need a map or we will get lost in a jungle of regulations (…)*".

The company priority was to focus on requirements pertaining to multiple regulations, and promoting people involvement and knowledge transfer in the modelling activities, which are essential values of their quality system.

4.2. CAR diagnosing

Managing multiple food safety standards is an information intensive task. First, this company has a complex product mix requiring five independent production lines, which creates difficulties for compliance evaluation and to establish a list of goals and indicators to cover the entire organization. Second, the frequent audits call for a graphical representation of the standards in the regulatory space, because (1) it is difficult to link requirements of multiple standards in a tabular form, and (2) it would simplify the auditors' perception of the whole quality and safety system. The organization wants to shift from a long-established perspective of managing each standard independently to the perspective of integration [49].

According to Sladjan Maras, Vice President of Gartner Information Technology Research and Advisory Company, when we "*speak to a business executive – it is not only about a model, but it is the right level of approach to communicate the model (pragmatic approach) that is important. Also, most of the modeling initiatives are too 'academic' – too broad, and without clear business value which is a large drawback, EM* [enterprise modelling] *is meant to achieve a strategic transformation (not on project level)*" [56]. The business processes in our setting are extensively described in typical quality procedures required by food safety standards [8, 27, 29], including about 30 flowcharts representing their most important activities. Although their documentation is considered compliant to the standards, the quality manager acknowledges difficulties in integrating their systems. She told us that "*it is necessary to represent a system of our quality systems*" and the main reasons are (1) the excessive amount of time spent in collecting information from different standards, some of it redundant, (2) the inefficiencies in obtaining representative indicators, and (3) the need to establish goals to address all major requirements of the standards.

4.3. CAR action planning

Researchers and practitioners agreed to engage in participative modelling effort [55] to implement a synergistic model with three levels of integration as proposed by [61]:

- *Strategic synergy*, integrating the goals and planning for compliance with the multiple standards;
- *Resource, structural, and cultural synergy*, ensuring a proper distribution of the organizational resources, actors coordination, and sharing cultural artifacts and principles to achieve standards certification;
- *Documentation synergy*, unifying the integration models and indicators.

In a previous research project involving the food company we developed a participative modelling approach to represent and link the company regulations, company functions, key business processes and the underlying IT support [5]. Auditing was out of the scope of that project, but we soon concluded that company goals and indicators were essential for using our models in practice.

Our approach for participative goal modelling is inspired by [41], which integrated the approach of Enterprise Knowledge Development (EKD) and balanced scorecard implementation. The plan that we sketched included modelling seminars [55] as follows:

- *Step 1*: Map the structures of the multiple standards into a unified model using a goal-oriented approach [31]. The purpose of this phase is to compare structural elements of each standard. The structure of the standards is represented by soft goals [31] modelled in jUCMNav, a graphical editor for GRL and URN in the form of and Eclipse plug-in [3];
- *Step 2*: Identify, for each soft goal, the requirements that need to be audited in organizational practice. This step can be accomplished by creating tailored checklists for each soft goal (e.g., extracted from IFS global checklist [27]) to guide auditors in compliance checking;
- *Step 3*: Establish the organizational goals and link them to the standards structure level (soft goals) of the integrated system;

- *Step 4*: Identify the key performance indicators, specify the quality factors and targets [24], and link them to each organizational goal of the integrated system.

The decision to adopt GRL-based models occurred at this stage, when evaluating different modelling languages that could fit our purpose (e.g.: i*, Tropos [21, 57]). On the one hand, GRL is designed to represent and reason over conflicts via negative contribution links and conflicting evaluation values, although it cannot automatically detect conflicts between models. On the other hand, as identified by [43], GRL has been successfully used for reasoning about regulatory requirements. There is ample guiding literature relevant for the particulars of our case [3, 20, 33, 47], and the Eclipse-based GRL graphical editor that we identified – jUCNNav – has been experimented in regulatory contexts [4, 17]. The IT department in our case company was already using Eclipse, and found GRL and the jUCMNav plug-in intuitive. Accounting for this preference had the potential to secure their early involvement and support. This would be key in identifying IT-based opportunities for compliance improvement and in the continued use of the approach in the company after we left. GRL was thus adopted, but allowing a broadminded use of its ontology by the organizational participants. The human-centred activity of identifying requirements in complex scenarios, including implicit requirements as presented by [40], can benefit with the contrast of stakeholders viewpoints [13]. Simultaneously with the modelling process, we aimed at assessing participants' use of GRL-based models as a communication tool for developing an integrated management system with multiple food safety standards.

4.4. CAR action taking

Following our plan, ISO 22000, IFS, and BRC were modelled using the jUCMNav graphical editor.

Step 1 consisted of modelling each standard independently, as illustrated in figure 2, for IFS.

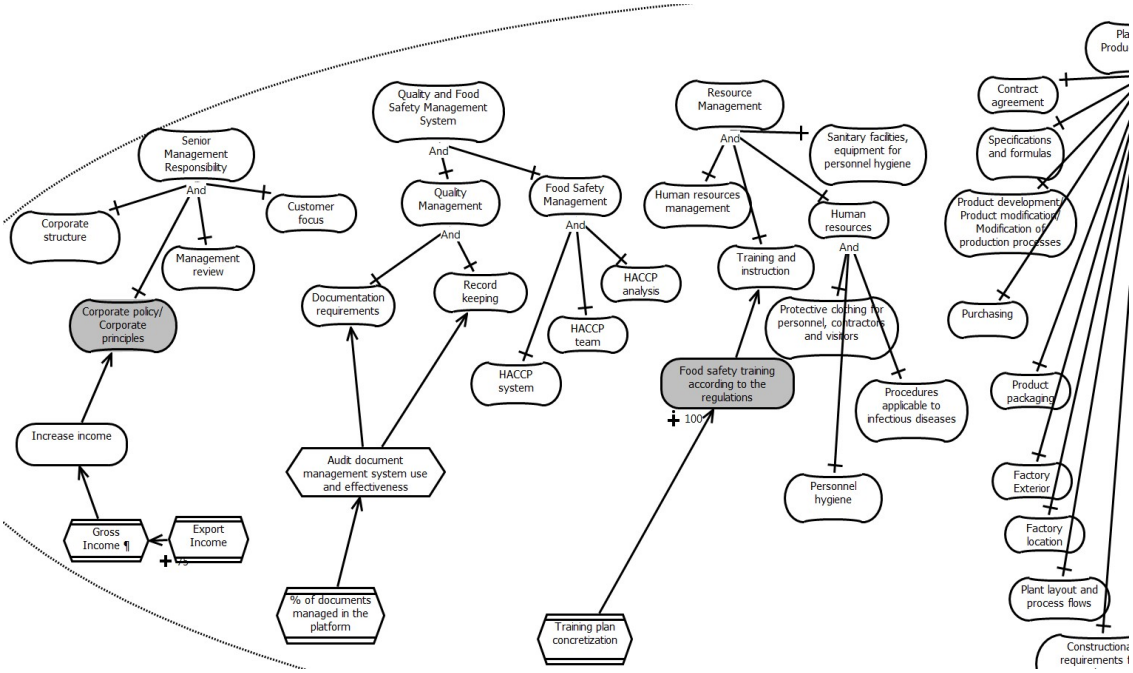

Fig. 2. IFS [27] structure model (extract for the level 2 of IFS clauses of requirements)

Figure 2 presents some of the main clauses of requirements of IFS [27], represented as soft goals in GRL. The topmost soft goals are the main chapters of the standard (e.g., "Senior management responsibility"), in the top left of the image. Then, we decomposed each chapter with the correspondent sub-chapters and clauses included in the standard. It is possible to map goals for specific clauses. For example, the corporate policy (represented with the gray colour, on the left of the figure) includes the goal of "increase income", with the associated indicator of "gross income" and the contributing indicator of "export income". Additionally, it is possible to include tasks required for compliance. In our example, "Audit document management system" that contributes to our soft goals of "Documentation requirement" and "Record keeping".

However, separated models for each standard are insufficient, because it would lead to a duplication of goals and indicators in each standard model. Therefore, we mapped the three standards in a new integrated model, as presented in figure 3, with each of the three top ovals defining the scope of a specific standard.

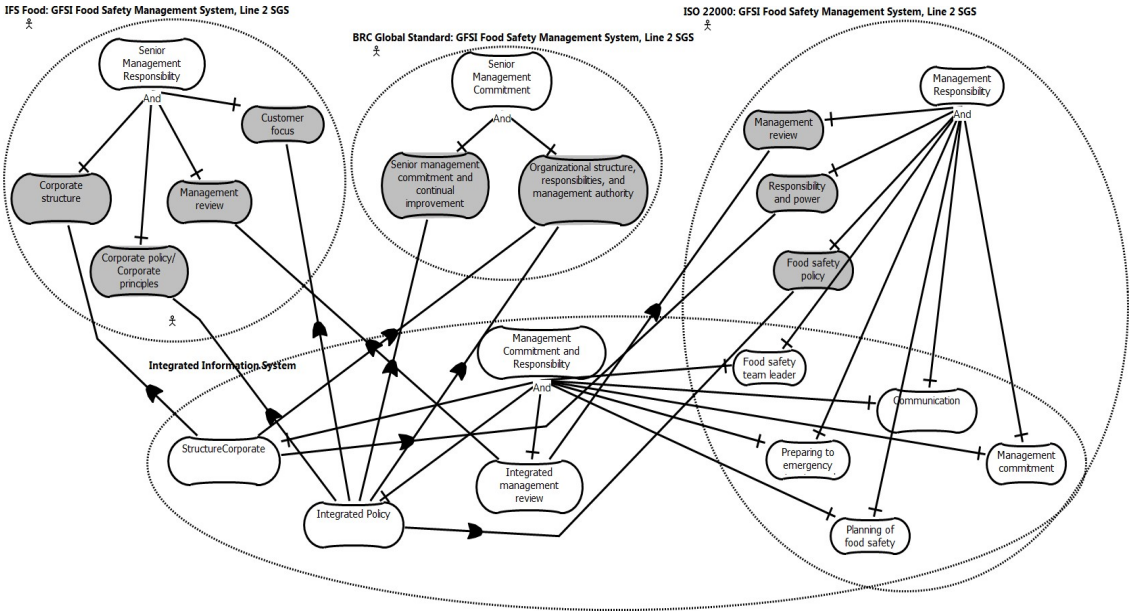

Fig. 3. Modelling integrated standards requirement (management clauses extract)

To reduce model complexity, we created one model for each main group (top-level clauses included in each standard) of similar standards requirements. Figure 3 presents the case of the management related clauses named “Senior management responsibility” in IFS [27], “Senior management commitment” in BRC [8], and “Management responsibility” in ISO 22000 [29]. The related high level clauses are according to the alignment matrix provided by [50], one of the leading certification companies in the world. On the top of figure 3 we represent the management clauses as soft goals: IFS, BRC, and ISO 22000 (actors). The integrated system is represented by the ellipse at the bottom of the figure. It is the result of two tasks: First, merging the clauses of each standard (represented with light grey background in the elements) in new aggregated soft goals, for example: “Integrated policy” is a combination of BRC, IFS, and 22000 specific soft goals; second, a direct association of soft goals that are specific to a standard, for example, “Communication” in ISO 22000.

Step 2 of our approach requires the identification of all the detailed requirements of the standards. The result is a checklist, in tabular form, summing up all the lowest level requirements for each node of the integrated system. For example, the “Integrated policy” soft goal has the checklist items that result from the dependent soft goals represented above (extracted from [8, 27, 29]).

Steps 3 and 4 of our approach are, respectively, the identification of the organizational goals – defined by the managers – and the corresponding indicators. We discussed the benefits and pitfalls of linking indicators with other elements of the model, for example, soft goals. According to the CAR participants, it was easier to define indicators for organizational goals, because they depended on their own choice and are specific to their organizational setting. However, soft goals can be (indirectly) assessed trough the performance of the related organizational goals, for example, using weighted averages of the selected indicators. Moreover, according to the team, visualization with layers (soft goals on the top, organizational goals below, followed by the layers of tasks and indicators) improves readability of the model by users that are not familiar with GRL notation.

We selected a minimum of one goal for each soft goal of level 2 and one indicator for each goal. The organizational goals ("to-be") are linked to the integrated system level on the bottom of figure 3. In figure 4 we present the final example for the management clauses of the three integrated systems.

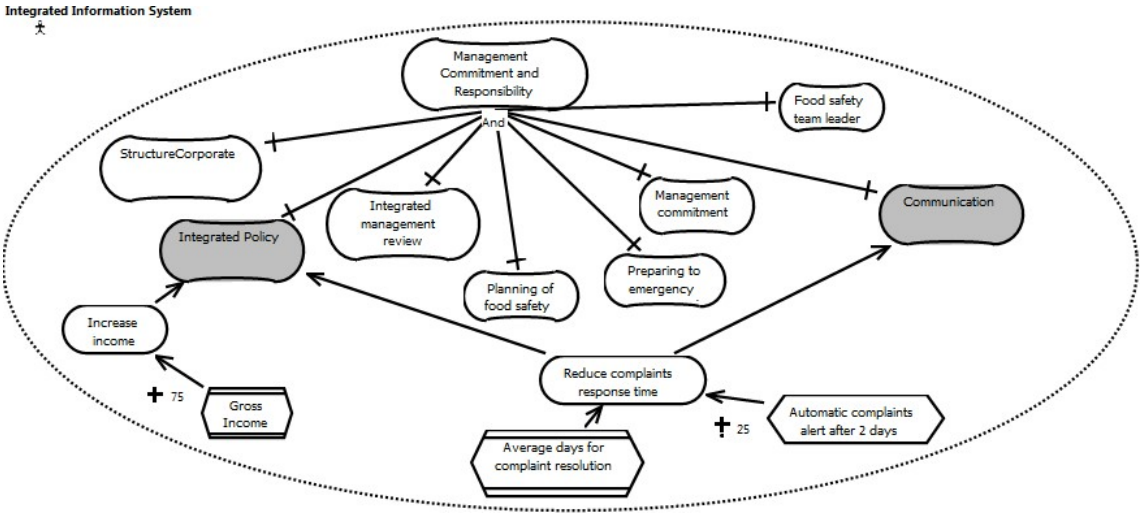

Fig. 4. Integrated goals, tasks, and indicators (management clauses extract)

Figure 4 presents the integrated soft goals of ISO 22000, IFS, and BRC for management commitment and responsibility, detailing the ellipse at the bottom of figure 3. For the sake of simplicity, we included in the image only two organizational goals of the organization ("Increase income", "Reduce complaints response time"); the indicators "Gross income" and "Average days for complaint resolution"; and a task "Automatic complaints alert after 2 days". A deeper comparative

example of the artifacts used before our intervention and as a result of this research is included in the appendix of this paper.

4.5. CAR evaluating

We found benefits in adopting GRL for modelling standards integration, following the recommendations put forward by [55]. We gathered empirical evidence of those benefits from the company documentation, observation during project meetings, and interviews with company managers and internal auditors. The organizational staff considered the models accessible, helping them in their communication about quality and safety. According to the quality manager of the food company "*it complements our text-based procedures with a graphical presentation of the regulatory requirements (… and) intertwines external – mandatory regulations – with our policies and operational goals. At run-time, perhaps the most interesting aspect is the auditing roadmap provided by the new goal models*".

The company pointed to the following positive aspects when comparing to their previous tabular and flowchart models:

- GRL can provide a global perspective of multiple standards and the rationale for the integrated system, which can be tailored for each organization. More specifically, it maps similar requirements and links goals to the integrated model level. This approach enables the easy identification of which standards requirements (soft goals) do not have associated organizational goals, and which goals do not have associated indicators to evaluate them;
- GRL models provide a distinct perspective of the organization, when compared to business process flowcharts. They highlight the most important aspects for quality and safety, the principles that must be followed, and their interconnections;
- The approach can be effective for understanding the potential impact of actions (tasks) in standards clauses (contributions). Moreover, it helps to recognize the areas that concentrate company improvement goals and, conversely, areas that are not receiving proper attention for certification;

- The models are complementary to checklists, for example, the ones included in IFS Food standard [27]. In fact, new integrated checklists were created using the integrated model, which simplifies the auditing tasks. The organization also created three checklist segments – accessible to specific teams of the company (for example, HACCP teams) – that are, notwithstanding, compliant with corresponding segments of the integrated model;
- GRL models were used to identify the requirements of a new mobile application for auditing food quality. The app includes customized integrated checklists and provides an evaluation of standards requirements per the model.

We confirmed [13]'s findings in merging stakeholders viewpoints, namely that "*the process of comparing and merging stakeholder viewpoints led to a deeper understanding of the problem domain, and improved backwards traceability to interview data*". We agree with [13] when they argue that "*the process of merging viewpoints was far more important than the products of that merging*". Therefore, as we recognize that automatic merge would probably improve the efficiency of the modelling process, we suggest that it could also decrease the benefits for learning standards principles, promote a critical debate and the internalization of best practices in daily practice of the organization.

As expected, we faced several difficulties during the CAR action phase, emerging from the use of a new language and a different form of modelling, evaluating, and implementing multiple standards in this company. One of our strategies was to simplify GRL models by representing all standards requirements as soft-goals, which can be imprecise in specific elements. In particular, the "HACCP team" – an ISO 22000 requirement, represented as a soft-goal, is in fact an actor in GRL ontology, while the requirement "Resource management", also represented as soft-goal, is a task if we consider it literally. Nevertheless, project participants preferred the interpretation of all standards requirements as soft goals. According to them, it allows a clearer identification the external requirements of the standards (clauses) in the models, contrasting them with the related goals defined by the organization.

The team identified synergies in three levels of the integration project [61]:

- *Strategic synergy*, integrating the requirements to comply with three standards;
- *Resource, structural, and cultural synergy*, using the models as communication tools fostering an organizational culture of quality, ensuring the resources for certification and the coordination of the staff;
- *Documentation synergy*, adopting the goal-oriented approach to develop integration models and identify the indicators to monitor performance and audit conformity.

On the one hand, we have implemented two of the possibilities suggested by [49] to integrate regulatory models, namely (1) graphically highlighting compatibility between multiple standards; and (2) through participative goal modelling, fostering a culture of people involvement and the emergence of actions for compliance with standards. On the other hand, we did not yet reach automated integration in our resulting models, and our approach does not yet allow full traceability between goal graphs and process models.

After concluding the CAR cycle we returned to the company to interview the quality manager and IT manager, to understand how the models were integrated in their daily practice. The quality manager told us that "*an important customer considered goal models innovative, to present the regulatory requirements and main interconnections of their multiple systems*". The customer found the models interesting, to understand the requirements of the standards, but also the company goals and indicators to accomplish them.

When we asked about potential drawbacks of GRL models missing the temporal perspective (i.e. ordering or prioritization of goals or tasks) we got contradicting answers: the quality manager does not see it as a problem, since quality plans contain that information. The IT manager, however, thinks that it would be important to improve the goal models with more information for the implementation phase, for example, requirements prioritization and compliance to IT-related standards and frameworks such as ITIL. We found these insights useful to prepare sequent cycles of our research, focusing on the impact of goal models on IT departments adopting quality standards and frameworks. One possible way to explore requirements prioritization could be to consider a

combination of the number of goal links and importance level, inspired by the exploratory proposal made by [36].

4.6. CAR specifying learning

We overall learned that goal modelling is critical for the integration of food safety standards. Organizations can select between (1) documenting their systems in disconnected platforms, documents, and flowcharts, or (2) adopt a more structured and integrative approach such as the one we have presented: understand their certification context, model their requirements, establish the desired goals, and then develop supporting tools. There are two types of goals in the developed models: (1) the prescribed soft goals that emerge from the standards, and (2) the goals that the organization decides to implement in their systems (including the information system) to ensure compliance and improvement.

Figure 5 summarizes the suggested approach to handle the quagmire of multiple standards with participative goal modelling.

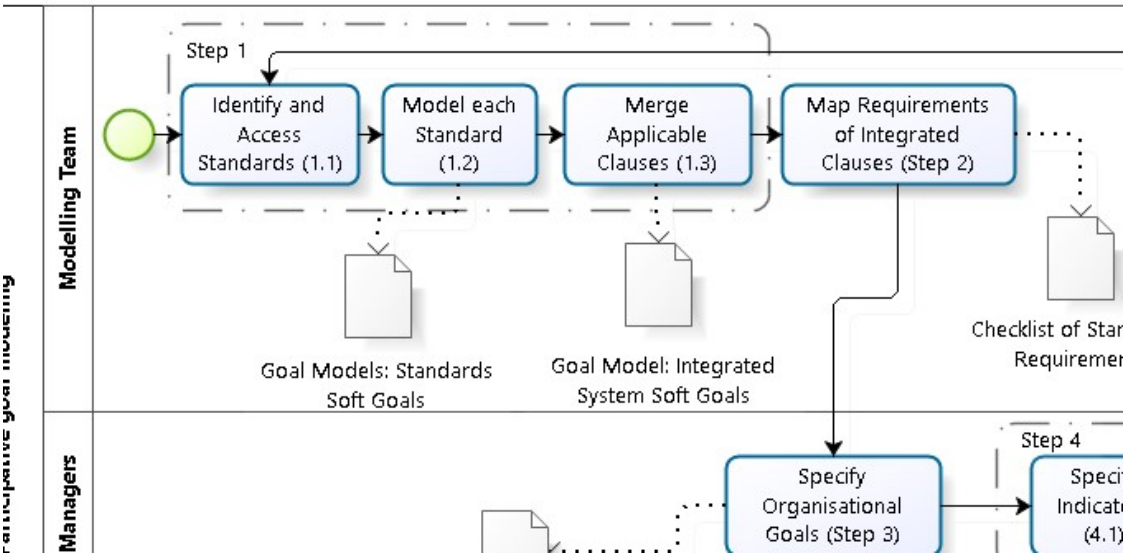

Fig. 5. Participative goal modelling of regulatory requirements

Figure 5 represents our suggested method and how the various stakeholders participate in different moments. The modelling team is represented in the upper lane, the company managers – who may also be part of the modelling team – are represented in the middle lane, and the internal and

external assessors are represented in the lower lane. The process addresses the need for collaboration between requirements engineers and domain specialists, contrasting their viewpoints [13, 37]. The goal models and checklists of standards' requirements – represented as document artifacts in figure 5, evolve according to the steps presented in our CAR action phase: *Step 1*, "*Map the structures of the multiple standards into a unified model using a goal-oriented approach*", is detailed by the three sub-steps (1.1 to 1.3) shown in the process model of figure 5. In *Step 2*, the modelling team obtains the integrated list of requirements from multiple standards and, in *Step 3*, completes that list with the organizational goals. Finally, *Step 4* identifies the key performance indicators (4.1) and the compliance tasks (4.2) for the operation phase of our model.

We obtain the final goal model after defining compliance tasks (4.2), however, it is a continuous development process, with multiple versions of the goal models, as required by complex and dynamic regulatory scenarios.

GRL models were not familiar to the managers of the food company, and their first reaction was not enthusiastic. They were worried about the possibility of (1) duplicated information in their traditional business process models and (2) the cost-benefit of involving multiple stakeholders in the modelling activities, which was a main responsibility of the quality manager. However, after a brief explanation of the purpose of the model and some hands-on practice, they quickly understood the differences to their usual process flowcharts. After showing the first GRL model of IFS, we definitely captured their attention to our proposal. Contrarily to the initial apprehension, the models enabled the simplification of their food safety management systems integration, and provided guidance for goals and indicators that were previously included in a spreadsheet and difficult to link to the certification requirements.

There are GRL elements that we did not use at this stage of the research (e.g., resources, some types of interactions, OR) and others partially used (e.g., qualitative contributions) to keep the model as simple as possible for the introduction in the organizational practice. Nevertheless, resources are important to consider, for example, to represent specific IT solutions that support specific goals or soft goals. Auditors can use the models to identify the IT platforms that contain evidences for compliance assessment. The approach that we followed, according to our action plan,

is a possible solution to represent the links of an integrated management system for food certification schemes.

Our findings confirmed several benefits of using the developed models in daily practice, namely to (1) communicate to all employees the organizational principles, its interrelations, and sources (e.g., standards, laws, and management policy) in the form of goals; (2) identify the potential impact of proposed tasks (solutions) in regulatory compliance; and (3) compare the goals at design-time (desired) and run-time (implemented) according to the defined performance indicators. We have shown that participative goal modelling can address the challenge of multiple food safety standards, combining impact engineering *and* social responsibility [15].

It is possible to use GRL tools such as the graphical editor jUCMNav in participative goal modelling in the context of integrated standards. The benefits can be found at design-time and run-time. At design-time, GRL supports the integration of the models, tracing relations from the high-level goals of standards to the more detailed requirements lists (included as checklist annexes in the IFS and BRC food safety standards). At run-time, the models were tested during this research to guide the internal audits conducted by the company quality manager. External hyperlinks can be included in tasks (for business process models) and in indicators, complementing the model with fine grained information.

Goal modelling can assist interested parties of the organizational regulatory space, namely (1) consultants, (2) industry-driven initiatives such as the GFSI in their recognition and benchmarking activities, (3) and auditors. Consultants can use GRL-based models to design the integrated system and to ensure that objectives are established and monitored according to all critical elements of the standards. Industry-driven initiatives can use models to compare standards and evaluate their gaps and complementarities. Auditors can use GRL-based models to gather evidence of compliance to requirements; for example, to check (1) if all requirements (of the integrated system and for each standard independently) are addressed by the organizational goals and improvement actions, (2) which indicators can be used to assess which requirements, (3) which resources are used for each requirement, and (4) to confirm that organizations take advantage of modelling for improvement and transparency.

5. Assessing our CAR project: relevance, rigor, validity, and generalizability

Our type of research setting – complex socio-technical contexts, where it is not possible to know every relevant variable, much less control them individually – poses significant threats to rigor and validity. For this reason, we adopted a framework of methodological guidance specifically designed to ensure rigor and relevance when using canonical action research [11]. The adherence to those guidelines is reviewed in the next section and, in the following one, we discuss the generalizability of the results.

5.1. Evaluating the research process

The compliance with each of the five principles and associated criteria proposed in [11] is discussed bellow:

(1) Principle of the researcher–client agreement

The client and the researchers agreed that CAR was appropriate for the purpose of contributing to science while solving a complex organizational problem in the scope of multiple standards and their intertwined requirements. The client made an explicit commitment to the project, identified the most relevant standards to include in the study, and the stakeholders involved. The main objectives of our client were to model the requirements of multiple food regulations – some derived from standards and some decided by the organization – and improve their integration in practice. Data collection included interviews, observation, and document collection, safeguarding confidentiality when applicable.

(2) Principle of the cyclical process model

Our research followed the five stages of CAR [58] starting with a diagnosis of the company setting and the requirements that emerge from its regulatory space. Researchers and company managers developed an action plan and a comprehensive evaluation after action taking phase. Based on the time constraints of our project, we considered that one CAR cycle was appropriate to develop

the initial version of a goal-oriented approach to address the problem of multiple standards requirements in the food industry for the case of this company.

(3) Principle of theory

According to [12], theory usually emerges from the diagnosis phase and guides the action plan. Our project activities were guided by a set of theories identified in the literature, including participative enterprise modelling [55], experiences of stakeholders involvement in goal modelling [33], and an well-known goal modelling language (GRL). We confirmed the relevance of managing a plethora of requirements in food certification contexts and the lack of solutions to assist companies in this challenge. We compared our findings with the guiding theory, extending the body of knowledge with a goal-oriented approach for participative goal modelling of the organizational regulatory space as described by [22].

(4) Principle of change through action

Action taking addressed the conceptual modelling and the integration of multiple standards. The modelling activities involved different stakeholders in the production of new artifacts that were previously unavailable, for example, for transparency assessment and audit support. We introduced GRL in the company modelling practices, although we stress that other languages could be used for our purpose of participative goal modelling in regulatory contexts. The organization situation was comprehensively evaluated before and after the intervention, ensuring that change was analyzed and documented.

(5) Principle of learning through reflection

We provided progress reports to the client and conducted regular meetings to plan actions and evaluate the results. Learning is a permanent activity in CAR, emerging from a joint reflection during the entire cycle. There was a joint reflection by researchers and practitioners to ensure that our results fit organizational practice and practices endure after the project conclusion. We learned about the benefits and difficulties of adopting participative goal modelling for managing multiple

standards. We confirm that the existing requirement languages such as GRL can address that challenge, yet, benefiting from adaptations to make them accessible to different stakeholders and to enhance model readability without compromising rigor. Moreover, we found benefits in the proposed steps to guide the participants during the goal modelling process. After concluding this CAR cycle we have visited three other companies in the food industry (sauce production; chip production; world leading bakery supplier) confirming that participative goal modelling is not used in this industry. We argue that participative goal modelling can assist standards requirements identification and integration, while contributing for comprehension of the standards and their diffusion in the company (during participative modelling sessions). Moreover, it can assist the mapping of company goals with standards requirements, ensuring compliance with requirements that emerge from external entities (certification companies, customer contracts) and internal policies. The positive feedback that we gathered – as discussed in the section CAR Evaluating – in these companies about participative goal modelling provides a strong motivation for sequent CAR cycles.

5.2. An additional note on generalizability

Besides ensuring that a rigorous process was followed, it is key to understand the grounds for generalization of the results. In this process, we must keep in mind the words of Kurt Lewin, about "*(…) the artificiality of splitting out single behavioral elements from an integrated system*" [14].

As [59] puts it, there is "*(…) no criterion agreed on by all philosophers that settles the matter (…)*" of what makes a theory scientific. And *"(…) Even for a theory that survived testing and criticism for a long time, it is always possible that someone will find a flaw in the argument or that a test will falsify part of the theory. Scientific theories are fallible. We should always consider them to be improvable.*" This view is in accordance with our practice and proposal [10] for action researchers to "*(…) find support for the epistemological legitimacy of their research on the roots of Critical Rationalism, by Karl Popper"* namely, *fasifiability* and *verifiability.*

According to Popper, scientific theories are only provisionally valid. They should be systematically challenged and replaced by better ones [46]. This stance has implications in the

process followed during research, which should include ways to enable such a dialectic. Some of the principles specifically formulated by [11] for canonical action research fit this requirement.

Following the categorization of [59], ours is a setting of "*conditions of practice*" and "*case description*". When approaching similar cases, other researchers can use our results, in their entire complexity, as guidance, but should be aware that they are not general laws. The proposed approach was effective in this particular company and it has the potential to be useful in others. The process of experimenting it in new contexts challenges its current form, as suggested by Popper. The result may be a contraction, expansion, or maintenance of the scope of application of this provisional truth. A new version, with adjustments, may emerge to account for particulars of the new settings.

6. Conclusions

We presented a canonical action research (CAR) project that used a goal-oriented approach to handle compliance with multiple, concurrent, food safety standards. Our setting is a company in the highly regulated food industry that adopted three main standards for quality and safety: ISO 22000, IFS Food, and BRC Global Standard. The proposed goal-oriented approach consists of four steps to assist in the integration of multiple regulations, resulting in a comprehensive model that links standards requirements, organizational goals, and indicators. Moreover, we assessed the benefits and the difficulties of adopting a modelling language such as GRL, by organizational stakeholders with different background educations, in their efforts to develop integrated management systems supported by standards. Rather than proposing a completely new method, our research explores the use of an existing requirements language, in the context of participative goal modelling to handle multiple regulations.

There are potential barriers to regulatory compliance of requirements in complex scenarios, as identified by [40]. The impediments include the identification and access to relevant standards, the number and complexity of regulatory documents, and the multiple domains of the system under consideration [40]. These authors highlight the difficulty of identifying applicable regulatory documents by automated techniques. Moreover, there is a lack of tools and approaches to deal with the noncontiguity of regulatory requirements, multiple references, abstract, and implicit

requirements. Therefore, the complexity in this field requires "*lateral and vertical communications to resolve compliance issues in system design […], cross-cutting requirements […], and relevant contractual sections*" [40]. Our contribution addresses these challenges and impediments to regulatory compliance, extends the existing knowledge in goal requirements modelling (1) focusing on multiple standards, (2) suggesting a participative approach, (3) exploring the use of a goal requirement language by non-specialists in requirements engineering, (4) in a demanding organizational setting such as food industry.

Companies dealing with multiple certifications are not yet exploring the full potential of participative modelling for quality improvement. In the case that we report, the organization already had defined and documented their business processes; however, the lack of integration of modelling standards resulted in excessive overhead in managerial activities related with goals and indicators, difficulties to assess the impact of improvement actions, and disconnected audits with duplicated checklists. The situation was improved by (1) modelling a new integrated system compliant with all their standards, (2) modelling goals and indicators customized for the integrated system, (3) creating integrated audit checklists that are well-matched to the company products and production lines, and (4) providing complementary support for their audits with GRL-based models.

6.1. Limitations

Our research has several limitations to take into consideration. First, it is a single case, and the company had scarce experience in goal-oriented modelling; it is possible and advisable to refine the models with more elements and increased detail as their experience develops. Second, the middle-level managers were the main participants from the organization, so there is an opportunity to include additional staff members in the modelling process. Third, in spite of the positive results that we found, we did not yet have the opportunity to test the models with an external audit. Forth, social studies are complex and there is also a potential risk of the Hawthorn effect [16], which suggests that the results can be affected by the special attention that is received by project participants.

6.2. Future work

As stated by [2]: "*there are still important challenges to be addressed, including the systematic extraction of URN models from textual laws and policies, and the prioritization of efforts to improve a partial degree of compliance*".

Future work can involve other modelling languages, methods, and tools for multiple certification schemes. There are opportunities to develop new software product lines for the market of multi-standards, to support the design-time and the run-time of quality certification; for example, to help consulting in automated standards integration (e.g., suggestions for merging goals or tasks based on description or properties), templates for different standards built in GRL or other modelling languages, and platforms for auditing. For other contexts, there are opportunities to address the integration of different standards and improvement models, for example, the IT-related CMMI-DEV, ISO 15504, ISO 12207, or other more specific to the defence industry (e.g., NATO AQAP) and aeronautical (e.g., AS 9100). The recent revision of ISO 9001 requires the identification of the context of the quality system [30], therefore opening possibilities for exploring modelling approaches as presented in this paper. Our plan for the next CAR cycle is to conduct multi-layered modelling that can reach process level detail, allowing traceability between goals (enforced or decided by the organization) and Business Process Modelling Notation (BPMN) models as suggested by [53]. It is also an opportunity to evolve the goal-oriented approach for the integrated management of standards in the long term, including version management and gap analysis.

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Appendix

This appendix provides additional detail on how goal modelling was used for integrating and managing multiple standards in the food company. Figure 6 shows and excerpt of the traditional annual plan of the organizational goals.

Objectives - Integrated Management System

Context	Goal	Target	Indicator	IFS		BRC		ISO 22000	
Integrated policy	Increase income	12.000.000,00 €	€ Gross Income	1	1.1	1	1.1	-	-
	Increase export income	3.000.000,00 €	€ Gross Export Income	1	1.1	1	1.1	-	-
Integrated policy	Monitor customer satisfaction and the perception of service quality	> 60%	% key customers	1	1.3	3	3.12	-	-
		> 80 %	% sales to key customers	1	1.3	3	3.12	-	-
Integrated policy	Reduce complaints response time	max 5 days	Average days for complaint resolution	1	1.3	1	1.1	5	5.6
	Reduce critical non conformity in external audits	0	Customer audit report: N° non conformities	1	1.3	3	3.12	5	5.6
Planning of food safety management system	Execute training plan for food safety	100%	% plan execution	3	3.3	7	7.1	6	6.2
Planning of food safety management system	Absence of non conformancy in sample plan to validate PPRO/PCC	0%	% Non conform results	5	5.6	5	5.6	8	8.4
Planning of food safety management system	Implement electronic audit records in production lines (mobile system)	December 2016	System tested and in use	5	5.3	3	3.3	7	7.8
R&D	Implement new ideas (process, product, marketing, organizational).	105	N° of R&D ideas	4	4.3	5	5.1	8	8.5
Production	Increase the number of cans produced and sterilized in Line A	5%	Number of sterilized cans increase / day (8 hours)	4	4.3	-	-	-	-
Production	Increase the number of products shiped in Line 4	10%	Number of products shiped in Line 4 / day (8 hours)	4	4.3	-	-	-	-
Produção	Increase the sauce X production in bottle size Z	15%	Number of bottles increased / week	4	4.3	-	-	-	-
Sustainability	Reduce annual energy consumption	83	Energy / production quantity (kgep/ton)	1	1.1	-	-	-	-
Sustainability	Reduce annual energy intensity	0,1	Energy/VAB (kgep/€)	1	1.1	-	-	-	-
Sustainability	Maintain annual carbonic intensity	2,11	Energy/emission of greenhouse gases ($kgCO_2$/tep)	1	1.1	-	-	-	-

Fig. 6. Annual objectives of the food company

The spreadsheet represented above includes the main goals for the integrated system (column 2), grouped by the context (column 1), the target and indicator (columns 3 and 4) and the relation to the adopted standards. The main problems with this existing approach are:

(1) It links goals with individual clauses of each standard, but does not address cases of goals that may be associated with multiple interrelated clauses of the standards;

(2) It does not provide a clear indication of missing clauses and the interrelations between goals or indicators;

(3) The spreadsheet is created at the end of the previous year and usually assessed at the end of the following year, lacking support for daily use or guidance on how to comply with the standards requirements;

(4) It does not trace to tasks involved in accomplishing the stated goals of the organization;

(5) It lacks pedagogic support to understand the requirements of the standards and their practical adoption in the organization.

Figure 7 presents an excerpt of the goal model for the food company Line 4 (sauce production), created using our proposal.

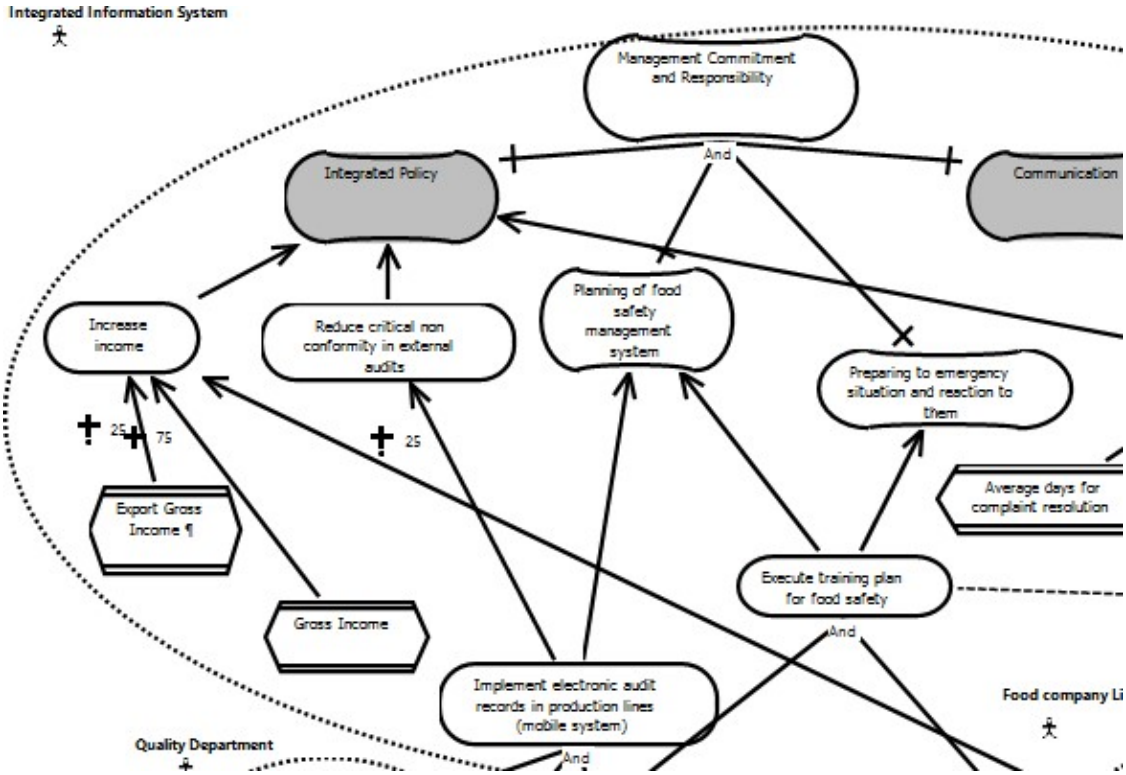

Fig. 7. The new GRL-based model for the integrated management system

The model included in figure 7 replaces the tabular presentation of figure 6, with several advantages:

(1) It increases rigor and traceability, revealing that goals may affect other goals and clauses of different standards, for example, “Implement electronic audit records in production lines (mobile system)” contributes to a company goal to reduce non-conformities and to a requirement of a standard for planning the food safety management system;

(2) It includes the tasks involved in accomplishing the objectives, at different levels of abstraction; for example, for actor Food company Line 4 (bottom right), it becomes clear that

the improvements that will lead to increased production simultaneously play a part in reducing complaints (associated with response time) and increase income;

(3) It improves the awareness of participants over the integrated system and the interconnections between goals, tasks, and compliance to standards.